

**O Processo Político de Construção das Políticas Públicas para as
Alterações Climáticas**

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**Dissertação de Mestrado em Sociologia - Políticas Públicas e
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Resumo

As alterações climáticas de origem antropogénica constituem um problema ambiental sobre o qual se desenvolveram desde a década de 90 políticas públicas e tratados internacionais de grande relevância. O peso desta problemática nas agendas políticas e mediáticas tem sido crescente em diversas nações, inclusive em Portugal e na União Europeia (UE). Com efeito, a UE constitui-se hoje como um dos principais agentes mobilizados e mobilizadores de políticas sobre esta problemática, com políticas públicas robustas implementadas no contexto do protocolo de Quioto e de outras decisões tomadas na Convenção Quadro das Nações Unidas para as Alterações Climáticas.

A ação internacional mais recente e ambiciosa promovida no âmbito da Convenção, ocorreu em 2015, o Acordo de Paris, mas foi recebida por uma renovada e estruturada oposição, nomeadamente a dos Estados Unidos da América (EUA), que com a sua saída do Acordo, despoletou desenvolvimentos imprevisíveis que representam atualmente um foco de preocupação e controvérsia, intensificando as interrogações face a um problema, que politicamente se veio a consolidar num desenho de políticas públicas com fortes implicações em diferentes áreas económicas, sociais e geopolíticas das diferentes nações e agrupamentos regionais representados na Convenção.

Este trabalho procura abordar o problema político como um processo, e sobre este, desenvolver uma análise sociológica, tendo como enquadramento teórico a teoria de campo de Pierre Bourdieu. O foco deste trabalho foi o de compreender o início deste processo, eventualmente lançando as bases para um estudo posterior que alcance as suas diferentes fases, até ao momento presente.

Assim, foi desenvolvido um método de investigação com base na análise documental de um *corpus* constituído por documentos produzidos em audiências legislativas no contexto de origem deste processo político: o Congresso dos EUA nas décadas de 50-60.

Finalmente procurou-se ter uma perspetiva sobre o campo científico, enquanto primeiro produtor da problemática das Alterações Climáticas (AC), e não apenas sobre o campo político, e aí compreender as dinâmicas, as transformações e as lutas internas e externas que terão moldado os primeiros desenvolvimentos do processo político das políticas públicas para as alterações climáticas.

Palavras Chave: Alterações Climáticas; Processo Político; Teoria de Campo; Políticas Públicas.

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Abstract

Antropogenic climate change is an environmental problem on which public policies and international treaties of great relevance have been developed since the 1990s. The weight of this problem in political and media agendas has been increasing in several nations, including Portugal and the European Union (EU). Indeed, the EU is now one of the main mobilized and mobilizer agent, acting on policies on this issue, with robust public policies implemented in the context of the Kyoto Protocol and other decisions taken in the United Nations Framework Convention on Climate Change.

The most recent and ambitious international action promoted under the Convention took place in 2015, the Paris Agreement, but was received by a renewed and structured opposition, namely that of the United States of America (USA), which with its departure from the Agreement, unleashed unpredictable developments that are currently the cause for great concern and controversy, thus intensifying the questioning of this problem, which over time has grown and consolidated politically into a design of public policies with strong implications in different economic, social and geopolitical areas of the different nations and regional groups represented in the Convention.

This work tries to approach the political problem as a process, and to develop a sociological analysis based on the theoretical framework of the field theory of Pierre Bourdieu. The focus of this work was to understand the beginning of this political process, eventually laying the groundwork for a later study that reaches its different phases, until its present moment.

Thus, a research method was developed based on the content analysis of a corpus composed by documents produced in legislative hearings in the context of the first political approaches on this issue: the USA congress in the decades of 50-60.

Finally, i sought not to resctrict my perspective to the political field, but also to look into the scientific field, given that it was the social field where the Climate Change problem firstly originated, and to understand the dynamics, transformations and internal and external struggles that shaped the developments in the political process of the public policies for climate change.

Keywords: Climate Change; Political Process; Field Theory; Public Policy.

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Introdução

A formulação de teorias sobre o clima tem origens conhecidas tão remotas como a antiguidade clássica, contudo os desenvolvimentos que estão na origem da formulação atual da problemática das alterações climáticas, encontram-se na produção científica do século XIX.

Estas primeiras formulações teóricas sobre a interferência humana no clima, não supunham que esta fosse motivo de preocupação, nem tampouco que devessem ser objeto de políticas públicas.

Com efeito, a grande maioria dos cientistas que desenvolveram a teoria do efeito estufa até meados do século XX, ou não consideraram as consequências da ação humana como sendo significantes para o sistema climático (o caso de Fourier e de Chamberlain), ou pensaram no aquecimento global de origem antropogénica como um aspeto com consequências positivas, quando muito justificando um intensificar das atividades que provocassem o dito aquecimento (Arrhenius, Ekholm e Callendar) (Flemming, 1998, pp. 55-93).

A construção social do problema das alterações climáticas, visando o seu reconhecimento político, teve início na década de 50 do século XX, no contexto do programa internacional de geofísica¹ (IGY), cujos resultados vieram também reintroduzir o *problema científico* das alterações climáticas de ação humana inadvertida na comunidade académica. Esses desenvolvimentos, apesar de prosseguidos no contexto internacional, foram conseguidos sobretudo no contexto do programa norte-americano do IGY².

Como tal, definindo como objeto de pesquisa o processo político de construção das políticas públicas para as alterações climáticas, direcionei o foco da pesquisa empírica para o período que tem início na data de realização da primeira audiência legislativa de aprovação do orçamento do programa americano para o IGY (1956), onde foi levantado, muito possivelmente pela primeira vez no congresso estadunidense, o problema das alterações climáticas visando o seu reconhecimento no campo político.

¹ Fleage (1994) ao procurar o início de uma “rota de pesquisa para a alterações globais” fixou-a no ano 1958 no Ano Internacional da Geofísica, justificadamente, uma vez que este “estabeleceu as bases para a observação da terra através de satélites, da monitorização de CO₂ e do estudo do gelo e dos oceanos para a descoberta dos padrões do clima no passado.

² O observatório Manau Loa no Havai, dirigido por Roger Revelle do Scripps Institution of Oceanography, foi o local onde Charles Keeling realizou as suas pesquisas sobre as concentrações de CO₂ na atmosfera, que conduziram à confirmação de que as emissões industriais estavam objetivamente a produzir alterações na composição química da atmosfera com potenciais consequências no clima (Keeling, 1970).

Essa fase do Processo Político, que tem como substrato o desenvolvimento do problema científico, decorre nos EUA com certa intensidade na década de 50 e de 60. Contudo, a tônica foi aí colocada numa vertente bastante diferente da atual: a ação advertida sobre o clima (tanto em escala localizada, como visando efeitos mais generalizados, inclusive militares e geoestratégicos). Esta vertente de políticas públicas correspondeu a uma reação do campo político a um processo iniciado, não na academia, mas na indústria, com investigadores em laboratórios privados a desenvolverem pesquisa e a produzirem serviços de modificação do tempo, numa indústria que rapidamente se tornou milionária: os chamados “rain makers”. No relatório sobre Modificações do Clima da *National Science Foundation* (NSF) (1965) a agência americana identificou que em 1953, três a quatro milhões de dólares eram gastos por ano em serviços de modificação do tempo (aproximadamente 23 a 31 mil milhões, nos dias de hoje, ajustados à inflação), e que pelo menos 10% do território norte-americano seria afetado por estas atividades. Existiriam a essa data cerca de 59 projetos comerciais a realizarem bombardeamento de nuvens (“cloud seeding projects”), a serem realizados por 15 entidades diferentes. Desde 1957 que diversos estudos seriam encomendados pelo governo para avaliar a pertinência de políticas públicas na área, e diversos programas iniciariam o seu funcionamento, envolvendo diferentes departamentos do Estado. O investimento nesta área também se refletiu no financiamento dirigido às universidades para projetos de pesquisa em Modificações do Clima canalizados pela NSF. O mesmo relatório avalia a despesa anual dos EUA em 1966 em projetos de Modificações do Clima (MC) no valor de 7,2 milhões de dólares (56 mil milhões nos dias de hoje, ajustados à inflação). Nesse mesmo ano decorrem audiências legislativas visando a formação de um programa nacional de modificação do clima. Essas audiências discutem em segundo plano os problemas relacionados com as alterações inadvertidas do clima, entre elas, a questão da acumulação de dióxido de carbono e o possível efeito designado por aquecimento global.

O processo legislativo das modificações do tempo, vê a primeira legislação promulgada em 1972, no *Weather Modification Reporting Act* (Pub. L. 92–205), e um programa federal a ser aprovado em 1976, pela lei *National Weather Modification Policy Act* (Pub. L. 94–490).

A promulgação do *National Climate Program Act* (1978) estabelece meios de financiamento e enquadramento legal para diversos serviços ligados ao clima, inclusive à questão das AC,

embora neste âmbito o foco seja o de produzir mais informação com vista ao esclarecimento do problema científico das AC de origem antropogénica. Esta lei inicia um programa de monitorização destinado a aferir com rigor dados críticos da teoria do aquecimento global. Poucos anos depois, o ano de 1980, vê ser promulgada a resposta americana à crise petrolífera da década de 70, com o *Energy Security Act*. Ambos os diplomas são promulgados pelo democrata Jimmy Carter. As audiências legislativas em torno desta lei registaram diversas intervenções acerca das preocupações com as Alterações Climáticas – e, num certo sentido profético – foi expresso o receio de que um apoio à produção endógena de combustíveis fósseis (em particular no desenvolvimento de novas formas de transformação de produtos derivados, nomeadamente os combustíveis sintéticos) assente na criação de um complexo industrial-científico público-privado, reproduzindo a experiência recente de um processo semelhante desenvolvido ao nível da indústria de armamento, criasse um lóbi de tal forma poderoso, que uma vez que o problema das Alterações Climáticas fosse sentido pelas gerações vindouras, não houvesse meios de travar os interesses estabelecidos. Estas preocupações não foram suficientes para impedir a promulgação da lei³, mas estabeleceram importantes características inovadoras da lei, que a consagram como a primeira lei no mundo, com medidas de estímulo à eficiência energética e apoio às energias renováveis (O Título IV e V da mesma, prevêm verbas para o desenvolvimento das energias renováveis, em especial da energia solar). Esta é também, uma das primeiras leis no mundo (se não a primeira) a mencionar o problema do aquecimento global no contexto de uma política energética. Paradoxalmente é simultaneamente um dos seus principais obstáculos.

No período seguinte, que decorre em simultâneo em diversos países industrializados, dos quais se destacam a Alemanha, a Suécia e o Reino Unido, até meados da década de 80, verifica-se um rápido desenvolvimento desta área científica, como da área política do Ambiente (o ativismo ambiental viera a intensificar-se significativamente desde os anos 60, e já dera nascimento aos primeiros partidos verdes na Suíça e na Alemanha). Verifica-se um

³ Esta lei está sem dúvida numa relação direta com a posição atual dos EUA como o maior produtor de crude em 2018 (EIA, s.d.), uma vez que alavancou a capacidade instalada para os avanços tecnológicos e condições vantajosas à exploração de novos reservatórios deste recurso que explicam o vertiginoso aumento da produção deste recurso nos EUA na última década, tornando-o inclusive um dos maiores exportadores de petróleo. Evidentemente que estes interesses económicos se opõem às preocupações ambientais relacionadas com as emissões de dióxido de carbono. A consideração deste facto *a posteriori* revela a longitude pós-geracional e o poderoso impacto das políticas públicas no âmbito económico e ambiental.

aumento da representação desta problemática no campo político, processo que culmina com a internacionalização do processo político das AC, assumindo a ONU o ponto focal do seu desenvolvimento – nomeadamente com a fundação do Painel Intergovernamental para as Alterações Climáticas em 1988 e com a Convenção Quadro das Nações Unidas para as Alterações Climáticas em 1992, na Conferência do Rio-92, que levou ao protocolo de Quioto em 1997. Os EUA, com a administração Clinton, assinaram o protocolo, mas acabaram por sair, pois este não foi ratificado pelo Senado, então controlado pelos Republicanos.

As fases seguintes, representam já uma maturidade do processo político suficiente para que possamos considerar as alterações climáticas uma problemática pública em diversas nações.

Sendo impossível cobrir todo este período, limitei-me a um segmento deste: o período compreendido entre as audiências legislativas do IGY e do Programa Nacional de Modificações Climáticas, portanto os anos 1956-66.

Este trabalho pretende ser uma primeira peça de um trabalho mais extensivo que fica em aberto como projeto futuro, e que cubra a total extensão do processo político com esta metodologia, da sua origem, até à atualidade, num esforço de análise sociológica, mediante as questões orientadoras que se apresentam nos capítulos seguintes.

Enquadramento Teórico

1 - Uma abordagem sociológica do processo político

No ensaio “modelos de análise das políticas públicas”, Luísa Araújo e Maria de Lurdes Rodrigues sintetizam diversas perspetivas sobre o estudo das políticas públicas que têm em comum uma abordagem do seu estudo enquanto processo (Araújo e Rodrigues, 2017), centrado no funcionamento dos órgãos de soberania e da administração pública enquanto pontos focais estruturantes do processo político.

O processo político é entendido como um modelo mais ou menos sequencial, com *inputs*, processos e *outputs*: problema social > agendamento > legislação > implementação > avaliação.

Utilizando este modelo realizei um primeiro trabalho, na conclusão do Curso de Estudos Avançados de Gestão Pública, com o tema “O Protocolo de Quioto e a génese do Programa Nacional para as Alterações Climáticas” (2016).

Tomando como ponto de partida este trabalho para a definição do objeto de estudo para a presente dissertação do mestrado em Sociologia, vertente Políticas Públicas e Desigualdades Sociais e apoiando-me sobretudo na abordagem de processo político em fases de Birkland (2011), iniciei prospectivamente a realização de uma cronologia dos eventos críticos do processo político das Alterações Climáticas, abstraindo-me da realidade nacional, e olhando para um plano global. Tendo-me deparado desde o início deste exercício com vários aspetos que contradiziam a linearidade da sequência mencionada, desenvolvi uma perspetiva crítica sobre essa abordagem.

Para esta crítica contribuiu ainda o contraste da abordagem feita no contexto de uma vertente mais próxima à Economia (CEAGP), e as aproximações ao mesmo objeto de estudo no contexto da Sociologia. Com o desenrolar da pesquisa tornou-se evidente a inadequação às minhas questões do modelo “tradicional” de processo político.

Seguindo a abordagem de Pierre Bourdieu (1930 - 2002) defini a política pública como um conjunto de medidas estruturadas e estruturantes do social, legitimadas segundo um ideal, uma visão reformadora da sociedade, que se impõe ao coletivo enquanto Direito, função do Estado, portanto como fruto de uma construção social complexa que só pode ser compreendida como processo, com um maior afastamento e um maior nível de abstração

do que o que nos permite o estudo do processo político focado nas instituições públicas, governativas ou administrativas ou partidárias.

O “caminho” de uma política pública, compreendida como a defini, pode nutrir-se, ainda na sua fase inicial, de múltiplas sequências completas de processos políticos sequenciais, de diversas áreas, nutrindo-se ainda, e de forma bastante relevante, de muitos outros fenómenos sociais que são secundarizados nesses modelos, nomeadamente a dinâmica da formação de um problema social. O aspeto que me parece mais relevante do ponto de vista sociológico, não será tanto a discussão em torno dos *outputs* conseguidos na implementação de uma dada política pública, mas antes os processos de construção social da realidade simbólica de uma ideia política enquanto produto da tensão entre grupos, das condições sociais em que essas ideias políticas têm origem, e das estratégias mobilizadas na dinâmica das lutas ocorridas num campo, através das quais um processo político é promovido ou bloqueado.

Para além da implementação de uma política pública, há uma outra dimensão que podemos identificar, que é o ponto de acumulação crítica de valores (i.e. capitais) em jogo, em que uma política pública passa de um estado de relativo desconhecimento público a um patamar em que já não pode ser ignorada, isto é, que subjuga/condiciona a realidade pública, forçando cidadãos em geral e aos agentes políticos em particular (no sentido comum da palavra, deputados, militantes, ministros, etc.) a uma vincada adesão ou oposição a ela. E é este processo de modificação generalizada dos esquemas de perceção sobre os quais a própria ideia de Estado se altera que me interessou numa perspetiva sociológica do processo político.

O tema deste trabalho é, portanto, uma análise do processo político, num sentido sociológico, de uma família de políticas públicas, hoje designada comumente, como Políticas Públicas sobre as Alterações Climáticas.

2 – Campo, *Habitus* e Capital

Os conceitos de Campo, *Habitus* e Capital, são centrais à teoria social de Pierre Bourdieu.

Um campo é um espaço estruturado de posições, onde agentes estão em concorrência pelos seus troféus específicos seguindo regras igualmente específicas (Barros, 2003, p. 120).

Em termos analíticos, um campo pode ser definido como uma rede ou uma configuração de relações objetivas entre posições. Essas posições são definidas objetivamente na sua existência e nas determinações que elas impõem aos seus ocupantes, agentes ou instituições, pela sua situação (*situs*) atual e potencial na estrutura da distribuição das diferentes espécies de poder (ou de capital) cuja posse determina o acesso aos lucros específicos que estão em jogo no campo e, ao mesmo tempo, pelas suas relações objetivas com outras posições (dominação, subordinação, homologia etc.) (Bonnevitz, 2005, p. 60).

Os agentes de um campo, independentemente da posição que nele ocupem, contribuem para a existência do campo através do reconhecimento recíproco dos seus papéis e do significado dos comportamentos nas relações que mantêm com os outros agentes, mediante uma estrutura (papeis, regras, significados) que configura esse campo. São os agentes que “vivificam” o campo, produzindo e reproduzindo em práticas (na qual se incluem as práticas discursivas) a sua estrutura. Por outro lado, os agentes encontram as suas opções delimitadas por constrangimentos de ordem social (i.e., estes constrangimentos, não obstante serem reproduzidos na realidade subjetiva do indivíduo, aliás através dos seus próprios esquemas de percepção, são interiorizados mediante a interação com os outros), que por não serem explicitamente objetivados a cada momento em que impõem as regras do jogo social que configuram o campo, transcendem o indivíduo. A contradição aparente é que a estrutura determina as opções percebidas pelos agentes sociais, ao mesmo tempo que esta estrutura apenas existe uma vez que os indivíduos a reconhecem e se reconhecem por meio dela na forma como aderem a um contexto específico de relações. A contradição é resolvida pelo conceito de *habitus*, uma vez que ao mesmo tempo que a estrutura é interiorizada no agente que a reproduz, a interiorização desta dá-se em condições em que o sujeito é um ente participante e reflexivo.

Com efeito, o *habitus*, é a interiorização realizada através da habituação produzida socialmente pela repetição e ritualização de interações, que visam produzir a interiorização de estruturas sociais (inclusive nos espaços e nos objetos).

O *habitus* é um instrumento concetual que auxilia a apreensão de uma certa homogeneidade nas disposições, nos gostos e nas preferências de grupos ou indivíduos produtos de uma mesma trajetória social, produtos de condições sociais comuns (Paes e Silva, 2012).

O *habitus* condiciona a percepção, as escolhas percebidas pelos agentes, e perpetua-se através dos processos de socialização pelos quais cada novo agente se torna participante num campo. É fundamental para este processo, que se encontre dissimulado o seu efeito de reprodução de uma estrutura de desigual distribuição de poderes e recursos, como o arbitrário por detrás da mesma estrutura, que assim se impõe e perpetua⁴.

Estes conceitos foram aplicados por Bourdieu ao estudo do funcionamento das instituições e dos processos políticos:

«A razão e a razão de ser de uma instituição (ou de uma medida administrativa) e dos seus efeitos sociais, não está na vontade de um indivíduo ou de um grupo mas sim no campo de forças antagonistas ou complementares no qual, em função dos interesses associados às diferentes posições e dos *habitus* de seus ocupantes, se geram “vontades” e no qual se define e se redefine continuamente, na luta, e através da luta – a realidade das instituições e dos seus efeitos sociais, previstos e imprevistos» (Bourdieu, 2007, p. 81).

Esta teoria, evitando o determinismo das práticas objetivadas, pressupõe uma relação dialética do sujeito com a sociedade, uma relação entre *habitus* e a estrutura socialmente determinada de um campo. Segundo este ponto de vista, as ações, comportamentos, escolhas ou vontades individuais não derivam de um cálculo subjetivamente insondável, nem pelo contrário, de um reflexo mecânico a normas sociais que transcendem o indivíduo, são antes concebidas como produtos da relação entre um *habitus* (processo reflexivo de interiorização) e as condições estruturais da sociedade.

Outro conceito fundamental em Bourdieu é o de capital. Capital, na teoria sociológica de Pierre Bourdieu, é um sinónimo de poder. Consiste em ativos económicos, culturais ou sociais que se reproduzem e promovem mobilidade social numa sociedade estratificada. Enquanto poder, a sua acumulação garante os meios legítimos de acesso à definição das regras de repartição e reprodução desses mesmos capitais. O *habitus* determina a inclinação para a conservação ou a transformação da estrutura desta distribuição e, portanto, para

⁴ Bourdieu (1983b, p. 65) define *habitus* como “[...] um sistema de disposições duráveis e transponíveis que, integrando todas as experiências passadas, funciona a cada momento como uma matriz de percepções, de apreciações e de ações – e torna possível a realização de tarefas infinitamente diferenciadas, graças às transferências analógicas de esquemas [...]”. Quando as representações oficiais daquilo que o homem é oficialmente num espaço social considerado se tornam *habitus*, tornam-se os princípios reais das práticas (Paes e Silva, 2012).

perpetuar ou subverter as regras do jogo, i.e. de repartir os capitais específicos de cada campo (Thiry-Cherques, 2006, p. 37).

Uma das formas específicas de capital considerado por Bourdieu, com grande relevância para o nosso estudo, é o capital cultural.

A reprodução do capital cultural é um caso específico que se relaciona diretamente com o *habitus*, e a forma como este se reflete em determinadas posições na estrutura social. O capital cultural encontra-se distribuído sob forma institucionalizada (ex: graus académicos), objetificada (ex: objetos, como peças de vestuário, obras de arte, livros, que sejam reconhecidos enquanto símbolo da posse de um determinado capital cultural) ou incorporada (na forma de falar, nos gestos, nos conhecimentos, etc.). As posições e hierarquias determinadas pela posse deste capital são profundamente relevantes na estrutura de uma sociedade. Um vasto conjunto de processos de socialização, como práticas discursivas, objetos, rituais, tem como objetivo a transmissão do mesmo.

Este é, portanto, um elemento fundamental no estudo do social, que se encontra ausente na teoria económica clássica. Com efeito, a posse de capital cultural, qualifica o agente para participar no acesso a formas específicas de capital económico, como de poder simbólico sobre a estrutura do económico, enquanto valor eficaz na produção de visões sobre o social.

Finalmente, a estrutura do campo refletida em posições alcançadas pelos agentes, determina e é determinada pelas redes de relações que correspondem a redes de obrigações e de contratos entre agentes, no que Bourdieu designou de Capital Social (Santos, 2011). Uma vez que essas relações representem um conjunto de obrigações sociais, elas podem garantir ganhos materiais ou simbólicos. Segundo o mesmo autor, o capital social «é determinante no campo, pois tê-lo em maior ou menor proporção é fundamental para impor o poder sobre os outros grupos». A estrutura familiar por exemplo, funciona como uma forma de capital social do indivíduo, que tendo um papel determinante sobre a estrutura económica, obedece a lógicas diversas da lógica de mercado - é um exemplo clássico da pertinência deste conceito sociológico.

Nas palavras de Bourdieu:

“As espécies de capital, à maneira dos trunfos num jogo, são os poderes que definem as probabilidades de ganho num campo determinado (de facto, a cada

campo ou subcampo corresponde uma espécie de capital particular, que ocorre como poder e como coisa em jogo, neste campo). Por exemplo, o volume do capital cultural (o mesmo valeria *mutatis mutandis*, para o capital económico) determina as probabilidades agregadas de ganho em todos os jogos em que o capital cultural é eficiente, contribuindo deste modo para determinar a posição no espaço social (na medida em que esta posição é determinada pelo sucesso no campo cultural) (Bourdieu, 2007, p. 134).”

Assim, os agentes (indivíduos ou grupos) envolvidos nas disputas pela acumulação e apropriação de ganhos específicos, são detentores, pela sua condição de origem, pelo seu *habitus*, e pelos valores materiais por si possuídos, de diferentes quantidades e espécies de capital, o que determina situações de poder desigual, no campo onde esses ganhos podem ser obtidos. Estes fatores conjugados e as motivações deles resultantes (dominação, subordinação, homologia etc.) estão na origem da formação de grupos, em função dos interesses comuns percebidos entre os agentes.

Um campo compreende os conflitos que se desenvolvem sobretudo num plano simbólico, envolvendo diferentes representações na visão da ordem legítima, ou justa - da qual depende implicitamente um determinado modo de uso e apropriação, dos valores económicos, sociais, culturais em jogo. Ocorre assim que as ideologias, enquanto produção simbólica e como produtos coletivos e coletivamente apropriados, servem interesses específicos – dos dominantes – que tendem a ser apresentados como interesses universais, comuns ao conjunto do grupo (Bourdieu, 2007, p. 10).

Segundo Márcio Santos (2011) «entendendo que a distribuição de bens materiais e/ou representativos são desiguais, os sistemas de classificação tendem a reproduzir as condições sociais. Cabe a uma certa fração do grupo dominante inculcar o discurso [que o legitima⁵] tanto no interior do seu segmento como a outros diferentes setores sociais. Essa internalização garante a homogeneidade do *habitus*, que ocorre pelas instituições de socialização dos indivíduos, o que, por sua vez, é direcionado a uma estrutura de *habitus* anterior à formação dos agentes, pois as escolhas subjetivas já se encontram estruturadas na sociedade.»

⁵ Nota do autor.

Os grupos estabelecem o domínio num campo, no sentido em que consigam assegurar a imposição de uma certa divisão/categorização que legitime o acesso do seu grupo aos valores/recursos em jogo no campo, bem como no estabelecimento de meios eficazes na reprodução dessas visões/categorias, empenhando-se, portanto, nos processos de reprodução dos tipos específicos de capital, que asseguram a renovação da legitimidade do valor da sua posição. Esta “imposição” enquanto poder, apresenta-se na teoria de Bourdieu, com a designação de poder simbólico, como um poder que permite obter aquilo que é obtido pela força económica ou física devido ao efeito da mobilização (2007, p. 14). O poder simbólico para ser exercido depende de não ser reconhecido como arbitrário, definindo-se numa relação entre aqueles que exercem o poder e os que estão sujeitos ao mesmo (Paes e Silva, 2012). Assim, «o que faz o poder das palavras e das palavras de ordem, poder de manter a ordem ou de a subverter, é a crença na legitimidade das palavras e daquele que as pronuncia, crença cuja produção não é da competência das palavras» (Bourdieu, 2007, p. 15).

Assim sendo, e na medida em que as ações e relações de agentes sociais são resultado da relação entre *habitus* e campo, o grupo dominante, acumulando a maior parte do capital simbólico e dominando os processos de formação dos *habitus*, estabelece o senso comum. Ao nível individual, isto significa que os indivíduos interiorizam categorias de classificação que reproduzem as relações hierarquizadas já construídas (Santos, 2011). Os seus esquemas mentais e de perceção não são livres, na medida em que são resultantes de uma arquitetura socialmente (e historicamente) construída.

O poder simbólico é tomado então como um poder subordinado pois representa uma forma transformada e legitimada de outras formas de poder. A destruição deste poder de imposição que tem a sua raiz no desconhecimento, segundo Bourdieu (2007, p. 15), depende de que ocorra uma tomada de consciência do arbitrário, podendo neutralizar o seu poder de desmobilização e encerrar um poder simbólico de mobilização e de subversão, tornando atual o poder potencial das classes dominadas (Paes e Silva, 2012).

Apesar da relação dialética dominante/dominado aqui identificada, um campo é também definido pela circunstancia de que as partes reasseguram a continuidade e existência do próprio campo. É facto que as posições legitimadas/dominantes são ocupadas por indivíduos capazes de levar a cabo estratégias de conservação e maximização do poder de

classe, ao passo que aqueles que ocupam posições dominadas, tenderão a desenvolver estratégias subversivas, tentando apontar a ilegitimidade do capital social. Contudo, a própria oposição pode corroborar e reformar a dominação, especialmente quando não contesta a estrutura do campo, mas se opõe dentro do mesmo funcionamento da ordem estabelecida (Santos, 2011), podendo, porém, suscitar alterações relevantes na sua estrutura. Essencialmente, o campo é um espaço social de contínuas tensões para a sua própria transformação, como forma de continuidade – evitando a rutura.

Finalmente, importa referir, que um campo não existe isoladamente: ele influencia outros campos, e é “perturbado” ou diretamente pressionado por campos que lhe são externos.

Além disso sofre o contínuo dinamismo que lhe impõe a admissão de novos elementos, as trajetórias destes, os novos *habitus*, a formação de novos grupos, que produzem novas tensões, novos vetores no jogo e que pressionam para um desenvolvimento constante da realidade social.

Assim, a teoria de Bourdieu propõe um estruturalismo construtivista dentro do qual podemos compreender a evolução de uma dada realidade social pelo estudo do campo onde esta é produzida, do posicionamento dos seus agentes (isto é, da distribuição dos capitais reconhecidos), do *habitus* dos agentes e das estratégias mobilizadas para manter, reforçar, alterar ou subverter a estrutura vigente.

3 – O Campo Político

Tratar o processo político como produto das tensões de forças antagónicas num dado campo, coloca-nos um desafio: o de conceptualizar esse campo específico.

Podemos considerar que, no contexto histórico e social em que se aplica este estudo, o campo político, como um macro-campo, integra uma dada sociedade delimitada pela figura do Estado-Nação. Compreende, portanto, uma estrutura formal – órgãos de soberania, uma administração, os aparelhos partidários, os cidadãos (administrados, mas também eleitores e intervenientes nos processos democráticos). Contudo, para uma definição sociológica teremos de identificar a(s) modalidade(s) específica(s) de poder, portanto o capital, que comanda o jogo político, pois é este que delimita o campo.

Bourdieu caracterizou assim o campo e o capital político:

«Há, no campo político, lutas simbólicas nas quais os adversários dispõem de armas desiguais, de capitais desiguais, de poderes simbólicos desiguais. O poder político é peculiar no sentido de se parecer com o capital literário: trata-se de um capital de reputação, ligado à notoriedade, ao fato de ser conhecido e reconhecido, notável. (...) O capital político é, portanto, uma espécie de capital de reputação, um capital simbólico ligado à maneira de ser conhecido.» (Bourdieu, 2011).

Sobre o capital político enquanto poder simbólico:

«Vê-se, pois, que o campo político tem uma particularidade: nunca pode se autonomizar completamente; está incessantemente referido a sua clientela, aos leigos, e estes têm de alguma forma a última palavra nas lutas entre os clérigos, entre os membros do campo. Por quê? O que faz com que a política não seja poesia, que o campo político não seja como o poético, é o fato de que o que está principalmente em jogo nas lutas simbólicas e políticas sobre o *nomos* (*nomos* vem do verbo *némo*, que significa operar uma divisão, uma partilha; comumente o termo é traduzido por "a lei", mas significa também, mais precisamente, o que chamo de princípio de visão e de divisão fundamental, que é característico de cada campo) são a enunciação e a imposição dos "bons" princípios de visão e de divisão. No campo político, se eu disser que a divisão principal é a divisão entre ricos e pobres, obterei uma determinada estrutura social. Se disser que a principal é a divisão entre franceses e estrangeiros, obterei uma estrutura inteiramente diferente. Em outras palavras, os princípios de divisão não têm nada de fortuito. Eles são constitutivos dos grupos e, portanto, das forças sociais. A política é uma luta em prol de ideias, mas um tipo de ideias absolutamente particular, a saber, as ideias-força, ideias que dão força ao funcionar como força de mobilização. Se o princípio de divisão que eu proponho for reconhecido por todos, se meu *nomos* se tornar o *nomos* universal, se todos virem o mundo como eu o vejo, terei atrás de mim toda a força das pessoas que compartilham minha visão. "Proletários de todos os países, uni-vos!" é uma declaração política que quer dizer que o princípio de divisão nacional não é muito importante em relação ao princípio internacional que opõe transnacionalmente ricos e pobres. (...) o campo político podia ser descrito como um jogo no qual o que está em disputa é a imposição legítima dos princípios de visão e divisão do mundo social.» (Bourdieu, 2011).

Além da divisão primordial referida políticos/leigos (cidadão comum), existem muitas outras dimensões na estrutura do poder político, sendo as mais evidentes as refletidas nas divisões esquerda/direita, e aquelas delineadas entre os chamados partidos de governação e os restantes partidos.

O campo político em democracia não se encontra isolado, a própria ideia de representatividade que o caracteriza pressupõe modos de influência e de pressão que se devem exercer. Estes modos de influência e pressão podem ser considerados como modos de transação entre formas diversas de capital (social, cultural, económico) em capital político, enquanto forma específica de capital simbólico: o financiamento de campanhas, a menção pública de louvor ou censura, a posse de competências e conhecimentos técnicos que são chamados ao processo político, o elevado peso da representatividade e mobilização social dos diversos grupos de pressão, sindicatos etc. são fatores que desempenham um contínuo “mercado” de valores em torno de oportunidades de acesso/influência à modulação do processo político.

Os campos externos ao círculo político, no sentido mais estrito dos “profissionais políticos”, participam ativamente no jogo político. Outras estruturas, como os órgãos de comunicação social, são particularmente eficientes na acumulação de capitais transacionáveis com o capital político.

Mas estes campos externos, embora participando, não possuem a legitimidade para uma participação direta, na verdade a questão da corrupção é uma das facetas da censura a que essa participação se efetive com demasiada promiscuidade, e há por certo muitas outras formas de censura em democracia, que levam à concentração do capital político num determinado campo que aqui consideramos. Uma das formas de concentrar poder político num grupo de profissionais políticos, é diminuir a visibilidade do processo político, burocratizando-o, o que tem o efeito de, ao tornar difícil a sua linguagem, contribuir para um fechamento das vias de acesso ao jogo político, limitando-o à posse de competências específicas, dispendiosas em tempo e recursos de adquirir. Bourdieu refere que «à medida que o campo político se burocratiza, o ingresso à instituição supõe direitos de acesso, e hoje esses direitos são com cada vez maior frequência outorgados pelos partidos (e pelas grandes escolas, notadamente a Escola Nacional de Administração, a ENA).» (Bourdieu, 2011).

Assim, tendo em conta que a estrutura formal do Estado reflete uma repartição desigual do poder político, entre os políticos, i.e., o grupo com acesso legítimo aos mecanismos do poder público, e o comum dos cidadãos e, seguindo Bourdieu, adotaremos o termo campo político num sentido mais limitado do campo, como o espaço social onde reside o poder ou controlo sobre as formas de acesso, e os modos de reprodução desse capital, nomeadamente os partidos políticos e os órgãos de soberania serão os mais evidentes.

Outra face do capital político é o acesso às formas formais do poder público – portanto o exercício de imposição legítima, que pode ser o uso da violência, que pode ser a cobrança de impostos, que pode ser a imposição de normas, que pode ser a aplicação de recursos, etc. Uma política pública é uma forma conjugada destes poderes, a qual veicula ainda, a imposição simbólica de visões e divisões no social.

4 - O problema público

Existem diferentes abordagens académicas que entendem que a adopção de políticas constitui apenas um marco no processo contínuo de abordar um dado problema (Mthethwa, 2012). Mais especificamente, a implementação de políticas públicas é vista como o conjunto de atividades e operações realizadas por várias partes interessadas para a consecução das metas e objetivos definidos por uma dada política autorizada.

Os problemas de implementação já não são, portanto, vistos apenas como um problema técnico, de gestão, confinado às relações entre um gerente e um subordinado, ou a processos dentro de uma única instituição (Mthethwa, 2012). A implementação de políticas públicas estende-se pelas esferas do governo, entre os agentes do poder legislativo, do poder executivo, das diversas unidades administrativas, e de todas as partes interessadas implicadas no processo de implementação, que são desse modo ativadas para a participação/oposição ao nível político. Pela própria dinâmica da implementação, os objetivos legislados (e os seus partidários e responsáveis, internos e externos ao campo político) encontram novos obstáculos e a mobilização de novas forças.

Há uma densificação das ideias sobre os problemas sociais inerente à implementação de políticas públicas e que torna o processo político, um conceito insipiente, se se quiser identificá-lo com a dimensão técnica da implementação de uma dada política pública. Um

conceito útil de processo político tem de enquadrar um conjunto de atividades prosseguidas pelo Estado como pelas partes interessadas, que visam a prossecução de abordagens sobre um tema, e que procuram para tal a acumulação de capital político, num processo que opõe forças, como exige o estabelecimento de alianças e consensos. Evidentemente que este processo, compreende por vezes múltiplas políticas públicas (no sentido técnico do termo), avanços e retrocessos e pode ter um ponto crítico, a que denominamos aqui de problema público.

O problema público, enquanto problema social que adquire um ponto crítico de capital simbólico, manifesto inclusive ao nível mobilização social, embora se nos apresente como uma pressão sobre o governo, ou sobre as forças políticas para introdução de um tema na agenda, que pode vir de fora do campo político como forma de contestação da sociedade civil, pode no entanto ter a sua origem no interior do processo político “normal”, como resultado de uma negociação (no sentido de luta entre forças organizadas no jogo político) que não consegue ser resolvida dentro do círculo fechado do campo político, e que transborda numa procura de alinhamento de interesses suficiente para mobilizar agentes influentes na opinião pública, para conseguir consagrar/legitimar uma determinada visão, autorizante das forças de imposição objetivadas numa dada política pública. Podemos considerar esta dinâmica de construção do problema público, como resultante de uma certa carência do político (um problema que não consegue ser resolvido dentro do campo político). Este processo de definição política do problema público decorre de uma estrutura estabelecida dos meios de acesso e conversão de capitais em capital político, que falha em traduzir novos estados de forças nas lutas partidárias (inter e intra partidárias), e das próprias forças sociais implicadas nos processos legislativos em questão. Nesta acepção, portanto, o problema público nasce apenas quando as negociações internas a este processo falham em resolver, em produzir consensos satisfatórios em problemas que entretanto, tenham tomado implicações profundas sobre a distribuição de capitais na sociedade - eventualmente porque se coloca em causa, com sucesso, o *statu quo* de uma forma estabelecida de dominação.

Contudo importa notar que:

- a) Este momento desestabilizador resulta de um avolumar de influência sobre o campo político exercido por grupos, que conectados ou não ao campo político, são externos a ele.
- b) Que o processo de formação de um problema público, pode decorrer essencialmente externo ao campo político, quando o problema social seja sistematicamente rejeitado ou ignorado neste campo.

Contudo, independentemente se o processo encontra formas de maturação internas ou não ao campo político, subjaz ao processo político a ideia de problema social, podemos considerar que um problema público é um problema social que adquire uma dimensão política relevante. Seguindo a conceptualização de problema social avançada por Tavares, M. C. (1967) este é o problema «daqueles que pressupõem um sentimento de insatisfação ante uma situação colectiva reconhecida como de inferioridade, mas considerada susceptível de melhoria e julgada injusta». Podemos, portanto, considerar que um problema social envolve:

- a) Uma dificuldade sentida por um coletivo;
- b) Que a dificuldade seja percebida e julgada por um número significativo de indivíduos como um problema coletivo;
- c) Que a causa dessa dificuldade seja identificada como resultante de uma dada ordem social e, portanto, seja ambicionada uma melhoria das condições.
- d) Quando o agente que se pressupõe ser o agente necessário para operar essa melhoria seja o Estado, os grupos sociais promovem o problema social sobre o campo político.

Sobre estes pontos a autora tece diversas notas pertinentes, sobre as quais nos debruçamos aqui. A saber:

Não é apenas por ser sentida uma dificuldade que tem origem um problema social. Antes, um problema social é construído através do exercício da comparação, e como tal é impulsionado por sentimentos de inferioridade e injustiça. A condição ou dificuldade que dá substância ao problema social, pode existir noutras sociedades e noutras épocas sem que tal se constitua aí como problema social - é pois, nesses casos, percebida por cada sujeito como um problema subjetivo, individual, que provém da ordem natural e não da ordem

social estabelecida, que não é passível de mudança - como tal, não se constitui como problema.

Para a autora o aspeto de perceber o problema como coletivo, é mais relevante do que a dificuldade que lhe dá origem, a percepção do problema e não o problema em si é que o torna real. Por outro lado, as forças conservadoras podem reagir à construção do problema social, promovendo ideias que o naturalizam, o perspetivam como um devir inevitável, ou como causa-efeito de uma falha ou problema moral do(s) indivíduo(s).

A este propósito cito a autora:

«Depois de tudo quanto atrás ficou dito acerca da natureza dos problemas sociais, parece-me quase inútil fazer notar que uma situação colectiva de inferioridade não tem necessariamente de suscitar um problema destes. Mesmo a degradação objectiva da situação (nos seus dados materiais, bem entendido) não tem por força de ocasionar um problema social. Em contrapartida, mercê da interferência doutros factores, pode eclodir um problema a partir duma situação que permaneceu inalterada — que não se deteriorou nem em termos absolutos nem em termos relativos— ou até que entrou já numa fase de melhoria. Esta hipótese não é sequer invulgar (...).» (1967, p. 213).

E ainda, sobre as forças de oposição à formação de problemas sociais:

«Entre os múltiplos motivos por que uma situação colectiva de inferioridade pode não dar lugar a um problema social, devem contar-se — mas advirto já que são estes os mais importantes — os factores susceptíveis de se oporem a que os sujeitos sociais se apercebam da existência da própria situação colectiva de inferioridade.» (1967, p. 213).

Este aspeto é muito relevante, pela forma como se conjuga com o conceito de campo de Bourdieu, por um lado, no sentido em que concebe o problema social como resultante de ideias que criam divisões (definem um “nós” e um “outros”), propiciam formas de sociabilidade que levam à constituição de grupos que se distinguem como “desfavorecidos” e se mobilizam para a contestação de um dado *statu quo*.

O problema social, constitui-se como um problema público na medida e quando impõe sobre o campo político não apenas o seu reconhecimento – mas uma ativa procura de soluções (ou redificações eficazes das visões subjacentes ao problema social), na medida em que a estabilidade da estrutura do campo político é colocada em causa. Torna-se transversal

às forças dominantes nesse campo o objetivo de conduzir à desmobilização dos grupos contestatários, como nas que procuram mudança o objetivo de se apoiarem no descontentamento. De uma forma ou de outra são criadas tensões sobre o campo político que “empurram” um determinado problema para o centro da agenda do processo político.

É apenas utilizado o conceito de problema público para aqueles problemas sociais que momentaneamente suspendem outros debates da sociedade e impõem a todas as forças políticas relevantes a introdução do problema no núcleo da sua agenda.

A resolução de um problema público, enquanto culminar de um processo político, resulta num processo de assimilação de mudanças profundas na estrutura do social, e numa certa consagração a um nível mais profundo de uma política pública. Há uma certa identidade que é alcançada. Por outras palavras, a partir de uma certa dimensão uma política pública só é eficiente, no sentido das forças que a colocam em movimento, se tiver sucesso em concretizar este processo de conversão – ideia que emerge da reação à ordem estabelecida > implementação de políticas públicas que abordam essa ideia > reação dos grupos sociais > problema público > novamente, em nova ordem estabelecida.

5 – Políticas Públicas

Há diversos entendimentos sobre o que é uma Política Pública, por exemplo, Mead (1995) define-a como um campo dentro do estudo da política, que analisa o governo à luz de grandes questões públicas e Lynn (1980), como um conjunto de ações do governo que irão produzir efeitos específicos. Peters (1986) segue a mesma linha: uma política pública é a soma das atividades dos governos, que agem diretamente ou através de delegação, e que influenciam a vida dos cidadãos. Dye (1984) sintetiza a definição de política pública como “o que o governo escolhe fazer ou não fazer”. Outras definições enfatizam o papel da política pública na solução de problemas, definindo-a como uma diretriz elaborada para enfrentar um problema público.

Algumas críticas são feitas a estas abordagens (Souza, 2006), a primeira, a de que sobrestimam aspectos racionais e procedimentais das políticas públicas, argumentando que elas ignoram a essência da política pública, isto é, o confronto em torno de ideias e

interesses. Além disso, ao centrarem-se nos governos, essas definições obscurecem o seu aspecto conflituoso e os limites que cercam as decisões dos governos.

Este trabalho adota esta perspectiva crítica, definindo políticas públicas não apenas como ações do Governo que mobilizam diferentes recursos, simbólicos e materiais, e que se configuram em torno de uma matriz ideológica, na qual um determinado problema social é pretensamente enfrentado/solucionado, mas antes de mais, como resultado de lutas e dinâmicas de diversos campos intervenientes no processo político.

6 – Distinção entre o problema científico e o problema social das alterações climáticas

Um termo importante e utilizado na pesquisa é o de problema científico.

O conceito de problema científico prende-se necessariamente com os desafios colocados com o estudo dos fenómenos, mas também com os fatores sociais que determinam os conflitos no campo da sua produção. Assim, quando me refiro ao problema científico das alterações climáticas refiro-me a uma de duas dimensões, dependendo do contexto:

- Problemas colocados pela complexidade dos fenómenos no processo de acumulação de conhecimentos na área das alterações climáticas e áreas afins (meteorologia, glaciologia, ciências ambientais, etc.)
- Problemas definidos no contexto de um campo, i.e. nas lutas pela acumulação de capital científico, nomeadamente (a) em torno da distribuição dos meios de produção do conhecimento científico disponíveis às áreas afins às Alterações Climáticas e (b) em torno do valor percebido dos conhecimentos nessa área dentro e fora do campo académico, e (c) em torno da legitimidade para produzir conhecimentos nessa área.

É, portanto, um termo independente do problema social das alterações climáticas, sendo que este se pode definir como o conjunto de situações de risco social, ambiental e económico, conforme sejam percebidas como resultantes da ação inadvertida do homem sobre a atmosfera – quando as causas/causadores, por um lado e os danos/vítimas possam ser atribuídos a grupos sociais concretos.

7 – Desenho da investigação e construção empírica

A investigação fez-se em duas fases: a primeira, uma análise, numa perspetiva histórica, mais do que sociológica, dos desenvolvimentos científicos que conduziram à problemática das alterações climáticas. O resultado desta análise encontra-se na Parte I deste trabalho.

Numa segunda fase, procurei situar a pesquisa num contexto Estado-Nação específico, uma vez que tal pareceu ser a melhor opção para captar os elementos mais relevantes do ponto de vista sociológico da análise do Processo Político. Como se focalizando uma lente, parti do geral e abstrato, para o concreto.

Este exercício de encontrar um fio condutor que permitisse ligar pontos focais ao nível da produção científica e do enquadramento político, levou-me aos Estados Unidos da América nas décadas de 50 e 60, como sendo um contexto de grande relevância para a matéria, argumento que justifico na primeira parte do trabalho.

Iniciou-se então um trabalho de análise documental focado em documentos (transcrições de audiências legislativas) produzidos no Congresso estadunidense.

Pensando o problema público como emergente do cruzamento de campos com o campo político, considerei as audiências legislativas como um circuito charneira, representativo do campo científico como do político no processo político do Processo Político das AC.

Optei, portanto, por tomar como fonte para o *corpus*, os testemunhos em audiências legislativas, tanto do senado como da câmara dos representantes, ou conjuntas, em que a problemática das alterações climáticas tenha sido debatida – mesmo quando o tema dessas audiências legislativas tenha sido diverso (como necessariamente aconteceu, nesta fase inicial).

Uma nota tem aqui de ser introduzida: A disponibilidade do material analisado em formato digital, e em modo de digitalização OCR⁶, foi sem dúvida um fator decisivo para a escolha deste método de investigação, bem como o suporte prestado pelo serviço de apoio do arquivo digital utilizado, o Hathi Trust (s.d.).

Não tendo tido acesso ao *download* dos documentos, tive de fazer a cópia destes, página por página, o que se revelou extremamente moroso e desgastante. Já na fase da análise dos

⁶ Acrónimo para o inglês *Optical Character Recognition*. O OCR é uma tecnologia para reconhecer caracteres a partir de um arquivo de imagem

mesmos, apercebi-me que apenas teria tempo de explorar menos de 10% do material recolhido. Fica já arquivado para um estudo posterior.

Outro dado importante a este propósito, é que de acordo com os serviços do Hathi Trust, o arquivo não é exaustivo, não garante que todas as sessões legislativas que tenham sido registadas em papel se encontrem digitalizadas e disponíveis. Ainda assim, o volume de material não encontra paralelo, quando por exemplo o comparamos com arquivos semelhantes. As mesmas pesquisas que devolveram centenas de resultados entre 1950 - 1980, com as palavras-chave “alterações climáticas”, “dióxido de carbono”, “combustíveis fósseis” “modificações inadvertidas do clima”, devolveram no arquivo britânico (Congress.Gov s.d.) apenas algumas dezenas a partir dos anos 70. Ora entre 1956 e 1966 nos EUA, foram já 11 os testemunhos em audiências legislativas disponíveis. A avaliação destes números, para poder levar a conclusões teria de ser analisada com maior detalhe quanto às suas causas: se o assunto simplesmente não foi discutido nesse período no parlamento do Reino Unido, se foi, mas não de forma documentada, se mesmo tendo sido, não foi ainda disponibilizado em arquivo digital. Este apuramento, ainda que interessante, não foi feito no âmbito deste trabalho, pois consumiria a maior parte do tempo: teria de ser feito exaustivamente para um conjunto de países onde há registos de intensa atividade científica no campo das alterações climáticas, como a Reino Unido, Rússia, Japão, França, Alemanha e a Suécia.

Já no contexto estadunidense, considerei que o arquivo de audiências legislativas do Hathi Trust é provavelmente o repositório documental histórico mais fiel, em torno da problemática das alterações climáticas – apesar da “impureza” que representa o facto de que a agenda dos comités do congresso, como a nomeação dos testemunhos, a decisão de publicação e a decisão sobre o não registo de partes do debate, pertencer ao arbítrio do presidente de cada comité. Assumo, portanto, a limitação do trabalho, deixando em aberto o potencial das ideias e agentes que não participaram neste fórum, em participar no processo político por outros meios, como da exploração de outros canais de acesso aos políticos.

Contudo é importante referir que esta escolha não foi feita sem antes ter sido realizada uma pesquisa sobre a existência de outras fontes, a saber:

- Relatórios independentes (organizações não governamentais (ONG's), laboratórios privados, associações civis, ou científicas, associações ambientalistas). Neste domínio foram pesquisados o arquivo da *National Academy of Sciences*, a principal instância no campo científico de representação institucional da comunidade científica, e os arquivos digitais das seguintes ONG's e grupos independentes:
 - *Rockefeller foundation*
 - *Sierra Club*
 - *National Audborn Society*
 - *National Parks and Conservation Association*
 - *National Wildlife Federation*
 - *World Wide Fund*
 - *RAND Corporation*
 - *Jason Defense Advisory Panel*

A conclusão da pesquisa realizada foi a de que nenhuma destas organizações tinha na sua agenda no período considerado [56-66] campanhas, artigos, estudos ou iniciativas relacionadas às alterações climáticas. Há uma exceção relativa a relatórios publicados pela NAS sobre modificações do clima e do tempo, mas que se encontram bem representados no debate congressional, onde são várias vezes mencionados.

Foram pesquisados ainda:

- Relatórios realizados por agências públicas. Pesquisou-se os arquivos digitais da NASA, ESSA, NCAR, e os importantes relatórios do entretanto extinto *President Science Advisory Committee*. Dos documentos encontrados, damos destaque ao que este comité terá emitido, como sendo o primeiro relatório produzido ao nível da cúpula política presidencial a dirigir-se extensivamente às alterações climáticas como problema público: o relatório denominado *Restoring the Quality of our Enviornment*, de 1965⁷. Foram encontrados

⁷ Assim conclui o relatório: «*Through his worldwide industrial civilization, man is unwillingly conducting a vast geophysical experiment. Within a few generations he is burning the fossil fuels that slowly accumulated in the earth over the past 500 million years. The CO₂ produced by this combustion is being injected into the atmosphere; about half of it remains there. The estimated recoverable reserves of fossil fuels are sufficient to produce nearly a 200% increase in the carbon dioxide content in the atmosphere.*

diversos relatórios pertinentes, o que é indicativo de que o setor público detinha no período considerado uma ampla participação e um importante capital científico nesta área. Estes grupos encontram-se, porém, bem representados nas audiências legislativas.

- Foi também pesquisada a legislação relevante nesta área.

Tomei a opção pela maior pertinência dos transcritos das audiências legislativas em documentar a relação de grupos e ideias perante o campo político – como pelo requisito (ainda que não integralmente cumprido) de homogeneidade e exaustividade do *corpus*. Uma outra abordagem necessitaria de um modelo de análise bastante mais complexo para que os resultados pudessem ter uma leitura homogênea.

Outras áreas que poderiam ser tomadas em consideração na produção e seleção de material documental relevante no processo legislativo poderiam ter sido: a produção documental da administração, a produção científica, a comunicação social, a produção cultural e literária sobre a problemática das AC.

A escolha tomada exige, pois, um cuidado epistemológico de reconhecer a sua limitação em não conseguir esgotar a representação de manifestações sociais relevantes. Tal será determinante na extensão das inferências possíveis a partir dos resultados da pesquisa. Contudo, como refere Durkheim (2003), para se estabelecerem relações não é necessário, e nem sempre é útil sequer, acumular experiência sobre experiência, importa muito mais que as experiências de que dispomos tenham sido bem-feitas e sejam verdadeiramente significativas. Citando: “Um fato único pode revelar uma lei, enquanto uma profusão de observações imprecisas e vagas nada pode produzir se não confusão. O homem de ciência, seja qual for a sua disciplina, afogar-se-ia nos factos que se lhe oferecem se não escolhesse entre eles. Precisa de distinguir os que prometem ser mais instrutivos, de centrar neles a sua atenção e de deixar provisoriamente os outros de lado (2003, p. 99)”.

Esta reflexão foi essencialmente a que fiz em diversas opções desta pesquisa, que se pautou por um carácter de inferência abductiva, e de análise qualitativa, baseada (*grounded*) nos

By the year 2000 the increase in the atmospheric CO₂ will be close to 25%. This may be sufficient to produce measurable and perhaps marked changes in climate, and will almost certainly cause significant changes in temperature and other properties of the stratosphere. At present it is impossible to predict these effects quantitatively, but recent advances in mathematical modelling of the atmosphere, using large computers, may allow usefull predictions within the next 2 or 3 years.» (PSAC, 1965)

dados empíricos e nas intuições emergentes da comparação entre os elementos do *corpus* – uma vez que, ao iniciar a análise do material coloquei de lado momentaneamente o enquadramento teórico de que parti, e a visão já formada sobre a problemática das alterações climáticas – para deixar que o material falasse por si próprio, e que conceitos e categorias me pudessem informar acerca das lutas existentes, e, regressando então ao enquadramento teórico, conseguisse ter uma leitura das estruturas e dos capitais assente em categorias que repousam nas ideias objetivamente expressas pelos agentes.

O resultado desta pesquisa encontra-se na parte II deste trabalho e é sobre ela que falaremos mais em seguida.

8 – Análise Qualitativa Indutiva (*Grounded Theory*)

A estratégia de investigação seguida, pode designar-se como Análise Documental Qualitativa Indutiva, na linha de Anselm Strauss e Corbin (1997), numa formulação de *Grounded Theory* moderada, que não abdica de um certo enquadramento teórico, evidentemente neste caso, a teoria de campo de Pierre Bourdieu.

Esta abordagem foi tentada após uma primeira tentativa de realizar a análise documental dedutiva e quantitativa, nos moldes apresentados por Bardin (1977). Foram formuladas um conjunto de questões, construiu-se um esquema analítico a partir do enquadramento teórico e procurou-se confrontá-lo com o material recolhido e constituído como um *corpus*. Ao não se revelarem satisfatórios os resultados obtidos, experimentou-se a abordagem da *Grounded Theory*.

Parti então sem perguntas, num trabalho de classificação, criação de *memes* livre a partir da leitura do material, e com estratégias de análise comparativa, procurando saturar nas categorias criadas, todos os aspetos tornados revelantes pela comparação.

Ao fim de algum tempo, contudo, mais relevante do que as esperadas diferenças ou variáveis explicativas das diferenças observadas entre os textos analisados, foram os aspetos comuns e foi sobre esses que comecei a elaborar um quadro conceptual, no qual pude começar a elaborar uma aproximação ao enquadramento teórico, que evidentemente condicionou o meu olhar sobre o material e me levou a identificar uma dada estrutura nos

discursos. Assim, há uma identidade entre os textos analisados, que os fazem falar a uma só voz, sobre um campo comum.

Foi no decurso da sua leitura que as categorias e conceitos foram criados, num processo criativo e que obrigou a vários retornos ao ponto de partida e de refinamento do modelo de análise. Assim há um encontro com o enquadramento teórico, mas segundo um conjunto de classificadores que se aproximam, das realidades discursivas concretas de onde emergem.

As categorias criadas permitiram identificar:

- Uma estrutura do campo;
- Uma perceção da distribuição de capitais nessa estrutura;
- Dinâmicas de mudança no campo;
- Sentido do investimento no campo político como produto de lutas internas e externas de determinados agentes (grupos) no interior do campo.

9 – Constituição do *Corpus*

Conforme já referido, o *corpus* é constituído pelos transcritos das audiências legislativas do congresso estadunidense onde o tema tenha sido debatido, no período em análise (1956-1966).

O arquivo pesquisado foi o Hathi Trust Digital Library – arquivo digital resultante de uma parceria entre diversas instituições e bibliotecas, onde foi possível pesquisar, graças à digitalização OCR dos documentos, por palavras-chave, os documentos visados e no interior destes os textos selecionados.

As palavras-chave de pesquisa foram as adequadas ao tratamento do assunto na época em questão:

- *Climate change*
- *Climate modification*

E de forma secundária:

- *Carbon dioxide*
- *Fossil fuels*

- CO₂
- *Global warming*
- *Inadvertent*

UNIDADES AMOSTRAIS

Foram selecionados os documentos classificados como “*Hearings*”, independentemente da Câmara e do Comité do Congresso, em que a questão das alterações climáticas tenha sido abordada inequivocamente enquanto problema público.

UNIDADES DE CONTEXTO

Os testemunhos foram sempre captados por inteiro.

APRESENTAÇÃO DOS RESULTADOS

A apresentação dos resultados da pesquisa é antecedida de uma parte I, que apresenta o contexto histórico do problema científico das alterações climáticas.

A parte II sistematiza os resultados da pesquisa.

PARTE I - História do problema científico das alterações climáticas

1 – As Ciências do Clima

O desenvolvimento do problema científico das alterações climáticas de origem antropogénica insere-se na construção de uma problemática científica mais alargada: a formulação de uma teoria generalizada do clima.

As Ciências do Clima são uma área científica que se autonomiza nos anos 70 do século XX (Slingo, 2017), contudo as raízes de uma teoria do clima encontram-se numa história mais profunda de outras disciplinas científicas como a meteorologia, a física, a astronomia, a química, a geologia, a geografia, a paleontologia e, mais recentemente, a ciência da computação.

Os primeiros documentos históricos que relatam conhecimentos e teorizações sobre o clima e a influência humana no clima datam da Grécia Antiga.

Segundo Flemming (1998), autor que historiografou a climatologia e em particular a teoria do efeito de estufa e em cuja obra extensivamente me apoiei para a minha análise:

“Clima - do termo grego klima, que significa declive ou inclinação — o termo foi originalmente pensado para fazer depender o clima, apenas da altura do Sol acima do horizonte, uma função da latitude. Uma segunda tradição, que podemos rastrear até Aristóteles, ligou a qualidade do ar (e como tal do clima) a vapores e gases exalados de um país. A tradição hipocrática aprofundou ainda a ligação do clima à saúde e ao carácter de uma nação⁸.” (p. 11)

Já a sistematização de um corpo de conhecimento segundo o método científico, nomeadamente a articulação e sujeição da produção teórica a observações e procedimentos experimentais acontece apenas a partir do período do iluminismo. A partir de observações registadas e comparações destas com relatos antigos (nomeadamente do período da antiguidade clássica, da civilização grega e romana), serão produzidas a partir do século XVIII ideias sobre mudanças do clima. Uma ideia comum à época é a de um mundo antigo mais frio do que o recente – o suposto aumento das temperaturas é relacionado então com a desflorestação e cultivo das terras e com a drenagem de massas de água. Subjacente a esta ideia é o “sentimento” de que a ação racional do homem, submete e

⁸ Tradução livre.

ameniza a natureza. Filósofos como David Hume, Abbe Du Bos, Montesquieu e Thomas Jefferson, desenvolveram esta ideia, que teve uma profunda influencia na motivação dos colonos no Novo Mundo, nomeadamente nas suas esperanças de que as condições climáticas mais severas aí encontradas, se tornassem mais amenas por força da intervenção humana (Flemming, 1998, p.11).

O século XVIII conhece o início de registos sistemáticos das condições meteorológicas na Alemanha, Estados Unidos da América e Rússia.

No século XIX a maioria das nações já possuía serviços meteorológicos oficiais e prosseguia com dinamismo a cooperação internacional nesta área científica⁹. Este processo alterou as perceções e o discurso sobre o clima. É também um período de grandes avanços científicos na física, na química e nas geociências, com grande importância para o estabelecimento de meios técnicos para a produção de observações regulares das condições meteorológicas.

Já no século XX, o desenvolvimento desta área científica passou, até à década de 60, por três grandes eventos de cooperação internacional, os Anos Internacionais Polares¹⁰, que vieram fortalecer um clima cada vez mais organizado de cooperação internacional. Destacamos entre as suas principais instituições promotoras a Associação Internacional das Academias (fundada em 1899) e o *International Research Council* (1919), que mais tarde se fundiram no Conselho Internacional de Uniões Científicas (ICSU), e a Organização Internacional de Meteorologia, criada em 1873 e que é em 1950 integrada na ONU sobre a designação de Organização Mundial de Meteorologia. Estas organizações, e os Anos Internacionais Polares são a coluna vertebral de uma área científica inerentemente (pelo seu objeto de estudo) global.

O último ingrediente para a climatologia, foram as ciências da computação (Slingo, 2017). Este desenvolvimento dá-se após a segunda guerra mundial. Com efeito, o advento da computação permitiu encarar com seriedade o projeto megalómano, iniciado com os eventos internacionais Ano Polar Internacional 1, 2 e 3 de levar a cabo, não apenas a recolha, mas o processamento de medições atmosféricas ao nível global, e construir um

⁹ A International Meteorological Organization (hoje *World Meteorological Organization*) tem as suas raízes numa reunião em Leipzig em 1872 e no primeiro congresso internacional de diretores de serviços meteorológicos em Viena em 1873.

¹⁰ Estes importantes eventos internacionais decorreram nas seguintes datas: o primeiro 1882-1883, o segundo, 1932-1933, e o terceiro 1957-1958. O último e mais recente ocorreu no período de dois anos entre 2007 e 2009.

campo de pesquisa indutiva a partir de dados diretamente recolhidos no campo (Barr & Lüdecke, 2010, p. 214). Inicia então, a partir da década de 70 a construção de modelos interpretativos, que, uma vez informatizados, computam o grande volume de dados recolhidos e geram antecipações do que será o clima no futuro.

Estes modelos, parametrizados para estimar o impacto das emissões dos Gases de Efeito de Estufa, são utilizados correntemente na produção dos relatórios para informação dos agentes políticos e constituem a pedra de toque do paradigma atual das ciências climáticas.

Importa, pois, conhecer a história da teoria por detrás dos modelos climáticos aplicados à problemática das AC, comumente apelidada de teoria do efeito de estufa.

2 – A Climatologia e o Efeito de Estufa

A climatologia debruça-se sobre o sistema climático. O sistema climático incorpora a atmosfera, o oceano, a superfície terrestre, e as interações entre estes subsistemas por processos físicos, químicos e biológicos.

A climatologia distingue-se da meteorologia na forma como concebe o seu objeto de estudo. Os estudos climatológicos referem-se, de uma maneira geral, a tendências predominantes do comportamento da atmosfera, num dado lugar ou em toda a superfície terrestre, num longo prazo¹¹. Por sua vez, à meteorologia compete o estudo dos fenómenos físicos da atmosfera, a que se convencionou chamar de *tempo*, que se manifestam num lugar preciso e num período de tempo relativamente curto (geralmente horas, dias ou semanas). O clima e o tempo atmosférico são, portanto, duas formas complementares de descrever o ambiente atmosférico, utilizando essencialmente os mesmos elementos (pressão atmosférica, temperatura, humidade, precipitação, radiação, etc.), mas fazendo referência a diferentes escalas de tempo. Fazem ambas parte de um conjunto de ciências denominadas de Ciências Atmosféricas.

A construção de uma teoria do clima não foi um processo contínuo, nem tampouco pacífico. Pelo contrário, dada a dimensão global do objeto de estudo, e a elevada complexidade dos elementos desse sistema (atmosfera, biosfera, oceanos, manto terrestre, características

¹¹ A Organização Meteorológica Mundial convencionou como parâmetro um período de 30 anos para os estudos climáticos.

astrofísicas do planeta e do sistema solar), a diversidade de abordagens foi e ainda é prolífica. Identificar os pioneiros do “efeito de estufa” é identificar os pioneiros de uma das correntes que participou na construção de um puzzle muito mais complexo do que temos hoje talvez tendência a pensar, enquanto leigos, quando pensamos no aquecimento global e nas alterações climáticas – uma vez que tendemos a pensar na teoria do efeito estufa, como uma teoria geral do clima, e nesta como um modelo causal simples, o que é errado. A história que aqui traçamos é sim, a história de uma das peças do puzzle de uma teoria do clima, sendo que muitas das outras peças conheceram uma história semelhante, como teorias rivais, apoiadas num modelo explicativo do clima com causa única. Conforme referido, a maturidade da disciplina foi-se produzindo no estudo da interação de diferentes fatores, em modelos multicausais cada vez mais complexos.

Podemos assinalar o aparecimento de uma teoria do efeito de estufa em inícios do século XIX, quase um século depois de uma das primeiras teorizações e modelos climáticos ter sido formulada por Hadley¹².

Joseph Fourier (Auxerre, 1768 - Paris, 1830), matemático e físico francês, é muitas vezes citado como o primeiro cientista a teorizar sobre o que mais tarde virá a ser apelidado de “efeito de estufa”. Apoiando-se nos estudos de Claude Pouillet, considerou que “a temperatura [da Terra] pode ser aumentada pela interposição da atmosfera, pois o calor no estado de luz encontra menos resistência em penetrar o ar, do que em repassar o ar quando convertido em calor não-luminoso” (Flemming, 1998, p. 61). A interposição do ar, seria para Fourier um fator importante para explicar o facto de as temperaturas à superfície terrestre serem superiores ao que seria de esperar pelo cálculo simples da energia solar recebida pela terra, em função da sua distância ao sol – contudo o principal fator, pensava o cientista francês, seria explicado pela transmissão de calor de estrelas distantes pelo espaço (hipótese entretanto refutada).

Citar Fourier como um fundador do efeito estufa tem alguma imprecisão. Como físico o seu contributo foi o de levantar o problema de como conseguir explicar a temperatura à superfície terrestre segundo um modelo astrofísico, e neste contexto avançar com intuições, algumas delas que se provariam acertadas, outras não.

¹² A Circulação de Hadley, formulada 1735, ainda hoje, apesar de modificada, constitui uma peça fundamental do sistema climático (Slingo, 2017).

No seguimento da hipótese de Fourier, irão surgir trabalhos de outros cientistas que, ainda no sec. XIX deram importantes contributos para o conhecimento sobre o papel dos constituintes do ar como fatores de controlo do sistema climático, nomeadamente pela sua capacidade de absorver radiação. Destes, destacam-se, Jhon Thyndal, Svante Arrhenius e Chamberlin (Flemming, 1998, p. 65).

John Thyndal, (1820 — 1893), físico britânico, dedicou-se à pesquisa em laboratório da propriedade dos gases de absorção e emissão de radiação térmica. Em 1859, ele identificou diversos gases que retêm e emitem energia térmica. O mais eficiente por ele detetado foi o vapor de água (H₂O), considerando acertadamente que o estudo destes vapores na atmosfera como da maior importância para as ciências atmosféricas. Mais tarde, as suas investigações concluíram que o dióxido de carbono também seria eficiente neste sentido (Weart, s.d.).

É Arrhenius, (1859 — 1927), químico sueco, quem formula pela primeira vez a questão da influencia antropogénica no clima, descrevendo o modelo causal que relaciona a queima de combustíveis fósseis e o aumento de temperaturas à superfície terrestre (Flemming, 1998, p. 65).

As experiências de Arrhenius demonstraram que, tal como uma folha de papel impede mais a passagem da luz do que um grande volume de água numa piscina, o dióxido de carbono, mesmo sendo um componente relativamente escasso da atmosfera¹³ seria um responsável de peso na retenção de energia térmica na atmosfera terrestre. Em 1896 Arrhenius supõe que uma variação na quantidade de CO₂ seria suficiente para alterar o equilíbrio de temperatura de toda a atmosfera.

Arrhenius é também o primeiro a admitir, em 1896, a hipótese de que o carvão queimado para produzir energia seria passível de emitir dióxido de carbono suficiente para provocar alterações climáticas. É importante notar que, apesar do relevo que as suas descobertas ganhariam posteriormente, para ele ainda não constituíam fonte de preocupação da qual se pudessem extrair ideias políticas consistentes, tendo, pelo contrário considerado que o aquecimento global poderia ser favorável à agricultura, empurrando para norte os limites

¹³ Atualmente o CO₂ compõe aproximadamente 0,04% (ou 400 partes por milhão, ppm) do volume total da atmosfera. A atmosfera é composta essencialmente de Azoto (78%) e Oxigénio (21%), Água (2,5%) e Argon (0,95%) (NOAA, s.d., a).

de terrenos disponíveis para a agricultura, aumentando a produtividade agrícola necessária ao crescimento populacional (Keith, 2000, p. 6).

Contemporâneo de Arrhenius e Thynnal, o estadunidense Chamberlain (1843-1928) deu importantes contributos para a compreensão do ciclo do carbono, e dos *feedbacks* do dióxido de carbono com o vapor de água atmosférico, considerados por ele, determinantes para explicar as variações de temperatura ao longo das eras geológicas da Terra. Chamberlain explorou a ideia de um ciclo global do carbono, com fontes de carbono (formação de montanhas, erupções vulcânicas) e sumidouros de carbono (erosão e formação de carvão e calcário). Ele calculou as quantidades de carbono nos seus diferentes estados, e foi pioneiro na construção de um modelo de causas múltiplas, descrevendo como os vários componentes do sistema terrestre estão ligados num sistema em equilíbrio de *feedbacks*, equilíbrio este dinâmico, compreendendo uma oscilação entre períodos glaciares sucessivos, com uma variação de temperatura global média de 12º Celsius entre os períodos glaciares e os períodos interglaciares. Numa perspetiva diferente da de Arrhenius, Chamberlain considerava que os fatores inorgânicos seriam determinantes para as mudanças climáticas, atribuindo um papel reduzido aos fatores orgânicos e dentro destes ao papel do homem como agente capaz de interferir com o clima (Flemming, 1998, p. 90). Com Chamberlain e Arrhenius e outros cientistas contemporâneos, apesar das divergências existentes quanto ao papel da ação humana no sistema climático, e ao peso das causas admitidas, estava construída uma teoria consistente do clima, assente em hipóteses que relacionavam causalmente a composição atmosférica com a sua temperatura, em particular com as variações na concentração de dióxido de carbono. Esta vertente nas teorias do clima, gozava ao final do século XIX de ampla aceitação (Mudge, 1997).

O climatólogo Ekholm, um dos defensores da vertente da teoria que postulava o aquecimento global de origem antropogénica, antevia uma era em que o homem passaria a ser um elemento ativo na regulação do clima, controlando a quantidade de CO₂ na atmosfera e conseguindo evitar a chegada de uma nova idade do gelo. A preocupação com uma idade do gelo vindoura, partilhada por Arrhenius, era fundada nas recentes descobertas das paleociências de períodos glaciares na orogénese terrestre (Flemming, 1998, p. 77). A dificuldade da ciência da época em conseguir explicar a periodicidade das eras glaciares e naturalmente de conseguir prever o advento de um novo período glacial,

contribuía para a preocupação expressa por Ekholm e Arrhenius. Em hipótese uma era glacial poderia estar a começar. A ciência do clima era, no início do sec. XX, uma ciência sobretudo voltada para o passado.

A questão do papel antropogénico no clima, no contexto de uma teoria do aquecimento global, podia ser entendida por alguns académicos, como uma possibilidade enquadrada no mesmo sentimento dos filósofos do iluminismo, de uma ação civilizadora, que tempera, harmoniza a rude natureza, neste caso, que impõe ao clima um confortável aquecimento e afasta o espectro de um fim gélido da civilização. De qualquer das formas, não teve consequências à época fora da esfera académica.

3 – O virar do século e a crítica da teoria do aquecimento global

Nas primeiras décadas do século XX, a teoria do aquecimento global de origem antropogénica, foi alvo de críticas que apontaram fragilidades da teoria. Os autores das críticas concluíram que a acumulação de CO₂ na atmosfera, ou não estaria a acontecer, ou seria irrelevante ao nível da afetação de temperatura (Mudge, 1997). As críticas provinham de duas observações:

- a) Não estaria a acontecer: Chamberlain e Hogborn consideraram que os cálculos de Arrhenius não tiveram em conta a capacidade de absorção de dióxido de carbono por parte dos oceanos. Esta capacidade de absorção seria (em hipótese) responsável por manter uma certa estabilidade do clima, diminuindo ou tornando insignificante a pressão da recente emissão de dióxido de carbono (fosse pela combustão de combustíveis fósseis, ou outra fonte) sobre o clima.
- b) Irrelevante ao nível da afetação da temperatura: Angstrom, Koch, Abbot e Fowle concluíram que a banda de comprimento de onda de absorção de radiação do dióxido de carbono estaria compreendida dentro da banda de comprimento de onda de absorção do vapor de água. Assim, este efeito estaria já “saturado” pela humidade presente no ar e seria indiferente para o clima a adição de mais dióxido de carbono.

Estas críticas, baseadas em demonstrações laboratoriais, dominaram o campo acadêmico, apesar de carecerem da verificação empírica no ambiente real¹⁴. No início do sec. XX a teoria do aquecimento global caiu num relativo esquecimento até à década de 50, época em que os meios de verificação e computação começam a tornar possível uma abordagem indutiva no método científico das ciências do clima. Os manuais de autoridade na primeira metade do século frequentemente referem a teoria do aquecimento global como um exemplo de especulação errónea¹⁵ (Mudge, 1997).

Com muitos dos cientistas a enveredarem por outras linhas de estudo, foi o momento propício para o desenvolvimento de outras vertentes da climatologia. Nos anos 50, Brooks, (1888-1957) climatologista inglês, que passara grande parte da sua carreira compilando as “*nine and sixty theories*” das AC, publicou uma bibliografia anotada sobre o tema no primeiro volume da publicação “*Meteorological Abstracts and Bibliography*” (Flemming, 1998, p. 111). A tabela 1 é adaptada do seu trabalho e reflete a diversidade, o interesse emergente, mas também sintomático da ausência de consenso científico em torno de qualquer uma das teorias do clima, em todo o período até à década de 50:

¹⁴ Importa, contudo, fazer uma distinção: o golpe não foi fatal para a teoria do efeito de estufa, mas quase fatal para a teoria do aquecimento global. O vapor de água continuava a ser considerado pela comunidade científica como um dos principais fatores explicativos do nível médio de temperatura à superfície terrestre, contudo os recentes desenvolvimentos experimentais lançaram sérias dúvidas sobre o papel do dióxido de carbono na regulação do clima.

¹⁵ A aceitação desta crítica está patente nesta observação publicada pelo Departamento da Agricultura dos EUA em 1941: “*The Theory received a fatal blow when it was realized that CO₂ is very selective as to the wavelengths of radiant energy it will absorb, filtering not only such waves as even minute quantities of water vapour dispose of anyway. No probable increase in atmospheric carbon dioxide could materially affect either the amount of insolation reaching the surface or the amount of terrestrial radiation lost to space.*” (Flemming, 1998, p.112)

Tabela 1 - Teorias das AC como classificadas por Brooks em 1950.

Mudanças nos elementos da órbita da Terra	Adhémar (1842), Croll (1864, 1875), Drayson (1873), Ekholm (1901), Spitaler (1907), Milankovic (1920, 1930, 1941)
Mudanças na radiação solar	Dubois (1895), Simpson (1930, 1934, 1939–40), Himpel (1937), Hoyle and Lyttleton (1939)
Influências solares e lunares nas marés	Pettersson (1914)
Elevação de massas terrestres – formação de montanhas	Lyell (1830–33), Wright (1890), Ramsay (1909–10, 1924), Brooks (1926, 1949)
Mudanças na circulação atmosférica	Harmer (1901, 1925), Gregory (1908), Hobbs (1926), Flint and Dorsey (1945)
Mudanças da circulação oceânica	Croll (1875), Hull (1897), Chamberlin (1899), Brooks (1925), Lasareff (1929),
Mudanças na distribuição dos continentes/oceanos	Czerney (1881), Harmer (1901, 1925), Gregory (1908), Brooks (1926), Willis (1932)
Mudanças na composição atmosférica	Arrhenius (1896), Chamberlin (1897, 1899), Ekholm (1901), Callendar (1938, 1939)
Cinzas vulcânicas na atmosfera	Humphreys (1913, 1920), Abbot and Fowle (1913)
Teoria da poeira cósmica	Hoyle and Lyttleton (1939), Himpel (1947) Sunspot theory Czerny (1881), Huntington (1915), Huntington and Visher (1922),
Teoria da migração dos pólos e da deriva continental	Kreichgauer (1902), Wegener (1920), Köppen and Wegener (1924)

Talvez mais relevante seja o facto de que terminava uma era de teorizações do clima a partir de uma única causa. A partir de então qualquer esforço teórico teria de partir de uma abordagem mais complexa, multidisciplinar, e de grande densidade de dados, requerendo uma base matemática e estatística no perfil académico dos cientistas do clima.

4 – O reacender do interesse pela teoria do aquecimento global na década de 50

Na década de 40, os meteorologistas Hans Wilhelmsson Ahlmann e Hurd C. Willet registaram subidas de temperatura e recuo dos glaciares na primeira metade do século. Esta foi a primeira alteração climática global de que há registo sistemático e com meios técnicos

capazes de alguma objetividade. No mesmo sentido apontavam as medições de Callendar, engenheiro e inventor britânico, que realizou estudos no campo da recolha e tratamento de dados empíricos do efeito de estufa no sistema climático, e em particular do papel das emissões antropogénicas no aquecimento global (Flemming, 1998, p. 113). Num artigo de 1949, *“Can Carbon Dioxide Influence Climate?”*, Callendar publicou dados de medições do dióxido carbónico atmosférico. Os dados indicavam um aumento de 10% no CO₂ observado nos últimos 35 anos. Callendar projetou uma previsão de um aumento de 25% de CO₂ atmosférico por século e retomou a hipótese de que o aumento, agora registado, tivesse causas não naturais, identificando a expansão da indústria como a principal causa. Na linha de Arrhenius, considerava a previsão de um aumento da temperatura à superfície terrestre como um fator benéfico para a humanidade (Flemming, 1998, p. 119). Nas suas palavras: *«the combustion of fossil fuel [...] is likely to prove beneficial to mankind in several ways, notably allowing cultivation at higher northern latitudes and because ‘the return of the deadly glaciers should be delayed indefinitely»* (Hawkings & Jones, 2013).

Apesar do cepticismo, então generalizado, em relação à teoria das AC¹⁶, o trabalho de Callendar, e o aquecimento global registado nas últimas décadas chamou a atenção de outros geólogos e climatologistas (Gilbert Plass, Charles Keeling, Gordon Manley, Hans Suess e Roger Revelle).

Em 1950 Gilbert Plass obtém fundos da marinha estadunidense e da indústria aeronáutica para estudar as alterações do CO₂ atmosférico e o campo de absorção do espectro infravermelho. Ao mesmo tempo que desenvolvia sistemas de mísseis guiados por radiação infravermelha, Plass produz novos dados relevantes para a climatologia, fundamentais para o reacender do interesse pela problemática do aquecimento global, dando uma confirmação académica das observações de Callendar, que haviam sido desvalorizadas na comunidade científica pelo seu suposto carácter amador. (Boykoff, 2011, p. 45).

A alteração global da composição química da atmosfera terrestre por adição de dióxido de carbono, derivada da queima de combustíveis fósseis, é descrita por Gilbert Plass como uma

¹⁶ Doravante o termo Teoria das Alterações Climáticas, simplifica e resume o termo Teoria do Aquecimento global de origem antropogénica. Opta-se pelo termo Alterações Climáticas (e não por Aquecimento Global) pelo enfase deste termo na diversidade de fenomenos atmosféricos implicados, ao invés do enfase no aquecimento, que em si mesmo, é um fator de menor relevância no contexto dos problemas públicos a considerar. Não é de ignorar contudo o efeito profundo que a imagem de um aquecimento global pode produzir na imaginação popular, e consequentemente enquanto instrumento de mobilização.

“experiência de proporções globais”, conceito já introduzido por Callendar, e mais tarde apropriado por Revelle, e por este último tornado popular, como um *slogan* das AC.

5 - O Caso Americano - A centralidade americana na geociência do pós-guerra

O investimento público americano em investigação nascera antes da 1ª grande guerra, em programas de financiamento de investigação implementados pelo governo federal dos EUA, nas áreas da agricultura, das minas, do mar e da meteorologia, e outras, nos finais do sec. XIX. Posteriormente, a primeira guerra estimulou nos EUA a criação de complexos de investigação ligados ou mesmo geridos pela indústria e financiados por capitais públicos. Muitas destas estruturas permaneceram depois da guerra, adaptando a sua produção ao consumo civil, gerando firmas orientadas para áreas como a farmácia, metalomecânica, petrolíferas e outras (Usselman, 2013, p. 8).

Posteriormente verifica-se uma importante relação entre o rápido desenvolvimento das geociências e o papel da investigação científica aplicada à área militar no paradigma geopolítico da primeira metade do século XX.

Os interesses geoestratégicos americanos, ligados ao forte envolvimento militar dos Estados Unidos da América na 1ª e 2ª guerras mundiais (inclusive como fornecedores de equipamento de guerra), terão sido o principal motivo nos níveis históricos de financiamento público de pesquisa científica. Este financiamento foi canalizado sobretudo para áreas chave a uma ambicionada eficácia militar. Além disso, estabeleceu-se neste contexto uma intensa cooperação internacional no âmbito da ciência aplicada a fins militares. Para apoiar as suas forças armadas na Segunda Guerra Mundial, os aliados ocidentais criaram uma extensa instalação global de redes de recolha e comunicação via rádio, de dados sobre o clima, as marés e as correntes oceânicas. Estas redes seriam ampliadas e melhoradas no período da Guerra Fria (Barr & Lüdecke, 2010, pp. 235-236).

Efetivamente verifica-se um *boom* de investimento na investigação nos EUA ligado à Defesa ao longo da primeira metade do sec. XX, impulsionado pelo advento das duas grandes guerras, e com o pico na década de 50 já no período da Guerra Fria.

É evidente a relação entre a afirmação dos EUA como potência mundial neste período, contestado apenas pelo bloco soviético, e o sustentado investimento no desenvolvimento

científico. Esta aposta estabeleceu balizas de financiamento público da investigação entre os 2% e os 3% do PIB, que foram (comparativamente a outros países) as mais elevadas de então e que se mantiveram nesses níveis até aos dias de hoje, continuando a ser dos mais elevados no mundo (Usselman, 2013, p. 24).

O número de cientistas empregados em laboratórios americanos de investigação aumentou dez vezes entre 1920 e 1940, de 2.775 para 27.777. É durante a segunda guerra que o orçamento dedicado a este modelo de investigação cresceu, atingindo meio bilião de dólares em 1945, continuando a subir no pós-guerra, atingindo um bilião em 1950 e durante a guerra fria atingiu o pico de 3,1 biliões em 1953, estabelecendo um poderoso lóbi tecno-industrial, bem como uma estrutura universitária fortemente inclinada para a inovação (Usselman, 2013, p. 21).

Em 1953, nove em cada dez dólares gastos pelo governo federal em investigação estavam ligados à Defesa (Usselman, 2013, p. 21). Os frutos deste investimento reverteram obviamente para um franco desenvolvimento da indústria do armamento, mas dentro do qual foram prosseguidos eminentes objetivos da dispendiosa e complexa pesquisa empírica nas geociências. A física da atmosfera superior e a geofísica planetária em geral, receberam um apoio financeiro essencial de agências militares como o Naval Research Office. Por sua vez, o Departamento de Defesa criou uma extensa estrutura para a consulta de cientistas civis, com base no Conselho de Pesquisa e Desenvolvimento (RDB)¹⁷. As Instituições militares e de segurança nacional dos EUA, como o Pentágono e a *Central Intelligence Agency* (CIA), estavam profundamente interessados e envolvidos no fornecimento de recursos à investigação, em influenciar ou ter controlo sobre os programas de pesquisa e em incentivar líderes políticos, como o presidente Eisenhower, a conceber o esforço científico como prioridade em termos de projeção no plano internacional e de vantagem geopolítica (Barr & Lüdecke, 2010, p. 239). As estruturas criadas e o intensificar do envolvimento aprofundaram um diálogo entre o governo, a academia e a indústria, criando sinergias que vieram a transformar profundamente os campos envolvidos.

