The historical development of fisheries in New Zealand with respect to sustainable development principles

Dr Mark T. Gibbs*

* Dr Mark T. Gibbs is Stream Leader of Aquatic Resources Monitoring and Modelling at CSIRO, the Commonwealth Scientific and Industrial Research Organisation.
Email: Mark.Gibbs=a=csiro.au (replace =a= with @)

Introduction

Over the last decade global fisheries have increasingly been under scrutiny from a range of viewpoints. The major driver of this scrutiny has been the lacklustre economic and biological performance of so many fisheries around the world ranging from small-scale artisanal fisheries such as for beche-de-mer in pacific island lagoons to major fish stocks that underpinned the economic development of whole nations. There is now clear evidence of the demise of so many fisheries (*i.e.* Mullon *et al.* 2005, Myers and Worm 2003, Hampton *et al*. 2005) that this chronic global problem is finally being widely recognised and addressed, albeit slowly.

However, the 'problem' as such depends on your perspective and worldview. For example from a neo-classical economic perspective the issue is typically defined in terms of the infuriatingly low economic efficiencies in many fisheries (often underpinned by subsidies that lead to excessive fleet sizes in relation to the resource base) and almost complete dissipation of rents. Often labelled as 'too many fishermen chasing to few fish', the dramatic overcapitalisation has often been attributed to the self-interested behaviour of individual fishermen (Clark 1985). While seemingly 'irrational' from a social perspective, this behaviour is perfectly rational from the perspective of individual fishers or boat owners faced with an open-access resource.

Under an open access regime, any fish left by boat A will be available for capture by boat B – and vice versa. So, the owners of both A and B have strong incentives to capture all the fish they can, subject to the constraint that the cost of capturing the last fish does not exceed the price that can be fetched at market. Hence, under open access, rational behaviour on the part of individual boat owners leads to over-fishing by the fleet. Economists such as Gordon (1954) predicted the resulting inefficiencies that have developed.

From a regional policy perspective, over-fishing and subsequent commercial extinction of fish stocks have the potential to lead to dramatic social problems, particularly for coastal communities that developed over centuries on the back of specific fish stocks. Similarly, from a fisher's perspective the collective behaviour of fishers, along with inadequate management and stewardship practices can lead to individuals being left with essentially worthless assets and little hope of passing on knowledge and seafaring culture to future generations. In addition, from an environmental advocacy perspective, industrial fishing in particular has now been shown to have the ability to reconfigure entire marine foodwebs (Pauly *et al*. 1998). The full effects of these practices are unknown, and may never be known, but are unlikely to be helpful in terms of the delivery of essential ecosystem goods and services.

Economists have long argued that the best solution to the 'fishing problem' has been to allocate property rights to fishers who will then have a strong incentive to look after the natural capital. Although such rights, either as ITQs (Individual Transferable Quotas), IFQs (Individual Fishing Quotas), specific area quotas, or community catch quotas have potential advantages, the establishment of such rights-based schemes has been slow. New Zealand has arguably been at the forefront of the implementation of rights-based schemes in fisheries and hence a number of researchers have followed the progress of this 'experiment'. Since there are now a number of analyses of the performance of the ITQ regime in New Zealand (*i.e.* Annala 1996; Batstone and Sharp 1999, Yandle 2003; Newell and Sanchirico 2005), the emphasis here has been to take a broader look at the development of New Zealand fisheries, the majority of which took place over the last century, culminating with the establishment of the ITQ regime. A further objective is to discuss whether ITQs are a necessary and sufficient condition to achieve broad sustainability in fisheries

where we define sustainability to include more than just the biological sustainability of target species.

The seafood sector has been a major contributor to New Zealand export revenue over a number of decades, and the sector is presently the fourth largest export earner behind the dairy, meat and forestry sectors. New Zealand's wild harvest fisheries have transformed from small-scale almost artisanal fisheries, to well-established domestic inshore fisheries, and are now sophisticated export fisheries dominated by catches of deepwater species. Similarly, much of New Zealand's fledgling aquaculture sector commenced only a few decades ago with a series of government-led research projects that spawned private sector investment, initially through the entrepreneurial activities of a small number of pioneering individuals, some of whom remain as major figures in the aquaculture sector. Of interest in the New Zealand case is the fact that due to the isolated nature of the majority of wild stocks, the fate of the fisheries has been largely determined by New Zealand policies and local responses to external markets. In other words, unlike the majority of large global fisheries, the fate of the fisheries have not been strongly influenced by the direct harvesting actions of neighbouring nations (with the exception of several sporadic examples such as the early Australian-based whaling vessels, as discussed below).

