

Resource Management

Snapper's-eye view of the inner Hauraki Gulf

Mark Morrison, Ude Shankar, Darren Parsons, Glen Carbines, and Bruce Hartill describe a multi-layered investigation into fish and their habitat.

Marine recreational fishing is a passion for many New Zealanders, providing both food and entertainment. It also generates significant economic activity, including the purchase of fishing gear, bait, boats, fuel, and holiday accommodation. However, increasing levels of recreational fishing have direct and indirect effects on marine fish populations. The most obvious direct effect is that more fish are caught. 'Indirect' fishing effects include anchor, chain, and gear damage to the seafloor, and changes to the food web caused by adding food (the bait) and removing higher-level predators (the fish). In addition to actual fishing, other human-induced pressures on coastal fisheries include increasing sedimentation and water turbidities, and loss or degradation of important biogenic (living) nursery habitats, such as sea-grass meadows, horse-mussel beds, and sponge gardens. The emerging challenge for resource management is to maintain productive and healthy fisheries by looking after the coastal ecosystems that effectively underpin them. This is known as 'ecosystem-based management'.

A model fishery

The inner Hauraki Gulf snapper fishery is a logical place to start looking at the interactions between recreational fishing and marine ecosystems. Ministry of Fisheries (MFish) figures for December 2004–November 2005 estimate a recreational harvest of 674 tonnes of snapper from the inner Gulf, or about 28% of all snapper caught recreationally between North Cape and East Cape. This means that around 761 000 snapper, weighing on average 0.84 kg each, are caught each year in the inner Hauraki Gulf by recreational fishing.

Knowing this, we focused our FRST-funded 'Marine Recreation' research programme in the inner Gulf to better understand the inter-relationships between the recreational snapper fishery, snapper populations, and the underlying seafloor habitats, including the invertebrate animals living there. We divided the inner Gulf into eleven zones representing areas of either higher recreational fishing catch (for example, Rangitoto, Motiuhē Channels) or lower catch (Bean Rock area, Tamaki Strait). Then we began a range of field projects to collect the data needed to 'populate' each of these eleven zones.

To manage these datasets, we turned to a geographic information system (GIS) – a software programme designed to store, display, and analyse spatial data. We based RECFISH, our GIS database, on the Marine Data Model developed by NOAA (US National Oceanographic and Atmospheric Administration).

The range of data we have collected has been quite broad. In the following sections we describe some of these data, how we collected them, and what they mean.

Fishing for answers

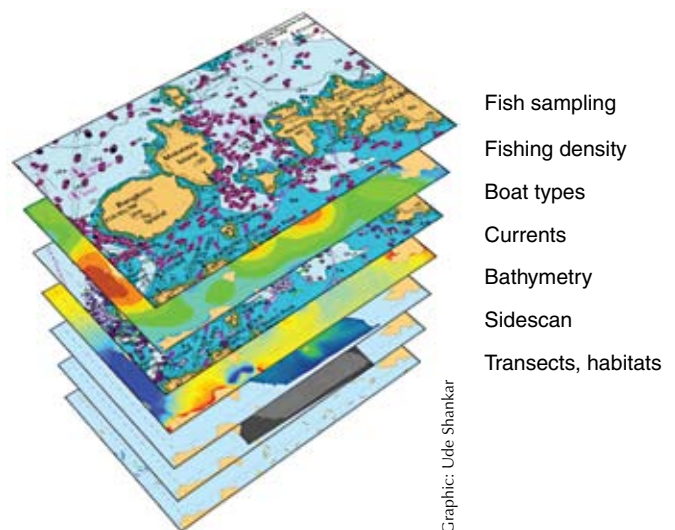
- Recreational fishing and other human activities are putting increasing pressure on coastal ecosystems.
- NIWA scientists are using a range of tools and techniques to study the interactions between snapper, recreational fishing, and seafloor habitats.
- Our findings about snapper in the Gulf will help in moving towards ecosystem-based fisheries management.

