The Search for Sustainable Seas

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KEYNOTE ADDRESS

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Recent sharp declines in numerous fish species and other ocean wildlife have forced serious re-evaluation of old assumptions about the capacity of marine systems to sustain large-scale taking, especially when coupled with drastic habitat destruction, by-catch and food-web disruptions. Achieving 'sustainable use' of ocean wildlife is a widely-held goal, but present capacity to find, extract and transport marine life to distant markets generally exceeds the capacity of the exploited species and supporting ecosystems to recover. The role of fully protected areas within large marine management regimes or 'seascapes' is becoming recognised as a vital part of what is needed to restore depleted populations and ecosystems and maintain their long-term integrity. Already, some nations have begun to develop broad management plans for their Exclusive Economic Zones and to consider policies governing protection and use of wildlife in the 60% of the ocean beyond national jurisdictions. Protection of breeding, feeding and nursery areas, more realistic catch expectations and development of non-destructive methods of extraction will help reverse the present declines. But inevitably, maintaining or enhancing present levels of food derived from aquatic animals will depend on identifying and cultivating the ocean and freshwater equivalents of cows, chickens and pigs — fast growing, nutritious creatures that are low on the food chain. These issues are explored in this paper, together with a focus on the economic and ecological importance of marine life other than as marketable commodities. In particular, the importance of life in the ocean as essential components of Earth's 'life support system' is acknowledged and a case made for maintaining the health of the ocean as a fundamental requirement for enduring human security.

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Introduction

It is an honor to have an opportunity to share ideas concerning fish, aquaculture and food security, and to consider the theme underlying the conference: sustaining fish as a food supply.

Before diving into this most timely topic, I must confess a certain bias. You see, I believe wild fish, generally speaking, are more important to humankind swimming around in the oceans, lakes, rivers and streams of the world — alive — than they are swimming with lemon slices and butter or wrapped around a rice roll or otherwise sliced, diced, fried, boiled, broiled or however else it is that people enjoy fish dead. After all, every fish is a miracle of chemistry and design. Live tuna, for example, cause engineers at the Massachusetts Institute of Technology to sigh with envy. They have developed a mechanical bluefin — robotuna — to try to determine how that fish can capture 97% of the energy generated as they swish their big tails back and forth, while humans have a hard time creating propulsion systems capable of exceeding 50% efficiency in the sea. Every fish is a component in the ocean's great living machinery, each contributing to processes that shape the way the ocean works. Every fish has answers to mysteries we would like to solve — if only we were smart enough to find them.

More valuable alive than dead!

Fish have essential roles — all 25 000 or so species of them — as links, along with the rest of the living world, in ancient ecosystems developed over billions of years, ultimately resulting in a planet that is just right for the likes of us. The living ocean shapes climate and weather, generates most atmospheric oxygen, absorbs much of the carbon dioxide, regulates temperature, drives planetary chemistry. In this sense, there is no such thing as an 'underexploited fish.' We are 'exploiting' them, taking advantage of the benefits they provide as elements of fine-tuned systems that keep the world on a more or less even keel as we career through time and space on a planet blessed with a great deal of salt water. In many ways, fish are better adapted to living on this ocean-dominated Earth than are we, and certainly they were around for hundreds of millions of years without humans as predators. As a scientist, it is hard for me to imagine that fish and other wild creatures actually have an 'excess' of large numbers just waiting for us to extract without consequences that may not be in our best interests — and certainly it is not in theirs.

