Recreational fishing in the Bay of Islands: intense pressure contributes to stress on fishstocks and to local ecological degradation

John Booth

A paper prepared for *Fish Forever*

December 2016

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Synthesis Bay of Islands contains probably the most extensive area of intensive recreational boat-fishing in the whole of East Northland (North Cape to Cape Rodney), this fishing effort almost certainly far exceeding that of the local commercial fleet. The principal fish recreationally sought and caught in the Bay of Islands is snapper, followed by kahawai; the shellfish include red rock lobsters, scallops, green-lipped mussels, cockles and pipi. For all species, the recreational harvest is comparable with, or exceeds, the corresponding commercial catch where there is one. Because most finfishes of recreational interest do not spend their entire lives in the Bay of Islands, the status of the underlying stock is critical to the status of the respective Bay of Islands fish population; this also applies to rock lobsters. The East Northland snapper substock of SNA 1 is overfished, and recreational fishing in the Bay of Islands contributes significantly to this overfishing through the large numbers of vessels going out to fish year round. The KAH 1 kahawai stock is not considered overfished but, nevertheless, Bay of Islands recreational fishing contributes significantly to the pressure on this stock. Although the CRA 1 red rock lobster stock is not considered overfished, recreational fishing pressure is intense, with most lobsters taken in and near the Bay of Islands being at or only a little above minimum legal size. 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, and consequential emergence of urchin barrens as extensive as those anywhere else 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, and that no-take areas be established. Fishing pressure derives from commercial, recreational and customary users. The Bay of Islands has long been known for its recreational fishing opportunities—not only for gamefish but also for other fishes such as snapper and kahawai, as well as dive-quarry like rock lobsters and scallops. Also, the Bay of Islands was one of the most significant commercial fishing ports of the country (*see* annual Reports on Fisheries, published by the Marine Department from the late 1800s on), and, at its peak in the 1980s, it supported something like 170 commercial vessels (King 1985). And customary harvesting has been—and remains—locally important, especially in remote coastal communities such as Rawhiti.

Harvest pressure on fish stocks in northeast New Zealand—including the Bay of Islands—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 (species whose impact on the ecosystem is disproportionately large relative to their abundance) such as large snapper and large red rock lobsters. In a process which started to become obvious in the 1970s, much of the shallow-reef kelp forests of the Bay of Islands (and elsewhere in Northland) has disappeared (Booth 2015); it is no coincidence that this corresponded with the era when highly mechanised commercial fishing pressure grew rapidly, leading to significant reductions in both the proportion of large fish, as well as in individual-fish mean size.

Recreational-fishing catch and effort data are notoriously difficult to pin down—particularly where, as in New Zealand, no licence is required in order to fish. Accordingly, it has taken much longer to gain a credible handle on the levels of recreational harvests than those of the commercial fishery. Most fishery data—commercial and recreational—are reported by species according to a 1 October-30 September fishing-year and enormous Fishery Management Areas (FMAs) or Quota Management Areas (QMAs); General Statistical Area 003 takes in the Bay of Islands (*see* Appendix 1). Recent reports particularly useful in estimating recreational catches and effort for the Bay of Islands, a subarea of FMA 1/QMA 1, include Hartill et al. (2007, 2013, 2015), Muller (2013), Armiger et al. (2014), Holdsworth (2014), Wynne-Jones et al. (2014), Hartill & Davey (2015), and Hartill & Bian (2016).

The purpose of this report is to summarise what is known about the catch, effort and individual-fish mean size associated with Bay of Islands' marine recreational fisheries. Such information, together with that for the commercial and customary sectors, is important when considering where no-take marine refuges might be placed, and in establishing where responsibility might settle when considering the reasons for ongoing loss of shallow-reef kelp to sea-urchin overgrazing. Accordingly, in this paper 1) first I summarise the overall Bay of Islands marine fishery, from first human settlement to the present; 2) then I summarise recent recreational harvests for the Bay of Islands; 3) I focus in some detail on the fishery biology and catch characteristics of the two main finfish species (snapper *Pagrus auratus*, and kahawai *Arripis trutta*) and the main shellfish species (red rock lobster *Jasus edwardsii*, scallop *Pecten novaezelandiae*, green-lipped mussel *Perna canaliculus*, cockle *Austrovenus stutchburyi*, and pipi *Paphies australis*) harvested in the Bay of Islands by recreational fishers, and the status of their respective fish stocks; and, finally, 4) I talk about the role of overfishing, including the intense recreational fishing, in the loss of shallow-reef kelp in the Bay of Islands.

2 Fishing history of the Bay of Islands from first human settlement

In early times, all fishing pressure in the Bay of Islands was, of course, customary; and then for a good portion of the 20th century, commercial fishing trumped all others. Today, most harvest pressure in the Bay of Islands almost certainly results from recreational fishing, seen, for example, in the high numbers of boats, and in the estimated recreational harvests being similar to or exceeding those commercial.

Even though the human population of the Bay of Islands may have been as great as 10 000 at the time of James Cook's arrival in 1769 (about half the total human population resident on its shores today; http://profile.idnz.co.nz/far-north), midden analyses point to there having been no enduring impacts on fish and shellfish stocks by pre-Contact fishing pressure—apart from local extirpation of the Cook Strait limpet *Cellana denticulata* soon after the first East Polynesian settlement, in about 1300 (Booth 2016b). The first commercial fisheries in the Bay of Islands, from the mid- to late-1800s, were for rock oysters and grey mullet (Booth 2016a), again without any known long-term consequences of concern. The Marine Department annual Reports on Fisheries show how set-netters and liners then came to dominate the commercial fleet, with a total of 30-60 vessels fishing the Bay of Islands and its immediate environs during the 1920s and 1930s. For Northland generally, sail and row boats were overtaken with a progression of more efficient commercial methods: beam trawls from about 1899; long lines from about 1912; Danish seiners from about 1923; and pair trawling during the 1970s to 1980s (Parsons et al. 2009). And after the war, rock lobster vessels joined the fishing fleet. At its peak, there were, all up, around 170 commercial vessels working out of the Bay of Islands (King 1985).

For the commercial landings, the published data from 1931 to the present show the following for the Bay of Islands (Francis & Paul 2013; Booth 2016a).

- 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 briefly exceeded 1000 t;
- Parore and yelloweyed mullet put on a bit of a show soon after World War II, the latter netted in large quantities (up to 60 t a year) near Opua in particular;
- Pelagic species such as blue and jack mackerel and skipjack tuna were first fished in the 1980s, after which large catches (thousands of tonnes) were being made in open waters just outside the Bay;
- 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 about 10 t a year.

In recent times only a handful of local commercial fishers have routinely worked the waters of the Bay of Islands (Booth 2013), most boats < 7-m long. Their main finfish by weight have included flounder, garfish (piper), grey mullet, kahawai, pilchard, snapper and trevally—totalling a few dozen tonnes across the board each year, caught using mainly set nets and beach seines. The main invertebrates taken within and near the Bay of Islands are potted or dived-for—particularly rock lobsters, but also some kina. There is no commercial harvesting of scallops or other shellfish.

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 mouth of the bay. The annual scale of these catches—apart from those purse-seined—are probably modest (Booth 2013).

The recreational fishing opportunities of the Bay of Islands became internationally known early in the 1900s, largely as a result of the Department of Tourist and Health Resorts' marketing of a 'sportsman's paradise', and the visits and writings of Zane Grey (Warne 2010). During the latter decades of the 20th century, in particular, Bay of Islands became a recreational mecca, fished by a growing local fleet that was soon to be pipped by the great summer influx of visiting vessels, many from Auckland. Bay of Islands is now arguably the most intensively recreationally-fished part of east Northland (Hartill et al. 2007).

Annual customary harvests for the Bay of Islands in recent times are unlikely to have exceeded 10 t across all species. But there is every chance the recreational catch estimates themselves include a portion of the catch representing the customary take (Plenary 2015), as not all customary harvesting is undertaken with permits issued under customary regulations.

3. Recreational harvests of the Bay of Islands

Recreational fishing can be undertaken all year round throughout the Bay of Islands, apart from the exclusions shown in Figure 1.

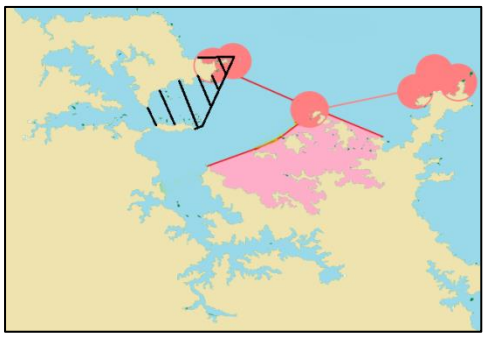

Figure 1. Area prohibitions that apply to recreational fishing in the Bay of Islands. Red, where set netting is totally prohibited (circles have 1-nautical mile radius); pink, where set netting is prohibited 1 October to 30 April, except for use of grey mullet and flatfish nets. The black-hatched area is Te Puna Mataitai, where there is customary and recreational fishing only, but no special rules for fishers have yet been instituted.

3.1 Species most sought and caught

Snapper are the most-sought and most-caught finfish in the Bay of Islands, followed by kahawai (Hartill et al. 2015; Figure 2). Others of particular interest include john dory, kingfish, red gurnard, tarakihi and trevally (Muller 2013; Hartill et al. 2013, 2015; Holdsworth 2014). Among the invertebrates, red rock lobsters, scallops, green mussels, and cockles and pipi are the principal species on account of they being popular, as well as they being landed in significant numbers and/or weight.

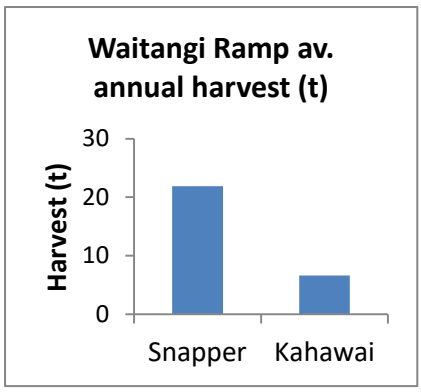

Figure 2. Average annual recreational harvest of the two main finfish (snapper and kahawai) landed over the Waitangi Ramp, 2011-14 (data from Hartill et al. 2015, who also give error estimates). Waitangi landings are thought to reflect those of other ramps, and of shore-fishing, in the Bay of Islands.

The recreational catches of snapper and kahawai in the Bay of Islands are significant relative to the commercial catch there; and in turn the estimated recreational harvests from Bay of Islands are significant constituents of the East Northland (North Cape to Cape Rodney) landings (Figure 3), even though the Bay makes up only about 10% of that coastline. For East Northland as a whole, 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.

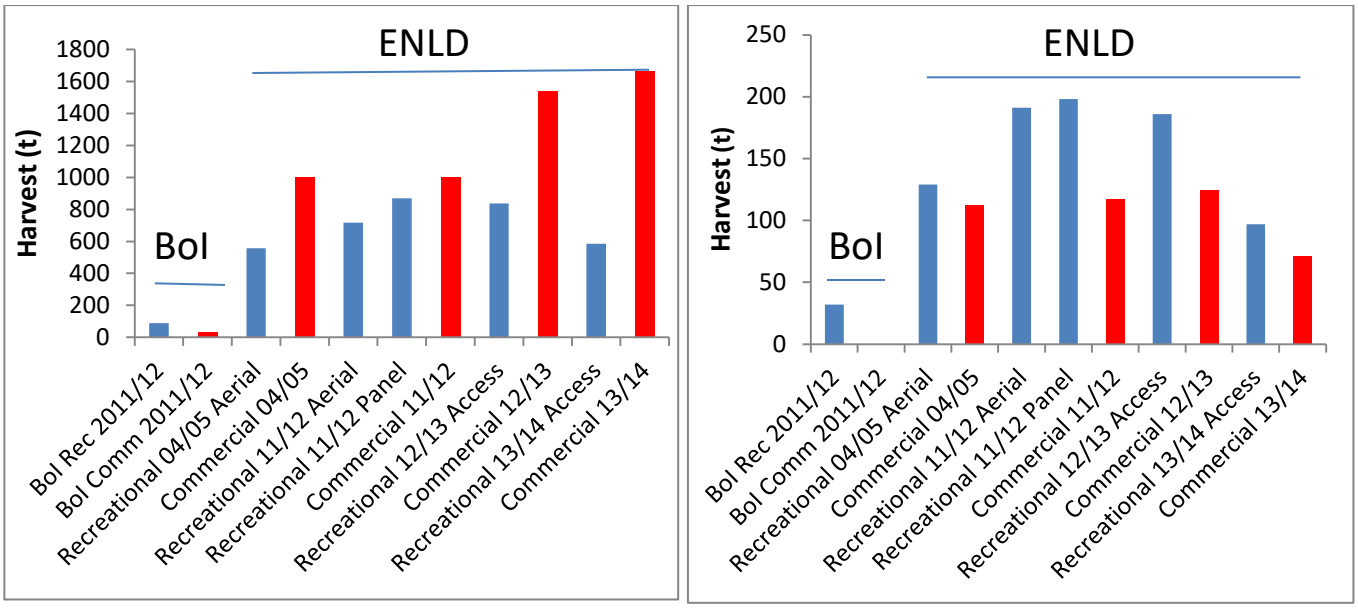

Figure 3. Estimated recent commercial (red) and recreational (blue) harvests of snapper (left) and kahawai (right) in the Bay of Islands (Bay of Islands) compared with those of East Northland (ENLD, North Cape to Cape Rodney) (*see* Table 3). (There were no known commercial harvests of kahawai within the Bay of Islands in 2011/12.)