¹⁷ O primeiro secretário executivo deste conselho, de 1946 a 1947, foi Lloyd Berkner. Loyd foi também o presidente do ICSU em 1957-1959, a importancia da sua presidencia para o desenvolvimento das geociências é reconhecida como fundamental, tendo sido o arquiteto e principal promotor do *International Geophysical Year*.

Destacamos os contributos dos seguintes projetos – simultaneamente relevantes do ponto de vista militar e do ponto de vista da pesquisa científica das geociências: a “corrida ao espaço” (que colocou os primeiros satélites de observação terrestre na órbita da terra), o *International Geophysical Year (IGY)* e o *Mannhatan project*. Este último, o projeto de desenvolvimento da arma nuclear, foi participado por Revelle, Suess, e Plass, coincidentemente três “grandes” das AC, e não é por acaso: foi pela similitude das questões científicas em ambas as áreas: Física aplicada à defesa e as geociências.

Foi efetivamente no âmbito de projetos de pesquisa nuclear e da balística destinada ao desenvolvimento de armamento, que foram produzidos conhecimentos cruciais para o estudo da química atmosférica, como por exemplo a identificação dos isótopos de carbono, que permitiram identificar a percentagem de dióxido de carbono atmosférico que havia sido emitida por meios não naturais, como para aferir o tempo que este carbono *não natural* permaneceria na atmosfera, fato crucial para a sustentação empírica do modelo teórico do aquecimento global. Já o programa americano do IGY (1957-1958), contou com um forte envolvimento no suporte logístico da Marinha, bem como de verbas do departamento da Defesa importantes na manutenção dos programas após o término do ano previsto pelo programa – já o fundamental do bolo orçamental do projeto foi canalizado via *National Science Foundation* – a estrutura charneira do sistema de financiamento público da ciência nos EUA.

O IGY é de particular importância no contexto deste estudo. Foi o terceiro evento internacional das geociências (antecedido por dois anos internacionais polares, o 1º em 1882-1883, o 2.º em 1932-1933 – e precedido pelo 4º e mais recente que ocorreu em 2007-2008). O IGY foi o único evento a produzir esforços cooperativos de grande envergadura na comunidade científica de grandes proporções no período da guerra fria. Este evento constitui a “semente” das estruturas de investigação nas geociências ao nível mundial, mas muito em particular nos EUA, que permitiram a consolidação do corpo teórico-experimental do processo científico das AC.

A proposta de um terceiro ano polar também refletiu mudanças nos planos intelectual e das estruturas institucionais de geofísica. No lado intelectual, os cientistas que estudavam a atmosfera superior e as interações solares-terrestres consideravam-se agora uma nova disciplina, ou grupo de disciplinas, independente dos campos estabelecidos, como a física, a

geofísica ou até a meteorologia. No lado organizacional, a situação geopolítica do pós-guerra era tal que o equilíbrio da liderança em geofísica estava a afastar-se da Europa e no sentido dos Estados Unidos. Os eixos centrais dos dois primeiros anos polares foram europeus e meteorológicos; o eixo do IGY era solar-terrestre e americano, o seu calendário em alinhamento com o ano fiscal dos EUA (Barr & Lüdecke, 2010, p. 238).

Houve de facto muita investigação fundamental feita fora do laboratório que conseguiu fundos em pesquisas parcialmente relacionadas com interesses militares. O alcançar destas verbas dependeria da capacidade dos cientistas conseguirem promover a ideia de que o conhecimento produzido na sua área seria vital no domínio militar, quando os seus objetivos académicos poderiam ser primeiramente responder a problemas científicos. Pelo menos os que promovessem assim o valor estratégico do capital científico com sucesso, estariam em posição de – via interferência do poder governamental – de produzir profundas alterações no campo científico: criar novas estruturas no seu campo, de impor novas relações de força, de formar/autonomizar novos campos científicos. Podemos considerar que esta época marca um novo período em que grupos de cientistas de diversas áreas reorganizam o campo científico em torno de um novo paradigma, mais heterónimo¹⁸, fortemente definido pela construção de respostas à demanda de domínio territorial e político dos EUA, por um lado, por outro na imposição interna de uma nova visão das geociências, fundamentada na cooperação internacional, na recolha de dados ao nível global, no recurso a tecnologias dispendiosas (satélites, submarinos, bases polares), na computação, nas matemáticas avançadas, nos esforços multidisciplinares e orientados para respostas a problemas práticos a questões do foro público, como privado, e não apenas a questões de natureza académica.

Com efeito os cientistas receberam um forte incentivo para politizarem as suas abordagens da ciência, no sentido da utilidade militar e estratégica dos produtos do conhecimento, como numa fase subsequente da sua utilidade económica, no sentido da inovação. Um novo tipo de protagonista é porventura “criado”, o cientista que atravessa/liga áreas científicas, que participa ativamente no campo político promovendo o valor público da investigação, na

¹⁸ Heteronomia, leis que se recebem a partir do exterior (segundo Kant, da natureza) por oposição à autonomia.

maior parte das vezes apelando à sua eficácia em questões de natureza militar, em segundo plano ao valor económico, social ou ambiental das pesquisas científicas.

Outro aspeto importante na explicação do rápido desenvolvimento científico nos EUA é a migração de cientistas dos países afetados pelas duas grandes guerras, e em particular da Alemanha Nazi.

Enquanto muitas destas migrações se realizaram de forma voluntária, muito notoriamente de cientistas judeus, do qual Einstein é talvez o exemplo mais famoso, outras migrações decorreram de forma forçada, num processo de “pilhagem” do capital científico, por parte dos americanos e dos russos.

A URSS terá sido a primeira a iniciar esse processo, mas os EUA rapidamente desenvolveram um processo paralelo, quando se tornou conhecido dos serviços secretos que o Regime Nazi, agora derrotado, estava na eminência de desenvolver potentes mísseis de longo alcance, verdadeiros foguetões com capacidade de atingir as camadas mais elevadas da atmosfera, e que colocavam num horizonte próximo a construção de armas intercontinentais. Ora este conhecimento estava agora do lado da URSS, e esse facto em conjugação com a recente descoberta americana da arma nuclear, precipitou a nação norte americana, em clara violação do direito internacional, na captura de 1.600 cientistas alemães entre 1945 e 1959 (IWG, s.d.). Muitos deles tinham estado ao serviço do regime nazi, alguns como membros e líderes do partido. Já a operação de captura conduzida pelos russos foi mais agressiva, recrutando de forma forçada 2.000 cientistas e deslocando mais de 6.000 membros familiares (Zak, s.d.)

A operação americana teve o conhecimento e aprovação do Departamento de Estado Norte Americano, e foi autorizada sobre o nome classificado de operação *paperclip*. Paralelamente foram conduzidas pelos Aliados muitas operações de espionagem tecnológica (ex: Operation Alsos, Operation Big, Operation Epsilon). Esta captura de cientistas, tecnologia e conhecimentos, como a migração de intelectuais fugidos da guerra, não obstante os danos morais cometidos, enriqueceram o campo científico americano, contribuindo para afirmação da ciência americana no plano internacional.

Dos dois lados começava a corrida ao espaço. A demonstração de capacidade balística intercontinental era a demonstração mais simples e direta de política dura, na qual uma

nação pretende demonstrar que detem o poder de subjugar a outra. Era um assunto vital e que colocou a ciência como um capital muito valioso no meio político.

A maioria destes cientistas permaneceu em solo americano, mesmo após o término do que foi o período de captura. O célebre Wernher von Braun, uma das figuras mais proeminentes no desenvolvimento de armas nucleares de longo alcance para o Departamento da Defesa americano, e posteriormente da NASA na década de 60, como diretor do *Marshall Space Flight Center*, responsável pelas primeiras viagens tripuladas à lua, havia sido capturado na operação *paperclip*.

Para além dos contributos indiretos de outras áreas científicas, o campo das ciências do clima nos EUA recebeu importantes contribuidores para o desenvolvimento da climatologia, e no debate sobre as alterações climáticas de origem antropogénica, cuja formação foi feita em universidades da Europa Central. Alguns exemplos notáveis: Hans Suess, Hans Panofsky, Walter M. Elsasser ou o austríaco Walter Heinrich Munk.

6 – O Ano Internacional da Geofísica, Charles Keeling e Roger Revelle e a afirmação da problemática das AC no plano científico

Podemos considerar que há quatro partes do modelo causal do aquecimento global pelo efeito de estufa de origem antropogénica:

- A primeira parte deve-se à tese de que há um aumento de dióxido de carbono atmosférico em relação à época pré-industrial¹⁹;
- Segunda, que este tem origem nas atividades humanas;
- Terceira, que a acumulação de dióxido de carbono tenha como efeito o aumento global de temperatura;
- Quarta, que este aumento de temperatura seja suficiente para provocar alterações consideráveis no sistema climático, afetando o ser humano.

¹⁹ Evidentemente que se trata de uma simplificação, que isola o argumento central da teoria, ignorando outros fatores como sejam outros gases com efeito de estufa oriundos da atividade humana ou o impacto ou da diminuição da superfície florestal. A simplificação é justificada uma vez que de acordo com o AGGI (*Annual Greenhouse Gas Index*) o CO₂ contribui com 66% do efeito de estufa de origem antropogénica e é o único GEE cuja contribuição está a aumentar rapidamente (NOAA, s.d. b).

A natureza da relação causal estabelecida é tal que a validação das partes posteriores assenta nas anteriores para o sentido político que se possa extrair delas, ainda que ao nível científico possam ser consideradas isoladamente. Se não houver aumento de CO₂ em relação à era pré-industrial, posso ainda indagar quanto do CO₂ atmosférico é de origem antropogénica, cientificamente continua a ser um tema interessante, mas em termos de política pública perderá a sustentação científica. O mesmo em relação à sensibilidade climática. O clima pode ser extremamente sensível à acumulação de CO₂, mas se este não estiver a acontecer, o tema é desinteressante. Ainda, se houver acumulação de CO₂ de origem humana, mas não se verificar um aumento da temperatura média, não haverá muitas pessoas preocupadas com as consequências que um aquecimento de 4°C terá no clima, ou das consequências da duplicação do CO₂ atmosférico – cientificamente o estudo destas hipóteses continuam a ser interessantes.

A substância científica da ideia política das AC, depende da comprovação das quatro partes enunciadas, e os esforços para a sua validação empírica ocorreram mais ou menos num encadeamento sucessivo.

No geral a teoria das AC depende da acumulação de evidências sobre diferentes aspetos do clima, presente e passado, implicados em cada uma das partes mencionadas, sucessivamente e sistematicamente permitindo uma redução gradual da incerteza dos modelos teóricos utilizados para antecipar cenários futuros.

Podemos considerar que o rastilho foi reacendido por Callendar em finais da década de 40. Essa linha foi percorrida, sem se quebrar, acompanhada de uma consiliência, consenso científico, preocupação e peso político crescente, até ao momento presente.

A primeira e segunda parte do modelo causal acima referidos, configuraram-se no contexto da cooperação internacional de cientistas do clima em torno da questão das alterações climáticas foi o programa internacional de investigação nas geociências denominado *International Geophysical Year (IGY)*.

O IGY teve a duração inicial prevista de 18 meses entre 1957 e 1958, orquestrado pelo *International Council of Scientific Unions*. Este fora o projeto de cooperação científica internacional de maior envergadura e complexidade até à data. Foi no contexto deste

programa que obtiveram financiamento as primeiras medições sistemáticas de dióxido de carbono atmosférico entre outros aspetos nucleares da obtenção de dados relativos à teoria do efeito de estufa (ICSU, 2006, p. 3).

O IGY é o terceiro programa, na sequência de eventos de cooperação internacional nas geociências, tendo sido precedido por dois Anos Polares Internacionais.

Co-patrocinadora do evento foi a *World Meteorological Organisation*, organização intergovernamental do quadro das Nações Unidas. Recebeu ainda financiamento da UNESCO. A maior parte do financiamento proveio, contudo, sobretudo dos membros da ICSU, isto é, de financiamento estatal de programas coordenados ao nível das organizações membro em cada um dos países participantes. O IGY resultou assim na coordenação destes diferentes programas (ICSU, 2006, p. 3) e contou com a participação de 67 nações.

Estimativas do número total de pessoas envolvidas ao redor do mundo em estações e redes do IGY apontam um número de 60.000 pessoas envolvidas, das quais 10.000 eram cientistas. Foram estabelecidas no Ártico 300 estações por 14 nações. 68 estações foram instaladas no continente Antártico e nas ilhas Sub-Antárticas dirigidas por pessoal de 12 nações. (Barr & Lüdecke, 2010, p. 261).

O IGY abrangeu várias áreas das geociências, desde a colocação de satélites na órbita terrestre com o fim de estudar a terra, lançando assim a era espacial, ao programa do ártico e do antártico, observações sísmicas, aprofundamento dos estudos das placas continentais, medições oceanográficas e da ionosfera, e a criação de um arquivo mundial de informação.

Entre os marcos mais significativos deste programa, cujo foco foi o da realização de medições ao nível global, constam:

- A criação do Tratado da Antártida, que estabelece o uso da Antártida para usos pacíficos e cooperação científica.
- O lançamento do primeiro satélite com sucesso, por parte da URSS, Sputnik 1. Seguiu-se, no decorrer do programa, o primeiro lançamento de satélites por parte dos EUA, em 1958, Explorer 1 e 3. Estes avanços permitiram avançar no estudo do campo magnético da terra e levaram à descoberta do cinturão de Van Allen, região onde ocorrem vários fenómenos atmosféricos devido a concentrações de partículas no campo magnético terrestre.

- O estudo das perturbações da ionosfera, que permitiram melhorar substancialmente as comunicações de rádio, aspeto crucial em termos militares.
- O aperfeiçoamento do cálculo do balanço radiativo, ou balanço energético total da terra, e como tal estabelecer bases mais sólidas para a previsão do tempo e para a climatologia.
- O estabelecimento de uma rede de instalações científicas na Antártida, com reporte centralizado na *Antartic Weather Central*, permitindo avançar muito no estudo deste continente, e da sua importância no clima e no tempo da Terra.
- A inauguração de estudos do ar encapsulado em camadas profundas de gelo, permitindo obter dados empíricos sobre a composição atmosférica, e variações de temperaturas de eras passadas, tão importante na climatologia contemporânea.
- Diversos estudos sobre o fundo dos oceanos e a circulação das massas de água.
- Diversos estudos conduzidos no oceano ártico e em estações erigidas sobre ilhas flutuantes nesse oceano, com reporte centralizado de dados em S. Petersburgo.
- A descoberta dos riftes oceânicos e confirmação da tectónica de placas.
- A criação de uma rede mundial de *World Data Centers*, sujeitos a normas de partilha e uniformização do tratamento de dados meteorológicos. Esta rede é utilizada ainda hoje para efeitos de monitorização de dados relativos à pesquisa sobre as alterações climáticas.
- O financiamento de um programa global baseado em tecnologias de medição infravermelha de gases para medir as concentrações atmosféricas de ozono e de gases com efeito estufa em diversas localizações remotas ao redor do mundo, incluindo o Polo sul e Mauna Loa no Hawaii.

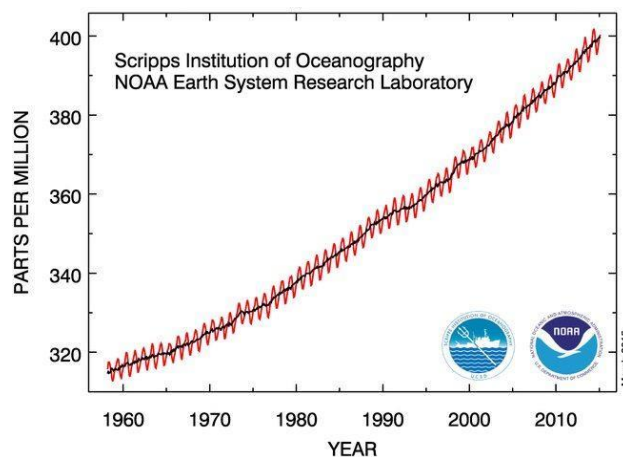
Este último projeto é particularmente relevante para a história do processo científico das AC. Os projetos que aí ocorreram, conduzidos por David Keeling, climatologista estadunidense, foram promovidos na sua continuidade pós-IGY pelo *US Weather Bureau* e pelo *Scripps Institution of Oceanography* e tiveram profundos impactos no desenvolvimento do conhecimento sobre a problemática das alterações climáticas (SCRIPPS s.d.). As investigações de Charles David Keeling e Roger Revelle constituíram-se como a autoridade

reconhecida para a quantificação do dióxido de carbono atmosférico (ACS, s.d.). Estas investigações foram cruciais para a confirmação de a) tendência de aumento do dióxido de carbono na atmosfera e b) da sua relação à ação do homem nomeadamente a queima de combustíveis fósseis e à desflorestação.

No conjunto de artigos publicados por Keeling no período compreendido entre 1958 e 1979, estes dois elementos da comprovação científica estavam consolidados após duas décadas de medições, e da conclusão de estudos isotópicos sobre o carbono atmosférico. Estes últimos permitiram distinguir entre origens distintas do dióxido de carbono atmosférico.

O gráfico 1 que então foi publicado é icónico, constitui a primeira imagem a ter forte impacto social no âmbito das AC. A pesquisa de Keeling afastou de vez a crítica à hipótese da teoria do aquecimento global de que as trocas dentro do ciclo de carbono mitigariam a subida dos níveis de CO₂ de origem antropogénica. Por outro lado, provaram que a subida anual da concentração de CO₂, acelerando ao longo de décadas, revelava o impacto crescente da combustão de combustíveis fósseis (ACS, s.d.).

Gráfico 1 - CO₂ Atmosférico no Observatório Mauna Loa



Legenda: Os métodos de mediação atmosférica de dióxido de carbono revelaram tendências naturais e outras realizadas pelo homem. A linha ziguezagueante vermelha revela oscilações naturais causadas pelo ciclo anual de crescimento das plantas, ao passo que o aumento ao longo do tempo é causado pelas atividades humanas, especialmente pela combustão de combustíveis fósseis. O gráfico de Keeling obtido no observatório de Mauna Loa no Hawaii, é conhecido como a curva de Keeling. Foi publicada pela primeira vez em 1960 na revista Tellus. (ACS, s.d.)

A primeira e segunda parte do modelo causal apresentado foram estudadas a partir da década seguinte apoiada nas estruturas de monitorização resultantes do IGY, e consolidadas na década de 70, de tal modo que já era aí possível quantificar com alguma precisão a quantidade de dióxido de carbono atmosférico de origem em emissões de combustíveis

fosseis que permanece na atmosfera (cerca de 55%) (SCRIPPS s.d.). Esta década viu os cientistas acumularem anos de experiências e monitorização sistematizada, o que permitiu o desenvolvimento de modelos de clima e a construção de cenários, num esforço de antecipação da evolução do clima.

Método indutivo e dedutivo, teoria e pesquisa empírica, laboratório e trabalho de campo, marcaram os anos subsequentes de uma área científica que, entretanto, se autonomizou. Mas o estabelecimento das terceira e quarta partes da teoria das AC revelou-se bastante mais complexo.

Os maus anos agrícolas, as secas, inundações, subida do nível dos oceanos, etc. tudo isto entrava no léxico dos climatólogos da década de 70, preocupando e interessando diversos setores de atividade económica, os meios de comunicação social, ambientalistas e os representantes políticos. Mas a complexidade do fenómeno atmosférico quando em conexão com a realidade social, revelou-se uma verdadeira caixa de pandora, uma espécie de ligação impossível de fechar entre a complexa linguagem estatística, as lógicas transnacionais dos fenómenos atmosféricos que não conhecem fronteiras, e a racionalidade política do sec. XX, assente num forte compromisso com uma racionalidade económica de curto prazo.

No que respeita a ciência, os esforços multiplicaram-se por todo o mundo. Nos anos 70, os cientistas postulavam que a aqui denominada 3ª parte do modelo causal requeria da verificação empírica um esforço que à partida se estenderia por quantidade grande de tempo (na perspetiva humana), uma vez que apenas um ou dois anos de medições não têm qualquer significado climatológico. O *ruído* estatístico de anos quentes e frios, só seria vencido, com medições ao longo de décadas, para se poder aferir o *signal* de uma tendência clara – que se pudesse relacionar à curva ascendente da acumulação de dióxido carbono atmosférico (Santer, B. D. et al. 2011).

Periodicamente, começaram a ser publicados relatórios e avaliações de ciência em diversos órgãos nacionais e internacionais. A comunidade científica habituou o público e o campo político a aguardar as publicações resultantes da avaliação das AC, numa linguagem estatística, profundamente enervante do ponto de vista das lógicas operantes no campo da decisão política, com conceitos eles próprios densos, como “sensibilidade do clima”, temperatura média à superfície terrestre, forçamentos, efeitos de *feedback*, etc.

A 4ª parte, a caracterização do impacto do aumento de temperatura no clima, aspecto de natureza necessariamente mais complexa, porque assente na incerteza anterior, desenvolveu-se em simultâneo no mesmo ritmo lento (da perspectiva do risco assumido com a produção crescente de emissões a cada ano) e sinuoso do ponto de vista da linguagem matemática necessária para a sua compreensão. Todos estes processos partilharam e partilham do mesmo esforço tripartido entre a) sistemas cada vez mais detalhados e internacionais de monitorização e processamento de informação acumulada, b) recolha de dados sobre o passado geológico da terra, c) desenvolvimento de modelos climáticos – modelos quantitativos que permitam conjugar e simular as principais interações dos fatores intervenientes do clima.

A resposta às duas perguntas, quanto é que o clima vai aquecer se se realizarem x toneladas de emissões de dióxido de carbono, e que consequências derivam desse aquecimento, é dada pelo IPCC, órgão intergovernamental da ONU encarregue de sintetizar a ciência sobre as AC para os decisores políticos implicados na CNUAC, na forma resumida de cerca de 200 páginas, repletas de expressões de natureza estatística (IPCC, 2014). Damos exemplo de uma passagem, onde é notória a dimensão da incerteza, como a dimensão do problema:

“Without additional efforts to reduce GHG emissions beyond those in place today, emissions growth is expected to persist driven by growth in global population and economic activities. Baseline scenarios, those without additional mitigation, result in global mean surface temperature increases in 2100 from 3.7°C to 4.8°C compared to pre-industrial levels (range based on median climate response; the range is 2.5°C to 7.8°C when including climate uncertainty” (2014, p.8).

Atualmente a comunidade científica tem alta confiança²⁰ de que as temperaturas globais continuarão a subir nas próximas décadas, em grande parte devido aos gases de efeito estufa produzidos pelas atividades humanas. O Painel Intergovernamental sobre Alterações Climáticas (IPCC), que inclui mais de 1.300 cientistas, prevê um aumento de temperatura de 2,5 a 10 graus Fahrenheit no próximo século.

²⁰ Esta expressão é aqui utilizada com base nos estudos sobre consenso científico em torno das principais conclusões do IPCC, realizados entre 2004 e 2016: Oreskes (2004), Doran (2009), Anderegg (2010), Cook et al. (2016).

De acordo com o IPCC, a extensão dos efeitos das mudanças climáticas em regiões individuais irá variar ao longo do tempo e com a capacidade de diferentes sistemas sociais e ambientais para adaptar-se à mudança.

O IPCC prevê que aumentos na temperatura média global de menos de 1,8 a 5,4 graus Fahrenheit (1 a 3 graus Celsius) acima dos níveis de 1990 produzirão impactos benéficos em algumas regiões e prejudiciais em outras, gerando novos vetores de desigualdades sociais. Os custos anuais líquidos aumentarão com o tempo, conforme as temperaturas globais aumentam (NASA, s.d.).

"Considerado como um todo", afirma o IPCC (2007), "as evidências publicadas indicam que os custos de danos líquidos das mudanças climáticas provavelmente serão significativos e aumentarão com o tempo²¹". Entre os efeitos já visíveis constam a diminuição dos glaciares, o degelo dos rios e lagos mais cedo no ano, a modificação das zonas de animais e plantas, o florescimento de árvores mais cedo no ano, aumento acelerado do nível do mar e ondas de calor mais longas e intensas. Como consequências futuras, resultantes da inação dos diversos estados nas políticas de mitigação, o IPCC (2013) apontou as seguintes pressões sobre os ecossistemas, e naturalmente sobre a humanidade:

- Continuação das alterações climáticas ao longo do século.
- As temperaturas continuarão a aumentar;
- Alterações mais significativas das estações agrícolas;
- Alterações nos padrões de precipitação;
- Mais secas e ondas de calor;
- Tempestades e furacões mais intensos;
- Aumento do nível do mar;
- Diminuição da Criosfera (das massas de gelo);
- Acidificação dos Oceanos.

Na década de 50, o IPCC ainda não existia, era o tempo de figuras "solitárias", Roger Revelle, Charles Keeling e Hans Suess, as luminárias das 1ª e 2ª partes da comprovação do modelo

²¹ Tradução livre.

causal das AC. A esta data já lhes era possível afirmar que estava em curso uma “experiência” de proporções planetárias que a humanidade inadvertidamente pusera em curso ao converter o carbono sepultado em eras longínquas, no estado gasoso. À luz do conhecimento da época sobre as reservas destes combustíveis, e dos relatórios da ONU sobre a produção e consumo anual deste recurso, Revelle estimou que em 100 anos todos os combustíveis tivessem sido consumidos. Daí que a sua perspectiva, nunca foi a de promover formas de evitar este consumo, mas antes a de prever, antecipando consequências, retirando delas oportunidades e minimizando ameaças. Nas suas palavras:

“Thus human beings are now carrying out a large scale geophysical experiment of a kind that could not have happened in the past nor be reproduced in the future. Within a few centuries we are returning to the atmosphere and oceans the concentrated organic carbon stored in sedimentary rocks over hundreds of millions of years. This experiment if adequately documented may yield a far-reaching insight into the process determining weather and climate (Revelle, R.; Suess, H. 1956, p. 19)”

A estimativa de Revelle era bastante precisa. Apesar de todos os anos se descobrirem novas reservas, a produção e consumo aumentam mais rápido, pressionados pelo aumento exponencial de população e pela industrialização de economias como a chinesa ou a indiana. Assim, presentemente, o modelo econométrico de Klass, prevê o esgotamento das reservas de petróleo, carvão e gás, em respetivamente, 35, 107 e 37 anos. Isto significa que as reservas de carvão existirão até 2112, e que serão o único combustível fóssil depois de 2042 (Singh, B. R.; Singh O. 2012, p.168).

A construção do problema social que subjaz ao processo político, revela-se dificultada por diversas forças opositoras como pela complexidade da informação científica que serve de suporte à questão ambiental.

Não obstante as dificuldades colocadas pela limitação da ciência atual, como do sistema político, as políticas públicas para as AC são eminentemente uma questão da responsabilidade das gerações presentes.

PARTE II - Resultados da Pesquisa

1 – O processo legislativo americano

Sem me querer alongar com uma descrição demasiado pormenorizada do processo legislativo americano, importa aqui abordar os aspetos formais básicos do Ramo Legislativo do Governo Americano, para contextualizar o material analisado.

A Legislatura é constituída pelas duas Câmaras do Congresso, o Senado (a Câmara alta) e a Casa dos Representantes (Câmara baixa do Congresso). A constituição destas câmaras provém do Artigo 1 da Constituição dos Estados Unidos.

O Senado é composto por senadores, cada um representando o seu Estado. Cada Estado é representado na sua totalidade por dois senadores, independentemente da sua população, servindo por termos de seis anos. Desde 1913, com a ratificação da 7^a emenda, que são eleitos popularmente através das eleições intercalares (até essa data eram nomeados pelas legislaturas estaduais). Nem todos os 100 lugares do Senado são sujeitos a eleições em cada eleição intercalar (*midterms*), que ocorrem em novembro, a cada dois anos, mas apenas os lugares vagos pelo fim de mandatos. Além das funções legislativas, o Senado possui outras funções, de aconselhamento, aprovação de tratados, confirmação de nomeações, entre outras. Comparativamente à Casa dos Representantes, os termos mais longos, a dimensão menor, a representação estadual, são elementos que contribuem para um ambiente menos partidário e para um funcionamento mais colegial bem como para uma discussão mais aprofundada dos temas.

Já a Casa dos Representantes, constituída por Representantes, eleitos nas eleições intercalares, um por cada distrito congressional, definidos de acordo com uma base populacional estabelecida no *US Census*. São eleitos diretamente desde a fundação desta câmara em 1789 no número fixado por lei de 435. Os termos de cada Representante têm a duração de dois anos. Assim todos os lugares são sujeitos a eleição, nas intercalares.

Evidentemente que as regras que organizam o sistema político americano sofreram alterações ao longo do tempo, mas os aspetos aqui referidos, emanando diretamente da Constituição americana, têm permanecido estáveis, uma estabilidade de mais de dois séculos, que não tem paralelo nas nações europeias.

Qualquer uma das câmaras pode iniciar o processo legislativo, com a apresentação de uma proposta de lei, e a sua atribuição para deliberação a um comité. Os comités formados em torno de áreas específicas de políticas públicas, são compostos por membros designados da Câmara respetiva do Congresso a que pertence. No decurso do trabalho do comité podem ser conduzidas audiências legislativas, destinadas a melhorar a proposta de lei. Posteriormente, o comité pode lançar a resultante proposta de lei, e calendarizar na Casa dos Representantes ou no Senado, um debate, uma emenda, ou uma votação. A proposta de lei aprovada por maioria simples, é remetida à outra câmara, e aí num processo semelhante é atribuída a um comité, que analisará a proposta, e pode conduzir audiências para reunir mais informação. Finalmente depois de aprovada pela generalidade da Câmara respetiva, processo que pode passar pelo trabalho a ser conduzido num comité conjunto das duas Câmaras, são trabalhadas as diferenças produzidas nas versões do Senado e da Casa dos Representantes. Neste caso, a proposta então alcançada, será novamente remetida à Casa dos Representantes e ao Senado para aprovação final. Em caso de aprovação, dá-se a impressão da proposta de lei, pelo *Government Printing Office* que a oficializa como “*Enrolled Bill*”, esta é então enviada ao Presidente, que no espaço de dez dias pode assinar o projeto de lei, ou vetar – se não fizer uma coisa nem outra nesse espaço, torna-se lei apesar disso e entra em vigor. O veto faz retornar a proposta de lei ao Congresso, que pode ainda assim repetir a votação, sem alterações, precisando agora de 2/3 de votos favoráveis na Casa do Representantes e no Senado para se tornar Lei e entrar em vigor. Uma lei federal denomina-se “*Public Act*”²².

As audiências legislativas são parte fundamental do funcionamento do Congresso americano e são conduzidas por comités específicos segundo temáticas de políticas públicas, no lado do Senado e na Casa dos Representantes, e ambos no caso de “*joint-committees*”. São espaços onde os senadores podem apresentar ideias, iniciar debates, e colocar questões, especialmente dirigidas a “*testemunhas*”, convidadas pelos membros do comité. As testemunhas são elementos da sociedade civil, da administração, de organizações não-governamentais, da indústria, de lobistas, etc.

²² O processo encontra-se descrito com detalhe nos sites oficiais (<https://www.house.gov/> e <https://www.senate.gov/>).

As sessões legislativas podem decorrer apenas para informar o Congresso sobre uma determinada área ou tema considerado relevante em matéria de políticas públicas, ou em torno de uma proposta ou propostas de lei concretas.

Nas audiências legislativas é frequente os congressistas pedirem relatórios e informações adicionais a serem submetidas posteriormente ao Congresso. Podem ser conduzidas publicamente, ou fechadas ao público, podem ser submetidas a registo ou não, ou parcialmente, pode ser ou não transmitida pelos meios de comunicação social, todos estes aspetos são definidos por norma pelo presidente, “*chairman*” do comité. Podemos considerar que as audiências são o mais público e mais acessível dos fóruns de debate político nos círculos elevados do poder político.

2 – Textos seleccionados

A tabela seguinte apresenta os textos seleccionados de audiências legislativas ocorridas no Congresso americano entre 1956 e 1966 contendo as palavras de pesquisa chave primárias e secundárias consideradas, e quando apresentando em alguma parte do texto uma exposição inequívoca da problemática das alterações climáticas.

Tabela 2 - Textos selecionados para análise

Tema da Sessão	Data	Contexto - Código	Texto
Second Supplemental Appropriation Bill 1956 (<i>IGY funding</i>)	1956	House of Representatives - subcommittee of the committee on appropriations (01HR56)	>> Statement of Roger r. Revelle, member, technical panel for oceanography; Anexo 4.
Education in the Field of Oceanography	1959	House of Representatives - Subcommittee on Earth Sciences of the Committee on Science and Astronautics (02HR59)	>> Statement of Dr. Gordon a. Riley, member of the National Academy of Sciences— National Research Council Advisory Committee on oceanography, and associate director, Bingham Oceanographic Laboratory, Yale University; Anexo 5.
The budget for 1960 (<i>IGY funding</i>)	1959	House of Representatives - committee on appropriations (03HR59)	>> Statement of Dr. Harry Wexler Concerning Meteorology and Glaciology Programs; Anexo 7. >> Statement or Dr. Roger Revelle Concerning the Oceanography Investigation; Anexo 6.
Frontiers in Atomic Energy Research	1960	Joint Committee - Subcommittee on Research and Development of the Joint Committee on Atomic Energy (04J60)	>> Statement of David b. Hall, Los Alamos Scientific Laboratory.; Anexo 8.
Weather Modification	1966	Senate - committee on commerce - (05S66)	>> Statement of Dr. Leland j. Haworth, director, National Science Foundation; Anexo 13. >> Statement of dr. Adrian chamberlain, vice president, colorado state University; chairman, national science foundation special commission on Weather modification; Anexo 9. >> Statement of Dr. a. Richard Kassander, professor of meteorology, director of the Institute of Atmospheric Sciences, University of Arizona; chairman of the board of trustees, University Corporation for Atmospheric Research; Anexo 12. >> Statement of Thomas f. Malone, second vice president and head of research department, The Travelers Insurance cos., Hartford, conn.; Anexo 14. >> Statement of Dr. Gordon j. f. Macdonald, chairman, panel on weather and climate modification, National Academy of Sciences; Anexo 10. >> Statement of Dr. j. Herbert Hollomon, assistant secretary of commerce for science and technology; Anexo 11.

Os campos da tabela identificam:

Tema da Sessão – Indica o tema oficial da audiência legislativa.

Data – Indica a data de realização da mesma.

Contexto / Código - Indica a câmara do Congresso e o comité ou sub-comité onde se realizou a audiência. O código que se encontra entre parênteses ajudará daqui em diante a identificar o texto, recomendando-se ao leitor que tenha o enquadramento destas páginas presente na leitura dos capítulos seguintes.

Texto – Indica o nome da testemunha e a sua apresentação formal, conforme consta no documento original. Finalmente, é indicado o Anexo onde consta o documento transcrito, que se encontra já anotado com os códigos que foram utilizados para construir as categorias, adiante explicados.

Apesar de não ser o objeto da nossa análise pareceu-me fundamental enquadrar os textos no quadro político-institucional onde foram produzidos. Este enquadramento encontra-se resumido na tabela que se segue.

Tabela 3 - Enquadramento político dos textos selecionados

Enquadramento Político	01HR56 R. Revelle	02HR59 Gordon	03HR59 Wexler et al.	03HR59 Revelle	04I60 David Hall	Kassander et. Al	Chamberlain	05S66 L. Haworth	05S66 Malone	Gordon MacDonald et al	05S66 Hollomon et. Al
Sessão do Congresso											
84th - 1955-1957	x										
86th - 1959-1961		x	x		x						
89th - 1965-1967									x		
Segundo a Câmara (HR/S/J)	HR	HR	HR		J				S		
Controlo da Câmara do Congresso (R/D)	D	D	D		D				D		
Segundo o presidente em funções											
(R) - Dwight D. Eisenhower	x	x	x		x						
(D) - Lyndon B. Johnson									X		

Legenda: HR - House of Representatives committee

S - Senate committee

J - Joint Committee

R - Republicano

D - Democrata

Assim, as sessões analisadas decorreram em comités de Câmaras do Congresso controladas pelo partido democrata.

Podemos considerar dois grupos: um primeiro onde se enquadram os textos produzidos em sessões da Casa dos Representantes, e ocorridos durante a presidência do republicano Dwight Eisenhower. Neste grupo encontram-se duas sessões de tema orçamental, onde os textos extraídos são relativos à orçamentação do IGY (01HR56 e 06HR59), e um outro (02HR59 – Gordon) relativo à discussão em torno da proposta de lei de um programa público para educação e investigação em oceanografia – de relevar aqui que as secções do IGY onde o tema das AC é debatido são também as do foro oceanográfico.

O segundo grupo formado pelo conjunto de textos extraídos da audiência legislativa em torno da proposta de lei para um Programa Nacional de Modificação do Clima (03S66). Esta decorreu em sessão do Senado, e durante a presidência de Lyndon B. Jhonson, já no seu mandato enquanto presidente eleito.

Como exceção, consta o texto extraído de uma audiência de um comitê conjunto (04J60), formado por membros do senado e da Casa dos Representantes, sobre a Pesquisa em Energia Nuclear. Esta sessão faz parte de um estudo preliminar do Congresso, ainda sem nenhum projeto de lei proposto. Ocorreu ainda na presidência de Eisenhower.

3 – Caracterização dos agentes

Segue-se uma breve caracterização dos agentes, segundo área científica, e segundo cargos ou posições ocupadas no momento da audiência, nomeadamente, quando referidos, aqueles pelos quais são designados na respetiva ata. Este retrato não tem em conta os cargos desempenhados na trajetória anterior ou posterior dos agentes.

Cientista em instituição de pesquisa controlada pelo estado federal:

David Hall, físico no Laboratório de Los Alamos (04J60 David Hall).

Cientistas em cargos de direção de instituições académicas e em cargos de representação internacional da academia científica:

Roger R. Revelle, oceanografo, membro do painel de oceanografia do *Comité Spécial de l'Année Géophysique Internationale*. (01HR56 Revelle e 06HR59 Revelle)

Cientistas em cargos de direção de instituições académicas e em cargos de representação nacional da academia científica:

Gordon O. Riley, oceanografo, membro da *National Academy of Sciences* (Comité de aconselhamento em oceanografia do Conselho Nacional de Investigação) e diretor associado do *Bingham Oceanographic Laboratory, Yale University*. (02HR59)

A. Richard Kassander, professor de meteorologia, diretor do Institute of Atmospheric Sciences, University of Arizona; Presidente do conselho de administração da *University Corporation for Atmospheric Research* (03S66 Kassander).

Gordon J. F. Macdonald, geofísico, presidente do painel em Modificação do clima e do tempo da National Academy of Sciences (03S66 Gordon Macdonald et al.).

Adrian Chamberlain, engenheiro, vice-presidente da Colorado State University; preside à comissão especial de Modificação do tempo, da National science Foundation (03S66 Chamberlain).²³

Cientistas com posição de direção em instituições públicas com vertente de investigação científica:

Harry Wexler, *Chief scientist* dos Serviços científicos do U.S. *Weather Bureau* (06HR59 Wexler)

Cientista com posição de direção da Agência Federal de Administração da Ciência:

Leland j. Haworth, físico de partículas; Diretor da *National Science Foundation* (03S66 Haworth).

Cientista com posição de direção em empresas com vertente de investigação científica:

Thomas f. Malone, segundo vice-presidente e diretor do departamento de investigação, da *The Travelers Insurance cos.*, Hartford.

Cientista com funções de direção em órgãos governamentais:

Dr. J. Herbert Hollomon, engenheiro, Secretário assistente para a Ciência e a Tecnologia no Departamento do Comércio.

4 - Uma estrutura do campo

4.1 - A estrutura do campo

Através da análise dos textos selecionados, considerados, pelas circunstâncias especiais da sua produção, como representativos de visões de especial relevância sobre a estrutura do campo onde se desenvolve o processo político das AC, chegámos a um retrato da mesma.

Os discursos analisados (que incluem exposições na forma de monólogos iniciais, seguidos de respostas a perguntas colocadas pelos congressistas) caracterizam-se pelo seu carácter político, mais do que científico. O poder de que se revestem estas ideias, é em grande medida alheio às ideias em si, isto é, à sua validade (característica que seria determinante

²³ O painel, apesar de ser de uma agência estatal de administração de ciência foi considerado de representação, uma vez que é uma comissão especial com funções de representação e síntese dos pareceres académicos sobre o tema.

no meio acadêmico, por exemplo) mas antes advém de formas acumuladas de poder simbólico e de formas específicas de reconhecimento possuídas pelos seus proponentes – e que encaixam, ou pretendem encaixar-se, como chave e fechadura com expectativas por parte dos congressistas. Isto objetiva-se na estrutura dos discursos que consistem numa exposição substancial dos recursos possuídos pelo agente, pessoalmente ou enquanto simbolizados no grupo que representa, valorizando por exemplo, um capital considerado transacionável, enquanto capital cultural, e que podemos denominar de capital científico²⁴.

Por exemplo, os textos redundam em frases em que se promove o valor público do progresso científico em áreas específicas:

Exemplo 1 (01HR56 – Revelle) – *“Man must study the oceans carefully not only chemically and biologically, but physically as well, in order to derive maximum sustained economic advantage from this great resource.”*

Exemplo 2 (02HR59 – Gordon) – *“We are deeply convinced that our country's defences will be more secure, and our long-term economic status will be more sound, if there is a considerable expansion of oceanographic effort during the next few years.”*

Exemplo 3 (03S66 – Chamberlain) – *“Improved prediction of weather phenomena may be as important in many cases as modification in terms of social and economic benefits.”*

Exemplo 4 (04J60 – David Hall) – *“Another important resource of the seas lies in the mineral content of the oceans both as dissolved salts and as precipitates in the sediments. The use of nuclear explosives might be feasible in breaking up a mineral belt on the ocean floor and preparing the ore for recovery by a deep sea dredge. Hydraulic lift or jet pumps working on the sea bottom might utilize nuclear energy efficiently in a marine environment. Important*

²⁴ O capital científico é um capital simbólico e constituído – representando uma estrutura específica de acumulação de capitais económicos, sociais e culturais, isto é, organizados segundo uma estrutura própria e apenas válida ou legitimada segundo regras sociais de um campo com as suas finalidades próprias – daí a vantagem de o tratar como um capital específico. Por exemplo, um cientista pode ganhar bastante prestígio se o seu projeto receber um financiamento elevado (capital económico), ou se publicar um livro prefaciado por um autor de grande renome (capital social), ou, evidentemente, se demonstrar a sua capacidade como cientista resolvendo um importante problema científico (capital cultural).

A acumulação de capital científico permite a obtenção de lucros que são próprios a este campo, não se reduzem por exemplo ao lucro económico (embora possam ser consistentes com ele, como no exemplo referido). Os agentes neste campo visam principalmente ganhos de prestígio e de acumulação da capacidade de imposição de ideias – capacidade esta aumentada pelo prestígio que o campo em si goza em relação aos demais campos da sociedade. Este conceito foi amplamente utilizado por Bourdieu (Bourdieu, 2015).

and critical minerals in this way may become available to nations now dependent on importation. These considerations are a matter of detailed economic evaluation.”

Todos os discursos são produzidos por agentes do campo científico, embora ocupem posições bastante distintas neste. Este facto leva-nos a concentrar a nossa atenção sobre este campo particular, e na sua interação com o campo político, procurando nesta dinâmica compreender a génese do processo político das alterações climáticas. Esta problemática específica não vai, apesar disso, limitar a nossa perceção do problema, mas antes tentei deixar que os textos falassem por si mesmos, deles extraíndo todos os conceitos e categorias que fossem indicadores de uma estrutura comum dos agentes interessados na problemática das AC: dos problemas, tensões e lutas que sejam comuns a estes e nos permitam caracterizar e perceber as forças em jogo no processo político das AC.

Assim sendo podemos dividir o campo segundo a distribuição desigual de duas formas de capital empregues numa primeira fase da construção do processo das políticas públicas das AC: o capital político, e o capital científico.

4.2 – Estruturas do campo – Perspetiva institucional

Com base nos textos analisados, e considerando nestes todas as referências a entidades/instituições identificadas como envolvidas na construção social de uma problemática ou assunto em debate nas sessões legislativas consideradas, construí um quadro de categorias que permite identificar os grupos institucionais envolvidos no processo político das AC. Reforço aqui a distinção entre o que, enquanto pesquisador, construo como campo do processo político das AC, e o contexto secundário em que a problemática das AC se situa nos discursos analisados. A problemática das AC é aqui integrada noutras problemáticas, o que não invalida a sua consideração segundo o chapéu do processo político das AC.

Tabela 4 - Perspetiva institucional do campo do processo político das AC nos EUA [56-66]

Campo Científico	Sub-Campo Académico	1 - Universidades/Unidades de investigação controladas por universidades
		2 - Organizações internacionais promotoras de investigação científica
		3 - Organizações de representação da academia (estruturas interuniversitárias, painéis de comités estatais ou nacionais, associações científicas)
	4 - Sub-campo da pesquisa científica privada (Industria, empresas com fins comerciais, não académicas, que desenvolvem atividades de investigação/experimentação)	
	Sub-Campo da Administração	5 - Instituições públicas, não militares, não universitárias, com funções de investigação científica (exclui agências com funções de investigação mas que tenham simultaneamente funções de regulação de um setor, ou de controlo sobre outros organismos)
		6 - Instituições de pesquisa científica militar (inclui todas as instituições militares que tenham participado ativamente em programas científicos, quer se trate da natureza das funções dessa instituição, quer se trate de ações de suporte a outras instituições)
		7 - Organismos ou agências federais de alto nível administrativo/coordenação
	8 - Campo político (Órgãos de soberania nacional ou estatal, altos secretariados dos departamentos do governo federal)	

O critério para a inclusão de uma dada categoria, foi quando mais de metade dos textos refiram instituições pertencentes a essa categoria, como sendo relevantes para as problemáticas abordadas pelos testemunhos, e em que se insere a problemática das AC.

Ficaram de fora, apesar de mencionados como relevantes pelos agentes, mas com representações menores a este critério: os órgãos de comunicação social, setores comerciais ou da indústria sem atividades de investigação científica e instituições científicas noutros países.

4.3 - Detalhe da estrutura do campo institucional

O processo de construção de políticas públicas para as AC pode ser entendido como produto de um único macro campo, compreendendo este o jogo pela acumulação de capitais eficazes na produção de modos de legitimação e de apropriação dos recursos compreendidos nos vários processos que compreendem as políticas públicas para as alterações climáticas. Tal envolve pensar em distribuições desiguais do capital científico e do capital político.

Há medida que o processo se desenrola no tempo, também se irá complexificar – e seria interessante um estudo posterior que abordasse o desenvolvimento do campo até aos dias de hoje. Para já, para o período inicial aqui considerado, delineámos um quadro genérico segundo dois tipos específicos e constituídos de capital simbólico – o científico, e o político – o quadro já apresentado no capítulo anterior. Vamos agora deter-nos sob o detalhe do campo, segundo as suas representações institucionais e, simultaneamente, segundo as ações empreendidas por cada subgrupo do campo.

Seguindo o quadro apresentado no capítulo anterior e as categorias institucionais aí introduzidas, apresentamos agora um outro quadro onde constam as “ações” (neste caso com o código a)) e “instituições” (com o código b)) que caracterizam cada categoria.

Consultando a tabela no Anexo 1 - “Categorias institucionais e Ações significantes no campo da construção de políticas públicas sobre as alterações climáticas” podem identificar-se as unidades de texto que foram sintetizadas nas categorias.

Por exemplo, para a categoria institucional 1 - “Universidades/Unidades de investigação controladas por universidades” o segmento do anexo que identifica as ações e as instituições que identifiquei nos testemunhos (colunas), como sendo relevantes para o processo de construção de políticas públicas das AC são:

Tabela 5 - Excerto da tabela analítica das categorias institucionais

	01HR56/R. REVELLE	02HR59/Gor don	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
Categorias	Referências no texto:										
1.a) Ações: Ensino; Investigação; Publicação de relatórios; Produção de literatura científica; Organização de conferências; Pareceres/recomendações sobre políticas públicas.		Train Oceanograp hers - Teaching	University research	research programs	Stanford survey - report SRIA - 7	University led research	University studies and symposiums	Statements in congress hearings	Programs on weather forecasting	University symposium	WM Research
				Published reports		Education programs on the field		Research activities	Published article	Experiment conducted by statistians	
				scientific literature and papers						University Research	
1.b) Instituições: Universidades; Departamentos Universitários e Laboratórios especializados nas Ciências Atmosféricas/Geociências e áreas conexas.		Oceanograp hy department s in universities	Universities	Academic research institutions and universities in general	Academy/uni versity controlled lab ; Stanford Research Institute	Universities	Universities	WM specific Research institutes	Von Neuman, matematitian	University WM projects	Universities
			Agricultural and Mechanical College of Texas			University programs of meteorology		Universities	Universities		

Na coluna categorias, encontram-se sintetizadas a informação das restantes colunas, que corresponde cada um a um dos testemunhos.

Este quadro foi construído através da classificação de unidades de texto que podem ser encontradas nos textos originais. Por exemplo, no texto 02HR59 Gordon, disponibilizado no Anexo 4, poderá procurar-se por código 1.a) e 1.b) para encontrar as unidades de texto a que correspondem as referências de texto que se encontram nas células da tabela:

- Ações: “Train Oceanographers - Teaching”.
- Instituições: “Oceanography departments in universities”;

1 - Universidades/Unidades de investigação controladas por universidades	1.a) Ações: Ensino; Investigação; Publicação de relatórios; Produção de literatura científica; Organização de conferências; Pareceres/recomendações sobre políticas públicas.
	1.b) Instituições: Universidades; Departamentos Universitários e Laboratórios especializados nas Ciências Atmosféricas/Geociências e áreas conexas.

2 - Organizações internacionais promotoras de investigação científica	2.a) Ações: Programa internacional de Geofísica (IGY); Relatórios; Encontros científicos; Coordenação de programas nacionais; Publicações científicas; Cooperação em Investigação com outros países; Pareceres/recomendações sobre políticas públicas; Financiamento de pesquisa científica; avaliação de ciência.
	2.b) Instituições: Comitê de coordenação do IGY (CSAGI); outras organizações internacionais de ciência; programas nacionais integrados nessas estruturas; representação nos comitês de gestão dessas estruturas.

3 - Organizações de representação da academia (estruturas interuniversitárias, painéis de comitês estatais ou nacionais, associações científicas)	3.a) Ações: Relatórios; Pareceres/recomendações sobre políticas públicas; Avaliação de Ciência.
	3.b) Instituições: National Academy of Sciences (NAS); outras associações acadêmicas e comitês interuniversitários.

4 - Sub-campo da pesquisa científica privada (Industria, empresas com fins comerciais, não acadêmicas, que desenvolvem atividades de investigação/experimentação)	4.a) Ações: Atividades de investigação e desenvolvimento e operações com inovação tecnológica; Avaliação de ciência.
	4.b) Instituições: Laboratórios privados; empresas com departamentos de investigação e desenvolvimento; empresas com serviços intensivos em inovação (nomeadamente em modificação do clima).

5 - Instituições públicas, não militares, não universitárias, com funções de investigação científica (exclui agências com funções de investigação mas que tenham simultaneamente funções de regulação de um setor, ou de controlo sobre outros organismos)	5.a) Ações: Atividades de pesquisa e desenvolvimento; patrocínio/contratação de pesquisa; desenvolvem missões com aplicação de ciência de ponta; produzem inquéritos e procedem à recolha de informação e dados estatísticos; pareceres/recomendações sobre políticas; Publicam estudos sobre temas de políticas públicas.
	5.b) Instituições: Laboratórios públicos; museus, agências com missões relacionadas com o oceano, atmosfera, ou recursos naturais, com especial relevância: Weather Bureau; Environment Sciences Services Administration (ESSA); National Center for Atmospheric Research (NCAR); Bureau of Reclamation (administra os recursos hídricos).

6 - Instituições de pesquisa científica militar (inclui todas as instituições militares que tenham participado ativamente em programas científicos, quer se trate da natureza das funções dessa instituição, quer se trate de ações de suporte a outras instituições)	6.a) Ações: Apoio financeiro e logístico e contratação de programas de investigação (públicos e privados); publicam relatórios; desenvolvem missões com aplicação de ciência de ponta (em particular programas operacionais nas áreas de MC).
	6.b) Instituições: Instalações de investigação do Departamento da Defesa; a Marinha; a Força Aérea.

7 - Organismos ou agências federais de alto nível administrativo/coordenação	7.a) Ações: Financiam investigação e ensino superior; Pareceres/recomendações sobre políticas públicas; Reportam ao Congresso; Atuam como autoridade sobre determinados setores de atividade económica, recolhendo registos sobre a atividade de agentes públicos e privados; avaliam e coordenam programas de pesquisa de diversas agências; realizam conferências; avaliação de ciência; apoiam a criação de agências/laboratórios/universidades; funções reguladoras.
	7.b) Instituições: National Science Foundation (NSF); Comités inter-agência.

8 - Campo político (Órgãos de soberania nacional ou estatal, altos secretariados dos departamentos do governo federal)	8.a) - Ações: Apropriação de fundos e alocação a projetos e programas de investigação; realizam audiências e legislam; relatórios de aconselhamento/recomendação sobre políticas públicas de alto nível; coordenam os esforços públicos e (numa certa extensão) privados; recomendações às agências.
	8.b) Instituições: Comissões, conselhos e comités de alto nível (em especial o Federal Council for Science and Technology e o comité de aconselhamento sobre o controlo do clima); órgãos soberanos (mais especificamente Congresso e Presidente e Departamentos da Administração/Governo)

4.3.1 - Análise

Será que podemos considerar que “quem move” o desenvolvimento deste (futuro) problema público, é a academia, enquanto produtora do problema científico que está na base da ideia que constituirá o problema público?

Embora as propostas de lei sejam autorizadas ou co-elaboradas por políticos, com ganhos políticos perspetivados na apresentação das propostas legislativas em questão, por outro lado, não podemos conceber que estes programas tenham nascido na esfera do campo político, uma vez que a especificidade dos seus problemas apenas encontra significado dentro do campo científico – isto é, sem o necessário conhecimento científico, um problema de geociências como o dispendioso estudo das correntes atmosféricas nas zonas glaciares, não seria “aprioristicamente” percebido pela sua relevância no plano da estratégia militar, ou mesmo o estudo do átomo não seria percebido como relevante para a produção de armas de destruição maciça, por exemplo. Podemos intuir um conjunto de problemas científicos que são utilizados com sucesso pelos seus proponentes (cientistas) para alcançar a agenda política.

Não sendo os criadores das propostas de lei, as testemunhas estão, no entanto, na posse das “chaves” do conteúdo e da forma das mesmas, chaves essas que apresentam no decorrer da audiência legislativa, por outras palavras, é evidente na leitura das mesmas o sentido de identificação das testemunhas com o sentido das propostas de lei, bem como a sua competência na explicação da sua forma e conteúdo. Podemos, portanto, considerar o seu papel como o de promotores do processo político das AC.

Este sucesso da problemática das AC (integrada num conjunto de outras problemáticas) em alcançar dinheiros públicos²⁵ e a criação de volumosos programas nacionais e internacionais décadas antes que o problema das AC se tenha tornado um problema público (no sentido da definição de problema público utilizada neste trabalho), é manifestamente sinal da existência de áreas bem estabelecidas de sobreposição entre ambos os campos político e científico.

Esta justaposição dos dois campos, assenta no processo político de outros problemas públicos mencionados nestas audiências e que vêm desde há décadas redefinindo o campo científico, o campo político e a sociedade americana: Problemas geoestratégicos pela disputa do domínio económico, militar, ideológico, ao nível global, com as potências europeias e depois da segunda guerra em particular com a URSS e a China, problemas relacionados com a proliferação do uso comercial de novas tecnologias com efeitos sobre a saúde e sobre o ambiente pouco estudados, e outros problemas diversos em que a ciência possa oferecer soluções/vantagens de natureza económica ou social. Estas tensões políticas fazem valorizar o capital científico no plano político, e com a criação de políticas públicas sucessivas, permitiram a formação de estruturas que reforçaram o acesso dos detentores do capital científico à decisão política.

Tal explica que as políticas públicas para as AC alcancem por meio dos atos legislativos em questão a sua fundação (em termos de infra-estruturas bastante dispendiosas, mão de obra altamente especializada, cooperação internacional e financiamento com horizontes de longo prazo), sem que se tenham constituído à época como um problema público – são

²⁵ Por via das propostas de lei que se tornaram lei – caso do IGY e da sua extensão, e do programa nacional para as modificações do tempo e do clima e de outras leis e apropriações conexas às ciências atmosféricas, como as que resultaram na criação do NCAR, da ESSA e da NASA.

certamente um problema científico, e em certa medida um problema político, mas não um problema reconhecido fora de uma esfera altamente técnica.

São sinais do fraco reconhecimento público à época:

- Não haver partidarização, nem oposição patente nas audiências legislativas em torno da problemática das AC;
- Não haver reconhecimento da problemática nos discursos ou agenda presidencial dos presidentes eleitos no período;
- Não haver ONG's com documentos ou atividade registada em torno da problemática.

Os agentes do campo científico que promovem problemas científicos, procurando torná-los problemas sociais, ambicionam em simultâneo às finalidades explícitas, as finalidades que podemos considerar implícitas ou necessárias ao aumento de poder e influência. Com estas finalidades em vista desenvolvem estratégias, que também são estratégias discursivas, através das quais procuram tornar o capital científico acumulado relevante nas estruturas mais próximas do poder político. Em última análise essa necessidade de transgredir as fronteiras do campo científico para o campo político, traduz lutas internas pela reforma do primeiro e lutas externas que visam a alteração do papel deste campo na sociedade, isto é, em relação a outros campos.

Quando se diz (no debate congressional) que uma área científica é de grande relevância militar, ou ambiental, e que o avanço científico é garante da supremacia económica de uma nação, promovem-se duas tensões, uma interna, outra externa: interna, de áreas científicas que se procuram libertar dos grilhões de um papel secundarizado face a outras áreas científicas; e externa, do aprofundar do papel do campo científico na sociedade, ambição evidentemente disputada com outros campos da sociedade. Não são motivos escondidos, ou inconscientes, nem se encontram desligados dos motivos explícitos das ideias orientadoras do discurso – contudo estão implicados nas mudanças promovidas como condição do objetivo que explicitamente se pretende. Quando se procura a criação de um comité de aconselhamento presidencial sobre ciência e tecnologia, procura-se obter um posto, uma permanência no campo político – um campo potencialmente hostil, porque

vivamente disputado por outros campos e onde muitas das estruturas criadas têm uma duração bastante curta.

A academia é representada neste processo político como estruturada entre a) os produtores da ideia e produtores dos produtores de ideias científicas, as Universidades, b) os grandes acumuladores de recursos para a consolidação das mesmas, as Instituições Internacionais, e c) as estruturas associativas interuniversitárias, que conferem à produção científica a forma de produto acabado. O principal interveniente neste grupo c) é a *National Academy of Sciences*, que é representada nos discursos como a responsável pela ortodoxia científica, simbolicamente suspendendo o contencioso inerente ao processo científico, e construindo um produto factual, supostamente consensual, passível de ser apresentado como um artefacto político da comunidade científica.

Sem a Academia, no seu todo, não há “clima”, muito menos alterações climáticas, significando isto, que não há a complexa estrutura social (que também é uma estrutura física, de instalações de pesquisa, livros, tecnologias, presente em todos os continentes) que permite o tratamento estatístico das propriedades da atmosfera, a que chamamos clima.

Num nível intermédio, mas extremamente relevante, está a indústria, com forte vocação para a inovação e desenvolvimento, isto é, para a mobilização do capital científico por si captado para a criação de novas tecnologias e de soluções aplicadas às práticas com valor económico, sejam estas agrícolas, industriais, civis, militares ou outras.

Um elevado nível de investimento público, atingido no decorrer da 1ª e da 2ª guerra mundial e que se manteve no período do pós guerra, direccionado a parcerias entre o público e o privado no domínio da investigação aplicada, permitiu a grande acumulação de capital científico em empresas e dotou a Indústria norte americana da capacidade de produzir os seus próprios domínios científicos, baseados em descobertas/inovações disruptivas, e assim de provocar ondas de choque afetando todo o campo científico aos níveis académico, administrativo e político – como é o caso das ciências aplicadas às modificações do clima, conhecidas como “semear as nuvens” (ing: *cloud seeding*), aliás um tema quente das ciências atmosféricas das décadas de 50 e 60. Com efeito as descobertas propiciadoras desta nova área foram realizadas por Irving Langmuir and Vincent Schaefer, cientistas da General Electric Co..

A presente evolução, em que uma ciência imiscuída de interesses económicos procura a sua afirmação, torna o campo permeável a uma ciência vista pelos académicos como falaciosa, do ponto de vista da pureza epistemológica enquanto jogo social particular às carreiras científicas no contexto académico. Este problema é amplamente debatido nos textos considerados, nos seis textos sobre modificações do clima considerados (03S66). Os cientistas/inventores são apelidados pela comunidade académica de “*rainmakers*” num tom depreciativo e defende-se que o campo académico e administrativo deve controlar, regular e avaliar a validade desse suposto conhecimento de modo a assegurar a honestidade e segurança das práticas comercializadas e ao mesmo tempo potenciar o progresso científico. Não obstante esse estigma, de proto-ciência ou mesmo de pseudociência, de que goza a investigação conduzida por departamentos de investigação das empresas, a National Academy of Sciences considerou vital, no caso das modificações do clima, criar uma disciplina “séria” – isto é – académica, que desenvolva os estudos inaugurados por engenheiros e cientistas das grandes empresas tecnológicas. Uma das ideias vigentes no debate sobre este programa, é precisamente a de que se desenvolva um esforço para concentrar em agências públicas, por força de lei, a ciência desenvolvida neste campo – obrigando a uma transferência desse capital do privado para o público. Isto revela as dinâmicas de campo envolvidas em setores habitualmente considerados como separados, indústria, academia, agências públicas, que só podem ser explicados numa visão conjunta de um mesmo campo.

Ainda num nível intermédio, mas numa camada separada, estão as agências públicas que desenvolvem, contratam, financiam ou apoiam a investigação científica. Estas agências têm o papel de conectores entre as diferentes partes do campo científico – através de estruturas como comités ou painéis para desenvolver soluções ou propostas políticas sobre problemas públicos, ou de laboratórios comuns, ou através de equipas de investigação com cientistas de diferentes origens disciplinares e institucionais, aplicadas a fins públicos. Por serem detentoras do quase monopólio da aplicação de ciência para fins públicos, desempenham um papel incontornável no processo político das AC, acumulando o capital científico mais específico do campo para o processo em causa.

No campo da administração, encontra-se ainda o sub-campo militar, representado como grande fornecedor de meios logísticos e infra-estruturais, como interessado financiador dos

aspectos estratégicos da ciência aplicada. Este sub-campo, sendo parte da administração, é retratado neste quadro em separado, evidenciando uma autonomia face às restantes instituições públicas, patente na forma como é retratado nos discursos.

Ao nível da coordenação, nível mais elevado na administração da ciência, está a National Science Foundation, fundada em 1950, na administração Truman. A NSF pratica diversos atos administrativos sobre o campo científico, como por exemplo decisão sobre critérios de financiamento, ou sobre a formação de comités e grupos de análise interagência e interuniversitário – constituindo uma super-estrutura do campo, ainda com funções paralelas à Academia Nacional de Ciências no que toca à avaliação da produção científica. Recolhe informação, regulamenta, impõe a submissão de informação, coordena esforços de agências, promove a criação ou extinção de laboratórios, museus, agências e universidades. É uma instituição que concentra uma parte importante dos capitais político e científico em jogo no campo. Desempenham ainda outro importante papel para o processo político, o de definir os parâmetros estatísticos sobre o campo científico, estando na base de uma autoreflexão muito importante do ponto de vista das ciências sociais que se queiram debruçar sobre o campo, mas também onde se realiza a aplicação dos conceitos e de metadados que serão utilizados, por exemplo na atribuição de fundos – reside nelas pois a aplicação direta de visões e divisões (definidas em instancias superiores) sobre o campo científico.

Finalmente, encontramos as instituições de soberania, que concentram as formas matriciais do poder legislativo²⁶, judicial e executivo, concentrando em si o capital político. Este nível contém ainda importantes funções e modos de acumulação do capital científico: Funções de monitorização, recolha de informação, síntese e avaliação das atividades científicas. Exemplos mencionados são o Secretariado do Departamento do Comércio, o *Science and Technology Committee*, ou o *President Science Advisory Committee* (que produziu o primeiro documento de topo a alertar sobre AC em 1961 – *Restoring the Quality of our Environment endereçado ao então presidente J.F. Kennedy*). Além disso essa acumulação ocorre através do próprio capital cultural e social dos senadores, representantes e outros

²⁶ Dito desta forma, porque se reconhece aqui o poder de delegação de poderes de regulamentação em agências do estado e órgãos da administração pública, que se devem aplicar e impor com a validade de norma legal.

elementos destes órgãos, como nos documentos submetidos sob requisição ou voluntariamente pelas partes interessadas do campo científico.

O método de pesquisa usado permite identificar evidentemente o congresso americano como agente do processo político das AC, e apenas de forma secundária são referidos os outros órgãos, sejam os órgãos de soberania estadual, o Presidente, os Tribunais...

Tendo como hipótese este método ser suficientemente representativo, o campo das políticas públicas das AC, encontra-se assim estruturado, à época e no contexto dos EUA. São referidos ainda, mas sem representação suficiente para o critério de formação de categorias, a esfera de organizações da sociedade civil, dos órgãos de comunicação social, ou da indústria de áreas não científicas.

O partido político, apesar de ser a organização que disputa as lutas no campo político, não é explicitado por nenhum dos testemunhos, ou dos congressistas, nem tampouco o debate decorrido nas audiências nos permite identificar divisões ao longo de linhas partidárias, como tal não arrisco aqui qualquer análise deste foro, considerando apenas que este deverá ser para já um tema consensual entre ambos os partidos.

4.4 - Estrutura do campo - Perspetiva disciplinar

Na estrutura do campo científico pesam as divisões disciplinares, constituindo as referências às mesmas, importantes elementos do discurso nas sessões consideradas. Assim, identificando estas referências e organizando-as segundo uma geometria baseada nas relações indicadas pelos agentes, delineei uma representação da estrutura do campo científico, segundo as representações disciplinares, situando nelas a problemática das Alterações Climáticas.

Uma recolha mais elementar dos termos empregues no contexto das disciplinas científicas, e do enquadramento disciplinar dado à problemática das AC, encontra-se na tabela na página seguinte. Já a tabela 7 contém uma representação da forma como as represento enquanto campo, recorrendo aos discursos analisados.

As referências utilizadas como base para este trabalho, podem ser consultadas, identificando na primeira tabela as respetivas disciplinas, e procurando no respetivo texto

(em anexo) os segmentos identificados como “Referências AC”, no caso dos termos constarem na primeira linha da tabela, e “Outras disciplinas mencionadas” no caso dos termos que constam na segunda linha da tabela. A compreensão das relações implica uma leitura integrada dos parágrafos utilizados.

Não foram feitas traduções dos termos, para não se perder a riqueza de significados próprios à língua original. No caso da segunda tabela, seguindo o mesmo raciocínio para as próprias categorias – utilizei exclusivamente termos empregues pelos próprios agentes.

As setas na tabela 7 identificam relações entre as áreas disciplinares. O sentido delas aponta para um fluxo de conhecimento e recursos para uma área mais específica. Por baixo das áreas disciplinares, a negrito, constam as disciplinas que são chamadas à sua composição.

Tabela 6 - Enquadramento do problema das AC no campo disciplinar

Unidades de análise	01HR56/R. Revelle	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
As AC são mencionadas enquanto problemática do campo disciplinar:	Geophysics, Meteorology and Oceanography	Climatology, Geochemistry	Meteorology, Oceanography, Agricultural Science; geophysics; glaciology; Climatology	Oceanography, Geology, Thermodynamics, Hydrodynamics; biology, chemistry, Physics, meteorology	Energy	Atmospheric Sciences	Weather and Climate modification	Weather and Climate modification	Weather and Climate modification	Weather and Climate modification	Weather and Climate modification; Environmental Sciences; meteorology
Outras áreas científicas mencionadas	Seismology, glaciology	Physics , Biology, Geophysics, Geology, Marine physics, meteorology, Oceanography, Medicine, Astronomy Chemistry; Earth Sciences; Astronomy; Space Sciences; Geochemistry	Mechanics; Biology	Geodesy, Geochemistry, Geophysics; Technology; Marine Sciences; Atomic Energy; marine sciences; military defense; marine resources; marine Radioactivity, Seismology; Pure and Applied Physics; Pure and Applied Chemistry; Geography; Marine Geophysics; Natural sciences; sciences of the sea; Earth Sciences	Oceanography; atomic Energy	Geosciences; Weather and Climate Modification; Physics; Social Science; Law; ecological studies	Engineering; Statistians (from other fields) Physical Sciences; Social Sciences; Biology; Law; ecology; atmospheric Sciences;	Atmospheric Sciences; Geosciences; Physic; Physical Sciences; Environmental Science; oceanography, meteorology, geophysics, geology, geochemistry; Social Sciences; Antropology; social Psychology; Engineering(transportation; sanitary engineering; systems engineering); Biological Sciences (ecology, Systematic Biology); Chemistry; Cloud Physics; meteorology	Atmospheric Sciences; Physical Sciences; Social Sciences; Life Sciences; environmental sciences; meteorology	Atmospheric Sciences; Planetary and Space science; environmental sciences; Physics; chemistry; engineering ; Physics; Chemistry	Atmospheric Sciences; Atomic Energy; Technology; Physics and Chemistry;

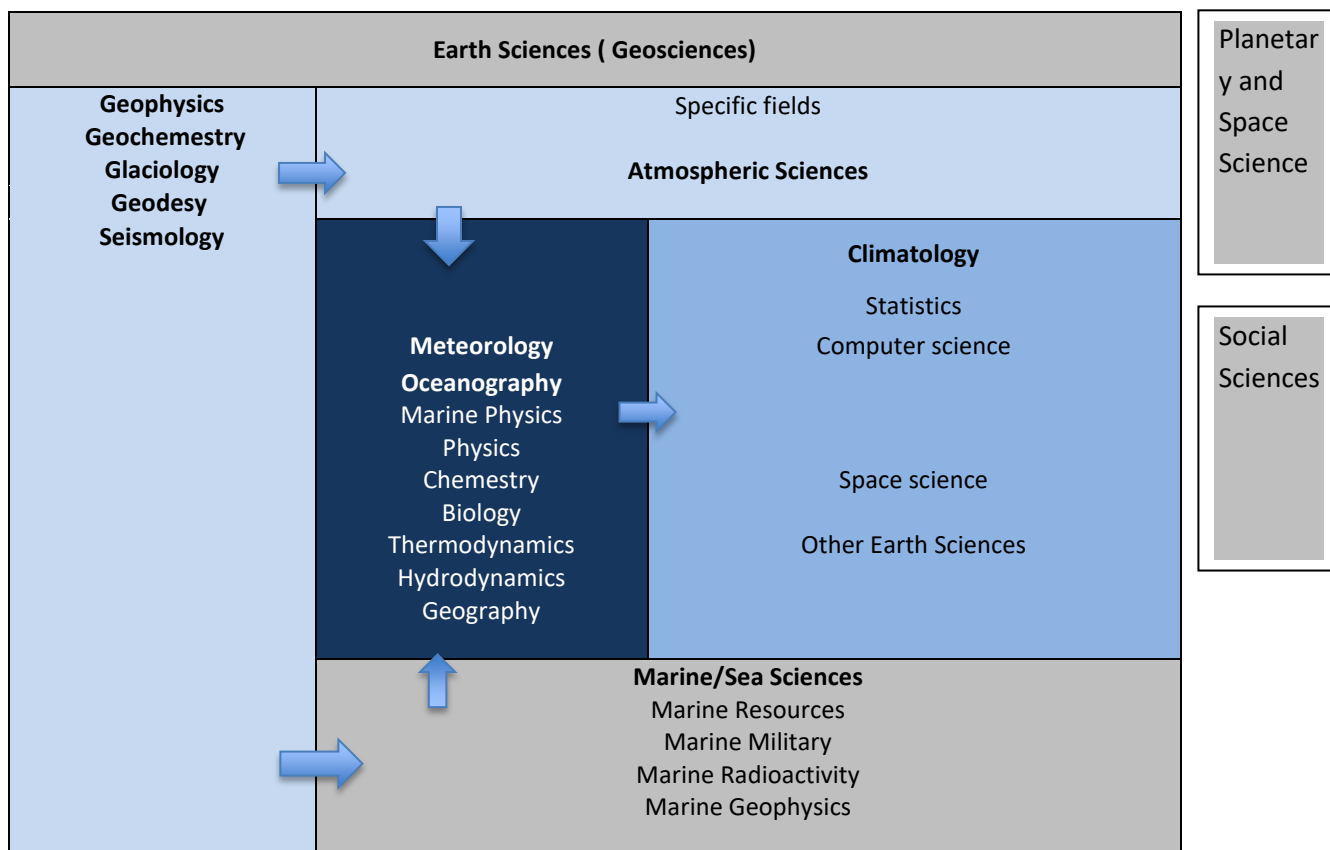
Tabela 7 - Estrutura disciplinar do campo científico da problemática das AC

NATURAL SCIENCES FIELD

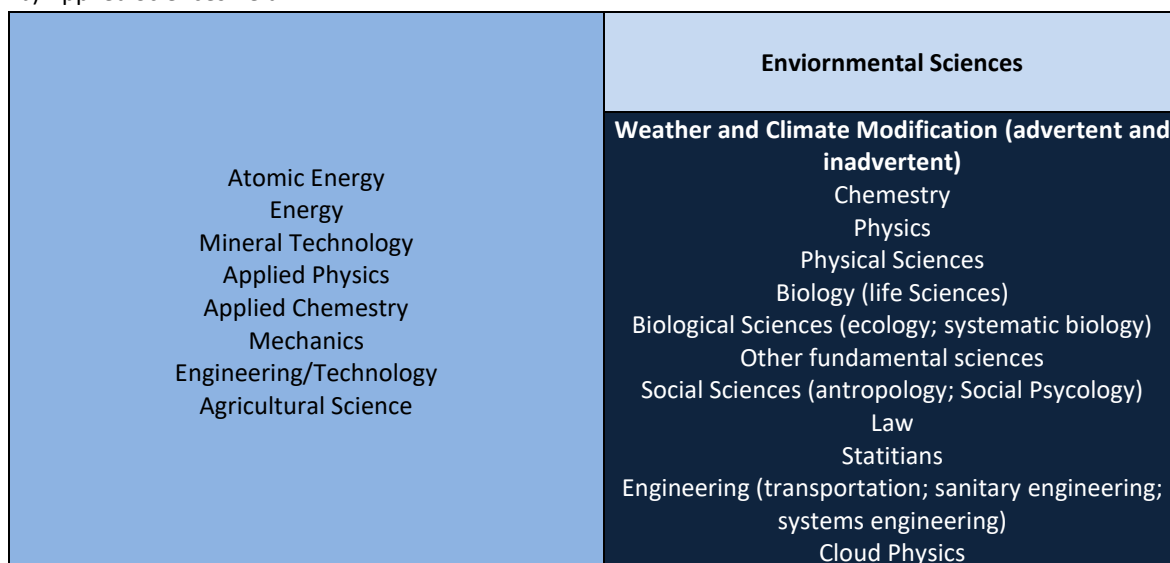
Privileged Fields – Basic Disciplines / Fundamental Sciences

Biology / Physics (pure) / Chemistry (pure) / Astronomy / Mathematics (Statistics)

Handicaped Fields – a) Interdisciplinary Disciplines (Physical Sciences)



b) Applied Sciences field



4.4.1 - Análise

O campo é delimitado pelo universo das ciências naturais. É neste campo que são reconhecidos os agentes com o capital científico relevante, e como tal com poder para exercer autoridade científica sobre as matérias em questão – sejam as alterações climáticas, sejam os outros temas tratados nas sessões.

As áreas sociais são mencionadas, como potenciais contribuidoras (no conceito abrangente e interdisciplinar das ciências ambientais) mas sobretudo vistas como áreas disciplinares que devem ser integradas dentro das disciplinas em desenvolvimento – prevê-se/estimula-se pelo discurso e pelo próprio objeto das propostas legislativas em questão, uma migração de cientistas destas e de outras disciplinas no sentido de engrossar as fileiras de novas disciplinas e de as dotar de uma abrangência disciplinar mais vasta do que as suas disciplinas progenitoras – ao mesmo tempo que o seu objeto se torna mais específico. Essa especificidade está refletida no nome das disciplinas: geociências, ciências atmosféricas e ciências marinhas, meteorologia e oceanografia, climatologia...

As disciplinas emergentes são caracterizadas pelo ênfase nas suas áreas de aplicação e pelos ganhos da abordagem multidisciplinar de um mesmo objeto ou problemática – Esta característica pode ser compreendida como uma estratégia, inerente à posição determinada pela estrutura do campo científico: Agentes de uma área científica que se distingue pelo seu objeto ou olhar próprio sobre um objeto científico, com menos capital acumulado do que as áreas mais estabelecidas e/ou mais “fundamentais”, investem na sua consagração como disciplina (o que é na verdade uma divisão/separação da disciplina progenitora), compensando uma redução e uma dependência do seu âmbito teórico, com outros aspetos, como sejam a maior visibilidade externa do conhecimento possuído sobre matérias relevantes noutros campos – sejam o económico, sejam o político, ou outros - e a versatilidade da abordagem multidisciplinar, que pode ter efeitos de diminuir a relação de dependência simbólica de uma única disciplina “progenitora”. Finalmente, estas disciplinas observam progressivamente uma maior dispersão do capital científico por agentes e instituições não académicas.

As disciplinas originárias, continuam a ser consideradas como dominantes, mencionadas segundo terminologias que contêm uma divisão simbólica, como “puras”, “fundamentais”, “básicas”. Estes termos implicam a dependência das outras áreas em relação a estas, não

obstante a distribuição de poderes no campo poder ter já sofrido uma alteração, num sentido de emancipação estrutural que as sessões legislativas analisadas acompanham.

Finalmente, um terceiro grupo de disciplinas, encontra-se representado em baixo: o grupo b) disciplinas de ciência aplicada, que se distingue pelo maior ênfase na aplicação. Algumas das características do grupo anterior (a)) apresentam-se para este grupo num maior grau: a heteronomia, a dispersão estrutural/institucional do capital e o ênfase na aplicação. No caso da área Modificações do Tempo e do Clima, referida como disciplina que compreende no seu âmbito o estudo das AC podemos também identificar os aspetos aparentemente contraditórios da multidisciplinariedade e o estreitamento da especificidade do objeto de estudo em relação às áreas de estudo originárias: ciências atmosféricas, geofísica, física, química...

A cor azul é utilizada para retratar as áreas representadas nos discursos como tendo conhecimento, isto é, autoridade para definir visões coletivamente construídas como factos, sobre as alterações climáticas. O azul é tanto mais carregado, quanto em mais textos se encontra essa referência.

Observamos que a posse desse conhecimento é reconhecida em disciplinas mais específicas, e que destas, duas áreas podem vir a “disputar” a autoridade sobre a questão das AC:

- A **climatologia**, originária da complementaridade entre meteorologia e a oceanografia principalmente (mas também de outras áreas mencionadas na tabela). Essa complementaridade fundadora de um novo campo disciplinar é por vezes referida como se tal acontecesse por móbil da própria realidade natural, isenta ou purificada de qualquer aspeto de natureza social.
- A área aplicada “**Modificação do tempo e do clima (MTC)**”.

Seja a climatologia, seja a Modificação do Tempo e do Clima na sua estratégia de emancipação, encontram-se, em hipótese, muito mais dependentes da sua validade reconhecida por agentes externos ao campo científico para a sua sobrevivência e afirmação. Por outro lado, poderão alcançar poder para impor sobre o campo científico as suas regras, ao alcançar noutros campos essa influência, segundo uma valorização do seu capital no plano político ou económico. Esta estratégia, e os problemas por ela levantados, estão presentes na génese do processo político das AC.

Finalmente importa referir que o poder público pode atuar diretamente sobre a redistribuição dos pesos/poderes entre campos disciplinares (entre outros aspetos estruturais) transgredindo as disposições internas ao campo académico. Por exemplo, através da representação do campo na estrutura departamental da Fundação Nacional para a Ciência (NSF). A este propósito citamos o diretor da NSF (03S66 L. Haworth):

“So great is my own concern with developing the Foundation role and stance in this problem area that I have recently established an Environmental Sciences Division within the Foundation, which is of equal organizational rank with the older research divisions, such as the Mathematical and Physical Sciences Division, the Biological and Medical Sciences Division, the Engineering Division, and the Social Sciences Division.”

Outro exemplo pertinente é a inserção departamental do Plano Nacional para Modificações do Tempo e do Clima na proposta de lei S9128, no Departamento do Comércio, e a proposta de mais do que uma testemunha, de que se entregue as funções de coordenação, não à NSF, mas à ESSA (*Environment Sciences Services Administration*). Este enquadramento mostra como os temas ambientais foram então encarados pela administração americana: Uma questão de natureza comercial. A atribuição da gestão de programas científicos fora da NSF, também corresponde a uma visão pragmática (menos académica) da gestão de ciência, o que vai no sentido do que já foi desenvolvido em cima. De facto, os temas compreendidos dentro das MTC, são maioritariamente destinados a desenvolver práticas intervencionistas, com potenciais aplicações comerciais, militares e de utilidade pública, e apenas de forma secundária a dirigir-se a problemas ambientais resultantes (nos termos da época) da ação inadvertida do homem sobre o tempo ou o clima.

4.5 – As lutas no campo e o dinamismo da mudança

Segundo a teoria de campo de Bourdieu, uma análise do campo requer o estudo das pressões e das tensões sentidas e exercidas no campo científico: as tensões referindo-se a lutas externas, ao passo que as pressões se referem às lutas internas.

São externas quando refletem pressões sentidas ou exercidas em torno do valor relativo de capitais específicos e entre campos diferentes.

São internas quando refletem tensões sentidas ou exercidas em torno do valor de capitais específicos e na sua estrutura e regras de distribuição no interior do próprio campo.

Este trabalho, com a limitação que nos impõem os dados utilizados, não nos permite identificar nas lutas externas, os agentes antagonistas, e que naturalmente fazem parte do campo, mas apenas deduzir que se encontram ativamente implicadas forças que vêm a sua posição estrutural na sociedade ameaçada, pelo avanço das forças representadas neste campo – já delineado institucionalmente e segundo áreas científicas.

A parte que se segue do trabalho encontra-se organizada segundo dois grupos de categorias: lutas externas e as lutas internas.

O método de criação destas categorias foi o seguinte. Em primeiro lugar, foram identificados nos textos analisados problemas, ideias, motivações. As unidades de texto assim identificadas foram resumidas em conceitos (Anexo 3). Por sua vez esses conceitos foram relacionados entre si, e na medida em que aparecendo em diversos textos sob a forma de ideias/problemas/motivações semelhantes, foram agrupados em categorias. Esse exercício encontra-se representado na tabela do Anexo 2, de que apresentamos em seguida um excerto.

Na tabela “Categorias das lutas internas e externas ao campo da construção de políticas públicas sobre as alterações climáticas” (Anexo 2), os conceitos encontram-se numerados e listados por debaixo de cada coluna relativa a um testemunho. Pesquisando nos textos que constam em anexo, pelo número do conceito, é possível encontrar as unidades de texto que lhe deram origem (ex: “conceito 2”). Os conceitos que contribuíram para uma categoria encontram-se identificados pelo número, conforme exemplificamos no excerto em baixo:

Tabela 8 - Excerto da tabela analítica das categorias das lutas externas

	Referências no texto:										
	01HR56/R. REVELLE	02HR59/Gor don	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
1- São necessárias políticas públicas consistentes bem como níveis mais elevados de financiamento público e privado da ciência para o progresso científico.		1, 11, 12, 17	17	2, 13, 20, 22, 23, 38		7	4, 25	15			12, 13, 21, 23, 24

Neste extrato da tabela, conseguimos perceber que na primeira categoria das lutas externas “São necessárias políticas públicas consistentes bem como níveis mais elevados de financiamento público e privado da ciência para o progresso científico”, o texto 02HR59 Gordon, contribuiu com quatro conceitos, 1, 11, 12, 17.

Consultando no Anexo 3, sei que estes conceitos são:

1 - Recomendação da NSF de mais financiamento (largas somas) destinadas a subsidiar os estudantes de determinadas áreas científicas.

11 - Não há expansão sem intervenção exterior.

12 - Deve haver financiamento a longo prazo para as universidades, de forma às universidades conseguirem garantir salários.

17 - Aumento de financiamento generalizado a todos os estudantes.

Pesquisando no texto 02HR59 Gordon – Anexo 5, por “conceito 1” ou “conceito 11”, encontramos as unidades de texto que se referem ao tema sinteticamente referenciado no conceito.

4.5.1 – As lutas externas

Categoria 1 – São necessárias políticas públicas consistentes bem como níveis mais elevados de financiamento público e privado da ciência para o progresso científico.

Conceitos analíticos

01HR56 /R. REVELLE	02HR59 /Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Hawthorn	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
	1, 11, 12, 17	17	2, 13, 20, 22, 23, 38		7, 16	4, 25	15			12, 13, 21, 23, 24

Legenda:

02HR59 Gordon :

1 - Recomendação da NSF mais financiamento (largas somas) destinadas a subsidiar os estudantes de determinadas áreas científicas.

