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MARINE FISHERIES

Intertidal flats in estuaries: are they useful to fish?

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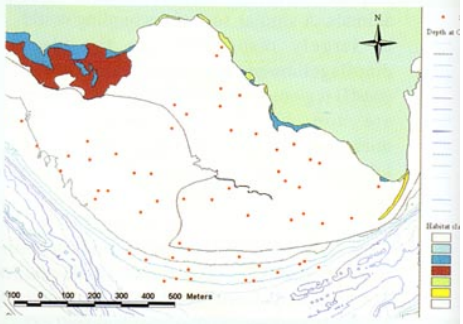
New Zealand has more than 300 estuaries spread along its coastline. The role these play in the life-cycle of coastal fish species is very poorly understood. Research is underway to improve our knowledge of how fish use these potentially important – yet vulnerable – areas.



above right:
Map of Wattle Downs sites, Manukau Harbour, showing substrates, and sampling locations (red dots).

ONE OBVIOUS FEATURE of many of our estuaries and harbours is the extensive areas of intertidal mud and sand banks. For example, 40% (136 km^2) of the Manukau Harbour in Auckland is intertidal. These flats can be highly productive, supporting dense concentrations of bivalves and other benthic species. Their importance to fish is considerably less well known, although they may play a major role as nursery habitats. Currently, even basic information is not available. What fish species are present? Which tidal zones and associated habitats are most important to them? What are they feeding on, and when? We wish to answer these questions in order to determine the potential impact of human activities on estuarine habitats. Our eventual goal is to produce habitat risk assessment models that will allow resource managers and other interested groups to incorporate this information into their decision making.

How do you sample an estuary?

To sample shallow waters immediately adjacent to the shoreline, we can use fine-mesh beach seines (9 mm mesh), dragged on to the shore at the end of each tow. This works well for the shore areas but as soon as we want to start sampling fish in deeper waters we run into problems.

Standard fish sampling gear simply doesn't work in such situations. For example, beach seines need a shoreline for retrieval, while standard trawl and gill nets have meshes too large to retain the small fish that we are interested in. Beam trawls (low box nets towed across the seafloor) do catch fish species associated with the sea floor – benthic species (e.g. flounders and soles), but fail to catch those species often found higher up in the water column – the pelagic and semi-pelagic species (e.g., yellow-eyed and grey mullets, piper and anchovies). We need a type of gear that catches all of the species present and that can be deployed in open waters away from the shoreline and in waters too deep and/or on seafloors too muddy to be worked by manually hauled nets.

Our solution was to build a hybrid between a beam trawl and a beach seine – an "outrigger" trawl. We already possessed a 6-m sampling barge, the *Patiki*, built to work in shallow estuarine waters. We rigged up a modified form of beach seine on a boom supported by an outrigger on one side of the barge. This net would be pushed, rather than towed, reducing potential boat avoidance by the fish and keeping the net clear of the barge's twin propellers. The net was built to fish depths from 0.5 m (the minimum operating depth of the barge) to 4 m (close to the maximum tide range in northern west-coast harbours).

An 8 hp outboard engine, remotely operated, was added to the outrigger to combat the drag induced by the net, which otherwise forced the

barge to go around in circles. A long cod-end, with choker rope, was incorporated to allow us to retrieve the catch at the end of each tow without having to haul the whole net from the water.

Sampling location

We knew from previous sampling that large numbers of the juveniles of several fish species live in the Pahurehure Inlet of the Manukau Harbour. A medium-sized tidal flat (approximately 800 m by 1 km) was selected as a study location, and its bathymetry sampled using a manually deployed RTK GPS system which accurately maps position and height. Deep mud over most of the study area made this a very strenuous process. From these data, a tidal elevation model (a contour plot of the tidal heights) was built to assist in designing our fish sampling programme and in interpreting our findings.

