THE LARKIN LECTURE

This lecture series is sponsored by an endowment fund established in memory of Dr Peter Larkin, University of British Columbia. Larkin Lectures are published, after peer review, in the quarterly journal Reviews in Fish Biology and Fisheries.

Fisheries Management After 2000: Will New Paradigms Apply?

John F. Caddy
FAO, Rome, Italy

The last decade has seen growing concern at the general ineffectiveness of current fisheries assessment and management approaches, as reflected in global statistics published by FAO. These indicate full exploitation of most fishery resources and a serious over-capitalization of fleets at the global level. The projected increase in demand, and hence future prices for fish products, as well as the ecosystem impacts resulting from growing world populations, all require urgent attention from fisheries authorities.

Improved management of fisheries is seen to require, first, a better understanding of the axioms and working assumptions underlying current fisheries management approaches, and how these evolved in response to a limited set of species and regional or local conditions. This should assist in developing more appropriate integration of methodologies which reflect local situations, and which can be expressed in the form of one or more working paradigms. These paradigms can often coexist, and should be wide enough to incorporate ecosystem considerations, including the role of environmental fluctuations, as well as socio-economic factors. They should avoid the automatic assumption that current production levels will continue into perpetuity irrespective of natural fluctuations and human impacts on the resource and ecosystems.

Academic institutions could aid the management process by a more participatory approach, by promoting inter-disciplinary teamwork with stakeholders in fisheries, and by breaking down excessive specialization and regionalization within fisheries studies.

On the management side, the key elements for improving the situation seem to be to construct consultative management frameworks that explicitly incorporate 'watchdog' functions which can implement 'precautionary' approaches to management. With respect to near-shore resources, governments could assist by partly devolving management responsibility to appropriate levels in society; involving coastal communities, individual use rights, and other vehicles for limiting access, as appropriate. An extension of the application of modern technology from fisheries exploitation to improved management is seen as one aspect of successful future management systems; incorporating geo-temporally defined access rights to near-shore and shelf resources.

Recent international agreements, including the formal ratification of the Law of the Sea in 1995, offer hope that governments are prepared to adopt a more ecologically appropriate approach to fisheries management. They should continue to support the key stake of the fisheries industry in sustainable fisheries development, particularly for developing countries, now the major source of aquatic marine products.

High priorities for management of marine resources will be to rebuild depleted resources and restore habitats, with appropriate concern for maintaining genetic and ecological diversity. There will also be a need to consider the implications of free trade in fisheries products for conservation of fisheries resources for future generations, particularly for developing countries if the incentives for proper management are to be maintained in the face of growing demand.

International agreements of relevance to future management paradigms which are compatible with the Law of the Sea Convention (and each other), include Agenda 21 of UNCED, the Biodiversity Convention, the Draft Agreement on Straddling Fish Stocks and Highly Migratory Fish Stocks, the Compliance Agreement, and the FAO Code of Conduct for Responsible Fisheries. Such agreements, and draft agreements now open for signature, provide a comprehensive basis for 'customary law' that can assist local and national authorities in constructing appropriate management frameworks. At the same time, current concern remains with respect to application of these resources in international waters, where the limited access rights required for proper management still have not been fully established.

THEME 1: THE PRODUCTION BASE AND ECOSYSTEM MANAGEMENT

Session Rapporteurs
Kathy Heise & Alida Bundy

Keynote Address

The Trophic Cascade and Food Web Management

James F. Kitchell
Center for Limnology
University of Wisconsin, Madison, USA

Abstract

We know that primary, secondary and tertiary production rates correlate with nutrient loading. We also know that these processes are highly variable. We know that most predators are size selective, that resource partitioning occurs, that functional responses link the density dependence of predator and prey populations, and that predator avoidance behaviors are common. A more significant challenge exists when attempting to use this knowledge in the context of resource management activities. At the community and population scales, prey selection by predators alters habitat selection behaviors of prey species, their abundance, size distributions, life histories and consequent effects on their own prey resources. At the whole system scale, predation by fishes alters community structure, nutrient cycling rates and production processes at all trophic levels. These are the central tenets of the trophic cascade argument. We have tested these assertions in a series of experiments conducted on small lakes where fisheries are fully controlled. The main conclusions are that food web interactions and nutrient loading are equally potent regulators of variability in production rates. When these ideas are implemented as management practices in Lake Mendota, the behavior of fisherman confounds and compromises the

net result. The main conclusion is simple: fishing causes much of the variability observed in ecosystem processes and, therefore, much of the uncertainty in resource management practices. Reducing that uncertainty requires a better understanding of food web and ecosystem process responses to fishery effects. Challenges for the future include adapting the lessons learned from lakes to the larger context of open, marine systems.

Discussion

David Policansky
The waters of Chesapeake Bay were incredibly clear in 1995, with a visibility of at least 15 feet on the Secchi disk. What was going on?

Jim Kitchell
Increasing eutrophication is occurring in Chesapeake Bay. There are typically two things occurring in marine systems that could cause this, both associated with water mixing. The system (the bay) could have been between plankton blooms. Could this also have been the first time you have actually measured the water clarity with a Secchi disk? (laughter). Also food-web interactions could have been occurring which would cause a dramatic change in the system. Marine systems are difficult to explain due to a high level of mixing. There are examples of similar occurrences in large scale systems. For example, in Lake Michigan in the middle 1980's the lake went through its greatest transparency. The alewife were clobbered by chinook salmon and the lake was dominated by *Daphnia*. Water transparencies of 18 m were reported. When alewife were dominant, typical summer transparencies were 5-7 m. The total production remained the same, but its location in the water column changed.

Tony Pitcher
Many lakes in the developing world form the basis for important fisheries. What advice would you give to those in the developing world in terms of ecosystem management for producing the maximum harvestable fish biomass?

Jim Kitchell
Add manure! I don't mean to be flip about it, because there are water quality concerns

There are exceptions, especially if it is the only local source of water. The Israelis ran into that in Lake Kinneret. They are using bio-manipulation but they are monitoring food web interactions because that is their only source of water. On the other hand, in stock ponds chicken manure is dumped to increase tilapia production, either because the protein or the money those fish produce are keeping people going. In the developing world there are trade-offs, but priority must go to the most parsimonious need. The concern is taking (manuring) it so far that it is lethal for the object of interest.

Craig Harris
You were able to involve the sports fishing community in your initial modifications of the lake. Were you able to keep that involvement going and perhaps expand it to lakeshore property owners, recreational users, the transient sports fishing users, business people and farmers?

Jim Kitchell
Lets start backwards with the farmers. Farmers on the land have been marginalized by their circumstances. They are already heavily set upon by a variety of constraints. The last thing they want to do in the world is take a bunch of acreage out of crop production, or get rid of some cows. Economies of scale are driving the farmers in this part of the world to a desperate situation.

Who is next? Fishermen from elsewhere will just go elsewhere. Folks from Chicago or Milwakee will show an adaptive response, they will go to Lake Wisconsin, or Lake Winnebago, wherever the fishing is hot. An interesting response that I did not elaborate on earlier was that within the catch per unit effort, the response in the lake years, the big peaks are the killers, when the folks with the $50,000 sports rigs with high mobility show up. They are very efficient predators, they swoop in on the system and get high harvest rates and then get out. What is happening in the US and I suspect it is happening in other places is that those folks are driving the leading edge of the catch release movement, and are being very effective. There are some remarkably big fish in Lake Mendota right now. And the leadership that came from the angling community actually pushed us harder than

either we or the BNR *(Bureau of Natural Resources?)* actually wanted to go. We encouraged them with a size limit of 15-18 inches and a bag limit of 5 reduced to three. We asked them if they could live with that, and they said lets go for a length limit of 21 and two fish.

Part of the reason is the context. Lake Mendota is one of 5 lakes in the Madison area, and there are other lakes nearby where people can fish for panfish. People were most upset with all of this: they had been accustomed to fishing for perch, and wanted perch out their back door. Perch has high reverence in this part of the world. I know it is treated with disregard in most of Canada, but it has high reverence because it was the food fish during the depression years. It was a social phenomenon, it was the one thing people could afford to do, to go to a bar where every Friday night there was a fish fry and everybody went. It was a big social event and perch was readily available and cheap. It became the cement of family life.

Perch has now become a commodity, and if you go to the market now it is one of the most highly priced fish, at $11 a pound (American), and that is a lot of money. The social impact of this is a concern.

unidentified
Do you have any information on comparison of the numerical response of anglers with other lakes where you did not announce to the local newspapers that you had stocks?

Jim Kitchell
I was hoping you guys would do that. Now we are manipulating people, we are engaging in disinformation campaigns, and the public's right to know is being violated by not telling them. I can imagine and would encourage a very aggressive program directed towards that kind of effort. Anglers have these remarkable communication networks, and I am not sure how they work, but it is remarkable how quickly they can respond. We see it especially in ice fishing. Seventy percent of the total exploitation in the Madison lake district occurs in the ice, and a lot of it is unemployed seasonal workers in the construction industry, and they spend their winters out there on the ice. My colleagues look at that and say 'bad marriages', but these folks love it out there, and in many parts of the world the city develops around the edge of the ice and there are all manner of things that are brought out to make it nice out there. The transient population comes out there on a remarkable short term basis and I don't know how they do it. Carl tells me it is through the bait houses, and that was our experience manipulating it.

We can see a numerical response when we advertise, due to several situations. If one of these lakes makes *Outdoor Life* or *Sports and Field*, there will be a huge increase in effort - up to a 10 fold response based on one article. That is well documented in some lakes. So you can constantly go out, and hope that your background will give you sufficient understanding of what the pre-manipulation condition was. You can also limit it, which is what has been one of the consequences of treaty rights in the northern lakes of Wisconsin. Six of the Chippewa peoples now have access to artisanal means to walleye and muskie. This is the follow-up from the Bolt decision and the consequence is that the state now has the obligation in conjunction with the Great Lakes Indian Fish and Wildlife Commission to prevent over exploitation. And unlike any time in the past, these lakes are now being carefully watched and bag limits are being adjusted readily to account for that which may be taken by the native American harvest and that which is available to angler harvest.

For the first time ever, there are several hundred lakes being carefully monitored and regulated and the general expectation is that that attention will cause an increase in productivity of the fisheries. Once again, manipulating the anglers makes a big difference, and probably expresses a level of ecosystem functioning that we haven't yet had a chance to look at.

Jordan Rosenfeld
You have demonstrated a strong trophic cascade in freshwater lakes. Is there any evidence in marine or pelagic systems that trophic cascades work?

Jim Kitchell
Over to John Caddy to tell us about the Black Sea.

John Caddy
In the Black Sea, and other 'inland' seas, including the Baltic, there is large scale runoff of nutrients, and industrialization. I mentioned the other day that the watershed is about 6 times the area of the Black Sea. Much of the industrial activity of the former Soviet Union and the eastern European countries, plus agricultural activity has resulted in a high level of fertilizer in the system. This has resulted in major runoff through the Soviet rivers and through the Danube into the Black Sea. There is an attempt now to clean up this watershed which seems to have happened subsequent to the overthrow of communism.

An even more drastic example of a trophic cascade exists. There used to be a transient population of bluefish that came in every year from the Mediterranean and also a large population of dolphins and monk seals, so there were a lot of top predators that are now gone. At the same time, there was also increased phosphorus through sewage. The anoxic effects showed up first, the small pelagics, the zooplankton population increased. There was a massive outbreak of the jellyfish population *Aurelia* in the 1980's in response to the supply of pomfret, and then a ctenophore (a type of jellyfish) which was introduced from the hold of a freighter from the western Atlantic, and the ctenophore essentially wiped out the large zooplankton population. The fish catch dropped from 500,000 to about 50,000 tonnes and the whole system went into a kind of toxic shock. The ctenophores died and the whole system then went anoxic and essentially there were no grazers. The system now seems to be recovering to some extent

It is a remarkable story. We've seen similar things in the Yellow Sea and in the Baltic. It's not been properly documented, the ecological thought of cascades has not yet permeated the fisheries environment because the marine environment is not supposed to show these trophic level effects. We still have lessons to learn in the marine environment.

Jim Kitchell
Our understanding and explanation of these events is often confounded in three ways:

1) increased nutrient loading as a consequence of having humans around;
2) exploitation alters the top of the food web;
3) introduction of exotic species.

