

6. Fisheries and coastal ecosystems: the need for integrated management

Daniel Pauly and Ratana Chuenpagdee

INTRODUCTION

How can it be that fisheries appear in trouble every time newspapers report on them? Coastal and marine fisheries have existed for a long time. Initially, people waded along the shore gathering shells and harpooned whatever marine mammal or large fish ventured inshore. Only those fish and other animal species that were large and had very narrow coastal distribution were then in danger of being over-fished. The invention and increased sophistication of crafts gradually extended our reach offshore but, for millennia, the elements and the very vastness of the ocean protected most fish populations from being over-fished; hence the notion that earlier, pre-industrial fisheries were 'sustainable' (Pauly et al., 2002). The gradual expansion of European fishing fleets in the seventeenth and eighteenth centuries, and their impact on the cod and other fish populations they exploited in European waters and off New England and Eastern Canada did not appear to change this, though signs of localized, fisheries-induced depletion were already then beginning to occur.

Things really changed when, as a result of the Industrial Revolution, steam trawlers began to expand into the North Sea, gradually mowing down one coastal stock after the other, then moving on to do the same offshore, inducing the first 'serial depletions' on record (Pitcher, 2001). Further technical developments – the invention of hydraulic winches, inboard refrigeration, acoustic fish finders, and so on – increased the ability of these boats effectively to locate and catch large quantities of fish and to bring them back from longer distances, thus opening up the entire North Atlantic to fishing operations (Cushing, 1988).

Similar development occurred in other industrialized parts of the world, for example in North America, North Asia and Australia. There as well, this occurred in waves following on the two World Wars, both of which accelerated the development of technologies that were later transferred to fishing operations.

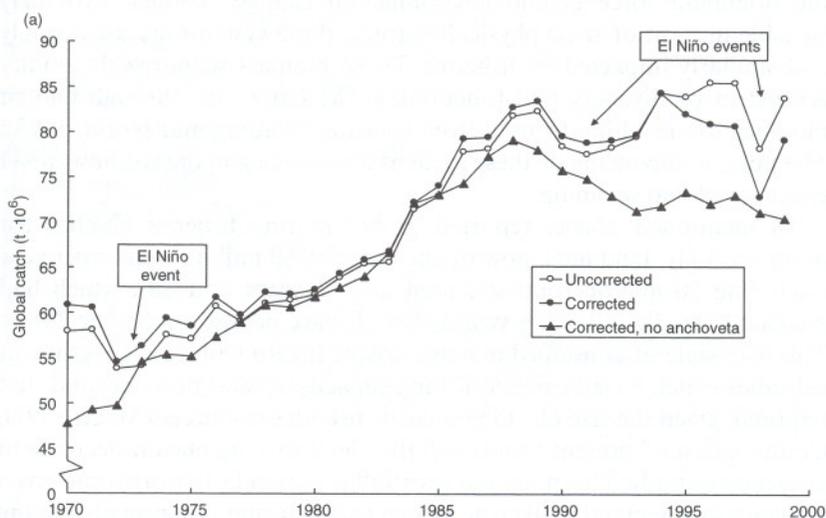
Thus, in the early 1950s, the industrial fleets of the world were poised for global expansion. Their effects became intensified by another great wave of fisheries industrialization, this time in newly independent and other countries of Southeast Asia, Africa and South America. As a result, global catches strongly increased in the 1950s and 1960s, grew more slowly in the 1970s, and peaked in the late 1980s, as for the first time, catches from newly exploited stocks failed to compensate for depleted ones. Global catches have been declining since, despite the ever-increasing capacity of the world's fishing fleets (Watson and Pauly, 2001) (Figure 6.1). This implies a massive decrease in the inherent profitability of these fleets now maintained in most parts of the world by massive government-sponsored subsidization schemes (Munro and Sumaila, 2001).

Growing populations in developing countries, and a growing taste for fish in many developed countries led at the same time to a great increase in demand which, being increasingly hard to meet, is causing fish prices to increase more rapidly than that of most other foodstuff (Sumaila, 1999). This has also led to an increasing export of fish from developing to developed countries, thus reducing access to the poor of many developing countries of a previously cheap source of animal protein.