Broad-scale habitat mapping

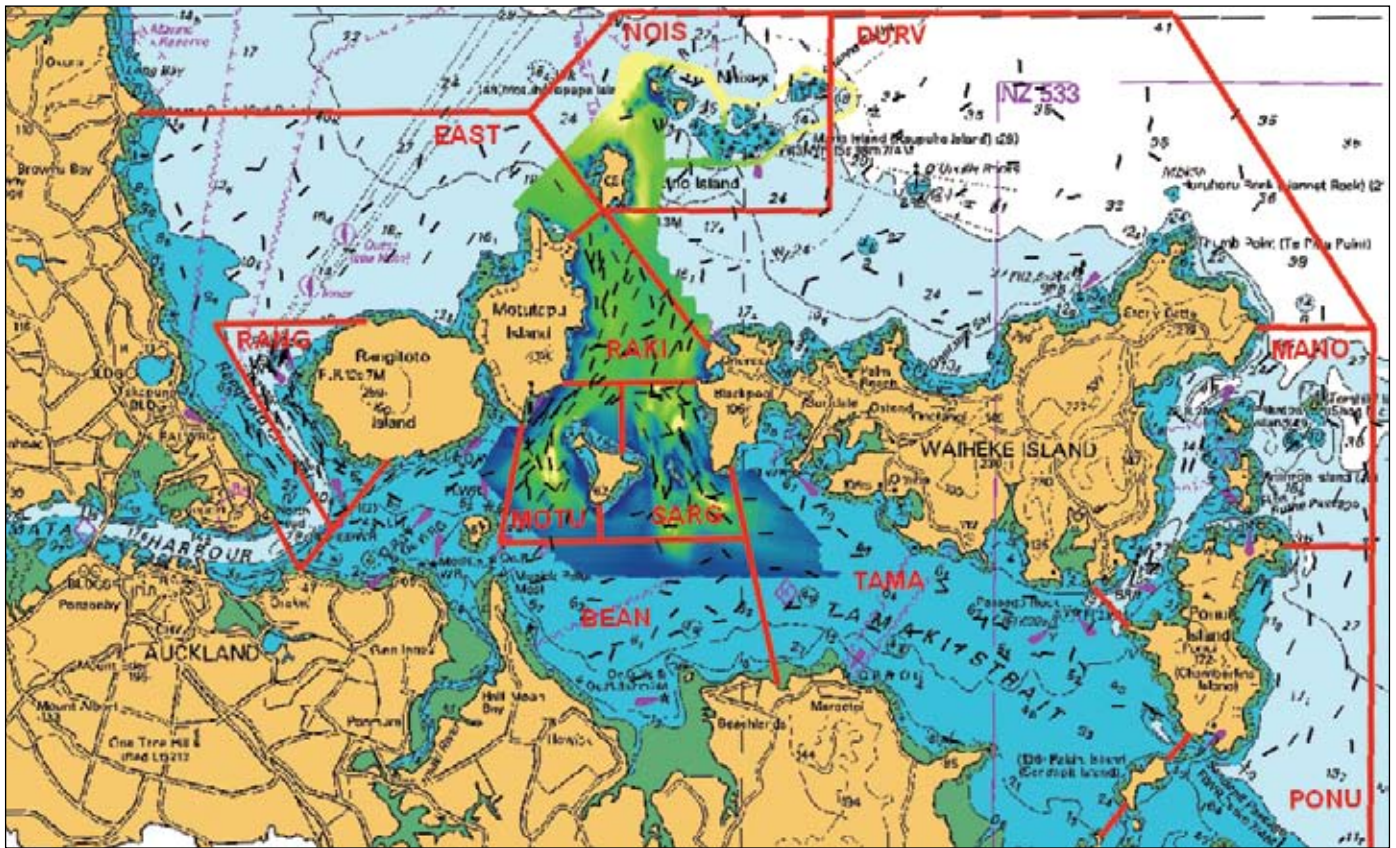
We used advanced mapping technologies (multi-beam, side-scan sonars) to map the seafloor bathymetry (contours) and texture, at very high resolution, in the middle part of the overall study area. From these data, we're using software tools to identify seafloor features such as plateaus, holes, ridges, slopes, and channels. These tools use the same basic principles as those for producing land topographic maps, such as the ones you might use for tramping. Along with such 'big' features, we've also identified smaller habitat components, such as patch reefs, sand/shell waves (like dunes), and regions with lots of pits and mounds. Overall, this information lets us create broad-scale seafloor habitat maps. In the surrounding, unmapped area, we've used existing marine chart information. We've also used an Auckland Regional Council hydrological model for the Hauraki Gulf to predict tidal current speeds, providing an additional layer of habitat information.

