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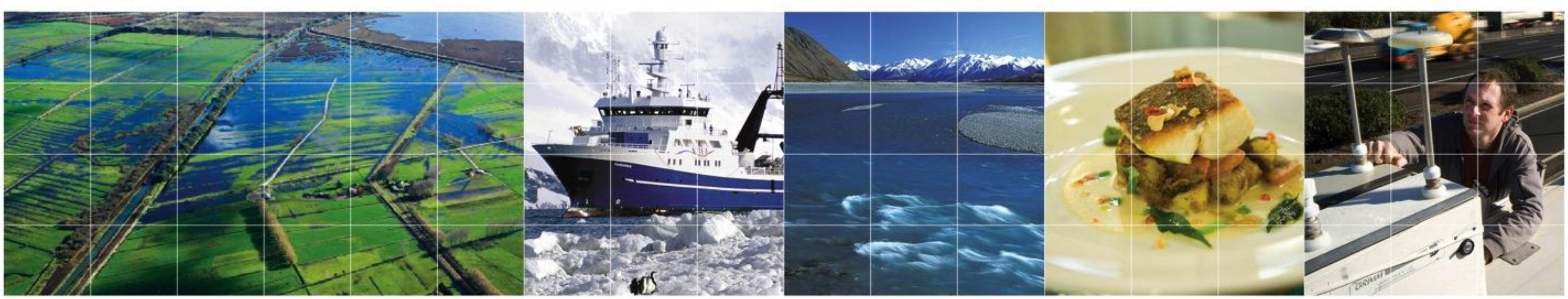
Coastal fish assemblages in the Hauraki Gulf: habitats, connectivity and threats – in particular from terrigenous fine sediments

Mark Morrison, Meredith Lowe, Darren Parsons, Emma Jones

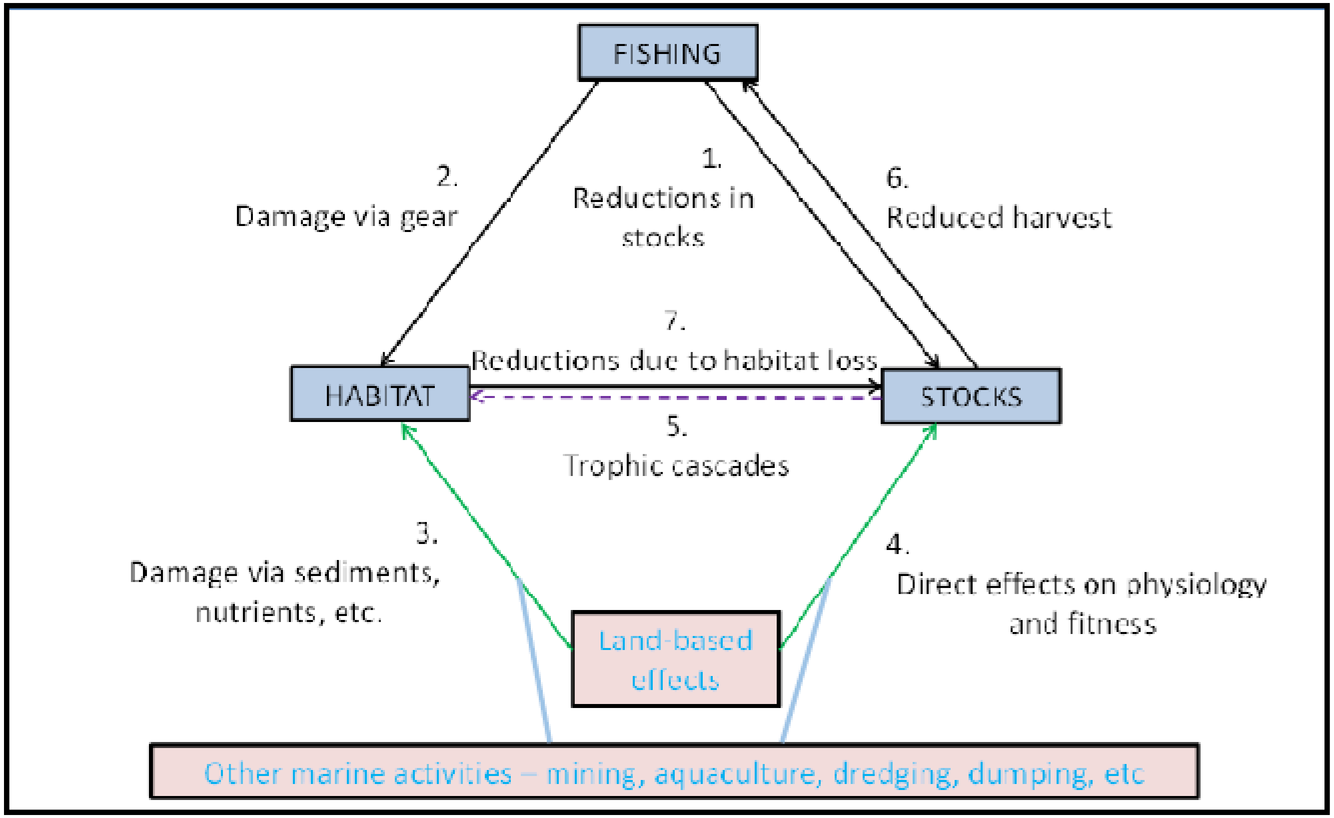


Outline

- Introduction - habitats & fish in the Hauraki Gulf
- Juvenile snapper and seagrass
- Sediment impacts on fish and habitat
- Habitats landscapes - towed camera
- Fish connectivity across landscapes
- Deeper water habitats
- Future work

Introduction

Introduction

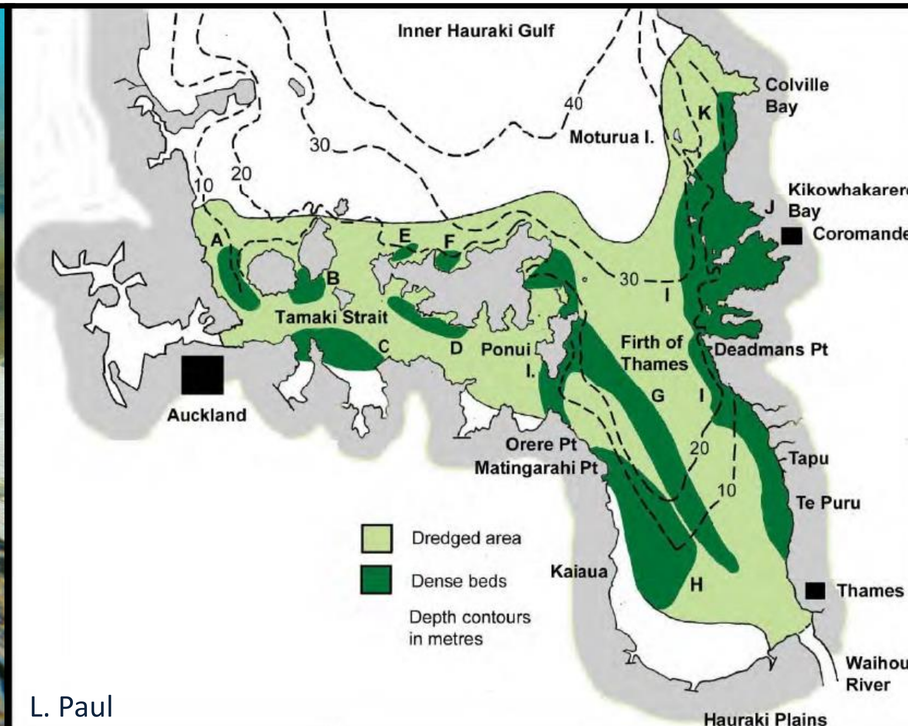


[modified from Peterson & Falk 2008]

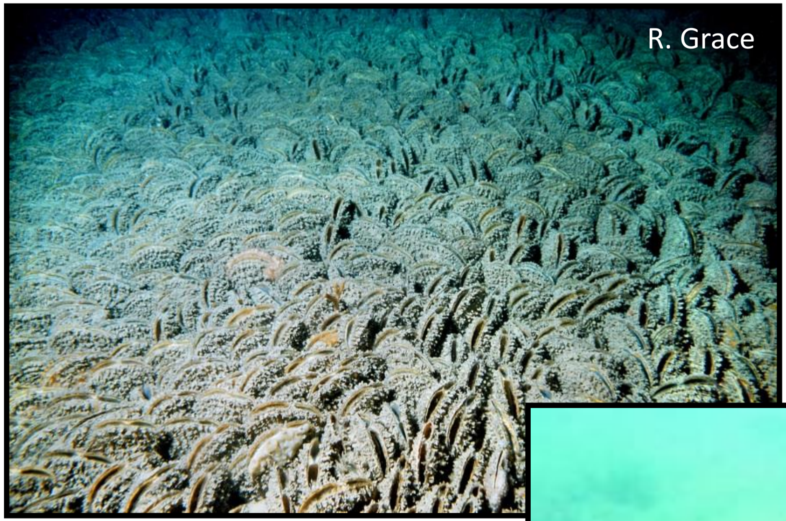
Why habitat is important

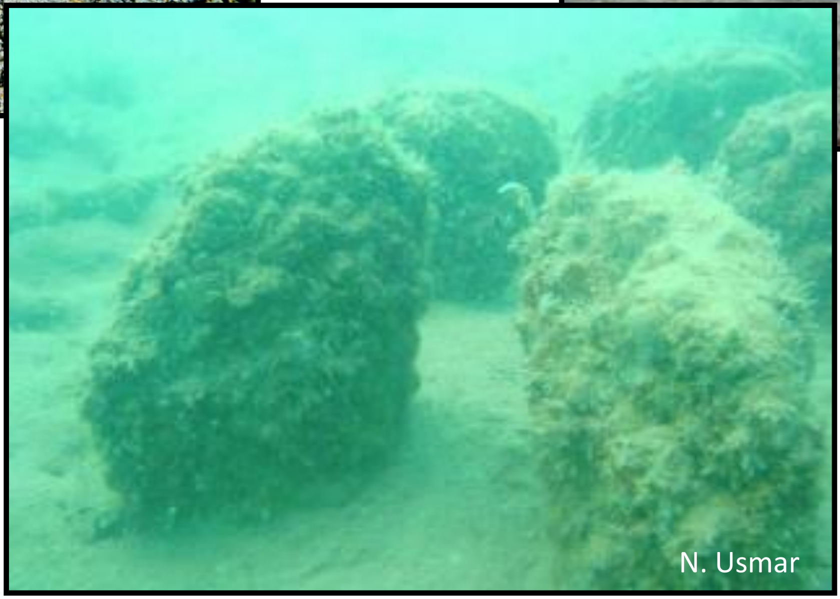
- Juvenile nursery habitat
- Protection from predation/increased feeding
- Spawning locations
- Migration corridors

