Factors influencing the scope and quality of science and management decisions (The good, the bad and the ugly)

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Abstract

The lecture traces the historical path to overfishing of the world's fish and shellfish stocks, and provides an assessment of marine fish resources in the later half of the 1990s. The basis of overfishing as noted by various fishery scientists is reviewed. Four factors, including institutional paralysis, the rapidity of technological developments, uncertainty of science, and the inability to monitor and enforce regulations are identified as the major problems leading to overfishing. The failure of the world community to deal with extensive overfishing, appears to have motivated managers and scientists to promote a new fishery management paradigm that focuses on a broader set of problems resulting from fishing, and establishes a more conservative decision-making process founded on precautionary principle and uncertainty. The author feels that the evolving paradigm will result in the rebuilding of a number of stocks in the United States, but is less certain of its adoption on a global scale, and whether or not science will play a more useful role in fisheries management. It is noted that the support for fisheries science and the status of fisheries have followed opposite courses. Over the past half century marine science has boomed, diversified and become intellectually and materially enriched, while the number of overfished stocks and ecological disasters has increased. Looking ahead it is expected that fisheries management will move into a more conservative era. The focus of fisheries has moved from full use of ocean resources to establishing yields that take into account the impacts of fisheries on target and non-target species and the ecosystem in general. Although there has been widespread abuse in the use of the world's fishery resources and condemnation of the fishing industries, the author feels that the government institutions must bear the primary responsibility for the historical course of fishery management and its failure.

Key words institutional paralysis, overfishing, paradigm shift, status of stocks, technological innovations, uncertainty

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Introduction

When I was asked to give the Larkin Lecture several months ago, I felt very honoured. Dr Larkin was a friend, a colleague, a mentor, an individual who made remarkable contributions to the field of natural resources management. As I began to sort through and consider the possible topics for the lecture, I became acutely aware of certain limitations. My contribution to fisheries science and policy has been winding down over the past decade, and I have not been engaged in any original research in recent years. Then, I read the papers of the previous Larkin lecturers.

An inner voice kept telling me, "you don't really have anything new or exciting to add to what has already been said". Recognizing the dilemma, it dawned on me that the debates regarding the state of global fish stocks, the ocean environment and the rational use of its resources had transcended my entire career. But, I had not put down in writing any comprehensive views on these issues. The legacy of a half-century as a fishery biologist, manager, and consultant, regarding factors perceived to have influenced the scope and quality of fishery science and management, follows. The selected sub-title has nothing to do with the movie having the same name, but rather incorporates some of my hidden perspectives on the course of fishery management history during the time period spanned. The audience has the choice of selecting among the adjectives to characterize the different time periods and events in the described history.

The path to overfishing

The rapid development and growth of marine fisheries, and the evolution of science and conservation policies that all have contributed to both expansion and responsible resource utilization, are activities almost exclusive to the 20th century. The process of intensification of harvest of marine fisheries that started even before the Second World War, accelerated notably after the termination of hostilities, leading to an exponential growth of fish production over the next several decades (Kelly and Harris 1994). The war, which had ravaged and decimated many of the traditional fishing fleets in the Northern Hemisphere, left an unexpected opportunity for technological advancement and spurred the development of complex fleets of modern, high-tech trawlers, seiners, driftnetters, squid vessels and long-liners, whose operations ultimately extended into all major oceans and their adjacent seas. It left me with a set of sad and warm memories, and the opportunity under the G.I. Bill of Rights to get an education. Thus, I arrived on the scene.

The early post-war fishery development involved the replacement or conversion of vessels lost or commandeered for military service. The post-war fleets rapidly abandoned steam for diesel propulsion, and adopted available World War II electronics, and within a decade moved to more durable and stronger synthetic nets. The fisheries of Northern Europe and Asia returned to their traditional fishing grounds. As the historical grounds were fished down and new competitors from Eastern Block nations appeared, the growing demand for fish could not be sustained. The solution was simple: expand to alternative, more productive distant-water fishing grounds.

In the later part of the 1950s, scientists had begun to speculate on the potential of the world's oceans to produce fish for a protein-hungry world. By the early 1960s, a range of estimates emerged which forecasted global, ocean sustainable, marine fish and invertebrate yields ranging from 50 to 2000 million metric tons (mt) (Schaefer and Alverson 1968). However, many scientists, fishery managers, and politicians ignored the caveats that limited and constrained achieving the stated production potentials. Instead, they seized and extolled the more optimistic forecasts. By the late 1960s, the famous Stratton Commission report (Stratton and Commissioners 1969) was issued, which echoed the optimism of certain sectors of the scientific community. Its

authors proclaimed, "It would be realistic to expect total annual production of marine food products to grow between 400 and 500 million mt annually, before expansion costs limited further development." 'Food from the sea' became a selling point for an expanded marine science programme in the US, as well as many other countries and sectors of the United Nations (UN).

It was an era of great enthusiasm in marine research. Resource exploration became a significant component of many national fisheries science programmes. Funds for the exploration and documentation of the untapped living ocean resources flowed from the UN Development Programme, the World Bank and other national entities as well as from private sources. The fields of population dynamics, resources assessment, fish behaviour, general biology of the exploited fishery resources, and fisheries oceanography were energized and given a higher funding priority at the national and international levels. In the US, the Sea Grant programme was seeded, and flourished. New high seas vessels were added to the fisheries research fleet, and new and expanded fishery laboratories were built in many areas of the world. Fishery management strategies that were linked to maximum use of surplus production (maximum sustainable yield, MSY), were strongly promoted by the major fishing nations, particularly by the US, thrived and became a pervasive management goal on a global scale.

Throughout the 1960s, 1970s and into the early 1980s, global explorations flourished, which added momentum to the international race to the sea. Whether or not these programmes were a major catalyst in the global expansion of fisheries is not well-documented and perhaps not relevant. Government promotion and industry commitments to expansion were significant and the rapidly increased fishing capacity and world fish totals reflected the success of their efforts. In the two decades following the World War II, the world fish catch increased over 300%, and the optimistic estimates of the ocean's potential looked good (Fig. 1). It was a period during which the major world fisheries were transforming from national to international markets, and the industry and government organizations were transformed and internationalized.

By the late 1960s, the success of the distant-water operations had engendered its own set of problems. The number and size of foreign vessels operating off