History of the development of New Zealand fisheries

Although indigenous Maori have been utilising fishery resources for many hundreds of years, commercial exploitation of fishery resources in New Zealand has largely been restricted to the last two hundred years, beginning with sealing and whaling crews often sent from Australia. Table I contains a list of key events in the history of New Zealand's fisheries. This list is by no means exhaustive, but rather aims to highlight key historical events. The information contained in Table I was compiled from a number of sources although the principal reference for the history of fishing in New Zealand must be considered to be comprehensive work of Johnson and Haworth (2004).

The evolution of these New Zealand's wild harvest fisheries, as shown in Table I, displays a number of consistent threads, which may be summarised as follows:

- The exploitation, and in some cases over-exploitation of accessible sedentary resources (*i.e.* shellfish beds) during the late 19th century.
- Boom and bust exploitation cycles of several stocks (*i.e.* Tasman Bay spawning snapper aggregations, Chatham Islands crayfish).
- Discovery and development of previously unfished deepwater stocks by foreign fleets prior to the establishment of the EEZ.
- State subsidised development of deepwater fisheries immediately following establishment of EEZ.
- Over-capitalisation resulting from government incentives and subsidies, and subsequent biological sustainability issues as fishers struggle to keep vessels fishing.
- Allocation and conservation conflicts between fishers and the management agency, and between the management agency and elected officials.
- More recently, allocation conflicts between developing recreational fisheries and established commercial fishers, and increasing public concern over bycatch and habitat destruction issues.

Of relevance here is that many, if not all of the recurrent themes identified above have occurred throughout fisheries in particularly industrialised nations. For example almost the same pattern can be seen in many fisheries in North America (Walters and Martell 2004). However, a key difference is that two of the greatest problems in global fisheries: over-capitalisation and illegal, unreported and unregulated (IUU) fishing practices (Gallic and Cox 2006) have largely been solved (with the main exception of poaching of abalone and rock lobster, and dumping/high grading practices driven by lack of availability of quota) in New Zealand, thanks largely to the introduction of the QMS and associated support processes (Annala 1996; Batstone and Sharp 1999; Bess 2005).

Dumping and high-grading are in some ways an almost inevitable outcome of quota-managed fisheries. The most common approach to solving this is better vessel monitoring and compliance regimes, combined with more selective gear, where possible. However, these compliance operations can be labour intensive and expensive, especially in large fleets of small vessels targeting many species. In an ideal compliance world, the gear would be so selective as to catch only target species of the desired size: every animal landed on deck would be recorded and either returned alive, or processed. However, while advances particularly in on-board remote vessel monitoring technology are underway, gear selectivity remains relatively poor in many cases. Meanwhile so long as the total allowable catch remains low and quota trades somewhat limited (at least at the time

Table I: **Summary of key dates in the development of New Zealand wild harvest fisheries**