Among the shellfish, only lobsters are fished commercially in and near the Bay of Islands. Again, the recreational catch of rock lobsters in the Bay of Islands is high relative to the commercial catch; and in turn the Bay of Islands recreational harvest is a significant constituent of the East Northland landings (Figure 4).

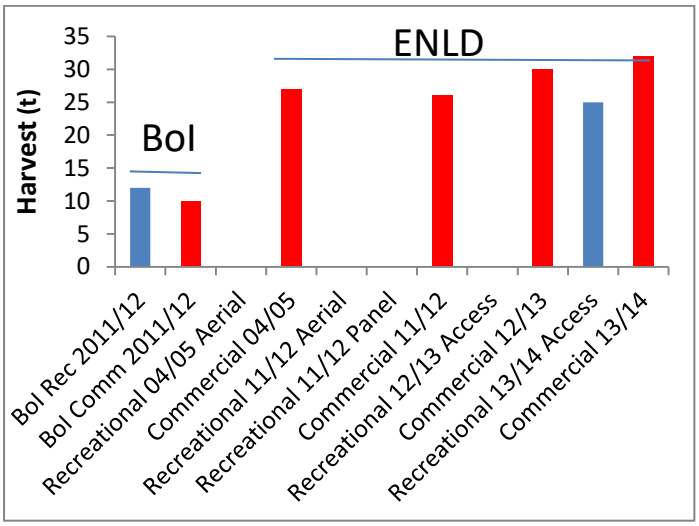

Figure 4. Estimated recent commercial (red) and recreational (blue) catches of red rock lobsters in the Bay of Islands (BoI) compared with those of East Northland (ENLD), 2011-12 (*see* Table 3). No bar means no data available. Bay of Islands makes up only about 10% of the coastline of East Northland.

3.2 Fishing effort hotspots

Bay of Islands contains among the most extensive area of intensive recreational boat-fishing in the whole of East Northland, this fishing effort almost certainly far exceeding that of the local commercial fleet for most species. There are hotspots (>100 vessels per square kilometre, annualised) of recreational boat-fishing north and southeast of Moturoa Island, near the Nine Pin and Whale Rock, and north of Motuarohia Island (Figures 5 and 6).

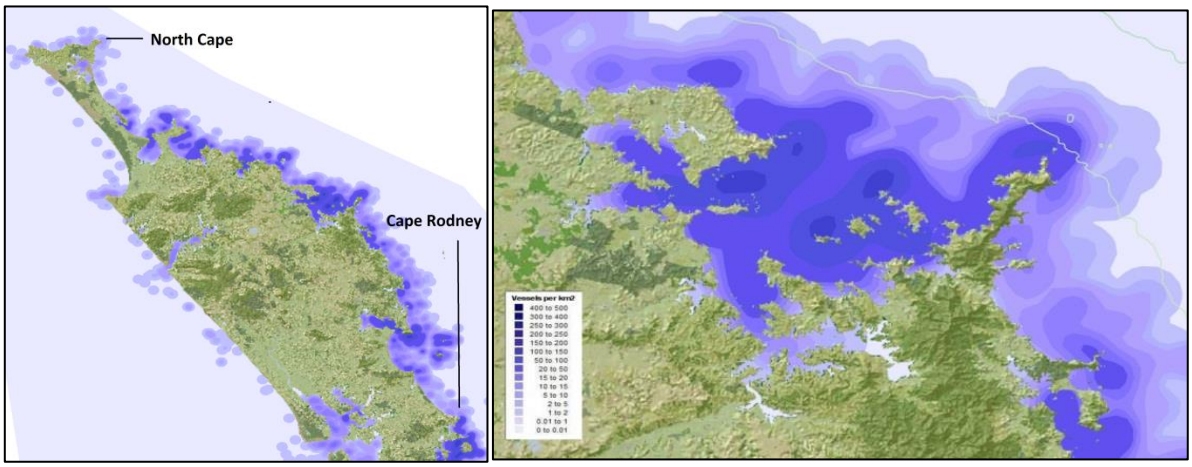

Figure 5. Distribution of stationary vessels recreationally fishing (vessels per square kilometre), 1 December 2004 to 30 November 2005, North Cape to Cape Rodney (Hartill et al. 2007, downloaded from NABIS [www.nabis.govt.nz/Map.aspx]). For the Bay of Islands, the areas with most-intense fishing activity (dark blue) contain 100-150 vessels per sq. km.

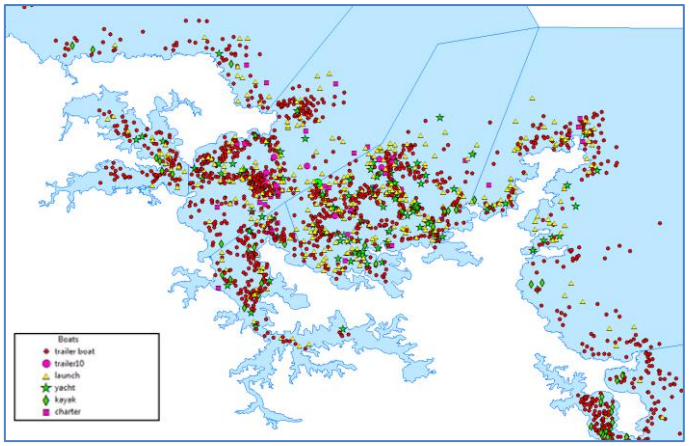

Figure 6. Distribution of stationary vessels recreationally fishing, 1 April 2011 to 31 March 2012 (Bruce Hartill, NIWA, pers. comm.).

A subsequent study of recreational harvests, in 2013-14, was entirely consistent with these: Bay of Islands (Sections 4 and 5 in Figure 7) had nominally the greatest boat-fishing effort, followed by the Whangarei area.

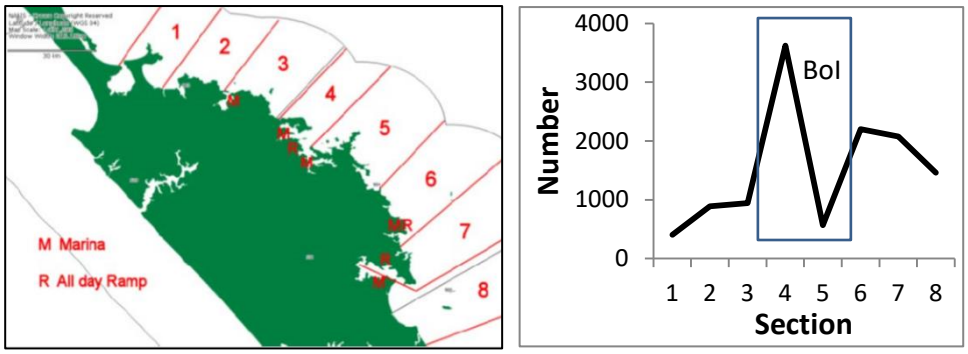

Figure 7. Sections of Holdsworth's (2014) survey area (left), and nominal numbers of fishing vessels, 2013-14 (right, with Bay of Islands sections boxed).

Rock lobsters are sought in outer, more exposed parts of the Bay of Islands. For scallops, over the past 10 years the principal beds in the Bay of Islands have been in the east (Ipipiri), with other scallop beds seemingly small and diffuse. In Ipipiri the main beds are 1) Albert Channel between Urupukapuka Island and the Rawhiti mainland (including Urupukapuka Bay); 2) the area between Paramena Reef, Poroporo Island and Ngatokaparangi Islands/reefs to the south of Motukiekie; and 3) Motukiekie Channel between Urupukapuka and Motukiekie Islands (Pacific Eco-logic Ltd. 2016) (Figure 8). The green-lipped mussel is harvested in open parts of the Bay of Islands, the foremost location probably still being the Black Rocks. In contrast, cockles and pipi are hand-gathered widely in estuaries and sheltered inner embayments (Figure 8).

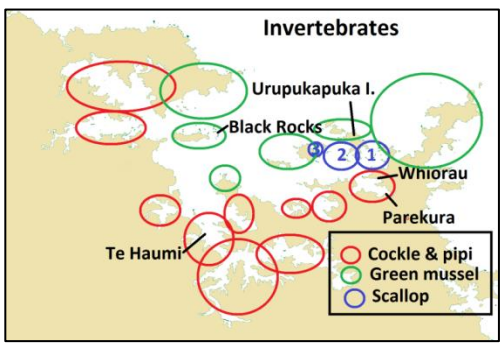

Figure 8. Main shellfish-harvesting areas. Blue numerals refer to the scallop grounds referred to in the text.

3.3 Time series of effort and harvests

For finfish, the relative recreational fishing effort in the Bay of Islands, based on comings and goings of boats at the Waitangi Ramp, has remained steady over nearly 10 years (Figure 9), as did snapper harvest rates during 2011-14 (Figure 10). On the other hand, kahawai boat-harvests fell significantly in 2013-14, to 0.75 kg (Figure 10).

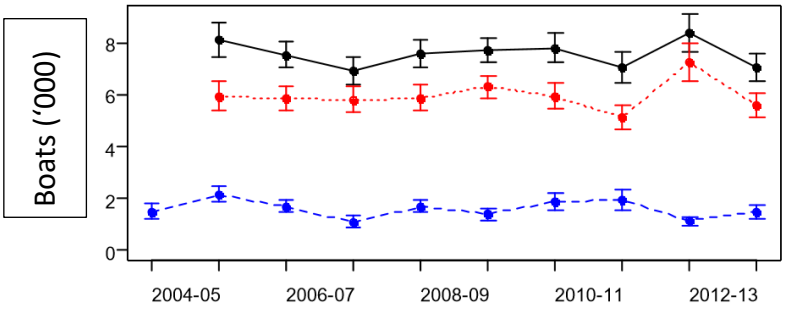

Figure 9: Indices of recreational effort (number of boats returning to ramp ± SE), based on imagery taken at Waitangi Ramp and a subsample of 60 days per fishing year, for the period 2004–05 to 2013–14 (Hartill et al. 2015). Black curve, total; red curve, summer; blue curve, winter.

