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The impact of empowering scientific advisory committees to constrain catch limits in US fisheries

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Following a 2006 revision to the US Magnuson–Stevens Act, the eight Fishery Management Councils that manage the nation's stocks have been restricted from setting regional catch levels that exceed the recommendations of their primary scientific advisory committees. This paper reviews the impact of that new requirement using principal–agent theory. After demonstrating that the advisory committees are still agents of the Councils, I show that the process of managing federal fisheries stocks now requires a lengthy dialogue between the two groups revolving around issues of risk tolerance, management buffers, and data availability that has resulted in the development of explicit rules for setting biological boundaries on catch.

Keywords: fisheries; science policy; principal–agent theory; National Oceanic and Atmospheric Administration; Magnuson–Stevens Act.

1. Introduction

The use of science in guiding public policy is generally consensual. Scientists do sometimes use science in direct roles as advocates (Majone 1989), or as 'honest brokers' (Pielke 2007) who can inform policy-makers of the potential risks of imaginable courses of action, but unless otherwise specified, they are actors whose counsel can be ignored if desired (Braun and Guston 2003). Shifting that role would require significant changes in the relationship between policy-makers and those who advise them.

This paper will examine the outcome of one such shift. Following a 2006 revision to US law, the eight Fishery Management Councils that manage the nation's stocks have been restricted from setting regional catch levels that exceed the recommendations of their primary scientific advisory committees. The impacts of this new requirement are still being felt, but sufficient time has elapsed that the general impact of the law on the regulatory process can be discerned. How has allowing advisory scientists to constraint policy-makers affected the relationship between the two groups? In particular, how has it impacted the process of managing fisheries stocks?

The primary analytical tool used here is principal–agent theory. A principal–agent relationship is established when the agent is delegated specific authority to act on behalf of a principal, as Congress does with bureaucracies generally (Kiewiet and McCubbins 1991). Principals are especially constrained when they lack the specialization to do the task themselves, making it difficult to choose an agent who will represent their interests—the problem of adverse selection. They will likewise have difficulty measuring whether the agent has completed the task correctly—the problem of moral hazard (Moe 1984). The relationship between policy-makers and the scientific community can be modeled as a principal–agent relationship (Braun 1993; Guston 2003; Van der Meulen 1998). The usual agent-controlling tools at the disposal of policy-makers are the ability to switch agents (to control the adverse selection problem) and, especially, to structure the contract carefully (to control the moral hazard) (McCubbins 1985). Both of these are in play in fisheries policy, but there are multiple levels of delegation by Congress and hence an iterated principal–agent structure (Guston 2000).

US fisheries regulation is somewhat complex, even to members of those interest groups most involved in the process: commercial fishing interests and recreational anglers traditionally, environmental groups more recently. Thus, I will spend Section 2 of this paper explaining the legal structure and regulatory history of fisheries administration in the USA, with an emphasis on those ocean waters under the direct supervision of the federal government. Since 1976, Congress has delegated part of that responsibility to the Fishery Management Councils and part of it to the National Oceanic and Atmospheric Administration (NOAA), so I will also explain the relationship between those bodies and the NOAA agency and the role of outside scientific advisors. Section 3 places particular emphasis on the role of science in fisheries policy, explaining how the fisheries scientific process works and the role of peer review in the agency's and the Councils' standard operating procedures. Section 4 uses principal–agent theory to review the original structure of US federal marine fisheries management. Section 5 explains the legal revisions to this process, followed by an analysis of the impact of those revisions on the relationship between the Councils and their scientific advisory committees in Section 6. The paper concludes by noting the implications for future fisheries policy and the lessons drawn from increasing the influence of scientific peer review in environmental policy.

2. A short history of US federal fishing management

Although the origin of fishing regulations in the USA can be dated back to colonial times, the national government is a relative latecomer. The first federal fishery agency was founded in 1871, and over the following century, various iterations of the Bureau of Fisheries were moved from the Department of Commerce to the Department of the Interior and back again with the birth of NOAA in 1970 (Ross 1996). By the 1970s, sufficient political and economic concern had developed about the presence of foreign fleets (particularly Soviet trawlers) in coastal waters to lead to the passage of the Fishery Conservation and Management Act in 1976 (or the Magnuson–Stevens Act, as it eventually came to be called). With the passage of that legislation, Congress pushed the limits of US fishery jurisdiction to 200 miles offshore, and put the newly renamed National Marine Fisheries Service (NMFS, which is a part of NOAA) and eight new regional Fishery Management Councils in charge of managing all of the additional territory (Wise 1991), as shown in Fig. 1. Voting Council members from the various states, territories, and tribes that border the area of their jurisdiction are chosen by the Secretary of Commerce from a list of nominees sent by the governors of bordering states and to serve for three year, renewable terms. The regional administrator for NMFS was also given a permanent vote on each Council.[1]

The regulatory system evolved into a process where NMFS and Council staff provided the data and scientific analysis on which the Councils act. The Secretary of Commerce retained the ultimate authority to approve or reject management measures. Legally, this arrangement clearly delegated ultimate authority to Commerce/NOAA/NMFS. In practice, authority became somewhat decentralized and overlapping, allowing the Councils great latitude in managing the stocks in their regions (Hanna 2000). There has been little analysis of Council voting behavior, but recent research indicates industry sectors (Thomas et al. 2010) and/or states (Holahan 2012) may vote together as blocks, prompted by accusations of regulatory capture to the detriment of fisheries stocks (Eagle et al. 2003; Okey 2003).

Regardless, Council members were intended to be, and still are, political appointees, chosen by governors to represent the various constituencies with a direct stake in the outcome of federal fishery policies—usually commercial fishermen, recreational anglers, and the heads of state fishery agencies (Eagle et al. 2003). Although Council members from state agencies are often fisheries scientists, and the regional NMFS administrator (like many NMFS personnel) may be a fisheries biologist by training, most Council members are not selected on the basis of their knowledge of fishery management science. Congress, recognizing this lack of scientific expertise, required each Council to establish a Scientific and Statistical Committee (SSC):

> . . . to assist it in the development, collection, and evaluation of such statistical, biological, economic, social, and other scientific information as is relevant to such Council's development and amendment of any fishery management plan. (National Marine Fisheries Service 2007)

The SSCs were not designed to be the primary analysts of data, but rather interpreters of the research presented to the Councils for making management decisions (Witherell and Dalzell 2008). The membership of the SSCs has traditionally followed the recommendations of Congress, which stated that they shall consist of:

> Federal employees, State employees, academicians, or independent experts and shall have strong scientific or technical credentials and experience.