We have just heard John Caddy talk about it in the Black Sea, but we are getting a big dose of it in Wisconsin with zebra mussels, that have caused a doubling and two and three fold increase in water transparency in lakes which causes changes in the food web. If anything I am an evangelist for looking for food web effects as a mechanism that alters the process of feedback in the nutrient related controls of productivity.

Paul Hart
Do you think the expense of doing research to understand web relationships in the ecosystem can be justified in terms of fisheries management?

Jim Kitchell
That is a hard question. Our goal in Lake Mendota for instance, and this is a direct quote from our proposal, is to evaluate the potential. We evaluated the potential of food web controls to improve water quality, and as a consequence of the management decisions required to do that, we improved fishing. We also, as a consequence of the science, have a number of variables that are treated as unknowns controlling the water quality of Lake Mendota and the five lakes downstream of it. Therefore by analogy other lakes downstream are a concern. So we took away some of the contentiousness about why the water quality of this lake was being compromised. It is very clearly a consequence of what is going on upstream - suburbanization and golf courses without adequate protection from run off. So what is the long term economic consequence of this? You have to evaluate that with an economic eye toward the future value of the property and recreational activities on Lake Mendota, because the way this food web manipulation turned out, the way that we behave towards rezoning, regulations, land use, and the protection of wetlands and riparian corridors which will be there in perpetuity and therefore the lakes water clarity may have improved. It didn't get worse, so that is a way to evaluate it. In direct terms of fishery yield, probably a small share.

Mike Sinclair

John Caddy answered this question for enclosed seas, but in open ocean systems, say shelves and deep ocean, what evidence is there that we do have trophic cascades and significant inter-species interactions? When you fish top predators, does it change community structure in a fundamental sense?

Jim Kitchell
I am a strong advocate of using large scale manipulations to understand interactions, at least when possible. We have done that in small lakes and we get criticized because they are small lakes, and we have now seen the sequence of opportunities when you move to larger lakes, and we have been criticized for that too. Scale is not an issue, since we have Lake Michigan and the Baltic etc..

Can we extrapolate to the open ocean? The interesting question is - can we do anything about it? We can understand it and that would amuse us academics, but does it matter? The answer is I don't think so, unless you want to reproduce the five seas. Probably not a good idea, although it would be an excellent experiment. The more insightful thing to test would be to take the basic arguments from lakes. What matters is determining the nature of the driving force of productivity, and the key facts about the species that express it and control productivity for fisheries. We have seen some large scale manipulations for fisheries, and we have top down regulations, and the interesting question there is, who gets to benefit? Who lives? That is the manager's plight.

Daniel Pauly has some evidence from ECOPATH how sensitive parameters are. If you do something to this, then it has an effect on that. This becomes the manager's domain. So my answer to the question is I think we could find this out for oceans, but it would be a very expensive and perhaps trivial result. What really matters is how species operate and respond in their life history strategies and interactions. Who gets to live there.

Mike Sinclair
If oceans do not respond in the same way as a closed sea, and there are different ecosystem properties, then what does this mean for management? There does not seem to be any evidence from the continuous plankton recorders that there is a change in the size composition of zooplankton, so I would suggest that something else is operating.

Jim Kitchell
I would argue (and boy we have argued about this!) that those data, and much oceanographic data are derived from systems that are already in an intermediate state. They are supremely unpredictable and you shouldn't look for tightly held relationships in that case. These are copepod-bound systems. Copepods are very complex, and there may be some evidence there from the evolutionary biologists.

I have just hidden behind unexplained complexity and I want to redirect the question to What can managers do? or What do managers need to know? It is managers and peoples' resources at the scale of two-fold changes that make for economic survival or collapse. People will lose their jobs, and the felons of the economies are set asunder by these kinds of interactions. So long as those of us who are interested in basic mechanisms and double log relationships and explaining the variance then we haven't helped the managers very much. The key is to home in on the part where you answer the questions by looking back what can you do about it. What are the likely most extreme outcomes?

Kevern Cochrane
In open upwelling systems we have the equivalent of controlled experiments on trophic cascades. The succession following an upwelling event I would say in broad terms follows very closely a trophic cascade. Now to extrapolate an isolated upwelling event to the open ocean might be going a bit far, but I would say the evidence is there to suggest that you are looking at the same principles.

Jim Kitchell
We started with the unwritten clear goal that we wanted to do for limnology was to say that fishing matters. Fishing is not effect, it is cause. When you manipulate fishing then you manipulate and change ecosystem behaviours and it is one of the tools that managers have at their disposal. Here is the magnitude of change that can occur as a consequence of fishing - use it.

Points of View - Theme 1

The Control of Undesirable Introduced Species in Small Freshwater Lakes: What we should Learn from Past Experiments

Pierre Magnan
Departmente de Chimie-biologie
Universite du Quebec a Trois-Rivieres, Canada

Abstract

The introduction of non-native fish species is a common phenomenon in freshwater lakes and often have tremendous impacts on local fisheries. In this point of view I will present (1) the most common practices to control undesirable species in these systems, (2) how these practices too often failed to enhance the target fisheries, and (3) an approach that my group recently proposed to control undesirable species, based on the principles of integrated pest management developed in agriculture. This approach will be used by the Quebec Government for the control of white sucker, which was introduced in many brook charr lakes of eastern Canada by bait fishers.

Discussion

Christine Soto
Is one of your treatments just removing the spawners, and separating the two strategies? I am curious whether these treatments will impact the trout by getting rid of the drifting invertebrates.

Pierre Magnan
Most of the populations are in lakes and we are speaking of lakes which are hundreds and hundreds of hectares. The white suckers spawn in these rivers in the inlets of the lakes in the spring. At this time there is no char in these inlets; there is some residual population of small trout, not a residual population but a stream population.

If the manager can use mass removal for 3-5 years, then he will use the electric fence just at the entrance to the inlets. The larvae of the white suckers drift to the lakes for a very short period of time, maybe three or four days, and always just during the night. They develop on the spawning grounds in the inlets and at certain periods they just drift.

We tested this with a small snapshot experiment, and it was very easy to kill almost all of these larvae with an electric fence. Without using the rotenone, it was very easy to maintain the white sucker under a certain level. It was acceptable in terms of management goals because it is impossible to eradicate the white sucker in these lakes, firstly because the risk of re-introductions is high and second because it passes from an acceptable economic level of eradication to increasing the cost by a minimum of 10 fold. The idea is to maintain the sucker population under a certain level and to do the control of larvae on an annual basis. It is like agronomy and forestry, you have to live with the problem year after year, and the question is, is it justifiable from an economic point of view? If the answer is yes, then you participate in the program. And if not, we just leave the systems there.

Constraints on the Intensity of Trophic Linkages in Lake Food Webs

Bill Neill
Fisheries Centre, UBC, Canada

Abstract

Models of food web structure and function in lake ecosystems offer the prospect of ecosystem-scale fisheries management through manipulation of food web components. One likely objective of such a management approach is the maximization of energy flow through the trophic web to achieve high fish yields of target species at intermediate or upper trophic levels. Thermodynamic constraint on the efficiency of biochemical conversion of prey biomass to predator biomass is not the major limitation in realizing this objective. Predictive uncertainty is.

Current ecological understanding admits of substantial unpredictability in how individual and population components of food webs, their spatial and temporal distributions and their trophic links to other components respond to both bottom-up and top-down perturbations. Unexplained variance in food web dynamics stemming from bottom-up signals (e.g., nutrient perturbations, temperature fluctuation, habitat alteration) probably exceeds that of top-down signals (e.g., recruitment pulses, habitat expansion), but the potential for surprise in even well-controlled experiments is still disturbingly high.

Further, the variances in effects of both bottom-up and top-down processes at each trophic level are likely to be greatest and structured least at intermediate biomass ranges which are required to maximize trophic transfer efficiency from 1st to nth trophic level. Unfortunately, the scope for uncertainty is probably also greatest when system productivity and biodiversity are high. Given current knowledge, predicting, regulating, or at least tolerating large variance in food web responses become necessities if fisheries are to be managed near maximal production capacity using ecosystem Constraints on the intensity of trophic linkages in lake food webs approaches.

Discussion

John Schnute
In one of your figures there is a response curve that was flat at one end, rose and became flat again, so that we have a low-end threshold, and a high-end threshold and something in between. If you put together a series of such responses then the theory is that the net effect will be that fairly large changes in the bottom will cancel out, am I right?

Bill. Neill
That is certainly one of the consequences. If you put together a series of these kinds of things, it becomes extremely unpredictable in the middle ranges. It is easily predictable at the extremes, and it is in the middle where uncertainty exists. Unfortunately it turns out that 95% of all lakes on the planet follow this pattern.

John Schnute
That model is also how a neural net works, you have nodes and transfer functions like that from one to the other, and of course a characteristic of the neural net is it does have those kinds of threshold responses. It is almost like flipping a coin at each of those levels, and you flip all the coins from the bottom to the top. What you end up with is pretty unpredictable. That curve can be horizontal, then vertical, and then horizontal, that is a very sharp shift from one level to the next and that is your real point.

David Policansky
I am unsure if this question is for Bill or Jim. Bill, you said that 95% of the lakes on the planet are unpredictable. Is that the same middle ground that Jim was talking about that was dominated by copepods, where he wasn't going to look for tight relationships?

Bill Neill
That middle ground where there is so much uncertainty occurs as a consequence of both bottom up and top down processes. One of those alone does not explain things. The middle ground is the zone of interaction in which a whole variety of life history strategies, shapes, sizes, of organisms can make a go of it at some times under those conditions as a consequence of the interactions that are going on and so I am a very firm believer that top down processes can have very strong consequences in there, as well as bottom up consequences.

Jim Kitchell
Note that 95% of the world's lakes are fished.

Ecosystem Management–The Next Step

Daniel Pauly & Villy Christensen
Fisheries Centre, UBC, Canada
& ICLARM, Manila, Philippines

Abstract

Fisheries science has long been split between those who emphasized environmental causes for stock fluctuations

(e.g. J. Hjort) and those who emphasized the impact of fishing itself (e.g. F. I. Baranov). The insights recently gen-erated by multispecies modelling may lead to a consensus because they reinforce the need for a form of fisheries management that explicitly accounts for ecosystem effects, inclusive of predator-prey interactions. (see also Abstract by Walters *et al.*, this volume, page 26).

Marine protected areas, also known as marine reserves, would be at the core of such ecosystem management, because they - alone among fisheries management tools - allow reconciliation of the different natural time scales with those of fishers and markets. The latter point is illustrated by a comparison of two contemporary (and relatively depleted) marine ecosystems with their reconstructed earlier states, interpreted through O. D. Odum's theory of ecosystem development

Discussion

Uli Reinhardt
For your prediction that an ecosystem may return to a state where it is in balance, on what time scale do you predict that this will occur? For example, in systems that are really disturbed by fishing pressure, will they ever come back in a reasonable time scale, to the stable state that you predict?

Daniel Pauly
I am afraid I must talk coral reefs because these are places where several marine protected areas have been set up and monitored for a few years. I would rather discuss a temperate shelf but there are no marine protected areas on the temperate shelf.
It seems that for some coral reefs that have been closed to fishing for over a decade or so, within 2-3 years the number of fish have increased tremendously and the numbers of small fish have increased enough to have offset the half of the loss due to fishing.

After 5-6 years, Gary Russ from Australia has noticed an increase in the groupers but even after 10 years they have not re-established the biomass known to have been there before.

There is a bay close to Manila where I have been diving over several years. The USA in its benevolence constructed a road along this part of the coast and the road was built such that the mountain came down and landed on top of the reef. It was a classic ecological catastrophe straight out of a textbook. After a few years you see coral reefs replanting themselves on those parts of the reef that are free of mud, that have been washed out.

So in that sense there is always hope, at least for connected systems such as marine systems, if you give them a break. I do not know if that is true in a terrestrial system. Deforestation has led to a loss of the topsoil and of the subsoil in some areas if the Philippines so you have desert in the middle of a monsoon system. In these terrestrial systems you have, on any reasonable time scale, irreversible change. You don't have that on coral reefs. That is my answer.