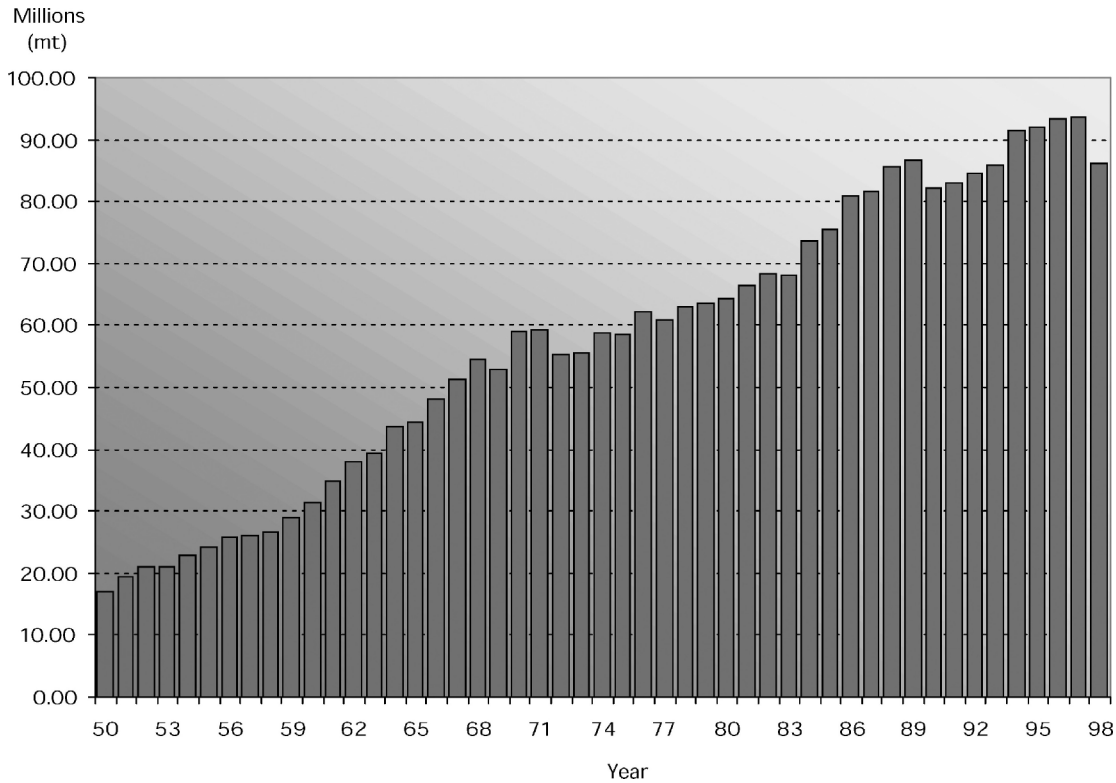

Figure 1 World marine commercial wild fishery harvest 1950–1998.

coastal states promoted allocation and conservation disputes. As the level of foreign fishing increased, the reported number of overfished stocks escalated and the bilateral and multilateral arrangements established to undertake fishery science and to provide advice to managers began to lose credibility. Simultaneously, the concept of freedom of the seas was attacked. Scholars, fishery managers, fishery scientists and politicians suggested alternative jurisdictional schemes, conservation objectives, and the priority rights of coastal states. The concept of freedom of the seas eroded and a number of nations began to unilaterally extend their jurisdiction over ocean space to 200 nautical miles from their coastlines.

Mounting international pressure resulted in the UN Conference on Law of the Sea III (UNCLOS III), and within hours after the opening of the first planning session, it was apparent that the world community would trash 300 years of Grotius Mare Liberum (Kelly and Harris 1994), in favour of the broad extension of national jurisdiction over the living and nonliving resources of the seabed. UNCLOS III grew into a protracted global debate, which extended into the next decade. Nevertheless, its doctrines regarding fisheries jurisdiction were adopted by a host of countries during the 1970s (Kelly and Harris 1994).

The problems of overfishing, that had accompanied the 'colonization' of distant-water fishing grounds during the post-World War II expansion era, continued throughout much of the late 1970s and 1980s, but mostly under the auspices of extended national management. The jurisdictional revolt that had established a radically new legal regime, including an array of commitments to conservation, seemed to have swept in with it all the institutional failures that had plagued fishery management during the great era of expansion. Quoting from Miles (1994), "We are forced to conclude that there is no necessary connection between extended coastal state control over fisheries and improved management performance." The conclusion must be that the underlying political and socioeconomic pressures, which galvanized growth, expansion, and overcapitalization of distant-water fisheries, continued to fuel and influence the development and management polices in the years following the extension of jurisdiction to 200 nautical miles.

During the 1980s, a number of conservation and environmental groups extended their interest to the ocean's living resources, paying special attention to the impacts of fishing on nontarget species, such as marine mammals and birds. The issue of ecological impacts of fishing surfaced, and by the early 1990s, a number of marine scientists and fishery managers sounded the alarm that global overfishing was becoming a major problem, thus contributing to production losses and economic tragedy (Hinman and Paulsen 1993; Alverson and Larkin 1994; Collins 1994; Holmes 1994; Grainger and Garcia 1996; Mace 1996; Pauly 1996; Garcia and Newton 1997; Alverson and Dunlop 1998; Pauly *et al.* 1998). By this time, Ludwig *et al.* (1993) had noted the demise of open access fisheries and the 'ratchet affect' leading to overfishing. Their paper fostered a growing debate on the contribution of science to fisheries management and the status of the world's marine fish stocks.

Reflections on the state of marine fish resources

A couple of years ago, a colleague and I examined the state of the world's marine fisheries. The study was stimulated by the increasing diversity of views and conflicting statements by various fishery scholars, the UN, and non-governmental organizations regarding the state of the world's oceans. At its onset, the status evaluation was based on the status classification used by the UN Food and Agriculture Organization (FAO) (Alverson and Dunlop 1998). In the present study, we considered three possibly 'stressed' stock scenarios, based on marine fishes, for which UN status evaluations were available. The analysis included:

Scenario A. A tabulation of all species/stocks reported as fully exploited, over-exploited, depleted or recovering, including multiple listed stocks within the above classifications;

Scenario B. A tabulation of all of the above stocks, but excluding fully-to-heavily fished stocks; and

Scenario C. A tabulation of only those stocks uniquely identified as overfished, depleted, or fully-to-over-exploited.

The results of these tabulations are shown in Fig. 2, and are based on the number of stocks and catch in each of the three classifications. Scenario A is equivalent to the grouping used by Garcia and Newton (1997), when they noted that roughly 60–70% of the marine fish stocks "were in need of urgent management". Scenario B is also similar to the number of overfished, depleted and recovering stocks reported by these same authors. Scenario C provides a more

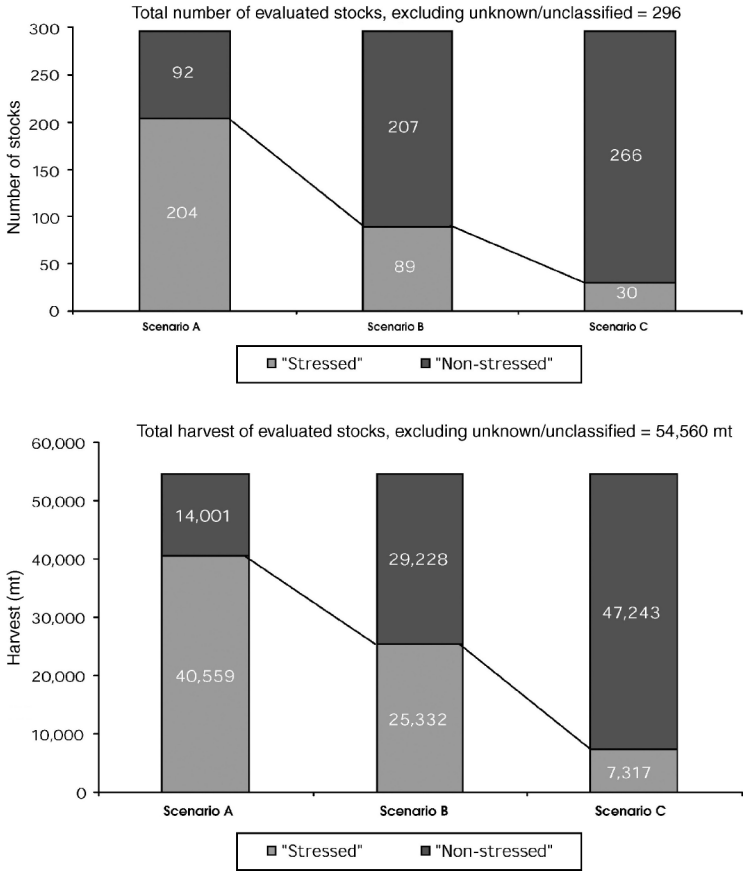

Figure 2 Cumulative status of FAO classified stocks by number and weight (mt $\times$ 10^3) presented by Scenarios A, B and C.