When I served as Chief Scientist at the National Oceanic and Atmospheric Administration (NOAA) in the early 1990s, I teased my colleagues about giving fish alive an accounting base of zero, suggesting that they only valued fish when they were dead — and then not even as individuals, but rather, as commodities, measured in pounds or tonnes of 'product.' 'They are to the sea as birds are to the land,' I pointed out. Our predecessors ate all sorts of birds, and we still do consume Kentucky Fried birds, roast turkey birds, and even take a few ducks, geese and other wild birds for an occasional meal. But we understand that there are limits to what can be extracted from the wild on the land. We are not attempting to sustain billions of people with wild-caught birds and other wildlife. Most of the calories that feed most people most of the time come from a small number of cultivated plants, mostly grains, and a small number of animals, all primarily herbivores (although some farmers insist on feeding cows to cows!). 'Are there not more efficient, more effective, ways to feed people that do not threaten our security by undermining the natural ocean ecosystems that fundamentally sustain us all?', I posed. Today, wild birds are valued largely for reasons beyond pounds of protein. 'Someday, we'll think the same way about wild fish', I said, 'and we'll wish we had done a better job of taking care of them ...' At NOAA, comments such as these earned me the title of 'Sturgeon General'.

The right aquaculture

Given all this, I also have developed another bias. That is, I am in favor of smart, responsible and closed-system aquaculture as the right way to go to provide large quantities of high-quality protein and oils derived from fast-growing animals that are low on the food chain, such as catfish, tilapia, carp and certain crustacea. Closed systems provide the best opportunities for controlling disease, preventing escapes, maintaining water quality and volume, ensuring food efficiency, eliminating predators issues and otherwise addressing current aquaculture problems. Relatively small numbers of carnivores may also continue to be cultivated, especially if plant proteins or farmed herbivores can be used to feed animals such as bluefin tuna, salmon of all sorts, pompano, mahi mahi, freshwater crayfish, sturgeon and others whose high market price makes high costs of production acceptable. Presently, enormous quantities of wild fish, squid and crustacea with low market value but high ecosystem importance are being caught to feed relatively small numbers of carnivorous farmed fish — rather like catching songbirds as food for pigs.

The outlook

I now want to suggest why and how I have come to believe that we can probably get away with taking some wildlife from the sea, but not nearly the hundred million metric tonnes (MMT) or so annually that were predicted years ago. If we want to catch fish for dinner to feed our families and communities on a small scale, with care, we can probably do so sustainably, but if we want to continue to generate food from the waters of the world at the same level that we are taking it today, let alone increase the volume, we had better quickly learn how to grow it as well as the food cultivated creatures consume. Based on current trends of decline, it appears that if we continue 'business as usual' for another thirty years, the prospects for making a living as a commercial 'capture' fisherman are bleak indeed, and the consequences potentially disastrous to the ocean as the cornerstone of our 'life support system'.

It should come as no surprise that wild populations of fish, shrimp, lobsters, oysters, clams and other targeted species are in big trouble, worldwide. A report published in 2003 by Canadian scientists based on a ten-year analysis of fisheries data indicates a loss in fifty years of 90% of many large species — tuna, swordfish, marlin, cod, sharks and many other fish that people have learned to like as food. It makes you wonder how large Earth would have to be to satisfy the appetites of six billion people with wildlife alone? How long would our predecessors have been able to survive as hunter-gatherers using modern trawling techniques over forests and grasslands, and deploying millions of hooks baited with other perfectly edible wild creatures? What is being lost to us today as a consequence of scraping the ocean floor with dredges and trawls, techniques that can be likened to bulldozing trees to catch birds and squirrels?

Harvard biologist E.O. Wilson noted in his book, *The Diversity of Life*, that humans equipped with modest tools eliminated 'the large, the slow and the tasty' from much of North American following the end of the last ice age, some ten thousand years ago. Equipped with somewhat better tools, it took less than two centuries to similarly succeed in swiftly reducing populations of whales, sea cows, manatees, otters, seals, turtles and many large sea birds, the ocean equivalent of mastodons and giant sloths. Now, with even better technologies and new demands, we are also making deep inroads into populations of the small (i.e. krill, squid and meso-pelagic plankton), the fast (think tuna, marlin and swordfish) and the not-so-tasty (menhaden and many others) for oil, fishmeal and fertiliser.