11 - Não há expansão sem intervenção exterior

12 - Deve haver financiamento a longo prazo para as universidades, de forma às universidades conseguirem garantir salários.

17 - Aumento de financiamento generalizado a todos os estudantes.

03HR59 Wexler:

17 - Ideia de que a ciência está apenas no início da compreensão de certos problemas e de que é necessário mais esforço e apoio por parte do Estado.

03HR59 Revelle:

2 - Condições precárias da pesquisa realizada em estações de pesquisa em regiões inóspitas.

13 - Diferencia a área segundo o valor dos resultados da pesquisa, justificando aumento do nível de financiamento pedido.

20 - Importância da conjugação de diferentes fontes de financiamento dos programas científicos.

22 - Procura enquadramento legal específico (isenção de regulações) para atividades de pesquisa.

23 - Problemas da gestão de recursos de pesquisa partilhados com os militares.

38 - A necessidade e os benefícios de envolver a indústria nos programas públicos de investigação científica.

05S66 Kassander et Al:

7 - Vantagens de programas nacionais no alcance de objetivos científicos.

16 - Desenvolvimento do campo, dependente do alcance de níveis críticos no financiamento.

05S66 A. Chamberlain:

4 - Procura de maiores níveis de financiamento.

25 - Os processos de decisão em função da incerteza necessitam de mais pesquisa (e maior nível de financiamento).

05S66 L. Haworth:

15 - Defesa do aumento do nível de financiamento.

05S66 Hollomon et Al:

12 - Importância do estado de recolher a informação relevante produzida pelos diferentes agentes públicos e privados.

13 - Promove estudos para futura legislação com vista a controlar atividades científicas comerciais, do governo local e estatal – como para atingir objetivos de controlo do tempo ao nível nacional.

21 - É necessário mais financiamento

23 - As preocupações ambientais envolvem aspetos legais, económicos sociais, de segurança pública, aos aspetos científico-naturais.

24 - Os aspetos não técnicos (legais, económicos, sociais) são fundamentais para a consideração de políticas públicas sobre o campo das MC.

Análise

Relativamente à primeira categoria, para ilustrar, apresento as unidades de texto sintetizadas em alguns dos conceitos que contribuiram para a respetiva categoria.

A este respeito apresento os conceitos identificados em 02HR59 R. Gordon:

11 – “Não há expansão sem intervenção exterior”

«The point is that we cannot expand significantly without outside support. All of these difficulties could be removed by enactment of H.R. 6298. »

17 – “Aumento de financiamento generalizado a todos os estudantes”

«Mr. Karth. Doctor, I was a little touched by the examples you gave of the problems which are suffered by those who are doing graduate or postgraduate work in oceanography as much as I generally am in this whole educational field.

Is it not true, however, that this problem is pretty germane in all areas of graduate or postgraduate work, whether you are talking about medicine, astronomy, or chemistry?

Dr. Riley. Yes, sir; it is. Over and above this particular bill, I would plead for better support of graduate students in general.»

Um melhor entendimento de que estas frases são expressão da categoria requer, no entanto, a leitura do documento.

Para a testemunha, o progresso científico nesta área está comprometido enquanto não se singularizar o apoio aos alunos e instituições na área disciplinar das geociências, em particular a oceanografia, e como tal diferenciar os níveis de financiamento da ciência consoante a sua importância ou valor público, ou pelo menos consoante o seu grau de especialização. Esta premissa, segundo ele próprio menciona, vai contra as regras e os princípios e indicadores que orientam a atribuição de fundos pela NSF. O agente sublinha que desejaria o aumento de financiamento para todo o campo científico, mas frisa em particular, que considera vital que esse aumento seja acompanhado por uma reformulação das fórmulas de repartição do orçamento da ciência.

Ora aqui, não se sai muito da visão conservadora de políticas públicas para a área científica focada nas vias tradicionais de financiamento das instituições académicas, mas existe a) a defesa de um maior nível de financiamento b) a produção via processo político de novas divisões no campo científico.

Os conceitos aqui mencionados são válidos para categorias das lutas internas como externas.

Acrescentamos ainda, para ilustrar, os conceitos 13 e 21 de O3S66 Hollomon et al., de resto semelhantes com os restantes conceitos do grupo O3S66 que constam na mesma linha da tabela:

13 - "Promove estudos para futura legislação com vista a controlar atividades científicas comerciais, do governo local e estatal – como para atingir objetivos de controlo do tempo ao nível nacional"

«While it is too early at this time to write comprehensive legislation on weather modification, in our view such legislation may be necessary and certainly deserves thoughtful study.

Sound legislation can strengthen any Presidential action and may well be necessary for an orderly achievement of national objectives in weather modification and climate control.»

(...) «Some of the general functions which would be part of this major responsibility should also include such activities as information gathering, preventing interference with Federal research, considering public safety, possibly paying meritorious claims, and indemnifying Federal contractors and grantees, and cooperating internationally. »

21 – “É necessário mais financiamento”

«Both the NAS Panel and the NSF Commission have called this level of expenditure inadequate and feel it should be increased to \$20 to \$30 million by 1970.»

As ideias apresentadas vão no sentido da categoria: (13) a necessidade de criar políticas públicas consistentes e (21) de aumentar os níveis de financiamento.

As categorias agregam visões mais ou menos incompletas em relação à sua forma final, mas nunca em contradição entre si. Seguidamente continuaremos a explorar as restantes categorias procurando dar exemplos ilustrativos da diversidade de ideias que contribuiu para a construção das categorias. Contudo o exame deste método pode ser feito utilizando o quadro anexo para identificar os conceitos e as frases que lhes deram origem, ficando aqui a ressalva de que o seu enquadramento nas categorias requer a leitura integral do texto.

Categoria 2 – As Políticas Públicas devem dirigir o elevado impacto da ciência na forma como a sociedade (americana) se relaciona com a natureza, com ela mesma, com os outros países.

Conceitos analíticos:

01HR56 /R. REVELLE	02HR59 /Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Hawthorn	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
5, 7, 8	21	5, 7, 8	27, 34	6, 11, 12	2	2, 12, 13, 18, 23, 24, 25, 26, 28	4, 18, 20	1, 2, 7	8, 9, 20	3, 23, 26, 27, 28

Legenda:

01HR56 Revelle:

5 - As alterações climáticas podem gerar novas divisões no arranjo geopolítico.

7 - A investigação científica como resposta para problemas de produção alimentar, militares, e fonte de oportunidades económicas.

8 - A ciência pode responder a problemas gerados pelo desenvolvimento da indústria.

02HR59 Gordon:

21 - "O tempo está a esgotar-se" - argumento ambientalista.

03HR59 Wexler:

5 - Aspectos combinados da meteorologia e oceanografia na monitorização do CO2 atmosférico, como resposta a um novo problema ambiental.

7 - Problemas ambientais globais podem atingir os USA.

8 - Novas visões e divisões geográficas decorrentes do conhecimento geofísico.

03HR59 Revelle:

25 - Função do estado como autoridade reguladora nos problemas ambientais resultantes do desenvolvimento tecnológico.

27 - Há necessidade de estudos sobre as áreas de pesca que sirvam para o desenvolvimento do setor comercial da pesca e de políticas nacionais a esse nível.

34 - É importante diversificar financiamento do campo científico, para manter independência em relação ao Estado.

04J60 David Hall:

6 - Escassez e consequências inadvertidas dos combustíveis fósseis – a alternativa do nuclear.

11 - A solução da energia atômica para os problemas ambientais resultantes dos combustíveis fósseis.

12 - Centrais elétricas como mecanismos de alteração intencional do clima, em especial as centrais de energia nuclear.

05S66 Kassander et Al:

2 - Disparidade entre o interesse congressional e as políticas da NSF (Finalidade Pública vs. Autonomia Académica).

05S66 A. Chamberlain:

2 - Ideologia obsoleta: a de que podemos explorar sem limites os recursos naturais.

12 - Recomendações de integração no plano nacional das dimensões das Alterações advertidas e inadvertidas do clima.

13 - Ideia de ciência em estágio inicial do conhecimento de matérias de interação oceano-atmosfera.

18 - Valor potencial das MC em outros aspetos ambientais.

23 - Ideia de uma nova possibilidade da sociedade poder intervir para melhorar o ambiente.

24 - A política pública como instrumento de mediação de novos conflitos emergentes das novas capacidades de MC. Antecipação de novas divisões no campo socio-económico geradas pela emergência destas técnicas.

25 - Os processos de decisão em função da incerteza necessitam de mais pesquisa (e maior nível de financiamento).

26 - Nascimento de um campo ambiental - o estudo integrado das consequências sociais, económicas e ambientais do desenvolvimento tecnológico

28 - Necessidade de mais estudo sobre soluções em termos de políticas públicas para problemas de propriedade levantados pelas novas técnicas.

05S66 L. Haworth:

4 - O segundo momento do desenvolvimento deste campo foi a pesquisa das suas implicações civis.

18 - Problemas de fundo sobre os efeitos inadvertidos do homem sobre o clima - podem por em causa a habitabilidade do planeta.

20 - O problema científico da próxima era é a relação do homem com o seu ambiente.

05S66 Malone:

1 - Aumento das responsabilidades públicas com o progresso científico – o que é novo é a urgência.

2 - Importância vital das MC para a humanidade.

7 - Antecipação de problemas de modificação inadvertida do clima resultante do aumento de população.

05S66 Gordon MacDonald et al:

8 - Nova perspectiva: a atmosfera não é um depósito inesgotável.

9 - A acumulação de CO2 atmosférico como experimentação ambiental.

20 - Problemas resultantes da expansão de atividades comerciais com técnicas de MC requerem atenção política.

05S66 Hollomon et Al:

3 - São necessários estudos para produzir legislação e regulamentação adequada do setor.

23 - As preocupações ambientais envolvem aspetos legais, económicos sociais, de segurança pública, aos aspetos científico naturais.

26 - Perigos derivados da própria experimentação / necessidade de regular e monitorizar a condução de experiências como a validade dos resultados.

Análise

No discurso dos agentes promotores há uma procura de romper com uma ideia percebida como dominante de que a natureza possui depósitos inesgotáveis de recursos, ou que a natureza pode absorver de forma ilimitada os resíduos da produção industrial, e como tal que a atividade económica deve ter livre passe para explorar e produzir sem considerar o eventual esgotamento de recursos ou os problemas ambientais decorrentes da sua atividade – a rutura com esta ideia vem-se a definir ao longo dos anos 60 com o conceito de Ambientalismo, para, já no final do século, surgir o enquadramento do “Desenvolvimento Sustentável”, este último, recuperando e desenvolvendo as dimensões de natureza social e económica das problemáticas de impacto ambiental, que a perspetiva ambientalista tendeu a desconsiderar ou mesmo incompatibilizar.

Os agentes promotores considerados desenvolvem a ideia de Natureza como uma realidade em mudança, à total mercê da exploração pelo homem, mas cujos recursos são escassos e os ciclos de renovação dos mesmos (quando existam) são lentos, por vezes em escalas irreconciliáveis com a procura e a necessidade humana. Por outro lado, estes ciclos naturais são sensíveis a interferências inadvertidas da ação humana. Os agentes promotores defendem uma visão de que a natureza não é um espaço garantido de reprodução das condições ecológicas propícias à vida e ao bem-estar. São mencionados problemas das tecnologias a este respeito, bem como consequências potencialmente catastróficas da indústria, mas também, a possibilidade de advertidamente produzir soluções ou alterações de grande escala no ambiente, com a ambição de controlar fenómenos também em grande escala, inclusive à escala planetária, com fins civis, económicos e militares – ambição marcadamente economicista e nacionalista, estranha à lógica posterior do ambientalismo, e também do desenvolvimento sustentável.

Onde é que estas ideias podem representar pressões exercidas sobre outros campos?

Essencialmente porque, como a cabeça e a cauda do dragão, o representante do campo científico vem com este argumento chamar a si a capacidade e a responsabilidade de antecipar, de produzir as leituras válidas das mudanças despoletadas pelo próprio progresso científico que evidentemente nasce no interior do campo científico. Neste entendimento, o campo científico, especialmente na cúpula académica, considera-se instrumental, mas não responsável pelo desenvolvimento e aplicação de novas tecnologias, não se identificando

consequentemente como o responsável pelos impactos da ação humana sobre o ambiente, seja sobre a própria sociedade. Consideram-se, em suma, catalisadores de uma mudança desordenada – de que, argumentam os agentes promotores, só a ciência pode surgir para interpretar e ordenar. É este aspeto que se procura politizar, fazendo alterar a avaliação do valor de transação do capital científico no meio político, necessariamente procurando impor a diminuição de outras formas de legitimação de valor público.

A título ilustrativo destas ideias, colocamos os conceitos 6 e 12 de 04J60 David Hall:

6 – “Escassez e consequências inadvertidas dos combustíveis fósseis – a alternativa do nuclear”

«However, in the not too distant future there may be compelling reasons to require that sizable blocks of fuel consumption be required to utilize nuclear energy in place of conventional fossil fuel. It might, for example, be motivated by the need to conserve natural fluid fuels such as oils and hydrocarbons for mobile power uses. Or alternatively, the increases of carbon dioxide content in the atmosphere from ever-increasing consumption of fossil fuels might conceivably be altering the temperature and hence the sea level by affecting the cloud formation and rainfall. There is no direct evidence for this now. Both of these effects would tend to make the average climate warmer and drier. In this connection one can point out that there are bodies of water in this country which have disappeared only recently after having been in existence for many thousands of years, and supporting marine life over that period. This is possible evidence that man is changing his environment.»

12 – “Centrais elétricas como mecanismos de alteração intencional do clima, em especial as centrais de energia nuclear”

«In the Los Angeles area of the California coast, a temperature inversion pattern in the air is apparently a normal phenomenon for long periods of time. This is a departure from the situation which prevailed in the recent past as little as 30 to 50 years ago. Again, it is possible that this changed weather condition and its influence on the local climate is the result of the fuel burning in the congested metropolitan area. It has been suggested that the temperature inversion pattern could be upset over a limited region by operation of a nuclear power plant in the offshore waters. Such a reactor would have to be very large to heat an air mass sufficiently to literally punch a hole in the warm barrier layer at the inversion point.»

However, this same large reactor might be distilling sizable amounts of sea water to support the area. Estimates have shown that a station of 100,000 megawatts (7 percent of U.S. fuel consumption in 1956) operating at relatively low temperatures could produce these results. Extreme as this suggestion is, it would be absurd with any other fuel.»

E ainda, o conceito 2, de 05S66 A. Chamberlain “Ideologia obsoleta: a de que podemos explorar sem limites os recursos naturais.”

“He is at last learning he cannot consider himself free to heedlessly exploit the air, water, land and growing things of the earth. (...) To be able to deliberately modify our environment in a predictable manner may be our salvation as a society on this planet.”

As unidades de texto constituintes desta categoria são prova analítica do desenvolvimento de uma ideia de um papel do estado como agente preocupado com os impactos da indústria, com a capacidade limitada da natureza de os conter, com a importância da ciência para a concepção de políticas públicas capazes de direcionar ou corrigir o uso industrial de novas tecnologias e processos produtivos, com a insuficiência/necessidade de mais meios para atingir os fins científicos instrumentais a problemas públicos ambientais e de outra natureza, e finalmente com a ambição de realizar projetos de grande escala para alteração de processos naturais (como o clima).

Resumindo, estes são aspetos que conduzem a uma visão do papel do estado como supervisor científico das atividades económicas - seja na prevenção de impactos negativos, seja no alcance de benefícios coletivos. Corresponde por isso a uma pressão exercida pelo campo científico sobre outros campos da sociedade.

Categoria 3 – É urgente o desenvolvimento de políticas públicas capacitadoras da pesquisa científica em áreas conexas à Defesa

Conceitos analíticos:

01HR56/ R. REVELLE	02HR59/ Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassande r et. Al	05S66 / A. Chamber lain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDon ald et al	05S66 / Hollomo n et. Al
4	19	7, 14	14				3	1, 22, 23	24, 25	

Legenda:

01HR56 Revelle:

4 - Os Russos retratados como adiantados, no caminho de se tornarem uma grande potência marítima.

02HR59 Gordon:

19 - O argumento da guerra fria: a corrida ao armamento nuclear submarino e os instrumentos de deteção.

03HR59 Wexler:

7 - Problemas ambientais globais podem atingir os USA.

14 - Apropriações políticas e territoriais da antártica (pressão sobre o Congresso para uma tomada de posição americana).

03HR59 Revelle:

14 - Extrema importância económica, militar de uma política da investigação científica em oceanografia.

05S66 L. Haworth:

3 - O primeiro programa de MC foi militar.

05S66 Malone:

1 - Aumento das responsabilidades públicas com o progresso científico – o que é novo é a urgência.

22 - A visão ou o pesadelo, confronto entre novas formas de cooperação internacional vs. escalada belicista em torno dos desenvolvimentos científicos de controlo do tempo.

23 - Compara a corrida à lua com a corrida pelo controlo da atmosfera.

05S66 Gordon MacDonald et al:

24 - Perigos do desenvolvimento de usos bélicos dos desenvolvimentos científicos na geofísica, como justificação da sua importância do campo.

25 - Importância do envolvimento do Presidente para a relevância política deste tema obter o devido reconhecimento.

Análise

No mesmo sentido da categoria anterior, de incremento de funções do estado segundo uma lógica "científica", mas adicionando o carácter de urgência, e a dimensão militar, encontra-se a categoria 3.

A este propósito, é ilustrativo o seguinte excerto de 03S66 Gordon Macdonald et al:

24 – “Perigos do desenvolvimento de usos bélicos dos desenvolvimentos científicos na geofísica, como justificação da sua importancia do campo”

«The point that Dr. Malone was making was that there is a danger that geophysical warfare might become important and we would wish to do everything that we can in these early preliminary stages to attempt to prevent any move in that direction.»

Malone e Gordon MacDonald consideram a possibilidade de utilizar técnicas de alteração do clima como arma de guerra, e exercem conseqüente pressão sobre o Congresso americano para apoiar o desenvolvimento da ciência necessária a atingir primeiro o domínio das mesmas, como por outro lado em aumentar os esforços de avaliação sobre o conhecimento científico possuído pelo “inimigo” – e que curiosamente, esta pressão é enquadrada num maior incentivo à cooperação internacional em áreas científicas. Do lado dos agentes promotores, são frequentes as menções das vantagens de um ambiente de cooperação científica, mesmo em ambiente de hostilidade entre nações (ver categoria seguinte). Sobre este tema específico o trabalho diplomático entre as duas superpotências veio a produzir posteriormente a Convenção sobre a Proibição Militar ou Qualquer Outro Uso Hostil de

Técnicas de Modificação Ambiental em 1977, com entrada em vigor em 1978 e hoje assinada e ratificada por 121 países.

As palavras de Malone 05S66 traduzem o sentido de urgência:

1 – “Aumento das responsabilidades públicas com o progresso científico – o que é novo é a urgência”

«For nearly two decades scientists have viewed with growing concern the troublesome events that have been evoked by the interaction between scientific progress and public affairs. With each increment of power, the problem of directing its use toward beneficial ends becomes more complex, the consequences of failure more disastrous and the time for decisions more brief. They go on to say: The problem is not new either In the history of human affairs or of science. What is without past parallel is its urgency.»

22 – “A visão ou o pesadelo, confronto entre novas formas de cooperação internacional vs. escalada bélicista em torno dos desenvolvimentos científicos de controlo do tempo” e 23 – “compara a corrida à lua com a corrida pelo controlo da atmosfera”.

«First, as I have already noted, the atmosphere itself is international. Second, there is a fine tradition of international cooperation in meteorology. Third, with only 6 percent of the world's population, 20 percent of the world's scientists and 40 percent of the aggregate gross national products we can multiply our own efforts through cooperation guided by the mind as well as the heart. Fourth, dedication of this effort to peaceful purposes might in some small way contribute to the unity of a world increasingly troubled and tormented by conflict. In conclusion, a word about our vision— and our nightmare.

The vision, I believe, is a world in which one finds in place "the suitable new political forms and procedures" that the great mathematician, John von Neuman, pointed out a decade ago will be required after global climate control becomes possible. A world in which the benefits of weather and climate control are allocated equitably among nations by methods that will have been developed —not by some "novel cure-all" but, as Von Neuman phrased it, by "a long sequence of small, correct decisions" —precisely the kinds of decisions before Congress during this session. The nightmare is a world in which the conflict—that will probably always, to a greater or lesser degree, be the lot of imperfect man —has been aggravated by dispute over the rights to one of the most international of our natural resources —the

atmosphere. A world in which the "race to the moon" is replaced by a race to extend mastery over the atmosphere; the problem of nuclear proliferation replaced by the proliferation of environmental modification capability.

A world in which scientists meet interminably in Geneva to put the genii back in the bottle.

A world we do not want to see.

A world that need not be.»

Relativamente à questão Russa, este exemplo extraído do testemunho de Roger Revelle 01HR56 é muito interessante, utilizando a comparação do investimento científico dos EUA ao da URSS como argumento político:

4 – “Os Russos como adiantados, no caminho de se tornarem uma grande potência marítima”

«Dr. REVELLE. The Russians, for the first time, showed their plans at Brussels and they have something like 15 ships which will be operating all over the world on the oceanographic aspects of the IGY program. Typical of their ships is a 5,000-ton research vessel which has room for 70 scientists and is completely equipped. The biggest American ship is the Scripps ship, the Baird, which is about a tenth of the size of the Russian ship. Nevertheless, I think we can do quite a few good things.»

Categoria 4 – É interesse estratégico (americano) desenvolver a cooperação internacional científica

Conceitos analíticos

01HR56 /R. REVELLE	02HR59 /Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Hawthorn	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
2, 3, 6		1, 10 16	1, 6, 8, 9, 11, 12, 14, 29, 30, 40, 41			11, 31, 32		3, 19, 20, 21	23	8, 20, 40

Legenda:

01HR56 Revelle:

2 - A competição entre diversos países, proporcionada por uma plataforma internacional, produz dinâmicas de cooperação e valorização do capital científico.

3 - A CSAGI recomenda a tomada de posição de outros países, inclusive dos EUA, em face do recente investimento da URSS.

6 - EUA em competição com a URSS em contraste com os benefícios dos EUA em cooperação com a URSS

03HR59 Wexler:

1 - O IGY como abordagem internacional de um problema científico.

10 - A pesquisa precisa de resolver/preencher os vazios entre as medições passadas e as atuais. Só o consegue aumentando a sua extensão territorial.

16 - Possibilidades de cooperação EUA - URSS.

03HR59 Revelle:

1 - Possibilidade de conhecer de perto a pesquisa realizada por nações rivais.

6 - Benefícios da partilha de infra-estruturas de pesquisa para fins científicos, proporcionada pela cooperação internacional.

8 - Vantagens do trabalho coletivo de cientistas em programas grandes, como complementares do trabalho individual de cientistas.

9 - Impactos positivos da cooperação científica.

11 - Avanço da ciência requer participação de outros países.

12 - Importância da cooperação internacional na captação de cientistas jovens de todo o mundo.

14 - Extrema importância económica, militar de uma política da investigação científica em oceanografia.

29 - Requisitos políticos da cooperação internacional nas ciências oceanográficas.

30 - Perspetivas de desenvolvimento intergovernamental de cooperação científica, envolve o estabelecimento e apoio de organizações regionais.

40 - Formas muito dispendiosas de pesquisa apenas possíveis ao nível da cooperação internacional.

41 - Compilar informação científica de diferentes nações.

05S66 A. Chamberlain:

11 - Necessidade de uma estrutura global.

31 - Relevância da cooperação internacional e impacto nas relações internacionais.

32 - Importância da cooperação entre nações rivais.

05S66 Malone:

3 - As questões ambientais vão além fronteiras, requerem uma abordagem internacional.

19 - Importância da cooperação política e científica para o desenvolvimento desta área.

20 - Relação da natureza, enquanto objeto da ciência, e as implicações dessa perspetiva sobre as estruturas sociais (perspetiva internacionalista).

21 - Existe uma tradição de cooperação internacional na meteorologia.

05S66 Gordon MacDonald et al:

23 - Benefícios da cooperação internacional

05S66 Hollomon et Al:

8 - Dimensão de cooperação internacional no desenvolvimento científico das MC.

20 - Paradigma de cooperação internacional em novas áreas científicas.

40 - Implicações geográficas das MC.

Análise

Alguns dos textos incidem particularmente neste aspeto, em particular aqueles relativos ao IGY (01HR56 e 03HR59), insistindo no incentivo à cooperação na área científica.

Exemplo disto é o conceito 11, de 06HR59 Revelle:

11 – “Avanço da ciência requer participação de outros países”

«Geophysical exploration under the sea floor. —What is primarily needed is the use of existing methods ; e.g., measuring heat flow through the ocean floor, and seismic exploration, by more countries, in order to provide a wider network of observations. (...) It was reported that Japan, U.S.A., and U.S.S.R. have already designated national committees as correspondents to SCOR (Security Council Official Records). A draft letter has been

prepared inviting other national scientific bodies to take similar action. This letter will also request financial support for the international planning activities and administration of SCOR. Advice will be sought from ICSU (International Council for Science).»

Este é apenas um dos muitos exemplos citados ao longo de toda a apresentação ao congresso do projeto do IGY, em que são referidas as diferentes exigências de cooperação lançadas pela necessidade de medidas de estímulo para o desenvolvimento da geofísica. A comparação com a URSS, com o Japão e com outras potências competidoras reflete também o “espicaçar” dos membros do congresso para acentuar a participação americana.

Também ligado com a categoria anterior, está o conceito 14, do mesmo texto:

14 – “Compilar informação científica de diferentes nações”

«Appraisal of the status of the marine sciences. — Through its national committees SCOR will attempt to compile information on the status of marine sciences in all countries, including financial support, numbers of scientists and technical personnel, research vessels, and amount of emphasis on different objectives.»

Confundem-se neste texto os motivos de segurança/defesa e os motivos científicos, ambos reforçando o interesse na participação em programas de cooperação.

O conceito 9 do mesmo texto, aponta, como impactos positivos da cooperação científica, o incentivar de outros países a investirem mais nestas áreas científicas, numa perspectiva de globalização científica:

«The committee took as its first task that of defining the needs for further international scientific cooperation in the marine sciences. It is clear that, as in other sciences, a very large part of the pioneering research and new ideas concerning the oceans must come from individual scientists or small groups working independently. A broadly based international organization can be helpful, however, in several ways. It can serve as a sounding board to emphasize the economic and social importance of greater knowledge of the oceans and thereby assist marine scientists in different countries to obtain support for their work.»

O conceito 6 alerta para os benefícios da partilha de infra-estruturas de pesquisa para fins científicos, proporcionada pela cooperação internacional:

«One of the most important proposals made by the International Advisory Committee has been that an international oceanographic ship should be commissioned and operated, either by UNESCO itself, under contract, or by a group of countries in accordance with the pattern for international operation of research facilities set by CERN (Comite Europeen de Recherche Nucleaire).»

Mas também a propósito do programa nacional de modificações climáticas a cooperação internacional é várias vezes referida como algo de muito positivo e essencial às áreas científicas representadas. A título de exemplo, o conceito 23 de O3S66 de Gordon Macdonald:

23 – “Benefícios da cooperação internacional”

«Dr. MacDonald. There is very fine interchange of information in the atmospheric sciences. For instance, the kind of day-to-day observations that are required for predictions are made available on an international basis almost immediately. The International Weather Service, obtains the data even from Communist China, essentially in real time. As far as the scientific advances have been concerned, there has been a very free interchange.»

A cooperação internacional é amplamente integrada no processo político das AC, desde esta fase da sua génese, defendida como forma de cumprir diferentes desígnios estratégicos dos EUA (observação do progresso científico dos seus competidores/inimigos, economia de recursos na investigação científica, acesso a infra-estruturas e informações produzidas por outros países, fundamentais para fins científicos e de estratégia militar, afirmação na esfera internacional pelo nível do seu investimento e pela proeminência do seu progresso científico e tecnológico).

Esta luta é feita necessariamente contra forças contrárias à cooperação, características do ambiente de hostilidade no período da Guerra Fria. A concretização de políticas públicas de cooperação internacional no domínio científico é, certamente, sinal da força política do campo científico e em particular dos agentes promotores dessas ideias.

Finalmente revelou-se vital para o desenvolvimento de políticas públicas ambientais, o fomento de plataformas internacionais - uma vez que o desenho de políticas públicas neste domínio dependerá, pela própria natureza global ou transnacional dos fenómenos de impacto ambiental, reunir a aceitação das diferentes nações. Mais uma vez podemos prever

um conjunto de anticorpos noutros campos, ou mesmo dentro do campo científico, que possam ver neste processo, o potencial de forças supranacionais que ameaçam o poder político nacional, i.e as suas estruturas de reprodução de poder político. Como tal esta categoria, identificando uma importante luta externa do campo científico, é fundamental na descrição do processo político das alterações climáticas.

4.5.2 - Resumo

O processo político das AC teve a sua génese nas lutas em torno da defesa das seguintes ideias políticas diferenciadoras do campo científico em relação aos restantes campos na sociedade:

1 - São necessárias políticas públicas consistentes bem como níveis mais elevados de financiamento público e privado da ciência para o progresso científico.

2 - As Políticas Públicas devem dirigir o elevado impacto da ciência na forma como a sociedade (americana) se relaciona com a natureza, com ela mesma, com os outros países.

3 - É urgente o desenvolvimento de políticas públicas capacitadoras da pesquisa científica em áreas conexas à Defesa

4 - É interesse estratégico (americano) desenvolver a cooperação internacional científica

Refletindo de forma dialética, podemos supor que o campo do processo político tem a sua contraparte opositora formada por interesses que se reúnem em torno de ideias mais conservadoras:

1 - O financiamento público para a ciência encontra-se em níveis adequados (ou demasiado elevados) e o financiamento público da ciência é em si mesmo uma medida suficiente em termos de política pública para a ciência – não se devendo ir além disso para não interferir com a autonomia e normal desenvolvimento do campo e o seu papel proporcional na sociedade.

2 - O funcionamento ótimo da sociedade depende da livre auto-regulação dos mercados perante as mudanças alavancadas pelo progresso tecnológico, não sendo necessária, ou sendo prejudicial a intervenção do estado no controle ou limitação do progresso científico e das várias utilizações da tecnologia.

3 - A guerra, ou o desenvolvimento científico ligado à guerra, não deve ser uma prioridade do uso dos dinheiros públicos.

4 - A cooperação internacional científica representa um perigo ou uma desvantagem (para os americanos).

4.5.3 – As lutas internas

Categoria 5 – Valorização externa do valor aplicado da ciência como nova lógica que visa uma reforma focada no desenho de um campo científico integrado: acadêmico, indústria, administração privilegiando determinadas áreas científicas (em função do valor para finalidades públicas/econômicas/militares).

Conceitos analíticos

01HR56 /R. REVELLE	02HR59 /Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
1, 9	3, 4, 5, 14, 15, 16, 18	2, 11, 13	1, 5, 13, 15, 16, 17, 27, 28, 39, 42	1, 2, 3, 4, 7, 10, 11, 12	2, 9, 16, 19	1, 3, 10, 19, 28, 38		6, 12	1, 3, 14	5, 14, 15, 22, 30, 37

Legenda:

01HR56 Revelle:

1 - A Ciência responde a questões com valor público.

9 - O argumento da experiência geofísica - urgência na aposta na ciência para prevenir desastre ecológico/adaptar ou ganhar oportunidades.

02HR59 Gordon:

3 - Argumentos em choque: NSF (financiamento deve ser igual para todas as áreas vs. Testemunha (financiamento deve destacar áreas estratégicas/mais desfavorecidas).

4 - Valor específico e destacado da oceanografia no sentido do valor público.

5 - Sentido prático vs. Sentido acadêmico nas considerações sobre financiamento/gestão da ciência.

14 - Fenômenos físicos como argumento para reforma da estrutura institucional.

15 - A necessidade de uma visão integrada do campo científico para dar resposta a problemas resultantes do desenvolvimento da ciência.

16 - A NSF não reconheceu suficientemente a importância da oceanografia.

18 - Valor público da oceanografia - responde a problemas militares.

03HR59 Wexler:

2 - Impacto da meteorologia em diversos serviços e atividades comerciais.

11 - Há necessidade de previsões meteorológicas mais extensivas.

13 - Valor público da meteorologia.

03HR59 Revelle:

1 - Possibilidade de conhecer de perto a pesquisa realizada por nações rivais.

5 - A participação de motivações sociais e econômicas na gestão de ciência.

13 - Diferencia a área segundo o valor dos resultados da pesquisa, justificando aumento do nível de financiamento pedido.

15 - Equiparação da oceanografia à ciência do espaço, na sua relação com problemas relativos ao armamento nuclear.

- 16 - Papel da oceanografia no desenvolvimento de respostas a problemas alimentares internacionais - manutenção de uma posição americana relevante/dominante no plano geopolítico.
- 17 - Valor crítico da oceanografia em diferentes problemas militares.
- 27 - Há necessidade de estudos sobre as áreas de pesca que sirvam para o desenvolvimento do setor comercial da pesca e de políticas nacionais a esse nível.
- 28 - Países com carências alimentares e países com responsabilidades científicas.
- 39 - Aplicabilidade dos conhecimentos oceanográficos a problemas militares.
- 42 - Formas de dispor de material radiativo
- 04J60 David Hall:
- 1 - Impacto de desenvolvimentos científicos em problemas com o consumo de energia e com a produção de energia.
- 2 - Implicações económicas dos desenvolvimentos científicos.
- 3 - A energia como um problema público que afeta todas as pessoas e a economia.
- 4 - Impacto dos custos da energia nos outros setores da economia.
- 7 - O valor público da oceanografia.
- 10 - A solução da energia nuclear para os problemas energéticos.
- 11 - A solução da energia atômica para os problemas ambientais resultantes dos combustíveis fósseis.
- 12 - Importância da cooperação internacional na captação de cientistas jovens de todo o mundo.
- 05S66 Kassander et Al:
- 2 - Disparidade entre o interesse congressional e as políticas da NSF (finalidade pública vs. Autonomia académica).
- 4 - Diferentes perspectivas sobre os indicadores de avaliação/financiamento de programas científicos.
- 9 - Valor público das técnicas de modificação do clima para a água e a produção alimentar.
- 19 - Deveria haver mais programas da NSF para encorajar novos estudantes a ingressar em estudos destas áreas.
- 05S66 A. Chamberlain:
- 1 - Recomendações sobre uma política integrada de ciência - enquadrando aspetos legais, físicos e sociais.
- 3 - Defesa de um programa nacional de ciência.
- 10 - Divisão do campo segundo previsão e controle do tempo (aspetos práticos da aplicação da ciência).
- 19 - Valor público das MC para a abundância de animais e plantas.
- 28 - Necessidade de mais estudo sobre soluções em termos de políticas públicas para problemas de propriedade levantados pelas novas técnicas.
- 38 - A dificuldade da NSF em gerar normas diferentes para apoiar um campo científico específico (lógica académica).
- 05S66 Malone:
- 6 - A área da pesquisa em MC tem o potencial de produzir benefícios económicos significativos.
- 12 - Valor público da ciência da atmosfera para outras atividades e serviços.
- 05S66 Gordon MacDonald et al:
- 1 - Atenção a área científica pelos seus méritos para a sociedade.
- 3 - Diferentes intuitos da pesquisa científica realizada na área das ciências atmosféricas.
- 14 - Uma nova área atraente a investigadores de outras áreas.
- 05S66 Hollomon et Al:
- 5 - Defende transferência de poderes da NSF para nova estrutura.
- 14 - Benefícios sociais e económicos do desenvolvimento das MC.
- 15 - Ideia próxima à geoengenharia: capacidade transformar o ambiente de forma generalizada.
- 22 - Conceito de nova ordem ou direção.
- 30 - Promoção da ESSA como a agência mais indicada para levar a cabo a coordenação, respondendo a problemas de falta de capital humano da área científica (transição da gestão de programa nacional científico para o domínio do Departamento do Comércio).
- 37 - O valor público das MC não é perceptível na ausência de uma percepção clara da sua validade (necessário a intervenção do Estado).

Análise

Os testemunhos desenvolvem ideias no sentido de abalar uma certa estrutura, que privilegia os campos teóricos sobre os aplicados. São representativas de tensões num campo científico onde a academia, concentra no binómio ensino/pesquisa fundamental, os mecanismos legitimados e legitimadores da acumulação de capital científico. Essas tensões encontram-se refletidas no questionamento e nas propostas de mudança dos indicadores e modelos tradicionais de financiamento da ciência, como sejam os centrados na NSF, como a quantidade de recursos humanos numa dada área, ou a quantidade de instalações afetas a uma dada área. Estes são representados como um obstáculo a uma "nova era". São considerados fatores conservadores, pouco favoráveis ao desenvolvimento de novas áreas disciplinares com abordagens e necessidades diferentes.

Os esforços de mudança são no sentido de diversificar e promover estruturas dentro do campo científico com a oferta de soluções nos campos envolventes – económico, público/civil, militar. Esta lógica desconcentrada, mas onde se vê o Estado com o papel de coordenador, de regulador e de suporte, é virada para o exterior da academia e atribui um maior relevo para as áreas aplicadas, e de desenvolvimento.

Esta visão e o seu contraditório são protagonizadas por agentes cujas posições na estrutura do campo científico revelam um certo antagonismo, entre áreas estabelecidas, predominantemente teóricas (unificadas) e vocacionadas para o ensino e que definem a sua pesquisa como fundamental, e outras novas, com diferentes aproximações teóricas dentro de uma mesma área disciplinar, focadas na pesquisa aplicada no desenvolvimento tecnológico, vocacionadas para a resposta a problemas (públicos, económicos, militares, sociais, ecológicos, etc.).

O processo político aqui descrito envolve uma clivagem no campo, nem sempre explicitada nos testemunhos, mas que vai muito além de novas normas na atribuição de financiamento, da criação de novas instituições ou da criação de novas disciplinas. Conforme já desenvolvido no capítulo sobre a estrutura do campo científico, o aumento da heteronomia do campo científico produz tensões sobre os esquemas de perceção sobre o que é científico e com que critério a legitimidade das regras de validação de conhecimentos, técnicas e tecnologias que são consideradas científicas.

Contribuíram para esta categoria, conceitos como os extraídos de 03S66 Gordon Mcdonald:

1 – “Atenção dada a esta área científica pelos seus méritos para a sociedade”

«These advances and their potential benefits to society suggest that this area of science and technology deserves careful and thoughtful consideration by the Government and the Nation.»

3 - “Diferentes intuitos da pesquisa científica realizada na área das ciências atmosféricas”

«It is important in discussing precipitation enhancement to distinguish those projects carried out primarily with the object of increasing our knowledge about rain from those operational projects designed specifically to increase rainfall for commercial profit. The former are guided by objectives and procedures for research and the latter by objectives and procedures of business.»

14 - “Uma nova área atraente a investigadores de outras áreas”

«Dr. MacDonald. I don't believe that there is a serious manpower problem in the field of weather modification at present. It is a field that is rapidly developing. From the scientific community it is growing, and I would suspect that many people who are perhaps working on other aspects of atmospheric sciences may devote a greater portion of their efforts to weather modification. I think that the problems have an excitement, an intellectual quality to them, that will draw scientists from other fields. I think that the problems of what goes on in a cloud are of interest to chemists in his studies of nucleation, of colloidities, to the physicists in the studies of hydrodynamics. One says this interest already is developing. And in the long term, I think that the field will carry itself, that the intellectual excitement and the long-term possible benefits to society will encourage a lot of people to go into this field. I feel very optimistic about the manpower situation.»

Todas as três citações referem-se a um contexto de distinção de uma nova área científica que se espera consolidar, como efeito da proposta de lei apresentada. São questões de contexto, mas extremamente relevantes, uma vez que visam ou criam tensões no sentido de produzir uma mudança de paradigma na estrutura do campo. O grupo de proponentes identificado desenvolve a estratégia de procurar uma alteração da estrutura, comprometendo a autonomia do campo, jogando a partir daí com novas dinâmicas de

valorização do capital científico em função do seu valor noutros campos (noutros jogos ou lutas).

Outras expressões desta faceta do processo político das AC, mas que também revelam interesse nas categorias das lutas externas, são as que constam nos conceitos extraídos de 06HR59 Revelle:

5 e 28 - “A participação de motivações sociais e económicas na gestão de ciência”

«In accordance with the advice of the International Advisory Committee, the principal objective of UNESCO's marine sciences program is to encourage development of these sciences in regions where little is known about the oceans or the organisms that they contain and where there is economic and social need for increasing the harvest of food from the sea. (...)

A scientific study of salt water fishpond culture should be started, aimed at providing a basis for greatly increasing the efficiency and productivity of this industry and thereby increasing the protein food supplies in protein-deficient areas such as southeast Asia.»

14, 15 e 16 - “a extrema importância económica, militar e política da investigação científica em oceanografia”

«It should be stressed, however, that the Committee considers its recommendations minimal ones. Action on a scale appreciably less than that recommended will jeopardize the position of oceanography in the United States relative to the position of the science in other major nations, thereby accentuating serious military and political dangers, and placing the Nation at a disadvantage in the future use of the resources of the sea. In considering the importance of the problems involved, the Committee concluded that the seas present a challenge to man which in magnitude approaches that of space. (...)

On the practical side, the problems to be solved concerning the oceans are at least as urgent as those of space. How many fish are in the sea? No man knows, nor do we know what determines the numbers of fishes in different regions, the quantities of plant and animal material on which they feed, or what could be done to increase these numbers. We must learn these things if we are to help solve the increasingly acute problems of providing animal protein food for the growing numbers of underfed people in the world. Given more study, man can economically harvest considerably more food from the seas than is now possible.

Considering the position of the United States in the community of nations, it seems appropriate, even essential, that we lead the way in this respect.»

Categoria 6 - Modelo de um novo campo científico emergente: multidisciplinar, experiências de larga escala, planejadas e executadas a longo prazo, elevado custo por investigador, pesquisa básica, aplicada e de desenvolvimento conjugadas - mas funcionalmente separadas, composição diversa (agentes de pesquisa acadêmicos e não acadêmicos - indústria e serviços do estado).

Conceitos analíticos

01HR56 /R. REVELLE	02HR59 /Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
10, 12	7, 9, 10, 11, 20	3, 5, 6, 9, 12, 15, 17	3, 4, 7, 10, 18, 19, 24, 31, 33, 34	8	1, 10, 11, 15, 18, 21, 23, 25	6, 7, 8, 15, 16, 17, 20, 21, 22, 33, 34, 35	1, 8, 14, 16, 17, 21	5, 11, 17, 24, 25	4, 10, 12	2, 3, 16, 29, 36

Legenda:

01HR56 Revelle:

10 - Escala internacional e multidisciplinar dos projetos científicos.

12 - Sublinha que o avanço na ciência para além de um certo limite, é dispendioso e requer investimento (de uma proporção que só o estado pode assegurar.)

02HR59 Gordon:

7 - *Handicap* das disciplinas sem ensino graduado multidisciplinar em relação às disciplinas básicas.

9 - Ciclo vicioso: condições mais exigentes da aprendizagem no campo - são mais dispendiosas que as restantes para os estudantes > atraem menos estudantes > os departamentos perdem relevância e acesso aos fundos.

10 - As condições físicas da pesquisa tornam especialmente difícil financeiramente para os estudantes concluírem a graduação.

11 - Não há expansão sem intervenção exterior.

20 - Programas de investigação conduzidos no exterior, requerendo planeamento a longo prazo e orientados para finalidades externas ao campo científico.

03HR59 Wexler:

3 - Satisfação com o apoio continuado a programas do IGY.

5 - Aspectos combinados da meteorologia e oceanografia na monitorização do CO2 atmosférico, como resposta a um novo problema ambiental.

6 - Diversas agências cooperam para a continuação dos programas do IGY.

9 - As disciplinas de matemática e computação são determinantes para o desenvolvimento das ciências atmosféricas.

12 - Cooperação entre diversas áreas científicas no estudo da atmosfera.

15 - Valor científico na manutenção de estações na antártica (em conflito com a lógica militar).

17 - Ideia de que a ciência está apenas no início da compreensão de certos problemas e de que é necessário mais esforço e apoio por parte do Estado.

03HR59 Revelle:

3 - A interpretação de dados recolhidos no IGY vai levar anos.

- 4 - Condições do planeamento de longo prazo dos programas científicos do IGY.
- 7 - Possibilidades e valor do apoio continuado e de longo prazo da ciência.
- 10 - Importância vital da continuidade dos programas internacionais do IGY.
- 18 - Natureza conjugada da investigação básica e aplicada.
- 19 - A investigação aplicada depende da acumulação de conhecimentos resultantes da investigação básica.
- 04J60 David Hall:
- 8 - Relação da pesquisa científica Espaço, Oceano, Energia atômica.
- 05S66 Kassander et Al:
- 1 - Elogia a perspectiva de um programa mais abrangente em ciências atmosféricas, não restrito apenas às técnicas de MC.
- 10 - Multidisciplinabilidade na abordagem de problemas de modificação do clima.
- 11 - A NSF como mais orientada para promover a pesquisa fundamental/básica (não vocacionada para as áreas aplicadas da ciência).
- 15 - Prevê uma transferência de cientistas das áreas científicas clássicas para as áreas interdisciplinares.
- 18 - O trabalho de campo das disciplinas envolvidas requer níveis de financiamento de uma escala diferente de áreas dependentes apenas de pesquisa em laboratório.
- 21 - Necessidade de diversificar e autonomizar diferentes estruturas para pesquisa básica e pesquisa aplicada.
- 23 - Os custos deste tipo de pesquisa científica não são proporcionais à quantidade de recursos humanos envolvida.
- 25 - Multidisciplinabilidade abrangente às áreas sociais e legais.
- 05S66 A. Chamberlain:
- 6 - O campo é concebido como contendo diversos agentes: governo, indústria, academia.
- 7 - Experiências de campo de grande dimensão são mais dispendiosas.
- 8 - A introdução de matemática nesta área é fundamental para o desenvolvimento do campo
- 15 - Ideia de um esforço federal, interdisciplinar e interagência, com implementação de um laboratório nacional.
- 16 - É necessário um apoio logístico à pesquisa dos diferentes laboratórios.
- 17 - A pesquisa em MC tem valor para outras áreas científicas.
- 20 - Requer uma perspectiva de longo prazo.
- 21 - O programa requer apoio para diferentes áreas científicas que a MC deve integrar.
- 22 - O desenvolvimento de políticas públicas sobre esta área requer pesquisa nos seus efeitos sociais e económicos.
- 33 - Desenho de um campo multidisciplinar.
- 34 - Diferenciação entre o campo científico clássico, do cientista de "papel e caneta" e do campo científico emergente, das experiências de campo em larga escala.
- 35 - Conjugação de diferentes modos de pesquisa básica e aplicada.
- 05S66 L. Haworth:
- 1 - O campo das MC começou com aplicações descobertas por cientistas em empresas privadas.
- 8 - Recomendação de um esforço especial no desenvolvimento das áreas conexas às MC.
- 14 - Cooperação entre cientistas de diferentes áreas.
- 16 - As áreas de desenvolvimento dependem da acumulação de conhecimentos básicos.
- 17 - Visão multidisciplinar, e integrada (investigação básica, aplicada e desenvolvimento) do campo das MC.
- 21 - A área ambiental como um campo multidisciplinar.
- 05S66 Malone:
- 5 - Importância de desenvolvimentos em diferentes áreas para a formação do campo das MC.
- 11 - Requer estabilidade do apoio orçamental.
- 17 - É necessária a continuidade dos programas de pesquisa para que estes possam ser eficientes.
- 24 - Quem detém mais conhecimento sobre as práticas operacionais de WM, os agentes comerciais, ou as agências estatais?
- 25 - O problema no desenvolvimento de técnicas válidas de MC pode ser, falta de conhecimento básico, ou falhanço em desenvolver ferramentas.
- 05S66 Gordon MacDonald et al:
- 4 - Resultados operacionais (da pesquisa feita por agentes não académicos) pode ser usada para avançar a pesquisa.
- 10 - Objetivos nacionais a serem prosseguidos com programas de investigação e desenvolvimento
- 12 - Riqueza de abordagens realizadas pelos operadores comerciais.
- 05S66 Hollomon et Al:

- 2 - Mais concentração (da ação política) no desenvolvimento de diferentes vertentes desta área científica (MC)
- 3 - São necessários estudos para produzir legislação e regulamentação adequada do setor.
- 16 - Pesquisa aplicada como assente nas bases lançadas pela pesquisa básica, deve ser tornada distinta ao nível das estruturas institucionais.
- 29 - Conjugação da previsão e da modificação do clima.
- 36 - Big Science vs. Little Science - o tamanho da pesquisa importa para o tipo de políticas a aplicar.

Análise

Esta ideia é apresentada uma e outra vez em todos os testemunhos, constituindo uma das preocupações básicas dos proponentes, a de anunciar um novo formato do campo científico, que precisa ser reconhecido e alavancado pelo poder público, sob o risco da nação perder nas lutas económicas, geoestratégicas e militares, e mesmo nas lutas pela preservação do ambiente. O financiamento da ciência nos moldes atuais, defendem, assente na reprodução da estrutura, impede o desenvolvimento de um campo, pouco intensivo na mão-de-obra, com pouca necessidade de pequenas instalações laboratoriais, mas com grandes necessidades de financiamento de missões, infra-estruturas e tecnologias de investigação a serem implementadas de forma concentrada, ou instalada além-fronteiras, com necessidades de manutenção ao longo de vários anos e proporcionalmente mais dispendiosa relativamente aos custos com capital humano. Além disso estes novos projetos de investigação transgridem as fronteiras disciplinares e instituem um leque variado de abordagens numa mesma equipa de investigação.

Finalmente possuem ainda a interligação/sobreposição de modalidades de pesquisa orientadas para a resposta a problemas teóricos, com modalidades de pesquisa orientada para fins comerciais, públicos ou militares, podendo mesmo conter ramificações com o desenvolvimento de novas tecnologias, ou outras formas de inovação.

Esta visão implica reformulações concretas no campo científico:

- A implementação de estruturas de investigação centralizadas a nível nacional, mas abertas à utilização por parte de universidades, agências e empresas com atividades de investigação;
- O financiamento de infra-estruturas de investigação de exterior (do oceano, da atmosfera, etc.) por todo o país e por todo o mundo, reduzindo a importância do laboratório e afirmando a importância da acumulação de dados diretamente monitorizáveis e a introdução da computação e das matemáticas avançadas nos

domínios das ciências da natureza - colocando em causa construções teóricas vigentes;

- A introdução de plataformas internacionais com partilha de informação entre universidades e com entidades estrangeiras, mas coordenadas, planeadas e financiadas centralmente;
- A instituição de organismos com múltiplas funções (de investigação, informação, e regulamentação - como o Weather Bureau ou a ESSA) e com equipas diversificadas em termos disciplinares;
- A criação de linhas de financiamento de ciência específicas para grandes objetivos científicos nacionais;
- O aprofundar da ligação estado - academia - industria na produção de ciência aplicada e de desenvolvimento.

Podemos supor um grupo até então dominante, e a correspondente ortodoxia em contraste com os elementos enunciados no parágrafo anterior.

Ilustrando a construção desta categoria, mencionamos aqui os conceitos de O2HR59 Gordon:

7, 9, 11 - *“Handicap das disciplinas sem ensino graduado multidisciplinar em relação às disciplinas básicas”*

«In the second place, oceanography, and to some extent other interdisciplinary fields, such as meteorology and geophysics, are handicapped in their efforts to support their graduate students, as compared with basic disciplines such as physics and biology. We are poor relations, and the money that we are requesting for student support is necessary in order to correct the situation. (...) The point is that we cannot expand significantly without outside support. All of these difficulties could be removed by enactment of H.R. 6298.»

20 - *“Programas de investigação conduzidos no exterior, requerendo planeamento a longo prazo e orientados para finalidades externas ao campo científico”*

«Dr. Riley. I would say both of those programs that I mentioned, particularly in geochemistry and harbor-defense work, are long-range programs. In my own laboratory we have a rather long-range program on Long Island Sound which includes some aspects that you might call earth sciences; that is, it includes the physical oceanography of the region, the rate at which

the water is transported in and out, the so-called flushing rate of the sound, but primarily it is a biological program. This program has been going on since 1952 and probably will be a long-range effort.»

O conceito 20 extraído do texto de Roger Revelle 01HR56 sumariza bem a questão do aumento da escala dos projetos científicos:

10 - “Escala internacional e multidisciplinar dos projetos científicos”

«The areas involved are too vast for any one nation to cover; observations are required not only in large numbers but simultaneously from carefully chosen places. Advantage should also be taken of the large programs in related sciences such as meteorology, glaciology, and seismology.»

E ainda sobre este tema, é bastante ilustrativo o conceito 10 extraído de 03S66 Gordon McDonald et al.

10 - “Objetivos nacionais a serem prosseguidos com programas de investigação e desenvolvimento”

«In summary, I believe that it is now time for an increased effort on a national scale in the fields of weather and climate modification. The emphasis in these efforts should be on research and development.»

Categoria 7 - O campo científico deve ser reformado em torno de grandes objetivos nacionais, a partir de uma estrutura de topo, em que o Estado, formando uma parceria com a Academia e agentes do setor privado (como garante da autonomia do campo), assume o controlo das infraestruturas de maior dimensão e de suporte, exerce a coordenação e regulação da ação de agentes públicos (estatais e locais) e privados com atividade em investigação e desenvolvimento (e outras) e orienta as diversas instituições do campo através de agências especializadas e grandes canais de financiamento.

Conceitos analíticos

01HR56 /R. REVELLE	02HR59 /Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
			25, 26, 37, 38		8, 12, 19, 20, 21, 22, 24	9, 15, 16, 22, 27, 29, 30, 33, 36, 37, 39, 40	6, 13, 19, 22, 23, 24	4, 9, 16, 18	10, 11, 15, 16, 18, 19, 21	3, 6, 7, 11, 12, 25, 34

Legenda:

03HR59 Revelle:

25 - Função do estado como autoridade reguladora nos problemas ambientais resultantes do desenvolvimento tecnológico.

26 - Importância do Estado na implementação de infra-estruturas de suporte à investigação científica.

33- As agências com programas de investigação devem gozar de autonomia na gestão desses programas.

34 -É importante diversificar financiamento do campo científico, para manter independência em relação ao Estado.

37 - (apenas) Metade do financiamento deve vir da NSF.

38 - A necessidade e os benefícios de envolver a indústria nos programas públicos de investigação científica.

05S66 Kassander et Al:

8 - Visão do modelo de parceria entre Governo e Academia tendo como modelo a NSF.

12 - Equilíbrio entre a autonomia e diversidade do campo científico e o contributo de programas nacionais.

16 -Desenvolvimento do campo, dependente do alcance de níveis críticos no financiamento.

19 - Deveria haver mais programas da NSF para encorajar novos estudantes a ingressar em estudos destas áreas.

20 - Necessidade da criação de uma nova agência com capacidade de mobilização de recursos para experiências de campo de grande dimensão.

21 - Necessidade de diversificar e autonomizar diferentes estruturas para pesquisa básica e pesquisa aplicada.

22 - Uma combinação de programas que dá origem a um programa nacional.

24 - Ideia de campo científico, com níveis políticos e administrativos, funcionalmente organizado e com diferentes níveis de ação.

05S66 A. Chamberlain:

9 - Divisão do campo segundo área: teórica, laboratorial, pesquisa de campo, operações.

15 - Ideia de um esforço federal, interdisciplinar e interagência, com implementação de um laboratório nacional.

16 - É necessário um apoio logístico à pesquisa dos diferentes laboratórios.

22 - O desenvolvimento de políticas públicas sobre esta área requer pesquisa nos seus efeitos sociais e económicos.

27 - Regulação federal das atividades de pesquisa e económicas ligadas À MC, pode servir como incentivo ao investimento em pesquisa científica nesta área.

29 - Ideia de Campo científico, político e administrativo, devidamente regulado e com diferentes organismos funcionalmente diferenciados.

30 - Relação entre a acumulação de conhecimento e a necessidade de regulação.

33 - Desenho de um campo multidisciplinar, apoiado por um programa com essas dimensões.

36 - Equilíbrio entre a diversidade/autonomia e a centralização de funções dentro de um programa nacional.

39 - Recomendação de uma estrutura ao alto nível político que coordene as políticas e os programas de MC.

40 - A recomendação política deve ser independente do governo, e representativa da academia.

05S66 L. Haworth:

6 - Conflito entre a pesquisa científica em WM, e as atividades comerciais nessa área, apelo à intervenção do estado para controlar os agentes privados.

13 - Impacto da NSF e dos programas anteriores na criação de novos departamentos específicos nas instituições académicas.

19 - Novas agências devem ser criadas, as anteriores não estão preparadas para os problemas operacionais de experiências em larga escala.

- 22 - Coordenação de vários programas, mais do que uma centralização num único programa.
23 - Diversas agências funcionalmente separadas devem exercer a autoridade sobre o campo das MC.
24 - É necessário um enquadramento legal para as atividades de pesquisa e operações de MC.

05S66 Malone:

- 4 - Afirma a necessidade de unificação de estruturas e de objetivos nacionais
9 - Promove uma estrutura diversificada do campo científico
16 - Promove uma estrutura campo científico de acordo com as finalidades externas (públicas e económicas) da produção científica
18 - Obsolescência da atual estrutura de administração das ciências ambientais, pedido por reforma, por novas instituições.

05S66 Gordon MacDonald et al:

- 10 - Objetivos nacionais a serem prosseguidos com programas de investigação e desenvolvimento.
11 - Interesse público conjugado com a gestão de programas científicos.
15 - Promove a centralização numa instituição estatal com poderes de coordenação sobre programas de ciência e desenvolvimento
16 - Equiparação da "*big Science*" da física com as grandes experiências de campo das ciências atmosféricas.
18 - As práticas comerciais de MC devem continuar, mas com monitorização e regulamentação do estado.
19 - O estado deve poder suspender a atividade comercial a fim de se levar a cabo testes científicos de forma a evitar a contaminação das novas experiências.
21 - Trabalhar em conjunto com os operadores comerciais de forma a resolver os problemas colocados à investigação é essencial.

05S66 Hollomon et Al:

- 3 - São necessários estudos para produzir legislação e regulamentação adequada do setor.
6 - Repartição de funções entre a NSF e uma estrutura de outro departamento.
7 - Funções reguladoras do estado vs. Interesses comerciais.
11 - Campo funcionalmente diferenciado, com funções reguladoras e a autoridades centralizadas a nível federal.
12 - Importância do estado de recolher a informação relevante produzida pelos diferentes agentes públicos e privados.
25 - Problemas a ter em conta de interferência dos projetos ao nível federal com projetos locais, ou das leis dos estados.
34 - Estado atual de esforços descoordenados de investigação sobre MC.

Análise

Esta visão chama ao campo científico uma diversidade de agentes institucionais, antes considerados externos ao campo científico - tradicionalmente constituído pelas estruturas consideradas académicas, com finalidades de pesquisa (normalmente considerada básica) e o ensino.

As novas extensões do campo científico consideradas no processo político das AC são:

- Agências com funções de serviço público que requerem conhecimentos e tecnologias de elevada complexidade;
- Operadores comerciais contratados para esses mesmos serviços;
- Operadores comerciais com unidades de investigação aplicada e desenvolvimento ou de grande intensidade tecnológica;

- Agências do Estado com funções de coordenação de programas científicos com objetivos nacionais;
- Infra-estruturas de pesquisa internacionais ou de grande dimensão, cujo principal proprietário é o Estado Federal;
- Agências de regulação, que exigem a concentração de elevado nível de especialização de conhecimentos científicos;
- Associações que avaliam e representam interesses de empresas, activistas e mesmo de cientistas (quando explicitamente externas à academia);
- Painéis, comissões e comités, nos variados níveis da estrutura político-administrativa, com composições variadas no que respeita à origem institucional dos seus membros.

A produção destes órgãos pode ser considerada, nesta visão, como parte de um capital científico. Uma citação de um relatório do instituto de meteorologia pode ser considerada num trabalho académico e considerado compatível com o rigor dos conhecimentos produzidos por uma unidade de investigação académica. O esforço de construir um campo com estas características está plasmado nas preocupações centrais destas propostas de lei, quando pretendem submeter (por exemplo a O3S66) estas diversas extensões a um controlo mais rigoroso por parte do estado, e a uma acumulação neste, de funções de coordenação e avaliação/certificação dos conhecimentos produzidos nestas diversas instâncias. Não se visa aqui (na ideia pura) monopolizar o controlo da ciência, mas antes consagrar a sua diversidade, e a possibilidade de diversas formas das suas manifestações poderem encontrar garantias de uma linguagem e de requisitos comuns e de contribuírem para objetivos comuns.

Utilizando a dialética de campo, podemos considerar a hipótese de uma visão contrastante ou antagónica de um campo científico, monopolizado pela academia, com forte autonomia e independência do estado, defendendo que a participação do estado federal se deveria limitar ao financiamento por via de uma única agência cujo corpo de dirigentes é ele próprio oriundo do interior do campo científico, a NSF, e cujos objetivos nacionais são restritos ao ensino e investigação fundamental e que se empenha em manter uma distinção clara entre a sua produção intelectual e a que ocorre no exterior do seu campo. Com efeito, as outras

manifestações de conhecimento fora desta fronteira, seriam excluídas do uso, por parte dos cientistas legitimados, i.e. acadêmicos.

A monitorização, regulação de setores da indústria altamente tecnológicos e controlo das principais infra-estruturas científicas por parte do estado, que são aqui defendidas, podem ser vistas como um entrave/obstáculo ao desenvolvimento por outros agentes, neste caso quer pelos operadores comerciais com forte concentração tecnológica ou de investigação (que evidentemente vêm sancionada e limitada a sua atividade), quer pelos grupos da academia que ocupam posições dominantes na estrutura tradicional (nestes últimos, porque implicam a migração de capital científico para o estado, criando grupos que o detêm em simultâneo com níveis elevados de capital político - e que como tal tendem a gerar tensões contrárias à autonomia do campo científico).

Ilustro esta categoria com os conceitos 4, 9 e 16 extraídos do texto 03S66 Malone:

4 - “Afirma a necessidade de unificação de estruturas e de objetivos nacionais”

«The need to transform our somewhat fragmented national effort in this field into a coherent national program;»

9 - “Promove uma estrutura diversificada do campo científico”

« With respect to the second issue, the character of the national program, quite apart from that portion of the effort which is concerned with national defense, it should possess the attributes of diversity — in that big science should be balanced with little science, research in the physical sciences accompanied by research in engineering and the social and life sciences, and activity in the public sector complemented by activity in the private sector.»

16 - “Promove uma estrutura campo científico de acordo com as finalidades externas (públicas e económicas) da produção científica”

«Basic research directed at a fundamental understanding of the principal aspects of the problem. Applied research directed at the development of techniques for successfully intervening in normal atmospheric processes as well as for assessing the consequences of inadvertent modification. Operational application of proven techniques as soon as their efficacy is established. Regulation as may be needed to protect the interests of the public and to prevent the contamination of field research projects. »

Os conceitos 11, 15 e 16 de O3S66 Gordon Macdonald também são bastante ilustrativos desta categoria, indo ao encontro do já expresso nos anteriores:

11 - “Interesse público conjugado com a gestão de programas científicos”

«Too many questions remain unanswered for the Nation to embark on very large operation projects in rainmaking without the most careful planning based on experimentation.

However, it is important that the advances in research and development go forward with operational efforts and that new understanding of the atmosphere be quickly translated into operational methods which may benefit the whole of society.»

15 e 16 - “promove a centralização numa instituição estatal com poderes de coordenação sobre programas de ciência e desenvolvimento”

«One cannot usefully consider this small part without looking at the others, and that the problems are common in many aspects. The subjects are interdisciplinary in the sense that they involve physics, chemistry, and engineering, and that the environmental sciences at present are diffused through many agencies. The big science part of the environmental science is the field project, going out and mounting a big program. It is unlike the big science in physics, which is a big accelerator. It requires logistic support, whereby ability to go into some part of the environment, the ocean, the atmosphere, and even the solid earth, and operate within that environment, requires platforms to carry out measurements. We feel that the present situation in which responsibility is diffused through these many agencies has not led to an optimum use of the Nation's resources, but we do not go on within the panel to make any firm recommendations. We feel this is a problem that we should bring to your attention.»

4.5.4 - Resumo

O processo político das AC teve a sua génese nas lutas em torno da defesa das seguintes ideias políticas diferenciadoras de grupos dentro do campo científico:

- 5 - Valorização externa (pública/económica/militar) do valor aplicado da ciência como nova lógica estruturante do campo científico

- 6 - Novo modelo de campo científico emergente: multidisciplinar, experiências de larga escala, planeadas e executadas a longo prazo, elevado custo por investigador, pesquisa básica, aplicada e de desenvolvimento conjugadas.
- 7 - O campo científico deve ser organizado em torno de grandes objetivos nacionais, concretizados em políticas públicas que garantem a concentração no Estado das principais infra-estruturas, de poderes de coordenação e regulação da ação de agentes públicos (estatais e locais) e privados.

Refletindo de forma dialética, podemos supor que o campo do processo político tem a sua contraparte formada por interesses que se reúnem em torno de ideias mais conservadoras:

- 5 - O campo científico deve permanecer imune a pressões externas, mantendo a sua autonomia, de forma a manter as regras e as estruturas garantes da validade epistemológica dos seus conhecimentos.
- 6 - O campo científico deve evitar a multiplicação de disciplinas, evitar expedições dispendiosas em assuntos passíveis de serem explorados em laboratório com pequena escala, com maior controlo das variáveis. A atividade mais nobre da ciência é o avanço do conhecimento e como tal deve a academia, e o investimento público na ciência focar-se na pesquisa básica ou fundamental e na atividade ensino.
- 7 - O campo científico deve gozar de uma grande concentração do seu capital na academia, devendo evitar a tentação de passar a integrar programas estatais e iniciativas privadas que comprometam por via interna a sua autonomia, com a necessidade de produzir *outputs* com valor económico ou público.

Conclusão

O processo de construção das políticas públicas para as alterações climáticas oferece-nos um exemplo de uma relação particular da ciência com a sociedade. Apresentei neste trabalho a tese de que, antes que fosse objeto de causas e lutas de grupos de pressão ambientalistas, esta problemática foi introduzida na política por cientistas.

Com efeito, o campo das ciências naturais, em particular da geofísica, conheceu em meados do século XX, uma ambição por parte dos seus maiores expoentes, de tornar as suas questões relevantes em diferentes dimensões da esfera política - seja pelo valor económico, social, ecológico, ou militar da aplicação dos “seus” conhecimentos. Participaram, pois, de uma mudança fundamental, seja da estrutura do campo científico, seja do seu papel na sociedade.

Neste trabalho procedi à identificação e caracterização das lutas encabeçadas neste domínio, nas discussões em torno de grandes ideias de políticas públicas em que o tema das alterações climáticas, embora aí tratado de forma secundária, foi claramente integrado. Foram essas ideias: o Ano Internacional da Geofísica, o apoio do Estado a programas de ensino e investigação específicos na área da Oceanografia, a aplicação dos usos civis da energia nuclear, e o programa nacional de modificações do clima.

Estes são programas estadunidenses, e a opção por estudar esta realidade, foi tomada no sentido de procurar captar a génese deste processo e efetivamente, a génese do processo político das AC dá-se, no contexto político dos EUA na confluência de um conjunto de fatores:

- Aumento do financiamento da ciência nos períodos dos grandes conflitos mundiais (GG I e II) e manutenção dos níveis de financiamento no pós-guerra e guerra fria;
- A destruição causada em solo europeu pelas duas grandes guerras, contribuíram também para uma grande acumulação de capital científico em território americano no mesmo período, reforçando fenómenos migratórios oriundos das potências europeias, ao que se somou a captura de cientistas e a espionagem de informação científica;

- Internamente foram também determinantes para o processo político das AC, as políticas que financiaram o desenvolvimento das áreas científicas da geofísica conexas ao desenvolvimento científico com aplicação militar;
- Modificação do paradigma científico das geociências, da dedução teórica assente na investigação em laboratório, para a observação direta, recolha de dados sistemática no campo, com forte recurso à computação e novas tecnologias de medição/observação, iniciando um processo de construção e revisão teórica a partir dos dados diretamente recolhidos/observados;
- Realização de um evento de cooperação científica de grande escala internacional nas geociências [IGY 1957-1958] que proporcionou um conjunto de avanços em várias áreas conexas à problemática das AC, em particular nos projetos liderados pelos norte-americanos;
- Criação de diversas estruturas de ligação entre o campo científico e o campo político no mesmo período, das quais se destaca a criação da NSF em 1950;
- Amadurecimento/acumulação crítica de conhecimentos na área científica que serve de suporte ao problema identificado.

Avaliar este problema a partir das condições sociais da sua produção dá-nos uma perspetiva mais alargada do que está em jogo com a progressão de um processo político, que definitivamente, envolve mais do que a procura de soluções para um problema ambiental (que à data ainda não se define claramente como tal) – pois é também, uma redefinição do papel da ciência e do cientista na estrutura política e em relação com outros agentes, como os económicos. As pressões de mudança também se fazem sentir no interior do campo científico, onde se observa uma transformação da estrutura do campo na direção de uma gradual transferência de capitais para estruturas de cooperação internacional, de uma maior diversificação dos contextos de produção de ciência, de uma maior heteronomia do campo científico e da instituição da multidisciplinariedade na abordagem de um mesmo objeto científico. Envolve também o maior peso das políticas públicas de apoio à ciência, e da afirmação de novos campos científicos com forte vocação para aplicações do foro económico e militar.

Finalmente é um prenúncio de uma função política de regulação ambiental do sistema económico, na qual o campo científico participa ativamente, quando não dirige mesmo esta

área administrativa e política, o que produz naturalmente efeitos na estrutura do campo científico (que vê inclusive surgir nesta época os primeiros departamentos de ciências do ambiente, área que integra uma forte componente social, administrativa e de políticas públicas).

Outra questão relevante que apresentámos como conclusão da pesquisa é relativo ao papel que políticas públicas que capacitem a produção de informação sobre um dado problema e a centralizem/legitimizem ao nível do Estado têm na produção de um problema social e, portanto, no avançar de um processo político.

O capital cultural implicado na construção de um problema social pode ter a forma da publicação/expressão de opinião, de notícias, de informação estatística, de produção académica, de menções oficiais de representantes de coletivos (aqui refiro-me a qualquer cargo de representação oficial de uma instituição ou grupo). Sobre este aspeto e relativamente ao processo político, saliento o papel da informação científica, pois trata-se de um elemento de fundo, supostamente neutro e isento.

Esta questão parece-me bastante pertinente, uma vez que a informação pode desempenhar um papel fundamental na passagem da percepção da injustiça (enquanto fundamento do problema social) que é tida como uma condição individual, para aquela injustiça que é percebida como uma questão coletiva.

Efetivamente, esta fase de construção de grandes infra-estruturas e equipamentos de monitorização do clima, ao redor do globo e com programas de financiamento de longo prazo, foi a base para que, não só houvesse um avanço na resolução do problema científico das alterações climáticas de origem antropogénica, mas também para que outros grupos pudessem dispor da informação necessária para identificar um problema, uma injustiça social (e ecológica) com contornos concretos ao nível das desigualdades sociais, e se pudessem mobilizar em torno desta área de políticas públicas. Esta é uma fase posterior e que não quero aqui aflorar, mas sim apenas deixar a ideia de que:

- a) Este processo de construção de uma política pública, envolveu um primeiro estágio em que foram legislados programas com finalidade de produção de informação com finalidades científicas e simultaneamente de interesse público.

- b) A produção de informação é fundamental na criação de um problema social, e o Estado tem um papel crucial nos processos de acumulação e centralização necessários à produção de informação “coletiva”.
- c) A construção de um processo político envolve frequentemente (senão sempre) a construção de um problema social, isto porque, a maturação uma nova ideia política produz tensões de reforma e alteração do *statu quo* nos campos e entre os campos de uma dada sociedade.

Se tal não fosse assim, haveria um processo político simples, linear desde a sua génese até ao momento presente, na construção de políticas públicas para as AC, acompanhando apenas o progresso do conhecimento científico nessa área. E é conhecido que não é o caso - o consenso científico não é suficiente - o campo científico não é suficiente para alavancar momentos posteriores de uma ideia política, mesmo que seja “dono” (embora muitas vezes contestado) das formas legítimas da informação que lhe serve de substrato.

Esta informação científica, que pode também ser informação estatística, não pode só por si produzir o efeito mobilizador, é evidente, mas a produção de relatórios científicos e estatísticos em particular tem o poder de alimentar interpretações que visam dissipar a ilusão do facto individual (quando exista), e revelar o facto coletivo por detrás desses fenómenos, e assim fornecer a matéria-prima dos problemas sociais.

Neste sentido os agentes administrativos nos corpos criados nesta fase do processo político, ESSA (mais tarde integrada no NOAA); NCAR; NASA, etc. são ainda hoje participantes cruciais na produção de informação relevante para a evolução do problema social das AC.

Aqui a academia, e as organizações privadas completam o mosaico com fontes independentes de informação do mesmo tipo. Este nível é fundamental na compreensão do problema social - uma vez que é também a este nível que se exercem significativamente “os factores susceptíveis de se oporem a que os sujeitos sociais se apercebam da existência da própria situação colectiva de inferioridade”. Será certamente um revés da maior importância para esta área de políticas públicas, se os Estados abdicarem do seu papel centralizador e produtor de informação sobre AC. Com efeito Tavares M. C. refere que “o seu conhecimento [enquanto problema social²⁷] pressupõe uma larga informação de ordem

²⁷ Nota minha.

estatística e outra que o comum das pessoas não encontra facilmente ao seu alcance, nem saberia utilizar na forma por que ela se apresenta.” (1967, p. 218).

Este aspeto permite ainda a interligação do problema social com o processo político, apoiando-nos na análise dos dados da pesquisa, podemos elaborar a tese de que políticas públicas de menor dimensão que atribuem ao Estado a função de produtor/centralizador de informação sobre um dado problema, atuem perante a sociedade como catalisadores para a criação de um problema social - embora não controle as formas da sua interpretação.

Concluindo, o processo político pode ser estudado com grande vantagem a partir da teoria de campo de Pierre Bourdieu. A análise documental pode ser utilizada com vantagem para identificar as categorias relevantes no discurso produzido pelos agentes em posições privilegiadas deste processo. O método comparativo próprio da *grounded theory* permite a flexibilidade de fazer emergir do próprio texto os conceitos que melhor traduzem as ideias e as estruturas percebidas pelos agentes. A conjugação destas abordagens constitui um método que pode ser replicado para o aprofundamento do estudo deste processo político, como de outros, constituindo um contributo para um olhar próprio que a sociologia deve reclamar sobre a temática das políticas públicas.

Acrónimos e Siglas

AC – Alterações Climáticas.

CO₂ - representação química do dióxido de carbono.

ESSA - do inglês: *Environmental Science Services Administration*.

EUA – Estados Unidos da América.

GG – Grande Guerra.

IGY – do inglês: *International Geophysical Year*.

MC – Modificação do Clima.

MTC – Modificação do Tempo e do Clima.

NASA - do inglês: *National Aeronautics and Space Administration*.

NCAR - do inglês: *National Center for Atmospheric Research*.

NOAA – do inglês: *National Oceanic and Atmospheric Administration*.

NSF – do inglês: *National Science Foundation*.

OCR - Optical Character Recognition, é uma tecnologia para reconhecer caracteres a partir de um arquivo de imagem ou mapa de bits.

ONG – Organização Não Governamental.

ONU - Organização das Nações Unidas.

PIB – Produto Interno Bruto.

UE – União Europeia.

URSS - União das Repúblicas Socialistas Soviéticas.

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ANEXOS

Anexo 1 - Categorias institucionais e Ações significantes no campo da construção de políticas públicas sobre as alterações climáticas

	01HR56/R . REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
Conceitos	Referências no texto:										
1.a) Ações: Ensino; Investigação; Publicação de relatórios; Produção de literatura científica; Organização de conferências; Pareceres/recomendações sobre políticas públicas.		Train Oceanographers - Teaching	University research	research programs	Stanford survey - report SRIA - 7	University led research	University studies and symposiums	Statements in congress hearings	Programs on weather forecasting	University symposium	WM Research
				Published reports		Education programs on the field graduate and undergraduate		Research activities	Published article	Experiment conducted by statisticians (Santa Barbara)	
				scientific literature and papers							University Research
1.b) Instituições: Universidades; Departamentos Universitários e Laboratórios especializados nas Ciências Atmosféricas/Geociências e áreas conexas.		Oceanography departments in universities	Universities	Academic research institutions and universities in general	Academy/university controlled lab : Stanford Research Institute	Universities	Universities	WM specific Research institutes	Von Neuman, matematitian	University WM projects	Universities
			Agricultural and Mechanical College of Texas			University programs of meteorology		Universities	Universities		

	01HR56/R . REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
2.a) Ações: Programa internacional de Geofísica (IGY); Relatórios; Encontros científicos; Coordenação de programas nacionais; Publicações científicas; Cooperação em Investigação com outros países; Pareceres/recomendações sobre políticas públicas; Financiamento de pesquisa científica; avaliação de ciência.	IGY science programs (US and other countries)		IGY programs	Cooperative programs						Interchange of information in the atmospheric sciences	Coordinate problems and held international meetings
	UN reports		IGY Developed and published research	Organization of new international committee, and of new international organizations							Reviewing SR in the field of the various countries
	International science meetings		Research Cooperation with other countries	Scientific assistance to other UN organizations							Planning World Weather Watch
	Centralised coordination of various nations science programs		International science meetings	Promotion of policies favorable to international scientific research							
			Policy Recommendations	International meetings and symposium, and congress							
			Worldwide assembly of data to be used internationally by scientists	Promotion/funding/planning of international research and development of sciences							

	01HR56/R . REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
2.b) Instituições: Comitê de coordenação do IGY (CSAGI); outras organizações internacionais de ciência; programas nacionais integrados nessas estruturas; representação nos comitês de gestão dessas estruturas.	CSAGI , IGY organisation		Special Committee on Antarctic Research (SCAR)	International cooperation administration				World weather watch		International weather service	World Meteorological Organization, which is a specialized agency of the United Nations.
			IGY Stations (american and other countries)	International Council of Scientific Unions - new created committee: Special Committee on Oceanic Research							
				UNESCO (and other international agencies support and cooperation) - the creation of International Advisory Committee on Marine Sciences							
				World Meteorological Organization							
				World data center							
				CSAGI							
3.a) Ações: Relatórios; Pareceres/recomendações sobre políticas públicas; Avaliação de Ciência.		NAS committee of Oceanography Reports	Statement in congress - member of the american geographical society	Creation of oceanography committee		NAS WM comission report	Assembly and assess data from various reports	Assessment Reports	NAS assessment report	NAS Study and report	NAS report
		Policy Recommendations		Survey, reports and assessment of the present status of specific science fields				Statements in congress hearings	Public Statements	Collection of studies produced by various institutions (other countries included) and assessment	
				Recommendations for policy development in the field							

	01HR56/R . REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
3.b) Instituições: National Academy of Sciences (NAS); outras associações acadêmicas e comités interuniversitários.		NAS committee of Oceanography		NAS (specific committees)		NAS panel on WM	NAS panel on WM	American meteorological Society	American Association for advancement of science.	NAS panel on WM	NAS panel on WM
								University Committee for atmospheric research (now corporation)	NAS panel on WM		
								National Academy of Sciences			
4.a) Ações: Atividades de investigação e desenvolvimento e operações com inovação tecnológica; Avaliação de ciência.							Operate WM techniques	Research activities	Programs on forecasting	Research evaluation Study on WM	WM operational activities
								Cloud seeding activities	Weather modification activities	Wm experiments	
									Assessment reports		
4.b) Instituições: Laboratórios privados; empresas com departamentos de investigação e desenvolvimento; empresas com serviços intensivos em inovação (nomeadamente em modificação do clima).		Private labs		Companies interested in deep sea drilling			Airports	General Electric Co. ; Arthur D. Little Co.	Travellers ins. co., companies	Commercial enterprises with WM projects	Large number of private parties doing WM activities

	01HR56/R . REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
5.a) Ações: Atividades de pesquisa e desenvolvimento; patrocínio/contratação de pesquisa; desenvolvem missões com aplicação de ciência de ponta; produzem inquéritos e procedem à recolha de informação e dados estatísticos; pareceres/recomendações sobre políticas; Publicam estudos sobre temas de políticas públicas.			Research activities	Sponsor research and science org.	Research and development	Underlying Research	Missions requiring WM knowledge	Research programs WM related	Weather bureau and other agencies contract research	Research evaluation Study on WM	Independent study on operational commercial WM
			Plans for global weather maps		Surveys	Specific issues depending on the agency on WM programs		Statements in congress hearings	Programs on forecasting	Research connected to NSF funded programs on WM	WM programs
						Weather reports		Research projects			Monitoring, W prediction, international representation
											Weather prediction and WM Research
											WM programs
5.b) Instituições: Laboratórios públicos; museus, agências com missões relacionadas com o oceano, atmosfera, ou recursos naturais, com especial relevância: Weather Bureau; Environment Sciences Services Administration (ESSA); National Center for Atmospheric Research (NCAR); Bureau of Reclamation (administra os recursos hídricos).		Labs	Various oceanographic institutions	Research museums	AEC	ESSA	National Center for Atmospheric Research (NCAR)	ESSA, NASA	Weather bureau and other agencies	Other agencies	ESSA
			Weather bureau	The Coast and Geodetic Survey	National laboratories on AE	NCAR	Several Federal agencies	Weather bureau; Bureau of Reclamation ; Forest Service's Project Skyfire, other government agencies	NCAR	US weather bureau	Bureau of reclamation
				Several institutions with interests in the ocean		Weather Bureau and the Bureau of Reclamation, other agencies		NCAR			Federal Aviation Agency
											US Weather Bureau

	01HR56/R . REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
6.a) Ações: Apoio financeiro e logístico e contratação de programas de investigação (públicos e privados); publicam relatórios; desenvolvem missões com aplicação de ciência de ponta (em particular programas operacionais nas áreas de MC).		Support Research programs	Cooperation in IGY science program	Oceanographic observations - cooperative studies with other research organizations		Logistic support by the military services	Logistic support by the military services	WM programs	Air force contracts in WM research	US Navy, preliminary WM experiences	Research Project (Stormfury)
				Disposal of submarines/navy ships for research purposes			Missions requiring WM knowledge				
				Sponsor research							
				Published Reports							
6.b) Instituições: Instalações de investigação do Departamento da Defesa; a Marinha; a Força Aérea.		The Geophysical Branch of the Office of Naval Research , marine physics laboratory	U.S. Army Signal Corps	The Navy				Navy	Navy	US NAVY	US NAVY
			Naval Research Laboratory	United States Hydrographic Office				Air force	Air force		
			US Army SIPRE (Snow, Ice and Permafrost Research Establishment)	Air Force Cambridge Research Center							
			U.S. Air Force Air Weather Service								

	01HR56/R . REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
7.a) Ações: Financiam investigação e ensino superior; Pareceres/recomendações sobre políticas públicas; Reportam ao Congresso; Atuam como autoridade sobre determinados setores de atividade económica, recolhendo registos sobre a atividade de agentes públicos e privados; avaliam e coordenam programas de pesquisa de diversas agências; realizam conferências; avaliação de ciência; apoiam a criação de agências/laboratórios/universidades; funções reguladoras.		University and students financial support		Recommendations for policy development in the field		Reports on WM to the congress	Policy recommendations report	Annual Interagency Conference on Weather Modification; NSF annual reports to the President and the Congress	NSF Report	NSF funding the WM activities	NSF regulations and authority to hold hearing and require information
						NSF increased record keeping of commercial operators WM activities	NSF increased record keeping of commercial operators WM activities	NSF funding for WM programs			NSF special commission report
						Funded research	Support to research activities/institutions	Assessment Report on WM (to the president and the congress)			NSF and ESSA funded WM programs
						Evaluating, reporting, trying to help coordinate agency programs		Support the creation of new agencies/labs/university departments			
						hold symposiums		Creation of Environmental division within the NSF			
7.b) Instituições: National Science Foundation (NSF); Comitês inter-agência.		NSF		NSF		NSF	NSF special commission on WM	NSF; Environmental division NSF; NSF commission for WM	NSF	NSF	NSF special commission
						NSF special commission on WM	NSF				NSF
						Interagency Committee on Atm. Science	NSF special commission on WM				

	01HR56/R . REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
8.a) - Ações: Apropriação de fundos e alocação a projetos e programas de investigação; realizam audiências e legislam; relatórios de aconselhamento/recomendação sobre políticas públicas de alto nível; coordenam os esforços públicos e (numa certa extensão) privados; recomendações às agências.				Funds allocated to the IGY		Federal support of WM R	Commission policy recommendations to NSF	Law enactment		report to the president	President's Advisory Committee on Weather Control report
				HR committee legislative hearings on IGY		reports	court cases	report (evaluation of public and private experiments) and policy recommendations			Coordination of policy issues
				Advisory reports		Enact Laws	State laws regulating WM activities	coordination of Science Administration			Request and develop studies for policy decision
						coordinate the field					Enact Laws
											Statement of the president
									Office of science and Technology		
8.b) Instituições: Comissões, conselhos e comités de alto nível (em especial o Federal Council for Science and Technology e o comité de aconselhamento sobre o controlo do clima); órgãos soberanos (mais especificamente Congresso e Presidente e Departamentos da Administração/Governo)				Atomic energy commission, atomic energy legislative committee		Department of Interior	states gov	Department of Agriculture	The Government	Advisory Committee on Weather Control	Department of Interior; Agriculture Department
				President science advisory committee		Congress	courts	Department of interior	Congress		Department of Defense
						President science advisory	Department of Defense	Department of Commerce			Federal Council for science and technology
						Advisory committee on weather control	Federal Council for Science and Technology	Congress and President			the Interdepartmental Committee on Atmospheric Sciences
						Federal Council for Science and Technology		Department of Defense			President of the US
									Advisory Committee on Weather Control		President's Advisory Committee on Weather Control

	01HR56/R . REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
10.a) - Structuring actions				Research programs				WM operational/co mmercial activity		Studies/rese arch in WM	Studies/resear ch in WM
10.b) existing structures structured and structuring the field				National Institute of Oceanography - England							
11.a) - structuring actions			Articles								
11.b) - existing structures structured and structuring the field			New york times								

Anexo 2 - Categorias das lutas internas e externas ao campo da construção de políticas públicas sobre as alterações climáticas

		Referências no texto:											
		01HR56/R. REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al	
Lutas Externas	1 - São necessárias políticas públicas consistentes bem como níveis mais elevados de financiamento público e privado da ciência para o progresso científico.		1, 11, 12, 17	17	2, 13, 20, 22, 23, 38			7	4, 25	15			12, 13, 21, 23, 24
	2 - As Políticas Públicas devem dirigir o elevado impacto da ciência na forma como a sociedade (americana) se relaciona com a natureza, com ela mesma, com os outros países.	5, 7, 8	21	5, 7, 8	25, 27, 34	6, 11, 12		2	2, 12, 13, 18, 23, 24, 25, 26, 28	4, 18, 20	1, 2, 7	8, 9, 20	3, 23, 26, 27, 28
	3 - É urgente o desenvolvimento de políticas públicas capacitadoras da pesquisa científica em áreas conexas à Defesa.	4	19	7, 14	14					3	1, 22, 23	24, 25	
	4 - É interesse estratégico (americano) desenvolver a cooperação internacional científica.	2, 3, 6		1, 10, 16	1, 6, 8, 9, 11, 12, 14, 29, 30, 40, 41				11, 31, 32		3, 19, 20, 21	23	8, 20, 40
Lutas Internas	5 - Valorização externa do valor aplicado da ciência como nova lógica que visa uma reforma focada no desenho de um campo científico integrado: acadêmico, indústria, administração privilegiando determinadas áreas científicas (em função do valor para finalidades públicas/econômicas/militares).	1, 9	3, 4, 5, 14, 15, 16, 18	2, 11, 13	1, 5, 13, 15, 16, 17, 27, 28, 39, 42	1, 2, 3, 4, 7, 10, 11, 12	2, 9, 19	1, 3, 10, 19, 28, 38		6, 12	1, 3, 14	5, 14, 15, 22, 30, 37	
	6 - Modelo de um novo campo científico emergente: multidisciplinar, experiências de larga escala, planeadas e executadas a longo prazo, elevado custo por investigador, pesquisa básica, aplicada e de desenvolvimento conjugadas - mas funcionalmente separadas, composição diversa (agentes de pesquisa acadêmicos e não acadêmicos - indústria e serviços do estado).	10, 12	7, 9, 10, 11, 20	3, 5, 6, 9, 12, 15, 17	3, 4, 7, 10, 18, 19, 24, 31, 33, 34		8	1, 10, 11, 15, 18, 21, 23, 25	6, 7, 8, 15, 16, 17, 20, 21, 22, 33, 34, 35	1, 8, 14, 16, 17, 21	5, 11, 17, 24, 25	4, 10, 12	2, 3, 16, 29, 36
	7 - O campo científico deve ser reformado em torno de grandes objetivos nacionais, a partir de uma estrutura de topo, em que o Estado, formando uma parceria com a Academia e agentes do setor privado (como garante da autonomia do campo), assume o controlo das infraestruturas de maior dimensão e de suporte, exerce a coordenação e regulação da ação de agentes públicos (estatais e locais) e privados com atividade em investigação e desenvolvimento (e outras) e orienta as diversas instituições do campo através de agências especializadas e grandes canais de financiamento.				25, 26, 33, 34, 37, 38			8, 12, 14, 16, 19, 20, 21, 22, 24	9, 15, 16, 22, 27, 29, 30, 33, 36, 37, 39, 40	6, 13, 19, 22, 23, 24	4, 9, 16, 18	10, 11, 15, 16, 18, 19, 21	3, 6, 7, 11, 12, 25, 34

Anexo 3 - Conceitos utilizados na construção das categorias

01HR56/R. REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
Conceitos utilizados										
1 - A Ciência responde a questões com valor público.	1 - Recomendação da NSF mais financiamento (largas somas) destinadas a subsidiar os estudantes de determinadas áreas científicas.	1 - O IGY como abordagem internacional de um problema científico	1 - Possibilidade de conhecer de perto a pesquisa realizada por nações rivais.	1 - Impacto de desenvolvimentos científicos em problemas com o consumo de energia e com a produção de energia.	1 - Elogia a perspectiva de um programa mais abrangente em ciências atmosféricas, não restrito apenas às técnicas de MC.	1 - Recomendações sobre uma política integrada de ciência - enquadrando aspectos legais, físicos e sociais.	1 - O campo das MC começou com aplicações descobertas por cientistas em empresas privadas.	1 - Aumento das responsabilidades públicas com o progresso científico – o que é novo é a urgência	1 - Atenção a área científica pelos seus méritos para a sociedade	2 - Mais concentração (da ação política) no desenvolvimento de diferentes vertentes desta área científica (MC)
2 - A competição entre diversos países, proporcionada por uma plataforma internacional, produz dinâmicas de cooperação e valorização do capital científico.	3 - Argumentos em choque: NSF (financiamento deve ser igual para todas as áreas vs. Testemunha (financiamento deve destacar áreas estratégicas/mais desfavorecidas).	2 - Impacto da meteorologia em diversos serviços e atividades comerciais.	2 - Condições precárias da pesquisa realizada em estações de pesquisa em regiões inóspitas.	2 - Disparidade entre o interesse congressional e as políticas da NSF (finalidade pública vs. Autonomia acadêmica).	2 - Disparidade entre o interesse congressional e as políticas da NSF.	2 - Ideologia obsoleta: a de que podemos explorar sem limites os recursos naturais.	3 - O primeiro programa de MC foi militar.	2 - Importância vital das MC para a humanidade.	3 - Diferentes intuições da pesquisa científica realizada na área das ciências atmosféricas	3 - São necessários estudos para produzir legislação e regulamentação adequada do setor.
3 - A CSAGI recomenda a tomada de posição de outros países, inclusive dos EUA, em face do recente investimento da URSS.	4 - Valor específico e destacado da oceanografia no sentido do valor público .	3 - satisfação com o apoio continuado a programas do IGY.	3 - A interpretação de dados recolhidos no IGY vai levar anos.	3 - A energia como um problema público que afeta todas as pessoas e a economia.	3 - Diferentes perspectivas sobre o alcance das políticas da NSF.	3 - Defesa de um programa nacional de ciência.	4 - O segundo momento do desenvolvimento deste campo foi a pesquisa das suas implicações civis.	3 - As questões ambientais vão além fronteiras, requerem uma abordagem internacional.	4 - Resultados operacionais (da pesquisa feita por agentes não acadêmicos) pode ser usada para avançar a pesquisa.	5 - Defende transferência de poderes da NSF para nova estrutura.