optimistic grouping. The scenarios encompass a range of perceptions, which various interest groups might use to portray the status of marine fishery resources. If the underlying classifications are consistent with the FAO database and the assumptions are properly defined, they constitute responsible observations. Nevertheless, the manner of groupings results in each scenario having a significantly different perception regarding the need for fisheries management.

The distribution of overfishing (mid-1990s), by FAO statistical regions shows the Atlantic Ocean as having the largest number of overfished stocks (Fig. 3), exceeding that of all other oceans. The Atlantic alone

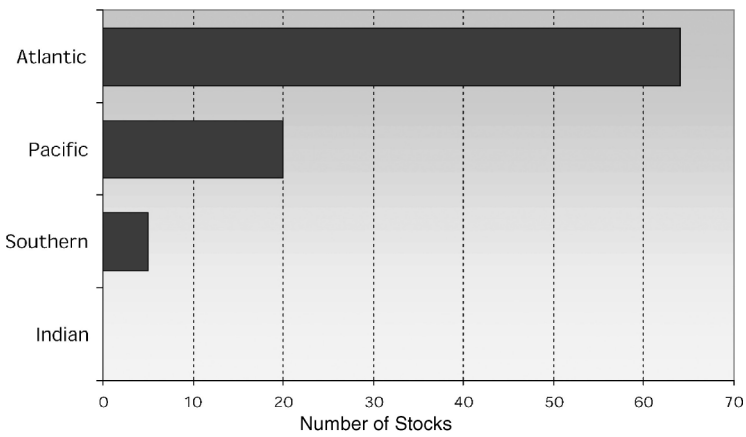

Figure 3 Overfishing by ocean as the number of stocks overfished.

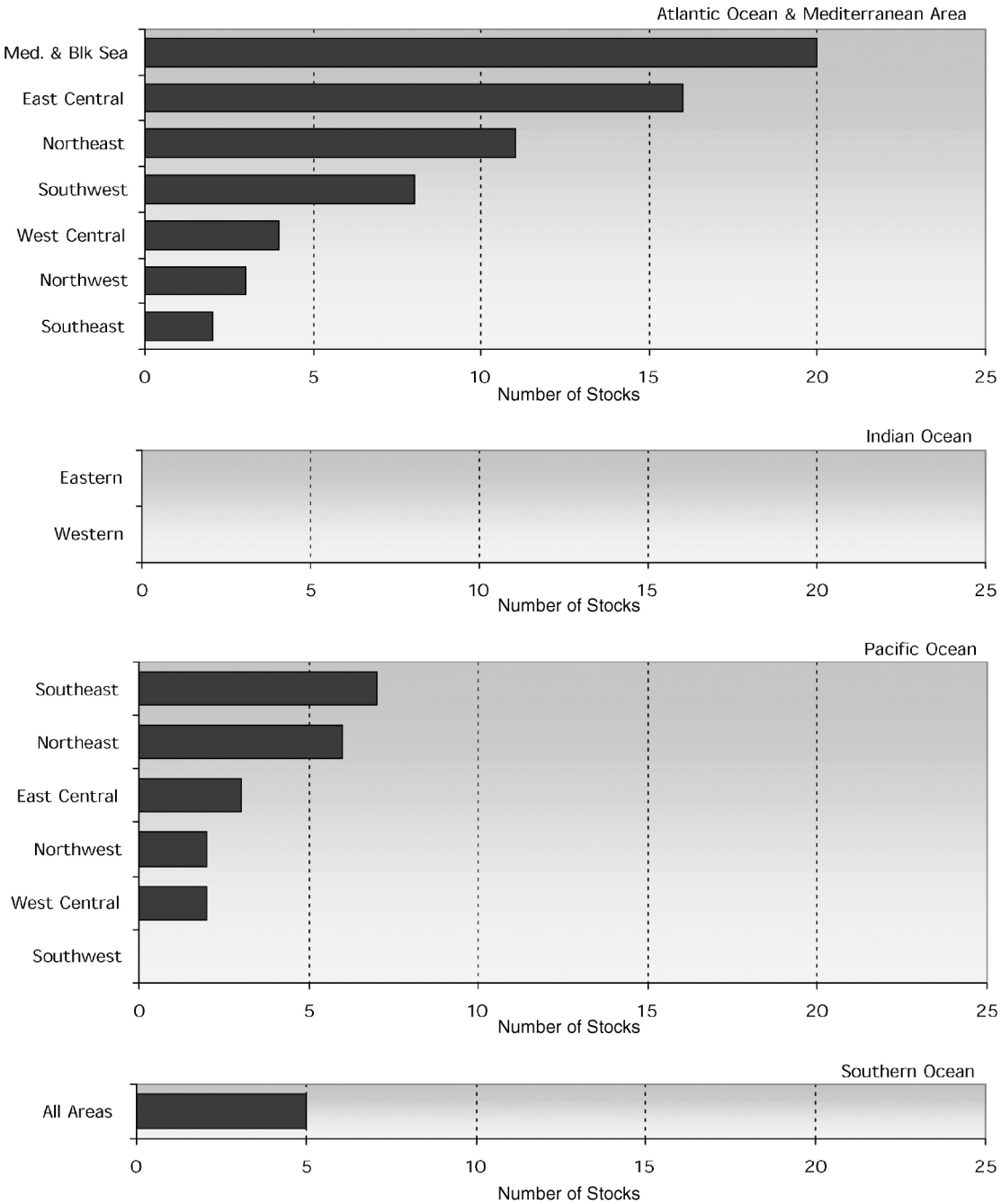

Figure 4 Overfishing in major FAO regions as the number of stocks overfished.

accounted for 62 of the 89 stocks reported (or about 70%) as overfished in the 1997 FAO status report (overfishing by statistical areas within the Atlantic is shown in Fig. 4). In the Pacific, the Southeast and Northeast regions account for more than half of the overfished stocks, but the total number of reported overfished stocks amounts to only 22% of the total. No overfished stocks were reported in the Indian Ocean, but five stocks in the Southern ocean are noted to be overfished.

If we examine overfishing by taxonomic groupings, redfishes dominate with 22 stocks in difficulty.