SSC members may come from a number of different disciplines which intersect with fisheries policy, including but certainly not limited to the different types of marine biology (habitat, stock assessment, physiology), statistics, and the social sciences. Likewise, some members may be employees of NMFS itself, predominantly from the Science Centers (which primarily conduct research) rather than from the Regional Offices (which primarily implement and help write policy). To understand the challenges posed by the Council–SSC relationship, it is useful perhaps to briefly explain the science of fisheries management in general and stock assessments in particular.

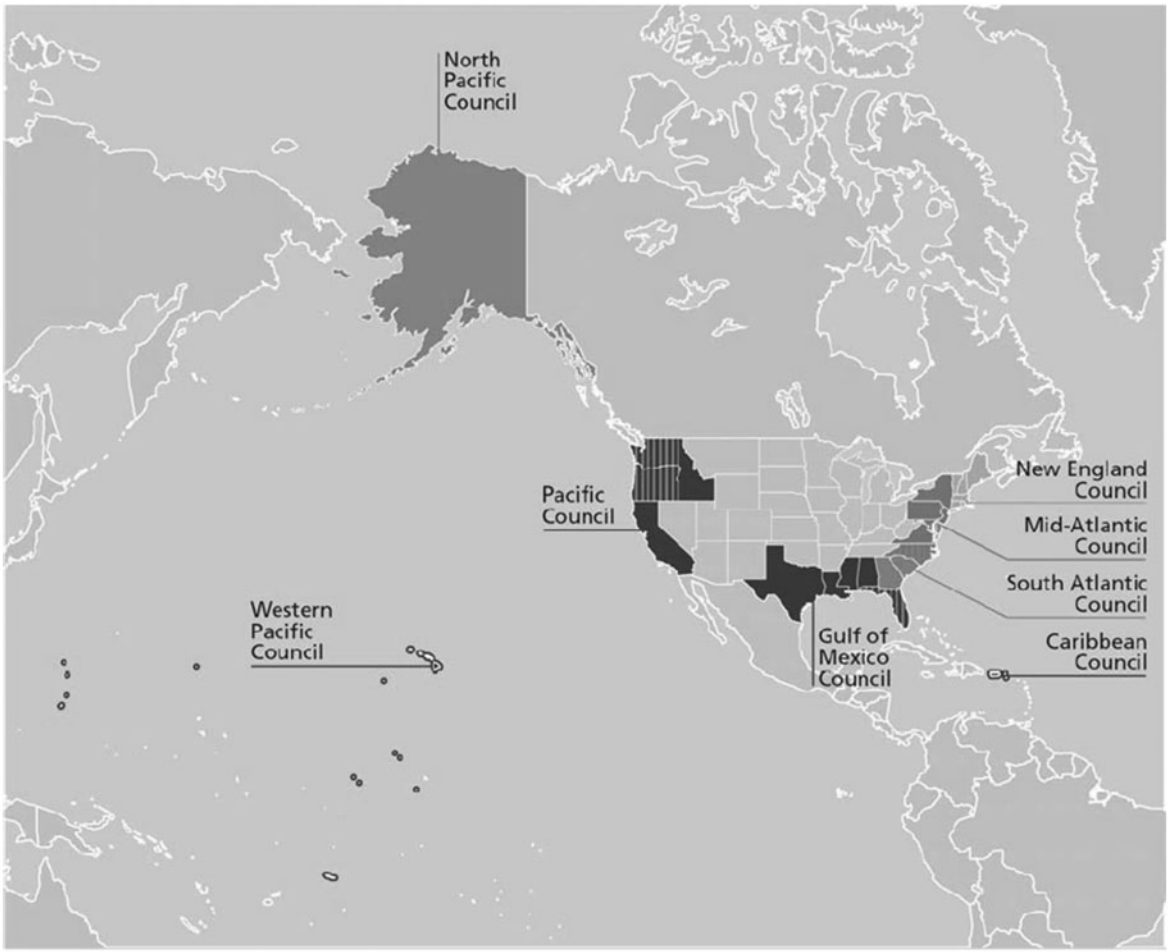

Fig. 1. Fishery Management Councils of the USA. States with striped shading (Washington, Oregon, Florida, North Carolina) are members of more than one Fishery Management Council.
Source: NOAA Fisheries.

3. The basics of federal fisheries management science

> Fish are born, they grow, they reproduce and they die – whether from natural causes or from fishing. That's it. Modelers just use complicated (or not so complicated) math to iron out the details. (Cooper 2006)

The primary job of modern fisheries assessment science is to determine the past and current sizes and compositions of fisheries stocks. To achieve this, it relies heavily on what are known as stock assessment models, which yield quantitative estimates of the ultimate number and ages of fish in the ocean. The data that feeds a stock assessment model is a mix of landings and by-catch data from commercial fishermen and anglers (fisheries-dependent data), and (ideally) from independent biological sampling surveys (fisheries-independent data) (Kilduff et al. 2009). The former tends to cover larger geographic areas and include more points in time, but relying only on catch data can be misleading. Good fishermen do not randomly choose the spots they fish, and advances in technology (especially satellite-based navigation systems) have made it easier to increase harvesting efficiency even when stock sizes are diminishing (Pauly et al. 2002). Fisheries-independent data collection is designed to randomly sample known habitats, but can be prohibitively expensive (Kelly and Codling 2006). Good assessment science incorporates both fisheries-dependent and fisheries-independent data, along with knowledge about the biology of the fish being studied (Cooper 2006). The timeliness and continuity of data is important, especially for fisheries-dependent data, because fisheries-independent data is not commonly collected every year in most areas. For this reason, the worst potential economic outcome for a fishery—a complete moratorium on catch and harvest, especially with area closures that eliminate the fish from being pulled in as by-catch—is often also damaging to the scientific process, because future stock assessments will lack data during that time and the fishery can get stuck in a 'trap'. Insufficient evidence exists that the stock is recovering, so the fishery cannot

be reopened, but the longer the closure, the less data are available on the stock's status, requiring alternative methods of data collection (Olney and Hoenig 2001; Olney et al. 2003).