Michael Bauman
Did you ever estimate the necessary size for a marine protected area under water?

Daniel Pauly
Some work has been done on what would be a reasonable size and you end up saying that you will not be able to protect large species, but you certainly can protect snappers, groupers, which on reefs stay in the same place once they have settled. I think this is a big problem in marine protected areas, to size them. It is an important area of research, not their usefulness but their size, and it is one of the most important in future.

Kevern Cochrane
I would like to follow up on that point. I don't think you can go from saying the big question is how big to make them and that their usefulness is assured. The two sides are totally interdependent and what I would like to suggest with marine reserves is two big questions. First, how long is a particular species resident in a reserve, and hence is that reserve effective in preserving that species? The other question is: what leakage is there from the reserve to adjacent areas and is that effectively supporting local fisheries?

For those two questions, ECOPATH is not the tool to use, unless you develop a spatial version of ECOPATH.

Daniel Pauly
Obviously ECOPATH is not the definitive tool, but it has shown that Odum's theory is compatible with what we think happens in a marine reserve and that is kind of neat.

The Understanding and Prediction of Marine Production: Considerations for the Future

James Scandol
Fisheries Centre, UBC, Canada

Abstract

It is often assumed that the best method to predict the behaviour of a system is to understand the processes operating within it. Although this assumption has proved extremely effective in the analysis of certain types of systems, the unconditional acceptance of such an assumption in the study of large marine ecosystems may be misleading. This Point of View focuses upon what methods we can use to refine our concept of an understanding so that we might make predictions of more applicability to management. I suggest scientists need to revisit three areas of production research. These are to:

1. Study the role and analysis of physical and biological scale in production. Variability and uncertainty are enmeshed with scale. Are scales of measurement that are convenient, or cost effective, for scientists the important scales of interest in production processes ? What modelling methods are most suitable for dealing with changes in scale within production ? What scale invariant tools have proved successful in other disciplines ?

2. Quantify the consequences of animal behaviour on production. Production processes will be impacted not only by metrics such as weight and water temperature, but also by individual behaviour. Organisms will behave in response to conspecifics, physical conditions, prey and predators. Furthermore behavioural response will be dependent upon developmental stage. The emphasis should be on understanding the outcome of behaviour on production variability.

3. Understand the relationship between understanding and prediction within science and management. Applicable process based understanding for management may not be formulated in terms that scientists find familiar. For example: a process-based model that yields a statistical distribution of expected production will be more applicable than the correct prediction of the maximum carrying capacity on any particular year, yet both studies are based upon valid scientific queries. The understanding of production processes should be focused upon predicting uncertainty. Let us ask when, where and how do rare events arise? With such information managers can design plans and policies that are robust to such variation.

Discussion

John Schnute
I was interested in your comment about understanding vs. prediction. I have often thought about the similarity between fish stocks and mutual funds. If you are a manager of a mutual fund and you report to your fund holders that our research staff really understand the stock market but it is not very predictable and your fund just dropped 15%, doesn't this make the point that what matters is predictability?

James Scandol
No, because management occurs over two time scales - setting up policy to deal with variability, and the short term dealing with trends and discrepancies. A general probability distribution can effectively design management policies to take this into account. These policies can be designed such that it doesn't matter that you don't know what is going to happen in any particular year and you can still essentially manage it. But if you know underlying variability might be reduced, then that is going to help you over the long term. So a view that you make - to think that you know what is going to happen -- might lead to worse management than saying that you don't know what is going to happen. Because if you get it wrong, then that is when you really get into trouble. Any

bubble or any empirical result will be potentially flawed and backed on assumptions that might be wrong. Short term management has to based on data collection and on short term information.

Carl Walters
A wise stock market analyst won't ever predict the market, he will develop a portfolio of investments that will make the client feel as safe as they want to be, without having to predict what will happen.

What do you see the prospects are for the ecomodels that you have been working on for the last few years? Will it solve the prediction problem for us at all?

James Scandol
In-season estimates are easier to manage. If something goes drastically wrong and there are no fish when we thought there were going to be a whole lot, then at least you have some fallback mechanism with in-season management. Any model - even a fancy mechanistic model with some weird geometry or a strictly good correlation - needs to be ready to be knocked out of the system if it looks as if there is incompatible information coming in from the short term data collection.

I think models need to be slaughtered as soon as the need occurs.

Laser Ablation ICP-MS – A New Method to Identify Individual Natal Stream Sources of Salmonids and Migration Patterns of Fish

S. H. Wang & R. Brown.
Elemental Research Inc., Vancouver, BC

Poster

Laser ablation inductively coupled plasma mass spectrometry (LA- ICPMS) has been applied as a method to determine elemental distribution in biological tissue specimens, providing high spatial resolution and sensitivity. It has been determined that certain elements are assimilated into growing biota from the food source and fresh water in natal streams, hatcheries, and fish farms. The elements are deposited into the skeletal structure of growing fish and remain throughout the life span in scales, otoliths and vertebrae. Variation in chemistry of the environment produces a pattern of discrete bands in the biota corresponding to the changes in chemistry and the duration of exposure. A micro-analysis of these regions allows the establishment of data to provide specific information on the unique elemental signatures (finger prints) in fish from a particular source, and subsequent exposure to environmental changes during migration. A classification accuracy of up to 100% is achieved when fish scales are examined.

Using mass-balance (ECOPATH) food web models to structure dynamic (ECOSIM) simulation models

Carl Walters, Villy Christensen[a] &
Daniel Pauly
Fisheries Centre, UBC, Vancouver, Canada
[a]*ICLARM, Manila, Philippines*

Demonstration

The linear equations which describe trophic fluxes in mass-balance, food web models of ecosystems (such as in the ECOPATH approach and software) can be re-expressed as differential equations defining trophic interactions as dynamic relationships varying with biomasses and fishing regimes. The trajectories of biomass predicted by these differential equations, and equilibrium system responses under different exploitation regimes are found by setting the differential equations equal to zero, and solving for biomasses at different levels of fishing mortality. This approach, incorporated as a routine (called "ECOSIM") into the well-documented ECOPATH software (see also Pauly and Christensen, this vol., page 23) will enable a wide range of potential users to conduct fisheries policy analyses that explicitly account for ecosystem trophic interactions, without requiring the users to engage in detailed information gathering (beyond that

those looking at oceans were looking more at ecosystem-based management. Marine protected areas might be perhaps a tool for that latter form of management.

I am on a fisheries resource conservation council on the Atlantic coast of Canada that tries to deal with recommending conservation measures to the government. We have been struggling with issue like this and we face questions like does it make sense to harvest capelin when the cod stocks are depressed, and does it make sense to trawl on the bottom of the ocean when that disturbs the bottom habitat?

Those kind of issues are ones raised by the fishers that we listen to. To me those are the fundamental questions that are out there, and I would be interested in any comments as to how to address them, apart from saying we need more research.

Tony Pitcher
I wonder how many of us feel about incorporating the ecosystem perspective in a management plan. How many people here feel that we have enough knowledge and the right tools to confidently include the ecosystem aspect in conventional fisheries management? I am talking about more than just the single species management. - the fish population dynamics that traditionally have been used by fisheries managers. Do we know enough after sessions like today, to include that in our management?

Jake Rice
There is not a yes or no answer. In some areas we have some knowledge that we could use to do ecosystem based management. For example, we have excellent experience with tuna-dolphins and with other species of bycatch, I wouldn't go further on other examples. That is the approach that we are trying to pursue but I wouldn't be bigheaded enough to assume we can do it.

John Schnute
It does seem as if there are two schools of thought. I belong to a school where a great deal of my professional energy is directed towards looking at the data we actually have and trying to decide what is actually happening out there. This is very Sherlock Holmes-like - here are the fingerprints and the footprints and all the clues, and now what can we say about what has transpired?

A person of my school of thought looks at this sort of ecosystem stuff and says it doesn't really help because it is so unpredictable and so it doesn't help solve the problem. On the other hand, the other school looks at me and says, well you idiot, of course these fish eat this and eat that and how can you possibly ignore these facts about the process.

It seems to me a theme of this meeting is try to see each other as Sherlock Holmes. How do we bridge between the two schools? Your question Tony was in some sense unanswerable. You would have to be an idiot to disagree that the food web matters somehow. But is the ecosystem perspective germane to the analysis? This is important because of the expense of ecosystem research. Where do we focus our attention for data? What is useful for the taxpayer?

I might say Jim that I thought that your talk was one of the most convincing that I have ever heard on how things can really happen. I guess it was expensive and you had the privilege of being able to manipulate things a bit. The question I have for you is that some of the manipulations in your system were handed to you, either by nature or by virtue of the fact that publicity brought in the sports fishermen. Other times you went and moved fish. It seems to me that most of us have to depend a lot on naturally induced contrasts.

Jake Rice
On that theme, and prompted by Tony's question, studies of marine ecosystems, whether they are pelagic, open ocean or whatever, have taught us a great deal over the last three decades.

But if you look at the assessment tools being used for fish stocks, and try to build analytical linkages between the research on ecosystems and actually doing the stock assessment to provide forecasts in the short and medium term - I raise my hand to Tony Pitcher's question and say yes- we do know a lot, we know a great deal, but we are not using these analytical paths to give advice to managers. And I don't know a jurisdiction in the world that is providing funding to build those links. We are

funding lots of ecosystem based research and lots of modelling on fish stocks, but we are not linking those two things. It seems very unglamorous work but it is where we are going to get the pay off.

Rashid Sumaila
We have several systems, from the fjords to the Barents Sea to the North Sea, where we can see that the production of phytoplankton can be modelled from the local conditions, but the biomass of zooplankton cannot be modelled from the local phytoplankton concentrations, only from the advection from the open ocean.

For instance, the Norwegian Sea supplies the whole Barents Sea (which is three times the size of the North Sea). It is driven by advection. Fish production is not driven by local conditions but by input from the Atlantic. This is not similar to a lake.

Kevern Cochrane
Can I respond to that, and put forward a gross oversimplification, but then that is what modelling is all about! I suggest that we could take one of Jim's half hectare models and with minimal change apply it to the Black Sea, but in doing so we would have to split it up into 4-5 little areas, and we would have to model interactions between those areas. We could apply it to the Mediterranean, but we would have to split it up into 20 -30 different areas, and look at the interactions between areas. And we could go on to do the same for the Pacific Ocean, with many little coupled areas.

What would be happening is that the interaction terms would be becoming more and more dominant. So what was happening in the box (for example what Jim was telling us) would become less and less important, and what is happening between the boxes would become more and more important. This leads to the uncertainty that we talked about earlier.

Tony Pitcher
The naturalistic fallacy in philosophy is to try to get an *is* from an *ought*. As scientists we are adept at avoiding this pitfall - we know we ought to use ecosystem management, but this discussion shows that we are very eager not to use it because we like to claim we dont know what it is. The papers in this session suggest that this claim not really true, but the discussion is symptomatic of our reluctance to get involved.

The freshwater people know more about their systems because they more bounded or coupled than marine ones, and so maybe they are more confident to use knowledge of the ecosystem in resource management. But our profession is very unhappy at the notion of trying to use such knowledge in the oceans.

There is an instructive paradox here: the public may be surprised at our professional coyness. We say that we do not have the knowledge to manage aquatic resources using information about their roles in ecosystems. Yet as several speakers have pointed out, we humans have already documented massive impacts on marine systems. So we may have the basis for more understanding more than we care to admit.

Several speakers pointed to massive uncertainties and unpredictability in aquatic systems. But similar massive uncertainties are incorporated as a matter of routine into everyday stock assessments. We baulk at the uncertainties of including prey, predator and trophic web effects, but often these trophic interactions turn out to be supported by food consumption data dating back many years. I suggest that we try to have the courage to develop and use ecosystem -based management tools.

THEME 2: ASSESSMENT, RISK AND ADAPTIVE MANAGEMENT

Session Rapporteurs
Alida Bundy & Kathy Heise

Keynote Address

Re-inventing Adaptive Fisheries Management

Keith Sainsbury
CSIRO, Division of Fisheries, Australia

Abstract

It is now 20 years since the use of adaptive controls was first comprehensively present-ed as an approach and framework for the scientific management of fisheries. The scientific superiority of this approach over ad hoc resource assessment and decision-making is very clear. Adaptive management recognises the uncertainty in the state of knowledge and dynamics of the system being managed, and requires examination of the ability of proposed controls to achieve management objectives despite the uncertainty. However there are still only a few actual cases in which adaptive man-agement has been formally developed and applied in the management of fisheries. Moreover most of these cases have relied on passively adaptive management regimes, rather than actively adaptive ones.