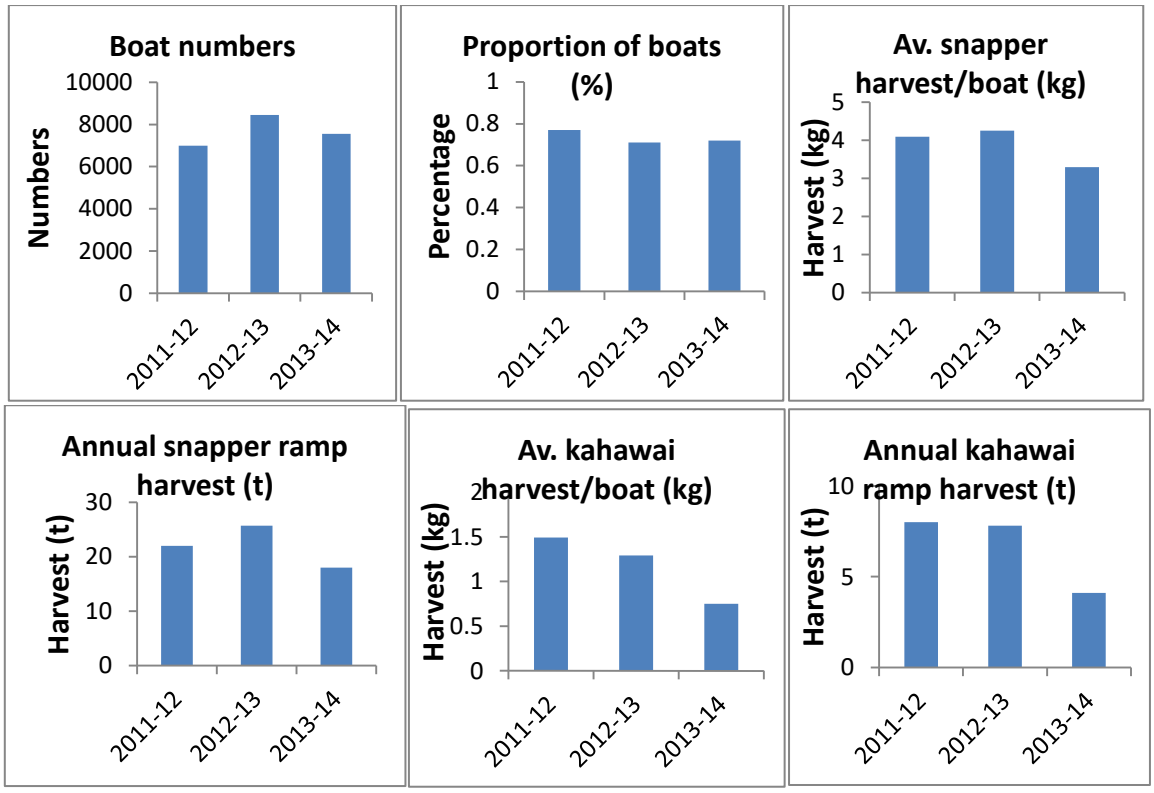

Figure 10. Annual estimates of numbers of boats using Waitangi Ramp (based on web camera counts); the proportion of observed boats that were being used for fishing; the average weight of snapper and kahawai harvested per boat; and the estimated annual snapper and kahawai harvests landed at the ramp (Hartill et al. 2015, who also gave associated error values).

In 2013-14, east-Northland catch rates of kahawai greatly exceeded those of trevally, and, in turn, red gurnard (no data were provided for snapper); Bay of Islands rates were averge or above average for kahawai and trevally, but below average for red gurnard (Figure 11).

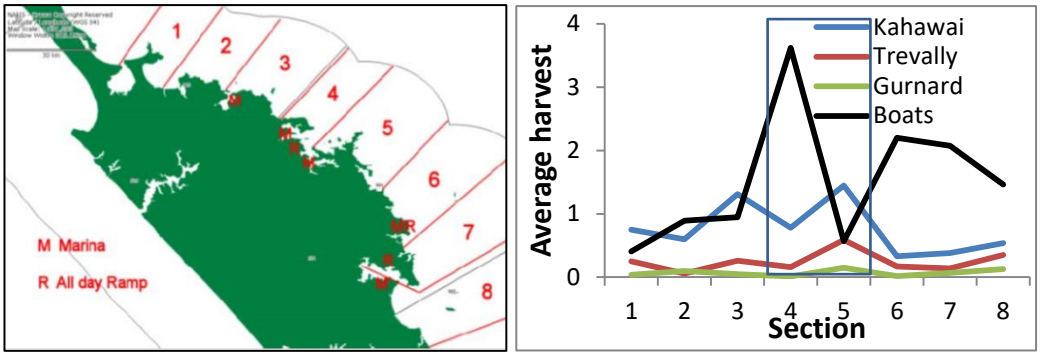

Figure 11. Sections of Holdsworth's (2014) survey area (left), and average catch-rates (kg) for finfish by section, 2013-14 (right, with Bay of Islands sections boxed). (Nominal boat numbers are shown as x10^{-1}.)

For FMA 1 invertebrates during 2011-12, Wynne-Jones et al. (2014) listed 17 individual and groups of species harvested recreationally (Table 1, which gives a sense of *relative scale* of harvests of all five of the Bay of Islands invertebrates because the Bay makes up perhaps 5% of the total FMA 1 coastline).

Cockles	299 765
Crayfish/Lobster Spanish	96
Crayfish/Lobster Spiny/Red	83 337
Crayfish/Lobster Packhorse/Green	1 191
Kina	2 018 810
Mussel	575 602
Oyster	212 862
Paua	23 441
Paua Yellow Foot	408
Pipi	361 303
Puupuu/Cats Eye/Cooks Turban	3 125
Scallops	755 525
Squid	4 236
Tuatua	565 207
Octopus	518
Crab	2 720
Paddle Crab	2 003
Other Marine	3 658

Table 1. Estimates of non-finfish species harvests (numbers of individuals) in FMA 1 (North Cape to Cape Runaway), 2011-12 (Wynne-Jones et al. 2014).

Unlike for finfish, there are no estimates of red rock lobster recreational harvests over time for the Bay of Islands. However, for East Northland (in this case, Rangiputa to Mangawhai Heads—Figure 12) during 2013-14, recreational fishers were estimated to have landed 25.4 t, the highest average catch rates being between the Bay of Islands and Whangarei (Sections 5 and 6) (Figure 12, Table 3) (Holdsworth 2014). The Bay of Islands rock lobster catch rates were above average. (Part of the Bay of Islands recreational harvest was an estimated 1709 lobsters, or about 1.25 t, taken in Te Puna Mataitai over the last seven months of 2013-14.)

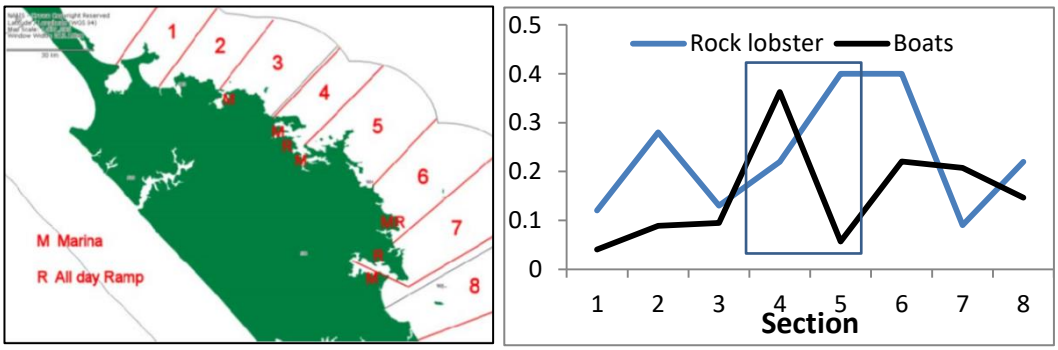

Figure 12. Sections of Holdsworth's (2014) survey area (left), and average catch-rates (kg) for rock lobsters by section (right, with Bay of Islands boxed). (Nominal boat numbers are shown as x10^{-2}.)

Green-lipped mussel stocks in the Bay of Islands have declined markedly over the past 10 years. In the eastern part, overharvesting of intertidal beds was followed by increasing focus on subtidal beds, only a few of which are known to survive today, most of these on the west side of the Cape Brett Peninsula (Pacific Eco-logic Ltd. 2016). At the Black Rocks, in the northwest Bay of Islands, there are various levels of depletion among some dense intertidal and subtidal beds.

For cockles and pipi, the important sheltered-water shellfish-gathering bays of the Bay of Islands include Te Haumi, Parekura and Whiorau (Figure 8); harvest rates are unknown. For Te Haumi, surveys showed a significant decline in the numbers of cockles ≥ 30-mm length during the late 1990s, but fairly constant stocks through until the most recent survey, in 2014/15; the pattern was similar for pipi ≥ 50-mm long (Berkenbusch & Neubauer 2015).

4. Characterising stocks underpinning the Bay of Islands recreational fishery

None of the main recreational finfish species in the Bay of Islands (nor the red rock lobster) is confined there throughout their entire lives. Because of general mixing during their life-histories, the status of Bay of Islands' main recreational fisheries ultimately depend on that of the QMA stock.

All exploited coastal fish species have declined dramatically in abundance since colonisation using every acceptable measure, many species now being well below their optimal stock size (Francis 2003; Plenary 2015). 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. Despite advances in fishery modelling, and a lot more research, there is no information on, or there still remains considerable uncertainty around, the status of all but a couple of the main stocks/substocks underpinning the fisheries of the Bay of Islands (Table 2)—and there is evidence of overfishing. (Overfishing 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 2. Stock status of selected fish of recreational importance in the Bay of Islands, and of rock lobsters (Plenary 2015). (None of the other invertebrates recreationally important in the Bay of Islands are part of a formal stock assessment.) Fishstock, the stock or substock applying to the Bay of Islands; 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 the period 1979-88. The terms used in relation to targets and limits are as given in Plenary (2015). The target and limits for KIN 1 (East Northland) are based on those for KIN 1 (Bay of Plenty); TRE 1 are based on TRE 7.

Fishstock	Species	Last assess	Target	At or above target?	Soft limit	Below the soft limit?	Hard limit	Below the hard limit?	Overfishing?
GUR 1E	Red gurnard	2013	B_{MSY}	Unclear	50% B_{MSY}	Unlikely	25% B_{MSY}	Very unlikely	Unknown
KAH 1	Kahawai	2015	52% B_0	Very likely	20% B_0	Very unlikely	10% B_0	Exceptionally unlikely	Very unlikely
KIN 1 (East Northland)	Kingfish	-	$F_{40\%}$	Unknown	20% B_0	Unknown	10% B_0	Unknown	Unknown
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
CRA 1	Rock lobster	2015	AW (1979-88)	Virtually certain	20% SSB_0	Exceptionally unlikely	10% SSB_0	Exceptionally unlikely	Exceptionally unlikely

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

4.1.1 Essential biology

Snapper are both abundant and widespread in Northland, most at depths of 15-60 m. Sexual maturity is achieved at an age of 3-4 years and a length of 20-28 cm; snapper may live up to 60 years or more (Plenary 2015).

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). Even so, there is anecdotal evidence for areas within East Northland having greater-than-average proportions of large fish (suggesting stock mixing is gradual and/or incomplete), as well as for localised depletions.

4.1.2 Harvest history and stock assessment

Snapper have always been an important harvest in the Bay of Islands, and in Statistical Area 003 generally (*see* Appendix 1). Harvest data, and Total Allowable Catch (TAC) allocations, are given in Table 3.

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 (Figures 13 and 14).

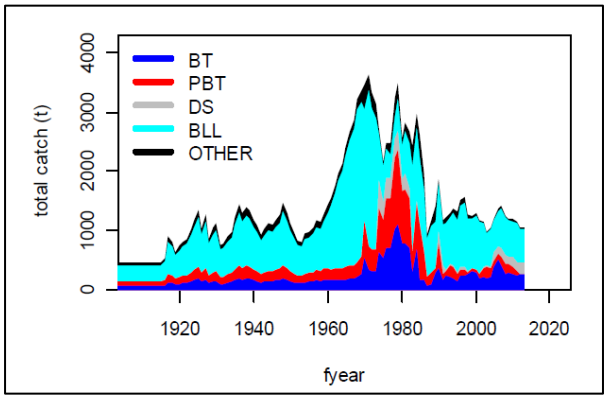

Figure 13. Commercial catch history by method for East Northland (Plenary 2015). BT, bottom trawl; PBT, bottom pair trawl; DS, Danish seine; BLL, bottom long-line.

The East Northland Substock is overfished: the 2013 biomass was estimated to be only 24% of the unfished state (Figure 14), 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).

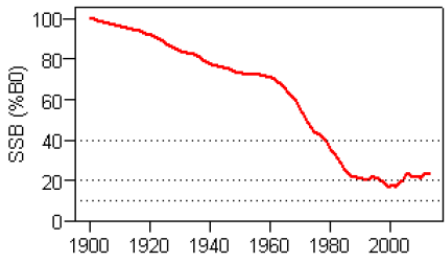

Figure 14. East Northland snapper spawning stock biomass (SSB) trajectory (t) as percentage of B_0 (virgin biomass). Dotted lines indicate the target (40% B_0), soft limit (20% B_0) and hard limit (10% B_0) (Plenary 2015).

4.1.3 Fish size

The mean size of snapper from early northern middens was around 50 cm (Figure 15), yet most fish harvested recreationally from the East Northland substock (and SNA 1) in recent years have not been much larger than 30 cm (the recreational MLS), with only small proportions of large fish (Figure 15; Appendix 2) (Walsh et al. 2011, 2014), demonstrating a greatly fished-down stock. (Bay of Islands' recreational snapper sizes closely approximate those for East Northland [Bruce Hartill, NIWA, pers. comm.], even after the likely high-grading). 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 younger than 10 years, and the proportion of fish older than 20 years is small (Plenary 2015).