While it is usually possible for the agricultural sector to intensify its productivity in response to increase in demand and thus to preserve food security, yields from fully developed fisheries can, at best, be maintained (Ricker, 1975; Hilborn and Walters, 1992). It is more common, however, for yields to decline due to excessive levels of fishing effort, and for over-expansion of fishing and coastal developments (including mariculture – the farming of marine fish and shellfish) to destroy the structural integrity of coastal and other marine food webs, as is presently occurring in most parts of the world (Pauly et al., 1998; 2002).

Clearly, we must try to prevent the situation from worsening by searching for proactive and integrative measures for managing our fisheries and other coastal activities, and for minimizing negative environmental impacts on our coastal ecosystems (Costanza et al., 1998). The task for scientists and others engaged in coastal and marine resource management is thus to find ways to accommodate the need of coastal populations for sources of food and gainful employment with practices that are compatible with the continued productivity of natural coastal and marine resources. Or, in other words, we must show that fisheries exploitation and resource conservation are mutually compatible.

This contribution discusses related fisheries research and coastal area governance issues based mainly on (a) insights gained during the first years of the 'Sea Around Us' project devoted to studying global fisheries impacts on coastal and marine ecosystems, initially focused on the North



Note: Excluding freshwater catches and aquaculture production, displaying – since the late 1980s – a downward trend that is visible once the over-reporting of catches from China is corrected for, and the widely fluctuating Peruvian anchoveta is disconsidered.

Source: Modified from Watson and Pauly (2001).

Figure 6.1 Trends in world global marine fisheries catches

Atlantic, led by the first author (see www.seaaroundus.org), and on (b) research by the second author on innovative methods for involving stakeholders in decision-making processes for ecosystem-based management.

These issues are presented under three headings, dealing with:

1. Downstream implications of fisheries impacts on marine ecosystems;
2. Fisheries and other human impacts on coastal systems; and
3. Alleviation of fisheries and other impacts at local and regional levels.

DOWNSTREAM IMPLICATIONS OF FISHERIES IMPACTS ON MARINE ECOSYSTEMS

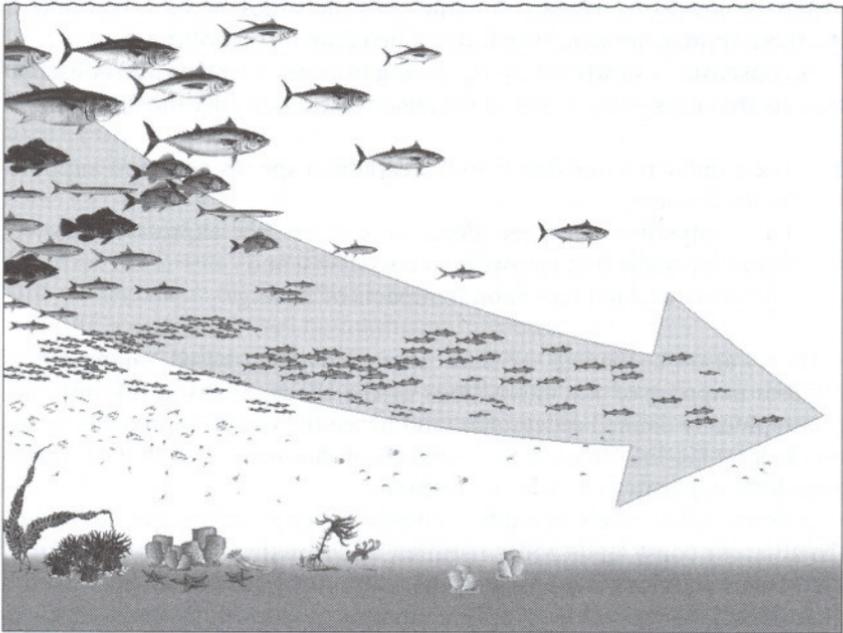
Marine fisheries systems comprise the productive shelves surrounding continents down to a depth of 200 m, and the deeper, oceanic waters of tropical, temperate and polar areas. In these systems, fisheries activity is

the dominant force behind environmental change. Though extremely variable in term of their physical features, these systems are all strongly and similarly impacted by fisheries. Those biomass withdrawals modify ecosystem biodiversity and functioning, the latter also through habitat modification resulting from bottom trawling (Watling and Norse, 1998). The polar components of these systems are also beginning to show direct effects of global warming.

