Commercial fisheries of the Bay of Islands: history, present harvesting pressure, and ecological impact

John Booth

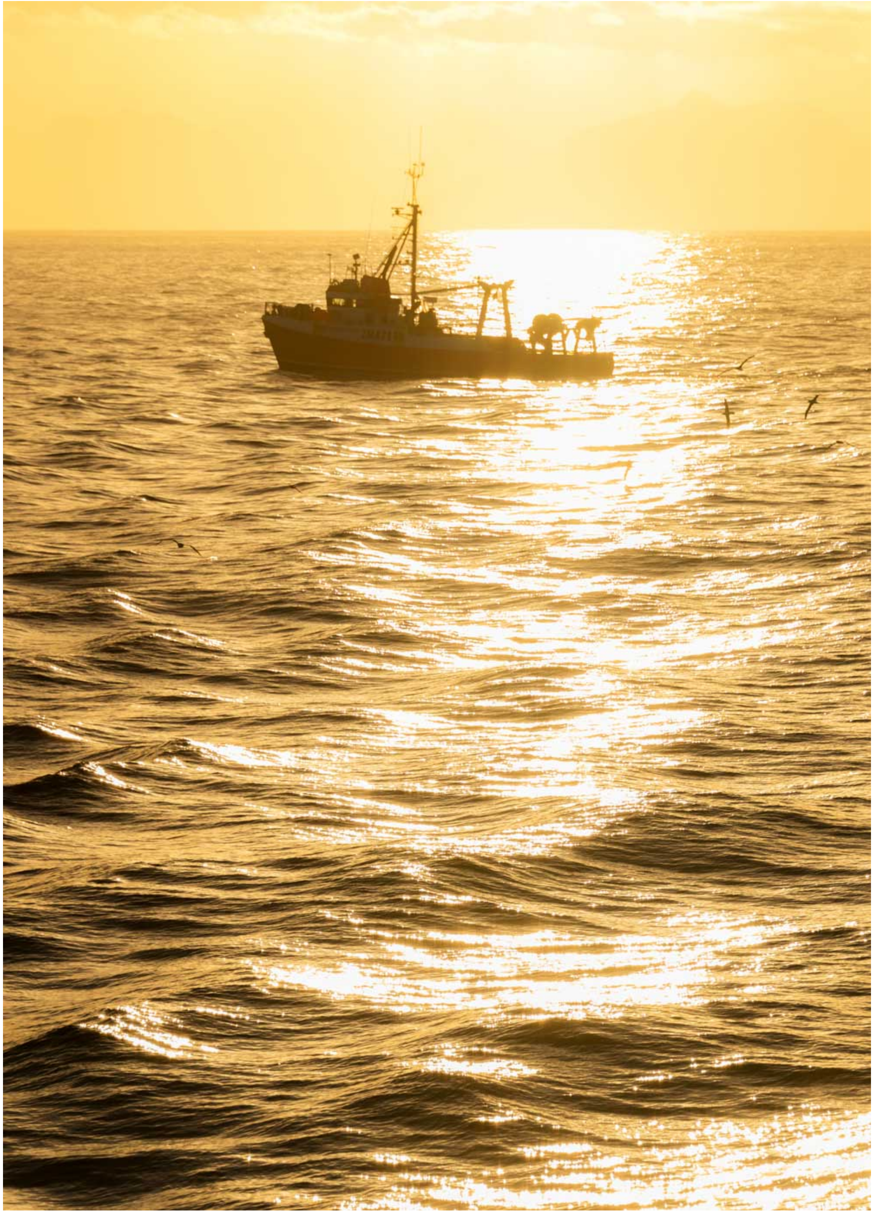

Photo: Dave Allen, NIWA

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Summary

For much of the late-1800s to the mid/late-1900s, the Bay of Islands, centred on the port of Russell, supported significant commercial fisheries. They were noteworthy because they began early in the piece (mid-1800s); they were close to the large Auckland and east-Australian markets; and, at least during the fish-down phase of individual species, harvests were significant. Today's remaining fish stocks are able to support only modest levels of fishing pressure, this being maintained by a small commercial fleet augmented by hundreds of recreational fishers and their vessels.

A handful of mainly small (<7 m) local boats continues to commercially fish within the Bay of Islands (Tikitiki to Motukokako, and part of General Statistical Area 003). Their main harvests include—using set nets and beach seines—flounder, garfish, grey mullet, snapper and trevally, with perhaps a few dozen tonnes across the board each year. (Also, red rock lobsters are potted.) However, from time to time, visiting vessels line, net and trawl within the Bay of Islands for such fish as snapper, trevally, flatfish and grey mullet. The total numbers of fishing events each year of these visiting vessels amount to an average of only a dozen or so net-sets and fewer than a dozen trawls, but around 33 long-line-sets. Also, purse seining of pelagic species like skipjack tuna, pilchards and mackerels near the mouth of the bay can be significant.

Because most finfishes of commercial interest in and near the Bay of Islands do not spend their entire lives there, the status of the underlying stock is critical to the Bay of Islands; this also applies to rock lobsters. The stock status of most species important in the area is poorly known, but many have been/are overfished. Overfishing of keystone predators—especially large snapper and large rock lobsters—has led to widespread loss of shallow-reef kelp in the Bay of Islands, the resulting urchin barrens being as extensive as those anywhere in the country.

1. Introduction

Sharing the ocean's living resources, and issues around the social licence of fishers to extract more-or-less willy-nilly, are topics of discussion in New Zealand at present, with a strong constituency arguing that fishing pressure should be reduced; no-take refuges be established; and that alternative, more-appropriate spatial allocations be considered (e.g., large commercial vessels leave alone areas heavily frequented by recreational/customary fishers, even though they may hold quota to fish there).

Fishing pressure derives from commercial, recreational and customary users. (Additional categories— estimated illegal catches and other sources of mortality—are also considered in some stock assessments.) Typically, a fish population exploited for the first time provides high catch rates, and yields a broad size- (and age-) distribution of individuals; catch rates usually remain high during the fish-down phase (often with serial depletion of localised groupings of individuals), with both the mean-size and the proportion of large individuals declining only slowly; and after the fish-down phase, the fishery becomes largely dependent on only a few year classes, with catch rates stabilising at a level much lower than when fishing began.

Bay of Islands, centred on the port of Russell, has in the past supported significant commercial fisheries (Booth 2016a). They were noteworthy because they began early in the piece (in particular, rock oysters and grey mullet, in the mid-1800s); they were relatively close to the large Auckland and east-Australian markets (rock oysters and grey mullet at first, but then a wide variety of species—*see* the annual Report on Fisheries, published by the Marine Department from the late-1800s to mid-

1970s, and overviewed by Paul 2014); and, at least during the fish-down phase of individual species, harvests (particularly of snapper) were significant.

Today's remaining inshore fish populations are able to support only modest levels of fishing pressure; this pressure is maintained by a small commercial fleet which is emphatically exceeded by that of hundreds of recreational fishers and their vessels (Booth 2016b). And customary harvesting has been—and remains—locally important, particularly in remote coastal communities such as Rawhiti, with my estimate being perhaps 10 t a year taken across all species.

Booth (2013) reviewed the Bay of Islands commercial fishery data for the fishing years 2008/09 to 2012/13; this report updates things to 2014/15. The earlier paper considered landings and relative $-values of essentially all commercial finfish species with local annual harvests of at least 10 t, as well as invertebrates and seaweeds, whereas this paper focusses only on the principal nearly-20 finfish species, as well as rock lobsters (although the fuller data sets are included here as appendices).

The purpose of this paper is to update the characterisation of the principal commercial fisheries of the Bay of Islands. First I summarise the overall Bay of Islands marine fishery, with particular focus on the history of the commercial sector; then I focus in some detail on recent catch characteristics of the nearly-20 main finfish and one main shellfish species harvested commercially in the Bay of Islands, and the status of their underlying stocks; and, finally, I discuss some of the ecological implications of the heavy harvesting pressure that continues to this day in the Bay of Islands.

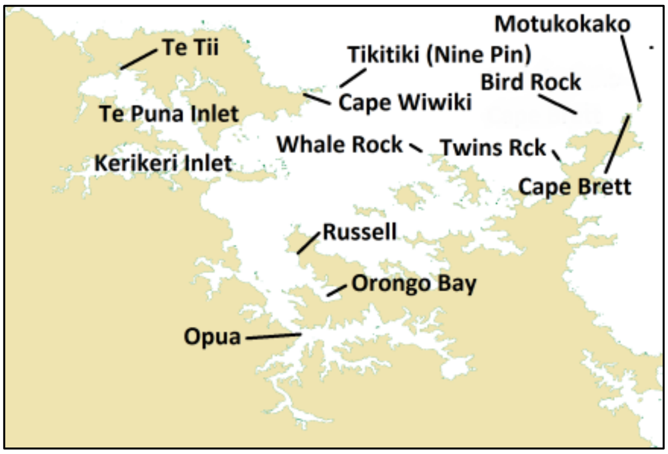


Figure 1. Bay of Islands showing place names mentioned in text.

2. Commercial fishery data

Most commercial fisheries in New Zealand waters are managed under the Quota Management System (QMS, the exceptions relevant here being albacore and skipjack tuna), with data reported by species according to the enormous Fishery Management Areas (Figure 2) or Quota Management Areas (QMAs; Appendix 1). The usual fishing year is 1 October to 30 September.

The finest-scale geographic subdivisions of catch and effort data for Bay of Islands' trifling fleet of mainly small commercial vessels routinely available to the general public are for (General) Statistical Area 003 (Karangi, near the west end of Taupo Bay, south about 200 km to Waipu Cove; Figure 2), available on the National Aquatic Biodiversity Index System (NABIS) website (http://www.nabis.govt.nz/). NABIS data for Statistical Area 003 for the 2008/09 to 2014/15 fishing years were examined on 21 August 2016.

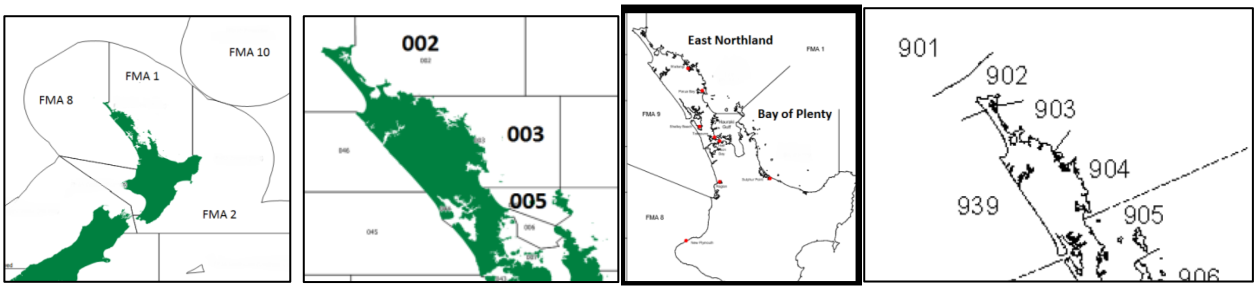


Figure 2. From left: Northern Fishery Management Areas; (General) Statistical Area 003; East Northland Substock of SNA 1; Rock Lobster Statistical Area 904.

In addition to the NABIS data, and to be found on the MPI website (http://www.fish.govt.nz/en-nz/Commercial/About+the+Fishing+Industry/Maps+of+Commercial+Inshore+Fishing+Activity/default.htm), are summaries of recent fishing activity reported by 1-nautical mile rectangles for trawlers, and lining and netting vessels. Almost certainly, these data are for visiting vessels, ones obliged to furnish more detailed locational data than the smaller, local inshore ones. On 21 August 2016, these data were available for the 2007/08 to 2012/13 fishing years.

3. History of commercial fishing in the Bay of Islands

3.1 Early fisheries

Although commerce with Māori began at very first European contact—at James Cook's visit in 1769, to followed soon after by the victualling of numerous foreign vessels including whalers—the first marine resource in the Bay of Islands to be commercially harvested in a contemporary sense was the native intertidal rock oyster *Saccostrea glomerata* (Booth 2016a). Concern over overfishing meant that in 1866 rock oysters came under the Oyster Fisheries Act 1866 which allowed 'the Commissioner of Crown Lands….to lease areas of foreshore adjacent to Crown land for a term of 14 years for the purpose of establishing oyster farms….Anyone who established a farm had to pay to lease the foreshore and pay again to pick his own oysters' (Johnson & Haworth 2004).

Keeping tabs on the harvesting of a wild stock occupying such an easily accessed band of the intertidal around much of the Bay of Islands was, however, always going to be difficult. Because of this, and with typhoid deaths attributed to oysters harvested near sewers, the Government itself in 1907 took over the whole business of commercial wild-oystering. Between 1912 and 1973 the Marine Department marketed close to an average 2000 sacks (each containing 90 dozen) of Bay of Islands oysters each year, the peak approaching 6000 sacks, in 1914 (Booth 2016a). And from about the early 1920s, many of the oysters came from kilometres of rock groynes established intertidally for spat settlement and oyster growth (Figure 3).