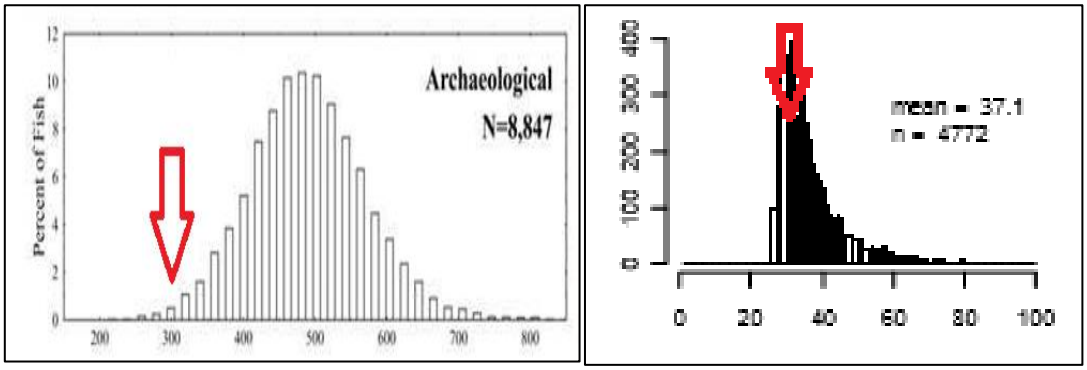

Figure 15. Length-frequency distribution (mm fork length) of snapper from a pre-Contact archaeological site at Houhoura, 100 km northwest of the Bay of Islands (Leach 2006) (left). Length-frequency distribution (cm fork length) of snapper recreationally harvested in the East Northland substock of SNA 1 in 2011-12 (Hartill & Davey 2015; *see* also Appendix 2) (right). Arrows indicate 30-cm length MLS.

4.1.4 Wrapping up for snapper

Most of this discussion has been for East Northland, but, because of stock mixing, it applies to the Bay of Islands too. Snapper are overfished in the Bay of Islands, most of the local pressure today coming from recreational effort which has, anecdotally, led to areas of local depletion.

4.2 Kahawai: KAH 1 (North Cape to Cape Runaway)

4.2.1 Essential biology

Kahawai, a coastal-schooling pelagic fish, is widespread and abundant in Northland. Sexual maturity is achieved at an age of 3-5 years and a length of 35-40 cm; kahawai may live up to 26 years or more (Plenary 2015).

Northland kahawai are assumed to be part of a northern stock (the other stock being focussed at the northern tip of the South Island) (Plenary 2015; Hartill & Bian 2016). Tagging suggests most kahawai remain in any one general area for several years. Recreational fishers typically land a wider size-range of kahawai, from a far greater number of geographically dispersed schools, than does the commercial fishery (Armiger et al. 2014).

4.2.2 Harvest history and stock assessment

Harvest data, and TAC allocations, are given in Table 3. The KAH 1 stock was gradually fished down until the late 1970s, followed by a steeper decline coinciding with the development of the purse seine fishery during the 1980s (Figures 16 and 17). There have been marked fluctuations in stock size since the early 2000s, with evidence of rebuild (Plenary 2015): only recently have landings become

constrained by the TACC (total allowable commercial catch) (Figure 16), probably a result, at least in part, of the halving of commercial landings over the past 10-15 years (Armiger et al. 2014). The KAH 1 stock is, therefore, not considered overfished, and is very likely to be above the reference target of 52% B_0 (Figure 17; Plenary 2015), with high probability of this continuing into the near future (Hartill & Bian 2016).

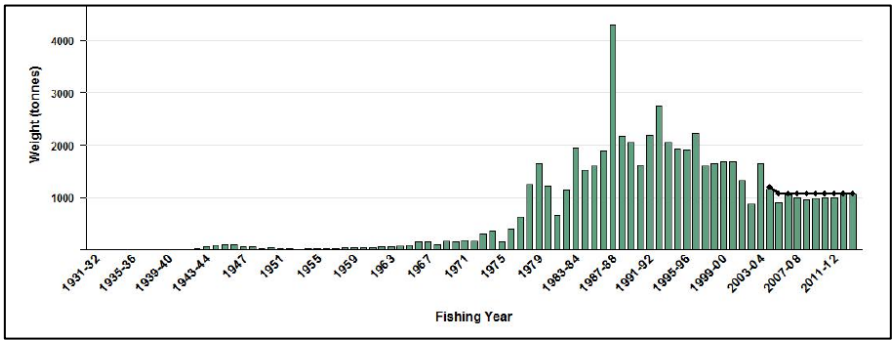

Figure 16. Commercial landings (t) and total allowable commercial catch (black line) for KAH 1 (Plenary 2015).

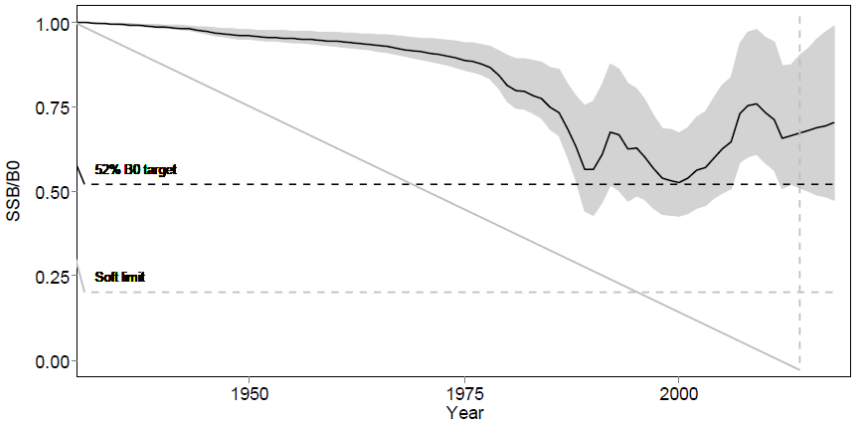

Figure 17. KAH 1 spawning stock biomass (SSB), with projection, relative to B_0 (virgin biomass). The 52% B_0 target set by the Minister of Fisheries in 2010 is denoted by a black dashed line and the 20% B_0 soft limit is denoted by the grey dashed line (Plenary 2015).

4.2.3 Fish size

The median size of kahawai recently caught recreationally in East Northland is around 40 cm, but the length-frequencies show strong bimodality (Figure 18) attributed to influxes of larger, older fish (Hartill et al. 2013). (Other size-data for kahawai are given in Appendix 3.) No length-frequencies of an unfished/lightly fished northern population were located to provide a comparison, but in an archaeological site at Foxton, towards the south of the North Island, most kahawai were 45-60 cm and longer (Figure 18). The suggestion is that the wide size-range of fish presently being caught recreationally in East Northland aligns with a relatively lightly fished resource.

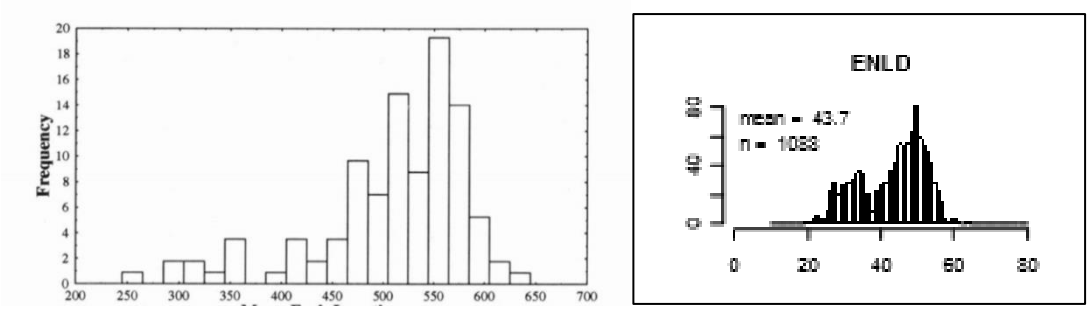

Figure 18. Length-frequency of kahawai from pre-Contact middens at Foxton (sample size 114; Davidson et al. 2000) (left). Length-frequency of kahawai from the 2011-12 East Northland recreational catch (Hartill & Davey 2015) (right). There is no size limit for kahawai.

4.2.4 Wrapping up for kahawai

Despite a widely held belief that kahawai are presently overfished, the numbers and concentrations of schooling fish having diminished greatly from even 20 years ago, the fish-size distribution of the recreational harvest, as well as the stock assessment referred to above, suggest otherwise for KAH 1 East Northland. Seabirds working fish boil-ups are more apparent than the fish themselves, and it may be that declines in seabird numbers is at least part of the reason for the apparent discrepancy.

4.3 Rock lobster: CRA 1

4.3.1 Essential biology

The red rock lobster is a keystone predator of the shallow reefs of East Northland even though it mainly lives much deeper, at 20-60 m. Sexual maturity in East Northland is achieved at an age of around 4 years by males and 6 years by females, and tail widths of about 48- and 55-mm respectively. Red rock lobsters have a very long larval life (around 18 months) during which they become widely dispersed; after settlement on reefs, they are thought to live several decades (Booth 2000). In Northland, males reach MLS (54-mm tail width) at about 5 years of age; females (60-mm tail width) at 6.5 years.

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 for moulting and mating (Booth 1997). Despite this, there is anecdotal evidence for localised depletion within East Northland, as well as areas (often remote) with higher proportions than average of large lobsters than elsewhere in the fishery, suggesting stock mixing is gradual and/or incomplete.

4.3.2 Harvest history and stock assessment

Harvest data, and TAC allocations, are given in Table 3. CRA 1 catches built steadily after World War II, rapidly peaking in the late 1960s as many new vessels joined the fleet, spurred along by the Chatham Islands rock lobster fishing boon (Figure 19).

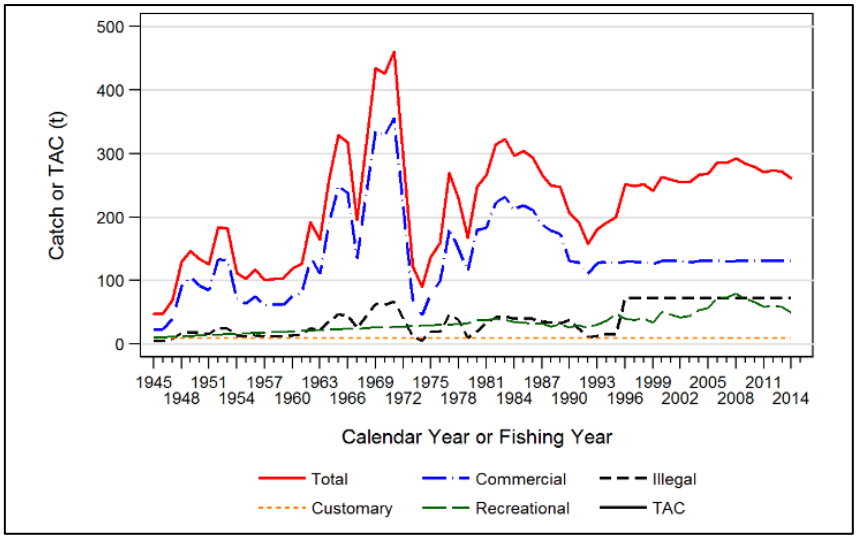

Figure 19. Catch trajectories (t) for CRA 1, showing estimates for commercial, recreational, customary and illegal categories (Plenary 2015).

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 just 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 20). Because the target biomass is that associated with the stock during 1979-88 (Table 2), when the vulnerable biomass was near its nadir (Figure 20), it is little wonder that this fishery is not considered overfished.

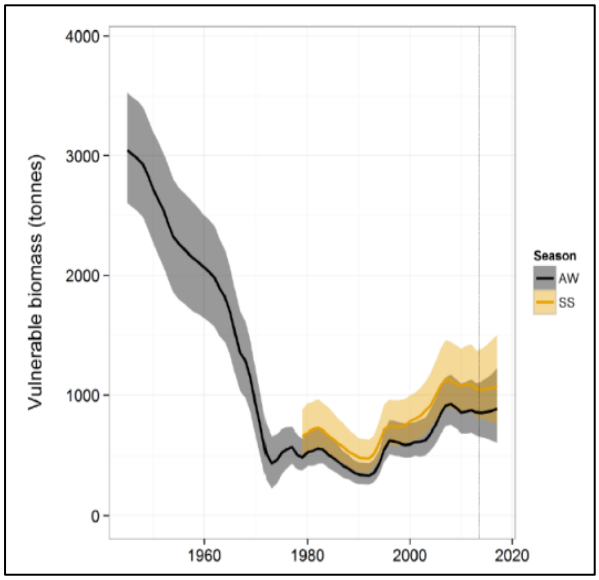

Figure 20. CRA 1 vulnerable biomass and projected vulnerable biomass by season (AW, autumn/winter; SS, spring/summer) (Plenary 2015). Shading shows the 90% confidence zones.