Some experiences of adaptive management in Australian fisheries are summarised. These include a passively adaptive regime used in the development of the Orange Roughy fishery, an actively adaptive regime for a tropical multi-species trawl fishery in northwestern Australia, and a soon-to-be-implemented actively adaptive man-agement regime governing fishing on the Great Barrier Reef. Some as-yet un-successful attempts to implement adaptive management approaches are also described, most notably attempts to develop an adaptive recovery strategy for the Southern Bluefin Tuna fishery.

The Australian experience to date is that the concepts and framework of adaptive management provide an excellent basis for scientific analysis and advice on fisheries management. Where it has been applied, adaptive management has 'delivered the goods'. However, it is also very noticeable that the use of adaptive management requires a significant and sustained effort to obtain and maintain the mutual commitment of 'stakeholders' in the fishery (industry, managers, research agencies). There remain technical challenges to be overcome, particularly in the characterisation and treatment of uncertainty; but the existing methods have already contributed much to the knowledge base on which scientific advice regarding sustainable resource management is made.

At present, it is not the technical constraints that present the major limitation to more widespread use of adaptive approaches to fishery management. The major constraints are

1. the reluctance of management structures and agencies to commit to a somewhat fixed and explicit management strategy, often because of a perceived reduction in capacity for flexibility under changed circumstances (which may range from changed political fortunes through to changed scientific understanding);

2. the reluctance of industry to accept catch reductions without a very high level of proof, especially at times of economic stress in the industry; and

3. the difficulty for scientific institutes in maintaining the focus or priority of staff and financial resources for the lengthy periods needed to develop and conduct adaptive management regimes (part-icularly actively adaptive regimes).

Each of these circumstances is quite under-standable, but not easily overcome.

The first and second constraints require significant involvement, understanding and persistence on the part of scientists in presenting and gaining acceptance from a wide range of stakeholders for new

approaches to management. This is often easier to achieve in newly developing fisheries, where economic and political constraints are usually not so strong. The development of adaptive regimes in these situations could and should be very actively pursued. The third constraint requires an ability to allocate scientific resources on a decadal time frame - always difficult and becoming more so in most parts of the world, but an issue that must be addressed and resolved.

Adaptive management is without doubt the best management strategy we have for achieving sustainable resource use. To gain wider application of adaptive management approaches demands that the issues of acceptance, communication and commitment in the broader social environment of fishery management be actively addressed. This will require scientists to be strongly involved in a broad spectum of communication media and forums, including the time-consuming activity of participating in management advisory committees.

The credibility of scientific input to fishery resource management suffers greatly from *ad hoc* approaches that even lack scientific evaluation of their chance of success with respect to the overall social aims of fishery management. It is certainly time that effort was put into re-vitalising, if not re-inventing, adaptive fishery management.

Discussion

James Scandol
What is the relationship between adaptive management and the precautionary principle?

Keith Sainsbury
Adaptive management provides a nice framework for evaluating how precautionary different strategies should be. Also I think that approaches to fisheries management that do not fully recognise and have strategies to deal with the uncertainty would not be called precautionary.

John Schnute
Why do you succeed with adaptive management whilst thousands of others fail? Some of those adaptive schemes you describe actually work. How much does the role of analysis have to play in this? Does it play a role in the sociology of the whole thing, how critical was it?

Keith Sainsbury
It certainly did - I'll explain it in a moment. I just want to say I may have left a mixed message. Adaptive management frameworks can and do work, but the other point that I was trying to make is that the investment to get them up and going is substantial and I am not sure that in the foreseeable future that it is going to come down. Maybe we are on a learning curve and when everyone fully understands what is going on we wont have to sit down and re-explain everything all the time. But at the moment I think that we are an awfully long way from that. So the problem is that to actually achieve something like this we have got to really work. We got to have some people who have the resources to put a lot of investment into working with the managers, other scientists and with industry and it drives you absolutely crazy at times.

On the role of analysis, from a very early personal experience I can tell you that decision trees do not help. It is very useful when talking with a bunch of other scientists or consultants for groups who do or do not want something to be done. It can be essential to get scientists and these groups on side. But I learnt very quickly that when dealing with 'real people', you go straight to the graph which summarises the whole thing.

Randall Peterman
User groups often do not want to be in the control areas in adaptive management regimes - i.e., in areas where fishing intensity is lower than in the experimental areas, and they feel that they are not getting a full share of any benefits, fishers may respond "hey don't do this to me, do it to the other guy", and that is often a barrier to implementing adaptive management. How do you get around this?

Keith Sainsbury
There is no easy solution to this. You have to try and talk it through.

Carl Walters
It is possible to design the experiments to

ameliorate this problem. It may be possible to avoid areas where this sort of situation exists

Laura Richards
Could you please comment on the costs of setting up a situation like the one on the Great Barrier Reef. How many people, how many days?

Keith Sainsbury
In the NW Shelf , the project cost 3 people per year for about 5 years. In the Great Barrier Reef - a lot of time, a lot of talking, a lot of redoing analyses.

Craig Harris
If you are talking about the costs of collecting information, it is also necessary to talk about the costs to families and outfits displaced. This, in aggregate must overwhelm the scientific costs.

Sainsbury
Good point. We try to put these costs in the expected value, i.e., value of lost catches, unemployment. The cost to the scientific research institute is a small part of this.

Points of View - Theme 2

An Overview of Tuna Assessment and Management World-Wide

Alain Fonteneau
ORSTOM Scientist
IATTC, La Jolla, California, USA

Abstract

Tuna resources world-wide are providing increasing and large catches (over 3 millions tonnes); those catches are of average high value. Tuna species are classified in the Caracas Law of the Sea, in the category of highly migratory species, doing extensive transoceanic migrations between multiple EEZs and offshore international areas. Consequently, those stocks are managed, at least in theory, by international *ad hoc* fishery commissions such as ICCAT and IATTC. This talk presents an overview of the management bodies active for tuna research and management, and discusses their strength and weaknesses for research and management.

The major stock assessment problems specific to the tuna species are summarized and discussed. A classification between the temperate tunas (most often fragile stocks) and the tropical tunas (very stable and resilient stocks) is used and discussed. This differential risk component in the exploitation of those two groups of tunas can easily be explained by multiple reasons, such as their ecological differences (behavior, migration, availability to the fisheries, levels of recruitment) and the economy of the fisheries (cost to catch the fishes and value of the fish caught). The strong resilience of most tropical tuna stocks explains why most (or all) of those stock are not yet overexploited, despite a tremendously increasing trend of fishing effort and permanently increasing catches observed worldwide.

Stock assessment done in most oceans upon tunas are made difficult, or often impossible, for various reasons which are often specific to the tunas:

- Complexity of the tuna migration patterns (well shown by tagging), combining complex and variable advective and diffusive movements (geographical and vertical); those movement can create unexpected interactions (or often surprising lack of interaction) between tuna fisheries. Those interaction are often very difficult to understand and to assess. In most cases some fraction of tuna stocks may remain unavailable to the fisheries (being too deep or to remote) and they may act as a cryptic biomass.
- Impossibility to really age the catches: all the VPA analysis are done basically on sizes.
- Great difficulties and very high coast to measure the trends in the abundance: most recent tuna fishery cpue indices are strongly biased by increased fishing powers of most fleets, and it is impossible for most stocks to obtain abundance indices independent of the fisheries. As a consequence of those two serious limitations, the VPA type analysis done on tunas are often quite controversial and uncertain.

The ecological problems of tuna by-catches

in purse seines (dolphins, log associated species) and longline fisheries (birds, sharks, turtles...) is briefly introduced, as they are of increasing importance in tuna fishery development and management.

Discussion

Jim Kitchell
An alternative interpretation to your observation of apparent positive feedback in tuna fisheries could have to do with released constraint to recruitment. We know that one of the best ways to find out about tunas is look at the stomachs of adult tuna, where cannibalism could be part of that feedback.

Alain Fontaineau
Yes, it is a good question and it is well known that tuna can be cannibalistic and there is probably this type of domed stock recruitment curve. It is not a contradiction of what I was showing, but it can complement it.

Gert van Sentsen
You mentioned in your presentation some of the points that have improved the fishing efficiency of the fleet. Have you been able to model the increase in fishing effort as a result of the ecology and are there general assessments of the overall resources?

Alain Fontaineau
Yes and no. It has been tried, so some improvement has been made. For example, some projections have been made where the fishers started off being able to locate fish at 5 km and later could search over areas of 30km. So this is well known. But afterwards when you add up all these affects, you don't know at all the final reasons. You can model one or the other but all the interactions are difficult to calculate.

Predictive Models of Growth, Survival and Reproduction

Jarl Giske
Dept. of Fisheries and Marine Biology
Univ. of Bergen, Norway

Abstract

The potential of developing predictive models to forecast growth, survival and reproduction of fish in an ecosystem is discussed, with examples from the Barents Sea. Currently, growth, survival and spawning of the Barents Sea capelin have been modelled by dynamic programming where the individual fish may select its horizontal position, influencing growth and survival. Temperature fields and currents are generated by a hydrodynamics model and zooplankton biomass is generated by a 3-dimensional model of *Calanus finmarchicus*. Fields of mortality risk by cod and mammals are superimposed on the horizontal map. The model has been run for 1979-1981.

The role of predictive models is two-fold: 1) to model historic events in order to reveal causal relationships and 2) to anticipate the future.

The first of these aims is often overlooked, perhaps due to the word `predictive'. However, revealing causal relationships is extremely important for our ability to give qualitative predictions in complex systems, and this aim is currently the major reason for performing predictive models. However, biological models are currently not developed for large-scale multi-species ecosystem dynamics.

Particularly for the atmosphere and the physics of the oceans, the second of these aims is currently out of range for science, due to the chaotic nature of the weather. Today's ocean climate models are driven by meteorological forces, and may therefore only be used in hindcasting.

Another type of forcing is needed for predicting the annual and inter-annual dynamics of fish stocks: improved understanding of the predictive celestial and planetary events and processes that cause oscillations in ocean climate and fish stocks is needed to enhance the predictive power of scenario modelling in fisheries biology. Research efforts should be directed into understanding these processes.

Discussion

John Schnute

You made the distinction between two approaches, (1) observation and statistical analysis, and (2) modelling and prediction. I am puzzled that you see these as distinct. I have an analogy of the scientist as a detective. There is a certain place in detective stories when the detective tries to re-enact the crime. I see the activity that you were conducting somehow in that vein and I have always thought that this was quite close to statistical analysis. But the risk that I see when re-enacting the crime is that there is more than one explanation that will adequately fit the facts. You may become enchanted by your own explanation. Comment?

Jarl Giske
Data is the fundamental thing that we have. We learn from nature, but we don't use data as input in these models. We input the spatial distribution, length frequency distribution, but then we have meteorological data or sunshine, wind. We have the overwintering biomass of copepods in the Norwegian Sea the year before as input data. The model is run from this overall paradigm that the ecological players have shaped.

Paul Hart
How do these models contribute to better management of the capelin stock?

Jarl Giske
Currently we are limited by hydrodynamic models. We believe in 10 years we can make hydrodynamic models which are based on other things than just the weather. There are signs now that to understand what is happening with fish we have to understand what is happening in nature. We have a good situation in the Bering Sea currently and a dodgy situation in the Canadian seas. Now, in Norway we see good management and in Canada we see overfishing.

What we see is the balances of nature shifting and those forces operate on a time scale which is longer than 7 days weather forecast. While we can not forecast for longer than this yet, we have to use scenario forecasts from the historical archives. We can pick a year which is most like the year we have now and we can use that year as an example of what we may happen in the near future.