Figure 3. Left: Oyster picking in the Bay of Islands in 1909. Right: Area of newly laid-out rocks in the lower reach of Kerikeri Inlet in 1922. (Sources: Auckland Weekly News)

Harvesting of wild rock oyster for direct sale ended in the 1970s, after the farming of them had proved both possible and economic in Australia. The first trial oyster farm was established on leased shore in Bay of Islands' Orongo Bay, in the mid-1960s; the next, at Te Tii soon after, was followed by a flood of new applications. Feral oysters were picked for transfer to the farms, and soon spat caught from the wild on sticks in harbours to the south were being trucked north.

The other early commercial fishery of note was for the grey mullet *Mugil cephalus*. Extraordinarily abundant along Northland's west coast and its harbours, mullet were also plentiful in the tidal reaches of east coast inlets, and specialised 'mulleties' were developed from which to net them. The first substantial canning operation was Masefield Brothers', established on the north end of Kororareka Beach (Russell) in 1889, and which ran for almost two decades (Figure 4). (Although fish-smokers outnumbered fish-canners around the turn of the century—no fewer than ten of them operating in the Bay in 1909, their primary products being grey mullet, snapper, blue maomao, and parore according to the annual Reports on Fisheries—the impression is that most were small, backyard affairs.)

In about 1891, Walter Mountain established the *Penguin* brand cannery on the north side of the Bay of Islands, and this one lasted longer (Figure 4). Most fish were netted in Kerikeri and Te Puna inlets, a couple of boats being engaged year-round (Boese n.d.). Opening of the rail link from Opua to Auckland in 1912 spurred things along, with the Purerua cannery producing 545 cases in 1914, each containing 6 dozen tins. Closure of the factory, in 1935, 'was due to the scarcity of the mullet; the depression; and the high cost of importing the ingot sheet-tin from England' (Boese n.d.).

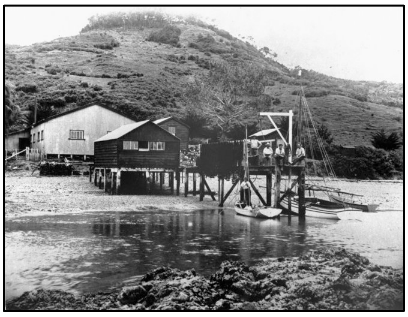



Figure 4. Left: Masefield's canning factory and wharf at the north end of Kororareka Beach, with a mulletie alongside to the right by the loading jib. (Source: National Library of New Zealand) Right: Purerua Packing Co's *Penguin* 'fresh' grey mullet was—of course—canned, 'every tin guaranteed'. (Source: Russell Museum)

3.2 Later fisheries

Fishing diversified as both the resident and the visiting population increased, but it was not until the dawn of the 20th Century did any meaningful sense around the scale and variety of the commercial landings for the Bay of Islands begin to emerge, for, from 1904, fishers had to provide for the first time details of their fish caught (Johnson & Haworth 2004). Fortunately, the Bay of Islands Port of Landing catch statistics were for only the Bay, rather than the much more extensive coastlines applying to most other Ports of Landing around the country. Reporting was at first sporadic, the main fish by weight for the Bay of Islands between 1906 and 1930 being snapper, grey mullet and flounder; the next most-caught brackets took in kingfish, hapuku and kahawai; and then tarakihi, maomao and garfish (piper) (Booth 2016a). It was not until 1931, however, that annual tables of landings data species-by-species were being routinely published—although they are, at best, the lower bounds of actual landings (Francis & Paul 2013).

The Marine Department's annual Reports on Fisheries show how set-netters and liners dominated the early commercial fleet in the Bay of Islands—just as they do today. During the 1920s and 1930s, a total of 30-60 vessels were fishing the Bay and its immediate environs. For Northland generally, sail and row boats were overtaken by a progression of more efficient commercial methods: beam trawls from about 1899; long lines from about 1912; steam trawlers from about 1915 (although not, it seems, in the Bay of Islands); Danish seiners from about 1923; and pair trawling during the 1970s to 1980s (Parsons et al. 2009). And soon after the war, rock lobster vessels had joined the fishing fleet. By the early 1980s, something like 170 commercial vessels were based in the Bay of Islands, landing around 700 t of wetfish—mostly from set netting and lining—and shellfish each year (King 1985; Booth 2016a).

Monumental changes in fisheries management took place in the early- and mid-1980s. Centred on a campaign of effort reduction aimed at conserving stocks, introduction of Controlled Fisheries turned out in the end to be more about shoring up access to the fish stocks for select quarters of the industry. With the full support of the Federation of Commercial Fishermen, the Ministry of Agriculture and Fisheries began to weed out part-time commercial fishermen. A full-time finfisherman was one who fished year-round, or for a specified season. Income from fishing had to be at least $10 000 a year, and 80% of annual income had to be derived from fishing, although there was a saving provision if fishing was a 'vital part' of an annual subsistence income (Johnson & Haworth 2004).

So keen was the Bay of Islands Fishermen's Association for the numbers of fishers to be reduced, it had asked in March 1983 for action immediately the new Fisheries Act came into force on 1 October that year.

> It [the Bay of Islands Fishermen's Association] calculated that the average catch for [Bay of Islands'] 70 boats fishing for snapper was 7.14 t a year. If the top ten boats were excluded, the average was only 4.26 t. With the cost of running a boat 40 percent of receipts, even 7.14 t left only $177 a week, less than the average wage and no return for a fisherman's investment in boat and gear. Working days had increased by 4 hours to 16-20 hours a day, which meant fishermen had to live on their boats…. The Association suggested compensation payments be split 50:50 between the government and the fishermen, with those who remained having the right to sell their licences. Once a buy-out had been completed they envisaged a quota system of some sort (Johnson & Haworth 2004).

But this flurry of management intervention was itself overtaken when, on 1 October 1986, the entire New Zealand finfishery—inshore and deepwater—came under the QMS, and with it came the instruments of Total Allowable Catches and Individual Transferrable Quotas (ITQs). ITQs for finfish were to be based on the average catch of each fisher for the years 1981 to 1983. Although 'many fishers took their money and ran' (Johnson & Haworth 2004), managers at last had a management tool with teeth, and New Zealand's QMS went on to become, for a while, the envy of many fishing nations. Rock lobsters came under the QMS in 1990; and today virtually all commercial and potentially commercial fish, invertebrates and seaweeds are subject to it.

We are now able to draw together for the Bay of Islands fishery information for the entire period 1931 to the present. The scale of landings for key individual species in and near the Bay of Islands is indicated in Appendix 1, the main points being as follows.

- Up until the late 1970s, the mainstay species in terms of weight—albeit with modest annual landings (up to about 100 t of each species)—were flounder, grey mullet, hapuku and snapper;
- Leading up to the management changes of the 1980s, annual snapper landings rose briefly to more than 1000 t;
- Parore and yellow-eyed mullet put on a bit of a show soon after World War II, the latter netted in quite large quantities (up to 60 t a year) near Opua in particular;
- Pelagic species such as blue mackerel, jack mackerel and skipjack tuna were first fished in the 1980s, after which large annual catches (thousands of tonnes) were being made in open waters just outside the Bay of Islands;

- The only invertebrate of significance has been the red rock lobster, fished to any extent only since World War II, with recent local harvests averaging up to about 10 t a year.

4. Recent commercial fisheries in Statistical Area 003

Restrictions applying to commercial fishing within the Bay of Islands today are summarised in Figure 5 for finfish, and Figure 6 for invertebrates.

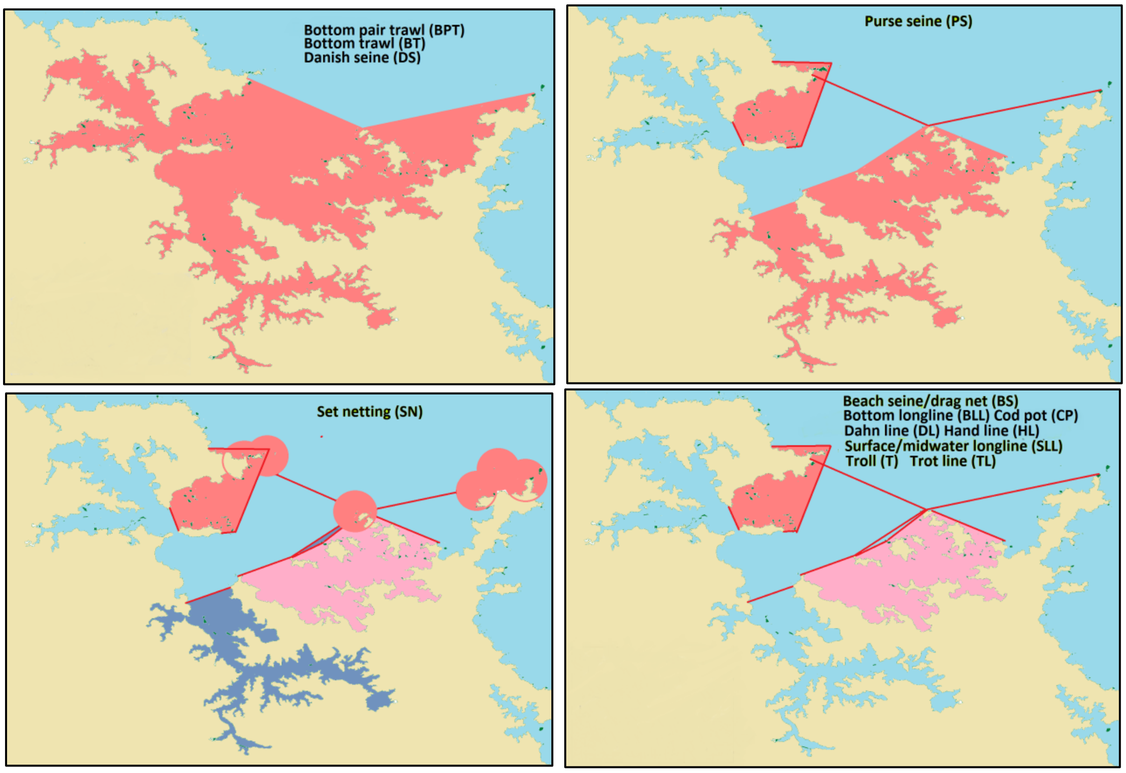


Figure 5. Areas and times of year various fishing methods for finfish can be used commercially in the Bay of Islands. Red, prohibited altogether (circles have 1-nautical mile radius and are for set netting at Cape Wiwiki, Whale Rock and Twins Rock; and all netting at Nine Pin, Cape Brett and Bird Rock; in the north is Te Puna Mataitai Reserve, established in 2013); pink, permitted 1 May to 30 September (but set nets must be less than 1-km long); dark blue, permitted all year for set nets less than 1-km long; light blue, permitted year-round.

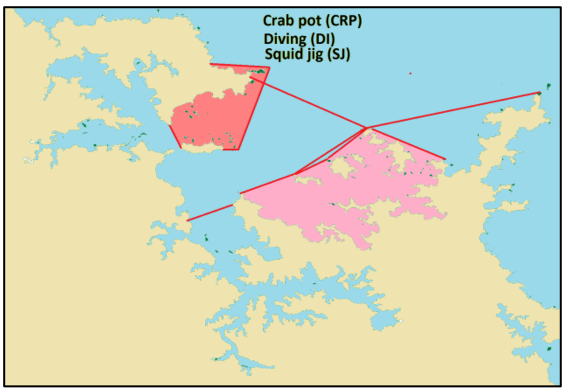


Figure 6. Areas and times of the year various fishing methods for invertebrates can be used commercially in the Bay of Islands. Red, prohibited altogether (Te Puna Mataitai Reserve, established in 2013); pink, permitted 1 May to 30 September; blue, permitted year-round. Rock lobsters can be fished at any time; commercial scallop fishing is banned altogether.

4.1 Finfish

Thirty finfish species/taxa managed under the QMS, and two tunas, were being harvested to a significant extent (usually >10 t total across five years) in Statistical Area 003 during the period 2008/09 to 2012/13 (Booth 2013), using 12 methods (Appendix 3, and Appendix 4 which shows Statistical Area 003 catches in relation to those of adjoining areas). The species supporting greatest catches were, in order, blue mackerel, skipjack tuna, snapper and jack mackerel (Appendix 3). The methods resulting in highest tonnages were, in order, purse seining, bottom trawling and Danish seining. Catches of the principal species (according to both tonnage in Appendix 3, and scale of $-value in Appendix 5) during 2008/09 to 2012/13 were updated to the 2014/15 fishing year (Figure 7, Appendix 6).

For the entire 7-year period 2008/09 to 2014/15, blue mackerel and skipjack supported the highest individual landings, but with a lot of variability from year to year; landings of most other species were less variable (Figure 7). (Kahawai landings are also considered here because it is frequently claimed that large quantities are routinely purse-seined or 'trawled' near the mouth of the Bay of Islands, when in fact reported catches over the past seven years or so have been trivial.)