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Conceitos utilizados										
4 - Os Russos retratados como adiantados, no caminho de se tornarem uma grande potência marítima.	5 - Sentido prático vs. Sentido acadêmico nas considerações sobre financiamento/gestão da ciência.	5 - Aspectos combinados da meteorologia e oceanografia na monitorização do CO2 atmosférico, como resposta a um novo problema ambiental..	4 - Condições do planeamento de longo prazo dos programas científicos do IGY.	4 - Impacto dos custos da energia nos outros setores da economia.	4 - Diferentes perspectivas sobre os indicadores de avaliação/financiamento de programas científicos.	4 - Procura de maiores níveis de financiamento.	6 - Conflito entre a pesquisa científica em WM, e as atividades comerciais nessa área, apelo à intervenção do estado para controlar os agentes privados.	4 - Afirma a necessidade de unificação de estruturas e de objetivos nacionais	8 - Nova perspectiva: a atmosfera não é um depósito inesgotável.	6 - Repartição de funções entre a NSF e uma estrutura de outro departamento.
5 - As alterações climáticas podem gerar novas divisões no arranjo geopolítico.	7 - Handicap das disciplinas sem ensino graduado multidisciplinar em relação às disciplinas básicas.	6 - Diversas agências cooperam para a continuação dos programas do IGY.	5 - A participação de motivações sociais e económicas na gestão de ciência.	6 - Escassez e consequências inadvertidas dos combustíveis fósseis – a alternativa do nuclear	5 - Ideia da finalidade da Nação em "controlar o ambiente"	6 - O campo é concebido como contendo diversos agentes: governo, indústria, academia.	8 - Recomendação de um esforço especial no desenvolvimento das áreas conexas às MC.	5 - Importância de desenvolvimentos em diferentes áreas para a formação do campo das MC.	9 - A acumulação de CO2 atmosférico como experimentação ambiental.	7 - Funções reguladoras do estado vs. Interesses comerciais.
6 - EUA em competição com a URSS em contraste com os benefícios dos EUA em cooperação com a URSS	9 - ciclo vicioso: condições mais exigentes da aprendizagem no campo - são mais dispendiosas que as restantes para os estudantes > atraem menos estudantes > os departamentos perdem relevância e acesso aos fundos	7 - Problemas ambientais globais podem atingir os USA.	6 - Benefícios da partilha de infraestruturas de pesquisa para fins científicos, proporcionada pela cooperação internacional.	7 - O valor público da oceanografia	7 - Vantagens de programas nacionais no alcance de objetivos científicos.	7 - Experiências de campo de grande dimensão são mais dispendiosas.	13 - Impacto da NSF e dos programas anteriores na criação de novos departamentos específicos nas instituições académicas.	6 - A área da pesquisa em MC tem o potencial de produzir benefícios económicos significativos.	10 - Objetivos nacionais a serem prosseguidos com programas de investigação e desenvolvimento	8 - Dimensão de cooperação internacional no desenvolvimento científico das MC.

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Conceitos utilizados										
7 - A investigação científica como resposta para problemas de produção alimentar, militares, e fonte de oportunidades económicas	10 - As condições físicas da pesquisa tornam especialmente difícil financeiramente para os estudantes concluírem a graduação.	9 - As disciplinas de matemática e computação são determinantes para o desenvolvimento das ciências atmosféricas.	7 - Possibilidades e valor do apoio continuado e de longo prazo da ciência.	8 - Relação da pesquisa científica Espaço, Oceano, Energia atômica.	8 - Visão do modelo de parceria entre Governo e Academia tendo como modelo a NSF.	8 - A introdução de matemática nesta área é fundamental para o desenvolvimento do campo	14 - Cooperação entre cientistas de diferentes áreas.	7 - Antecipação de problemas de modificação inadvertida do clima resultante do aumento de população.	11 - Interesse público conjugado com a gestão de programas científicos	11 - Campo funcionalmente diferenciado, com funções reguladoras e a autoridades centralizadas a nível federal.
8 - A ciência pode responder a problemas gerados pelo desenvolvimento da indústria	11 - Não há expansão sem intervenção exterior	10 - A pesquisa precisa de resolver/preencher os vazios entre as medições passadas e as atuais. Só o consegue aumentando a sua extensão territorial.	8 - Vantagens do trabalho coletivo de cientistas em programas grandes, como complementares do trabalho individual de cientistas.	10 - A solução da energia nuclear para os problemas energéticos.	9 - Valor público das técnicas de modificação do clima para a água e a produção alimentar.	9 - Divisão do campo segundo área: teórica, laboratorial, pesquisa de campo, operações.	15 - Defesa do aumento do nível de financiamento .	8 - Visão de um programa abrangente que conjugue diferentes modalidades de pesquisa, de setores e de disciplinas.	12 - Riqueza de abordagens realizadas pelos operadores comerciais.	12 - Importância do estado de recolher a informação relevante produzida pelos diferentes agentes públicos e privados.
9 - O argumento da experiência geofísica - urgência na aposta na ciência para prevenir desastre ecológico/adaptar ou ganhar oportunidades	12 - Deve haver financiamento a longo prazo para as universidades, de forma às universidades conseguirem garantir salários.	11 - Há necessidade de previsões meteorológicas mais extensivas.	9 - Impactos positivos da cooperação científica	11 - A solução da energia atômica para os problemas ambientais resultantes dos combustíveis fósseis.	10 - Multidisciplinaridade na abordagem de problemas de modificação do clima.	10 - Divisão do campo segundo previsão e controle do tempo (aspectos práticos da aplicação da ciência).	16 - As áreas de desenvolvimento dependem da acumulação de conhecimentos básicos.	9 - Promove uma estrutura diversificada do campo científico	14 - Uma nova área atraente a investigadores de outras áreas	13 - Promove estudos para futura legislação com vista a controlar atividades científicas comerciais, do governo local e estatal – como para atingir objetivos de controle do tempo ao nível nacional.

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Conceitos utilizados										
10 - Escala internacional e multidisciplinar dos projetos científicos	14 - Fenómenos físicos como argumento para estruturas institucionais	12 - Cooperação entre diversas áreas científicas no estudo da atmosfera.	10 - Importância vital da continuidade dos programas internacionais do IGY.	12 - Centrais elétricas como mecanismos de alteração intencional do clima, em especial as centrais de energia nuclear.	11 - A NSF como mais orientada para promover a pesquisa fundamental/básica (não vocacionada para as áreas aplicadas da ciência).	11 - Necessidade de uma estrutura global.	17 - Visão multidisciplinar, e integrada (investigação básica, aplicada e desenvolvimento) do campo das MC.	11 - Requer estabilidade do apoio orçamental.	15 - Promove a centralização numa instituição estatal com poderes de coordenação sobre programas de ciência e desenvolvimento	14 - Benefícios sociais e económicos do desenvolvimento das MC.
12 - Sublinha que o avanço na ciência para além de um certo limite, é dispendioso e requer investimento (de uma proporção que só o estado pode assegurar.)	15 - A necessidade de uma visão integrada do campo científico para dar resposta a problemas resultantes do desenvolvimento da ciência.	13 - Valor público da meteorologia	11 - Avanço da ciência requer participação de outros países.		12 - Equilíbrio entre a autonomia e diversidade do campo científico e o contributo de programas nacionais.	12 - Recomendações de integração no plano nacional das Alterações advertidas e inadvertidas do clima.	18 - Problemas de fundo sobre os efeitos inadvertidos do homem sobre o clima - podem por em causa a habitabilidade do planeta.	12 - Valor público da ciência da atmosfera para outras atividades e serviços.	16 - Equiparação da "big Science" da física com as grandes experiências de campo das ciências atmosféricas.	15 - Ideia próxima à geoengenharia: capacidade transformar o ambiente de forma generalizada.
	16 - A NSF não reconheceu suficientemente a importância da oceanografia.	14 - Apropriações políticas e territoriais da antártica (pressão sobre o Congresso para uma tomada de posição americana).	12 - Importância da cooperação internacional na captação de cientistas jovens de todo o mundo.		15 - Prevê uma transferência de cientistas das áreas científicas clássicas para as áreas interdisciplinares.	13 - Ideia de ciência em estágio inicial do conhecimento de matérias de interação oceano-atmosfera.	19 - Novas agências devem ser criadas, as anteriores não estão preparadas para os problemas operacionais de experiências em larga escala.	16 - Promove uma estrutura de acordo com as finalidades externas (públicas e económicas) da produção científica	18 - As práticas comerciais de MC devem continuar, mas com monitorização e regulamentação do estado.	16 - Pesquisa aplicada como assente nas bases lançadas pela pesquisa básica, deve ser tornada distinta ao nível das estruturas institucionais.

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Conceitos utilizados										
	17 - Aumento de financiamento generalizado a todos os estudantes.	15 - Valor científico na manutenção de estações na antártica (em conflito com a lógica militar).	13 - Diferencia a área segundo o valor dos resultados da pesquisa, justificando aumento do nível de financiamento pedido.		16 - Desenvolvimento do campo, dependente do alcance de níveis críticos no financiamento.	15 - Ideia de um esforço federal, interdisciplinar e inter-agência, com implementação de um laboratório nacional.	20 - O problema científico da próxima era é a relação do homem com o seu ambiente.	17 - É necessária a continuidade dos programas de pesquisa para que estes possam ser eficientes.	19 - O estado deve poder suspender a atividade comercial a fim de se levar a cabo testes científicos de forma a evitar a contaminação das novas experiências.	20 - Paradigma de cooperação internacional em novas áreas científicas.
	18 - Valor público da oceanografia - responde a problemas militares.	16 - Possibilidades de cooperação USA - URSS	14 - Extrema importância económica, militar de uma política da investigação científica em oceanografia		18 - O trabalho de campo das disciplinas envolvidas requer níveis de financiamento de uma escala diferente de áreas dependentes apenas de pesquisa em laboratório.	16 - É necessário um apoio logístico à pesquisa dos diferentes laboratórios.	21 - A área ambiental como um campo multidisciplinar.	18 - Obsolescência da atual estrutura de administração das ciências ambientais, pedido por reforma, por novas instituições.	20 - Problemas resultantes da expansão de atividades comerciais com técnicas de Mc requerem atenção política.	21 - É necessário mais financiamento
	19 - O argumento da guerra fria: a corrida ao armamento nuclear submarino e os instrumentos de deteção.	17 - Ideia de que a ciência está apenas no início da compreensão de certos problemas e de que é necessário mais esforço e apoio por parte do Estado.	15 - Equiparação da oceanografia à ciência do espaço, na sua relação com problemas relativos ao armamento nuclear.		19 - Deveria haver mais programas da NSF para encorajar novos estudantes a ingressar em estudos destas áreas.	17 - A pesquisa em MC tem valor para outras áreas científicas.	22 - Coordenação de vários programas, mais do que uma centralização num único programa.	19 - Importância da cooperação política e científica para o desenvolvimento desta área.	21 - Trabalhar em conjunto com os operadores comerciais de forma a resolver os problemas colocados à investigação é essencial.	22 - conceito de nova ordem ou direção.

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Conceitos utilizados										
	20 - Programas de investigação conduzidos no exterior, requerendo planeamento a longo prazo e orientados para finalidades externas ao campo científico	8 - Novas visões e divisões geográficas decorrentes do conhecimento geofísico.	16 - Papel da oceanografia no desenvolvimento de respostas a problemas alimentares internacionais - manutenção de uma posição americana relevante/dominante no plano geopolítico.		20 - Necessidade da criação de uma nova agência com capacidade de mobilização de recursos para experiências de campo de grande dimensão.	18 - Valor potencial das MC em outros aspetos ambientais.	23 - Diversas agências funcionalmente separadas devem exercer a autoridade sobre o campo das MC.	20 - Relação da natureza, enquanto objeto da ciência, e as implicações dessa perspectiva sobre as estruturas sociais (perspetiva internacionalista)	23 - Benefícios da cooperação internacional	23 - As preocupações ambientais envolvem aspetos legais, económicos sociais, de segurança pública, aos aspetos científico naturais.
	21 - "O tempo está a esgotar-se" argumento ambientalista.		17 - Valor crítico da oceanografia em diferentes problemas militares.		21 - Necessidade de diversificar e autonomizar diferentes estruturas para pesquisa básica e pesquisa aplicada.	19 - Valor público das MC para a abundância de animais e plantas.	24 - É necessário um enquadramento legal para as atividades de pesquisa e operações de MC.	21 - Existe uma tradição de cooperação internacional na meteorologia.	24 - Perigos do desenvolvimento de usos bélicos dos desenvolvimentos científicos na geofísica, como justificação da sua importância do campo.	24 - Os aspetos não técnicos (legais, económicos, sociais) são fundamentais para a consideração de políticas públicas sobre o campo das MC.
			18 - Natureza conjugada da investigação básica e aplicada.		22 - Uma combinação de programas que dá origem a um programa nacional.	20 - Requer uma perspetiva de longo prazo.		22 - A visão ou o pesadelo, confronto entre novas formas de cooperação internacional vs. escalada bélica em torno dos desenvolvimentos científicos de controlo do tempo	25 - Importância do envolvimento do Presidente para a relevância política deste tema obter o devido reconhecimento	25 - Problemas a ter em conta de interferência dos projetos ao nível federal com projetos locais, ou das leis dos estados.

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Conceitos utilizados										
			19 - A investigação aplicada depende da acumulação de conhecimentos resultantes da investigação básica.		23 - Os custos deste tipo de pesquisa científica não são proporcionais à quantidade de recursos humanos envolvida.	21 - O programa requer apoio para diferentes áreas científicas que a MC deve integrar.		23 - Compara a corrida à lua com a corrida pelo controlo da atmosfera		26 - Perigos derivados da própria experimentação / necessidade de regular e monitorizar a condução de experiências como a validade dos resultados.
			20 - Importância da conjugação de diferentes fontes de financiamento dos programas científicos.		24 - Ideia de campo científico, com níveis políticos e administrativos, funcionalmente organizado e com diferentes níveis de ação.	22 - O desenvolvimento de políticas públicas sobre esta área requer pesquisa nos seus efeitos sociais e económicos.		24 - Quem detém mais conhecimento sobre as práticas operacionais de WM, os agentes comerciais, ou as agências estatais?		27 - Requer instrumentos legais, que permitam aos tribunais assegurar os direitos civis em relação a atividade de pesquisa levada a cabo pelo estado.
			22 - Procura enquadramento legal específico (isenção de regulações) para atividades de pesquisa.		25 - Multidisciplinária de abrangente às áreas sociais e legais.	23 - Ideia de uma nova possibilidade da sociedade poder intervir para melhorar o ambiente.		25 - O problema no desenvolvimento de técnicas válidas de MC pode ser, falta de conhecimento básico, ou falhanço em desenvolver ferramentas.		28 - Problemas da aplicação das MC nas relações internacionais.

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Conceitos utilizados										
			23 - Problemas da gestão de recursos de pesquisa partilhados com os militares.			24 - A política pública como instrumento de mediação de novos conflitos emergentes das novas capacidades de MC. Antecipação de novas divisões no campo socio-económico geradas pela emergência destas técnicas.				29 - Conjugação da previsão e da modificação do clima.
			24 - O financiamento deve prever custos com a manutenção de bases e com operações em mar, a gestão de recursos entre NSF e a Marinha, custos com pessoal e com infra-estruturas.			25 - Os processos de decisão em função da incerteza necessitam de mais pesquisa (e maior nível de financiamento).				34 - Estado atual de esforços descoordenados de investigação sobre MC.
			25 - Função do estado como autoridade reguladora nos problemas ambientais resultantes do desenvolvimento tecnológico.			26 - Nascimento de um campo ambiental - o estudo integrado das consequências sociais, económicas e ambientais do desenvolvimento tecnológico				36 - Big Science vs. Little Science - o tamanho da pesquisa importa para o tipo de políticas a aplicar.

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Conceitos utilizados										
			26 - Importância do Estado na implementação de infraestruturas de suporte à investigação científica.			27 - Regulação federal das atividades de pesquisa e económicas ligadas À MC, pode servir como incentivo ao investimento em pesquisa científica nesta área.				37 -O valor público das MC não é perceptível na ausência de uma percepção clara da sua validade.
			27 - Há necessidade de estudos sobre as áreas de pesca que sirvam para o desenvolvimento do setor comercial da pesca e de políticas nacionais a esse nível.			28 - Necessidade de mais estudo sobre soluções em termos de políticas públicas para problemas de propriedade levantados pelas novas técnicas.				37 - O valor público das MC não é perceptível na ausência de uma percepção clara da sua validade (necessário a intervenção do Estado).
			28 - Países com carências alimentares e países com responsabilidades científicas.			29 - ideia de Campo científico, político e administrativo, devidamente regulado e com diferentes organismos funcionalmente diferenciados.				30 - Promoção da ESSA como a agência mais indicada para levar a cabo a coordenação, respondendo a problemas de falta de capital humano da área científica (transição da gestão de programa nacional científico para o domínio do Departamento do Comércio).

01HR56/R. REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
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Conceitos utilizados

	<p>29 - Requisitos políticos da cooperação internacional nas ciências oceanográficas.</p> <p>30 - Perspetivas de desenvolvimento intergovernamental de cooperação científica, envolve o estabelecimento e apoio de organizações regionais.</p> <p>31 - Necessidade de compromisso de longo termo no financiamento dos programas oceanográficos.</p> <p>33- As agências com programas de investigação devem gozar de autonomia na gestão desses programas.</p> <p>34 -É importante diversificar financiamento do campo científico, para manter independência em relação ao Estado.</p> <p>37 - (apenas) Metade do financiamento deve vir da NSF</p>		<p>30 - Relação entre a acumulação de conhecimento e a necessidade de regulação.</p> <p>31 - Relevância da cooperação internacional e impacto nas relações internacionais.</p> <p>32 - Importância da cooperação entre nações rivais.</p> <p>33 - Desenho de um campo multidisciplinar, apoiado por um programa com essas dimensões.</p> <p>34 - Diferenciação entre o campo científico clássico, do cientista de "papel e caneta" e do campo científico emergente, das experiências de campo em larga escala.</p> <p>35 - Conjugação de diferentes modos de pesquisa básica e aplicada.</p>	
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01HR56/R. REVELLE	02HR59/Gordon	03HR59 Wexler et al.	03HR59 Revelle	04J60 David Hall	05S66 / Kassander et. Al	05S66 / A. Chamberlain	05S66 / L. Haworth	05S66 / Malone	05S66 / Gordon MacDonald et al	05S66 / Hollomon et. Al
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Conceitos utilizados										
			38 - A necessidade e os benefícios de envolver a industria nos programas públicos de investigação científica.			36 - Equilíbrio entre a diversidade/auton omia e a centralização de funções dentro de um programa nacional.				
			39 - Aplicabilidade dos conhecimentos oceanográficos a problemas militares.			37 - Ideia da criação de uma agência nova que consagre a autonomia do campo ao nível administrativo.				
			40 - Formas muito dispendiosas de pesquisa apenas possíveis ao nível da cooperação internacional.			38 - A dificuldade da NSF em gerar normas diferentes para apoiar um campo científico específico.				
			41 - Compilar informação científica de diferentes nações			39 - Recomendação de uma estrutura ao alto nível político que coordene as políticas e os programas de MC.				
			42 - Formas de dispor de material radiativo			40 - A recomendação política deve ser independente do governo, e representativa da academia.				

Anexo 4 - 01HR56 - Revelle

Fonte: <https://babel.hathitrust.org/cgi/pt?id=umn.31951d00742016t;view=1up;seq=3> (pp. 466-473)

STATEMENT BY DR. ROGER R. REVELLE, TECHNICAL PANEL ON OCEANOGRAPHY, UNITED STATES NATIONAL COMMITTEE FOR THE INTERNATIONAL GEOPHYSICAL YEAR

2.a)

The budget presently before this committee contains an amount of \$1,864,000 for programs in the science of oceanography.

2.b)

This program is based not only upon the worldwide plan for IGY studies but upon the basic importance to this country of securing more information about the oceans.

The oceans are intimately associated with the history of man and the growth of his civilizations.

Although we are predominantly creatures of the land, some of the most brilliant and successful ancient civilizations were clearly dependent upon man's mastery of the sea for transportation and commerce.

The seas have always played a fundamental role in providing food for many civilizations.

In fact, with new demands upon the food supply of the world being made by the rapidly increasing population, men are turning increasingly to the resources of the seas, both for natural foods such as fish and other sea life, and to new Conceitos of foods—algae and plankton which could be "farmed" in the marine environment.

Boundless as their resources appear, however, the seas are not actually without limit in their ability to provide foods, for a delicate balance and interdependence of marine life exists.

CONCEITO 7

Man must study the oceans carefully not only chemically and biologically, but physically as well, in order to derive maximum sustained economic advantage from this great resource.

These statements apply with special emphasis to the United States, for we are a maritime nation on a global scale, living as we do on the great island of the American continent, surrounded by the world-girdling oceans.

*

As you know, our modern industrial civilization is almost completely dependent upon the sea for transportation of basic material in astronomical tonnages from all parts of the world to our ports, and then for redistribution of these materials as the finished products of our exporting industries.

While transportation of materials by sea is one of man's oldest accomplishments, our search for new or improved navigation methods continues to improve the safety and reliability of sea travel.

Underwater travel has recently received considerable attention and new techniques of communications and navigation are rapidly expanding the possibilities of this facet of oceanic transportation.

*

In very recent times we have begun to tap the enormous mineral wealth of the sea.

Magnesium from sea water and oil from tidelands are perhaps the most important current mineral products of the sea, but manganese, nickel, cobalt, and copper are also present on the sea bottom in what may be commercial quantities.

CONCEITO 8

Besides giving up mineral treasures, the sea, because of its vastness, may prove to be a convenient repository for radioactive wastes of our new atomic age.

If this possibility is to become a reality, however, we must have exact and detailed information about the structure of the oceans, the current systems, the stability of the deep water masses and many other oceanic processes.

In this respect no amount of information can be too large or too great in detail, engineers and scientists cannot afford to take chances where it involves our whole civilization.

*

A more subtle effect of the ocean on man's environment is to be found in the relation and interactions of the oceans, weather, climate, and water budget of the earth.

For example, the great ocean currents profoundly affect the climate of land masses. Although the British Isles are in the approximate latitude of Labrador, they have a climate more similar to Washington.

The average temperature of Reykjavik, Iceland, is only 1 degree colder than that of The New York City, although 1,700 miles closer to the North Pole.

This mildness of such a northern region is related, in a way that is not clearly understood, to the warming effect of the Gulf Stream.

Upwelling of cold water from depths can, on the other hand, cool certain coastal areas, as the west coast of North America.

The sea level of the oceans is dependent upon how much water is stored on the continents in the great ice sheets of Greenland and Antarctica, and on the warming and cooling of the oceans which changes the volume of water from summer to winter.

The seasonal change in sea level on the coasts of the United States is only about a foot but during past millenia, sea level has risen and fallen many hundreds of feet.

It does not appear likely that man will be able to exert much influence on these great adjustments but we certainly need to understand them and know about them in advance in order to adapt to the fluctuations as they occur.

*

Referência AC

In one respect, however, human beings during the next few decades may, almost in spite of themselves, be doing something that will have a major effect on the climate of the earth.

I refer to the combustion of coal, oil, and natural gas by our worldwide industrial civilization, which adds carbon dioxide to the atmosphere.

Estimates by the United Nations indicate that within the next 50 years we will have produced 1,700 billion tons of new carbon dioxide from combustion of industrial fuel.

This astronomical amount is 70 percent of the carbon dioxide now in the atmosphere.

In this way we are returning to the air and the sea the carbon stored in sedimentary rocks over hundreds of millions of years.

CONCEITO 9

From the standpoint of meteorologists and oceanographers we are carrying out a tremendous geophysical experiment of a kind that could not have happened in the past or be reproduced in the future.

CONCEITO 1

If all this carbon dioxide stays in the atmosphere, it will certainly affect the climate of the earth, and this may be a very large effect.

The slight general warming that has occurred in northern latitudes during recent decades may be greatly intensified, with all that this means for the development of northern lands and waterways.

Before we can make any confident forecasts about the effects of this great increase in carbon dioxide, we must answer two questions.

First, how much of the carbon dioxide will leave the atmosphere and go into the ocean and, secondly, how will the carbon dioxide remaining in the atmosphere affect the infrared radiation balance of the earth.

The second question is an extremely complicated one, and the best answer will probably come from experience during the next 30 to 40 years.

It is hoped that the answer to the first question will come from the meteorology and oceanography programs contemplated during the IGY.

One of the essential parts of these programs is to study the exchange of carbon dioxide between the air and sea.

*

Considering the aspects of the oceans which I have briefly touched on, it was only natural that a program in oceanography should have been a part of the international plans for the International Geophysical Year.

CONCEITO 10 – Referência de disciplinas mencionadas

The areas involved are too vast for any one nation to cover; observations are required not only in large numbers but simultaneously from carefully chosen places.

Advantage should also be taken of the large programs in related sciences such as meteorology, glaciology, and seismology.

*

2.a)

At the Rome meeting international oceanographic plans were met with enthusiasm and the CSAGI recommended that long wave recorders and tide gages be installed on as many islands as possible and on continental coasts as well.

CSAGI also urged a maximum effort by all nations to improve understanding of oceanic circulation.

2.a)

At the Brussels meeting of CSAGI in 1955 many actions important to oceanography were taken, and for the first time it was realized, after many nations had made known their plans, that the oceanography program would become a very large undertaking involving some 80 ships covering almost all major oceanic areas.

CONCEITO 2

To illustrate the growth of the international oceanographic program, at the Rome meeting in 1954 only 5 countries, including the United States, made definite proposals in oceanography, and 5 other countries indicated they would consider cooperating in any plans developed at the meeting.

About 12 ships were involved in the proposals.

However, during the time intervening between the Rome, 1954, and Brussels, 1955 meetings, oceanographers in many countries realized the need for a broad and comprehensive international program, and this is the current status of the Brussels meeting: 21 countries are now participating with some 80 ships and other countries are contributing by operating coastal tide gauges.

*

The following table summarizes the IGY oceanographic program in terms of its earlier and present status:

(...)

CONCEITO 3

This expansion of effort stresses the need to restore and reconsider the United States program in oceanography in order that we would fill in vital gaps in the work.

With the announced participation of the U. S. S. R. the Arctic regions drew much attention, and the CSAGI urged participating nations to extend their Arctic programs.

Valuable data for determination of Arctic circulation in connection with interpreting long-term climatic changes can be obtained from drifting stations in the Arctic ice pack.

Also, advantage should be taken, at little extra cost, of the regular weather reconnaissance flights over the Arctic Ocean to obtain ice coverage information photographically.

The development of sound photographic methods for the recording and prediction of sea-ice conditions in the Arctic Ocean is directly related to this effort as well as to the greatly increased use of northern waters by United States vessels.

Increased interest was aroused in Brussels in utilizing the recently developed powerful research tool of radioactive tracers in the study of oceanic circulation, sea-water age, diffusion of river waters and sediment, and air-sea interchange.

Observations of this type will shed light on past planetary conditions that otherwise might be difficult or impossible to determine.

Referência AC

Far more important, they will give us the essential information on the carbon-dioxide exchange between the sea and the air that is needed to understand the probable climatic effects of the predicted great industrial production of carbon dioxide during the next 50 years.

*

One of the principal objectives of the oceanography program is to measure the currents at great depths in the ocean.

CONCEITO 11

Practically nothing is known about these deep currents.

CONCEITO 12

This is understandable — it is not because oceanographers are incompetent, but because it is difficult and expensive to make measurements below the iron curtain of the sea's surface, and effective methods have only recently been developed.

Such measurements must be made on ships—the oceanographers don't have the advantage that the meteorologists have of being able to send up inexpensive balloons from fixed land stations.

So little is known about the circulation of the deep ocean water that nobody knows whether it takes a hundred years or 10,000 for this water to travel from the Antarctic to the Equator and back again.

*

Why should we try to learn more about the deep ocean currents?

There are several practical reasons—one is that the deep currents may be of great importance in long-range weather forecasting, particularly because of the exchange of water between the Antarctic and low latitudes.

Second, the fertility of the ocean depends upon the water exchange between the deeps and the surface; that is, the amounts of fish and other food we can harvest from the ocean are finally limited by the rate at which the ocean overturns and thereby fertilizes itself.

In order to get a better estimate than we can make at present of what the potential food supply from the ocean is, and to learn how we can do something about it, we have to know about the deep currents.

Third, the development of peaceful uses of atomic energy will probably result in the production of unbelievable quantities of radioactive substances, and somehow these must be safely disposed of.

As I have suggested above, one possible thing to do with them is to dump them into the deep sea; its currents might spread them out to such an extent that they would be harmless.

But we really don't know whether this would be true or not because we don't know how fast the deep waters move or how they mix with the waters near the surface.

*

The deepwater circulation of the oceans will be studied on the series of oceanographic expeditions that will be sent out during the International Geophysical Year.

At the same time, considerable effort will be expended during these expeditions to find out more about the shape of the deep-sea floor and about the interior of the earth.

We can't really understand such things as the distribution of mineral deposits, nor can we develop geological methods to find resources to feed the insatiable maw of our industrial machines, until we know more about the history of the earth, and we can't get much further with this history until we find out more about that part of the earth that is covered by the ocean.

At present we know less about it than we do about the surface of the moon.

(GRAPH)

PROGRAM BACKGROUND

The oceans cover approximately three-fourths of the surface of the earth.

Together with the atmosphere they constitute an enormous heat engine which is one of the major factors in world weather and climate affecting populations wherever people live on the globe.

The ocean's circulatory system—the large scale movements of the waters resulting from the winds at sea and the sun's heating, modified by the rotation of the earth—is among the basic phenomena embraced by the science of oceanography.

*

Aside from the incalculable returns to basic research, there are many promising practical applications of oceanography.

In the field of meteorology the interaction of the air and sea is so close that one must understand both to understand either.

Weather changes occurring within a few days depend on instability within the atmosphere itself, but in order to extend weather forecasts over periods of a month or more, it is necessary to consider the changes in oceanic circulation and related phenomena.

*

CONCEITO 12

As in the other fields of geophysics, the study of oceanography requires the conduct of many experiments and the taking of many measurements if major problems are to be solved.

These problems have to do with the nature of oceanic currents, temperature, composition and levels, and total water content.

A major problem is the study of the annual cycle in sea level and the global water budget of the oceans.

Although all available tide gauge and temperature data have been studied, the problem remains unsolved—because a minimum of 20 years of tide observations at a station are required to give a meaningful average, so that values in one area can be compared with values in another area taken at a different time.

As much or more could be learned by synchronous measurements during one specific year.

Simultaneous measurements of fluctuations in sea level are probably the most effective and the least expensive means of studying the weather of the oceans—i. e., the fluctuations in ocean currents with time.

To be of value, these observations must extend over vast ocean areas.

*

In low latitudes the recorded seasonal changes in sea level are about what can be inferred from observed changes in temperature of the superficial layers, indicating a change in specific volume rather than in mass.

In high latitudes, there is also a change in mass.

*

If these changes are associated with changes in currents, the currents at mid latitude may be essentially confined to superficial layers, whereas at high latitudes they may extend to the very bottom and are therefore not measurable by present standard techniques.

Moreover, recorded sea level is lower by about one half foot in the Northern Hemisphere in northern spring, and in the Southern Hemisphere in southern spring, than in the respective fall seasons.

From present data it cannot be determined whether this involves flow of water across the Equator or between the fringes of the ocean basins (where nearly all tide stations are located) and the central portions (where observations are inadequate).

*

Such problems are analogous in oceanography to those in the meteorology program involving measurements of air flow across a meridian and across the Equator.

Similarly, the solution of oceanographic problems requires synchronous global measurements, which include (a) observations and reduction of data from existing tide stations; (b) temporary tide gauge IGY stations at many widely spaced island locations; and (c) weekly temperature readings to depths of about 1,000 feet offshore from as many tide gauge stations as possible.

In addition to these tide and surge observations, a major study will be undertaken on the sub-Antarctic oceans.

The structure and dynamics of currents and other oceanic phenomena of this region, which is little known but of great importance in several fields of geophysics, will be explored intensively.

SUPPLEMENTAL PROGRAM

Detailed program requirements, and the circumstances leading to their inclusion in this IGY supplemental budget, are set forth below.

Tide and surge oceanography, (\$318,000)

The Rome meeting of the Special Committee for the IGY (CSAGI) recognized the need for better coverage of the vast ocean areas of the globe, which are by far the greatest single topographic feature of the globe, and for many reasons the most difficult regions in which to secure adequate coverage for geophysical purposes.

In this connection CSAGI recommended acceptance of United States plans that long-wave recorders and tide gauges be installed on as many islands as possible as well as on continental coasts.

CSAGI stressed the need to improve our understanding of oceanic circulations, and urged the importance of a maximum effort by all nations in these measurements.

*

Accordingly, the program in oceanography has been reexamined and observations are now planned for a number of additional islands to measure water temperature, salinity, long and short period waves, and seasonal changes in sea level.

Problems in oceanography are analogous to those in meteorology involving air flow across a meridian and across the Equator; it is only by making measurements of the type planned in this program over vast ocean areas that solutions to current flows and seasonal changes can be examined.

It is expected that the studies of short surges in sea level will be particularly important, when coupled with seismic measurements, in investigating tsunami effects, which are tidal waves caused by underwater upheavals and in many instances have led to great destruction of property and loss of life.

*

New island stations are planned in the Pacific at Hawaii, Guam, Wake, Ocean Island, Norfolk, Galapagos, Juan Fernandez, Hobart, Invercargill, Jarvis, and in the Atlantic at Barbados and possibly one other location.

Stations will be equipped with tide gauges, surge gauges, bathythermographs to measure ocean temperatures to a depth of about 200 meters, and water samplers.

Measurements will be made of temperature, salinity, long and short period waves, and seasonal changes in sea level.

Use of trained native observers is planned in order to reduce costs.

CONCEITO 4

*

Dr. REVELLE. The Russians, for the first time, showed their plans at Brussels and they have something like 15 ships which will be operating all over the world on the oceanographic aspects of the IGY program.

*

Typical of their ships is a 5,000-ton research vessel which has room for 70 scientists and is completely equipped.

The biggest American ship is the Scripps ship, the Baird, which is about a tenth of the size of the Russian ship.

Nevertheless, I think we can do quite a few good things.

*

I think that actually, in cooperating with the Russians and the Japanese, we will find out a great deal.

There are two practical aspects of the oceanographic program in the International geophysical year.

DEEP OCEAN CURRENTS

One of our major problems is to study the deep ocean currents.

What we are particularly interested in is how rapidly does the deep water of the ocean, of which there is a great deal—most of it is deep water—how rapidly does this exchange with the surface water where all the fish live?

*

All the commercial fisheries really depend on the animals that live in the top few hundred fathoms of sea water and below that there is a big mass of ice-cold, always dark water.

The exchange between these two masses of water has a lot to do with how many fish you have.

NUCLEAR WASTE PRODUCTS

More important, at least for the next 30 or 40 years, we have one of the essential facts about the ocean; that is, that it is a big hole in the ground.

It is an ideal place for disposing of nuclear waste.

*

Mr. THOMAS. What was that proportion of water to the land mass?

Dr. REVELLE. The actual area of the ocean is about 71 percent of the earth's surface; about 29 percent is land.

The water part of it we really don't know very much about.

Oceanographers are fond of saying we know less about the bottom of the ocean than we do about the surface of the moon.

*

The fact that the ocean is a big hole in the ground means that probably it is the best place to dispose of atomic waste if you produce these in the gigantic quantities, which we are likely to do in the next 100 years.

*

The figure which does not seem to me to be too radical is that the amount of atomic waste produced, say 100 years from now, will be equal to the explosion of 100,000 1-megaton atomic bombs a year.

When you get this enormous quantity, you have to use some large scale method of disposing of it, and the method which seems to me, at least, the one which will have to be used is to dump it in the deep ocean.

*

The question at issue is whether this will do any harm to commercial fisheries.

The answer lies in how rapidly this deep water comes up to the surface where the fish live.

We really don't know how fast that happens.

Different people have given estimates ranging from 10,000 years to 100 years.

*

My own guess is that it is about 300 or 400 years.

This is probably long enough and we can undoubtedly find deep places in the ocean where the water stays down there a great deal longer.

These will be the places to dump radioactive waste.

Referência AC

FUELS AND CARBON DIOXIDE

There is still one more aspect of the oceanographic program which I thought you gentlemen would be interested in.

This is a combination of meteorology and oceanography.

Right now and during the past 50 years, we are burning, as you know, quite a bit of coal and oil and natural gas.

*

The rate at which we are burning this is increasing very rapidly.

This burning of these fuels which were accumulated in the earth over hundreds of millions of years, and which we are burning up in a few generations, is producing tremendous quantities of carbon dioxide in the air.

2.a)

Based on figures given out by the United Nations, I would estimate that by the year 2010, we will have added something like 70 percent of the present atmospheric carbon dioxide to the atmosphere.

This is an enormous quantity.

It is like 1,700 billion tons.

Now, nobody knows what this will do.

Lots of people have supposed that it might actually cause a warming up of the atmospheric temperature and it may, in fact, cause a remarkable change in climate.

WARMING OF THE EARTH

CONCEITO 5

We may actually, for example, find that the Arctic Ocean will become navigable and the coasts become a place where people can live, then the Russian Arctic coastline will be really quite free for shipping, as will our Alaskan coastline, if this possible increase in temperature really happens.

CONCEITO 6

This would have the effect, if it does happen, of changing the character of the Russians as opposed to ourselves.

We are now the greatest maritime nation on the earth.

We are essentially living on an island surrounded by a world-circling ocean.

*

CONCEITO 4 - Referência AC

If the Russian coastline increases by something like 2,000 miles or so, the Russians will become a great maritime nation.

Mr. THOMAS. Didn't I read, from what Dr. Gould says, we have been warming up for the last 50 years?

*

Dr. REVELLE. The reason may be because of the carbon dioxide.

It may be because we have been adding carbon dioxide to the atmosphere.

There are two questions here that we have to answer.

*

One question is, How much of the carbon dioxide that we are producing goes into the ocean, and one of the aspects of this IGY oceanographic program is to try to find out.

What proportion of the total carbon dioxide produced by the burning of fossil fuels goes into the ocean and how much stays in the atmosphere.

*

We think that something like 30 percent of it stays in the atmosphere.

This would be, in other words, by the year 2000 an increase of about 25 percent of the amount now in the atmosphere.

*

This may actually have the effect that I spoke of.

Nobody really knows, because we don't know what the effect of the CO₂, in the atmosphere is.

We can't do it by figuring it on paper.

It has to be done by experiment.

*

Here we are making perhaps the greatest geophysical experiment in history, an experiment which could not be made in the past because we didn't have an industrial civilization and which will be impossible to make in the future because all the fossil fuels will be gone.

All the coal and gas and oil will be used up.

*

In this 100-year period, we are conducting, in effect, this vast experiment, and we ought to adequately document it.

One of the main parts of the oceanographic program is to try to do just that.

POLAR SUBMARINE TRAFFIC

Mr. YATES. May I ask a question?

I was talking to an expert submariner about wars in the future.

He thought that probably the submarine would develop into the capital ship of the future as opposed to the carrier or battleship.

He envisioned the day when a submarine, powered by atomic fuel, of course, would stay under the ocean for an indefinite period of time, go under the polar ice cap, really, and just shower guided missiles upon the enemy.

Does that make sense in your book or not?

Dr. REVELLE. I would personally look at it as a more serious hazard to us than to anybody else.

Mr. YATES. You think it is possible?

Dr. REVELLE. Yes, very much so.

It seems to me that what we really have to say at the present time is that we just don't know enough about the ocean to know whether it is possible or not.

*

Mr. YATES. From the various data you accumulate, it may be helpful.

Mr. THOMAS. I don't know how you are going to take guided missiles out.

Dr. Gould wants to punch a hole in that ice about a thousand feet to find out what is down there.

*

UNITED STATES MARITIME INTERESTS

Dr. REVELLE. What I would like to say is basically that what we find out about the ocean will help the United States in many ways, simply because we are a great maritime nation.

It will help us in peace and it will help us in war.

*

Mr. THOMAS. That is fine, Doctor.

Mr. OSTERTAG. This gas that you speak of that will have an effect on the atmosphere.

Has that had any effect on human life, do you now?

*

Dr. REVELLE. It may be having an effect already, primarily through the effect on the weather.

It certainly doesn't have a direct effect.

*

Mr. YATES. You don't mean that Los Angeles may be affected?

Dr. REVELLE. The smog is not dangerous due to carbon dioxide.

It is due to the ozone and the hydrocarbons.

*

The increase in the number of hurricanes on the east coast, however, is certainly tied in one way or the other with the general northward movement of the warm air.

AFTERNOON SESSION

Anexo 5 - 02HR59 - Gordon

Fonte: <https://babel.hathitrust.org/cgi/pt?id=mdp.35112104239613;view=1up;seq=1> (pp. 3-14)

STATEMENT OF DR. GORDON A. RILEY, MEMBER OF THE NATIONAL ACADEMY OF SCIENCES
— NATIONAL RESEARCH COUNCIL ADVISORY COMMITTEE ON OCEANOGRAPHY, AND
ASSOCIATE DIRECTOR, BINGHAM OCEANOGRAPHIC LABORATORY, YALE UNIVERSITY

Dr. Riley. Yes; I do.

My prepared statement was particularly on this bill, H.R. 6298.

Would you like me to read the prepared statement first?

The Chairman. Yes. I think that that would be preferable.

Dr. Riley. Then I will talk a little about the problems of oceanography and geophysics in general.

*

3.a) e 3.b) CONCEITO 1

As you know, the Committee on Oceanography of the National Academy of Sciences has recommended that rather large sums be appropriated to subsidize both the teaching of oceanography and the support of competent graduate students.

CONCEITO 2

We recommended that the fellowship program be handled through the National Science Foundation.

CONCEITO 3

We were aware that our recommendation violated certain policies of the Foundation with respect to the size of the stipends requested and particularly with respect to singling out a certain field for special support.

We expected some opposition.

Indeed, I tell you frankly that the recommendation, although deemed necessary, was repugnant to some members of our committee.

We and the National Science Foundation are essentially the same kind of people.

Trained in the university tradition, we respect all kinds of scholarly endeavor and can find no scholarly reason for favoring any one discipline.

*

Why, then, did we vote this recommendation?

There are two reasons.

One can be disposed of quickly because it has already been given so much space in our report.

CONCEITO 4

We are deeply convinced that our country's defenses will be more secure, and our long-term economic status will be more sound, if there is a considerable expansion of oceanographic effort during the next few years.

CONCEITO 5

We believe this to be a practical need which must override purely academic considerations.

CONCEITO 6

The expansion that we urge can only be accomplished by producing more oceanographers than we are able to produce now.

*

CONCEITO 7 - outras disciplinas mencionadas

In the second place, oceanography, and to some extent other interdisciplinary fields, such as meteorology and geophysics, are handicapped in their efforts to support their graduate students, as compared with basic disciplines such as physics and biology.

We are poor relations, and the money that we are requesting for student support is necessary in order to correct the situation.

*

The reasons why this is so are complicated.

To make you understand the picture clearly I need to tell you how we go about producing oceanographers and how our graduate students are supported.

*

You understand, of course, that oceanography is a concerted attack by any and all sciences on problems of the ocean.

A competent oceanographer must have a thorough grounding in a basic science of his choice and as much knowledge of the others as he can acquire within the framework of ordinary academic training.

CONCEITO 9

If a young man has been well advised, he takes care of these prerequisites at the undergraduate level, but often we must require students to make up deficiencies in graduate school, thus adding to the length of their training period.

As to graduate training in oceanography, I quote a paragraph from chapter 8 of the Committee report.

I think it is permissible to quote this in a personal statement, since I wrote the paragraph myself.

*

The type of graduate education varies widely.

Some universities offer a full course and a degree in oceanography.

Others offer a degree in a basic scientific discipline, with the oceanographic program consisting of two or three courses and thesis supervision.

Opinions differ as to whether the major emphasis at this level of training should be on the basic discipline or on the more specialized professional aspects of oceanography.

Thus, the young oceanographer is not a standardized product.

This is probably a healthy situation in any interdisciplinary profession, leading to diversification of knowledge, interests, and technical skills.

However, it must be admitted that thorough education in both oceanography and basic science cannot be accomplished within the usual span of graduate study.

Postgraduate study and on-the-job training are generally necessary.

*

In short, it is a long and grueling course, and it is made more so by the fact that the fieldwork associated with thesis research is likely to be more time-consuming than the laboratory experiments of the basic disciplines.

*

CONCEITO 9

Next let us consider the problem of financial support; first, in general terms of graduate students in all disciplines.

Most of them earn their living as teaching assistants.

This is part-time work — 12 to 18 hours a week—supervising undergraduate laboratories, grading papers, and other menial but necessary teaching chores.

The salary is not magnificent ; \$1,500 to \$2,000 a year plus tuition is typical of most universities.

*

Then there are research assistantships, paying about the same or a little more and generally requiring about the same amount of work.

These are mainly derived from grants and contracts obtained by departmental staff members, the majority from Federal sources of one sort or another.

*

Thirdly, there is a graduate student elite class.

The most brilliant 5 to 10 percent can win fellowships from the university or from several Government agencies.

These generally pay a little more than teaching assistantships and require no supporting work.

*

These are the main sources of financial aid, although a number of minor sources are discovered from time to time.

In almost every case there is rather minimal support for one person.

A couple can live in reasonable comfort if the spouse has a job.

But there is hardly a professor in the land who has not faced the dreary spectacle of a student with a pregnant wife.

CONCEITO 9

What should be a source of great happiness in any family is a dreaded occurrence in the life of a graduate student.

It generally means dropping out of school, or a poverty-pinched, prolonged existence at the graduate level while the student spends extra hours earning money and has less time for studies.

*

Most of these young people see it through, for better or for worse, because they are dedicated scientists.

But is it right to turn our intellectual elite into second-class citizens?

And, if we want to increase our output of scientists to any great extent, we are going to have to promote them to the status of first-class citizens.

This is a general indictment of the whole system —all of the disciplines —but it is the kind of thing our Committee had in mind when we recommended stipends of \$3,500 to \$4,000 a year.

*

Now for the particular problems of the oceanographers.

CONCEITO 8

One university has an undergraduate curriculum in oceanography, but all other university departments of oceanography are exclusively for graduate students.

With no undergraduates to teach, these students are deprived of what otherwise would be their readiest source of income.

*

1.b) – 1.a)

In my own university, prospective oceanographers are members of a basic discipline and are eligible for teaching assistantships.

But here, as in strictly oceanographic departments, there is another problem.

CONCEITO 10

Three of our current roster of seven graduate students are conducting or have conducted their theses research under circumstances which preclude their support by teaching or research assistantships.

One spent a year at ice island T-3 in the Arctic and is now at weather station Alert.

One did his research in the waters of Bermuda.

A third is working not far away in Connecticut waters, but so intensively during certain seasons that he cannot maintain a schedule of assigned work at the university.

Thus, nearly half of our students have been cut off from the common sources of income for a considerable part of their graduate student career.

We have managed to support them in one way or another, often with considerable sacrifice of private funds that we would prefer to spend otherwise.

CONCEITO 11

The point is that we cannot expand significantly without outside support.

* All of these difficulties could be removed by enactment of H.R. 6298.

7.b) e 7.a)

Under the present system we decide in departmental staff meeting whom we will recommend for fellowships from NSF or other agencies.

They are the top 10 or 15 percent of our student body.

*

We know that there is no point in recommending a man unless we can recommend him highly.

With limited funds, NSF must pick the best people.

*

But all of our students who make the grade are competent people.

They are required to demonstrate scholarly knowledge and imagination in research.

Our recommendation emphasizes that all such students should be eligible for support if we are unable to take care of them in other ways.

*

I recall a graduate student who was with me for 2 year's some time ago.

He acquired family responsibilities.

We had no job at the time that would support him properly, so he went to another university.

He took an almost full-time job as a research assistant.

He managed to take a course or two from time to time and did a little thesis research when he could.

This year he got his Ph. D. after 11 years as a graduate student.

He is going to be an able and dedicated scientist, although admittedly he was only an average student.

This is the kind of man who desperately needs H.R. 6298.

*

Finally, I mention briefly the other recommendation — for Federal support of teaching facilities.

Without going into the situation fully, let me just say this : Already, universities have found themselves unable to maintain adequate teaching staffs with private funds.

Increasingly, junior staff members are being supported by Federal research grants and contracts.

It is an awkward situation, fraught with insecurity.

It will become more awkward with further expansion of teaching facilities.

CONCEITO 12

Our recommendation simply asks for honest recognition of the importance of teaching, and financial support on a sufficiently long-term basis so that the universities, in turn, can guarantee salaries for a specified contract period.

*

The Chairman. Doctor, we want to thank you for a very fine statement.

You are from Yale University?

*

Dr. Riley. That is right, sir.

The Chairman. You are directly connected there with the oceanographic laboratory ?

Dr. Riley. Yes.

We would prefer

The Chairman. How long have you been connected with the oceanographic laboratory ?

Dr. Riley. Practically all of my career, except for a short time during the war years.

The Chairman. Have you had experience generally with the earth sciences ?

*

Dr. Riley. I have no immediate personal experience.

I am primarily a biological oceanographer, but it is necessary in our field to know what other people in the field are doing, so in conversations with them I have learned a little bit.

*

Outras Disciplinas Mencionadas

The Chairman. Can you give us a general statement regarding earth sciences?

Tell us what it covers generally, if you can.

Give us in a general and brief way an idea of the program we have to outline for this committee in the time that lies ahead.

*

Dr. Riley. The earth sciences include all of the studies of the crust of the earth and its interior, the atmosphere and the oceans that cover the earth, and it goes beyond that into a study of problems of astronomy and other aspects of space science.

*

The Chairman. Does it cover things like mining?

When we refer to seismographic activities, it covers that, does it not ?

*

Dr. Riley. It covers seismographic activities and geological studies, all of which are essential in the promotion of mining.

The Chairman. Also it is essential in the location of earthquakes and things of that sort ?

Dr. Riley. Yes.

The Chairman. Likewise, it might be very important in determining or detecting atomic blasts ?

Dr. Riley. Yes.

The Chairman. To that extent it would be interesting as a weapon of defense or instrument of defense ; is that not so ?

Dr. Riley. Yes.

The Chairman. What do you mean when you say you are a biological oceanographer ?

Dr. Riley. I mean that I am interested in all life in the ocean, the purely scientific aspects, and also their application to problems of natural resources.

The Chairman. When you refer to "life in the ocean," do you mean principally fish ?

*

Dr. Riley. The whole regime of life in the ocean—the green plants, which are the basic food source for all of the animals in the ocean; the small animals, the plankton, the fishes, and the other large animals that live upon the smaller members.

We feel as if we should understand all the life in the ocean in order to properly evaluate the natural resources and the optimum level of fishing.

*

The Chairman. I judge from your statement confining made the progress you would like to make in reference to that particular science.

*

Dr. Riley. Well, sir, I think there has been great progress in the last 10 years, but we also feel in a good many respects we have not made enough progress and time is running out on us.

Perhaps I can explain that with a few simple examples.

*

CONCEITO 19

We have a wonderful new weapons system.

We think it is probably the best weapons system in the world.

I am referring to the nuclear submarine armed with rockets, and yet every time you take a weapon system to sea you find that there are oceanographic problems that must be solved in order to use it efficiently.

In one respect — namely, the navigation of these submarines —we know about what we need to know in order to navigate effectively, but we also need a very intensive program of surveying of the oceans which cannot be done in less than perhaps 10 or 20 years.

The sooner we get started on that the better.

*

In some other respects we do not know yet exactly what needs to be done.

As far as detecting other submarines is concerned, to be sure, our sonar systems have improved a great deal during the past few years since the war, but the ocean still is not what we would like it to be—transparent to our instruments so that we can detect submarines anywhere in the ocean at any time.

This is going to require a major breakthrough and it will be on the basis of basic science which we develop during the next few years, I hope.

*

The Chairman. That would be the development of sound waves which will produce echoes from one object to another?

*

Dr. Riley. That is a system we have now.

We hope that it can be greatly improved, or perhaps someone can dream up an entirely new system that can be more effective.

*

The Chairman. In your school, how many people do you have working generally on the matter of earth sciences ?

Dr. Riley. Offhand, I would say perhaps not more than six or eight.

*

The Chairman. What is their field of endeavor?

What are their studies?

outras disciplinas mencionadas

6.b)

Dr. Riley. We have one group in the marine physics laboratory, which is primarily a Navy-supported organization, which is working on problems of harbor defense specifically, but it is also doing a lot of basic science on sonar, radar, and various things that are subsidiary to this field.

outras disciplinas mencionadas

Then in our geology department we have people who are involved in various aspects of geophysics and geochemistry.

*

The Chairman. Do you have any long-range programs that you could give the committee?

9.a) – CONCEITO 20 – Outras disciplinas mencionadas

Dr. Riley. I would say both of those programs that I mentioned, particularly in geochemistry and harbor-defense work, are long-range programs.

In my own laboratory we have a rather long-range program on Long Island Sound which includes some aspects that you might call earth sciences; that is, it includes the physical oceanography of the region, the rate at which the water is transported in and out, the so-called flushing rate of the sound, but primarily it is a biological program.

This program has been going on since 1952 and probably will be a long-range effort.

*

The Chairman. I have been asking you all the questions. Anyone on the committee who wishes to ask a question, just join in.

*

Mr. Sisk. Mr. Chairman, I simply want to congratulate Dr. Riley on the very fine statement, particularly with reference to the need for some legislation aiding in the education of oceanographers, and I would like to ask this question of Dr. Riley : In the field of oceanography, roughly, how many people do we have today that are what you consider to be competently qualified to do various phases of work needed in this field?

*

Dr. Riley. I would have to look in our report to give you a precise answer, but it is of the order of 600 people who are trained at the graduate level and whom I would regard as thoroughly competent.

4.b)

One of the difficulties, however, is that a great many of these people are located in Government laboratories or private laboratories which conduct no teaching program.

It is hardly a tenth of these people who are actually involved in teaching, and this is a major problem.

We need to build up teaching staffs in universities in order to produce oceanographers at a faster rate.

*

Mr. Sisk. That leads me to my next question, and that is this: What are the opportunities for a man in oceanography outside of Government work as such ?

Are these extensive opportunities in private enterprise or private research?

Will you discuss the field of opportunity that is available and which might lead people to seek the opportunity of fellowships in this field?

*

CONCEITO 13

Dr. Riley. There is a distinct shortage of trained men.

This shortage is extreme in the earth sciences and moderate in biological oceanography.

I have never yet failed to place one of my graduate students.

Just at the moment, we have been in the market for a physical oceanographer for over a year and have thus far failed to find one.

We have two possible candidates who will complete their degrees next year.

Such people are snapped up immediately.

*

Mr. Sisk. In other words, there is a lot of opportunity ?

*

Dr. Riley. Yes.

We are not by any means producing enough to fill the demand.

*

Mr. Sisk. In your opinion, insofar as the overall studies in oceanography are concerned — and I am thinking of the whole broad scope of your problem—you have hardly scratched the surface in your studies of the ocean.

I am confining this specifically to that portion of the scientific field.

*

The Chairman. Rather than the earth sciences?

Mr. Sisk. I am talking about that having to do with our oceans, the life in the ocean, and other things concerning the ocean floor, and the problems of the breakthroughs needed in the exchange of signals and so on underwater.

Do you feel that we have only scratched the surface in this whole field?

*

Dr. Riley. I am sure if you had asked that question of any scientist in any field he would say that he has not scratched the surface yet, but I do think it is particularly true of oceanography.

Mr. Sisk. That is really the point that I had in mind ; whether or not in this particular field of scientific research and endeavor we are substantially behind, let us say, where we might be in the life science field.

*

Dr. Riley. Yes; I think that we are.

outras disciplinas mencionadas

CONCEITO 14

There is another aspect in which we are terribly behind, and that is the problem of climatology, which is really a combination of meteorology and oceanography.

It is quite apparent now that we cannot hope to have any long-range weather forecasting that will be successful until we understand more thoroughly the relationship between the ocean and the atmosphere.

We are heavily handicapped by the fact that we do not have any extensive records from the midocean.

Until we can develop that field we cannot have any hope of understanding even the next 30 days in our weather, let alone long-range predictions.

*

Mr. Sisk. In other words, then, that ties in pretty much to a problem we have had before this committee quite often, and that has to do with weather satellites.

CONCEITO 15

I draw the conclusion from your remarks that even though we may build the instrument and the vehicles and develop the propulsion power to put into orbit or into space vehicles that might give us certain information, we may lack the manpower to analyze and properly use that information ; is that correct ?

*

Dr. Riley. That is correct.

*

Mr. Hechler. I was very interested in your statement, Dr. Riley.

think all of us on this committee believe very deeply in expansion in this field.

However, I have not been completely sold by your argument yet as to why we should use a rifle approach on oceanography to the possible exclusion of any other of the earth sciences.

In order to put this in a little better perspective, you have used a rather strong word here in the first paragraph of your statement.

You say :

“Indeed, I tell you frankly that the recommendation, although deemed necessary, was repugnant to some of the members of our Committee.”

I wonder if you could give us an objective statement of the minority views, so we could have a feeling on this committee just how this repugnance was expressed.

*

Dr. Riley. It is simply as I stated in that first paragraph.

All of us recognize the importance of all sciences and we would like to see increased support for all the earth sciences and any other science.

CONCEITO 21

We would prefer not to ask for special treatment for oceanography if there were any other way out of it, but since there is a greater shortage of oceanographers than in any other field, and since we are handicapped in our efforts to support them, and because, as I said, in some practical respects time is running out on us, we felt that it was necessary to make this recommendation.

*

Mr. Hechler. Of course, time is running out in many fields in the eyes of a lot of people.

Dr. Riley. I grant you that.

Mr. Hechler. You just said that there was a greater shortage of oceanographers than scientists in any other field ?

Dr. Riley. Well, I should not say "in any other field," but I know of few other fields in which it is so easy to place men and so hard to get them.

Mr. Hechler. I wonder if you could supply for the record later some figures amplifying your answers to Mr. Sisk's question on the number of oceanographers available, the amount of

money available, and perhaps some comparative information that would demonstrate and support your statement that there is a greater shortage in this field.

Dr. Riley. Chapter 12 of our Committee report, of which I can give you a copy, tells about the rate of growth in this field, the number of people that are involved, and the amount of financial support.

Now, this does not give the data that you might want to compare with the other fields, and I do not feel competent to give you that.

There are National Science Foundation reports that do discuss that kind of thing.

(The information requested will be found on p. 17.)

Mr. Hechler. In order to support a concerted effort in one field it seems to me that we should have the facts on which we can proceed.

Dr. Riley. Yes.

*

Mr. Hechler. Now, I will ask you a toughy.

6.5

Is this not in a sense a reflection on the National Science Foundation, whose program is supposed to be broad enough to include the study of oceanography, if we try to single out one field like this ?

Do you care to comment on that?

*

Dr. Riley. I certainly would not want to criticize the National Science Foundation, whom I regard as having done an excellent job.

outras disciplinas mencionadas

I do feel that they have not fully recognized the special problems of the interdisciplinary fields that I mentioned, and they cannot, within the limits of their act at present, give them special support.

I do think that these fields, such as meteorology and oceanography and geophysics and geochemistry, at the moment need special support.

*

Mr. Hechler. Just one further question, if I may.

CONCEITO 16

I wonder if you would expand on that phrase —that the National Science Foundation has not fully recognized the importance of oceanography.

*

Dr. Riley. It is simply this: Because of the fact that many of these departments are graduate departments, they have no under graduates to teach and hence cannot supply support for their students in the ordinary way.

These fields are handicapped in their support of students.

*

The other point that I made is that many of them are doing fieldwork.

This applies not only to oceanography but to some of the other fields such as geophysics.

They are doing fieldwork which prevents them from being supported except by rather roundabout means.

*

Mr. Hechler. You mentioned only one university has an undergraduate course in oceanography.

Dr. Riley. That is true.

Mr. Hechler. Would you recommend that oceanography be extended as a subject of undergraduate instruction in other universities?

*

Dr. Riley. It depends upon what kind of oceanographer you want to produce.

For a man who wants to take an undergraduate degree, simply a bachelor's degree, and go into service in, say, fisheries work, or the Hydrographic Office, I think that an undergraduate degree in oceanography is excellent, but if a man wants to go to the top, get his Ph. D., I would be absolutely against it.

It would be much better to do his early work in basic disciplines and then specialize in oceanography at the graduate level.

*

Mr. Hechler. I appreciate your statement, Dr. Riley. It has been very enlightening.

*** CONCEITO 17**

Mr. Karth. Doctor, I was a little touched by the examples you gave of the problems which are suffered by those who are doing graduate or postgraduate work in oceanography as much as I generally am in this whole educational field.

Is it not true, however, that this problem is pretty germane in all areas of graduate or postgraduate work, whether you are talking about medicine, astronomy, or chemistry ?

*

Dr. Riley. Yes, sir; it is.

Over and above this particular bill, I would plead for better support of graduate students in general.

*

Mr. Karth. But this bill and your prepared statement here deal only with oceanography, do they not ?

*

Dr. Riley. The bill, yes.

Our Committee recommendations, yes.

Being an oceanographic committee, we were thinking primarily of our own discipline, but I would be terribly disappointed if this were not an entering wedge which would give better conditions for all graduate students.

*

The Chairman. In other words, you think it should be broadened to include specialists in the earth sciences generally, rather than limit it to one science like oceanography ?

*

Dr. Riley. Yes, sir; I do.

As I say, these interdisciplinary sciences need it most, but certainly we need better support for all graduate students, regardless of discipline.

*

Mr. Karth. Doctor, you say the interdisciplinary sciences.

Would you care to enumerate all of those that you have in mind ?

*

CONCEITO 7

Dr. Riley. Oceanography, meteorology, geophysics, and geochemistry are the main ones in the earth sciences group.

*

Mr. Karth. You stated before, I think, in answer to one of Mr. Hechler's questions, that the National Science Foundation does not give special consideration to the discipline problems of oceanography.

Is it not true that, irrespective of whether we are talking about oceanography or something else, they cannot give special consideration; that their consideration must be in perspective of the whole, the need and the demand, the use, the importance, et cetera ?

*

Dr. Riley. That certainly is correct at the present time.

*

Mr. Karth. One further question.

What did you mean when you said time is running out ?

Would you care to elaborate on this ?

I did not quite get the significance of your statement with respect to this question.

*

CONCEITO 18

Dr. Riley. I was speaking in particular of the Navy problem.

We cannot use our submarines and our antisubmarine defenses efficiently until we know more about the ocean.

Referência AC

In other respects I think time is running out, too, with respect to some climatological problems.

It is quite evident, for example, that, because of the *industrial use of fossil fuels*, the carbon dioxide content of the atmosphere is gradually building up.

This we can expect to have a sort of general warming effect on the earth as a whole, simply because carbon dioxide blankets the earth against back radiation.

*

We know that the oceans have warmed up several degrees in the arctic and subarctic regions during the last few years.

We know that there is more ice-free water in the Arctic. T

his is such a complicated problem that we cannot say definitely that this is cause and effect, but it is something that we need to have concern about.

*

Mr. Karth. Have there ever been other periods in history when this has been true, where the arctic regions have warmed up several degrees and a century later cooled off ?

Dr. Riley. Yes ; there are fluctuations in climate.

We do not know for sure at the moment whether this is a direct result of carbon dioxide or just a variation in solar radiation.

But what is giving oceanographers nightmares at the moment is the hypothesis that was advanced a few years ago by a distinguished colleague of mine and also a member of this Committee, Dr. Maurice Ewing.

Understand, this is just a hypothesis, one of these things that scares us but we do not know whether it is true or not.

He claims that if the Arctic Ocean ever warms up to the point where it is ice free, there will be sufficient evaporation to increase the precipitation over the northern part of the continent, and this will send us irreversibly into an ice age again.

This is a cold war that will really be a cold war for us.

*

Mr. Karth. This is the reverse of what you would expect.

Dr. Riley. Yes.

The Chairman. It is a boomerang.

*

Dr. Riley. You understand there is a terrific argument about this at the moment.

A lot of people think that this would not happen, but it has stimulated a great deal of research on the carbon dioxide content of the air, the interchange of carbon dioxide between the air and the water, as well as a lot of thinking along theoretical lines.

I feel as if in that respect this is a problem we have to solve fairly rapidly.

There, again, time is running out on us.

If Dr. Ewing is correct, within the next 100 years or so we will be forced at great expense to precipitate the carbon dioxide out of our factory flues.

*

Mr. Karth. Of course it is true, is it not, Doctor, if the sun cools off, the earth will cool off correspondingly, eventually?

I do not know what year we are talking about.

I cannot project my thinking that far into the future.

*

Dr. Riley. You are talking about an inevitable event that will come millions or billions of years from now.

In the other case we are talking about something which is almost our immediate future and something we can do something about.

Mr. Karth. In the hypothesis that your colleague propounds, he is not talking about this occurring in the next 100 years.

Dr. Riley. It would take a long time for it to build up.

Mr. Karth. He is talking about this thing happening sometime in the distant future.

Dr. Riley. It would be a matter of slow growth, with the climate gradually worsening.

Mr. Karth. According to the latest statistics, if we have any, what is the rate of growth of carbon dioxide in the atmosphere?

Dr. Riley. I am not enough of a geochemist to give you those figures precisely, but it certainly is a distinctly measurable amount.

*

Mr. Karth. Enough so that you have grave fears that perhaps something will have to be done about it within the next 100 years?

Is that not what you said ?

*

Dr. Riley. Yes ; I think we can expect a change in the climate of one sort or another; perhaps mild, perhaps severe.

The Chairman. In how many years ?

Dr. Riley. We are beginning to feel the effects already, if there is a casual connection.

That, again, we cannot be sure of.

The Chairman. You do not bring it down to this present heat wave ; do you ?

Dr. Riley. No, sir.

Really, I am not trying to scare you or to predict something awful, but these are the things that oceanographers have to think about and work on.

6.b)

Mr. Karth. Does the Navy agree that we must do considerably more work in oceanography before our submarine methods of warfare will be efficient ?

Dr. Riley. We are wholeheartedly in agreement.

*

Mr. Karth. They have made no recommendations along that line to this committee, and that is why I asked the question.

They talked about everything else.

*

6.b)

Dr. Riley. The Geophysical Branch of the Office of Naval Research wrote what they call the tenoc plan, 10 years of oceanographic effort, and their proposal within the limits of certain sciences was very much the same as our own committee recommendations.

They were with us 100 percent.

*

Mr. Karth. To the best of my knowledge, they have not testified here that the submarine warfare they are now entering into is not extremely efficient.

In fact, they state it is so efficient that this is the only way, in their opinion, really to fight an intelligent modern war, such an efficient method of warfare that this is the only intelligent approach to the whole space age theory of nuclear warfare.

*

Dr. Riley. They might very well say that and be correct, yet knowing that some of their methods are not nearly so efficient as they ought to be, particularly this problem of detecting other submarines.

Mr. Karth. Of course, Doctor, we will agree that almost anything that either you or I could think of is not so efficient as it could possibly be, but I suppose the real question is whether or not it is within the realm of possibility.

That is all, Mr. Chairman.

Anexo 6 - 03HR59 - Revelle

Fonte: <https://babel.hathitrust.org/cgi/pt?id=mdp.39015036820085;view=1up;seq=289>
(pp. 67-96)

STATEMENT OF DR. ROGER REVELLE CONCERNING THE OCEANOGRAPHY INVESTIGATION

The next group of speakers will speak about the heat and water problems, the heat and water regimen. Once again our first speaker,

Dr. Roger Revelle, will talk about the water program in oceanography and the future in oceanography. He is the director of the Scripps Institution of Oceanography, University of California, and I suppose it is now called the University of California at La Jolla.

Mr. Thomas. Dr. Revelle, it is nice to see you again.

Dr. Revelle is a member of this committee, too. He is an oldtimer. For the record, I imagine you have a new boat coming up.

Dr. Revelle. I am glad to be here, Mr. Chairman. It is a pleasure to have a chance to talk to this distinguished group of scholars on this committee.

Mr. Yates. It is a good thing we do not have to take a test.

Dr. Revelle. Today I brought along these props. First I brought along a very long statement of some 38 pages.

Mr. Thomas. We will put every word of it in the record.
(Dr. Revelle's prepared statement follows:)

RESULTS OF THE IGY OCEANOGRAPHIC INVESTIGATIONS; FUTURE U.S. AND INTERNATIONAL PROGRAM IN OCEANOGRAPHY

I. IGY Program

Mr. Thomas and members of the committee, it is indeed a pleasure to appear before you again to summarize the U.S. IGY program in oceanography and to discuss with you what we think this program means to the future geophysical work in this country.

CONCEPT 1

Aside from the actual accomplishments of the IGY programs in terms of new discoveries and new and better observations, U.S. oceanographers have also had many opportunities to

meet with oceanographers from other countries and even to participate in work on oceanographic vessels of other countries.

8.a) , 1.a) e 1.a), 10.a) e 10.b)

When I first spoke to this committee in May of 1957, for example, I told you of the very important program carried out in the Atlantic Ocean by Atlantis, of Woods Hole Oceanographic Institution, and Discovery II, operated by the National Institute of Oceanography, England. During the IGY there have been many more such examples.

2.a) - outras disciplinas mencionadas

In the Atlantic Ocean, Argentine, Brazilian, and South African vessels joined Vema, of Lamont Geological Observatory, in cooperative programs, and there was exchange of scientists between the ships of these countries.

Woods Hole scientists worked on Discovery II during several cruises collecting additional important information in the North Atlantic Ocean.

Similarly, in the Pacific, two Colombian frigates played an essential part with our Scripps ships in studying the equatorial counter current.

2.a)

In November 1958 the U.S.S.R. research vessel Vityaz put into port in Vancouver, British Columbia. Dr. Richard H. Fleming of the University of Washington went to Vancouver to visit the ship. He was cordially received and learned that his work and books were well known to the Russian oceanographers.

1.b)

Dr. Fleming had a most informative visit with them. Later, Vityaz put into San Francisco. Her scientists and crew were welcomed by representatives of the U.S. National Committee, by the officials of San Francisco, and many scientists from my own institution, Scripps Institution of Oceanography, who traveled to San Francisco for the occasion.

The Russian scientists conducted an extensive tour on board their vessel and engaged in detailed and thorough exchange of information and scientific ideas. Ten of the Russian scientists were flown to La Jolla where they visited the Scripps campus. Scientific discussions were held with members of the Scripps scientific community. Altogether this was a fine opportunity to inspect in detail one of the largest oceanographic vessels in the world and to learn first hand from our Russian colleagues about their techniques and progress. Vityaz also visited Honolulu just a few weeks ago. The Russian scientists met with American scientists from the various research organizations in Hawaii.

2.a) e 4.1

On other occasions, such as during the Fifth General Assembly of CSAGI at Moscow, American oceanographers who attended this conference participated in scientific discussions with their colleagues from other countries and had the opportunity to visit some of the U.S.S.R. educational and research institutions.

But now I should like to tell you more about the actual U.S. program itself which we have just completed.

Oceanographic work in the Pacific Ocean

1.b)

The Department of Oceanography of the University of Washington completed two very important cruises with their research vessel Broim Hear in the Northeast Pacific Ocean.

They made observations on the flow of water through the Aleutian passes and the exchange of water between the Bering Sea and the Pacific Ocean. They collected deepwater samples in the Aleutian Trench which they are now analyzing chemically and by radioisotope tracers to determine the age and origin of this water. They also made observations and measurements of the anomolous warm-water masses which have recently been observed in the Pacific Ocean. University of Washington scientists have also developed their techniques of chemical analyses to the point where the water samples taken on the cruises were analyzed on board ship and the data were rapidly converted to punchcards. This allowed immediate corrections to be made as well as reductions of the observations to the standard depths used by oceanographers.

8.a)

In the tropical and South Pacific, three extensive cruises were completed by Scripps Institution of Oceanography. When I appeared before this committee in 1958, I described for you briefly some the findings of the first of these cruises :

The mapping of Nasca Ridge, the Albatross Plateau, and the Peru-Chile Trench ; the study of the flow of heat through the Pacific Ocean from the interior of the earth ; and the discovery of areas where low-grade deposits of manganese, cobalt, nickel, and copper exist in very large quantities on the sea floor.

4.b)

Several companies are now giving serious study to the possibility of mining these deposits.

1.a) e 1.b) e 2.b) e 3.b)

In the meantime, the various scientists at Scripps who participated in this effort have worked more on the data taken during the cruise and a comprehensive preliminary report has been published in cooperation with the U.S. National Committee for the IGY, World Data Center A, and the National Academy of Sciences.

In 1958, I also mentioned briefly the preliminary results from the second cruise undertaken by Scripps, when a great subsurface current, flowing toward the east some 3,500 miles long and carrying approximately 1,000 times as much water as the Mississippi River, was explored and mapped. The third IGY cruise shortly thereafter studied the equatorial counter current. They found that, contrary to previous ideas, this eastward flowing current extends downward to at least 1,000 meters and carries twice as much water (about 2,000 times the flow of the Mississippi) as had previously been supposed.

1.a)

The preliminary description of these current systems has already been reported in the scientific literature and comprehensive papers are now in preparation.

Other aspects of the U.S.-IGY oceanography program in the Pacific are the observations taken not on ships but on some 32 islands spread throughout the vast expanse of the Pacific Basin. Some difficulties were encountered at these stations which range from Hawaii to Koror and as far south as Pitcairn.

CONCEITO 2

Heavy waves and hurricanes destroyed some of the instruments and the lack of communication made some of the operations at remote stations difficult. Even so, local inhabitants, schoolteachers, weather personnel, and private citizens cooperated enthusiastically: they kept the instruments in operation and braved rough seas in small boats to take the necessary measurements and water samples.

Scientists at the Scripps Institution are analyzing these data in the hope of understanding the long period waves which are generated by great storms at long distances, the monthly changes in sea level, and the seasonal exchange of water between the Northern and Southern Hemispheres.

Atlantic Ocean

Referência AC

1.b)

Scientists of the Agricultural and Mechanical College of Texas completed cruise with a their research vessel Hidalgo.

They studied currents in the Gulf of Mexico, in the Florida Straits and various tributaries of the Gulf Stream in the western Atlantic. They took many water samples of large volume and

are studying the geochemistry of various metals and radioactive isotopes. These Texas scientists are also engaged in an extensive study of how carbon dioxide is absorbed by sea water.

1.b)

Lamont Geological Observatory carried out long cruises with their research vessel Vema in the southern Atlantic, studying the crustal structure of the ocean in cooperation with ships of other countries ; they studied also the distribution of carbon dioxide, the distribution of radioactive isotopes and made extensive use of underwater cameras and sediment coring apparatus to study the ocean floor itself.

One of their cruises in the summer of 1958 took them around the Cape of Good Hope into the Indian Ocean and from there into the Red Sea, where for the first time two-ship seismic profiles were made in this area of extremely interesting geological structure. The research vessel Atlantis from the Woods Hole Oceanographic Institution cooperated in this part of the Vema cruise. Lamont scientists have also extensively explored the earth crust In the Caribbean. Based on preliminary examination and study of their data they believe that this is an area of continental growth.

Referência AC

The research vessel Crawford of the Woods Hole Oceanographic Institution completed 12 sections across the Atlantic Ocean. In all of these sections many oceanographic stations were occupied and water samples obtained from the surface to the bottom. The temperature profiles across the North Atlantic shows that effects of the Gulf Stream can be seen all the way to the bottom. When the sections are analyzed and the results plotted, scientists will be able to study as never before the large-scale circulation features of this important body of water. One of the products of the Woods Hole work will be a new atlas of the water masses of the Atlantic. Woods Hole scientists have also specialized In the study of certain chemicals and radioactive isotopic components of the ocean water and their determination of the productivity of the ocean is already turning up new and significant information. Scientists from Woods Hole have equipped an aircraft with a carbon dioxide analyzer and have made many measurements of the change in concentration of carbon dioxide with altitude and also along great horizontal distances.

At six island stations in the Atlantic Ocean, observations were made of sea level and ocean waves. Lamont scientists report that storm waves may be useful in forecasting impending severe weather conditions. They have also observed some anomalous changes in sea level and have made important observations on the nature of waves of various periods.

Arctic Ocean

1.b) e 1.a)

Scientists from Lamont, Woods Hole, Air Force Cambridge Research Center and the University of Washington carried out oceanographic observations in the Arctic Basin at the two IGY stations A and B.

Important topographic details were revealed of the floor of the Arctic Basin for the first time. Bottom photographs were obtained and it was found, for example, that rocks and pebbles are scattered along the sea floor at great distances from land. Some of these rocks were recovered by letting the drifting station drag a wire net across the bottom.

When the rocks were inspected they were found to be similar to rocks in north Greenland and Ellesmere Island. It is postulated that icebergs, even pack ice, have rafted these rocks from the edges of the Arctic Basin into its interior.

The distribution of rocks and their time of deposition, determined from examining bottom photographs which reveal how much new sediment was deposited on them, is a new tool for understanding past circulation of this ocean. Some of the sediment cores obtained in the Arctic Basin reveal clues as to the nature of climatic changes during the recent glacial epochs.

Along the arctic coast of Alaska and out to sea for a distance of about 250 miles, Scripps Institution scientists have been making continuous records of tides, and have been studying the bottom geology and the circulation of the water.

A varied biological program was carried out and the biologists examined the underside of the pack ice using "frogman" equipment. Many samples were collected for study at home laboratories.

6.a)

The United States made a great contribution to exploration of the oceans when two atomic powered submarines were successfully navigated under the arctic ice pack.

Although not a part of the IGY program, I thought I should call to your attention the possibilities and implications of this work. These vessels are uniquely adapted to research work in such a region, and we look forward hopefully to their peaceful utilization in the gathering of basic scientific data in otherwise almost completely inaccessible regions of the earth.

Antarctic oceanographic observations

6.a)

Ships of the U.S. Navy Task Force 43 were able to undertake some oceanographic observations during the expeditions each year to the Antarctic.

6.a) e 6.b)

The U.S. Hydrographic Office has published several reports on this work.

6.a)

This Office has also published a most important oceanographic atlas of the polar seas, the first volume of which is devoted to Antarctica. Hydrographic Office oceanographers on board the Navy vessels collected marine specimens for the National Museum, occupied hundreds of oceanographic stations and took many core and bottom samples.

Important observations were also made of the antarctic convergence and several detailed profiles across the convergence were obtained.

Interpretation and implications of the IGY oceanography program

CONCEITO 3

The basic interpretation of the vast quantities of data will take several years.