Date	*Event*
Pre ~ 1800	Indigenous Maori subsistence fishing along many stretches of NZ coastline.
~1800–1820	Sealing boom period and to a lesser extent sea-based commercial whaling (collapsed in 1840s).
1820–1840	Sporadic pakeha (a Maori term describing European settlers and their descendents) fishing and oyster harvesting (wild stocks), Maori utilising coastal finfish stocks.
1840	Treaty of Waitangi signed between Maori chiefs and pakeha representatives gives Maori a set of rights to fishery resources.
1840–1880	Oyster trade 'gold rush': primarily North Island rock oysters but also Tasman Bay and Foveaux Strait beds developed.
1866	First NZ fisheries legislation gazetted (Oyster Fisheries Act 1866) in response to concerns of overfishing of oysters and to a lesser extent mussel beds.
1877	Fish Protection Act gazetted to allow for area closures arising from concerns over overfishing of several coastal fish stocks.
1882	First commercial steam trawling operations established.
1883	Refrigeration practices become widespread and first shipment of frozen NZ flounder arrives in London. A number of coastal canning operations were set up during this period for species including mullet and 'groper' to feed newly established markets particularly in North Island coastal towns (*i.e.* Sanford fish market in Auckland established in 1894). Conflicts with Maori over access to coastal stocks begin to intensify.
1899	L.F. Ayson appointed NZ's first Chief Inspector of Fisheries. Ayson was committed to developing fisheries in order to supply domestic consumption. Ayson played a major role in reducing exports (in order to make more domestic product available) and the widespread introduction of trawlers.
~1900	Oil-engine vessels introduced into fisheries. These vessels rapidly replaced traditional oar or sail powered inshore dories and fishing vessels.
1907	First government trawling expedition with the objective of identifying and discovering new fishing grounds.
~1910	A number of new local fisheries established, including Chatham Islands cod fishery.
1920–1940	Trawling and Danish seining operations increased and put pressure on inshore stocks such as snapper. A number of domestic conflicts between fishers, processors and retailers occurred, often as a result of an influx of particularly Dalmatian fishers and merchants. However, Sea Fisheries Investigation Committee (1936) recommended further reduction in exports (and effort), and increased emphasis on distribution to ensure consistent domestic supply (total NZ catch estimated at ~18 000 t).
1933	First foreign-registered fishing vessel to fish in NZ coastal waters.
1939–1944	A large proportion of steam powered fleet seconded to armed services. Despite dramatic fleet reduction, unlike in Europe, landings still remained high (~16 000 t p.a).
1944	Trawling re-commenced in Auckland. Port Chalmers is the largest fishing port in the South Island, principally landing inshore demersal species such as sole. Vessels still restricted to landing at port of registration and vessel size still mostly small.
1950	Trawling becomes by far the most popular method (70% of landings by 1955). Inshore fishing restrictions increase and fishers must steam further to grounds. Total landings still increasing (25 000 t by 1959). South Island Association of Federated Fisherman formed (1952).
1956	Fiordland crayfish boom resulting in a dramatic increase in catching effort as vessels from the east coast based themselves on the remote south-west coast.
1961	Secretary of Marine reported that "Conservation of our fisheries resources through restrictive licensing is no longer effective". Japanese vessels began fishing close outside territorial (3 nm) limit. Total NZ landings ~26 000 t.
1964	Scott Report released and an end to restrictive licensing followed. This opened up the catching sector to newcomers and merchants/processors following removal of privileged rights of existing vessel registrations. Fishing Industry Board established and the majority of appointed members had no direct sectoral experience. Fisheries Research Division established and first large research vessel (*James Cook*) acquired in 1969. Tory Channel whaling station closed. Tasman Bay open access scallop fishery established.

Date	*Event*
1965	Territorial Sea and Fishing Zone Act allowed the existing 3 nm national fishing zone to be extended to 12 nm offshore. Extended zone refused to be recognized by Japanese vessels until 1970. Total New Zealand catch thought to be around 56 000 t. Sanford fishing company breaks into Japanese market although primary export market still Australia.
1966	Chatham Island crayfish boom commences and many vessels relocate from Fiordland to follow the new boom.
1969	Squid fishery developed by Japanese just outside 12 nm zone. National Development Conferences identify opportunity to significantly expand exports from fisheries resources although 1962 Export Incentive Scheme had already been offering substantial incentives to the sector.
1971	Japanese fishing immediately offshore of the 12 nm zone increases as a result of extensive Japanese fisheries research identifying new stocks. Catch from this sector thought to be ~ 130 000 t in 1971- around three times the total catch within 12 nm zone from NZ domestic fleet (43 000 t- primarily snapper at 14 000 t). Soviet trawlers develop Southern Blue Whiting fishery and Soviet and Japanese trawlers begin to extensively target hoki (Blue Grenadier).
1973	Chatham's crayfish boom over as stocks heavily depleted. During the peak of the boom over 230 vessels were thought to be fishing the stock and one factory (Yovich & Hopkins) was processing up to 33 t wet weight per day. During the peak period (1966–1969), around 25 000 t of crayfish are thought to have been caught- over twice that caught from the extensive Fiordland coast over a longer ten-year boom period.
1975	New species fisheries began to develop in earnest (barracouta, kahawai, mackerel, pilchards, trevally, red cod…), often underpinned by government tax incentives. Rapid industry development facilitated by strong central government support. Concerns over resource sustainability often quashed by strong development pressure. Hake fishery developed by Japanese (18 000 t caught in 1977).
1975–1976	Orange Roughy 'discovered' by NZ'ers on Chatham Rise although Roughy had been caught by Russian vessels since late 1960s. By 1981, value of Rough fishery third in NZ behind snapper and skipjack tuna.
1977	First NZ Total Allowable Catch (TAC) set at 262 000 t for fin fish in anticipation of forthcoming EEZ determination. 95 000 t was set aside for NZ vessels, 167 000 t for foreign vessels.
1978	200 nm Exclusive Economic Zone established. Automatic access to foreign vessels disabled and Joint Ventures (JVs) established with NZ companies such as Talley's, Sealord, Sanford, and Solander. Fletcher Fishing company established and a number of JVs were created with other traditionally non-fishing NZ companies. Tasman Bay snapper boom targeting spawning aggregations begins and ends (1977–1982).
1979	Wellington trawlermen campaign to control 'over capitalization and effort' in inshore fisheries although Government strongly encourages increases in fishing effort in deepwater fleets.
1980	Snapper landings fall from 18 000 t to 12 000 t despite increased fishing effort.
1982	New Zealandisation of fisheries underway as more NZ crewed vessels enter deepwater fishery. Two-thirds of total catch now exported. Deepwater TAC set at 363 000 t (104 000 t for foreign vessels, 126 000 t for JV vessels and 110 000 t for NZ vessels). Vessels still largely allowed to fish when and where they pleased although particularly inshore fishers concerned over the biological status of stocks. The beginning of the end of the emphasis on fishery productivity and the beginning of a move towards more emphasis on biological sustainability of stocks. Tasman Bay scallop fishery closed to allow recovery.
1983	Concern that larger deepwater vessels were moving into inshore areas and catching inshore stocks. Government policy to develop deepwater fisheries thought to be often largely ignoring over-capitalisation in inshore fisheries. Fisheries Act 1983 passed and led to restructuring of fisheries management services. This led to a major attempt to remove latent effort (part-timers) from particularly inshore fisheries although Government was still supplying financial assistance and export incentives to inshore fishers under Muldoon National Government.
1984	New Labour government announced a moratorium on financial assistance to fishers. Industry and government considered approaches to reduce effort and over-capitalisation in NZ fisheries and general opinion is that decades of subsidies have encouraged fleets to become over-capitalised. Concept of establishing ITQs (Individual Transferable Quotas) floated. Value of deepwater fisheries still steadily increasing (~20% p.a). Orange Roughy contributed one-quarter of total fishery export value (1 000 t of Roughy was worth around $1M to NZ). Hoki catch increasing (35 000 t landed in NZ in 1985) and the TAC increased to 250 000 t in 1986 against recommendations by key industry stakeholders.

