PACIFIC ECOSYSTEMS, PAST, PRESENT AND FUTURE:
Integrating Knowledge and Values, Anticipating Climate Change

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Abstract

First Nations developed 'Integrated, ecosystem-based management' thousands of years ago, creating some of the richest societies on the planet. Today, with resources depleted and fisheries in crisis, politicians seek 'alternative' sources of jobs and revenue. In British Columbia, government statistics put fisheries (commercial, sport, processing and aquaculture combined) at only 0.5 % of GDP. This puts depleted ecosystems on a game board where farmed salmon, oil and gas, etc., are sure to win.

Unlike the integrated, ecosystem-based management developed by First Nations, today, ecosystem-based management tends to be seen as an obstacle to more lucrative developments, e.g. farmed salmon and oil and gas and an additional cost or constraint on industrial activities from intensive commercial fishing to waste disposal.

First Nations recognize a much broader range of values to present and future generations. The Aboriginal view of a connected ecosystem, essential to life can play a key role in re-uniting ecosystem-based and integrated management. First Nations have vital contributions to make in providing the time-depth necessary to know what the ecosystem is capable of producing; linking fine-scale knowledge and management to regional and global issues and processes; and identifying the full scope of values to present and future generations.

We present an approach to linking ecosystem knowledge and values where synergy between traditional knowledge and past ecosystem records, computer modelling and current research enables prediction of future ecosystem states and ecological, social and economic consequences.

Introduction

Aboriginal creation stories recount that people have always lived in the Pacific Northwest. In 'Raven and the First Men', Haida people tell how Raven, the Creator and trickster, heard some strange sounds from a clamshell on the beach. Being curious, he opened it and the first Haida people came out, some boldly, some timidly, into the light of day. They have lived on Haida Gwaii (formerly known as the Queen Charlotte Islands) ever since. Other Nations have their own stories of their creation and relationship to their traditional lands, waters and sea zones. Raven and the First Men just happens to be particularly well-known because of the sculpture by noted Haida artist Bill Reid at the Museum of Anthropology in Vancouver[1].

[1] http://www.moa.ubc.ca/exhibits/permanent_exhibits.php

What matters here is that people have co-existed and depended on the environment and resources for an extremely long time. So far, the earliest archaeological evidence puts humans on Haida Gwaii over 12,000 years ago, when most of the land was covered with thick ice (Fedje 2004). What is now the archipelago of Haida Gwaii was then connected to the mainland by a grassy plain because of the vast amount of water locked up in continental ice sheets (Fedje and Josenhans 1998).

In the 12,000 years since then, the coastal ecosystem changed from tundra to rainforest, sea level rose as the ice retreated and six species of Pacific salmon (*Oncorhynchus* spp.) adapted to colonize rivers, lakes and streams. Slaney *et al.* (1996) identified ~9,600 different stocks of salmon. This count was made after extremely heavy commercial fishing, so the actual number of distinct populations may have been 40 % higher or over 13,000 (Carl Walters, UBC Fisheries Centre, pers. comm.).

While all this was taking place, Aboriginal people developed rich cultures, with at least 34 distinct languages[2] in British Columbia alone and sophisticated forms of governance and resource management. This cultural richness has formerly been credited to the abundance of salmon and the year-round availability of other resources, sometimes described as 'the myth of abundance and leisure'. Consistent upward revision of human population estimates, natural dips in the cycle of resource abundance and accounts of famine indicate otherwise. More recent thinking suggests that Aboriginal people accelerated the spread of salmon by transplanting salmon from one stream to another and the use of trap and weir fishing technology for genetic selection and to adjust run timing to meet food requirements (Haggan *et al.* 2006; Turner 2005). Salmon are a particularly striking example of resource management and enhancement before European contact (Johnsen 2001) but many other land and sea resources were also managed and enhanced to feed large populations and generate wealth (Haggan *et al.* 2006; Turner 2005; Deur and Turner 2005).

Salmon, people and the rainforest

The coast of British Columbia is made up of mountains with long inlets fed by glaciers and rivers. The climate is wet, with average rainfall increasing from south to north (Vancouver 1120 mm, Port Hardy 1,870 mm, Prince Rupert 2,410 mm). The luxuriant rainforest covering the coastal plains and well up into the mountains, retains significant quantities of water, regulating the hydrologic cycle and retaining soils and nutrients that would otherwise wash out to sea.

The six species of Pacific salmon[3] are specialized to spawn and rear in different freshwater habitats, but all migrate to saltwater when they are very small. Depending on species, salmon spend 2-5 years feeding in the ocean, before returning to freshwater to spawn. Pacific salmon die after spawning, contributing hundreds of tonnes of nitrogen, phosphorus and carbon to freshwater and forest ecosystems (Stockner *et al.* 2003). The size of past salmon runs is reflected in the growth rings of riverside trees (Reimchen 2001), but it doesn't stop at the bank. At least 40 creatures from people to bears to insects transport nutrients from salmon carcasses into the forest (Watkinson 2001). We know this because marine nitrogen is a different isotope (^{15}N) from terrestrial nitrogen (^{14}N) and has been used to trace the influence of salmon carcasses

[2] http://www.library.ubc.ca/xwi7xwa/lang.htm#bc
[3] Chinook, (*Oncorhynchus tshawytscha*); Sockeye, (*O. nerka*); Coho, (*O. kisutch*); Chum, (*O. keta*); Pink, (*O. gorbuscha*); and Steelhead, (*O. mykiss*).

up to 1 km away from the water's edge (Watkinson 2001). Gresh *et al.* (2000) estimated historic salmon escapements to the Pacific Northwest at 160-226 thousand tonnes, *vs* 11.8-13.7 today, indicating that nutrient inputs are about 6-7 % of pre European contact levels.

