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STATUS OF WORLD MARINE FISH STOCKS

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KEY WORDS

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INTRODUCTION

During the period 1950 until the late 1970s, when world fish catches increased rather steadily (except during the Peruvian anchovy stock crash), fisheries were considered to be in a rapid growth phase responding to geographic expansion, increased diversity of exploited species, and rapidly developing fishing capacity. However, by the late 1980s and the onset of the 1990s, production of marine capture fisheries dropped slightly and has since stabilized between 80 and 85 million metric tons (mmt). Concern over the state of the world's oceans, its resources, and environment has escalated in recent years, and in 1998 it has become a focal issue of discussion during this Year of the Ocean.

With the planned celebration for the Year of the Ocean, an increasing number of statements have been made by marine scientists, environmental and conservation groups, and international fisheries entities suggesting the oceans are "suffering from excessive overfishing, relentless pollution and the worldwide spread of disruptive foreign species."[1] Concurrently, the internet is bursting with commentary that would make these concerns seem conservative and which conveys a great sense of urgency for action regarding the status of world fish stocks and their environment. For example, in describing the state of the world's oceans, one author[1] states, "If the earth's oceans were a human being they'd be rushed to the hospital, admitted to the intensive care unit and listed in grave condition."

These sort of apocalyptic statements regarding the state of the world's marine fishery resources have already stimulated actions on the part of national governments and various grant foundations to respond to the current perception of the ecological damage being imposed on the world's oceans by human activity. However, there are the questions that need to be addressed by the community of fishery and marine scientists:

1. What does the scientific literature support regarding the state of the world's living resources.
2. How good are the data underlying the status of global and national fisheries?
3. Is there underlying evidence supporting the many claims regarding the state of world fisheries and is there a basis for confusion?
4. How can the assessment of the status of world fish stocks be improved?

This paper purports to examine (a) Food and Agriculture Organization of the United Nations (FAO) and national reports on the state of current fisheries and related resources, (b) theoretical information on the state of marine fisheries resources, (c) the quality of the FAO state of stock reports, and (d) whether evidence supports recent claims made regarding the state of the oceans' fishery resources. The authors also identify comments and conclusions that may have contributed to the current perceptions regarding the "catastrophic" nature of the oceans' marine fisheries.

THE STATE OF WORLD FISH PRODUCTION

On the basis of FAO (1997a) data, total fish production continues to increase, reaching over 112 mmt in 1995 although the catch of wild marine fish peaked at about 83 mmt in the late 1980s (Figure 1). Wild marine fish harvests declined in the early 1990s, plateauing between 78.38 and 79.24 mmt before increasing to 84 mmt in 1994. In 1995, total marine capture fisheries exceeded that of 1994. The recent increases seen in 1994 and 1995 marine catches can largely be attributed to the high abundance in Peruvian anchovy (*Engraulis ringens*) harvests. Primary sources for the continued increases observed in the world's total fish production can be accounted for by the aquaculture and inland fishery sectors. The majority of aquaculture and fishery harvest growth has occurred in Asian developing countries undergoing relatively rapid economic growth: for instance, China, the Philippines, and Indonesia. By ocean basin, several significant catch trends are evident (Figure 2).

The Atlantic Ocean

Until the 1970s, the Atlantic Ocean dominated world marine fish landings, contributing over 50% of the total marine catch. The North Atlantic region alone accounted for 40% of global marine harvests. Catches from the North Atlantic peaked in 1976 at 16 mmt (Figure 3) before steadily declining to the region's total marine catch of just

[1]Unattributed source.

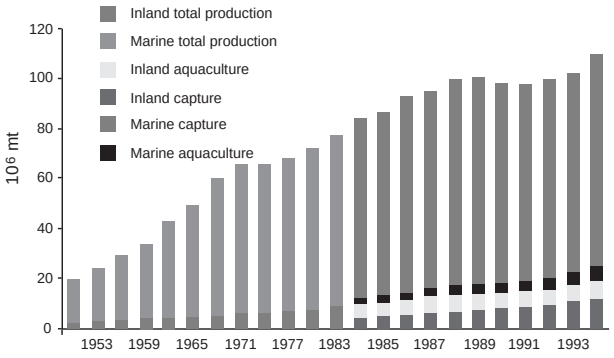

FIGURE 1. Trend in world fish production, million metric tons (mmt), 1950–94. Source: Food and Agriculture Organization of the United Nations (FAO 1997b).

under 12 mmt in 1994. Areas showing decreasing catches include the Northeast, Northwest, Eastern Central, and Southeast Atlantic. Today, the North Atlantic regions contribute only about 15% to global harvests. Most of these declines are the result of lower abundances of demersal cods, hakes, haddock (*Melanogrammus aeglefinus*), and various flatfish species. However, evidence indicates the Northeast Atlantic cod (*Gadus morhua*) stock rebounded somewhat in 1994 and 1995.

The most surprising catch landings are those reported from the Mediterranean and Black seas. Total landings from this area have steadily increased since 1950, from about .75 mmt to just under 1.6 mmt in 1994. The large decline in harvests in 1991 can be attributed to the collapse of European anchovy (*Engraulis* spp.) and sprat (*Sprattus sprattus*) stocks, primarily in the Black Sea. Catches from the Mediterranean Sea have continued to show increased landings across most species groups despite regional managers' belief that many stocks are heavily fished and under pressure from pollution and other environmental factors. It is now believed the area might be undergoing ecological change catalyzed by the increased primary productivity (FAO 1997a).

In the Western Central Atlantic, menhaden (*Brevoortia* spp.) stocks contribute nearly 38% of the total harvests from the area. The region continues to see small increases in shrimp, redfish, and miscellaneous marine fishes whose state is not well understood. Catch trends for the Southwest Atlantic suggest a period of rapid development. Increased catches of demersal species, particularly Argentine hake (*Merluccius hubsii*), deepwater Patagonian toothfish (*Dissostich eleginoides*), and coastal stocks of croakers (*Micropogonias* and *Umbrina* ssp.) and weakfish (*Cynoscion* spp.) account for the majority of growth in the area's fish production. Since 1986, large harvests of shortfin Argentine squid (*Illex* sp.) and the small common squid (*Loligo* spp.) have become increasingly important to the area although their abundance varies and landings declined in 1994 and 1995.

Southern African pilchard (*Sardinops sagax*), anchovy (*Engraulis* spp.), and other small pelagic species, influenced by oceanographic factors, seem to have caused wide fluctuations in the total fish catch from the Southeast Atlantic area. Total landings from the region have been as high as 3.25 mmt; however, the catch declined dramatically across most species groups in the early 1980s to 1.2 mmt in 1991. During the 1960s and 1970s, distant-water fisheries harvested considerable amounts of Cape hake (*Merluccius capensis*), Cape horse mackerel (*Trachurus trachurus capensis*), and other species/stocks, and restrictive catch plans were implemented during the late 1980s and early 1990s.

The Pacific Ocean

Total landings from the Pacific Ocean continue to increase, growing from close to 6 mmt in 1950 to over 58 mmt in 1994 (Figure 4), when they accounted for 65% of

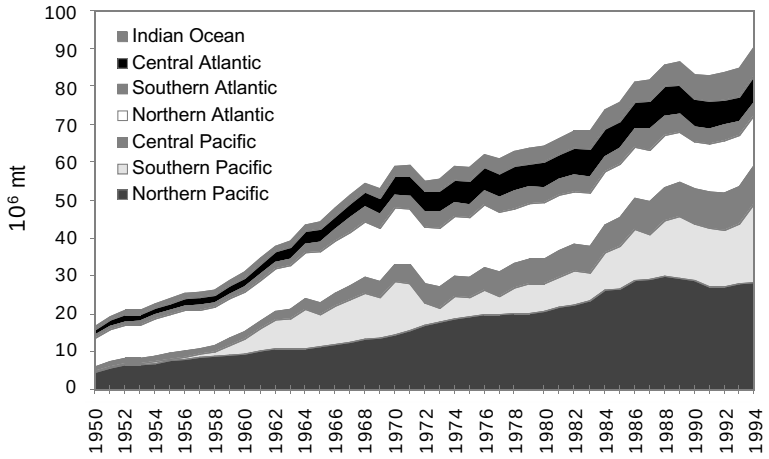

FIGURE 2. Trends in catch (mmt) by ocean region, 1950–94. Source: FAO FISHSTAT database (for further information on the database, contact Bernan Associates, 4611-F Assembly Drive, Lanham, Maryland 20706-4391, tel. 1-800-274-4447).

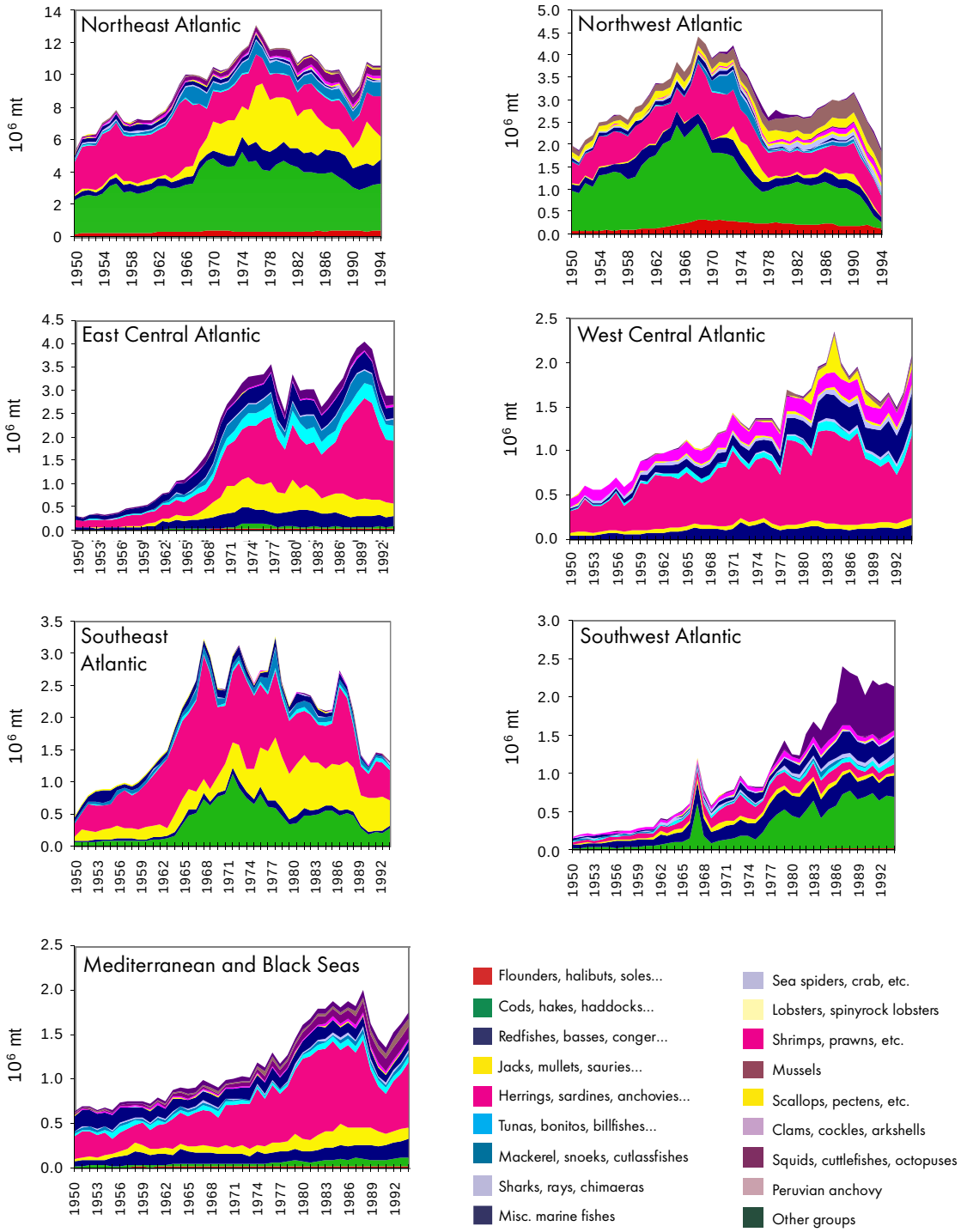

FIGURE 3. Trends in catch (mmt) by major Atlantic Ocean region, 1950–94.[a] Source: FAO FISHSTAT database.

[a]Data categories in all charts are in reverse order of the legend. That is, the data categories from the bottom up in each chart correspond with (1) flounder…, (2) cod…, (3) redfishes…, (4) jacks…, and (5) herring…, etc.

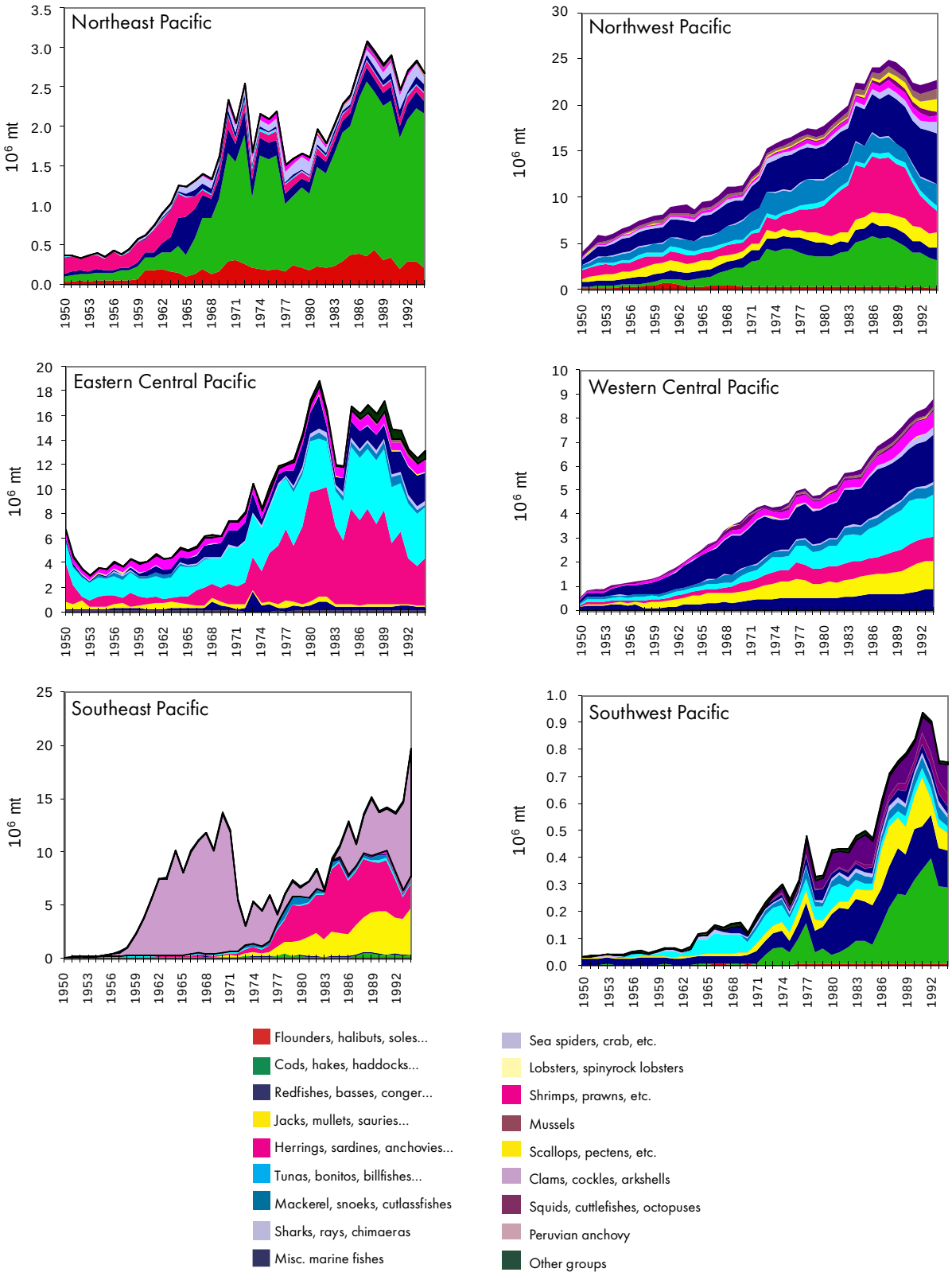

FIGURE 4. Trends in catch (mmt) by major Pacific Ocean region, 1950–94. Ordination of chart and legend data categories as per Figure 3. Source: FAO FISHSTAT database.

the world's total marine fish catch. Landings from all Pacific regions except Northeast and Eastern Central have exhibited increases in production since 1950.