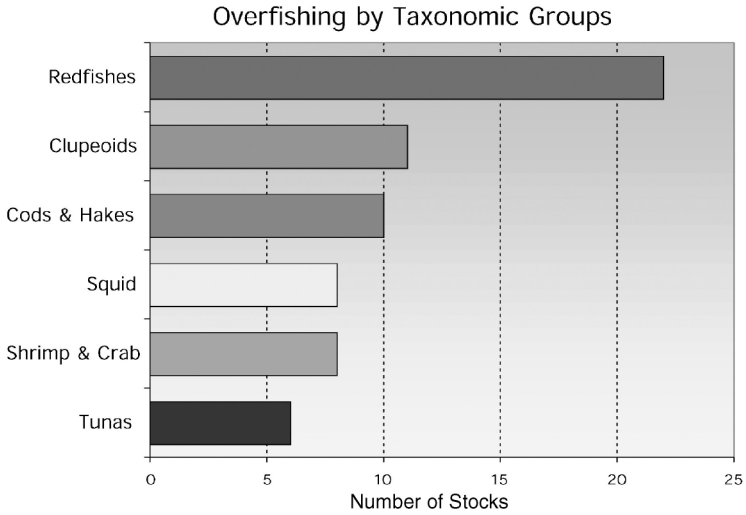

Figure 5 Overfishing by taxonomic group as the number of stocks overfished.

Clupeoids, cods and hakes, shrimps and lobsters, squids and tunas all have multiple overfished stocks (Fig. 5).

The perception of the status of the world's marine fish resources has been frequently influenced by (1) the selection of the categories of stocks considered to be in difficulty and stressed as a result of fishing, (2) the extent to which overfished stocks are presumed to have been depleted, (3) the level and scope of national status reports, (4) the credence placed on stock estimates, and (5) the presumed capacity of the world's oceans to produce optimum and sustainable yields. The status perception varies between individuals, academic institutions, nations, international entities, stakeholder groups, and politicians.

In more recent years, the FAO status reports have become much more robust and are not merely an accounting of stocks in the various status categories. Current reports incorporate regional reviews involving discussion of trends in particular resources and the environment. Nevertheless, the status of marine fish stocks may be worse than that implied in a strict interpretation of the FAO status report because:

1 The status of many stocks in developing states is not clear and may not be reported to the FAO;
2 The FAO classification deals only with targeted species and does not include nontarget species that may have been overfished as a result of bycatch;
3 The conditions of many small-scale inshore fisheries are not included in the FAO analysis;
4 The timing of the FAO reports is such that the database and conclusions are always several years out of date; and
5 Unobserved fishing mortality might have resulted in underestimates of the impacts of fishing on the stocks and their habitats.

Despite certain limitations of the FAO status of stock reports, policymakers, stakeholders, the public and news media frequently reference them. These status reports have, to a significant degree, stimulated recent conservation and management initiatives, such as the FAO Code of Conduct for Responsible Fisheries, the UN Stocks Straddling and Migratory Stock Agreement, the application of the Precautionary Approach, and the International Plan of Action for Fishing Capacity (FAO 1995c, 1995d, 1999; Alverson and Dunlop 1998). They have also been used in an irresponsible manner to misrepresent the state of marine resources (Alverson and Dunlop 1998). I do not believe the world's marine fish stocks are in a catastrophic situation. It is the author's view that many of the stocks designated as overfished by FAO are suffering from growth overfishing, which could be easily rectified by reductions in effort or adjustments in gear selectivity. Further, it is felt that many fish stocks are rather robust and that they will rebound if appropriate conservation actions are taken. I remain guardedly optimistic that a new conservation ethic is being adopted throughout much of the world. This paradigm shift and the political support driving it should alter the behaviour of fisheries managers, leading to more conservative decision-making and the opportunity for stock-rebuilding.

The basis of overfishing

The number of papers speculating on causes of overfishing is surprising. The literature is rich in retro-

spective views on this issue (Hinman and Paulsen 1993; Ludwig *et al.* 1993; Alverson and Larkin 1994; Alverson *et al.* 1994; Fox 1994; Holmes 1994; Miles 1994; Mace 1996, 2000; Meyer 1996; Pearse 1996; Santen 1996; Alverson and Dunlop 1998; Healy and Hennessey 1998; Sainsbury 1998; Heinz 2000; Hennessey and Healy 2000; and many others).

Quoting from the above chorus and the public media, overfishing is the result of a range of factors, such as industry greed, overcapitalization, poorly defined objectives, open access fisheries, uncertainty in science, the inability to effectively monitor and enforce regulations, institutional paralysis, institutional voids, user group influences, the pace of technology, a spectrum of subsidies to fishers and fish processors, consensus management, the inability of managers to establish conservation regimes that constrained fishing to optimum yield (OY) or MSY levels, failure to deal with allocation and equity/fairness aspects of management, belief in the rich bounty of the seas, the inability of science to differentiate between anthropogenic and natural impacts on fish stocks and their ecosystems, the constant debate regarding what constitutes overfishing, risk-prone management decisions, failure to account for bycatch and other unobserved fishing mortality, etc. This is a rather exhaustive list, but far from complete. Each of these items has, in various ways, contributed to overfishing problems, at one time or another, in some places. Many of the leading fishery scientists seem to have made observations on this topic.

Regardless, failures in management that have led to overfishing on a global scale have not been examined in any real detail (Meyer 1996). There seems to be no comprehensive pathology of our failures. Of course, there is a smattering of case histories concerned with overfishing. Hennessey and Healy (2000) provide a detailed and excellent history of the collapse of New England groundfish stocks, but many historical reviews concerned with overfishing leave the reader confused as to the underlying causes. Most of the above noted factors dealing with the causes of overfishing are the opinions of various scholars, scientists and resource managers. As for fisheries science, Ludwig *et al.* (1993) dismiss it as having any significant influence on renewable resource conservation. Instead, they suggest socio-economic and political factors have driven fisheries towards collapse. In their model, there are four major components to the overfishing 'ratchet' equation:

1. Profit or the promise of profit in the fishery attracts political and economic power that, in the face of uncertainty, drives the decision-making process;
2. Science is unable to measure the abundance of fish accurately enough to predict the future status of the fish stocks well enough to demonstrate the negative effects of over-exploitation until it is too late;
3. In the face of uncertainty, investment in the fishery expands to the point that rents are dissipated, and the economic viability of individual fishing units becomes marginal; and
4. When there is a short-term increase in fish abundance, investment in the fishery expands. When there is a short-term decrease in fish abundance, disinvestment is slow and the industry appeals to government for assistance. Governments typically give assistance, ostensibly as a short-term measure. In reality, the assistance tends to become incorporated into the functional economics of the fishery.

Ludwig's 'ratchet' is a compelling and simplified explanation of the path to overfishing. I suspect there are many fishery failures that can be traced to the four identified elements of the ratchet, but perhaps the ratchet explanation is too narrow an interpretation of the overfishing problem. The ratchet explanation does not incorporate overfishing problems that might be traced to bad scientific advice or the inability of management agencies to monitor or enforce enacted legal regimes, even when the scientific advice is clear and uncontested. Further, it is unclear to me the nuance or spin the authors intended in stating that science has not had any significant influence on renewable resource conservation. If the suggestion is that science, because of its uncertainty, failed to significantly alter the slippery slide to overfishing, I suspect they are right. However, there are obvious exceptions.