If I could, I would take you into the ocean, right now, as a reminder of what it is like down there. Below a few hundred feet, it is cold and always dark, but also always filled with life, including many creatures that make their own luminescence. Ninety-seven percent of Earth's water is ocean, and the ocean also contains 97% of life on Earth, both in terms of diversity and sheer volume. Diving into the sea is like diving into the history of life; examples of all of the major players are there, from the smallest viruses and microbes, through sponges, many kinds of worms, starfish and their kin, and numerous gelatinous forms to the largest creatures ever, giant squids, and the great whales. In contrast only about half of the major divisions of animals and photosynthetic organisms live on the land or in freshwater.

To make a tuna requires that a hatchling fish survives through years of swimming in a living soup of creatures with two basic concerns about whatever is encountered: First, 'Is that thing up ahead edible?' Or second, 'Is that thing going to try to eat me?' I used to refer to tuna and sharks as the lions and tigers of the sea, but this does not really do justice to the complexity of the realm they occupy. After all, lions and tigers usually consume grazers that in turn eat plants. The food chain is fairly simple and straightforward, from sunlight to plants to herbivores to carnivores. In the sea, much of the action begins with photosynthetic microscopic plants that are consumed by microscopic zooplankton that in turn is consumed by somewhat larger zooplankton that in turn may be consumed by small fish, even baby tuna.

Carnivorous jellyfish are actually the ocean equivalent of lions and tigers. Tuna are much further up the food chain. It takes 6–8 years of eating other carnivores, consuming a great deal of energy along the way while swimming around finding food and resisting becoming lunch for something else, before a bluefin or other large tuna species reach maturity. Of the millions of eggs released by a mother tuna at the time of spawning, very few live to spawn themselves. Lucky individuals that grow to be fifty-pound fish consume rather large fish that in turn have consumed somewhat smaller fish, large crustacea and squid, and so on down the intricacies of ocean food webs. To make a pound of farmed chicken or catfish or tilapia takes a few months and about two pounds of plants; to make a pound of a ten-year-old tuna involves burning through tens of thousands of plants consumed over the years by many thousands of animals invested in every pound of grown-up fish.

Much concern is expressed these days about 'by-catch' — the large number of creatures taken incidentally when nets, hooks, trawls, traps and cages are used to capture ocean wildlife. Every year, more than 20 MMT of marine life are killed and discarded including 300 000 marine mammals, and tens of thousands of sea birds and turtles. But there is another kind of by-catch that is generally not counted — that is, the large biomass involved in making many of the fish we consume. When we extract large carnivores from the sea, we are not just snipping the top of an immense food pyramid; in effect we're taking the whole thing, the cumulative investment required to yield each old giant. Imagine how many meals each of you has consumed to make each pound of you! Think of the investment in a 30-year-old Chilean sea bass (aka Patagonian toothfish), a hoki (aka deep sea rat tails), a monkfish (aka deep sea angler), or a 100-year-old orange roughy or California rockfish?

In 1967, as a promising young biologist/oceanographer at Harvard University, with my husband, Giles Mead, also a biologist and Curator of Fishes at Harvard, I embarked on a venture to explore the viability of aquaculture as an alternative to capturing wet wildlife as a source of food for humans. We formed a company, 'Aquaculture International,' and for several years looked at various young but promising enterprises in oyster, clam and scallop culture, catfish farming and shrimp 'ranching'. We met and talked with many experts including Dr John Ryther of Woods Hole Oceanographic Institution, Dr John Bardach from the University of Hawaii, Dr Paul Galtstoff, the famous oyster biologist, and researchers at the new Harbor Branch Oceanographic Institution.

At the time, many were concerned about how to feed the world's large and growing population, and it seemed to us even then that there would be sharp limits to how much fish could be extracted from the ocean without dire consequences for ocean ecosystems — and for us as well. World population was about half what it is today, a mere three billion. The craze for bluefin tuna consumption had not yet swept the world, and most sharks were swimming around unconcerned about humans as predators. A few sea cucumbers were being caught to satisfy a small Asian market, but no one imaged there could or would soon be a demand for millions of tonnes of them. Shrimp, crabs and lobsters were considered luxury items, available sometimes in some restaurants, but not everywhere at every season for every consumer who could pay the price.

