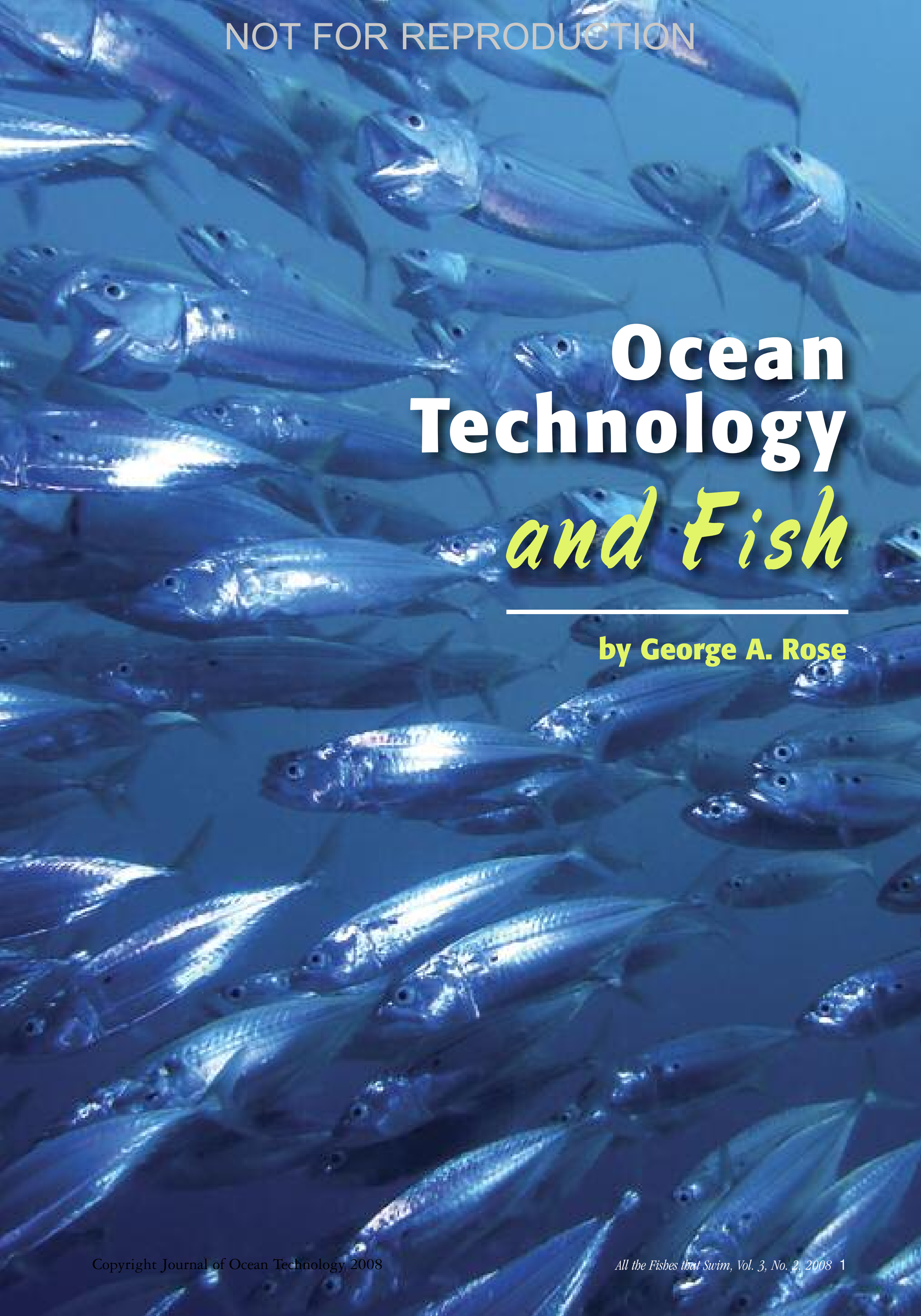

# Ocean Technology and Fish

by George A. Rose

I will begin this essay with three general points.

First, technology has traditionally been the arch-enemy of fish – used mostly to find and kill them, then to package and transport them for human or animal consumption.[1] The history of fishing can be traced through several stages paralleling the industrial revolution,[2] with changes in fish finding methods (from indirect methods of correlating seasons, tides, weather and biological signals with fish presence, to direct methods of sonar), vessels (from dugout canoes to 100 m trawlers with freezer storage for hundreds of tonnes of fish), and gear (from single fish hooks to trawls capable of catching > 100 tonnes in one tow). In most fishing zones of the world, technology has enabled the catching of more fish, faster, and with less immediate cost, often supplanting age old fisheries that used less technologically efficient gear and destroying fish stocks that had supported those fisheries for hundreds or even thousands of years. The northwest Atlantic cod fisheries are just one example among a litany of ecological disasters brought about by indiscriminate use of advancing technologies. In many ways, we are still Titanic passengers, convinced that technology can surmount any obstacle, unbelieving that even a minor natural phenomenon like an iceberg can sink us if we cling to that delusion.