As mentioned above, reported global marine fisheries catches (or more precisely: landings), now of the order of 80 million tonnes per year (including 30 million tonnes(t) used for fish meal and oil), which had increased rapidly following World War II, have peaked in the late 1980s. This is in spite of continued massive private investments and government subsidies which have increased fishing capacity several times beyond that required, given the size of global marine fisheries resources (Mace, 1997). Continuation of present trends will thus lead to a significant decrease in global fish supply. This potential shortfall is particularly worrisome given an increasing demand unlikely to be met by fish farming (especially not the farming of carnivorous fishes such as salmon, which requires meal and oil derived from small fishes also suited for human consumption; Naylor et al., 2000).

Considering other components of fisheries catches, that is discarded by-catch (10 million t), and illegal/unreported catches, including 'ghost fishing', that is fishing by lost gear (20–30 million t; Pauly et al., 2002) results in a global marine catch largely exceeding previous estimates of potential yields (Pauly, 1996). Available ecosystem indicators suggest present catches (and especially fishing effort) levels to be unsustainable, despite institutionalized systems for 'single-species' assessments and management of fleet operations (Ludwig et al., 1993). Fisheries impacts have caused shifts in species composition, notably toward species with lower sizes and trophic levels (Pauly et al., 1998; Pauly and Watson, 2005), (Figure 6.2), and decline in biomass (often by one order of magnitude; Christensen et al., 2003).

Also, with onboard high technology (fish finding and navigation) having enabled access to previously inaccessible natural refugia (great depths and distances offshore, rough bottoms, and so on), fisheries have caused numerous local extinctions of marine fish and higher vertebrate populations and caused widespread habitat alteration and loss. As some of these are still reversible, this has led to increasing calls for the (re-)establishment of marine refugia and other forms of ecosystem-based management (National Research Council, 1999; Pauly et al., 2002) that would encourage resource conservation.



Note: A fishery starts by catching abundant large fish high in the food web (upper left corner), then gradually shifts to smaller fish, lower in the food web, as the former resource becomes less abundant. This process, which occurs in virtually all fisheries of the world, usually goes along with habitat destruction, as illustrated here by the gradual disappearance of the bottom structure created by bottom organisms.

Figure 6.2 Schematic representation of 'fishing down the the food web'

FISHERIES AND OTHER HUMAN IMPACTS ON COASTAL SYSTEMS

A large fraction of the global human population lives on coastal lands, and the building of cities and their resulting effluents have always had a strong impact on coastal ecosystems. These impacts have much increased in the last decades, especially in tropical developing countries which saw, besides the expansion of cities, a massive expansion of brackish water shrimp culture in areas previously covered by mangrove (Pauly and Ingles, 1999; Chuenpagdee et al., 2001a), direct exploitation of coral reef for lime and building materials, dredging of seagrass areas, and so on.

This makes ecosystem-based management even more important in coastal waters (down to 30–50 m), whose previously abundant fisheries resources have traditionally been managed based on single-species, sectoral approaches.

Given the downstream impacts of land-based activities on coastal productivity, these approaches were even less justified than further offshore.

A consensus is slowly emerging among fisheries scientists and conservationists that ecosystem-based management must consider the following:

- a. The trophic relationship between exploited species and their supportive forage base;
- b. The competition between fleets or sectors that express themselves through trophic linkages within ecosystems; and
- c. The direct and indirect habitat impacts of fishing.

It is also becoming evident that ecosystem-based management requires mapping of the interactions of the effects of (a) to (c) onto biogeographically defined ecosystems, and hence the use of approaches based on Geographic Information Systems, a tool that has so far found surprisingly little application in fisheries research.

In terms of research, extending coastal fisheries ecosystems to include the adjacent coast lands zones requires, additionally, the identification of land-based activities impacting on the relationships in (a), (b) and (c), and quantifying, as opposed to only assuming, relationships between mangroves and coastal fisheries productivity (Pauly and Ingles, 1999). Similar research is required for seagrasses, estuaries, coral reefs and other sensitive coastal features in order to allow consideration in coastal project developments of the benefits forgone by the loss of such features (Costanza et al., 1998). Valuation of the importance of these ecosystems can be undertaken using the damage schedule approach, a non-monetary valuation method developed by Chuenpagdee et al. (2001a) (see also Appendix 6.1).

