The Changing Face of Fisheries Science and Management

Nigel Haggan and Barbara Neis

> *Great complaints are made against the use of the net called 'wondyrchoun'* [beam trawl] *which drags from the bottom of the sea all the bait that used to be the food of great fish… …*[it] *runs so heavily and hardly over the ground when fishing that it destroys the flowers of the land below the water and also the spat of oysters, mussels, and other fish upon which the great fish are nourished . . . …Through means of this instrument fishermen catch `such great plenty of small fish that they do not know what to do with them, but fatten their pigs with them'.*
>
> UK Rolls of Parliament (1376/77)

Today, 99% of the world's 51 million fishers are small-scale, producing over half of the global foodfish catch of 98 million tones. One billion people rely on aquatic resources as their main source of dietary protein (Berkes *et al*. 2001 and references therein). Globally, many fish stocks are depleted. Overall, our capacity to harvest fish continues to outpace our capacity to monitor the effects of fishing, let alone design, implement and enforce effective conservation measures. Fish populations once deemed inexhaustible (Huxley 1883), have been reduced to a fraction of their past abundance (Hilborn *et al.* 2003). High-level predators in the North Atlantic hover round 10% of their 1900 levels (Christensen *et al*. 2003; Myers and Worm 2003). Some sharks have suffered declines of over 50% since the mid 1980s (Schindler *et al.* 2003; Baum *et al*. 2002). Other species as diverse as marine turtles (Hays *et al.* 2003) and many species of whales hover at very low levels (Roman and Palumbi 2003). In too many cases, stocks are so depleted that conserving what is left would amount to sharing the present misery (Pitcher 2001). In these cases, the only meaningful option is recovery but we generally know even less about recovery than we do about conservation.

'Fisheries science' and 'management', as currently practiced, are relatively new phenomena. However, knowledge about marine and freshwater ecosystems and social institutions mediating human relationships with those ecosystems is ancient, being a necessity of survival as well as the product of natural human interest in the surrounding world. Together, these have led, throughout the world, to acute observation, experimentation, the formulation and testing of hypotheses, and the development of theories and practices as well as social institutions to regulate resource use and transmit knowledge from generation to generation (Berkes 1999).

This book has brought together many case studies from different parts of the world where the knowledge of fishers, their institutions and often the fishers themselves is being actively integrated into fisheries science and management. The chapters represent different points on a number of continua; between contexts where mutual respect, cooperation and reciprocity (Stanley and Rice this vol.) are just evolving and those where formal co-management arrangements operate (Baird and other this vol.); between Indigenous management, state management, and state management mitigated by the re-emergence of elements of traditional management and values (Hickey this vol.); and between documenting the richness and scope of the indigenous knowledge still in use in some fisheries (Nsiku this vol.) and clear cut applications of Fishers' Knowledge (FK) and science in the struggle to understand and conserve fish stocks (Baird this vol.). In this concluding chapter, we underscore the urgent need for approaches to fisheries science and management that promote the collection, critical examination and synthesis of all potential types of fisheries knowledge and all effective mechanisms for promoting information sharing and sharing of the responsibility and struggle to protect and ideally restore the world's endangered wild fish stocks.

> *One man stood before the microphone, his face grey with fatigue and anxiety, and said in a breaking voice: 'Let's face it: we've caught them all'*
>
> (Storey 1993, cited in Ommer 1994).

This quote from a participant in a post-mortem after the collapse of the Atlantic cod (*Gadus morhua*) captures, like nothing else, the dawn of awareness that people now have the capacity to destroy not only local stocks and ecosystems but great resources distributed over thousands of cubic miles of ocean. Frank *et al.* (2005) suggest that changes induced by overfishing are so profound as to make recovery of the Atlantic cod unlikely.

Despite enormous investments in 'science' and 'management', marine and riverine ecosystem structures and responses to stress are poorly understood. There is mounting evidence that some key, taken-for-granted assumptions about the behaviour of fish and fishers associated with fisheries science and management are incorrect. For example, perversely, that the increasing power of fishing technology now appears to have been reinforced by the catchability effects of shoaling behaviour found in Atlantic cod, herring (*Clupea harengus*), capelin (*Mallotus villosus*) and many other important food species. Pitcher (1997) notes that under adverse conditions, shoaling fish concentrate in areas of prime habitat rather than getting 'thin on the ground' over their entire previous range. Fish finding equipment, mobile vessels and dense shoals help to account for situations where catch rates remain high until stocks collapse.