Once a stock's current status has been assessed (and increasingly, even if it has not, more on that shortly), fisheries managers are faced with the responsibility of adjusting regulations if necessary to prevent overfishing (depleting stocks faster than they can reproduce) or restoring stocks that are overfished (have dropped below a specified threshold, such as half the biomass that produces a maximum sustainable yield) (Hilburn and Walters 1992). Stock assessment projection models are then used to estimate the effects of potential future harvests on the health and well being of the stock (Kilduff et al. 2009). NMFS and Council staff then work to assess the impact of management alternatives under consideration by the Fishery Management Councils (Jepson and Jacob 2007). Throughout this process, the SSC works with the Council, often meeting in conjunction (sometime staggered to begin a few days beforehand, so that the SSC can get a head start on reviewing assessment science and management options, and provide input to the Council when it comes into session) (Witherell and Dalzell 2008).

Despite the seeming orderliness of this process, scientific and policy complications can occur. One complication that consistently arises is centered on the timeliness of the stock assessment process. The process for assessing a fishery stock varies by region, but an assessment of stocks inside US jurisdictional waters generally consists of a series of data set building and analysis workshops that include staff from academia, industry consultants, Councils, NMFS, and state fisheries agencies. Assessments using new methods will then be peer reviewed by independent stock assessment biologists recruited from organizations such as the Center for Independent Experts (Carmichael and Feske 2010). Stock assessment updates, in contrast, are often only reviewed by the SSC. Assessments are expensive and labor-intensive, and many of the hundreds of harvestable species have never been assessed or have only been assessed infrequently.

The Councils work with NMFS to schedule coming assessments, with input from their SSCs. However, the complexity of the process means that only a limited number of assessments can be completed in a given year. Delays in the reconciliation of data mean that even a just-completed assessment may be a few years out of date. The SSC must meet and certify the assessment as 'best available science' before the Councils make decisions based on it, and staff must write the management plans (Witherell and Dalzell 2008). By the time a Council has a final assessment before it, certified by its SSC and incorporated into formal documents, the situation may have changed. Stocks may have rebounded. Patterns of catch may have changed due to market fluctuations in the commercial sector or changes in recreational fishing preferences. Councils must consistently choose among courses of action from data that are out of date.

If a stock has never been successfully assessed or the time of the last assessment is too distant, the Council must choose how to regulate based on a lack of data. SSC input may be sought, but without scientific data to review, the advice may be limited.

The more severe complication, however, relates to the stock assessment process itself. Stock assessments attempt to mathematically estimate population sizes and explain trends in population dynamics (such as growth and reproduction) in order to guide management (Cooper 2006). The results include considerable uncertainty related to the quality of the data set and the influence of unknown parameters (Hilburn and Walters 1992). Many oceangoing fish stocks (especially migratory species that dwell near the ocean's surface) are highly mobile and famously disrespectful of jurisdictional boundaries, so even a relatively 'clean' assessment that shows a depression of stocks in one area does not necessarily indicate localized overfishing of that species is the cause or even a problem. Even if the species has a restricted range, it has a niche in its ecosystem, and the harvests of some species can ripple through the ecosystem to affect seemingly unrelated stocks (Myers et al. 2007).

Thus, what the Councils are provided with, is open to interpretation. The SSCs exist to help decipher the science, but the Councils' choices ultimately rest on their trust in the value of the science which they are provided by NMFS, their tolerance for risk, and whatever influence is exerted by the Secretary of Commerce's ability to veto Council actions. When a Council implements actions to rebuild a depressed stock, the stock should have a high probability of being rebuilt within the maximum time allowed (ten years presently). Stock biology, the degree of depletion, and human needs can be used to adjust the duration. The probability of success for that rebuilding plan was also originally left open to the Councils.

4. Principals, agents, and federal fisheries management

It should be evident by now that there are multiple actors in the US marine fisheries management arena. However, all legal authority for fisheries regulations ultimately flows from the Magnuson–Stevens Act, and hence from Congress itself, as shown in Fig. 2.

Responsibilities for implementing the Magnuson–Stevens Act are split between the executive branch, as represented by the Department of Commerce and the NOAA agency/NMFS sub-agency, and the Councils, which as noted above are not parts of the federal government (and are not staffed by federal employees answerable to NMFS). The sub-national governments (states, territories,

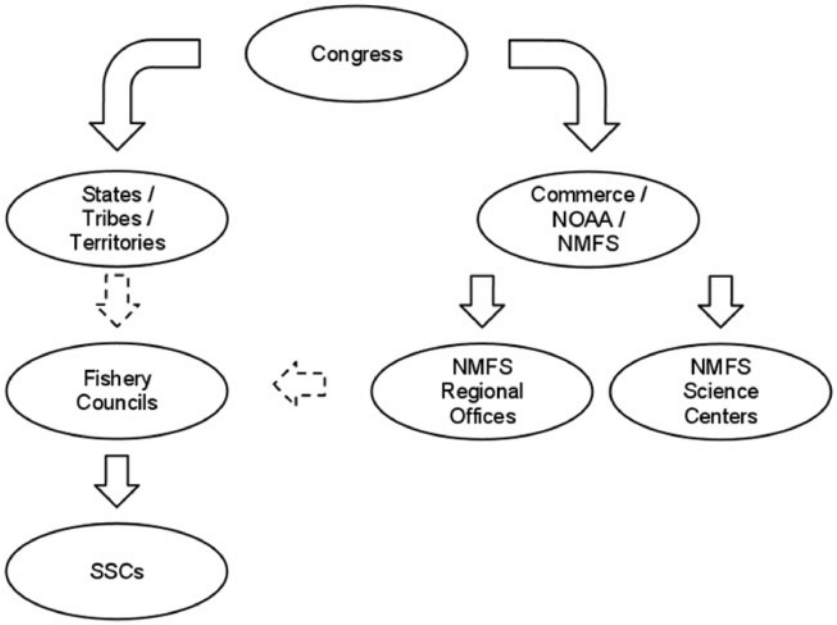

Fig. 2. Delegation of responsibilities under the Magnuson-Stevens Act.