ALLEVIATION OF FISHERIES' AND OTHER IMPACTS AT LOCAL AND REGIONAL LEVELS

How could the dire and worsening situation of fisheries develop as it did? One answer clearly lies in the 'open-access' nature of marine resources which encourages the much decried 'race for fish'. Studying the actors involved provides another useful perspective. Who are the actors in fisheries? Are they being included in or excluded from the governance of fisheries? We shall elaborate on these two questions, as they provide a foundation for discussion of structure and power related to the principles of fisheries governance.

Actors are normally seen as those who are 'directly' or 'indirectly' related to the fisheries' resources or those with 'in-vested' interests. The general

public, although frequently mentioned in the fisheries management literature, is generally not well represented in such discussions, as the government agencies tasked with managing fisheries on behalf of the citizenry at large (the true owner of the resources) have been 'captured', in most countries by the very industry they are supposed to regulate.

It is obvious, however, that unless all major actors who take part in fisheries are being effectively represented in the governance process, fisheries' resource sustainability and the related food security issues will continue to worsen. In addition, the inclusion of all concerned by the state and management of the coastal and marine resources must be coherent with the ecosystem-based management introduced above.

Fishers and other persons who rely on fisheries as the major sources of income (for example, processors and suppliers) are the main, and often the only, group of actors considered in discussion about fisheries governance. Here, a gradual consensus has emerged in many parts of the world that a transition is required from a top-down, government-based, centralized approach to management to bottom-up, community-based, decentralized 'co-management' approaches (Pinkerton, 1989; Jentoft and McCay, 1995), which imply recognition of fishers and fishing community as quasi-owners of the resources. This movement also requires new institutional arrangements and strategies to deal with issues such as heterogeneity of user groups (Felt, 1990), community representation (Jentoft et al., 1998), community support (Noble, 2000), and genuine devolution of state power (Sandersen and Koester, 2000).

A variant of this approach, the community-based management (CBM) model, suggests that fishers, other resource users and the community at large should become increasingly engaged in decision-making, and ultimately taking leadership in management. In this model, power is shared between 'authorized' (that is government) managers and the community, with increasing responsibility for management and decision-making authority for the latter.

One of the most important issues associated with this model is the 'inclusiveness' of the actors in the community, and their interactions, which can be either positive or negative. Positive interaction involves open dialogue, communication, negotiation and transparency, which are expected to result in conflict resolutions and collaboration. Negative effects, on the other hand, are partly caused by marginalization (Pauly, 1997), when interaction is not considered fair or just by all involved parties. This may consequently result in rejection of the interactions or at least the growth of mistrust.

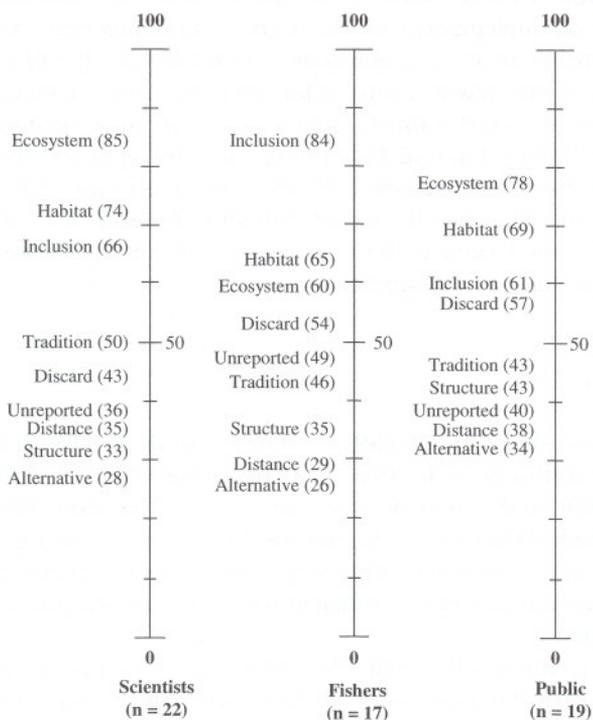
While the CBM model acknowledges the need to involve a wider range of actors than the naïve versions of co-management models, it fails to recognize that the fishers themselves may have short-term interests, such as

repaying the loan used to purchase a new fishing vessel, that are incompatible with the continued existence of sensitive coastal or marine resources, and hence at variance with the non-extractive interests of other actors. This problem becomes even more acute (for example, in Southeast Asia) where growing numbers of impoverished coastal fishers are forced by circumstances to eke a living from finite coastal resources, that is from resources which, in the process, they may effectively annihilate.