It's not that advances in technology are of necessity destructive – not at all – but once the genie is out of the bottle, economic incentives often lead to unfettered uses no matter the intention. Nuclear energy is one example[3], but there are countless others with closer relevance to conservation and resource management. Elephant numbers were not seriously impacted until the advent of modern firearms,[4] nor were many of the great whales until the exploding harpoon gun,[5] nor northwest Atlantic groundfish until the trawler.[6] In the 21$^{st}$ century, we are faced with an ever increasing list of badly perturbed ecosystems and declining numbers of species (biodiversity) and productivity of species that are highly valued by humankind (e.g., salmon, cod, tuna). Note that any assumption that biodiversity equates with high productivity of highly valued species is questionable, but that is another argument.[7] Nevertheless, there is a need for technologies that will help reverse this trend – green technologies if you like – that will assist in upping the odds of achieving sustainability of biodiversity or productivity or whatever the goal may be in marine ecosystems.

A second and related point is that development of technologies relies heavily on incentives, mostly economic, subsidized and directed towards military applications, marine navigation, carbon fuel extraction and related industries. Fisheries and ocean conservation remain the poor cousin. Making matters worse, the 'race for the fish' has led to most incentives in fisheries being short-term and geared towards catching fish as efficiently

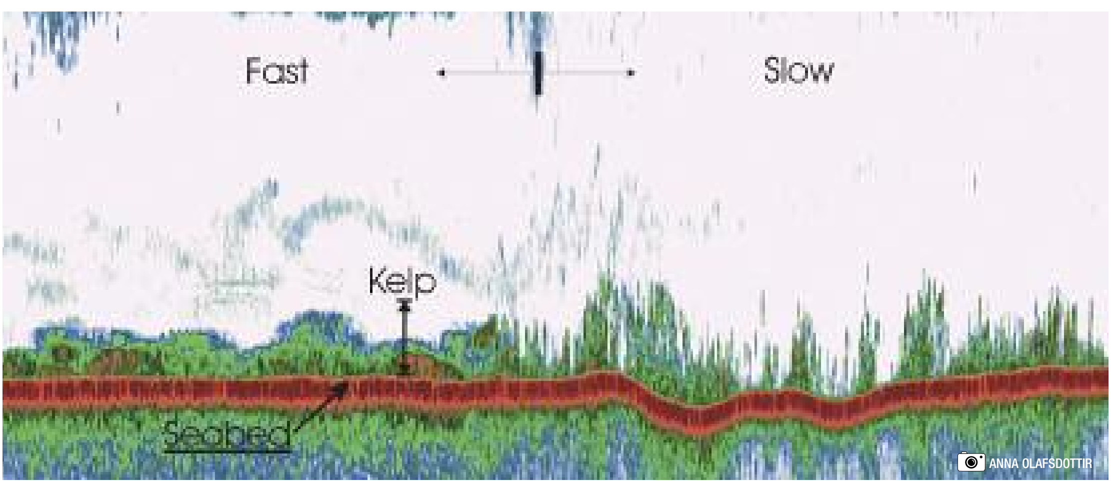


Figure 1: Echogram (Biosonics DTX sounder, 120 kHz from GECHO) showing kelp at about 8.5 m depth in Smith Sound. Left half of echogram shows about 650 m run at 5 knots; right half shows about 11 m run drifting slowly for high resolution of individual plants.

 

as possible, ignoring longer-term costs attributed to stock reduction or ecosystem damage, and potential costs to persons and communities. If moose hunters were subsidized by governments to hunt with high-tech Huey gunships, this would no doubt result in a lot of dead moose in short order, but would not likely be sustainable, even with the best available science. This may be an imperfect analogy with fishing technology, but the point needs to be made. Incentives for technological innovation must change if we are to promote conservation, stewardship and sustainability, and not just an easy kill.