or Indian tribes; for simplicity's sake I will use states from this point) nominate individuals to serve on the Councils and represent the different interest groups (commercial, recreational), but the Secretary of Commerce has the authority to choose Council members from that list (Okey 2003). In this sense, most members of the Councils are directly answerable to neither side—although, of course, each state retains a direct seat representing itself, and the NMFS also has a seat for its Regional Administrator.

Why did Congress set up a system of shared management responsibilities? The answer most likely lies with the need for third-party monitoring of the constantly shifting fisheries management process. In this, the Council process clearly follows that of other instances of setting up a Congressional 'fire alarm' rather than a 'police patrol' (McCubbins and Schwartz 1984). Monitoring fisheries policy in just one region amounts to a sufficiently sized workload that each Councils meets 4–6 times per year, for multiple days at each meeting. The sum of those meetings would exceed that of most Congressional standing committees. By delegating a large part of the authority to the Fisheries Councils, Congress clearly indicated that it did not want to entrust NOAA with sole authority for setting fisheries policy. The Council memberships enclose most of the major stakeholders in this area and force them to work with the agency in setting policy, thus relieving Congress of the headaches of trying to oversee the agency's management of hundreds of stocks (Natural Resource Council 2006, Mikalsen and Jentoft 2001, McCay and Jentoft 1996). Congress does sometimes intervene directly in the process, as it did with the crab and pollock fisheries in Alaska (Fina 2005; Holland and Ginter 2001). For most fisheries, Congress allows the process to play out through the Council process. At the same time, the agency retains ultimate veto authority over Council decisions via the requirement that the Secretary sign off on Fishery Management Plans. In this sense, the Councils and NOAA are both direct agents of Congress for setting fisheries policy, with each keeping an eye on the other, breaking the 'bilateral monopoly' (Niskanen 1971) and providing more information to the principal (Guston 2003).

There are two places for independent scientific input into this process. NMFS itself is split into two primary divisions, the Regional Offices (where policy is made and whose staff works with that of the Councils to develop regulations and management plans) and the Science Centers, where the primary research is done that feeds into the regulatory process (NMFS 2012). The Science Centers answer to NMFS headquarters and not to the Regional Office in the same area, keeping the science separate from the policy-making that depends on it, although of course the Regional Office and Science Center in each area are in regular contact. For the Councils, scientific advice is derived from the SSC, as originally designed by the law that birthed the Councils.

Although their existence is mandated by Congress, SSCs are agents of the Councils and not equal partners in this process because:

- The memberships (both individually and *in toto*) of the SSCs are determined by the Council which they advise, as are SSC meeting schedules and agendas.
- The SSCs have expertise that the Councils do not possess, but that expertise can only be applied to

tasks in the management process chosen by the Councils.
- All actions of the SSCs feed into actions of the Councils and not to NMFS or to other actors.

As with principal–agent relationships generally, and ones with information asymmetries especially, the Council–SSC relationship is faced with issues of adverse selection and moral hazard. The first issue relates to the issue of appointing members to the SSCs. If most Council members are not professional fishery managers, how can they choose scientific advisors who will 'understand the science' while not ignoring issues of importance to the constituent groups that the Councils represent? The second issue (moral hazard) is even more glaring—if the Council has limited understandings of fisheries management science, how can it judge the value of the scientific advice the SSC has provided?

In contrast to the tools of control in the Council/SSC relationship, there are fewer means for Congress to influence pending fisheries decisions on the allocation of stocks between fishing sectors or the selection of management tools. In the long term, Congress has the ability to make changes in fisheries law through revisions to overriding legislation or shifting resources within the agency's and Councils' budgets, but attempts to directly supervise stock management will lead to the issues outlined above: the complexity and length of the stock assessment process, a lack of scientific expertise in fisheries management science, and the sheer volume of individual species managed in the largest exclusive economic zone in the world. Congress's primary tool for influencing the process has been to revise the fisheries law, as will be show in Section 5.

5. Revisions to the Magnuson–Stevens Act

After the foreign fleets were 'kicked out' of the seas near the USA in 1976, Congress initially provided subsidies for the expansion of the domestic commercial fleet. As time progressed, however, it became apparent that the biological productivity of American stocks could not keep pace with the expansion in harvest (Conrad 1987). The Magnuson–Stevens Act was revised in 1996 to shift the emphasis from the 'Americanization' of the fishing fleet to biological conservation (Hanna 2000). Councils were forbidden to allow fishing harvests at levels that exceeded the maximum sustainable yields of a stock, and to rebuild depleted fisheries within ten years. Biomass did increase for almost half of federally-managed stocks in the decade following this revision, but most troubled stocks were still having difficulty rebuilding (Rosenberg et al. 2006; Safina et al. 2005). By the turn of the century, interest in further revisions grew, and President Clinton signed the Oceans Act of 2000 which called for a commission to provide a general oceans policy including fisheries management.

The US Commission on Ocean Policy delivered its recommendations in 2004, calling for among other things, Councils:

> ... should be required to rely on the peer-reviewed advice of their Scientific and Statistical Committees (SSCs), particularly in setting harvest levels. [A Council] should not be allowed to approve any measure that exceeds the allowable biological catch recommended by its SSC. (United States 2004)

Simultaneously, the Pew Charitable Trusts created the Pew Oceans Commission, which delivered its report in 2003 and likewise called for a strengthened role for the SSCs (Pew Oceans Commission and Panetta 2003). Essentially, both groups were calling for the Councils to be bound by the numbers delivered by their scientific advisory committees.