Management models structured around fishers' (quasi)-ownership of coastal fishing grounds fail in such cases, as they lead to impoverished fishers being the owner of a non-existent resource.

Put differently: while some authors claim that small-scale fishers' ownership of the resources would lead to good stewardship practices and sustainable fisheries, the field evidence shows that in the absence of formal property rights, these fishers overwhelmingly compete for the resources, with the short-term objective of maximizing their individual benefits with no consideration of the costs to society, as do the owners of large industrial fleets (see contributions in Coward et al., 2000). While the CBM model appears a useful component of our response to the crisis in fisheries around the world, it is by no means sufficient. A 'proactive' governance model is urgently needed that would help us quickly halt further destruction, and to foster ecosystem-based management principles. Moreover, resources will have to be extended to motivating small-scale fishers (and especially their young sons) out of fishing, through training and livelihood schemes. This is in contrast to most field-based fisheries projects run so far, which seek to improve the conditions of existing fishers and thus contribute to attracting more landless farmers and other rural poor into fishing (Pauly, 1997). This is particularly true in the wake of the December 2004 tsunami which devastated fishing communities throughout South and Southeast Asia (Pauly, 2005). Appendix 6.1 presents an approach through which the views of communities regarding perceived impacts or merits of various interventions can be elicited without undue bias due to the subjective perceptions of individual benefits alluded to above. As illustrated in Appendix 6.1, scientists, fishers and representatives of the public at large agreed that human influence of fish habitats, fishing impacts on the ecosystem, and inclusion of fishers in fishery management were the most important considerations in the design of fishery policies (Figure 6.3). Incorporating the community's perspectives into ecosystem-based management framework, such as shown in Appendix 6.1, is one important step toward proactive governance.

At levels above that of fishing communities, dealing with overfishing will require abolishing the government subsidies that have so far kept the industrial fleets of the world's fishing nations afloat (Munro and Sumaila, 2001; Pauly and Maclean, 2003). It is hard to conceive that such economic



Code	Management considerations
Ecosystem	Fishing impacts on fisheries ecosystem
Habitat	Human influences on fish habitats
Inclusion	Inclusion of fishers in fishery management
Discard	Level of utilization of fish which are caught in a fishery
Tradition	Existence of traditional or historical fishing access
Unreported	Existence of fishing practices beyond regulations
Distance	Distance to and the reliance on the fishery
Structure	Existence of social/political structures influencing fishers' values
Alternative	Existence of alternative sources of livelihood

Note: Based on three respondent groups (see text in Appendix 6.1).

Figure 6.3 Damage schedule of fishery management decisions

intervention, and the large-scale vessel decommissioning schemes that it implies, could be implemented by the agencies presently responsible for managing the fisheries of various fishing nations. Rather, it will probably be necessary to create new institutions for the purpose, in which the interest of the public at large (in functioning ecosystems, and in economically viable, smaller fisheries) would be represented. This approach would be guided by a restorative ethic (see contributions in Coward et al., 2000), structured around what may be called 'fisheries conservation biology', a discipline that would need to be created around concepts drawn from fisheries biology and conservation biology.

CONCLUSIONS

Marine fisheries catches are globally declining, mainly due to overfishing, although other anthropogenic impacts in coastal areas have contributed to reducing the high productivity of inner shelf waters. The strong increase in small-scale fishers in the last decades implies decreasing catches for millions of small-scale fishers as well as declining incomes, as the increase of fish prices in the marketplace is not sufficient to compensate for the declining catches per fisher.

There is no techno-fix that will allow meeting, in the next decades, an increasing global demand for fish driven by increased population, increased incomes, increased taste for fish, and increased requirements for fish meal and oils for use in fish culture such as salmon farming. Indeed, maintaining present catch levels will not be possible if the present trend toward increasing fishing pressure continues (Pauly et al., 2003).