Similarly, for much of the history of industrial fishing, we have assumed that overfishing would lead to a reduction in the density of fish populations, declining catch rates and, eventually, to cessation of fishing for economic reasons. We now know that industrial fisheries and contemporary artisanal fisheries tend to respond to declining catches by increasing effort and shifting to other, frequently lower trophic level species (Pauly *et al*. 1998). Patterns of intensification and expansion with spatial, temporal and ecological dimensions have been documented (Neis and Kean 2003). Fish do eventually become scarce, but fishers often keep on fishing, sometimes ploughing their own resources into bigger boats, more horsepower and more sophisticated gear, a form of self-subsidization. Alternatively, they are displaced by large, mobile, corporate-owned fisheries. Big and small industry players are often kept in business through annual subsidies estimated at US$ 20 billion worldwide (Milazzo 1998).

A third common but problematic assumption in fisheries science and management is that marine fish stocks are 'panmictic', i.e. that individuals are unrestrictedly capable of interbreeding. Cury (1994) observes that there can be a high degree of variability within stocks of small pelagic fish including Peruvian anchoveta (*Engraulis ringens*) and Northwest Atlantic herring. The implication is that marine fish species may well be composed of many different stocks, some small and a few large, a characteristic previously associated only with salmon. The information that Ames (this vol.) collected from retired fish harvesters confirms the existence of many now 'extinct' cod and haddock (*Melanogrammus aeglefinus*) spawning areas in the Gulf of Maine, supplementing other cod-related findings that suggest population structures are more complex than formerly thought. Hutchinson *et al*. (2003) used DNA recovered from archived otoliths of North Sea cod (*G. morhua*) to show a significant decline in genetic diversity between 1954 and 1998, with implications for the ability of this species ability to withstand fishing pressure and environmental change. Prince (2003) makes a case for abalone (*Haliotid*) populations being composed of numerous 'micro stocks' that are 'myriad and complex to study, monitor, assess and manage'.

Hauser *et al*.'s (2002) study of a New Zealand snapper (*Pagurus auratus*), showed a reduction in genetic diversity comparable to that described by Hutchinson for North Sea cod. They also observed that, unlike terrestrial species, where a small number of survivors can regenerate a population, marine fish populations tend to have a relatively small percentage of highly effective breeders. In the case of the New Zealand snapper, only 10,000 out of the residual population of three million were found to be effective breeders (Hauser *et al*. 2002). Similar research on cod and lobster points to the importance of protecting larger, experienced and more fecund spawners (Corson 2004; Trippel 1998). Berkeley *et al.* (2004) report that the eggs of older spawners have a higher oil content leading to greatly enhanced larval survival.

All of the above scientific findings may come as no surprise to indigenous and artisanal fishers; indeed the Haida, Heiltsuk and Nuu-chah-nulth First Nations[i] of BC have all taken action to close herring fisheries approved by Canada's Department of Fisheries and Oceans under the assumption that stocks could withstand a 20% harvest rate, an assumption the Aboriginal people felt to be untenable (Jones this vol; Lucas, this vol. Ross Wilson, Chief Councilor, Heiltsuk Nation, Personal communication). Many inshore fishers in Newfoundland expressed concern that large mesh gillnets and dragger fisheries that targeted large, spawning cod were destroying the 'mother fish' and thereby affecting recruitment to local populations (Neis *et al*. 1999).

These and other recent findings on the state of the world's fisheries and the vulnerability of fishery communities, as well as on the ways interactions between fish, fisheries, science and management have contributed to the precariousness of fish and fisheries, all point to the need for new approaches. Science and management need to take place at finer temporal and spatial scales with rapid feedback between fishers, scientists and managers. We need longer time series so that short-term fluctuations can be separated from long-term trends and so that current and former habitat and stock remnants can be identified, protected and ideally enhanced. The dynamism of fisheries means that scientists and managers tend to follow fisheries around (Neis and Kean 2003), often discovering after the fact what used to be there and why it is now gone.