Benefits of Taking Uncertainties into Account when Making Decisions in Fisheries Management: Example Applications of Bayesian Decision Analysis

Randall M. Peterman, Shane W. Frederick
Christina A Robb, Calvin N. Peters &
Milo D. Adkison

School of Resource & Environmental Management,
Simon Fraser University, Canada

Abstract

Fisheries management agencies are attempting to identify precautionary approaches to management that make an appropriate balance between harvesting stocks sustainably and avoiding detrimental situations. However large variability and estimation errors in fisheries data make estimating risks and identifying appropriate management strategies difficult. Decision analysis is an appropriate method to deal with this problem because it explicitly represents uncertainties about current stock abundances or about underlying relationships in dynamics of the fish or the fleet. Bayesian statistics can be used to place degrees of belief on different estimates of abundance or the possible relationships. Decision analysis then calculates the optimal management action for each specified management objective.

We discuss several examples that apply these methods to choosing appropriate management actions for, (1) marine fish species (i.e. appropriate harvest rates), (2) Pacific salmon (best decision rule for when to open an in-river trout fishery to harvest fish that are surplus to spawning requirements), and (3) rainbow trout (best density for stocking lakes with juveniles). Specifically, we will illustrate how taking uncertainties into account may in some, but not all, cases affect the appropriate decision about the level of precaution (reduction in harvest rate below that considered optimal when uncertainties are ignored in a

deterministic analysis).

We also show examples of the expected value of including uncertainty, which is the difference in expected benefits between choosing a management action based on a full decision analysis (uncertainties included) and the expected benefits from choosing the action based on only the best point estimates of all quantities.

Our analyses of salmon and trout fisheries calculated the value of improving information through research programs that provide better estimates of parameter values, as illustrated by comparing the expected values of benefits from two decision analyses, one with the current estimate of variance on some uncertainty and another with a lower variance.

Such calculations of the value of additional information are useful to management agencies that are making difficult decisions about allocating limited funds to different research and operational programs.

Discussion

Rashid Sumaila
How do you take care of true uncertainty?

Randall Peterman
True uncertainty is an irreducible thing that we will never know. It is part of the residual error, which is weighted differently in different data, part of the error which we can never explain.

Craig Harris
I was curious whether in any projects you have worked on, you have tried to involve user groups and stakeholders in data gathering and modelling, either directly in the sense of the fishers going out and gathering data themselves or perhaps using biologist or scientists that they hired. Are there ways of getting the stakeholders involved I this analytical exercise?

Randall Peterman
Yes, but we only have very indirect experience in the Nass Sockeye case by talking with consultants who work for the Nsgaa tribe on the Nass River. In this case it was a very interactive process and there is no reason in principle why this should not be done on a more extensive basis.

Intelligent Fisheries Assessment in an Uncertain World

Laura J. Richards
DFO Science Branch
Nanaimo, Canada

Abstract

Intelligent fisheries stock assessment requires carefully archived historical data. But, in many cases, the necessary data are either limited or entirely nonexistent. These limitations result from poor estimates of catch and effort, noisy survey biomass indices, and inappropriate spatial and temporal scales of data collection. Current stock assessment models generally fail to acknowledge the full uncertainty in data inputs. Thus, model projections may appear overly precise. Optimistic stock size estimates potentially expose the stock to overfishing. By contrast, analysts lose credibility with their clients when they produce excessively conservative estimates. Recent improvements to stock assessment models may help to define the true uncertainties in fish stock abundance, but only if appropriate data are available.

How do we resolve this dilemma for a re-invented fisheries management? We can improve data collection procedures, perhaps through industry partnerships, but many types of analyses still require historical time series. On the short term, we must seek mechanisms for including non-traditional data in stock assessments and for analyzing traditional data in novel ways. We can also employ natural perturbations (e.g., recruitment variability) as tools for learning system dynamics. I give examples of possible analyses based on my experience with British Columbia fisheries. I also argue that we must invest now in database archival and documentation as our legacy to the next generation of analysts.

Discussion

Jim Kitchell
Errors in aging fish has become a big problem and every time we look closely we find fish to be older than we had thought. Might a margin of safety be built into the aging and therefore the process of allocation of stock assessment that says we underage these to begin with, now lets go from there. And if so, how much do you think this margin is?

Laura Richards
In the late 1970s there was lots of work on aging where they began to discover some of these differences and there is new work now using radiometric methods. But for a lot of these species that we have pretty well reached the plateau. If you've underestimated age, you are going to assume that productivity is much higher than it is, which means that you've got to be more conservative. There are a lot of problems with just trying to implement that general concept, given all the other kinds of uncertainty that we have as well. We should probably implement something like John Caddy talked about. This is the generic approach where we should be heading.

Carl Walters
In the late 1980s, there was a large adaptive management experiment proposed for the Pacific Ocean Perch in BC. Why did DFO oppose this when all the indications were that this would be a much better way to manage the fishery and it would have provided a pile of useful information?

Laura Richards
We did two other experiments and both had problems with long term industry collaboration.

One of these was an overfishing experiment at the northern end of British Columbia for 7 years, followed by closure for 7 years. There is a survey of the closed area planned for the summer of 1996. It is one of the best examples of adaptive management that we have on this coast. But we don't know the results. There were lots of growing pains, for example, community issues, potential loss in communities. Its an on-going battle every year to keep the experimental area closed.

Fixed Exploitation Rate Strategies for Coping with Effects of Climate Change

Carl Walters & Ana M. Parma

Fisheries Centre, UBC, Canada &
International Pacific Halibut Commission
Seattle, USA

Abstract

Survival rates and carrying capacities for larval and juvenile fishes may be strongly impacted by long-term, unpredictable climatic fluctuations. When climate impacts produce strongly autocorrelated interannual variations in recruitment, harvesting a constant fraction of the stock each year allows the spawning stock to track such variations. Dynamic programming analysis indicates that this tracking effect is likely to produce long-term harvests that are very close (within 15%) to the theoretical optimum that could be achieved if all future climatic variations were known in advance.

Fixed harvest rate strategies are likely to degrade performance more than 10% only when there is little interannual correlation in environmental effects or when there is a large, abrupt climate change that can be predicted well in advance if it is going to increase carrying capacity, or detected immediately if it causes a decrease in capacity. This finding implies that it may be more cost-effective to invest in research on how to implement fixed harvest rate strategies than to invest in research on explaining and predicting climatic effects.

Successful implementation may require a combination of improved stock size assessments, and stringent regulatory measures to substantially restrict the proportion of fish at risk to fishing each year.

Discussion

David Policansky
A question about Carl's proposal where holes are cut in sockeye salmon runs, i.e.,

the idea of small (green) fishing windows in a mainly closed (red) area. Whenever you start something new, weird things start happening. When you are basically pounding the hell out of a stock for half an hour, half a day or whatever the window is, I could imagine two things happening (1) powerful genetic selection, and (2) short-lived but profound ecosystem effects?

Carl Walters
(1) Genetic selection - the graph you saw had about 60 genetic races of sockeye salmon mixed in the green part of that curve. All of them are fairly spread out, so they are all subject to having holes cut in them. From movement data from radio tracking and so on, we are pretty sure that the variation in movement speed within each run during their migrations is fairly high, so everyone of the runs is spread out wide enough in time and space as they pass through those small fishing areas, so you are cutting small bits out of them several times. The old fisheries method was often to let enough escape to get the spawning count, then knock the rest of the run off and that had to have major deleterious effects in the Rivers Inlet. They shifted the timing curves and screwed up return times. But we have also been smart enough not to do that in a whole lot of other places and to distribute the mortality out across the genetic structure of the run. That's not a hard thing to do once you put your mind to it.

(2) In that particular situation the ecosystem effects are indeed profound. Those holes you saw in the graph are by gillnet fishery, one of the filthiest kinds of fishing there is in this area. It does big damage to a lot of incidental populations ranging from sharks to sturgeons to recreational species - bad news from that point of view. But on the other hand, spreading those gillnets out over the whole seas would be a whole lot worse.

Ramon Bonfil
You inject fresh optimism in how to cope with problems with uncertainty and management, but it all looks too nice for the situation of the salmon fisheries in BC in which you have a very restricted area where all the fish runs come, you know where go to fish and precisely when to do it. Can you tell us how this would apply to other fisheries?

Carl Walters
Take a look at any of our so-called very successful long term fisheries, ones that have been going for centuries. Every time that you look at one of them, what you find is large spatial refugia that were created by economics. In the case of cod fisheries of the East Coast of Canada or the tuna fisheries of the tropics and so on. Those spatial, economic refuges are vanishing and when they vanish we have problems.

So I think that the key lesson. A lot of fishes migrate or have life histories with strong on-shore/off-shore dynamics like John Caddy talked about. There are lots of very simple ways that we could re-initiate the kind of spatial structuring of mortality risk that made those fisheries sustainable in the first place.

You could make it too costly to fish on the high seas for example, through a variety of economic constraints. We can use explicit closures that protect deep water spawning stocks There are a whole lot of things that we can do that are not utterly destructive to fisheries. But I think that it begins with the principle that if you don't know what you are doing, your first precautionary step is to turn the world red (close all areas to fishing), and then start backing away from that and see what can be done safely.

Keith Sainsbury
Several people have asked me during the break whether there is there any conflict of my view with the presentation given by Carl Walters?

Well no, there is zero conflict. The use of spatially based management is a powerful way to go. When and where is based on the ecological model. And just as our ways to assess biomass is poor, our ability to construct movement models will be quite poor, so we still have to look for and evaluate uncertainties

---

General Discussion on Theme 2

Kevern Cochrane

I refer to Craig Harris's question to Keith Sainsbury about the social and economic impacts of adaptive management experiments.

As Keith told us this is a very important consideration and probably the overriding consideration. But we in doing that we must not lose sight of the fact that every time we make a TAC other management recommendation and that recomm-endation is incorrect (which is every single time we make one), we are incurring social and economic costs. We are not usually able to quantify that, but there is a cost, so when we bring into the equation the social and economic costs of doing the experiment, we must also bring into the equation the social and economic costs of not doing the experiment.. And base our decision upon that.

Carl Walters
One of the first suggested implementations of adaptive management, which is actually where the idea came from, was on the Fraser River Sockeye Salmon in BC in the 1970s. We have done the numbers on what it has cost not to do that experiment: it has cost the people of Canada about $1 billion in lost catches. If the experiment had been done back in the 1930s and 1940s we'd be more than a billion dollars ahead in that fishery. The costs of doing experiments are trivial compared to the cost of not doing them.

Keith Sainsbury
The equating of adaptive management with actively experimental management is something that we have been trying to get away from. I think that this is perhaps one of the reasons why the base concepts of adaptive management have not been picked up as they should have been The focus came to be on actively adaptive management, and that's got its place, but don't forget the whole framework and evaluation of passively adaptive management processes.

Nigel Haggan
There is no evidence of collective government ability to do the type of overall cost/benefit analysis talked of here. It is an intractable problem - the government is composed of hundreds of separate ganglia that communicate only partially.

Antonio Diaz de Leon
A question for Carl Walters. The constant harvest rate - the Golden Rule to preserve stocks in time and provide a buffer. to natural variation - could you elaborate more on it

Carl Walters
In a fixed exploitation policy, when productivity conditions in the environment of the stocks change, the stock is free to track them up and down. Probably the best example is the Bristol Bay Sockeye Salmon in Alaska. The Alaskans say that they manage this fishery with a fixed escapement policy. Well, if they actually had a fixed escapement policy they wouldn't have seen record catches over the last 4-6 years The fact of the matter is their management tactics lead to a fixed harvest rate and when marine productivity increased in the north Pacific, up went the stock. Because of a fixed exploitation rate, it allowed large catches. Fixed escapement would not have done this. When the productivity drops, those stocks will come back down.

Antonio Diaz de Leon
I am worried that I am the only representative from south of the US border in reinventing fisheries management here. A question for Laura Richards.

We are faced in management issues with two different frames of understanding. In the northern hemisphere, industries are strong and developed. So trying to make changes is constrained by their economic interests. But in Mexico our problems in science are not in the relationships with the industry or communities. When science is available to show them the benefits and the costs of different management strategies, people are quite keen to be adopt them. What do you think about that Laura?

I am talking about the problem of collapse, the problem of science, the problem of the public adapting to stringent management measures. In other parts of the world, the science is in place and people are keener not to loose money. But for example in Mexico, the industry started to use Turtle Excluding Devices (TEDs) and were very keen on them after they had some

experience with them.