Total landings from the Northwest Pacific grew steadily from the 1950s to the 1970s before peaking in 1988 at 25 mmt. Increases in harvests during the 1970s and 1980s can primarily be attributed to the Alaska pollock (*Theragra chalcogramma*) and Japanese pilchard (*Sardinops melanosticta*). But, since 1988, total landings dropped off for the region primarily due to declines in these species. On the other hand, increasing harvests of hairtail, shrimps, squids, and miscellaneous species appear to be sustaining overall growth in the region. A significant portion of the catch in the region has been taken by China, which has greatly increased its fishing capacity. It is difficult to envision the 1994 sustained levels of removals continuing into the future.

Removals from the Northeast Pacific have leveled off in recent years, with small declines seen in some demersal stocks. Landings in the area peaked in 1987 at 3 mmt primarily attributable to very high abundance of Alaska pollock. Since 1987, total landings have trended downward with most decreases occurring in flatfish, herring (*Clupea pallasi*) and crab stocks, while landings of Alaska pollock have rebounded somewhat.

Fish harvests in the Eastern Central Pacific region have been dominated by pelagic species, both small pelagics and highly migratory tunas. Total production from the area peaked in 1980, reaching some 1.9 mmt before steeply dropping to just over 1.2 mmt in 1984. Landings quickly rebounded in the late 1980s but have steadily declined somewhat since that time. Small pelagic species/stocks, most importantly, the pilchard and anchovy (*Engraulis* spp.), have accounted for recent declines in production from this area. Abundance of these stocks can be dramatically impacted by environmental changes. Overfishing of squid and mackerel (*Scomber* spp.) stocks may have contributed to the decline in landings from this region. Harvests of tuna species, primarily yellowfin tuna (*Thunnus albacares*), and shrimps have continued to increase in recent years.

Perhaps no marine area of the world has grown as fast as the Western Central Pacific. Total landings have grown from .545 mmt in 1950 to nearly 9 mmt in 1995, now accounting for 10% of the world's total marine fish production. The most rapid period of growth occurred during the 1970s, primarily in response to the introduction of trawling to Southeast Asian nations in the 1960s. In recent years, the rate of growth in landings has slowed although catch across most major species groups continues to increase. Sizable landings of tunas, scads, mullets, shrimps, and squids continue in an upward trend; however, the category showing the greatest increase, by far, is the miscellaneous marine fish group. This is an expected outcome given the high biodiversity of species in the region and the increased retention of shrimp bycatch species for food and aquaculture feed.

Catches in the Southeast Pacific have trended sharply upwards since the recovery of the anchovy stocks in 1980s and the beginning of the harvest of pilchards (*Sardinops sagax sagax*) and jack mackerels (*Trachurus symmetricus*) in the early 1970s. The three species have constituted the majority of the catch by weight along the western coast of South America, swamping increases in catch of other more valuable species. In the Southwest Pacific, where catches have shown marked increases since the mid-1960s, landings have been dominated by cod-like species, miscellaneous marine species, and mackerel-like species. The landings in the two South Pacific areas have increased from insignificant levels to over 25 mmt over the past 2 decades.

Landings from the Southwest Pacific did not experience any sizable growth until the early 1970s, at which time production increased rapidly before peaking in 1991 at .973 mmt. Deep, midwater gadoid species accounted for early harvest increases, particularly the southern blue whiting (*Micromesistius poutassou*) and hoki (*Macruronus novaezelandiae*) stocks, with redfishes, primarily oreo dories (*Zenopsis* spp.) and orange roughy (*Hoplostethus atlanticus*), and greenback horse mackerel and snoek fisheries developing later towards the end of the 1970s. Since 1991, landings across many FAO International Standard Statistical Classification of Aquatic Animals and Plants (ISSCAAP) species groups in the Southwest Pacific have dropped sharply and significantly. In 1993 and 1994, reported landings for orange roughy have declined nearly 50% and those for greenback horse mackerel 90%. Squid harvests from the region have helped bolster total production from the region; however, yearly variability in squid stock abundance can be great.

The Indian Ocean

The Indian Ocean has experienced rapid development with steadily increasing landings from .85 mmt in 1950 to 7.2 mmt in 1994 (Figure 5), accounting for 8% of the world's total marine production. In the Western Indian Ocean, the drop-off in landings between 1992 and 1994 was largely due to declines in catches of small pelagic species, such as the Indian oil sardine. Species groups experiencing rapid growth in the area include tunas and shrimps. Additional increases in production are anticipated

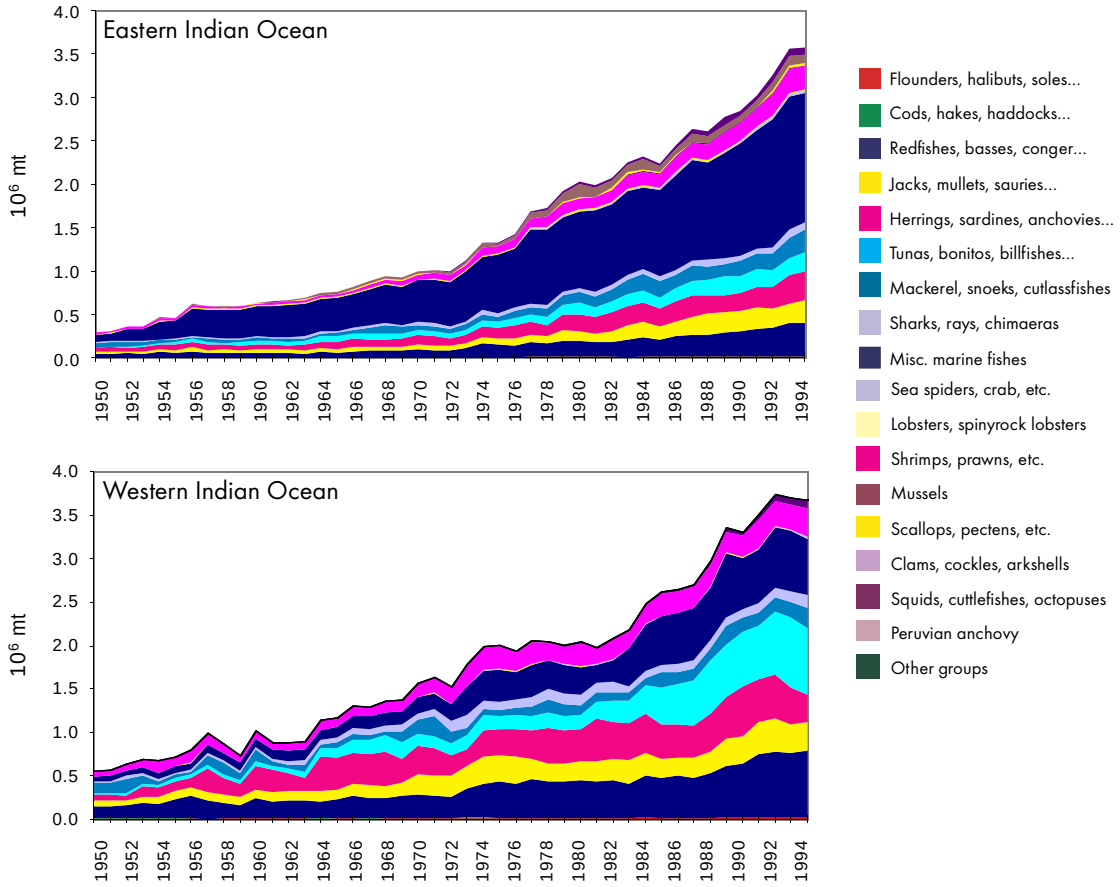

FIGURE 5. Trends in catch (mmt) from the Eastern and Western Indian Ocean regions, 1950–94. Ordination of chart and legend data categories as per Figure 3. Source: FAO FISHSTAT database.

in the Western Indian Ocean owing to the development of the meso-pelagic lanternfish (myctophid) fishery.

Summary Observations

Production trends for each ocean basin clearly show that three major FAO areas in the Atlantic—Northeast, Northwest, and Southeast—declined significantly from 1950 to 1994. Losses in these three areas alone have amounted to over 5 mmt. Catches in the Pacific Ocean have, for the most part, shown long-term increases with some leveling or declines in catches following the mid- to late 1980s. Landing trends in the Indian Ocean have steadily increased over the past half century with much of the added catches in recent years coming from the miscellaneous marine species grouping. Catches of miscellaneous species have also increased significantly in the Northwest and Central Pacific Ocean. Total landings of these species have risen from 2 mmt to over 10 mmt over the past several decades and have helped offset declines of more traditional foodfish species, such as cods and hakes in the Atlantic Ocean. Large portions of the catch of this species group are currently being used to support the growing aquaculture industry in Asia. However, the use of some of these species as foodfish, which only several years ago were discarded, is growing. The major growth of the miscellaneous species group has significantly altered the mix of dominant species in world catches since 1950 (Figures 6 and 7). The percentage of miscellaneous marine species reported has continued to increase, along with catches of jacks and mullets, while the percentage of cods in the world marine harvest has fallen off sharply.

THE STATUS OF THE WORLD'S MARINE FISHERY RESOURCES

The United Nations (UN) Food and Agriculture Organization (FAO) has prepared reports on the state of world's marine fisheries since the 1970s. These reports provide regional (Figure 8) information on landing trends by taxonomic groups, state of stocks or groups of species, and factors influencing their population trends. Tabular information on landings by stock or species groupings and de-

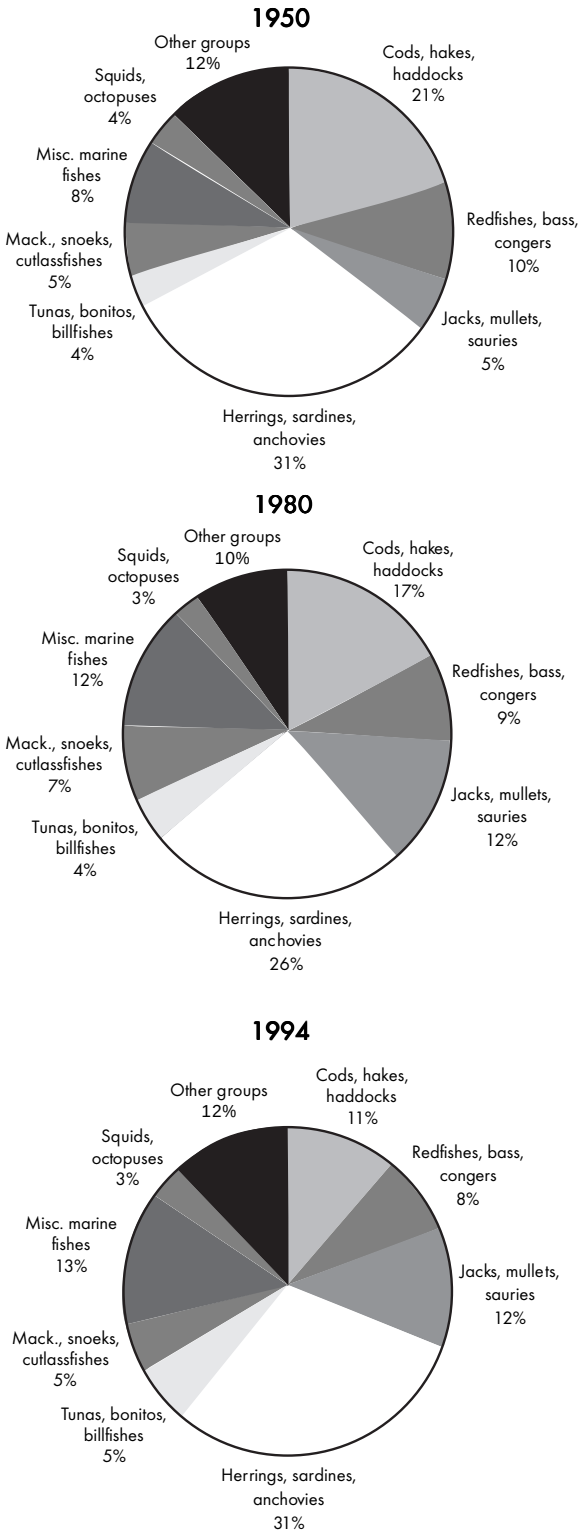

FIGURE 6. Percent contribution of major fish species groups in 1950, 1980, and 1994. Source: FAO FISHSTAT database.

scriptive commentaries on the state of stocks are also given. Historical information on the state of resources is classified by FAO into six categories defined as follows:

1. Underexploited—Underexploited, unexploited, or new fishery. Believed to have a significant potential for expansion in total production.
2. Moderately exploited—Exploited with a low level of fishing effort. Believed to have some limited potential for expansion in total production.
3. Fully exploited—The fishery is operating at or close to an optimal yield level with no expected room for further expansion.
4. Overexploited—The fishery is being exploited at[2] or above a level which is believed to be sustainable in the long-term, with no potential room for further expansion and higher risk for stock depletion/collapse.
5. Depleted—Catches are well below historical levels respective to the amount of fishing effort expended.
6. Recovering—Catches are again increasing after a collapse from a previous high.

Classification of marine stocks into these categories has formed the foundation of numerous observations on the state of marine resources. Scientists have examined FAO data sources to evaluate trends in production of global marine fish stocks and the implications of such trends regarding the status of these populations. They have generally found that conservation of marine fishery resources has been less than adequate to maintain sustainable production of food from the world's oceans. Summaries of their findings based on published documents and current studies follow.

Alverson and Larkins

In the early 1990s, Alverson and Larkins (1994) studied the historical trends of the state of fish stocks classified by FAO and noted that the number of overfished stocks had increased over 250% during the 1980s, and that the number of underexploited species had decreased steadily over this period (Figure 9). Of the 176 stocks classified to state in 1987, 7 were underexploited, 39 were lightly to moderately fished, 79 were fully to intensely exploited, and 51 were overexploited or depleted (Alverson and Larkins 1994). Twenty-nine percent of the stocks for which classifications

[2]Defining a fishery as being exploited "at" its maximum sustainable yield is inconsistent in that fully exploited and overfished stocks then cannot be differentiated.