We need to learn more about former and current practices that have conserved and ideally enhanced fish populations and the larger ecosystems upon which they depend and substantially expand the tool kit of cultural, scientific and management practices that have been shown to promote recovery, preservation and to encourage effective stewardship by all stakeholders. To illustrate, Haggan *et al*. (2004) suggest that the 'inexhaustible' fish, forests and wildlife seen by early explorers of the Pacific Northwest of Canada were, to a large extent, the result of active enhancement and stewardship of a very wide range of aquatic and terrestrial resources. While more research is needed, it is apparent that the Pacific Northwest was far from a 'wilderness' when Europeans arrived in the mid 1700s. What is indisputable is that, compared to pre-contact times, the Pacific Northwest is now a wasteland, and that the resources of government agencies are not adequate for the task of conserving and managing what remains to us, to say nothing of the reinvestment in natural capital needed to restore some level of historic abundance, a point made eloquently throughout this volume.

The failure of centralized management to avert major stock collapse and the 'vicious cycle' where depleted resources require more study and more management, but produce fewer benefits or negative returns to government, is prompting two divergent courses of action. The first is to transform commercial fishing licenses into transferable quotas that have most of the characteristics of property rights. This enables those with deep pockets to purchase sufficient quota to make harvesting efficient. A standard proviso is that the quota holders pay for the research and management cost for 'their' fishery. Canada's west coast fisheries for halibut (*Hippoglossus stenolepis*), blackcod (*Anoplopoma fimbria*), geoduck clam (*Panope generosa*) sea urchin and sea cucumber have been effectively privatized, raising quota value to levels beyond the reach of small-scale fishers and creating a problem for the return of resources to First Nations under the modern-day treaty making process in BC[ii]. A proposal by McRae and Pearse (2004) to privatize the Pacific salmon fishery is even more problematic (Haggan et al. 2004; Jones *et al*. 2004). It is clear that this approach is having serious social and economic consequences for many fishers and their communities.

The second direction is the effort to 'bale out' or beef up fisheries science and management, by 'harnessing', 'capturing', 'incorporating', or sometimes 'integrating' FK. This, as one would properly expect, raises no end of practical, ethical and epistemological problems, most of which result from trying to fit FK into the current framework of resource management and ownership, i.e., to the benefit of those who control the lion's share of the resource and to the preservation of existing institutions (see Holm 2003 and responses from Neis and Pinkerton in the same issue). FK does not come out of thin air. It is 'situated' knowledge in that it is tied to place (Newell and Ommer 1999) and to particular social, ecological and historical contexts, and in some cases may be based on 100s or 1000s of years of interdependence with particular environments, resources and social institutions. It is often expressed in ways that are hard for those from other socio-cultural circumstances to understand, even if they speak the same language. FK is generally collective and individual, a socio-ecological product mediated by ecology, technology, divisions of labour, culture, knowledge sharing and transmission. To some degree the same is true of scientific knowledge and the knowledge of managers (see, for example, Finlayson 1994; Neis and Morris 2002; Hutchings *et al*. 2002). People of other cultures have often developed similar, if somewhat less rigid ways to transmit their knowledge and practices about fish, fisheries and ecosystems (many chapters this vol.).

FK is generally partially passed down through oral traditions, sometimes by people trained to prodigious feats of memory. In the Haida Nation on the west coast of Canada, students learning from elders were required to repeat lessons verbatim. It was not acceptable to stumble, recall and continue; each lesson had to be repeated from the beginning (Russ Jones Technical Director Haida Fisheries Program, Personal communication). Science is generally written, but is also influenced by dominant paradigms. Informal cultures and knowledge systems can also be found in science. Intergenerational transfer of FK and science (Narcisse and others this vol.) maintains continuity, and ensures a shared knowledge of past events, interpretations of those events, as well as lessons learned and institutions that reflect those lessons. However, both FK and science may have minority points of view that can be valid and important but tend to get marginalized and forgotten.