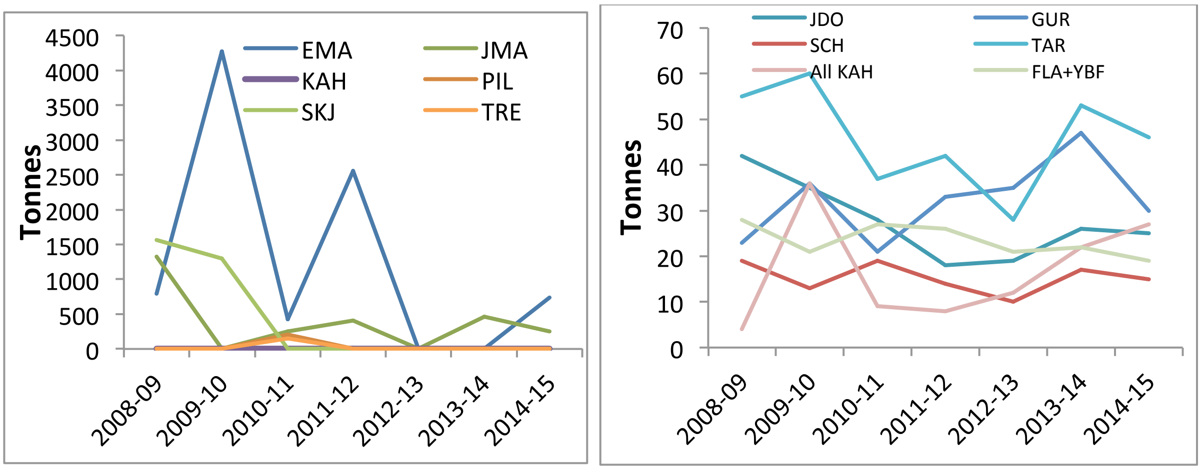


Figure 7. Harvests of principal finfish species (as well as flounder species combined, and kahawai) in Statistical Area 003 by the main method shown used in Appendix 3, for the 2008/9 to 2014/15 October fishing years (NABIS download 21 August 2016). Left: Purse-seined fish (EMA, blue mackerel; JMA, jack mackerel; KAH, kahawai; PIL, pilchard; SKJ, skipjack; TRE, trevally), but note that some 'zero' catches were in fact years in which data were unreliable or were withheld (*see* Appendix 6). Right: Fish taken by methods other than purse-seine (JDO, john dory by bottom trawl; GUR, red gurnard by Danish seine; SCH, school shark by bottom long line; TAR, tarakihi by bottom trawl; KAH, kahawai by all methods; and FLA, flounder and YBF, yellow-belly founder combined by set net).

These data have been for all of Statistical Area 003, of which the Bay of Islands' shoreline makes up only about 40% of the coast-length when harbours and islands are included. Today, just a small handful of commercial fishers routinely fish the waters within the Bay of Islands (waters inshore of a line from Tikitiki to Motukokako), most using small (<7 m) vessels, their main finfish by weight including flounder, garfish, grey mullet, pilchard, snapper and trevally—totalling a few dozen tonnes across the board each year and harvested using set nets and beach seines.

However, from time to time, visiting vessels line, net and trawl within the Bay of Islands for such fish as snapper, trevally, flatfish and grey mullet, and purse seine pelagic species like skipjack tuna, pilchards and mackerels near the entrance to the Bay. General spatial overviews of this fishing catch and effort in Statistical Area 003, and within the Bay itself, at fine scale for the lining, netting and trawling vessels for the 2007/08 to 2012/13 fishing years are given in Figures 8 and 9. The total number of fishing events each year amounts to an average of around a dozen net-sets and fewer than a dozen trawls, but around 33 long-line-sets. The lines and nets will have taken essentially only finfish, whereas trawls may have also taken significant quantities of such invertebrates as arrow squid.

It has been difficult to judge just what level of effort 33 long-line-sets represent. Advice from NIWA scientists suggests each set typically involves up to 1500 baited-hooks (although other advice suggests it could be as many as 7000 hooks). Also, it is not clear if any one set involves more than one check of each hook. In any case, it may not be unreasonable to conclude that 33 long-line-sets represent no fewer than 6.6 x 10^4 hook-fishing events.

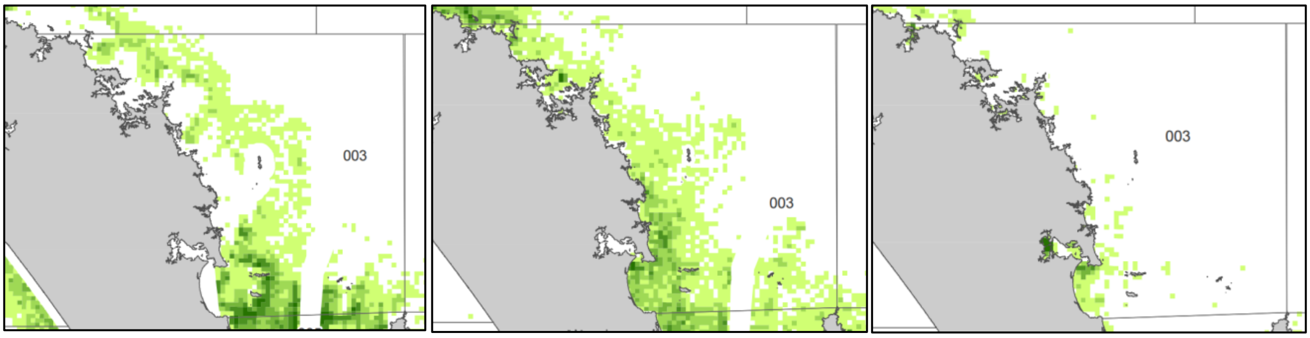


Figure 8. Spatial pattern of average annual number of fishing events (from left, trawl, longline then set net) starting in each 1-nautical mile grid for 1 October fishing years 2007/08 to 2012/13 in Statistical Area 003 for those vessels obliged to furnish such data (taking in ~70% of longline events, ~33% of set-net events, but essentially all trawls). The five categories, from lightest green, are >0-1 event, >1-2 events, >2-3 events, >3-5 events and >5 events. (http://www.fish.govt.nz/en-nz/Commercial/About+the+Fishing+Industry/Maps+of+Commercial+Inshore+Fishing+Activity/default.htm downloaded 21 August 2016, and which also provides catch rates)

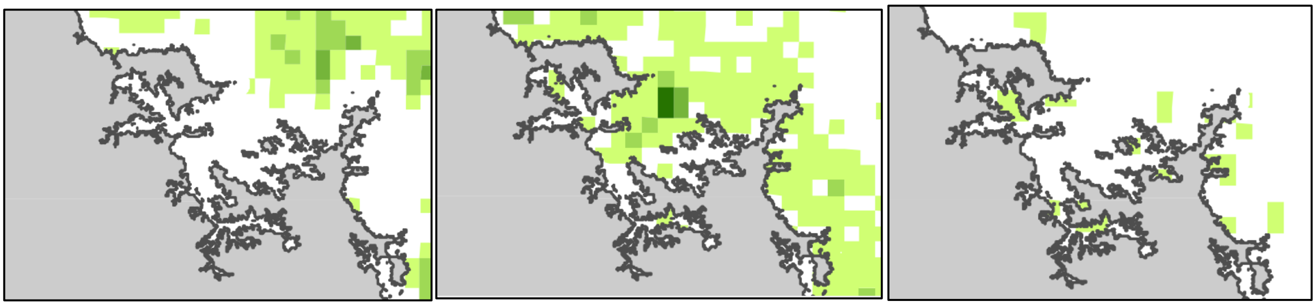


Figure 9. Spatial pattern of average annual number of fishing events (from left, trawl, longline then set net) starting in each 1-nautical mile grid for 1 October fishing years 2007/08 to 2012/13 in and near the Bay of Islands (a zoom-in of Figure 8). The five categories, from lightest green, are >0-1 event, >1-2 events, >2-3 events, >3-5 events and >5 events.

4.2 Invertebrates

Only one invertebrate was identified in 2013 to be of significance—the red rock lobster (others are shown in Appendices 7 and 8, and the scale of $-value in Appendix 9). Rock Lobster Statistical Area 904 landings have remained steady at 13 ± 3 t each year (Figure 10).

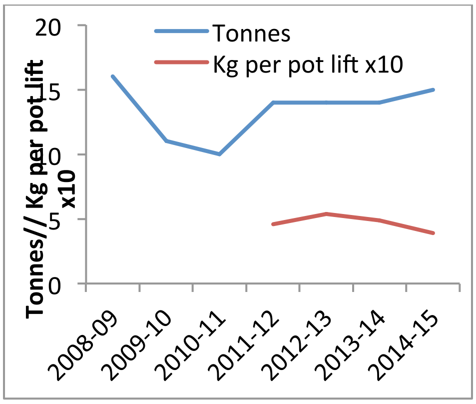


Figure 10. Harvest of red rock lobster (CRA) in Statistical Area 904 (*see* Figure 1) using rock lobster pots, and catch (kg) per pot lift x10, 1 October 2008/9 to 2014/15 fishing years. (NABIS download 21 August 2016; Plenary 2015)

4.3 Commercial versus recreational fishing

No discussion about fishing pressure in and near the Bay of Islands, and the present status of fishstocks, is complete without considering recreational fishing. This is because FMA 1, and especially the east coast of the North Island Hauraki Gulf north, is among the most-intensively fished parts of the country recreationally, and, in turn, the Bay of Islands is arguably the shore north of the Hauraki Gulf most heavily fished by recreational fishers (Booth 2016b) (Figure 11).

Figure 11 demonstrates how intense recreational *fishing pressure* is in the Bay of Islands area compared with the only associated commercial fishing effort data available at a fine scale (Figure 9). Although the measures of effort are very different, and that associated with the handful of small, locally-based vessels is not included, the impression is that the recreational fishing effort far exceeds that of the commercial fleet. For example, whereas there may be on the order of 7×10^4 commercial hook-fishing events each year (based on 2000 hooks per set), the corresponding recreational value may be on the order of 5×10^5 (low 8×10^4; high 12×10^5) events (based on Figure 11, and 3 [1, 5] people per boat, each baiting one hook 10 [5, 15] times).

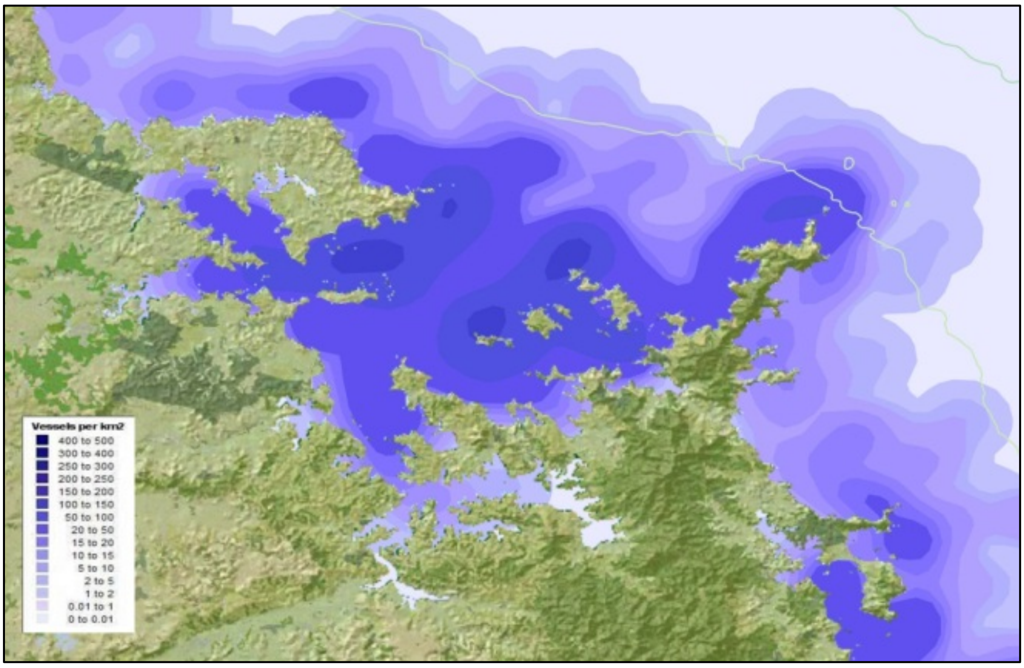


Figure 11. Distribution of stationary vessels recreationally fishing (vessels per km^2), 1 December 2004 to 30 November 2005, North Cape to Cape Rodney (Hartill et al. 2007, downloaded from NABIS [www.nabis.govt.nz/Map.aspx]). For the Bay of Islands, the areas with most-intense fishing activity (dark blue) contain 100-150 vessels per km^2; the lightest-blue contours represent 0-0.01 vessels per km^2.

The *scale of harvests* are also indicative of the relative pressure expended by the commercial fleet compared with the recreational fishers. First, for FMA 1, recreational harvests of kahawai and snapper are large, similar in scale, or greater than, the commercial catches. For all other species, the recreational harvest is relatively small (Figure 12).