Congress again revised the Magnuson–Stevens Act in 2006 (NMFS 2007). The amended law has many parts, but the most important to this paper are that stocks subject to overfishing were required by the end of 2010 to have annual catch limits that would eliminate overfishing. Additionally, the law states that:

> ... each Council shall, in accordance with the provisions of this Act... develop annual catch limits for each of its managed fisheries that may not exceed the fishing level recommendations of its scientific and statistical committee or the peer review process. (National Marine Fisheries Service 2007)

With this provision, the Councils are now, for the first time, required to provide 'hard' numbers for every species under their jurisdictions—an Annual Catch Limit. Furthermore, that number has to be equal to or lower than the numbers provided by their SSCs. This stipulation received little commentary during the final Congressional passage, although Representative Barney Frank (whose Congressional district encompassed New Bedford, the most profitable fishing port in the country (Portman et al. 2009) did specifically ask the ranking committee member introducing the legislation whether the SSCs would:

> ... in fulfilling their role under this legislation, consider [a] broad array of scientific opinion and sources. (Library of Congress 2006)]

Upon hearing that they would, the discussion moved on.

With this shift, though, Congress has initiated a substantial change in the relationship between the Councils and regulatory science. The longstanding ability of individual Councils to use the science provided by the assessment process as they see fit has been removed (I shift to the present tense because this is now the current reality). As the SSCs are the primary reviewers of Science to the Councils, and those reviews now included the ability to set upper boundaries on Council actions, we would

expect there to be a substantial impact on the interplay between these bodies. From a principal–agent perspective, there are specific avenues along which the alteration in the Council–SSC relationship might travel.

From a Fishery Council's perspective, the agent is now giving scientific advice that cannot be ignored and has the capacity to restrain the actions of the principal. The structure of the relationship is otherwise unaltered, so the basic tools of agent selection and contract structuring remain. If there is a conflict between the wishes of a Council and the actions of its SSC, the Council will consider changing the composition of the SSC. The Council will also consider limiting the decision-making of the SSC, by wording review requests carefully or perhaps not making them at all.

From the SSC's perspective, its members have now been placed in a situation where they may be forced to choose between Council approval or scientific credibility. We might expect the SSC to likewise avoid being forced to make those difficult choices (a mutual avoidance with the Council of reviewing certain questions). Furthermore, we might expect that the SSCs might prefer to make decisions in ways that reduce individual accountability, such as consensus decision-making. Otherwise, given the strong scientific background of SSC members and a desire to maintain the credibility that resulted with being originally selected to serve on an SSC, we would expect the SSC to refrain from being influenced by Council preferences (when known) on catch recommendations. The rewards of SSC membership are not sufficient that members would sacrifice their reputations.

A further consideration (and one not based on principal–agent theory) is that of the public as represented by interest groups invested in the fisheries policy-making process. We would expect that groups that would suffer from reductions in fisheries quotas, such as the commercial fishing industry and recreational anglers, to express unease at a reduction in their ability to influence policy via representation in the Council process. We would expect groups critical of current fisheries policies (such as environmental groups) to favor an expansion of the ability of scientists to constrain the Councils. Because NMFS has an influence on structuring the Council process via its rule-making ability, those voices have been well documented, and we will review that feedback first before moving on to the actual impact on the Councils' policy-making.

6. A newly dynamic relationship

Following the signing of the Magnuson–Stevens Fishery Conservation and Management Reauthorization Act of 2006 (MSRA), NMFS almost immediately began soliciting feedback on proposals for implementing the act, in particular the requirements that the Councils begin implementing Annual Catch Limits for all species as well as Accountability Measures for dealing with any overages in those limits. NMFS implements the Magnuson–Stevens Act through its National Standards (originally seven, later expanded to ten) for Fishery Management Plans, the first of which requires a plan to prevent overfishing and providing an optimum yield (Restrepo 1998). In the context of the new law, this means setting the new catch limits. NMFS published a notice of intent to solicit opinions on the implementation of this standard in the Federal Register and received feedback from 14 February to 14 April 2007, including opportunities for public comment at all eight Council meetings held during that time.

The volume of responses (2960, although 2479 of them were the same form letter) was sufficient that the agency aggregated and analyzed the content and sources of these opinions (Wright 2007). Responses mostly fell into predictable patterns, depending on the author. Using 'best available science' for setting catch limits, for example, was supported by nine members of the environmental community (and few others). In contrast, concerns about using inadequate or unrepresentative data for management (essentially the same thing, but with the opposite spin) were solely voiced by state fishing agencies. Environmental interests overwhelmingly argued for Annual Catch Limits to be absolute numerical limits and to include all fish species that are caught, discarded, or killed—views that found almost no support from members of other groups. The environmental community also overwhelmingly pushed for the standardization of high probabilities of success for management actions, in the neighborhood of 75–100%, as did many comments from the general public. The two comments supporting the standardization of a minimum 50% probability of success, on the other hand, were both from members of the commercial fishing industry.

The issue of buffers also provoked a large number of responses. An overfishing limit is a technical variable derived from a successful stock assessment and represents the threshold above which more fish are harvested or killed than the stock can naturally replace, but to generate a static number from that limit depends on the distribution of probabilities associated with the assessment. The comments from the environmental community strongly pushed for requiring buffers between the overfishing limit numbers and the actual catch limits set by the Councils depending on the availability of data (with less data requiring larger buffers), whereas comments in opposition to this came from fishers and Council representatives.

These latter groups also left comments that the SSCs should avoid doing anything beyond setting the overfishing level or formula lest the SSCs stumble into the policy-making arena. Environmental representatives pushed just as hard in the opposite direction, with 11 groups in favor of allowing the SSCs to set the annual catch limits for all stocks—a policy that would strip all

scientific considerations from the Council process and prevent the Councils from making any meaningful decisions beyond choosing the management system for implementing their SSCs' fishing targets.