Green lipped mussels

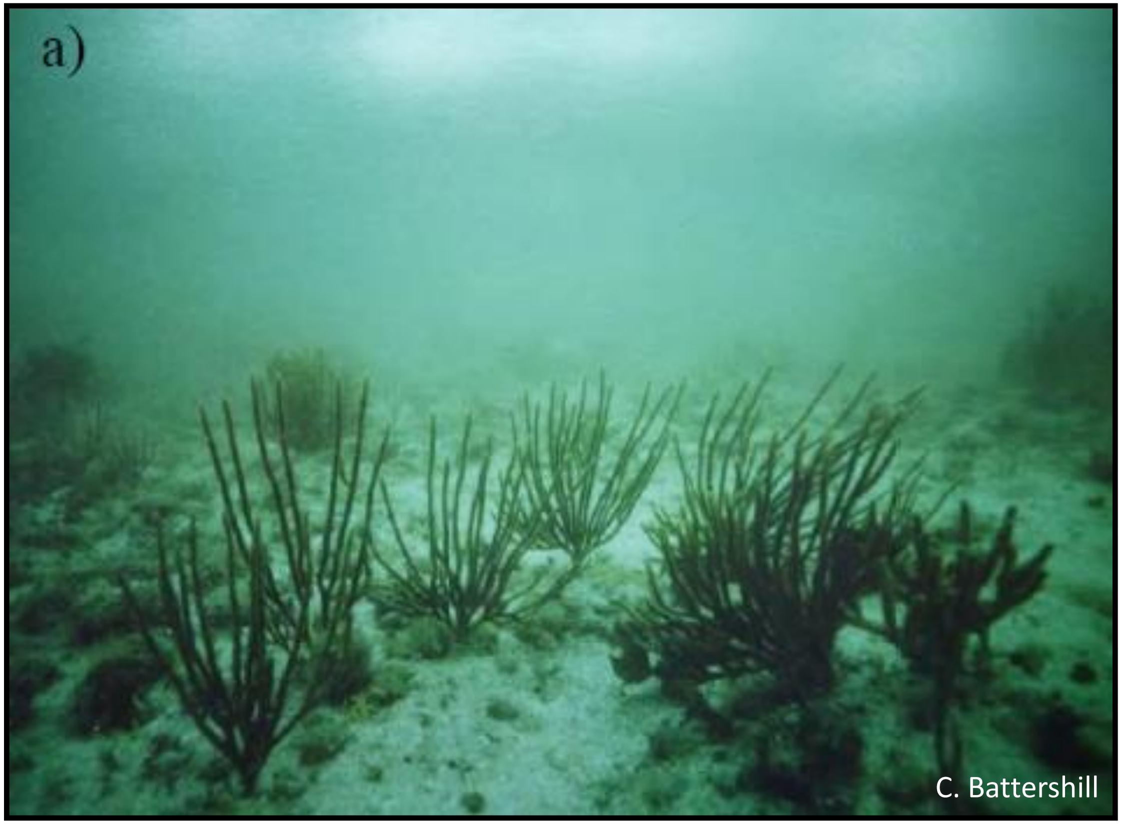


Horse mussels



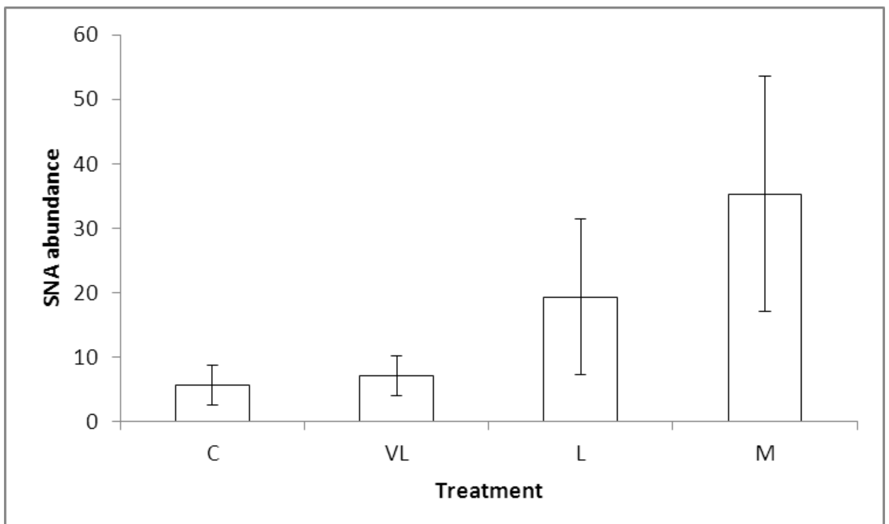


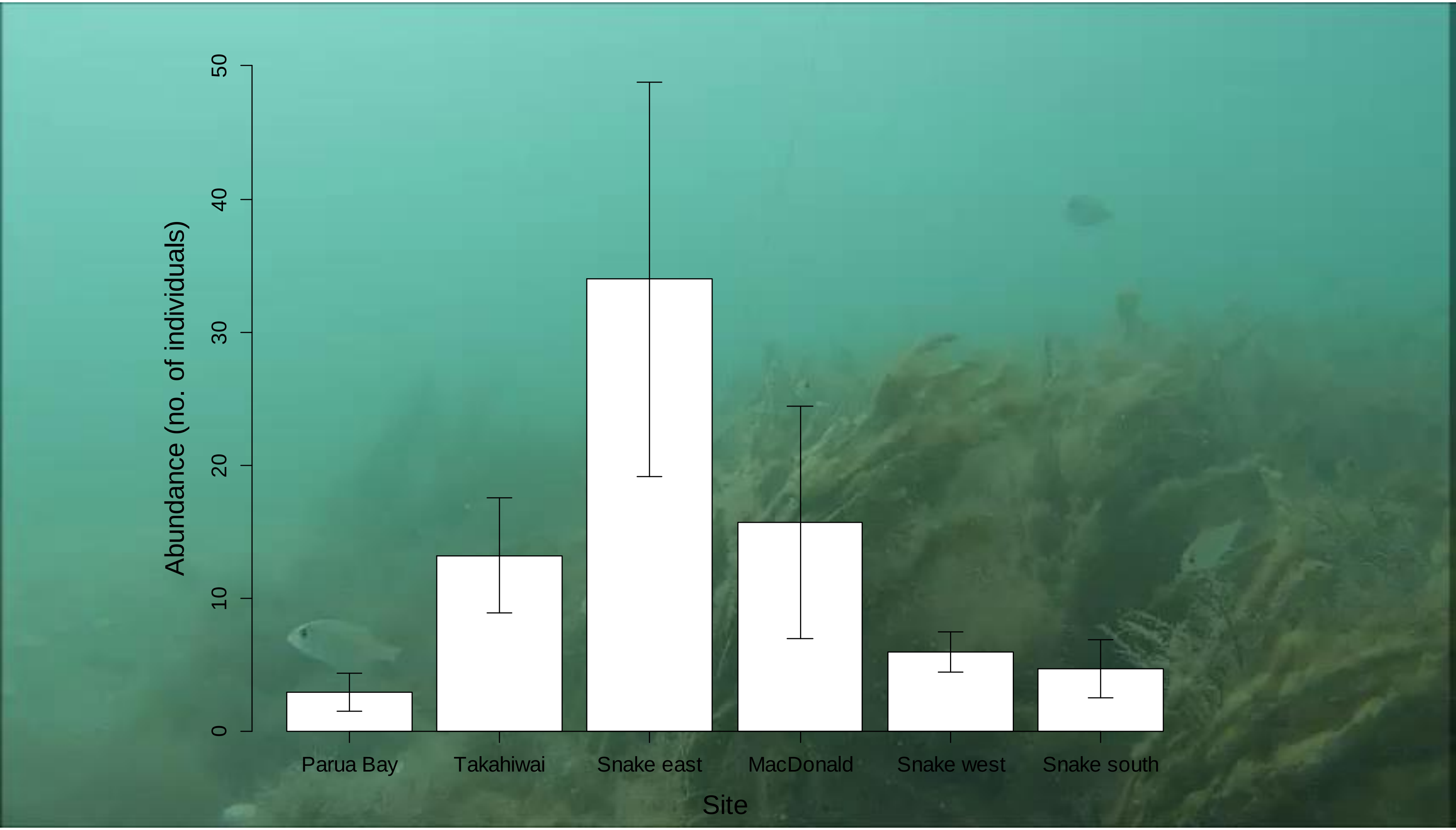
Sponges



Seagrass


C. Middleton


60
50
40
30
20
10
0
SNA abundance
C
VL
L
M
Treatment



Current strength

Sediments and fish habitats

- NZ predominantly mountainous/hilly with 50% of land mass at slopes >28°; highest conversion rate to pasture in the world ~ 60%
- Erodible soils – soft siltstones/mudstones
- High loads of suspended sediments into coastal zone especially by world standards ~ 1%
- Increased frequency of storm events – may have profound long-term effects e.g., Cyclone Bola
- Changes in water clarity; expansion of mangroves cover; broad scale increase in muds


NIWA file photo

Example – Seagrass meadows

- Sensitive to sedimentation and eutrophication from the land, changes in water clarities and light regimes, physical disturbance by fishing, dredging and spoil dumping.

Declines in seagrass:

- Whangarei Harbour 12–14 km^2 in the 1960s Tauranga Harbour 34% from 1959–1996 (90% subtidal) Whangapoua Harbour 50% from 1945

- Historical large losses from the Manukau, Waitemata, Avon-Heathcote harbours and others..

- Many other structured habitats have also been impacted – e.g. horse mussel beds have declined in the Mahurangi Harbour; green-lipped mussels Firth of Thames – collapsed 1960's with no recovery

Whangapoua Harbour after major storm in 1995.
Up to 10cm thick sediment layer: complete loss of seagrass
In some areas; major mortality of shellfish

Effects of suspended sediments on fish

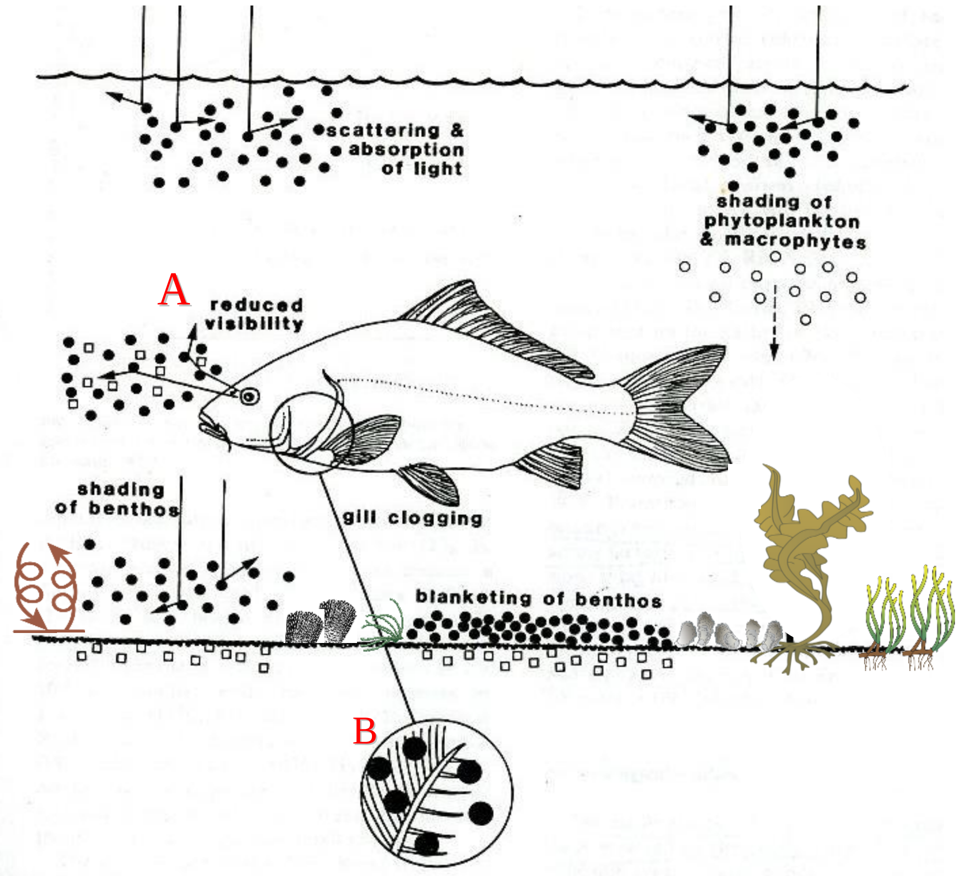
Direct

- Reduction in foraging efficiencies; reduced visual acuity
- Clogging of gills with fine sediments

Indirect

- Loss of important nursery habitats e.g. biogenic habitats such as seagrass / horse mussels

Arrows show extent to which TSS cause light to be scattered or absorbed



Juvenile snapper as a model species

Examined how habitat/environmental change influenced fish feeding/health

Laboratory based experiments

- Whether turbidity/substrate type influenced feeding rates
- Effects of turbidity over time: duration of exposure (from 2 hours to 30 days)

Field surveys:

- How turbidity related to fish diet, physiology, and gill structure across 7 harbors spanning a gradient of environmental degradation