Date	*Event*
1986	Quota Management System introduced to the fishery on 1 October. Initially set as total tonnages, quota holdings were subsequently changed to a proportion of the TAC. The newly developed assets in the form of ITQ property rights are also thought to have led to change in the relationship between MAF and larger fishing companies to a more litigious relationship.
1987	First signs of social consequences of QMS- aggregation of quota and catching effort and subsequent loss of small operators. Soon nine companies will own 86% of lucrative Orange Roughy quota.
1990	First full factory trawler processes hoki at sea (Vela trawler *Ottar Birting*). This led to a trend in reduction of shore-based processing operations. Development of the scampi fishery underway.
1992	The 'Sealord deal' whereby the government purchased Carter Holt fisheries assets and used the purchase to settle the Treaty of Waitangi fisheries action (the Treaty of Waitangi [Fisheries Claims] Settlement Act). Indigenous Maori in a position to purchase half of Sealord fishing, a major quota owner.
1993–1995	Quota aggregation and consolidation of the fishing interests. By the end of this period the majority of quota had been purchased and held by a small number of large-vertically integrated companies. For example, Sanford had purchased around half its quota and Talleys around 99%, being initially allocated only around 1%. This is thought to have led to substantial increases in economic efficiency of the industry, but acted to disenfranchise many small operators and foreign catching had been substantially reduced.
1995–2004	A lack of new quota has constrained industry growth (but capped landings and restrained fishing mortality on stocks) and large companies either investigated non-QMS species, such as scampi (Simunovich had five vessels fishing for scampi in early 1990s), or overseas investments. Sanford had three vessels fishing in Tasmania and in 1994 invested in Chilean pelagic fishing operations. Sealord invested in operations in Namibia in 1996 with the transfer of the *Will Watch* and *Whitby*. Southern Ocean Toothfish fishery developing and Sealord gained a CAMMLR (Commission for the Conservation of Antarctic Marine Living Resources) license in 1997 with others to follow soon after.
2004–2006	High NZ dollar, increasing fuel prices and in some cases cuts to quota (*i.e.* hoki and other deepwater species with the major exception of squid) has resulted in lower retail and landed returns and increased catching costs. Major companies becoming less reliant upon domestic stocks and more reliant upon international operations. The decade 1995–2005 also saw more active participation from the recreational sector. As New Zealand's economy has grown, more effort has been directed towards catching recreational stocks such as North Island snapper and blue cod in the Marlborough Sounds. Increased public scrutiny over ecosystem effects of fishing including bycatch and habitat destruction. Ministry and industry relationship remains litigious.

the fish is being caught), dumping is likely to continue in many quota managed fisheries.