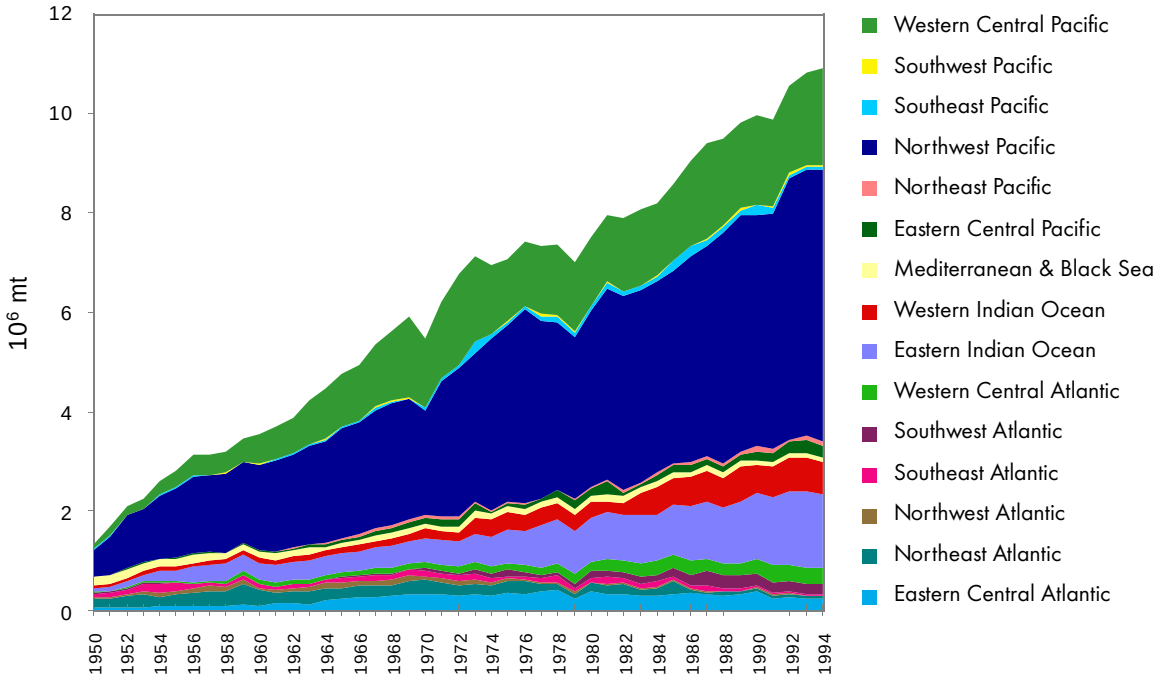

FIGURE 7. Trend in catch (mmt) of miscellaneous marine fishes by FAO region, 1950–94. Source: FAO FISHSTAT database.

had been made were noted to be overfished. No status information was available on over one-third of the stocks. In terms of regional performance, the Northeast, Northwest, East Central, and Southeast Atlantic areas were noted to have the poorest performance and suffered from excessive overfishing. Of 72 stocks classified to status in these regions, more than half were overexploited.

Alverson and Larkins (1994) summarized their findings as follows:

> The great geographic expansion of fisheries which marked the 1960s and 1970s appears largely to have run its course. Although some further developments [sic] of resources beyond national jurisdiction is likely to occur, more and more species are moving into the fully exploited and overexploited categories. The FAO state of world stocks reports do not, in most instances, differentiate between effects associated with natural fluctuations and those associated with fishing and of the environment. Nevertheless, it must be concluded that most of the world's great

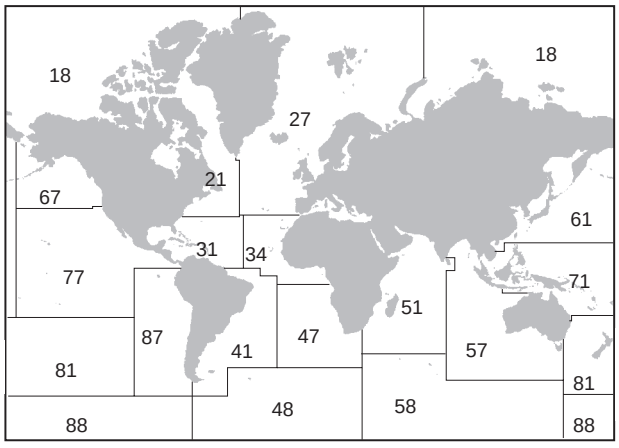

FIGURE 8. Map of major UN Food and Agriculture Organization (FAO) fisheries statistical areas. Source: FAO.

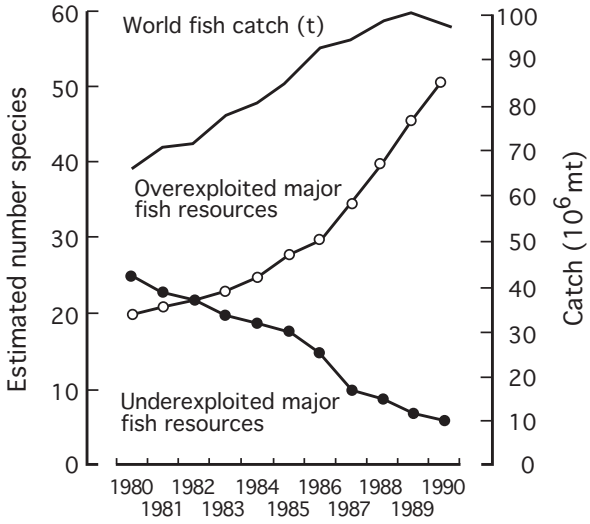

FIGURE 9. Changes in the number of overexploited and underexploited species, 1980–90. Source: Alverson et al. 1994 (based on FAO data).

> fish stocks (herrings, cods, and tuna-like species) are now subject to relatively intense fishing and an increasing number suffer from growth or recruitment overfishing.

In their concluding remarks they noted,

> Many developing countries are giving greater attention to fisheries. But many of these efforts seem too little and too late. The necessary fundamental changes in human attitudes and social structures that will bring the world to a stable human population size and a secure sustainable environment will not happen overnight.

FAO

A commentary in FAO (1993) noted that "an aspect of more concern is that of the continued overfishing of many individual stocks of fish. Although there are instances of stock rebuilding through the adoption of conservation measures, these are scarce in most areas of the world. The more general situation is one of depletion." Although the FAO state of stocks reports for this period do not support this statement, this rather qualitative expression relating to the state of marine fisheries helped to fuel international concern regarding the state of world fisheries.

Garcia and Newton

Garcia and Newton (1997) presented a comprehensive analysis of the state of marine fisheries resources based on 1994 stock conditions. Using the FAO status classifications, they graphically depicted the state of world fisheries (Figure 10) and concluded 25% of the stocks were overexploited, depleted or recovering, 44% of the stocks were fully fished, and 32% were underexploited or moderately fished. However, in their discussion, fully fished, overexploited, depleted, and recovering stocks were combined to show that 69% of the world's fish stocks classified to state were fully exploited to overexploited.

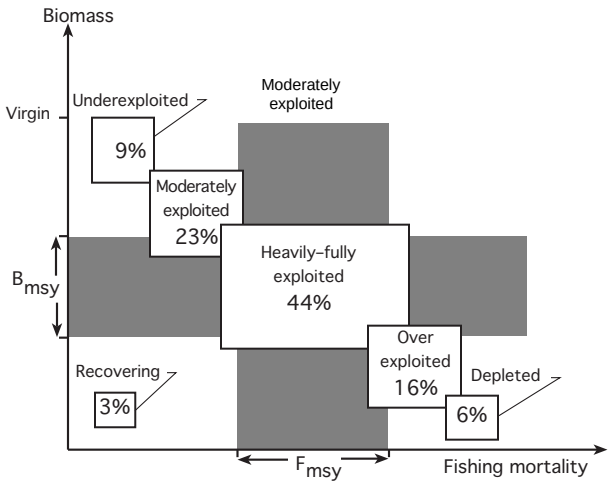

FIGURE 10. State of world fishery resources: Proportion of the assessed stocks that are underexploited, moderately or fully exploited, overfished, depleted, or recovering (figures do not total to 100% due to rounding). Source: FAO (1994).

The grouping of the heavily and fully exploited stock classifications with the overexploited and depleted stocks led to some confusion and unsupported conclusions that 69% of the world's fish stocks were being mismanaged. However, the authors carefully noted, "this does not imply that 69% of the stocks are improperly utilized." Nevertheless, the issue may have been confused by competing text that may lead the reader to conclude that (a) fully utilized stocks are being rationally utilized, or (b) many of the fully utilized species are candidates for overexploitation. Although these statements are not internally inconsistent, they have led readers to differing perceptions of the state of marine resources.

For example, the report notes that the fully fished category "comprises stocks that are exploited at a level of fishing close to F_{msy} (the fishing mortality corresponding with the maximum sustainable yield [MSY]).…" This definition was later made less certain: "However, because of (a) the uncertainty in the position of MSY, (b) the non-precautionary nature of MSY as a management target for many stocks, and (c) the inertia in fleet dynamics and the fishery development process, 'fully fished stocks' are obvious (and likely) candidates for overfishing in the near future if past behavior persists."

Garcia and Newton (1997) also provided an analysis of the regional state of marine resources, concluding that the Northwest Pacific, and Eastern Central, Southwest, and Northwest Atlantic areas had the highest percentage of heavily to fully fished, overfished, recovering, and depleted stocks. The absence of the Northeast Atlantic from this list, which had a great number of overfished stocks in 1987, comes as a surprise and will be discussed later. In this portrayal of regional fisheries status, the fully exploited category was again grouped with overexploited, depleted, and recovering stocks. The authors concluded by noting, "These overall statements on the average status of species or regional resources aggregates should be cautiously interpreted." Nevertheless, the overall statistics indicated that the state of world fishery resources should be a subject of major concern and that this global assessment sufficiently confirmed that, at the regional, country, or stock level, its findings need to be taken seriously.

Although the definition of fully fished remains unchanged, FAO scientists have, over time, placed a somewhat different nuance on the "fully exploited" category in consideration of the state of global marine fish stocks, portraying a

sense of national urgency in responding to the observed and potential overfishing problems. This change in perception seems to have been motivated by the increased number of negative signs in fishery management, as well as a growing awareness of the potential implications of uncertainty in the source evaluations.

Grainger and Garcia

Grainger and Garcia (1996) published long-term landing records of important marine fisheries, as well as an analysis of their catch trends and potentials. This document, summarized in 1996 at the Second World Fisheries Congress in Brisbane, Australia, incorporates information on the trends in overexploited species in addition to a new and different analytical consideration of the development and state of world marine resources.

In evaluating the potential losses of fishery production from overexploited marine fish stocks, the authors aggregated, by FAO marine area, the catch trends from 1950 through 1994 for all stocks classified as overexploited or depleted (Figure 11), showing that landings declined from a peak of over 14 mmt in 1985 to about 8 mmt in 1992. This constituted a loss in landings of about 6 mmt over a 9-year period. The upper plot for the Southeast Pacific involved a single species—the South American pilchard—which was largely unexploited until the early 1970s, produced nearly 6 mmt in 1985, and then trended irregularly downward until 1994.

Grainger and Garcia (1996) noted that the decline in the aggregate of these overexploited stocks started in the mid-1970s and, "the pattern of long-term decline is also evident for landings of some tunas which are classified as overfished, including albacore in the Atlantic which has shown a downward trend since the mid-1960s and southern bluefin tuna, which has shown a more recent but steeper decline as catches have been limited by management in response to declining stock sizes." They observed that many of the resources classified as overexploited in 1992 have shown decreasing catches over the past 25 years. The authors said, "the aggregate decline of the overexploited and depleted stocks constitutes a loss of 6 mmt but masks the successive declines in individual resources and compensation by increased exploitation of others. The sum of the difference between observed and historical peak landings in the time series of each area (smoothed by five) and recent landings reported lead to a potential gain of about 9 mmt." This observation implies that, if these individual areas could all be restored to their historical maximum levels, an increase of 9 mmt of landings might be expected.

Grainger and Garcia (1996) examined the state of fisheries development and their status using a Generalized Fishery Development Model (GFDM) (Figure 12; for a more complete understanding of the development of the model, use of available data, and its application, see Grainger and Garcia 1996). Application of this model provides a rather novel approach independent of the population dynamic models or other resource assessment methodologies used in the historical FAO state of stock reports. Fisheries are placed into one of four development phases based on the historical rate of increase or decrease in catches: Undeveloped, Developing, Mature, and Senescent. Implicit in the model are the assumptions that fishing capacity and effort both increase over time and drive the fishery from one stage to the next.

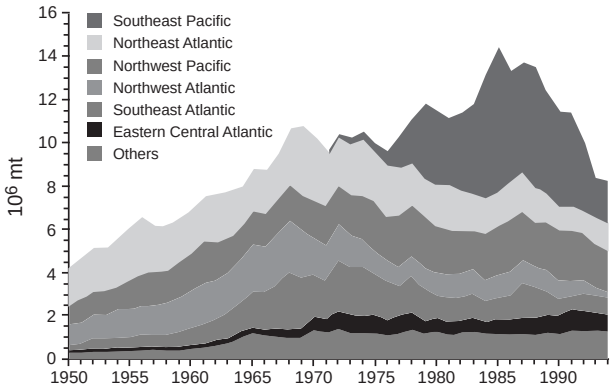

FIGURE 11. Landing by fishing area from all resources classified as overexploited or depleted in 1992. Source: Grainger and Garcia (1996).

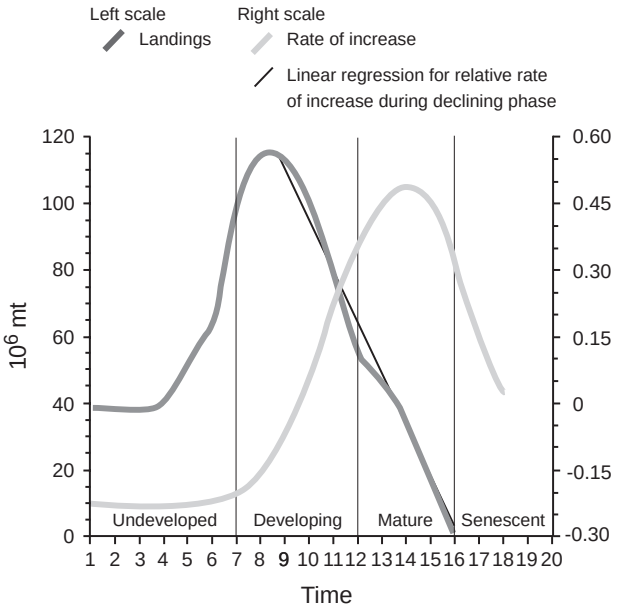

FIGURE 12. Generalized fishery development model (GFDM). Source: Grainger and Garcia (1996).

Grainger and Garcia (1996) categorized the 200 top-producing species (landings) by the four developmental stages for 1950–94, concluding these species accounted for 77% of world fish production. Species aggregates were excluded from this group except where groupings have been confined to a single genus. Of the 200 top-producing species showing increases, decreases, or showing little change from 1951 through 1994 (Figure 13), the percentage of species whose rate of increase was declining increased rather steadily while the portion whose rate was increasing rose steadily until about the mid-1980s before declining irregularly.

On the basis of the percentage of the group of 200 that falls into the four development phases over the period of study (Figure 14), the authors concluded that "this simple analysis shows strikingly the fact that there is very little room for further expansion of harvest from marine fish stocks and that further development of fishing effort will only result in lower catch rates." The analysis illustrates vividly the large proportion of world resources that are subject to declines in productivity and the increase in the number of these resources over time. It also underlines the fact that an ever-growing total tonnage of world fishery production gives a misleading vision of the state of world fishery resources and a false sense of security. The groupings for 1994 indicated about 35% of the top 200 resources are senescent, 25% are mature, 40% are still developing, and none remain at low exploitation levels.

The Grainger and Garcia (1996) study concluded, "given that few countries have established effective control of fishing capacity means that 60% of the major world fishery resources are either mature or senescent and in urgent need of management action to halt the increase in fishing capacity or the rehabilitation of damaged resources." These results were subsequently compared with Garcia and Newton (1997), who found that 69% of the world fish stocks were fully fished, overexploited, depleted, or recovering; Grainger and Garcia noted the striking similarity in the results; they also stated the Garcia and Newton paper concluded that 69% of the world marine fish stocks were in need of urgent management. However, we observed that this conclusion was perhaps implied but it was not explicitly stated in Garcia and Newton's paper.

Although many of the underlying factors that influence the GFDM may similarly impact the status of stock analysis, there remains significant methodological differences between the approaches that can lead to different interpretations and conclusions. For example, the GFDM excludes newly developing fisheries from entering the analysis, thus limiting many potential growth fisheries. Further, strictly managed fisheries may show no increases in landings and a zero rate of increase although the fishery state is excellent. Nevertheless, one cannot help but note that some of the world's largest fisheries are increasingly moving towards senescence. But is that not what one would expect if the underlying assumptions hold?