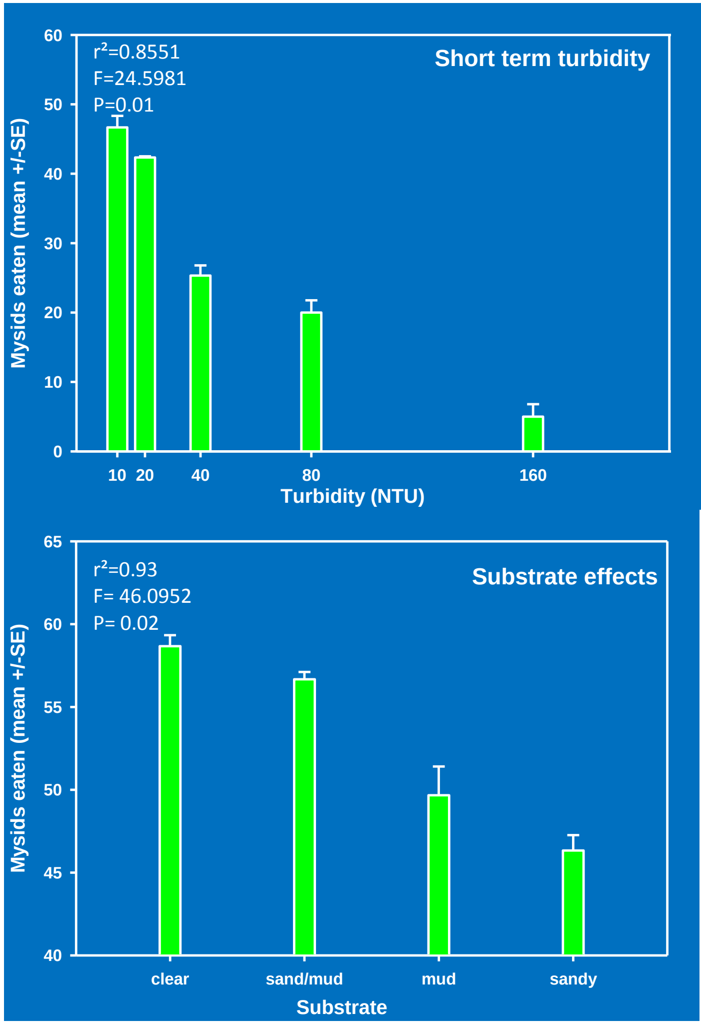
Short term effects of suspended sediments

A. Effects of turbidity on feeding

- Snapper 50–90 mm long
- 5 treatments: clear → turbid
- Decreased feeding with increasing turbidity

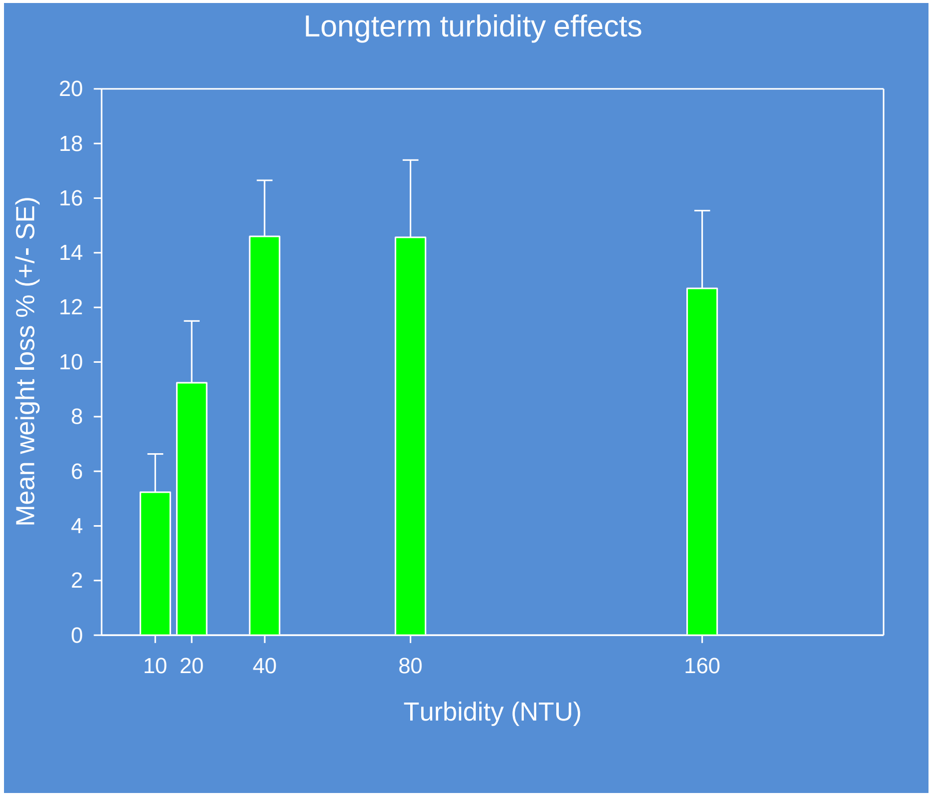
B. Effects of substrate on feeding

- 4 treatments:
- Bottom type: clear, sand, sand/mud, mud
- Highest feeding rates were for sand/mud



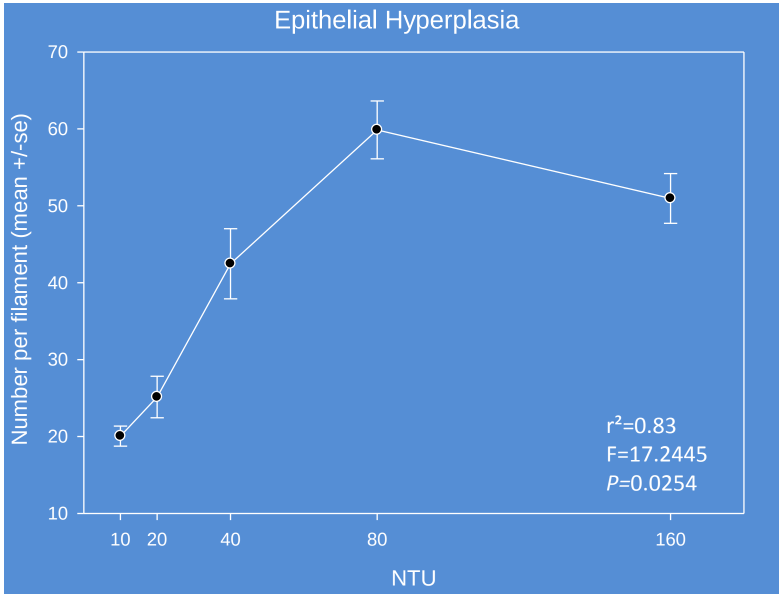
Long-term effects of suspended sediments -

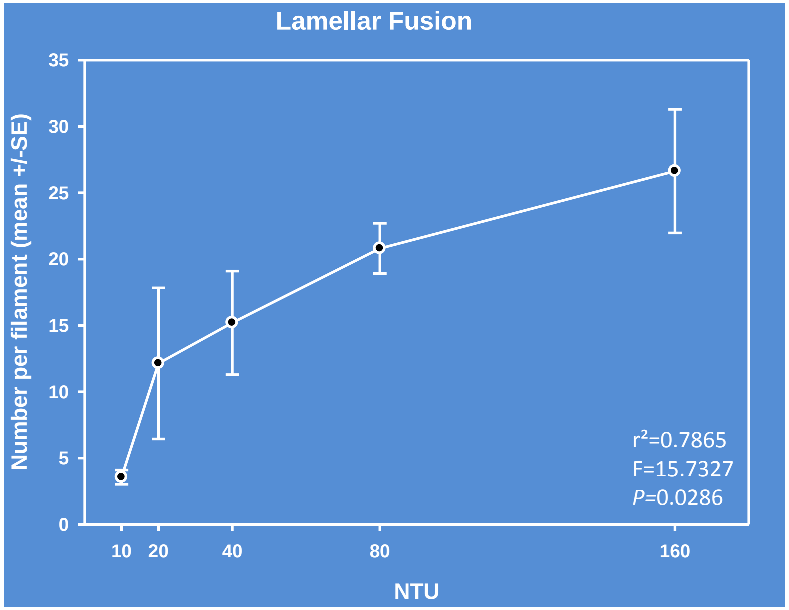
- 6 treatments 10 → 160 NTU
- 4 week duration
- Higher weight losses & mortality for the higher turbidity levels
- Sub lethal responses included increased coughing, gulping at surface, higher respiration rates and decreased activity
- Paler colouration



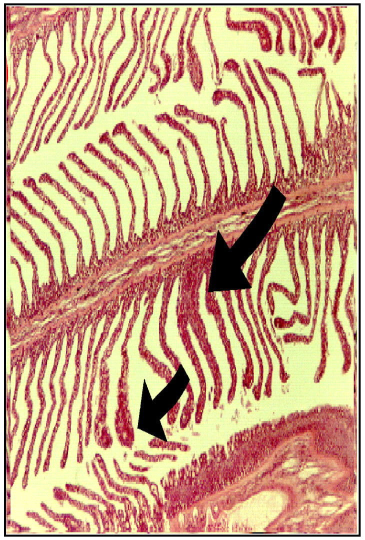
Gill structure

- Juvenile gills vulnerable to pollutants due to large surface area/external location – indicator of water quality
- Hyperplasia a defense mechanism to decrease respiratory surface against irritants
- Significant positive relationship with increasing epithelial hyperplasia and fusion of lamellae with increasing sediments

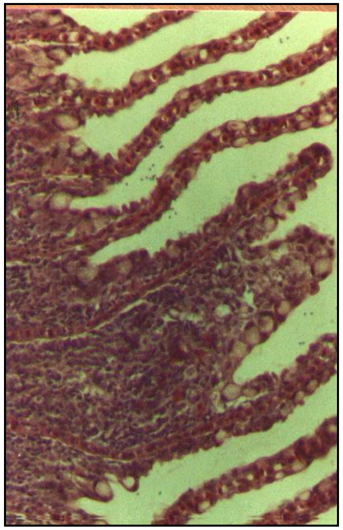




Epithelial hyperplasia

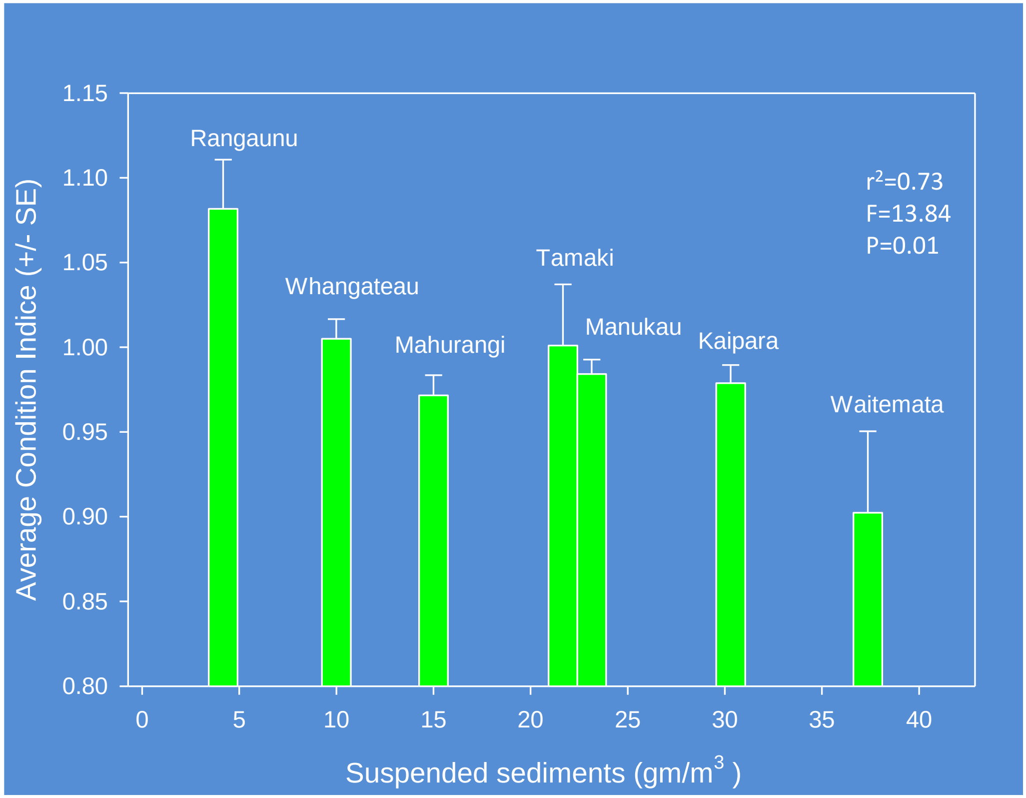


Fusion



Cross-harbour comparisons

- Decreasing Relative Condition Index with increasing suspended sediment loads
- Rangaunu Harbour most ‘pristine’ – highest average CI
- Waitemata Harbour least ‘pristine’ – lowest average CI
- Suggests snapper in higher suspended sediment harbours are less healthy, and weigh less for a given length