Bay of Islands lies within Rock Lobster Statistical Area 904 (Takou Bay to Bream Bay; Appendix 4) 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 (Plenary 2015). This points to severe regional depletion.

4.3.3 Lobster size

Consistent with intense fishing pressure, most rock lobsters caught recreationally and commercially in and near the Bay of Islands are not much larger than the MLS (Figures 21 and 22). 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 23.

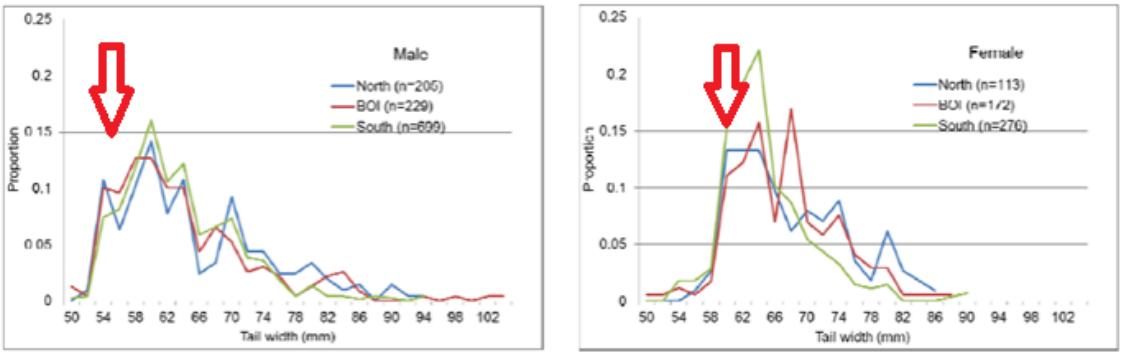

Figure 21. Rock lobster proportion of harvest by tail width by sex for the Bay of Islands (red) versus north to Rangiputa (blue) and south to Mangawhai Heads (green) in 2013-14 (Holdsworth 2014). MLS (arrows) are 54- and 60-mm tail width for males (left) and females (right) respectively.

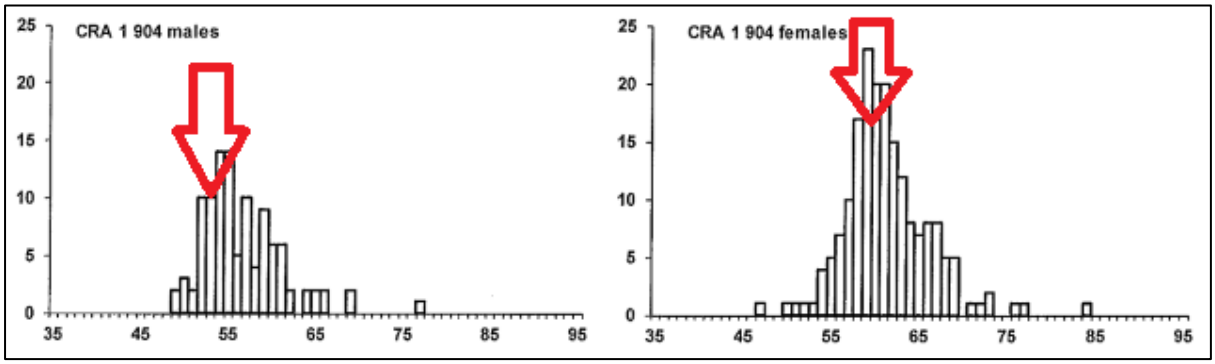

Figure 22. Length-frequencies (tail width) of male (left) and female red rock lobsters (right) taken in observer commercial-catch samples in Statistical Area 904, 2011-12 (D. Sykes, pers. comm.). The arrows show the MLS (54 and 60 mm tail width for males and females respectively).

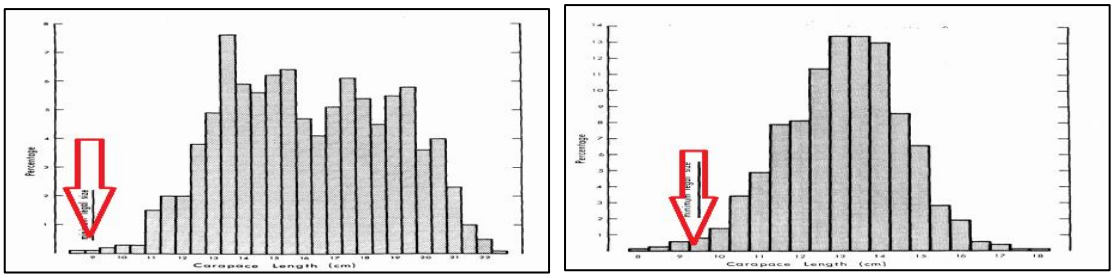

Figure 23. Percentage carapace-length (CL) frequency distribution of >1000 males (left) and >1000 females (right) red rock lobsters in October 1966, near to when commercial fishing began at the Chatham Islands (Kensler 1969) in 10-mm groups. The current MLS for East Northland is roughly equivalent to 96-mm CL for males (left) and 97 mm for females (right) (red arrows).

4.3.5 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 recreational and commercial catches there, point to severe regional depletion.

4.4 Scallop: SCA 1

4.4.1 Essential biology

Scallops are found in a variety of coastal and intertidal habitats, but particularly in semi-enclosed areas (Plenary 2010, apparently the most recent year that SCA 1 was considered by the Plenary). Scallops mature at about 60–70-mm shell length, and are extremely fecund. Larval development lasts about 3 weeks, with initial settlement taking place on filamentous material or dead shells on or close to the seabed. After reaching about 5-mm shell length, the juveniles may move several times before taking up the relatively sedentary adult mode of life (Plenary 2010).

The very high fecundity, and likely variability in the mortality of larvae and pre-recruits, leads to great variability in annual recruitment. This, combined with variable mortality and growth of adults, leads to highly variable scallop populations from one year to the next, especially in areas of rapid growth where the fishery may be supported by only one or two year classes (Plenary 2010). Such variability is characteristic of scallop populations world-wide, and often occurs independently of fishing pressure.

4.4.2 Harvest history

Scallops in the Bay of Islands have not been commercially harvested for many decades—if at all. Anecdotally there has been a rising trajectory recently in recreational harvesting pressure, thought to reflect increases in the local resident human population, together with more visiting vessels over the summer when the beds are open. Harvest data, and TAC allocations, are given in Table 3.

Scallops in the Bay of Islands have become largely confined to the clear, near-oceanic waters of Ipipiri, yet they were once common—among others—in the northwest off Rangihoua and Onewhero, and off the west side of Motuarohia (Nevin 1984).

There have been two recent surveys of scallops on the Ipipiri beds, in 2006 and 2007 (Williams et al. 2008, Williams 2009) (Figure 24). The Rawhiti bed (1 in Figure 8) pre-season had relatively high densities of legal-sized scallops compared with other northern beds in 2006, but there was a massive reduction in density in 2007. The Urupukapuka beds (2 in Figure 8) had relatively high densities in both years.

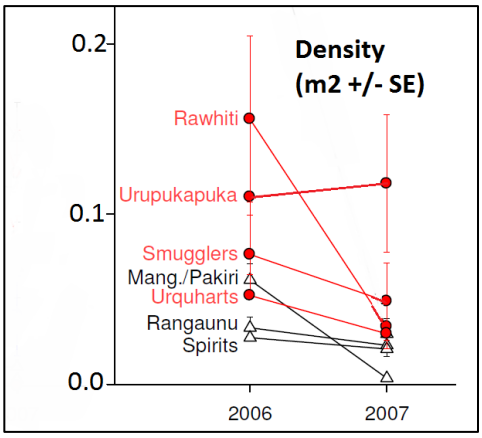

Figure 24. Density of legal scallops (≥ 100-mm width per square metre) on the Urupukapuka and Rawhiti grounds compared with other northern scallop fisheries, winter 2006 and winter 2007 (modified from Williams 2009).

4.4.3 Scallop size

The size-frequency histograms from the 2006 and 2007 pre-season surveys referred to above show pre-recruit cohorts (Figure 25), and exemplify the high interannual and spatial variability in abundance characteristic of scallop populations.

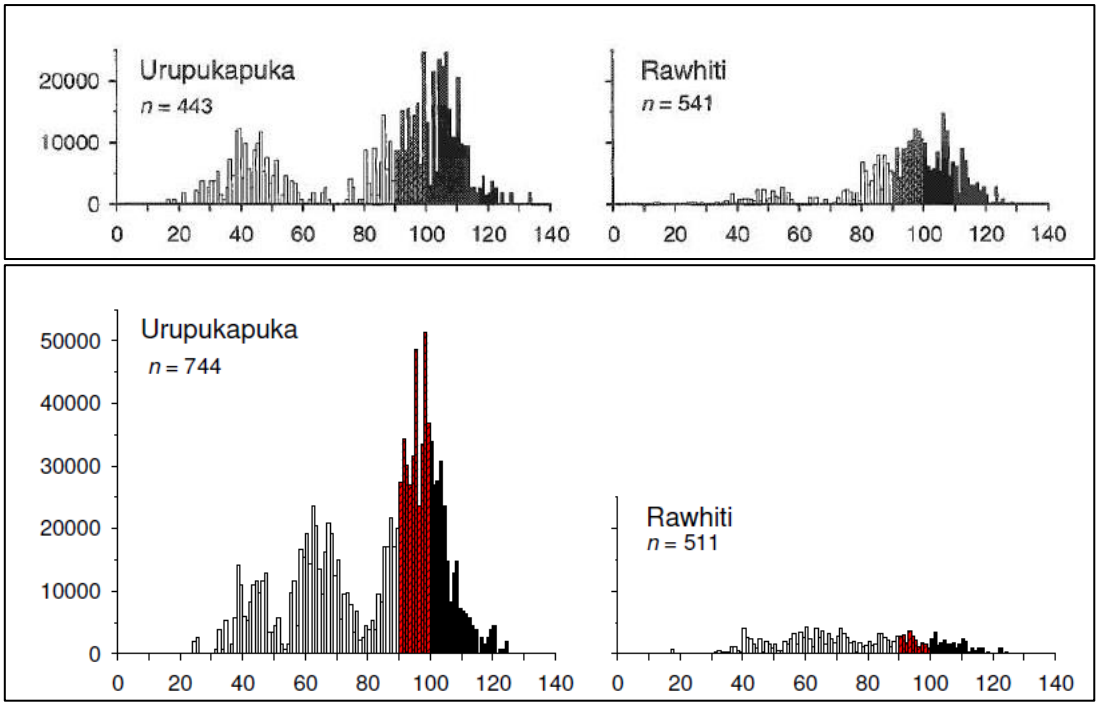

Figure 25. Length-frequency distributions of scallops in the eastern Bay of Islands, 2006 (upper) and 2007 (lower) (Williams et al. 2008; Williams 2009), using the same methodologies. Shaded bars show scallops 90-mm or larger shell length and black bars show scallops 100-mm or larger.

4.4.4 Wrapping up for scallops

Scallops are keenly pursued by recreational fishers; they are now largely confined to the waters of Ipipiri; and there is a lot of variation in harvests between areas and between years.

4.5 Green-lipped mussel: GLM 1

4.5.1 Essential biology

The green-lipped mussel is typical of the lower shore and open coast, and is most common in northern and central parts of New Zealand where it can form dense beds of up to 100 per m^2 (Plenary 2015).

The planktonic stage lasts 3-5 weeks, with larvae settling over a wide range of depths, preferring fine filamentous surfaces including hydroids, bryozoans, and filamentous and turfing algae. Secondary settlement, after a form of mucous drifting, is thought to be the means by which most juveniles recruit into mussel beds, this drifting ability being lost once the mussels reach about 6-mm shell length (Plenary 2015).

4.5.2 Harvest history

Green-lipped mussels in the Bay of Islands have not been commercially harvested for many decades—if at all. Although huge reefs of green-lipped mussels overlying soft subtidal seafloors were once characteristic of several Northland harbours—and particularly the Hauraki Gulf, very small quantities of dredged mussels have been reported from the Bay of Islands, mostly in the late 1960s to mid-1970s (Marine Department annual Reports on Fisheries). (Significant landings indicated for east Northland in the 1920s by Paul [2012] are very unlikely to have come from the Bay of Islands.)

For GLM 1 (*see* Appendix 1), the recreational and customary allowances are 162 t and 243 t respectively (Plenary 2015). Anecdotally there has been a rising trajectory of recreational plus customary harvesting pressure, in recent decades at least, thought to reflect increases in the local resident human population, together with more with vessels from elsewhere visiting the Bay of Islands during summer. Unlike scallops, the mussel beds are typically highly clumped and often very visible—so can be rapidly overharvested.