Finer-scale seafloor habitat types

Mapping technologies such as sonar are good for identifying different physical elements of the seafloor, but they don't tell you what the elements actually are, though an experienced operator can make a pretty good guess. They also cannot



Components of the RECFISH GIS data scheme.



Map: Mark Morrison

The inner Hauraki Gulf survey area marked with our eleven sampling zones.

detect individual plants and animals on the seafloor, unless they are so dense that they literally form a living cover (for example, high-density beds of green-lipped mussels or horse mussels). We used a dropped underwater video (DUV) to determine what the different physical features from the remote mapping actually were – a process called ‘ground-truthing’ – and to count individual plants and animals of reasonable size. A DUV is a forward-facing video camera attached to a lead ‘torpedo’ with stabilising fins, that is towed along just above the seafloor. Small lasers attached to the DUV are aimed at the seafloor, with a 20-cm gap between them. This 20-cm scale-bar is captured in the video, so we can estimate the size of individual objects on the seafloor, such as fish.

We used the DUV to identify seafloor type and count animals living on the seafloor at more than 400 locations spread across the eleven zones. At each location, we towed the DUV along a line, or ‘transect’, for a distance of about 400 m, with a transect width of 0.5–2 m, depending on water clarity. Back at the office, we viewed each video transect and determined the seafloor type, such as mud, sand, shell grit, shell ‘armouring’, or rocky reef. At random points along each transect, we counted and measured all the biogenic habitats (horse mussels, sponges, sea-squirts, scallops, large dead shells), as well as physical features like ripples, pits, and burrows. These data are being used to describe what the different habitats are, what lives in them, and how this varies across the study area. Many of these features are potentially important components of ‘good’ snapper habitat.

Fishery catch-and-effort dynamics

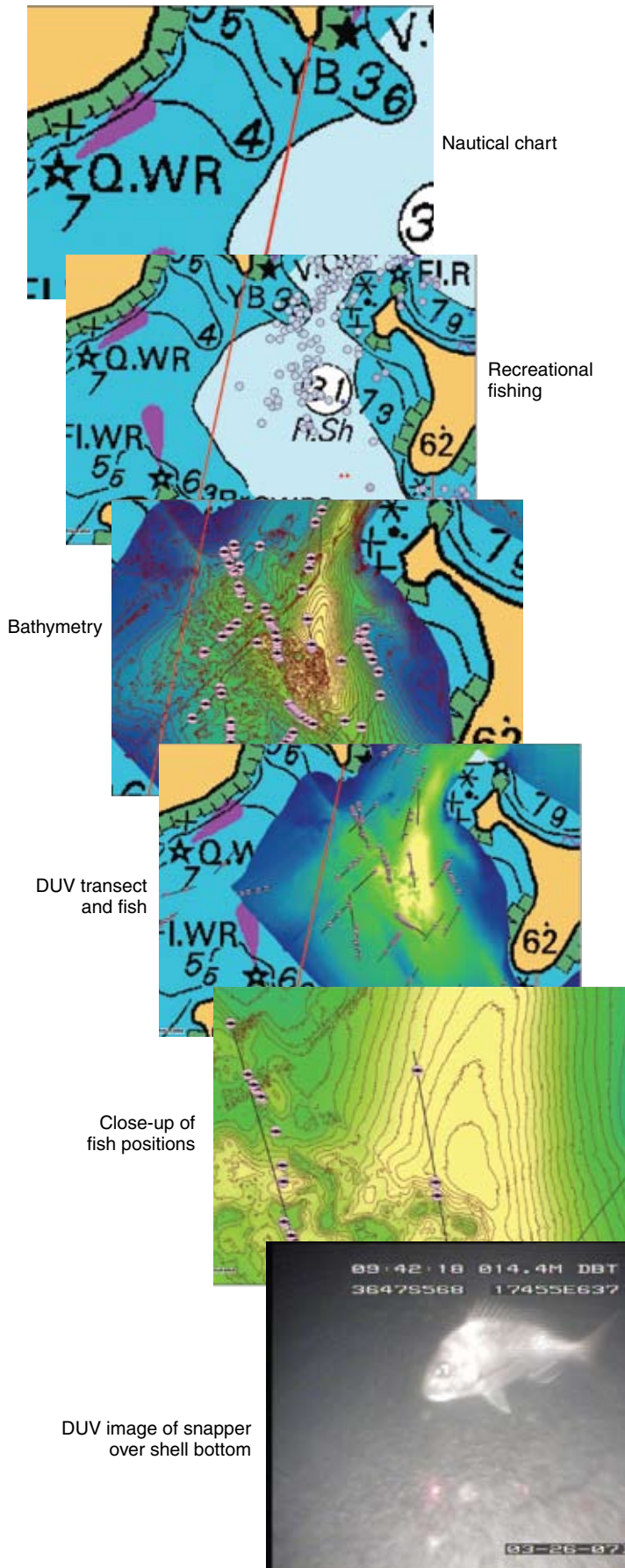
We’re using survey techniques we developed in earlier work for MFish to estimate how many snapper (and other species) are caught, and at what sizes, in each of the eleven zones. Observers in small planes count the number of recreational boats fishing in each zone; on the same day, we interview fishers as they return to nearby boat-ramps, measure their fish catches, and ask questions such as how long they had fished that day. We ran these surveys on 45 randomly selected days throughout the year.