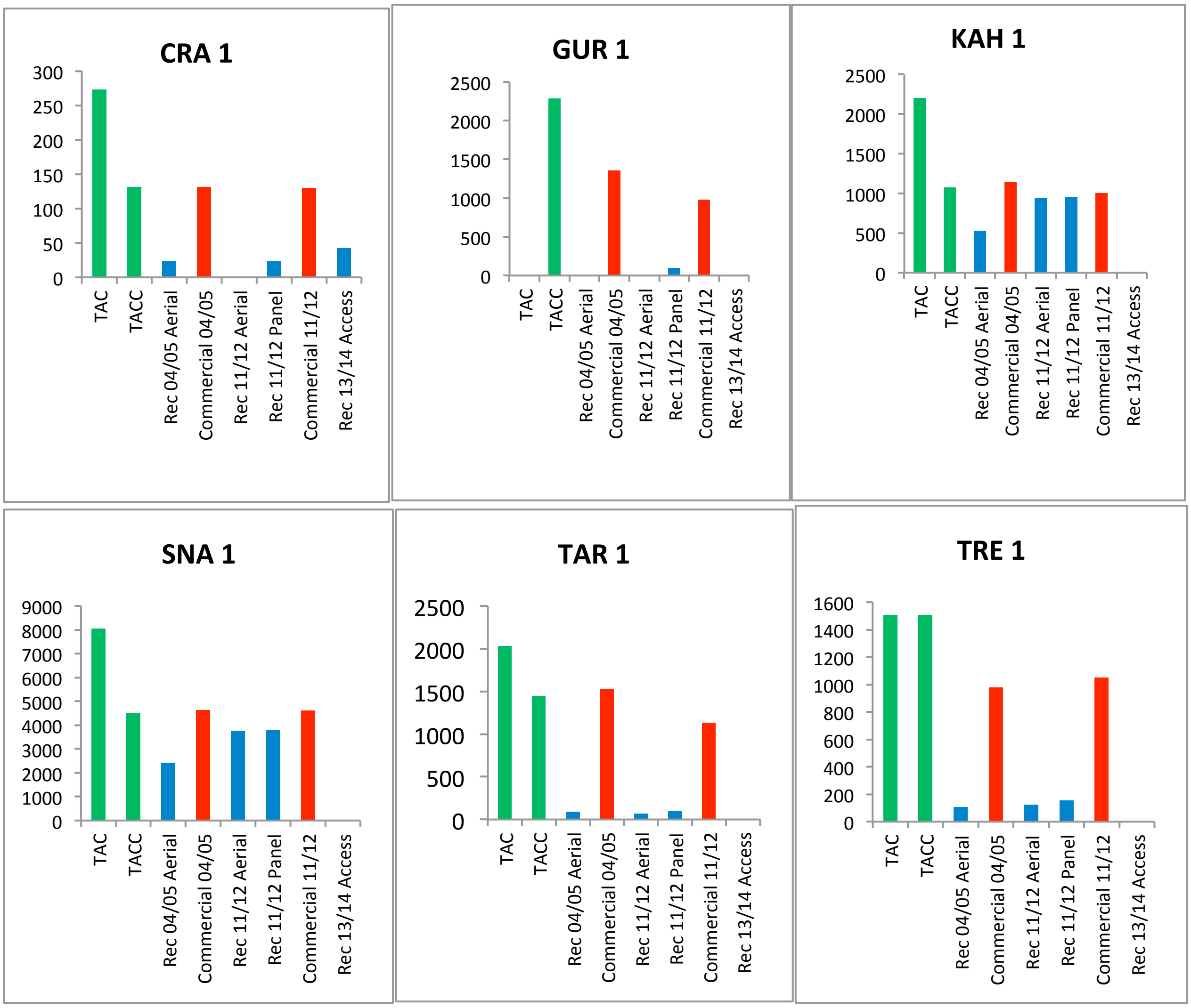
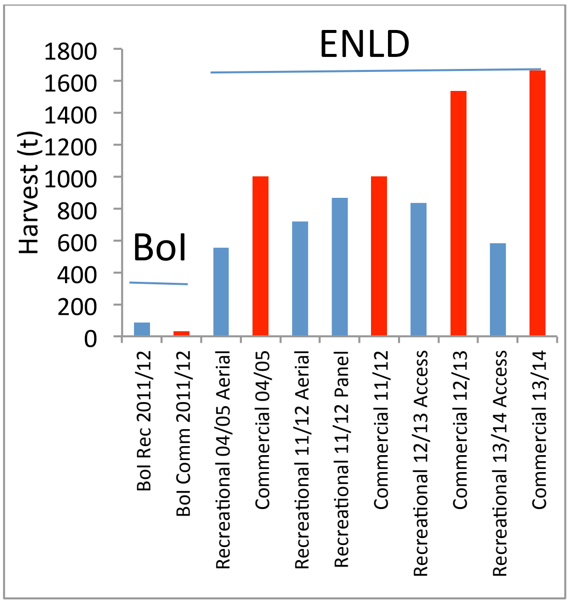


Figure 12. Overview of recent FMA 1 commercial versus recreational harvests (t) of selected species. TAC, current Total Allowable Catch; TACC, current Total Allowable Commercial Catch; Rec, Recreational. No bar means no TAC established (GUR 1) or no data are available. The difference between the TAC and TACC is the sum of the recreational and customary catch, as well as the estimated illegal catch and/or other mortality. CRA, red rock lobster; GUR, red gurnard; KAH, kahawai; SNA, snapper; TAR, tarakihi; TRE, trevally. For FMA 1 boundaries, *see* Appendix 1. For sources and qualifying information, *see* Booth (2016b).

Then, for East Northland (North Cape to Cape Rodney), estimated recreational harvests of snapper are highly significant, in some years almost equalling the commercial landings; for kahawai they usually far exceed the commercial harvest (Figure 13). And for the Bay of Islands itself, the estimated recreational harvests of these species are also significant, even though the Bay makes up only about 10% of the coastline of East Northland.



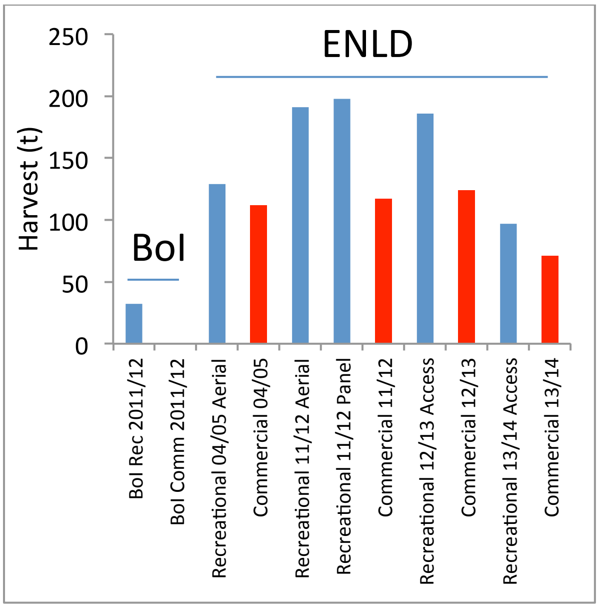


Figure 13. Estimated recent commercial (red) and recreational (blue) harvests of snapper (left) and kahawai (right) in the Bay of Islands compared with those for East Northland (North Cape to Cape Rodney) (*see* Booth 2016b, Table 3 for sources of recreational catch data). (There were no known commercial harvests of kahawai within the Bay of Islands in 2011/12.) Bay of Islands makes up only about 10% of East Northland's coastline.

Among the shellfish, only rock lobsters are important. Again, the Bay of Islands recreational harvest is a significant constituent of the East Northland landings, and the recreational catch of lobsters in the Bay of Islands, and in the east Northland part of CRA 1, is high relative to the commercial catch (Figures 12 and 14).

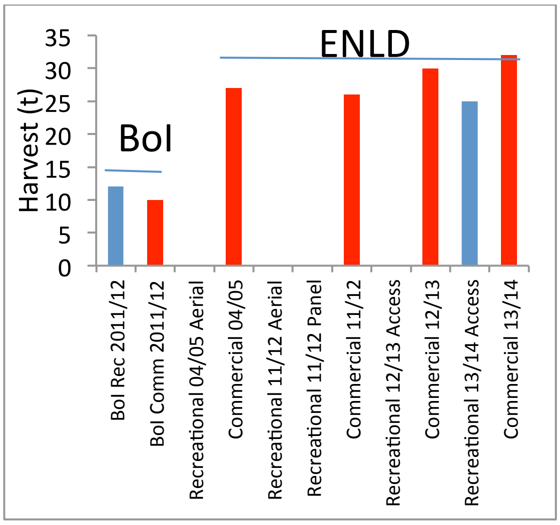


Figure 14. Estimated recent commercial (red) and recreational (blue) catches of red rock lobsters in the Bay of Islands compared with those of East Northland (*see* Booth 2016b for sources of recreational catch data). No bar means no data available. Bay of Islands makes up only about 10% of East Northland's coastline.

5. Characterising fish stocks underpinning the Bay of Islands commercial fisheries

5.1 Overview

None of the main commercial finfish species in the Bay of Islands (nor the red rock lobster) is confined there throughout their entire lives. Because of the general mixing within many individual species during their life-histories, the status of most Bay of Islands commercial fisheries is ultimately dependent on that of the underlying QMA stock or substock.

All exploited coastal finfish species around New Zealand have declined dramatically in abundance since colonisation using every acceptable measure. In northern New Zealand, many predatory finfish species (as well as the red rock lobster) had by the mid-1980s declined in biomass to less than one quarter of their virgin state (annual Plenary reports). Despite advances in fishery modelling, and a lot more research, there is no information on, or considerable uncertainty remains around, the status of all but a couple of the main stocks/substocks underpinning the fisheries of the Bay of Islands (Table 1)—and there is evidence of overfishing. (Overfishing in this context is deemed to be taking place if F_{MSY} [the maximum fishing pressure that can be applied constantly without impairing the stock's renewability through natural growth and reproduction], or its proxy, is exceeded, on average.)

Table 1. Stock status of finfish of commercial importance (and of rock lobsters) in the Bay of Islands (Plenary 2015). (Kahawai is included, even though it is not important commercially.) Fishstock, the stock or substock applying to the Bay of Islands; assess, assessment; B_{MSY}, the average biomass associated with a maximum sustainable yield strategy; B_0, the biomass of the unfished stock; SSB_0, the biomass of the unfished spawning stock; AW (1979-88), mean of beginning autumn-winter vulnerable biomass for period 1979-88; na, not applicable; HG, Hauraki Gulf; ENLD, East Northland; *, SKJ is not part of the Quota Management System. The target and limits for TRE 1 are based on those for TRE 7. The terms used in relation to targets and limits are as given in Plenary (2015). Sand flounder (SFL) is not considered here because the entire Statistical Area 003 annual harvests 2008/09 to 2014/15 were trivial (average about 2 t/year).

Fishstock	Species	Last assess	Target	At or above target?	Soft limit	Below the soft limit?	Hard limit	Below the hard limit?	Overfishing?
CRA 1	Rock lobster	2015	AW (1979-88)	Virtually certain	20% SSB_0	Exceptionally unlikely	10% SSB_0	Exceptionally unlikely	Exceptionally unlikely
EMA 1	Blue mackerel	None	-	-	-	-	-	-	Unknown
FLA 1	Flatfish 8 spp.								na
GAR 1	Garfish	None	-	-	-	-	-	-	Unknown
GMU 1	Grey mullet	None	-	-	-	-	-	-	Unknown
GUR 1E	Red gurnard	2013	B_{MSY}	Unclear	50% B_{MSY}	Unlikely	25% B_{MSY}	Very unlikely	Unknown
JDO 1 (HG + ENLD)	John dory	2015	CPUE (Plenary 2015)	Very unlikely	50% target	Either/or	25% target	Unlikely	Unlikely
JMA 1	Jack mackerel 3 spp.	1993	B_{MSY}	Unknown	20% B_0	Unknown	10% B_0	Unknown	Unknown
KAH 1	Kahawai	2015	52% B_0	Very likely	20% B_0	Very unlikely	10% B_0	Exceptionally unlikely	Very unlikely
PIL 1	Pilchard	None	-	-	-	-	-	-	Unknown
SCH 1	School shark	2014	B_{MSY}	Unknown	20% B_0	Unknown	10% B_0	Unlikely	Unknown
SKJ*	Skipjack								na
SNA 1 (East Northland)	Snapper	2013	40% B_0	Very unlikely	20% B_0	Unclear	10% B_0	Very unlikely	Likely
TAR 1	Tarakihi	2012	B_{MSY}	Unknown	20% B_0	Unknown	10% B_0	Unknown	Unknown
TRE 1	Trevally	?	40% SSB_0	Unknown	20% SSB_0	Unknown	10% SSB_0	Unknown	Unknown
YBF 1	Yellow-belly flounder	2015	B_{MSY}	Unknown	20% B_0	Unknown	10% B_0	Unknown	Unknown

The stock status of two of the most highly conspicuous species—snapper and rock lobster—are explored below in more detail.