It is also important to highlight that many of the biological sustainability issues generated by past fishing practices cannot simply be blamed on the 'greed' or single minded wealth-pursuing behaviour of the fishing industry, or individual operators. For example there are a number of cases where government policy has directly led to over-capitalisation of fishing fleets, against the strongly voiced views of many fishers. Having said that, it would be wrong to blame central government alone for the over-exploitation of fisheries resources, since often decisions were based on very limited information on the catch or stock size, or information that was subsequently proved to be incorrect. Analyses of the performance of the QMS suggest that New Zealand has been able to rein in rampant over-fishing (Batstone and Sharp 1999). However, there appears to have been substantial social side-effects: as quota became aggregated, social inequality most likely increased and many traditional Maori fishers lost their cultural connection with fishing practices (Batstone and Sharp 1999, Stewart. *et al.* 2006.).

Does this mean that current New Zealand fishing practices have become sustainable? There are several different viewpoints on this. For example, whilst MFish (New Zealand Ministry of Fisheries) has stated that it believes that present management strategies should mostly allow those stocks below acceptable limits to rebuild (MFish 2006), prominent non-governmental organisations (NGOs; Forest and Bird, and Greenpeace, Allsopp *et al.* 2007) have been particularly critical of aspects of the biological management of New Zealand fisheries, including the management of the hoki fishery (under the ITQ regime) and benthic habitat destruction in deepwater fisheries in general. However, before investigating these issues, that are actually biological sustainability issues, it is worthwhile briefly clarifying definitions of sustainable development.

The Brundtland Commission defined Sustainable Development as '*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*' (WCED, 1987). Attempts to interpret and codify these concepts have led to a rapidly expanding literature and new tools that claim to assess sustainability (*e.g.* triple bottom line reporting systems). However, many such approaches rapidly converge to arguments about trade-offs that lead to disappointment for environmental advocates when the economic benefits are judged to outweigh environmental costs. In some cases, advocates have sought to utilise new methods of non-market valuation of ecosystems and ecosystem goods and services in order to redirect these trade-offs in favour of their preferred environmental outcomes, although this approach has often not been well accepted.

The concepts of hard (strong) and soft (weak) sustainability offer a potentially useful distinction. Weak sustainability allows for the substitution between natural and human capital sources (Pearce and Atkinson, 1992). For example, natural capital (such as a fish stock) may be reduced through harvesting and replaced by a corresponding increase in other forms of capital of at least equal value (Garcia and Staples 2000). It has been claimed that managing a fish stock under weak sustainability criteria might lead to the commercial extinction of the stock (Clark, 1985; Hilborn 2007).

By contrast, hard or strong sustainability assumes that natural, social and economic capital are not interchangeable and cannot be traded off against one another. As applied to fisheries, the concept means that no stock may be reduced beyond the point in which it cannot be renewed. The concepts of *Maximum Sustainable Yield (MSY)* and equivalent biomass (B_{msy}) are loosely related to strong sustainability. These have a long and contentious history (*i.e.* Punt and Smith 2001) and are a foundation of both the 1982 Convention on the Law of the Sea and the 1995 FAO Code of Conduct for Responsible Fisheries. However, *MSY* and B_{msy} have been exposed to criticism over the ethical and practical uncertainties surrounding the transfer of capital from natural to anthropogenic sources and sinks and this has hindered their utility.

Even the definition of biological sustainability is open to various interpretations. For example under some definitions a stock status of below 20% unfished biomass may be regarded as endangered. In the US, the National Standard Guidelines under the Magnuson-Stevens Act state that "*overfishing occurs whenever a stock or stock complex is subjected to a rate or level of fishing mortality that jeopardizes the capacity of a stock or stock complex to produce MSY on a continuing basis*". It is theoretically possible that stocks that have been fished down to extremely low levels relative to the unfished biomass may be sustainable as long as the catch rates still allow for at least the maintenance of stock size or prevent declines to the point where the population goes extinct. It has long been argued that the point of commercial extinction occurs before population extinction and hence commercial fisheries rarely lead to the actual extinction of species. Nevertheless, allowing a stock to get to low levels relative to unfished biomass may constitute a failure of management; unless of course this was the intention. Biological sustainability in this article is defined in terms of the trajectory of the stock status. In other words, if a stock status is already low by comparison to the unfished biomass and is on trajectory leading to smaller stock sizes then this is regarded as a biologically unsustainable trajectory if allowed to continue.