NMFS published guidance on National Standard 1 that recommended a tiered approach, with the SSCs developing Overfishing Limit formulas (or barring that, proxy mechanisms) for all stocks in their Councils' jurisdictions, and applying it to the stock assessments or catch histories to develop species-specific biologically-based catch levels. This 'Acceptable Biological Catch' for a species is a 'hard' number, designed to represent the concerns of science, minus the complications of management. The Councils then pass Annual Catch Limits for those same species that incorporate the uncertainty of the management process—catch limits that cannot exceed the SSCs' biologically-based recommendations, and ideally undershoot it because the effects of regulations (recreational angling regulations especially) are notoriously difficult to predict. As seen in Fig. 3, NMFS recommends that the SSC set an Acceptable Biological Catch that is equal to or lower than the Overfishing Limit, and that the Councils set an Annual Catch Limits equal or lower to that—and an even lower Annual Catch Target is further recommended (but not required) that, if accidentally transgressed, does not require the Council to institute disruptive Accountability Measures such as sudden shifts in regulations in the middle of a fishing year.

The development of this system took several years to finalize, as it has been subject to the complicated process of federal rule proposal, feedback, revision, and publication. As NMFS has worked with the public and the Councils, however, the timeline included in the revised law have continued to tick away—in particular, the requirement that domestic[2] stocks subject to overfishing were required to have annual catch limits by the end of 2010 and that all remaining stocks have 'hard' quotas in time for the 2012 fishing year. The Councils and the SSCs have sorted through that process in addition to the 'regular' workload of managing established fishery management plans. The resulting jump in workload for the Councils, the SSCs, and NMFS has resulted in considerable negotiating and reconsidering of the respective roles of all.

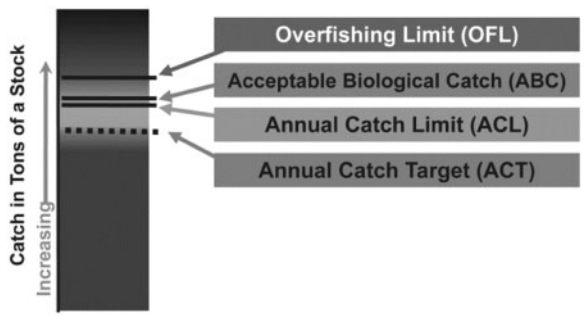

Fig. 3. Scientific and management buffers.
Source: NOAA Fisheries.

If the highest priority for NMFS has been developing guidelines for managing the implementation of the revised Magnuson–Stevens Act, then the top items on the Councils' agendas have been implementing annual catch limits to cease overfishing by 2010 and to declare annual catch limits for all species under their jurisdictions (along with accountability measures for dealing with instances where the catch limits are exceeded) by the following year.

In terms of the first goal, NMFS keeps track of 230 recreationally and commercially important species through what it terms the Fish Stocks Sustainability Index. In 2005, prior to the legal revisions, 46 of the species in the Index were undergoing overfishing (National Marine Fisheries Service 2006). By 2010, that number had dropped to 40—and nine of those were internationally migratory stocks (such as bluefin tuna) that are regulated directly by NMFS rather than the Councils. The Index itself increases in score as more assessments are completed, overfishing ends, and stocks rebuild. Out of 920 possible points, the Index score had risen from 495.5 in 2005 to 583 in 2010 (National Marine Fisheries Service 2011). Furthermore, all of the Councils have enacted measures to end overfishing, although in areas like the Caribbean assessments still needs to be conducted for verification.

Developing catch limits for all species has proven more difficult. The percentage of unassessed stocks varied widely by region in 2006. In the Mid-Atlantic Council's area (New York to the North Carolina/Virginia border), the status of all stocks has been determined through a full stock assessment process; in the waters governed by the Caribbean Council, none have been (National Marine Fisheries Service 2011). Regardless, the Councils have needed to develop 'hard' catch limits for all managed species—numbers that has some scientific basis in fact, and that did not (as per the new law) exceed the recommendations of their SSCs.

As described above, the Councils have retained the ability to select or remove members of its SSC, and to task them with very explicit terms of reference. The Councils have used both of these techniques, but subject to some constraints.

In regards to member selection, Councils must find individuals who will voluntarily review highly technical scientific documents and are also qualified to do so. As participants in an advisory committee, SSC members have traditionally been reimbursed for travel and per diem expenses, but compensation for meeting and preparation time was not permitted until the 2006 revision of the Magnuson–Stevens Act, which allowed (but did not require) Councils to pay a stipend to SSC members not employed by the Federal government or State fisheries agencies. If compensation is not the primary draw, why do SSC members serve? The most likely reasons relate to

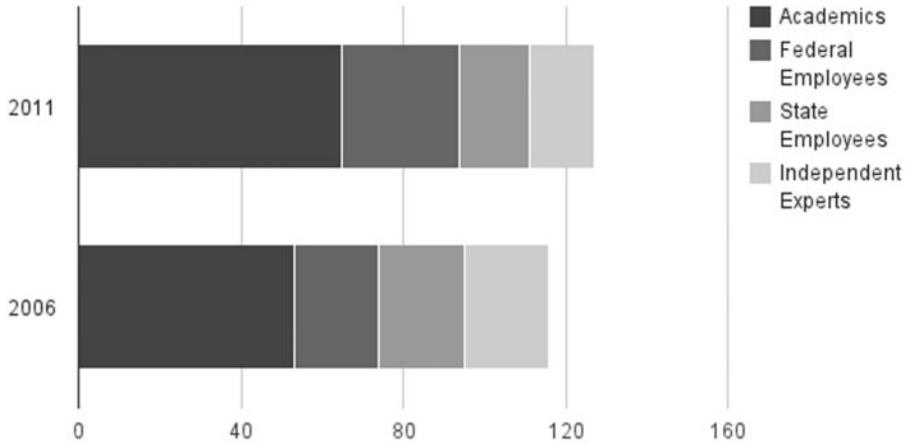

Fig. 4. Makeup of SSCs, 2006 and 2011.
Sources: Fisheries Councils.

prestige and networking. SSC members are published in peer-reviewed journals in areas related the Councils' needs, have well-recognized expertise in the regions and species affected by Council actions, or (ideally) both. SSCs often provide recommendations to their Councils for new SSC members. The professions of marine fisheries management is heavily connected through academic and work ties, and membership on an SSC, if not prestigious, is still a recognition of individual expertise significant enough that it is suitable for a Fishery Management Council to consult it. The SSC is also a good place for members of the field to find potential research collaborators who work in their area. In terms of their professional behavior, they are more likely to consider themselves 'horizontally accountable' to other members in their field (Schillemans 2008) than to the Councils that appoint them. Hence, a Council's ability to influence SSC members via the selection process is limited.