A third point is that in the early 2000s the world fishery employed over 35 million people and its production remains critical to human survival.[8] In the western world we sometimes portray seafood as pricey lobster or crab or sushi, served in restaurants in urban centres — hardly a survival issue. But this is far from being representative. A huge amount of fisheries production goes to low cost protein that feeds millions of people, particularly in the developing world in Africa and southern Asia. Without this source of food millions would starve. Technologies have enabled large vessels serving interests in the more developed world to decimate fish stocks and ecosystems in all oceans, often with paid off local collaborators in corrupt governments, and in so doing compromise long standing small scale fisheries. For example, at present off much of Africa a vast flotilla of heavily subsidized trawlers and long-liners largely from the European Union, China and Russia are destroying fish stocks essential to local human populations.[9]


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So with this background, I will attempt to challenge readers that it need not be so, that blaming the gun for the murder conveniently absolves the guilt of the murderer and does not solve the problem. The same time, the point must be acknowledged that the technology may have enabled the person to do it — leading to an obvious conclusion that technology usage needs controls. The same is true in fisheries. There is little hope of sustaining commercial fisheries if "techno-escalation" cannot be put to better use. This is a major challenge facing the world today.

In the overall scheme of things, catching fish is easy, counting them difficult, and sustaining stocks, well … let us just say we have not always been successful, with about 20-25% of stocks over-exploited and another 50% near or at maximum production.[10] Nevertheless, there are examples of successfully managed and sustainable fisheries that often go unnoticed, and from these we may learn how it can be done.[11] A new algorithm for the application of technology is needed to replace the old one that focussed on making catching more efficient, hence counting more important and sustaining fisheries difficult. One new algorithm would make catching less efficient, such as is often done in recreational fisheries and hunting, hence making counting less critical and sustainability more likely. In many fisheries this is the only possible option, such as the myriad of small-scale tropical fisheries that may be quickly eliminated, along with the fish stocks, if technological developments occur too quickly. Lack of knowledge about fish abundance, along with little control over the fishery and less enforcement, make such an outcome inevitable, and this scenario has been repeated over and over around the world.[12] But one solution will not suit all situations, and a reduced technology solution is not suited to many highly industrialized fisheries, many in the northern hemisphere. In these fisheries it is the counting that must become more accurate (and determinations of fishery caused mortality), hence making increased technology in catching less damaging, and sustainability at least possible.

It's worth a moment to think about advances in ocean technology.[13] What goals should we have that technology could support? And what incentives are needed to get there? Allow me to offer up a few. The over-riding objective is sustainability of productive ecosystems and


commercially important fish stocks and rebuilding those that are depleted to some level of productivity and diversity determined, either qualitatively (common) or quantitatively (rare), by management.

1) The first goal is better methods to estimate the abundance of fish and the principle factors of population dynamics, especially mortality rates. And before anyone objects that we are now managing ecosystems not fish — we are entering the age of ecosystem-based management — I would request they tell us how that can be done without knowing these factors, in particular as they relate to harvested species. There are several ways in which current and developing technologies can help. One is the use of remote and non-lethal counting methods, especially sonar (acoustics).[14] Fisheries acoustic methods use underwater sound physics rather than nets to assess fish abundance, and have advanced considerably within the past decades with digital technologies. Sonar has the ability to quickly and cost-effectively map the distribution and abundance (at least relative) of many species of interest. It has distinct advantages over netting in that it is non-destructive and simultaneously assesses most of the water column up to thousands of metres deep. All of these features are pertinent to any attempt at ecosystem information and management.[15] In addition, new developments in tethered ROVs (remotely operated vehicles) and AUVs (autonomous underwater vehicle requiring no tether), housing sonar and underwater video systems make possible visual qualification if not quantification of fish and habitat.

Another technology that has potential to revolutionize abundance measurement is a new twist on a old technique, namely tagging. Tagging has been one of the most useful technologies to fisheries science, but thus far has been used mostly to track where fish have travelled, in the first instance between release and capture points, then with sonar tags intermittent locations while the fish is at liberty, and finally quasi-continuously with satellite tags. Tags are now available that record or transmit depth, temperature, behavioural information and even latitude and longitude (with considerable error). However, none of these data are particularly useful to assessing stock abundance. What is needed are better estimates of mortality and production within a stock. If a small and cost-effective tag could be developed that could be implanted *in situ* on wild fish and transmit — at a minimum — place and time of death it would be invaluable to stock assessments and understanding the fundamental dynamics of the population. Such a tag, although simple in concept, is difficult engineering, and does not currently exist.[16]

 

2) A second goal is better information gathering, utilization and display. We need to be able to catch the cheaters — literally put them out of business — illegal fishing being one of the greatest threats worldwide to sustainability of fishing economies. Technology is key to this. Low cost devices that enable fishing vessels to be tracked at sea (VMS or vessel monitoring systems) and report catches immediately to a centralized database could be universally used. Once data is in, GIS technologies would, in near real time, display, summarize and interpret information for managers so that decisions could be made without delay, such as limiting a fishing area or tracking an offending vessel. On the biological side, fish product itself must be better tracked so that its origin is known. At present, it is all too easy to report an illegal catch as if it came from a legal fishery. In many supermarkets in the western world, fish mongers and consumers alike have little idea of where the product came from, how it was caught, shipped and processed. I have confidence that to many consumers, knowing that their food came from a legal, well managed fishery and was handled and processed in as efficient a manner as possible will make a difference — something they will pay for — and this economic incentive should drive industry and technology in that direction.