In a broad theoretical sense, the Brundtland definition has wide and intuitive appeal. However, as we now know, implementing sustainable development principles is not straightforward, and as recently highlighted by Beckerman (2007), definitions of sustainable development such as Brundtland's can be so vague that they become operationally useless. Furthermore, the concept of sustainable development as presently advocated is loaded with ethical conundrums, such as dealing with inter-generational equity issues that are far from resolved. There has unfortunately been a tendency to gloss over these shortfalls and move directly towards developing and implementing methodologies for assessing whether an activity is actually sustainable. However, there is a conspicuous absence of a common methodology for assessing sustainability. This is unsurprising in light of the vagueness of the concept.

In fisheries management, several key meetings have been held to discuss this issue; for example the workshop on Fisheries Sustainability Indicators held in association with the World Fisheries Congress in Brisbane, Australia in 1996, and the Australian-FAO Technical Consultation on Sustainability Indicators in Marine Capture Fisheries in Sydney during January 1999. A key outcome of the FAO work has been the development of the FAO approach titled: *Indicators for Sustainable Development of Marine capture Fisheries*. Although there have been other methods of assessing fisheries, for example the RAPFISH approach (Pitcher and Preikshot 2001), the FAO standards encapsulate the key concepts as interpreted by the developers. To the author's knowledge, NZ fishing practices have not been formally assessed against

these frameworks and it is beyond the scope of this work to undergo this exercise. By contrast, it is within the scope to discuss pertinent aspects of NZ fisheries that have in the past been on a biologically unsustainable trajectory, as this can be achieved without necessarily agreeing on a consensus-based definition of exactly what sustainable development is.

As highlighted previously, two of the biggest issues in global fisheries are over-capitalisation and illegal, unreported and unregulated fishing (IUU fishing; Jackson *et al.* 2001). New Zealand had made great strides into solving both of these global issues, and has been more successful than most -- if not all – governments in solving some of the issues. For example, the New Zealand approach of compulsory catch and landing reporting, in co-operation with balancing logbooks against receipts from licensed fish receivers has gone a long way in reducing IUU fishing practices, with the main exceptions being poaching of high value inshore species such as abalone (paua) and rock lobsters, and some dumping practices rumoured to occur. Similarly, the Quota Management System, introduced in 1986 largely in response to over-capitalisation issues, is generally thought to have been successful at least in slowing down over-capitalisation through output controls (Total Allowable Catch limits and Individual Transferable Quotas; Batstone and Sharp 1999).

However, having said this, many of New Zealand's fisheries resources were already depressed to around, and in some cases below, 20% of virgin (unfished) biomass prior to the introduction of the QMS (*http://fish.govt.nz* 2006). A number of fisheries in New Zealand still remain at very low stock levels by comparison to the virgin biomass, and the likelihood of these stocks ever being able to recover to unfished biomasses is often argued to be low. Hence after 20 years of ITQs, little rebuilding is evident in many stocks and in some cases stocks, such as hoki, may actually be in a worse state (MFish, 2006). We must also remember that over the past century there have been a number of conspicuous examples of biologically unsustainable fishing practices in New Zealand whereby stocks were rapidly fished down over a very short time: these could include the Chatham Islands crayfish boom in the late 1960's, some of the Orange Roughy harvesting practices, and rapid fishing down of Tasman Bay spawning snapper aggregations. The Orange Roughy fishery in particular was widely criticised as a mining operation rather than sustainable exploitation of a renewable resource even before it was discovered that the growth and reproductive rates of the stock were extremely slow by comparison to coastal and pelagic species (Coburn *et al.* 1994). Similarly, the rise and fall of the rock lobster or crayfish fishery in the remote Chatham Islands off the east coast of New Zealand reads like a textbook Wild West boom and bust cycle (Johnson and Harworth 2004).

The success of the QMS in reigning in excess capacity and helping to slow down biologically unsustainable fishing practices (Annala 1996) makes a case for the effectiveness of this output controlled management regime on helping to control biological sustainability problems with individual fish stocks, despite the data-hungry nature of this approach. However, there are several areas where the effectiveness of the QMS as a means for establishing and maintaining even biologically sustainable practices is less clear. The first of these areas is also ecological and involves the 'ecosystem' effects of fishing.