Laura Richards
I think that you are right, and that their is a lot of resistance by our industry towards some change. But there are also some positive things too. Industries tend to get polarised and you're always trying to fight both sides. But certainly there are some people within our industries who recognise what is going on and are very eager to adopt some of these new technologies, such as the TEDs that you mentioned, because they look to the future and see the writing on the wall.

Paul Hart
A fundamental issue in fisheries management is the conflicts of interest that exist between the different factions involved in fisheries management. In that sense the managers and scientists have their own particular agendas that they are trying to push forwards, which lead them to propose measures which are often in conflict with end users of the management advice.

Because of this fundamental opposition of interest, systems fail from the start because fishers will try to avoid the measures imposed. I think that the question that Randall Peterman raised about the question of opportunity cost that some fishermen are going to suffer as a result of having their fishing areas used for adaptive management experiments highlights this issue. The first question to start with is how all sides can have the same interest.

Jake Rice
On Paul Hart's comment about the interests of different parties which start off diametrically opposed.

My experience is that when you have a well defined single fishery, the interests of scientists, managers and industry are in fact quite similar, possibly integrated over slightly different time frames, but they are not that diverse. The difficulty occurs when the fishing industry itself is split into sectors who have very different feelings and the gain of one sector is at the expense of another sector. The really intractable problems do not come because fisheries scientists, managers and industry have different objectives, its when the fishing industry itself sees someone else's economic benefit as their loss. These are the diametrically opposed groups where any kind of constructive innovation takes for ever.

Paul Hart
I agree: in a single species fishery this is OK. But fisheries biologists often have a different time horizon from fishers themselves. Fishers simply can't stop fishing for 2 weeks because they will have no income. The fisheries biologist is not constrained by that, so they tend to propose measures that economically don't work.

Meryl Williams
I don't agree with Keith Sainsbury that there is little difference between active and passive adaptive management. It is like running a clinical trial and you have to get people to give their consent. There are ethics involved and you need consent - all the patients need to give consent. And its not just a few patients who have to give their consent, its all the patients.

Randall Peterman
A short comment on the discussion of adaptive management being like clinical trials. That's exactly right, and one needs the users co-operation and recognition. But, quite frankly, they are being experimented on now. We don't know exactly what the effects are of any given management act. We act on the best of our knowledge, but experimenting is happening in a disorganised manner and you cannot associate effect with cause. Keith Sainsbury was talking about experimenting in an organised way, where you have an experimental design, monitoring and evaluation.

Meryl Williams
A question for Alain Fontaineau on the increase in fishing power of the tuna purse seine fleet. One thing that wasn't on the list, and I was wondering if he can do anything in the analysis on this, was the fleet dynamics and the impact that that has had.

My early experience with the purse seine in the central western Pacific was that some parts of the fleets fished as teams. Once catch rates went down in a search area, the

fleet masters in Tokyo would send a couple of boats off to search and after a few days the rest of the team would follow. That has an enormous impact on the overall CPUE of the fleet and this is not obvious when just doing individual vessel averages.

Alain Fonteneau
This is not a new factor, it has been happening in tuna fisheries for the last 30 years. It is a difficult thing to do. There is no information, but it is an important factor.

Anthony Charles
A comment on adaptive management.

The key is robust and resilient management, management that is going to work under conditions of uncertainty. To me, adaptive management to me is part of that strategy.

But Carl Walters made a good point, almost as an aside, about shifting away from quota management. One of the startling aspects in the Atlantic Canadian groundfish fishery was that there was a lack of control and monitoring of fishing effort at sea. This relates to Carl's comment: there was over reliance on quota management and a lack of attention to the pressure on the resource.

Limiting seasons to a slice of the pie is one option with dealing with effort at sea. Another option would be Marine Protected Areas (MPAs) where there would be direct control over fishing effort at sea. Whether you have one boat fishing 1000 days or 1000 boats fishing 1 day - they are empirical issues. But, the key is controlling effort at sea.

Carl Walters
I think that one thing that is going to make our lives easier, at least in North America, in regard to the types of problems Jake Rice was discussing is that there has been a big change in public attitude to fish and fisheries.

There is a growing recognition of the commons, that the public has an interest in the fisheries. But this does not mean that the stakeholders have to be the decision makers. You see a rising kind of demand that our public management agencies (that our tax payers pay for in North America) act on the public's behalf and the stakeholders be damned. It means that there are fish and you'd better protect them.

And that eliminates the discounting problem as well as the problem of dealing with bickering stakeholders.

Paul Flanning
A comment on the north/south distinction. It also relates to Tony Charles' comment about quota management and in general about restrictive fisheries management practices.

In most of the Caribbean the relationship between the fish authorities and fishing industry is a relatively close one and they are working with the same goals in mind. I think that a large part of the difference comes from the fact that the adversarial system in North America and developed countries tends to relate to a management regime that is put in place, and most of them are driven by quota management, which the fishing industry does not accept.

I think that in the Mexican situation you might find that the imposition of a restrictive fisheries management regime would generate the same problems. What fisheries management is trying to achieve in a country determines how successful it will be.

James Scandol
Would it be feasible to extend Decision Analysis to include the essential uncertainty of implementing policies? The fact that there is so much difficulty and there are a lot of unknowns, would it be a futile attempt to try to quantify it? Because I think that one of the most interesting aspects of Carl Walters' scheme is that it is so incredibly simple and it is very easy to communicate, so therefore has a higher probability of being implemented.

John Schnute
Certainly a theme of this session has been whether or not analysis is useful, can or cannot be correct and I was relieved a little at the end of Carl's proposal that he said there would still be some need for analysis even after implementing his very good scheme.

And in fact, I have not lost complete faith that eventually people will figure out ways to understand the ecosystem. I am not a complete pessimist on that and in fact, I just have to remark that if Carl Walters policies were followed, the kinds of data generated could be very revealing about the characteristics of the ecosystem and may quite improve our analysis.

Keith Sainsbury
Adaptive management terminology is important in framework and evaluation. The focus should be on a robust procedure. Ther is a need for the concept of a feedback loop. Adaptive management is nothing more than an elaborate Decision Analysis. Presented in Carl's usual oversimplified way, just using area closure would, down the track, be found not sufficient. The reason, going on the experience in terrestrial systems, conservation by closed areas (parks), showed that you need to manage outside the parks too. We will end up with a mixture of approaches.

Jake Rice
On closed areas: not all closures are created equal.

From 1988 to 1991, in a particularly critical period for the Newfoundland Northern Cod fishery, we had a natural closure. Between 50 - 70% of the catch was taken in the off-shore fishery and over that period of time the southern limit of the ice moved from closing off a third of the traditional area in 1988 to over 70 % of the area by 1991. But all that did was aggregate the fishing effort and the fish in a smaller and smaller portion of the traditional range. It was a tragic oversight not to have included that geography in the assessments. We did have 70% of the area effectively closed to the off-shore fishery by the time that the stock was at the point of effective collapse. So there'll still be analysis because we have to find ways to make closed areas reduce the actual fishing effort.

Carl Walters
I was not recommending closed areas.

What I was recommending was to close the whole world and then work out, using adaptive management, stock assessment, good biology and a lot of other stuff, just how big you can make the holes that you fish in.

I am not talking about making parks: I am talking about turning the whole idea of what is management is about around.

We must start with the notion that the whole world is iced over and we can cut a few holes to fish in.

THEME 3: THE ROLE OF POLICY IN RESPONSIBLE FISHING

Session Rapporteurs
Dave Preikshot & Steven Mackinson

Keynote Address

People, Purses and Power: Some Features of the Debate Surrounding a Developing Fisheries Policy for South Africa

Kevern L. Cochrane
Fisheries Division, FAO, Italy

Abstract

At present, arising in part from the former policy of apartheid, many of the major fisheries in South Africa are in the hands of a limited number of quota holders, dominated by the white sector of the population. The early adoption of a limited-entry approach to fisheries has had substantial advantages for fisheries management and utilisation, and most of the major stocks are either in a productive state, or are recovering, under biologically conservative management, from earlier depletions.

The introduction of democracy in South Africa has created a case study in which it will be possible to see the evolution of new fisheries policies. The current access rights system is being challenged by many who had previously been excluded from access on political grounds. The policy-makers are therefore faced with the task of introducing a just and widely accepted system of user rights to a mature fishery, without undue disruption to the existing industry which plays an important social and economic role in the coastal regions of the country.

The search for suitable approaches, which is far from complete, has highlighted some of the strengths and weaknesses of existing approaches to fisheries management in the country. Analysis of these features, and consideration of future approaches, has relevance to fisheries management in many areas. This presentation suggests that, in common with many other countries, South African fisheries management has placed very heavy emphasis on analyses of the status of the resources and their potential productivity.

Under policies of limited access, with small numbers of quota holders and landing sites, this approach met with some success. However, even under these circumstances, social and economic pressures, coupled with the inevitable uncertainties in resource assessment, have led to over-exploitation in some fisheries. In an environment in which access may be broadened substantially, with a definite shift towards greater involvement of smaller-scale operators, the human considerations and impacts could become even more pronounced.

Changes in policy will be necessary consequences of the new South African constitution. Significantly, for fisheries these have been embodied by eight guiding considerations;

1. Responsible use and management
2. Democratic institutional structures
3. Protection of the resource
4. Equitable allocation of rights
5. Creating social development and benefits
6. Consideration of worker related issues
7. Maintenance of an efficient, investor-friendly, and competitive industry
8. Enhancement of tourist fishery

Fisheries managers and agencies in South Africa need to take cognisance of the causes of past failures, and the probable changes in the structure of the industry over the next few years, and develop the expertise and approaches to facilitate the achievement of desired social and economic objectives, within the constraints of sustainable utilisation.

Far greater emphasis than in the past, therefore, needs to be placed on analysing the social and economic dynamics of fisheries, and incorporating these into management procedures and approaches. This will inevitably also require greater participation by users in the management

of fisheries. It is suggested that similar changes are happening, and need to be encouraged, in other fisheries around the world.

Discussion

David Policanski.
Are there any cross quota holders in the fisheries of South Africa.?

Kevern Cochrane
Yes, in fact, the major pelagic fish quota holders also possess lobster quotas, and these are two of the most lucrative fisheries in South Africa.

Carl Walters
Since redistribution of the fishery may impose heavier costs due to more labour, why not address the problem by placing a royalty on the fishery and using the monies so obtained to employ more people in other industries?

Kevern Cochrane
The redistribution alluded to in the question is not a necessary result of the process; a royalty is, indeed, another option. In fact, if the industry had been cagey it would have rewarded employees with better salaries and options for shares, thus avoiding some of the perceived need for redistribution. One problem in introducing a royalty collection system is that the industry fears it could make them internationally non-competitive, although this is suspected of perhaps being a whinge.

Tony Davis
Apartheid obviously moulded fisheries policies to marginalis the participation of Blacks. How are the fisheries to be changed such that power is redistributed to give Blacks power and influence? As a specific example has any action been taken on the redistribution of ownership of motorised vessels?

Kevern Cochrane
The moral implications of the question simply focus on addressing what to do in order to make South Affica morally acceptable. The goal of the process described in the discussion was to look at both the resource and society's needs and find solutions to meet those needs.

Jake Rice
Will fishery scientists have an increasing or decreasing role in the formulation of new fisheries policy in South Africa?

Kevern Cochrane
The old role of fishery scientists used to be purely to estimate fishing mortality (F). But it is now preferable to emphasise the implementation of the desired F as well. This can expand the discipline of fishery science by allowing the examination of new foci in work to implement F.
Rognvaldur Hannesson
What attitude was adopted by the hake fishing industry with respect to conservation of the resource?

Kevern Cochrane
Industry was rather co-operative and supported the imposition of the $F_{0.2}$ objective and wanted to help ensure high catch rates. This has been particularly true of the two largest corporations, which have also maintained a good working relation with scientists.

John Sproul
Given the increasing eco-friendly trends of social science and fishery science, might it be possible to finance change in policy by incorporating aspects of this new attitude? Perhaps this might be accomplished via an internationally certifiable labelling mechanism to translate the value of the product through a scheme addressing biologic, social, and economic concerns.