From my point of view, fishery science has been a major contributor to the (a) expansion and growth of fisheries in the post-war era; (b) conservation strategies employed in the Northwest Pacific and Alaska that have led to successful natural resource management; (c) the formulation of conceptual models against which MSY, OY, and rational management could be tested and even if not followed, they provided a sustainable-use strategy to evaluate the success and failure of management; and (d) development of scientific advice to many management groups. Some of these were applied successfully, some ignored because of uncertainty, and some

cast aside because of the political influence of user groups and the potential socioeconomic consequences of proposed management (Hennessey and Healy 2000). There remains the question as to whether or not overfishing stemmed largely from uncertainty in science or an unwillingness to accept the scientific recommendations in the face of strong user-group political influences. This difference may be a matter of semantics, and the 'ratchet affect' provides a model that could account for an important component of overfishing that became widespread in the 1980s and early 1990s.

In my review of overfishing, four major factors appear to have formed the basis of overfishing during the post-war and the present era. These include (a) institutional paralysis, (b) the rapidity of technological development and fisheries expansion following World War II, (c) the uncertainty of scientific advice, and (d) the inability to monitor and enforce fishery regulatory regimes. A multitude of factors frequently noted as elements in the overfishing equation could be clustered under these four factors.

Institutional paralysis

The management entity has been, and is, the focal point for natural resource decisions. It establishes the goals and game rules, and relies on a set of referees to monitor the game process. It is the tool that the players and other interested parties use to address their problems. Decisions are ultimately based on the technical and socioeconomic evidence and advice given by the scientists and the concerns of the user groups. The process can be compared to a 'tug-of-war'. On one side are the users who frequently sought assistance from the politicians, and on the other side are the scientists and fishery managers. Until very recently, the big advocacy guns were in the holsters of the developers (Fig. 6). These are the people pictured with black hats. Thus, as noted by Ludwig *et al.* (1993), the political and economic factors, plus the inability to enforce adopted regulations has driven many fisheries to levels and conditions that have been characterized as overfished.

In most instances where fisheries management has succeeded (1) the management institutions retained the political support of the resource(s) users, (2) they were able to monitor and enforce imposed regulations, and (3) they largely accepted the advice of their scientists. The anatomy of institutional failure is, however, not well understood and Santen (1996) notes, "Without a basic understanding of the institutional processes which determines the actual outcome of fisheries management, the effectiveness of fisheries management is bound to continue to be restricted and inequitable."

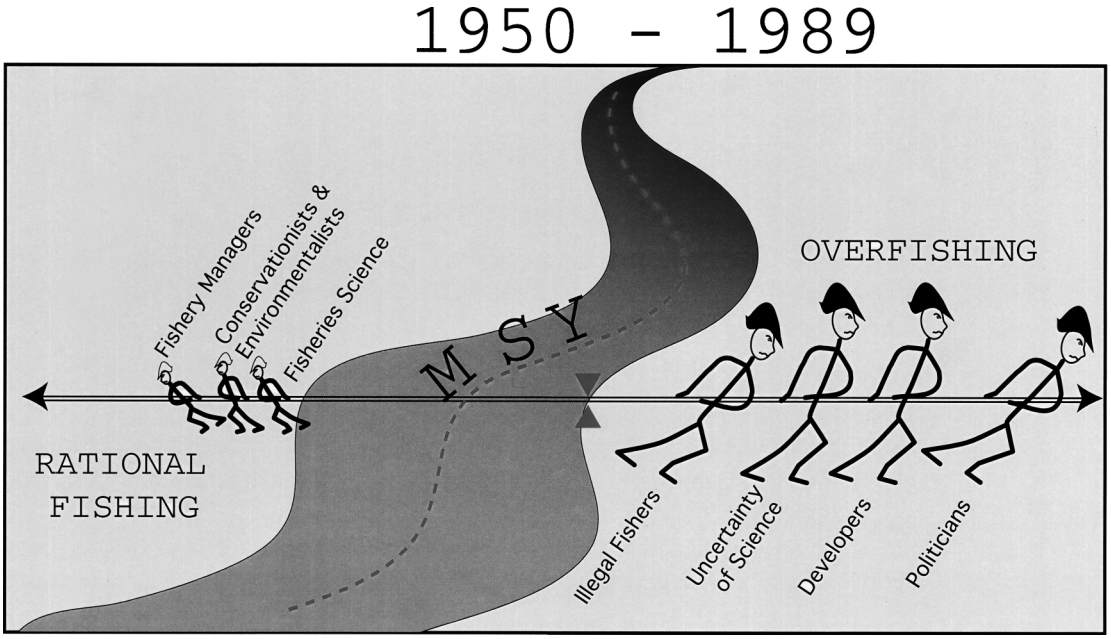

Figure 6 Struggle between user groups and interest groups over world fishing in 1950–1989.

Rapidity of technological development and fisheries expansion

The expansion of fisheries following World War II was fuelled by an urgent need to provide animal protein to areas of the world ravaged by the war. Entrepreneurs in Europe, Asia and North America adopted the technological innovations that could lead to profitable operations. Fisheries, both small and large, became engulfed in the great race to the sea. Harvests accelerated, catalyzed by technological innovations and the freedom to move from one fishing ground to another around the world. The visions of the ocean's bounty were reinforced by a number of high profile fishery scientists, and the globalization of fisheries soon became a reality (Stratton and Commissioners 1969). A sharp rise in fish prices in the early 1980s fostered further expansion and diversification to alternate target species. Jurisdictional changes pushed exploration and development to areas beyond national control and fisheries began to exploit the deep continental slopes and submarine ridges of the world. Governments were often caught in an internal conflict of interest; many were both natural resource managers and at the same time promoters of expansion who provided information on growth opportunities and direct and indirect subsidies to fishers. The political and economic forces for continued and greater production and the socioeconomic concerns of users frequently won over conservation arguments. The pace of development and technological innovations greatly exacerbated the job of the scientists and added to the uncertainty of the status of stock analysis. The rapid expansion of the Soviet fleets in the Atlantic and Pacific, surge of new technology into the Northeast Pacific, and the distant-water developments off Africa are examples, where vessel and fishing gear technology moved rapidly. Sainsbury (1998) notes, "Increased technology has arguably been the major factor driving fishery impacts and resource assessments in the past 50 years."

Uncertainty in fisheries science

Fisheries science in the post-World War II years evolved during a period of rapid fisheries expansion and changes in shipboard technology. The pace of development frequently surpassed the capacity and ability of the scientists to stay abreast of these developments and account for the continued changes in vessel-fishing efficiency. The quality of fishery data available to make management decisions was frequently poor and delayed, thus the mandate to establish yields that would leave the fish populations at sizes that would produce MSY was difficult (Fox 1994; Sainsbury 1998). Fisheries scientists perhaps confused managers by continued technical debates over (a) what constituted overfishing, (b) anthropogenic and natural factors impacting stock abundance trends, and (c) the presentation of statistical limits that measured nothing more than the precision of the methodology. Finally, unobserved fishing mortality was not taken into account when formulating estimates of total fishing mortality, thus adding to the uncertainty surrounding status of stocks.

Mace (1996) recognized that incorrect scientific assessments have contributed to the failure to achieve sustainability. Hennessey and Healy (2000) added fuel to the uncertainty of the science debate by noting, "It was not just normal scientific uncertainty that weakened the influence of scientific advice in the management of New England fisheries, but scientific uncertainty coupled with low credibility of scientists among managers."