Local knowledge and management systems, like formal science and management are also dynamic in that they expand and change in response to changes in policies and practice, species distribution, species targeted, the movement of people from one area to another, fishery and climate-induced ecosystem shifts, market preference and other factors. Often marginalized in the process of colonization through displacement, mortality, indoctrination and resource degradation, FK can contract in scope and complexity under unfavourable conditions, but is also resilient and can re-emerge as conditions change (Hickey; Satria and others this vol.). When resurrected and given support, indigenous and local knowledge and management systems can contribute to the development of innovative approaches to research, conservation and management of species as diverse as turtles (Küyük *et al*. this vol.), serranid spawning aggregations (Phelan this vol.) and trout (Spens this vol.).

The 'First Salmon Ceremony' practiced in various forms by First Nations throughout the Pacific Northwest (Swezey and Heizer 1993) is an example of the symbolic importance of rituals within which knowledge is contextually nested. The ceremony gives thanks for the gift of salmon and shows proper respect to ensure their return in future years. It includes a feast where salmon are eaten and the bones and intestinal organs are returned to the river, while the flesh passes, sooner or later, back to the land.

Recent scientific research on the pivotal importance of marine nitrogen and phosphorous from salmon carcasses to the forest as well as the freshwater ecosystem is a longer way of saying the same thing, but important in that it increases scientific and public awareness of connections not obvious to most people. The huge runs of Pacific salmon transport 1,000s of tonnes of nutrients[iii] from the ocean to inland watersheds (Stockner 2003). Core samples taken from riverside trees indicate the strength of past salmon runs in the differential ring growth (Reimchen 2001). Watkinson (2001), a member of the Tsimshian Nation on the North coast of British Columbia used ecosystem modelling to quantify the importance of these nutrients to the coastal ecosystem, and identified ~40 species, ranging from bears to insects that depend on salmon for food, and subsequently transport nutrients up to one km, or even more, back from the riverbank. This is an excellent example of traditional knowledge and science working effectively together. Legend, theory and practical implications for the 'resource economy' converge in our growing awareness of salmon as an ecological keystone species (Paine 1969; Power *et al*. 1996). The salmon is also a 'cultural keystone species' (*sensu* Garibaldi and Turner 2004), in that it is central to the spiritual well being of Aboriginal peoples and a key focal point for the intergenerational transfer of knowledge (Narcisse and others this vol.).

Knowledge gains power when it is shared.

This saying of the Stó:lõ Nation whose traditional territory is on the Lower Fraser River in BC, identifies both the reward and the price of knowledge integration (Haig-Brown and Archibald 1996). The nature and application of FK cannot be fully understood outside of the culture, belief and value systems in which it is embedded. Such knowledge is the product of long interaction with its cultural as well as its geographical and biological context. Some elements transplant readily to neighbouring or even distant communities, but caution is indicated (Sultana and Thompson this vol.). It is also the product of a belief system or worldview, and differs from the 'fisheries science' of the last 200 years in the particular values that it embraces (Hickey; Poepoe *et al*. this vol.). The local science of more recent fishing communities, such as the small fishing ports of Canada's east and west coasts is also 'situated' knowledge and commonly incorporates important values such as continuity and respect for the environment and species that are the reason for their community's existence.

Industrial fishers who are part of the same fleet or fish for the same species are also 'communities', that often share a common corporate culture, shaped by the societies from which they originate, industry associations and interactions with scientists and managers over the life of their fishery. Industrial fishers have detailed knowledge of their target and associated species, indeed, it is only through the sheer amount of time spent on, and indeed under the water (Meeuwig *et al*. this vol.) that we can hope to be able to comprehend and map the fine scale detail shown in the fisher maps of Ames (this vol.); and Williams and Bax (this vol.), and bring their knowledge to bear in the design and analysis of information and new management processes (Baelde; Mulrennan; Stanley and Rice, this vol.; see also Neis and Felt (2000) for other examples of efforts to combine local ecological knowledge and science related to commercial fisheries).

Common to all the cases presented in this book is the fact that some form of cooperative management is often required to maximize the utility of the knowledge. Contributions from Baird; Kalikoski and Vasconcellos; Mulrennan; Satria; Sultana and Thompson and others (this vol.) underscore that legal recognition of local management and guaranteed access to resources is a pre-condition of conservation and potential sustainability. This can only be achieved when we expand our concept of 'science' to include the wealth of knowledge at local level and the analytic power of stock assessment and modelling tools and commit to a genuine sharing of the benefits that come from the application of our collective wit and wisdom.