Grainger and Garcia (1996) also examined regional production histories and potentials based on data aggregated to world totals, summing estimates made from each ocean and for each FAO statistical area (Table 1). This analysis gives three different estimates of potential ocean yield ranging from 82 to 125 mmt. The table suggests that out of 16 statistical areas, 9 are overfished, 6 are increasing, and 1 is fully fished, but the authors' noted that the regional analyses are "shaky" at best (S. Garcia, FAO, Rome, pers. comm.).

The conclusion that 60% of 200 important world fish stocks which were considered mature and senescent and, therefore, "in urgent need of management actions," and the observation that Garcia and Newton (1997) had concluded 69% of the world fish stocks were in need of urgent management appears to have confused and misled a

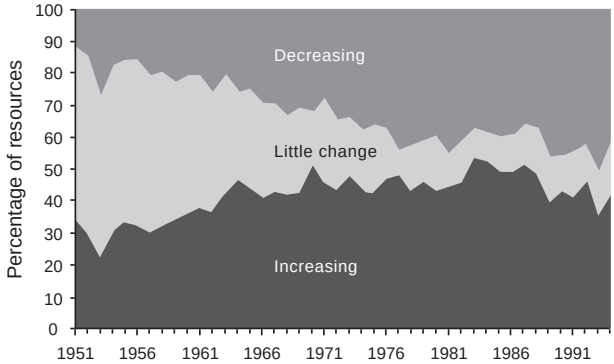

FIGURE 13. Percentage of major marine fish resources showing increases, little change, and decreases in landings by year. Source: Grainger and Garcia (1996).

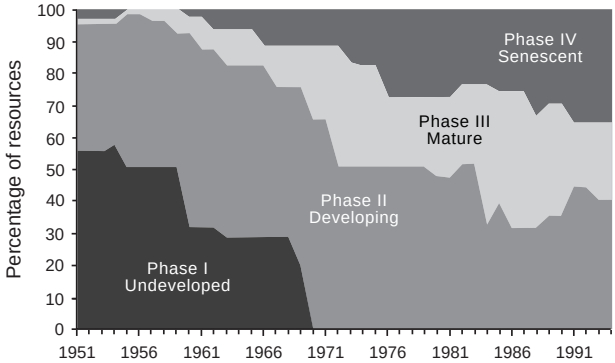

FIGURE 14. Percentage of major marine fish resources in various phases of fishery development. Source: Grainger and Garcia (1996).

TABLE 1. Comparison between estimated potentials and average landings for 1990 through 1994. State of resources codes: O = overfished, I = increasing, F = fully fished (all figures rounded to nearest mmt). Source: Grainger and Garcia (1996).

Area	Potential (A)	Landings (B)	Difference (A-B)	State
EC Atlantic	4	3	1	O
NE Atlantic	12	10	2	O
NW Atlantic	4	3	1	O
SE Atlantic	3	1	2	O
SW Atlantic	1	2	-1	I
WC Atlantic	2	2	0	O
E Indian	10	3	7	I
W Indian	13	4	9	I
Med & Black Sea	2	2	0	F
EC Pacific	3	1	1	O
NE Pacific	4	3	1	O
NW Pacific	26	24	2	I
SE Pacific	29	15	14	I
SW Pacific	1	1	0	O
WC Pacific	11	8	3	I
Antarctica	0.2	0.3	0.1	O
Sum of Areas	125	83	42	
N Atlantic	14	13	1	O
N Pacific	30	27	3	F
Atlantic total	21	21	0	I-F
Pacific total	54	53	1	I-F
Indian Total	23	7	16	I
Med & Black Sea	2	2	0	F
Sum of oceans	144	83	17	
World	82	83	-1	

number of readers, who interpreted these statements as implying that there has not been adequate management on any fully fished or overfished stocks anywhere in the world. A discussion with S. Garcia (FAO, Rome, pers. comm.) revealed that the intent was to alert managers that all stocks falling into this classification category require timely and effective management to ensure their continued high productivity or to be rebuilt to sustainable productive levels.

The possibility that all fully exploited important stocks that are yielding catches at or near MSY are in need of urgent management ignores the fact that many fully utilized stocks are already subjected to restrictive management regimes. For example, strict and conservative management of fisheries stocks has prevailed in the Northeast Pacific for several decades and stringent management has been imposed over the groundfish stocks off the eastern USA and Canada for several years. In addition, rather effective management of fully exploited stocks occurs in New Zealand, Australia, South Africa, Chile, Namibia, and many other areas. Nevertheless, we would agree that many and perhaps a majority of the fully fished and mature or senescent stocks are likely to be in need of improved management.

Alverson and Dunlop[3]

The 1997 review of the state of world marine fishery resources is perhaps the most comprehensive ever published by FAO (1997a). The document covers a grand total of 569 stock units, groupings, and so forth, with landing records extending back to the 1950s along with some excellent discussions of regional fisheries and selected topics concerned with ocean fisheries. The report also includes more detailed remarks on the FAO statistical regions along with introduction of the GFDM analysis of the history of growth and development of the world's 200 most important fisheries. The document is a substantial improvement over earlier status reports and undoubtedly reflects the growing concern and importance placed on the status of marine fisheries.

We have disaggregated the data in FAO (1997a) to identify the number of stocks and the weight of their catch that fall into each of the six status groups identified previously. All of the stocks listed in the 1997 report were entered into spreadsheets by area and subsequently combined into a master database. Tables in the report were organized by FAO statistical areas and broken out by FAO ISSCAAP group. The line entry for selected species, which appears to be a subtotal for evaluated stocks, was not entered into our database although we included the "other category" in our catch summaries. Stocks classified with a question mark were considered to have an unknown status whereas those given an exploitation rate classification incorporated with a question mark were conservatively assigned the exploitation status even though a firm classification was not given.

Of the 569 stocks for which catch data are available, just under half (273) are unknown. However, included within the stocks classified to state are some that have questionable status. The number of stocks we could clearly categorize to status was 296, which represents about 65% of the world catch classified to state in 1994. Many of the classifications include a combination of categories that result from several stocks or populations of the same species occurring in one statistical area or lack of certainty regarding the state of a stock, or both. We emphasize that, in this multiple listing mode, some stocks or portions of their populations may not be overfished or depleted. Mul-

[3]Current study.

tiple listed stocks account for about 33% of the total known stock states while unique status classifications are available for 199 stocks or 67% of the stocks considered in the 1997 FAO review. The status reporting classifications have been examined to determine the number of stocks and quantity of landings by status group (including unknown) falling into each FAO statistical area (Table 2).

To examine a range of possibilities regarding the state of marine fish populations, we considered three "stressed stock" scenarios using stocks for which status data are available:

A. an analysis grouping all species/stocks reported as fully exploited, overexploited, depleted, as well as multiple listed stocks including overfished, depleted, or recovering classifications (Table 3);
B. an analysis including all of the above groups but excluding fully to heavily fished stocks (Table 4); and
C. an analysis including only those stocks uniquely identified as overfished, depleted, or fully to overexploited (Table 5).

The results of this evaluation are given below:

1. When fully/heavily fished stocks (Scenario A) are designated as stressed along with overexploited, depleted, and recovering stocks, slightly over 74% of the global marine fish catch is derived from stressed groups (Table 3a) and 204 of the 296 stocks (69%) are considered stressed (Table 3b).
2. Under Scenario A, the Southeast Pacific, Northeast Atlantic, and Northwest Pacific have the largest quantity of catch taken from stressed groups or stocks, and in 11 of the 16 statistical areas, over half the catch has been derived from stocks that are fully fished, overfished, depleted or recovering (Table 3).
3. If the data (Table 4) are limited to Scenario B, 89 of the 296 stocks or about 30% are stressed. When the weight of the catch is considered, then 46% of the world marine catch is derived from these stressed stocks while in 4 of the 16 FAO statistical areas, more than 50% of the catch is derived from stressed stocks.
4. The largest quantity of landings taken from stressed stocks (Scenario B) is taken from the Southeast Pacific (statistical area 87) and involves stocks of hakes, anchovies, and sardines. The second largest landings from stocks potentially depleted or overfished are derived from the Northeast Atlantic and involve a number of demersal species. Together these two areas include over 80% by volume of landings of stocks categorized as stressed under Scenario B (Table 4).
5. The greatest number of stressed stocks under Scenario B occur in the Mediterranean/Black Sea (area 37), followed by stocks in the central Northeastern Atlantic (area 34), and stocks off western Europe (area 27) (Table 4). These three areas reportedly have 46 overexploited stocks, over half of the 89 stressed marine stocks.
6. If we take the more optimistic view in Scenario C, then 13% of the total marine catch is taken from stressed stocks and only 30 of the 296 stocks classified to status (about 10%) are involved (Table 5).

The results of Scenarios A, B and C (Figures 15 and 16) can be summarized as follows: When the fully/heavily fished stocks are added to the stressed category, the state of the world's marine wild fish stocks matches that noted by Garcia and Newton (1997). When the fully fished stocks are taken out of the stressed stock category (Scenario B), the results are still not very encouraging. On the other hand, if we restrict the analysis to only those stocks that are uniquely identified as overexploited, depleted, and fully to overexploited (Scenario C) and disregard stocks for which classifications are uncertain, the state of world fish stocks would seem quite good. The scenarios constitute three different ways investigators may group and evaluate the state of resources, and if the underlying grouping methodology and assumptions are properly defined, they constitute responsible observations. Nevertheless, the results of each scenario result in significantly different perceptions and risks regarding necessary management actions.

Little published data exist regarding changes in state over time, but Alverson and Larkins (1994) noted in 1987 that 29% of the reported fish stocks for which data were available were overfished or depleted. A similar analysis by Garcia and Newton (1997) noted 28% of the world marine fish stocks were overfished, depleted, or recovering in 1992, and for 1994 we have noted 30% of the reported stocks classified to status were overexploited, depleted, or in a multiple-status classification including overexploited or depleted stocks. The percentage of stocks classified as fully/heavily exploited was 45% in 1989, 44% in 1992, and 48% in 1994 (including stocks classified as moderate to fully exploited). Although some differences may have occurred in the manner of classification between investigators, the data do not support an erosion of the status of marine resources over this time period but *do* suggest a broader and fuller use of the stocks available.

One cannot conclude from these data that the number of overexploited or fully fished stocks has not increased in recent years as the number of stocks classified to state has increased from 176 in 1987 to just under 300 in 1994. The number of overexploited stocks during this period has

Table 2. FAO classifications, by ocean area, for all evaluated stocks (including unknown/unclassified) by (A) number of stocks and (B) weight (10^6 mt). Data based onFAO (1997a).

	Atlantic							Indian		Pacific							
Status	NW	NE	W Central	E Central	Med. & Black Sea	SW	SE	W	E	NW	NE	W Central	E Central	SW	SE	South-ern	Grand total
A. Number																	
Depleted	2	-	-	-	6	-	-	-	-	-	1	-	-	-	-	4	13
Fully Exploited–Depleted	-	4	-	-	-	-	-	-	-	-	2	-	-	-	1	-	7
Moderately Exploited–Depleted	-	3	-	-	-	-	-	-	-	1	-	2	1	-	-	-	7
Overexploited	-	4	-	3	-	1	2	-	-	-	-	-	-	-	-	-	10
Fully–Overexploited	-	-	3	13	13	4	-	-	-	1	2	-	1	-	5	-	42
Moderate–Overexploited	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	2
Moderate–Fully–Overexploited	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	3
Under–Moderately–Overexploited	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Under–Overexploited	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Undeveloped–Fully–Recovering	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Moderately Exploited–Recovering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Recovering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Fully/Heavily Exploited	19	7	10	1	9	1	13	11	10	8	11	3	-	9	1	2	115
Moderate–Fully Exploited	-	-	3	4	5	2	1	1	3	-	-	7	2	-	1	-	29
Under–Fully Exploited	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Moderately Exploited	5	2	3	3	1	2	1	-	1	4	-	3	1	13	4	-	43
Under–Moderately Exploited	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2
Undeveloped/Underexploited	2	-	-	-	-	1	1	-	-	-	1	-	3	4	-	5	17
Unknown	8	10	22	31	14	19	14	24	35	18	8	34	13	11	10	2	273
Grand Total	37	30	42	55	49	33	32	36	49	32	27	49	24	37	23	14	569
B. Catch																	
Depleted	0.06	-	-	-	0.06	-	-	-	-	-	0.03	-	-	-	-	-	0.14
Fully Exploited–Depleted	-	3.72	-	-	-	-	-	-	-	-	0.02	-	-	-	1.79	-	5.54
Moderately Exploited–Depleted	-	1.13	-	-	-	-	-	-	-	1.29	-	0.17	0.00	-	-	-	2.59
Overexploited	-	1.49	-	0.06	-	0.09	0.01	-	-	-	-	-	-	-	-	-	1.64
Fully–Overexploited	-	-	0.07	0.29	0.62	1.04	-	-	-	0.14	0.05	-	0.07	-	12.57	-	14.86
Moderate–Fully–Overexploited	-	-	-	-	-	0.13	-	-	-	-	-	-	-	-	-	-	0.13
Under–Moderately–Overexploited	-	-	-	-	-	-	-	-	-	-	-	-	0.03	-	-	-	0.03
Moderate–Over Exploited	-	-	-	-	0.02	-	-	-	-	-	0.09	-	-	-	-	-	0.11
Recovering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.00
Moderately Exploited–Recovering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	-	0.05
Undeveloped–Fully–Recovering	0.24	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.24
Fully/Heavily Exploited	0.75	1.86	1.07	0.11	0.09	0.02	0.87	0.89	0.53	5.98	2.16	0.70	-	0.15	0.04	0.01	15.23
Moderate–Fully Exploited	-	-	0.03	0.30	0.36	0.15	0.28	0.24	0.09	-	-	0.98	0.34	-	4.26	-	7.03
Under–Fully Exploited	-	-	-	-	-	-	-	-	-	-	0.07	-	-	-	-	-	0.07
Moderately Exploited	0.39	1.03	0.12	0.94	0.03	0.03	0.00	-	0.00	2.91	-	0.21	0.02	0.20	0.32	-	6.20
Under–Moderately Exploited	-	-	-	-	-	-	-	-	-	-	-	-	0.10	-	-	-	0.10
Under–Overexploited	-	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-	-	0.03
Undeveloped/Underexploited	0.05	-	-	-	-	0.02	0.06	-	-	-	0.11	-	0.01	0.25	-	0.08	0.57
Unknown	0.15	0.55	0.73	1.18	0.28	0.65	0.08	1.32	2.70	9.72	0.48	5.82	0.67	0.02	0.26	-	24.61
Grand Total	1.64	9.78	2.06	2.89	1.46	2.11	1.30	2.46	3.32	20.05	3.01	7.88	1.24	0.62	19.29	0.09	79.17

Table 3. Scenario A—FAO classified stocks, by ocean area, grouped as stressed (including depleted, overexploited, and fully/heavily exploited) by (A) number of stocks and (B) weight (10^3 metric tons). Data based on FAO (1997a).