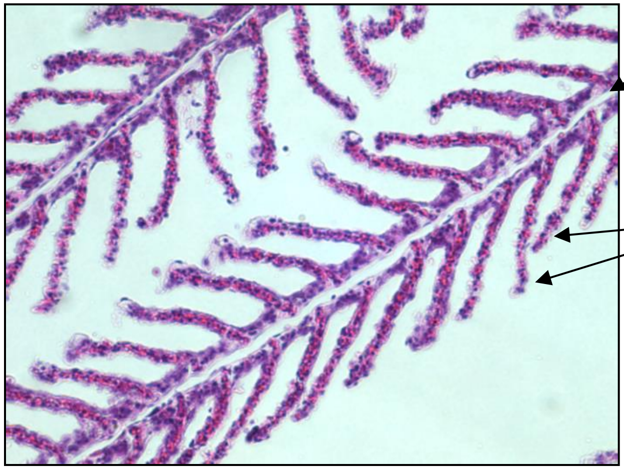


Inter-harbour gill structures

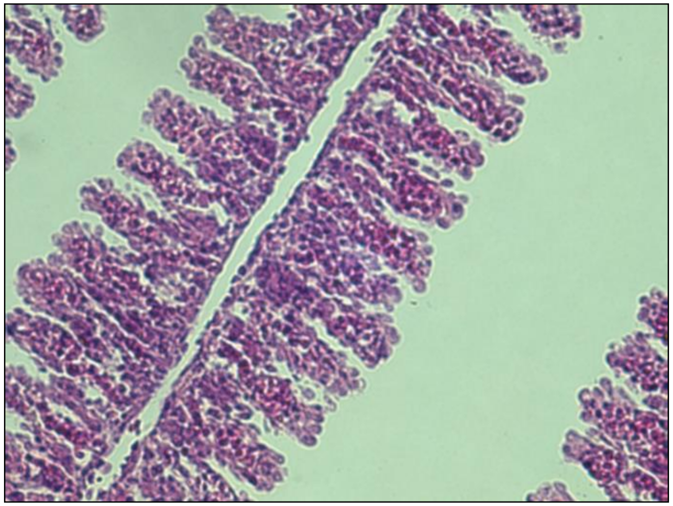
- Northern harbours (i.e. Rangaunu / Whangateau) recorded healthy gills

- More southern harbours (i.e. Mahurangi, Manukau, Tamaki, Waitemata) showed increasing swelling; shortening of the lamellae & increasing presence of bacterial infection

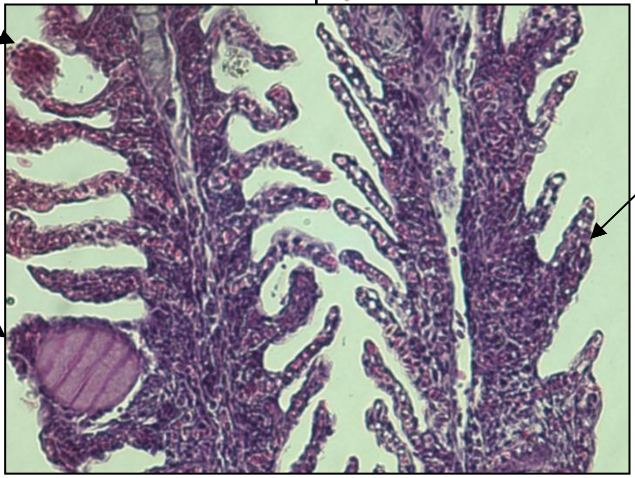
Rangaunu Harbour



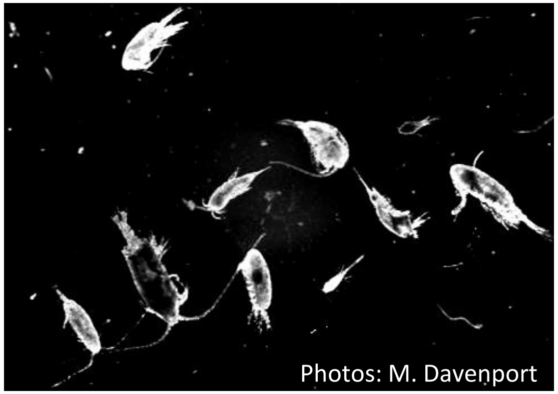
Manukau Harbour



160 NTU Tank Expt.



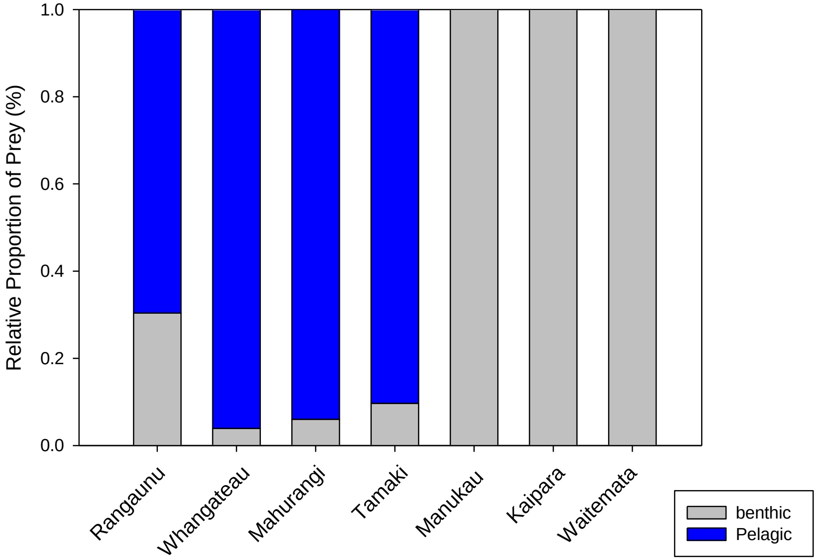
Snapper – bentho-pelagic prey switching



Pelagic - copepods

Benthic - mysids

- Mysids & copepods major dietary component for all estuaries
- Biomass of categories varied relative to suspended sediments/secchi measures
- Suggests a change in feeding strategy from active (visual) selection of pelagic prey to larger/slower moving benthic prey.
- May reduce growth



Implications for fisheries

- Increased levels of suspended sediments can have negative effects compromising fish health & fitness
- Mechanisms are synergistic and may operate simultaneously
- Need to manage not just the fish populations but wide range of biogenic habitats that support them and their prey
- Vulnerable to sedimentation/eutrophication effects – may act as bottlenecks to fish production at certain stages
- Reductions in subsequent productivity at the population level, including fisheries production

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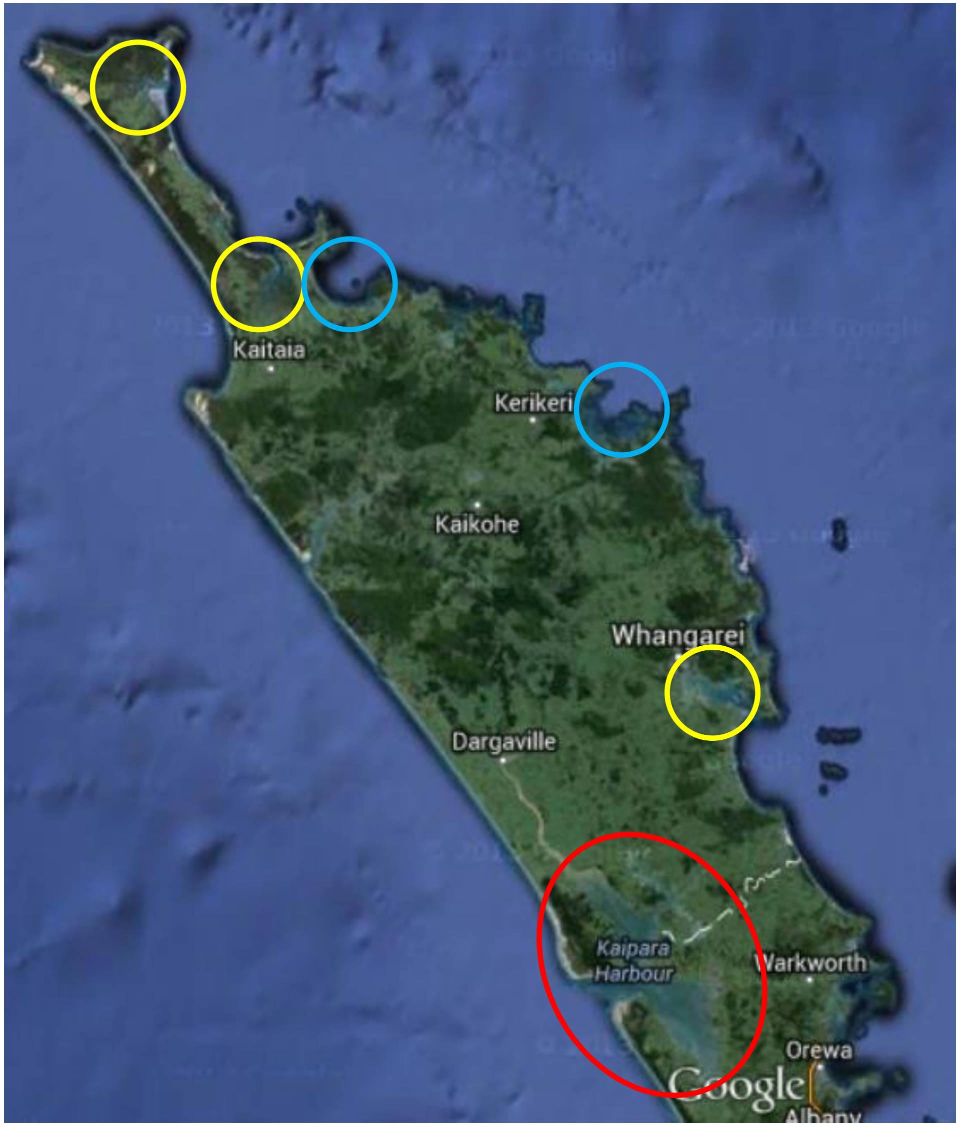
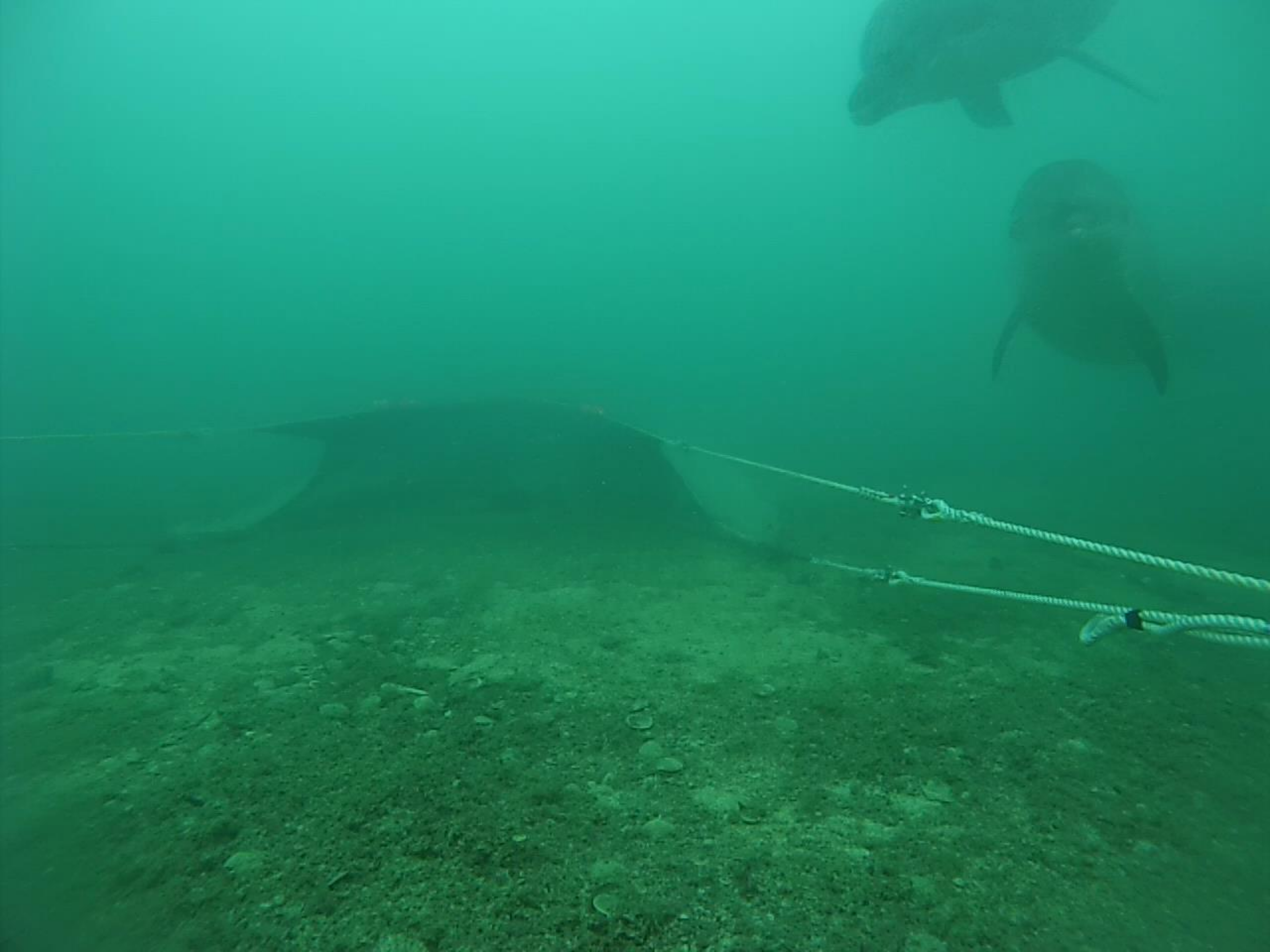
Habitat landscapes and regions