5.2 Snapper: East Northland Substock of SNA 1 (North Cape to Cape Rodney)

There is little mixing between East Northland and the other two SNA 1 substocks (Hauraki Gulf and Bay of Plenty) (Plenary 2015). There are no reported alongshore migrations, but there is seasonal mixing within substocks once juveniles have dispersed from shallow nursery habitats (Plenary 2015).

5.2.1 Harvest history and stock assessment

Snapper have been the most important finfish harvest in the Bay of Islands, and in Statistical Area 003 generally, in terms of being both highly sought and most-caught.

The SNA 1 substock underpinning Bay of Islands snapper, East Northland, experienced a long, steep decline, from 3500 t in 1970 to about a quarter of that by 1985, and has fluctuated without trend since (Figure 15).

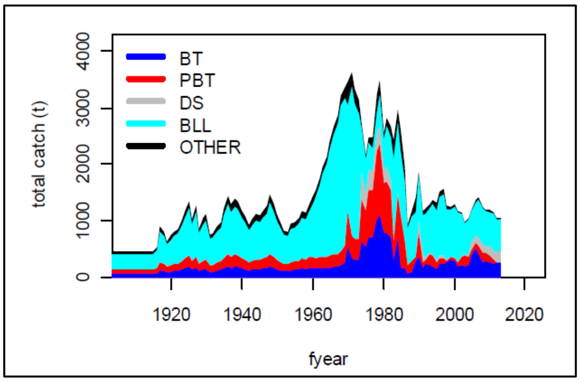


Figure 15. Commercial catch history by method for the East Northland Substock (Plenary 2015). BT, bottom trawl; PBT, bottom pair trawl; DS, Danish seine; BLL, bottom long-line.

The East Northland Substock is overfished: the 2013 biomass was estimated to be only 24% of the unfished state (Figure 16), compared with the target of 40% (Plenary 2015). Although five-year projections pointed to increasing stock biomass, current catches were nevertheless considered likely to lead to continued overfishing (MPI 2013).

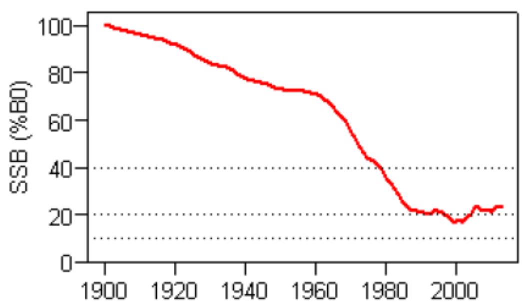


Figure 16. East Northland snapper spawning stock biomass (SSB) as percentage of B_0 (virgin biomass). Dotted lines indicate the target (40% B_0), soft limit (20% B_0) and hard limit (10% B_0) (Plenary 2015).

5.2.2 Fish size

The mean and median size of fish caught, and the proportions of large individuals, provide insight into the status of fish stocks (Plenary 2015), and are also key to the environmental role fulfilled by particular species. Size and age are linked in snapper, but the relationship is not necessarily direct: for example, Hauraki Gulf snapper appear to have increased in growth rate as the stock was historically fished down, meaning that large fish were not necessarily as old as they had before been (Paul 2014). But in terms of the predatory impact of snapper (and other species) on kina *Evechinus chloroticus*, it is much more the size, rather than age, that is important, for it requires large individuals to prey on urchins (Ayling & Babcock 2003).

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The mean length of snapper from early northern middens was around 50 cm, yet fish harvested commercially from the East Northland Substock (and SNA 1) in recent years have averaged only 35 cm (Walsh et al. 2011, 2014; fish taken recreationally are of similar size), demonstrating a greatly fished-down stock (Figure 17). And, although there is evidence from the East Northland long-line catch of a slight increase in mean age in recent times, most of the fish landed are still younger than 10 years, and the proportion of fish older than 20 years is very small (Plenary 2015).

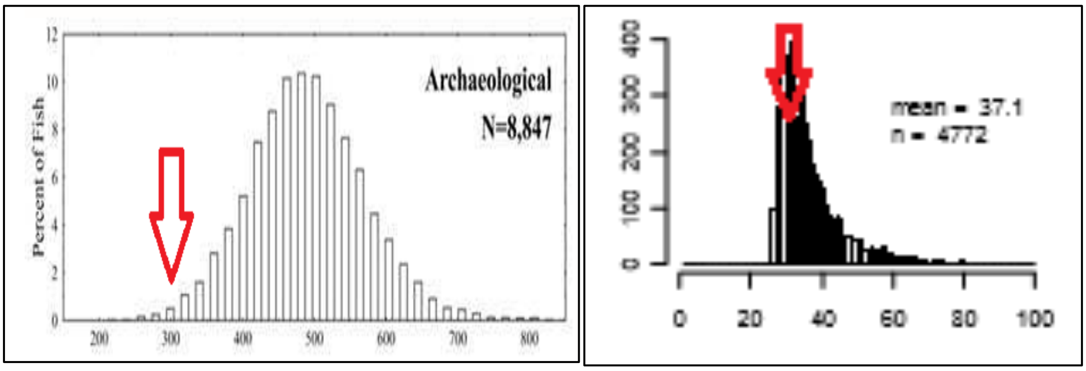

Figure 17. Left: Length-frequency distribution (mm fork length) of snapper from a pre-Contact archaeological site at Houhoura, 100 km northwest of the Bay of Islands (Leach 2006). Right: Length-frequency distribution (cm fork length) of snapper recreationally harvested in the East Northland Substock of SNA 1 in 2011/12 (Hartill & Davey 2015). The mean commercial fish-length for this substock in 2009/10 was, at 35 cm (Walsh et al. 2011), similar to that of the recreational catch in 2011/12. Arrows indicate the 30-cm length recreational MLS.

5.2.3 Wrapping-up for snapper

Most of this discussion has been for East Northland, and focussed on Statistical Area 003, but, because of stock mixing, it applies generally, too, to the Bay of Islands. The East Northland Substock of SNA 1 has been fished down to a low level; snapper are overfished in the Bay of Islands area, most of the fishing pressure today coming from recreational effort which has, anecdotally, even led to areas of local depletion. The mean fish-length of both the commercial and recreational harvests, at around 35 cm, is near the extreme left limb of the length-frequency distribution of a lightly fished northern population.

5.3 Rock lobster: CRA 1

There is no evidence for genetic subdivision of lobster stocks within New Zealand (Plenary 2015). Most postlarvae settling along the east Northland coast were spawned along the west coast of central New Zealand; spawnings in east Northland result in settlement in eastern Bay of Plenty and as far south as about Cook Strait (Chiswell & Booth 2008). There may be alongshore migrations northward by some proportion of the juveniles approaching maturity, but in any event there is seasonal mixing associated with inshore-offshore movements to do with moulting and mating (Booth 1997).

5.3.1 Harvest history and stock assessment

CRA 1 catches built steadily after World War II, rapidly peaking in the late 1960s as many new vessels joined the fleet, spurred on by the Chatham Islands rock lobster fishing boon (Figure 18).

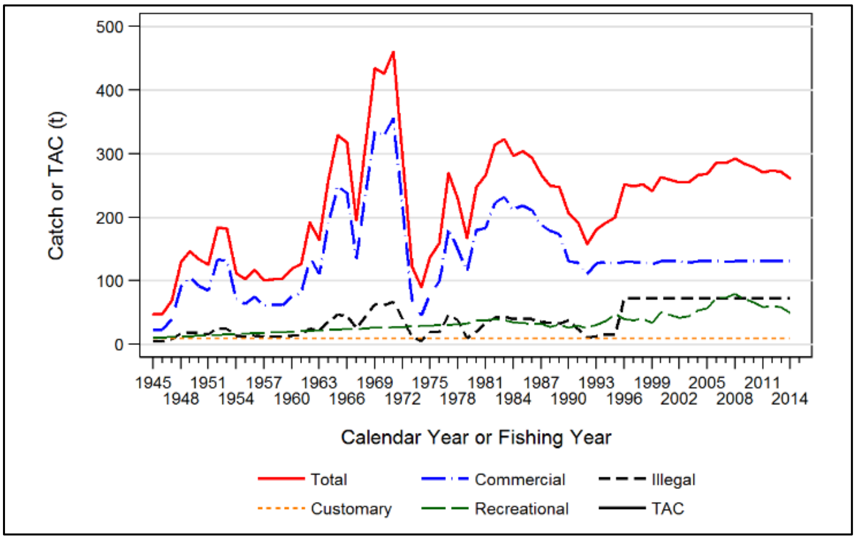

Figure 18. Catch trajectories (t) for CRA 1, showing estimates for commercial, recreational, customary and illegal categories (Plenary 2015).

The CRA 1 stock assessment shows how the vulnerable biomass collapsed to one quarter of its original, from 3000 t in the mid-1940s to only 600 t, in the early 1970s. It has fluctuated since, with a modest overall increase; projections are that the vulnerable biomass will remain steady (Figure 19). Because the target biomass is that associated with the stock during 1979-88 (Table 1), when the vulnerable biomass was near its nadir (Figure 19), it is little wonder that this fishery is not considered overfished.

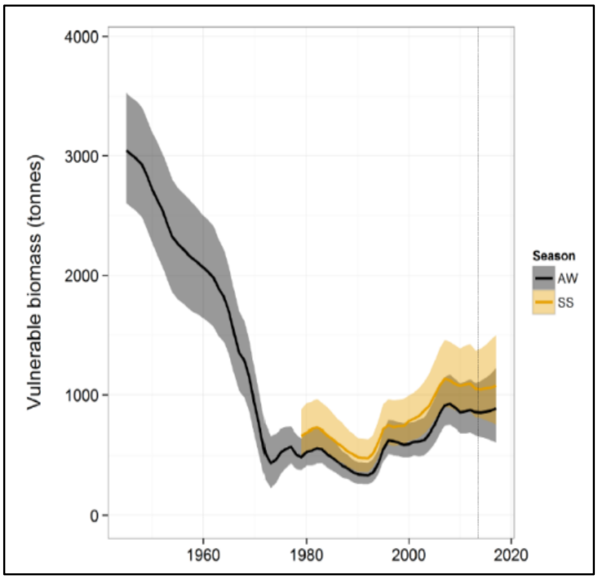

Figure 19. CRA 1 vulnerable biomass and projected vulnerable biomass by season (AW, autumn/winter; SS, spring/summer) (Plenary 2015). Shading shows the 90% confidence zones.

Bay of Islands lies within Rock Lobster Statistical Area 904 (Takou Bay to Bream Bay; Figure 2) where commercial CPUE over the past four years has averaged around 0.5 kg per pot lift, only 20% of that of the other CRA 1 statistical areas, and one of the lowest in the country (Plenary 2015). This points to severe regional depletion.

5.3.3 Lobster size

Consistent with intense fishing pressure, most rock lobsters caught both commercially and recreationally in and near the Bay of Islands are not much larger than the MLS (Figures 20 and 21). By way of comparison, the wide size-distribution, and predominance of large lobsters, that made up a lightly fished rock lobster population is illustrated in Figure 22.

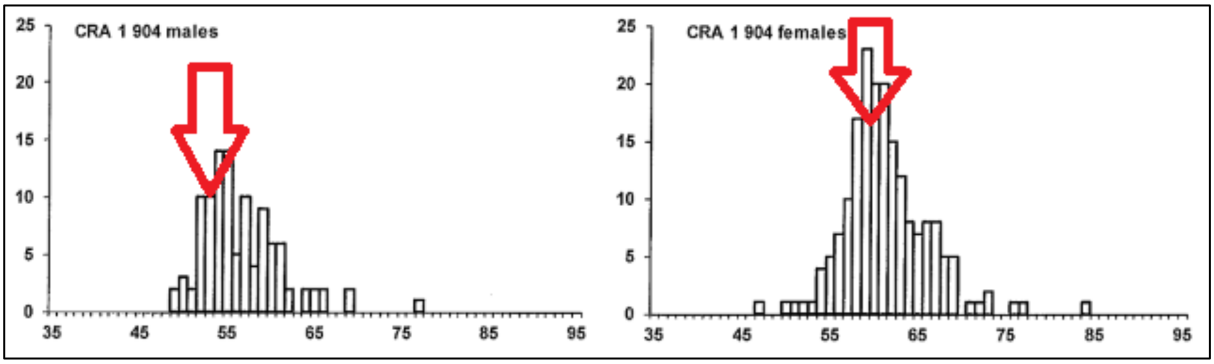

Figure 20. Length-frequencies (tail width) of male (left) and female red rock lobsters (right) taken in observer commercial-catch samples in Statistical Area 904, 2011-12 (D. Sykes, pers. comm.). The arrows show the MLS (54- and 60-mm tail width for males and females respectively).