Other examples of incorrect or ignored scientific advice are provided by Walters and Maguire (1996), Munro (1987) and Johannes (1998). The latter authors concluded that "performance of sustainable use of tropical fisheries has been dismal" and also that "a major contribution to this poor performance is resource managers waiting for quantitative resource analysis on which to underpin their decisions".

Inability to monitor and enforce regulations

Success in fisheries management has assumed that the regulatory regimes adopted could be effectively enforced or that the conservation ethic of the users would lead to compliance with regulations (Sutinen and Hennessey 1986). Although there are a few examples that suggest these assumptions were met, in many other instances they were not. The expansion of fisheries to distant-water grounds and operations on the high seas made effective regulations of many fisheries extremely difficult. Elements of many fishing fleets were ingenious at finding ways to avoid gear and quota regulations. Landing a controlled species as another species (grayfish), and landing illegal fish (blackfish) in ports not monitored became a game for those who had little respect for the management process or lived without a conservation ethic. These 'black hat' elements of the fleet frequently cast the image for the fishing industry as a whole.

The changing tide

During my career as a fisheries scientist, I have worked as a fishery biologist, science administrator, and for the past 20 years as a fishery consultant. In the early stages of my involvement with fisheries, the oceans were portrayed as the earth's last frontier, a reservoir that would provide protein for an expanding world population, a region of the globe less understood than the surface of the moon, and a new energy source to augment the dwindling fossil fuel supplies. More recently, oceans have been characterized as a global cesspool for medical and other wastes and a dying biological system, whose resources are contaminated, over-exploited and depleted, with more and more species being threatened with extinction. This is not a very encouraging story to pass on to my grandchildren.

My generation was spoon-fed by the premise that the application of MSY principles would lead to sustainable fisheries and insure production from the ocean's vast resources. Was the concept wrong, or have we been overly naive regarding (a) the ability of science to provide reasonably robust estimates of stock states, and (b) that the management would be unfettered with politics? One thing seems certain – our preoccupation with setting MSY as a management target, and not just an academic explanation of how stocks might respond to fishing under unlikely assumptions, led to MSY being a part of the problem rather than the 'grand solution'.

The 1999 Larkin Lecture (Cochrane 1999), commented on a depressing series of stock collapses and depletion between the 1950s and 1980s; In the 2001 Larkin Lecture (Mace 2001), the major paradigm change associated with MSY, shifted from a target to a limited reference point. Rothschild (2000) states, 'Overall fisheries management is entering a new era of sustained productivity within the boundaries of natural stock variations and responses to ocean climate events'. Caddy (1999a) examines the question "Will new management paradigms apply in the 21st century?" Sainsbury (1998), asked the question, "Will there need to be a paradigm (technical) shift in living marine resource assessment?" and answers "Yes". He also goes on to identify the potential elements of the paradigm. In a recent paper presented to the American Fisheries Society (unpublished data, D. L. Alverson, 1998. *Perspectives over Time: the Scattering of Dreams.* Presented at AFS annual meeting), it was observed that:

> "As the historical causes of fishery management failures have been debated and come under attack, a range of new remedies has surfaced, including dealing with MSY as a management goal, taking into account uncertainty and risk aversion management, co-management, use of marine sanctuaries, and addressing biodiversity and ecosystem management. We are witnessing the emergence of a new fisheries management paradigm governed by changing scientific and philosophical approaches to marine resources management."

There is no assurance that that the paradigm shift, which includes reference points, green lights, yellow lights, red lights, and application of the precautionary approach, coupled with uncertainty (Caddy 1999b, 1999c) will lead to natural resource management that is more responsive to science or to the "best available science". The issues of bycatch, unobserved fishing mortality, impacts of fishing on marine habitats, biodiversity, cumulative impacts of fishing on nontarget species, and ecosystem management are difficult and complex subjects. They will require the collection and analysis of additional data sets. For example, Sainsbury (1998) states, "It is becoming widely recognized that information required for scientific assessment of marine resources is considerably greater than that currently being provided." At least in the short-run, the paradigm shift is likely to add to the uncertainty factor.

It is perhaps ironic that the key factors of political and economic power and scientific uncertainty, that have been identified in Ludwig's 'ratchet' as the culprits leading to overfishing are the strengths of the new paradigm shift. The political power of user groups has waned and the environmental/conservation movement has gained financial and political strength. Uncertainty now drives the precautionary approach and forms the basis of the conservative management strategies now in vogue. Its implementation is insured by the fishery agencies that are currently responding to politicians who previously contributed to the ratchet affect. The institutional decision process does not appear to have changed, although there is an ever-increasing level of legislative and legal micro management. However, political forces are now on the other side of the equation and uncertainty has become an ally (Fig. 7). The good guys, in white hats, have arrived.

It is unclear how pervasive the paradigm shift has or will become in other areas of the world, or whether or not science will play a more significant

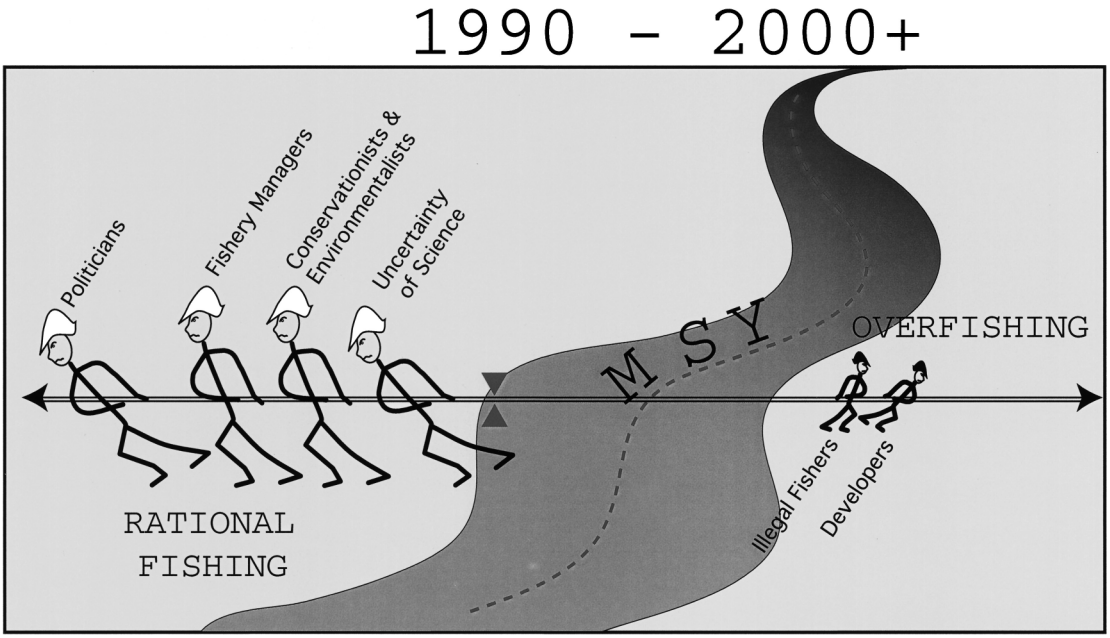

Figure 7 Struggle between user groups and interest groups over world fishing in 1990–2000+.

role in natural resource conservation. I suspect, however, that many management agencies will continue to dance to the tune of politics. Science that fits into the contemporary management paradigm will be welcomed.