Present government arrangements, though they usually do not formalize property rights over marine resources, imply their quasi-ownership by the fishing industry. This can be inferred by the deferential treatment given to that industry by the government agencies tasked with regulating fishing fleets and gear deployment. It is clear that the public interest will have to be considered more explicitly in the governance and management of fisheries. This will involve the following:

1. The maintenance of marine ecosystems and their biodiversity as a public resource to be bequeathed to future generations;
2. A steady reliable supply of marine food stuffs, rather than the boom and bust operations resulting from serial depletions of marine resources;
3. An equitable use of the tax money presently wasted as subsidies whose major result is to maintain destructive fisheries that would otherwise have gone bankrupt;

4. Addressing the issue of poverty represented by millions of desperately poor Southeast Asian and other developing country fishers locked into a mode of resource exploitation that cannot support their activities in the long term, nor indeed meet their needs or those of their families; and
5. A transparent and inclusive process for incorporating communities' perspectives into an ecosystem-based management framework for fisheries and marine resources.

Despite encouraging noises (for example, at the recent World Conference on Sustainable Development in Johannesburg) we cannot at present conceive of the societal framework within which these issues would be seriously addressed and some of the mitigating approaches mentioned above implemented. As is the case for the issue of global warming (which, incidentally, also impinges on fisheries, by threatening the coral reefs sustaining many tropical fisheries, for example), these issues will not go away, and the underlying trends, notably a declining fisheries catch, will worsen until they are effectively addressed. Capacity-building at the local level, particularly for alternative employment, and an education and public awareness program for marine conservation and stewardship are two initiatives that need active promotion and firm support from all government levels and governance institutes, as they are promising means that can help alleviate the current fisheries crises.

Overall, we must conclude with an observation by Professor Katherine Richardson, Chair of the International Council for the Exploration of the Sea's Advisory Committee for the Marine Environment, that 'Sustainable management of fisheries cannot be achieved without an acceptance that the goals of fisheries management are the same as those of environmental conservation.'

ACKNOWLEDGEMENTS

We thank Professor Peter Nemetz for inviting this contribution, which updates a Vancouver Institute Lecture given by the first author, and entitled 'Global fisheries and marine conservation: is co-existence possible?' (documentation in www.library.ubc.ca/archives/vaninsti.html). Our final quote is from a keynote presentation at the ICES/SCOR Conference on Ecosystem Effects of Fishing, Montpellier, France, March 1999.

APPENDIX 6.1 THE DAMAGE SCHEDULE APPROACH AND ITS APPLICATIONS TO COASTAL AND MARINE ECOSYSTEMS

One promising valuation method to elicit preferences of stakeholders concerning the perceived impacts or merits of various interventions is called the 'damage schedule' approach. This methodology is based on the observation that it is usually far easier for individuals to compare pairs of choices, or objects, when asked to make a decision about them. By combining a number of decisions by a group of respondents, an investigator can then obtain a list ranked by preference, from least to most desirable (or important). Empirical research in various coastal and marine systems has established that such ranked lists will tend to reflect a consensus among respondents, even when they differ strongly in their perceived interests or even compete for the same natural resources (as do, for example, coastal fishers, shrimp farmers and tourist operators; see Chuenpagdee et al., 2001b).

Research by Power and Chuenpagdee (2003) has shown that this 'consensus-eliciting' aspect of the damage schedule approach can be used to identify important variables to consider when formulating fisheries policies. As the damage schedule relies on paired comparisons, it is constructed in this case from individuals' responses to a questionnaire containing a series of management considerations presented one pair at a time. The respondents, including scientists, fishers and general public, are then asked to select, for each pair, the management consideration that they consider more important. As shown in Figure 6.3, the ranking of important considerations varied slightly between the three respondent groups. These rankings were nonetheless significantly correlated at alpha level 0.05.

The detailed description of the approach is presented in Chuenpagdee et al. (2001a), and examples of application to coastal resources in Thailand and the Eastern Bering Sea Ecosystem are described in Chuenpagdee et al. (2001b), and in Chuenpagdee and Vasconcellos (2000), respectively. The damage schedule approach may also be used to help identify the optimal or most acceptable location of 'no-take' marine reserves and their surrounding marine protected areas (MPAs). The establishment of ecosystem-based fisheries management tools, increasingly required to restore damaged coastal and marine ecosystems, will be able to fulfill that role only with the acquiescence of the impacted communities in the context of new governance arrangements (Chuenpagdee et al., 2002).