4.5.3 Wrapping up for green-lipped mussels

Green-lipped mussels are keenly pursued by recreational fishers. Both intertidal and subtidal populations have been heavily reduced by recreational/customary harvesting.

4.6 Cockle: COC 1B

4.6.1 Essential biology

The cockle is found in soft mud to fine sand on protected beaches and enclosed shores, and is often a dominant species, with densities as high as 4500 per m^2 (Plenary 2015). The planktonic larval stage lasts about three weeks. Significant depression of larval settlement has been recorded for areas of otherwise suitable substrate from which all live cockles have been removed, suggesting the need for some conditioning factor.

Quite extensive movements of juveniles have been documented, but individuals over 25-mm long remain largely sessile, moving only in response to disturbance (Plenary 2015).

4.6.2 Harvest history

Middens show how cockles in the Bay of Islands were highly sought by pre-Contact Maori, the extent of harvestings in Kerikeri and Waikino inlets—where the cockle shells were later mined and kiln-burnt to sweeten local soils—so prominent as to be singled out in the 1922 geological chart (Booth 2016b). Although arguably evidence of something more than mere artisanal harvesting of the shellfish in at least parts of the Bay of Islands during the Late Period (AD 1650-1800) and perhaps into the Historical Period, it seems there was no lasting ecological legacy (c.f., the failure of some of the cockle beaches near Auckland to recover after closure in recent times (Kelly et al. 2014)). This is probably because, for at least the easily accessible and highly sought species, there was 'ownership' and active stock management that prevented abundance and mean-size from plummeting.

For COC 1B (East Northland, excluding Whangarei Harbour; Appendix 1), both the recreational and customary allowance is 22 t (Plenary 2015). Bay of Islands cockles have not been commercially harvested for many decades—if at all. The shellfish remains one of the most widespread and abundant in the Bay of Islands (Hewitt et al. 2010), with major harvesting beaches including Te Haumi, Parekura and Whiorau (Figure 8). There are no known estimates of harvest rates over time, but length-frequency distributions for Te Haumi show a significant reduction in shellfish size since the late 1990s. Indeed, the mean size of the cockles present today will be much smaller than before harvesting began for most, if not all, of the Bay of Islands.

4.6.3 Wrapping up for cockles

Cockles are popular among recreational and customary fishers. Surveys in 2009 showed moderate or high densities of cockles in many inner areas of the Bay of Islands (Hewitt et al. 2010). They are similar to scallops in that there is probably a great deal of variability in cohort-strength between years.

4.7 Pipi: PPI 1B

4.7.1 Essential biology

Pipi are characteristic of sheltered beaches, bays and estuaries (Plenary 2015). They are tolerant of moderate wave action, and commonly inhabit coarse, shell/sand substrates in bays and at the mouths of estuaries where silt has been removed by waves and currents. Larval settlement and metamorphosis take place about three weeks after spawning. In general, pipi have been considered sedentary when settled, although they may utilise water currents to disperse actively within waterways (Plenary 2015).

4.7.2 Harvest history

Pipi in the Bay of Islands were less-highly sought than cockles by pre-Contact Maori, but nevertheless they form significant components of midden-contents (Booth 2016b). As for cockles, 'ownership' and active stock management probably prevented abundance and mean-size from plummeting. Bay of Islands pipi have not been commercially harvested for many decades—if at all, and the shellfish remains one of the most widespread and abundant (Hewitt et al. 2010). There are no known estimates of harvest rates over time, but length-frequency distributions for Te Haumi show a significant reduction in shellfish size since the late 1990s. Indeed, the mean size of the pipi present today will be much smaller than before harvesting began for most, if not all, of the Bay of Islands.

For PPI 1B (East Northland excluding Whangarei Harbour), both the recreational and customary allowance is 76 t.

4.7.3 Wrapping up for pipi

Pipi are popular among recreational and customary fishers. They are similar to scallops in that there is probably a great deal of variability in cohort strength between years.

5 Evidence for, and implications of, ecological overfishing of keystone predators

One consequence of overfishing in the Bay of Islands, as well as in other parts of eastern Northland, has been reduction in the proportions of large-individual, keystone predatory finfish (particularly snapper) and shellfish (particularly red rock lobsters) capable of preying on kina (sea urchin *Evechinus chloroticus*). This has led to burgeoning kina populations and to the widespread loss of shallow-reef kelp forests to sea-urchin overgrazing (Andrew & MacDiarmid 1991; Shears & Babcock 2002; Ayling & Babcock 2003; Ballantine 2014). The science around this is now secure, urchin barrens being a world-wide phenomenon and one surprisingly difficult to reverse (Ling et al. 2014).

In a recent development, the long-spined urchin *Centrostephanus rodgersii* now seems implicated 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 in the late 1960s to be extending its distribution and increasing its abundance in the north of New Zealand (Morton & Miller 1968), and 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 rock lobster there (also *Jasus edwardsii*) is its primary predator (Sinauer Associates 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 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 26 and 27). 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 did persist until quite recently. And no evidence has been found for any kelp recovery since 2009.

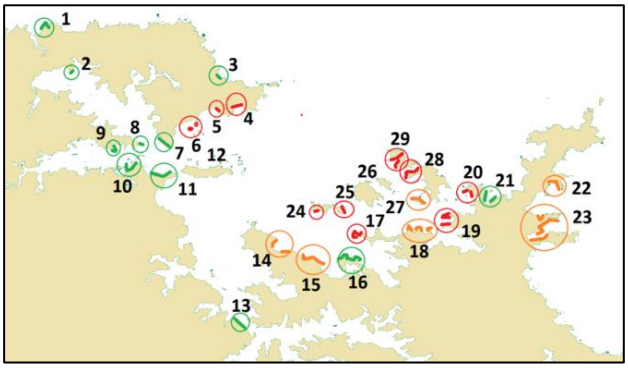

Figure 26. Changes in kelp cover between the 1950s/early 1960s and 2009 (Booth 2015). For each site there were at least four aerial images, each separated by at least a decade, and among which at least two of the early images showed extensive dark shadows associated with reef (usually kelp but possibly 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), recognised the presence of widespread kina barrens in the Bay of Islands at those times.

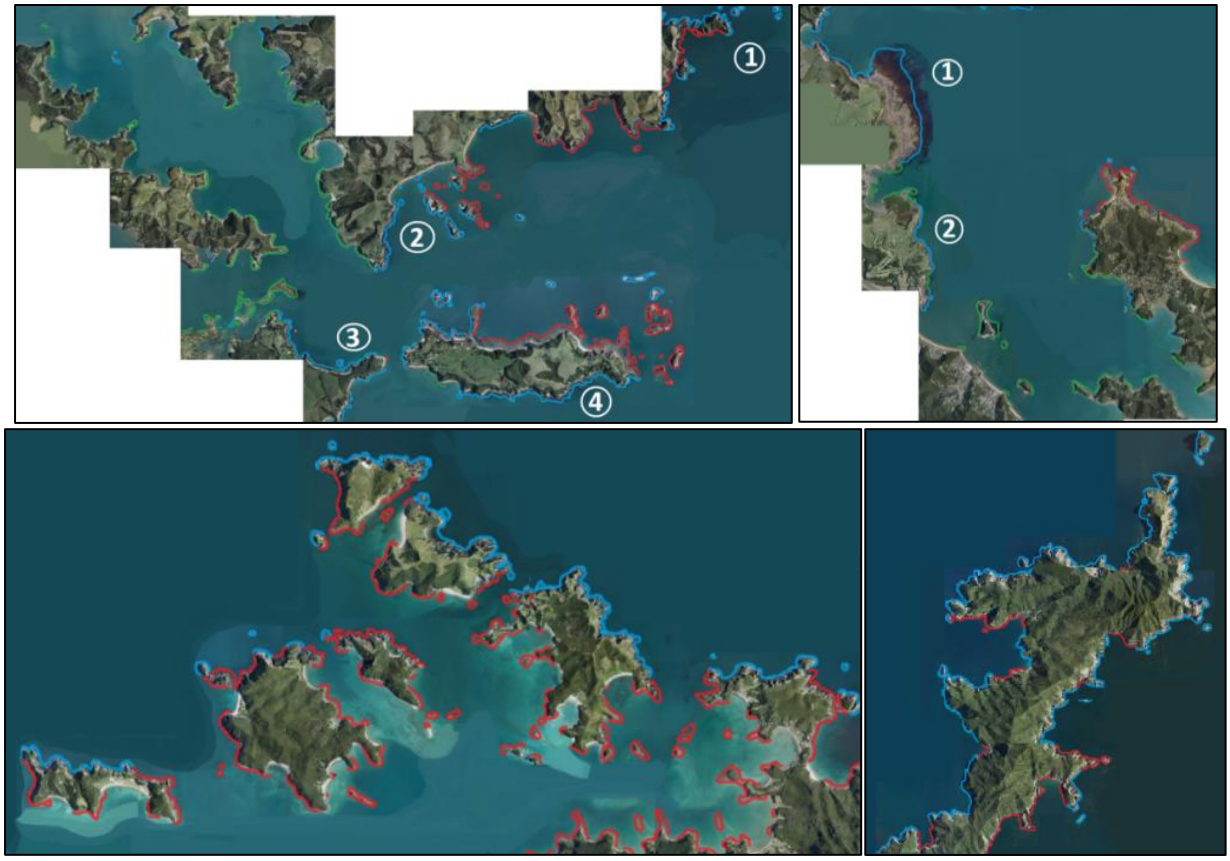

Figure 27. Urchin barrens (red) are now widespread in the Bay of Islands, particularly in the main basin (aerial photographs in 2009; Booth 2015). What appeared to be intact kelp forests persisted mainly near inlets (green). In top left, the reef was too steep to assess, or was in shadow (1); or the 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).

The Bay of Islands presents an extreme and extensive example of ecological overfishing resulting from reduction in the abundance of the main predators of sea-urchins. 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 recognised, let alone understood. On the bright side, the experience in the marine reserve at Leigh and elsewhere is that once large keystone predators return, the sea urchins are held in check, and the kelp recovers (Ayling & Babcock 2003, Ballantine 2014).

6 Overview

Table 3 (with Figures 3, 4 and 28) provide overviews of recreational versus commercial harvests by FMA 1 (and subarea), not only for snapper, kahawai and rock lobster, but also for other finfish of recreational interest in east Northland generally, and the Bay of Islands specifically.

Recreational harvests of snapper are high along the east coast of Northland, including in the Bay of Islands, in recent years having been fully two-thirds or more of the corresponding-area commercial catches. Most of the snapper landed recreationally in the Bay of Islands—and generally in east Northland—are near MLS (even after some high-grading for larger fish that is likely to be taking place). This all points to intensive overall fishing pressure, which is what the stock assessment says (Table 2).

For kahawai it is a different story. Recreational catches are high—of similar scale to the commercial catches—but there are significant proportions of large fish in the recreational catches. (The rather large discrepancy between the 2013-14 estimates of 349 t and 97 t of kahawai landed recreationally remains unresolved; Table 3.) This points to less-intensive overall fishing pressure, which is what the stock assessment says (Table 2).

For finfish species with smaller recreational harvests, kingfish are of note: the estimated recreational harvest in 2011-12 was five times that of the corresponding commercial harvest (Figure 28, Table 3). Red gurnard, tarakihi and trevally recreational harvests are small compared with their respective commercial harvests (Figure 28, Table 3). The stock status of these species is unclear (Table 2).

Rock lobsters are enigmatic. On the one hand, recreational harvests are only about 20% of the commercial CRA 1 landings, and the stock assessment says a healthy and recovering stock. On the other hand, 1) the reference period 1979-88 was when the landings were near their nadir (Figure 20); 2) most of those harvested recreationally (and commercially) are near the MLS, pointing to heavy fishing pressure (Figures 21 and 22); and 3) the point-estimate of 42 t recreationally harvested in CRA 1 in 2013-14 (Holdsworth 2014) may mean that other recent recreational harvests have been underestimates.

All the other shellfish are heavily harvested, with green-lipped mussels being the one to have been least-well able to withstand high fishing pressure, perhaps because of its tendency to clump.

Bay of Islands' recreational fishery is intensive and extensive, and is likely to continue to expand and intensify even more over the next five years, mainly through more and more vessels visiting the Bay, particularly from Auckland over the summer. Because of the biological links between the Bay of Islands' keystone predator populations and those of the FMA (or subarea), reduction of fishing effort in the Bay of Islands alone is unlikely to bring much relief; across-the-board measures at the stock/substock level are required. This sluggishness to respond has been seen at Maunganui Bay where, after six years of prohibition from fishing (except for kina) under a rahui, it has not been possible to detect any significant change in size or abundance of snapper, even though the anecdotal reports suggest increases. A useful gauge of fishstock recovery in the Bay of Islands area will be the revitalisation of the shallow-reef kelp forests, but because of the resilience of urchin barrens (Ling et al. 2014), this will almost certainly take decades—if not centuries—to achieve unless there are urgent and significant reductions in fishing pressure.