The First Salmon Ceremony

This 'new' scientific knowledge consists of elements that have been known for millennia, as reflected in the First Salmon Ceremony celebrated throughout the Pacific Northwest (Swezey and Heizer 1993; Anderson 2005). The first salmon to return in the spring are welcomed back to the territory. A feast is held where salmon are eaten and the bones and remains are respectfully returned to the river. If all is done properly, the spirit of the salmon will tell the rest of the salmon people that they were well treated, so that more salmon will come upriver the same and future years. The salmon consumed at the feast also make their way back to the forest sooner or later, linking people, salmon and forests. Myth, theory and practical implications for the 'resource economy' converge in our growing awareness of salmon as an ecological and cultural keystone species (Garibaldi and Turner 2004).

The First Salmon Ceremony had been driven underground and/or fallen out of use by missionary influence and other pressures, but is making a strong comeback. In 1994, Agnes Pilgrim and Dennis Martinez held the first salmon ceremony in 150 years on the Rogue River, Oregon (Martinez 2005). Vivian and Arnie Narcisse, co-author on this paper, played a lead role in reviving the ceremony on the Fraser River.

Salmon are an ecological keystone species (Power *et al.* 1996). Where they are plentiful, trees and bears grow bigger, there are more fish, more ducks, everything, the whole ecosystem thrives (Watkinson 2001). Salmon are also a cultural keystone species (Garibaldi and Turner 2004). Their contribution to economic and cultural wealth is signified by appearing in family crests on ceremonial regalia and works of art. The doors to Sty-Wet-Tan Great hall at the First Nations' House of Learning at the University of British Columbia, carved by Heiltsuk Nation artist Bradley Hunt, show how people, salmon and forests contain and support each other (Figure 1). These doors, signifying entrance to an Aboriginal education facility at a major research university, itself located on the traditional lands of the Musqueam Nation convey the importance of passing ecosystem knowledge down the generations.

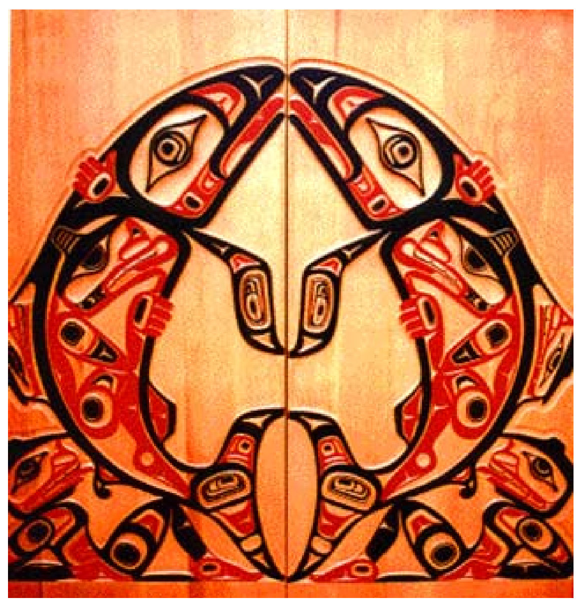

Figure 1. Salmon, cedar trees and people contain and support each other. Doors of Sty-Wet-Tan Great Hall, First Nations House of Learning, University of British Columbia. *Bradley Hunt, Heiltsuk Nation.*

Salmon consumption before European contact

There is a tendency to regard early Aboriginal fisheries as insignificant compared to the present day commercial catch. As indicated by the global importance of small-scale fisheries, this is far from the truth (Berkes *et al.* 2001). Current estimates of the coastal population prior to European contact vary between 200,000 and 400,000. The area round Prince Rupert Harbour and the mouth of the Skeena River supported some 8,000 people, one of the highest pre-contact population densities in North America (David Archer, Northwest community College, *pers. comm*.), with approximately 14,000 in Tsimshian territory and another 14,000 on Haida Gwaii (Boyd 1990). An early map showing Haida towns and villages on Gwaii Haanas (South Moresby Island) shows an extremely high density of occupation (Swanton 1905).

Taking the mid range of 300,000 and an annual consumption rate of 230kg of salmon, gives an annual requirement of 69,000t, or more than the average catch for the last 50 years of the commercial salmon fishery. There has been a steep decline in the overall catch over the 10 years from 1991-2001 (Figure 2; Haggan *et al.* 2006). The 230kg estimate is likely low as it dates to the late 19th century when populations had suffered successive waves of disease and diets were shifting increasingly to flour and potatoes (Jones, J.T. 2002). The climate is normally wet, but was particularly cold during the Little Ice Age between 1450 and the end of the 19th century, so there was a need for lots of high-energy food. During the fur trade, 'boat brigade' crews working for the Hudson's Bay Company consumed 4kg of salmon per person per day (Jones, J.T. 2002).

Declining salmon abundance

BC salmon catch has declined in recent years (Figure 2), with negative impact on the salmon fishing and processing industry. In response to this downturn and the need for increased Aboriginal access to salmon as part of the settlement of modern-day treaties, the governments of Canada and BC commissioned a report that recommended privatization of the very salmon fisheries that sustained Aboriginal people for over ten thousand years (McRae and Pearse 2004). The substantial drawbacks in this approach are analysed extensively in Jones *et al.* (2004) and Haggan *et al.* (2004).