Will the new paradigm prove successful and will society as a whole benefit from its adoption? That will depend on how we choose to measure success. I have little doubt that the stocks off the coast of the US will be subject to a significant reduction in fishing mortality, bycatch will decline, and habitat impacts that are a consequence of fishing will ease. As the US courts become the ultimate arbitrators of conservation science and policy, production of capture fishes will be curtailed. Currently, there are over 140 lawsuits filed against the National Marine Fisheries Service (NMFS), which, if won, could drastically restructure US fisheries management.

Over time, the reduced fishing mortality should lead to increases in abundance of overfished stocks. Rosenberg (2000) has identified a number of fish stocks which were well-managed and rebuilt, including improvement in the stocks of Atlantic sea scallops (*Aequipecter irradians*), Georges Bank groundfish, mackerel (*Scomber scombrus*), herring (*Clupea harengus*), surf clams (*Mactromeris polynyma*) and lobsters (*H. americanus*). In the Southeast Atlantic, good marks were given to king mackerel (*S. cavalla*) and Spanish mackerel (*S. maculatus*), which have recovered in the Atlantic and are recovering in the Gulf of Mexico. Red snapper (*Lutjanus campechanus*, Lutjanidae) are noted to be showing evidence of recovery. However, a number of other species remain in the bad news category, but are subject to increasingly restricted harvests.

There is some evidence, on a global scale, that the number of overfished stocks have not measurably increased during the 1990s (Sissenwine and Rosenberg 1993; Alverson 1998; Csirke 2000). Lassen (2001) states "contrary to the dramatic and somewhat fatalistic 'Statement of the Oceans' in the introduction of the magazine 'Seafood Solutions'," ocean ecosystems are not in peril. While regional management problems have and may continue to occur within specific fisheries, the overall global status of fisheries has remained stable for the past decade." Lassen's comments appear to flow from the 1999 FAO 'State of World Fisheries and Aquaculture', which reports that, at the MSY level, "31% of the stocks are moderately fished, 44% are fully fished, 16% are overfished, 6% are depleted and 3% are recovering". This constitutes a slight decline in the number of overfished, depleted, and recovering stocks from the mid-1990s when about 30% of the stocks were in these classification groups.

However, these numbers have varied over time and Csirke (2000) expects the 2001 FAO status report will show a significant increase (to 36%) in

the overfished, depleted and recovering categories. If true, then the status of marine stocks continued to deteriorate through the last half of the 1990s, and/or the increased efforts (FAO 1999) to improve the status documents have merely caught up with reality.

If the new management paradigm is broadly implemented, the productivity of marine stocks should increase. If so, will there be a commensurate rebuilding of historic capture fisheries? Perhaps, but this may largely depend on the recovery time, the durability of the fisheries infrastructure, and metamorphosis of management under the new paradigm. The dominance of advocacy politics in the management process, coupled with uncertainty, could lead to significant reshaping of ocean harvesting, and a marginalizing of large-scale fisheries regardless of what the scientific evidence suggests regarding the status of resources.

Marine science, the benefactor of overfishing and ecological disasters

The state of financial support for fishery science and status of marine living resources, for the most part, have followed opposite courses. While fisheries have spiralled down, marine sciences have bloomed, diversified and become intellectually and materially enriched. The explosive growth of fisheries and related sciences have largely followed fisheries management failures, biological and economic threats posed by distant-water fisheries, the fate of threatened and endangered species, national security concerns, and human-induced ecological disasters.

Fisheries science has, more often than not, been called on to investigate and compile the history of disaster:

1. The creation of the International Pacific Halibut Commission emerged after significant declines in halibut (*Hippoglossus stenolepis*) catches.
2. The US and Canada formed the International Pacific Salmon Commission following the earth slides at Hells Gate Canyon, British Columbia.
3. The formation of the California Cooperative Fisheries Investigation, which brought together the California Department of Fish & Game, the US Bureau of Commercial Fisheries and Scripps Institution of Oceanography, occurred during the decline of the California sardine (*Sardinops sagax*, Clupeidae).
4. The rise in funding for oceanographic research that was provided by the military, responding to national security concerns following World War II.
5. The legislation of the Magnuson Fisheries Conservation and Management Act, which formed the Council, and national management strategies in the US, was fostered by concerns over the impacts of foreign fisheries on the marine resources off the US coasts, as well as allocation and access issues.
6. The collapse of groundfish stocks in the Northwestern Atlantic led to a significant increase in government funding.
7. The decline of the Columbia River salmon runs and the demise of Atlantic salmons (*Salmo salar*, Salmonidae) have generated unbelievable sums of money into the hands of scientists and fisheries managers.

As more and more species are added to the threatened and endangered species lists around the US, new money pours into the national resources management arena.

More recently, critical funding events have been associated with environmental disasters such as oil-spills, hypoxia in the Gulf of Mexico, saving the coral reefs, eutrophication of the Mediterranean, or the plight of threatened and endangered species, bycatch, saving biodiversity, global overfishing and the health of ocean ecosystems.

These examples are admittedly orientated to North American events, but similar cases can be made world-wide.

I do not want to leave you with the impression that fisheries science is over-funded and overcapitalized. It's just a simple conclusion, that our profession has been the beneficiary of overfishing, threatened and endangered species, and human-induced ecological degradation. This process is, of course, not unique to the marine science discipline. These are issues that are likely to foster responses from legislative bodies. They are also the issues that conservation and environmental groups have focused on in attempts to access public and private funding. Their efforts have largely been successful. Some of the funds have been added to the natural sciences coffers. But I have this intrinsic feeling that the process invites abuse. Is there a possibility that the characterization of the state of natural resources and the ocean environment, to the lay public, may be tainted, or exaggerated by a budget process that largely responds to crisis management, fear and management failures (Lassen 2001)?

The increase in marine science funding in the US has flowed to universities, grant institutions, federal and state laboratories and management agencies of

counties and cities. There can be little doubt that the quantity of scientific activity has significantly increased, the number of disciplines involved has broadened, and our knowledge of biological resources and physical processes, which affect their abundance, has leapt forward in the past half-century. Biodiversity, fisheries genetics, endangered species, bycatch and ecological impacts of fishing became the more important components of the research collage.

Wealth, however, did not come without its obligations. Government fishery scientists, both state and federal, frequently driven by the need to update status of stock reports or research related to specific conservation management problems, have had to come to grips with the realities of responding to the information needs of the Endangered Species Act, environmental impact statements, and a host of lawsuits imposed on management agencies. Dealing with the emerging management problems and the burgeoning conservation movement along with legal challenges, even with additional funds, has likely eroded the quality of government science at a time when they are much needed to enlighten public controversy on the national and international scene (Alverson and Larkin 1994).

Looking ahead

The adoption of the precautionary approach, management reference points and the emergence of the FAO Code of Conduct for responsible fishing are factors which are moving fisheries management into a more conservative era, identified as a major management paradigm shift. The focus over the past half-century has moved from resource development to sustaining the productivity of exploited resources and the overall productivity of the ecosystem. The application of ecosystem principles has become a mandate for fisheries seeking the approval of the Marine Stewardship Council.