Table 3. Overview of FMA 1 recreational and commercial harvests (t). TAC, current Total Allowable Catch; TACC, current Total Allowable Commercial Catch; Rec, Recreational; Comm, Commercial. Sources: [1], Plenary 2015 (2016 for rock lobster); [2], Hartill et al. (2013); [3], Holdsworth (2014); [4], Hartill et al. (2015); [5], Hartill et al. (2007); [6], Wynne-Jones et al. (2014); [7], 2010 Plenary is the most recent available; [8], meat weight x 8; [9], Sum of catches from Statistical Areas 002, 003 & 005 from NABIS, which together closely approximate ENLD; [10], Sum of catches from Statistical Areas 903 & 904 from NABIS, which together closely approximate ENLD[3]; -, not applicable or not available.

Fishstock	Species	Current TAC	Current TACC	CRC	CCC	Rec harvest (Aerial)	Comm harvest	Rec harvest (Aerial)	Rec harvest (Panel)	Comm harvest	Rec harvest (Access)	Comm harvest (t)	Rec harvest (Access)	Comm harvest
						2004-05	2004-05	2011-12	2011-12	2011-12	2012-13	2012-13	2013-14	2013-14
BCO 1	Blue cod	46[1]	46[1]	2[1]	2[1]	-	9[1]	-	8[1]	6[1]	-	9[1]	-	9[1]
GUR 1	Red gurnard	-	2288[1]	-	-	-	1354[1]	-	98[1]	981[1]	-	1103[1]	-	1005[1]
GUR 1 (ENLD)	Red gurnard	-	-	-	-	127[2]	-	24[2]	-	-	-	-	6[3]	-
KAH 1	Kahawai	2200[1]	1075[1]	900[1]	200[1]	530[1]	1147[1]	942[1]	958[1]	1004[1]	-	1095[1]	-	1062[1]
KAH 1 (ENLD)	Kahawai	-	-	-	-	129[1]	112[9]	191[1]	198[1]	117[9]	186[4]	124[9]	349[3]; 97[4]	71[9]
KAH 1 (Waitangi)	Kahawai	-	-	-	-	-	-	8[4]	-	-	8[4]	-	4[4]	-
KIN 1	Kingfish	673[1]	91[1]	459[1]	76[1]	-	58[1]	-	488[1]	87[1]	-	88[1]	-	100[1]
KIN 1 (ENLD)	Kingfish	-	-	-	-	77[5]	-	-	-	-	-	-	-	-
SNA 1	Snapper	8050[1]	4500[1]	3050[1]	50[1]	2419[1]	4641[1]	3754[1]	3792[1]	4614[1]	-	4457[1]	-	4459[1]
SNA 1 (ENLD)	Snapper	-	-	-	-	557[1]	~1000[1]	718[1]	869[1]	~1000[1]	837[4]	1537[9]	585[4]	1664[9]
SNA 1 (Waitangi)	Snapper	-	-	-	-	-	-	22[4]	-	-	26[4]	-	18[4]	-
TAR 1	Tarakihi	2029[1]	1447[1]	487[1]	73[1]	90[1]	1527[1]	67[1]	97[1]	1134[1]	-	1184[1]	-	1425[1]
TRE 1	Trevally	1507[1]	1507[1]	-	-	105[1]	977[1]	124[1]	154[1]	1050[1]	-	1301[1]	-	1431[1]
TRE 1 (ENLD)	Trevally	-	-	-	-	-	-	-	-	-	-	-	88[3]	-
CRA 1	Rock lobster	273.1[1]	131.1[1]	-	-	24[3]	131[1]	-	24[1]	130[1]	-	131[1]	42[3]	131[1]
CRA 1 (ENLD)[3]	Rock lobster	-	-	-	-	-	27[10]	-	-	26[10]	-	30[10]	25[3]	32[10]
SCA 1	Scallop	600[7,8]	320[7,8]	60[7,8]	60[7,8]	-	319[7]	-	84[6]	?[7]	-	?[7]	-	?[7]

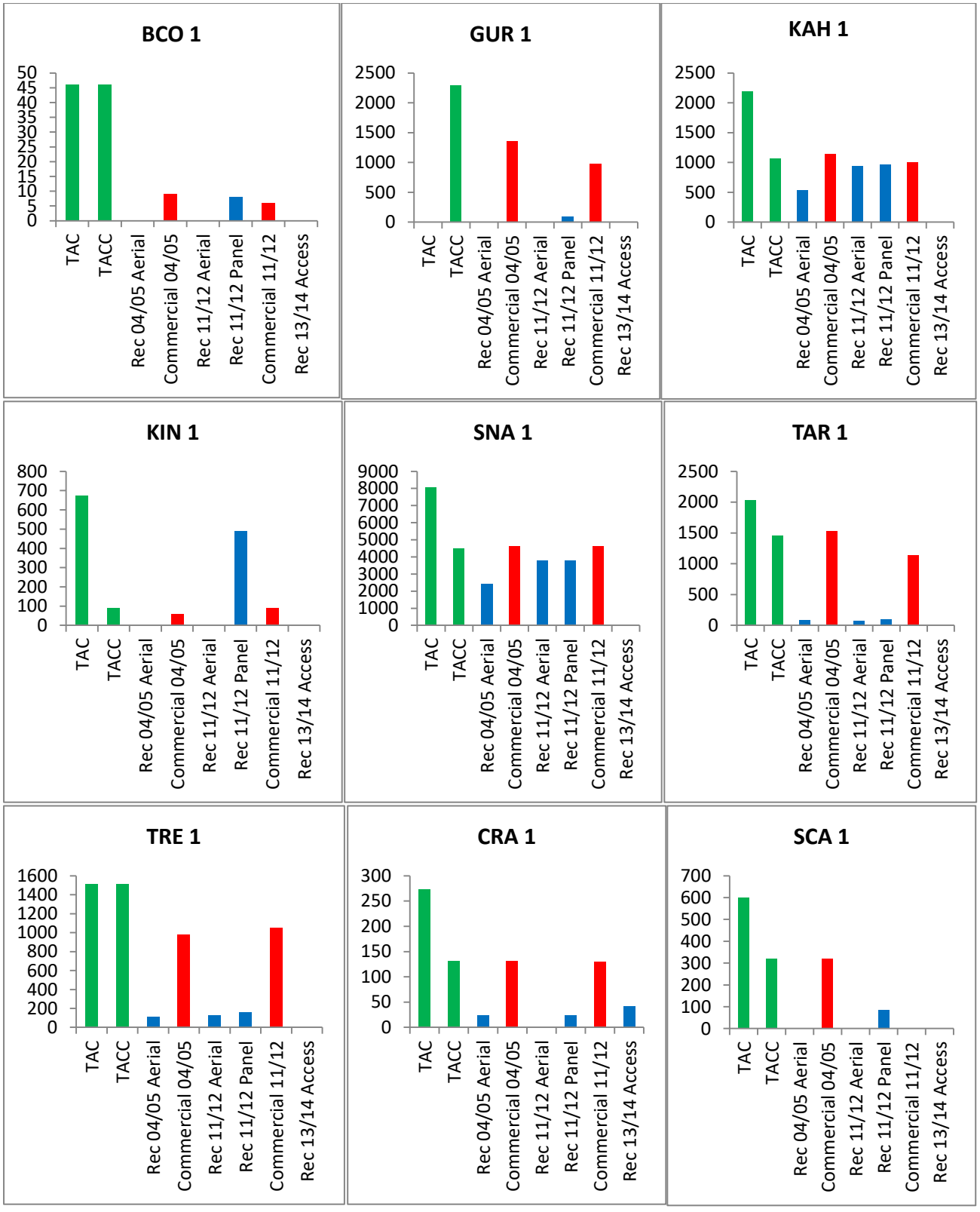

Figure 28. Graphical interpretations of recent FMA 1 harvests (t) in Table 3. No bar means no data are available (and, for GUR, no TAC established). For species acronyms and area boundaries, *see* Appendix 1. The main points are 1) recreational harvests of kahawai, kingfish and snapper (and possibly blue cod) are of similar scale, or greater than, the commercial catches; and 2) for all other species, the recreational harvest is relatively small.

Summary

1. The principal finfish recreationally sought and caught in the Bay of Islands is snapper, followed by kahawai. The most important invertebrates are red rock lobsters, scallops, green-lipped mussels, cockles and pipi.
2. Bay of Islands takes in the most extensive area of intense recreational boat-fishing in the whole of East Northland (North Cape to Cape Rodney). This fishing effort almost certainly exceeds that of the commercial fleet, for several species the recreational catches being similar to or exceeding those commercial.
3. There are hotspots (>100 vessels per square kilometre, annualised) of recreational boat-fishing north and southeast of Moturoa Island, near Nine Pin and Whale Rock, and north of Motuarohia Island. In contrast, only about five local boats—most <7-m long—have commercially fished the Bay in recent years, although larger vessels do visit from time to time.
4. The East Northland snapper substock of SNA 1 is overfished, and recreational fishing in the Bay of Islands contributes significantly to this overfishing. In recent years, the estimated recreational East Northland harvest has been 560-870 t, around two-thirds that of the commercial harvest, with most fish not much larger than the MLS.
5. The Bay of Islands component is inextricably linked through seasonal migration to the rest of the East Northland snapper fishery. The annual recreational harvest by fishers using the Waitangi Ramp alone (to say nothing of harvests from boats using other ramps in the Bay, and from the shore) is at least 20 t (similar to the estimated total annual commercial harvest of snapper by local vessels).
6. The KAH 1 kahawai stock is not considered to be overfished. Nevertheless, Bay of Islands recreational fishing contributes significantly to fishing pressure on the stock. The annual recreational harvest for KAH 1 is 500-950 t (the East Northland component being 100-200 t), 60-100% of the commercial catch. The annual recreational harvest by fishers using the Waitangi Ramp alone is up to 8 t.
7. Although the CRA 1 red rock lobster stock is not considered overfished, most lobsters locally caught recreationally and commercially 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 to other parts of the lobster fishery, so local recreational fishing contributes to pressure on stocks. The annual recreational harvest for an east-Northland portion of CRA 1 was around 25 t, about 80% of the commercial catch.
8. In northern New Zealand, commercial fishing had, by the mid-1980s, reduced the biomass of many predatory finfish species, and rock lobsters, to less than one quarter 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 up until now kina has been the species implicated, it is now clear that the long-spined urchin *Centrostephanus rodgersii* is also overgrazing reefs. Ongoing intense recreational fishing in the Bay ensures little or no recovery of the kelp in the near future.
9. 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.
10. Although scallops are highly sought in the Bay of Islands, their beds (and those of cockles and pipi) are isolated and small compared with the areas fished for finfish, and there is little systematic information regarding levels of fishing pressure. Beds of green-lipped mussels, both intertidal and subtidal, have been serially fished down, virtually to local extinction.
11. On-going web-camera monitoring at the Waitangi Boat Ramp, with concomitant sampling of catches, ensures (for now) a growing body of knowledge around recreational harvests in the Bay of Islands that should reveal any trends in effort, catches and fish-size.
12. The Bay of Islands recreational fishery is intensive and extensive, and it is likely to intensify and expand over the next five years, mainly through ever more vessels visiting the Bay, particularly from Auckland over the summer.