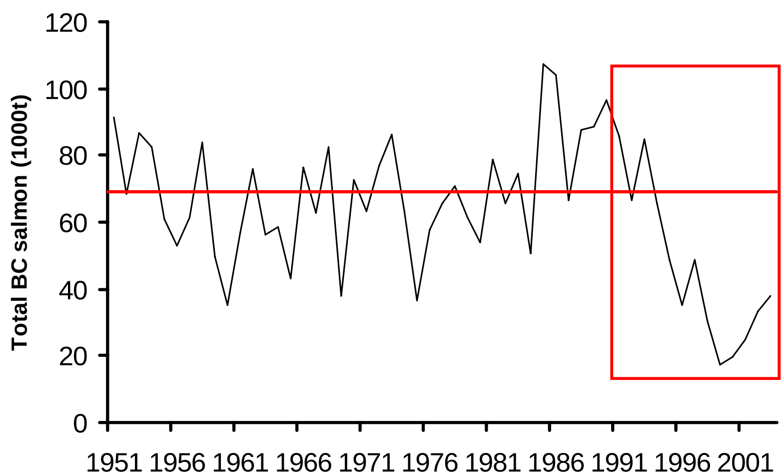

Figure 2. Total BC salmon catch 1951-2001. Red line shows average consumption for population of 300,000 at $230kg/yr^{-2}$. Box shows decline from 1991-2001. Data assembled by Ainsworth and Pitcher (2005).

Salmon, important then and now

Salmon are still vitally important to Aboriginal people. As Chairman of the BC Aboriginal Fisheries Commission, Arnie Narcisse spends his working life fighting for fisheries conservation and the rights of all Aboriginal people to manage as well as access marine and freshwater resources. This is a family tradition. His Great Grandfather Uthla, signed the 1911 Lil'wat declaration of sovereignty (Terry-Drake 1989) under his English name of John Baptiste. The declaration stated that the Stl'atl'imx people had owned their territories since ancient times and had never been conquered or ceded them to the settlers. The declaration required:

'…that all matters of present importance to the people of each of our tribes be subject to [treaties], so that we shall have a definite understanding regarding lands, water, timber, game, fish, etc…'

A mere 23 years after the Lil'wat Declaration, Fraser River salmon were so depleted that the government was building fish hatcheries. For Arnie, the fight to protect the great salmon runs is no academic struggle. Every year, he returns to the same fishcamp where his grandparents taught him to fish, and where he and his family are now teaching their grandchildren (Narcisse *in press*). One small family fishery on a short stretch of river might not seem to matter much in the great scheme of things, but globally, one billion people, or $1/6^{th}$ of the world's population depend on fish and seafood, mostly from small-scale fisheries (Berkes *et al.* 2001).

Threats to salmon

Today, the great salmon runs of the past are under threat from water diversion and habitat loss in their freshwater phase, overfishing and salmon aquaculture, climate change and privatization. Overfishing is a continuing threat. Although there are still over 9,500 stocks of salmon (Slaney *et al.* 1996), many are very small in number, while a few, notably 7 sockeye salmon stocks, are amazingly productive. The conventional wisdom is that salmon must be caught in, or close to, saltwater if they are to make the maximum market price. The problem is that many salmon stocks mingle on their homeward migration, so that, while some might tolerate a high catch rate, other, weak and less productive stocks can be severely overfished (Walters 1995). Some coho salmon stocks in the Strait of Georgia have been fished at 80 % (Walters 1995) with estimated loss of 30 % of the stocks (Riddell 1993, in Walters 1995).

While catch levels may be maintained by a few, highly productive populations; e.g. catch rate on Fraser River sockeye from 1954 – 1998 was 69 %[4], the loss of diversity and reliance on enhancement is risky in the long term. The huge Bristol Bay sockeye salmon fishery in Alaska depends on around 20 different stocks, but the stocks that support the fishery today are different than those that supported it 20 years ago, thus economic stability depends on biodiversity (Hilborn *et al.* 2003). Similar loss of genetic and/or bio-diversity has been noted for species as diverse as North Sea cod (*Gadus morhua*) (Hutchinson *et al.* 2003), New Zealand snapper (*Pagrus auratus*) (Hauser *et al.* 2002) and abalone (*Haliotis* spp.) (Prince 2003). The likelihood is that many more marine species will prove, over time, to be made up of many small and a few large populations, requiring a fine-scale, place-based approach to science and management closer to the traditional systems. At the same time, the existence of highly productive stocks and current fishing patterns demand cross-scale communication and collaboration between traditional and local knowledge, science and management.

[4] http://www-comm.pac.dfo-mpo.gc.ca/publications/speciesbook/Salmon/sockeye.fraser.html

In salmon farms, fish are held at high densities in net pens anchored in coastal waters. Salmon farming threatens wild salmon stocks and marine ecosystems in a number of ways. It contributes to overfishing by driving the price of wild salmon down, forcing fishers to catch more to stay economically viable (Naylor *et al.* 2003; Schwindt *et al.* 2003). Sealice from netpen sites infect salmon smolts as they migrate out to sea killing large numbers (Krkosek *et al.* 2004).

Salmon spawning and rearing habitat is also affected by habitat encroachment, water diversion for electrical generation, industry, agriculture, growing cities and towns and many sources and types of pollution. Salmon require cool water with lots of oxygen, so the combination of water diversion and higher temperatures attributed to climate change are a growing threat. Predicted warming of the Pacific Ocean due to climate change could make BC waters unsuitable for sockeye salmon in the foreseeable future (Welch *et al.* 1998).

Natural variability, ecosystem knowledge and wealth

Marine species are affected by natural cycles in the ocean. Thousand-year sequences of abundance of sardines and anchovies show huge fluctuations prior to modern industrial fisheries (Baumgartner *et al.* 1992). Total Pacific salmon catch also fluctuates with changes in ocean regime (Klyashtorin and Smirnov 1995). Almost 2000 years of salmon abundance from Karluk Lake in Alaska show changes in abundance that correlate to natural cycles long before the onset of the commercial salmon fishery (Finney *et al.* 2002). Natural variability would have impacted pre-contact harvests, creating, at times, scarcity and the real possibility of starvation. Pre-contact fishing technology was powerful enough to wipe out salmon runs many times over (Anderson 1996; Johnsen 2001; Jones 2002). So much so, that strict rules were developed to ensure that enough got through to spawn. Myths that convey the dire consequences of greed, waste and other 'disrespect' for fish are universal amongst BC First Nations. The inference is that mistakes were made and hard lessons learned as technologies were developed. The profound difference between then and now is that powerful fishing technology was used to increase abundance, rather than deplete the ocean as we do today.