Snapper population dynamics

Previously, we discovered that snapper and other species can be counted during the night as they sleep on the seafloor, using either divers or DUV. For this programme we took advantage of this behaviour to estimate how many snapper, and at what sizes, were present in each of the zones, and how that changed through the year. From the 400+ DUV transects, we counted and measured every sleeping fish seen, a ‘catch’ of more than 2200 snapper, ranging from 2 to 75 cm in size. We also noted the habitat associated with each individual fish. From these observations we are quantifying what habitats snapper prefer, and how they vary across the survey area.

We also wanted to know more about snapper movement patterns, and how popular fishing areas, such as Rangitoto and Motiue Channels, were linked by snapper movement to other places that were much less fished, such as East Coast Bays to Rakino, Tamaki Strait, north of Waiheke Island. To

RECFISH: example of data layers from the Motiue Channel.



do this, we tagged snapper throughout our study site and in adjacent areas: around 9300 fish in the summer of 2006/07. At last count, more than 560 tags have been returned, revealing patterns ranging from strongly resident (less than a kilometre movement) to migratory (moving tens to hundreds of kilometres). The extremes of movement include a snapper re-caught off the Hokianga Harbour, and another off Gisborne.

Snapper habitat usage

While snapper are found across all habitat types, their numbers and sizes vary considerably with bottom habitat type. To investigate possible reasons for this, we selected five locations, each containing a specific type of bottom habitat. These included the fine muds north of Rangitoto (known to fishers as the ‘worm beds’), sands, shell gravel, and shell-armoured seafloor (dog-cockles). At each location, we sampled both the benthos (invertebrate animals) and snapper (to see what they had been eating). From these data we are assessing what prey items snapper are targeting versus those that they are not, and how this relates back to the different kinds of seafloor habitats.

‘Derived’ spatial maps and models

With the various datasets described above, we’re creating new maps that incorporate multiple data sources. For instance, we’re working on fish–habitat suitability models, using data from DUV, remote sensing, and our current-speed model. We’re also looking at the relationships between anchoring/fishing gear intensity and biogenic habitat densities on the seafloor, recorded across fishing intensity gradients (using DUV, drop cameras, and boat counts summed over time). These models will enable us to go to other places, rapidly assess the habitat features, and then predict the relative values of those places for fish and fishers, and likely threats to those values. Many places are under increasing environmental and human pressures, similar to the inner Hauraki Gulf; these include the Bay of Islands, Kaipara Harbour, Coromandel, and Tauranga, as well as more southern regions of New Zealand where recreational fisheries target colder-water species such as blue cod.