In summary, the knowledge of those who live, move, and have their being on or beside the water contains much biological and ecological information, sometimes explicitly expressed in ways that scientists can easily comprehend, and sometimes opaquely entwined in rituals and other socio-cultural aspects. Viewed from the point of view of fishers, there are similar problems with science. FK has value to the holders for management, food security, wealth (however defined), spirituality, and ultimately for peace, order and good government. It is of interest and value to scientists and educators, and it has inherent value amongst the holders of the knowledge, regardless of whether outsiders understand it, accept it, are able to validate it, make use of it, or not. Knowledge of fisheries science and the principles that guide formal management are also of potential value to fishers. Above all, FK is not a fossil, but dynamic and capable of change and adaptation.

More than twenty years ago, in *Words of the Lagoon*, the late Bob Johannes (1981) drew attention to the serious neglect of the FK of 'native fishermen' by social and natural scientists. He commented that the type of research he had done for this book:

> *'offers a shortcut to some of the basic natural history data we need in order to understand these vast and valuable resources … I gained more new (to marine science) information during sixteen months of fieldwork … than I had during the previous fifteen years using more conventional research techniques. This is because of my access to a store of unrecorded knowledge gathered by highly motivated observers over a period of centuries. This book, then, is really the work of uncounted individuals carried out over many generations.'*

Johannes was seriously concerned that without more attention to FK, a vast storehouse of primarily oral information would be lost. Twenty years later, some of his comments about the relationship between FK seem naïve and even ethnocentric, particularly to social scientists. We have also heard natural scientists complain that he should have done more to verify the information he learned from the Palauan fishing elders. Whatever the validity of these criticisms, Johannes cannot be faulted for working persistently, in his dedicated but humble way to promote attention to FK and to the fishers who carried that knowledge. Twenty years later, with the world's supplies of freshwater and marine species much diminished, and much FK lost with the passing of more generations of elders, and due to rapid changes in fisheries and the erection of serious barriers to intergenerational transmission of FK, we can only wish that we had all reacted faster and more fully to his call for more attention to FK. Meaningful and respectful exchanges of knowledge between fishers, scientists and managers remain the exception rather than the norm, even in fisheries like the lobster fishery in Maine where enormous resources have been dedicated to one fishery and one species and where differences of class, ethnicity and background between fishers and scientists are relatively small (Corson 2004).

While it is heartening to know that there are more cases where fishers and their knowledge are being integrated into science and management than it would take to fill one book, it is disturbing to note that there is still no international institution dedicated to the ethical collection, preservation and dissemination of FK. Bob wanted us to change this and it is about time that we did.

References

Ames, T. (2005) Putting Fishermen's Knowledge to Work: The Promise and Pitfalls. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 17, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Baelde, P. (2005) Using Fishers' Knowledge Goes Beyond Filling Gaps in Scientific Knowledge – Analysis of Australian Experiences. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 19, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Baird, I.G. (2005) Local Ecological Knowledge and Small-scale Freshwater Fisheries Management in the Mekong River in Southern Laos. In: *Fishers' Knowledge in*

Fisheries Science and Management (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 12, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Baird, I.G. (2005) The Last Anecdote. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 22, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Baum, J.K., Myers, R.A., Kehler, D., Worm, B., Harley, S.J. and Doherty, P.A. (2003) Collapse and conservation of shark populations in the Northwest Atlantic. *Science* **299,** 389-392

Berkeley, S.A., Chapman, C. and Sogard, S.M. 2004. Maternal age as a determinant of larval growth and survival in a marine fish, *Sebastes melanops*. *Ecology*, **85**(5), 1258-1264.

Berkes, F., Mahon, R. McConney, P., Pollnac, R. and Pomeroy, R. (2001) *Managing Small-scale Fisheries: Alternative Directions and Methods*. International Development Research Center, Ottawa, 320p. Online at: http://web.idrc.ca/en/ev-28049-201-1-DO_TOPIC.html

Christensen, V., Guénette, S., Heymans, J.J., Walters, C.J., Watson, R., Zeller, D and Pauly, D. (2003) Hundred-year decline of North Atlantic predatory fishes. *Fish and Fisheries*, **4**(1), 24.

Corson, T. (2004) *The secret Life of Lobsters*. Harper Collins, New York, 298p.