	Atlantic							Indian		Pacific							
Status	NW	NE	W Central	E Central	Med. & Black Sea	SW	SE	W	E	NW	NE	W Central	E Central	SW	SE	South-ern	Grand total
A. Number																	
Depleted	2	-	-	-	6	-	-	-	-	-	1	-	-	-	-	4	13
Fully Exploited–Depleted	-	4	-	-	-	-	-	-	-	-	2	-	-	-	1	-	7
Moderately Exploited–Depleted	-	3	-	-	-	-	-	-	-	1	-	2	1	-	-	-	7
Overexploited	-	4	-	3	-	1	2	-	-	-	-	-	-	-	-	-	10
Fully–Overexploited	-	-	3	13	13	4	-	-	-	1	2	-	1	-	5	-	42
Moderate–Over Exploited	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	2
Moderate–Fully–Overexploited	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	3
Under–Moderately–Overexploited	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Under–Overexploited	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Undeveloped–Fully–Recovering	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Moderately Exploited–Recovering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Recovering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Fully/Heavily Exploited	19	7	10	1	9	1	13	11	10	8	11	3	-	9	1	2	115
Subtotal	22	18	14	17	29	9	15	11	10	10	17	5	3	9	8	7	204
Moderate–Fully Exploited	-	-	3	4	5	2	1	1	3	-	-	7	2	-	1	-	29
Under–Fully Exploited	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Moderately Exploited	5	2	3	3	1	2	1	-	1	4	-	3	1	13	4	-	43
Under–Moderately Exploited	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2
Undeveloped/Underexploited	2	-	-	-	-	1	1	-	-	-	1	-	3	4	-	5	17
Subtotal	7	2	6	7	6	5	3	1	4	4	2	10	8	17	5	5	92
Grand Total	29	20	20	24	35	14	18	12	14	14	19	15	11	26	13	12	296
B. Catch																	
Depleted	55	0	0	0	57	0	0	0	0	0	26	0	0	0	0	0	138
Fully Exploited–Depleted	0	3,720	0	0	0	0	0	0	0	0	22	0	0	0	1,793	0	5,535
Moderately Exploited–Depleted	0	1,128	0	0	0	0	0	0	0	1,294	0	167	4	0	0	0	2,593
Overexploited	0	1,494	0	59	0	85	6	0	0	0	0	0	0	0	0	0	1,644
Fully–Overexploited	0	0	72	290	619	1,042	0	0	0	144	49	0	67	0	12,574	0	14,857
Moderate–Fully–Overexploited	0	0	0	0	0	125	0	0	0	0	0	0	0	0	0	0	125
Under–Moderately–Overexploited	0	0	0	0	0	0	0	0	0	0	0	0	34	0	0	0	34
Moderate–Over Exploited	0	0	0	0	24	0	0	0	0	0	89	0	0	0	0	0	113
Recovering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Moderately Exploited–Recovering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	50	0	50
Undeveloped–Fully–Recovering	243	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	243
Fully/Heavily Exploited	754	1,857	1,071	108	94	16	866	894	528	5,982	2,161	703	0	152	36	5	15,227
Subtotal	1,052	8,199	1,143	457	794	1,268	872	894	528	7,420	2,347	870	105	152	14,453	5	40,559
Moderate–Fully Exploited	0	0	30	304	363	151	284	239	86	0	0	978	338	0	4,255	0	7,028
Under–Fully Exploited	0	0	0	0	0	0	0	0	0	0	70	0	0	0	0	0	70
Moderately Exploited	389	1,026	123	941	25	27	1	0	3	2,911	0	212	22	197	324	0	6,201
Under–Moderately Exploited	0	0	0	0	0	0	0	0	0	0	0	0	97	0	0	0	97
Under–Overexploited	0	0	34	0	0	0	0	0	0	0	0	0	0	0	0	0	34
Undeveloped/Underexploited	52	0	0	0	0	19	56	0	0	0	108	0	6	249	0	81	571
Subtotal	441	1,026	187	1,245	388	197	341	239	89	2,911	178	1,190	463	446	4,579	81	14,001
Grand Total	1,493	9,225	1,330	1,702	1,182	1,465	1,213	1,133	617	10,331	2,525	2,060	568	598	19,032	86	54,560

Table 4. Scenario B—FAO classified stocks, by ocean area, grouped as stressed (including depleted and any combination of overexploited) by (A) number of stocks and (B) weight (10^3 mt). Data based on FAO (1997a).

	Atlantic							Indian		Pacific							
Status	NW	NE	W Central	E Central	Med. & Black Sea	SW	SE	W	E	NW	NE	W Central	E Central	SW	SE	South-ern	Grand total
A. Number																	
Depleted	2	-	-	-	6	-	-	-	-	-	1	-	-	-	-	4	13
Fully Exploited–Depleted	-	4	-	-	-	-	-	-	-	-	2	-	-	-	1	-	7
Moderately Exploited–Depleted	-	3	-	-	-	-	-	-	-	1	-	2	1	-	-	-	7
Overexploited	-	4	-	3	-	1	2	-	-	-	-	-	-	-	-	-	10
Fully–Overexploited	-	-	3	13	13	4	-	-	-	1	2	-	1	-	5	-	42
Moderate–Over Exploited	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	2
Moderate–Fully–Overexploited	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	3
Under–Moderately–Overexploited	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
Under–Overexploited	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Undeveloped–Fully–Recovering	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Moderately Exploited–Recovering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
Recovering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Subtotal of stocks	3	11	4	16	20	8	2	0	0	2	6	2	3	0	7	5	89
Fully/Heavily Exploited	19	7	10	1	9	1	13	11	10	8	11	3	-	9	1	2	115
Moderate–Fully Exploited	-	-	3	4	5	2	1	1	3	-	-	7	2	-	1	-	29
Under–Fully Exploited	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
Moderately Exploited	5	2	3	3	1	2	1	-	1	4	-	-	3	1	13	4	-	43
Under–Moderately Exploited	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	2
Undeveloped/Underexploited	2	-	-	-	-	1	1	-	-	-	1	-	3	4	-	5	17
Subtotal of stocks	26	9	16	8	15	6	16	12	14	12	13	13	8	26	6	7	207
Grand Total	29	20	20	24	35	14	18	12	14	14	19	15	11	26	13	12	296
B. Catch																	
Depleted	55	-	-	-	57	-	-	-	-	-	26	-	-	-	-	-	138
Fully Exploited–Depleted	-	3,720	-	-	-	-	-	-	-	-	22	-	-	-	1,793	-	5,535
Moderately Exploited–Depleted	-	1,128	-	-	-	-	-	-	-	1,294	-	167	4	-	-	-	2,593
Overexploited	-	1,494	-	59	-	85	6	-	-	-	-	-	-	-	-	-	1,644
Fully–Overexploited	-	-	72	290	619	1,042	-	-	-	144	49	-	67	-	12,574	-	14,857
Moderate–Fully–Overexploited	-	-	-	-	-	125	-	-	-	-	-	-	-	-	-	-	125
Under–Moderately–Overexploited	-	-	-	-	-	-	-	-	-	-	-	-	34	-	-	-	34
Moderate–Over Exploited	-	-	-	-	24	-	-	-	-	-	89	-	-	-	-	-	113
Recovering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Moderately Exploited–Recovering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	-	50
Undeveloped–Fully–Recovering	243	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	243
Subtotal	298	6,342	72	349	700	1,252	6	0	0	1,438	186	167	105	0	14,417	0	25,332
Fully/Heavily Exploited	754	1,857	1,071	108	94	16	866	894	528	5,982	2,161	703	-	152	36	5	15,227
Moderate–Fully Exploited	-	-	30	304	363	151	284	239	86	-	-	978	338	-	4,255	-	7,028
Under–Fully Exploited	-	-	-	-	-	-	-	-	-	-	70	-	-	-	-	-	70
Moderately Exploited	389	1,026	123	941	25	27	1	-	3	2,911	-	212	22	197	324	-	6,201
Under–Moderately Exploited	-	-	-	-	-	-	-	-	-	-	-	-	97	-	-	-	97
Under–Overexploited	-	-	34	-	-	-	-	-	-	-	-	-	-	-	-	-	34
Undeveloped/Underexploited	52	-	-	-	-	19	56	-	-	-	108	-	6	249	-	81	571
Subtotal	1,195	2,883	1,258	1,353	482	213	1,207	1,133	617	8,893	2,339	1,893	463	598	4,615	86	29,228
Grand Total	1,493	9,225	1,330	1,702	1,182	1,465	1,213	1,133	617	10,331	2,525	2,060	568	598	19,032	86	54,560

Table 5. Scenario C—FAO classified stocks, by ocean area, grouped as stressed (including depleted and overexploited) by (A) number of stocks and (B) weight (10^3 mt). Data based on FAO (1997a).

	Atlantic							Indian		Pacific							
Status	NW	NE	W Central	E Central	Med. & Black Sea	SW	SE	W	E	NW	NE	W Central	E Central	SW	SE	South-ern	Grand total
A. Number of stocks																	
Depleted	2	0	0	0	6	0	0	0	0	0	1	0	0	0	0	4	13
Fully Exploited–Depleted	0	4	0	0	0	0	0	0	0	0	2	0	0	0	1	0	7
Overexploited	0	4	0	3	0	1	2	0	0	0	0	0	0	0	0	0	10
Subtotal	2	8	0	3	6	1	2	0	0	0	3	0	0	0	1	4	30
Moderately Exploited–Depleted	0	3	0	0	0	0	0	0	0	1	0	2	1	0	0	0	7
Fully–Overexploited	0	0	3	13	13	4	0	0	0	1	2	0	1	0	5	0	42
Moderate–Over Exploited	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	2
Moderate–Fully–Overexploited	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	3
Under–Moderately–Overexploited	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Under–Overexploited	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Undeveloped–Fully–Recovering	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Moderately Exploited–Recovering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Recovering	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Fully/Heavily Exploited	19	7	10	1	9	1	13	11	10	8	11	3	0	9	1	2	115
Moderate–Fully Exploited	0	0	3	4	5	2	1	1	3	0	0	7	2	0	1	0	29
Under–Fully Exploited	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Moderately Exploited	5	2	3	3	1	2	1	0	1	4	0	3	1	13	4	0	43
Under–Moderately Exploited	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Undeveloped/Underexploited	2	0	0	0	0	1	1	0	0	0	1	0	3	4	0	5	17
Subtotal	27	12	20	21	29	13	16	12	14	14	16	15	11	26	12	8	266
Grand Total	29	20	20	24	35	14	18	12	14	14	19	15	11	26	13	12	296
B. Catch																	
Depleted	55	-	-	-	57	-	-	-	-	-	26	-	-	-	-	-	138
Fully Exploited–Depleted	-	3,720	-	-	-	-	-	-	-	-	22	-	-	-	1,793	-	5,535
Overexploited	-	1,494	-	59	-	85	6	-	-	-	-	-	-	-	-	-	1,644
Subtotal	55	5,214	-	59	57	85	6	-	-	-	48	-	-	-	1,793	-	7,317
Moderately Exploited–Depleted	-	1,128	-	-	-	-	-	-	-	1,294	-	167	4	-	-	-	2,593
Fully–Overexploited	-	-	72	290	619	1,042	-	-	-	144	49	-	67	-	12,574	-	14,857
Moderate–Fully–Overexploited	-	-	-	-	-	125	-	-	-	-	-	-	-	-	-	-	125
Under–Moderately–Overexploited	-	-	-	-	-	-	-	-	-	-	-	-	34	-	-	-	34
Moderate–Over Exploited	-	-	-	-	24	-	-	-	-	-	89	-	-	-	-	-	113
Recovering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Moderately Exploited–Recovering	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	-	50
Undeveloped–Fully–Recovering	243	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	243
Fully/Heavily Exploited	754	1,857	1,071	108	94	16	866	894	528	5,982	2,161	703	-	152	36	5	15,227
Moderate–Fully Exploited	-	-	30	304	363	151	284	239	86	-	-	978	338	-	4,255	-	7,028
Under–Fully Exploited	-	-	-	-	-	-	-	-	-	-	70	-	-	-	-	-	70
Moderately Exploited	389	1,026	123	941	25	27	1	-	3	2,911	-	212	22	197	324	-	6,201
Under–Moderately Exploited	-	-	-	-	-	-	-	-	-	-	-	-	97	-	-	-	97
Under–Overexploited	-	-	34	-	-	-	-	-	-	-	-	-	-	-	-	-	34
Undeveloped/Underexploited	52	-	-	-	-	19	56	-	-	-	108	-	6	249	-	81	571
Subtotal	1,438	4,011	1,330	1,643	1,125	1,380	1,207	1,133	617	10,331	2,477	2,060	568	598	17,239	86	47,243
Grand Total	1,493	9,225	1,330	1,702	1,182	1,465	1,213	1,133	617	10,331	2,525	2,060	568	598	19,032	86	54,560

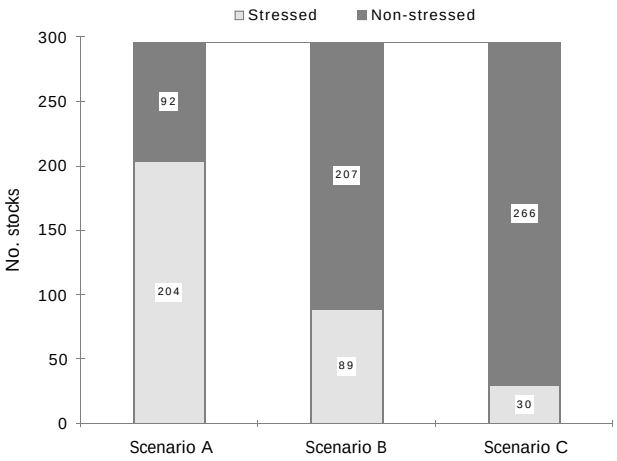

FIGURE 15. Cumulative status of FAO classified stocks by number presented by Scenarios A, B, and C. Total number of evaluated stocks, excluding unknown/unclassified = 296. Data based on FAO (1997a).

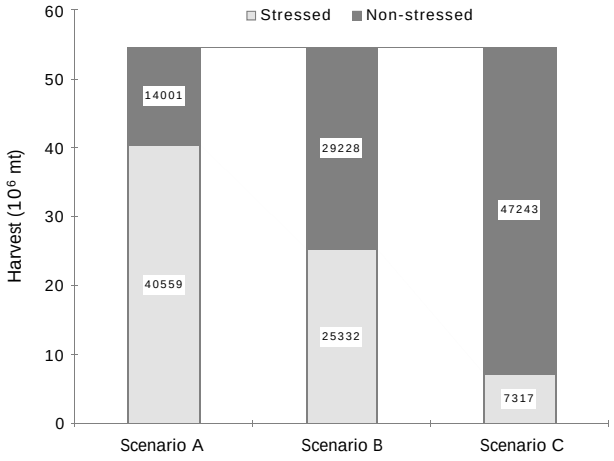

FIGURE 16. Cumulative status of FAO classified stocks by weight (10^6 mt) presented by Scenarios A, B, and C. Data based on FAO (1997a).

increased from 51 to 89, and the number of fully fished stocks increased from 79 to 115. The proportion of stocks in the overfished, depleted, and recovering categories has remained remarkably constant since 1987. However, the data do suggest an increasing diversity of target species or an improved level of observations on the state of fish stocks. Preliminary 1995 FAO landing statistics indicate that landings from most taxonomic groups have increased, including a substantial rise in the landings of cod-like species, redfishes, and salmon. When the landings by taxonomic groups are compared between 1994 and 1995, they clearly are increasing for most taxonomic groups and particularly for some foodfish species (Table 6). The interyear comparisons are encouraging but there is a danger in placing any great significance on this short-term trend. The above observations provides a gross impression of the current state of world fisheries but little data on what important commercial species/stocks are under stress from overexploitation and in what areas they are located.

Trends in catch in Scenario B were compiled for all cod-like species (Figure 17). Clearly, there was a downward trend in world catch until 1994—a trend largely driven by the condition of cod-like stocks in the North Atlantic. In terms of catch trends, the basis for the classified overfished cod stocks in the Pacific and Southwest Atlantic is not readily apparent. This apparent contradiction may reflect stocks that have multiple-status listings: for instance, cod stocks of the Northeast Pacific where the large cod population off Alaska is considered underfished but is categorized along with a small cod stock off British Columbia that is overfished. It may also reflect uncertainty in status or stocks that are still yielding relatively high catches but are considered to be heavily exploited to overexploited with anticipated reductions in future catches.

Similar catch trend information was analyzed under Scenario B for overexploited, depleted, and recovering stocks of (a) herring-like species; (b) shrimps and lobsters; (c) redfishes; (d) squids, octopuses, and cuttlefishes; and (e) tuna-like species (Figures 18–22). The trends for these species are discussed as follows.