Further reading

Hartill, B.; Bian, R.; Armiger, H.; Vaughan, M.; Rush, N. (2007). Recreational marine harvest estimates of snapper, kahawai and kingfish in QMA 1 in 2004–05. *New Zealand Fisheries Assessment Report 2007/26*. 44 p.

Morrison, M.; Carbines, G. (2004). Let sleeping fish lie. *Water & Atmosphere 12(2)*: 21.

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Morrison, M., Taylor, R., Walker, J., & Parsons, D. (2007). Marine recreation and coastal ecosystems. *Water & Atmosphere 15(2)*: 20–21.

Graphic: Mark Morrison and Glen Carbines



Photo: Sam Mossman



Photo: Jarrod Walker

Images of the real world.

Left: Recreational fisher with large snapper tagged at the Noises Islands and later re-caught (and released) at Kawau Island, 30 km away.

Material from a benthic core sample from the 'worm beds' north of Rangitoto Island.

Below: Examples of biogenic seafloor habitat elements valued by snapper and vulnerable to fishing damage and sedimentation. Top to bottom: an ascidian (sea squirt), a wandering anemone, and a sponge (with resident hermit crabs).

Fishy preferences: emerging patterns and implications

As we analyse our data, we're seeing the emergence of strong spatial and temporal associations. For instance, snapper in general show a strong preference for habitat patches and areas of higher structural complexity, such as beds of horse mussels, sponges, and sea squirts, and pits and burrows. Juvenile snapper especially are almost always observed very close to, or on top of, such structures (a pattern also seen in estuarine nursery environments). The two most likely reasons for this are that the structures provide shelter from larger predators (John dory, kahawai, and coastal sharks), and/or better foraging opportunities.

In turn, while we found such biogenic structures right across the inner Hauraki Gulf study area, these habitats are more common, and larger, in areas of coarser soft-sediment habitats (such as shell grit, gravel, shell 'armouring') and stronger tidal flows. It's no coincidence that such places are also where recreational effort and catch are most concentrated, for example Rangitoto, Motiuhe, Rakino, Seargant's, and Ponui channels. Unfortunately, such biogenic structures are also vulnerable to fishing impacts, such as being dislodged or crushed by anchors and chain, being physically removed by lines and hooks, or clogged by re-suspension of bottom silts. As most of these species are filter-feeders, they are also affected by more generic threats, including higher sedimentation rates to the seafloor, which smothers them, and suspended sediment in the water, which makes them spend extra energy to extract their food. These degraded conditions also affect the smaller species living in and on the soft sediments, such as marine snails, polychaete worms, and bivalves, which provide food for snapper.

While these habitats and areas have some natural resilience to such disturbances, there is probably a threshold beyond which natural regeneration processes, such as recruitment and regrowth, cannot counter the continuing loss of suitable habitat. Resiliency and thresholds will vary across different habitats, depending on the kind of disturbance. We can see historical examples of such thresholds being reached and exceeded in less resilient – or perhaps more stressed – areas; witness the extensive expanses of dead (and presumably old) relic shell beds in Tamaki Strait and the inner Firth of Thames, along with the complete loss of once extensive, and dense, green-lipped mussel beds growing on soft sediments. These beds were commercially dredged from the 1920s to the 1960s for the Auckland market, until the fishery completely collapsed; forty years on, the beds have never returned. Such areas are now dominated by large expanses of soft mud and silts; there is little emergent structure, and the snapper catch is modest compared to other areas.


All things considered, the inner Hauraki Gulf recreational snapper fishery is still in a pretty good state. This current research programme is quantifying the likely magnitude of, and the mechanisms behind, some of the potential problems outlined above. Our findings will give us a much better understanding of how this coastal ecosystem supports its fisheries, how human behaviour affects these relationships, and what new approaches might be developed to proactively manage our impacts on this and similar systems. Ultimately, ecosystem-based management will not only support the value and pleasure of recreational fishing, but also maintain a healthy and functional ecosystem, with all its wide and wonderful diversity of habitats and species. 



Photo: Matt Smith

Photo: Jarrod Walker

Photo: Jarrod Walker

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