Cury, P. (1994) Obstinate nature: an ecology of individuals. Thoughts on reproductive behavior and biodiversity. *Canadian Journal of Fisheries and Aquatic Sciences,* **51,** 1664–1673.

Diamond, J. (1998) *Guns, Germs and Steel: The Fates of Human Societies*. W.W. Norton, London, UK, 480p.

Finlayson, A.C. (1994) *Fishing for Truth: A Sociological Analysis of Northern Cod Stock Assessments from 1977-1990*. ISER Books: St. John's.

Frank, K.T., Petrie, B., Choi, J.S. and Leggett, W.C. (2005) Trophic Cascades in a Formerly Cod-Dominated Ecosystem. *Science*, **308,** 1621-1623.

Garibaldi, A. and Turner, N. (2004) Cultural keystone species: implications for ecological conservation and restoration. Ecology and Society **9**(3): 1. Online: Http://www.ecologyandsociety.org/vol9/iss3/art1. Last accessed 27/6/2005.

Haggan, N., Turner, N.J., Carpenter, J., Jones, J.T., Menzies, C. and Mackie, Q. (2004) 12,000+ years of change: Linking traditional and modern ecosystem science in the Pacific Northwest. *Proceedings of the 16th Society for Ecological Restoration Conference* (ed Seaton, R), Victoria, BC.

Haig-Brown, C. and Archibald, J. (1996) Transforming First Nations research with respect and power, *Qualitative Studies in Education*, **9**(2), 245-267.

Hauser, L., Adcock, G.J., Smith, P.J., Bernal Ramírez, J.H. and Carvalho, G.R. (2002) Loss of microsatellite diversity and low effective population size in an overexploited population of New Zealand snapper (*Pagrus auratus*). *Proceedings of the National Academy of Science, USA*, **99**(18), 11742-11747.

Hays, G.C., Broderick, A.C., Godley, B.J., Luschi., P. and Nichols, W.J. (2003) Satellite telemetry suggests high levels of fishing-induced mortality in marine turtles. Marine Ecological Progress Series, **262**, 305–309.

Hebda, R. and Frederick, S.G. (1990) History of Marine Resources of the Northeast Pacific Since the Last Glaciation. *Transactions of the Royal Society of Canada, Sixth Series*, **1**, 319-342.

Hickey, F. (2005) Traditional Marine Resource Management in Vanuatu: worldviews in transformation. In: *Fishers' Knowledge in Fisheries Science and Management* (eds

Haggan, N., Neis, B. and Baird, I.G.), Chapter 7, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Hilborn, R., Branch, T.A., Ernst, B., Magnusson, A., Minte-Vera, C.V., Scheuerell, M.D. and Valero, J.L. (2003) State Of The World's Fisheries. *Annual Review of Environment and Resources,* **28,** 359-399.

Holm, P. (2003) Crossing the Border: On the Relationship Between Science and Fishermen`s Knowledge in a Resource Management Context, MAST, **2**(1), 5-33.

Hutchings, J.A., Neis, B. and Ripley, P. (2002) The nature of cod: perceptions of stock structure and cod behaviour by fishermen, 'experts' and scientists from the nineteenth century to present. In: *The Resilient Outport: Ecology, Economy and Society in Rural Newfoundland* (ed Ommer, R.), ISER Books, St. John's, 360p.

Hutchinson W.F., van Oosterhout, C., Rogers, S.I. and Carvalho, G.R. (2003) Temporal analysis of archived samples indicates marked genetic changes in declining North Sea cod (*Gadus morhua*). Proceedings of the Royal Society London - *Biological Sciences*, **270**, 2125-2132.

Huxley, T.H. (1883) 'Inaugural address', The Fisheries Exhibition Literature, International Fisheries Exhibition, London Vol. 4, pp. 1–22.

Johannes, R.E. (1981) *Words of the lagoon: fishing and marine lore in the Palau district of Micronesia*. University of California Press. Berkeley, 245p.

Johannes, R.E. and Neis, B. (2005) The value of anecdote. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 1, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Johnsen, D.B. (2001) Customary law, scientific knowledge, and fisheries management among northwest coast tribes. *N.Y.U. Environmental law Journal*, **10**(1), 1-69.