Integrated, ecosystem-based management before European contact

High human populations and natural variability in the abundance of salmon led to the cultivation of many land and sea resources long before European contact (Haggan *et al.* 2006; Anderson 2005; Deur and Turner 2005; Turner 2005). Knowledge of salmon biology, behaviour and genetics was likely responsible for the transformation of Aboriginal people from hunter-gatherers to sophisticated, knowledge-based economies (Johnsen 2001). Intergenerational transfer of knowledge, including rules to constrain over-harvest and waste, enabled accumulation of 'surplus' wealth leading to social complexity and cultural richness. The link between knowledge, management and wealth is the key to 'Integrated, ecosystem-based management'.

Changing values

The Chiefs are instructed so that when they deliberate on the serious matters of the Council, they are to consider the impact of their decisions on the seventh generation into the future.

(From the Great Law of the *Hau de no sau nee*[5])

[5] http://sixnations.buffnet.net/Culture/?article=seventh_generation

The lion's share of pre-contact wealth came from the coastal and marine ecosystems. The ability to create this wealth demanded knowledge of the environment and ways to maintain and enhance resource productivity into the far future. This 'long view' is common to Aboriginal peoples and indeed, to many longstanding communities that depend on natural resources for their distinct identity and continuing existence. The long view is possibly best articulated in the 'Seventh Generation' principle of the *Hau de no sau nee* or Six Nations (Clarkson *et al.* 1992), from which, incidentally Thomas Jefferson and Benjamin Franklin are said to have borrowed the principle of representative democracy for the US Constitution[6]. From this perspective, harvesting all the fish to generate cash to invest in something else is insanity.

Today, we have many other sources of wealth; the information technology (IT) sector, service industries, pharmaceutical and bio-engineering industries, entertainment, cars, consumer electronics, construction, etc. Power and wealth tend to be measured in dollars. Fisheries are the most obvious source of dollars from marine ecosystems, but fisheries are a tiny fraction of 21st century economies (Table 1).

Table 1. Fisheries as percentage of GDP of the US, Canada and British Columbia

Country / Region	% of GDP	Source (and remarks)
USA (2003)[7]	0.30	FAO Country Profiles (Incl. forestry and hunting)
Canada (2000)[8]	0.21	Fisheries and Oceans Dept. of Canada (Commercial, aquaculture and processing)
British Columbia (2001)[9]	0.50	BC Govt. statistics (Commercial, sport, aquaculture and processing)

The small percentages in Table 1 explain why governments are reluctant to take fisheries seriously and why other investment opportunities such as offshore oil and gas and salmon farming appear so attractive to decision-makers. Another key reason is that dollars grow faster than fish (Clark 1973[10]). This insight accounts for the recent depletion of ecosystems. We want money for other investments, educating our kids, mortgages, SUVs, etc., faster than the ecosystem can produce fish to sell. It also accounts for government reluctance to invest in rebuilding depleted ecosystems (Sumaila 2004).

The separation of *Ecosystem-Based Management* and *Integrated Management*

Earlier we defined *integrated, ecosystem based management* as the application of ecological knowledge to generate wealth from natural resources. In other words, there was one main branch of knowledge related to one major source of wealth. Most of what we now count as wealth comes from other sources, each with its own branch or area of knowledge. This explains the separation of *ecosystem based management* from *integrated management* in Canada's Oceans Act and Oceans Strategy. The ecosystem principles are good, but the game of integrated management pits the potential revenue from depleted ecosystems against the money-making potential of oil and gas and farmed salmon and weighs ecosystem health against the costs of

6 http://www.ratical.org/many_worlds/6Nations/
7 http://www.fao.org/fi/fcp/en/usa/profile.htm
8 http://www.dfo-mpo.gc.ca/communic/statistics/oceans/economy/contribution/table3_4_e.htm
9 http://www.agf.gov.bc.ca/fish_stats/pdf/BC_Fisheries_&_Aquaculture_Sector_2002.pdf
10 Extinction is likely when the national discount rate is more than twice the species population growth rate.

proper treatment of urban and industrial waste. In the power game, the 'clout' of government ministers is determined by the profile of their departments and size of their budgets. This puts the fisheries minister at or near the bottom of the Cabinet food chain. Even if you can get their attention, there's not much they can do.

This is a bleak picture. What it suggests is that even if we get the science right, even if we could attain the level of ecosystem knowledge of an hereditary chief of the pre-contact era, able to draw on hundreds to thousands of years of knowledge and trained from infancy in the ecology and management of their territory, we would still have to contend with the perception that fisheries are trivial and ecosystem considerations are at best, a barrier to development.

We also have to address a tradition that is deeply rooted in and committed to single-species management and unduly influenced by industry and government priorities (Finlayson 1994). Ecosystem-based management is the new kid on the block. The lion's share of fisheries science and management funds still go to single-species approaches. This is not entirely a bad thing. There is a great deal of excellent single-species work. What we are not doing with any success is relating these individual studies and models to an ecosystem framework that connects species, habitats, people and environment.

Challenging today's integrated management

The core of the argument is that we have to balance long term environmental and resource conservation against the immediate need of citizens for jobs and government need for revenue. Fish stocks are depleted, so they produce fewer jobs and less income. Government management costs are high, given that fisheries are such a small part of the economy. Farmed salmon alone are worth more than the entire wild stock fishery, most of the revenue in foreign exchange. The oil and gas potential of northern BC is estimated at $110,000 billion[11]. Reducing urban and industrial pollution to save fish is just too expensive, some will argue.