This is not to say that that there have not been significant changes in the membership of the SSCs since 2006. One reaction to the increasing workloads under the revised law has been to increase the number of individuals serving. The size and membership of the SSCs has expanded since the law was revised, from 116 total members in 2006 to 127 total members in 2011. As the demands on the SSC have grown, the Councils have shifted the membership by adding academics and federal employees, and reducing the number of state employees and independent experts, as shown in Fig. 4.

The cause of the change in membership composition is unknown. The Councils cover all travel and per diem expenses for SSC members (save those of federal employees, which are handled directly by NOAA), but state employees are not eligible for daily stipends for SSC service under current law as academics and independent experts are (Seagraves and Collins 2012). The current state of state budgets may be a large factor, as was voiced during the 2011 National SSC Workshop—with fewer

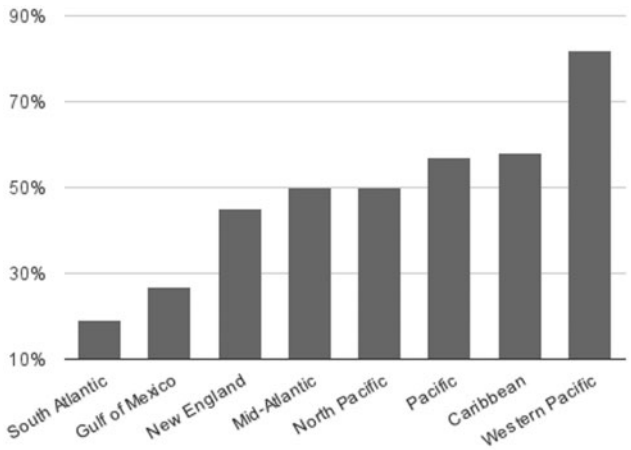

Fig. 5. Percentage of 2006 SSC membership still present five years later.
Sources: Fisheries Councils.

staff handling the same responsibilities, the time to invest in multi-day meetings several times a year may not exist as it once did (present author's notes from meeting). Turnover in the SSCs (as measured by the percentage of 2006 membership rosters still serving five years later) varies widely by Fishery Council, from low of 19% on the South Atlantic Council SSC to a high of 82% in the Western Pacific SSC. Service on an SSC must be mutually agreed upon, and it is unknown how many members leave an SSC by resigning or not asking for reappointment to another term as discussions of SSC membership compositions are held in closed Council sessions. The Western Pacific Council allows SSC members to serve indefinitely and had the lowest turnover ratios (see Fig. 5). The remaining SSCs have fixed, renewable terms for members of between one and three years (Witherell and Dalzell 2008). Turnover has been higher in the Atlantic SSCs, particularly the Gulf of Mexico and the South Atlantic, both of which have reliable landings data but a large number of unassessed stocks (64% and 62%, respectively) (National Marine

Fisheries Service 2011). Because those are the stocks that require the development of alternative methods for determining allowable biological catch levels by the SSCs, it is possible that Councils have used membership selection as a tool to limit the influence of their scientific advisors. Another explanation (not necessarily conflicting) is that SSCs with the most difficult workloads (making control rules for unassessed stocks) have seen more members decline reappointment. However, the three SSCs with the lowest turnover (Pacific, Caribbean, and Western Pacific) also have assessed less than half of their stocks, so the relationship between changes in SSC membership and SSC decision-making is unclear.

As agents of their respective Councils, the SSCs have not traditionally been in close contact with one another. SSC members sometimes serve on multiple SSCs, though, allowing some cross-pollination of SSC ideas and concepts. Cross-examination of SSC membership rosters reveals that the Atlantic-based SSCs often have members who also served in geographically close SSCs. For example, the SSC for the South Atlantic Council includes members who also serve on the Mid-Atlantic, Caribbean, New England and Gulf Council SSCs. Given the overlap in fisheries and species at Council boundaries, it is understandable that the limited expert pool would sometimes be spread out. In contrast, the more geographically dispersed Councils of the Pacific region currently share no SSC members in common.

The more significant impact on the relationship between the Councils and their SSCs has been the explicit development of the rules under which the SSCs make recommendations to the Councils—particularly the acceptable biological catch recommendations for stocks that the Councils may not legally exceed when setting catch limits. As the Councils lack the scientific knowledge of the SSC members, this process has been educational and at times tense, reflecting the bilateral monopoly that is essentially a reciprocal relationship.

The primary technique of the SSCs for dealing with the ABC requirements has been to develop 'control rules' (systematic approaches) for making biologically-based catch level recommendations to their Councils. Different approaches have developed, depending on the area of jurisdiction and the availability of data for stocks. SSCs advising Councils with a large percentage of assessed stocks (especially those in the Mid-Atlantic, North Pacific/Alaska, and New England) primarily relied on a P* approach, which includes a scientifically-based estimate of the uncertainty surrounding a probability of overfishing a stock (Prager et al. 2003). Under a P* approach, a Council decides a risk tolerance policy for a fishery, and the SSC then applies the P* analysis to the stock using scientific standards. SSCs required to set biologically-based upper limits in the South Atlantic and the Gulf of Mexico (areas with large numbers of unassessed reef fish species under management) developed semi-quantitative approaches for those stocks, assigning stocks to tiers depending on assessment status, life history characteristics, current stock status and whatever uncertainty levels could be quantified (Patrick et al. 2010). SSCs in areas lacking little information beyond incomplete catch records like the Western Pacific and Caribbean were forced to make estimates based on discernible trends in catch and effort (Witherell 2009). The institutionalization of control rules for setting ABCs has not been finalized in all regions, with interim catch recommendations used for many species as temporary measures.