In the 1960s, most coral reefs were intact and well-populated with an amazing assortment of large grouper, snapper, barracuda, big parrotfish, giant wrasses, lobsters and turtles, among many other species now greatly depleted. Long lines were not yet common, nor were factory ships and giant trawls. But even then it was obvious that the great library of life in the sea was being eroded, the books consumed before the titles were read or their contents known. Over the years since, thousands of square miles of ocean have been trawled before anyone so much as glimpsed the nature of the life below. Sampling with a net, by the way, does not qualify as 'looking,' any more than sampling Canberra with a trawl deployed from the sky would yield real insight into the complexities of the systems below. Even today, less than 5% of the ocean has been seen, let alone explored.

At this seminar we are considering the value of fish and other aquatic life as a source of food, but there are other economic issues to consider. Whales have a certain value as food and as a source of oil, bone and other materials, but presently their economic significance as a living attraction for people delighted to pay for the privilege of getting close to them far exceeds their value dead. I am among those who have paid good money to be able to swim with the giant potato cod famous on the Great Barrier Reef. A single fish alive can yield profits to local people for decades, or it can be profitable just once if taken for food or sport.

Striking a balance

So comes the question: how can we strike the balance, to use the ocean like the fabled Golden Goose, taking some golden eggs, perhaps plucking a few feathers, without killing the goose, and thereby harming our own chances for survival? In a sense, we're riding on the back of the 'goose', and will suffer or prosper right along with her. A year ago, 150 people — scientists, economists, educators, government representatives, business men and women, media experts — met in Los Cabos, Mexico, with this question in mind at a conference called 'Defying Ocean's End', convened by Conservation International but involving 73 organisations representing 20 countries. Australia's Graeme Kelleher, for many years the Director of the Great Barrier Reef Marine Park Authority, was talked into chairing the event; the Gordon and Betty Moore Foundation and a number of other supporters funded and participated in it, and after a year of preparation and a week of intense, thought-provoking deliberations, the group made various recommendations including the following that are especially relevant to this conference.

Fisheries reform

There was concurrence that capture fishing policies today are not working to sustainably yield large quantities of food from the sea, and that ecosystem-based management was clearly needed to replace the current single-species models that guide most fisheries policies. The need for gear modification to reduce or eliminate by-catch was acknowledged, and true sustainable fishing needs to be demonstrated — not just in models, but in reality, maintained over long periods of time without hidden 'down sides' to other parts of the ecosystem.

Recognising that fleets are overcapitalised, with too many fishermen trying to extract too few fish, fueled worldwide by subsidies of more than $50 billion (US), a fund should be created to buy out fishing interests where the pressures are greatest and where populations of wildlife are most at risk. A good place to begin reforms would be through redirecting the perverse subsidies toward positive, enduring practices including responsible aquaculture.

Sea mounts

One example of the way exploitation has far outpaced exploration concerns present policies about fishing on recently-discovered sea mounts. More than 30 000 sea mounts have been identified in the past two decades, using satellite survey techniques and verified by acoustic technologies from ships. Seamounts with peaks within current fishing range, 1000 m or so, are being targeted by commercial trawlers for extraction of large quantities of marine life such as the famous orange roughy, handsome red fish with large, luminous eyes curiously known to scientists as 'slimeheads.' The taste of orange roughy is now widely appreciated, but few consumers know what the fish looks like, nor are they aware that pristine forests of centuries-old deep sea coral communities are destroyed when the fish are trawled. Most are surprised to learn that it takes about 30 years for roughy to mature, and by the time one reaches your plate it may be older than your great grandparents. Depletion of old, slow-growing, slow-reproducing fish is one concern, but another is the 'collateral damage' — devastation of unique deep-sea systems. Sea mounts are literally underwater islands, each bearing an assemblage of life that is unique to that mountain; that is, many species that are found just there and nowhere else. It is easy to destroy these ancient systems, but we have no idea how to put them back together again, and have not a clue about how to restore even the orange roughy.