The counter-argument is that coastal and marine ecosystems sustained societies for millennia. We do need jobs and wealth today, but ecosystems are key to our long-term survival. That being so, our first priority should be to ensure that the other sources of revenue we need today do no harm to the environment, and indeed should contribute to ecosystem restoration. For example, we should not extract the oil and gas until we are confident to be able to extract it without harm to the marine environment. When we do, we should use some of the revenue to address the cost of rebuilding depleted systems, so that a non-renewable resource could contribute to a legacy of sustainability. To make a convincing argument for restoration, we need to answer two questions:

1. What is the productive potential of marine ecosystems?
2. What is the total value of ecosystems to present and future generations?

How rich were past ecosystems? The Back to the Future Project

The failure of single-species fisheries science and management has led to calls for 'Ecosystem-Based Management', but the emerging concepts have little or no sense of history (Haggan *et al.*

[11] http://www.ens-newswire.com/ens/may2004/2004-05-27-01.asp

2006). Put another way, they aren't looking at the productive potential of the ecosystem as proven by past abundance. To find out what the ecosystem of northern BC was capable of producing, we had to go back to a time before modern industrial fishing began. Four computer ecosystem models of northern BC were built (Ainsworth *et al.* 2002):

- The present day (2000);
- The 1950s, at the peak of the salmon fishery;
- The 1900s, before bottom trawling started; and
- The 1750s, before Europeans arrived.

Figure 3 shows the percentage change in biomass for different groups and species between the 1750s, 1900s, 1950s and the present day. The results question assertions that northern BC waters are in 'good shape'. Indeed they are, compared with the Atlantic coast, and in great shape compared with the South China Sea (Cheung and Pitcher 2004; Cheung and Sadovy 2004), but are significantly depleted compared to their former abundance.

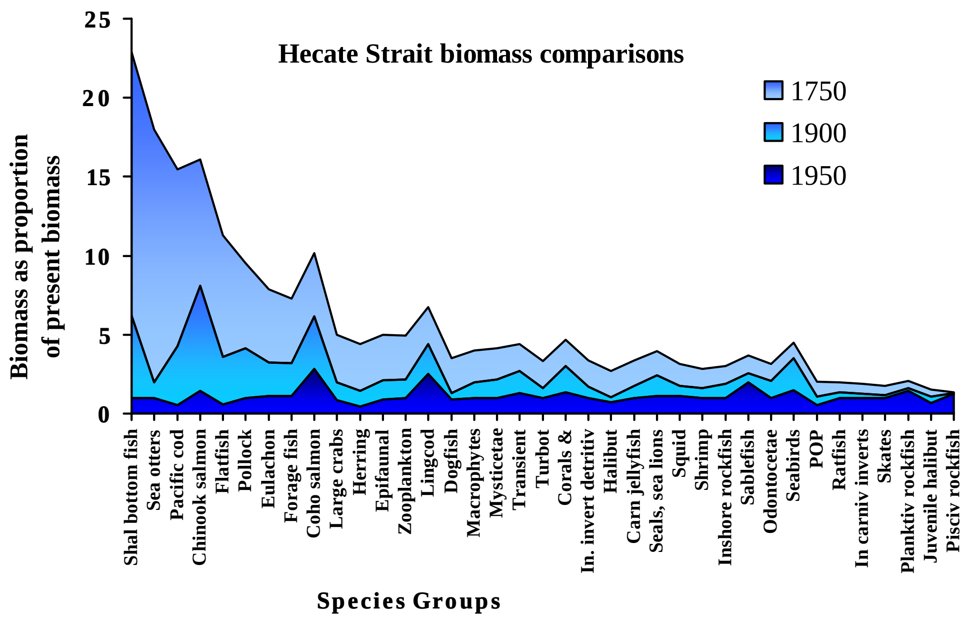

Figure 3. 1750s, 1900s and 1950s Northern BC biomass compared to present day, from Ainsworth *et al.* (2002).

These results question the wisdom of using present-day biomass as the 'baseline' against which to evaluate oil and gas, salmon farming and other development. Figure 3 also shows clearly that the current generation is having a raw deal with respect to ecosystem values. Projecting this picture into the future, the outlook for future generations is even bleaker.

Fishery values

As an audit of past performance, the model results show a dismal failure in stewardship. On a more positive note, they show a significant potential for restoration. Table 2 uses the 2000 ecosystem as a baseline to demonstrate the maximum revenue that could be derived from each of the 4 ecosystem states in Figure 3 after 50 years of fishing with a fleet adjusted to meet criteria in the UN Code of Conduct for Responsible Fishing (FAO 1995). The results clearly indicate that previous ecosystem states were considerably more valuable (Ainsworth *in press*).

Table 2. Sustainable production potential of 1750, 1900, 1950 and 2000 ecosystems in multiples of present. All figures are optimized for long-term economic harvest benefits (Ainsworth *in press*).

Model period	Catch	Value
1750	12.1	8.1
1900	4.2	4.9
1950	6.0	6.7
2000	1.0	1.0

As Table 2 indicates, the past systems could generate much more sustainable wealth in fish sales alone, but that is just one small aspect of total ecosystem value.

Total ecosystem value

"Half of the world's primary production comes from the ocean, so every second breath you take comes from the sea."

(Field *et al.* 1998)

Table 3. Contribution of fisheries to BC's Gross Domestic Product. Reproduced from BC Stats (2002).