The application of semi-quantitative approaches has sometimes been controversial. Councils who agreed to the use of the semi-quantitative control rules in the abstract sometimes balked at their actual application to some stocks. Tiered approaches are designed to trigger additional buffers to deal with the added uncertainty about stock health, and when initially applied to unassessed stocks the approach was requiring the SSCs to set catch levels that were often 25–50% (or greater) reductions from what resources users in their area had grown accustomed to harvesting. Some Councils began rejecting the recommendations of their SSCs and asking for reconsideration of ABCs, forcing further development of control rules that are not (from the Councils' perspectives) unnecessarily conservative (Seagraves and Collins 2012). SSCs may address this by developing policies under which they will reconsider a maximum catch level recommendation. For example, the SSC of the Mid-Atlantic Council will only reconsider a recommendation if new data is found or an error is discovered in an assessment (Mid-Atlantic Fishery Management Council 2009). Such an arrangement, of course, has to be approved by the SSC's Council and as such represents a mutual agreement. Remanded catch level recommendations can, however, produce lower catch recommendations due to new modeling information, as has had happened with the wreckfish fishery (South Atlantic Fishery Management Council 2012).

SSCs have also had to consider whether 'underages' (annual catches that are lower than the limit a Council has set in place) can be added to quotas for the following fishing year. In the Gulf of Mexico, the widespread area closures put in place in the summer of 2010 in response to the Deep Water Horizon oil spill meant that the red snapper harvest was roughly a million pounds under the catch level the Gulf of Mexico Fishery Management Council had established for that species. The Southeastern recreational fishing industry, especially the chartered headboats, has relied on red snapper for decades as a staple that customers are willing to pay to catch (Holland et al. 1992). Red snapper has been a contentious fish in the region, subject to moratoriums (currently in place in the area under the South Atlantic Fisheries Council's jurisdiction), large seasonal closures, and the eventual implementation of a catch share system

for the commercial fishery in the Gulf of Mexico. The Gulf Council asked its SSC to consider 'rolling over' the 2010 underage into the following fishing year. That SSC eventually agreed to raise the 2011 limit by 300,000 pounds to make up for the 2010 underage—only to face an overage that year anyway, forcing the Gulf Council to implement a measure to 'make up' for the overage in 2012 through more stringent regulations (Powers 2011).

SSCs have negotiated additional agreements with their Councils to preserve scientific independence. No SSCs currently allow alternates to attend in place of members who are unable to attend a meeting, as that might imply that:

> . . . you're representing your agency or your stakeholder group or whoever pays your paycheck. You are there as an objective scientist. (Witherell and Dalzell 2008)

Almost all SSCs operate on a consensus model rather than have explicit votes, which makes it more difficult to hold members individually accountable. Roll call voting by scientific bodies may better encapsulate scientific uncertainty (Guston 2003) but it also adds very specific valuations of the amount of uncertainty by implying that close votes are less certain. A Council might therefore find it easier to remand an ABC recommendation back for reconsideration.

7. Conclusions

The SSCs of the Fishery Management Councils were originally designed as advisors to help the Councils wade through the complexities of stock assessment and policy science. Due to the 2006 revisions to the Magnuson–Stevens Act, they have become quite a bit more, but are still subject to Council authority. The revisions to federal fisheries law, as shown above, had a significant impact on the relationship between the political body charged with making policy decisions and the scientific body charged with sorting through the reams of data and risk assessments. Ultimately, how were the relationships changed, and what might we expect from similar changes in other areas? What has been the impact on the policy-making process?

Lentch and Weingart (2011) lay out four criteria for securing quality scientific advice: distance between advisor and advised, representation from multiple disciplines, transparency of the process, and open access to the information. By those standards, the Council–SSC relationship is doing quite well and has been improved by the new requirements of the Magnuson–Stevens Act. The changes undoubtedly increased the burden on both the Councils and on the SSCs. The process of setting new catch levels now requires a long dialogue between the two groups. The SSCs simultaneously require information on acceptable levels of risk tolerance from the Councils and need to inform the Council about the likely statistical and biological consequences of setting those risk tolerance levels. The Councils cannot assume extremely high levels of risk tolerance and expect SSC compliance, as the SSCs are unlikely to set upper boundaries to catch levels that are unlikely to rebuild or maintain a stock. The process requires a certain level of give-and-take and is particularly lengthened when the policy-making body and the scientific advisory body are not meeting concurrently.

Furthermore, maintaining the principal–agent relationship between a policy-making body and its scientific advisors—defined by the fact that the advisors are still chosen by the policy-makers, and not independently appointed by an external actor—does not mean that the principal will tightly control the situation by acquiring and releasing agents. The complexity of the scientific process means that there are a limited number of advisors available, and the length of time required to set catch levels combined with a legislative deadline meant that a large amount of continuity in the SSCs had to be preserved for the Councils to be in compliance by the end of 2011. Failure for the Councils to act ultimately meant that the Secretary of Commerce might choose to reconstitute them or issue catch levels directly. As long as the policy-makers have legal accountability, then they will have to work with their scientific advisors. Undoubtedly some of the changes in the SSC memberships were due to conflicts with Councils, but the Councils did not 'run over' the SSCs or their deliberative processes.

Likewise, scientific advisors are by definition not working directly for policy-making bodies. Their primary rewards are increased prestige and satisfaction in providing valuable information in an area to which they have dedicated their careers. SSCs did not simply follow the preferences (where discernible) of their principals, but instead developed dialogues with policy-makers. Science advisors are not omnipotent and, in particular, need to deal with tolerance for risk. The requirement that the Councils not exceed the recommendations of the ABCs meant that they could become, in effect, better policy-makers with a better understanding of how risk is quantified.

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Notes

1. Non-voting representatives from the US Fish and Wildlife Service, State Department, regional interstate fishing commissions, and the Coast Guard (which ultimately enforces regulations at sea) participate in Council meetings.
2. Some stocks (such as bluefin tuna) are managed under international agreements.

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