Presently, there is a global effort to win support from the United Nations to halt trawling in the high seas, aimed at waters beyond the jurisdiction of national Exclusive Economic Zones (EEZs). There is some precedent for this in a 1992 United Nations Resolution banning the use of drift nets on the high seas. Individual nations set policies concerning fishing within their own waters, seaward to 200 nautical miles, but there is little governance — and thousands of sea mounts — in the open ocean beyond.

A small example from the *South China Morning Post* on 26 July 2004 suggests why there is a sense of urgency about international action to protect the waters that no one 'owns', but in which everyone has a vested interest. According to the article, Hong Kong fishermen, faced with rapidly depleted fish stocks, are pressing into deeper offshore waters with new technologies that enable them to catch more fish with fewer people.

One fisherman, now aiming for the trenches in the South China Sea, said it has been his dream to go out further for 20 years, and that 'The recent depletion of fish stocks has pushed me to realise my dream … We have to move fast in building up our operation.' His goal is to secure a leading position in deep-sea fishing before international restrictions are in place. Others, of course, are hoping for international restrictions before a small number of commercial interests forever take away opportunities to establish management regimes aimed at sustained use, not one-time blitzes that benefit a few short-term interests.

Marine protected areas

Participants in the Defying Oceans End Conference endorsed the need for marine protected areas within large marine regions or 'seascapes' to maintain the integrity of ocean ecosystems and protect biodiversity, while extracting some level of wildlife. Realistically, fishing will continue far into the future, but to have some hope of maintaining popular species and restoring depleted populations and damaged ecosystems, protective measures must be taken — the sooner the better. On the land, the need to protect feeding, breeding and nursery areas, as well as migration corridors, has long been acknowledged to ensure that wild ducks, geese and other wildlife, whether or not taken for food, will prosper. In most countries, policies exist that restrict methods used for killing wildlife along with when, where and how much of what kind can be taken. There are real concerns about the impact that new upscale markets for terrestrial 'bush meat' are having on wildlife, but rarely is the concept applied to the ocean, where captured fish, shrimp, lobsters and other wild creatures all qualify as 'bush meat.' Indeed, many people regard marine species as potential pounds of protein or oil, not wildlife.

In the 20th century, the importance of protecting wild places and wildlife on the land grew with cultivated food supplying most human needs, and with the recent, swift decline of species hunted on a commercial scale (in North America, buffalo, muskrats, beaver, passenger pigeons, Eskimo curlews, prairie chickens, Carolina parakeets, many species of ducks and geese among others). Policies now protect the cultural, historic and natural heritage of nations worldwide in perpetuity over about 12% of the land. A fraction of 1% of the ocean enjoys similar protection.

Australia has been a world leader in recognising the good sense in identifying critical marine systems and then taking measures to protect them. The Great Barrier Reef National Marine Park Authority is the most obvious example, an earnest attempt to manage a large piece of the ocean with multiple interests taken into account. It is especially noteworthy that the system has been monitored over the years, and policies have changed in response to needs that have developed. I was particularly pleased to see the recent increase of full protection from about 4% to 33% in an effort to reverse the decline of the reefs and depletion of fish in the region. In Australia and elsewhere where full protection is given to marine areas, there are soon larger, more abundant and more diverse fish and other species, and there is a 'spill-over' effect that serves to replenish adjacent, exploited areas. In short, marine protected areas 'work'.

Worldwide, the economic lift and other benefits of having protected areas in the ocean is beginning to be recognised. In 2003 Madagascar, Indonesia and the Bahamas each committed 20% of their coastal water for protection, and Costa Rica announced this year their intent to give full protection to 25% of their entire EEZ. At the Defying Ocean's End conference, the need to establish science-based policies was affirmed, as was the need to quickly develop a global system of protected areas within broad management regimes, both in national waters and on and within the high seas. Some areas seem obvious, such as the Great Barrier Reef, the Gulf of California, the loosely-defined 'coral triangle' involving Indonesia, the Philippines and others, the greater Caribbean Sea, the Abrolos Reef area of Brazil, and the eastern tropical Pacific including the Galapagos, Malpelo, Coiba, Gorgona and Cocos Islands.