Gross domestic product ($1997 million)	***2000***	***2001***	***% of total***	***% change since 1984***
Fisheries & aquaculture	***564***	***601***	***0.5***	***-5.0***
Commercial fishery	157	170	0.1	-14.9
Aquaculture	85	116	0.1	4907.2
Fish processing	89	82	0.1	-52.4
Sport fishing	233	233	0.2	-9.8
Goods sector	30,293	29,102	25.6	37.0
All resource-based industries	17,837	17,256	15.2	27.8
Agriculture & food	2,496	2,585	2.3	42.3
Service sector	82,764	84,746	74.4	82.0
Total, all industries	***113,058***	***113,849***	***100.0***	***68.2***

Fisheries accounted for just 0.5 % of the GDP of British Columbia in 2001 (Table 3; BC Stats 2002). Compared to 1984, commercial fisheries have declined by 15 %, fish processing by 52 % and sport fishing by 10 %. Aquaculture, almost all farmed Atlantic salmon (*Salmo salar*) is the only growth sector (BC Stats 2002). Contrast the pre-contact economy where fisheries made up the lion's share of wealth, and it becomes clear why the marine ecosystem counts for so little in private sector and government visions of the future. The recommended privatization of the BC salmon fishery (McRae and Pearse 2004) is directly attributable to a short time frame and an incomplete set of values (Haggan *et al.* 2006). Similarly, the rush to expand salmon farming and fast-track oil and gas is driven by the immediate boost in revenue anticipated by industry and government.

The decline in fisheries and other natural resources has drawn increasing attention to new and more comprehensive ways to value the natural world. Costanza *et al.* (1997) valued the Earth's ecosystem services at $US 33 trillion/year. Ecosystem services include the air we breathe, and the global conveyor belt that stopped in the movie, 'The Day After Tomorrow', a bit over-dramatic, but a good illustration of the importance of services which do not generally enter into economic analysis. We suggest that marine ecosystem valuation be based on benchmarks of past abundance (e.g. Figure 3) modified by the ocean and climate conditions we expect in the coming decades. This will give values many times higher than those in Tables 1 and 3; and provide incentive to rebuild ecosystems. It will also ensure that the marine environment becomes the context within which to evaluate other development.

Value to future generations

Most of us would rather have $100 today than $100 a year from now. Economists translate this time preference for money into a 'discount rate'. Both Canada and the US have national discount rates of around 7 %, to reflect the overall time preference. Applied to fisheries, a 7 % discount rate means that fish caught 50 years in the future have no value. Discounting future benefits explains why we overfish in the first place and why government is reluctant to put cash today into rebuilding depleted stocks that will take decades to recover and provide benefits, when voters are demanding healthcare, education, rebuilding the armed forces, etc., discounting works against ecosystem restoration, as benefits in the far future become inconsequential and cannot be used to justify the immediate expenditure (Sumaila 2004).

Discounting the future is unacceptable to First Nations who take a long view, as in the *Hau de no sau nee* principle of '7th Generational thinking' (www.iisd.org/7thgen/environment.htm; Clarkson *et al.* 1992) and fishing communities who would like to see their children and grandchildren enjoy the opportunities that existed in their or their parents' lifetime. It also runs counter to Canadian laws that requires management for future as well as present generations. The UN Code of Conduct for Responsible Fishing (FAO 1995) suggest that current fishing practices be subjected to much greater scrutiny, but it is unlikely that short term profit-taking will stop until we can find and agree on a more comprehensive and long-term valuation approach.

Intergenerational equity or fairness to future generations is at the core of First Nations' determination to protect natural resources to sustain culture and existence into the far future. This determination underlies the principle of 'Seventh Generational Thinking'. Canadian law for the environment, oceans, fisheries, forestry and parks requires that resources be managed for future as well as present generations. 'Intergenerational discounting' is a new approach that resolves the dilemma by including resource value to future generations (Ainsworth and Sumaila 2005; Sumaila 2004; Sumaila and Walters 2005).

Re-valuing US marine ecosystems

Marine ecosystem values are many and varied. Total value can be broken down into: (i) direct use value, e.g. fisheries and non-consumptive use from eco-tourism to cultural and spiritual values, physical and mental health; (ii) indirect use value, e.g. ecosystem services; (iii) option value, i.e., the ability to enjoy something that you may not be aware of now later in your lifetime; (iv) existence value, or the right of species, indeed all of nature, to exist independent of value to people and, (v) bequest value, i.e. the ability of all sources of value to benefit future generations. Aboriginal people and resource-dependent coastal communities are acutely aware of many of these values. There is increasing public concern that the natural world is undervalued when development decisions are made (Costanza *et al.* 1997; Daily 1997).

New methods developed by UBC Fisheries Centre and partners allow us to compute the ecological and social as well as the market value (Angelsen *et al.* 1994; Angelsen and Sumaila 1996; Sumaila *et al.* 2001). Table 4, derived from Sumaila *et al.* (*in press*), shows the increase in US fishery values obtained by applying the total resource valuation approach. The Non-market values include option, ecosystem service and existence values. Commercial and sport fishery values are based on current catch. The assessment of management as 'poor' is based on the depleted status of commercial fish stocks. Net present value (NPV) is the value of present and future catch discounted at the National discount rate of 7 % (Sumaila *et al. in press*). 'Restoration' corresponds to an 'Excellent' management scenario where depleted stocks are partially rebuilt. Some value to future generations is increased by reducing the discount rate from 7 to 3 %, but this likely does not go as far as the 7th Generation principle.

Table 4. Increase in value derived from US marine ecosystems using total resource value approach and interest of future generations.

Source of Value	**Management**	**Discount rate (%)**	**NPV ($USbillion)**
Commercial and sport fisheries	Current (Poor)	7	33
Add non-market values	Current (Poor)	7	108
Restoration	Excellent	7	377
Add future generations	Excellent	3	879

Is the valuation complete?