1. Unlike cod-like stocks, the trend in landings (Figure 18) for stressed herring-like species reached an all-time high in 1994, largely driven by the sharp increases in Pacific anchovy landings off western South America. This stock is considered to be moderately to overexploited although landings have been increasing during the 1990s. Two of the 11 stressed stocks, the North Pacific herring and the Northwest Japanese pilchard, have shown significant declines since the early 1980s, while trends in the remainder of the herring-like stocks are stable or slightly increasing.
2. The landings of stressed wild shrimp and lobster resources peaked during the late 1970s and since have shrunk to about half their historical high (Figure 19). The declines in shrimp catches for stressed stocks result largely from overfished or depleted pink shrimp populations taken in the Northeast Pacific region—an area where evidence suggests that environmental factors may have played a significant role in the downward trend (Alverson 1992). Further, none of the tropical penaeid shrimp species, which are fast growing and have relatively short life spans, are included in the stressed group for 1994.
3. A large number of stressed stocks are reported in

TABLE 6. Catch and trend in catch (mt) by FAO International Standard Statistical Classification of Aquatic Animals and Plants species group, 1994–95. Trend code: U = up, D = down, N = no trend. Source: FAO data (including aquaculture).

Rank	FAO species group	Catch 1995	Catch 1994	% change 1995–94	Trend-direction
1	Herrings, sardines, anchovies	22,016,712	25,855,914	-15%	D
2	Jacks, mullets, sauries	11,195,405	10,089,017	11%	U
3	Misc. marine fishes	11,158,163	10,965,680	2%	U
5	Cods, hakes, haddocks	10,617,580	9,664,689	10%	U
6	Redfishes, basses, congers	6,959,772	6,456,281	8%	U
8	Tunas, bonitos, billfishes	4,782,592	4,680,433	2%	U
9	Mackerel, snoeks, cutlassfishes	4,654,258	4,522,000	3%	U
10	Shrimps, prawns, etc.	3,193,132	3,117,582	2%	U
11	Squids, cuttlefish, octopuses	2,841,060	2,776,233	2%	U
12	Clams, cockles, arkshells	2,133,988	2,021,427	6%	U
13	Salmon, trouts, smelts	2,100,595	1,814,020	16%	U
14	Scallops, pectens, etc.	1,651,602	1,634,256	1%	U
15	Oysters	1,338,761	1,220,967	10%	U
16	Sea spiders, crab, etc.	1,293,094	1,257,747	3%	U
17	Misc. marine molluscs	1,283,832	826,211	55%	U
18	Mussels	1,265,091	1,262,410	0%	N
20	Misc. marine crustaceans	1,015,871	938,857	8%	U
21	Flounders, halibuts, soles	929,597	999,725	-7%	D
22	Misc. diadromous fishes	808,548	821,280	-2%	D
23	Sharks, rays, chimaeras	754,864	749,592	1%	U
24	Shads, etc.	673,800	644,905	4%	U
28	Lobsters, spinyrock lobsters	215,545	214,963	0%	N
30	Sea urchins & other echinoderms	127,505	116,644	9%	U
31	Krill, plankton, crustaceans	118,815	81,725	45%	U
32	Abalones, winkles, conchs	99,547	99,524	0%	N
33	Sea squirts & other tunicates	39,414	55,557	-29%	D
35	Squat-lobsters	11,044	7,288	52%	U
	Total catch	93,280,187	92,894,927	0%	

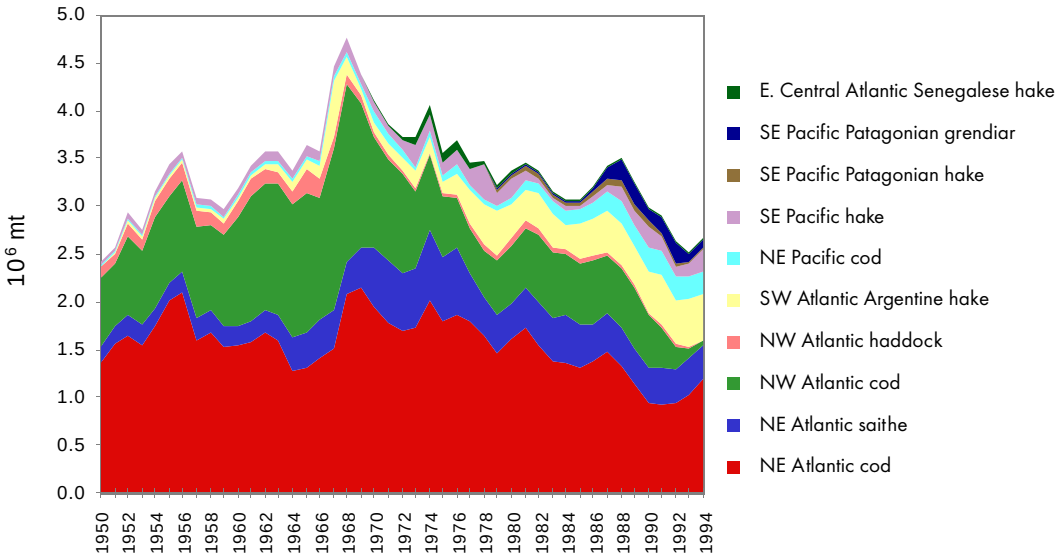

FIGURE 17. Trends in catch (mmt) of overexploited cod, hake, and haddock stocks, 1950–94. Source: FAO (1997a).

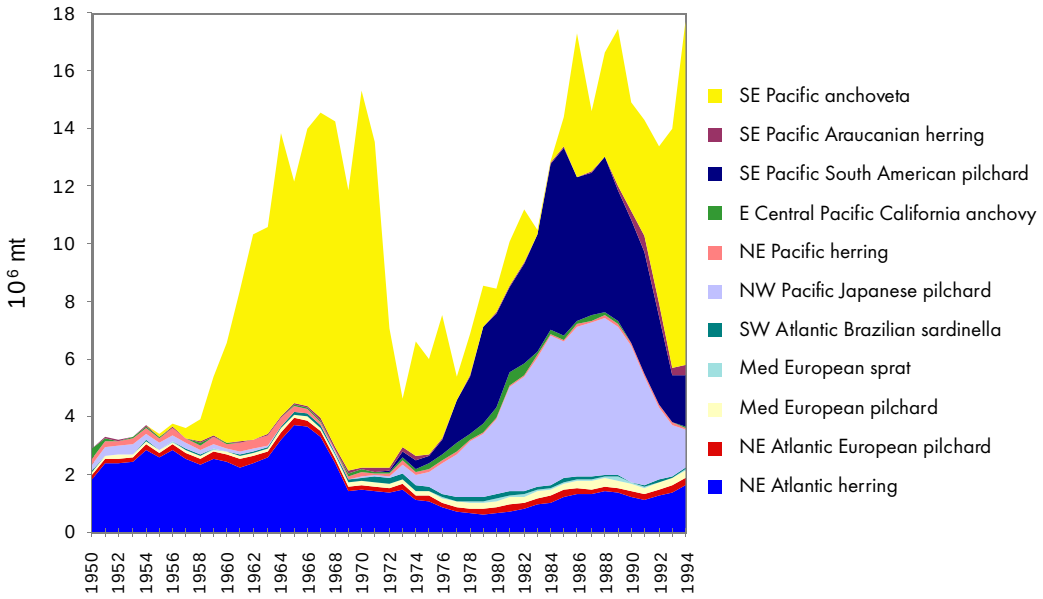

FIGURE 18. Trends in catch (mmt) of overexploited herring, anchovy, and sardine stocks, 1950–94. Source: FAO (1997a).

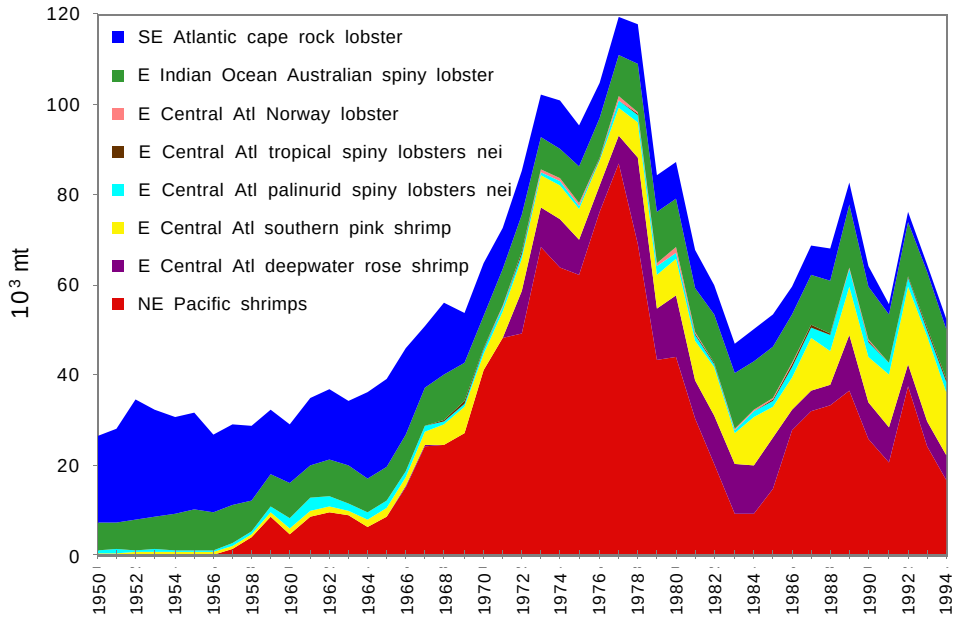

FIGURE 19. Trends in catch (1,000 mt) of overexploited shrimp and lobster stocks, 1950–94. Source: FAO (1997a). nei = not elsewhere included.

the diverse redfish group. Stressed stocks in this group can be found in many of the FAO statistical areas, and their catch trends have been very erratic (Figure 20). Despite their classification as stressed, the total landings from this group remains well above the long-term average for 1950–94.

4. The catch history for stressed squid and octopus stocks is reflected by the increased targeting on diverse species and sharply increased catches following the beginning of the past decade (Figure 21). Landings for these species (stocks) have been more unstable in recent years. The total catch has remained relatively high and the overall trend is dominated by a variety of miscellaneous squid species taken in the Southwest Atlantic.
5. The overall trend line for tuna and tuna-like stocks (Figure 22) is characterized by a significant increase in reported albacore (*Thunnus alalunga*) and bigeye

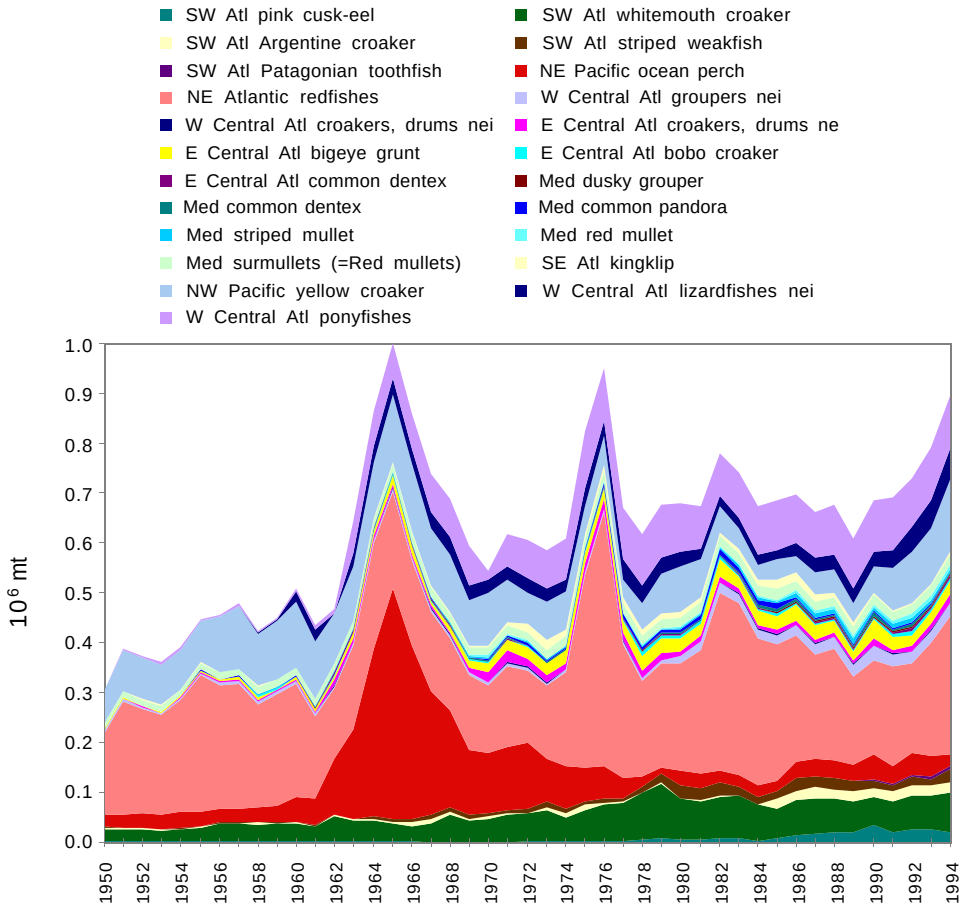

FIGURE 20. Trends in catch (mmt) of overexploited redfish stocks, 1950–94. Source: FAO (1997a). nei = not elsewhere included.

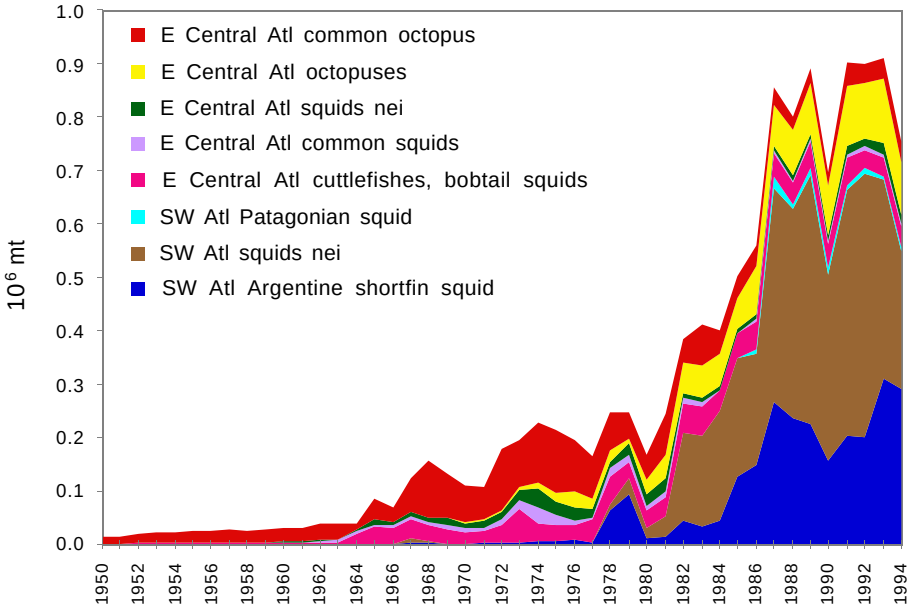

FIGURE 21. Trends in catch (mmt) of overexploited squid and octopus stocks, 1950–94. Source: FAO (1997a). nei = not elsewhere included.