- Estuaries, sheltered and open embayment's, coastal seas, open seas, mid to outer continental shelf – all connected by fish life histories (connectivity)
- Snapper – juveniles in shallow sheltered structured area – large adults out to open semi-oceanic to 200 m water depth – 60 year life span
- What contributions do different habitats/ landscapes make? Production bottlenecks, cascades of effects…

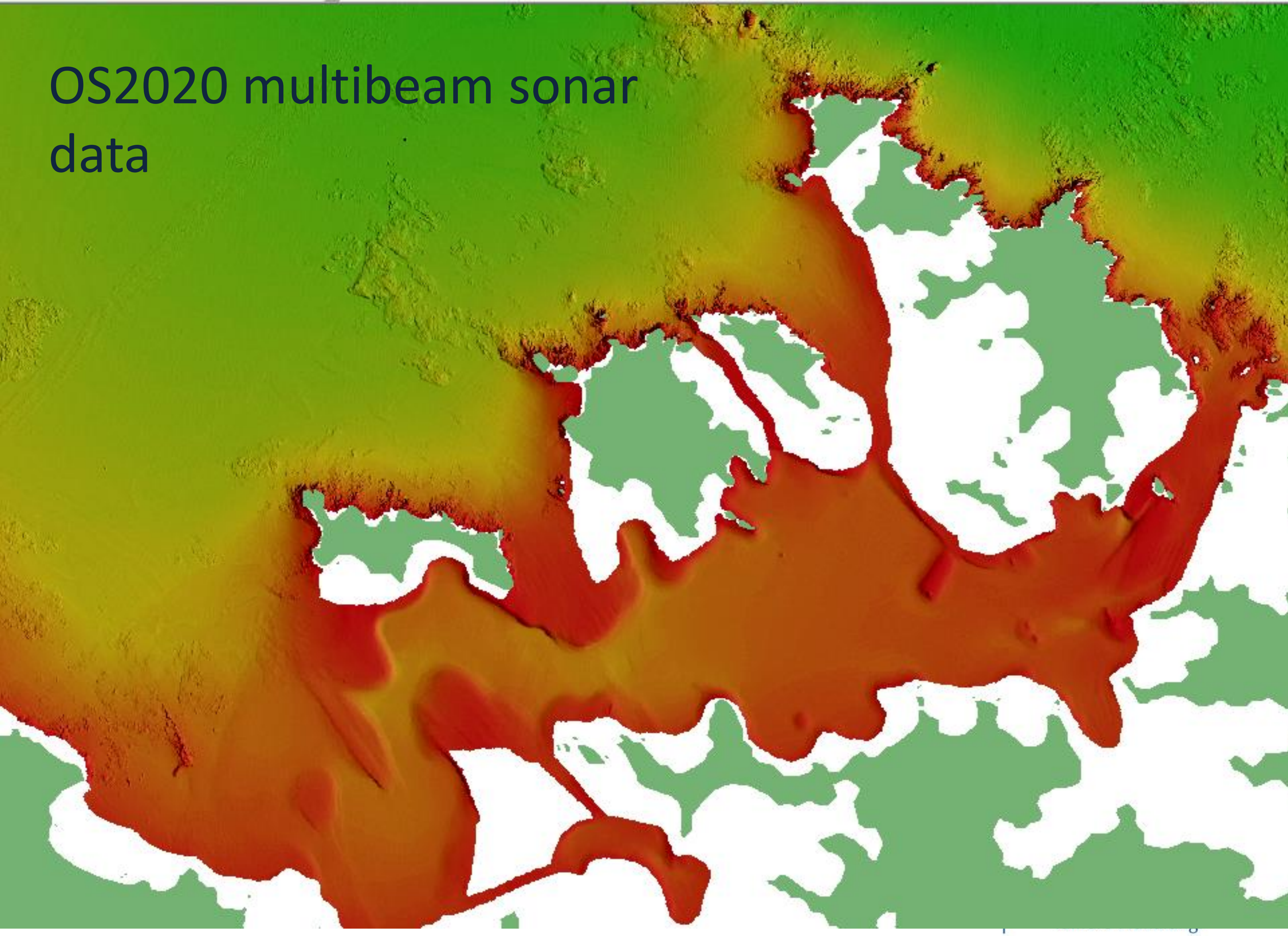




Bay of Islands – Te Rawhiti Strait

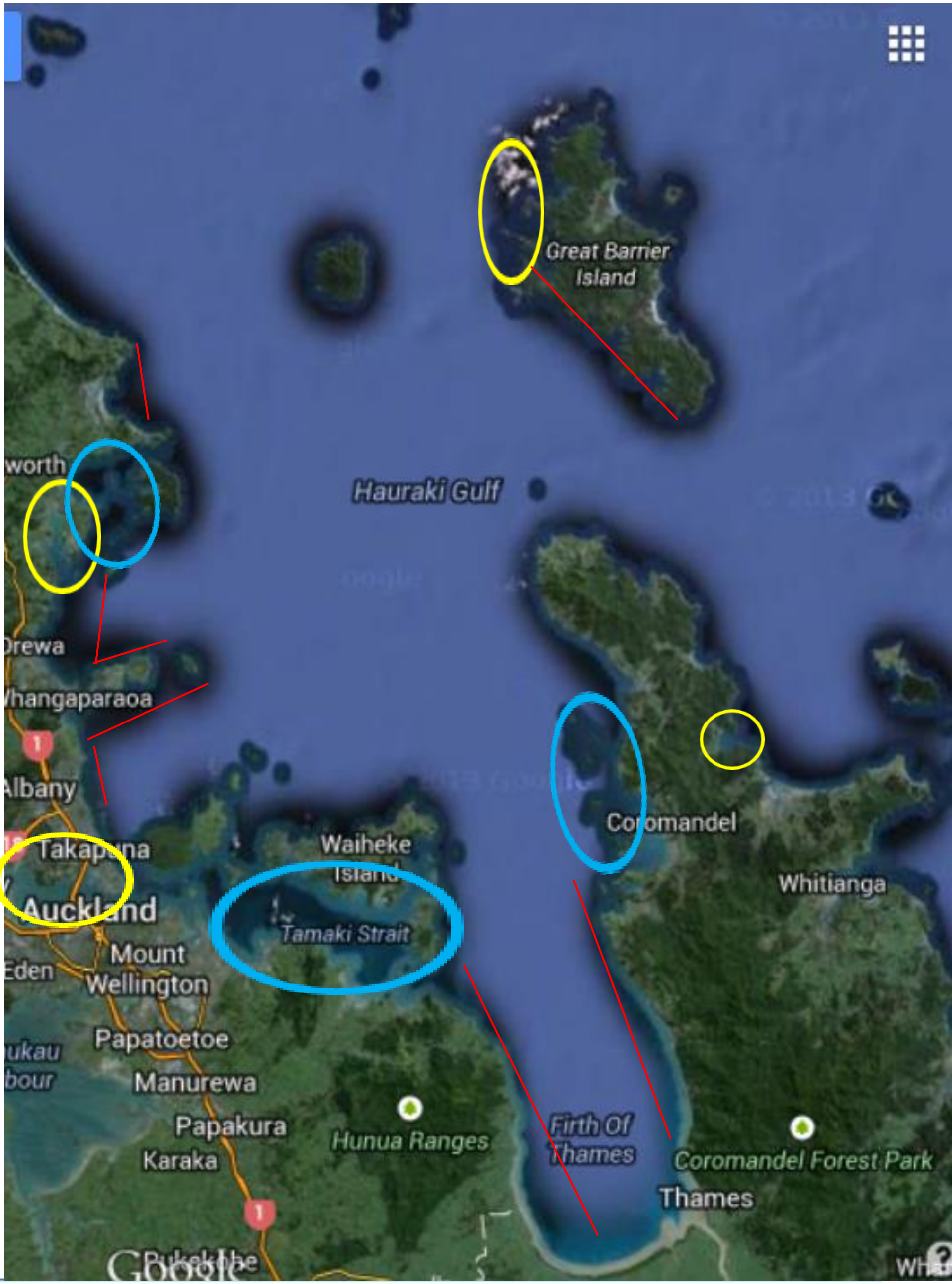
- High juvenile snapper abundances, lots of biogenic structure, esp. horse mussels and red algae

OS2020 multibeam sonar data



The Hauraki Gulf?