The QMS is inherently a single species approach to fisheries management and although allowances can be made for associated and dependent species in the setting of TACs (Total Allowable Catch) and TACCs (Total Allowable Commercial Catch), these are largely treated as externalities in the allocation processes. By contrast, proponents of ecosystems-based fisheries management (EBFM; Pikitch *et al*. 2004) argue that management agencies and stakeholders should be managing ecosystems, rather than simply target populations within ecosystems. Critics of EBFM on the other hand argue that managing entire ecosystems on a scientific basis is ineffective given our present lack of knowledge about particularly the behaviours of large marine subsystems (Mace 2001). If one seeks to achieve 'strong' sustainability, any fishing-related habitat destruction and incidental bycatch issues would have to be addressed under whatever management regime is adopted. However, this need not be the case under 'weak' sustainability.

New Zealand has tackled incidental bycatch issues (*e.g.* dolphin bycatch in set nets, seabird bycatch in longline fisheries and sea lion bycatch in squid fisheries) in a generally constructive manner. Nevertheless, proponents of 'strong' sustainability continue to complain. For example, the NGO Forest and Bird has made repeated submissions to the Marine Stewardship Council (MSC) that the hoki MSC sustainability certification should be renounced as a result of the issue of incidental bycatch of fur seals (submission to MSC on 16 December 2002).

Since the introduction of the QMS, there has been a strong emphasis on the biological components of sustainability in New Zealand with particular regard to restricting fishery outputs to a point where stocks are around or above a best estimate of long-term sustainable

yields. However, the introduction of the QMS has led to substantial changes in the socio-economic aspects of fisheries in New Zealand (Stewart *et al.* 2006). There have clearly been increases in economic efficiency of fisheries associated with amalgamation of quota and vertical integration of harvesters and processors (Bess 2006); although there appear to be exceptions to this, such as the major reduction in hoki quota that occurred in 2004 (down to 100 000 t from 250 000 t in 2001). But the same changes that led to increased efficiency have also led to social upheaval and measurable changes to some traditional smaller fishing communities around New Zealand (Stewart *et al.* 2006 report that over 3000 fishers have exited the fishery since the introduction of the QMS). For example, many of the smaller ports around New Zealand have seen a decline, whilst larger ports such as Nelson have expanded. There has also been a substantial decline in the number of smaller owner-operator vessels.

Of course, many of these social changes had to occur in order to resolve the issue of over-capitalisation in fisheries. But they could have taken place in different ways, depending on the structure of the institutional arrangements adopted. The key question to ask here is whether the objective of a fishery is to create a sustainable income stream for quota owners through increases in efficiency and more effective management controls, regardless of the impacts on the wider community, or whether it should have a broader social goal. As far as the author can determine, there is yet to be any clear investigation of how well economic benefits derived from increasing the fishery efficiency have been converted into other forms of capital.

One of the major assumptions behind introducing a property rights regime is that the property rights-holders (quota owners) will have a positive incentive to take care of the resource. But as with any property rights system – especially one in which rights are held in common, such as an ITQ – there are imperfections. In New Zealand, the majority of quota (by tonnage) are vested in large companies, whereas a very large proportion of fish are harvested by contract fishers, who purchase Annual Catch Entitlements (ACE) from quota owners. Hence the rights-holders are generally one-step removed from the actual on-water operations. This causes classic 'principal-agent' problems: the quota owners (principals) are not able perfectly to observe the behaviour of the harvesters (agents), who are liable to inflict damage in various ways. One specific consequence of this principle-agent problem is ecological damage, such as benthic habitat destruction.

Another problem arises from the often strained and increasingly litigious relationship between the industry and the Ministry of Fisheries. While it takes two to tango, the Ministry has failed adequately to shift away from its 'command and control' mentality to become a true facilitator of the implementation of the ITQ regime. Had it done so, it would have enabled better resource stewardship by rights-holders. One reason for the failure of the Ministry to change is that individual fishery managers still retain a strong sense of mistrust of industry members that was spawned long before the establishment of the ITQ scheme. This culture is also reinforced by the fact that the ITQ scheme has done little to stop some of the negative ecological side-effects of fishing. This is not surprising: it was structured to increase economic efficiency in the harvesting and management of commercial species, not to achieve broader ecological goals. In order to address some of these ecological effects, the Ministry has resorted to traditional command and control approaches, thus undermining the trust with the industry and reintroducing perverse incentive for the industry not to be good stewards.

Conclusions

In the past 100 years, the New Zealand fishing industry has grown from an almost artisan base of many small owner-operated boats to a highly economically efficient industry dominated by a few large vertically-integrated companies. These companies manage a number of contract harvesters, and process and market a range of products from intertidal shellfish to deep-water species caught using very sophisticated technology.