Sampling design

Fish usage of tidal flats is likely to be dynamic, driven by the state of the tide (obviously tidal flats are not available at low tide) and other key factors such as the day–night cycle. Therefore we incorporated tidal state (high/low) and time (day/night) into our fish sampling design. Sampling the shallow water near the waterline at low tide is also important, to assess whether juvenile fish might use these areas as "holding areas" when the tidal flats are not available, and then migrate on to the tidal flats as the tide floods in.

For the beach seine sampling, fish were collected over both high and low tides, day and night. Only the first 20–50 m of water immediately adjacent to the shoreline could be sampled using this method. For the outrigger trawl, sampling stations were placed across the full range of tidal heights over the high-tide periods, while for low tides only the area alongside the low-tide mark was sampled. As with the beach seining, both day and night periods were sampled.

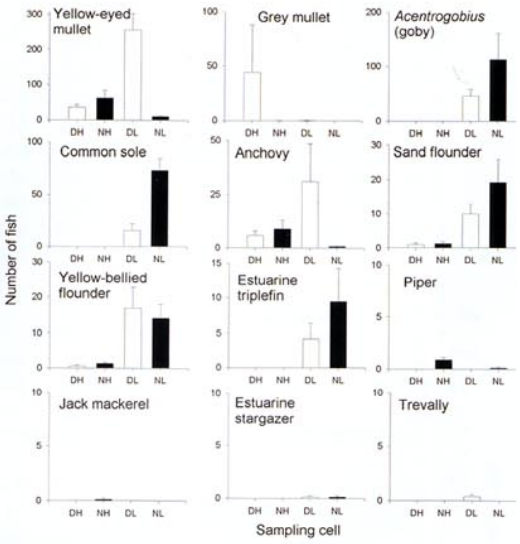
Samples of fish were retained from each of the treatments to assess gut contents and fullness. This allowed us to get a better picture of what fish were actually doing in terms of their feeding over the different times and tides sampled.

Some results to date

Beach seining was completed at eight stations at high and low tide during the day and night. The results showed some clear patterns.

- Species diversity and fish abundance were greater over low-tide periods, for both day and night sampling. This is not surprising, given that fish are concentrated by the falling tide into limited habitat, but it does suggest that some species are not moving fully into the high-tide zone as the water returns (*Acentrogobius* (goby), estuarine triplefin, common sole, estuarine stargazer). Some of these are small benthic species for which large-scale movements over a short time are unlikely. The lower abundance of other fish over high tides (yellow-bellied and sand flounders) suggests that these species may spread widely across the tidal flats at high tide.
- Yellow-eyed mullet and anchovy were caught in highest abundance during low tides, but only during the day. At night, they were almost absent from the immediate subtidal zone. Large numbers of mullet were observed feeding further offshore on the surface during the very early hours of the morning. This suggests they may feed nocturnally and may use the shallow zone adjacent to the shoreline at low tide during the day as a holding area only.
- Piper were caught only at night, suggesting some form of net avoidance during the day (they have been taken during daylight sampling with the outrigger trawl).
- Most grey mullet captured were in one large school of 1-year-old fish (14–19 cm), which was only partially sampled (these fish are very fast and many escaped). Grey mullet of this size are seldom encountered in our larger-scale beach-seining programme.

The outrigger trawl net. (Also see front cover of this issue.)



Abundances of fish species caught by beach seining (no. per tow). Eight sites have been sampled for each tide state/day–night combination. Vertical lines above each bar are standard errors. DH, day high; NH, night high; DL, day low; NL, night low.

We used a multivariate statistical technique known as Correspondence Analysis to identify fish assemblages. Grey mullet and three rare species (piper, jack mackerel and trevally) were omitted from this analysis. Yellow-eyed mullet and anchovy contrasted strongly with the other five species along the dimension 1 (i.e., this difference accounted for the greatest proportion of explainable variability in the data set). This results from the low abundance