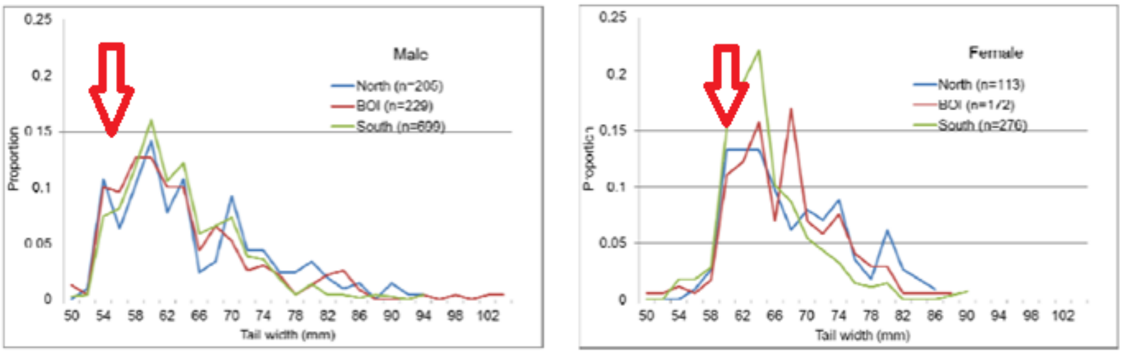

Figure 21. Rock lobster proportion of harvest by tail width by sex for the Bay of Islands (red) versus north to Rangiputa (blue) and south to Mangawhai Heads (green) recreational catch in 2013-14 (Holdsworth 2014). MLS (arrows) are 54- and 60-mm tail width for males (left) and females (right) respectively.

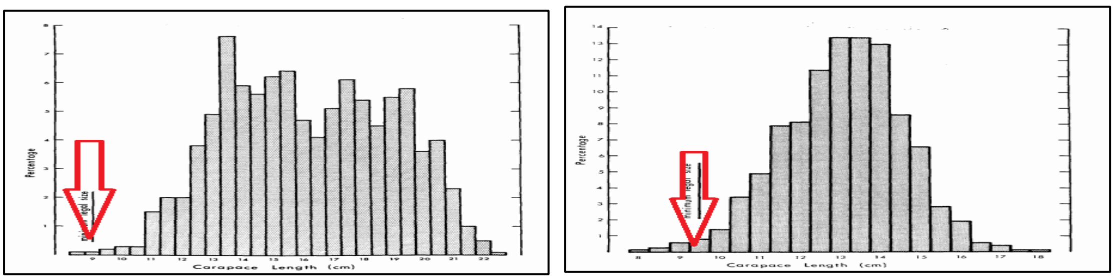

Figure 22. Percentage carapace-length (CL) frequency distribution of >1000 males (left) and >1000 females (right) red rock lobsters in October 1966, soon after commercial fishing began at the Chatham Islands (Kensler 1969) in 10-mm groupings. The current MLS for East Northland is roughly equivalent to 96-mm CL for males (left) and 97 mm for females (right) (red arrows).

5.3.4 Wrapping-up for rock lobster

Although the CRA 1 lobster stock is said to be healthy overall, the low commercial CPUE in at least Statistical Area 904, as well as the high proportion of lobsters near MLS and the low proportions of large animals in both the commercial and recreational catches in the region, point to severe regional depletion.

6. Evidence for, and implications of, the ecological overfishing of keystone predators

Harvest pressure from all sources on fish stocks in northeast New Zealand has been so intense as to have had catastrophic impact on marine ecosystems—particularly the shallow-reef kelp communities, which in many places have been overgrazed by sea urchins (Booth 2015).

Whereas the reason for the emergence of 'urchin/kina barrens' in northern New Zealand was for a time contested, there is now consensus that these barrens are a direct result of the overharvesting of keystone predators (predators whose impact on the ecosystem is disproportionately large relative to their abundance) such as snapper and red rock lobsters. Reductions in the proportions of large individuals of these predatory species—the ones capable of preying on kina—have led to burgeoning kina populations and to the widespread loss of shallow-reef kelp forests (Andrew & MacDiarmid 1991, Shears & Babcock 2002, Ayling & Babcock 2003, Ballantine 2014). Resulting urchin barrens such as these are a world-wide phenomenon and one surprisingly difficult to reverse (Ling et al. 2014).

The loss of the shallow-reef kelp forests throughout the main basin of the Bay of Islands has been extensive, and among the most severe in the entire country. Booth (2015) distinguished 29 discrete locations for which there was a series of aerial images, from the 1950s/1960s, through to 2009, in which the extent of seaweed cover could be clearly discerned (Figures 23 and 24). For most parts the reduction in kelp cover over the intervening decades has been monumental: loss of kelp was obvious by the 1970s, although some kelp forests seem to have persisted until quite recently. And no evidence has been found for any kelp recovery since 2009.

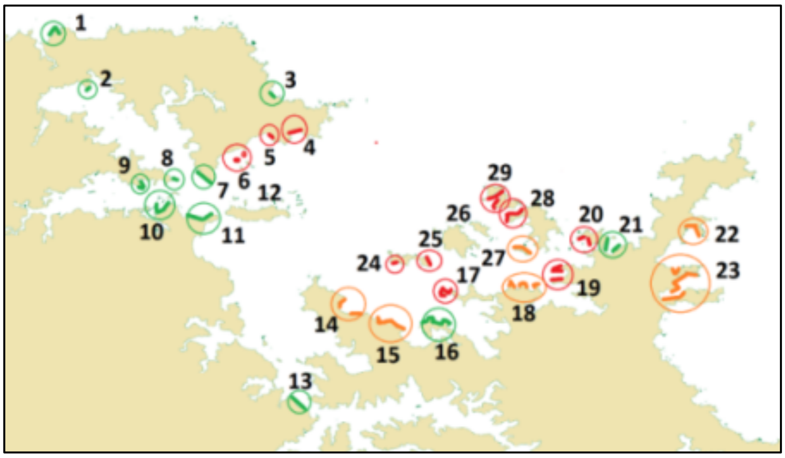

Figure 23. Changes in kelp cover between the 1950s/early 1960s and 2009 (Booth 2015). For each site there were at least four aerial images, each separated by at least a decade, and among which at least two of the early images showed extensive dark shadows associated with reef (usually kelp but possibly sometimes dark-coloured rock). The previously existing dark shadows had largely vanished by the 1970s (red), or certainly by the 2000s (orange); green indicates little apparent change in the intensity or extent of shadow (although thinning of kelp was sometimes obvious), most often seen near inlets where waters are presumably too fresh for kina. Extensive dive surveys in 1985-86 (Trenery et al. 1987), and again in 1991 (Brook & Carlin 1992), reported widespread kina barrens in the Bay of Islands at those times.

The Bay of Islands presents an extreme and extensive example of ecological overfishing of the main predators of sea urchins, resulting in reduction in the abundance of sea-urchin predators. The loss of significant areas of the shallow-water kelp community is likely to have led to a multitude of cascading consequences, most of them not yet even recognised let alone understood. On the bright side, the experience in the marine reserve at Leigh is that once large keystone predators return, the sea urchins are held in check, and the kelp recovers (Ayling & Babcock 2003, Ballantine 2014).

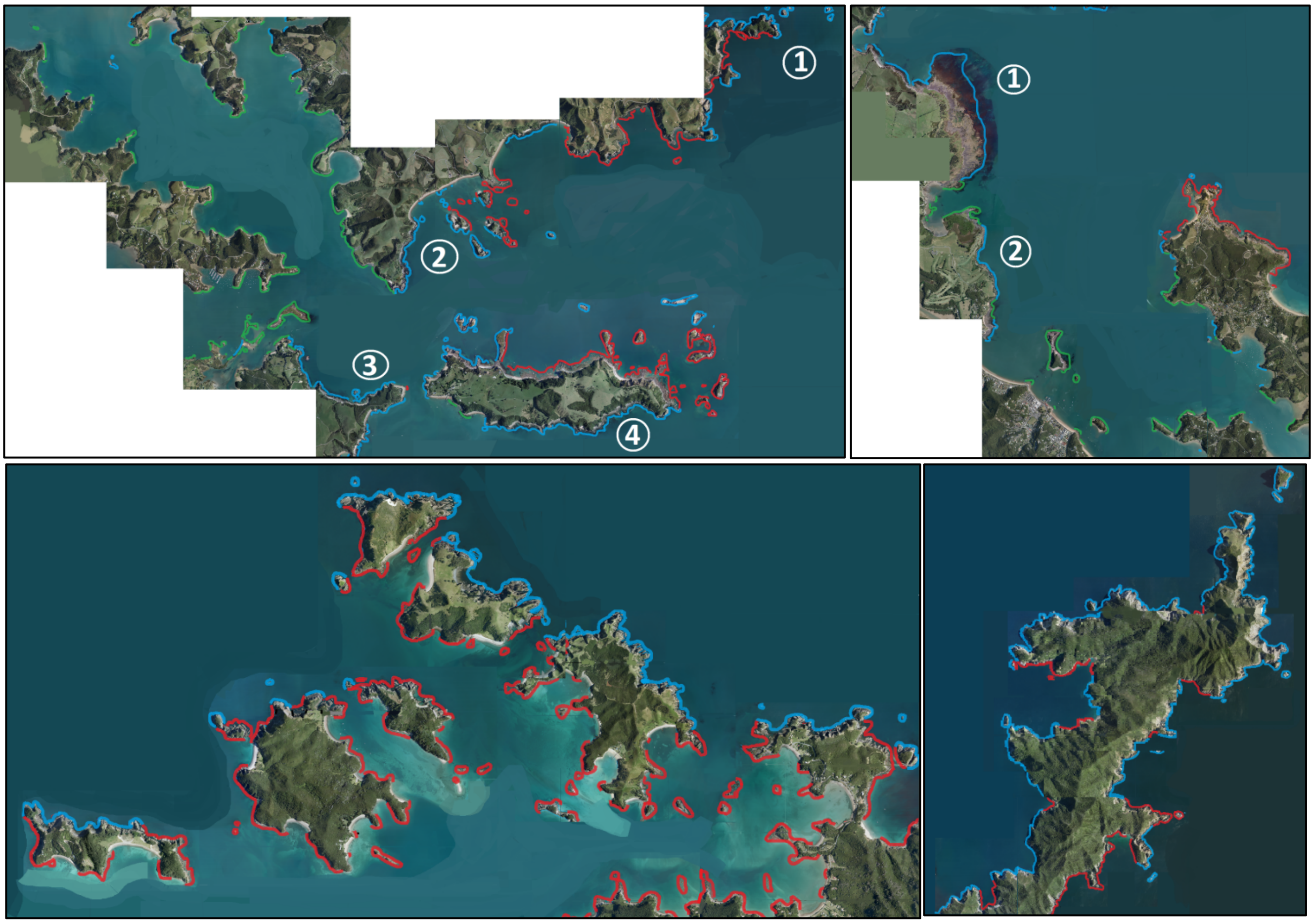

Figure 24. Urchin barrens (red) are now widespread in the Bay of Islands, particularly in the main basin (aerial photographs in 2009; Booth 2015). What appear to be intact kelp forests persist mainly near inlets (green). In top left, the reef was too steep to assess, or was in shadow (1); or the reef itself appeared dark, most probably for reasons other than kelp cover (2-4). In top right, the reef itself appeared dark, but not necessarily because of kelp cover (1 and 2). In the bottom row, open shores were often too steep, or were in shadow (blue).

In a recent development, the long-spined urchin *Centrostephanus rodgersii* now seems significant in the overgrazing of shallow-reef kelp, particularly in the more exposed, outer parts of the Bay of Islands (C. Richmond & V. Froude, pers. comm.). *Centrostephanus*, which also is found on the east coast of Australia, was reported as early as the late 1960s to be extending its distribution and increasing in abundance in the north of New Zealand (Morton & Miller 1968), and it is now common in shallow open waters of the Bay of Islands. In southeast Australia, this urchin has long been known as a significant contributor to urchin barrens (Andrew & Underwood 1993), and the commercially valuable rock lobster there (also *Jasus edwardsii*) its important predator (Sinauer Associates 2014).

Summary

1. The earliest commercial fisheries in the Bay of Islands were for rock oysters and grey mullet, but by the early 1900s a wide variety of finfish were being landed for market;
2. Useful statistics around these catches began to emerge in the 1930s: until the late 1970s, the mainstay species for the Bay of Islands in terms of weight—albeit with modest annual landings (up to about 100 t of each species)—were flounder, grey mullet, hapuku and snapper;
3. Leading up to the management changes of the 1980s, annual snapper landings rose briefly to >1000 t, when there were around 170 commercial boats based in the Bay of Islands;
4. Pelagic species such as blue mackerel, jack mackerel and skipjack tuna were first fished in the 1980s, after which large annual catches (thousands of tonnes) were being made along open waters just outside the Bay of Islands;
5. The only invertebrate of significance has been the red rock lobster, fished to any extent only since World War II, with recent local harvests averaging up to about 10 t a year;
6. Today, just a small handful of commercial fishers routinely fish the waters within the Bay of Islands, their main finfish by weight including flounder, garfish, grey mullet, snapper and trevally—totalling a few dozen tonnes across the board each year and harvested using set nets and beach seines;
7. However, from time to time, visiting vessels line, net and trawl for such fish as snapper, trevally, flatfish and grey mullet within the Bay of Islands, and purse seine pelagic species like skipjack tuna, pilchards and mackerels near the entrance to the Bay of Islands;
8. Recreational fishing effort within the Bay of Islands almost certainly far exceeds that of the commercial fleet for most species, the recreational catches being similar to or exceeding those commercial;
9. The East Northland snapper substock of SNA 1 is overfished, and both commercial and recreational fishing in the Bay of Islands contributes significantly to this overfishing, with most fish not much larger than the MLS. The Bay of Islands component is inextricably linked through seasonal migration to the rest of the East Northland snapper fishery;
10. Although the CRA 1 red rock lobster stock is not considered overfished, most lobsters locally caught commercially and recreationally are at or only a little above MLS, which is consistent with heavy fishing pressure. The Bay of Islands component is inextricably linked through larval drift and seasonal migration to other parts of the lobster fishery, so local fishing contributes to pressure on stocks;
11. In northern New Zealand, commercial fishing had, by the mid-1980s, reduced the biomass of many predatory finfish species, and rock lobsters, to one quarter or less of their virgin state. Consequently, sea-urchin grazing burgeoned, resulting in loss of much of the shallow-reef kelp in places like the Bay of Islands. Whereas until now kina *Evechinus chloroticus* has been the species implicated, it is now clear that the long-spined urchin *Centrostephanus rodgersii* is also overgrazing reefs;
12. A suitable gauge of finfish and rock lobster fishstock recovery in the Bay of Islands area will be revitalisation of the shallow-reef kelp forests, but because of the resilience of urchin barrens, this will almost certainly take decades to achieve—and only when there are sufficient large-enough predators present.