Kevern Cochrane
There is currently no debate in South Africa with respect to this, but I support the idea and would like to help popularise the concept in South Africa. I think such ideas would likely be taken quite seriously.

Points of View - Theme 3

Regime Formation and Community Participation in Fisheries Management

Craig K. Harris
Dept. of Sociology
Michigan State University, USA

Abstract
The fisheries of Lake Victoria in East Africa provide an paradigmatic case study of an emerging pattern in the management of fisheries in developing countries.

During the 1970's and 1980's, a fairly rich and complex trophic community shifted to a simpler and more sparse trophic structure dominated by an introduced top predator (Ogutu-Ohwayo), and a small scale artisanal fishery was largely replaced by an intermediate scale industrial fishery (Yongo). The causes of these changes include both the introduction of exotic species (Pitcher), increases in siltation-borne and precipitation-borne nutrients (Hecky), land-use changes in the riparian ecotone (Bugeny), and the incorporation of the Lake Victoria region into the global fish trade system (Harris *et al.*).

These changes in the fisheries of Lake Victoria have generated high levels of concern in lakeside communities, in the riparian nations, and in international bodies. The topic has been addressed in at least seven international forums; the World Bank, in conjunction with the Global Environ-mental Facility of UNDP and UNEP, is currently considering a 65 million dollar program for Lake Victoria. Funding to support research concerning the Lake Victoria aquatic ecosystem has been allocated by at least ten donor nations, two international scientific bodies, and the European Union.

These various programmatic and scientific efforts relate to the management of the Lake Victoria fisheries through the establishment of a regime. A regime is established by a coalition of actors which gains control of the authority for fisheries management. Since the management of a fishery involves, at least in part, the resolution of claims on the fishery that are not fully mutually compatible, the establishment of the regime almost always entails a contest among the various stakeholders for control of the relevant authority.

The past ten years has been a period of significant conflict over the management of the Lake Victoria fishery. At least three distinct viewpoints have been expressed during that conflict: species conservation, commodity production, and riparian well-being. The contest for the establishment of the Lake Victoria fisheries management regime has involved many different actors advocating one or more of these viewpoints: international scientific organizations, global organisations, transnational corporations. That contest is now coming to a resolution with the establishment of the trilateral Lake Victoria Fisheries Organization.

In establishing a fishery management regime, the dominant actors attempt to structure relevant institutions so as to ensure the actors' continued influence. At the same time, for these institutions to be perceived as legitimate, they must include a significant element of democratic openness, often referred to as community participation. This interplay between regime formation and community partic-ipation establishes a dynamic for the development of the new Lake Victoria Fisheries Organization

Discussion

Richard Porter
Is it possible to reconcile the two post modern views of fishery management (the first from within, the second from those outside a fishery), and if so, what is the mechanism with which to do this?

Craig Harris
To answer the question it is necessary to consider the two levels, within and outside, of the fishery management process. Within the fishery the extent to which fisher's participation in management is effective depends on the perceived legitimacy of the management authority from outside. The two sides are reconciled when it is possible to get trustworthy information on the quality of fisher's participation in management..

Tony Pitcher
Fishery scientists have long been used to dealing with uncertainty in their work. However, we rarely hear how economists and social scientists deal with it, or how, in another instance, the general public deals with it with respect to Lake Victoria. How can these uncertainties be conveyed?

Craig Harris
The premise of the question is denied:

sociologists always deal in uncertainty. For example, most of the questions in the discipline point to gaps in knowledge about management of communities. What biologists say to managers about ranges of likely stock sizes becomes public discourse about exact stock sizes. Economists do the same thing by implying certainty in their models. Sociologists, in fact, seem most likely to deal with uncertainty.

Measuring the Unmeasurable: a Multivariate Interdisciplinary Method for Determining the Health of Fisheries

Tony Pitcher, Alida Bundy,
Dave Preikshot & Daniel Pauly
Fisheries Centre, UBC, Vancouver, Canada

Abstract

This paper describes an attempt to devise a multivariate, multi-disciplinary taxonomy of world fisheries that could be used to diagnose problems. The scheme might be useful in a triage of fisheries to determine where limited management resources might be focused to greatest effect.

Fisheries attributes are grouped into ecological, technological, economic and social categories. For each category, we chose fifteen to twenty attributes that are easily and objectively scored from readily available data, and that are likely to discriminate among fisheries. The selection of these attributes is important because they must remain fixed if future analyses are to be comparable. Candidate attributes are discussed.

A multivariate ordination (at this stage we used Principal Components Analysis, PCA) is then performed within each disciplinary set of attributes. The ordination scores are then brought together into an overall interdisciplinary analysis (also at this stage using PCA).

A preliminary analysis of a diverse set of world fisheries from commercial, subsistence, artisanal, industrial and recreational sectors is presented. Preliminary results suggest that the technique may be useful in objectively evaluating the health of fisheries.

Extracting useful data for an interdisciplinary overview entails delving into detailed studies in a range of disciplines, each of which has evolved its own ground rules, jargon and unstated assumptions. Ordination within each category here represents the disciplines. This may be approximate, as here, using simple ranking scale for attributes, or, after careful surveys and questionnaires have been carried out, made more precise. The hierarchical technique introduced here is designed to withstand robust disciplinary review at this first level of analysis, while re-ordinating the fisheries in interdisciplinary multivariate space at the second stage.

Discussion

Jake Rice
The method appears to be quite interesting but does not appear to adequately deal with issues like multi-species fisheries, multi-license fisheries where properties are common, or fisheries where individuals in boats fish for different species.

Daniel Pauly
Such issues can be dealt with by separating out component fisheries. For example, in Ghana fishers may take sardines some of the year, then fish in lagoons. These *two* fisheries can be separately examined.

Tony Pitcher
Whenever a different species (a target) is the focus of a gear, differentiation from other fisheries is implied.

Jon Schnute
What is the application of economic attributes? Some of them appear to be unrelated to fishery health *per se*, further how do the effects of international fishing manifest themselves?

Daniel Pauly
It should be remembered that the paper is based on the work of two teams; Tony Pitcher/Alida Bundy, focusing on large scale temperate fisheries, and Daniel Pauly/Dave Preikshot, concentrating on small scale artisanal fisheries, who developed this assessment tool after discovering a common approach in analysis. One goal for

the latter group is to see whether Malthusian overfishing can be diagnosed with such a method, requiring an assessment of local economic conditions. Also, it was hoped to see whether the fisheries could be tracked through time as they evolve. The different gross character differences of the fisheries studied by the two groups, such as many temperate versus few tropical boats, was hoped to provide useful contrast in results. Other attributes such as latitude and temperature may have overarching effects so the attributes presented are not a final list.

Carl Walters
There is a growing interest in regulators only monitoring prices of quotas. What this approach seems to do is capture lots of information on such trends. Can trends be captured thus allowing the tool to be used to predict events like fishery collapses?

Daniel Pauly
To be able to recover such information is definitely one of the goals of the project.

Politics and Fisheries

Gert van Santen
World Bank, Washington, D.C., USA

Abstract

Traditional fisheries management, until the early 1960's was dominated by biologists, and scientific aspects of assessing stocks received most attention. The 1970's and 1980's were a period in which the economist and biologist dominated management debates; more recently sociologists have become more vocal.

The dominance of scientific involvement in the process of defining management measures and (lately) analyzing the less than successful record of many past efforts at fisheries management, may have led to the misconception that the performance of the scientific community (from creating theories to collecting and interpreting data) is to blame for most of the failures. I believe such conclusion reflects what has been a fundamental weakness in the past: the idea that fisheries management is basically a scientific process of assessing fish stocks and their sustainable yields in biological or economic terms.

Fisheries management surely affects fish stocks, but is foremost a political process among humans (not unlike for example tax legislation), in which income and access to the fish resources is redistributed between fishermen, suppliers, consumers, processors, the State, the scientific community, foreigners and locals, etc.

It is often true that the economic and financial effects of management measures on each of those parties is difficult to determine; substantial uncertainty not only surrounds the biological aspects of many management measures, but equally the economic and social impact.

But fisheries management is a political process, in which political influence often determines whether something happens or not. The influence of each affected party depends on many factors and legislation, but in many countries raw political power largely determines the outcome of any attempt to introduce effective management systems. Hence, the key constraints to introduction of effective fisheries management is first, the lack of scientific and economic knowledge that could help define in more certain terms who gains and who loses. Secondly, it is lack of experience on the part of the Government in managing the political process, or the inability or unwillingness on the part of the authorities to muster sufficient political power to counterbalance heavyweight private interests who wish to maintain the status quo. Only when resources are very heavily overfished, and private pressure for some form of management, does a 'window of opportunity' exist to do something meaningful. However, if the situation is serious, uncertain long-term benefits and substantial short-term costs still limit the extent to which fundamental changes can be made and maintained. It is not by accident that historically fisheries display a boom-bust cycle; many factors, including technical and economic ones, encourage such a pattern.

If one reviews the New Zealand experience with ITQ's, or Japan's experience with coastal fisheries management, it becomes clear that these examples still are

exceptions because political aspects of the process of creating a better system, were, in very different ways, effectively being taken care of. It also shows the overriding importance of how to effectively manage the process to establish a fisheries management system, taking care of technical and scientific aspects, while building-up 'political' capital, often by including the most directly affected party, the fishermen, in the political decision making process. Because the interests of the fishermen, processors, suppliers and consumers vary so much, skill in negotiating and building consensus is needed to gain sufficient support for effective management measures.

The World Bank's experience in Yemen, Indonesia, India, Turkey and Morocco highlights the difficulty of inducing countries to spend the time and political and financial effort to overcome internal resistance against change, notably if the economic, social and political benefits and costs of the operation are virtually impossible to define in detail. Even in the devastated Black Sea anchovy fishery, traditionalist forces are able to avoid effective action for fisheries and investment regulation.

Discussion

Jon Schnute
The World Bank must face similar technical and negotiations problems to those of DFO. What is the mandate of the bank and how does it deal with such problems?

Gert von Santen
The World Bank faces the conundrum of helping poor countries, while banks are typically averse from such perceived high risk loans. Before providing funds for development, the bank will negotiate and ensure that certain conditions are met by the country to maximise the chance of getting the loan repaid.

James Scandol
Are there principles from the World Bank's implementation of policy that may be directly applicable to fisheries?

Gert von Santen
The World Bank is in a constant state of learning new lessons, one of the most important of which has been that success in the implementation of a scheme in one country will not guarantee success in another state.

Modifications of Scotian Fundy Groundfish Management for Sustainable Use

Michael Sinclair
DFO, Dartmouth, Canada

Abstract

Two workshops have been held on Scotia-Fundy groundfish management.

The first, in December 1993, evaluated the degree to which the objectives of management between 1977 and 1992 were met and the reasons for the shortfalls (Angel *et al.* 1994). This retrospective analysis evaluated the problems with the implementation of single-species quota management for multi-species harvesting technology of groundfish.

The second workshop, in October 1995, which was planned jointly with representatives of the fishing industry, discussed practical measures to improve the management system. The focus was on the four tactics or tools by which conservation objectives can be met (quota, days-at-sea, closed areas, gear restrictions). For each of the tools, the strengths and weaknesses were discussed, as well as the costs to industry and the taxpayers. The conclusions of the two workshops are presented, setting out what went wrong, and what should be changed.

Discussion

James F. Kitchell
As a non-Canadian it was surprising to see unemployment insurance as an issue in fisheries management

Mike Sinclair.
Yes, it is a Canadian reality. Although not a fisheries issue *per se* it does impact the fishery milieu as a policy of government that is an inherent character of the society.

Another example of such an effect has been

the constitutional problems between Quebec and the Canadian federal government which has diverted resources and slowed down government policy development in other areas.

Carl Walters
One problem of trying to use a total allowable catch (TAC) management, as the government is attempting, is the over-reliance on catch per unit effort (CPUE) data. It would be far better to use more sophisticated survey data. Who will pay for this?
Mike Sinclair
The use of TAC data is satisfactory in this fishery as long as there is reasonable allowance for probability and use of in-season feed back to allow for adjustments. The ADAPT model is not the only tool available either, policies such as long term area quotas could also prove useful. Therefore, surveys are not seen to be a necessary requirement for successful management.