Jones, R.R. (2000) The herring fisheries of Haida Gwaii: An ethical analysis. Pages 201-224 in, Just Fish: Ethics and Canadian Marine Fisheries (eds Coward, H., Ommer, R. & Pitcher, T. J.). ISER Books, St. Johns, Newfoundland. 304 Pages.

Jones, R.R. (2005) Application of Haida Oral History to Pacific Herring Management. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 4, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Kalikoski, D.C. and Vasconcellos, M. (2005) The Role of Fishers' Knowledge in the Co-management of Small-Scale Fisheries in the Estuary of Patos Lagoon, Southern Brazil. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 14, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Küyük, K., K.E., Nichols, W.J. and Tambiah, C.R. (2005) The Value of Local Knowledge in Sea Turtle Conservation: a Case from Baja California, Mexico. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 15, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Lucas, S. (2005) Life Supports Life. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 5, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

McRae, D.M. and Pearse, P.H. (2004) *Treaties and Transition: Towards a Sustainable Fishery on Canada's Pacific Coast*. Hemlock Printers. Vancouver 58p. Online:

http://www.gov.bc.ca/tno/down/pearse_mcrae_report-joint_fish_task_group.pdf. Last accessed 27/6/05.

Meeuwig, J., Samoilys, M., Erediano, J. and Koldewey, H. (2005) Fishers' perceptions on the seahorse fishery in central Philippines: Interactive approaches and an evaluation of results. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 11, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Milazzo, M. (1998) Subsidies in World Fisheries: a Re-examination. *World Bank Technical Paper* **No. 406**. World Bank, Washington.

Mulrennan, M.E. (2005) Sustaining a Small-boat Fishery: Recent Developments and Future Prospects for Torres Strait Islanders, Northern Australia. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 9, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Myers, R.A. and Worm B (2003) Rapid worldwide depletion of predatory fish communities. *Nature*, **423,** 280-283

Narcisse, A. (2005) My grandfather's knowledge: First Nations fishing methodologies on the Fraser River. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 2, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Neis, B. & Morris, M. (2002) Fishers' ecological knowledge and fisheries science. In: *Ommer, R. (ed.) The Resilient Outport*: Ecology, Economy, and Society in Rural Newfoundland. ISER Books, St. John's.

Neis, B. and Felt, L. (eds) (2000) *Finding our sea legs. Linking fishery people and their knowledge with science and management*. ISER books, Memorial University, St. John's, Newfoundland, 318p.

Neis, B. and Kean, R. (2003) Why fish stocks collapse: an interdisciplinary approach to understanding the dynamics of 'fishing up'. In: *Retrenchment and Regeneration in Rural Newfoundland* (ed Byron, R.) University of Toronto Press, Toronto.

Neis, B., Schneider, D., Felt, L., Haedrich, R., Hutchings, J. and Fischer, J. (1999b) Northern cod stock assessment: what can be learned from interviewing resource users? *Canadian Journal of Fisheries and Aquatic Sciences*, **56**, 1949-1963

Newell, D. and R.E. Ommer (eds). (1999) *Fishing Places, Fishing People: Traditions and Issues in Canadian Small-Scale Fisheries*. Univ. of Toronto Press. Toronto. 374p.

Nsiku, E. 2005) Indigenous Technical Knowledge of Malawian Artisanal Fishers. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 3, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Ommer, R. (1994) One hundred years of fishery crisis in Newfoundland. *Acadiensis*, **23**(2), 5-20.

Paine, R.T. (1969) A note on trophic complexity and community stability. *The American Naturalist*, **103**, 91-93.

Pauly, D., Christensen, V., Dalsgaard, J., Froese, R. and Torres Jr., F.C. (1998). Fishing down marine food webs. *Science*, **279**, 860-863.