3) A third goal is to develop more selective fishing gear that does not damage the environment. Bycatch (catch of non-target species or small fish) is a major concern in many fisheries, with some having a history of discarding as much or more than they kept. In some industrial fisheries, as it has been in many artisanal fisheries for a long time, it is becoming standard practice that there is no such thing as bycatch, everything caught being utilized. There is thus an economical incentive for fisheries not to catch fish that are not marketable at a profit. Where this is not feasible, such as fisheries in which a keep everything rule would encourage deliberate over-fishing, or where bycatch may be endangered or highly valued species, more selective gear is required. There are also concerns about fishing gear damaging marine habitat. Of particular importance is a better bottom trawl, or near-bottom trawl, that will catch demersal marine species but have minimal impact on the seafloor and its biological community. One of the best ways to limit destructive fishing practices is to use incentives. If it is a choice between being closed down and cleaned up, industry is likely to show remarkable inventiveness.[17]

4) A fourth goal is to map ocean habitat. This is a wide ranging goal that sometimes is narrowed to multi-beam sonar images of the seafloor, but should include other aspects of habitat, such as the distribution of aquatic macrophytes especially in coastal waters, which are the main habitat of juvenile fish. Recent work has shown for example that kelp beds in coastal Newfoundland can be mapped using relatively simple acoustic measures.[18] (see Figure 1).

5) More efficient vessels and fishing methods will be required in 21st century fisheries. Fuel costs (if not subsidized) will drive innovation in how to catch fish with true efficiency. (A study in the 1950s indicated cod were caught most efficiently with traps and long-lines — trawlers were the most inefficient, but subsidized by governments.)[19] For the sake of argument, rural villages with small vessels and cottage industries, producing high quality product to sell at top prices, may be more efficient in overall terms than large fuel burning vessels crossing oceans, employing relatively few people, and producing food product of questionable quality. In subsidizing new technologies, consideration of longer-term efficiencies and sustainability must become a priority in fishing industries and all human endeavours.

In closing, the challenges facing marine fisheries in the 21st century are formidable.[20] As we enter the new age of ecosystem-based management, a key element in achieving greater sustainability will be to create incentives that result in technology being used to sustain rather than deplete ocean productivity, while rebuilding already depleted fish stocks and their ecosystems. The challenge awaits.


George Rose on his "sonar boat" GECHO in Smith Sound, Trinity Bay.

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[2] The industrial revolution has not affected many world fisheries, especially those in the tropics, in the same way as in the developed world.
[3] Two quotes from Albert Einstein are pertinent: "The release of atom power changed everything except our way of thinking … the solution to this problem lies in the heart of mankind," and "technological progress is like an axe in the hands of a pathological criminal."
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[10] FAO statistics (op cit.).
[11] Cunningham, S. and T. Bostock (eds). 2005. Successful fisheries management: Issues, case studies and perspectives. Eburon Press.
[12] See Kaunda-Arara, B., Rose, G.A., Muchiri, M.S., and Kaka, R. 2003. Long-term trends in coral reef fish yields and exploitation rates of commercial species from coastal Kenya. Western Indian Ocean J. Mar. Sci. 2: 105-116.
[13] The scientific world is rife with technology for its own sake - solutions looking for problems, and sometimes creating them.
[14] Simmonds, E.J., and D. MacLennan. 2005. Fisheries and Plankton Acoustics. Oxford Press.
[15] Research progress in this area has been driven primarily in Europe. In June 2008, two key conferences, the SEAFACTS (Ecosystem approach with fisheries and complementary technologies) in Bergen Norway and the European Acoustics Conference in conjunction with the Acoustical Society of America in Paris France, will highlight recent developments.
[16] Walters and Martell (op cit.) p 348.
[17] Walters and Martell (op cit.) p 33.
[18] Olafsdottir, A. (PhD thesis, Memorial University).
[19] Doucet, F.J. 1979. The utilization of northern cod. Report to Fisheries and Oceans Canada.
[20] Some have speculated on the total demise of commercial fisheries within decades (an unfounded projection in my view); see Worm et al. 2006. Impacts of biodiversity loss on ocean ecosystem services. Science 315: 787.