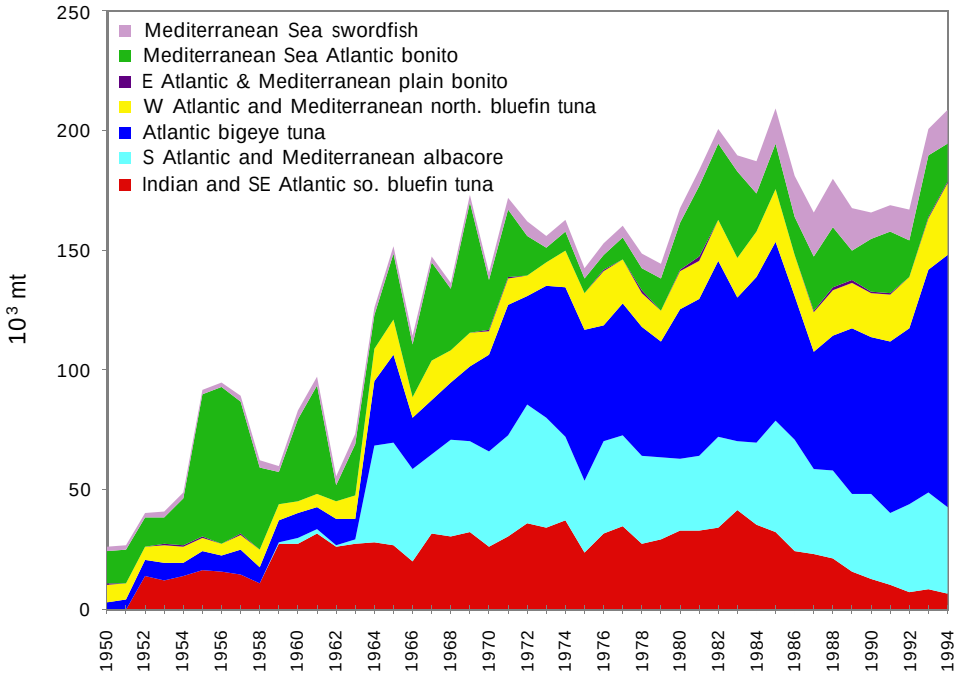

FIGURE 22. Trends in catch (10^3 mt) of overexploited tuna and tuna-like stocks, 1950–94. Source: FAO (1997a).

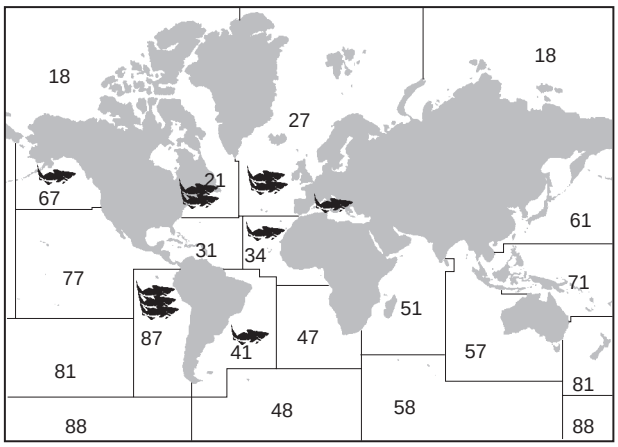

FIGURE 23. Distribution of cod, hake, and haddock stocks by FAO statistical area designated as depleted, overexploited, or any classification in combination with overfishing. Data based on FAO (1997a).

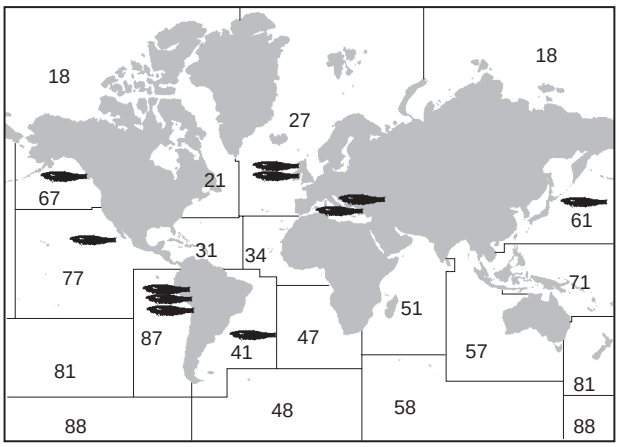

FIGURE 24. Distribution of herring, anchovy, and sardine stocks by FAO statistical area designated as depleted, overexploited, or any classification in combination with overfishing. Data based on FAO (1997a).

(*T. obesus*) tuna catches between 1963 and 1964 and a significant growth in the catch of bigeye tuna over the reporting period. The major decline in this group has been in the landings of bluefin tuna (*T. thynnus*) and Mediterranean Sea Atlantic bonito (*Sarda sarda*).

The geographic distribution of overexploited, depleted, and recovering stocks is shown in Figures 23 through 28. As of 1994, the greatest number of stressed stocks occurred in the Mediterranean/Black Sea followed by the Eastern Central and Northeast Atlantic. No overexploited stocks were reported in the East or West Indian Ocean in the FAO 1997 state of stock report or in the Southwest Pacific (FAO 1997a).

THEORETICAL EVIDENCE

Since the middle of this century, various authors have speculated on the potential of the world's oceans to provide protein resources for the burgeoning world population. These efforts have led to rather disparate estimates ranging from about 22 to 2,000 mmt (Table 7; Pauly 1996, Schaefer and

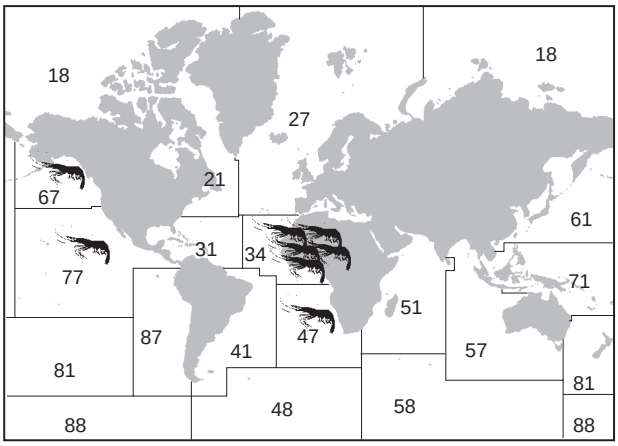

FIGURE 25. Distribution of shrimp and lobster stocks by FAO statistical area designated as depleted, overexploited, or any classification in combination with overfishing. Data based on FAO (1997a).

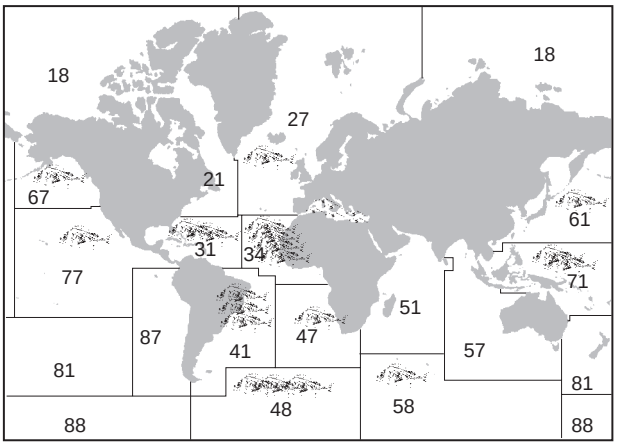

FIGURE 26. Distribution of redfish stocks by FAO statistical area designated as depleted, overexploited, or any classification in combination with overfishing. Source: Data based on FAO (1997a).

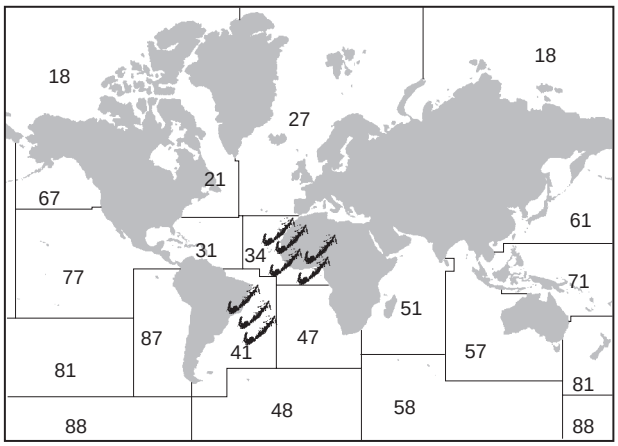

FIGURE 27. Distribution of octopus and squid stocks by FAO statistical area designated as depleted, overexploited, or any classification in combination with overfishing. Data based on FAO (1997a).

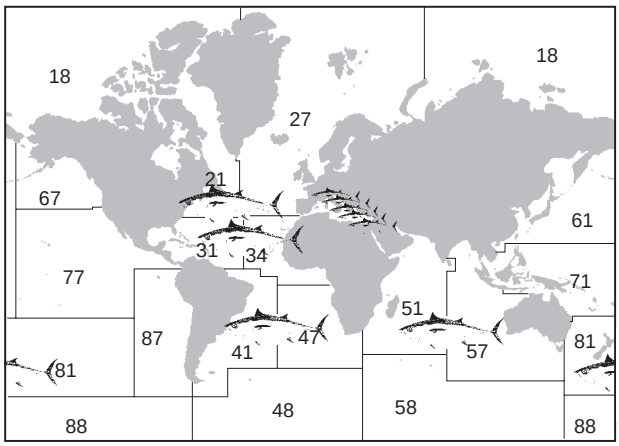

FIGURE 28. Distribution of tuna and tuna-like stocks by FAO statistical area designated as depleted, overexploited, or any classification in combination with overfishing. Data based on FAO (1997a).

Alverson 1968). In developing the forecast of world fish potentials, scientists' estimates have largely been based on extrapolated estimates of catch trends, extrapolations from landings in known areas to other regions of the world, and extrapolations from primary production of phytoplankton. Schaefer and Alverson (1968) noted that the extremes of those estimates are often related to underlying assumptions and what types of fish and invertebrates might be harvested, including "conventional" and "unconventional species," bony fishes, and available nekton. Pauly (1996) reviewed most of the estimates and noted pitfalls in the historical efforts to predict the oceans' total harvest potential.

Perhaps one of the most robust and frequently cited estimates of world marine fish potential is that of Gulland (1971). This estimate (100 x 10^6 mt yr^{-1}) of conventional species was developed as the result of combining a number of individual and area estimates derived by authors commissioned by FAO. World fish production is frequently evaluated against the Gulland estimate to demonstrate the approximation of the catch to this theoretical production limit. These analyses frequently ignore the fact that the estimate was confined to catches of "conventional marine species" and did not include (1) freshwater production, (2) aquaculture, and (3) catches of cephalopods, krill, and lanternfish. Independent annual estimates of 100, 50, and 100 mmt were derived for these taxonomic groups, respectively.

Alverson et al. (1994) noted that efforts to relate marine fish catches with the Gulland estimate of 100 mmt have

TABLE 7. Estimates of the potential fisheries of the oceans. Source: Schaefer and Alverson (1968), Pauly (1996).

Authors	Year	Estimates ($t\ 10^6\ yr^{-1}$)	Methods[a]	Remarks
Thompson	1949	21.6	ext	
FAO	1955	55.4	ext	
Finn	1960	50-60	ext	
Graham & Edwards	1962	55	ext	Bony fishes only, i.e. 2/3 of
Graham & Edwards	1962	60	ext, f	available nekton
Meseck	1962	55	ext	To be reached by 1970
Schaefer	1965	66	ext	To be reached by 1970
Meseack	1962	70	ext	To be reached by 1980
Alverson	1965	80	ext	
Bogdanov	1965	70-80	ext, f	Comprehensive review
Graham & Edwards	1962	115	f	
Schaefer	1965	160	ext	
Schaefer	1965	200	f	
Pike & Spilhaus	1965	200	f	
Chapman	1966	1000	f	
Pike & Spilhaus	1962	180-1400	f	
Chapman	1965	2000	f	
Gulland	1970	100	ext	Conventional species only
Gulland	1970	260-350	ext, f	Including non-conventional species
Idyll	1978	400-700	none	

[a]ext = extrapolated from catch trends or existing knowledge of world fish resources; f = flow of material through food chain

often failed to account for imposed fishing mortalities resulting from discarding; illegal, recreational, and subsistence fishing; and other sources of unobserved fishing mortality. When unconventional species are eliminated from the global marine catch, the 1994 landings marine landings amount to roughly 80 mmt or about 80% of the Gulland estimate (Figure 29). But if an additional catch amounting to 34% of the reported landed catch is added to account for discards (Alverson et al. 1994) and 25% of reported catch to accommodate for deaths due to all unobserved fishing mortality (speculation), the addition of the discards alone leads to a catch in excess of the Gulland limit, and the added loss for other unobserved fishing mortality, if in the ballpark, puts the world fish catch and associated mortalities well above the Gulland "line" for conventional species.[4]

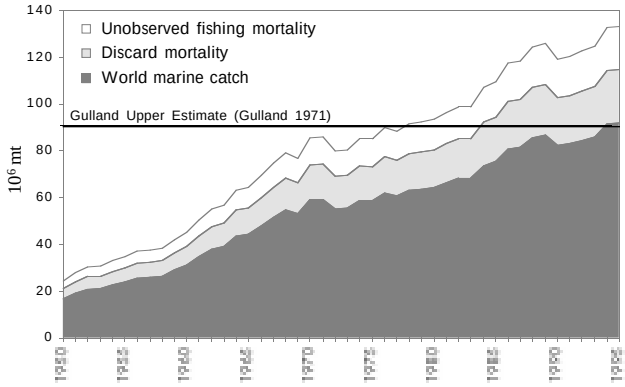

FIGURE 29. Total world marine catch, discards, and unobserved fishing mortality (mmt), 1950–95. Date include some unconventional species. Source: Alverson 1998.

Pauly and Christensen (1995) noted, "the primary production required to sustain the reported catches plus 27 mmt of bycatch amounted to 8% of global aquatic primary production, nearly four times the previous estimate." By ecosystem type, the requirements were only 2% for open ocean systems, but ranged from 24% to 35% in freshwater, upwelling, and shelf systems. The authors concluded that these data justify concerns for the sustainability of ocean fisheries. Of course, if some additional losses are included to account for unobserved fishing mortality, the argument is strengthened.

Pauly et al. (1998) also recently noted that the trophic level of marine fish catch declined between 1950 and 1994. The decline is associated with the overfishing of many of the higher trophic food fish species. The authors noted that the trend "reflects a gradual transition in landings from long-lived, high trophic level, piscivorous bottomfish toward short-lived, low trophic level invertebrates and planktivorous pelagic fish." They also observed, "fishing down the food

[4]It is not clear whether Gulland's estimate took into account mortalities from discarding or unobserved fishing morality or both, and thus, the relationship between total fishing mortalities and the reported catch is uncertain.

webs (that is to lower tropic levels) leads at first to increasing catches, then to a transition phase associated with stagnating or declining catches" and concluded that the results indicate that present exploitation patterns are unsustainable.

Although overfishing of many demersal fish stocks has undoubtedly contributed to the decline in the average trophic level in world marine fish catches, the decline may also have been influenced by more intense exploitation of high-value invertebrates (a broadening of the diversity of sea life acceptable to world markets), the global synchrony in fish populations (FAO 1997a), and the resilience of many of the large clupeoid populations to fisheries exploitation. But these potential influences are not mutually exclusive of the consequences noted by Pauly et al. (1998). However, we are concerned with the Pauly et al. observation that fishing down the food webs ultimately leads to stagnating or declining catches: The ecological theory and empirical evidence supporting this conclusion are unclear.

Comments on the FAO Status of Stocks Reviews

The FAO status reports on world fish stocks have been published since the early 1970s. During its infancy, the review was produced as a qualitative commentary to the FAO Committee on Fisheries (COFI) to update the Gulland (1971) report. The information on the state of resources has been, and continues to be, a descriptive column in the reviews that classifies stocks as being unfished, underfished, lightly exploited, moderately exploited, fully/heavily exploited, intensively exploited, overexploited, depleted, recovering, and unknown. At times, these classifications are modified by the application of descriptive terms such as "probable," "mostly," "at least," and "somewhat." Over time, the reviews became progressively more quantitative but were confined to the FAO circular series and not intended to be a highly scientific document. In fact, for almost 2 decades, these status reports were produced without operational definitions of the status categories used. Nevertheless, the state of stocks reports stemmed from a vast amount of scientific literature and have been increasingly used to gauge the state of world fisheries.