Hopefully, the new conservative paradigm shift, which seems to have taken hold in the US, has or will become established throughout much of the world. But, this is not at all certain. The necessary fundamental changes in human attitudes and social structures that will bring the world to a stable human population size and secure sustainable environment will not happen overnight (Alverson and Larkin 1994). Further, it is not at all clear that the paradigm shift will be a durable feature, even in the near future. The US and the global society commitment to conservation and the environment could be quite ephemeral and fickle. With rising costs of electrical power, fuel, food and clothing, the paradigm shift could be short-lived.

In the fishery setting, sectors of society involved in influencing decision-making have, until recently, been relatively narrow and associated with user groups. However, over the past two decades the breadth of societal involvement has been greatly enlarged. As a result of technological developments in the communication media and the ability to disseminate information almost immediately to significant sectors of the world population, the extent of human involvement in natural resource management has become increasingly pervasive. Advocacy groups ranging from the outright aggressive to the non-use philosophies have become increasingly aware of the power of the press and other communications media to promote their positions and influence policy-makers. Using selective facts and statistics in the public influence game has become an art form that frequently puts science in the back seat (Alverson 1998). This process has contributed to the adoption of a conservative management paradigm.

In the US fisheries, as well as environmental management, there is an expectation that regulations are to be based on the best scientific information available. Further, the law prescribes steps to insure the precautionary approach is considered in the management of fisheries. The concept of what constitutes best available science, however, is being questioned and seemingly moulded to favour "preconceived or agency views" (Lee 1994; Copsey 1997). Although science may well play an increasing role in natural resources management, one cannot escape the fact that advocacy groups will co-opt the products of science and reshape them to influence the political process that has and will always play a role in fisheries decisions. It is perhaps naive to hope that the concept of the best available science will allow inputs and consideration of information from user groups and academia, when it is alien to the contemporary beliefs or philosophical views of the management institutions and the governments for whom they work.

> "Science is not really about the advance of human intelligence through rational processes of inquiry and experiment. It is really about maintaining hegemony of certain assumptions, providing cherished hypotheses, and often just ignoring data that won't conform to expectations. It is about upholding the tenets of certain

> paradigms which every now and then collapse in the face of overwhelming contradictions, exceptions, and anomalies (Kuhn 1970)."

For the students among the audience, I recognise there may be a desire to focus efforts so they might contribute to attaining the moral high ground. But the moral high ground is shaky at best and is constantly being reshaped over time. Ludwig *et al.* (1993) notes, correctly, "scientists and their judgements are subject to political pressure". Of course, they are right. Students, scientists, fishery managers, and professional societies must recognise that user and non-users alike drive political pressure, although their motivations differ. Maintaining scientific objectivity, in the face of intense media advocacy and political pressure from the users and advocacy groups will not be easy. I will suggest that concentrating on learning and practising the methods and language of science can enrich our understanding of important natural resources processes. A broader sector of society will decide whether or not the information has value in fishery management decision-making.

A parting shot

When we look around for the bad and ugly elements of fisheries management, I suspect those of us in my age-bracket need to look carefully into a mirror. Over the past half-century, I have been, in turns (a) enthusiastic about the potential of the world's oceans to feed the world's hungry, (b) worked to promote more effective harvesting systems, (c) helped to secure added funding for ocean exploration which led to development, (d) raised my concern about excess fishing efforts, overcapitalization and overfishing, (e) exposed the potential magnitude of bycatch in ocean fisheries, and (f) joined with others in noting the potential impacts of a range of unobserved fishing mortality. My view and understanding of the ocean environment and its capacity to produce food and goods for humanity have been continuously reshaped over the decades as new information has challenged historical perspectives.

Over the past decade, there has been a growing tendency for the media, fishery managers and scientists, including academia, to point fingers at the world's fishing industry as the greedy, irresponsible, morally bankrupt culprits responsible for overfishing, as well as blaming them for incidental and indirect impacts on other marine life (Alverson and Larkin 1994). The following is an example quoted from Sainsbury (1998):

> "Perhaps the most significant evidence for failure of the recent approaches to assessment and management of marine living resource ... is the increased frequency of negative publicity media articles, documentaries, and reports. They describe an irresponsible fishing industry that is managed inadequately on the basis of insufficient understanding. The bad press is a world-wide phenomenon, and the present approaches to management and decision-making will not be sustained very long under such exposure."

My perspective on this matter is admittedly biased. As a boy, I lived on Tatoosh Island, at the entrance to the Strait of Juan de Fuca in Washington. I was taken out on a salmon troller at the age of 6 years. At 9 years of age, I was spear-fishing tropical reef fish off Hawaii, and in my teens, I was harvesting abalone off California. My first job was in a tuna cannery in San Diego. During my career, I conducted research on board trawlers, purse seiners, gillnetters, sampans, long-liners, tuna pole and line vessels, and crab boats, among others. During those years, I drank a lot of bad coffee, and argued and swapped stories with a lot of fishermen. As a result, I have a very different and more positive image of most fishers.

Yes, segments of the industry have been irresponsible and there is greed within the fishing industry. But greed, as noted by Lee (1993), is evident in many spheres of human life. It may be relatively pervasive in society, and perhaps even invades the scientific community. The image of the world's fishers has been jaded and tarnished, but is it fair? Fundamentally, the responsibility for management of the ocean's living resources is vested in national and international entities. These groups must bear the responsibility for the historical course of fisheries management. They constitute the institutional framework for policy implementation and establish and enforce the game rules. If industry pressures have over influenced those responsible for fishery management and enforcement, the fault lies with the management entities and their political masters (Alverson and Larkin 1994). It seems incredible that the same governments and institutions that, less than two decades ago, promoted fishery development, subsidized their growth and provided tax shelters for them (Mooney 1997), are now bashing and condemning the same industry. They have now climbed upon the moral high ground and are contemptuous of those whom they earlier encouraged to "go to sea and compete".

For those of you who feel that we are not making any significant progress towards rational use of the world's oceans, you have a powerful deity on your side. Several weeks ago someone threw a copy of a pamphlet named 'Awake' (Anonymous 2000) on my front door step. My wife picked it up and suggested that I read it. 'Awake' is a religious publication, and this particular pamphlet was titled 'The Oceans Reveal Their Deepest Secrets'. I took it to work and read through it as I was having a cup of coffee. The introductory material on wonders and mysteries of the deep was well written, educational, and consistent with the facts regarding deep ocean vents. As I came to the end of the article, I found some interesting prophesies regarding those who continue to contaminate and overfish our world oceans. You may wish to take refuge in the concluding observations from 'Awake'.

> "The more we learn about the earth and its living marvels, the more we ought to develop respect for this truly dynamic planet . . .. Of course, many people demonstrate their love for earth, perhaps by getting deeply involved in environmental issues. Sadly, however, these people face insurmountable obstacles, including human greed and ignorance, which the noblest intentions cannot eradicate."
>
> "Nevertheless, sincerely concerned persons can take comfort in the Bible's promise that God himself will soon act by eliminating all greedy, godless individuals who are 'ruining the earth' (Revelations 11 : 18; 2 Timothy 3). Thereafter, the Creator whose name is Jehovah, will institute a programme of rehabilitation that will thoroughly cleanse the earth and turn it into a paradisiacal fountain of life."

I don't expect God will submit an environmental impact statement.

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