REFERENCES

- Christensen, V., S. Guénette, J.J. Heymans, C.J. Walters, R. Watson, D. Zeller and D. Pauly (2003), 'Hundred year decline of North Atlantic predatory fishes', *Fish and Fisheries*, **4**(1), 1–24.
- Chuenpagdee, R. and M. Vasconcellos (2000), 'Application of the damage schedule approach on the Ecopath ecosystem modelling', in: U.R. Sumaila, R. Chuenpagdee and M. Vasconcellos (eds), *Proceedings of the INCO-DC International Workshop on Markets, Global Fisheries and Local Development*, Bergen, Norway, 22–23 March 1999, Brussels, ACP-EU Fisheries Research Report (7).
- Chuenpagdee, R., J. Fraga and J. Euan (2002), 'Community's perspectives toward marine reserve: A case study of San Felipe, Yucatán, México', *Coastal Management*, **30**(2), 183–91.
- Chuenpagdee, R., J.L. Knetsch and T.C. Brown (2001a), 'Environmental damage schedules: community judgments of importance and assessments of losses', *Land Economics*, **77**(1), 1–11.
- Chuenpagdee, R., J.L. Knetsch and T.C. Brown (2001b), 'Coastal management using public judgments, importance scales, and predetermined schedule', *Coastal Management*, **29**(4), 253–70.
- Costanza R., F. Andrade, P. Antunes, M. van den Belt, D. Boersma, D. Boesch, F. Catarino, S. Hanna, K. Limberg, B. Low, M. Molitor, J. Pereira, S. Rayner, R. Santos, J. Wilson and M. Young (1998), 'Principles for sustainable governance of the oceans,' *Science*, **281**, 198–99.
- Coward, H., R. Omner and T.J. Pitcher (eds) (2000), *Just Fish: Ethics and Canadian Marine Fisheries*, Institute of Social and Economic Research, Memorial University of Newfoundland, St John's.
- Cushing, D.H. (1988), *The Provident Sea*, Cambridge: Cambridge University Press.
- Felt, L. (1990), 'Barriers to user participation in the management of the Canadian Atlantic salmon fishery: if wishes were fishes', *Marine Policy*, July, pp. 345–60.
- Hilborn, R. and C.J. Walters (1992), *Quantitative Fisheries Stock Assessments: Choice, Dynamics and Uncertainty*, New York and London: Chapman and Hall.
- Jentoft, S. and B. McCay (1995), 'User participation in fisheries management: Lessons drawn from international experiences', *Marine Policy*, **19**(3), 227–46.
- Jentoft, S., B.J. McCay and D.C. Wilson (1998), 'Social theory and fisheries co-management', *Marine Policy*, **22**(4–5), 423–36.
- Ludwig, D., R. Hilborn and C. Walters (1993), 'Uncertainty, resource exploitation and conservation: lessons from history', *Science*, **260**, pp. 17 and 36.
- Mace, P.M. (1997), 'Developing and sustaining world fisheries resources: the state of fisheries and management', in: D.H. Hancock, D.C. Smith, A. Grant and J.P. Beumer (eds), *Proceedings of the 2nd World Fisheries Congress*, Collingwood, Australia: CSIRO Publishing, pp. 1–20.
- Munro, G.R. and U.R. Sumaila (2001), 'Subsidies and their potential impact on the management of the ecosystems of the North Atlantic', in: T.J. Pitcher, R. Sumaila and D. Pauly (eds), *Fisheries Impacts on North Atlantic Ecosystems: Evaluation and Policy Exploration*, Fisheries Centre Research Reports, **9**(5), pp. 10–27, (Available online at www.seaaroundus.org/report/impactpolicyF.htm).
- National Research Council (1999), *Sustaining Marine Fisheries*, Washington, DC: National Academy Press.
- Naylor, R.L., J. Goldberg, J.H. Primavera, N. Kautsky, M.C.M. Beveridge, J. Clay,