8.a)

However, a good start is being made through the supplemental funds recommended in 1958 by this Committee and now allocated by the U.S. National Committee for the IGY to the various institutions participating in this program.

In the Atlantic Ocean, we will have a much better idea of the distribution of water masses and of the circulation of water around the edges of the basin and the deep waters from the polar to the equatorial regions. The tracing of various radioactive isotopes, natural and artificial, is already telling us something of the way in which surface waters mix with deep waters. The extensive seismic explorations are yielding important new information on the structure of the earth crust and the changes in the earth crust leading to formation of undersea mountain ranges and deeps. In the Pacific the great equatorial current systems pose important problems to oceanographers studying the general circulation of the ocean. The vast amount of water transported by surface and subsurface currents must be accounted for and our present theory must be examined in the light of these new data. We know that the water of 1,000 Mississippi Rivers cannot just disappear near the Galapagos Islands. But what happens to all the water? In what way does it have effects on the airmasses over the ocean, and on conditions in the great fishing areas in the Pacific?

Where does all the water come from in the western Pacific? An even more interesting question is, Why is there a great countercurrent north of the equator and not a similar one symmetrically placed south of the equator? Scripps Institution of Oceanography is already planning a cruise in 1959 to return to these most interesting currents and to learn more about them. Of equal importance to man and his use of the oceans and his dependence on the ocean for food is the appearance and disappearance of warm surface waters in the Pacific. The

changing water temperature has an important effect on the appearance and disappearance of economically important fish populations.

We have just begun to study properly the waters of the Arctic Basin and their relation with the Pacific and Atlantic Oceans. The Arctic Basin is almost landlocked with very low exchange of water through the Bering Strait and Davis Strait. Most of the water is exchanged in the area of east Greenland, to Iceland, northern Scotland, and Norway. There may be a most significant relation between the exchange of Atlantic and Arctic Basin waters which may be the product, perhaps even the cause, of the great ice ages of the past million years. The internal circulation of the Arctic Basin is also important, as this in turn affects the distribution of pack ice and the navigability of the waters around the edges of the basin.

The Antarctic Ocean is the only place in the world where circumpolar currents can exist without being deflected or stopped by land masses. The antarctic circulation undoubtedly plays a critical role in the antarctic weather, which in turn is one of the most important factors in the circulation of the atmosphere, certainly in the Southern Hemisphere.

CONCEITO 4

The scientific implications of the IGY program are just beginning to be understood and in the next few years, as the scientists continue their extensive study of this data, we will understand more fully what scientific contribution the IGY has made.

However, even now we can say that the IGY, irrespective of the individual scientific discoveries, is playing a most significant role in immediate and long-range planning.

The IGY program has shown us (1) how much we can do in terms of present resources of scientific manpower and equipment, (ii) indicated what directions our immediate and future research might most profitably take, and (iii) has furnished us with clear Ideas as to how we will have to enrich our resources of scientific manpower to accomplish the work that we are convinced should be done by the United States within the next decade.

II. International Cooperation

2.a) e 2.b)

Last year, I informed the committee that oceanographers have been so inspired by the planning and early results of the IGY that a special new international committee was organized by the International Council of Scientific Unions.

A great scientific symposium on recent oceanographic work will be conducted next September in New York, where oceanographers from all over the world will gather and exchange information and ideas.

Outras Disciplinas mencionadas

The United Nations Educational, Scientific, and Cultural Organization, in its natural sciences program, has recently begun to place emphasis on the international development of the sciences of the sea, especially in regions where there has been little emphasis in the past.

To guide this work, which is being carried out in cooperation with the Food and Agriculture Organization of the United Nations, UNESCO has established a nine-man International Advisory Committee on Marine Sciences.

At the same time, the International Council of Scientific Unions, having in mind the successful planning of the IGY program, has established a Special Committee on Oceanic Research, with responsibility for developing an international cooperative program of fundamental research.

UNESCO'S MARINE SCIENCE PROGRAM

The amount of funds available to UNESCO for promotion of scientific research is not comparable to the expenditure of any major country for this purpose.

Consequently, its activities in the sciences must be very largely confined to the planning of international action, facilitation of the making of contacts among scientists of different countries, and exchange of ideas and information.

CONCEITO 5

In accordance with the advice of the International Advisory Committee, the principal objective of UNESCO's marine sciences program is to encourage development of these sciences in regions where little is known about the oceans or the organisms that they contain and where there is economic and social need for increasing the harvest of food from the sea.

2.a)

Up to the present, UNESCO has taken steps toward the realization of this objective by providing (i) fellowships for advanced training of scientists from these regions at major centers of marine research; (ii) intensive training programs, lasting from a few weeks to a few months, for technicians and field workers within such a region; (iii) intraregional conferences that give local scientists opportunities to discuss their common problems; (iv) international symposia, conducted by scientists of wide reputation on general topics in the marine sciences, in countries or regions where these sciences have been little developed; and (v) funds to make possible the joint planning of cooperative observational programs. A modest start has been made in all these directions.

CONCEITO 6

One of the most important proposals made by the International Advisory Committee has been that an international oceanographic ship should be commissioned and operated, either by UNESCO itself, under contract, or by a group of countries in accordance with the pattern for international operation of research facilities set by CERN (Comite Europeen de Recherche Nucleaire).

This ship would be used primarily in such a little-known area as the Indian Ocean and could serve both for obtaining scientific information and as a training ship for younger scientists in the bordering countries.

2.a)

A third area of activity has been that of furnishing scientific assistance to other United Nations organizations; for example, a report on sea and oceanic disposal of atomic wastes has been prepared.

CONCEITO 7

UNESCO, because of its broad educational and scientific responsibilities, can draw the attention of the governments of its member states to the importance of marine research without overemphasizing the prospects of immediate useful results.

It can stress the longer-range possibilities and the value of the marine sciences as a means of introducing science for its own sake.

Finally, UNESCO, as an intergovernmental organization, can, by various means, encourage the member States to maintain policies favorable to international scientific work on the oceans.

2.a)

Examples are the facilitating of exchange of scientists between research vessels and laboratories of different countries in the face of political difficulties, the relaxing of customs regulations and of other barriers to the exchange of scientific instruments for use in international cooperative marine investigations, and the maintaining of freedom of scientific research on the Continental Shelf and offshore waters.

Special Committee on Oceanic Research

outras disciplinas mencionadas

The Special Committee on Oceanic Research (SCOR) of the International Council of Scientific Unions consists of 15 members. Six members were nominated by the International Council of Scientific Unions, four by the International Union of Geodesy and Geophysics, two by the International Union of Biological Sciences and one each by the International Union of Pure and Applied Physics, the International Union of Pure and Applied Chemistry, and the International Geographical Union. This committee held its first meeting at the Woods Hole Oceanographic Institution from August 28-30, 1957 and its second meeting in Paris from September 26-27, 1958. Members present at both meetings were : A. P. Bruun, Denmark ;

G. Bohnecke, Germany ; L. R. A. Capurro, Argentina; G. E. R. Deacon, United Kingdom; M. N. Hill, United Kingdom; C. O'D. Iselin, United States of America; N. B. Marshall, United Kingdom ; Y. Miyake, Japan ; H. Mosby, Norway ; N. W. Rakestraw, United States of America ; R. Revelle, United States of America ; E. Steeman Nielsen, Denmark; and L. Zenkevitch, U.S.S.R. ; Prof. Y. Le Grand of France, and Dr. N. K. Pannikar of India were unable to attend. Representatives of FAO, UNESCO, UGGI, UAT, WMO, and interested national organizations In France, Germany, Finland, Italy, and Sweden were present at the Paris meeting.

CONCEITO 8 / CONCEITO 9

The committee took as its first task that of defining the needs for further international scientific cooperation in the marine sciences. It is clear that, as in other sciences, a very large part of the pioneering research and new ideas concerning the oceans must come from individual scientists or small groups working independently. A broadly based international organization can be helpful, however, in several ways.

It can serve as a sounding board to emphasize the economic and social importance of greater knowledge of the oceans and thereby assist marine scientists in different countries to obtain support for their work.

CONCEITO 6

By arranging wide dissemination of ship-operating schedules, it can help scientists to participate in cruises or to obtain desired data and collections.

CONCEITO 9

By pointing out areas and kinds of observations where work needs to be done, it can encourage more efficient use of research vessels. It can facilitate the exchange of techniques, personnel, samples, and data. By sponsoring or encouraging discussions of ocean research problems at national and International scientific meetings, it can help enlist scientists from other fields. It can arrange for coordinated work at sea by research vessels and shore observatories of different countries in attacking problems where a wide network of observations is needed. It can serve as a mechanism for the standardization and intercalibration of techniques and instruments, and can arrange for the introduction of techniques newly developed in one country or laboratory to other scientific groups elsewhere in the world.

The committee considered that its principal objective should be to encourage and coordinate an international program of observation and measurement In the deep ocean. One point of this program would Involve an intensive effort to understand the relationships between the dynamics of the upper water layers and the populations of plants and animals. Another would be the study of the region below the thermocline down to the greatest depths of the sea, and be neath the sea floor. Because so little is known about this region, its investigation will be, to a large extent, a task of widespread exploration. Such exploration must proceed hand in hand with theoretical studies and development of new techniques by individual scientists, and must supplement rather than interfere with their work.

In making a decision to concentrate its program in the deep oceanic regions, the committee recognized the necessity of geophysical and geological studies of the earth beneath the sea in elucidating the structure and history of the earth.

With regard to the waters and their contained organisms, it emphasized three long-range problems that may be critical to the future welfare of mankind.

The first of these concerns the use of the deep sea as a receptacle for the waste products of our industrial civilization. This may be a particularly important problem in the future, when very large quantities of poisonous radioactive wastes will be produced by the industrial use of atomic power. We need to know whether we can dispose of at least part of these wastes in the deep sea or whether the oceanic circulation or the vertical movements of the fauna will result in too rapid a transport of dangerous material to levels in the sea from which some of the world's food supplies are derived.

The second problem concerns the oceans as an important source of protein food for many of the world's peoples. With the growth of populations, man's need for food from the sea may be expected rapidly to increase. The living resources of the oceans are by no means infinite and, like the land, different parts differ widely in fertility. The fertile areas are those where nutrient trace substances, essential for plant life, are brought up from the deep waters. To obtain the maximum harvest, the processes by which this occurs must be elucidated.

Referência AC

The third problem is perhaps the least well understood of the three. It concerns the role of the oceans in climatic change. During the last 50 years the average temperature over eastern North America and northern Europe has markedly increased, while elsewhere prolonged droughts have destroyed the work and hopes of decades. Will this trend continue over the next 50 years, or will it be reversed? Because we do not have sufficient understanding of the processes that control climate, we are quite unable to make a forecast. Nevertheless, a prediction of future climate would be of inestimable value to society.

The waters of the ocean may play an important role in changing climates.

For example, an excess of heat from the sun can be stored in the deep water and slowly released over many years to warm the air. Likewise, the amount of carbon dioxide in the air controls, at least to some extent, the average air temperature and the loss of heat from the earth. Any change in atmospheric carbon dioxide, for example, by addition from fossil fuel combustion, may be damped or modified by the absorption of carbon dioxide in the ocean waters.

For all three of these problems greater knowledge is required of the rate and character of the exchange between the deep and surface waters of the oceans.

Referência AC

It is only within the last few years that we have been able to make an effective attempt to gain such knowledge through theoretical analysis of the thermodynamics and hydrodynamics of the oceans, laboratory and field experimentation, and the development and field use of new techniques.

Among these new techniques are : the use of natural radioactive substances occurring in the water, such as radiocarbon and tritium, to trace the paths of motion and the mixing of the waters; means for the direct measurements of the deep currents, by following free-floating neutrally buoyant buoys or by using deep current meters (for these it is necessary to maintain a fixed reference position and this can now be achieved by tautly anchoring a subsurface buoy to the sea bottom) ; measurement with a new order of precision of the salt content of the water, allowing the salt to be used as a tracer of the water movements ; measurement of the heat flow from the interior of the earth into the deep water, so that the heating of the water can be used as an index of its time of passage over the bottom ; the possible introduction of relatively large amounts of artificially radioactive substances, of the order of tens of thousands of curies or more, into deep ocean areas and the measurement of the dispersion and transport of this material by the deep currents; detailed biological, chemical, and physical studies of the variations in the sediments of the deep sea floor, to decipher past changes in the water conditions : new methods of high precision for determining carbon dioxide in the water and the air.

CONCEITO 9

Deep sea exploration, because it involves the use of relatively large and heavily equipped ships for long periods, is the most expensive kind of oceanic research.

An adequate program of exploration is beyond the resources of any one country.

Moreover, the total cost will be minimized through planned international cooperation in the use of ships and facilities.

Working groups of SCOR

Five working groups have been formed, each consisting of active research workers in particular fields.

1. Radioactivity in the ocean.— Primary objectives : standardization, intercalibration and exchange of information on analytical methods; coordination of worldwide oceanic measurements of artificial radioactivity : oceanic tracer experiments.

2.b)

Support for meetings of the working group should be sought from the International Atomic Energy Agency, FAO, and UNESCO.

Referência AC

2. Carbon dioxide in the ocean and atmosphere. — Primary objectives : assay of present concentrations in ocean and atmosphere and monitoring changes; study of exchanges between ocean, atmosphere and biosphere ; use of carbon dioxide content and isotopic relationships to characterize water and air masses.

3. Measurement of the productivity of the sea and of the standing crops phytoplankton and zooplankton.- —Primary of objectives : to appraise and recommend methods for worldwide comparisons of organic productivity and standing crops.

4. Physical properties of sea water. — Primary objectives : to appraise the accuracy of present values of the physical constants and to encourage research leading to more accurate values. This is a joint working group with the International Association of Physical Oceanography. An international conference on the subject was recently held in the United States.

5. International Indian Ocean expeditions. —Primary objective: to plan and organize international cooperative exploration of the Indian Ocean. This is the major project of SCOR. The working group must meet as a whole or in part on several occasions and needs considerable financial support.

Continuation of IGT research in oceanography : The most immediate responsibility of SCOR has been to make recommendations about the continuation of the IGT oceanographic research during 1959. The following specific recommendations were made :

1. Sea level spectrum. — It is strongly recommended that the net of stations for sea level recording, supplemented by regular observations of temperature and salinity (density), established during IGY, be continued. Displacement of water from one area to another, changes of volume due to temperature and salinity changes, precipitation, evaporation, fresh water supply from rivers and other processes enter into a complex water balance problem, of interest not only to marine sciences, but also to geodesy, for which the sea level measurements are key values of great importance.

2. Long waves. — A continuation of the international program of longwave recording, on the other hand, does not appear to be much needed at the moment.

Difficulties in taking and in interpreting these observations seem to be due to imperfect instrumentation and to local effects which often dominate the wave spectra. It, therefore, appears more desirable that interested individuals and laboratories continue their studies of these phenomena and in particular of the problems of methods.

2. General circulation of the ocean.—The committee will make a detailed appraisal of the requirements for future work. It considered that work along the following lines should be continued in 1959.

2.a)

- (a) Expeditious publication of data obtained during the IGY, particularly those from the Indian Ocean.

(b) Direct measurements of currents at all depths; for the deep circulation, it is particularly important to study the western boundary currents, e.g., below the Gulf Stream and the Brazil current and in the Tonga-Kermadec region.

(c) Studies of the "age" of the deep water. Ch samples are needed at all depths in high latitudes.

(d) Studies of mixing across the thermocline. Concentration of artificially radioactive substances above and below the thermocline should be measured and studies made of the possible effects on interpretation of the measurements of biological transport across the thermocline.

(e) Continuation of the ICES "Polar Front" program with particular reference to the overflow of water from the Arctic basin to the North Atlantic Ocean.

(f) Studies of the equatorial current in the West Pacific. It is hoped that Japan, in cooperation with the U.S.S.R., if possible, will undertake multiple ship operations.

g) Studies of water motion near the deep sea floor with the help of photographs and direct observations from the bathyscaphes.

(h) Studies of the deep circulation of semienclosed seas such as the Black Sea, Baltic Sea, and the deep basins of the Caribbean Sea.

Referência AC

4. Carbon dioxide in ocean and atmosphere. — We seem to be well on the way toward determining the present average concentration of carbon dioxide in the atmosphere, by means of a program of sampling by airplane, as well as by the results from a number of fixed stations where intermittent or continuous analyses are being made under conditions as favorable as possible for establishing average values.

We are still very ignorant of the rate and extent of the exchange of carbon dioxide between the atmosphere and the ocean. Further study of the conditions of equilibrium between the atmosphere and the sea is necessary and more extensive field work at sea must be undertaken to ascertain the actual relation between the atmospheric carbon dioxide and that in the sea surface, and the dependence of this relation upon meteorological conditions and the biological and other activities in the water. It is important that this phase of the whole study be continued.

The study of the synoptic pattern of carbon dioxide in the atmosphere may have considerable importance to meteorology and certainly has important relations to the primary objective, determining the present average level of atmospheric carbon dioxide.

CONCEITO 10

This study seems to be satisfactorily organized at present, and its support beyond the IGY assured. This support must not be allowed to fail.

CONCEITO 11

5. Geophysical exploration under the sea floor. —What is primarily needed is the use of existing methods ; e.g., measuring heat flow through the ocean floor, and seismic exploration, by more countries, in order to provide a wider network of observations.

Formation of national committees

It was reported that Japan, U.S.A., and U.S.S.R. have already designated national committees as correspondents to SCOR. A draft letter has been prepared inviting other national scientific bodies to take similar action. This letter will also request financial support for the international planning activities and administration of SCOR. Advice will be sought from ICSU.

International Oceanographic Congress

2.a)

The Committee enthusiastically agreed to sponsor, together with UNESCO and the American Association for the Advancement of Science, the International Oceanographic Congress to be held at the United Nations, August 31 to September 11, 1959.

CONCEITO 12

ICSU will be requested to invite its adhering bodies in the different countries to be represented at this Congress and especially to send young scientists. In addition, countries will be asked to send their research vessels, if possible.

International Indian Ocean expedition

outras disciplinas mencionadas

During the past year members of SCOR have been much encouraged by the enthusiasm with which scientists have received the proposal made by the Committee at its Woods Hole meeting, that there should be an international cooperative attack on the scientific problems

of the Indian Ocean. Marine physicists are enthusiastic about the opportunity to study the response of density layering and currents to the changing monsoon winds ; marine biologists are keenly interested in the high and varying productivity of different parts of the Arabian Sea, where there are shifting populations of important food fishes and frequent catastrophic mass mortalities of fish ; geologists and geophysicists have emphasized the lack of knowledge of the submarine topography, sediments, and structure of this vast region.

CONCEITO 11

Partly because of SCOR's emphasis on the problem, U.S.S.R. and the U.S.A. vessels have already undertaken preliminary explorations in the Indian Ocean during the IGY and further expeditions are being planned for 1953-60. The Committee felt strongly that the climax of this work should be an international collaborative effort with many ships during 1961-62. It is anticipated that UNESCO will play a major role in enabling scientists and students from the countries bordering on the Indian Ocean to take an active part in this series of simultaneous expeditions. The expeditions would thus serve not only their primary purpose of research and exploration, but also would have a lasting effect in encouraging and developing the marine sciences and fisheries in those countries. It is estimated that at least 16 ships from 11 different countries could be enlisted. Each research vessel would spend approximately 8 months at sea.

The combined scientific party on all the ships would total around 125 persons; at least 25 of these might come from countries bordering the Indian Ocean area, and it would be desirable to give many of the latter a year's prior training in centers of advanced oceanic research. At least 100 scientist years would be required for working up the results. A program of international cooperation in deep sea research cannot be carried out successfully without the enthusiastic support of existing international marine science organizations. Every effort will be made to utilize their facilities and procedures.

CONCEITO 13

Ideally the total expenditure for a year-long program of multiship exploration would be about \$4 million, largely for ship costs. Half of this amount could come from the normal operating funds for ships and marine research laboratories of the participating countries, but additional funds totalling \$2 million should be raised. Although this is a large sum, it is small in comparison with the results that are expected and with the amounts spent in other kinds of international scientific collaboration.

Important gains would be realized with a carefully planned series of expeditions each consisting of one or two ships or with a limited program for several ships, but the overall value of much of the work will be greatly increased if a large number of ships operate together. The committee* therefore, urges that as many countries as possible should participate in the plan for 1961-62.

Additional projects

SCOR and its working groups are investigating what can be done by more international cooperation (supplementing that of other international associations) in the following ways :

1. Oceanic populations and productivity. —Except in a few cases it is not yet possible to assess the sizes of marine populations at different trophic levels, or the biological productivity on a worldwide basis. Quantitative data are absent or inadequate in many regions, while in others inter-calibration of collecting; and assay methods is necessary.

2. Life histories and distributions of important and interesting oceanic species.—Collections of all stages of the life history should be made by ships of many countries in accordance with problems defined by specialists. To enable these scientists to determine the factors which govern the distribution, careful environmental data should be obtained for each sample.

3. Study of convergences and divergences. — The relations between abundance of organisms and zones of convergence and divergence are not clear and should be studied on a worldwide basis.

CONCEITO 14

4. Appraisal of the status of the marine sciences. — Through its national committees SCOR will attempt to compile information on the status of marine sciences in all countries, including financial support, numbers of scientists and technical personnel, research vessels, and amount of emphasis on different objectives.

5. The best use of existing facilities. — Many creative marine scientists do not now have sufficient opportunity for work at sea. Others who could be enlisted for oceanic investigations do not know of the existing facilities. The Committee believes that this situation can be greatly improved by international exchange of information on ships' schedules and availability, and will attempt such exchanges through its secretariat.

6. Oceanic surveys. — Systematic surveys of the deep sea floor, and of physical properties of the deep water are very inadequate and are greatly needed. These should be carried out by the national surveying organization of the different countries. Standards of accuracy need to be established. This task is too great for any one country, but is well within the capabilities of the major maritime countries working together with a coordinated plan.

7. Cooperation in tracer experiments. —During future years when the present difficulties of making measurements at depths of several thousand meters and of obtaining accurate positions on the high seas have been sufficiently overcome, tracer experiments using large quantities of artificially radioactive material to study deepwater movements and biological transport should be undertaken in appropriate deep sea areas. These will involve very careful international planning and procedures.

Budget for administration of SCOR

Commitments and expenditures for 1058 total about \$4,500 — almost entirely for the Paris meeting. For 1959 approximately \$23,000 are required as follows : SCOR meeting in New York \$5, 000 Administrative assistance and stenographer for SCOR secretary 5,000 Meetings of 2 working groups 10,000

Total 23,000

II. Ten-Year U.S. Program Recommended by the National Academy of Sciences

3.a) e CONCEITO 14

Man's knowledge of the oceans is meager indeed when compared with their importance to him. Recognizing that neglect in this area of endeavor might well result in our being placed in a precarious position from the scientific, technological and military points of view, the National Academy of Sciences-National Research Council decided in 1957 to form a Committee on Oceanography.

outras disciplinas mencionadas

In May of that year President Detlev Bronk appointed Harrison Brown, professor of geochemistry at the California Institute of Technology, Chairman of the Committee. The Committee itself was formed during the following months and its first meeting was held in November 1957. The members of the Committee are:

Harrison Brown (Chairman), California Institute of Technology, Pasadena, Calif. Maurice Ewing, Lamont Geological Observatory, Columbia University, Palisades, X.T. Columbus O*D. Iselin, Woods Hole Oceanographic Institution, Woods Hole, Mass. Fritz Koczy, Marine Laboratory of the University of Miami, Miami, Fla. Sumner Pike, Lubec, Maine, formerly Commissioner, U.S. Atomic Energy Commission.

Colin Pittendrigh, Department of Biology, Princeton University, Princeton, NJ. Roger Revelle, Scripps Institution of Oceanography, La Jolla, Calif. Gordon Riley, Bingham Oceanographic Laboratory, Yale University, New Haven, Conn. Iilner B. Schaefer, Inter-American Tropical Tuna Commission, La Jolla, Calif. Athelstan Spllhaus, Institute of Technology, University of Minnesota, Minne apolis, Minn. Richard Vetter (Executive Secretary), formerly with the Geophysics Branch of the Office of Naval Research, Washington, D.C.

5.a) e 5.b)

The work of the Committee was made possible by the sponsorship of several Government agencies, all of which have interests in the oceans : Atomic Energy Commission, Bureau of Commercial Fisheries, National Science Foundation, and the Office of Naval Research.

3.a)

The Committee has made a survey of the present status of the marine sciences in the United States. It has attempted further to assess the major problems of operations, administration, and funding in this area and to evaluate the probable needs for oceanographic knowledge in the years ahead.

On the basis of its findings, the Committee has drawn up a series of recommendations which, if followed, can result in a strengthening of the marine sciences during the next 10 years to a level which is consistent on the one hand with the assessed needs, and on the other with limitations such as the rates at which ships and laboratories can be built and new oceanographers can be trained.

CONCEITO 14

It should be stressed, however, that the Committee considers its recommendations minimal ones. Action on a scale appreciably less than that recommended will jeopardize the position of oceanography in the United States relative to the position of the science in other major nations, thereby accentuating serious military and political dangers, and placing the Nation at a disadvantage in the future use of the resources of the sea.

CONCEITO 15

In considering the importance of the problems involved, the Committee concluded that the seas present a challenge to man which in magnitude approaches that of space.

At least we have been able to observe the moon, planets, and stars directly with our telescopes. But the ocean depths, shrouded in darkness, have been obscured from our view. We know less about many regions of the oceans today than we know about the lunar surface. Yet we have learned enough to know that major features of the ocean floor — 35,000-foot-deep trenches ; 2,000-mile-long fracture zones ; flat-topped undersea mountains ; broad ocean long ridges ; abyssal plains as flat as a calm sea— are uniquely different from anything either on the surface of the moon or on the land surfaces of earth. How and when were these features formed and why are they so different? An answer to these questions is essential if we are to decipher the history of our planet and its sister planets. Part of the answer lies in the records of ancient earth history locked in deep sea sediments ; part will come from an intensive study of the rocks under the ocean. These studies, combined with studies of the waters and the living creatures of the sea, will also tell us much about the origin and evolution of life on earth.

During the last few years, four great subsurface ocean currents— rivers in the depths of the sea 1,000 times greater in flow than the Mississippi— have been discovered using newly developed current measuring techniques.

We suspect that others exist and we need to know where the waters come from and where they go.

CONCEITO 16

On the practical side, the problems to be solved concerning the oceans are at least as urgent as those of space. How many fish are in the sea? No man knows, nor do we know what determines the numbers of fishes in different regions, the quantities of plant and animal material on which they feed, or what could be done to increase these numbers. We must learn these things if we are to help solve the increasingly acute problems of providing animal protein food for the growing numbers of underfed people in the world. Given more study, man can economically harvest considerably more food from the seas than is now possible. Considering the position of the United States in the community of nations, it seems appropriate, even essential, that we lead the way in this respect.

About a third of the energy of sunlight is used to evaporate sea water. This evaporation and the subsequent condensation are the primary means by which solar energy is absorbed in the atmosphere. There is good reason to believe that changes in the location where interchange of matter and energy takes place between sea and air affect persistent weather patterns. We know that the average weather conditions we call climate can change over a few decades, and we suspect that changes in the storage of gases and heat in the oceans will profoundly influence the process. Studies of the mechanisms of interchange between the air-sea boundaries of regions where intense interchange occurs and of the slow mixing between the ocean depths and the surface which controls storage of heat and gases are essential for further understanding, hence for prediction and possibility of control.

CONCEITO 17

From the point of view of military operations there is no comparison between the urgencies of the problems of the oceans and those of outer space. The submarine armed with long-range missiles is probably the most potent weapon system threatening our security today. It seems clear that the pressures of establishing effective bases, and of protecting ourselves from attack, are relentlessly driving us into the oceans.

outras disciplinas mencionadas

The problems involved in military operations in the sea are enormous. We will not be able to navigate under the oceans with adequate precision until our knowledge is greatly expanded. Nor will we be able to detect submerged submarines efficiently unless we learn far more about the ocean depths than we now know. We will not be in a position to negotiate an adequate international submarine control and monitoring system until we have the ability to make the oceans transparent so that we can track all submarines in the oceans, both our own and all others. To accomplish this, we must place greater national emphasis on research in the marine geophysical sciences, on surveys of the ocean background against which tracking must be accomplished, and on the development of effective devices to achieve such oceanwide surveillance. The Committee's recommendations constitute an essential first step in these directions.

The Committee made five general recommendations concerning basic research, oceanwide surveys, applied research, allocation of support responsibility among Federal agencies, and the role of private foundations, industry, and the States.

CONCEITO 18

1. Basic research. — The key to the growth of oceanography in the United States lies in basic research — research which is done for its own sake without thought of specific practical applications.

The very nature of basic research is such that the problems which will be attacked and the results which will be obtained cannot be predicted.

CONCEITO 19

The very nature of applied research is such that its success depends upon the size of the reservoir of fundamental knowledge upon which it must draw. The rate of progress in the applied marine sciences will be determined in the long run by the rate of progress in the basic marine sciences.

The Committee has concluded that both the quantity and quality of basic research in the marine science-; can and should be increased substantially during the years ahead. Specifically the Committee recommends:

The U.S. Government should expand its support of the marine sciences at a rate which will result in at least a doubling of basic research activity during the next 10 years.¹ It should be emphasized that doubling the basic research activity will require more than doubling the total expenditures.

A large part of the deliberations of the Committee were devoted to discussions of the conditions under which basic research can flourish. First and foremost, progress depends upon the interests, experience and creative imaginations of individual scientists. But the individual scientists does not work in a vacuum. He must have instruments and facilities. He must live in an atmosphere which is conducive to creative activity. These necessities in turn give rise to problems involving marine research laboratories — problems of leadership, financial stability, flexibility, growth, academic associations, and physical facilities.

2. Oceanwide surveys. — Not only for research but in order to exploit and use the oceans we need more detailed knowledge which can only be obtained through systematic surveys in three dimensions. These surveys should include such features as depth, salinity, temperature, current velocity, wave motion, magnetism and biological activity. It is essential that these surveys be conducted on an oceanwide ocean-deep basis as quickly as possible. Our knowledge is now largely limited to waters 100 miles from shore and even here it is inadequate for present and future needs. Accordingly, the Committee recommends : The increase in support of basic research should be accompanied during the next 10 years by a

new program of oceanwide surveys. This will require a twofold expansion of the present surveying effort.

outras disciplinas mencionadas

3. Applied research and development. — We believe that, on a long-range basis, basic research coupled with systematic ocean surveys are of paramount importance in solving a number of urgent practical problems involving military defense, the development of ocean resources and possible future increases of radioactive contamination of the seas resulting from the rapid development of atomic energy. However, research and surveys must go hand in hand with a vigorous and imaginative applied research and development program. Accordingly, the Committee recommends :

The United States should expand considerably its support of the applied marine sciences, particularly in the areas of military defense, marine resources and marine radioactivity.

4. Proposed allocation of support responsibility among Federal agencies. — The implementation of these general recommendations requires action upon a number of broad fronts. More marine scientists must be educated. Additional ships and shore facilities must be built. New instruments and techniques must be developed. International cooperation in the marine sciences must be strengthened.

To achieve these aims in the next 10 years will necessitate many agencies of the Federal Government working together both in planning and in providing moneys.' Taking into account the relative degrees of interest and importance of oceanography to Individual agencies, the Committee recommends : The Navy and the National Science Foundation should each finance about 50 percent of the new basic research activity except ship construction. The Navy should finance 50 percent of the new research ship construction with the Maritime Administration and the National Science Foundation sharing the remainder. The Navy, through the Hydrographic Office, should finance 50 percent of the deep ocean surveys, while the Coast and Geodetic Survey should finance the balance. The Navy should sponsor completely all military research and development operations. The Bureau of Commercial Fisheries should finance the greater part of the recommended ocean resources program. The Atomic Energy Commission should finance the major part of the research dealing with the problems of radioactive contamination of the oceans. The National Science Foundation and the Office of Education should sponsor jointly the proposed program for increasing scientific and technical manpower in the marine sciences. Efforts aimed at fostering international cooperation in the marine sciences should be sponsored by the Department of State, the International Cooperation Administration and the National Science Foundation.

Other agencies should take responsibility for certain aspects of the proposed program, particularly the Public Health Service, the Geological Survey and the Bureau of Mines.

CONCEITO 20

5. Support from non-Federal sources. —Although the bulk of oceanographic research and survey work must of necessity be financed by the Federal Government, the value of State and private funds cannot be overestimated. Such funds are especially helpful for supporting initial exploratory basic research and for starting new laboratories. Accordingly, the Committee recommends:

Private foundations and universities, industry and State governments should all take an active part in the recommended program of expansion.

Education and manpower

1. In order to finance new faculty in oceanography at existing or new teaching centers, the U.S. Government should provide funds on long-term commitments. This Committee recommends that about \$500,000 per year be appropriated for salaries and the equipment and indirect costs associated with such positions. This program could be operated through the Office of Education.

8.a) e 8.b)

'One method suggested for developing more effective Interagency cooperation is through the proposed Federal Council for Science and Technology. This Council is described in "Strengthening American Science." a recent report of the President's Science Advisory.

2. In order to attract competent graduate students to the long and somewhat arduous schooling required of well-qualified oceanographers, it will be necessary to provide substantial long-term fellowships. It is believed that 80 fellowships should be supported on a 5-year basis and at an average stipend of \$3,500 to \$4,000 per student each year. This will produce 12 to 15 new Ph. D.'s per year (allowing a reasonable attrition factor) at an annual cost of about \$300,000.

This would provide approximately one-third of the student support that will be needed in order to double the number of oceanographers at the Ph. D. level during the next 10 years. It is desirable that fellowships permit students to attend more than one university. This can provide students with well-rounded educations in all branches of oceanography without each university having to provide a full curriculum.

Such a program should be handled through the National Science Foundation.

New ships for research, development, and surveying

1. A shipbuilding program should be started aimed at replacing, modernizing and enlarging the number of oceangoing ships now being used for research, surveying, and development. Specifically in the period 1960-70 the research, development, and survey fleet should be increased from its present size of about 45 ships to 85 ships. Taking into account the replacement of ships which must be retired during the next decade, this means that 70 ships should be constructed at a total estimated cost of \$213 million.

2. The size ranges recommended for new oceangoing ships are about 500 tons, 1,200 tons and 2,200 tons displacement.

CONCEITO 21

3. The conversion of vessels, which were originally designed for other purposes, into research, development, or survey vessels is to be discouraged. Such conversions are generally uneconomical.

4. The recommendations for the construction of ships for specific purposes (basic research, military research and development, oceanic surveys, resources and fisheries) are given in table 1.

5. The recommended size distribution for new ships is given in table 2.

6. The Navy should provide about 50 percent of the financing for the construction of new ships for basic research, all of the financing of new ships for military research and development, and 50 percent of the financing for new ships for oceanic surveys. The Coast and Geodetic Survey should provide 50 percent of the financing for the construction of new ships for oceanic surveys. The Bureau of Commercial Fisheries should finance the construction of all of the new ships for marine biological resources and fisheries studies. The National Science Foundation and the Maritime Administration should each provide about 25 percent of the financing for new ships for basic research.

7. Estimated capital costs by year and by agency are given in table 5, based upon the assumption that a 500-ton ship will cost about \$1.65 million, a 1,200- 1,500-ton ship will cost about \$3.80 million and a 2,000-ton ship will cost about \$5 million.

8. The Maritime Administration should be consulted in the designing of all ships paid for from public funds and used for marine studies.

CONCEITO 22

9. Research ships operated by private institutions like those operated by the Navy, Coast Guard, and Coast and Geodetic Survey should be exempt from those existing legal requirements for living accommodations, safety and the licensing of crews, which are practical and sensible only on large (3,000 tons) merchant ships.

CONCEITO 23

10. All noncombatant surface ships used for research, development or surveying should be operated by the laboratory or agency directly concerned and should have civilian crews.

11. In most cases the annual costs of operating vessels for basic research by non-Government laboratories should be paid for separately from the other expenses of research, for example, through a long-term facilities contract distinct from any research contracts.

12. The costs of ship operations paid by the Federal Government should be subdivided as follows: the Navy should pay for 50 percent of the operational costs of ships used for basic research, all of the operational costs of ships used in military research and development and 50 percent of the operational costs of ships used for oceanic surveys.

The Coast and Geodetic Survey should pay for 50 percent of the operational costs of ships used for surveys. The Bureau of Commercial Fisheries should pay for the operations of ships used for resources and fisheries studies. The National Science Foundation should pay for 50 percent of the operational costs of ships used for basic research.

1.a). Estimated costs of ship operations, both by function and by agency, are given in tables 6 and 7.

Shore facilities for basic research

CONCEITO 24

In order to derive the maximum knowledge from observations and collections made at sea, it is estimated that 60 technical persons must be available for the average ship involved in high seas research activity. Most of these persons are involved in land-based activities which require laboratories and associated facilities.

1. It is recommended that for every additional oceangoing research ship put into operation, an average investment of \$1.5 million be made for essential shore facilities. These costs should be divided between the Navy and the National Science Foundation.

2. It is estimated that the costs of research other than ship operations will average about \$1.2 million per ship per year. The committee recommends that Federal funds for this purpose be divided between the Navy and the National Science Foundation.

Oceanwide surveys

1. The committee recommends that for every new survey ship put into operation an investment of about \$0.75 million be made for essential shore facilities.

2. It is recommended that an average of \$0.75 million be allocated each year for the operation of shore facilities for each new survey ship placed in operation.

These costs should be divided between the Navy and the Coast and Geodetic Survey.

3. Consideration should be given to conducting some aspects of the survey program through contracts with commercial organizations and private institutions.

Engineering needs for ocean exploration

1. A vigorous program should be conducted for the development of manned submersibles that can operate down to and on the bottom of most of the ocean : (a) An improved bathyscaphe using the best materials and techniques available should be designed and built immediately.

(6) Following up the recent commendable ONR action in bringing the bathyscaphe Trieste to the United States, it is recommended that funds be made available for a mother ship together with auxiliary equipment in order to make maximum use of this deep submersible.

(c) A continuous design and development program should be initiated aimed at building deep and mid-depth manned vehicles as the need arises and as the state of the art progresses.

2. The need for open-ocean manned research platforms which are stable, and which can remain in place so that time studies can be made, seems essential and the design for such a buoy should be started.

3. A major program should be supported aimed at developing and using anchored and drifting buoys for obtaining space and time coverage of ocean characteristics.

4. It seems likely that aircraft can be used effectively for some research and surveys on the open ocean, particularly for studies involving the joint problems of oceanography and meteorology. Nearly all laboratories will need single-engine planes; several will need twin-engined amphibious planes; some will need four-engine commercial-type aircraft.

5. Surface icebreakers are of limited value to arctic oceanographic research compared to properly equipped submarines. Efforts should be made to develop a submarine capable of breaking into and out of the ice.

6. Instruments should be developed for survey purposes which are more accurate, effective, and trouble free than those now in use. The techniques needed to use them more effectively should be developed. Specialized devices such as Loran C, inertial navigation equipment, gravity meters, and stable platforms should be made available for research as well as surveys as soon as possible.

7. A major program aimed at developing new high-seas engineering techniques should be started. Our abilities to handle heavy equipment and to conduct such operations as drilling and bottom sampling at sea limit our operations at present. Many of these difficulties would be appreciably lessened given proper effort. We have not included the very important problem of drilling to the Mohorovicic discontinuity in our budget because another academy group is studying this problem.

8. Machine aids to computation and data storage have much to offer and should be budgeted.

9. High pressure facilities to permit controlled physical and biological experiments in the laboratory are needed.

10. Efforts should be made to secure the active participation of private industry in the development and manufacture of new devices and instruments for oceanographic research and surveying.

11. The unpredictable aspects of new devices make difficult the formulation of an exact budget over a 10-year time scale. The Committee recommends that \$48 million be allocated during the next 5 years. It further recommends that a minimum of \$10.5 million be allocated each year thereafter. The cost of this program should be divided between the bureaus of the Navy and the National Science Foundation.

Radioactivity in the oceans

The widespread use of nuclear energy for peaceful or military purposes necessitates studies to determine the effects of radioactive contamination upon the oceans and the life therein.

3.b) e 3.a)

The Committee on Effects of Atomic Radiation on Oceanography and Fisheries in its report to the National Academy of Sciences made certain general recommendations concerning national policy in this area. Both the Committee on Oceanography and the Committee on Effects of Atomic Radiation on Oceanography and Fisheries believe that more specific and detailed recommendations can now be made.

CONCEITO 25

1. A single agency should be given the overall responsibility and authority for regulating the Introduction of radioactive materials in the oceans. Monitoring of disposal sites should be done by some agency other than the regulating agency.

It is recommended that either the Coast and Geodetic Survey or the Public Health Service be made responsible for engineering studies in and near disposal areas, for routine monitoring of disposal areas and their surroundings and for a continuing assessment of the effects on the environments of added radioactive materials.

2. Vigorous programs should be started for the purpose of determining the circulation and mixing processes which control the dispersion of Introduced contaminants in coastal and estuarine environments and in the open ocean.

These studies represent the major part of the proposed budget in this area.

3. A program should be pursued aimed at determining the inorganic transfer of radioactive elements from seawater to the sediments.
4. Studies should be made of the effects of living organisms on the distribution of radioactive elements introduced into the sea.
5. The genetic effects of radiation upon marine organisms should be studied.
6. A variety of biological field experiments should be conducted utilizing radioisotopes.

It is estimated that 10-year costs of new research in this area will be about \$44 million.

Ocean resources

Lack of adequate understanding of the occurrence, behavior, and potential harvest of fish and other marine organisms serves as a serious barrier to extensive economic development and utilization of marine biological resources.

Existing knowledge is inadequate to evaluate the feasibility of creating a marine mineral industry.

1. The sea and its contents should be studied on a broad basis to enlarge our knowledge of its potential resources.
2. In order to elucidate the problem of population fluctuations of commercial fish stocks, which in large part is due to variable infant mortality, laboratory studies of the survival requirements of larval and juvenile stages of commercially important fish and shellfish are needed urgently.
3. There is an urgent need for facilities for studies of fish behavior in the laboratory under controlled conditions. This will require aquarium facilities of sizable physical dimensions.
4. Greater attention should be given to studies of the genetics of fish and other marine organisms.
5. Investigations should be made of the feasibility of adding nutrients to the euphotic zone of the sea in order to increase the productivity of marine organisms.
6. A program to investigate the possibilities of transplanting useful organisms from one region of the sea to another should be conducted.
7. More research is needed on the nature of the aggregations of organisms in the sea.

8. Biological surveys in the seas should be intensified, and programs should be initiated aimed at utilizing new devices such as unmanned buoys and the mesoscaph.

CONCEITO 26

9. A data center for all oceanographic research should be established for the storage, routine processing, and "read-out" of such information as sea surface temperatures, currents, and meteorological data. This data center would not perform the functions of more specialized computing centers such as will be required for oceanographic forecasting.

10. There is a need for scientific, sociological, and engineering studies directed toward the wider utilization of marine products in protein-deficient areas of the world.

CONCEITO 27

11. There is a pressing need for studies of the economic and legal aspects of commercial fisheries, especially in comparison with other industries, in order to provide a basis for national policy decisions.

CONCEITO 28

12. A scientific study of salt water fishpond culture should be started, aimed at providing a basis for greatly increasing the efficiency and productivity of this industry and thereby increasing the protein food supplies in protein-deficient areas such as southeast Asia.

13. Many aspects of the potential mineral resources on the deep sea floor should be investigated. Such work should be supported through the Bureau of Mines.

14. An expanded program of estuarine research is recommended in order that we can make most effective use of this habitat of important resident stocks of food fish and shellfish and the nursery areas for other stocks which are later harvested from the open ocean.

5.b)

15. Many lines of marine research depend upon precise definition of species. The study of species is centered in research museums which generally have been supported very poorly.

It is recommended that established museums having significant study collections be given financial support so that this kind of work can be carried forward.

16. It is recommended that a program on diseases and other toxic effects in the marine environment be established.

A 10-year operating budget of \$78 million is proposed. The mineral resources investigation should be sponsored by the Bureau of Mines with the balance being supported by the

Bureau of Commercial Fisheries through grants, contracts and in its own laboratories and with the assistance of other branches of the Department of the Interior.

Programs involving international cooperation and technical assistance to other countries budgeted under this heading should be supported at least in part by the International Cooperation Administration and the State Department.

International cooperation

It is clear that, as in other sciences, a very large part of the pioneering research and new ideas concerning the oceans must come from individual scientists or small groups working independently. But international cooperation in work at sea is essential in several kinds of marine research and should also greatly facilitate surveys of the ocean floor and of the waters.

There is at present a high level of international cooperation among physical and chemical oceanographers of different countries resulting from the International Geophysical Year. This cooperation should be maintained and broadened throughout all aspects of the marine sciences, particularly including biology. To this end, the Committee recommends :

1. The United States through the National Science Foundation should give its proportionate share (amounting to perhaps \$20,000 per year) of financial and other support to the Special Committee on Oceanic Research of the International Council of Scientific Unions. The Committee on Oceanography has been designated as the U.S. National Committee for this long-range cooperative program.

2. Grants should also be sought from foundations and governmental sources to support special projects such as the proposed year-long international expedition to the Indian Ocean by covering the increased expenses to United States oceanographic institutions and by making the participation of other countries possible. Special funds needed for the Indian Ocean project are estimated at about \$2 million.

CONCEITO 29

3. An intergovernmental conference of the maritime countries should be called, after suitable preparation, to discuss means by which the governments can cooperate in increasing man's knowledge of the oceans. Specifically, agreements should be sought regarding the means of carrying out oceanwide surveys, including allocation of responsibility to different countries, intercalibration of techniques, and free exchange of data. It would be expected that the United States proportion of this international responsibility for surveys would be about the same as its proportion of financial responsibility for support of United Nations agencies. This conference should be a first step toward the establishment of a World Oceanographic Organization; a United Nations specialized agency corresponding to the World Meteorological Organization.

- 4 .In the study and conservation of the living resources of the sea, regional international organizations, such as the various international fisheries commissions, have proven effective.

CONCEITO 30

In developing formal intergovernmental cooperation in the marine sciences, the Federal Government should give special emphasis to the establishment and adequate support of such regional organizations, and should seek to broaden their charter to allow an integrated research program on all aspects of a particular oceanic region.

5. IN order to increase the effectiveness of cooperation between U.S. marine scientists and laboratories and marine scientists in other countries, the U.S. State Department should be prepared to assist positively, sympathetically and promptly in facilitating research ship operations and the exchange of information, persons, equipment and supplies.

6. The need for Increased protein foods from the sea is especially urgent in underdeveloped countries. The International Cooperation Administration in Its programs of technical assistance should give greater emphasis to marine resources surveys and to research projects and training programs in the marine sciences. The Federal Government should also encourage United Nations specialized agencies such as UNESCO and FAO in their efforts to aid underdeveloped countries to achieve greater utilization of marine resources. The funds needed for both these purposes have not been budgeted separately in this report but are included in the budget for ocean resources studies.

Budget and operations

CONCEITO 31

Concerning the actual funding and operations', the Committee recommends : 1. A higher percentage of longer term funding must be made available in oceanographic research. Past funding has been inefficient, and has held back much longer term imaginative research. A reasonable portion (30 to 50 percent) of the annual operating budget should include 5-year money which is refreshed annually. Existing laws permit allocation of many funds on a 5-year basis.

CONCEITO 23

The military is accustomed to making long-term commitments of 5 to 10 years when they adopt a new weapons system and it is equally essential that they make long term commitments for research.

CONCEITO 32

3. Administrators of research and laboratory directors must have a higher percentage (25 to 50 percent) of their funding free to spend on those good research problems which emerge without the benefit of planning.

5.a), 6.a), 6.b)

4. Government organizations which presently fund or carry on extensive research and development in oceanography should continue to do so in the field of their special interests. For example, the Navy, the Atomic Energy Commission, and the Bureau of Commercial Fisheries all have their own important oceanographic problems.

CONCEITO 33

It is recommended that each bureau and organization sponsor and finance much of the research which it needs to meet the demands of its present and future objectives. Any duplication of effort which might be involved appears trivial compared to the value of insuring that scientists are in close touch with changing bureau problems.

5. There will still remain a need for a great deal of research which should be funded by the National Science Foundation. This agency should carry a much heavier portion of the long-term basic research in the Nation. A reasonable percentage of grants should be made to individuals and a reasonable portion should be allocated for long-term funding of institutional activities such as vehicles, facilities and major expeditions.

CONCEITO 34

6. Foundations, States and industries should take an active part in the support of marine research. Their support is particularly valuable in new and unusual research programs, in filling technological gaps and through appropriate assistance insuring that private laboratories and academic groups do not become solely dependent on Federal assistance.

Dr. Revelle. Second, I thought it would be well to have both the Pacific Ocean, which, as you know, is the real ocean covering about half the world, and the small canal called the Atlantic Ocean represented here, I brought along a personal prop in the form of the Director of the Woods Hole Oceanographic Institution, Dr. Paul Fye.

Mr. Thomas. We are glad to have you.

Dr. Revelle. This is one of the nuggets that was spoken of.

Mr. Thomas. How deep did you get this one ?

Mr. Yates. What is it *

Dr. Revelle. I will get to it.

Mr. Yates. It sounds like a mystery story.

OCEAN CURRENTS —ATLANTIC

Dr. Revelle. I thought I would first talk briefly about a few of the outstanding results of the IGY program in oceanography. Perhaps the most interesting and far reaching was the work done on the currents below the surface of the sea. Ever since the days of Benjamin Franklin and, in fact, long before that, people have been aware of the fact that the surface waters of the ocean move in great currents as, for example, the Gulf Stream. Any globe or any map of the earth usually has a picture of these surface currents.

However, it is only within the last few years that it has been possible for us to determine that the ocean waters below the surface are also moving and we have just very recently developed methods of measurements and methods of analysis that will enable us to understand movements of the waters below the surface. A typical thing about the oceanographic work of the past has been that it has been exploration. People have gone out and made measurements and recorded them and described what they measured or what they observed. It has not been possible in this science of oceanography until quite recently to use a standard method of science, namely, to have a hypothesis first, to have some theory that you want to test or some question you want to ask, but it is now becoming possible. Dr. Henry Stommel of the Woods Hole Oceanographic Institution made a prediction about the currents in the western Atlantic

Ocean; namely, that underneath the Gulf Stream there would be found a current flowing in the opposite direction, from north to south, of rather high velocity, a velocity of about a half a mile an hour, and of very large magnitude. At the beginning of the IGY the ships of the Woods Hole Oceanographic Institution and of the British National Institution of Oceanography made some measurements to test this hypothesis of Stommel's to ask the question of the ocean to see if they could get an answer and, lo and behold, the current existed. There is a current flowing underneath the Gulf Stream from north to south in just exactly the opposite direction.

DISPOSAL OF RADIOACTIVE WASTE

8.b) CONCEITO 34

Mr. Thomas. If you will yield, Doctor, when the Atomic Energy Legislative Committee meets on the subject of disposal, we certainly must have you there. Doubtless you have done a little thinking.

With these crosscurrents, one at one level in one direction and one at another level going in the opposite direction, would it be wise to have a lot of study made before great quantities of harmful and poisonous atomic waste material are dumped in the ocean?

Dr. Revelle. It certainly is highly desirable to make more careful surveys and careful analyses of the measurements before we dispose of very large quantities of radioactive wastes.

This has been considered by several committees of the National Academy of Sciences and by the Atomic Energy Commission. I think we can say at the present time two things.

One of them is that low-level waste can be disposed of fairly near shore in quantities of the order of a few hundred curies per month, let us say, in certain areas, not everywhere, but in

carefully selected areas. The quantities may be increased, as has happened for Windscale, in the Irish Sea, to perhaps as much as 10,000 curies a month of low-level waste.

The second thing we can say is that it is quite certain that in the deep ocean we could dispose at the present time, of quantities of the order of a few million curies without doing serious harm to any of the other resources of the sea. Whether we could dispose of the very large quantities of atomic waste that will be produced in the future of the order of thousands of millions of curies is not by any means clear at the present time.

Mr. Thomas. It is a wonderful and sensible statement. It looks to me that perhaps the answer to the whole problem is further research in the subject of disposition of those materials. I think science will come up with the answer in 3, 5, 6, 7, 8 or 10 years, where the disposal of that product will be comparable to taking a pig to the slaughterhouse. They will not even lose the squeal. You will use all of that material and perhaps if you were to throw it away now, you would be throwing away a wagonload of money. Excuse me for interrupting.

Dr. Revelle. This is something I should add. No nation at the present time has plans for disposal of high-level waste in the ocean.

The engineers are thinking about storing it, continuing to store it on land or disposing of it in, for example, deep salt deposits on land.

Dr. Bronk. The committee might be interested in the findings of that previous committee of yours on the concentration of radioactive elements by marine plants and animals.

Dr. Revelle. This is a real problem, that marine plants and animals tend to concentrate radioactive materials by factors of 10 to 100,000 over the concentration in the water. This is what makes it difficult to make predictions about how much can be disposed of.

Mr. Thomas. Go ahead, sir.

PACIFIC CURRENTS

Dr. Revelle. I was talking about the fact that it was actually possible to test a hypothesis. This is very rare in these earth sciences.

Another example of the discoveries on the subsurface circulation made during the IGY is the work done in the equatorial region of the Pacific by United States, Japanese, and the Columbian ships. Here the charts show very definitely a fast-moving current right at the Equator going to the west, moving at a speed of about 2 knots or about 21.2 miles an hour, A very broad stream of water. Oceanographers in that region a few years ago lowered some fishlines into the water, down to depths of several hundred feet, and instead of moving to the west, as they thought they ought to. Judging by what was on all the charts, they moved to the east. They said, there must be something wrong with our navigation. This just cannot happen.

Everybody says the water here is moving to the west. However, it was felt desirable to look into this further. During the IGY a half dozen ships spent about 2 months right along the Equator, and it was found again that there is a subsurface current moving in the opposite direction. This is a great river of water actually shaped like a ribbon, some 2.50 miles wide and about a thousand feet thick. Its top is about 200 feet below the surface of the sea and its bottom is about a thousand or 1,200 feet below the surface of the sea.

This enormous mass of water is moving to the east at a speed of about 2*A knots. It is a great ribbon or river in the sea moving to ward the east. Underneath it is a third current moving toward the west, a very much thicker current, very much deeper but more slow moving, moving at only about a half mile an hour.

Mr. Thomas. What about the width?

Dr. Revelle. We do not know about the width of the deep one.

We know the width of the middle one. The high-speed one moving toward the east is about 2.50 miles wide and about a thousand feet thick.

Mr. Yates. Did you not trace that to a group of islands?

Dr. Revelle. This is just in the Pacific. We traced it 3,500 miles from an area south of Hawaii east to the Galapagos Islands. There is a curious thing about this current. It is not certain whether it exists east of the Galapagos Islands. It seems to come up to the Galapagos Islands and stop. What in the world happens to the water? Does it go into a big hole in the ground? It seems unlikely.

The water must turn to the north or turn to the south or something, but we have no idea at the present time what happens to it. This is one of the things we are dying to go down and have a look at.

Mr. Yates. Can you go down that deep ?

Dr. Revelle. I was thinking of going down to the Equator and lowering measuring instruments. This great current has a great transport of water, a river a thousand times the volume of the Mississippi River.

Another example was a study of the equatorial countercurrent to the north of the Equator, which had always been thought to be a very shallow current, and it turned out to be at least 3,000 feet thick and to carry about three times as much water as everybody had thought previously, about 2,000 Mississippi Rivers. It is a huge current, very much bigger than had previously been thought.

Our whole conceit of the general circulation of the ocean, where the water comes from and where it goes and how these currents are connected, has now been thoroughly upset. In this field of the IGY at least, as so often happens in science, we know more now than we

did before, but we know the problems facing us are much greater and more complicated than the problems we started with.

HEAT FLOW THROUGH THE CRUST

Another development of the same kind was the study of the heat flowing from the interior of the earth through the sea floor. Some measurements have been made prior to the International Geophysical Year. These measurements suggested that we would find a pattern on the sea floor, that underneath ridges such as, for example, the mid-Atlantic ridge, which is the spine of the Atlantic Ocean, and the great Albatross Plateau, which extends from Antarctica north to Mexico in the Pacific, we would find a lot of heat coming from the interior of the earth, whereas, along the South American coast and great gashes or trenches that parallel the coast and lie quite close to it, we would find a very small amount of heat coming from the interior of the earth.

outras disciplinas mencionadas

During our Downwind expedition during the first part of the IGY, a great many measurements were made of the heat coming from the interior and indeed this proved to be the case. The heat flow coming from the earth underneath the ridge was about seven or eight times the average value, so high that if your previous ideas about how it got out were correct, namely, that if it were simply conducted out like heat is conducted along a rod—that the rock would be molten at a depth of a few miles. Actually we know from seismology that the rock is not molten. Something very funny is happening here to give this enormous quantity of heat in this area.

On the other hand, west of that area, between the two and the Equator, the heat is very low. There is a real pattern to this heat flow from the interior which strongly suggests that in fact the inside of the earth is like porridge that is being heated and slowly turning over and carrying heat by what is called convection.

OCEAN BOTTOM DEPOSITS

The third interesting discovery was the discovery of the extent of these materials here.

This [indicating] is a crust of manganese dioxide and this is what is called a nodule of manganese dioxide. Each of these contain about 25 percent manganese and somewhere between a half and 1 percent of nickel, a half and 1 percent of cobalt, and about 1 percent of copper.

Mr. Yates. Where do you find them ?

Dr. Revelle. These occur over very large areas of the sea floor and the IGY theory is that the abundance of this material and its extent— I can give you some figures on this —the metals in this material are worth about \$45 a ton. There are somewhere between 15,000 tons per square mile and 120 tons per square mile over millions of square miles in the Pacific.

We also believe that they exist over very large areas of the Atlantic.

Dr. Bronk. How much does it cost to get them up ?

Dr. Revelle. The depths range from 1,500 feet to fifteen to twenty thousand feet

CONCEITO 35

Mr. Yates. You can offer competition to Arizona one of these days?

Mr. Rhodes. That is what I am afraid of.

outras disciplinas mencionadas

Dr. Revelle. The Mineral Technology Division of Berkeley has looked into the possibility of mining this material and recovering it. Their report is quite optimistic, but my own opinion is that it is way too optimistic. Nevertheless, it does seem that something should be further investigated. For example, it might be very well that you could actually extract the metals in this material, transport them to where you want them, recover the material, and extract the metals and transport the material for somewhere around \$30 a ton, giving about a \$15 a ton profit.

This may be way overly optimistic as a figure, but nevertheless it should be thoroughly investigated.

U.S.S.R. oceanography

CONCEITO 14

One other result of the IGY has been that we have been able to get a better appraisal of Russian oceanography.

CONCEITO 1

For example, when the Russian ship Vityaz was in San Francisco a few weeks ago, a lot of people went up to look at it, and I think that our present feeling about Russian oceanography is that it is a very effective survey operation on a very large scale and growing larger all the time whereas American oceanography has tended to go beyond the survey type of thing toward asking and attempting to answer questions about the ocean.

Mr. Yates. If I understand you correctly, it is more like our Coast and Geodetic Service?

Mr. Revelle. No; I do not mean that. Scientific oceanography and the study of temperature and currents and so forth, the Russians are doing in a sort of systematic routine, in what strikes one as a fairly unimaginative way or on a fairly unimaginative basis.

Mr. Rhodes. Would you yield at that point? Is there any great amount of benefit to be derived from all of that information in as massive a quantity as they are apparently trying to get it?

Dr. Revelle. I think there is a very great need for knowing it from a variety of points of view.

Mr. Rhodes. I mean, a superficial knowledge like the Russians seem to be getting by their survey methods ?

Dr. Revelle. I think that is an essential requirement in understanding the ocean, to have more adequate surveys. I will come to that in just a minute.

FUTURE PROGRAMS

As for the future, I would like to mention three things : First, planning for international cooperation ; second, the future oceanographic program of the United States; third, possibilities of studying the earth itself underneath the ocean.

As one result of the IGY, the International Council of Scientific Unions has organized a Special Committee on Oceanographic Research which represents many different countries, just as the Special Committee for the IGY did. They are laying plans for a variety of cooperative ventures, particularly an international expedition to the Indian Ocean, which would involve some 16 ships and would last for about a year. This is the largest unknown area on earth. It is one of considerable interest, both because of the rich potential fishery resources and because of the fact that the changing monsoon winds change the circulation pattern and we would like to know how the atmosphere and the ocean are linked together here. A very large area of the sea floor is so little known.

Referência AC

Another program of this international committee is to continue to try to obtain a good assay of the amount of carbon dioxide in the air which is increasing because of the burning of oil, coal, and natural gas, and which is decreasing because of absorption by the ocean.

2.b)

UNESCO and the International Cooperation Administration of the United States are also concerned with international cooperation in oceanography, particularly in attempting to give technical assistance to underdeveloped countries and to improve their use of marine resources and fishery resources.

They are both absolutely essential for the survival of those people because it is their principal source of protein.

NAS COMMITTEE ON OCEANOGRAPHY

2.a)

As far as the United States own program is concerned, this has been spelled out in great detail by a committee of the National Academy, a Committee on Oceanography headed by Harrison Brown, of Cal Tech.

In the material I have submitted for the record, I have summarized the report of that Committee.

CONCEITO 36

Briefly, the Committee recommends that some 70 new oceanographic ships should be built by the United States during the next 10 years— 70 ocean research and survey vessels. This would increase our ocean research and survey fleet by about 45 ships because our present ships are for the most part obsolescent or out of date.

CONCEITO 10

Secondly, the committee has recommended that there should be an intensive national and international program of oceanwide surveys.

5.b) - outras disciplinas mencionadas

The Coast and Geodetic Survey and the Hydrographic Office, which are our principal American survey agencies, have concentrated almost entirely on surveys of the Continental Shelf near the areas of land.

We believe and feel quite strongly that there should be surveys of an accurate and comprehensive nature made of the currents, water, biology, and the bottom, as well as magnetism and the gravity topography of the bottom on a worldwide basis. This should be done by international agreement in which the United States would take perhaps 30 percent of the world's ocean as its share and the remaining maritime powers would take the other 70 percent.

2.b)

We have recommended that an intergovernmental conference should be called to arrange such a survey program and that a world oceanographic organization should be established, like the World Meteorological Organization, to accumulate and foster the use of data obtained by the surveys.

7.b) e 7.a)

As far as the special interest of this committee is concerned, the National Science Foundation has recommended a total of some \$650 million should be spent by the Federal Government during the next 10 years in oceanography ; about \$123 million should be spent by the NSF.

CONCEITO 37

They should support about half of all the basic research in that field. They should spend about \$10 million for oceanographic research vessels and about \$12 million for research operations over the next 10 years ; some \$5 million for new items such as bathyscaphes for exploring the ocean and about \$45 million for research facilities and in research operations. Our recommendation, of course, is quite apart from what may actually happen.

The average expenditure by the NSF for marine sciences should be about \$12 million a year for the next 10 years.

DEEP DRILL THROUGH THE CRUST

CONCEITO 38

Finally, I would like to point out that one very exciting program for studying the earth is now being considered by the National Science Foundation and the National Academy. That is the program for drilling into the deep sea floor to a depth right through the crust of the earth down to the mantle of the earth. We talk glibly and learnedly about what the earth is made of and how it is put together but nobody has any idea whether we are right or not. We will not have an idea until we drill down into the earth to find out what is there. This is the only real way to do that.

Mr. Thomas. You mean you are going to drill to the bottom of the ocean, Doctor ?

Dr. Revelle. That is what we propose to do. Oil companies are doing that now and they are capable of drilling now through water some 1,500 to 3,000 feet deep.

Mr. Thomas. You want to drill in water that is 10,000 feet deep? Dr. Revelle. We would like to drill through water that is about 15,000 and then through rock for another 15,000 feet.

Mr. Yates. Is it not easier to do it on land ?

Dr. Revelle. No; because on land you get down to the mantle of Old Man Earth, the interior, and you have to go down to at least 100,000 feet or probably 130,000 or 140,000 feet. This is beyond present drilling capabilities.

Mr. Thomas. Suppose you hit an oil well down there? What would you do if you were drilling in 15,000 feet of water and hit an oil well ?

Dr. Reveix. These oil company people drilling in water do not think that is much of a problem.

Mr. Thomas. That is, not in the couple of companies where they are drilling 15,000 feet. Go ahead, Doctor.

MONITORING OF SUBMERGED VESSELS

CONCEITO 15

Dr. Revelle. That is all I have to say except that I would like to mention one other thing, and that is that this National Academy Committee on Oceanography has felt, or feels, that even more of a problem than inspection of nuclear explosions will ultimately be, if we are going to have a peaceful world, our ability to monitor submerged vessels in the ocean —in other words, submarines.

CONCEITO 14

We must make the ocean transparent and we must have a really adequate monitoring system for all submerged submarines, everywhere in the ocean and at all times, if we are going to eliminate what seems to us to be the most serious threat to peace that we now have or perhaps the most serious.

Mr. Thomas. Is that the job for you oceanographers, or people dealing with sonar ?

Dr. Revelle. These things involve two things. We cannot deal with sonar unless we understand the ocean and you cannot deal with the ocean unless you deal with sonar and other devices for getting information through sea water. You cannot see through the water. You have to hear through it or use other ways.

Mr. Thomas. In developing one, you have to develop the other ?

Dr. Revelle. That is right.

Mr. Yates. Is sonar your exclusive method of detection at the present time?

Dr. Revelle. No ; there are other methods.

Mr. Yates. Are they classified ?

Dr. Revelle. Yes ; we do not want to go into that.

Mr. Thomas. That is a wonderful statement and that is exactly what we expected from you ; nothing short of it. You always deliver.

Mr. Jonas. May I ask a question?

Mr. Thomas. Yes.

scientific use of submarines

Mr. Jonas. Did we get any useful information from it other than the knowledge that they negotiated that distance under the arctic ice pack with submarines ? Did they pick up any useful information on those trips ?

Dr. Revelle. Yes ; I think they did. There were two scientists on those ships; Dr. Waldo Lynn, on the Nautilus, and Eugene LaFonte, on the Skate. They got quite a bit of sounding information and some information about the water.

Mr. Jonas. New information that we had not known ?

Dr. Revelle. That is correct.

Mr. Jonas. Or suspected ?

Dr. Revelle. You cannot suspect. You cannot really suspect what the shape of the bottom is like. We did get good soundings across the Arctic. Oceanographers in general are quite enthusiastic about the submarine as a tool.

CONCEITO 39

Mr. Jonas. That was the next question I wanted to ask you. You envision a large field of surface ships in the next 10 years ? I wondered if much of that work could not better be performed or accomplished with submarines ?

Dr. Revelle. I think it is fair to say this: We definitely need to use undersea vessels, but these undersea vessels should be of a type quite different from the present submarine. They should be capable of going down to the greatest depths of the sea and moving around at any depth. They should be vessels that have as accessories the bathyscaphe or the present underwater balloons where people go down to about 15,000 feet. They should actually be flying-through-the-water things like an airplane flies through the air and control their depth by the height of-

Mr. Jonas. Actually, most of your exploration will have to be underwater anyway. If you are doing it from a surface ship, you have to send men down underwater.

Dr. Revelle. Actually, you need both. A great deal can be done with instruments. An oceanographic surface ship is merely a platform for carrying winches around which are lowered into the water. Any contraption which you use to send men down from the surface usually requires a surface ship to act as a tender. The instruments that we will use with men are simply instruments that are another kind of instrument that you lower from an oceanographic ship.

Mr. Rhodes. This undersea boat that you are talking about, would it carry its own propulsion system ?

Dr. Revelle. Yes, sir.

Mr. Rhodes. Would it be capable of sustaining itself out in the middle of the ocean without, a tender?

Dr. Revelle. No.

Mr. Rhodes. It would be based on a surface tender?

Dr. Revelle. Yes ; but not at the present time.

Mr. Rhodes. What about the engineering? Could we. Explore the bottom of the ocean in the deepest parts with a boat like the one you mentioned?

Dr. Revelle. We are quite certain that this can be done because, as I say, bathyscaphes and underwater balloons now exist and go down to 15,000 feet. The problem of carrying them down to 35,000 is well within our physical capabilities.

CONCEITO 38

One of the important recommendations of the Committee was that we should really get industry involved in this business of under-sea exploration on a much larger scale than it has been done in the past. Oceanography has been a rather primitive, poorly supported, thrifty kind of science. If we are going to do as well, for example, as the space merchants, whom you are going to hear from in a minute, we have to do that.

Mr. Thomas. Let us come back at 10 minutes to 1.

AFTERNOON SESSION

Mr. Thomas. Gentlemen, will the committee please come to order?

When we recessed for luncheon, I think our distinguished friend and guest, Dr. Eevelle was talking.

Doctor, will you proceed ?

Dr. Kevelle. I am all through, sir.

Mr. Thomas. During the luncheon hour? I heard a lot of nice things about all of our friends here this morning.

Dr. Kaplan, who is next ?

Dr. Kaplan. Dr. Wexler, Mr. Thomas, who will combine both his report and that of Dr. Gould. Dr. Wexler's report is on meteorological and glaciological programs, and Dr. Gould's on Antarctica.

Mr. Thomas. Dr. Wexler, we are honored to have you with us.

Of course, you are part of the Committee too. The doctor is one of the old timers and a real valuable servant of the country. He has been with the Weather Bureau for many, many years and is one of the top scientists of the country. Doctor, we are delighted to have you. We want you to talk for yourself and for our friend Dr. Gould, too.

Dr. Wexler. Thank you, Mr. Thomas.

Anexo 7 - 03HR59 - Wexler

Fonte: <https://babel.hathitrust.org/cgi/pt?id=mdp.39015036820085;view=1up;seq=289> (pp. 107-125)

STATEMENT OF DR. HARRY WEXLER CONCERNING METEOROLOGY AND GLACIOLOGY PROGRAMS

Dr. Wexler. In view of what happened yesterday, I threw away my notes which were supposed to be supplementary to my testimony, which, with the Chairman's permission, I hope will be inserted in the record.

(Dr. Wexler's statement follows:)

Mr. Thomas, members of the committee, I am very happy to have the opportunity to discuss with you the IGY programs in meteorology and glaciology.

2.a)

Dr. Revelle, in his statement on the oceanography program, has covered part of what we call the heat and water budget of the earth.

I will tell you some thing of the glaciological results and, of course, also of the work that I am most interested in, the meteorological program.

I. Meteorology

CONCEITO 1

The international IGY program in meteorology was motivated by the desire to obtain as complete a description as possible of the atmosphere on a day-to day basis so that scientists could analyze the changing patterns of the atmospheric circulation.

Among other things it was hoped to assist in the development of new theories and the refinement of existing theories, and to help explain some of the little understood happenings in the atmosphere.

2.a)

According to recommendations developed at international meetings, countries were urged to take special efforts to reach very high altitudes with meteorological sounding balloons and to establish new stations in areas where meteorological data were missing.

Referência AC

Some special programs were also recommended, for example, the study of the incoming solar radiation and the outgoing terrestrial radiation and the distribution of important minor constituents of the atmosphere like carbon dioxide and ozone.

2.a) e 5.b)

As you know the U.S. Weather Bureau network of balloon sounding stations was rather extensive even before the IGY.

2.b) e 2.a)

The addition, however, of just a few new stations for the IGY— two in the Arctic Basin, seven on the Antarctic Continent, and, in cooperation with South American countries, five

on the west coast of South America — the U.S. meteorological coverage was greatly extended.

I am very happy to report that the stations have all operated on a very high level of competence and reliability.

CONCEITO 2

The five stations in South America have had a tremendous impact on the increase in knowledge of the atmosphere in this region and have benefited not only the countries in which they are located but also various commercial services as, for example, the airlines.

CONCEITO 3

We are most pleased to report that these stations, having been established for the purpose of the IGY, will continue to operate on a cooperative basis with new support from other agencies in the United States.

2.a)

This opportunity afforded to the meteorological services of the South American countries to train additional personnel may also, it is hoped, contribute to the strengthening of these services in the future.

Prior to the IGY emphasis on obtaining very high altitudes, meteorological soundings using 600-gram balloons averaged about 71,000 feet in altitude.

6.b)

Even before the IGY, however, the U.S. Weather Bureau, the U.S. Air Force Air Weather Service, and the U.S. Army Signal Corps cooperated with balloon manufacturers to increase the performance of these balloons.

During IGY, an improved 600-gram balloon was used. This balloon had an average bursting altitude of over 80,000 feet and quite frequently reached altitudes of approximately 100,000 feet. At certain stations for soundings at noon, Greenwich time, special 800-gram balloons were employed. Soundings using these special balloons averaged over 100,000 feet in height and quite frequently attained altitudes in excess of 100,000 feet. The high altitude program was very successful and provided important data on the high stratosphere circulation.

It is expected that most countries, and certainly the United States, will continue to use these higher performance balloons, for our present scientific studies of the atmosphere, as well as aircraft operational requirements, demand more and better data from these very high levels.

In addition to the extensive measurements of temperature, pressure, wind speed and direction, cloud cover, and precipitation, in the synoptic aspects of the program, some special studies provide a great deal of very important information to the meteorological scientists.

Ozone

One of the most important minor constituents of the atmosphere is ozone, a variety of oxygen which has very important properties. Normal oxygen molecules absorb ultraviolet radiation in the high atmosphere to form atomic oxygen. These free atoms of oxygen collide with oxygen molecules to form ozone, and ozone in the absence of sunlight decays slowly to normal oxygen with the release of energy. Ozone has a short lifetime in the photo-equilibrium layer (25 to 30 miles) but at 12 miles ozone may persist for 3,000 days. So we might say that ozone is a reservoir of energy in the high atmosphere, the effect of which on the atmospheric circulation may be far greater than its low concentrations may indicate.

At Little America Station both surface concentration and total ozone in the atmosphere were measured. The total ozone concentration was measured by observing how much of the sun's ultraviolet radiation penetrated to the surface.

In the polar winter, sunlight reflected from the moon was used to measure the ozone concentration although, of course, this method is not as sensitive as observing the solar light directly. The seasonal variations of ozone in the Antarctic differ from what would be expected from casual consideration of the photochemical mechanism of ozone formation. Since ozone is only formed in any quantity in the presence of ultraviolet light from the sun, it might be expected that in the long polar night the ozone would gradually decrease. However, the opposite is found. There was a rapid rise of surface ozone concentration in March and April and a slow decrease in September after the sun returned.

The total ozone content also showed a maximum in the dark hours. The explanation of this anomalous behavior must be sought in the study of vertical and horizontal circulation systems carrying ozone poleward from sunlit regions.

Perhaps, on the other hand, some generation of ozone occurs during the polar winter by auroral activity.

At the Weather Bureau station on the slopes of Mauna Loa in Hawaii the ozone showed a daily variation related to the nocturnal descent of air from upper layers and daytime ascent up the heated mountain slopes.

Atmospheric purity

Specialized studies of solar radiations at certain key stations have turned up some interesting information on the clarity of the atmosphere. It turns out that the atmospheric clarity at Little America (at sea level) and at Mauna Loa (13,000 feet elevation) is very high and about equal, while at the South Pole the sky is even clearer. The atmosphere in this region of the world may be the clearest and most transparent anywhere. Preliminary results

from station Alpha In the Arctic Basin indicate that long wave radiations from over cast skies are an important factor in the melting of surface ice. It was observed that melting proceeded much more rapidly when the sky was overcast rather than clear and sunny ; refreezing may actually occur under the clear summer sky because of increased radiation to space through the clear atmosphere.

Referência AC

Carbon dioxide

Air temperature in the lower level of the earth's atmosphere is extremely important to man and it is probable that the amount and distribution of carbon dioxide in the atmosphere plays an important part in regulating these temperatures.

CONCEITO 4

One of the special projects of the IGY was to try to determine the amount of carbon dioxide in the atmosphere so comparisons could be made with past determinations (which are, however, not as reliable as present measurements) and with measurements to be made in the future.

CONCEITO 5

By these means we will be able to determine if and by how much the concentration of carbon dioxide is changing as our industrial civilization pours millions of tons of carbon dioxide yearly into the atmosphere.

It was also decided to measure the carbon dioxide in the atmosphere at sea, and in sea water to attempt to study the mechanism by which carbon dioxide is absorbed by sea water.

CONCEITO 6

The U.S. Weather Bureau and the various oceanographic institutions cooperated in obtaining observations on carbon dioxide concentrations.

2.a)

Measurements made in the Arctic by U.S. and Scandinavian scientists indicated a great fluctuation of carbon dioxide concentration but surprisingly enough, when the oceanographers took their instruments to sea they found that measurements over thousands of miles of open sea water showed variations of only a few percent.

Continuous measurements of pure air at Little America showed the smallest variation yet obtained, over any period of observation about 0.1 percent.

A slightly larger variation of about 1 percent was observed at Mauna Loa.

5.b)

During August of 1958, scientists of the Woods Hole Oceanographic Institution conducted some observations of the vertical distribution of carbon dioxide in the area of Nantucket Island.

Their soundings showed marked variations of carbon dioxide with altitude and it was also noticed that a minimum was sometimes developed between altitudes of 1,000 and 3,000 feet. No particular correlations were found between the carbon dioxide values and the various meteorological parameters; however, it was noticed that vertical carbon dioxide concentrations persisted whenever meteorological conditions in the same area remained unchanged.

1.b) e 1.a)

Scientists of the Agricultural and Mechanical College of Texas observed that during and after a violent rain squall, the carbon dioxide in the water and atmosphere changed markedly.

Twenty-four hours after the squall, the carbon dioxide in the water had not returned to normal while the atmospheric carbon dioxide had returned to its original level in about 6 hours.

Samples of air were taken at selected stations in the Arctic and Antarctic and during aircraft meteorological reconnaissance flights of the Air Weather Service.

5.b)

These samples are being analyzed at Scripps Institution of Oceanography where a special laboratory was constructed to provide for an absolute calibration of all of the carbon dioxide instruments.

nuclear radiation

Data collected along the 80th meridian for the measurements of nuclear radiation show the north-south spread of radioactive debris from tests conducted during the IGY. The radioisotope analysis has revealed the strontium 90 in the ground level Southern Hemisphere air to be much older than in the Northern Hemisphere. Further, the air concentrations of strontium 90 Northern Hemisphere air is about five times greater than in the Southern Hemisphere. Since the origin of almost all of the strontium 90 in both hemispheres is from the stratospheric reservoir, these facts will assist the meteorologist in propounding theories of stratospheric circulation and exchange mechanisms.

CONCEITO 7

North-south profiles of the monthly average gross fission products from U.S.S.R. tests show a rapid southward spread into Southern United States.

On the other hand, essentially negligible amounts of tropospheric fission products have mixed into the Southern Hemisphere ground levels from tests in Nevada and the U.S.S.R. fission products of the Hardtack test series conducted at 11° N. on the other hand, were found in readily measurable quantities in the Southern Hemisphere.

World weather maps

5.b)

One of the plans of the IGY is that daily weather maps of the entire globe will be prepared from the IGY observations. The U.S. Weather Bureau will prepare maps for the Northern Hemisphere; the South African Weather Bureau, the Southern Hemisphere maps; the Federal (West) German Weather Service, the equatorial maps. It is planned that the maps will be drawn for two levels, sea level and 500 millibars (about 18,000 feet).

Stratospheric meteorology

10.a)

The worldwide radiosonde data upon which stratospheric research depends, are now being assembled on microcards in Geneva, Switzerland, for distribution to research meteorologists.

Never before have complete data for so large a portion of the globe been accessible to these scientists. Their work will be accelerated by the U.S. Weather Bureau program of synthesizing data by analysis of pole-to-pole cross sections and daily hemispheric 100-millibar, 50-millibar and 10-millibar constant pressure charts. The resulting analyses will be published in convenient booklet form.

Experimental 10-millibar charts that, for the first time, represent daily flow at the 100,000-foot level over a large area have been prepared and put to use by several scientific groups concerned with very high level flight in the atmosphere.

CONCEPT 8

The major upheavals of stratospheric circulation in each hemisphere usually occur but once or twice in a single year. This phenomenon as it occurred in the Northern Hemisphere differed in some important respects during the two winters of the IGY and much depends on the observations from additional winters.

Discussions among meteorologists have also been stimulated by preliminary information revealing that the development of wavelike perturbations within stratospheric jetstreams of the north polar region are fundamentally different from those of the south polar region.

Results of earlier antarctic expeditions revealed that the thermal structures of the arctic and antarctic stratospheres were quite different. This difference was especially noted in the winter months. During this season the antarctic stratosphere was found to be on the average, 20° F. colder than arctic stratosphere. A number of hypotheses were advanced to explain this difference, but the amount of data available from the Antarctic was too limited to determine which, if any, of these were correct. Now that upper-air data are being obtained for the first time from the interior as well as the periphery of the Antarctic Continent, it appears that the winter antarctic stratosphere is more effectively "sealed off" than is the arctic stratosphere. The arctic circulation is apparently more unstable than that found in the opposite hemisphere. This instability permits warm air to invade the arctic stratosphere during midwinter and cause the normal wintertime cooling to be reversed, resulting in anomalous temperature rises. The stable circulation in the Antarctic effectively prevents this anomalous wintertime stratospheric warming and the temperature falls quite steadily through the autumn and winter months at an average rate of 0.5° F. per day.

CONCEITO 9

To quantitatively determine the basic causes for the variances in the stability of the polar-stratospheric circulations will require a continuing program of high-altitude, high-latitude observations. This data may then be fitted into mathematical models for analysis by high-speed electronic computers.

Meteorological observations in the Arctic Basin

Two extremely important meteorological stations were those established in the Arctic Basin. Station Alpha, at which high-altitude wind, pressure, and temperature observations were taken, was constructed on a floe imbedded in the arctic icepack; station Bravo, where an intensive micrometeorological program including vertical temperature gradient soundings with tethered balloons and heat flux and solar radiation observations were undertaken, was located on the floating ice island, T-3. In August 1958, the high temperature at station A was 37° F. and the low was 23° F. By October the average temperature had dropped to just under 20° F., and a low was recorded of almost -31° F. During the summer months the high-altitude balloons performed exceptionally well, with average heights in July and August in excess of 110,000 feet, but in October, with much lower temperatures, the highest altitude reached was only 88,000 feet. At station Bravo the high temperature in August was 40° F. and, as usual, there were many problems because of the melting of the ice—leaving the buildings on 6-foot-high pedestals of ice—and the formation of lakes. The October average temperature decreased to 5° F. and a low was recorded of -33° F.

Unfortunately, late in October 1958, the pack-ice conditions at station Alpha began to deteriorate, and a study by station personnel over the whole period of occupation of the station showed that since the original occupation of the site in the spring of 1957, there had been a great change in the size of the floe. It was found that an open-water lead had

separated approximately 40 percent of the remaining floe on the east and southeastern side, that there was another separated portion on the western side, and that one long crack extended toward the southern part of the floe. Finally, by November 2, the runway had separated into two parts ; and the floe had decreased its size to the point where it was decided to end operations.

6.a)

On November 7, 1958, the U.S. Air Force evacuated the personnel from station A and recovered most of the scientific data.

It was not possible, however, to evacuate some of the bulky ice and water samples which IGY scientists had collected and most of the equipment on the floe.

Antarctic weather

Each time I have appeared before this Committee I have been able to report a new record low temperature and I shall not disappoint you this time. As you know, for many years Siberia had the lowest temperatures on record, -90° F.

The -102° F. temperature observed at our IGY South Pole station gave the United States its brief moment of meteorological glory in 1957 and early 1958.

2.b)

But in July and August of 1958 the Soviet IGY Vostok and Sovietskaya stations, 2 and a half miles altitude, on the high, icy plateau of east Antarctica, broke this record and the new records again and again, until Vostok won with a temperature of -125° F.

Here is a brief summary of some interesting information which we received from the various stations in their regular reports.

Amundsen-Scott (South Pole) station.— At the South Pole station in July the average temperature was -67° F. and a low was recorded of -90.8° F. Aloft, on July 16, a radiosonde recorded what may be the world's lowest atmospheric temperature, -93° C. (-135.6° F). July was also a record month for wind speed, but the meteorologist in charge reported that at the surface it was the warmest winter month of the 2 years of record. During July the average height for the sounding balloons was 55,000 feet.

By August the average temperature had dropped to -79° with a low temperature of -100° F. The atmosphere continued to cool in the lowest layers. The low part of the stratosphere, however, showed a termination of cooling, but cooling continued in its upper layers. The stratosphere above the 50-millibar level showed cooling for 8 continuous months. During August the average altitude reached by the meteorological sounding balloons was 50,000 feet.

In September the lowest temperature was -101.7° F., equaling the previous minimum for 1958 that was measured in June. However, the average temperature in September was -09° F., 10° warmer than that of August. With the return of sunlight to the stratosphere to provide some warmth for the meteorological balloons, sounding heights improved and the highest altitude reached was 83,000 feet. In October and November considerable warming was experienced at the pole both at the surface and aloft, the average temperature near the surface in November being only -37° F. On October 24, a balloon sounding showed that a temperature of plus 30° F. existed at a height of 116,400 feet while surface temperatures were about -50° F. This particular sounding set a new altitude record in the Antarctic of 122,200 feet.

To give you an example of the special work carried out at the South Pole, almost 200 wind profiles were obtained each month using a micrometeorological mast with special anemometer cups at several levels and thermocouples for careful measurements of vertical temperature gradients. Such information not only gives in detail the various conditions to which a man might be exposed, but it also provides necessary information for further scientific studies of the process whereby heat is exchanged between the air and the snow surface.