Reports produced during the 1990s have included definitions of the status categories; however, the percentage of stocks classified to an individual category has decreased in recent years. In a discussion (S. Garcia, FAO, Rome, pers. comm.) regarding the FAO status reports, it was noted that this trend as well as the attitude of FAO scientists concerning fully exploited stocks has changed over time as a result of (a) greater concern over the issue of certainty of stock status information, (b) the continued growth of fishing capacity in the face of fuller utilization of the oceans' marine fishery resources, and (c) lack of improvement in the state of stocks that had been reported as overexploited for many years.

Current FAO information on the state of marine stocks is acquired from individuals who are assigned on a regional basis and who are responsible for review and interpretation of scientific information produced by FAO, national or international fisheries bodies, universities, and other credible fishery organizations and individuals (e.g., the International Council for the Exploration of the Sea, the Inter-American Tropical Tuna Commission, the World Bank, national scientists, and the gray and peer-reviewed literature). This process requires a degree of subjectivity on the part of the regional reviewer. As a result, the FAO status classifications may not always agree with national or international fisheries assessments. For example, we have compared the FAO status report covering years to 1994 with similar information produced by the National Oceanic and Atmospheric Administration (NOAA, U.S. Dep. Commerce) and find a significant implied difference in the state of stocks as reported by the two entities (Table 8). For the Northwest Atlantic, NOAA lists 11 species as overutilized while FAO lists 2 species as being overexploited.

These conflicting classifications in the state of a stock may reflect definition differences, but both entities seem to include growth and recruitment overfishing within their definitions. This issue is further complicated by the fact that some the stocks listed by NOAA as overutilized in their state of resource report for 1994 are not overfished with respect to the legal definition given in the Magnuson Fisheries Conservation Management Act of 1976. The evolving legal definitions in the USA and elsewhere concerned with conservation policy frequently incorporate political and social agendas, divergent views of marine scientists on what constitutes overfishing, and attempts to define overfishing or overexploitation that incorporate associated operational requirements for management actions, and they must make the FAO task increasingly complex and give rise to controversial status classifications. Even though differences between national and FAO state of stocks reports may occur at times, the FAO, as a matter of policy, does not question national assessments.

Some of the FAO status of stock reports also show some rather interesting and seemingly unexplainable changes over time. For example, we note that in the report covering the status of stocks for 1987 (FAO 1989), over a dozen stocks are overexploited or depleted in the Northeastern Atlantic, but in the following year, 1988, the FAO status review (FAO 1990) showed no stocks as being overexploited. We can only surmise that the regional definition

TABLE 8. Comparison of the status of fish stocks of the Northwest Atlantic Ocean (FAO Area 21) between the NOAA/NMFS and FAO status document. Status: U = underfished, M = moderately fished, F = fully fished, O = overfished. Modified from NOAA/NMFS (1996) and FAO (1997a).

Species	NMFS	FAO
Atlantic cod (*Gadus morhua)*	O	O
Haddock (*Melanogrammus aeglefinus*)	O	O
Saithe (*Pollachius virens*)	F	F
Silver hake (*Merluccius bilinearis*)	O	U
White hake (*Urophycis tenuis*)	F	F
Cusk (*Brosme brosme*)	O	
American plaice (*Hippoglossoides platessoides*)	O	F
Yellowtail flounder (*Pleuronectes ferrugineus*)	O	F
Winter flounder (*P. americanus*)	O	F
Greenland halibut (*Reinhardtius hippoglossoides*)	O	F
Witch flounder (*Glyptocephalus cynoglossus)*	O	F
Atlantic herring (*Clupea harengus*)	U	U, M, F
Atlantic mackerel (*Scomber scombrus*)	U	U
American lobster (*Homarus americanus)*	O	F
Sea scallop	O	F
Surf clam (*Spisula solidissima*)	F	M
Ocean quahog (*Arctica islandica*)	F	M
Northern shrimp (*Pandalus borealis*)	F	F

of overfishing changed or the stocks dramatically improved between years. By 1994, many Northeast Atlantic stocks were back in the overexploited category. We also note that there are no overexploited bigeye tuna in any FAO statistical region for 1994 (FAO 1997a), but the Atlantic bigeye tuna is reported as overexploited in the state of exploitation table (Table XVII, FAO 1997a) for tuna and tuna-like species across all oceans. These inconsistencies are troubling.

Regardless of the inherent difficulties in interpretations, the FAO reports on the state of the world's fish resources have served as the only biannually produced systematic perspective of marine fisheries. Their quality has improved over time as the seriousness of overfishing has taken on greater significance. In our view, the global assessments constitute an essential product that has aided the world community in understanding marine resource trends and emerging conservation requirements.

What is Being Claimed?

Confusion in the presentation of statistics and the relative state of ocean fishery resources is compounded as information is passed from the scientific community to other scientists, policy makers, interest groups, and finally the public at large. We have compiled a list of the more common statements that have been published in technical reports, outreach and education publications, special interest group advertising, informational pamphlets, and the internet (Table 9). The statements were examined in relationship to the facts and numbers summarized previously and categorized as supportable (S), unsupportable (U), or questionable (Q).[5]

DISCUSSION AND CONCLUSIONS

As noted previously, a number of problems confront the UN/FAO in the development and interpretation of data concerning the state of world fish stocks. Further estimates of the potential of the world's oceans to produce sustainable fish catches are at best "guesstimates" that provide a spectrum of potential yield choices. Regardless, the FAO assessments plus efforts to estimate global fish production constitute the best scientific observations currently available to characterize the state of global marine fisheries. On the basis of our analysis of FAO (1997b), the following conclusions and interpretations are supportable by FAO state of stock reviews or other FAO reports.

1. Of the 569 marine fish stocks examined for 1994, only 296 (52%) are clearly classified in regards to their status. These stocks made up 65% of the reported marine catch in 1994.
2. Seven percent of the 296 stocks for which status is clearly noted are uniquely classified as overexploited or depleted. These stocks make up slightly over 3% of the world catch of marine fishes. Of course, their importance in the world catch has probably declined as they have been overfished.
3. About 30% of the world fish stocks classified to state are categorized as being overexploited, depleted, or have status codes in combination with overexploitation or depletion. These stocks yield 46% of the landings of marine capture fisheries.
4. Nearly 69% of the stocks categorized as overexploited, depleted, or that are multiple-status classifications, including overfishing, depleted, or recovering, are from the Atlantic and associated seas.
5. Of the world marine fish stocks for which status is

[5]We acknowledge that the statements can be interpreted in different ways by individuals, groups and governments with different concerns, sensitivities and backgrounds.

TABLE 9. Common perceptions of the relative state of ocean fishery resources: S = supportable, U = unsupportable, Q = questionable.

Perception	Reality
Overfishing, inadequate management, and destruction of essential habitat have pushed many populations of cod, haddock, plaice, Atlantic salmon, bluefin tuna, sharks, swordfish and other species to all-time lows.	S
According to the UN/FAO, at least 60% of the world's top 200 marine fish species are either overfished or fished to the limit.	S, Q
70% of the world's fish stocks are heavily exploited, depleted or only slowly recovering from overfishing, according to the UN/FAO.	S
Every species of fish that is deemed commercially valuable is overexploited.	U
It is estimated today 70% of the world's fish stocks are being exploited unsustainably, particularly by what have been termed Grim Sweepers, high-tech factory ships that tow mile-long nets, catching 400 tons of sea life in a single haul.	U
All 17 of the world's major fishing areas have reached or exceeded their natural limits.	U
According to the FAO, indiscriminate fishing practices kill and waste between 18 and 40 mmt of unwanted fishes, seabirds, turtles, and marine mammals—fully one third of the world's total catch.	S
The general state of the world marine fisheries is depletion.	U
Most shrimp stocks throughout the world are fished beyond the point of MSY.	U
Most major fisheries in the world have experienced significant losses in yield due to depletion of stocks.	Q
The oceans' marine fishery stocks have eroded significantly in the 1990s.	U, Q
Catches of oceanic species are plummeting.	U, Q
Virtually all stocks of marine living resources that are or have been commercially exploited are being or have been depleted.	U
The stock of pollock in the eastern Bering sea is being overfished and shows signs of exhaustion.	U

known, roughly 70% are reported as being fully exploited, overexploited, and depleted or are stocks with a combination of classifications including overexploited or depleted. These stocks made up more than 74% of the world's marine catch in 1994. Conversely, 70% of the world marine fish stocks are fished at levels near or below MSY. Catches of these species constituted 55% of the stocks reported to state in 1994.[6]

6. In 6 of the 16 FAO statistical reporting areas, more than 50% of the catch is taken from fish stocks that are overexploited, depleted, or in status combinations that include overfished or depleted listings.
7. Five percent of the stocks, classified to status, are underfished or unfished.

We also make several conclusion from the Grainger and Garcia study (1996) on global fish trends:

1. Overfishing, in terms of regional estimated potentials, occurs in 9 out of the 16 FAO statistical areas.
2. When the growth rate of 200 of the world's important fish resources, which make up 77% of world marine fish production (1994), is examined, 60% have catches that are growing very slowly, are stable, or are declining.
3. Grainger and Garcia (1996) considered that 60% of the major world fish resources are in need of urgent management, and an earlier study (Garcia and Newton 1997) concluded that 69% of the world's fish stocks for which status was known was in need of urgent management.

A broad range of estimates exists on global ocean fish production but the most robust forecast for conventional species range from about 80 to 125 mmt (Schaefer and Alverson 1968, Gulland 1971, Grainger and Garcia 1996, Pauly 1996). If these forecasts are considered in light of current world catches of conventional marine species (about 84 mmt) and a global estimate (27 mmt) of bycatch discards along with some loss due to unobserved fishing mortality, then actual catches exceeded the highest of these catch forecasts. Assuming the forecasts are correct, we conclude there will be no significant increase in production of world marine capture fisheries. These theoretical studies of world fish potentials—along with the recent analysis of Pauly and Christensen (1995) on primary production required to sustain marine fisheries and Pauly et al.'s (1998) study on fishing down the food chain—support claims that we are pushing the sustainable global marine production envelope.

Regardless of the theoretical forecast that we can expect little more from the world's oceans in the way of added food, we cannot ignore the fact that marine catches have increased in 1994 and 1995 and world fish production continues to grow. In addition, responsible management could help return a number of stocks to higher productive levels. Finally, the estimates of Gulland, which have been broadly used to convey the message that we are approaching the oceans' production limit, are incomplete in that

[6]These alternative impressions of the state of stocks results from the manner in which data are presented.

Gulland also estimated a production potential of 350 mmt of conventional and unconventional species.

The issue of the perception that the state of the world's marine fish stocks comes down to (1) the selection of the categories of stock's considered to be in difficulty and stressed as a result of fishing, (2) the extent to which the overfished stocks are presumed to have been depleted, and (3) the credence placed on the various estimates made of the oceans capacity to produce sustainable fish catches. As such, there is considerable leeway for different opinions as to the state of fisheries exploitation and the potential yield that may be derived from the world's oceans.

We are inclined to accept Scenario B, which included all stocks identified as overfished, depleted, and recovering, and which also includes any multiple-listed stock with a categorization of overfished, depleted, and recovering as the most realistic, contemporary depiction of the state of world marine fish stocks. Therefore, if 30% of the world's fish stocks are being overexploited and 45% of the world catch is derived from these stocks, then excessive and unnecessary hemorrhaging of the world's fish supply is occurring. The state of management reflects interpretations of the effective stewardship of stocks that are fully utilized, overexploited, and depleted. Although not well-documented, the situation does not appear good in many areas, raising questions as to the future of world marine fishery resources.

Our general view is that most fishery scientists and managers concur that a significant increase in the production of marine wild capture fisheries is unlikely and there may even be a decline until such time that effective management has been broadly implemented worldwide on fully and overexploited species/stocks. We also conclude that the data supporting overfishing is pervasive and suspect that effective management is lacking in many areas of the world in both developed and developing countries. A very significant component of the overexploited and depleted stocks exists in the Atlantic Ocean and associated seas. Over two-thirds of the world's overexploited, depleted, and recovering stocks are reported to be in this one ocean basin, which produces only 15% of the global marine fish catch—surprisingly a region subject to rather intense fisheries investigations.

The actual status of the world's marine fish resources may be somewhat worse than our analysis suggests for the following reasons:

- The state of knowledge regarding stock dynamics is probably less certain for many Pacific and Indian ocean fisheries.
- FAO status of stock reports omit information on the status of many smaller, inshore fish populations that inhabit the inner littoral zone. These stocks have been the target of subsistence, recreational, and commercial fisheries (including sport and commercial scuba divers) on a global scale and many of these may be overfished or depleted (see Pauly 1997),
- Uncertainty exists as to the state of almost half the stocks for which catch data are reported.
- Our review includes neither the trends that have prevailed over the past 3 years nor the state of living marine resources that are not the direct target of fisheries.

Also, other factors may exaggerate our various assessments, including our assignment of the most conservative classification to multiple classified stocks, differentiating between localized and stock overfishing, and scientific caution, which leads to identifying harvested stocks in a conservative manner.

Although we find substantial evidence supporting many comments made by advocacy groups, scientists, and fishery administrators on the state of marine fisheries, the scientific information we have reviewed does *not* support the following conclusions:

- There has been a rapid erosion of the status of marine fish stocks during the 1990s.
- Every major FAO area is fully fished or overfished.
- Every economically important commercial stock has been overfished.
- Catches and production of oceanic fishes are plummeting.
- Bering Sea pollock stocks are overfished and are showing signs of exhaustion.
- Virtually all stocks of marine living resources that are or have been commercially exploited are being or have been depleted.
- The general state of world fisheries is depletion

Data examined in our review do not suggest world fisheries are in a catastrophic situation or that catches of most overexploited stocks are "plummeting" although sharp declines are noted for some overfished stocks (cods in the Northwest Atlantic and probably sharks and bluefin tuna in several ocean areas). On the other hand, many overexploited stocks seem to be suffering from growth overfishing, which could be corrected in a short time period if countries would implement conservation principles to which they have already committed; the world catch for the vast majority of marine fish and shellfish groups increased in 1995; and the percentage of overexploited stocks between 1987 and 1994 has remained relatively constant.

We suspect that some of the public media observations regarding the deplorable state of world fisheries may have been fostered by misinterpretations of FAO authors' state-

ments that 60–69% of the world's fish stocks are in need of urgent management or management actions and by the statement in the commentary of FAO (1993) that "Although there are instances of stock rebuilding through the adoption of conservation measures, the more general situation is one of depletion." We can find no evidence in the FAO state of stock reports that supports this latter conclusion. In 1994, 7% of the stocks for which status data are available were noted as depleted or fully exploited to depleted, or moderately exploited to depleted, and only slightly over 3% were uniquely described as depleted. The comment seems to be a visceral feeling rather than a conclusion based on scientific evidence. Further, scientific evidence or analysis does not support the conclusion that 60-69% of the world's exploited fish stocks "are inadequately managed." The fact that 69% of the stocks are fully-fished, overfished, depleted, or recovering is not in question, nor is the fact that the future of world fish production will hinge on effective management.

In conclusion, what has been presented should not be taken as an indictment of FAO. On the contrary, it is the organization's efforts that have provided a global perspective that has focused our attention on extant and potential overfishing problems. However, like all of us, they are not infallible. Quoting Richard Martin (1998), "What is desperately needed is better assessment of fisheries stocks and improved, objective analyses of fish harvests and fish culturing practices." However, the fact that a significant number of scientists, fisheries managers, advocacy groups, and politicians use the FAO status reports as a barometer of the health of the world fishery resources suggests that these reports need to be carefully reviewed, edited, and pruned of insupportable conclusions. Further, thought should be given to providing FAO with additional resources to improve the timeliness and quality of the documents. Finally, the possibility of a more formal international peer process to assist FAO in the classification of the state of marine fishery resources should be given immediate consideration.

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