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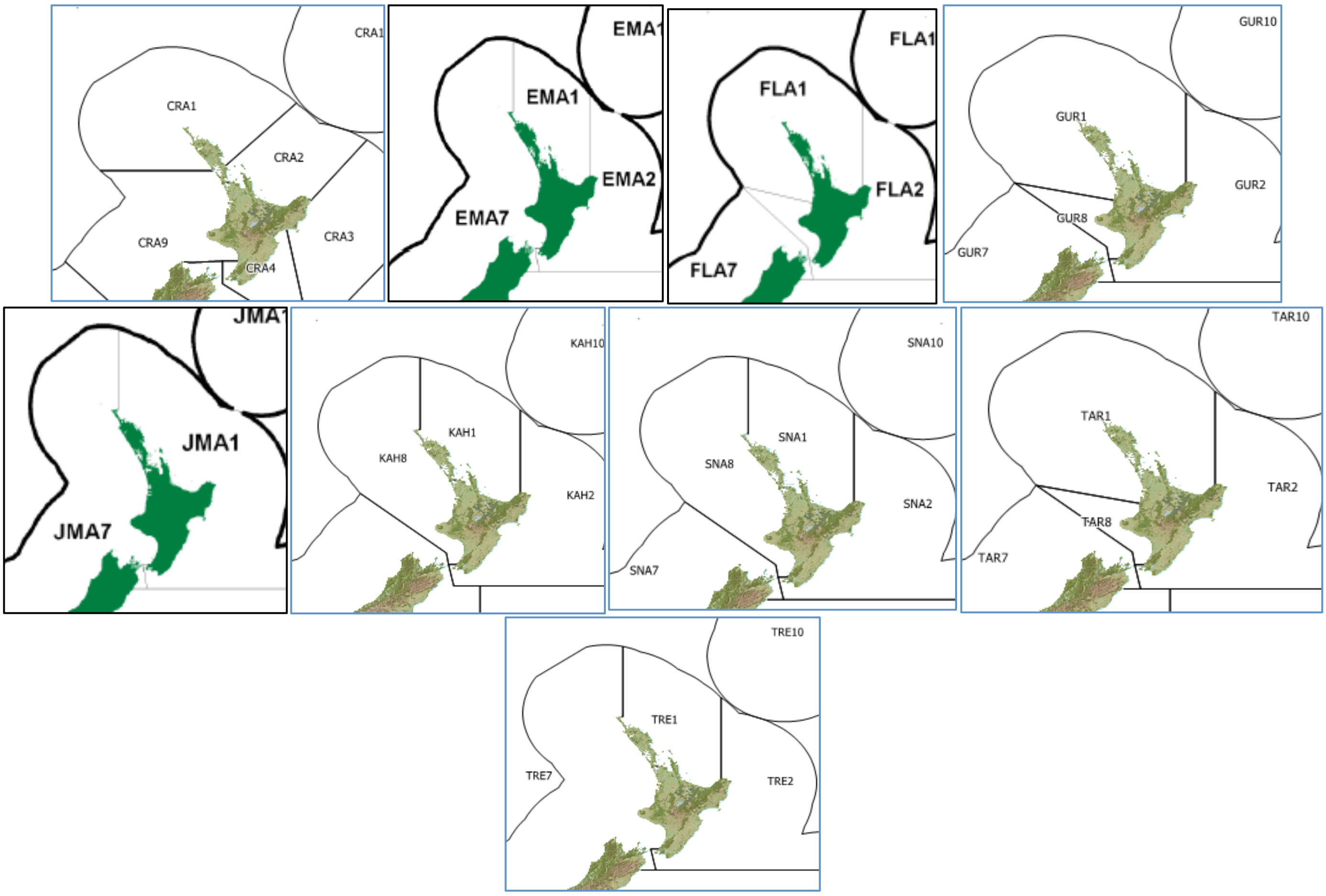
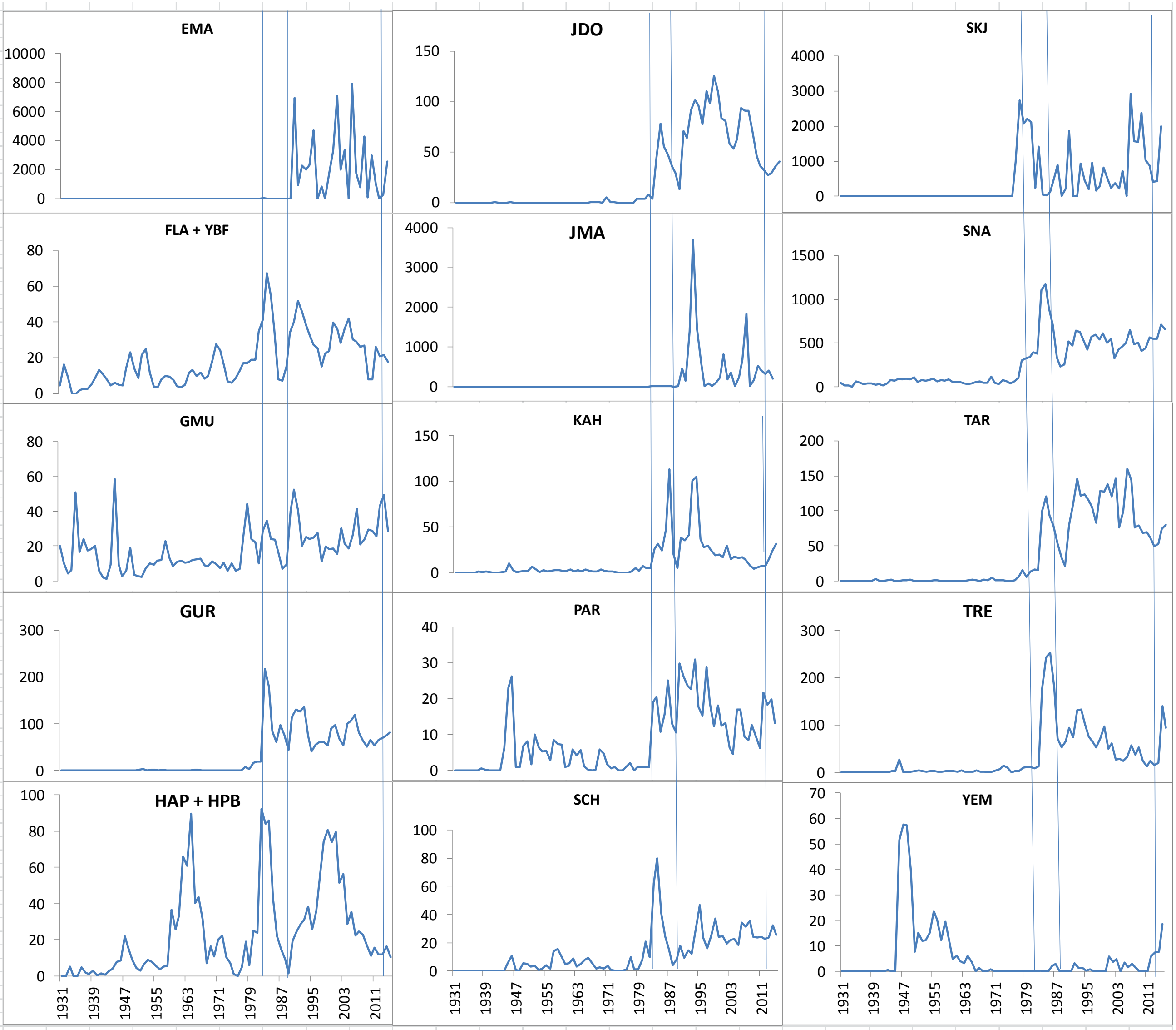
Appendix 1. Northern Quota Management Areas for the main species caught commercially in the Bay of Islands (as well as others of interest). CRA 1, red rock lobster; EMA, blue mackerel; FLA, flatfish; GUR, red gurnard; JMA, jack mackerel; KAH, kahawai; SNA, snapper; TAR, tarakihi; TRE, trevally. (Albacore and skipjack each form a single fishstock around the entire country.)



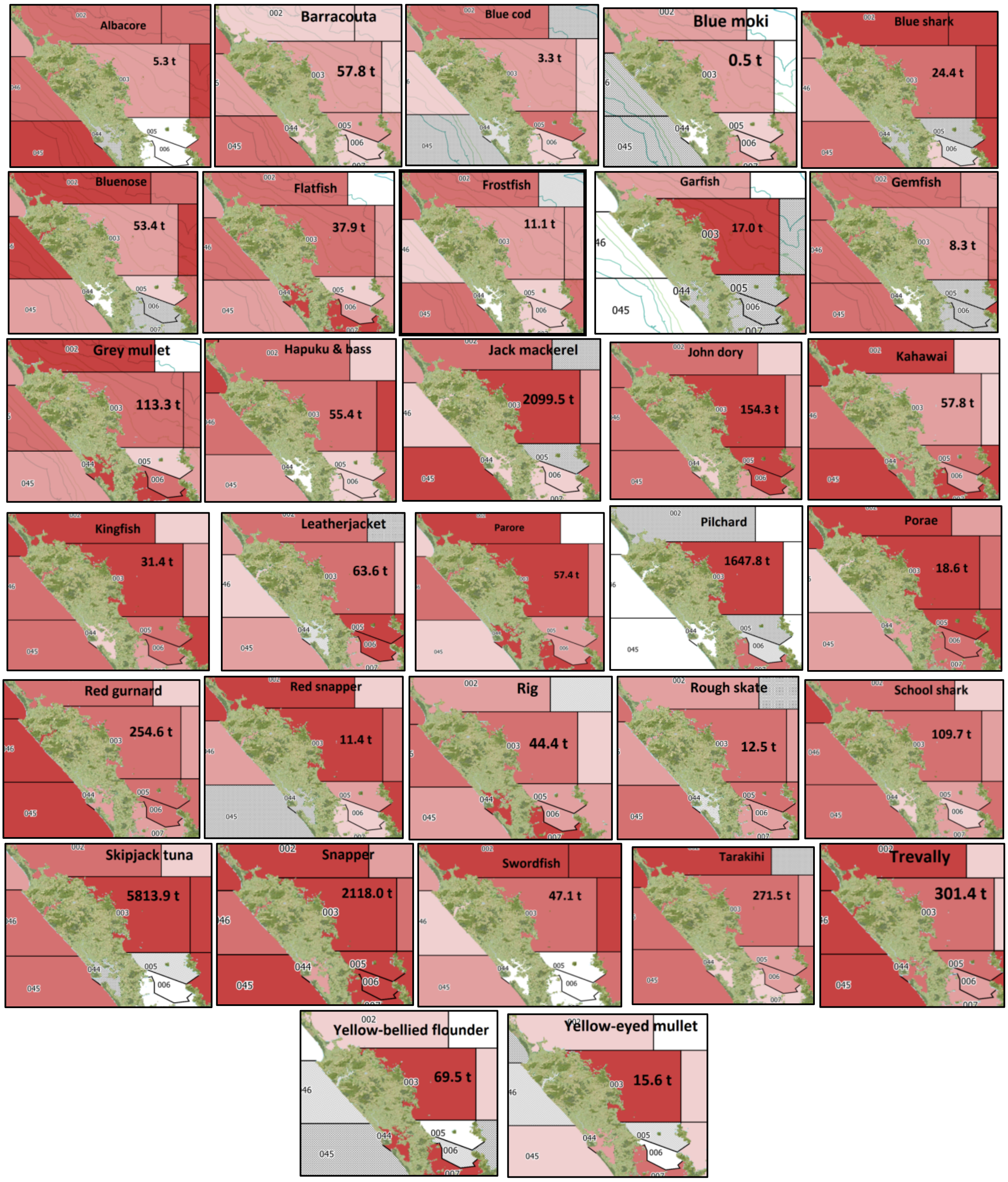
Appendix 2. Indicative annual commercial catches/landings (t greenweight) of principal finfish species (as well as others of interest) for the northeast of the North Island centred on the Bay of Islands, 1931-2015. For some species, no landings were reported before 1983. The vertical lines separate very different areas and/or sources of fishery reporting. Values for 1931-82 are from Francis & Paul (2013) for the Russell Port of Landing (Nine Pin to Cape Brett, and subsequently referred to in the record as 'Bay of Islands'), and at best can be considered a lower bound of the true landings. Values for 1983-88 are the estimated catches for Statistical Area 003 (which, excluding harbours and embayments, extends about 200 km, from near Taupo Bay to Waipu Cove) from the Ministry of Primary Industries' *new_fsu* database at 17 July 2013, but are considered incomplete. Values for 1989 to 2012 are the estimated catches for General Statistical Area 003 from the Ministry of Primary Industries' (MPI) *catch-effort database* at 17 July 2013. Values for 2013 to 2015 are the estimated catches (all methods) for General Statistical Area 003 from MPI's NABIS website (http://www.nabis.govt.nz/) at 21 August 2016. Note that the finfish values from 1983 onwards will be undercounts because fishers need estimate the weight of only their five most abundant species—with fewer than five often being recorded. Also, small amounts of data were withheld for reasons of confidentiality, the catches in those instances being shown here as zero. (EMA, blue mackerel; FLA, flounder; GMU, grey mullet; GUR, red gurnard; HAP, hapuku; HPB, hapuku/bass; JDO, john dory; JMA, jack mackerel; KAH, kahawai; PAR, parore; SCH, school shark; SKJ, skipjack; SNA, snapper; TAR, tarakihi; TRE, trevally; YBF, yellow-belly flounder; YEM, yellow-eyed mullet.)