The fishing industry has had periods where harvesting practices have clearly not adhered to the concepts of hard or strong sustainability. Particular events in this category include the Chatham Islands crayfish boom, some of the early Orange Roughy fishing practices and the fishing down of Tasman Bay spawning snapper aggregations, all of which saw stocks almost driven to commercial extinction over a handful of years. However, these instances occurred under the close management of the government department of the day, and in some cases were actually subsidised through government schemes.

The establishment of the QMS in 1986 signalled a move towards a fisheries management regime that focused on increasing economic efficiency and co-incidentally went a long way towards solving many of the pressing issues that still remain in global fisheries: namely gross over-capitalisation of fleets and illegal, unregulated and

unreported fishing activities (with the exception of some nearshore poaching, dumping and 'trucking'- harvesting in one area and claiming to have harvested in another, infringements). The introduction of the QMS thereby sent a strong message that New Zealand's fisheries were no longer a social activity, but rather were to be viewed as a wealth generating activity.

Whilst the QMS may have addressed at least some of the main biological sustainability issues with targeted fish stocks, some argue that there is still some way to go towards addressing other sustainability issues, such as those associated with incidental bycatch and benthic habitat destruction.

As to whether the development of the New Zealand fisheries has adhered to wider sustainable development principles: this really depends on the particular sustainability framework under consideration. For example, over the last century many of the fish stocks have been reduced to a small fraction of virgin unfished biomass, and remain in this category. According to a weak sustainability approach, this is acceptable as long as the natural capital extracted from the fish stocks have more than been compensated by an increase in economic and/or social capital. To my knowledge, this question has never been formally or adequately answered.

From a strong sustainability standpoint, many observers claim that New Zealand fisheries remain unsustainable. Viz., benthic habitat destruction, incidental bycatch and appropriation of marine biological productivity to sustain fishery yields. However, there have been a range of government and industry initiatives to address these issues. Plausibly, New Zealand might even create a fisheries industry that complies with strong sustainability criteria. However, given that science is constantly finding new ways in which mankind is damaging the environment, it is questionable whether any fishing activity will ever be truly strongly sustainable. Moreover, as the fishery attempts to move towards strong sustainability, it might be less sustainable according to 'weak sustainability' criteria, if for example less human capital were created.

The establishment of rights-based schemes in New Zealand led to property rights being allocated in perpetuity and this has enabled the establishment of an effective quota market and allowed more investment security. However rights allocated in perpetuity also have the potential to restrict future options: although in theory the rights have no explicit spatial component, in reality there is an implicit spatial component to the rights which may potentially act to hinder the establishment of, for example, new marine protected areas and space for alternative uses such as energy generation of aquaculture activities (Gibbs 2007a). Hence, despite the obvious short-term benefits of the ITQ regime in New Zealand, the medium to long-term implications are more difficult to adduce.

Nevertheless, the management of these fisheries does seem to be more effective (but not perfect) at ensuring the *biological* sustainability of target stocks than perhaps the majority of alternative regimes presently being practiced around the world (Kaufman *et al.* 1999). So in that sense they do seem to be moving towards sustainability, however it is defined. Who knows, maybe one day it will even be possible to extract some direct rent from fisheries.

It is equally clear, however, that ITQ regimes which explicitly manage target species are insufficient to ensure the sustainability of associated and dependent species. By definition, ITQ approaches aim to cap the harvest of quota species. There is no reason why ITQ approaches cannot be expanded to include non-target and non by-product species although these other species for the most part lack commercial value, so there is no direct incentive for fishers to purchase quota for these associated species unless these quota substantively act to restrict the ability of fishers to harvest commercially valuable species. In such cases fishers could trade quota on, say, corals, which would then lead to the realisation of monetary value for these species that are incidental to the fishery. The major drawback to this approach is that a great deal of scientific information is required in order to set a defensible quota. In addition, the collection of such information is generally costly, especially if a large number of species or marine communities are involved and fishers often have no direct incentive to subsidise the acquisition of such information. Policing the compliance of the take or destruction of these other species has also proven to be problematical, although new on-board catch monitoring technology may alleviate this issue in the future.

It therefore appears that ITQ regimes as presently practiced are neither a necessary nor a sufficient condition to ensure sustainable development. However, at least in the case of New Zealand, they have been a major milestone on the pathway that ultimately hopes to achieve sustainable domestic fisheries.

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