Particular attention was given the relation of radiant energy exchange and sensible heat flux with conditions of extreme cold, i.e., temperatures near -100° P. During a clear period, in mid-September, for example, when the surface temperature averaged -99° F. for 6 hours, the snow surface was losing 50 percent more radiant energy to the atmosphere than it was receiving. It was found that this energy loss was not made up by additional cooling of the snow surface, but by fluxes of sensible heat from the relatively warmer layers just above and below the snow surface. During this particular case, 48 percent of the energy came from the reservoir of sensible heat under the snow surface where the temperature remains near -60° F., and 52 percent of the energy came from the warmer air of the surface inversion. During the winter nights, clouds, which were invariably warmer than the snow surface, transmitted so much energy to the surface, that it would rapidly warm up as if the sun had suddenly appeared.

Byrd station. — At Byrd station in the Interior of the continent temperatures were also quite low. In July the average temperature was -40° F. with a station record low of -82° F. In August the average temperature decreased to -44° F. and a low of -80° F. was recorded. The first sunrise occurred on August 25 with 95 minutes of sunlight. By October the average temperature warmed up to -22° F. and the recorded low was -49° F. Large accumulations of snow with drifts hampered observations, particularly balloon soundings. The snow had piled up several feet higher than the roof of the balloon shelters, and each day it was necessary to shovel the snow away from the trap door on top of the building. The endless drift of snow into the interior of Marie Byrd Land, where a deep trench exists in the snow near the foot of the Horlick Mountains raises a question as to why in the milleniums of wind drift this trench has not tilled.

Little America station. — At Little America average temperatures in July, August, and September were -35° F., -32° F., and -32° F., respectively; low temperatures were -70° F. in July and August and -73° F. in September.

The latter occurred after the return of the sun and after the record maximum of plus 22 was recorded for August, normally one of the coldest months with temperatures well below zero. The warming trend of Little America temperatures, amounting to nearly 5° F. since 1812, continued into 1958.

Ellsworth station.—The Ellsworth station, although located on the opposite side of the continent from Little America has a very similar physical location.

Both of these stations are at about the same geographic latitude (78° S.) and elevation above sea level (about 145 feet), and both are situated on a floating ice shelf on the edge of a major sea. These two seas, the Ross Sea at Little America and the Weddell Sea at Ellsworth form embayments in the Antarctic Continent and are preferred regions for cyclonic storms. All of these similarities result in both stations experiencing nearly the same average weather conditions.

The average temperature for 1958 at Ellsworth was —10.5° F. while at Little America it was — 9.7° F. The coldest and warmest temperatures recorded during 1958 nt Ellsworth were — 68.1° F. on May 13 and +34.0° F. on December 31, compared to the extremes at Little America of —72.9° F. on September 10 and +33.1° F. on January 4. Both of these stations along with Byrd Station have proved to be very Important In mapping the paths of cyclonic storms across west Antarctica, which are believed to be responsible for the heavy snow accumulation in this region.

Hallett station. — The Hallett station, located on the northwestern edge of the Ross Sea and about 300 miles north of McMurdo Sound (and on the direct air route from New Zealand to McMurdo) has provided important information on the storms entering the Ross Sea from the west. These major storms pass Hallett station at the rate of about four or five per month with the most severe of storms rivalling the intensity of a Florida hurricane. The most severe storms occur during the months of March through October. During each of these months in 1958, an extreme wind speed in excess of 50 m.p.h. was recorded at Hallett station with the highest wind being 85 m.p.h. during a June storm. During this particular storm, the temperature rose to +14° F. The coldest temperature recorded during 1958 was —39° F. on August 22.

This combined weather and emergency station more than paid for itself one day In October 1958 when, because of poor weather at McMurdo Sound, 5 aircraft, with 52 crew members aboard, made emergency landings on the smooth bay ice near the station.

Wilkes station. — At Wilkes station during 1958, as in 1957, the warmest climate of any of the U.S. stations was experienced; this station is considered by personnel at other stations as situated in the "banana belt." This is due, of course, to the fact that its latitude Is only 66°16' S. or almost 15 miles north of the Antarctic Circle. Although the summers are relatively cold with average monthly temperatures for December, January, and February being about +28° to +32° F., the winters are mild. During 1058, the coldest winter month was June with na average of —7.a)° F. The absolute minimum temperature for Wilkes station of —36° F. was recorded on July 27, 1058. But what the station lacks in frigid

temperatures it more than makes up in wind. The wind cascading down the nearby ice cap often reaches speeds greater than 100 m.p.h. The commencement and cessation of these strong winds are abrupt and are usually accompanied by simultaneous large rises and falls in pressure. An analysis of one of these occasions found the pressure suddenly dropping about 2.5 mb. with an increase in wind speed from 10 to 50 m.p.h. Two hours later the pressure just as rapidly jumped up 3.5 mb. and the winds immediately slackened to 10 m.p.h. A special high speed barograph was used to record these rapid changes in atmospheric pressure.

2.b)

IGY Antarctic weather central. —IGT weather central operations at Little America continued through 1958 in the same manner as was reported to this Committee last year. During the IGY the staff. Including meteorologists from Argentina, Australia, France, New Zealand, South Africa, the United States, and the U.S.S.R. have worked most successfully together.

2.a)

Research papers on antarctic meteorology have been published. Forecasts were issued for aircraft, field and ship operations. Map analyses and weather data were broadcast from Little America four times daily. Many of the special weather studies begun in 1957 were continued and expanded in 1958. Vertical time-sections and crosssections were prepared to analyze the detailed structure of the storms moving over Antarctica. Eight papers by U.S. meteorologists will be presented at an Antarctic Meteorological Symposium opening today at Melbourne, Australia.

The weather central operations were terminated with the closing of the Little America station in January 1959. However, the work begun there will be continued by an International Antarctic Weather Central to be located in Melbourne, Australia.

It is expected that an American meteorologist will be assigned there to assist in the preparation of forecasts and analyses, which will be useful operationally, and also in the study of world weather.

II. Glaciology

3.a) e 2.a)

At our discussions with this Committee last year, Mr. William Field of the American Geographical Society, described for you the progress in the first year of the United States IGY glaciological program.

The first season of station glaciology and oversnow traverses in the Antarctic provided significant and hitherto unavailable information on the thickness of ice in the Antarctic and of the nature of the underlying terrain. This season's traverses have again set out, but at this time there is only a small amount of preliminary information available.

All together, the past 2 years have seen over 10,000 miles of surface and air borne traverses made by nine separate groups of United States IGY scientists operating mostly in areas hitherto unknown.

6.b) e 6.a)

Antarctic deep drilling program. — The deep drilling program at Marie Byrd station was successfully completed by the U.S. Army SIPRE drill teams and temperatures and cores were obtained to a depth of 1,013 feet.

Some preliminary analyses of the cores were done in the Antarctic : for example, they were placed in a trough and viewed from above with the aid of a light source under the core.

The exact positions of the various layers of Ice were then obtained by measuring with tapes, and photographs of the layered structures were taken. It was found that distinctive layers could be obtained to the depth of 400 feet, farther on the cores did not show any visible stratification. Some small samples were removed from the core for determination of the density. Density increased from about one-half gram per cubic centimeter near surface to over nine-tenths gram per cubic centimeter at a depth of 720 feet. The cores have been transported to the laboratory, at the U.S. Army Snow, Ice and Permafrost Research Establishment (SIPRE) Wilmette, Ill., where scientists will complete the density studies and analysis of the ice crystals, included foreign particles and trapped gas bubbles, and will make measurements of tritium and other radioactive substances.

1.a) e 1.b)

Measurements of the ratios of the oxygen isotopes 16 and 18 will be carried out at the California Institute of Technology.

This work will help identify the winter and summer layers in the deep parts of the core.

In the meantime, the hole in the ice itself at Byrd station remains an important tool for measurements of temperature at various depths. Beneath the station the ice was found by seismic soundings to be about 10,000 feet thick, exacting 5,000 feet below sea level. The snow at 150 feet depth, which was laid down approximately 150 years ago, is warmer than the surface by 1° F., apparently a result of a slightly warmer period which occurred during the past century, the warmth from which is propagating downward. Below this warm layer the temperature decreases at such a rate, that if extrapolated deep down in the ice, would indicate that the snow was deposited at a time when the climate was several degrees colder than now. Plans are underway to drill a hole all the waythrough the ice to observe how far down the temperature decrease persists and at what level it begins to increase with depth —as it should under Influence of the slow influx of heat from the earth's interior over the millenniums.

Special microphones were lowered into the hole to receive sound signals from distant explosions to record the speed of waves so important in the study of ice structure and the

thickness of the earth crust. The hole will be observed over a period of many years to determine how it deforms under influence of the slowly moving Antarctic ice.

The drill rig was moved by tractor train to Little America and on October 31, 1958, drilling was started on the Ross ice shelf. Drilling was completed on December 17. The first core was taken at a depth of 22 feet, with loss of only 1 percent of the total core. layers of foreign matter were observed at 580 feet, 730 feet, and 744 feet. The first of these was identified as probably volcanic ash.

There was no evidence of saline ice in the bottom of the hole, but the drilling was terminated at 838 feet to prevent possibility of the drill bit breaking into a pocket of brine and freezing in. The temperature at 818 feet was 24° F., or 5° below the freezing point of sea water indicating that there was only a few feet of ice left at the bottom of the hole when drilling was stopped.

Antarctic traverse program. — On November 1, a traverse party left Byrd station to explore the area around the Horlick Mountains in the direction of the pole. By December 31, 357 miles were covered, and the party returned on January 21, 1959. In the Horlick Mountains, petrified tree remains, including one section 12 feet long, and leaf fossils were discovered in sedimentary layers of sandstone, shale, and coal.

On October 31, the glaciological traverse party left Ellsworth station destined for Byrd station and arrived on January 8, 1959. after crossing most of west Antarctica.

Seventeen seismological and glaciological stations were occupied and 1,250 statute miles were covered. Eight hundred miles were traveled before the first mountains were seen. Maximum ice thickness of 12,000 feet was found in the area of 80°35' S. and 114°47' W.

A topographic and geologic survey reconnaissance was extended to a previously unvisited area south of the Windmill Island area, near the Wilkes station.

A 100-foot raised beach was surveyed. Ice surveys revealed great differences between some areas of stagnation and the nearby Vanderford Glacier which advances several feet per day. In contrast to the normally negative regime — that is, where the ice is slowly retreating— a small shelf 1 square mile in area was found where excessive local precipitation is nourishing the ice. Evidence was found of various fluctuations in the ice regime since the last major glaciation.

Samples were blasted from undisturbed areas for isotope dating.

The traverse from Little America, led by Mr. A. P. Crary. traveled to the Victoria Land Plateau, reaching their farthest point west by January 8. 1959; the party returned on January 31 to McMurdo Sound. Twelve seismic stations were occupied, and it was found that although reflections were poor from the bottom of the ice, the values obtained suggested land at sea level under the plateau ice.

Cores of ice were taken as well as samples for later analysis for tritium and oxygen isotopes. Stakes were set in the Skelton Glacier about 90 miles south of NAF MerMurdo for future observations of accumulation and motion of the ice.

Northern Hemisphere program

Work was completed at the Blue Glacier in the Olympic National Park in the State of Washington. The scientific party occupied this station until late in 1958 when they completed their series of observations.

1.a) e 1.b)

The data is now under study at the University of Washington and promises to become an important milestone in the study of glaciers.

The scientific program at McCall Glacier in Alaska was similarly completed and the data is now under study.

1.a) e 1.b)

A special analysis project was initiated at the Ohio State University under the direction of Professor Goldthwait.

There, the glaciologists returning from the antarctic traverses and stations are studying their data with the full benefit of the association with this distinguished academic Institution.

The Arctic Basin ice studies

Station Alpha. —It was noticed that the summer of 1958 was a season of very heavy ice loss. The 1958 ablation season (during which snow and Ice were removed) was 3 months longer than in 1957 and twice as much ice was lost than in the previous year. The amount lost, however, was not equal to the accumulation during the previous winter. Dozens of ice cores were taken from the pack Ice and an extensive program of mechanical study of the ice was accomplished. In September 1958 It was noticed that cooling began in the upper layers of the ice while the lower layers still showed warming. It was not until October that cooling was found at all layers. One of the most interesting occurrences during the summer at Station Alpha was the visit to the station of the nuclear-powered submarine U.S.S. Nautilus. This accomplishment opens up a whole new vista of possibilities of scientific exploration of the Arctic Basin, its floor, and the waters of the Arctic Ocean.

Station liravo. —At station B the ice structure was studied and the various levels of the pack ice with respect to the island surface were recorded. IGY scientists from Argentina carried out studies of ice structure and properties at station B during the summer.

INTERPRETATION AND IMPLICATIONS

Studies of meteorology, oceanography, and glaciology, although dealing with different scientific disciplines, are related by common Interests In several things :

First, water, of course, is a principal element in these studies, in liquid form in the oceans, in solid form as ice, and as water vapor in the atmosphere; second, these sciences deal with phenomena close to the surface of the earth and, therefore, are of great interest and importance to man and his civilization ; and third, the sun provides the energy to link together the world's ice, liquid water, and water vapor in a ceaseless exchange. Perhaps one of the most significant results of the IGY has been the bringing together of the scientists interested in these areas of research, because it is only by the complete study of the heat and water budget of the earth that better understanding will result.

Meteorology is benefiting enormously from better data obtained from the surface and higher atmospheric levels and, as a result of the IGY program, of the completely new data furnished by all the IGY stations in the remote and formerly inaccessible areas.

CONCEITO 10

The data from hitherto unknown portions of the earth's surface has great importance in filling the gaps in pre-IGY meteorological coverage.

CONCEITO 11

To improve forecasts, and to make them more extensive in time and space, additional data from widespread areas on the earth's surface are required.

We also find that observations of events in the higher regions, the stratosphere, may be required to increase our understanding of weather in lower regions, the troposphere. Much more work, of course, needs to be done in examining our observations, but the IGY has already made possible systematic study of very high altitude disturbances and the completion of weather maps at surface and upper levels for most of the world.

Referência AC

The special meteorology programs are also providing a significant return of scientific information. Studies of solar radiation and complete energy balance of the- earth will be of the greatest importance in studying the general circulation of the atmosphere. The increased emphasis on carbon dioxide and ozone has produced results which indicate aspects of the circulation which will require increased attention in the future. The study of the distribution of airborne isotopes is also yielding data on circulation phenomena not possible by any other known method. We have also laid to rest some Incorrect theories of the antarctic air circulations, while at the same time discovering new features of that atmosphere which are of interest because of their contrasts with the artic circulations.

CONCEITO 12

The glaciologists have become partners of climatologists, for they have opened up a frozen storehouse of information on the past climate of the earth and its fluctuations by their explorations and probing into the interior of the great ice sheets.

Of course, the glaciologists have also increased tremendously their body of knowledge of glacial behavior itself: the interaction between the ice and atmosphere, the ice and the oceans, and the behavior of a huge mass of ice as a mechanical and thermal system.

One of the valuable byproducts of the IGY effort has been to bring to the attention of scientists previously engaged in other work, the attraction and opportunities available in geophysics.

Many competent young experimental scientists and students have engaged in geophysical activities for the first time through the opportunities created by the IGY.

This is indeed a very important aspect since, among other things, the IGY has shown us how much more needs to be done in the coming years while at the same time it has helped to create the kind of exciting and stimulating atmosphere which attracts the interest of young people in schools.

Dr. Wexler. First let me say we did not time this launching yesterday to agree with this hearing, although we are very glad it did happen.

Mr. Thomas. If you did, more horsepower to you.

11.a)

Dr. Wexler. Although Dr. Reichelderfer came very close to it in an article which appeared in the New York Times yesterday.

He called me up a few minutes before the launching.

I was in the NASA control room, and he said, "Tell the people we didn't try to steal their thunder." I said, "Don't apologize. It might prove to be a good tradition."

5.a)

What we get from a more sophisticated version of the satellite now flying above us will be a photograph of the earth's surface somewhat similar to this remarkable picture that was put together as a mosaic 4 years ago when a minor hurricane, aloft and out of ground, actually sneaked by our observing network, big gaps of our observing network in the Gulf of Mexico. It entered Texas in the lower Rio Grande Valley. It so happened that on that very day a rocket was being launched at White Sands with a camera and took pictures as the camera rotated. One hundred and seventy pictures were put together giving this view.

6.b)

When this was done, the people at the Naval Research Laboratory, with whom I had been in contact before, called me up and said, "You had a hurricane down in Mexico, October 4, 1954." I said, "No, we didn't have any such thing. We had some showers, squally weather, but no hurricane."

They said the developed picture showed a hurricane, whirlpool clouds very similar to the one you people talk about as determined from radar. I went down to take a look at the picture and said, "It does look like a hurricane." We have seen these on radar, spiral nebulae that the astronomers see, rotating into the center and the more we looked into it, the more we were convinced that there was something aloft which we did not suspect from our sparse ground observations in that area.

Further study revealed that there was indeed a storm in the lower Rio Grande, and this is White Sands here, El Paso, Mexico, Gulf of Mexico. We are looking to the southeast, Corpus Christi, and in the lower part of the Rio Grande Valley was the storm that moved up the valley, gave Roswell, N. Mex., a very heavy rainfall, curved, headed toward Chicago, gave them flooding rains, which actually flooded the basement of the Chicago Tribune, and ruined tens of thousands of dollars worth of newsprint.

Mr. Thomas. At what altitude were the pictures made and at what altitude was the storm?

Dr. Wexler. The picture was taken from about a hundred miles.

Mr. Thomas. A rocket from the Weather Bureau?

Dr. Wexler. It was a regular rocket of the Aerobee type that the Naval Research Laboratory has been sending up for years; a hundred miles above the earth. The storm was perhaps 5 to 8 miles above the surface, way, way down, so we are having a picture looking down and as such we get a bird's eye view of the weather that we haven't been privileged to look at. We are like ants crawling on the surface and trying to piece together bits of information to give us a mosaic of the weather as it actually occurs. Here, now, for the first time, the satellite gives us an observing platform of global extent, in keeping with the global nature of the atmosphere and the storms that know no boundaries.

Of course, the present satellite does not have cameras. It has photocells.

It is something like trying to take a picture with the light meter, piecing together the light and dark instead of using a camera.

That is what we will get out of the present satellite, but it will give us some real data to work with from a height between 335 miles to 2,050 miles, much higher than this. It will give us a much broader area, from 34° north to 34° south and, therefore, it will prepare the way for our experience, knowledge, dealing with more sophisticated and elaborate instrumentation which we hope subsequent satellites will have, not only for the tropical belt, but for the whole world.

This is, I would think, one of the most significant facts IGY has had on meteorology. This is not to say the satellite will solve all problems or replace the observing systems. It will give us a global view, interrelationships of Northern and Southern Hemispheres, polar regions, where we have a few observations, but we will still need the very detailed reports, which we can only get from the surface, necessary for aviation, agriculture, and other purposes. We think that having the data now from portions of the atmosphere, we have never had before, that we will be able to truly examine world weather on a daily basis and learn a lot more about how the atmosphere works and, in so doing, improve our short-range forecasts and extend our forecasts to the future.

FUTURE SATELLITES

CONCEITO 13

As I mentioned in previous hearings, meteorologists have not been able to explain why we have these unusual spells of weather. One year we have a drought, next year we have floods in the same area.

We tried to explain these based on Northern Hemisphere weather and essentially low-level observations. We haven't succeeded. The IGY has lifted our booms up much higher, has given us a satellite which will now give observations from the entire world in the next few years and, in so doing, it gives us a lot more opportunity to explore these very unusual spells of weather that affect the entire Nation's economy and welfare.

This is the main impact that IGY has brought to meteorology and this, of course, will develop to such a point that I can envisage a system of meteorological satellites, perhaps six or eight of them simultaneously orbiting the earth, most of them from pole to pole on various meridians and perhaps one or two around the equator; in so doing, observing each and every significant cloud area on earth continuously, and interpreting those cloud observations in terms of significant weather and the motions of storms. I believe this is not very far off and I think it will greatly improve the service that meteorologists can give to the public in the practical sphere and greatly improve our understanding of the atmosphere.

CLOUDS AND STARS

Mr. Thomas. Doctor, will you let me interrupt you there? You made one statement that excites my imagination. What connection is there between storms and clouds ?

Dr. Wexler. Generally speaking, to have a significant storm you must have clouds. The heat of condensation, which is released by water vapor as it condenses to form clouds, is one the principal sources of energy of storms. You can have occasional winds going down mountainsides, sand storms in deserts, which are not associated with clouds, but most storms have typical clouds. For example, this whirlpool type cloud is a rather typical characteristic of hurricanes with the arms winding right into the storm. Another type of cloud would be characteristic of a cold front— a long line of clouds extending a few thousand miles, with striations and cellular occurrence which would be individual thunderstorms, squall lines and even tornadoes imbedded in the individual storms.

Meteorologists have developed experience over the years in interpreting clouds in terms of storms, but we have never had the unique view of looking down that the satellite will give to us.

SATELLITE WEATHER MAPS

We are quite confident, in fact, on the basis of experiments we are now carrying out, that if we have cloud observations of this type we can draw a weather map of a rather rough type ; not in fine details, but enough to give us a good deal of information in areas like the oceans, where we have very few observations indeed.

Today's satellite, in terms of today's weather—this is today's weather map, just to show you what we might expect, and I hope to verify this in a few moments, when we get the data and have it put together —would go something like this: As you know, the satellite will only go up as far as 34 north, about to this point, but in so doing it will show some cloud systems. It will show the typical stratus off of California, sort of a dull gray cover, low down, as you know, with foreign substances in the air around southern California which keep things a little on the dull gray.

Mr. Yates. You do not mean smog?

Dr. Wexler. Yes. I didn't want to use that in Dr. Revelle's presence.

Mr. Yates. Dr. Revelle does not have any smog; do you?

Dr. Wexler. There will be a clear area over the western mountains, and then, as the satellite comes farther east, over Texas, to the north, there will emerge a very solid cloud deck caused by air from the mountains, pushing over this dome of Canadian arctic air coming down from the north.

This gray area is some snow, with clouds, and so this would show up very good. There would be clear weather for the most part in Texas and along the gulf coast, but then coming here to the east we would get to the southern part.

Mr. Yates. What is this?

Dr. Wexler. This is rain and snow in the Great Lakes area. The satellite does not go quite that far north. It would get the southern part of this developing storm, which is now taking shape here in the East, and shows a very extensive cloud deck in the Southeast.

As far as Chicago is concerned, Dr. Reichelderfer's prediction is exactly correct. It is an improving situation.

Dr. Bronk. How about LaGuardia ?

Dr. Wexler. That is a tougher situation. The coastal storm is taking shape but not too quickly. I hate to stick my neck out as vigorously as I did for Chicago, but I think it would be operational.

ANTARCTIC PROGRAM

The other great impact of the IGY has been in the Antarctic.

Here, for the first time, we have had sort of a meteorological unveiling of the Antarctic, and we found out that the Antarctic is not flat climatologically speaking. Everyone speaks of the Antarctic as cold, snowy, and miserable. It isn't. It has a great range of climate. As a matter of fact, I was quite interested in seeing that the difference in temperature that occurs in wintertime between our "banana belt" station, the Wilkes station, and the Pole, is larger than the difference in temperature between Miami Beach, Fla., and the Canadian Arctic.

There is a difference in temperature of something like 74 degrees Fahrenheit, average winter temperatures between here and here, which is greater than —or just about as great as Miami Beach and the Arctic.

Mr. Yates. What would the temperatures be?

Dr. Wexler. It is pretty cold. The average would be 15 degrees F. plus at Wilkes and minus 60 here.

Mr. Yates. Wilkes would be like Chicago ?

Dr. Wexler. Yes. They have very strong winds. What they lack in low temperature they make up in terrific winds. 100 miles, or 150 miles an hour are by no means rare.

Dr. Bronk. Isn't there a big valley where you don't have winds and also a reasonably high temperature (Dr. Wexler. That was once thought to be the case. This whole thing is a high plateau and the winds cascade down.

Dr. Bronk. What is this area that Berkner is advertising as a tourist resort ?

Dr. Wexler. That is over here. I was going to describe its tourist aspects in a little while.

The Antarctic is composed of these two regions, East and West Antarctica. This is where the ice is piled up to great heights, perhaps 14,000 or 15,000 feet, resting on rock a few thousand feet above sea level. Here the elevations are not quite so high, perhaps 7,000 feet. Over the valley, storms have sort of sculptured the shape of Antarctica. The winds and the snow storms accompany all these storms, and have put down snow, ice, and it has been like an enormous sculpture, just shaping this whole big plateau of ice, which has taken thousands of years to do. Theoretically, it could be done in 15,000 years. In so doing the storms become affected themselves. That is, the storms which could cross into here and deposit snow are now blocked by this great bulk of ice, and tend to go along the coast, and in so doing help suck down, you might say, that air, which gives the very strong blizzards at.

Wilkes, and other coastal stations. The storms have been deflected so that now, instead of going in as they did in prehistoric times, they apparently come into this area and are deflected into the Ross Sea area and come into West Antarctica. This again is where IGY revealed something interesting. Storms have no difficulty in crossing from here to here and in so doing — from the Ross Sea to the Weddell Sea, and in so doing deposit very heavy amounts of snow at Byrd station.

ICE AGES

All evidence seems to point to the fact that here the Ice Age has reached its maximum and is receding, and here are some of the valleys, the dry valleys that Dr. Berkner talked about which once were covered with ice, but which are now receding because the ice is diminishing, the spillover over the heads of the valleys of ice have diminished so now they are very large, dry valleys, since they are not nourished, and could be, probably, with some experimentation, suitable for human occupation the year around.

The lowest temperature observed in one of these valleys last year was 15 below, not bad at all. There is plenty of water there.

Also, another evidence that the ice is receding is the fact that you see some raised beaches, beach lines, perhaps 75 feet higher above present sea level, which indicates that the land is rebounding, as Dr. Woollard pointed out, as the burden of ice recedes.

Mr. Yates. I think you would do the reader of these hearings a favor, if when you say "here," you would name the place.

Dr. Wexler. Yes. These would be raised beach levels at Marble Point near the Taylor dry valley, on the east coast of the Ross Sound.

In West Antarctica the ice is building up extremely rapidly and it is estimated that at the present rate of accumulation, about 10,000 years of snow storms would be enough to have built that ice up to 10,000 feet, which seems to be an average thickness here.

CONCEITO 14

What I am trying to get at here is the connection between events that took place here, the depletion of storms that passed when this thing built up and the beginning of the Ice Age in West Antarctica as the Ice Age in East Antarctica is receding.

To put the thing in the world context, the ages I speak about fit in very nicely with Northern Hemisphere ages ; namely, it is about 10,000 years ago that the melting of ice in North America reached its maximum. As you know, we had, perhaps 30,000 years ago, a rather warm interglacial period in North America, followed by the Ice Age, that locally has been called the Wisconsin Age, which reached its maximum some time around 18,000 years ago, from 18,000 to 20,000 years ago. Most of that ice melted in that time, during which the sea level raised by 220 feet. These years I give you are quite comparable to the times that have occurred here in Antarctica, namely, about 10,000 years ago, apparently, the ice started

building up in West Antarctica, at about the time, we think, although we don't have sure evidence on this right now, that the ice reached its maximum in East Antarctica, There seems to be very definite connections between events here governing ice ages in Antarctica and ice ages in the Northern Hemisphere. We still have a potential of another 200 feet rise in sea level, which definitely took place in 8,000 years. If all this ice should melt we would get another 200 feet in sea level.

Well, what I have tried to give you is a connection between meteorology, glaciology, climatic changes, oceans involved, as sort of an example of the interplay that takes place between scientific disciplines brought on by the IGY.

ANTARCTIC STATIONS

In a few moments I would like to mention the plans for the future.

2.a) e 2.b)

As you know, the United States has supported during the IGY seven stations all together: the Ellsworth station on the Weddell Sea, the Byrd station in the middle of Marie Byrd Land, the South Pole station, the famous and historical Little America, the McMurdo station, which is a limited scientific, mostly a logistics base, Cape Hallett station, and the Wilkes station.

In addition, we have done a good many traverses as shown by the red, blue, solid; and dashed lines, perhaps 10,000 miles of traverses has been done since the IGY program began 2 years ago in the Antarctic.

FUTURE ANTARCTIC WORK

Our plans for the future are somewhat in fluid stage.

CONCEPT 14

We definitely know that the South Pole is being retained, in fact, it is being manned now by scientists.

The Byrd station is being maintained. The McMurdo, the Navy logistics base, is being maintained in close cooperation with the New Zealand-Scott station in the neighborhood ; the joint station at Hallett is being maintained. Wilkes is being operated by a joint program between Australia and the United States, with the United States furnishing three scientists. At Ellsworth, it is being maintained with a joint program with Argentina, with the United States furnishing one scientist.

CONCEPT 15

Little America has been abandoned temporarily, we hope.

Little America is perhaps the most valuable or all scientific stations in Antarctica. It is a station that has shown clearly for the first time in Antarctica a warming trend of perhaps 5° F. since 1912, which fits in with the warming trend that has been noticed elsewhere in the world, particularly in the Arctic. There has also been drilling at Little America which has almost pierced the 850-foot-thick Ross ice shelf and this Ross ice shelf in itself deserves a little bit of mention.

Using the temperatures at Little America, it appears as if the ice has been over Little America over 200 years, perhaps, during a fourth of which the ice has been melted by the ocean current.

Outras disciplinas mencionadas

There are units here which are unique. Here we have the darkness of the great depths because of the thick coating of ice and snow, but not the pressures. Here we have the separation of the water from the air by the thick ice, meaning you do not have the nutrients coming down from top layers as found in other areas, so you might have a very unique form of marine life, biologists tell me.

INTERNATIONAL PLAN, SCAR

2.b) e 2.a)

Internationally, there is an organization which has replaced the IGY, SCAR, Special Committee on Antarctic Research, which has had two meetings and will have a third meeting in early March in Canberra, Australia.

There are 12 nations members of SCAR, and each of the nations involved in IGY work has kept up its possible IGY Antarctic programs. As a matter of fact, Poland has announced an intention to join in Antarctic work and has taken over a Soviet station at Bunger Oasis, an ice cover discovered by the American naval aviators a decade ago.

Poland will undoubtedly become a member of SCAR because of its activity in Antarctica.

Two other nations, Germany and Italy, have talked about participating, so the program in Antarctica is proceeding nearly as vigorously as during the IGY. In fact, there has been no diminution we have been able to find on the part of the Soviets:

in fact, an increase in their activities and other nations are coming in. I think that is about all I have to say on the combined subjects of meteorology, glaciology in the Antarctic. I will be very glad to answer questions.

REDUCING U.S. EFFORT IN ANTARCTICA

Mr. Thomas. Doctor, what, did our friend Dr. Gould mean when he said we were abandoning our activities in the Antarctic? Did you read his telegram?

Dr. Wexler. Yes, sir. I believe he said we have abandoned Little America and have reduced our activities in Antarctica.

Mr. Thomas. I believe I understood you to say that perhaps the best station of all, regardless of all the nations' stations, was Little America. Why was it abandoned ?

Dr. Wexler. This station is the most valuable, because of its long history, going back to Amundsen in 1912, and the large number of years of occupation, totaling about eight, which enables you to get a trend. Its abandonment, I think, was probably simply a question of money and manpower.

Mr. Thomas. Which ones do we keep now ?

Dr. Wexler. We are keeping the South Pole, Byrd, McMurdo, and jointly with New Zealand, Ilallett, and we do have cooperative programs at Wilkes with the Australians and at Ellsworth with the Argentines, which nations have taken over custody.

IMPORTANCE OF LITTLE AMERICA

Mr. Thomas. Anyway, we elected our choice in keeping four or five stations open and you abandoned that one through choice ? The choice was measured on the relative importance of that particular station, Little America, with some four or five others we had there?

Dr. Wexler. I don't know whether the scientific aspects were given as much weight as some other aspects.

Mr. Thomas. Who decided it?

CONCEITO 15

Dr. Waterman. There is a difficulty there, as I understand the Navy's part in it. They said the station was in bad condition and had to be renovated in order to be maintained permanently. Further more, it is on the ice shelf and in danger of breaking off from the continent.

Mr. Thomas. Which base do we use as our main supply base now ?

Dr. Wexler. McMurdo Sound.

Dr. Waterman. The value of Little America is very great from the scientific standpoint, from the continuity of observations. This was a very awkward position to be in. The Navy maintained it was a most expensive thing to bring it back and ultimately it might be lost.

Mr. Thomas. How do you mean, it might be lost ultimately.

Dr. Waterman. It was a dangerous situation, as I understand it, at the edge of the Ross ice shelf. It might be overwhelmed, as other ice would subside. That was admitted by everyone but no one knows when that might happen. Is that right ?

Dr. Wexler. Eventually it will drift away, as all ice does, but Mr. Crary, who studied this, thinks it has a minimum life of 10 years, and probably 20 years. I think one of the difficulties facing the Navy was the problem of unloading supplies at the bottom of that big ice barrier. The ships are in rather a hazardous position when they tie up at the edge of the ice which towers above them, and large hunks can fall down.

Mr. Thomas. How many months of navigation do we have a year at that port ?

Dr. Wexler. About 3 mouths, from December through February.

OTHER INTERNATIONAL EFFORTS IN THE ANTARCTIC

CONCEITO 14

Mr. Yates. Is there any diminution in the efforts of the U.S.S.R. in its activities?

Dr. Wexler. No. I believe it is going the other way around. They have not only set up stations in the interior, the deep interior, places where, they said they would, but they have now proposed traverses across the continent. One of the traverses will be from one of these interior stations to the South Pole, past our Byrd station, and over to the Bellingshausen coast.

Mr. Thomas. Is there any diminution in cooperation between the U.S.S.R., American, and the other people there ?

Dr. Wexler. No. Cooperation has been very friendly and fruitful.

We have had an exchange of meteorologists in Antarctica for 2 years. It has worked very well.

CONCEITO 17

Mr. Boland. Should we increase our efforts in this area instead of cutting them back?

Dr. Wexler. Well, all I can say-

Mr. Boland. I mean increasing them over and above what you plan for the next year.

Dr. Wexler. All I can say is that the scientific problems here in Antarctica have merely been scratched. I think that we could put more effort into this area from the scientific point of view.

In other words, it would be desirable to find out a lot more things than we have found out so far, but weighing this with other aspects of national policy is something beyond my particular capability.

Mr. Thomas. Dr. Wexler, did you ever hear the old expression that the most permanent thing on earth was a temporary Government installation?

Dr. Wexler. Yes.

Mr. Thomas. I imagine that holds true on ice, too.

Dr. Wexler. It certainly does. One of the early Little America ramps built in 1939 has been completely engulfed in ice but still people can get to it by going down a ladder.

2.a)

I should say now that Dr. Berkner has come in, it reminds me of the fact that he, Mr. Shapley, myself, Dr. J. Tuzo Wilson, of Canada, president of the International Union of Geophysics, and a few other project leaders, spent the month of November in Antarctica for the purpose of assessing the IGY results and making plans for the future.

U.S.S.R. STATIONS IN THE INTERIOR

Mr. Jonas. May I ask a question, Mr. Chairman ?

Mr. Thomas. Surely.

CONCEITO 14

Mr. Jonas. As I look at the map, I am struck by the fact that the only stations in the interior are Russian stations.

Dr. Wexler. We have two over here.

Mr. Jonas. I mean in the eastern area.

Dr. Wexler. That is correct.

Mr. Jonas. Have we deliberately refrained from establishing stations in that great land mass to the east ?

Dr. Wexler. We do have a coastal station.

Mr. Jonas. I am talking about the interior.

Dr. Wexler. We felt our concentration in this area fitted in with our previous work in this area beginning with Admiral Byrd's expedition in 1928. This is a very important stretch of territory.

Mr. Jonas. We deliberately elected then to take the western side and concentrate there ?

Dr. Wexler. Yes, with the exception of the Wilkes coastal station.

Mr. Jonas. We have never expanded Wilkes or moved out from it?

Dr. Wexler. We did. We set up an interior station perhaps 60 miles in on the island at Wilkes.

Mr. Jonas. You do not think we would accomplish anything worth while by establishing stations between Wilkes and the South Pole?

Dr. Wexler. Well, the south magnetic pole was occupied by the French, and they have abandoned it after the IGY. The Soviets have the south geomagnetic pole at Vostok, which will be maintained.

Mr. Jonas. It seems to me the only people who are exploring that section of the land mass are the Russians. I am just wondering whether we are not abdicating the whole area and turning it over to them and we might some day wake up and regret having done so.

Dr. Wexler. You will notice that heavy blue line going westward out of McMurdo Sound. Cary and his group made a traverse in this area in the past few months and has returned now to McMurdo. We would like to see our capability increase so we could continue such traverses not only from McMurdo but from the South Pole into this area, not setting up stations, but getting out there and taking scientific observations.

Mr. Yates. Dr. Wexler, you indicated that the eastern part of Antarctica was warming up in contrast to the western part. There was more shelter.

Dr. Wexler. That the ice was receding.

Mr. Yates. The ice was receding. I assume, therefore, it is warming?

Dr. Wexler. Not necessarily.

Mr. Yates. Can people live where those Russian posts are located for any length of time ?

Dr. Wexler. Only if they take the utmost precautions. They have to bring in food and heated clothing.

Mr. Thomas. What is the maximum period, 90 days to 4 months?

Dr. Wexler. No. The Russians have stayed the year around. This is the station where they observed the temperature of 125° below zero.

In so doing the men have to use tubes to breath from and the tubes go under the heated parkas and warm up the air before it goes into their lungs.

Mr. Yates. They lived there a year ?

Dr. Wexler. Yes.

Mr. Yates. What kind of shelter do they have ?

Dr. Wexler. They bring shelters in by sleds and wherever they stop, that is their camp. Then they pushed on the next season until they got to these spots.

Mr. Thomas. Dr. Berkner, do you want to add anything, or do you want to come in later ? What is your pleasure ?

Dr. Berkner. I might only repeat what Dr. Wexler has already said, that the IGY has shown that Antarctica is a continent in a true sense and not just an icy mass; that it ranges from a relatively warm climate on some parts of the coast, very habitable areas to very for bidding areas in the interior.

Mr. Thomas. What do you mean, a relatively warm temperature ?

Dr. Berkner. Dr. Wexler probably wouldn't be willing to say this ; I will stick my neck out. If you go to Taylor dry valley, the guess is the temperatures probably run from 70 above to 30 below, which is probably a better climate than many American cities and it is an area of great rivers, lakes, and I suspect the hills get green in the summer time with reindeer moss, et cetera.

Mr. Thomas. Is that the resort area that Dr. Berkner was going to open up ?

Dr. Berkner. It is not going to open up in the sense this will ever become a farming community, but after all, Antarctica does have a considerable strategic value to us in other areas.

Mr. Thomas. All right, Dr. Kaplan. __

Anexo 8 - 04J60 - David Hall

Fonte:

[https://babel.hathitrust.org/cgi/pt?id=mdp.a\)9015003423111;q1=FRONTIERS%20IN%20the%20atomic%20age%20ENERGY%20RESEARCH%20hearings](https://babel.hathitrust.org/cgi/pt?id=mdp.a)9015003423111;q1=FRONTIERS%20IN%20the%20atomic%20age%20ENERGY%20RESEARCH%20hearings) (pp. 165-169)

STATEMENT OF DAVID B. HALL, LOS ALAMOS SCIENTIFIC LABORATORY
Dr. HALL.

Thank you, gentlemen. I am very happy to be able to support the testimony which you have just heard from Dr. Spinrad, although there was no specific collaboration beforehand.

5.a) e 5.b) – Outras disciplinas mencionadas

I had the opportunity of seeing a copy of his remarks a few days ago, and I was pleasantly surprised to find that many of the things which he was saying were ones which I had intended to cover in my remarks. This is really not an embarrassment; it is indicative of the fact that those of us in the laboratory working with fuels are continually searching for the natural role of atomic energy in the family of fuel sources.

Of the topics which Dr. Spinrad has listed as being unique, I would choose to emphasize four as being particularly important in determining the position of nuclear energy derived from power reactors in the complex of energy sources. These are first, the low cost of fuel as, it is mined. I think the emphasis should be on the fact that it is as, it is mined, nor as it is fabricated.

Secondly, the compactness of the fuel or the concentrated source of the energy.

The third item would be the lack of oxidant being required for release of the energy.

The fourth item would be the very high temperature limitation or lack of temperature limitation.

The application of reactors which has been emphasized by all of the countries to date is that of developing electrical power generation.

5.a)

This presents a very clear objective and a useful starting point in adapting nuclear power for peaceful purposes. But the generation of electrical power is not the major consumer of our fuel resources, as has been pointed out in many surveys.

CONCEITO 1

Using figures for the year of 1956 as compiled in the AEC quarterly, the Tower Reactor Technology, less than one-fifth of the energy consumed in the United States today is used for electrical energy generation.

CONCEITO 2

Process heating and space heat account for about one-half. In the present stage of our national economy, electrical energy generation amounts to about 700 billion kilowatt-hours annually, and, at an generating cost of 6 to 7 mills per kilowatt-hour, is approximately 1 percent of our gross national product.

CONCEITO 3

The cost of electrical power is obviously very vital to an important Segment of our industry but it represents a relatively minor position in the overall economy.

CONCEITO 4

This is not to say that a significant change in the cost structure of electrical power would not be reflected in changes in the importance of a few products, even many products, and might even result in painful dislocation of some selected areas.

CONCEITO 5

At the same time, it is difficult to see how the national economy can be affected in a significant manner by replacing centralized electrical power generating stations, using conventional fuels, with ones using nuclear energy.

I think these statements should be interpreted as pointing out that the power industry has done its job so well that there appears to be little margin for improvement and makes the work of developing nuclear power just that much harder. But if the cost of the generation of electrical energy went to zero, the resulting cost of fabricated items in the market could not change very greatly. One would still have charges for plant, labor, distribution, taxes, forth; and so all of which represent more than 90 percent of the value of the fabricated items. .

A survey of typical fabricated goods, will show that the cost of energy contributes about 3 percent to the product value, and only rarely is it more than 5 percent. The cost of electricity in the home for the average small consumer is considerably greater than the bare generating cost.

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CONCEITO 6 – Referência AC

However, in the not too distant future there may be compelling reasons to require that sizable blocks of fuel consumption be required to utilize nuclear energy in place of conventional fossil fuel. It might, for example, be motivated by the need to conserve natural fluid fuels such as oils and hydrocarbons for mobile power uses. Or alternatively, the increases of carbon dioxide content in the atmosphere from ever-increasing consumption of fossil fuels might conceivably be altering the temperature and hence the sea level by affecting the cloud formation and rainfall. There is no direct evidence for this now. Both of these effects would tend to make the average climate warmer and drier. In this connection one can point out that there are bodies of water in this country which have disappeared only recently after having been in existence for many thousands of years, and supporting marine life over that period. This is possible evidence that man is changing his environment.

The same intrinsic feature of a nuclear powerplant that makes it so attractive for a space power station, that is, requiring no oxidant, also suggests extensive applications in the submarine environment.

1.b)

These have been explored in a survey conducted by the Stanford Research Institute in Report SRIA—7, dated August 1959, and several ideas appear to have merit.

CONCEITO 7

Among them is the application to oceanographic research where the requirement would be for a small powerplant output with a very long fuel life and a vessel capable of withstanding the required pressures. Presently available equipment is severely hampered by the lack of mobility and of power for undersea exploration. These may not appear to have commercial value now but authorities working in oceanography have stated that even now we know less about the oceans than we do about outer space. It seems almost inescapable to me that if the day comes when the population of the world cannot be adequately supported by land grown foods we will have better success in augmenting food supplies by farming the seas than by cultivating the planets.

CONCEITO 8

Another important resource of the seas lies in the mineral content of the oceans both as dissolved salts and as precipitates in the sediments. The use of nuclear explosives might be feasible in breaking up a mineral belt on the ocean floor and preparing the ore for recovery by a deep sea dredge. Hydraulic lift or jet pumps working on the sea bottom might utilize nuclear energy efficiently in a marine environment. Important and critical minerals in this way may become available to nations now dependent on importation. These considerations are a matter of detailed economic evaluation.

The prospect of using reactor power for process heat, using the term very loosely as a way of differentiating between electrical energy generation and nonelectrical energy stationary power, has not received all of the attention which it may merit in the long-range picture.

This statement is based on the conviction that the valuable fuels which support our highly mobile way of life and our flexible marketing techniques are being depleted much more rapidly than the total reserves increase; two-thirds of our present energy is obtained from oil and gas, with a consumption rate of 0.04 Q per year and an indicated reserve of one to two Q. A Q, you may recall is 10¹⁸ B.t.u., a very large number. If this pattern continues or worsens, we will have to find a replacement fuel or change our way of living. Nuclear energy itself is not suitable for this application as has been mentioned, nor is coal, but the energy obtained from nuclear reactors can be used for the synthesis of hydrocarbon fuels and for the manufacturing of basic materials to be used in fuel cells. '

CONCEITO 9

Speculations of this type which try to probe the future are at best difficult to substantiate, and in no case have I tried to make an attempt to establish the feasibility, either technically or economically, of any of these suggestions.

They are mentioned here only as statements of faith, that the potential of the role of nuclear energy is far broader than that of generating electrical energy by conventional steam turbine equipment. It can be stated categorically, however, that the more efficiently and more cheaply, the utilization of power from fission energy is made, the more widespread its application will be. The property of a potentially cheap energy source may well be the outstanding characteristic of nuclear power.

CONCEITO 10

In order to exploit this feature, it will be necessary to depart radically from what have become standard conceitos of complicated fuel elements, and the costly refining and fabrication stages which nuclear fuel must undergo and the attendant auxiliary costs of precise positioning and handling of these fuel elements. These requirements in present reactor conceitos do much to nullify the low cost of fuel as it is mined.

Representative PRICE. Thank you very much, Dr. Hall.

(Dr. Hall's formal statement follows:)

SOME SPECIAL APPLICATIONS FOR NUCLEAR REACTORS

The energy obtained from nuclear reactors has several unique properties when compared to other forms of fuel. Consideration of these special features can lead to speculation concerning applications where atomic energy might be used in the future to particular advantage.

5.b) e 5.a)

Some of these applications are under development now as part of the AEC long-range program. Others are logical outgrowths of current or planned development, and yet others are merely fragmentary possibilities.

Some of the unique properties which can be considered are the concentrated nature of the energy source, the limitless temperature of the energy, the self-contained feature which requires no oxidant to be present, and the relatively low cost of the fuel before fabrication. Some special applications which take advantage of these unique features may be found in regions outside of the earth's atmosphere, either in far outer space as satellite power stations, or under the sea as special submarine vessels for exploration, or mining operations.

If the inexpensive nature of the fuel can be fully exploited, it is conceivable that changes in climate can be effected over a modest area at reasonable costs. Less than one fifth of the energy consumed in the United States is used for electrical generation; process heat and space heat account for about one-half. At the present stage of our national economy, electrical energy generation amounts to approximately 700 billion kilowatt-hours per year and, at an average generating cost of 6 to 7 mills per kilowatt-hour, represents only 1 percent of the gross national product. The cost of electrical power production is obviously vital to an important and vocal segment of our industry, but it represents a relatively minor position in overall economy. This is not to say that a significant change in cost structure of electrical power would not be reflected in changes in the importance of a few products and might even result in painful dislocations in some selected areas of our national life. At the same time it is difficult to see how the national economy can be affected in a significant manner by replacing centralized electrical power generating stations using conventional fuels with ones using nuclear energy.

CONCEITO 11 – Referência AC

However, in the not-too-distant future there may in fact be compelling reasons to require, through legislation, that sizable blocks of fuel consumption be required to utilize nuclear energy fuel in place of conventional fossil fuel. This might, for example, be motivated by a need to conserve natural fluid fuels such as oil and hydrocarbons for mobile power uses. Alternatively, the increases in the CO₂ content of atmosphere from ever-increasing consumption of fossil fuel might conceivably be altering the climate and geography of the world both through increasing the mean temperature and hence the sea level and also by affecting the cloud formation and rainfall. Both of these effects would tend to make the average climates warmer and drier.

It is a matter of record that bodies of water have recently disappeared after supporting marine life for many thousands of years, a fact which gives credence to the theory that man is changing his environment.

CONCEITO 12

In the Los Angeles area of the California coast, a temperature inversion pattern in the air is apparently a normal phenomenon for long periods of time. This is a departure from the

situation which prevailed in the recent past as little as 30 to 50 years ago. Again, it is possible that this changed weather condition and its influence on the local climate is the result of the fuel burning in the congested metropolitan area. It has been suggested that the temperature inversion pattern could be upset over a limited region by operation of a nuclear power plant in the offshore waters. Such a reactor would have to be very large to heat an air mass sufficiently to literally punch a hole in the warm barrier layer at the inversion point. However, this same large reactor might be distilling sizable amounts of sea water to support the area. Estimates have shown that a station of 100,000 megawatts (7 percent of U.S. fuel consumption in 1956) operating at relatively low temperatures could produce these results. Extreme as this suggestion is, it would be absurd with any other fuel.

CONCEITO 8

The same intrinsic feature of nuclear powerplants that make it attractive for space power stations, i.e., no requirement of an oxygen source to liberate the energy, also suggests extensive applications in the submarine environment.

These have been explored in a survey conducted by the Stanford Research Institute (SRIA—7, dated August 1959) and several ideas appear to have merit.

Outras Disciplinas mencionadas

Among them is the application to oceanographic research where the requirement would be for a small powerplant of modest output with very long fuel life in a pressure vessel capable of withstanding the required pressures. Presently available equipment is severely hampered by lack of mobility and of power for under sea exploration. This may not appear to have commercial value, but authorities working in oceanography have stated that even now, we know less about the oceans than about outer space. It seems almost inescapable that if the day comes when the population of the world cannot be supported by land-grown foods, we will have better success in augmenting the food supplies by farming the seas than by cultivating the planets. Another important resource of the sea lies in the mineral content both as dissolved salts and as precipitates in the sediments. The use of nuclear explosives (Plowshare) might be feasible in breaking up a mineral belt on the ocean floor and preparing the ore for recovery by a deep-sea dredge. Hydraulic lift or jet pumps working on the sea bottom as dredges might utilize nuclear energy efficiently in a marine environment.

Speculations of this type which attempt to probe the future are at best difficult to substantiate, and in no case is there an attempt here to establish the feasibility, either technical or economical of the suggestions which are made.

They are mentioned only as statements of faith that the potential role of nuclear energy is far broader than that of generating electrical energy by conventional stream turbine equipment. As we learn how to utilize this energy source, new applications will suggest themselves to us as outgrowths of the work which is underway.

Representative PRICE. The next witness will be Mr. Bernard Manowitz of the Brookhaven National Laboratory.

Anexo 9 - 05S66 - Chamberlain

Fonte: <https://babel.hathitrust.org/cgi/pt?id=uc1.b5164561;view=1up;seq=143> (pp. 95-118)

STATEMENT OF DR. ADRIAN CHAMBERLAIN, VICE PRESIDENT, COLORADO STATE UNIVERSITY; CHAIRMAN, NATIONAL SCIENCE FOUNDATION SPECIAL COMMISSION ON WEATHER MODIFICATION

7.b)

Dr. Chamberlain. Gentlemen, it is a pleasure to discuss with you the results of the work of the National Science Foundation Special Commission on Weather Modification as you consider S. 2916.

*

7.a) * 8.b) * 8.a)

The Commission was chartered to make recommendations to the National Science Foundation and to provide a response for a committee of the Federal Council on Science and Technology.

CONCEITO 1

The assignment included consideration of the physical, legal, social, biological and political aspects of weather and climate modification.

*

Man's growing knowledge of the natural environment has given him an increasing awareness of the changes taking place in his earthly habitat.

Fortunately, his increasing knowledge has also indicated some possible means of deliberate modification of the environment.

*

This knowledge may make it possible, hopefully, for him to for plan conservation and development of the environment for the benefit of man.

CONCEITO 2

He is at last learning he cannot consider himself free to heedlessly exploit the air, water, land and growing things of the earth.

*

CONCEITO 3

The central issue of public policy considered by the Commission was: Do the scientific and engineering possibilities of meaningful deliberate weather and climate modification seem sufficiently promising of social benefits to indicate the time has arrived for the Nation to direct substantially larger resources of money and manpower to the many facets of the field?

WEATHER MODIFICATION

The Commission concluded the answer is: Yes; for reasons of scientific, human, biological, legal, and international need.

CONCEITO 4

Such a national program will require a budget increase of at least \$40 million to \$50 million per year by 1970 over the fiscal year 1966 level for weather and climate modification activities.

*

SCIENTIFIC PROSPECTS

CONCEITO 5

The Commission feels the study of weather and climate modification is ready to pass from being considered a speculative field to one ready for a rapid expansion of carefully planned research and development.

CONCEITO 6

Many interesting and potentially valuable opportunities are becoming evident that will attract many of the Nation's best minds to the field if fiscal resources are made available to support the intellectual talent of industry, academic institutions, and Government agencies.

*

The atmosphere can be viewed as a complex system in which ascertainable changes in air motion will take place in response to identifiable forces.

If the forces are altered, in principle the motion of the air can be influenced.

*

Therefore, in principle, meaningful modification of the weather and climate should be feasible if one can demonstrate the capability to alter these forces so as to produce predictable consequences.

*

In a practical sense, it is necessary to establish only beyond reasonable doubt that the cause and effect are related.

Aside from intellectual curiosity, this has been the central problem of weather modification research.

*

Progress has been made.

4.a) * 4.b)

That seeding (the cause) can dissipate supercooled fog (the effect) has been so clearly demonstrated it is moving to the operational phase for some airports.

*

On a larger scale, there is evidence, though somewhat ambiguous, to support the view that precipitation from some types of clouds can be increased by the order of 10 percent by seeding.

The question of corresponding decreases outside the target area is unresolved.

*

Hail and lightning research is beginning to show some promise.

CONCEITO 7 e 8

A program of large, carefully instrumented and statistically designed field experiments is needed.

These will take a great deal of money.

*

The study of the energy levels of atmospheric subsystems such as tornadoes, hurricanes, and extratropical cyclones leads to the conclusion that it is not practical to think of altering these subsystems by direct application of energy.

Yet the study of instabilities in the atmosphere indicates at least four kinds of instabilities may be susceptible to man's effort to "trigger" natural reactions.

CONCEITO 9

These instabilities — (1) phase instability of water, (2) colloidal instability of cloud particles, (3) convective instability of the atmosphere, and (4) baroclinic instability of the large scale circulation — will all require a great deal of theoretical, laboratory and field research.

*

I am sure that as your scientific testimony is presented, that there will be further elaboration on these particular instabilities.

*

CONCEITO 10

Improved prediction of weather phenomena may be as important in many cases as modification in terms of social and economic benefits.

CONCEITO 11

For this end and others a global observation network will be necessary.

CONCEITO 8

Numerical stimulation studies need to be expanded.

*

CONCEITO 12 - Referência AC

The Commission was greatly concerned about the inadvertent modification of weather and climate underway due to the activities of man.

Air pollution from our cities is an example.

This is a problem of grave importance.

CONCEITO 13

Little is understood of the weather and climate modification being induced by this means.

*

Non atmospheric means or modifying weather and climate need to receive increased attention.

The atmosphere interacts with the expanses of earth and sea.

Man's ability to induce large-scale alterations of the land and sea continues to increase.

The possible consequences of such alteration on weather and climate need a great deal of study.

*

CONCEITO 13

To illustrate this, conversation is taking place with regard to pouring oil over the seas, thereby setting the air-sea interaction which might potentially, at least from a speculative point of view, influence hurricanes, as an example of nonatmospheric means.

*

CONCEITO 14 – Outras Disciplinas Mencionadas

The Commission concludes the scientific and engineering prospects of meaningful progress in weather modification are sufficiently attractive that a great deal more manpower should be drawn into the field.

CONCEITO 15

This expansion of activity will require talent from several disciplines.

*

CONCEITO 16 e 8

Also required will be a great increase in the logistics support for field and laboratory research and operations.

CONCEITO 17

The results of increased intellectual concentration on the field would be important not only to those interested in precipitation augmentation, but also the entire field of atmospheric resources.

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BIOLOGICAL RELATIONSHIPS

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CONCEITO 18

Anything that has a significant effect upon plants and animals is of primary concern to man.

Plants and animals are the foundation of his existence.

*

CONCEITO 19

Modifying weather and climate may initiate changes in the abundance of certain plants and animals.

It may also induce instabilities in numerous biological populations —including those that prey on man and challenge his existence.

*

CONCEITO 15

Thus, a national program of weather and climate modification must include support for a substantial research program in ecology and related biological sciences.

*

The present state of knowledge is very inadequate for making good predictions of the biological consequences of specific weather modification projects except under limited conditions.

*

The ecological system of agricultural fields is well enough understood that reasonably good predictions can be made.

But in a more complex system such as that of large uncultivated watersheds containing many species of interacting plants and animals it is not now possible to make quantitative predictions.

*

Living things are adapted to the weather that prevails.

Any change in the weather will be generally deleterious to them.

Weather and climate modification over large areas of a few hundred square miles or larger for long periods of time is likely to induce a decreased stability of biologic communities.

This instability would manifest itself as an increase in pests, weeds, and pathogens.

*

CONCEITO 8

It is extremely necessary and important that a national weather modification program involving large areas for field experiments have fiscal support for ecological studies by numerical stimulation and field study.

*

To obtain a net benefit from a biological point of view will require much better knowledge than now available of the interactions of weather and organisms.

Such research is expensive.

CONCEITO 20

Such studies span many years for obtaining meaningful conclusions.

*

The largest social credit item for weather modification is likely to be an increase in primary plant production of the drier parts of the land surface.

STATISTICS

*

As is well known, a controversy among statisticians over the validity of the conclusions of early research did not encourage weather modification research during the late fifties.

The situation is better now.

*

The current central question on the role of statistics in weather and climate modification research is not whether to use statistics but how to use it in the early design through to the analysis of the research data.

*

CONCEITO 21 – Outras disciplinas Mencionadas

The national program in weather and climate modification needs to provide for support of statisticians to work on all facets of physical, engineering, and biological studies in the field.

Furthermore, support is needed for basic statistical methodology research.

*

HUMAN EFFECTS

*

CONCEITO 22

Sound public policy in the face of uncertainty about the techniques of weather modification requires that research also be initiated on the social and economic effects.

CONCEITO 23

Such research is needed to fully exploit what may be an historic opportunity to improve the environment for society, and at the same time be prepared to avoid activities which might be detrimental to man.

*

So intricate are the interlocking motivations in human behavior that subtle changes may be initiated by weather modification and not even be detected.

*

Some beneficial changes, such as bountiful crops and their impact on the economy, can be readily followed.

But because the organization of society is so complex it is not evident whether the quality of life may be enhanced or degraded by every possibility of weather and climate modification.

*

It seems clear, for example, that the power and motion of severe storms provide some of the most exhilarating opportunities that the human mind experiences.

Would it be of social benefit to completely control weather and remove these phenomena from the realm of human experience ?

How could one put a value on such a possible degradation of the quality of the life experience ?

*

From an economic point of view many effects of precipitation augmentation for crops, hydroelectric power, et cetera, can be fairly readily measured.

But other effects might not be so simple to evaluate.

*

CONCEITO 24

For example, what would be the economic, social, and political problems of shifting a hurricane so it hit North Carolina instead of Florida?

To learn how to deal with such problems in advance of the technological capability, in the face of large uncertainty about the ability to modify weather, will require a great deal of effort.

*

Several areas of potential conflict of interest are already recognizable.

Public policy should seek to provide a means to reconcile conflicts equitably.

It should seek to prevent victimization, either by people who mistakenly think they are gaining benefits or of individuals who are unaware of damages being inflicted on them.

*

Conflicts may arise between those trying to conduct experiments and those wishing to carry out operational projects for utility or agricultural clients.

*

CONCEITO 22

A national program on weather and climate modification should include support for research on the social and economic consequences of alternatives.

For example, it might be more profitable to pursue research in crop genetics to improve drought resistant crops than to augment precipitation.

*

Further, if weather modification includes serious pests and weed problems, the costs of these might overshadow the benefits of increased crop production.

Because the answers to such questions are not known, research is needed.

*

Research is needed on the basic relationships between weather characteristics and human behavior.

CONCEITO 25

The decisionmaking process of man in the face of uncertainty needs further study.

CONCEITO 26 - Referência AC

The social effects of inadvertent weather and climate modification, such as air pollution, need further investigation.

The social consequences of commercial operations and field experimentation need to be studied.

*

CONCEITO 27

The providing of indemnification against damages for federally supported work would encourage more academic, industrial, and private scientists and engineers to seek support for research and development work.

*

CONCEITO 28

LAW

*

A demonstrated capability to modify weather and climate over areas of substantial size presents legal problems of great difficulty.

*

CONCEITO 29

Yet even before such an ability is assured the law is involved on at least two counts: (1) the rules over responsibilities and liabilities of weather and climate modification to other members of the public, and (2) regulation by Government.

*

CONCEITO 28

It does not seem possible to recommend, without a great deal of further study, appropriate rules of law to govern "property rights in weather."

Easy analogies to the law regarding water, land, air space, et cetera, do not seem adequate for the problems of weather modification.

*

The liability of weather modifiers with respect to those claiming in jury to their person or property, for example, need to be decided on their own merit.

11.a) e 11.b)

The few court cases to date do not give much basis for predicting how the law will develop.

*

17.a) e 17.b)

Some 22 States have enacted laws regulating weather modification.

Most of these States require licenses.

7.a) e 6.4

Effective January 1, 1966, the National Science Foundation increased its recordkeeping requirement and imposed on all operators a requirement of advance notice to it of any activity.

This information is an aid to the Federal research and development effort.

*

CONCEITO 27

The Commission concluded that Federal legislation should be enacted adequate to—the first is essential preemption by the Federal Government—

(1) Delay or halt all activities, public or private —that is the power to do this—in actual or potential conflict with weather and climate modification programs of the Federal Government, whether these programs are conducted for the Federal Government by its own agencies, or by its public or private grantees or contractors.

(2) Immunize Federal agents, grantees, and contractors engaged in weather and climate modification from State and local government interference.

(3) Provide to Federal grantees and contractors indemnification or other protection against liability to the public for damage caused by Federal programs of weather and climate modification.

*

These recommendations are restricted in scope because it is felt that regulation should be only the minimum necessary for permitting accomplishment of immediate national goals.

*

CONCEITO 30

As knowledge develops more comprehensive regulation will be required.

CONCEITO 26 e 28

And since weather transverses national boundaries, study needs to be made of international legal problems.

*

INTERNATIONAL

CONCEITO 31

As weather and climate modification research and development continue to expand, some form of international collaboration will be essential in the planning and carrying out of operations which may affect localities of other countries and continents far distant from the scene of the operation.

Such events have a bearing on the political relationships among nations.

CONCEITO 32

*

With weather modification still in its infancy, it provides an inviting opportunity to encourage multinational interest in mutual cooperation among the people of rival nations.

*

Weather and climate modification might well serve as an avenue to widening the areas of common interest among nations, thereby helping in accomplishment of the objectives of easing tensions.

CONCEITO 3

In the process the field of weather modification may be able to contribute significantly in the growing international food crisis.

*

The international aspects of weather modification require careful study of the biological, social, economic, and political factors.

CONCEITO 32

The results of study of these fields in the United States may not be directly applicable to many of the developing countries where the social institutions, biological environment, and political system are different.

*

Now is the time to start the steps, in concert with other nations, to explore the international institutional mechanisms that may be appropriate to foster international cooperation.

*

To provide an appropriate public policy setting for weather and climate modification, the Commission feels the Nation should enunciate policy containing these two points :

(1) It is the purpose of the United States, with normal and due regard to its own basic interest, to pursue its efforts in weather and climate modification for peaceful ends and for the constructive improvement of human life throughout the world.

(2) The United States, recognizing the interests and concerns of other countries, welcomes and solicits their cooperation, directly and through international arrangements, for the mutual achievement of human well-being.

FISCAL NEEDS

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The Commission concluded that weather and climate modification research and development activities of the Federal Government should be increased by \$40 to \$50 million per year by 1970, excluding any national laboratory type capability which might be initiated.

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5.b) e 8.b) e 6.a)

These figures were derived by estimating the program needs which should be increased from the fiscal year 1966 level of \$7.2 million of agency budgets, excluding logistical support provided by the Department of Defense.

CONCEITO 33 – Outras Disciplinas Mencionadas

About half of the increase will be needed for basic research, including such things as much larger computer capability.

Much increased support is necessary for conducting carefully designed and adequately instrumented field experiments.

*

The budget increases should definitely include funds for the physical sciences, statistics, engineering, the social and biological sciences, and the law.

*

No estimate beyond 1970 was made by the Commission.

CONCEITO 22

It was felt the level of funding for the 1970-80 period could be much better estimated after a couple more years of experience.

The field is capable of going ahead so rapidly that long-range cost estimates would probably have little validity.

ORGANIZATION OF GOVERNMENT

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CONCEITO 15

The field of weather and climate modification needs to have the services of government, private industry and academic institutions.

CONCEITO 34

It must be able to accommodate participation by the individual scientist who only needs pencil and paper to the large complex organization necessary for a massive field experiment.

The following factors enter into analysis of the organizational needs :

CONCEITO 35

*

(1) There is need to bridge the organization gap between laboratory research and large-scale field experiments ; this gap can exist even in the basic research aspects.

There is need for organizational arrangements for enough applied research to develop the field, while preserving scientific objectivity in the basic research effort.

The economic, political, and spectacular aspects of weather and climate modification operations must not be permitted to crowd out the basic research.

*

(2) There is need for biological and social science research to go hand in hand with the physical science and engineering research ui support of the missions of all agencies, contractors, or grantees concerned with weather modification.

CONCEITO 27 e 36

There is need to preserve diversity in the research effort, but there is the need also to establish a Federal organizational mechanism for accomplishing what cannot be done through diverse research activities.

CONCEITO 32

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(3) Responsibility should be clearly assigned for the formulation of arrangements for appropriate scientific cooperation with the governments of other nations.

*

CONCEITO 27

(4) Adequate enforcement power needs to be provided an administering agency so as to insure the filing of information relative to all weather modification field experiments and all commercial operations.

The agency assigned regulatory functions should have a regional or field office establishment.

CONCEITO 29

*

(5) The conduct of research and development in this field should be kept insulated from activities involving the regulation of weather modification operations, but at the same time

the two types of activity should be sufficiently proximate organizationally to assure immediate access to data derived from the operations being regulated.

*

5.a) e 5.b) , 8.b) e 6.a)

Based on these considerations, plus the fact several Federal agencies have missions —such as Department of Defense— that require weather modification knowledge, the Commission concluded a pluralistic organization for assignment of responsibility would best insure progress of an expanded national program.

*

The suggested assignment of responsibilities can be summarized as follows :

*

CONCEITO 37

(1) The mission of developing and testing techniques for modifying weather and climate should be assigned to an existing or new agency in the executive branch of the Federal Government.

The mission should include support and conduct of research and development and such operational activities as are needed for the furtherance of the technology of weather and climate modification.

*

Substantial authority to contract for services should be provided.

This agency should have major but not exclusive responsibility, in collaboration with the State Department, for formulating and implementing programs of weather and climate modification involving international cooperation.

*

7.a)

(2) The National Science Foundation should continue and expand its support of research in the atmospheric sciences, including its program directed at providing a satisfactory scientific basis for weather and climate modification.

This should be carried on primarily at universities and colleges.

*

CONCEITO 38

The National Science Foundation program has been the major source of funding for development of manpower for weather modification activities.

The National Science Foundation should be given increases in funds for expanding this support since the manpower needs will continue to grow.

*

7.a) CONCEITO 34

The National Science Foundation should continue maintenance of the National Center for Atmospheric Research as a facility for the conduct of basic research on a scale beyond that feasible for individual university investigators.

CONCEITO 25

The degree of continuing and special attention given by the Foundation to support of the physical sciences, engineering, and biological sciences and the social sciences aspects of weather and climate modification should be reviewed from time to time in the light of the progress of the overall national program.

*

(3) Federal agencies should undertake such operational activities as may be required for the effective discharge of their mission.

Also, pursuant to Executive Order 10521, Federal agencies should be free to conduct and support such research and development as may be required in the discharge of their missions.

*

CONCEITO 15

The Commission also felt that a national laboratory type of capability is needed for an expanded interdisciplinary program encompassing all the relevant disciplines.

Yet it is not clear that creation of a national laboratory per se is the answer.

8.b)

The President's Special Assistant for Science and Technology could perhaps be called on to initiate appropriate feasibility studies.

*

Insofar as the nature of a regulatory agency is concerned, care must be taken to insure access of all agencies to the information generated, while at the same time keeping regulation organizationally separated from research and development.

*

Whether the regulatory function needs to be divorced completely from the operating agencies, or can be assigned to a separate branch or subagency of an existing agency will depend largely on the extent of activity and the degree of regulation required.

*

As to the jurisdiction of a regulatory agency over other Federal agencies, to the extent regulation involves requirements of notice, reports, licensing of activities, et cetera, there seem to be good reasons why all agencies should be subject thereto.

In addition, the regulatory agency should be given power to resolve minor conflicts between agencies, such as the timing of particular experiments.

*

CONCEITO 39

The Commission recommends that the Office of Science and Technology consider establishment of a special mechanism for the coordination of weather and climate modification policies and programs.

Such an entity could not only serve to resolve major conflicts but could serve to promote unity in policy and deployment of funds and manpower.

*

CONCEITO 40

Both the executive branch and the Congress may wish to have available scientific and public policy advice from a group of knowledgeable people from outside the Federal Government.

This need might well be met by the appointment of a standing committee in the National Academy of Sciences, in cooperation with the National Academy of Engineering.

The group should include persons with experience in the physical, biological and social sciences and engineering.

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SUMMARY

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In closing the Special Commission on Weather Modification was made up of 11 men from several disciplines.

They were provided background data by numerous individuals and groups such as—

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1.4 e 1.a), 10.4

(1) Panel on Weather and Climate Modification of the National Academy of Sciences ;

(2) Study Committee of the Ecological Society of America;

(3) University of Minnesota conferences on statistics and weather modification ;

(4) Participants in the University of Chicago Symposium on Economics and Social Aspects of Weather Modification ; and the

(5) Southern Methodist University study of certain legal aspects in weather and climate modification.

*

In summary, the Commission feels the time has arrived for the United States to initiate a much expanded interdisciplinary research and development program in weather and climate modification.

This program should be adequately organized and funded.

Provision should be made for participation by individuals, educational institutions, private firms, the several levels of government and foreign countries.

Regulation should be kept to a minimum consistent with available knowledge.

*

CONCEITO 2

To be able to deliberately modify our environment in a predictable manner may be our salvation as a society on this planet.

Thank you, Mr. Chairman.

Senator Caxnon. Thank you, Dr. Chamberlain.

We will now hear from Dr. Roberts.

Anexo 10 - 05S66 - Gordon MacDonald et al

Fonte: <https://babel.hathitrust.org/cgi/pt?id=uc1.b5164561;view=1up;seq=143> (pp. 144-156)

STATEMENT OF DR. GORDON J. F. MacDONALD, CHAIRMAN, PANEL ON WEATHER AND CLIMATE MODIFICATION, NATIONAL ACADEMY OF SCIENCES

*

Dr. MacDonald. I am delighted to appear before you and discuss current progress in weather modification.

There have been rapid advances in this field in recent years.

CONCEITO 1

These advances and their potential benefits to society suggest that this area of science and technology deserves careful and thoughtful consideration by the Government and the Nation.

*

3.a) e 3.b)

During the past 2 years, a Panel of the Committee of Atmospheric Sciences of the National Academy of Sciences has carried out a study of weather and climate modification.

Referência AC

The purpose of the study was to provide an assessment of the possible modes of the interference with the atmosphere both deliberate and inadvertent and to discuss the principal theoretical and technological problems that are now apparent.

In carrying out the study, the Panel took a very broad view of weather modification.

Problems in modifying clouds and storm systems were recognized as having an immediacy of interest not presently shared by other areas.

However, the Panel did not restrict its interest to questions of modifying cloud systems, but studied a broad range of scientific and technological problems associated with many aspects of weather and climate modification.

CONCEITO 2

In these studies the Panel did not go deeply into the complex legal, sociological, or economic aspects of weather modification, but throughout its work was keenly aware of these nontechnical factors.

*

Since the completion of the report in November of 1965 a number of new results have been presented in conferences and I will refer to these since they add in a substantial way to certain of the conclusions reached by the Panel. I will first discuss the stimulation and redistribution of precipitation.

I will review the fundamental aspects of the precipitation process as a background to the discussion of experiments and operations in increasing rainfall.

*

CONCEITO 3

It is important in discussing precipitation enhancement to distinguish those projects carried out primarily with the object of increasing our knowledge about rain from those operational projects designed specifically to increase rainfall for commercial profit.

The former are guided by objectives and procedures for research and the latter by objectives and procedures of business.

CONCEITO 4

The operational experience, however, can be used to provide new knowledge if the limitations of the data are clearly recognized.

*

The development of rain from water vapor contained within the atmosphere requires a number of physical steps. First, the air must be cooled or water vapor added until the air becomes saturated with water vapor and a cloud forms. The air must contain nuclei which enable the vapor to condense to water or ice. Next, some of the cloud particles, either water or ice, must grow large enough to fall out of the cloud.

The first step, that of cooling the air or increasing the degree of saturation, can be accomplished by the gradual lifting of the air, for example the lifting the air becomes saturated with water vapor and a cloud forms. The air must contain nuclei which enable the vapor to condense to water or ice. Next, some of the cloud particles, either water or ice, must grow large enough to fall out of the cloud.

*

There have been proposals to enhance the degree of saturation by changing the thermal properties of the ground, but these projects are still tentative. Most efforts in precipitation enhancement are directed toward increasing the number of condensation nuclei and thus encouraging the transition of water vapor to ice.

Clouds are complex systems and may contain water in a variety of forms. The entire cloud may be warm, above the freezing point, and consist exclusively of liquid droplets. If it is made up of liquid droplets and the temperature is below freezing, it is a supercooled or cold cloud. An ice cloud is one composed entirely of ice crystals. To get precipitation out of any of these clouds, it is necessary to cause some of the minute suspended particles to grow very large, possibly at the expense of other particles.

The particles can grow either by mechanical agglomeration, that is the collision of small droplets or ice crystals to form a large one, or ice crystals can grow at the expense of water droplets. The basis for the growth of ice crystals from water droplets is the difference between the vapor pressure of the water and the ice. In order for the ice crystals to grow at the expense of water vapor, it is necessary that both ice crystals and water droplets exist. The mixed supercooled water droplet and ice crystal cloud system required by those processes seem to occur frequently in a variety of forms. In all the principal precipitating systems, cyclonic storms, orographic storms, and convective shower clouds, the vertical extent of the cloud mass is usually high enough to reach sufficiently cold temperatures for the two types of particles, water droplets and ice crystals, to coexist.

The basis for increasing precipitation in these mixed cloud systems lies in the introduction of additional nucleating particles. The small particles enable further ice crystals to grow at the expense of the water droplets. A number of substances have been used as nuclei. The most effective appears to be silver iodide, which on burning releases a very large number of extremely small particles, each one capable of initiating an ice crystal provided the temperature is somewhat below freezing.

I now turn to some of the experimental evidence and results from operations. The experimental results can be categorized under the headings of orographic, cumulus, and cyclonic cloud systems.

*

Orographic cloud systems are those produced primarily by the forced ascent of air passing over mountain barriers.

Cyclonic and convective systems are often superimposed.

8.a) e 8.b)

In 1957 the President's Advisory Committee on Weather Control reported that 10 to 15 percent increases of rainfall resulted from the introduction of silver iodide nuclei into orographic wintertime storm systems in the western coastal regions of the United States.

CONCEITO 5

This early result was challenged by statisticians who complained of the methods of analyzing the data.

1.a)

The statisticians suggested a properly randomized experiment and this was begun near Santa Barbara, Calif.

CONCEITO 6

Unfortunately, the results of this experiment were indecisive, since it was believed contamination of certain of the control areas resulted from commercial efforts at rainmaking.

This early difficulty illustrates the kinds of problems that are raised in attempts to obtain definitive information on the effectiveness of cloud seeding.

*

4.a) e 4.b)

Perhaps the most complete study of seeding of orographic storm systems is now underway in California under the sponsorship of the Pacific Gas & Electric Co.

1.a)

This program is not discussed in the Panel report but preliminary results were presented at the Weather Modification Section of the Fifth Berkeley Symposium on Mathematical Statistics and Probability held in December of 1965.

4.b) e 4.a)

This experiment, is company planned and company executed in the Lake Almanor region, 200 miles northeast of San Francisco.

It is scheduled for 5 years ; this is the fourth year and 2 years of data have been analyzed. The target area in which the seeding is supposed to increase the precipitation is 500 square miles and is in the lee of the Sierras.

For southerly flows the air is still rising over the target area.

The Pacific Gas & Electric workers have stratified the data in four ways: with respect to the wind, which is either southerly or westerly and with respect to the temperature at the 7,500-foot level. The clouds are termed warm if the temperature is greater than 23° F. at 7,500 feet and are called cold if the temperature is less than 23° F. at 7,500 feet.

*

With southerly flow, no additional precipitation was detected when the seeded target areas were compared with the control areas. With westerly flow, the cold clouds, that is, those clouds with a temperature less than 23° F., gave 32 percent more precipitation, and the chance of obtaining such an increase purely as a result of statistical fluctuations is about one in a hundred. On the other hand, the westerly warm clouds, when they were seeded, gave 23 percent less precipitation.

*

I next turn to the seeding of cumulus clouds.

1.a) e 1.b)

The University of Chicago Whitetop project has studied the precipitation from showerproducing summertime cumulus in southeast Missouri over a period of 5 years.

CONCEITO 7

Preliminary analysis of the experiments which were properly randomized in the statistical sense showed an increase of 5 to 10 percent of the precipitation in the seeded clouds.

*

10.a)

At the Berkeley conference a new and important study from Australia was reported.

In this study, individual cumulus clouds have been seeded.

The results are striking.

Sixty clouds in all have been investigated.

Of these, 23 involved clouds with temperatures less than 14° F at the cloud tops. In these, the precipitation was seven times greater in the seeded cases than in the unseeded.

The warm clouds with a temperature greater than 14° F showed less precipitation in the seeded cases.

These results have led the Australian workers to reinvestigate earlier long-term projects for which cloud-top temperatures were available.

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Cold clouds show positive anomalies ranging from 10 to 40 percent as a result of seeding while warm clouds show decreases in precipitation ranging from 4 to 25 percent. These last results illustrate the complexity of the physical processes within A cloud. Furthermore, at the present time there is no known physical reason which would explain why seeding is more effective in cold clouds.

There have been fewer experiments on extratropical cyclonic storm systems. The most complete study has been carried out in Israel, where randomized silver iodide seeding of winter cloud systems conducted over 4¹/₂ years shows 15 percent more rain on seeded days than might have been expected.

*

3.a)

During the course of its investigation, the National Academy of Sciences Panel obtained over a hundred reports of commercial rainmaking operations.

The Panel then selected certain of these reports for an independent evaluation.

Fourteen of the selected reports were concerned with projects in the Eastern and Middle Atlantic States and covered a wide range of meteorological conditions.

The projects ran from 19 days to 5 months and in all but one of the 14 cases there was an increase in precipitation, with an average increase of about 15 to 20 percent.

5.a), 5.b) e 2.a)

This result was so striking that the Panel asked for and obtained additional studies by the Kand Corp. and the U.S. Weather Bureau.

These independent groups substantiated the Panel's results.

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The Panel also studied four long-term projects in the westerly United States.

Here increases averaged about 10 percent in the seeded areas as compared with the control regions.

*

The analysis of these operational results combined with a close study of the experiments led the Panel to conclude that there is increasing but still somewhat ambiguous statistical evidence that precipitation from some types of cloud systems can be increased or redistributed by seeding techniques.

CONCEITO 7

The evidence is complex and in part contradictory.

The Panel thus concludes that the enhancement of precipitation is in the research and development stage and that one should approach large-scale operation with caution, since there are conditions where seeding may lead to a decrease rather than an increase of precipitation.

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The Panel also investigated the question as to whether or not the local increase of precipitation would result in a decrease in precipitation downwind of the area of increase.

The data are insufficient for any firm conclusion, but what data are available show no rain shadow effect.

*

I will now turn from the questions of precipitation enhancement and redistribution to other aspects of weather modification. It has been postulated that hail can be suppressed by the introduction of nuclei such as silver iodide. The physical basis for this suggestion is that the formation of many ice crystals will prevent the growth of any one ice particle to a very large dimension as is required for the formation of hail.

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10.a)

Extensive efforts aimed at reducing hail have been carried out in Argentina, Switzerland, and the Soviet Union.

*

In Switzerland the preliminary analysis of the data suggests that seeding increases the frequency of hail rather than decreases it, while in Argentina it appears that a small reduction in the frequency of hail follows from seeding.

The workers in the Soviet Union are most enthusiastic about hail reduction and have mounted sophisticated operational programs, but hard data on the results of their projects are not available.

*

The introduction of many ice crystals or of chaff into lightning producing clouds may reduce the frequency of fire-producing ground strokes.

Preliminary experiments carried out in the Western United States indicate that, indeed, substantial reduction in lightning strokes can be produced in this way.

*

In certain regions of the world fogs at temperatures below freezing present a hazard for aircraft operations. The seeding of these fogs has been shown to be effective in cutting lanes for landing and takeoff. On the other hand, there is no known way of dispersing warm fogs, that is fogs whose temperature lie above 32° F.

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6.a) e 5.a) – 6.b) e 5.b)

Preliminary experiments have been carried out by a team of U.S. Weather Bureau and U.S. Navy scientists in attempting to modify hurricanes.

The variability of hurricanes is so great and their dynamics and energetics so little understood that the Panel concludes that it is impossible to determine whether or not changes were brought about in the hurricanes.

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CONCEITO 8 – Referência AC

In the above discussion I have emphasized the deliberate change of our atmospheric environment. As civilization grows more complex, society places greater burdens on the atmosphere. We are just beginning to appreciate that the atmosphere is not a dump of unlimited capacity, but we do not yet know what the critical capacity of the atmosphere is or by what effects it should be measured. For example, we can consider carbon dioxide introduced into the atmosphere as a result of the Industrial Revolution.

*

CONCEITO 9

It is generally agreed that the amount of carbon dioxide has increased by 10 to 15 percent in this century and that this increase is due to the burning of fossil fuels.

Calculation of the effects of this increased carbon dioxide are still tentative and crude, but they indicate that the temperature averaged over the surface of the earth has increased by two- or three-tenths of 1° Fahrenheit, and that this increase will continue as a result of further introduction of carbon dioxide into the atmosphere.

CONCEITO 9

An increase of temperature of similar magnitude might also result from the water vapor introduced into the high atmosphere by the planned supersonic transports.

However, the Panel has not come to any firm estimate because the residence time of the water vapor in this part of the atmosphere is still unknown.

*

CONCEITO 9

In a sense each city is an experiment in weather modification. It is known that urban regions have climates that differ significantly from the surrounding rural regions. We know very little of the causes of these differences. For example, there are data that suggest that in cities the temperature and rainfall are greater than in the surrounding areas. What is not known is whether these differences are due to the artificial energy sources within the city, to the changing of the heat absorption characteristics by construction or to changing the roughness of the ground.

*

CONCEITO 10

In summary, I believe that it is now time for an increased effort on a national scale in the fields of weather and climate modification.

The emphasis in these efforts should be on research and development.

In the precipitation enhancement there are a multitude of unanswered questions.

For example, why should the seeding of cold clouds be more effective than the seeding of warm clouds ?

*

Why is there an apparent decrease in the effectiveness of seeding with the passage of time in a given locality ?

*

Is this due to a carryover of the nuclei or is it due to a feedback effect resulting from changing the thermal characteristics of the ground by increased moisture?

CONCEITO 11

*

Too many questions remain unanswered for the Nation to embark on very large operation projects in rainmaking without the most careful planning based on experimentation.

However, it is important that the advances in research and development go forward with operational efforts and that new understanding of the atmosphere be quickly translated into operational methods which may benefit the whole of society.

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That is my statement, Mr. Chairman.

Senator Dominick. Thank you, Doctor. I think this has been very helpful to our understanding of some of the problems that we are faced with.

Senator Hart ?

Outras disciplinas mencionadas

Senator Hart. The chairman by his questions has indicated a much greater understanding of some of these problems than the other member of the committee that is here this morning.

How many students are in the planetary and space science department at UCLA?

Dr. MacDonald. It is a graduate department. About 50 students working toward a doctorate degree in the general field of planetary sciences.

Senator Hart. What will the majority of them do upon graduation?

Dr. MacDonald. Some will work in atmospheric sciences, some will work on problems dealing with the earth's interior, some will work in space-related areas.

Senator Hart. There is a broad employment opportunity available?

Dr. MacDonald. Yes, indeed. There is an area for which the demand far outstrips the supply.

Senator Dominick. Doctor, I have a few questions. You referred to hail problems in Switzerland, the Soviet Union, and Argentina, where experiments have been going on.

Did you do any investigation of commercial operations in Canada?

3.a)

Dr. MacDonald. Yes; we have looked at commercial operations in Canada, some in this country. None of them have been as extensive programs as the ones that I mentioned, and, again, we find complexity in the results. There are individual cases where the data apparently indicate a reduction in hail. There are other cases where again the data indicate an increase in frequency in hail.

Senator Dominick. Did these situations vary according to geographic location where the applications were going on ?

Dr. MacDonald. We have attempted to make a crude stratification of the data on the basis of geographic locality, and on general meteorological conditions, and have not been able to get a clear separation between when seeding would be effective and when it would not be.