Phelan, M. (2005) Tropical Fish Aggregations in an Indigenous Environment in Northern Australia: An Example of Successful Outcomes through Collaborative Research. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and

Baird, I.G.), Chapter 8, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.
Pitcher, T. J. (2001) Fisheries managed to rebuild ecosystems? Reconstructing the past to salvage the future. *Ecological Applications,* **11**, 601-617 .
Pitcher, T.J. (1997) Fish shoaling behaviour as a key factor in the resilience of fisheries: Shoaling behaviour alone can generate range collapse in fisheries. In: *The development and Sustainability of World Fisheries* (eds Hancock, D.A., Smith, D.C., Grant, A. and Beumer, T.P.), pp. 143-148. CSIRO, Collingwood, Australia, 797p.
Poepoe, K.K., Bartram, P.K. and Friedlander, A.M. (2005) The Use of Traditional Knowledge in the Contemporary Management of a Hawaiian Community's Marine Resources. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 6, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.
Power M. E., D. Tilman, J. A. Estes, B. A. Menge, W. J. Bond, L. S. Mills, G. Daily, J. C. Castilla, J. Lubchenco, and R. T. Paine. (1996) Challenges in the quest for keystones. *Bioscience,* **46**(8), 609-620.
Prince, J.D. (2003) The barefoot ecologist goes fishing. *Fish and Fisheries,* **4**(4), 359-371.
Reimchen, T. E. (2001) Salmon nutrients, nitrogen isotopes and coastal forests. *Ecoforestry* **16**, 13-17.
Roman, J. and Palumbi, S.R. (2003) Whales Before Whaling in the North Atlantic. *Science,* **301**, 508-510.
Satria, A. (2005) Sawen: Institution, local knowledge and myth in fisheries management in North Lombok, Indonesia. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 10, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.
Schindler, D.E., Essington, T.E., Kitchell, J.F., Boggs, C., Hilborn, R. (2002) Sharks and tunas: fisheries impacts on predators with contrasting life histories. *Ecological Applications,* **12**(3), 735-748.
Spens, J. (2005) Can Historical Names & Fishers' Knowledge Help to Reconstruct the Distribution of Fish Populations in Lakes? In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 16, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.
Stanley, R.D. and Rice, J. (2005) Fisher Knowledge? Why not add their scientific skills while you're at it? In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 20, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.
Stockner, J.G. (ed.) (2003) *Nutrients in Salmon Ecosystems: Sustaining Production and Biodiversity*. American Fisheries Society, Symposium 34. Bethesda, Maryland, 285p.
Storey, K. (1993) Defining the Reality. *Proceedings of the conference The Newfoundland Groundfish Fisheries: Defining the Reality*. ISER Press, St. John's NFL, 246p.
Sultana, P. and Thompson, P. (2005) Use of Fishers Knowledge in Community Management of Fisheries in Bangladesh. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 13, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

Swezey, S.L. and Heizer, R.F. (1993) Ritual Management of Salmonid Fish Resources. In: *Before the Wilderness. Environmental Management by Native Californians* (eds Blackburn, T.C. and Anderson, K.), pp. 299-327. Ballena Press, Menlo Park, CA.

Trippel, E.A. (1998) Egg size and viability and seasonal offspring production of young Atlantic cod. *Transactions of the American Fisheries Society*, **127,** 339-359.

UK Rolls of Parliament (1376/77) Vol.2, p.369. 50 Edward III, (99H3).

Watkinson, S. (2001) *The importance of salmon carcasses to watershed function*. MSc thesis, University of British Columbia Fisheries Centre, Vancouver, Canada, 111p.

Williams, A. and Bax, N. (2005) Integrating Fishers' Knowledge with Survey Data to Understand the Structure, Ecology and use of a Seascape off Southeastern Australia. In: *Fishers' Knowledge in Fisheries Science and Management* (eds Haggan, N., Neis, B. and Baird, I.G.), Chapter 18, this volume. Blackwell Science. Oxford, UK and UNESCO-LINKS, Paris xxxp.

---

[i] Westcoast and other Aboriginal peoples living in what is now Canada describe themselves as 'First Nations', a term that serves the dual purpose of affirming their presence long before the 'discovery' of Canada and that they must be treated on a nation to nation basis.

[ii] BC is unlike the rest of Canada in that few treaties were negotiated, leaving a vacuum. In 199o, the First Nations Summit, a group representing many BC First Nations entered into an agreement with the governments of Canada and BC to negotiate treaties. The process has been slow, and currently a number of First Nations have dropped out of the treaty process and are pursuing their claims through the courts.

[iii] Commercial salmon catch on the west coast of Canada varies between 60-80,000 tonnes, a substantial amount of which would have been returned to the watersheds prior to European contact and development of the commercial salmon fishery.