While the broader valuation in Table 4, derived from Sumaila *et al.* (*in press*) increases value by almost twenty seven times, some factors are not yet included. The number of people who go to the seaside for holidays is huge. Some portion of this vast economic sector is certainly due to the general perception of the sea as wild and unspoiled and because of the likelihood of seeing whales, seals, seabirds and fish. This would also account for a significant amount of the generally higher price of waterfront property. Globally, almost 10 times as many people live on or near the coast as inland (Gommes *et al.* 1998). As noted, one billion people, or 1/6th of the world's population depend on fish and seafood for protein (Berkes *et al.* 2001). This type of value could be fairly readily quantified by the methodology used for Table 4, leading to much higher figures.

Other values and qualities, such as the spiritual and cultural values of particular species, places and the intergenerational rights that may be associated with them are less readily quantified (Lucas 2004). Also, the holders of such values are likely to resist attempts to express them in dollars as it seems to trivialize the value or open them up to commercial exploitation. While Aboriginal people are the most articulate about these values, e.g. Lucas (2004 and *in pressa*), most people have some favourite place, possibly associated with their childhood; that it would grieve them to see changed, or some article handed down to them that they would not part with for money. Expressing these values in a way that the holders find respectful and that decision-makers will take into account is a challenge that can only be addressed where different traditions of knowledge are respected (Haggan 2000; Lucas *in pressb*). The same applies to the whole body of literature, art, poetry, songs and other forms of expression inspired by the beauty, wildness, terror and bounty of the ocean. The list is far from complete, but if we can add up what these are worth to us and our children, the figures will be very large.

Anticipating climate change

Climate change scenarios indicate that as temperatures increase, key species such western red cedar (*Thuja plicata*) may well disappear from BC, or be sharply reduced in range and/or abundance. Such changes will impact the social-ecological fabric of BC, falling particularly hard on First Nations. They will challenge our current watershed and coastal management systems, calling for policy responses and initiatives undreamed of today.

Figure 4. Ian Reid examining Heiltsuk paddle at the Royal BC Museum, Victoria. *Photo by Bessie Brown*

Cedar trees were integral to Aboriginal society for everything from housing, storage boxes, and clothing to canoes, the main means of transportation and trade. No canoes had been built for a long time, until the Heiltsuk Nation revived the tradition in 1986 by carving a traditional dugout cedar canoe. As it was the first in a long time, they named the canoe *Glwa*, the Heiltsuk word for ocean-going canoe. *Glwa* made a profound impression when the Heiltsuk arrived at Expo '86, Vancouver's Centennial celebration after paddling 100s of miles from their home in Bella Bella. In 1989, the Heiltsuk paddled to Seattle and issued a challenge to other First Nations to meet in four years in Bella Bella. This evolved into a great canoe celebration which has come to be known as '*Qatuwas*'—'people gathering together. In 1993 the Heiltsuk hosted the historic *Qatuwas* festival, when 23 great Canoes from Washington and BC were paddled to Bella Bella to celebrate the return of the Canoe Culture (Cranmer 1997).

In 2005, Ian Reid, a young Heiltsuk artist carved a 37' (11 m) traditional red cedar canoe and paddled to Klallam in Washington, as part of the 2005 Tribal Journey, visiting 11 Tribes on the way. 80 canoes took part in the 2005 expedition, including the first ever Aleut entry (Ian Reid, Heiltsuk Nation carver, *pers. comm.* 2005).

Marine ecosystem change

Rising temperature will reduce overall survival for all salmon species[12]. Climate change may increase natural variability in the future, but has already been shown to have the effect of moving the spawning area of fish northwards, as for small demersal fish in the North Sea (Perry *et al.* 2005) and herring in the Strait of Georgia (Tom Therriault, Fisheries and Oceans Canada, *pers. comm.* 2005). A relatively small rise in ocean temperature could make BC waters unsuitable for sockeye salmon (Welch *et al.* 1998) with devastating effect on Aboriginal people and the commercial fishery. 'Southern' species from Humboldt squid (*Dosidicus gigas*) (Cosgrove 2005) to hammerhead sharks (*Sphyrna zygaena*) are appearing in BC waters with greater frequency. This is new to us, but the Tsimshian language has a word for hammerhead shark (Watkinson 1999) and Nuu-chah-nulth oral history and archaeology confirm the presence of

[12] http://wlapwww.gov.bc.ca/air/climate/indicat/salmonsea_id1.html

bluefin tuna (*Thunnus thynnus*) (Crockford 1994; 1997). Brown (2005) gives an interesting account of uncommon sea visitors that figure in Haida art, regalia and house design. Warm water species of note include green sea turtles (*Chelonia mydas*), loggerhead turtles (*Caretta caretta*) and great white sharks (*Carcharias carcharodon*), known to early Haida people as the 'mother of dogfish' (Brown 2005).

Future directions

The goal of the Back to the Future project was to use benchmarks of past abundance, diversity and trophic structure to set restoration goals that relate to the productive potential of the ecosystem rather than present scarcity (Figure 3 and Table 2). Present and future changes in species due to climate change mean that we will have to look, not just back in time, but also south to warmer waters to predict future ecosystems.

Linking global and regional oceanographic, climate and foodweb models

'When Captain Cook came to our country, he saw salmon, he saw sea otter skins, he saw forests, he saw wealth, he saw people in loincloths. What he didn't see was intelligence.'
Chief Simon Lucas, Fourth World Fisheries Congress, Vancouver, 2004

Over the next 2-3 years, we propose to link global, regional and local climate change ocean regime and foodweb models. Global model output will drive regional and local models that combine the knowledge of Aboriginal partners with the strengths of regional foodweb models (e.g. Ainsworth *et al.* 2002; Ainsworth *in press*) and the fine-scale mapping capability of MARXAN used for conservation and marine use planning in BC (Ardron 2002, 2003, 2005) and GIS. Climate change scenarios will modify benchmarks of past abundance, diversity and trophic structure to account for new 'species assemblages', e.g., warmer water ecosystems similar to those of Oregon or California.