- C. Folke, J. Lubchenco, H. Mooney and M. Troell (2000), 'Effect of aquaculture on world fish supplies', *Nature*, **405**, 1017–24.
- Noble, B.F. (2000), 'Institutional criteria for co-management', *Marine Policy*, **24**, 69–77.
- Pauly, D. (1996), 'One hundred million tonnes of fish, and fisheries research', *Fisheries Research*, **25**(1), 25–38.
- Pauly, D. (1997), 'Small-scale fisheries in the tropics: marginality, marginalization and some implication for fisheries management', in: E.K. Pikitch, D.D. Huppert and M.P. Sissenwine (eds), *Global trends: Fisheries Management*, American Fisheries Society Symposium 20, Bethesda, Maryland, pp. 40–49.
- Pauly, D. (2005), 'Rebuilding fisheries will add to Asia's problems', Correspondence to *Nature*, **433**, 457.
- Pauly, D. and J. Ingles (1999), 'The relationship between shrimp yields and intertidal vegetation (mangrove) areas: a reassessment', in: A. Yañez-Arancibia and A.L. Lara-Dominguez (eds), *Mangrove Ecosystems in Tropical America*, Instituto de Ecología, A.C. Mexico, IUCN/ORMA, Costa Rica, NOAA/NMFS, Silver Spring, MD, USA, pp. 311–16.
- Pauly, D. and J. Maclean (2003), *In a Perfect Ocean: The State of Fisheries and Ecosystems in the North Atlantic Ocean*, Washington, DC: Island Press.
- Pauly, D. and R. Watson (2005), 'Background and interpretation of the "Marine Trophic Index" as a measure of biodiversity', *Philosophical Transactions of the Royal Society*, (B), **360**, 415–23.
- Pauly, D., V. Christensen, J. Dalsgaard, R. Froese and F.C. Torres Jr (1998), 'Fishing down marine food webs', *Science*, **279**, 860–63.
- Pauly, D., J. Alder, E. Bennett, V. Christensen, P. Tyedmers and R. Watson (2003), 'The future for fisheries', *Science*, **302**, 1359–61.
- Pauly, D., V. Christensen, S. Guénette, T. Pitcher, U.R. Sumaila, C. Walters, R. Watson and D. Zeller (2002), 'Toward sustainability in world fisheries', *Nature*, **418**, 689–95.
- Pinkerton, E. (1989), *Cooperative Management of Local Fisheries: New Directions for Improved Management and Community Development*, Vancouver: University of British Columbia Press.
- Pitcher, T.J. (2001), 'Fisheries managed to rebuild ecosystem? Reconstructing the past to salvage the future', *Ecological Applications*, **11**, 601–17.
- Pitcher, T.J., P.J.B. Hart and D. Pauly (eds) (2001), *Reinventing Fisheries Management*, Fish and Fisheries Series 23, Dordrecht: Kluwer Academic Publishers.
- Power, D. and R. Chuenpagdee (2003), 'Fishers and scientists: no longer foe, but not yet friend', in: N. Haggan, C. Brignall and L. Wood (eds), *Putting Fishers' Knowledge to Work*, pp. 259–66, proceedings of a conference held at the Fisheries Centre, University of British Columbia, 27–30 August, 2001, Fisheries Centre Research Report 11(1). (Available on-line at www.fisheries.ubc.ca/publications/reports/11-1/28_power_chuenpagdee.pdf)
- Ricker, W.E. (1975), 'Computation and interpretation of biological statistics of fish populations', *Bulletin of the Fisheries Research Board of Canada* (191).
- Sandersen, H.T. and Koester, S. (2000), 'Co-management of tropical coastal zones: the case of the Soufrière marine management area, St. Lucia, WI', *Coastal Management*, **28**, 87–97.
- Sumaila, U.R. (1999), 'Pricing down marine food webs', in: D. Pauly, V. Christensen

- and L. Coelho (eds), *Proceedings of the '98 EXPO Conference on Ocean Food Webs and Economic Productivity*, pp. 13–15, Lisbon, Portugal, 1–3 July 1998, ACP-EU Fisheries Research Report, 5.
- Watling, L. and E.A. Norse (1998), 'Disturbance of the seabed by mobile fishing gear: a comparison to forest clearcutting', *Conservation Biology*, **12**(6), 1180–97.
- Watson, R. and D. Pauly (2001), 'Systematic distortion in world fisheries catch trends', *Nature*, **424**, 534–6.

Agrikulture