Appendix 3. Combined reported estimated catches (t greenweight) of the principal finfish species caught in Statistical Area 003 by fishing method for the 2008/09 to 2012/13 1 October fishing years examined on 20 March 2013 (Booth 2013). BLL, bottom long-line; BPT, bottom pair trawl; BS, beach seine/drag net; BT, bottom trawl; CP, cod pot; DL, dahn line; DS, Danish seine; HL, handline; PS, purse seine; SLL, surface/midwater longline; SN, set net; T, troll; dw, data withheld, usually to protect the identity of the few vessels fishing the area. Note that the Total column often exceeds the sum of the previous columns, mainly because of withheld data. Note too that the values will be under-counts because the estimated weight of only the five most abundant species need be recorded by fishers—and often even fewer than five are recorded. The term 'Flatfish' takes in several species, meaning that the reported estimated catches of yellow-belly flounder are probably underestimates. Catches >100 t are highlighted.

	BLL	**BPT**	**BS**	**BT**	**CP**	**DL**	**DS**	**HL**	**PS**	**SLL**	**SN**	**T**	**Total (5 years)**
Albacore						dw				2.6		2.7	5.3
Barracouta	0.6	dw		53.3			1.2	dw	0.9		0.2		57.8
Blue cod	2.3			dw	dw								3.3
Blue mackerel									**8823.2**				**8825.1**
Blue shark	0.1									24.2			24.4
Bluenose	51.3					0.8							53.4
Flatfish							0.9				36.8		37.9
Frostfish	0.1	dw		9.1			0.9						11.1
Garfish			4.4								12.4		17.0
Gemfish	3.4			2.2		dw	dw						8.3
Grey mullet											110.1		**113.3**
Hapuku & bass	51.7			0.3		2.4		0.9					55.4
Jack mackerel				12.6					**2074.6**				**2099.5**
John dory		dw		**123.9**			24.3				0.7		**154.3**
Kahawai	4.7	dw	dw	0.6				0.1	dw		19.2		57.8
Kingfish	12.9	dw		4.9			0.5	4.0	5.8		2.1		31.4
Leatherjacket		dw		56.6			2.9				dw		63.6
Parore			1.6								55.4		57.4
Pilchard									**1647.4**				**1647.8**
Porae	7.5	dw		3.7			0.1	0.1			6.9		18.6
Red gurnard	76.3	dw		53.5			**118.6**	0.1			2.0		**254.6**
Red snapper	10.2			0.6									11.4
Rig	4.2	dw		1.9				dw			37.0		44.4
Rough skate	1.5	dw		10.7									12.5
School shark	66.1	dw		31.5		0.2					10.7		**109.7**
Skipjack tuna									**5813.6**				**5813.9**
Snapper	**929.1**	dw	0.3	**630.6**		dw	**498.3**	6.6			11.1		**2118.0**
Swordfish								dw		46.3			47.1
Tarakihi	38.5	dw		**200.2**		dw	28.6	0.2			1.3		**271.5**
Trevally	8.9	dw	2.4	74.1			1.5	0.1	**200.1**		10.4		**301.4**
Yellow belly flounder											69.5		69.5
Yellow-eyed mullet			dw								14.7		15.6
TOTAL													**22412.3**

Appendix 4. Reported estimated finfish commercial catches (t greenweight) for Statistical Area 003, in relation to adjoining areas, for the fishing years 2008/09 to 2012/13 from NABIS, at 20 March 2013 (Booth 2013). The intensity of colour is clue to the scale of catches (range breaks are calculated on an 'Equal Count' basis, where each catch range has approximately the same number of statistical areas).



Appendix 5. Scale of estimated $-value of finfish species/taxa taken in Statistical Area 003 based on annual catch and the port price which had been used to establish levy rates for 2011–12 for the finfish species in Appendix 4 (Booth 2013). Port prices reflect what fishers are paid for their catch, but the actual value of any one fishery to the community can be much higher when onshore processing and export value are taken into account. FMA, Fisheries Management Area. YBF 1 was ascribed the same value as FLA 1. na, not applicable. Species with an annual value >$200 000 are highlighted.

Common name	FMA	Port price ($/t)	Rounded port price ($/t)	5-year Catch (t)	Mean catch (nearest t)	Mean annual value ($1000)
Albacore	na	2196.667	2200	5.3	1	2
Barracouta	BAR 1	290	300	57.8	12	4
Blue cod	BCO 1	4446.667	4400	3.3	1	4
Blue mackerel	EMA 1	380	400	8825.1	1765	**706**
Blue shark	BWS 1	456.6667	500	24.4	5	3
Bluenose	BNS 1	5010	5000	53.4	11	55
Flatfish	FLA 1	3203.333	3200	37.9	8	26
Frostfish	FRO 1	493.3333	500	11.1	2	1
Garfish	GAR 1	6696.667	6700	17.0	3	20
Gemfish	SKI 1	1890	1900	8.3	2	4
Grey mullet	GMU 1	3270	3300	113.3	23	76
Hapuku & bass	HPB 1	5116.667	5100	55.4	11	56
Jack mackerel	JMA 1	200	200	2099.5	420	84
John dory	JDO 1	6636.667	6600	154.3	31	**205**
Kahawai	KAH 1	413.3333	400	57.8	12	5
Kingfish	KIN 1	5613.333	5600	31.4	6	34
Leatherjacket	LEA 1	563.3333	600	63.6	13	8
Parore	PAR 1	1836.667	1800	57.4	11	20
Pilchard	PIL 1	746.6667	700	1647.8	330	**231**
Porae	POR 1	2210	2200	18.6	4	9
Red gurnard	GUR 1	2153.333	2200	254.6	51	112
Red snapper	RSN 1	7973.333	8000	11.4	2	16
Rig	SPO 1	4420	4400	44.4	9	40
Rough skate	RSK 1	490	500	12.5	3	2
School shark	SCH 1	1956.667	2000	109.7	22	44
Skipjack tuna	na	630	600	5813.9	1163	**698**
Snapper	SNA 1	5350	5400	2118.0	424	**2 290**
Swordfish	SWO 1	6096.667	6100	47.1	9	55
Tarakihi	TAR 1	3290	3300	271.5	54	178
Trevally	TRE 1	1753.333	1800	301.4	60	108
Yellow-belly flounder	YBF 1	3203.333	3200	69.5	14	45
Yellow-eyed mullet	YEM 1	2530	2500	15.6	3	8

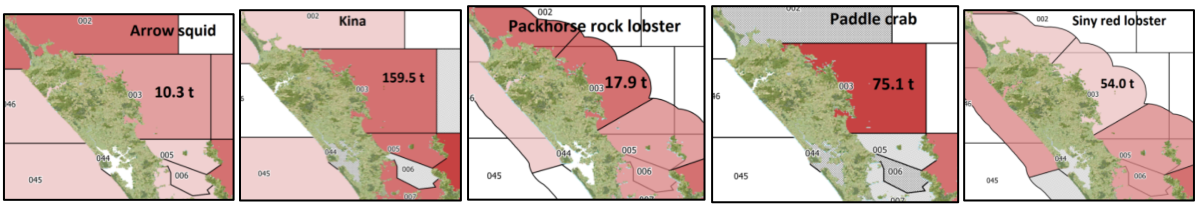
Appendix 6. Estimated catches (t greenweight) of the main finfish species (as well as flounder species combined and kahawai) reported by Booth (2013) to have been caught in Statistical Area 003 during 2008/09 to 2012/13 fishing years by the single-most important fishing method (*see* Appendix 3) and here reanalysed for the 2008/09 to 2014/15 fishing years (NABIS, examined on 21 August 2016) for EMA, blue mackerel; FLA, flounder; GUR, red gurnard; JDO, john dory; JMA, jack mackerel; KAH, kahawai; PIL, pilchard; SCH, school shark; SKJ, skipjack; SNA, snapper; TRE, trevally; TAR, tarakihi; YBF, yellow-belly flounder. BLL, bottom long-line; BT, bottom trawl; DS, Danish seine; PS, purse seine; SN, set net; du, data unreliable; dw, data withheld (usually to protect the identity of the few vessels fishing the area). Also given is the total estimated catch of kahawai using all methods; and combined set net-catch of flatfish/yellow-belly flounder.

Method	PS	SN	DS	BT	PS	PS	PS	BLL	PS	BLL	BT	PS	SN	All	SN
Species	**EMA**	**FLA**	**GUR**	**JDO**	**JMA**	**KAH**	**PIL**	**SCH**	**SKJ**	**SNA**	**TAR**	**TRE**	**YBF**	**All KAH**	**FLA+YBF**
2008/09	789	9	23	42	1326	du	dw	19	1562	172	55	du	19	4	28
2009/10	4273	8	36	35	dw	du	dw	13	1298	225	60	du	13	36	21
2010/11	422	9	21	28	248	dw	209	19	dw	258	37	150	18	9	27
2011/12	2559	9	33	18	411	0	dw	14	dw	247	42	du	17	8	26
2012/13	dw	8	35	19	dw	0	dw	10	dw	247	28	0	13	12	21
2013/14	du	8	47	26	463	0	dw	17	dw	340	53	0	14	22	22
2014/15	738	6	30	25	248	0	dw	15	dw	340	46	dw	13	27	19

Appendix 7. Reported estimated catches (t greenweight) of principal invertebrate species by fishing method for the 2008/09 to 2012/13 fishing years for Statistical Area 003 (904 for rock lobster) examined on 20 March 2013 (Booth 2013). BPT, bottom pair trawl; BT, bottom trawl; CRP, crab pot; DI, diving; DS, Danish seine; RLP, rock lobster pot; SJ, squid jig; SN, set net; dw, data withheld. Note that the Total column often exceeds the sum of the previous columns, mainly because of withheld data. Arrow squid would be from the more open waters; it is unknown how important—if at all—paddle crabs were within the Bay of Islands itself.

	BPT	BT	CRP	DI	DS	RLP	SJ	SN	Total (5 years)
Arrow squid	dw	7.0			0.7		dw	dw	10.3
Kina				157.2					**159.5**
Packhorse rock lobster						17.9			17.9
Paddle crab			74.1						75.1
Red spiny lobster						54.0			54.0

Appendix 8. Combined reported estimated invertebrate commercial catches (t greenweight) for Statistical Area 003 (904 for rock lobster) in relation to adjoining areas, for the fishing years 2008/09 to 2012/13 from NABIS, at 20 March 2013 (Booth 2013). The intensity of colour is clue to the scale of catches (range breaks are calculated on an 'Equal Count' basis, where each catch range has approximately the same number of statistical areas).



Appendix 9. *Scale* of estimated $-value of the principal invertebrate species taken in Statistical Area 003 based on annual catch and the port price which had been used to establish levy rates for 2011–12 (Booth 2013). FMA, Fisheries Management Area. Species with an annual value >$200 000 are highlighted.

Common name	FMA	Port price ($/t)	Rounded port price ($/t)	5-year Catch (t)	Mean catch (nearest t)	Mean annual value ($1000)
Arrow squid	SQU1 T	896.6667	900	10.3	2	2
Kina	SUR1 A	1450	1500	159.5	32	48
Packhorse rock lobster	PHC 1	36063.33	36100	17.9	4	144
Paddle crab	PAD 1	4580	4600	74.1	15	69
Red spiny lobster	CRA 1	46686.67	46700	54.0	11	**514**