- For snapper (and all other species), we have really only a broad idea
- Largely driven by fisheries research trawl surveys (1982 – 1999) targeting 1+ juvenile snapper
- Also egg surveys by Zeldis et al.
- In the inner Gulf, we deployed underwater video at night when most fish species sleep



Night-time towed video

Unusual behaviours

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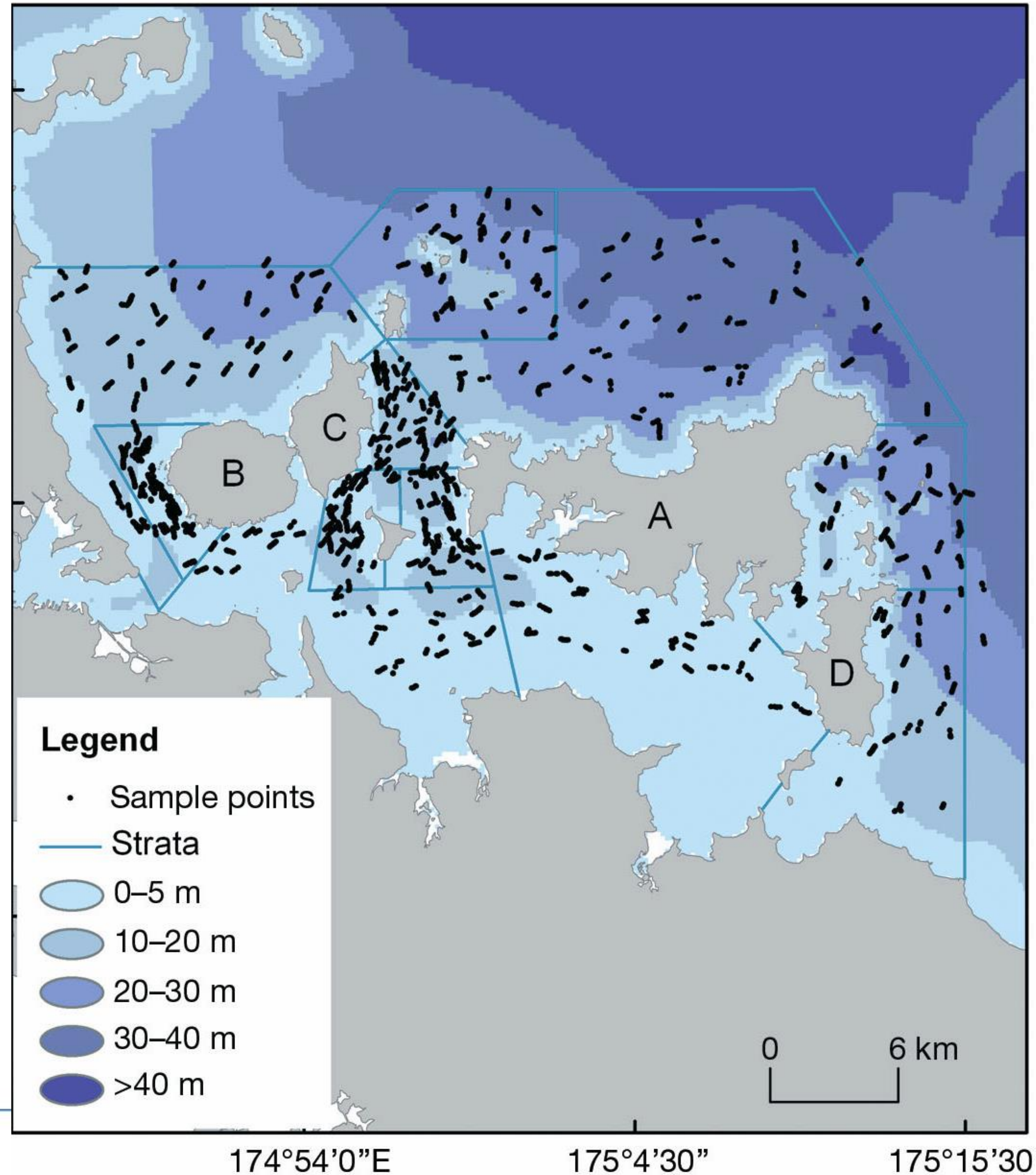
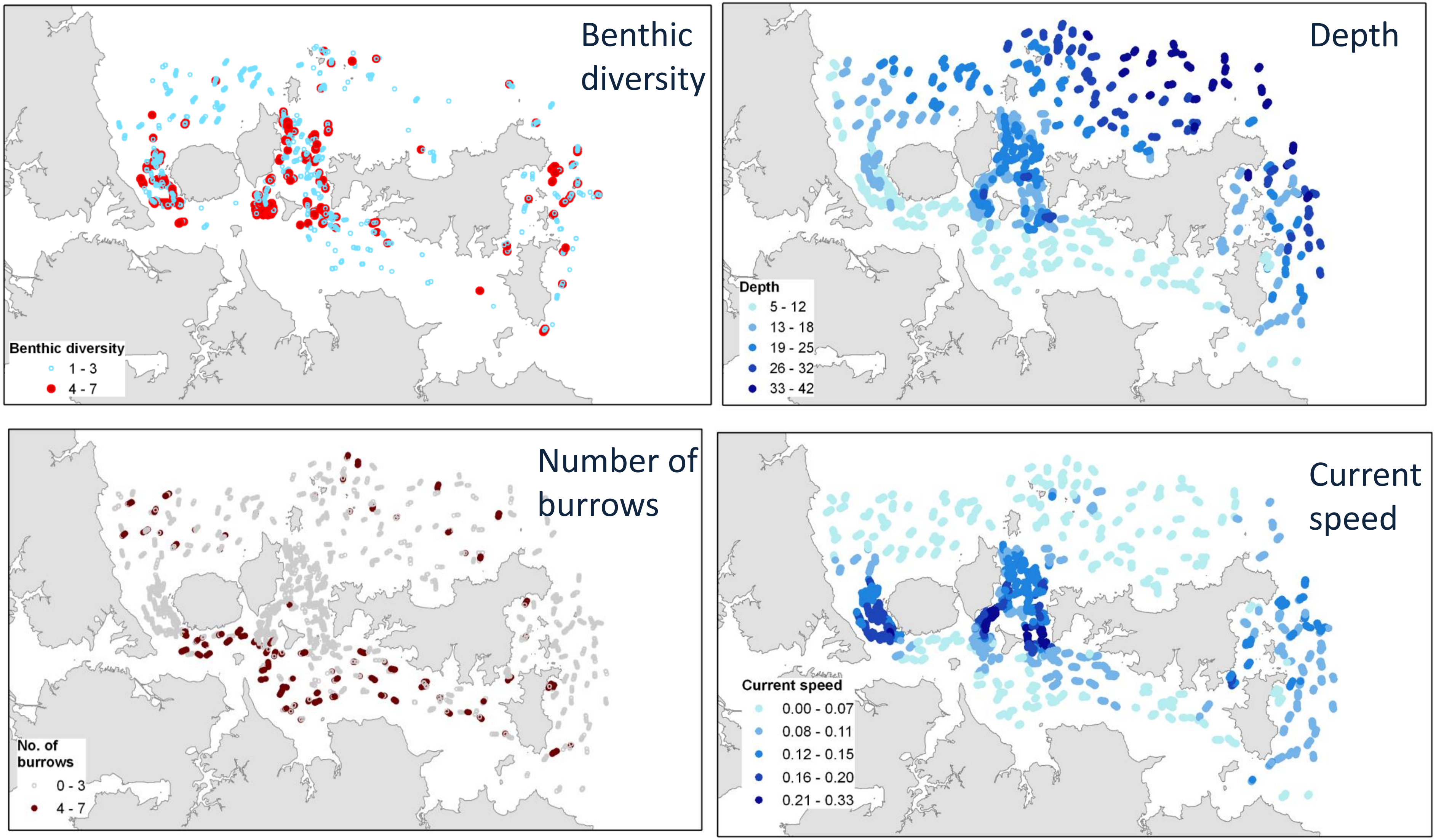
Inner Hauraki Gulf

- Circa 400 transects over 4 seasons, c. 2,000 snapper
- Habitat measures taken at for each snapper plus equal random points
- Snapper occurrence assessed against habitat and environmental variables
- Includes fish size and seasonal effects





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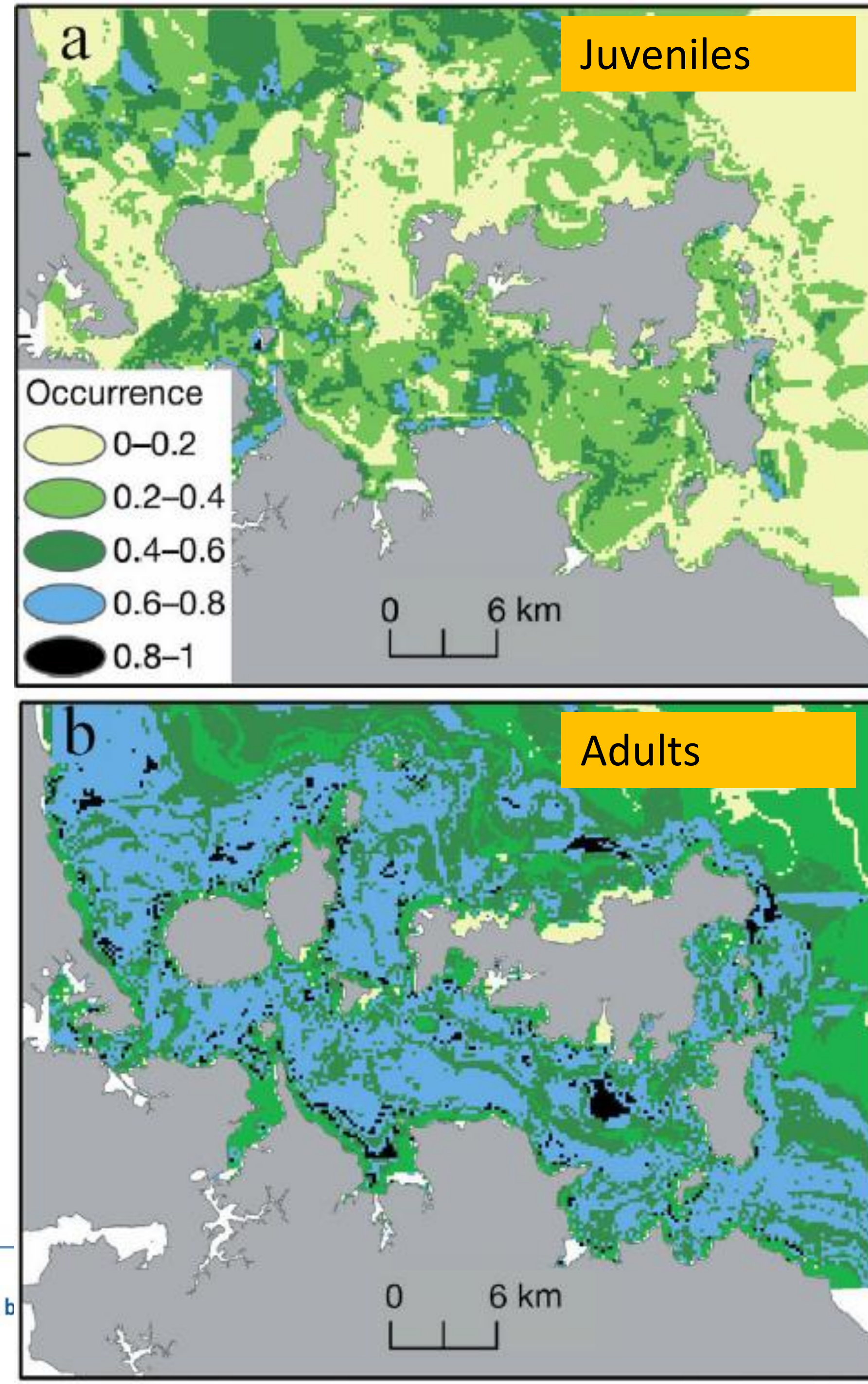
- Juvenile snapper most frequently associated with slow orbital velocities and tidal current speeds, and presence of sedimentary structures, like mounds, pits and burrows.

- Adult snapper associated with fast tidal current, fast orbital velocities and higher epi-benthic diversity.