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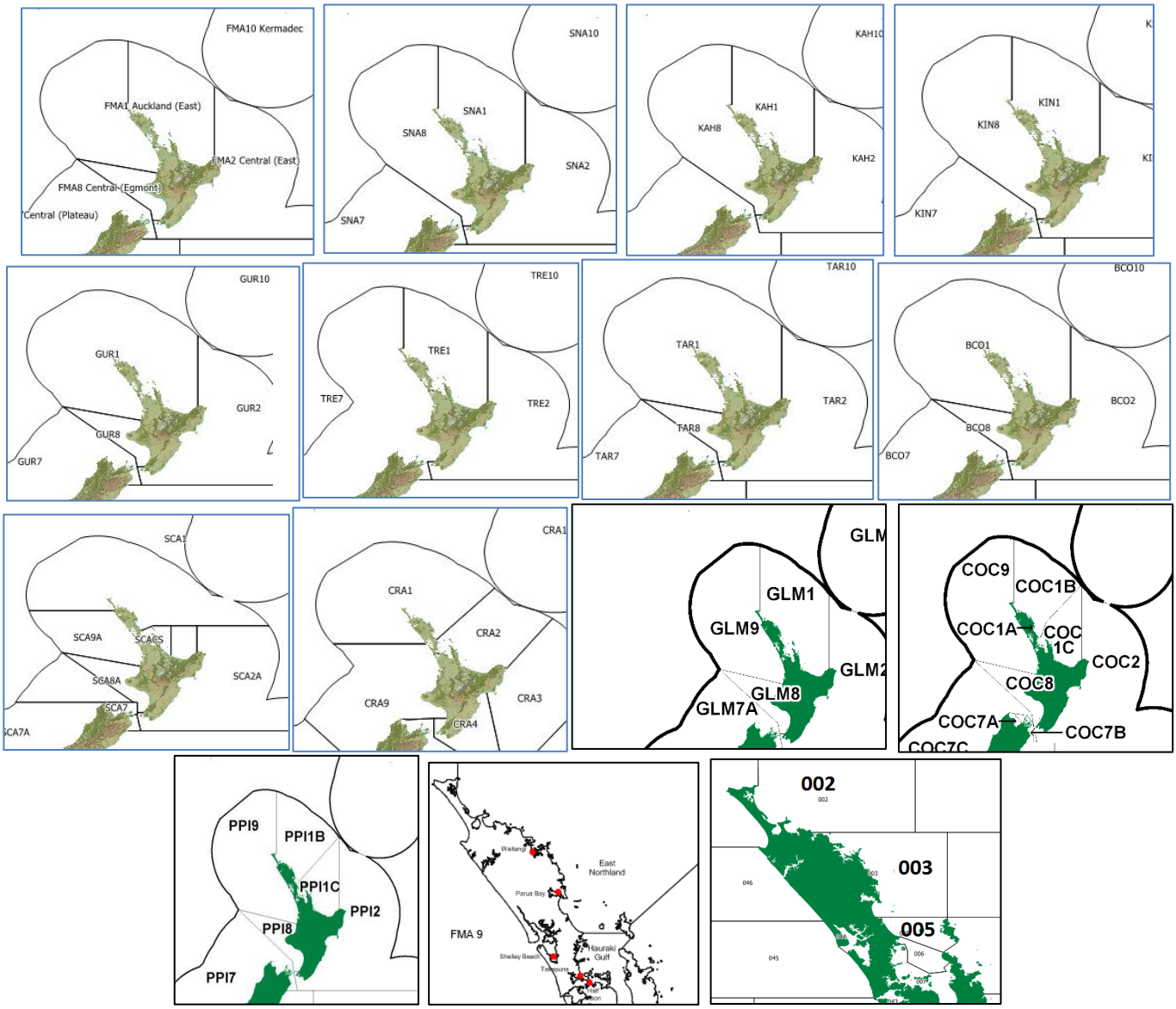
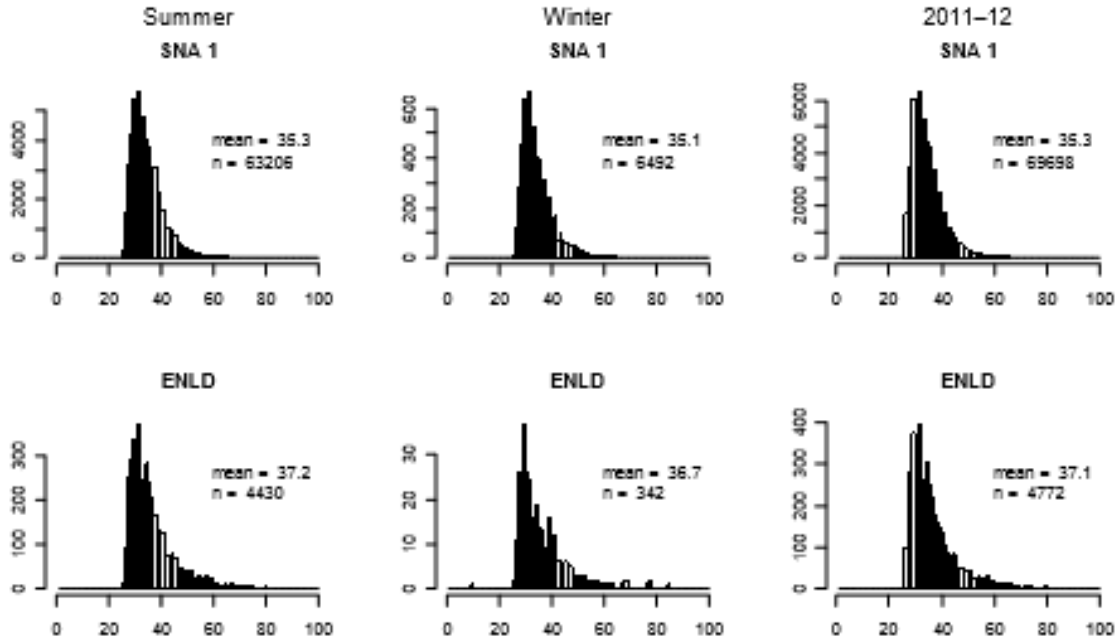
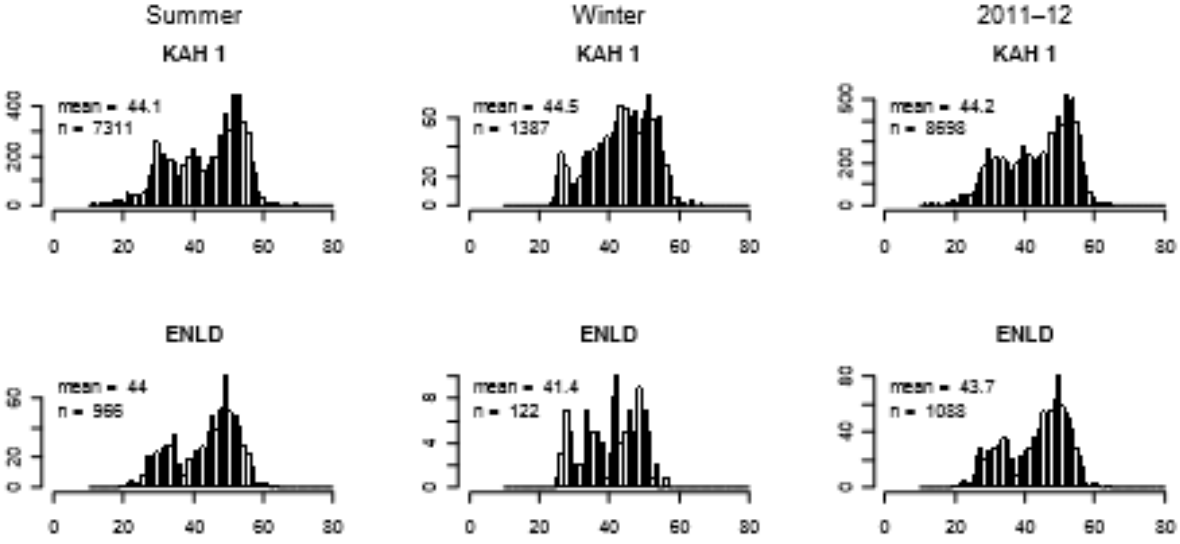
Appendix 1. Fishery Management Areas (FMAs, top left), and Quota Management Areas (QMAs) for the main species caught recreationally in the Bay of Islands. (SNA, snapper; KAH, kahawai; KIN, kingfish; GUR, red gurnard; TRE, trevally; TAR, tarakihi; BCO, blue cod; SCA, scallop; CRA, red spiny rock lobster; GLM, green-lipped mussel; COC, cockle; PPI, pipi. (Albacore, skipjack and packhorse rock lobster each form a single fishstock around the entire country.) Bottom line: the East Northland Substock for snapper extends from North Cape to Cape Rodney, and also takes in the north end of Great Barrier Island (Hartill et al. 2015); Bay of Islands is in General Statistical Area 003.



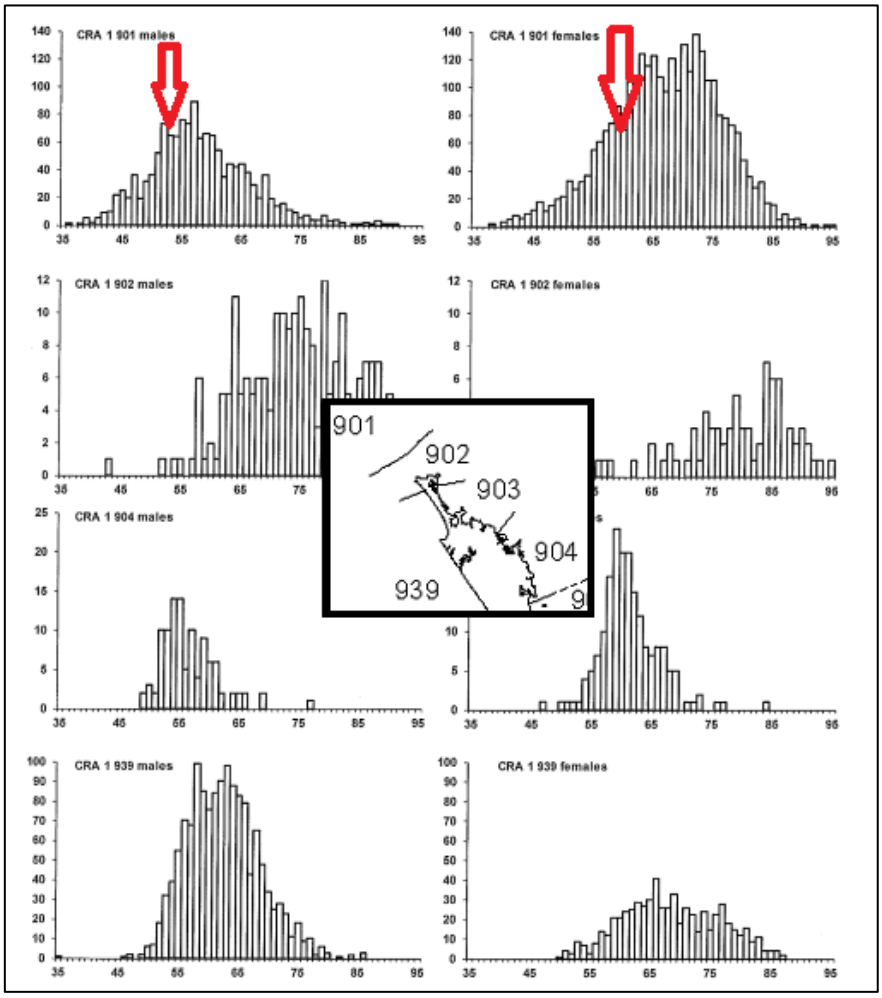
Appendix 2. Length-frequency distributions of recreationally harvested snapper measured in QMA 1, by region and season (Hartill & Davey 2015). ENLD, East Northland.



Appendix 3. Length-frequency distributions of recreationally harvested kahawai measured in QMA 1, by region and season in 2011-12 (Hartill & Davey 2015). ENLD, East Northland.



Appendix 4. Length-frequencies (tail width) of male (left) and female red rock lobsters (right) taken in observer commercial catch-samples in CRA 1 statistical areas, 2011-12 (D. Sykes, pers. comm.). The arrows denote MLS for males (left) and females (right). The smaller mean lobster size suggests Statistical Area 904 is more heavily fished than the others.



Appendix 5. Source of additional recreational harvesting data specific to the Bay of Islands.

Several recent papers on recreational harvesting in FMA 1 and QMA 1 (and sub-regions) contain data specific to the Bay of Islands which have not been separated out for use in this paper. (Note that the databases of Wynne-Jones et al. (2014) are unlikely to be useful for the Bay of Islands because of too few local interviewees.)

1. Hartill et al. (2007), separately for Opito Bay and Waitangi ramps, contains raw species-specific data for 2004-05: trips, counts, bag size, weight, season, method and platform. Also, the distribution of boats fishing recreationally in the Bay of Islands is available by season. (Similarly, Hartill et al. [2013, 2015] for subsequent years.)
2. Armiger et al. (2014), separately for Opito Bay and Waitangi ramps, contains raw data for kahawai for 2011 and 2012: trips, counts, bag size, weight, size distributions, age distributions, season, method and platform.
3. Holdsworth (2014) contains red rock lobster raw data separately for Sections 4 and 5 (Bay of Islands) for 2013-14: trips, counts, bag size, weight, season, method and platform. Similarly, there is species-specific information for packhorse rock lobsters, kahawai, trevally and gurnard (and surely snapper too).