A New Paradigm for Managing Marine Fisheries in the Next Millennium

Michael Sutton
World Wildlife Fund International
London, UK
(Presented by Indrani Lutchman)

Abstract

The objective of this paper is to suggest the foundation for a new paradigm for managing worldwide marine fisheries to replace the failed model of the past.

The need for fundamental reform of marine fishery management has become abundantly clear over the past decade. Nearly everywhere, fisheries that have sustained coastal communities for generations have suffered catastrophic declines. In some areas, excessive fishing has driven staple species such as Atlantic cod commercially extinct. Increasingly volatile fish wars, such as the dispute earlier this year between Canada and the European Union, have erupted over remaining stocks. Governments pay $54 billion per year in fisheries subsidies to bolster a faltering industry. These payment sustain massive fishing fleets that continue to hoover up fish at an alarming rate. Huge, sophisticated vessels able to stay at seas for months seek fisheries farther and farther afield, often in the waters of developing countries.

The essential question is thus not whether the past model of marine fishery management has failed, but why? What lessons can we draw for the future? Throughout modern history, governments have largely managed marine fisheries for the growth and development of their associated commercial fishing industries. Decision makers have paid scant attention to the sustainability of those fisheries, much less the health of their associated ecosystems or the needs of artisanal fishers exploiting the same species. In virtually every case, the short-term socioeconomic needs of a region's fishing industry have rendered long-term sustainability of catches a futile management goal. Fishery managers have thus been unable to prevent the mining of fishery resources. Unsustainable, indiscriminate fishing has literally become an industrial addiction.

This predicament cannot be attributed to a lack of scientific information. Fisheries scientists have for years provided more-or-less accurate models of fish population dynamics and educated estimated of fishery production. But all too often, fishery managers more concerned with political than scientific realities have been compelled to ignore the implications of the best available science. Politicians, often at the highest levels, have frequently intervened in decisions about specific fisheries. Society has simply lacked the political will to forestall the fishing industry's tendency to use up its capital and thereby destroy itself.

Powerful social, economic, and political forces, firmly entrenched in our management infrastructure, drive unsustainable fishing. As a result, governments have typically avoided any actions that carry a price unacceptable to industry. Reversing this situation will require harnessing public support for a new paradigm of management. The foundation of this new model must be greater public involvement and accountability in the fishery management process. If we are to save marine fishes and sustain healthy

fisheries, we must somehow bring to bear the same worldwide public concern that banned the trade in elephant ivory and outlawed commercial whaling. We must create social and economic incentives for sustainable fishing. Only concerted public interest has the power to stop overfishing and to shift the paradigm of fishery management from development and exploitation to conservation and sustainability.

This will not be easy, fish neither sing like whales nor look like pandas. But the stakes are high: the health of world fisheries, their associated marine ecosystems, and the millions of people that depend on them for food and employment.

Discussion

James Kitchell
If society were to address phenomena such as overexploitation as a crime against nature what sort of punishment should be meted out for the offenders? Is there any applicability of the kind of disincentives used to curb the illicit ivory trade?

Indrani Lutchman
The focus should not be on the idea of punishment of offenders, rather, getting users on-side with conservation to give the fishery resource a needed break and try to decrease the number of fishers, as there is now, clearly, an imbalance.

The WWF has recently come to an agreement with Unilever, to establish marine stewardship. The aim of this was to provide consumers with choices to obtain fish from sustainable sources and/or industries using eco-friendly methods. Therefore, consumer power can be used to force industry to act in ecologically sustainable ways, this represents a new approach.

Cristina Soto
Eco-labelling may seem like a nice phrase, but considering the social aspect of its possible consequences, how are small-scale fishers protected from falling through the cracks of such a system?

John Sproul
Much of the criticism for eco-labelling has grown from the experience with dolphins and the tuna fishery, which appeared to have poorly regulated eco-labels when they were introduced. There is a requirement to establish a scientific body set up to oversee future eco-labelling, not to judge social practice, but to give consumers information on the context for social aspects of fisheries practices.

Indrani Lutchman
It is essential that the process create a win-win situation for all involved. Practices are important and it should be kept in mind that small-scale fishers might do well in such schemes, as they are often more eco-friendly than large industry.

First World Fishers and the Fisheries of Developing Countries: Impact on Resources, Economy and Society

Alida Bundy & Tony J Pitcher
Fisheries Centre, UBC, Vancouver, Canada

(Poster,

Until the early 1980s and the UN Law of the Sea, distant water nations were free to fish the world's oceans at will (up to 12 miles from the coast) reaping huge harvests whilst resource adjacent nations gained little, if any, benefit. In this paper we investigate the impact of first world fishing on developing countries since the declaration of 200 miles EEZs and pose the question "have the expectations of EEZ holders in the developing world been met?" We establish a taxonomy of interaction and conflict, present a conceptual model of the system, map existing knowledge in the system and identify critical areas where data is required. We then analyse two case studies with this scheme, the South Pacific Islands Tuna Fishery and the fisheries of Mauritania and North West Africa and evaluate its utility. We conclude that while the physical, measurable components of the model such as catch and license fees are generally well-known, the less tangible effects of first world fishing on the resource, the economy and society are little studied. The expect-ation of earning foreign exchange is met, the development

of autonomous domestic fisheries can happen, but the hope of increasing employment may be an unrealistic expectation. The level of success for developing countries appears to depend on the level of economic development.

General Discussion on Theme 3

Craig Harris
With regard to some of the perceived problems and uncertainty of getting useful indicators for different user groups, in many instances this might be quite easy, for example, such data is often collected by government agencies.

John Sproul
Uncertainties at the consumer level will also decrease in the development of the information age we are said to be in.

Nigel Haggan
We must keep in mind that, as social scientists and managers, we constitute an interest group and should not try to hide behind a cloak of objectivity . Thus, we should always attempt to define all the interested parties as user groups, from industry even to groups like the WWF.

Tony Charles
The need exists for institutions involved with fisheries management to examine the applicability of disciplines other than biology. It will be crucial to decide who will get to take part in future management by identifying who the stakeholders are and how to develop selection criteria. For example, there are two contrasting instances from my experience with the Canadian federal government. In the case of the new *Fisheries Act* the focus was to engage just government and industry. In the instance of the *Oceans Act,* the public was felt to be a legitimate participant with government and industry.

Nigel Haggan
The example of the *Common Ground* project a model for different groups coming together to manage fisheries. In the project, the University of British Columbia was used as an honest broker to help facilitate the development of plans to change a First Nation's fishery. If such examples can be determined to be workable, they can be showcased in the media as positive examples of fishery management working. This would erase the usual public impression of high handedness by DFO working with a paternalistic business-as-usual approach.

Michael Sinclair
There is often a lack of coherent policy and, since fisheries often represent a small part of the political scene, management regimes need to be adaptive to cope with changes in policy that are likely to occur.

Keith Sainsbury
New Zealand faces a situation similar to Canada, of conflicting objectives and dealing with uncertainty. He suggested that Canada could improve the quality of groundfish management in light of recent studies which have yielded salient data and suggestions for new decision processes, keeping in mind the need to demonstrate the performance of new strategies as they are introduced.

Tony Davis
I wan to raise three observations and a question

1. Unemployment insurance (UI) patterns mask many qualities of fisheries, especially distribution of income, which can yield important contrasts across the whole fishery, or across crew members of a single boat in the fishery.

2. There is a close correlation between recent increases in UI and the increased use of limited entry controls, on the east coast of Canada, as an attempt to make fishers more specialised. This system has only resulted in creating dependency by income transference.

3. One should keep in mind that in Atlantic Canada there are often few options to the fishers for money to live on outside the UI system. Many have migrated to other parts of the country to find work, but there is a limited ability to absorb migration.

In holding a discussion on the fishery, who is to be included, and what will they want as a result of any such discussions?

Michael Sinclair
A steering committee for an Atlantic Canada fishery had been created with three representatives from DFO, ten from industry (two offshore, eight inshore), and the remainder from what was felt to be a representative cross-section, to total about fifty people. He felt that other factors such as trying to impose employment targets were complicating control.

Jake Rice.
I wan to amplify Keith Sainsbury's point of how to grapple with uncertainty. We should emphasise uncertainty associated with implementation, specifically, what are the consequences of implementing so-called solutions? New problems seem to always arise as people simply try to find ways to get around the new rules. Therefore, we should pursue studies of how these behaviours may change with new rules before we go ahead and change management practice.

Kevern Cochrane
The group has largely glossed over the main point of there being too many fishers with respect to the number of fish.

No management plan can be successful unless this fundamental truth is first addressed. Thus, finding jobs for the fishers who will be left unemployed by such cutbacks will have to be dealt with before new plans are brought into use.

THEME 4: ROLE OF THE INTERFACE BETWEEN SOCIAL SCIENCE AND NATURAL SCIENCE

Session Rapporteurs
Steve Mackinson & Dave Preikshot

Keynote Address

Fisheries Management: Science and Decision Making

David Policansky
National Research Council
Washington, D.C., USA

Abstract

Many fishery-resource controversies are couched in scientific terms, although often they are not scientific disputes. I discuss controversies involving anadromous salmon in the northwestern United States, sea turtles off the U.S. southeast and Gulf of Mexico coasts, tuna and dolphins in the eastern tropical Pacific, and the Bering Sea ecosystem, among others. In each case, the scientific conclusions were not obvious to at least one party in the dispute; in some cases, they were not clear to any of them.

The lack of scientific information is sometimes due to the inherent complexity of the situation and the difficulties of collecting good data. Often, however, much better information would have been available if managers had taken the time to design data collection into their management regimes.

Common barriers to resolving fishery resource controversies include mutual mistrust, the amount of money and time needed, the lack of a coherent management authority or multiple jurisdictions, and scientific uncertainties. The last is strongly related to the others; a good scientific understanding reduces mistrust, saves time

and money, and encourages coherent management authority. Scientific uncertainty increases mistrust and incoherent management and often increases expenditure of time and money. Understanding these relationships is necessary for effective management and decision making.

Discussion

Jim Kitchell
In relation to studies on salmon smolts in the Pacific Northwest, the problem may be the overcapitalisation of science.

David Policansky
The problem is not the overcapitalisation of scientific enterprises, it rather that the science was not done in an organised and objective way. There was no way to ensure that the most important scientific problems had the necessary money spent on them. Problems that might have bad answers were not attacked.

Carl Walters
In light of clear evidence that barging (transporting fish in a river barge) was identified as the only clear policy option in the case of the salmon smolts in the Columbia river basin, why then did it take so long before action was taken?

David Policansky
The great diversity of different interests involved in this situation may have been partly responsible. Perhaps the process was also hindered by dishonesty among the involved parties, as implied by Dr Walters.

Laura Richards.
With very diverse user groups, can 'consensus' be achieved, and, in fact is it the best thing to do.

David Policansky
A strong conscious effort would clearly be required to achieve consensus, but regarding this issue of whether or not it was desirable, there is no way of telling. But providing consensus on an issue is likely to be a powerful influence for management processes.

James Scandol.
If not the scientists, then who should take on the policy?

David Policansky
First, I stressed the need that scientists should be divorced from but not disconnected from the policy. Whilst they should be involved they should not pretend to know all. But the very fact that scientists are people too ensures that they should be represented in the policy decision process.

For scientists getting involved in policy there may be a balance of duties. For example, a scientist advocating too much policy may not then be taken so seriously as a scientist, a delicate issue that is difficult to get right.

Keith Sainsbury
Returning to the general issues outlined in your talk relating to the need for institution/political structures for future management. What as scientists can we do in order to move in this direction?

David Policansky
I re-emphasise the need to keep telling people in current management and policy positions that the requirement for these structures is paramount and can only evolve with involvement of people who have some knowledge of the actual problem. The important lesson for the scientists is to ensure that scientific answers are not given in response to questions that are not fundamentally scientific. In short, we have to stop answering bad questions.

Craig Harris
Is wanting a zero dolphin kill in tuna fisheries a scientific or a policy question?

David Policansky
Whether we want to have zero deaths of dolphins is a conservation issue not a scientific question. But the question of whether the current mortality rate will allow for the conservation of dolphins is a scientific question. Such an issue needs to be approached by a process of the policy makers, managers and scientists working together, but they need to be clear in their minds of the contribution that each can offer.