Widely scattered data need to be gathered and assembled, and much more need to be acquired, before fully justified, rational plans can be given for protection of most parts of the oceans, but common sense and the 'precautionary principle' suggest that it would be a good idea to protect broad areas now, while there is still a chance to do so, starting with the best information available, refining restrictions over time to allow uses where minimal damage to the systems can be demonstrated. Shifting the 'burden of proof' to those who unilaterally aim to extract seems like a good idea, but presently it is typically left to those who want to protect the ocean to demonstrate the potential harm that may be done by large-scale fishing and use of damaging gear such as long lines and trawls, while making a case for the economic benefits of intact systems.

Again, Australia and an Australian, Graeme Kelleher, are taking the lead to organise the first world conference on marine protected areas, to be held in Geelong, Australia, in October of 2005. It promises to be a turning point, an unprecedented and timely event that may set the world on a new course for positive ocean policies.

Ocean governance

Looking at a map of the world with EEZs defined, it is obvious that many nations, including Australia, New Zealand, the United States and island nations everywhere, have a vast amount of aquatic territory. Forty per cent of the ocean lies within national jurisdiction, and the future of coastal waters will largely be determined by actions taken by individual nations in the next few decades. There is a chance to build on experience, gained over thousands of years of land use, to establish policies that could result in sustained use of this large and vital part of the planet. But what about the heart of the ocean, the 60% that is beyond the EEZs?

The concept of a Global Ocean Public Trust as a form of governance for these vast and vital international waters was deliberated and endorsed at the Defying Ocean's End conference — a possible means of securing continuing use, while limiting abuse, of the open sea. Until recent years, ocean wildlife in deep seas and on the high seas have been protected largely by their inaccessibility. Now, new markets, new technologies and subsidies are making it possible for large-scale fishing interests to risk going further and deeper into parts of the ocean where there are few rules and virtually no enforcement. Again, Australia is taking the lead in addressing these matters through the formation of a committee dedicated to High Seas issues through the World Conservation Union (IUCN), again headed by that irrepressible Graeme Kelleher.

Just suppose …

Now, just suppose … in the next decade, policies to govern both the EEZs and the high seas are implemented with an eye toward long range sustainability rather than swift, short-term exploitation …

Suppose we took 1/10 of the annual cost of perverse subsidies for unsustainable fishing and applied those resources to give fishermen other options …

Suppose we took another 1/10 and invested in restoration of species and systems devastated by destructive fishing activities …

Suppose we applied to aquaculture 1/10 of the resources now being invested in agriculture …

Suppose we seriously researched that great library of aquatic life to identify a few that can be adapted for farming to supply us with food and other needs, while understanding the vital roles that all wildlife have in maintaining a viable, healthy planet …

Suppose we learned from ten thousand years of successes and failures in agriculture, and focused on developing a suite of aquatic organisms for cultivation that have the following characteristics:

- low on the food chain
- fast growing
- disease resistant
- tasty and nutritious or valuable for oils or other substances
- suitable life cycles
- tolerant of crowding
- efficient conversion of plants to protein.

Suppose we focused more on microbes, yeasts and certain micro and macro algae as food sources that can be tailored by selective processes to yield desired features and high yields of cultivated animals — rather than taking wildlife to feed to farm animals. Or considered acceptable ways to genetically modify fast-growing sources of food for fast growing aquatic species …

Suppose we looked at water issues, recognising that raising cows on an open pasture takes a huge amount of water, and so does raising salmon in open pens. Suppose we accounted for the real water consumption involved in open or semi-closed systems as compared to recycling water in closed systems, and put the real cost of water on the balance sheet. Suppose a priority for aquaculture — and agriculture — is more crop per drop …

Or suppose these things don't happen.

Imagine the cost of continuing business as usual.

We do have choices. As never before we have a chance, an unprecedented opportunity as individuals and together, to do what it takes to find an enduring place for humankind within the natural systems that sustain us.

And maybe, we have a chance as never again.