Senator Dominick. I was interested in your statement regarding hail because earlier you had said that cold clouds, if we may call them that in nonscientific terms, produced more precipitation.

For example, Switzerland, which is undoubtedly colder than the Argentine except in the Andes area, is producing more hail, than the Argentine, which would seem, offhand, to comply with this cold-warm theory.

Dr. MacDonald. Indeed, in Switzerland there was an increase in frequency of hail and also an increase in total amount of precipitation associated with the seeding operations, so this kind of correlation apparently holds up. Unfortunately, we do not have good data on the cloud top temperatures either in Switzerland or in Argentina to make clear comparison.

Referência AC

Senator Dominick. You also refer to the introduction of additional amounts of carbon dioxide over the last 60 years.

Dr. MacDonald. Since 1900 we would estimate the 10- to 15-percent increase.

Senator Dominick. In previous conversations with Dr. Roberts, he has referred from time to time to ozone. What is ozone ?

Dr. MacDonald. Ozone is a form of oxygen. It plays an important role in our atmosphere in that it is formed as a result of ultraviolet radiation striking the atmosphere at high levels and it plays an important role in controlling the thermal balance within the atmosphere —that is, where the atmosphere is warm and where it is cold.

And there have been suggestions in the past of changing the amounts of ozone.

We did not look specifically at this problem. The industrial contamination, the introduction of ozone by industrialization is completely negligible, but the big production is just due to the ultraviolet coming in from the sun and striking the atmosphere.

Senator Dominick. And contamination in the air, as a result of industrialization, does not increase the degree of saturation of ozone?

Dr. MacDonald. Not at these high levels. Locally, of course, it is very much a problem, and I am quite aware of it, living in Los Angeles.

Whether or not it has an influence on the climate, the long-term climatic situation in A local area, based on the situation as in Los Angeles, is not certain. This is one of the problems that we point to. We do not know the extent to which the climate—the long-term weather conditions within a limited area— is influenced by the pollutants, by the local energy sources, by the construction, and so forth.

Senator Dominick. Am I correct in understanding that ozone is poisonous?

Dr. MacDonald. I am certain if you were breathing nothing but pure ozone you would not survive.

I don't know how one would define it in a medical terminology. In low concentration it is just a high irritant.

Senator Dominick. Have you heard of any reports that the socalled ozone layer is coming down in terms of height ?

Dr. MacDonald. No. Observations and fairly careful monitoring of the ozone layer have been underway for the last 15 years. It fluctuates in its intensity and somewhat in its position with the solar cycle. That is, there is long-term variability, but it is small and there is no noticeable long-term change of the total character of the ozone layer.

Senator Dominick. You would be surprised, then, if another scientist should dispute this?

Dr. MacDonald. Yes, and we would have an interesting argument.

Senator Dominick. We deferred before on my questions to Dr. Malone on the need for additional tools. Do you have any comment on that ?

Dr. MacDonald. Yes. In order to carry out the kind of studies that are needed to determine whether or not seeding actually is increasing precipitation, and identifying the mechanism by which this is happening, we have to improve our ability to describe the cloud.

Now, this improvement can come about in many ways. Dr. Malone referred, let's say, to the kind of instrumentation that you carry aboard airplanes and fly through a cloud and determine essential instantaneous distribution of cloud droplet size. This is an important factor because it determines how the cloud droplets themselves grow and Reach a critical size.

Another kind of instrument that one would wish to carry aboard an airplane and needs very marked improvement are instruments designed to count the number of nuclei. Dr. Malone referred to the question of following the path of the nuclei. A problem that we have is that there is an apparent difference in the effectiveness of seeding, depending on whether the silver iodide is introduced at ground level or in airplanes, and is a major question that still remains unanswered.

What is the path that the nuclei follow as they enter into the cloud?

Are they indeed carried up by the internal drafts, the upgoing drafts within the center of the cloud, or do they follow on a much more complex pattern?

Is it better to seed at ground level than to seed within the cloud itself? These are the kind of questions that would be answered by detectors that permit you to count the nuclei and count them in essentially in real time.

Senator Dominick. In these experiments that you referred to on precipitation, were the nuclei introduced by ground-burning generators or airborne ?

CONCEITO 12

Dr. MacDonald. Generally the operations that are carried out for commercial reasons introduced the silver iodide by ground-burning generators. The white top experiments, some of the Australian experiments, and some of the others I referred to, introduced the silver iodide from airplanes.

CONCEITO 13

Senator Dominick. On page 6 of your statement you referred to a properly randomized experiment begun at Santa Barbara and you said that result? were indecisive since it was believed contamination of certain control areas resulted from commercial efforts of rainmaking.

Dr. MacDonald. Yes, sir.

Senator Dominick. I presume you felt these control areas should be free from seeding activities ?

Dr. MacDonald. That is correct.

Senator Dominick. You were concerned that commercial activities had carried over into these areas ?

Dr. MacDonald. That is right.

Senator Dominick. Were these control areas actually target areas of commercial operators ?

Dr. MacDonald. They were in the vicinity of target areas of commercial operations.

Senator Dominick. I see. How much of a shortage is there of qualified manpower in the research that is now going on ? Is it serious, progressive, or decreasing ?

CONCEITO 14 – Outras disciplinas mencionadas

Dr. MacDonald. I don't believe that there is a serious manpower problem in the field of weather modification at present. It is a field that is rapidly developing. From the scientific community it is growing, and I would suspect that many people who are perhaps working on other aspects of atmospheric sciences may devote a greater portion of their efforts to weather modification. I think that the problems have an excitement, an intellectual quality to them, that will draw scientists from other fields. I think that the problems of what goes on in a cloud are of interest to chemists in his studies of nucleation, of colloidalities, to the physicists in the studies of hydrodynamics. One says this interest already is developing. And in the long term, I think that the field will carry* itself, that the intellectual excitement and the long-term possible benefits to society will encourage a lot of people to go into this field. I feel very optimistic about the manpower situation.

Senator Dominick. That is encouraging, Doctor.

On page 6 you refer to the fact that the experiment at Pacific Gas & Electric is scheduled for 5 years, that this is the fourth year and 2 years of data have been analyzed.

Do you have any idea why only 2 years have been analyzed ?

Dr. MacDonald. This is a company-sponsored and company-implemented project. They have limited manpower, and it is a small project within the company, and —

Senator Dominick. This is being coordinated with UCLA?

Dr. MacDonald. No. We are aware of their work, and follow their presentations at meetings with great interest.

Senator Dominick. Is this under contract or are they doing it themselves ?

Dr. MacDonald. They are doing it themselves.

CONCEITO 15

Senator Dominick. Neither you nor Dr. Malone, as far as I can see, has indicated the direction that the Federal Government might go in this program as to whether or not we should keep the programs of research and applied research separated among the various agencies or whether we ought to try and put them together in one agency or a new agency.

Dr. MacDonald. I do, but I would be speaking now more as an individual rather than as representing the panel. The panel's view was that weather modification is in itself a small part of atmospheric sciences.

CONCEITO 16 – Outras disciplinas mencionadas

One cannot usefully consider this small part without looking at the others, and that the problems are common in many aspects. The subjects are interdisciplinary in the sense that they involve physics, chemistry, and engineering, and that the environmental sciences at present are diffused through many agencies. The big science part of the environmental science is the field project, going out and mounting a big program. It is unlike the big science in physics, which is a big accelerator.

It requires logistic support, whereby ability to go into some part of the environment, the ocean, the atmosphere, and even the solid earth, and operate within that environment, requires platforms to carry out measurements.

CONCEITO 15

We feel that the present situation in which responsibility is diffused through these many agencies has not led to an optimum use of the Nation's resources, but we do not go on within the panel to make any firm recommendations. We feel this is a problem that we should bring to your attention.

CONCEITO 17

Senator Dominick. In other words, you are going to let government fight government instead of getting involved in the middle ?

Dr. MacDonald. Yes, sir. I think in the present instance, this may be the wisest course. [Laughter. J]

Senator Dominick. Well, under no stretch of the imagination could we say we now have a national weather modification program?

7.a) e 7.b)

Dr. MacDonald. I believe this is a correct statement. The National Science Foundation during the past 8 years has played a very important role in supporting weather modification research.

5.a)

Other agencies have their programs designed to fulfill the agencies' mission.

But I do not believe that under any stretch of the imagination, as you put it, we have a national program, and I think we need one.

Senator Dominick. Let me get your viewpoint on one more thing.

CONCEITO 18

Do you see any problems in permitting commercial applications of weather modification programs to continue?

Dr. MacDonald. First, with respect to the scientific aspects, I think that there is every reason to believe that we can learn a great deal about the atmosphere by studying the reports of commercial operations, that new standards should be set for the level of reporting and this is one of our recommendations, that in the past, reports where available, were not always in the best, shape, and a great deal could be learned from these operations.

CONCEITO 19

Secondly, however, one has to be careful that the kind of experience of the Santa Barbara experiment is not repeated, that, if a scientific experiment or research and development kind of experiment designed to determine whether or not one can bring about increase in precipitation let's say, in a certain region, there is very little chance of contamination from commercial sources. This will continue to be a problem.

CONCEITO 20

I think, of course, that these scientific considerations are almost secondary to the economic, legal, and sociological questions that a very much increased level of commercial seeding will bring about. These, I am certain, would present very serious problems. But they are out side our area of competency.

CONCEITO 21

Senator Dominick. I can see lots of difficulties in trying to tell commercial operators that they have no right to contract with a landowner for producing more precipitation in a certain area, simply because a university or someone else wants to conduct an experiment. It has to be done on a cooperative basis more or less.

Dr. MacDonald. It certainly does, and I think the procedure one would follow in this would be that these long-term research and development-oriented projects would be announced, attempts would be made to plan these in areas that would be unlikely that there would be commercial operations in the succeeding 3 to 5 years, the time scale that I think most people would agree is required in order to get good statistics.

It is only in working together and determining where it is likely that there will be commercial operations that one could do this. One is obviously not going to carry out a scientific experiment in, let's say, a ski resort region, where there is going to be over the years a good deal of commercial operations.

CONCEITO 22

Senator Dominick. There have been reports that high-altitude nuclear explosions have created a change in the upper air pressures which, in turn, have increased the degree of the bends in the jetstream.

This has had the effect of increasing the intensity of weather in various sections of the country. It either gets colder, or cold air from the north goes deeper into the south.

Dr. MacDonald. We looked very carefully at a number of these suggestions and I think we can state categorically that there is no evidence whatsoever that the nuclear explosions brought about any measurable change in the lower part of the atmosphere.

There is one change that is measurable that has been brought about, and that is the abundance of lithium in the upper atmosphere has changed. One can see this by very sophisticated observations of the airglow, night time airglow, that there is now a higher abundance of lithium, at 75 miles up in the atmosphere than there was before the test. But that, I think, is the sole change that one has been able to detect.

Senator Dominick. Has anybody made any effort in the process of this weather analysis to determine the course of the so-called jetstream over a period of time?

Dr. MacDonald. Yes, sir, there have been climatological studies of this.

Senator Dominick. In other words, to chart them on a map and see where they go?

Dr. MacDonald. Yes, sir, and follow them in detail over the years.

Senator Dominick. Have there been any changes ?

Dr. MacDonald. There are always changes but there is certainly no sudden change or marked change that one can identify with a particular event. The way to say it is, referring to your very apt quotation from Mark Twain, on a longer time scale, there are many more than 13(5 different kinds of weather. There is a very great spectrum of possible conditions and if we look at the configurations of a Jetstream at any one time, it will differ from the configuration at a later time. But there is no overall change or sharp change that we can identify for the particular event.

Senator Dominick. Has there been a change recently in the bends in the jetstream, so that these bends are much deeper than they were before?

Dr. MacDonald. Tom, do you know?

Dr. Malone. Yes, there are changes. We have been particularly conscious of this in the Northeast where we have a severe drought, and the change has been of a prevailing northwesterly flow at these high levels, which carry the storms off the coast. More recently, a greater preponderance of the southwestern flow which has given us some badly needed rainfall. Our problem is that we don't understand what causes these changes as yet.

Senator Dominick. Senator Hart?

Senator Hart. You heard Dr. Malone, who preceded you, make the comment and conclusion about desirability of international cooperation and he noted that there is a fine tradition of international cooperation in meteorology.

Is there free exchange of information of that sort? If, for example, if country A had made at least some tentative finding that would indicate why the jetstream bent the other way, is that made immediately available to us or to you ?

CONCEITO 23 – 2.b) e 2.a)

Dr. MacDonald. There is very fine interchange of information in the atmospheric sciences. For instance, the kind of day-to-day observations that are required for predictions are made available on an international basis almost immediately. The International Weather Service, obtains the data even from Communist China, essentially in real time. As far as the scientific advances have been concerned, there has been a very free interchange.

CONCEITO 24

The point that Dr. Malone was making was that there is a danger that geophysical warfare might become important and we would wish to do everything that we can in these early preliminary stages to attempt to prevent any move in that direction.

Senator Hart, what specific action should the Federal Government take to move in the direction you suggest ?

CONCEITO 25

Dr. Malone. I would endorse the recommendation of the NSF Commission, that a statement of policy be issued by a responsible officer of the Government ;I believe the President was mentioned, setting forth our intent to use any capability that was developed in this program in a, well, a humanitarian sense within the limits of normal prudence in maintaining national security.

I would strongly endorse the recommendation, and I believe that is the important action.

Senator Dominick. Thank you both very much.

The next witness is Dr. Chalmers W. Sherwin, Deputy Director of Defense Research and Engineering for Defense Research and Technology, Department of Defense.

Dr. Sherwin.

Anexo 11 - 05S66 - Hollomon

Fonte: <https://babel.hathitrust.org/cgi/pt?id=uc1.b5164561;view=1up;seq=143> (pp. 167-190)

STATEMENT OF DR. J. HERBERT HOLLOMON, ASSISTANT SECRETARY OF COMMERCE FOR SCIENCE AND TECHNOLOGY; ACCOMPANIED BY DR. ROBERT WHITE, ADMINISTRATOR, ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION, AND GORDON CHRISTENSON, ASSISTANT GENERAL COUNSEL, DEPARTMENT OF COMMERCE

Dr. Hollomon. Senator Cannon, I have with me this morning Dr. Robert M. White, who is the Administrator of the Environmental Science Services Administration, and Mr. Gordon Christenson, who is Assistant General Counsel for the Department of Commerce. I have a statement, sir, which I would like to submit for the record, if I may, and then try to make its key points more briefly in the presentation.

Senator Cannon. Very well. You may proceed as you so desire.

Dr. Hollomon. I am pleased to be here today to have the opportunity to present the views of the Department of Commerce on weather modification, S. 23 and S. 2916, bills on this subject.

The question these hearings can illuminate and help answer is how we shall achieve a coherent national policy for weather modification.

The Department of Commerce strongly supports sound steps toward such a policy, including needed legislation and favors the purposes of S.2916.

8.a) e 8.b)

The President said last week in his transmittal message to Congress on the annual weather modification report :

Two sets of problems face us, and both are difficult. One consists of finding out how to modify the weather and climate, and the second consists of determining how best to utilize this knowledge for the benefit of mankind once it is achieved.

CONCEITO 1

The first of these requires an expanded and redirected effort in the science and technology of weather modification itself. This should proceed without delay, with major reliance upon the resources of the Environmental Science Services Administration in the Department of Commerce.

Senator Cannon. Do you mind if I interrupt as you go along ?

Dr. Hollomon. No.

Senator Cannon. What do you mean by a redirected effort, and why do you say there should be a redirected effort ?

CONCEITO 2 e 3

Dr. Hollomon. We believe there needs to be very much more concentration on broad field experiments, which I will try to make clear later, and there should be a more intense evaluation of both the benefits and the possible harmful consequences of weather modification efforts. We should examine in a broader way how to modify severe storms, for example, so that there is some redirection toward what I consider more developmental kinds of application rather than as it has been largely in the past, toward basic sciences. This is what I mean by redirected.

Senator Cannon. In other words, more in the operational area?

Dr. Hollomon. More applied research and development directed toward operational applications than in the basic sciences.

The second problem the President presented requires thorough considerations of public policy of economic, legal, and social consequences, when the scientific results are put to use privately or by the Government. It means thoughtful study, dialog, and debate on questions of public law and organization.

These considerations should begin at once, though there are immediate steps which can be taken in support of the expanded Federal research program.

CONCEITO 3

Before long, however, we must decide what kinds of future policies and regulatory controls are desirable for public and private activities seeking to modify the weather or climate.

In my statement I give a brief review of the bills before you, which I don't think is necessary verbally.

Thereafter I would like to describe the need for redirection of the national effort in weather modification and try to outline what we believe are the elements and scope of this redirection.

Then I shall discuss the capabilities of the Department of Commerce and other agencies.

Finally I think it is appropriate to spell out our recommendations for needed legislation to support the immediate research effort and suggest some legislative questions for the consideration of the Congress.

CONCEITO 4

S. 23 directs the Secretary of the Interior to conduct a program in five geographic areas of the United States to increase usable precipitation.

5.b) e 5.a)

The Department of the Interior already has underway a program similar to that proposed in the bill.

It has certain mission responsibilities concerning the Nation's water resources, and we support its efforts in using weather modification to assist in carrying out its mission.

CONCEITO 4

But we do not believe that legislation is necessary for this purpose. For this reason, we do not recommend enactment of S. 23.

CONCEITO 5

S. 2916 would transfer to the Secretary of Commerce the authority now in the National Science Foundation to carry out a weather modification program, including applied research, development, and experimentation.

7.b)

It would restate such authority, but in greater detail than the Foundation's existing statutory authority.

CONCEITO 5

It also would limit the research authorized to that for applied research, development, and experimentation.

CONCEITO 6 – Outras disciplinas mencionadas

It would provide authority for the transfer of personnel, property, and appropriations and would repeal existing statutes authorizing the Director of the National Science Foundation to conduct a weather modification program.

It would make clear that the National Science Foundation would continue to have authority for scientific studies in weather modification as part of the atmospheric sciences.

CONCEITO 7 e 7.a)

Further, S. 2916 would authorize the Secretary of Commerce to issue regulations affecting any operation of commercial enterprises engaged in weather modification which conflict with or impede any authorized activities. It would require a report to Congress, within a year after enactment, or recommendations for additional legislation concerning the enforcement of such regulations.

The authority now in the National Science Foundation to hold hearings and obtain information also would be placed in the Secretary of Commerce.

CONCEITO 8

The bill specifically would authorize international cooperation under the policy guidance of the Secretary of State and would require the Secretary of Commerce or his designee to be a member of the U.S. delegation at intergovernmental meetings and conferences relating to weather modification and climate control.

CONCEITO 9

We fully support the purposes of S. 2916, although we believe that it is premature and that the aspects of this bill which relate to reorganization in the executive branch can be accomplished best through an executive reorganization. A Presidential reorganization plan along these lines is now under active consideration.

CONCEITO 6

We do not agree, however, that the authority in the Secretary of Commerce should be limited to applied research since there are many scientific investigations of a fundamental nature which would be carried out in any large scale weather modification research or experimentation program.

CONCEITO 10

Also, if legislation on this subject is enacted, it should contain effective authority to limit private weather modification activities providing they are in direct conflict with the research or experiments carried out by the Department of Commerce.

CONCEITO 11

Authority to issue regulations governing these conflicts would be of little significance to any large-scale research effort if there is no enforcement mechanism.

Senator Cannon. What do you have in mind there, the types of things that would be in direct conflict?

Dr. Hollomon. Let me give you an example. Suppose you have laid out in a certain area of the country a very major program of cloud seeding or other kind of modification activity, which required large amounts of field equipment and in which there had been planning of a

very substantial kind, and then inadvertently, due to a private activity, this whole area was contaminated by seeding by private parties. This would be a conflict between the research and development effort of the Federal Government, it would obviously waste the taxpayer's money and might make the results of these experiments completely invalid.

4.a) e 4.b)

Senator Cannon. Has there been any evidence of conflicts up to the present time in the limited areas that we have been going ahead in, that is, between the commercial operators and the funded Government research programs?

Dr. Hollomon. I personally do not know of any. One of the difficulties, of course, is that we have not had adequate reports of what actual activities were taking place in the private sector of the economy, and therefore it has been somewhat difficult to know when this kind of contamination is possible.

There is another technical problem which I think is interesting and that is that we have not been adequately monitoring condensation nuclei throughout the country, to see what the persistence is, how long it persists after someone has put them in the atmosphere, and over what regions. And it has therefore been difficult to tell exactly what the possible contamination might be.

I can't explicitly answer the question. Dr. White may be able to.

Dr. White. Yes. During the Santa Barbara project in 1957-59, there was some doubt cast upon the results of this project because of possible contamination by other seeding activities.

Senator Cannon. Now you say there has been no cataloging up to the present time? Would the NSF requirement now in effect, giving them notice, would that help bring this into proper perspective ?

CONCEITO 12

Dr. Hollomon. It certainly would. We have been discussing it at some length. As you know, the recent regulations the National Science Foundation has issued under their authority do require notification of experiments. We think this is essential, if we are going to take advantage of the work of other people. We can learn from them. On the other hand, we can assure that there won't be contamination either by Federal experiments affecting theirs or conversely.

I think this notification is an essential element of any national program.

8.b) Conceito 13

While it is too early at this time to write comprehensive legislation on weather modification, in our view such legislation may be necessary and certainly deserves thoughtful study.

Sound legislation can strengthen any Presidential action and may well be necessary for an orderly achievement of national objectives in weather modification and climate control.

7.b) e 7.a), 3.b) e 3.a), 5.b) e 5.a), 8.a) e 8.b)

I have three general comments to make before discussing the scope of the new national effort. The substance of these comments may already be familiar to you —thanks to the studies and reports issued over the past year by the Weather Bureau, by the Panel on Weather Modification of the National Academy of Sciences, by the Special Commission on Weather Modification of the National Science Foundation— established after recommendation by the Interdepartmental Committee on Atmospheric Sciences, of which I am chairman—and by the statements which this committee has heard in the course of these hearings.

CONCEITO 14

My first comment concerns the importance of weather modification. We must keep in mind at all times the vast potential benefit of weather modification to the people of the United States —in fact, to all mankind.

If we can develop the capability to blunt and weaken the thrust of hurricanes, tornadoes, and other severe storms, to increase, lessen, or redistribute precipitation, to suppress hail in crop areas, to cope with lightning discharges in forest areas, and to dissipate all types of fog, we would have a notable scientific and technological achievement which would provide enormous economic benefit.

CONCEITO 15

If we can ever develop the ability to modify weather and climate on a large scale—to effect slight increases or decreases in the average annual rainfall or temperature over a particular locality —we would have a truly staggering achievement. I need only cite here the implications of such an achievement for world food production.

CONCEITO 16

My second comment is that modern science and technology have now brought us to the stage at which it is possible to carry out a broad program of scientific research to determine what types of weather modification are feasible and under what conditions.

In this respect, the National Science Foundation, in supporting research, has laid a scientific foundation, and we are now ready for more extensive field tests and experiments.

Our understanding of the physical and chemical processes of the atmosphere and our theories of atmospheric phenomena, while still deficient in many respects, provide a strong base from which to pursue new knowledge about weather modification.

CONCEITO 19

Using the high-speed electronic computer, we have been creating mathematical models for the simulation of atmospheric phenomena.

Soon we will be able to experiment with the atmosphere under "controlled" conditions in a computer and seek a deeper scientific understanding of the greater forces affecting weather and climate. And we will be able, we hope, to predict what it means to interfere with these dynamic forces.

CONCEITO 20

We now have a new capacity for observing the atmosphere and gathering the raw data that the research scientist must have. For example, we now are considering an international effort to bring the total global atmosphere under proper observation using satellites and other new technological developments which will be vital to any exploration of large-scale weather modification.

CONCEITO 16

Also, we now have systems to place manmade materials into the atmosphere more effectively, that were unavailable to us a few years ago. These developments —if taken all together —have brought weather modification out of the realm of speculation and have made it possible for the scientists for the first time to determine what types of weather may be modified and controlled. It will take many years of hard work —decades of work in the case of the larger forces of weather. But the point is that we can now develop the scientific and technological capacity to explore how to affect many different kinds of weather conditions.

My third comment is that there is now evidence that we may already be able to increase or redistribute precipitation from some types of cloud and storm systems by seeding techniques. In some rainfall, increases have averaged between 10 and 20 percent.

8.b) e 8.a)

Although the President's Advisory Committee on Weather Control in 1957 reached similar conclusions, I could not have said this with as great confidence 6 months ago.

Verifying this evidence was one of the important results of the recent report of the NAS Panel, composed of some of the Nation's leading scientists, which undertook a very thorough scientific review of the evidence.

The Soviets indicate that hail storms possibly can be affected.

The foregoing comments demonstrate that scientifically we are on the threshold of achieving real progress in weather modification research.

Conversely, the NAS Panel and the NSF Commission point out that at present the United States lacks a broad, systematic, and comprehensive program to extend and exploit available scientific knowledge.

7.b)

For example, during fiscal year 1965 the Government spent only about \$5 million for direct weather modification studies. During the current fiscal year it will spend approximately \$7 million.

CONCEITO 21

Both the NAS Panel and the NSF Commission have called this level of expenditure inadequate and feel it should be increased to \$20 to \$30 million by 1970.

The NSF Commission also feels that an additional equivalent amount should be available for the conduct of related basic research and the acquisition of facilities.

Further the NAS Panel believes our efforts have been fragmentary and subcritical, far below the size and quality for effective work.

Both the NAS Panel and the NSF Commission urge an immediate and thorough study of ways and means of improving the U.S. efforts in weather modification.

CONCEITO 22 / 8.a)

The Department of Commerce, as a result of its own studies and evaluations, similarly feels that the old order must change and that the United States must give vigorous new direction to its weather modification activities to extend and exploit our capabilities to make significant scientific and technical advances.

What should be the scope of this new national program ? The report of the NAS Panel suggests four broad areas of study.

The first is the modification of clouds and storm systems. This would embrace the augmentation and redistribution of precipitation, hail mitigation, lightning suppression, the dissipation of both supercooled and warm fog, and the modification of hurricanes and tornadoes.

The second is the modification of weather and climate over large areas. Here we would be concerned with the science which relates to the altering of the general circulation of the atmosphere. We have no known way of doing so at the present time.

The third area is the modification of local and regional climates. This would involve such things as altering the agricultural micro climate to reduce plant damage due to frost, excessive heat and wind, and ameliorating desert conditions over limited areas.

CONCEITO 23 – Referência AC

The fourth activity is the inadvertent modification of the atmosphere by man's activities. Here we would be concerned with the rising level of carbon dioxide in the atmosphere due to the burning of fossil fuels, with the effects of air pollution and smog on weather and climate, with the effects of alterations in the rural landscape such as forestation, deforestation, and irrigation, with the effects of the injection of additional water vapor into the stratosphere by the supersonic transport, with the contamination of the very high atmosphere by rocket exhausts, and with the meteorological side effects of weather modification experiments.

I should like to emphasize that the question of the inadvertent modification of the weather needs to be as carefully examined as the advertent steps we take. One of the most serious possible problems we have in the future in air pollution is the rising level of the CO₂ content of the atmosphere which, if some of the scientists are correct, would indicate it may change the general temperature of the earth and have very serious effects with respect to the melting of the ice cap.

This is not something we can say with any definiteness at the moment, but it is certainly a concern that all of us should have, and we should be monitoring and studying these inadvertent things we are doing to the atmosphere.

CONCEITO 23

At this point I would like to emphasize again that we need to expand our general understanding of the science and technology of weather modification and climate control and to assess the economic, technical, political, social, and legal consequences of the results.

Conceito 13

Some of the general functions which would be part of this major responsibility should also include such activities as information gathering, preventing interference with Federal research, considering public safety, possibly paying meritorious claims, and indemnifying Federal contractors and grantees, and cooperating internationally.

CONCEITO 24

I think these issues having to do with the less technical aspects of weather modification, from a scientific point of view, are important, and I think your committee should consider them most seriously.

CONCEITO 22

In a field as new as weather modification, and in which activities are so widespread, information gathering is important.

CONCEITO 12

We can find out what each of the Federal departments and agencies is doing through an interagency coordinating mechanism. But what of the activities of State, local, and private, groups?

Under its statutory authority, the National Science Foundation is expressly empowered to obtain information by regulation, subpoena, or otherwise, to the extent necessary to carry out the purposes of the act.

For many years the National Science Foundation relied upon voluntary after-the-fact reports from State, local, and private cloud seeders.

Recently, however, it has issued regulations compelling them to furnish information on their weather modification activities, both advance notices of an intention to seed clouds, and after-the-fact reports.

This authority is vital and should be continued in any expanded program.

It is the only way we have of obtaining a total view of what is being done in the United States in the field of weather modification, and the information we gather will also help in the study of particular problems. The agency with the major responsibility must have this information-gathering authority, which needs, in our opinion, to be clarified and strengthened.

Another important problem is how to prevent interference with Federal weather modification projects. As weather modification activities increase in number throughout the Nation and extend over more and more territory, there is a growing risk that weather modification research projects conducted by the Federal Government or by groups operating under Federal contract or grant may be severely handicapped by the cloud-seeding activities of State, local, and private weather modifiers.

If the problem is neglected, every weather modification research project conducted by or for the Federal Government and covering a substantial geographical area could be vitiated.

CONCEITO 11

The best way to deal with this problem is to authorize the Federal Government to limit any State, local, or private weather modification activity when there are reasonable grounds for belief that it would interfere with another Federal project.

CONCEITO 25

Another potential problem of interference with Federal projects carried out by contractors or grantees might arise under State laws.

About half the States have now enacted laws dealing with weather modification. They are not uniform. Some are concerned with the rights and powers of the State in weather modification. Others regulate private weather modifiers in one way or another. And one State, Maryland, has prohibited all cloud seeding for a period of 2 years.

These State laws do not bind the Federal Government and cannot legally limit or affect the authorized weather modification activities that the Federal Government conducts through its own officers and employees.

However, a broad, systematic national program on weather modification cannot be carried out by the Federal Government solely through its own officers and employees.

The Federal Government will have to seek the assistance, through contract or grant of both industry and the scientific community in our universities and research institutions, and these contractors and grantees, even though they would be operating with Federal funds, would, in all likelihood, be subject to the laws of the various States on weather modification.

CONCEITO 13

Accordingly, we should seriously consider Federal legislation which would exempt such contractors and grantees from compliance with State laws on weather modification to the extent that their activities are being conducted at the direction of or with the approval of the Federal Government and are supported by Federal funds. This exemption might also be extended to include injunctions by State courts.

In any event, the Federal Government should see to it that the spirit and policy of the various State laws on weather modification are respected to the fullest extent possible.

CONCEITO 23

There is another broad question in weather modification that has to do with public safety.

CONCEITO 26

Because we lack comprehensive knowledge about weather modification, there may be some danger that large-scale Federal weather research experiments may endanger public safety.

We must consider whether this potential danger will require a single agency to have authority to modify or limit Federal experiments where there is unreasonable risk of endangering life or threatening damage to property.

CONCEITO 27

Still another serious problem is the question of liability for harm caused by the Federal Government.

The present scientific view is that the risk that a weather modification activity will cause catastrophic harm is minimal. Nonetheless, we must face the possibility that a broad and vigorous program might inflict some damages on innocent third parties in particular cases. If a claimant can satisfactorily establish a causal relationship between the damage he has suffered and a weather modification activity conducted by the Federal Government, we should consider whether he should be compensated even though there is no fault.

At present, there is no Federal statute which clearly authorizes the payment of a weather modification claim of this type. We believe it is desirable for the agencies of the Federal Government to have authority of this kind. It should be considered within the traditional limits for similar activities.

A significant portion of a national weather modification program will be conducted by Federal contractors and grantees. What is their liability? They do not share in the sovereign immunity of the Federal Government and will be subject to suits for damages. In many instances of liability, they will be fully protected by insurance. In other instances, however, they may have been unable to obtain insurance, or they may sustain liability in excess of the available limits of insurance.

Fairness demands that the Federal Government carefully consider whether it should have authority to indemnify its contractors and grantees who suffer liability in the performance of governmental weather modification research —where the contractor or grantee can not obtain adequate insurance and is not himself at fault. The Federal departments and agencies cannot do so, however, without express statutory authorization. The question of indemnification must be settled before large-scale research is undertaken for the Government.

CONCEITO 28

Large-scale weather modification activities raise a particularly serious problem about international cooperation. The movement of the atmosphere knows no national boundaries, and a weather modification activity within one nation, if sufficiently large, can affect the weather of other nations. The nations of the world will ultimately have to develop a mechanism to control weather modification activities that can have effects beyond the borders of any one nation.

2.b) e 2.a)

At the present time the international forum in which the governments of the world meet to exchange views and/or coordinate the problems of weather modification is the World Meteorological Organization, which is a specialized agency of the United Nations.

The United States is a member, and the Administrator of the Environmental Science Services Administration is the permanent U.S. representative to the Organization.

In time the United States will, however, undoubtedly wish to enter into new international arrangements—both for international cooperation in weather modification research and for the international control of weather modification activities. The international activity alone will require the most careful planning and coordination.

Senator Cannon. What is being done by the World Meteorological Organization now?

2.a)

Dr. White. It has been conducting reviews of what is going on in the various countries. It has issued reports summarizing this work, and has taken the general stand that in the case of large-scale weather modification, one should know what the consequences will be before one attempts to accomplish it in the field.

Senator Cannon. In other words, it has just been a matter of drawing together information so far? They have had no direct participation in the field of research, either in basic or applied ?

Dr. White. That is correct, Mr. Chairman. It is principally a coordinating body. It is not an operating body and does not conduct research by itself.

Senator Cannon. What about the World Weather Watch ? Is that part of the same organization?

2.a)

Dr. White. The World Weather Watch, Mr. Chairman, is being planned by the World Meteorological Organization, with the participation of the various nations. They would not operate the World Weather Watch. The various aspects of the World Weather Watch would be operated by the various member countries in accordance with the plans agreed upon.

Senator Cannon. Would that information be channeled through some other source?

Dr. White. It would be channeled through the World Meteorological Organization, sir.

Senator Cannon. Doctor, getting back to this previous statement relating to indemnification of Federal contractors and grantees, you indicated that the question must be settled before large-scale research is undertaken through private contractors or grantees. I was wondering,

has there been any reluctance on the part of private contractors or grantees, insofar as the Government programs up to this time are concerned?

Dr. Hollomon. It is my understanding that in some cases at the moment some of the private contractors are having some difficulty obtaining adequate insurance. I know of no specific reluctance, but I do understand that the difficulty of getting insurance is increasing. As you may know, there has been a case in Texas in which, as a result of an injunction, experiments were prohibited on the part of private parties.

Senator Cannon. And, of course, there have been some damage suits filed, too. But I don't know whether that involves any of the direct Government grantees or not.

Dr. Hollomon. I do not believe there has been such a case where it involved the direct Government grantees.

The launching of an expanded weather modification program on a national scale will undoubtedly create future problems which we can't anticipate.

CONCEITO 11

Ultimately, a regulatory body may be required which would function separately from the research and operational programs of the Federal agencies. That body at some time in the future even may be called upon to prescribe regulations for private operations and, possibly, the technical and financial qualifications of those who may engage in weather modification activities or to license these operations. One major responsibility will be to study and assess the national program and periodically report the results of this study to the President and the Congress with emphasis on the need for future regulatory controls. This duty might well be spelled out in any legislation enacted.

We do not believe it is wise at this time to consider the nature of such controls.

7.b)

I should like to describe briefly the activities of the Environmental Science Services Administration. This Administration was created by Reorganization Plan No. 2 of 1965, which consolidated the Weather Bureau, the Coast and Geodetic Survey and the Central Radio Propagation Laboratory of the National Bureau of Standards.

In his transmittal message to the Congress, the President stated this "new Administration will then provide a single national focus for our efforts to describe, understand, and predict the state of the oceans, the state of the lower and upper atmosphere, and the size and shape of the earth."

7.a)

ESSA's Weather Bureau has been heavily involved in weather prediction and weather modification research.

In its role of weather prediction, the Weather Bureau observes, measures, records, reports, and forecasts the weather for the public benefit. It also provides special forecasting services which are of immense benefit to aviation, agriculture, shipping, and other commercial, as well as Government interests. It maintains about 300 principal stations throughout the United States. In addition, there are about 12,000 part-time observation facilities. As weather is international, the Weather Bureau receives observations from all over the world. Data are evaluated by high-speed electronic computers and transmitted to users by teletypewriter and facsimile.

CONCEITO 29

I would like to make the point that the weather modification role of ESSA is bound to its weather-prediction role much like Siamese twins with a common heart. Weather modification research cannot be viewed as something apart from weather prediction, since they both use similar data and equipment. Both require sophisticated observational equipment, such as satellites, radar, ocean and land observations, and balloon soundings. If we fail to recognize this fact, we run the risk of inefficiency in the use of facilities and in scientific research. There are other reasons why weather prediction and modification are bound together. If we ultimately attempt to modify the weather on a large scale, we shall have to be able to predict beforehand what would have happened had we not made the attempt.

In addition, many field experiments will require particular atmospheric conditions, and we must be able to predict when these conditions will exist. And when any particular type of weather modification becomes fully operational, the decision as to whether to modify the weather in a given instance will depend in large measure on our prediction of what the weather will be if we don't modify it.

CONCEITO 30

Finally, weather modification research requires considerable background information that only the atmospheric sciences can provide, such as the movement of water through the atmosphere. In its weather modification and associated activities, ESSA has a large corps of scientists and engineers — numbering approximately 200 — with special capabilities in the field of weather modification and related areas. About 25 percent of these have doctorates. It also has research facilities throughout the United States for weather modification.

6.a)

I would like to comment to you on several of these. The largest single project has been Project Stormfury, in cooperation with the Navy, to seek to determine the structure of hurricanes and how they may be modified.

At its National Severe Storms Laboratory in Norman, Okla., it is conducting extensive research on tornadoes. The Norman Laboratory is also studying the origin and structure of hail. And ESSA is now designing a project for the Great Lakes area, which is a vast natural laboratory for the study of atmospheric processes and the structure of storms. These projects require extensive facilities — a network of observing stations, radar, and most costly, specially instrumented aircraft.

In precipitation augmentation, ESSA has carried out scientific evaluation studies of various cloud-seeding activities to assist the NAS Panel. To follow up the work of the Panel, ESSA is now designing a project in the Northeast to determine under what conditions precipitation augmentation and redistribution is possible in the eastern portion of the United States.

I have already commented on the large computer facilities now in existence studying the simulation of the atmosphere and one of the largest and most sophisticated of these is Geophysical Fluid Dynamics Laboratory of ESSA.

We have also begun in ESSA to study the interactions and the exchanges of energy between the atmosphere and the underlying earth and oceans.

As the NAS panel pointed out, an understanding of these exchanges is fundamental to the development of a capability in largescale weather and climate modification and in the modification of local and regional climates. Investigations are also underway on the physics and chemistry of the atmosphere.

7.a) – Referência AC

Finally, I must not fail to point out the problem of the inadvertent modification of weather and climate by man himself — by the burning of fossil fuels, by the expansion of cities, by the flight of aircraft, and by the launching of space vehicles. ESSA is very much concerned with the meteorology of inadvertent modification. It is continually monitoring the levels of carbon dioxide in the atmosphere and analyzing the effects of man's activities on weather and climate. This activity will support the missions of agencies and others trying to do something about pollution of the atmosphere or city smog.

CONCEITO 12

I should emphasize that, in addition to the scientific facilities and skills of the Department of Commerce and other agencies, the private resources of industry, universities, and the scientific community have proved essential in past weather modification research. The continued use of these resources through contracts and grants must be accelerated and amplified in carrying out a strengthened national weather modification program.

1.b)

Senator Cannon. What will be the effect of transferring NSF authority to ESSA on the existing programs in the universities and private organizations?

Dr. Hollomon. I think the existing programs should be continued and expanded, Mr. Chairman.

Senator Cannon. In other words, there would be no contemplated change in the conduct of these programs, going ahead with these programs.

Dr. Hollomon. Only insofar as we learn something new, which obviously means we ought to modify them. But the general thrust of those programs in my opinion should continue, Mr. Chairman.

Senator Cannon. Is ESSA now supporting university research in weather modification ?

7.a)

Dr. White. We support extensive university research in the atmospheric sciences. We have not had a large amount of resources in the particular field of weather modification in past years, and our support for particular items labeled weather modification in the universities has been small. But our general contract program in support of atmospheric research in the universities has been quite substantial.

Senator Cannon. Where have you been conducting that? In many or just a few universities?

Dr. White. All over the country. Many universities indeed have contractual support from the ESSA organization.

Senator Cannon. For example, my own State University of Nevada, is their program supported by ESSA?

Dr. White. That is not supported by ESSA, Mr. Chairman. I don't have a list of the contracts available. But we support projects at MIT, University of Wisconsin, Florida State University, and a large number of others. I have provided a list.

Senator Cannon. The list will be included in the record at this point. You may proceed.

5.a)

Dr. Hollomon. I will now speak of weather modification activities of other Federal agencies.

To be successful, an expanded national weather modification program will require weather modification to be specially applied to the missions of other Federal agencies.

The Department of Commerce, of course, we believe should be concerned with advancing the science and technology of weather modification generally.

The Department of the Interior, however, must assess the Nation's water resources and investigate weather modification techniques to carry out this specific mission.

8.b), 5.b)

The Federal Aviation Agency must conduct research into safe and efficient methods for the dissipation of airport fog. Similarly, the Department of Defense is concerned with research into the military applications of weather modification, and the National Science Foundation must continue to support basic scientific studies that relate to weather modification.

8.b)

The Interdepartmental Committee for Atmospheric Sciences (ICAS), which was established by and reports to the Federal Council for Science and Technology, has in the past coordinated matters of basic policy in weather modification as part of atmospheric science. It will continue to do so and can easily be strengthened in this role, if necessary.

8.b)

While ICAS provides a competent body for the coordination of questions of basic policy, there is a definite need for the coordination of weather modification operations and supporting research.

Recent experience suggests that this need for coordination of operational aspects should follow the successful pattern for coordinating meteorology, as set forth in Bureau of the Budget Circular A-62. Under this circular, the Department of Commerce coordinates the meteorological activities of the Federal departments and agencies and to do this has established, in ESSA, an Office of Federal Coordinator for Meteorological Services and Supporting Research. It has a competent staff in that direction and provides a report every year to the Congress on the total program in meteorology.

It has not so far included weather modification. It would be our recommendation to do so. It has also been possible, as a result of this coordinating mechanism, to save money on the part of various agencies, to provide a common program and common directions for the program.

Having examined the scope of a redirected national weather modification program and discussed the activities of ESSA and other agencies, I return to the legislation now being considered.

As I said earlier, there are two sets of problems now facing us. The first is acquiring the knowledge to change the weather and control climate. The second is deciding how best to use this knowledge.

To carry out an expanded Federal research program, legislation is desirable now (1) to authorize appropriate limitations on State and private weather modification activities which would interfere with Federal research, and (2) to clarify existing authority to permit regulations to be issued requiring full reporting of private activities before they occur.

It is reasonably clear, however, that comprehensive legislation may be necessary for a coherent national policy covering both sets of problems with emphasis on the regulatory aspects.

If legislation is enacted now, it would be desirable in such legislation to call for studies and reports on the regulatory controls that will be necessary in the future. These studies could form the basis for comprehensive legislation dealing with the following problems, as well as others.

We would like to raise for the committee some questions which we think need to be carefully considered:

(1) Whether expanded authority is necessary to clarify the scope of research and experimentation necessary to carry out the major responsibilities for advancing the science and technology of weather modification and climate control, after any executive reorganization.

(2) Whether the broad national objectives should be established by legislation.

(3) Whether the Secretary of Commerce should have appropriate authority to assess all private and State research and operational programs to preclude endangering the public safety.

(4) Whether the Secretary of Commerce and heads of other agencies should have appropriate authority to pay claims resulting from their research and to indemnify Government contractors and grantees, within traditional limits.

(5) Whether there should be clear authority that Federal contractors and grantees are exempt from State laws and regulations on weather modification.

(6) Whether it is desirable for the Secretary of Commerce to have appropriate authority to facilitate international cooperation in weather modification activities, including the authority to enter into international arrangements on behalf of the United States, subject to the foreign policy guidance of the Secretary of State.

(7) Whether the Secretary of Commerce should have regulatory responsibilities which would be a function separate from the conduct of research and development .

Mr. Chairman, the problems we have in achieving a coherent national policy in weather modification are extraordinarily complex. If we cope with them boldly and with imagination, the opportunities we have can be extended to benefit all mankind. And we in the Department of Commerce stand ready to help this committee in its deliberations in any way possible.

Senator Cannon. Thank you very much, Dr. Hollomon, for a very fine statement.

In connection with your point No. 7 there, of course, you pose this as a question to us, but I would like to ask you whether you believe that ESSA is the right agency to regulate activities in weather modification, and if so, why ?

Dr. Hollomon. I do not believe at this time there should be regulation. My personal view is that we are not ready for the regulation of private activities, except insofar as they affect the Federal programs. I do not believe that we now have enough knowledge, and we don't have enough experience. I am sure that I would not be ready to recommend to you the character of that Federal regulation, as to whether, for example, the Federal law should preempt the laws of the States in this regard.

I think that is a very serious question. So therefore I don't think we are concerned at the moment with the problem of regulation of private activities except insofar as they affect the Federal program.

Senator Cannon. In other words, your answer is that you don't think there is any need for the regulation except in these limited areas at the present time, either by ESSA or anyone else?

Dr. Hollomon. Except for the regulation that would affect Federal programs.

Senator Cannon. Where it might interfere with the Federal programs?

Dr. Hollomon. Right. In that case it is our view that the ESSA organization should arrange for a group separately to make these decisions, that is, separately from the people who are actually carrying out any research and development in that field. And they should do it because they have a widespread reporting capability through the various weather offices, and they have, also, or should have, available to them the technical expertise of their own people and of the other Government agencies.

CONCEITO 31

That kind of regulation I think one can vest in ESSA. But I do not believe we are ready to vest in anybody the regulation of private activities generally.

Senator Cannon. Does the Weather Bureau or ESSA have a plan or program for sizable activity in weather modification at this time?

Dr. White. Mr. Chairman, we are working on such a program and generally the nature of our program would be to follow up on the recommendations of the National Academy Panel and to develop a broad program to meet these recommendations.

Dr. Hollomon. We have an outline of a plan, Mr. Chairman. We have not yet put dollar figures to it. We would be prepared to supply to the committee the details of what we think ought to be done. But in general, as Bob White said, what it goes to is to implementing the

technical recommendations of the NSF Committee, NAS Committee, and the earlier study of the Weather Bureau.

Senator Cannon. You say it is in the process of being put together? You don't really have a complete plan worked out?

Dr. Hollomon. I have not a complete plan we are ready to submit for the record this morning. On the other hand, we are prepared to provide that to you if you would like us to do so.

Senator Cannon. Well, you are talking about while we are considering this matter; is that it ?

Dr. Hollomon. Oh, yes; right.

Senator Cannon. Who participated in the development of this program you are putting in, what agency ?

Dr. White. This program or this plan we are now working on is being worked on by the scientists within our own organization.

CONCEITO 4

Dr. Hollomon. This is one of the reasons why, Mr. Chairman, I don't want to submit it for the record this morning, because I want to insure that discussion is carried out among all of the agencies. The plan we have this morning is in response to a request of mine to the Weather Bureau to draft what they believe ESSA needs to carry out a major program within their own organization, and it has not yet been discussed in detail with the other affected agencies.

This is one of the things I think is essential.

Senator Dominick. Mr. Chairman, unfortunately, I have to go to an executive committee meeting of another committee at this point. I have a number of questions that I would certainly like to ask Dr. Hollomon and Dr. White. As soon as this other meeting is over, I shall come back.

Senator Cannon. Now, Doctor, you have indicated that there should be some regulation, and in view of the fact that ESSA is apparently going to get into the operational field, too, do you think there is any conflict of interest here in having ESSA as a regulatory

Dr. Hollomon. Of course, any authority which is given by a reorganization plan runs to the Secretary of Commerce and does not run to ESSA. I would recommend any legislation in this regard running to the Secretary of Commerce under the general authority of the Reorganization Act of, I believe, 1952.

CONCEITO 32

My own view at this moment is that it is perfectly satisfactory the way ESSA is organized at the moment, for the regulatory aspects having to do with the prevention of interference to be vested in ESSA, but in a completely separate group from that which is responsible for the research and development. I believe that would be satisfactory.

If it turns out to have any conflict of interest, which I can't imagine at the moment, I would then suggest to the Secretary that this be vested in the Secretary's Office, rather than in ESSA. But as long as it is a major technical question on regulation - —that is, does a particular technical operation conflict with another technical operation? I really think such a technical judgment is best vested in an organization that can bring the technical forces throughout the Government to bear on it.

When we get to the other question, however, to where one is regulating essentially commercial activities, I think this poses an entirely different kind of problem.

Outras Disciplinas Mencionadas

The AEC has a similar kind of problem, of course ; the problem of supporting research and development in atomic energy on one hand and being responsible for insuring that the regulations with respect to safety of atomic nuclear plants on the other hand are properly maintained. What they have done is completely separated those two operations, but still keeping them within AEC.

I think from what knowledge I have of it, it has worked reasonably satisfactorily. But I assure you I think they should be clearly separate, and the President and the Congress should be able to get reports on each issue and not from the same people.

CONCEITO 4

Senator Cannon. The Weather Bureau has not been an exponent of weather modification historically. How do you account for their move now to be the dominant agency in this field?

Dr. Hollomon. Mr. Chairman, there are three comments I would like to make on that subject. One is that the reorganization with respect to providing the ESSA organization, which was recommended by the President last year, has done a tremendous amount to change the responsibilities and attitudes of both the ESSA organization and others in the Government.

The second comment I would make, which I tried to say indirectly in my statement, is that the old order does have the same motivation to change. Dr. White and I and the technical people in the Weather Bureau believe that there are serious questions and possibilities about weather modification that this country cannot refuse to evaluate and seek the possible benefits of.

CONCEITO 33

I think another fact of the matter is that there were true questions in the scientific community in the 1950's that made the people feel that broad studies were premature. The statistical evidence was not clear.

I think the evidence is becoming clearer; people are becoming more convinced. Personally, I find myself in a strange position in this business. I was one of the close associates with Langmuir and Schaefer. I personally wrote one of the early scientific papers on the subject of weather modification. Perhaps my own bias has something to do with the change in the feeling of our own organization and the possibilities.

CONCEITO 4

Senator Cannon. Isn't it a fact that there is a great deal of competence in the weather modification field outside of the Weather Bureau and ESSA today ?

Dr. Holomon. Of that there is no question.

Senator Cannon. In private life, universities and foundations. As a matter of fact, I think there is probably more competence outside of the Weather Bureau and ESSA in this field than inside; wouldn't you say that is true ? Or is that sort of putting you on the spot ?

Dr. Hollomon. I think if you add up the total technical effort in the country, without doubt the total number in the technical field, in all of the private and public organizations, probably exceeds that in ESSA.

On the other hand, I think with the basic work that goes on in the general dynamics of the atmosphere, cloud physics, Project Stormfury, and on tornadoes, ESSA has competence and it is a growing competence in this area. I simply think that there have been substantial changes in this organization, and that they will continue.

Dr. White. Mr. Chairman, with your permission, I would like to respond to that question, because it has been raised by a number of people.

I think it is important that the record reflect that the Weather Bureau has always taken a realistic attitude toward weather modification. Now it has been very active in weather modification in the past. It was heavily involved in a large-scale rain project in the West many years ago.

Senator Cannon. When was that and where ?

Dr. White. That was called the ACN project, I don't have the exact date. It was in 1953-54. We must recognize that many of the weather modification experiments that were conducted during that period produced inconclusive results. And the indications on the basis of these inconclusive results was what was required was more fundamental research in the atmospheric sciences and all of the problems of the weather modification.

The program of the National Science Foundation was for the purpose of acquiring this additional basic knowledge.

The Weather Bureau some 4 or 5 years ago decided to initiate a program on hurricane modification. This was and still may be the single largest effort in weather modification in this country, requiring the deployment of many, many aircraft, I believe about 17 of them. It is one of the most difficult projects in weather modification that one could conceive of carrying on. It is viewed as a research activity.

There have been questions in the scientific community, for example, as to whether we should go ahead with a project such as this. But it certainly is not an evidence of conservatism. I would also like to respond to your question about the competence in weather modification in ESSA.

We have many scientists who have been involved in various aspects of the atmospheric science research and all atmospheric science research in one way or another is related to weather modification.

There is also no question that in the university community, private industry, and all of the other groups in the country, there is a much larger competence in the field of weather modification than we have in our organization. The competence must be used wherever it is.

Senator Cannon. I know, Doctor, you referred to some of the interest of other agencies. I wonder if you could perhaps spell that out a little better for the record? If you are not prepared to do so right now—but I would be interested in having it spelled out in more detail, the interest of, for example, Department of Defense, Agriculture, Interior, AEC, NASA, other agencies that may be directly involved.

If you wish, you can supply that for the record.

Dr. Hollomon. Let me supply it for the record, Mr. Chairman.

Senator Cannon. All right.

(The information referred to ...)

Senator Cannon. Now do you see this action before us now as a means of moving the weather modification program ahead faster or do you think this is going to be another just sort of coasting along type of thing?

Dr. Hollomon. I hope it would be a matter of moving. I don't know what it will be. But I would express my hopes in this field :

First, I think the combination of the President's proposed reorganization plan and legislation which I hope can be worked out in the near immediate future will substantially strengthen the weather modification activities in this country.

Second, I think the same combination will lay the groundwork for future questions of public policy, regulation, economics, that will be necessary when we become successful or more successful in any of these fields.

I sincerely hope that the result of the legislation in S. 2916, as it develops, will be to thoroughly and appropriately stimulate substantial increases in the weather modification activity in this country, both in ESSA and in other agencies.

Senator Cannon. Senator Pearson?

Senator Pearson. Dr. Hollomon, in line with what you just said, and with reference to your comment that the first problem is acquiring knowledge, is the thrust of this legislation to increase our activity in weather modification, or is it to decide who is going to do the job?

Dr. Hollomon. The purposes of the legislation, as it now lays on the table, seem to me to be twofold : One is to help decide who is going to do the job, and the second is to provide for the basis of certain kind of regulation and policy questions that are immediately raised by this field.

Senator Pearson. Excuse me, Doctor, would you please start over again ?

Dr. Hollomon. I think the present thrust of the legislation as now drafted does two things. One, it assigns certain responsibilities with respect to weather modification and secondly, provides certain indications of regulations that may be needed immediately in this field.

It does not provide for the major expansion of the program, as now drafted.

CONCEITO 34

Senator Pearson. Is there a great deal of uncoordinated effort, private and governmental research today?

Dr. Hollomon. Right now?

Senator Pearson. Yes.

Dr. Hollomon. Yes, sir.

Senator Pearson. You said you would submit for the record the degree of participation of the various Federal agencies.

Dr. Hollomon. We will be glad to do that.

Senator Pearson. I am sure that will be very helpful to us. But where is the activity outside of the Government taking place ? Is it primarily in the private weather modification.

4.b)

Dr. Hollomon. There is a large number — 25, 50, or something like that—of private parties who engage in private weather modification activities. This is primarily in new England, the West, the Middle West.

Senator Pearson. Any State agencies ?

Dr. Hollomon. State agencies? As such, I do not believe there are any State agencies, subject to correction. I don't remember them off hand.

But there are a very large number of private experimenters, and I hope they will continue to go forward.

One of the major findings of the National Academy of Sciences' Panels on this subject was that the data of the weather modification activities of private parties were very useful in determining what the consequences were, and these data had not been available to the Federal Government heretofore.

Senator Pearson. You mentioned that, in regulating private and State activity, you would do it only so far as it would affect Federal participation ?

Dr. Hollomon. At this time.

Senator Pearson. Are you anticipating a problem or do you think there are existing problems ?

CONCEITO 10

Dr. Hollomon. Dr. White commented on an experiment in Santa Barbara, where it is believed that there was possible contamination of an experiment, in this case by private parties. As this program expands, I think it is perfectly clear that the possibility of contamination of one or the other sets of operations will be a serious question.

Senator Pearson. Thank you.

Senator Dominick is back-, so why don't you go ahead, Senator Dominick ?

Dr. Hollomon. May I interpose one comment ?

There is a possible way to deal with this problem of regulation, interference with Federal parties, which we are considering, and that is to lay out a zone in which certain Federal experiments are going to be performed for a time and suggest during that period there be no contamination.

Senator Pearson. Of course, all of this is regional. Weather modification is not going to be subjected to State lines or areas.

Dr. Hollomon. That's right.

Senator Pearson. It is very close to the problem of air and water pollution, as a matter of fact, or water pollution.

Dr. Hollomon. I quite agree with you, Senator.

CONCEITO 35

Senator Dominick. Doctor, do I gather from your statement that the Weather Bureau feels that it is possible at this point to increase precipitation from weather modification programs?

Dr. Hollomon. We think that the evidence is clear that this possibility is very strong; yes, sir.

Senator Dominick. This is the same conclusion that was reached in 1957, isn't it?

Dr. Hollomon. Yes. Well, I think the conclusion as stated in the bare statement is essentially the same; yes, Senator. But I think the evidence is substantially greater today than it was in 1957.

Senator Dominick. The evidence is substantially greater?

Dr. Hollomon. Yes, sir.

Senator Dominick. Evidence from what ?

Dr. Hollomon. From experiments which have been carried out by private seeding operations, by Government operations, and by the large Australian experiments, the evidence I think is substantially greater.

Senator Dominick. You feel then that although it would have been possible to go ahead in 1957, that it now looks like it has even a better probability of success?

Dr. Hollomon. "Go ahead" is a difficult question. I believe that the program was justified in 1957 ; I certainly wouldn't want to try to look back and say whether the right things were done in 1957 or 1964 or 1965, but I do believe it is now necessary to substantially increase the activities leading to enhanced precipitation, to determine the conditions under which that can be done.

Senator Dominick. Is it your feeling that Commerce is the agency which should have overall authority in this field ?

Dr. Hollomon. That is a very difficult question. I don't know what you mean by "authority." Certainly I don't believe that all the weather modification and activities of the Federal Government should be carried out by a single agency; no, sir, I don't believe that.

Senator Dominick. In your statement you recommended that the Commerce Department at least be given a much larger share in the activities. Is that correct ?

Dr. Hollomon. I believe Commerce should be given a major responsibility with respect to weather modification broadly, yes, sir. This we believe is consistent with the recommendation of the NSF Commission, and consistent with the recommendation of the National Academy of Sciences Panel.

Senator Dominick. I am trying to be clear in my own mind as to really what you are recommending, because in your statement you recommended that existing activities continue through the agencies that are now dealing with them.

Dr. Hollomon. I did ; yes, sir.

Senator Dominick. Then you said you wanted some kind of change where the control was in the Weather Bureaus, as I understand it.

Dr. Hollomon. No, sir ; I did not say "control." I tried to imply three things, there are three or four major kinds of weather modification activities that affect almost any kind of program, almost any kind of program you would carry out.

First off, what you are really trying to do is to modify in some substantial way the characteristics of the atmosphere. In some cases this will produce enhanced precipitation. In some cases it will produce diminution of precipitation, presumably. In some cases it will affect hail production, in some cases it may? in the future, affect hurricanes. But in every case what you are doing is trying to modify the basic characteristics of the atmosphere.

Now this basic problem, the technology of it, how to simulate it on computers, how to provide the right kind of statistical analysis, there are common problems. No matter what you do in weather modification, there is a certain common aspect of weather science and technology. I believe we should have some common agency that assures that we are advancing that common technology, without restricting the ability of the FAA, as an example, to be able to do technical work with relation to fog dispersal at airports.

But that technical work should be brought together and evaluated to see how it relates to the overall problem and how that same technical information can be used by other people.

Senator Dominick. Am I correct in understanding from your comments that ICAS is not able to coordinate and correlate these programs?

Dr. Hollomon. The Interagency Committee for Atmospheric Sciences has been primarily concerned with the problem of coordinating the more basic research activities and has been

concerned with general policies with respect to weather modification. I think it should continue to have that responsibility.

Secondly, however, we are now proceeding to much larger experiments, hopefully of many more diverse kinds. They will be more connected with possible operations, where one changes the weather in a certain area. We need to predict that change, and correlate it with other activities. That kind of coordination, I think, should follow the general coordination mechanism which is specified in Bureau of the Budget Circular A-62, which assigns to the Department of Commerce the responsibility of carrying out the coordination of meteorological activities. The problem is becoming one of coordinating major field programs, hopefully, in the future, and their relationship to weather prediction and the relationship or semi-operational programs.

Senator Dominick. Now, in general you have advocated as a part of your recommendations that the Commerce Department be given authority to prohibit either State or private weather modification programs where they might interfere with any Federal activity.

Dr. Hollomon. I do.

Senator Dominick. What is the position that the Government has with regard to the citizen on this, who wants to go forward with getting increased precipitation on his land in order to prevent disaster and he is told by the Federal Government he can't do it?

Dr. Hollomon. We haven't worked out the procedures in any detail certainly, but my view of the procedure that should be adopted is that the scope of the Federal programs and the geographic areas in which they are going to be operated should be made public. Then, by the same token, the scope of the private parties' activities, what they intend to do in a given area, should also be made available to the Government and the public.

The determination then has to be made on a reasonable basis by due process as to whether or not there would be interference with some major Federal program by a private party. And we should be able to cause the private party to delay or to change his program during that period or otherwise the major Federal program will simply not be able to be carried out or evaluated.

Senator Dominick. For example, suppose the Federal Government decided it was going to go into a hail suppression program in one of the hail areas of the country. It has a target area for doing this and it issues an order saying that no other hail suppression programs or cloud modifications can be carried on which might interfere with this.

Dr. Hollomon. In a certain area, for a certain period of time.

Senator Dominick. Suppose a State program or a private operator has a different theory on how hail suppression should be carried out. You prohibit him from doing it, and they cannot carry on because the Federal law presumably preempts the field.

Dr. Hollomon. Only for Federal programs now.

Senator Dominick. Yes, I understand that. Then let's take the possibility that the Federal Government is wrong. What happens to the landowner who is wiped out ?

Dr. Hollomon. Well, in my view, in any such process, the private party should be able to have A hearing, and a determination made under these conditions as to where the public interest lies. This is not any unusual activity. But I see no alternative, to be able to provide a secure area for appropriate experiments, if we are to progress in this field. Because otherwise the experiments cannot be evaluated.

Senator Dominick. Let me ask you this question and perhaps this will bring it out more clearly.

Dr. Hollomon. I will also say the following : It is certainly possible that a recommendation would be made that the experiment might be delayed on the part of the Federal Government for a certain period. In other words, I think Senator Dominick. You could only do this during the hail season, so that is pretty hard.

Dr. Hollomon. Another area could be chosen, for example, if it has equal technical characteristics.

Senator Dominick. What degree of disagreement is there between the Weather Bureau or the other agencies, and the State modification and private modification programs as to how best to go about a given problem ?

Dr. Hollomon . Could you repeat that ? I don't quite understand it

Senator Dominick. What degree of difference is there in the operational techniques between the Federal research programs and the State and local programs? Do they use different techniques? Do they have different theories? Do they have different principles as to how to attain a set result ?

Dr. Hollomon. Certainly there is a variety of ideas about when is the best time to carry on seeding. These are some of the things that are not definite. There are certainly notions as to the—there are things we don't understand about the amount of concentration that is required. There are certainly differences in view, I would suspect, technically, in a field such as this, which is still in the experimental stage. If that was an answer to your question.

Senator Dominick. That helps, because this leads to my next question and that is, what therefore gives the Government a superior expertise over the State or local programs?

Dr. Hollomon. I did not intend to imply that. I simply said if we were going to have a very substantial program in the Federal Government ; and if we are going to lay out experiments which, let's say, depends upon a certain concentration of seeding element ; and if then in an uncontrolled fashion, the conditions are modified, inadvertently or advertently, by someone

else, that chain of events vitiates the results of the experiments. That is all I am saying. I didn't say our knowledge is greater than anyone else's.

Senator Dominick. But the difficulty is if the Federal Government starts a research program and prohibits anybody else from operating, this is exactly what you are saying.

Dr. Hollomon. I beg your pardon.

Senator Dominick. The difficulty with trying to resolve this problem is that if you give any Federal agency the right to prohibit any other activities in the area, the research program conducted by the Federal Government is of sufficient national interest that no one else can do anything in the area, even if it means the destruction of some body's property.

Dr. Hollomon. Even if what means the destruction of somebody's — you mean the natural phenomena?

Senator Dominick. The failure to go ahead with the other system.

Dr. Hollomon. On the other hand, Senator, it seems to me that the Federal Government should give due notice as to what the experiment is going to be in the area. This does not indicate that all areas of the country, by any manner of means, would be preempted by the Federal Government, but only those areas where the Government has specific experiments to undertake. I simply don't know how one would proceed without this kind of authority.

Senator Dominick. How good is the reporting system from State and local operations to ICAS?

Dr. Hollomon. At this time?

Senator Dominick. Yes.

Dr. Hollomon. We have not undertaken to obtain these reports. This was a responsibility, up until now, of the National Science Foundation. Until recently they had not obtained these reports. They only carried this, their responsibility forward, on a voluntary basis. It was as a result of discussions among ICAS, and the National Science Foundation, myself, and others that the current regulations by the National Science Foundation were published. This is only, as I think you know, a recent act on the part of the NSF.

Senator Dominick. In Colorado, for example, we have a State scientific advisory board, advising the Governor what weather modification programs to go into, and we also have some private operations in our area, because of the dryness on the eastern slope and the need for getting more snow in the mountains.

Now if we are going to conduct a Federal program, I would presume therefore all of these activities would be stopped.

Dr. Hollomon. I wouldn't think so, Senator. I would think you would have a program in which you would notify the appropriate people as to the limited area in which the program is going to be carried forward and the purposes. Then a fair determination would be made as to the balance of the interests in the matter.

I think that this is certainly an appropriate process which would have to be established. And I hope I am not stating or implying that all programs in any State, would be stopped. I don't think that is the appropriate thing to do. And I feel very strongly that this is not now the time to determine that the Federal Government should issue regulations affecting private parties, except in this narrow area.

CONCEITO 36

Senator Dominick. Yesterday we heard a statement describing big science and little science, in terms of experimentation or applied research. How big an area is covered by the type of program geographically?

Dr. White. Hundred miles on a side.

Dr. Hollomon. This is the kind of area one is talking about. Of course in hurricanes one is talking about larger areas.

Senator Dominick. Yesterday they were talking about a hundred square miles being a big science area. This is 10 miles by 10 miles, not a 100 by a 100.

Dr. Hollomon. The experiments have been planned and carried out, in the West for example, on the order of 10,000 square miles, and the experiments in Stormfury, seeding with respect to hurricanes, are very large areas.

Senator Dominick. The seeding with regard to hurricanes, however, is mostly done over the ocean, as I understand it, where there can be no impact on land masses for 48 hours?

Dr. Hollomon. That is what we try to do, that is correct.

Senator Dominick. How big are the operations now being conducted by State or private programs in terms of geography?

Dr. White. We do not have at the present time extensive private weather modification programs being supported out of ESSA

Dr. Hollomon. No, he didn't ask that question.

Senator Dominick. I am talking about private operators.

CONCEITO 36

Dr. Hollomon. The scale of private programs. Pacific Gas & Electric is over a large area. There are other programs that cover small areas. There are a wide variety.

Senator Dominick. Do they have them as big as 100 miles by 100 miles ?

Dr. White. I wouldn't be able to answer that question. The sizes vary, Mr. Chairman.

CONCEITO 37

Senator Dominick. In your statement, Dr. Hollomon, you refer to one of my pet peeves with the Weather Bureau and that is forecasting. Throughout you imply that weather prediction carried on by the Weather Bureau is of enormous value to the country. I am sure I could find 9 out of 10 citizens that disagree with you on that, but the major point I would like to stress is your view of the relationship between forecasting and weather modification.

Dr. Hollomon. I tried to make this clear in the statement. I hate to let your comment about the value of weather prediction go with out making some response.

Senator Dominick. Go ahead. I expected you to defend it.

Dr. Hollomon. Perhaps I will surprise you. It is perfectly true that there are still large inaccuracies from time to time in weather prediction, the ability to predict in exactitude the character of the atmosphere, is not yet complete. In my view, it will always be a difficult subject. I do not, however, feel there is any question on two points, first, that the prediction of the weather on a quantitative basis has substantially improved in this country over the last 10 to 15 years, and, second, that it is still improving.

Senator Dominick. By "quantitative," you mean, the amount of it?

Dr. Hollomon. I am talking about the degree of accuracy with respect, to quantitative objective measures of such things as wind velocities, temperature, that sort of thing, made for a given region. There has been substantial improvement and that has come about largely, but not entirely, due to two factors:

One is increased observational capability throughout the country and the world.

And secondly, the ability to use, on an objective basis, the large computer for simulating and calculating the character of the atmospheric changes. And there is good quantitative evidence that the predictability of the atmosphere, from the standpoint of serving the citizens of this country, has improved.

We will be glad to furnish you the record of the quantitative measures on that subject.

Senator Dominick. I don't suppose my recent letter has come to your attention, containing a report on the Weather Bureau predictions of temperatures for eastern Colorado during the month of January 1966. On 4 days you were within maybe 5 degrees. The rest of the time you were off between 20 and 30 degrees on both high and low temperatures.

Dr. Hollomon. I haven't seen your letter. We will take a look at the problem.

Senator Dominick. I sent it to Dr. Cressman and made some suggestions in it. Now, as to the value of the predictions. I just find it very difficult to believe that the general predictions that the Weather Bureau makes with respect to hurricanes, are substantially inaccurate four-fifths of the time. I think there is clear evidence that over a period of time, there has been great reduction in loss of life and property, for example, in the case of hurricanes and tornadoes.

One of the serious problems here is not only the prediction in these cases of severe storms, but the adequacy of the warning systems, getting the information to the proper people at the proper time.

Senator Dominick. That is correct. I think your observational techniques are excellent all of the way through.

Dr. Hollomon. Now, the situation on improving the dissemination and advising the people, this year's Weather Bureau budget includes a substantial increase for providing an improved nationwide natural disaster warning system. We are serious in the fact that there have been deficiencies in this, and we want to correct them and provide much better warning services of all kinds in a more effective way than we have in the past.

Senator Dominick. Dr. Holomon, are you a flyer?

Dr. Hollomon. Only as a passenger. I don't have a license.

Senator Dominick. I am an amateur flyer. I have been flying for 30 years, and I can assure you that the pilots of this country do not share your enthusiasm for weather predictions.

Dr. Hollomon. I tried to indicate this fairly, that it had improved, that they were not perfect, but they had improved, and they need substantial improvement. I honestly don't think that we are differing. I only say they are better than they were. I think they can be improved and I further believe that we can take the steps to do so.

Senator Dominick. In your statement, you say that when any particular type of weather modification becomes fully operational, the decision to modify the weather in a given instance will depend in a large measure on the prediction of what the weather will be.

Dr. Hollomon. That is right.

Senator Dominick. I gather that there are systems of getting rid of cold fog right now ?

Dr. Hollomon. That is right.

Senator Dominick. You don't need any weather predictions on that, because you have your installations ahead of time ; do you not ?

Dr. Hollomon. That is right. It is a local phenomenon, and you can go out and see it. But, in that, condition the prediction is clear. It is not a case of whether rain will or will not occur, a storm will or will not occur. It is a short-term problem, and it is perfectly clear in the case of cold fog, in a sense. You don't need the prediction. You wait until it is there.

Senator Dominick. When you are doing ground generation to increase precipitation, the target area has been pretty carefully examined ahead of time and the generator is set up largely from the prevailing wind system, and so forth ?

Dr. Hollomon. That is correct.

Senator Dominick. Is it not true that having these reasonably well set up, depending upon wind changes you could then wait until the required type of storm from an observational point of view would come over the area, which you could properly seed ?

Dr. Hollomon. Or from a prediction point of view, either one.

Senator Dominick. It would be helpful to alert the people, if you could predict it a day ahead of time.

Dr. Hollomon. And also that the likelihood of rain from that storm would not be high, with or without the seeding. We would like to know that too.

Senator Dominick. But these are observational techniques of storms as they are moving in ; is this not true ?

CONCEITO 38

Dr. Hollomon. Cloud systems as they are moving in, yes; or that might change as a result of the other climatic conditions, yes; that is correct.

Senator Dominick. Do you have some comments on that, Dr. White ?

Dr. White. No, Mr. Chairman.

Senator Dominick. So there are, at the present time, weather modification techniques which are available in certain types of weather, which are not necessarily reliant on accurate predictions observations ; and, depending on the size of the area, on the character of the weather one is trying to modify, they depend to a greater or lesser degree on prediction.

Senator Dominick. To what degree has the Weather Bureau analyzed the difference between their weather forecasting techniques and the techniques used by other forecasters?

Dr. White. We generally do not conduct evaluations of the forecasts of private forecasters. We do conduct extensive evaluations of our own forecasts, which are published.

Senator Dominick. Would it be helpful on an experimental basis to determine whether others might have techniques which are an improvement on the ones now in operation ?

Dr. White. Well, the problem of evaluating forecasts is a very, very difficult one. There are almost as many schemes for evaluating forecasting as there are meteorologists, and it is very difficult to decide upon an acceptable one.

Senator Dominick. The best one, it seems to me, is to forecast what is going to happen tomorrow and then find out what happens tomorrow.

Dr. White. Yes, if you can get meteorologists to agree this a proper way. There are many private groups who are making forecasts. If they have forecasts which they wish to submit to the scientific journals, to illustrate the accuracy of their forecasts, this is the normal way in which this is done. And the normal way in which the forecast evaluations are presented.

Senator Dominick. I am not quite clear on this. It would seem to me, if the forecasting ability of the Weather Bureau is under question, that it might be helpful to run an experimental program, side by side with the private forecaster, and determine which one has the techniques to more accurately predict the weather.

CONCEITO 39

Dr. Hollomon. Isn't it true, Senator, that any private forecaster, as well, relies, to some degree at any rate, upon both the total observations certainly reliant on accurate tions and the central forecasting calculations of the Weather Bureau?

Senator Dominick. I am absolutely positive they rely on the observations prepared by the Weather Bureau all over the world.

Dr. Hollomon. Also, the calculations of what the essential weather fronts are throughout the world ?

Senator Dominick. I assume this is part of the observational techniques.

CONCEITO 39

Dr. Hollomon. It is more than that. It is a question of applying dynamics to these operations in terms of the kinds of analyses we have available now. It is my understanding, I believe to be correct, that all private parties, use, if they are professionally sound, the total observation and basic predictions that are made out of the weather central operation here in Suitland. Now, the question I think is, the comparative degree of accuracy with which local weather is predicted by the Weather Bureau or by private parties. I believe that everybody uses now the very sophisticated wind patterns, pressure patterns, temperature patterns, and so on, that are not just observations but which are calculations from observations and the forecasting of how these will change in time. These are generally available to everyone and serve, I believe, as the core of this problem.

Senator Dominick. If they are so used and they come up with different results, it would seem to me that maybe the techniques of interpretation of those would be worthwhile exploring.

Dr. Hollomon. On a local basis, particularly.

Senator Dominick. Local basis is what the purpose of the prediction is surely designed for. It just occurs to me that perhaps this is one way of finding out whether the interpretive process is correct.

Dr. Hollomon. I was only trying to make the point that there are several interpretive processes that take place, interpretive processes that take into account of calculation of the total airmass, the total motion of that airmass, its effect on local weather, and so on.

I know of no private parties that carry on that kind of very broad scale calculation of the total motion and types of flow of airmass over the United States or over the world.

I think the question, at least from my observation of it, is a question of the degree to which that information now is interpreted with respect to the detailed variations from the local areas. It is to that kind of predictability that I refer in my comments. It seems to me the way to get at this problem, if there are private parties who do believe that they have better prediction capabilities than the Weather Bureau is to publish the results. And I think they can be fairly evaluated.

Senator Dominick. That is what I am talking about. Run them side by side.

Dr. Hollomon. I see no reason why this evaluation can't take place by the full publication of both sets of results and let's see what happens.

Senator Dominick. In general, you don't believe that there is any usefulness in doing this, because there would be the same results.

Dr. Hollomon. No, that is not what I am saying. It seems to me that the meteorological literature offers an adequate forum for the publication of technical literature on the predictability of the weather in relation to anybody who makes these predictions.

Senator Dominick. Isn't it the responsibility of the Weather Bureau to use the most advanced techniques they can to find out if their predictability is accurate?

Dr. Hollomon. Without question.

Senator Dominick. This is one way of getting at it.

Dr. Hollomon. The data have to be published in some fashion.

Senator Dominick. It can be published in the daily newspaper, side by side with the Weather Bureau prediction.

Dr. Hollomon. It seems to me that does not provide the basis of a very scientific evaluation. What needs to be published is the record over a period.

Senator Dominick. That is what I mean; a year or more, whatever you want to do.

Dr. Hollomon. I have difficulty finding out what stops a private person from publishing at this moment —and he is encouraged to do so—the results of weather prediction, contrasting his prediction of pressure, temperature, and so on, as against what actually happened. It seems to me this kind of information —there are journals, media for publishing this kind of evaluation. I just don't know what the problem is.

What you are implying is---

Senator Dominick. I know what the problem is and I think you do, too. The problem at the present time is getting any kind of an evaluation, side by side, with the Weather Bureau report. What we are trying to do is to see if the mode of interpretation is different from what the Weather Bureau's doing, and if the other mode is more accurate. I can't see anything wrong with trying that.

Dr. White. The Weather Bureau reports are published and open and available to anybody, and, if there is a desire on the part of some one to make comparisons, these data are available to him. He can make such comparisons and he can publish the results he obtains from these.

Dr. Hollomon. Conversely, it seems to me, if the results of private parties are made public, we certainly can make the comparisons as to what the relative accuracy is over a long period.

CONCEITO 39

Senator Dominick. But you are opposed to the idea of giving an experimental contract to anybody to do this, side by side, with the Weather Bureau ?

Dr. White. I would have to know the particular circumstances of the contract, the proposal in detail, before I would want to make a decision on it.

Dr. Hollomon. It is certainly not a decision I would make.

Senator Dominick. I was interested in your recommendations on Nos. 3 and 4, which you said we ought to think about. In No. 3 you say the Secretary of Commerce might be given the appropriate authority to assess all private and State research and operational programs to preclude endangering the public safety.

Do you feel that these programs are or might endanger the public safety as they are now conducted ?

Dr. Hollomon. I don't believe that is the case at the present time. I don't think the technical evaluation, as far as I hear it and read about it in the various reports that have been issued, that this is currently a problem. That is why I don't make a recommendation in this area.

I think this is a matter, though, that the Congress and we should keep under careful study. As you know, if we really learn to modify the characteristics of hurricanes, as an example, this kind of question could arise, particularly if private parties also attempted to make the same modification.

Senator Dominick. Are any State or private groups now engaging in either hurricane or tornado modification?

Dr. Hollomon. I know of none at the moment.

Senator Dominick. So your recommendation is against No. 3; is that what I understand you to say ?

Dr. Hollomon. No, sir. We made certain specific recommendations on the preceding page as to what should be included in the legislation now. What we are suggesting on page 22 are questions which the committee now and in the future should consider, and we stand ready at a future time to give our views on these various problems, but we are at this stage simply presenting them as questions for the committee's consideration.

I am not ready, certainly, to take a position on the matter at this moment.

Senator Dominick. The National Science Foundation discussed some of the problems which might result both from an ecological and sociological point of view if large-scale weather modification programs were put through.

Who should conduct that kind of research?

Dr. Hollomon. Regarding the effects of climate on living systems, particularly the effect of climate on the general character of man's activities, I think that should be conducted by ESSA. Where you have a problem with the effect of microclimate, and other changes on, let's say, agricultural activities, I think it ought to be conducted by the Agriculture Department in cooperation with ESSA.

Senator Dominick. Is the Agriculture Department now engaged in weather modification research?

8.b)

Dr. Hollomon. You can correct me, Bob, if this is wrong. There are certain joint programs underway on the effect of microclimate, small-scale changes in climate, in Agriculture and

between Agriculture and ESSA. There are certain programs, I think I am correct on lightning suppression in the Agriculture Department. Is that correct ?

Dr. White. That is correct.

Senator Dominick. As you know, this country in selected areas at the present time —and undoubtedly in selected areas in the futures — will have sharp problems with regard to having enough water to keep going even with what it now has.

Dr. Hollomon. Yes, sir.

Senator Dominick. Do you feel that we are presently in a position where applied research could be put into effect to try and increase water in those areas ?

Dr. Hollomon. I feel clearly we are in a position to lay out programs to determine the best way to increase the water content in those areas, and that we should proceed to evaluate them and we have the techniques now ; we should proceed to operate.

Senator Dominick. And this would be true, I would gather, in the northeast section of the country?

Dr. Hollomon. I don't think we are ready there yet. I think we have to do some experiments in that area to determine the consequences of seeding.

Senator Dominick. Do you think we are ready to do it in the Colorado Basin ?

Dr. Hollomon. Experiments are now planned for a Colorado River Basin.

Senator Dominick. On an applied basis?

5.b)

Dr. Hollomon. Certainly they are planned now, broadscale experiments to evaluate carefully the consequence of seeding, how it should be done and what the results are. This is by the Bureau of reclamation.

Senator Dominick. I am talking about putting into operation now existing techniques that are known, with the probability of increasing, by at least 10 to 15 percent, the precipitation in an area.

Dr. Hollomon. I think my position is that we are ready to go to the stage of determining the engineering feasibility, the technical steps one has to specify in order to do that accurately and that program is under way.

Senator Dominick. As you probably know, there has been substantial discussion in Congress of the need for importing water from streams not being entirely used into other areas of the country.

Dr. Hollomon. I know something about this. I am not thoroughly familiar with it.

Senator Dominick. It strikes me that if we could get going on a weather modification program, we might be able to produce more water at a much cheaper price.

What are your comments on that ?

Dr. Hollomon. I think this is the kind of question that needs to be asked, as to what the trade-off costs are between the various alternatives and in order to do that we have to know the efficiency and effectiveness of the weather modification in these areas. I think that is an appropriate question to ask and we should seriously ask it.

Senator Dominick. Recently the National Science Foundation issued regulations compelling State, local, and private cloud seeders to furnish information on their weather modification activity, together with advanced notice of an intention to seed and after-the-fact reports.

Dr. Hollomon. Yes.

Senator Dominick. Are these being received ?

Dr. Hollomon. I cannot tell you at the moment. That regulation went into effect —it is dated December 21. It is to become effective January 1. And I can't tell you whether they are being received at the moment or not.

Senator Dominick. Under what authority were those regulations issued ?

Dr. Hollomon. They were issued by the National Science Foundation under the authority in—do you have the references, Mr. Christenson?

8.a)

Mr. Christenson. The act of July 11, 1958 (Public Law 85-510; 42 U.S.C. 1872a) is the authority of the National Science Foundation for issuing the regulations.

Senator Dominick. This is not then under the authority of any existing weather modification law that Congress has passed. It is an executive order.

Dr. Hollomon. Oh, no. This is the authority in the law which is in the National Science Foundation's legislation.

Mr. Christenson. It refers specifically to weather modification.

Senator Dominick. Will these reports be coming to the National Science Foundation or to ICAS?

Dr. Hollomon. The present situation is that these reports will be coming into the National Science Foundation, and the substance of their analysis will certainly be made available to ICAS and other interested agencies.

Senator Dominick. I wonder if we could have the staff find out who will be doing the evaluation of these reports and to what extent they will be available to the general public ?

(...)

Senator Dominick. Now, Doctor, you have been here on the Washington scene long enough now and you know as well as I do that one of the problems that we as a committee are going to face is the question of what agency is going to have the major responsibility for advancing the general technology of weather modification, I gather you think it ought to be incorporated in Commerce?

Dr. Hollomon. That is correct, sir.

Senator Dominick. Do you anticipate that legislation of this type would receive pretty sharp reactions from the other agencies?

Dr. Hollomon. I do not, sir.

Senator Dominick. That is encouraging. And I hope you are right.

Dr. Hollomon. I also pointed out —I don't know whether you were here —I pointed out in my statement that there is under consideration a reorganization plan to transfer the responsibilities from NSF to the Department of Commerce.

Senator Dominick. How long have we been using weather observation satellites ?

Dr. Hollomon. On an operational basis, and by this I mean routinely on an operational basis, from the standpoint of systematic continuous basis we have been using them starting the beginning of this year. The launch hopefully is being counted down for the second operational satellite at this moment. We were supposed to launch it 2 days ago, the second satellite of the operational system 2 days ago, and we hope to have it launched on Saturday. However, there have been since April 1, 1960, experimental satellites which have provided cloud cover observations

Senator Dominick. Is this the Tiros satellite ?

Dr. Hollomon. Right. The Tiros system provides cloud observations particularly, and on a more or less routine basis. There have been periods in which we haven't gotten coverage. It

was an experimental program. Each satellite was somewhat different from the preceding one, and so on.

The first operational satellite was launched about 2 weeks ago, February 3. This will be a continuous operational program.

Senator Dominick. This is being coordinated, I gather, with the Navy, in its work in the oceans on reporting buoys and things of that kind?

Dr. Hollomon. No; this satellite is for the purposes of cloud observations.

Senator Dominick. I understand that, but is this being coordinated with the Navy ?

Dr. Hollomon. The data we get from the buoys feeds into the same system the satellite feeds into, which is weather central in Suitland.

Senator Dominick. This is the computer system you referred to previously ?