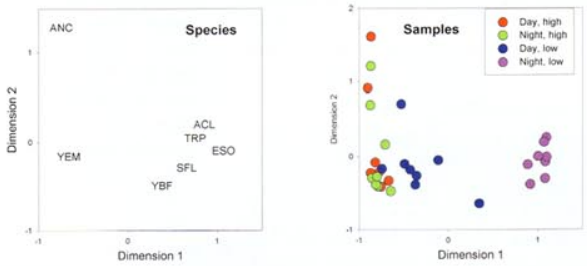
of yellow-eyed mullet and anchovy in the night-time low-tide samples, due to offshore movement. The remaining species were abundant in low-tide samples at night. Yellow-eyed mullet and anchovy separated out along dimension 2. Although these two species had similar patterns of mean abundance among the four day–night/tide combinations, anchovies were more variable in their abundance, and were often uncommon or absent from tows that contained large numbers of yellow-eyed mullet.

Not surprisingly, the night-time low-tide samples had a catch composition that was quite distinct from all other samples. Day-time low-tide samples were also distinct from the high-tide samples, which differed little between day and night.

The outrigger trawl data showed clear evidence that different species were accessing different parts of the intertidal areas over high-tide periods. There was a clear decrease in fish abundance at around 300 m above the low-tide mark. Most of this abundance was in the form of high numbers of anchovies. For the flatfish species, yellow-bellied and sand flounders were found across the full extent of the intertidal zone, but the common sole ranged only about 300 m up from the low-tide mark. This result was consistent with the beach seine sampling: no soles were caught during the high-tide sampling, but they were present at the low-tide stations.

Among the semi-pelagic species, anchovies were only found in any numbers up to 300 m above the low-tide mark, while yellow-eyed mullet were more cosmopolitan, occurring across the full extent of the tidal flats. The small benthic-associated species (a goby and a triplefin) only extended in range to approximately 300 m and 150 m respectively into the intertidal flats during high tides. This matched up well with the high-tide beach-seine results, where these species were not present. This is consistent with what we might expect for small benthic species that are not great swimmers and run the risk of being stranded with rapidly falling tides on such low-slope intertidal areas.

Other species were caught, but in numbers too low to make meaningful comments on their distribution on the tidal flat.

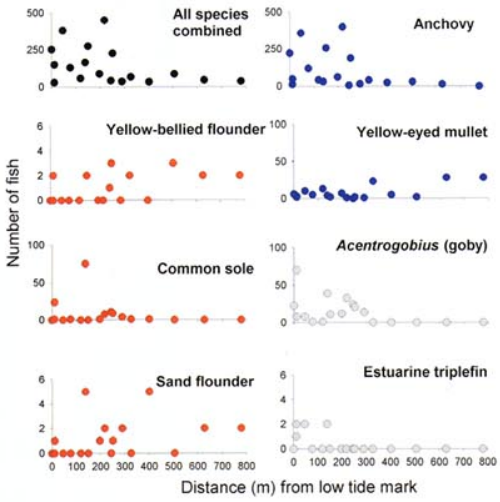


above:
Correspondence analysis plots for species and tide/time combinations. ANC, anchovy; YEM, yellow-eyed mullet; YBF, yellow-bellied flounder; SFL, sand flounder; TRP, triplefin; ACL, Acentrogobius *(goby); ESO, common sole.*

Outcomes

Once we have completed a formal analysis of this work, we will have a much clearer picture of the dynamics of fish usage of estuarine tidal flats. Those results will be incorporated into ongoing work to determine what fish species are closely linked to estuaries, which habitats are most critical to them, and how potential changes in such systems may adversely impact on fish species and assemblages. For example, in systems where the intertidal flats are several kilometres wide, it may prove that only the lower tidal portions are heavily used by fish, and that areas further away from channels are of little relative importance.

This coming summer, we intend to undertake a large-scale fish sampling survey of about 25 estuaries throughout the northern North Island. The results from the current work clearly show that beach seining at low tide is the best way to maximise the number of species encountered and to allow collection of adequate numbers of fish for estimating juvenile population size structures. ■



below left:
Catch rates of fish by the outrigger trawl for the night/high tide treatment. Distance is measured from the mean low-tide mark. Symbol colour denotes a species functional group: black, all; red, flatfish; blue, semi-pelagics; grey, small benthic species.

Acknowledgements

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