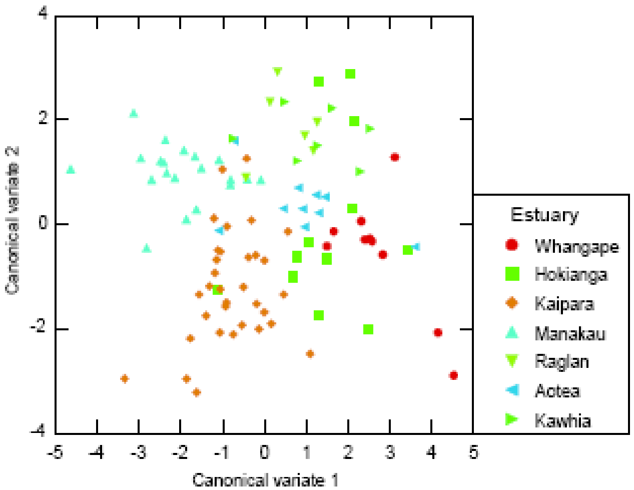
- Snapper are cannibalistic, and we suspect there is a negative interaction between small juveniles and adults

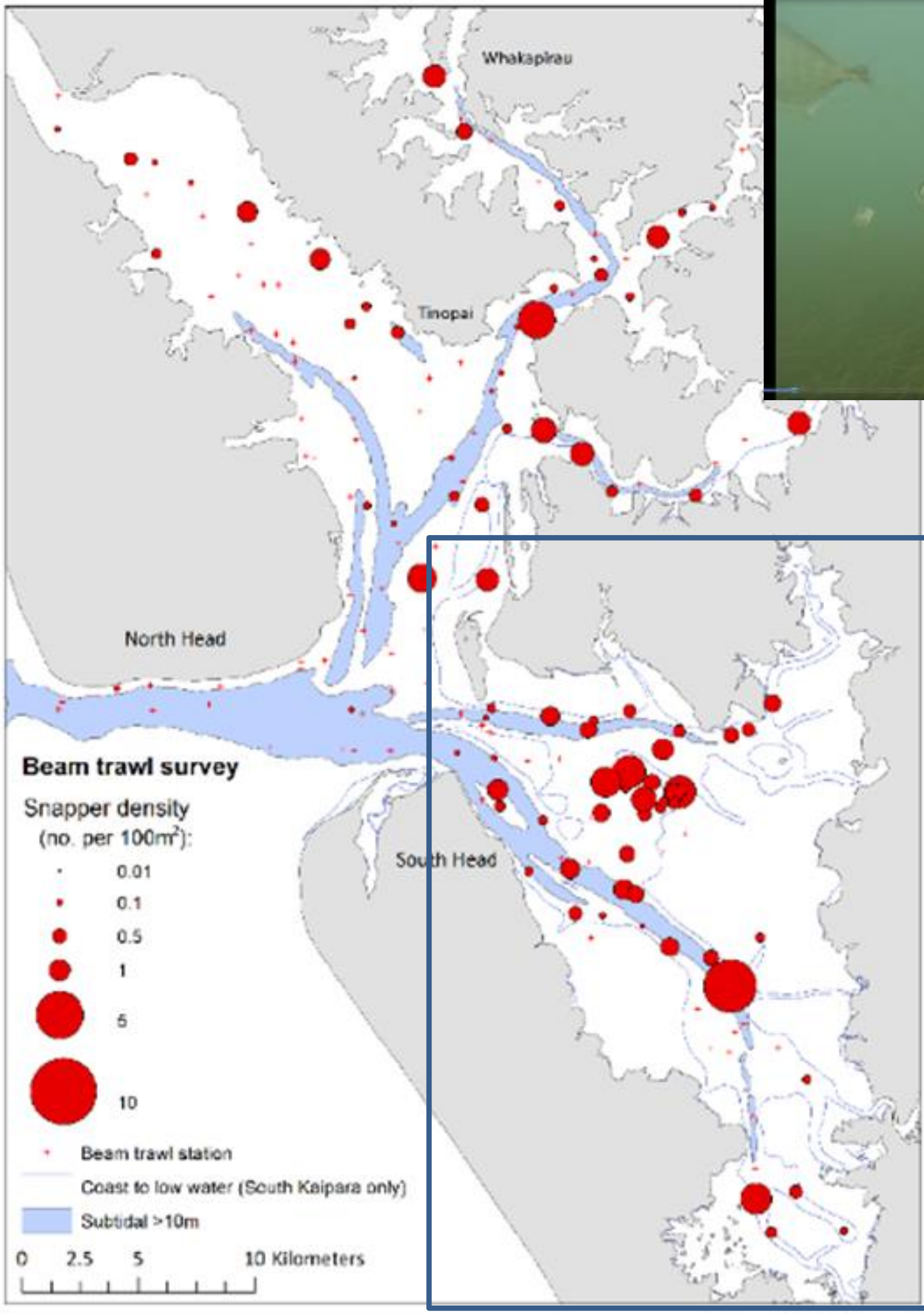


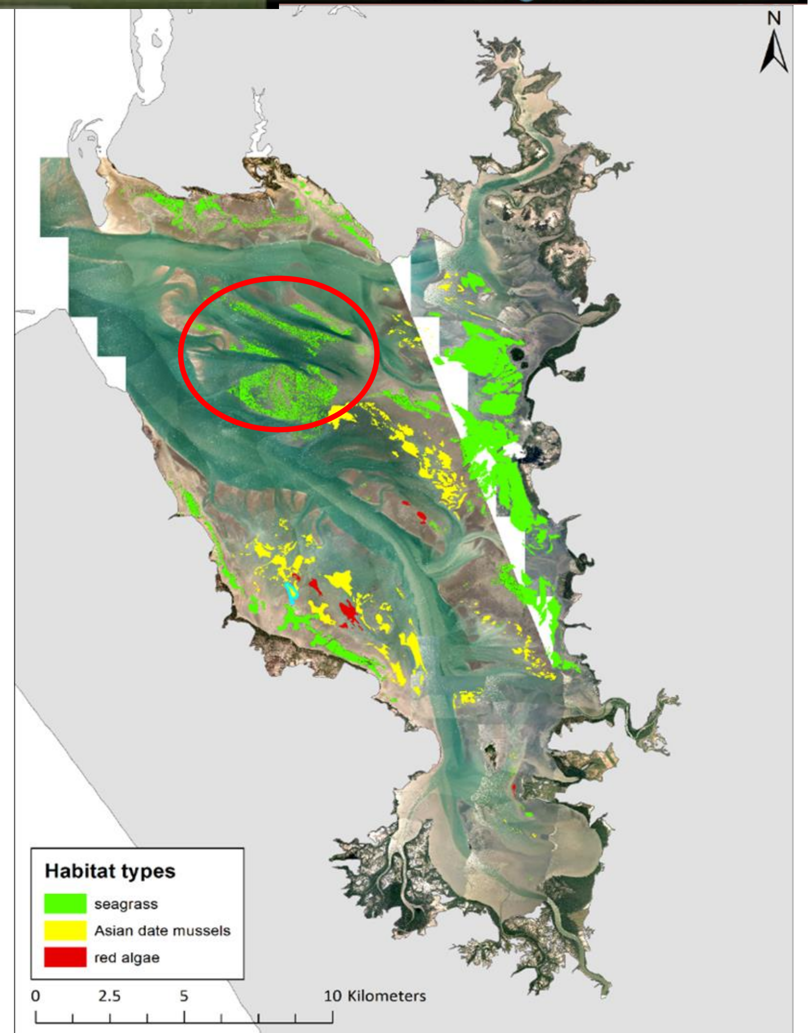
Connectivity – fish movement

West Coast snapper (SNA 8) and the Kaipara Harbour

- Juveniles concentrated in estuarine systems, relatively rare on the open coast.
- Otolith chemistry of 2003 juvenile year class matched with 4+ coastal adult fish in 2007 – majority of fish sourced back to the Kaipara Harbour
- Within the Kaipara, juvenile fish are strongly associated with sub-tidal sea-grass, horse mussels, and other biogenic habitats. These are under stress.
- Potential for large-scale cascade of effects



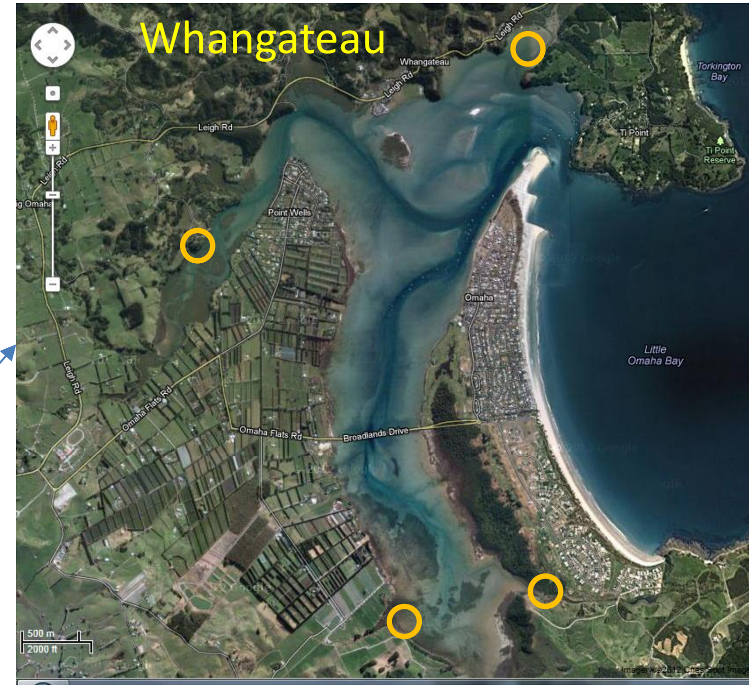


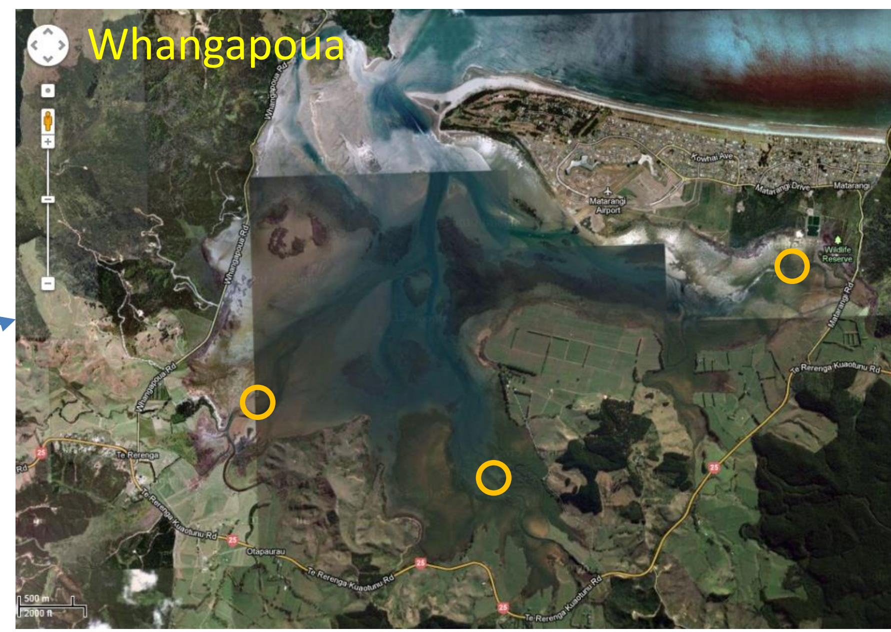


Kaipara Harbour

Grey mullet nurseries

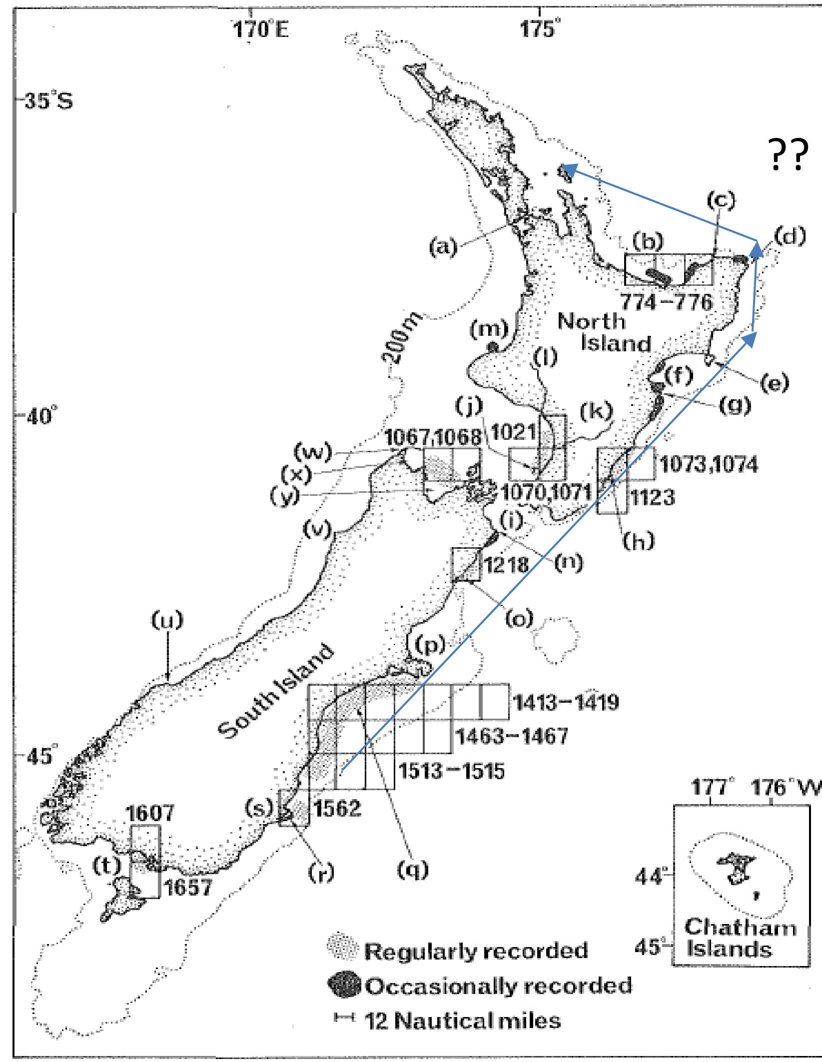
- Where and what are the nursery habitats?
- How do the nurseries link to adult populations?
  - Stock structure
  - Source-sinks
  - Natal homing
- Different life histories – freshwater, estuarine, sheltered to very exposed coasts – why, consequences?
- Otolith chemistry, genetics