Dr. Hollomon. Not only the computer system, but then the satellite information is used to monitor the computer system, where this cloud cover information can give us, particularly over areas of the world— this is one of the serious problems about weather prediction — over areas of the world where we do not have adequate observations, particularly the Southern Hemisphere, and the Pacific, we just don't have adequate observations. This satellite gives us qualitative, not quantitative, information, over these areas. And this is used to moderate, as much as possible, the observation and prediction capabilities of the central weather information, to make it more accurate.

CONCEITO 40

Senator Dominick. Would either one of you be able to render even a guess as to where weather starts ?

Dr. White. It starts everywhere, in a sense. Disturbances are continuously being formed in the atmosphere at various places. There are preferred places where these disturbances are formed. For example, one of the preferred places is in the Gulf of Mexico, or off Cape Hatteras. But, literally, weather forms and stops just about everywhere.

Senator Dominick. From the point of view of the continental United States, does weather start, as far as observational techniques and interpretation, largely from the Northwest Pacific, plus the interaction from---

Dr. White. Generally, weather moves from West to East, and it is very vital, therefore, that you have data and observations to the West, and in our continent? also to the North. So if I had a choice for just one observation point, if I were in the middle of the United States, I would choose a point in the Northwest.

Senator Dominick. Thank you very much, gentlemen. We appreciate it. As far as I am concerned, if I have any more questions, I will drop you a line and see if you can give me some answers.

Dr. Hollomon. Thank you very much, Senator.

Senator Dominick (presiding). We will now hear from Dr. Thomas Bates, science adviser to the Secretary, Department of the Interior.

Fonte: <https://babel.hathitrust.org/cgi/pt?id=uc1.b5164561;view=1up;seq=143> (pp. 167-190)

STATEMENT OF DR. A. RICHARD KASSANDER, PROFESSOR OF METEOROLOGY, DIRECTOR OF THE INSTITUTE OF ATMOSPHERIC SCIENCES, UNIVERSITY OF ARIZONA; CHAIRMAN OF THE BOARD OF TRUSTEES, UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

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Dr. Kassander. Thank you, Mr. Chairman.

It is a privilege for me to appear before you as chairman of the board of trustees of the University Corporation for Atmospheric Research.

Although it is not possible for anyone to speak for the University community, I welcome the opportunity to speak on its behalf with reference to an enlarged program in atmospheric modification.

3.b) e 3.a) e 7.b) e 7.a)

Frequent reference has been made to the two recently-released documents relating to climate and weather modification: the National Academy of Sciences —National Research Council two-volume report and that of the National Science Foundation's Special Commission on Weather Modification.

CONCEITO 1

In many ways, these are tremendously exciting reports, and are certainly our most definitive and complete documents when considered in the light of a total program in atmospheric modification, as opposed to an important but rather restricted program in cloud seeding.

CONCEITO 2

The commission report discussed the apparent disparity between congressional interest in weather modification and National Science Foundation policy.

CONCEITO 3 – 1.a) e 1.b)

It has been stated that the academic community has failed to respond to the tremendous challenge of atmospheric modification with its promise of great public benefit.

I personally do not subscribe to this reservation and believe there are some measures of activity that support evidence of as healthy a responsiveness as could have been expected in the light of the total obligation of the universities.

3.a) e 8.a)

In assembling data from various reports, the Academy publication indicates that Federal support of university meteorological research in fiscal year 1965, for example, was about \$20 million.

In the same year, \$4.97 million was in direct support of weather modification, with \$1.6 million used in support of academic research.

Thus, for reasons of financial pressure alone, only 8 percent of the academic community's resources could have been marshalled in support of weather modification.

I believe at least that much was marshalled.

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CONCEITO 3

One could then ask what the Government received for this expenditure to the academic community.

CONCEITO 4

This is hard to assess, but one measure might be to ask what fraction of the total information cited in the Academy report was generated by academic research.

There are 243 literature citations, of which I estimated 96, or approximately 40 percent, are references to work conducted by the academic community.

CONCEITO 5

One obviously does not want to push this kind of evaluation too far, but a first impression would be that the academic community has been an active and productive partner in the Nation's search for control of its environment.

The universities have responded to the charge of weather modification research.

For example, in 1957 there were only 12 to 15 universities where weather modification research could be carried on under competent scientific direction.

CONCEITO 4

Today the number of universities has increased to 40 and 50.

*

CONCEITO 6

In addition, although it is possible to contribute to scientific and engineering discovery without formal training, significant instances are extremely rare.

The academic community has the exclusive responsibility for preparing the minds and imaginations of the people who will bring us the important discoveries to advance the technology.

*

In view of the above observations, I would like to comment specifically on the relationship of the academic community to the National Science Foundation.

The Academy report does offer a hope that, with very carefully devised engineering-oriented tests, more progress could be made in weather modification.

The report also points out the very many areas wherein our basic knowledge is deficient on details that are needed for careful planning and analysis for larger programs.

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CONCEITO 7

Although the universities can conduct and have conducted modest cloud-seeding programs, larger programs depending on sophisticated and complex logistics, including large amounts of heavy aircraft time, should be able to be more efficiently and effectively conducted by the Federal Government assisted by commercial contractors.

However, the parallel study of the "gaps" in our knowledge is a role in which the academic community makes a great contribution ; such study is indispensable to good progress of the larger programs.

*

The enlargement in size of a study does not, by itself, eliminate deficiencies in details of knowledge but more often encompasses more deficiencies to confuse the picture.

CONCEITO 8

The partnership between Federal Government and the academic community, as exemplified by the relationship with the National Science Foundation, has been an extremely fruitful and healthy arrangement with even greater potential for the future.

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In this latter regard, we should also observe that both reports put heavy emphasis on the alternatives and opportunities of atmospheric modification by, for example, changing the energy transfer processes at the ground or by modification of the agricultural microclimate, and both offer new speculations for ameliorating arid climates.

CONCEITO 9

The attainment of a measure of weather control has implicit in it a strong interdependency of food and power production with water production.

To consider any of these without due regard for the others is to be delinquent in our concern for the total health and welfare of our society.

*

There is already some evidence that we can modify or control aspects of our environment that may have much greater impact than will weather control, as we use this term today.

CONCEITO 10 - Outra disciplina mencionada

Not only must we have the full impact of the physical scientist, but there is clearly an important role for the biological and social scientist.

Since it is almost certain that the final realizations of our dream to control our environment can not even be imagined in our generation, we must maintain the opportunity for one group of scientists to give full rein to the imagination while another group studies and implements ideas that we have today.

7.a) e 7.b) e CONCEITO 11

The National Science Foundation is ideally organized for effective mobilization of the entire scientific community to maintain the flow of new basic information so badly needed for effective applications today and also to nurture the new, but perhaps seemingly impractical, ideas that will form the basis of our technology tomorrow.

It is hard to imagine that our country cannot afford both avenues to the great goals set up by the bill under consideration by this committee.

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I strongly endorse the principle of the bill to authorize the Secretary of Commerce to carry out a program in weather and climate control research, development, and experimentation.

CONCEITO 12

I do not believe it is in the best interest of the public to restrict by law the activities of another agency with the competence to contribute to this enormous task.

We cannot know now all the possible areas of science and technology which will contribute to our mastery of our environment, and any limitation of our ability to draw on the total manpower of our Nation can only delay achieving our goals.

There are more than enough problems with more than enough work for many decades for the several Government agencies with interest and competence to do this important work.

I believe, as resources become available, the contributions of the academic community, which have been great in the past, will be even greater and more significant in the years to come.

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Thank you very much.

Senator Cannon. Thank you, Dr. Kassander.

Dr. Haworth, do the other gentlemen intend to testify ?

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Dr. Haworth. No.

Senator Cannon. They will be available in the discussion, as I understand it.

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I think it would be well, at this time, for me to note for the record that it is not the intent of the committee, through these hearings, to affect weather modification activities presently underway or the appropriation needed to carry these programs forward.

To stop any of these programs would be a great waste in money and effort and it would be a mistake, in my view, for Congress to hold up appropriations for presently authorized programs, because of these hearings.

In other words, what we are trying to do is to go into the future picture of what we might do in the way of planning and where we go from here with this legislation if it is approved.

8.b) e 8.a)

The 1957 report of the Advisory Committee on Weather Control said that seeding of winter-type storm clouds in mountainous areas produced an increase of 10 to 15 percent, and in 1966 the National Academy of Sciences reported precipitation increases of 10 percent.

*

Does this mean that no further progress can be made with this type of seeding? Would you care to comment on that? In other words, is this about the limit of where we can go with this type of activity ?

Dr. Haworth. I will answer that in only a very general way and perhaps Dr. Roberts will add some detail.

*

I don't feel that we have in any sense reached the limit, although there certainly are limits.

As was said by Dr. Roberts and as has been said many times, there is still a great deal that we don't know about how to do this sort of thing most effectively and under what circumstances, what time, what place, how we can best get seeding into the clouds, etc.

We don't even know what is the best particle size or what is the best way to make it.

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So there is room for progress.

*

Senator Cannon. Have we made any progress in this area in the past few years ?

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Dr. Haworth. We certainly have.

But it is difficult to determine how much we have made.

*

We certainly are surer of what we are able to do now than we were in 1957.

And here I think it might be worth pointing out that one of the very great difficulties—and this is one of the reasons why statistical questions come up so much —is that the effects that people have been able to produce so far are relatively small compared to the naturally occurring differences.

Clouds that seem to be just the same will give a lot more rain on one occasion than another, for reasons that we don't thoroughly understand.

*

It is not as extreme as looking for a needle in a haystack, but it is trying to find a not very large effect under circumstances where natural causes may have brought about changes much bigger than the seeding can now be expected to do.

*

There are, of course, cases where apparently there have been very large effects, and other occasions where there seems to be very little.

Dr. Roberts might want to add to that.

*

Dr. Roberts. I think you have covered the point quite adequately, Dr. Haworth.

I think it is going to require somewhat of a new approach, perhaps even a quite different approach to weather modification if we are to visualize very large increases, increases comparable with the naturally occurring increases which are sometimes by factors of two in certain locations.

*

It may be that if we are ever to achieve results of this sort we will have to go about weather modification by completely different kinds of techniques, such as the effort to modify the general circulation of the atmosphere that brings the moisture and the temperature variations into the region.

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Dr. Kassander is quite an expert on these questions.

I think perhaps he would want to comment.

*

Dr. Kassander. I don't consider myself sufficiently expert to add very much.

I think the most important problem —it appears on the surface that we have not made very much progress.

This has been stated by the Australian group, for example, that there is some evidence showing very large increases and there is equal evidence in the same experiment showing decreased precipitation, such that in the average the difference is rather small.

*

The thing we have to do now is to try to determine the cloud situations where, in advance, we could have predicted which efforts would have made the larger increase and which situations might actually produce a decrease.

Under those circumstances we might anticipate that the net result on the days that we attempted to augment precipitation would have been much, much more satisfactory.

CONCEITO 13

Senator Cannon. Of course, the thing that disturbs me, and the point that I am trying to make, is that we were talking in 1957 of a 10- to 15-percent increase.

Supposedly we have made or should have made some progress in this period of time, and yet we are still talking about generally, in terms of a 10-percent increase.

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I am curious to know whether you think there is a good chance for progress beyond this point.

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Dr. Roberts. Certainly there is good prospect for progress beyond that point.

I think the real difference that has occurred between 1957 and now is that when the Advisory Committee on Weather Control estimated that a 10-percent increase might be produced, the evidence on which this estimate was made was not universally or even perhaps very widely agreed upon.

In the intervening time we have convinced ourselves that there is indeed good scientific evidence that such an increase can be achieved.

*

Given that, the efforts of a much larger group of people are likely to be involved in developing adequate theories of why precipitation increases can be achieved.

If by trial and error, so to speak, you have discovered the possibility of producing a 10-percent increase, it seems likely, by sophisticated application of scientific and engineering techniques, you will be farther than the first empirical trials.

Beyond that, it is difficult to say any thing authoritative.

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Senator Cannon. In that connection, Dr. Haworth indicated that there would be a corresponding decrease in the downwind areas.

And I think Dr. Chamberlain indicated that there was disagreement as to whether there would be less in the downwind areas.

*

Dr. Haworth. I think I said, Mr. Chairman, that this was very uncertain, that in certain circumstances certain observers seemed to have found that effect.

But this is considerably less certain than the general positive effect in the target area.

*

Senator Cannon. Mr. Orville, Chairman of the 1957 Advisory Committee, said there was an extreme shortage of competent scientists and engineers in the field of weather modification, and we have had testimony on that effect today.

*

Has the situation improved in this area since 1957, or is it still about the same?

*

Dr. Haworth. Yes, it has improved markedly in two respects.

1.a) – CONCEITO 14

One is that there are now many more formal programs of training graduate students in meteorology and atmospheric sciences in general than there were in 1957.

For example, in 1956 there were essentially no Ph. D.'s granted in this field.

Even in 1959 there were I believe some thing like 15 or 16 Ph. D.'s that were labelled Ph. D.'s in meteorology.

In 1965 there were 50.

*

So this is growing rapidly.

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CONCEITO 15 – Outras Disciplinas Mencionadas

A second and perhaps equally important factor, is that, especially in understanding the basic phenomena that have been talked about so much here, there is a great deal of room for

scientists who had their original training in what I call the fundamental sciences, physics, chemistry, and so forth.

Scientists who, as physicists or as chemists, attacked the problems of the atmospheric sciences, and who move on to become atmospheric scientists, if you will.

That is increasing very rapidly and is probably equally important in increasing the manpower pool.

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CONCEITO 16

Senator Cannon. Are there other stimuli that could be brought into effect that would further improve the situation, or is that going to depend on the level of funding?

*

Dr. Haworth. Of course, it will depend in part on the funding.

*

But in my opinion the most important thing is the psychological effect, that these problems, these areas, are becoming prominent and more youngsters realize that they are interesting and very important in science in general and to society.

*

In other words, it is going to be easier, if you can use the word, to "recruit", to have people be stimulated to go into these fields.

I think that is one of the important things.

*

This is a much more modest sort of thing at the present, just as you are completely aware, the great interest in space, for example, stimulated many people to go into sciences related to the space effort.

*

Senator Cannon. The National Academy of Sciences report states "The question of acceptable statistical design and evaluation of atmospheric experiments must be resolved."

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What prevents the formulation of adequate statistical designs for experiments and tests now ?

*

Dr. Roberts. There have been quite a few questions as to what optimum statistical designs should be, and as you will remember, following the 1957 Orville report, there were considerable criticisms of the statistical methods used there.

*

Scientists have not been of a single mind as to what the optimum procedures are.

CONCEITO 17

I think even today there are doubts in many areas as to the degree of randomization versus the degree of pilot or test operation aimed primarily at increasing water resources.

*

I think that it will only be through the establishment of a broad national program with adequate management and coordinated guidance on the development of statistical designs that this will come about.

I think the framework to do this is here today.

It was not in 1957.

*

Senator Cannon. Many of the experiments are said to be below a critical size or quality needed for effective work, according to the report.

I would like to ask if you agree with that, and if so, why, after 15 or 20 years of experiments, hasn't some action been taken to correct that situation.

*

CONCEITO 18

Dr. Haworth. There is no question but what in the past many experiments have been below critical

Not only experiments but groups of people have been below critical size.

This is one of the problems of organization.

It is a field that in many of its aspects is not as susceptible to attack by one scientist and some graduate students and assistants as many other fields.

*

In the laboratory sense it is but in the field sense it is not.

There must be, on the part of both the Federal organizations that support the work and the organizations that carry out the work, greater attention paid to the joining together of forces and of groups and so forth, and of the enlargement of groups, so that there won't be too much fractionated effort in the future.

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The situation is certainly much better than it was.

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Senator Cannon. The NAS report indicates that the conclusions about silver iodide are still tentative.

Why is that after such a long period of testing?

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Dr. Kassander. I think there is no question but that silver iodide is an effective nucleus in the seeding of freezing clouds.

There is question — and we still have to do much more work on this—as to the relative role that the freezing process plays in our rainfall process.

There is also the question as to how one best releases the silver iodide, whether from the ground or from the air, in order to get into the clouds.

I can only say in this regard, of course, the atmosphere, as those of us who travel in airplanes know, is best described as a miserable boiling place of great turbulence and motion.

It is an extremely difficult place to make measurements.

*

In addition, as is well known, if the rain gage on the ground has moved 10 feet, one is likely to get rather a different answer.

And the main problem, which involves statistics, has simply been a matter of trying to get all the little additional pieces of information to try to put a very complex jigsaw puzzle together.

Ten years has been expended on getting these bits and pieces.

We have gotten lots of them.

There are still some bad holes.

*

However, the number of people involved, and the number of institutions involved, have increased by approximately a factor of three.

The competent scientists have reproduced themselves in more students.

The high school programs now include units of meteorological studies so that more students are being attracted to the field.

CONCEITO 15

I think we are now on the threshold where we can hope to muster the kind of manpower needed to thoroughly study these extremely complex and messy situations in the atmosphere.

We have the kinds of airplane platforms and other observing tools we need, so that there is great hope that we can make some significant advances even though the last 10 years have essentially been years of equipping our arsenal.

*

So that perhaps now we feel we can really go to battle.

*

Senator Cannon. Do you think a high enough priority has been given to the design and execution of effective tests in this particular area ?

*

Dr. Kassander. No, sir.

I think the crude kind of statistics I offered on university buildup were modest because of the pressure of other needs on the atmospheric sciences and the obligations in other areas.

For financial reasons alone, the academic community could marshal only 8 percent.

I think for that 8 percent we have made real great progress.

*

Referência AC

Senator Cannon. The report states, and the hearing here today has brought out, that one question deserving a great deal of attention is the degree to which climate already has been altered or may be altered in the future inadvertently.

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What type of funding is NSF doing in this area now for research ?

*

Dr. Haworth. There is some general support, but directed more at the total problems of the atmosphere.

I think I would be stretching it to say that we have had any concerted program along this line.

But we have tried to study, tried to support people who wanted to study, and this is one of the problems.

There have not been a great many people who desired to study this sort of thing, the facts of inadvertent changes.

*

We keep referring to inadvertent changes such as air pollution, and we keep thinking of smoke and such in that connection.

There are many other things.

We don't know, for example, what effect has there been on the weather and climate by virtue of the fact that the forests were cut down, and that we have arable land, cultivated land, where there once was prairie grass, and many things of that sort.

*

Another thing that is in a strict sense a pollutant but not usually thought of as such is the carbon dioxide that comes from all our burning of fossil fuels—coal, oil, gas, and so forth—which is adding to the carbon dioxide content of the air.

It is not a pollutant in the sense of doing any harm to us directly, but it could change the temperature balance of the world.

*

CONCEITO 19

These all need much more attention than they have had, and there needs probably to be more aggressive programs on the part of the Federal Government, NSF, for example, in trying to encourage people to study these problems.

*

Senator Cannon. Would your answer generally be the same insofar as the economic and social impact of modification is concerned?

*

Outras Disciplinas mencionadas

Dr. Haworth. Yes. There have been some studies, but they have been part of our general programs in the social sciences rather than part of the concerted weather modification program.

*

So the same general answer stands.

*

5.b) – CONCEITO 20

Senator Cannon. The NSF report recommends a national laboratory. What do you mean by that recommendation, in view of the fact that the NCAR is in existence ?

*

Dr. Haworth. Dr. Chamberlain ?

*

Dr. Chamberlain. I can speak to this, Mr. Chairman.

The Commission document does not actually recommend the creation of a national laboratory.

What it does is recommend that the capability of such, what we normally think of as a national laboratory, come into existence.

*

Specifically the need of logistics capability, of many aircraft for some of these experiments, large computers, and the manpower resources associated with it, need to be made available.

But whether it should be made available by the creation of a national laboratory or made available through administrative use of contracts for such service from private industry or otherwise, is a moot question.

*

7.14

Our recommendation ended up suggesting that the President's Science Adviser mount A feasibility study on the best mechanism by which to provide this capability to the scientific community.

*

Senator Cannon. You don't necessarily recommend then that a separate laboratory be established? Are you recommending a study at the present time ?

*

Dr. Chamberlain. We are not recommending that a specific laboratory be created.

But we are very concerned that the capability that we normally think of a laboratory providing, certainly does need to be made available to the scientific community.

And we suggest that a feasibility study not only of the organizational approach to it but also of what its specific capability ought to be, should be undertaken.

*

Dr. Haworth. Mr. Chairman, if I could add one thing to that.

You spoke of NCAR.

I do not believe that NCAR would be an appropriate laboratory to do the sort of thing —at least in the extreme —that Dr. Chamberlain has talked about.

*

CONCEITO 21 / 5.a)

The purpose of NCAR is to do the underlying research —and I won't use either the words "basic" or "applied" —but the research that underlies our knowledge of the atmosphere, not only for weather modification but for all aspects, and is very properly a center of activity for the university groups that are interested in studying the atmosphere.

*

This is done in two ways : One, many university people go and work at NCAR on problems that they could not work on at home, where there is a concentration of effort and so forth that makes their work more effective.

*

Two, it also provides facilities for university groups working under their normal auspices.

I believe that it would be a mistake to change the emphasis of NCAR and get it into the very large operational types of things that are in the offing with respect to attacking these weather modification problems.

*

8.a)

Senator Cannon. The NSF report states the intention of Public Law 85-510 was that the Foundation would carry primary responsibility with the executive branch for weather modification.

8.b) e 8.a)

Subsequently the Federal Council for Weather and Technology took over the coordination role, and the Weather Bureau and the Bureau of Reclamation operate in the research field.

Do you consider that fragmentation of responsibility to be consistent with the intent of Public Law 85-510?

*

Dr. Haworth. I can't speak to precisely what the Congress had in mind in passing Public Law 85-510.

But I do feel that what has happened is appropriate and in keeping with the statute.

*

The responsibility of the Foundation was to do everything it could to see that a program in weather modification moved forward.

And I believe in all cases that it is appropriate for an agency that has a sort of a focal point or central role to encourage as much assistance, if you want to call it that, as it can from the other agencies.

5.a)

The other agencies had particular problems that they wanted to attack, and I believe this is entirely appropriate.

7.a)

The Foundation does have specific responsibility for evaluating, reporting, trying to help coordinate, and some of the things that I mentioned in my testimony, such as the annual symposium, the Foundation's annual report to the Congress and so on, which have been parts of that.

*

Furthermore, the Foundation felt a responsibility for seeing to it that as much as feasible of the underlying research was done and, of course, it has supported a major fraction of that itself.

*

Senator Cannon. Would you say that we have a definable national program of weather modification now ?

*

Dr. Haworth. It is becoming more and more focused.

But, of course, as I have said, and practically everyone here has said, the first job was to learn as much as we could about the natural phenomena that underlie, to try to understand the processes and so forth, after which one could begin to focus down on specifics —focus with greater effort on the more specific things such as the program of the Bureau of Reclamation, and so on.

*

7.b)

It is being pretty well coordinated through the efforts of the Interagency Committee on Atmospheric Sciences, which I believe to be a proper mechanism for coordination.

I mean this type of committee.

And, it is becoming more and more a coordinated program.

*

Senator Cannon. Do you think we are at a point now where we could actually define a national program of weather modification at this point in time ?

*

CONCEITO 22

Dr. Haworth. With pretty fuzzy edges; actually, I think it will inherently be—and as always in cases like this—not a single program, but a combination of programs that one can then perhaps define as a national program.

*

Senator Cannon. How big an activity do you see weather modification becoming, say, by 1970?

We have used the time frame of 1970.

*

Dr. Haworth. I have no reason to disagree with the statements made in the two reports that if funds were available — and one must remember, of course, that there are many other things demanding support — that if funds could become available, then funds at the general levels spoken of by the two reports could be usefully used.

CONCEITO 23

It may seem a little strange to say that much when we speak simultaneously of not yet having really adequate supplies of manpower, but one of the important things is that the stage that has now been reached is going to call for much larger experiments, field experiments and things of that sort, that will demand large logistic support, so that the amount of funds expended will be much larger relatively compared to the number of key scientists involved.

*

As you move from the laboratory and the small field experiment to the very large-scale things, such as the large operations that the Bureau of Reclamation is planning, then the costs go up more than in proportion to the number of scientists.

*

Senator Cannon. The figure of \$40 or \$50 million was used here and in testimony earlier. Does that relate to the \$20 million that you used in your statement for fiscal year 66, when you said---

*

Dr. Haworth. No.

The former was meant to be support for weather modification activities or closely related things for the Federal Government as a whole ; whereas my \$20 million was the NSF alone, for all the atmospheric sciences.

*

They are quite different.

I believe the Federal support of weather modification as such that has been identified as such, this current year, is a bit more than \$7 million.

There are some things that are not included in that figure.

*

6.a)

For example, nobody knows exactly how much is being spent in logistic support by the military services.

This is not always sharply definable.

This is one of the reasons that, I believe, the Commission, for example, had to sort of give quite a range to its estimates.

*

Senator Cannon. That \$40- or \$50-million figure to be used by 1970, or recommended, say, is that based on a plan or is that based on just a guess-timate?

*

Dr. Haworth. I think I had better let Mr. Chamberlain answer.

*

Outras Disciplinas Mencionadas

Dr. Chamberlain. It is not worked out to the extent of a very fine building-block approach coming up to that total.

However, it is based upon first of all the National Academys recommendations in regard to the physical sciences, and then has added to it what the Commission discussed in crude terms of the necessary amounts of physical funding for the biological sciences, the law, and the social sciences that the Commission considered to be so important.

*

The largest blocks of money, however, look like they would go into the field experiments and physical sciences and some of the ecological studies, particularly the field ecological studies.

*

The simulation work again can be very expensive.

CONCEITO 16

But an overriding consideration in the Commission's analysis was that without substantial increases in funding over current levels, the type of field experiments that could be mounted would be inadequate to give us the **conclusions** which we are seeking; that it is mandatory that there be substantial increases in funds or the logistics necessary for well-designed, meaningful field experiments just plain won't work.

*

Senator Cannon. In other words, it would be impossible for you to furnish an outline or a plan of action for the amount of funds that you are talking about?

*

Dr. Chamberlain. Not down to the last \$500,000 in each category.

*

We could not give you that good an estimate.

This is one of the basic reasons why the Commission did not attempt to extend its budget projections beyond 1970.

*

We felt that the progress in the intervening time, would be so substantial and so much better, in that period, would go into careful design of large experiments, that we could beyond 1970 make much better estimates based upon the work in the intervening period.

*

Senator Cannon. What kind of Federal administrative machinery do you see evolving in this area ? You talked about different authority or different placing of responsibility.

What do you actually have in mind ?

*

Dr. Haworth. As I said in my testimony, I believe that the field has now reached the stage where there needs to be greatly added emphasis to moving on to the more specific applications, that is, with specific objectives in mind, to large-scale field experiments and so on.

CONCEITO 20

That the type of central responsibility that NSF has had, which was appropriate during the time when most of the work was of a more basic nature, should now be assigned to another agency —in my recommendation to ESSA.

By this, I mean the general central responsibility, as we move on toward development and demonstration and things of that sort.

*

I believe that NSF should continue very actively and in increasing magnitude to support the underlying research.

I don't mean, in any sense, to say that the central agency shouldn't also do underlying research as it finds it appropriate, but I don't believe there should be any change in the point of view that the agencies with specific missions to perform, which also do work in the field ---

Senator Cannon. NSF should retain the authority they have now?

*

Dr. Haworth. Yes.

And they too should, as their opportunities and needs increase, increase their efforts.

*

8.b)

One of the largest-scale examples now is, of course, the Department of the Interior.

I believe that they should work intensively in the field.

They are responsible for natural resources, and water is a resource.

I believe that they should continue to work.

And again there should be no bar to their doing research, clear through development and, of course, eventually operations.

By operations I mean trying actually to get water for use next year and so on.

And the same thing applies to the other agencies.

*

But I think of being responsible for the general aspects, for the evaluation of the whole field, and so on, should now be assigned to ESSA.

*

7.b) e 7.a)

Senator Cannon. Do you think it would be better to administer and regulate weather modification programs through an independent office rather than through an already existing office in the executive department ?

Dr. Haworth. I believe that— and I will distinguish between the two things—the actual work, the substantive work and so forth, should, I am sure, be in ESSA.

It has responsibility of course, general responsibility, for the other aspect, the weather prediction and so forth.

These two things have very close relationships, as has been pointed out several times this morning.

So I think that belongs there.

CONCEITO 24 , 7.a)

I think the regulation should be divorced from any agency, or perhaps I should say subagency, that has any R. & D. or any operational responsibility.

But I see no reason why it should not be in the same department —for example, as in the Atomic Energy Commission where that organization is divided into two parts; one is the research and development and promotion of atomic energy, and the other is the regulation.

That to my mind is working out very well.

It helps. It is, of course, useful for the regulatory agency to have a close enough relationship with the technical agency to be familiar with what is going on.

*

Senator Cannon. In your statement you referred to the fact that effective January 1, 1966, NSF increased its record keeping requirements and imposed on all operators a requirement for advance notice, to it, of any activity. Have you had any filings up to the present time?

*

Dr. Haworth. Dr. Droessler, would you answer that?

*

Dr. Droessler. Yes, we have, and the letters are continuing to come in a rather steady stream. There are considerable filings already on record.

*

Senator Cannon. Do you have an estimate as to roughly how many ?

*

Dr. Droessler. I would say we have had on the order of 2 dozen or more.

*

Senator Cannon. Have you found that the information made available to you by the filings. Is something that is going to be of assistance in the research and development effort ?

*

Dr. Droessler. Yes, it undoubtedly will be of assistance because for the first time we will be able to appreciate what plans are being made for new activities in weather modification and also keep abreast of the field activity as it goes forward.

*

Senator Cannon. How did you keep current with the field activity prior to this requirement ?

*

Just by accident ?

*

Dr. Droessler. We didn't make an attempt to keep up to date, up to the minute, on the field activities that were ongoing, except those large field activities which were well known to us, because of our general overview.

*

However, every year we did make an assessment of what had gone on during the past year.

In that way we developed a detailed knowledge of the total extent of the activity in the United States.

*

Senator Cannon. In your statement, Dr. Chamberlain, at page 10, you said, in the second paragraph:

*

These figures were derived by estimating the program needs which should be increased in the fiscal year 1966 level of \$7.2 million of agency budgets.

CONCEITO 25

That is in relation to your \$40 or \$50 million a year by 1970. Would that include money for the social and biological studies that were referred to as being necessary in the future?

*

Dr. Chamberlain. The \$7.2 million does not include any biological and social type of research. However, the, \$40 to \$50 million increase does include such activities because there is no significant activity of that nature currently financed by the Federal Government as we understand it.

We do feel that this is one of the basic needs, that is, the support of the social sciences, biology and law.

Further, that the NSF should continue to support this research activity, for this is the best mechanism currently within the Federal establishment for communication with individual people throughout the academic world, whether they be social scientists, lawyers, and so on, to initiate individual work that would be of importance to the field.

*

However, the NSF is not an appropriate mechanism for the mounting of major field experiments which perhaps should be under our other management, that is, that some agency, either existing or new, should be given a major mission of weather modification.

*

Senator Cannon. Senator Dominick?

*

Senator Dominick. Mr. Chairman, I want to say that I am very sorry, and I apologize to Dr. Chamberlain and Dr. Roberts and the others for not having been here for their full testimony.

I look forward to reading it in detail.

*

I have only one question, which is a pretty fundamental one.

Do you feel that knowledge of this phenomenon of weather modification has now gone far enough that applied experiments could be made?

For example, in two fields —hail suppression and increased precipitation?

*

Dr. Chamberlain. Taking the second part first, the matter of hail suppression, as I understand from our Commission reviews, the matter of hail suppression, there is an unresolved question on the efficacy of cloud seeding for the suppression of hail.

CONCEITO 24

Further research would be needed before you could expect this to be really operational.

In regard to precipitation augmentation, under some circumstances, the evidence appears to be on the positive side.

Increases are of the order of 10 percent for quite a wide distribution of cloud circumstances.

But again, further work is necessary before you can consider it operational to the extent that cold fog dispersal can be considered operational.

There are still many, many unresolved questions.

*

Senator Dominick. The reason I bring this up, being a practical soul and a nonscientist, as you well know, is that we have continued problems in Congress with the Colorado River Basin as to which State is going to get what water out of it, and how we are going to get more water into it.

One of the major programs that has been suggested from time to time is the importation of water from the other areas.

*

It occurs to me that, in the process of the weather modification research that is going on, instead of emphasizing the need for canals, dams, and tunnels with the obvious evaporation that you will get.

That we might try some applied experiment to try to get more water out of the Colorado River Basin by weather modification, either through additional snow or through additional rain.

I would like your estimate of whether it would be feasible to even start a program of this size which would be meaningful.

*

Dr. Chamberlain. Carefully designed, adequately instrumented, including the ecological support, such projects could be meaningful and presumably not do detrimental.

*

Senator Dominick. This I presume would have to be pretty care fully coordinated with research on the results and techniques; is that correct ?

*

Dr. Chambeblain. That is right.

*

Senator Dominick. Would you suggest that there be an overall coordinator of any kind of effort like that.

If so, what organization?

*

Dr. Chamberlain. The recommendation of the Commission is that the Office of Science and Technology establish a special mechanism for coordination of weather modification activities, including policy as well as allocation of funds among several agencies of the Federal Government.

*

CONCEITO 27

Senator Dominick. One thing that I am concerned about, and I am sure that the chairman in many ways shares the same concern, is an effort not to get into an interdepartmental fight as to who is going to do what to whom.

Apparently it is a fundamental psychosis of government that this almost inevitably happens when you are trying something new.

*

We have an organization now, NCAR, which is coordinating efforts in research in many ways, and Dr. Roberts is here representing NCAR.

Some time before we suggested that perhaps NCAR, not being a governmental agency as such, might be in a position to do a lot of the basic ground work on this.

Do you have any comment on that ?

*

Dr. Chamberlain. The Commission did not consider that NCAR had a sufficient authority from which to operate effectively to do this coordination.

*

Senator Dominick. And what commission are you talking about ?

*

Dr. Chamberlain. This was the NSF special committee on weather modification.

However, with the filing of the commission's documents we have been afforded the unusual opportunity as a committee of being allowed to be disbanded.

*

Senator Dominick. As you probably know, the Department of Interior has been moving rather rapidly into a position where they would like to get at least a large portion of control in this field.

What is your position on that ?

*

CONCEITO 27

Dr. Chamberlain. Our position is that any agency of Federal Government, pursuant to the existing executive orders, as well as statutory authority for these agencies, should have the opportunity to pursue such weather and climate modification research as is necessary for the conduct of their particular mission, and that in addition some one Federal agency, either

new or already in existence, should be given an overriding specific mission for pursuing technology development of this particular field.

The commission did not take a position on which specific agency ought to, if you picked an existing one, have this overriding weather modification mission.

*

Senator Dominick. You mean that is something that we are going to have to wrestle with.

*

Thank you, Mr. Chairman.

*

Senator Cannon. The hearings will stand in recess until February 24, at room 1114 of this building.

Dr. Haworth, I don't know whether you have had the opportunity to examine the hearings that were conducted earlier, but we have a very graphic and visual demonstration of effects of cloud seeding under very ideal conditions that Dr. Mordy, who is here from the DEI, presented in connection with his testimony out there.

You might want to see some of the photographs and some of that record.

I will admit it was under ideal circumstances, but it made a very graphic display of what could be done.

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Dr. Haworth. Thank you, Mr. Chairman.

Senator Cannon. Thank you very much.

The hearing will stand in recess.

(Whereupon, at 12 :30 p.m., the committee was recessed, to reconvene on Thursday, February 24, 1966, in room 1114, New Senate Office Building, Washington, D.C.)

Anexo 13 - 05S66 - Haworth

Fonte: <https://babel.hathitrust.org/cgi/pt?id=uc1.b5164561;view=1up;seq=143> (pp. 85-103)

STATEMENT OF DR. LELAND J. HAWORTH, DIRECTOR, NATIONAL SCIENCE FOUNDATION; ACCOMPANIED BY DR. ADRIAN CHAMBERLAIN, VICE PRESIDENT, COLORADO STATE UNIVERSITY, CHAIRMAN, NATIONAL SCIENCE FOUNDATION SPECIAL COMMISSION ON WEATHER MODIFICATION; DR. WALTER ORR ROBERTS, DIRECTOR, NATIONAL CENTER FOR ATMOSPHERIC RESEARCH; DR. A. RICHARD KASSANDER, PROFESSOR OF METEOROLOGY, DIRECTOR OF THE INSTITUTE OF ATMOSPHERIC SCIENCES, UNIVERSITY OF ARIZONA, CHAIRMAN OF THE BOARD OF TRUSTEES, UNIVERSITY CORP. FOR ATMOSPHERIC RESEARCH; DR. EDWARD TODD, SPECIAL ASSISTANT TO THE ASSOCIATE DIRECTOR (RESEARCH), NATIONAL SCIENCE FOUNDATION; DR. EARL DROESSLER, HEAD, ATMOSPHERIC SCIENCES SECTION, NATIONAL SCIENCE FOUNDATION; AND DR. HORACE R. BYERS, DEAN OF SCHOOL OF GEO-SCIENCES, TEXAS A. & M. UNIVERSITY

Dr. Haworth. With your permission, I would like to introduce the others sitting with me.

Senator Cannon. Fine.

Dr. Haworth. On my left is Dr. Richard Kassander, of the University of Arizona, who is the chairman of the board of trustees, University Corp. for Atmospheric Research.

He will be one of the witnesses.

*

Next is Dr. Adrian Chamberlain, Colorado State University, who was Chairman of the National Science Foundation Special Commission that prepared the report you mentioned.

On my right is Dr. Walter Roberts, Director of the National Center for Atmospheric Research.

Both Dr. Chamberlain and Dr. Roberts will be witnesses.

Outras Disciplinas Mencionadas

Still further to the right is Dr. Earl Droessler, head of our Atmospheric Sciences Section.

And further down is Dr. Edward Todd, who is the special assistant to the Associate Director for Research of the Foundation.

The last two named will not formally testify.

Also, in the audience is Dr. Horace R. Byers, dean of the School of Geosciences at Texas A. & M. University, who is Chairman of the National Science Foundation Advisory Committee on Weather Modification, and was formerly chairman of the University Corp. for Atmospheric Research board.

Thank you, Mr. Chairman.

Mr. Chairman and members of the committee Senator Cannon. Would Dr. Byers raise his hand so we will have him identified, too?

Dr. Haworth. That is Dr. Byers.

Mr. Chairman and members of the committee, I am happy to have the opportunity to speak to you this morning.

7.b)

In the next 20 minutes or so I will outline the development of the National Science Foundation's support of research in weather modification and allied fields, and conclude with some recommendations concerning the Federal weather modification program for the coming years.

I will not dwell extensively upon a description of the current state of our ability to modify weather and climate.

7.a)

As you are aware, the Foundation has just released a report which you have already mentioned, entitled "Weather and Climate Modification" which was prepared at the request of the Foundation by a Special Commission appointed in June 1964 to examine the physical, biological, legal, social, and political aspects of the field.

1.b) e 7.b) e 7.a)

Dr. Adrian Chamberlain, vice president of Colorado State University, who served most capably as the Chairman of that Commission will speak to you later this morning.

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3.b) – Outras disciplinas mencionadas

The Commission relied very heavily on the National Academy of Sciences Panel on Weather and Climate Modification for its analysis and evaluation of the current state of weather and climate modification from the point of view of the physical sciences.

I understand that your committee will hear from representatives of that Panel later in the week.

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5.b) e 5.a)

Following Dr. Chamberlain's remarks, Dr. Walter Orr Roberts, director of the National Center for Atmospheric Research, will discuss some of the current opportunities for research progress in the atmospheric sciences and relate them to our needs for modification of the weather.

1.b), 7.b), 5.b)

He will also describe some of the activities of his laboratory which are directly related to weather modification objectives, especially with universities and other Government agencies such as the Bureau of Reclamation, ESSA, and NASA.

1.b)

Dr. A. Richard Kassander, chairman of the board of the University Corp. for Atmospheric Research, will comment on the university-based atmospheric science community and its contribution to weather modification studies.

4.b) * 4.a)

It was some 20 years ago that General Electric Co. scientists, Irving Langmuir and Vincent Schaefer, modified clouds by seeding them with dry ice pellets.

Not long afterward Bernard Vonnegut, a coworker, demonstrated that a smoke of silver iodide crystals would accomplish the same results.

CONCEITO 1

This was the beginning of modern American weather and climate modification through cloud seeding.

*

CONCEITO 2

The 1946 demonstration that clouds might be modified and rain produced by scientific means arose out of World War II investigations of fog particles by Langmuir and Schaefer.

6.a)

The military possibilities of this discovery led the armed services to support a broad theoretical, laboratory and field program in cloud modification from 1947 to 1952, known as Project Cirrus.

5.a) * CONCEITO 4

Civilian implications were investigated by the cloud physics project of the U.S. Weather Bureau and the National Advisory Committee for Aeronautics from 1948 until 1951.

5.b)

The Department of Defense followed the termination of Project Cirrus in 1952 with a 5-year cloud nucleation project.

CONCEITO 5

Whether or not the multi-million-dollar rainmaking activities of the late 1940's and early 1950's grew out of the obvious interest of the Federal Government in weather and climate modification research or from coincidental severe drought conditions in many parts of the Nation, large cloud seeding operations became a fact of life.

Soon \$3 to \$5 million a year was being spent by water users, particularly in the West, for commercial cloud seeding, and about 10 percent of the land area of the United States had become the target of cloud-seeding attempts.

10.a)

There was also considerable activity in other countries.

*

8.b), 8.a) , CONCEITO 6

The drought that then held sway in many parts of the country the claims of some of the rainmakers, and criticism from portions of the scientific community led the Congress to create an Advisory Committee on Weather Control to study and evaluate public and private experiments in weather modification.

*

CONCEITO 7

In its final report in 1957 the Advisory Committee on Weather Control found, on the basis of statistical evaluations, that cloud seeding in the mountainous areas of the western United States, of storms occurring during the cool, moist winter and spring months produced an average increased precipitation of 10 to 15 percent from seeded storms with a satisfactory degree of probability that the increase was not the result of natural variations in the amount of precipitation.

*

On the basis of its physical evaluations the committee found that seeding from the ground with silver iodide is a valid technique for seeding clouds.

8.a)

The advisory committee then recommended that the development of weather modification must rest on a foundation of fundamental knowledge that can be obtained only through scientific research into all the physical and chemical processes in the atmosphere.

*

The committee also recommended that encouragement be given the widest possible competent research in meteorology and related fields, such research to be undertaken by Government agencies, universities, industry, and other organizations; that the Government sponsor meteorological research more vigorously than before; that the administration of Government sponsored research provide freedom and latitude for choosing methods and goals with the emphasis to be put on sponsoring talented men as well as their specific projects; and that the National Science Foundation be designated to promote and support research in the needed fields and to coordinate research projects.

*

3.b) e CONCEITO 8

These recommendations together with the 1957 report of the American Meteorological Society and the 1958 Third Report of the Committee on Meteorology of the National Academy of Sciences emphasized the need for: fundamental knowledge; research; experimentation; education and training in meteorology and related fields; information assembly and dissemination; and increased Federal support to universities for basic research in the atmospheric sciences.

8.a) e 8.b)

The result of these recommendations was the passage by the Congress of Public Law 85-510, signed by the President on July 11, 1958, which in pertinent part authorized and

directed the National Science Foundation to "initiate and support a program of study, research, and evaluation in the field of weather modification * * *."

*

CONCEITO 9

Beginning even before the issuance of its report, the conclusions of the Advisory Committee on Weather Control had come under direct attack by several elements of the scientific community, primarily the statisticians.

The validity of its data was brought into question and the correctness of its conclusions was seriously questioned.

By the time Public Law 85-510 was passed, about the only aspect of weather modification upon which general agreement could be reached within the scientific community was that basic research and a great deal of it was needed.

CONCEITO 10

The bright hopes sparked by the experimental research of Langmuir and Schaefer in 1946-47 had failed to bring forth the anticipated results, and it now was necessary to put the infant art of cloud modification on a sound scientific basis.

CONCEITO 11

It was at this point that the National Science Foundation, in fiscal year 1959, began its task of lending credibility to a field of effort which had been plagued with lack of technical and scientific understanding by approaching the leading meteorologists and other scientists in the United States of America and abroad to undertake scientific investigations which would open the doors to knowledge.

CONCEITO 12

The previous years of arguments, adverse publicity, and sometimes downright quackery, had taken their toll, and NSF found a reluctance on the part, of established researchers to enter the field and risk the possibility of being called a "rainmaker."

7.a)

In the years following, the NSF pursued a vigorous campaign to enlist new capabilities and talent from both the academic and professional community.

CONCEITO 13

These efforts were influential in the formation of new academic arrangements such as the Desert Research Institute at the University of Nevada, the Department of Atmospheric Sciences at the Colorado State University, the Cloud Physics Laboratory of the University of Washington, the Institute of Atmospheric Sciences at the South Dakota School of Mines and Technology, the Annual Yellowstone Field Expeditions of the State University of New York, the Langmuir Mountain Observatory of the New Mexico Institute of Mining and Technology, and the Showers Project Group of the Pennsylvania State University.

*

From this ever-increasing willingness of the academic community to perform research in weather modification have emerged new and valuable meteorological research talents.

CONCEITO 14 – Outras Disciplinas Mencionadas

These were supplemented by the talents of chemists, physicists, and mathematicians who were needed to round out the scientific team and find answers for many obscure atmospheric problems.

CONCEITO 15

In the past 6 years, the NSF-supported effort in research specifically directed at weather modification problems has risen from \$1.1 million in fiscal year 1959 to \$2 million in fiscal year 1966 and an estimated requirement of \$3 million in fiscal year 1967.

In addition, and very importantly, the support of general basic research in the atmospheric sciences, much of which contributes to the fundamental understanding necessary for success in weather modification has risen from approximately \$3 million in fiscal year 1959 to a total, including NCAR, of \$20 million in fiscal year 1966.

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Senator Dominick. I wonder if I might ask a question, Mr. Chairman ?

Senator Cannon. Yes.

Senator Dominick. Could you tell the committee what the budget request for fiscal 1967 is, for weather modification, on behalf of NSF?

Dr. Haworth. \$3 million.

Senator Dominick. This has been included in the President's suggested budget ?

*

Dr. Haworth. Yes, sir.

And as I say, that does not include much work that really is very closely related.

It represents the line item labeled "Weather modification" in the budget.

For example, none of NCAR's work is in the \$3 million.

*

Senator Cannon. That \$3 million is the figure you stated just earlier when you said that it ranged from \$1.1 million in 1959 to \$2- million in 1956, and \$3 million in 1967 ?

Dr. Haworth. Yes, sir.

Senator Cannon. You may proceed.

*

Dr. Haworth. For example, much of NCAR's work actually bears very directly on weather modification.

In the 7 years of sponsorship of weather modification research, NSF grantees have learned much which will be useful for weather modification.

*

The University of Chicago Project Whitetop, for instance, has demonstrated the importance of the warm rain coalescence process in many supercooled convective cloud systems which formerly were thought to depend entirely on the Bergeron-Findeisen ice process.

In addition, radar studies of seeded clouds have tentatively indicated about 5 to 10 percent rainfall increases in the nearby target areas with decreases of about the same size (rainshadow effect) downwind from the target area, the latter phenomenon being, however, quite uncertain.

*

1.a)

Chemical research at Lehigh University and the University of Arizona has revealed that the nucleating ability of silver iodide is a surface phenomenon riot associated with the lattice structure of AgI as previously thought, but is strongly influenced by trace impurities.

Strangely enough, ultrapure silver iodide has been found to be an extremely poor ice nucleator and to exhibit no photosensitivity in sunlight.

At Colorado State University, an intensive investigation has revealed that there is a carryover and redistribution of silver iodide ice nuclei from one day to the next.

This results in a persistent buildup in observed ice nuclei concentration on days when no seeding is performed.

*

Research carried on at the New Mexico Institute of Mining and Technology has pointed out the significant role of freezing upon the generation of electrical fields in clouds.

The influence of electrical fields upon the coagulation of cloud particles has suggested the possibility of modifying clouds through artificial changes in the potentials which occur when the droplets freeze.

These possibilities are also being investigated by scientists at the Arthur D. Little Co. and others.

*

Another noteworthy development has been the discovery of an entirely new class of nucleating materials by a researcher at the University of Wisconsin.

These materials are of the type which strongly absorb heat when they go into solution in water. One such substance is common urea, such as used in fertilizer.

When ground into particles of between 1 micron and 20 microns in size, urea has been shown to be effective in producing ice crystals from micron-sized cloud droplets at temperatures as high as 6° C. above freezing, which is roughly 10° F. above freezing.

*

Research at the State University of New York, University of Washington, and the University of Chicago has brought out the fact that supercooled water droplets will freeze at a warmer temperature when the nucleant is introduced externally to the droplet surface than when the nucleant is embedded in the droplet initially during the cooling process.

The difference in freezing temperature may be as high as 15 to 30 degrees Fahrenheit, and indicates the desirability of introducing the nucleant by rocket or mortar shell high up in the cloud to take advantage of this effect.

CONCEITO 16

As the Foundation's programs grew it became obvious that a central research facility in the atmospheric sciences with the capability of staging meaningful experiments and large-scale laboratory efforts was necessary to stimulate the field of atmospheric sciences and to serve as a central focus for the efforts of the university community.

7.a) e 3.b)

This led the Foundation, with the advice and encouragement of the National Academy of Sciences, to support the request of the University Committee (now Corporation) for Atmospheric Research that a National Center for Atmospheric Research be formed.

Dr. Roberts will speak to you later about its programs.

At this point I want to say only that the Foundation is pleased with its performance and believes that Dr. Roberts can be proud at having built NCAR so quickly and so well.

*

The Foundation's program in weather modification does not stand alone.

Their mission requirements have caused many other Federal agencies to mount strong programs and, to properly round out the picture, I would like to mention very briefly some of their present activities.

Outras Disciplinas Mencionadas

The Department of Commerce, the Environmental Science Services Administration (ESSA) carries on a research program in weather modification.

The work includes—

(a) Experiments on tropical clouds and hurricanes conducted with the Navy on Project Stormfury.

(b) Development of theoretical models of the atmosphere capable of reproducing the natural processes which produce the weather.

*

Within the Department of Defense all three services have strong interests.

6.b) e 6.a)

The program of the Air Force is directed mainly toward a study of the life cycle of clouds and their electrical properties utilizing ground radar and highly instrumented, cloud-physics aircraft.

The Air Force also has undertaken a comprehensive field research program to understand the natural life cycle and variability of warm fog.

Outras Disciplinas Mencionadas

The Army program of research in weather modification has emphasized three areas: the basic study of cloud physics mechanisms, the basic understanding of precipitation phenomena, and the basic conceitos of cloud modification.

6.b)

The efforts by the Navy in weather modification, including both laboratory and field work, are centered around studies of warm fog, trade winds, cumulus clouds, the hurricanes.

The latter involves joint work with the Weather Bureau on Project Stormfury.

*

5.a) e 8.b)

The Department of the Interior's interest in weather modification is concerned with the atmospheric water resources of the Nation and the possibility of stimulating additional precipitation and runoff to the river basins which feed the Bureau of Reclamation reservoirs.

The Bureau program is founded in part on the continuation of a number of programs initially developed under Foundation sponsorship.

8.b)

In the Department of Agriculture the primary effort is the continuation of the Forest Service's Project Skyfire. The project has two long-range objectives:

- (a) To obtain a better understanding of the occurrence and characteristics of lightning storms and lightning fires in the northern Rocky Mountain region ; and (b) To investigate the possibility of preventing or reducing the number of fires caused by lightning by applying techniques of weather modification.

*

The Foundation has helped in the support of this program for several years.

7.a)

The Foundation's responsibility has been not only to support weather modification research, but to present an overview of the state of knowledge and effort in the field.

Its annual reports to the President and the Congress —now seven in number—have given this overview by describing the total national efforts in the field.

*

Additionally, the third annual report presented for the first time the highlights of weather modification activities around the world.

The seventh one has some of that in it, too.

7.a)

The Foundation promoted the exchange of information about plans and programs of the various Federal agencies and effectively provided for cooperation and coordination at the

working level through various mechanisms, including the Annual Interagency Conference on Weather Modification, where much of the current Federal interest in weather modification has been kindled.

*

Your perusal of the reports of the National Academy of Sciences Panel on Weather and Climate Modification and of the Foundation's Special Commission, I am sure indicated to you that the scientific community generally feels that the field of weather modification presents a great opportunity for progress.

Research supported by NSF and the other Government agencies has produced increased knowledge sufficient to convince leading scientists that there are indeed great opportunities here.

In the words of the Academy Panel:

CONCEITO 10

An earlier era of speculation has gradually been superseded by the present period, in which rational and systematic exploration of modification potentialities has become possible.

*

The Foundation is proud that its programs of the past few years have also served to reduce the manpower limitations that heretofore existed, although even now the number of scientists available is not as large as we would like.

CONCEITO 16

There are, however, very strong limitations on basic knowledge even in those fields where we know enough to be optimistic concerning our chances for success in the development of engineering methods and there are, of course, technology limitations which developments of the postwar era in instrumentation, flight capabilities, and data processing have done a great deal to minimize.

*

CONCEITO 17

The large computers, of course, are very important in this respect.

*

Three of the major developments are the weather satellites, the use of radar for observing clouds, and the use of computers to simulate atmospheric phenomena.

The advent of large computers, particularly, has immeasurably brightened the prospects for rapid progress in climatic research.

The fundamental way in which these machines have changed our approach to atmospheric studies and the prospects for progress has been emphasized by both the Academy Panel and the Special Commission.

*

CONCEITO 17

Additionally they point out that certain areas of weather and climate modification require, for their adequate exploitation, an immediate increase in applied research and in the development of technology.

The problems of the clearing of fog, and the enhancement of precipitation are two of these.

The Foundation is in hearty agreement.

It is none too soon for us to increase our efforts in applying our knowledge to the further development of these techniques.

At the same time, both groups have made it abundantly clear that our fundamental knowledge and understanding are still woefully incomplete, and that there are hazards, particularly in the biological field, whose magnitude is but dimly seen.

CONCEITO 18 – Referência AC

Both groups have also pointed out the potentially serious problems associated with inadvertent modification of weather and climate as an undesired and largely unforeseen consequence of man's habitation of this earth.

In all too many areas, the exact nature, magnitude and time scale of these problems is distressingly obscure, but in those few places where the veil has been lifted, both the National Academy and the Special Commission have found cause for serious concern.

With this concern, and with their expressed recommendation of the need for a stepped-up program of basic and applied research in weather and climate modification and on the natural causes of climate change, the Foundation is also in hearty agreement.

*

CONCEITO 19

Whatever the course of events, the Foundation feels that its own research activities must receive increased emphasis.

As the committee is well aware, the NSF's authority is limited as a consequence of its creation as a scientific research and education oriented agency.

It would be quite inappropriate for the Foundation to carry its weather modification activities into extensive development of technology or to the conduct of large field operations for the express purpose of enhancing precipitation.

*

Here, I am distinguishing between an operation designed to increase precipitation in order to have more water as compared to experiments to see what can be done.

Likewise, regulation through licensing, or other means, of weather modification research or commercial operations is not an appropriate role for the Foundation, and we do not feel that the Foundation should go further in developing such activities.

*

To repeat, however, the Foundation is strongly of the opinion that its research and education efforts both directly and indirectly supporting weather modification should increase.

*

Senator Cannon. Are you thereby increasing your funding level to permit you to do more ?

*

Dr. Haworth. Yes.

That is a requirement to do more, yes.

*

Senator Cannon. What level are you talking about ?

What do you envision ?

*

Dr. Haworth. I think we should continue to grow at something like the rate we have been growing during the last 2 or 3 years.

*

Senator Cannon. That doesn't quite support your statement if you say we continue to grow at about the same level that we have.

Did you say "go" or "grow" ?

*

Dr. Haworth. Grow.

Senator Cannon. What would you then envision, for example, in the 1968 budget?

*

Dr. Haworth. I don't think I figured that out exactly.

It should go up by fiscal year 1970, say, to perhaps more than double what we are hoping for in 1967.

*

Senator Cannon. All right.

Dr. Haworth. Of course, it has to be in competition with all the other needs for funds.

*

Senator Cannon. I understand.

I was just trying to get into proper focus the type of growth you were talking about.

*

Dr. Haworth. This is for the underlying research.

*

The necessity for indirect or related research on weather modification deserves some comment.

CONCEITO 20

There are many scientists including members of the Foundation staff and the National Science Board who have become increasingly convinced that the changing character of man's interaction with his environment will constitute the central scientific problem for the next generation or two.

*

The Foundation is vitally concerned with developing and shaping the role it must have in this general problem area in order properly to serve the coming needs of society.

CONCEITO 21 – Outras Disciplinas Mencionadas

Study of the problems of human interaction with the environment requires a broad range of scientific skills—physical sciences (oceanography, meteorology, geophysics, geology, geochemistry),

social sciences (anthropology, social psychology), engineering (transportation, sanitary engineering, systems engineering), biological sciences (ecology, systematic biology), and so forth, not all of which are directly related to weather modification.

*

The magnitude of environmental problems is growing at an amazing rate, as is the number of thoughtful citizens, both scientists and others, who are becoming alarmed at the prospects before us.

It is my feeling that the National Science Foundation has sufficient breadth and contact with the broad academic scientific community to bring all fields of science to bear upon developing an improved understanding of environmental problems, including weather modification.

The Foundation also has great resources in the fields of science education and science information which it can bring to bear on the problem.

7.a) – Outras Disciplinas mencionadas

So great is my own concern with developing the Foundation role and stance in this problem area that I have recently established an Environmental Sciences Division within the Foundation, which is of equal organizational rank with the older research divisions, such as the Mathematical and Physical Sciences Division, the Biological and Medical Sciences Division, the Engineering Division, and the Social Sciences Division.

*

To sum up, I agree with the reports you have read that, in addition to increasing our basic research activities, it is now time for enhanced Federal support of applied research and engineering development aimed toward economically beneficial operation in several areas of weather modification.

*

My recommendations are as follows:

7.a)

1. The National Science Foundation must continue to have the authority and expanding resources to support a broad program of underlying research in weather and climate modification at universities and colleges and other appropriate institutions, particularly NCAR.

CONCEITO 22

2. Other Federal agencies should be encouraged to undertake such research and development activities in weather modification as may be required for the effective discharge of their specific missions.

Examples are : suppression of lightning by the Department of Agriculture, fog dispersion by the Federal Aviation Agency, rainfall augmentation by the Department of Interior, and severe storm suppression by the Department of Commerce.

CONCEITO 19

3. With the advance of weather modification capabilities to a point calling for experimental and developmental activities going beyond the scope of the National Science Foundation, another agency should be assigned major responsibility for the overall progress of the field.

*

Because of its broad interest in the atmosphere, and its capabilities including extensive field organizations, I believe that the Environmental Science Services Administration is the logical agency to assume this major responsibility.

*

I might say, Mr. Chairman, that serious consideration is being given in the administration to a reorganization plan that would transfer to ESSA much of the responsibility that was given to the NSF, by the 1958 congressional action, leaving, however, the National Science Foundation's authority and responsibility to continue to do the underlying research.

*

In discharging such responsibility ESSA should give emphasis to large-scale field experiments and to research on the broad question of climatic change and modification and should consider the establishment of a substantial laboratory for weather and climate modification activities.

This agency should also undertake necessary data collection, dissemination, and evaluation.

It should in addition bear principal but not sole responsibility for international arrangements and programs relating to weather modification, working of course with the Department of State.

2.b)

ESSA is particularly appropriate for this role because of its activities in other aspects of worldwide meteorology, including the world weather watch.

*

The discharge of these general responsibilities should be in addition to ESSA's present specific programs.

In consonance with recommendation 2 above, this assignment should not preclude other agencies from engaging in activities appropriate to their specific missions.

8.a) e 8.b)

4. The responsibility for insuring adequate coordination for the Federal Government rests with the Office of Science and Technology.

Among the objectives of such coordination are the most rational use of the resources of funds and manpower devoted to the various agency programs in relation to each other and a unity of overall governmental policy in this field.

CONCEITO 23

5. A single agency, or subagency, not having responsibilities for research and development or for operations in weather modifications should be given the necessary authority to monitor weather modification operations and to exercise such regulation as may be necessary to protect the integrity of Federal programs.

*

Dr. Chamberlain will discuss the Commission's recommendations on these matters.

CONCEITO 24

6. Study should be given to the provision of appropriate compensation to the public for damages arising from Federal weather modification activities and protection for Government grantees and contractors.

I thank you for the opportunity to discuss briefly this very complex and important problem.

I will be glad to try to answer any questions you may have.

*

Thank you, Mr. Chairman.

*

Senator Cannon. Thank you, Doctor, for a very fine statement.

I have a number of questions relating to organization, proposed organization, the funding, and so on.

Perhaps it would be well to hold those until after we have heard from the entire panel.

*

Dr. Haworth. I would greatly appreciate that.

Senator Cannon. Very well.

The next witness I presume will be Dr. Chamberlain.

Senator Hart, do you agree with going ahead with the panel statements?

Senator Hart. Yes, I do.

Anexo 14 - 05S66 - Malone

Fonte: <https://babel.hathitrust.org/cgi/pt?id=uc1.b5164561;view=1up;seq=143> (pp. 134-144)

STATEMENT OF THOMAS F. MALONE, SECOND VICE PRESIDENT AND HEAD OF RESEARCH DEPARTMENT, THE TRAVELERS INSURANCE COS., HARTFORD, CONN.

Dr. Malone. Thank you, Mr. Chairman.

3.a) – 3.b)

It is a great pleasure to appear before this committee to discuss with you the issues raised by the findings of the panel on weather and climate modification of the National Academy's Committee on Atmospheric Sciences, and to share with you both a vision and a nightmare of the future that, by turn, in spire and trouble the scientific community.

*

My particular delight in being with you this morning has its roots deep in the hope that the wisdom of Congress will be exercised with the right mixture of prudence and imagination so that our nightmare may be banished forever and the vision remain as a national goal worthy of our mightiest efforts.

8.b)

The importance of the decisions now before Congress can be summed up succinctly in some thoughtful words set forth a few years ago by the Committee on Science in the promotion of human welfare established by the American Association for the Advancement of Science.

They said:

CONCEITO 1

For nearly two decades scientists have viewed with growing concern the troublesome events that have been evoked by the interaction between scientific progress and public affairs.

With each increment of power, the problem of directing its use toward beneficial ends becomes more complex, the consequences of failure more disastrous and the time for decisions more brief.

*

They go on to say:

The problem is not new either In the history of human affairs or of science.

What is without past parallel is its urgency.

*

Outras Disciplinas mencionadas

We in the atmospheric sciences have rather special responsibilities in this regard for three reasons.

*

Senator Dominick. I was interested in your quotation, and I will just break in to ask you a question.

*

You say :

With each increment of power, the problem of directing its use toward beneficial ends becomes more complex.

*

What power are you talking about?

*

Dr. Malone. Power over matter, power over energy, the kind of power we are talking about today, potential power over the environment.

*

Senator Dominick. Thank you.

CONCEITO 2

Dr. Malone. Our concern is for three reasons. The first is the immediate, vital, and profound part played by weather and climate in the lives and affairs of all men.

*

CONCEITO 3

The second is the special international character of an atmosphere that is constantly in restless motion, crossing and recrossing national boundaries—an international resource, if you will, shared by all men.

The third is the obvious choice that lies before us to use mastery over this international resource to aggravate or to ameliorate conflict among nations.

7.a) e 7.b)

It seems to me that the particular strength of our position in these early months of 1966 — and if I may say so, Mr. Chairman, the challenge and the opportunity before Congress—rests in the fact that there is still time for deliberate thought and decision on the issues raised by the reports of the Academy Panel and the NSF Commission.

*

The Academy report itself will be summarized by Professor Mac-Donald, the Chairman of the Panel.

I would propose to comment briefly on what I believe to be the principal issues of public policy raised by this report.

I don't mean to be presumptuous by identifying them, but they seem to me to warrant comment.

*

They are these:

CONCEITO 4

(1) The need to transform our somewhat fragmented national effort in this field into a coherent national program;

- (2) The character of that program;
- (3) The size of that program;
- (4) The rate of growth at which the national program is developed ;
- (5) The manner in which it is organized and managed; and
- (6) The international implications.

*

In support of an affirmative conclusion on the first issue are these four points:

CONCEITO 5

First, development of mathematical modeling of physical processes in the atmosphere, the availability of electronic computers, and prospects for more precise measurements —all of which have combined to thrust the problem of conscious and meaningful tinkering with the atmosphere across the threshold that separates speculation from rational and systematic exploration of possibilities and limitations.

*

Second, demonstration of operational capability in dissipating supercooled fog and the still incomplete, but very persuasive, evidence that rainfall can be influenced by seeding techniques.

*

CONCEITO 6

Third, the prospects for significant economic benefits in land utilization and water management in a world which is confronted with growing problems of agricultural productivity.

CONCEITO 7 – Referência AC

And fourth, the compelling necessity of understanding and being able to anticipate the kinds of inadvertent modification of climate that may be set in motion within the next generation or so as the population expands into an environment with fixed limits.

*

CONCEITO 8 e 9 – Outras Disciplinas mencionadas

With respect to the second issue, the character of the national program, quite apart from that portion of the effort which is concerned with national defense, it should possess the attributes of (1) diversity—in that big science should be balanced with little science, research in the physical sciences accompanied by research in engineering and the social and life sciences, and activity in the public sector complemented by activity in the private sector.

*

Senator Dominick. Doctor, I don't pretend to be a scientist, and I am sure you are well aware of that, but what do you mean by big science and little science ?

Dr. Malone. By big science, I mean the kind of expedition into the tropics which requires half a dozen airplanes, large-scale computers, great logistical support, extensive management of many people and large facilities.

*

By little science I mean the individual investigator carrying out work in his laboratory or at his desk with pencil and paper.

Senator Dominick. How big is big ?

*

Dr. Malone. That is a matter of interpretation. For our purposes, I would say a big project is one which has an annual budget of say a half million dollars or more per year. A small size is of the order of tens of thousands of dollars a year.

*

Senator Dominick. Thank you.

*

Referência AC

Dr. Malone. The second attribute is one of balance.

By that I mean a balanced program which addresses itself to the problems of cloud physics, to hurricanes, tropical convection, hail, lightning, water budget, all conscious attempts at intervention, as well as the inadvertent modification caused by an increase of CO₂, air pollution, and rocket exhaust at high levels.

CONCEITO 10

The third attribute is integrity, in that the unity of the four principal tasks of the meteorologist be preserved, that is the observation, understanding, prediction, and control of atmospheric phenomena.

CONCEITO 11

Stability, in that budgetary support should be consistent with the long-range nature of the program and should avoid violent fluctuations.

*

Adequacy, in that the level of the effort should be commensurate with the difficulty and complexity of the problem.

*

Senator Dominick. Doctor, again pardon me for interrupting your direct testimony here.

4.b) e 4.a)

Am I correct in my understanding, that some of the companies that you are affiliated with are engaged in research on forecasting, weather forecasting ?

Dr. Malone. Yes, sir.

Senator Dominick. Am I also correct that it is under a grant from FAA or Weather Bureau ?

6.a) e 6.b) , 5.a) e 5.b)

Dr. Malone. It is the Weather Bureau and the Air Force and other agencies; the Travelers Research Center does contract work for a whole array.

Senator Dominick. Is one of these research efforts designed to fulfill a proposed need for accurate 9-hour forecasting?

Dr. Malone. Yes, sir, several different things, and included is the one of the 9-hour forecast.

Senator Dominick. Have reports been issued on the results ?

Dr. Malone. Yes, sir.

Senator Dominick. Could you tell me whether or not you feel there has been predictable forward motion in this ?

CONCEITO 10

Dr. Malone. Yes, sir, I believe that progress has been made in prediction and more importantly, in the interpretation of the prediction in terms of the sorts of operational decisions for which the prediction is needed.

*

By that I mean that there is an uncertainty in any prediction.

When you use that prediction in an operational decision, it is helpful to know the degree of uncertainty.

This is known as probability forecasting and the value of the forecast is enhanced by incorporating a measure of the uncertainty of the forecast into the forecast itself.

*

Senator Dominick. I don't mean to be blunt, but I am a flier, as you may or may not know. From what you have said we are no further ahead in finding out what is going to happen 9 hours from now than we were before.

Dr. Malone. Well, I would not be quite that pessimistic, sir.

Senator Dominick. Suppose you were a flier; and you receive a weather prediction, and a degree of uncertainty is built into the prediction ; how are you supposed to know what you are going to face when you get there?

CONCEITO 12

Dr. Malone. Well, if I were a flier, and a forecaster gave me a forecast for 9 hours, I would first of all recognize that from previous experience that he is not always going to be right.

What I would like very much to know is in this particular instance what kind of confidence he attaches to that prediction.

Is he quite sure of it, as he is on some days, or is he relatively unsure of it as he is on other days. This would be useful, I believe.

*

Senator Dominick. As fliers, we have a rule of thumb in our area. If the forecast is for good weather 9 hours from now, we can be relatively assured it will be miserable weather, and vice versa. Have the results of your experimental program been transferred to the Weather Bureau?

Dr. Malone. Yes, sir, the Weather Bureau has access to all of this.

We work quite closely with them.

Senator Dominick. Do you know whether the people are being trained in the methods and modes which are advocated in this report, or are there no new methods and modes advocated?

CONCEITO 13

Dr. Malone. Yes, sir, I think there is continual progress in the application of new techniques and in particular, the use of the computer in analysis of the tremendous amount of data which is available to the airlines forecaster, the airways forecaster, and there is constant updating and incorporation of these newer techniques into operational procedures.

Senator Dominick. Is this part of an overall weather modification program then?

*

Dr. Malone. No, sir.

That is directed at the prediction problem.

*

Senator Dominick. Don't you have to have that in order to be able to determine what you are going to do to modify the weather?

*

Conceito 14

Dr. Malone. Yes, sir, that was my point here on the unity of the meteorological problem.

To the extent that you can't describe some thing, you can't understand it.

So you start with measurement.

You can't with any intellectual satisfaction predict something you don't understand, and if you can't predict something, you are limited in the degree to which you can control it, because you don't know whether your intervention produced results or whether those results would have happened by natural processes anyway.

*

Now it is not quite that rigid, but that is the sequential set of steps which make up the whole problem.

Senator Dominick. In the consideration of this 9-hour forecasting proposal, did you go further and try to determine whether it was easier or more difficult to give a 24-hour or 48-hour forecast of general weather conditions? In other words, it might, not be accurate within 100 or 200 feet on ceilings or whether the clouds were going to be scattered or broken, but you could describe the general conditions of the area.

CONCEITO 15

Dr. Malone. In general, the accuracy deteriorates with increasing time, so that your 24-hour prediction is less precise than your 9-hour prediction, given the same element as the predictant.

Senator Dominick. Wouldn't you say that in order to conduct accurate weather modification programs you must be able to determine whether a storm is going to be moving into the area at least 24 or 48 hours ahead of time, so that you can be prepared to start modification programs?

Dr. Malone. Yes, sir.

Senator Dominick. What I am trying to figure out is which comes first. In other words, whether in the effort of trying to modify weather we first need a system of accurate forecasting, or whether we need the science of modification when you already have the weather overhead.

*

Dr. Malone. This is a vexing problem, Mr. Chairman.

The evidence indicates that the amount of rainfall can be increased in certain cases by something like 10 percent.

*

Now it is extremely difficult to predict rainfall within 10 percent of the actual amount that falls.

So that we have the anomalous situation in which it seems likely that one can influence the amount of rainfall by a percentage change, which is finer or closer than the limits of satisfactory forecasting.

*

Senator Dominick. Have you any idea how many programs are now in operation on an experimental basis to determine the best methods for weather forecasting?

*

Dr. Malone. No, sir.

I don't have a ready number to give you.

5.a) e 5.b), 1.a) e 1.b) , 6.a)

There are programs inside the Government, the Weather Bureau, the Air Force, and the Navy : there are programs at the universities, where forecasting is taught.

There are efforts in industrial concerns directed to forecasting, but I don't have a single number that I can give you of which I would be confident.

*

Senator Dominick. How many of these programs is Travelers involved in ?

Dr. Malone. Well, it does work for the Navy, for the Air Force, and for the Weather Bureau.

Senator Dominick. These are separate programs ?

Dr. Malone. Yes, sir, they are.

Senator Dominick. Separately funded?

Dr. Malone. Yes, sir.

Senator Dominick. Are they operated by the same group of people or different people?

Dr. Malone. Same group of people ; yes, sir, so that the coordination is achieved internally.

Senator Dominick. They are all concerned with forecasting?

Dr. Malone. Not all of the programs that Travelers Research Center is concerned with are forecasting; no, sir. There is an activity within the Center which is addressed specifically to the forecasting problem.

Senator Dominick. You said you were doing work for the Navy, Air Force, and for the Weather Bureau ; is that correct ?

Dr. Malone. Yes, sir.

Senator Dominick. Are you doing anything for FAA ?

Dr. Malone. I don't believe so right now. I can't tell you exactly.

Senator Dominick. Do you have more than one program from each of those agencies?

Dr. Malone. Not in forecasting ; no, sir.

Senator Dominick. Do you have one forecasting program for each of those agencies, each separately funded ?

Dr. Malone. Yes, sir.

Senator Dominick. Is there any interrelation of information between one organization and another?

Dr. Malone. Oh, yes, sir; the degree of coordination is really very high.

Senator Dominick. What is the difference in the three programs?

Dr. Malone. They are addressed to different kinds of problems. The Navy, for example, is interested in the state of the sea, in the conditions over the marine areas. The Weather Bureau was interested, for example, in the airways forecasting problem. The Air Force is interested in high level problems concerned with the winds, the free air turbulence, the cloud cover at high altitudes for their military missions.

Senator Dominick. How long have these programs been going on ?

Dr. Malone. At Travelers or in general ?

Senator Dominick. At Travelers.

Dr. Malone. For about 5 years.

Senator Dominick. Thank You. Excuse me for interrupting you.

Dr. Malone. Yes, sir. The character of the program will, to a large extent, be determined by the kinds of things that need doing; that is, the elements of the program. They would appear to be these four:

CONCEITO 16

*

Basic research directed at a fundamental understanding of the principal aspects of the problem.

*

Referência AC

Applied research directed at the development of techniques for successfully intervening in normal atmospheric processes as well as for assessing the consequences of inadvertent modification.

*

Operational application of proven techniques as soon as their efficacy is established.

*

Regulation as may be needed to protect the interests of the public and to prevent the contamination of field research projects.

*

It seems clear that the most conspicuous gap in the present national effort is in the applied research activity directed at the development and evaluation of techniques for weather modification.

*

Important considerations in the third issue, that is, the size of the program, are:

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The need to conduct large field studies which require substantial logistical support.

The need to assemble groups that are sufficiently large and diverse in their disciplinary interests to make an impact on a very difficult and complex problem.

*

The level of \$30 million by 1970 is, in my opinion, an austere estimate which takes into account these two factors.

*

An important consideration in the rate of growth of the program is the availability of competent manpower.

*

I endorse and call to your attention the comments of the panel that the intrinsic scientific interest and the national importance of this problem are likely to attract to it both the quality and the quantity required to expand the program from a \$5 million level in 1965 to the \$30 million level of 1970.

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Senator Dominick. This is very interesting testimony. You say one of the most conspicuous gaps in the present national effort is in applied research activity.

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Now what is the effect of the present commercial operators who are working on weather modification in certain areas?

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Dr. Malone. Their effect is to contribute to that gap, or rather to the closing of that gap.

4.a)

The commercial operator has the immediate objective of increasing rainfall.

For example, in other words, his objective is a technique which will accomplish the weather modification.

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Senator Dominick. And some of them are also involved in forecasting, are they not ?

Dr. Malone. Yes, sir.

Senator Dominick. Has there been any effort that you know of to try and correlate the results of the commercial operators in the two fields with the gap that you are referring to ?

3.a)

Dr. Malone. Well, I believe that the studies of the Academy Panel were the first attempt to bring together into a single treatment the results of operational weather modifiers and the various research programs which are conducted around the country.

*

Senator Dominick. You talked about big science a little while ago, in reference to applied research. How big an area are we talking about ? Suppose you are going to conduct applied research in a big science category for the production of more precipitation. How big an area are we covering, how extensive is it, and how long would it take to do it accurately?

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Dr. Malone. This depends upon the kind of problem you are at tacking. If you are talking about the tropical convection problem, for example, you would be talking about thousands of square miles over the ocean areas. If you are talking about the orographic rain increasing problem, you would be talking about something of the order of 100 square miles. If you are talking about the cumulus problem, you would be talking about an area which would encompass several hundreds of square miles. If you are talking about the ---

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Senator Dominick. Would It be feasible, Doctor, to take the upper reaches of the Colorado River—which I am very familiar with and I am sure you are too—in the high mountainous areas of the Rockies, and conduct applied research activity which would determine more or less scientifically whether or not you could produce more snow or more rainfall in that area?

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Dr. Malone. I am not sure I understand your questions, sir.

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Senator Dominick. Would it be feasible to prepare a program which would be scientifically accurate in a reasonable sense for the production of more snow or more rain in the upper Colorado River reaches ?

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Dr. Malone. Yes, sir.

Senator Dominick. And what kind of an expense item are we talking about for a productive program of that kind?

Dr. Malone. You could put it at various levels, depending upon the amount of basic measurements or basic research or understanding of the process that you wish to build into it.

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My estimate here would be that a meaningful program would have a minimum level of several hundreds of thousands of dollars per year. If you instrumented this extensively and included aircraft, radar measurements, the expense could very easily escalate into a million dollars or more per year. This is about the range.

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Senator Dominick. How long a period would a program of that kind have to be carried on in order to be meaningful ?

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Dr. Malone. I would estimate about 3 years, 5 years —I am sure you would get opinions that would require 5 years to get meaningful results. And it would depend upon the kind of design you established as a basis for your experiment.

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Senator Dominick. Is it correct to say that you must have continuity in these applied research activities on a yearly basis in order to determine whether there is any scientific background for increase in precipitation or snow fall ?

CONCEITO 17

Dr. Malone. In general ; yes, sir. I say in general because you can conceive of a design which covers several parts of the country in which you have in effect traded space for time, but you are quite correct, in general you need continuity.

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Senator Dominick. We had testimony from the National Science Foundation about so-called rain shadow, and whether or not down wind areas get less rain after you have seeded than they would get otherwise.

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Have you delved into this problem ?

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Dr. Malone. I believe Professor MacDonald is going to delve into this in his testimony. I would be glad to give you my views if you would like them, but this is part of his testimony, and I think you would get a more authoritative response from him than you would from me.

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Senator Dominick. I just want to say to Senator Hart, who has joined us here, I have been questioning the witness as he is going along in his testimony on matters that concern me and have been bothering me for a number of years. We are now on page 6 of his testimony.

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Senator Hart. Thank you, Mr. Chairman.

Senator Dominick. If you have no questions, we will continue.

Dr. Malone. Sir, I think we are moving into an issue where you are a master and that has to do with the question of the management of the national program, the reorganization and the administration, agency responsibility of a program with far-ranging socioeconomic, and political consequences.

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Do you wish me to resume, Mr. Chairman?

Senator Dominick. Please.

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CONCEITO 18 – Outras Disciplinas mencionadas

Dr. Malone. Several options would appear to be open. One would be to allocate among existing agencies the four program elements mentioned earlier. Generalized guide lines are provided for this course of action in the report of the NSF Commission. Another, and one that would be quite responsive to the report of the Academy Panel and yet not be inconsistent with the alternatives set forth by the NSF Commission would be to recognize the obsolescence of the administrative division of the environmental sciences in the Government and provide a more appropriate home for weather and climate modification within a new structure that would take proper cognizance of the "increased interdependence among the areas of environmental research and engineering" noted by the Academy Panel.

I am sure that it is not necessary to point out the difficulties were this second option to be exercised, but the benefits that might flow from it and the appropriateness of Congress undertaking this task prompt me to suggest it as an opportunity to exercise statesmanship of the highest kind.

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CONCEITO 19

The final issue—and one that I would personally rank first in importance—is concerned with the international implications. Neither we in this country nor our counterparts in other countries as yet know how to manipulate large-scale weather processes. A formidable scientific problem must first be solved. But today, it is only a scientific problem. If it is solved, it becomes a political problem incredibly more difficult even than the scientific problem. We see about us the vexations in continuing this kind of problem. The question arises: Would it be possible to ameliorate potential difficulty in things scientific and political by a cooperative effort among nations while problems are only scientific? I think so—for four reasons.

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CONCEITO 20

First, as I have already noted, the atmosphere itself is international.

CONCEITO 21 – Outras disciplinas mencionadas

Second, there is a fine tradition of international cooperation in meteorology.

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Third, with only 6 percent of the world's population, 20 percent of the world's scientists and 40 percent of the aggregate gross national products we can multiply our own efforts through cooperation guided by the mind as well as the heart.

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CONCEITO 22

Fourth, dedication of this effort to peaceful purposes might in some small way contribute to the unity of a world increasingly troubled and tormented by conflict.

In conclusion, a word about our vision— and our nightmare.

1.b) e 1.a)

The vision, I believe, is a world in which one finds in place "the suitable new political forms and procedures" that the great mathematician, John von Neuman, pointed out a decade ago will be required after global climate control becomes possible.

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A world in which the benefits of weather and climate control are allocated equitably among nations by methods that will have been developed —not by some "novel cure-all" but, as Von Neuman phrased it, by "a long sequence of small, correct decisions" —precisely the kinds of decisions before Congress during this session.

CONCEITO 23

The nightmare is a world in which the conflict—that will probably always, to a greater or lesser degree, be the lot of imperfect man —has been aggravated by dispute over the rights to one of the most international of our natural resources —the atmosphere. A world in which the "race to the moon" is replaced by a race to extend mastery over the atmosphere; the problem of nuclear proliferation replaced by the proliferation of environmental modification capability.

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A world in which scientists meet interminably in Geneva to put the genie back in the bottle.

A world we do not want to see.

A world that need not be.

That is the end of my formal testimony, Mr. Chairman.

Senator Dominick . Thank you, Doctor. Senator Hart ?

Senator Hart. Only to comment on the note you strike in the conclusion here. It is a very succinct expression that should intrigue us and alarm us. You put it well.

Dr. Malone. Thank you, sir.

Senator Dominick. Doctor, the report of the National Academy of Science again refers to the fact that increases of precipitation on the order of 10 percent apparently can result from using groundbased silver iodide.

Why the word "apparently," after 9 years? Haven't we gotten any further than that?

Dr. Malone. Mr. Chairman, I think that Professor MacDonald is going to address himself to this kind of question in his testimony and again, I don't mean to duck your question, but I know that he is going to include a discussion of this. I don't want to say things he is going to say.

Senator Dominick. When you actually have seeding operations going on, do you have any idea of whether the research activities, or applied commercial experiments or efforts are producing the most seeding ?

Dr. Malone. Would you repeat the question, please ?

CONCEITO 24

Senator Dominick. Yes. I will make it much more simple. Seeding is now going on. Which branch of the present science is doing the most, the commercial firms or the research activities? Can you give us any idea of the scope ?

Dr. Malone. I would guess perhaps commercial. Would you agree with that, Gordon ?

Dr. MacDonald. Yes, sir.

Dr. Malone. But I can't buttress that with facts.

Senator Dominick. Your report also stated that the design development and testing of equipment for field measurement and experimentation have been inadequate.

CONCEITO 25

Now what is the reasoning behind that ? Is this lack of basic knowledge or failure to develop the tools or what ?

Dr. Malone. Failure to develop tools; not lack of basic knowledge.

Senator Dominick. And in whose area does this responsibility is?

Dr. Malone. I think it is a diffused responsibility. It is partly responsibility of the scientific community, partly the responsibility of the Government. It is easy to point the finger at one or the other and say that the Government did not provide enough money or to point the finger at the scientific community and say that they haven't come forward and asked for these things that are possible. I think it is a shared responsibility.

Senator Dominick. Could you give the committee any idea of what type of tools you need but don't have and that could be developed?

Dr. Malone. Specifically the kinds of instrumentation for conducting very comprehensive tracing of the seeding ingredients in large systems, for making measurements of the physical, what we call the physical parameters of the cloud, in other words, the drop size distribution, the number of condensation nuclei in the cloud, these kinds of physical measurements.

Senator Dominick. Are we talking about radioactive materials that could be traced by counters, or are we talking about visual type of ingredients?

Dr. Malone. We are not talking about radioactive materials, specifically. But the point is not addressed to radioactive tracing.

Senator Dominick. Are we talking about visual type of ingredients then?

Dr. Malone. Yes, sir; visual types, and those which are measured by instrumentation, which is an extension of the visual perception, of course. For example, the drop size distribution is something you can't measure with your eye, but you can measure by instrumentation. It is a dimension.

Senator Dominick. Do we have anybody working on these problems?

Dr. Malone. Yes, sir; there are groups working on these. I think the point is that the effort to develop these tools needs strengthening.

Senator Dominick. Who is now working on it ?

Dr. Malone. These have been worked on at the University of Arizona, at the University of Chicago, at the National Center of Atmospheric Research, University of Nevada, I believe Colorado State College, at the Pennsylvania State University, at MIT, just to cite a few, and I don't mean to exclude any important work or any important group. There are other groups.

4.a)

Senator Dominick. You arrived at certain conclusions in your report on Project Storm Fury. Could you give us some idea of what these conclusions mean? Was it too small an effort or too large or did it move along the wrong lines?

Dr. Malone. May I refer that question to Professor MacDonald who is going to address himself to it ?

Senator Dominick. Perhaps we had better have Professor Mac-Donald's testimony now. This might clear up some of the questions I have.

Dr. Malone. I believe it would, sir.

Senator Dominick. Thank you.

Professor MacDonald, will you come forward ?