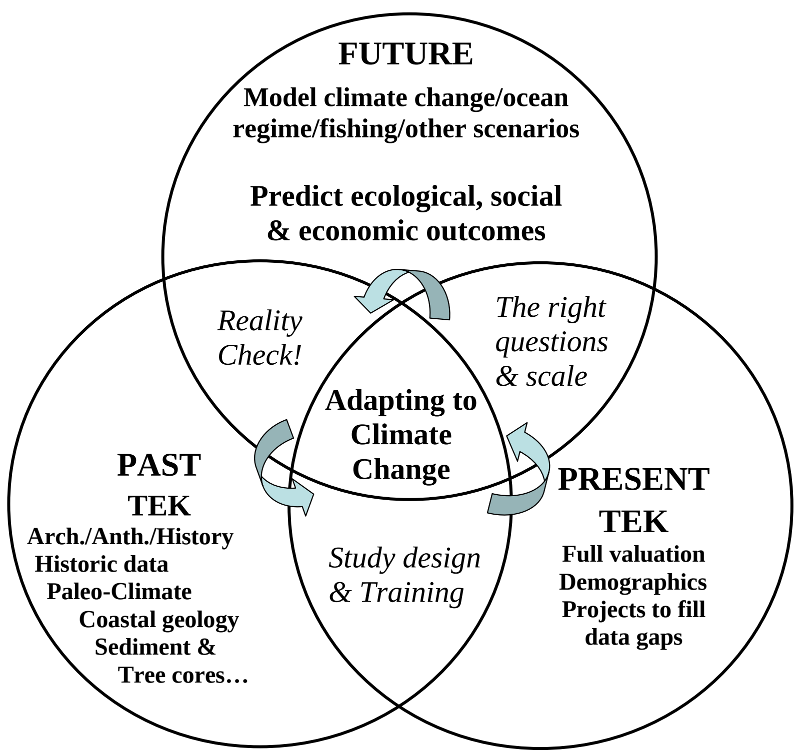

Figure 5. Synergy between knowledge of the past, present research and computer modelling enables prediction of future ecosystem states and ecological, social and economic consequences.

Economic and social outcomes

Comprehensive valuation of ecosystem benefits to present and future generations (Sumaila *et al. in press*) combined with impacts on property values, social fabric, services etc, will be used to predict the ecological, economic and social consequences of climate change scenarios (Figure 5).

Conclusion

The world ocean covers 70 % of the planet and provides unseen but vital services to all life on earth. Marine ecosystems are our common human heritage. Their fisheries, scenic, cultural and other attributes have sustained human communities for thousands of years and have the potential to bring sustenance, wealth and joy to future generations. There is growing acceptance that living creatures have a right to exist, captured in the concept of 'ecosystem justice' (Brunk and Dunham 2000) and that their survival cannot be assured by their market value (Ommer 2000; Sumaila and Bawumia 2000; Ainsworth and Sumaila 2005).

For these reasons, the health of marine ecosystems should be the primary consideration in the decision whether to proceed with oil and gas, offshore mining, salmon farming and other activities such as effluent disposal which are more lucrative and/or convenient in the short term, but may foreclose options for future generations.

We need to re-create the *Integrated, ecosystem-based management* of earlier days by re-linking climate, ecosystems and society (Figure 6). To achieve this we need to combine the power and beauty of integrative science with the intelligence and experience that Captain Cook failed to see.

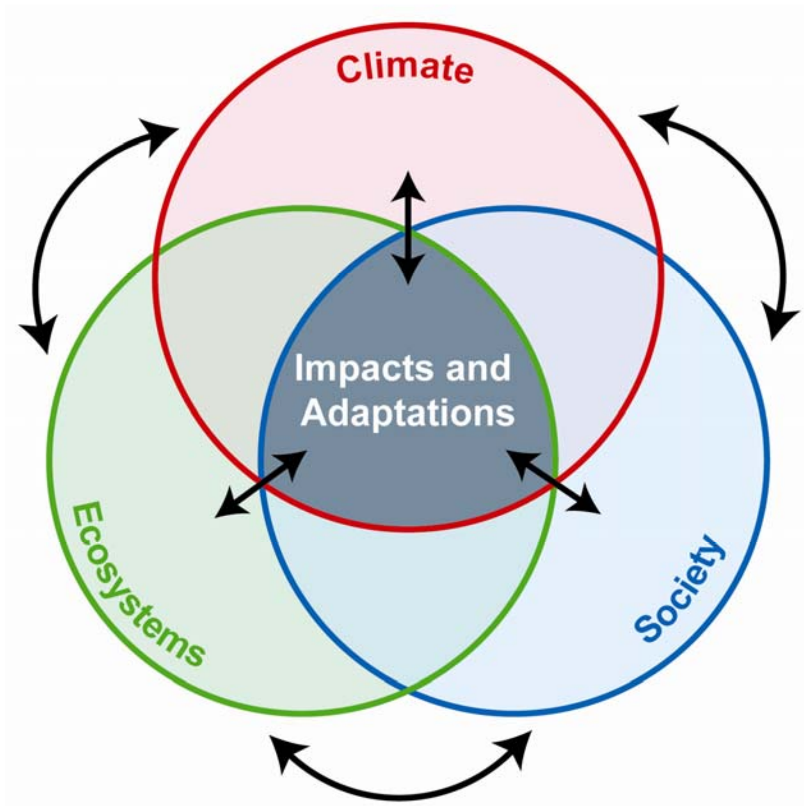

Figure 6. A Social-Ecological model linking ecosystem knowledge to social values in a changing environment. Figure courtesy of Rosemary Ommer and Carrie Holcapek, Coasts under Stress Project.

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