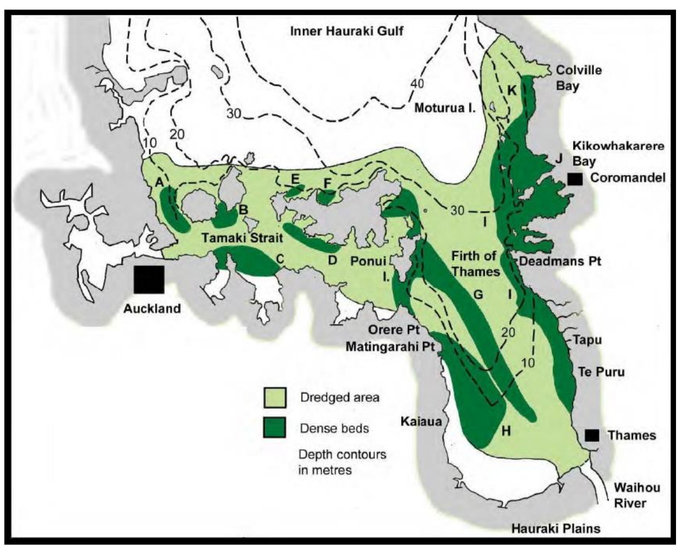
Tarakihi – national connectivity including Hauraki Gulf

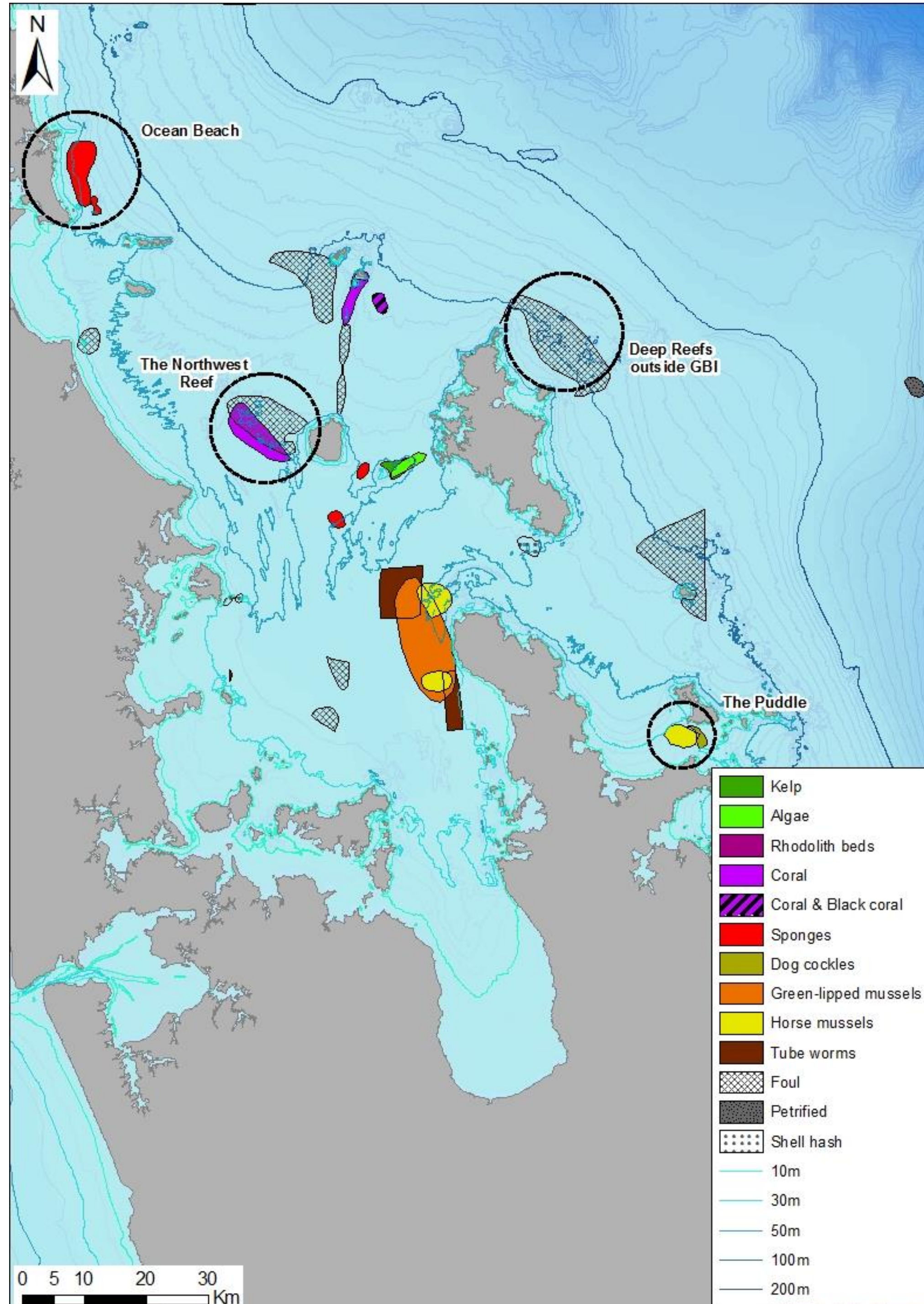
- Important commercial and recreational species – evidence of declines
- Caught out along the continental shelf edge, comes in shallower during the winter months
- Few fish < 20 cm (juveniles) are caught in northern New Zealand
- Evidence that nursery grounds are largely in South Island – biogenic seafloors under threat from sedimentation/fishing
- Greater Hauraki Gulf connected at large spatial scale to distant nursery grounds

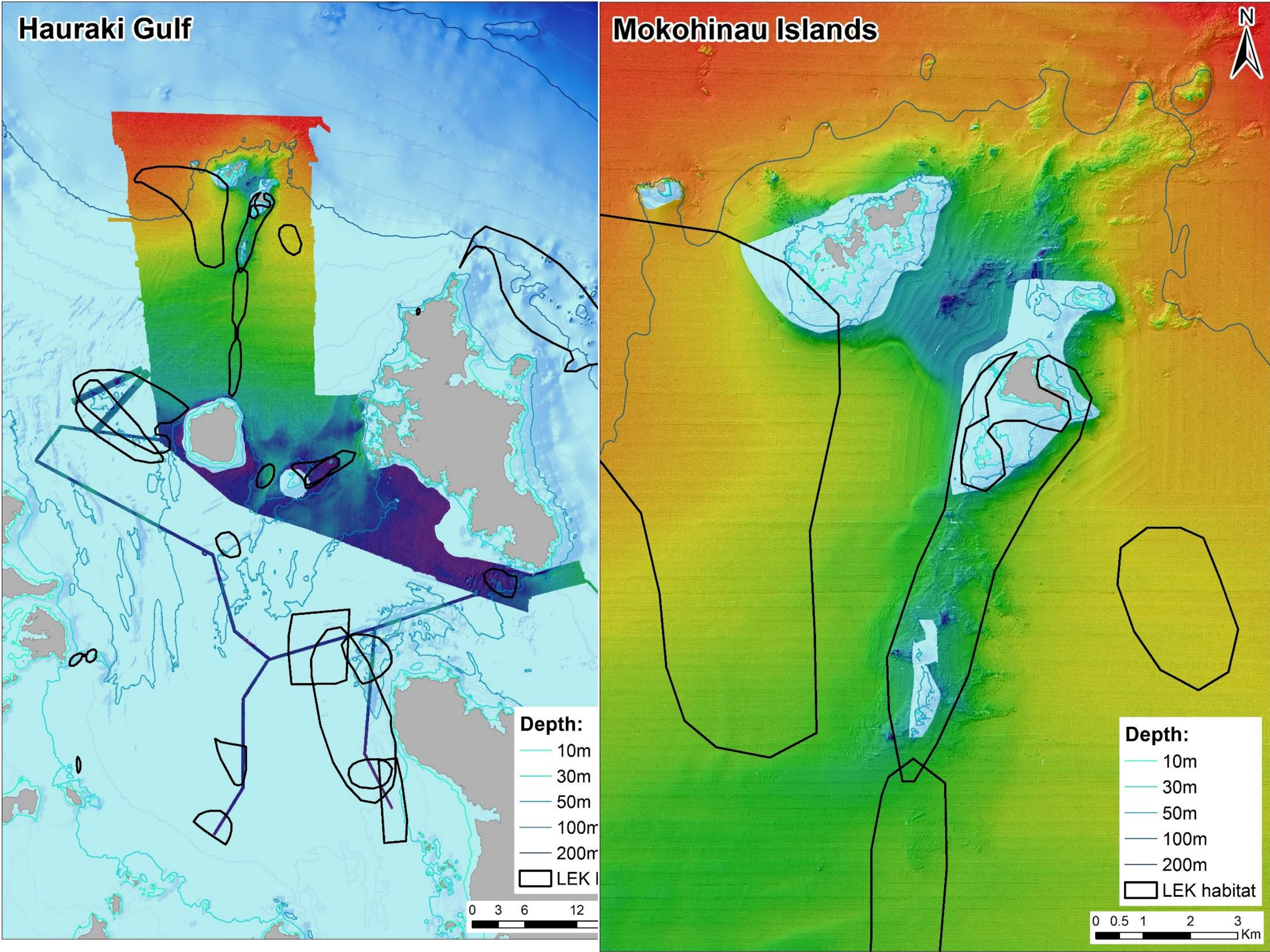


Biogenic habitats on the continental shelf

- Poorly known – important knowledge held by long-time fishers – known as Local Ecological Knowledge (LEK) – used interview process to 'capture' this knowledge (MPI BRAG programme)
- National Tangaroa voyages – but not the Hauraki Gulf






Hauraki Gulf
Depth:
10m
30m
50m
100m
200m
LEK
0 3 6 12
Mokohinau Islands
N
Depth:
10m
30m
50m
100m
200m
LEK habitat
0 0.5 1 2 3
Km

Ongoing work relevant to Hauraki Gulf

- Location of snapper/other species nursery habitats, threats especially sediments and fishing.
- Fish-habitat interactions in these habitats – how, why, outcomes?
- Fish connectivity of life history phases – otolith chemistry, morphological markers, genetics, direct tagging
- Mapping of biogenic habitats – e.g. aerial photography, satellites, multibeam and side-scan sonars…
- Models of how habitat/landscape changes may change production of key fisheries species
- Key species currently snapper, grey mullet, tarakihi – expand to others (e.g., red gurnard, John dory, kahawai, blue cod*)
- Potential for fisheries habitat reserve areas to enhance fisheries production
- Creation of national coastal (fish-) habitat classification, and companion threats and stressors framework (MBIE Coastal Conservation Management programme)

Acknowledgements

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