Marine reserves, fisheries, and the north-eastern New Zealand *Jasus edwardsii* population

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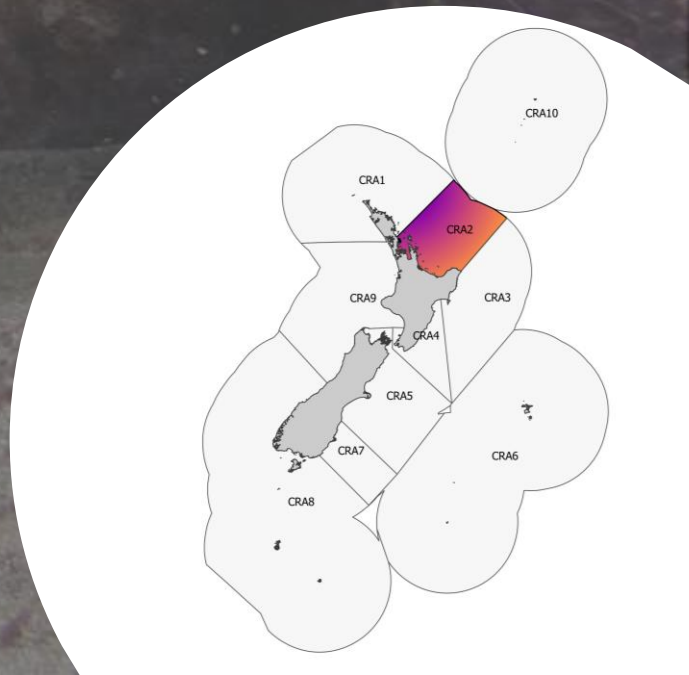
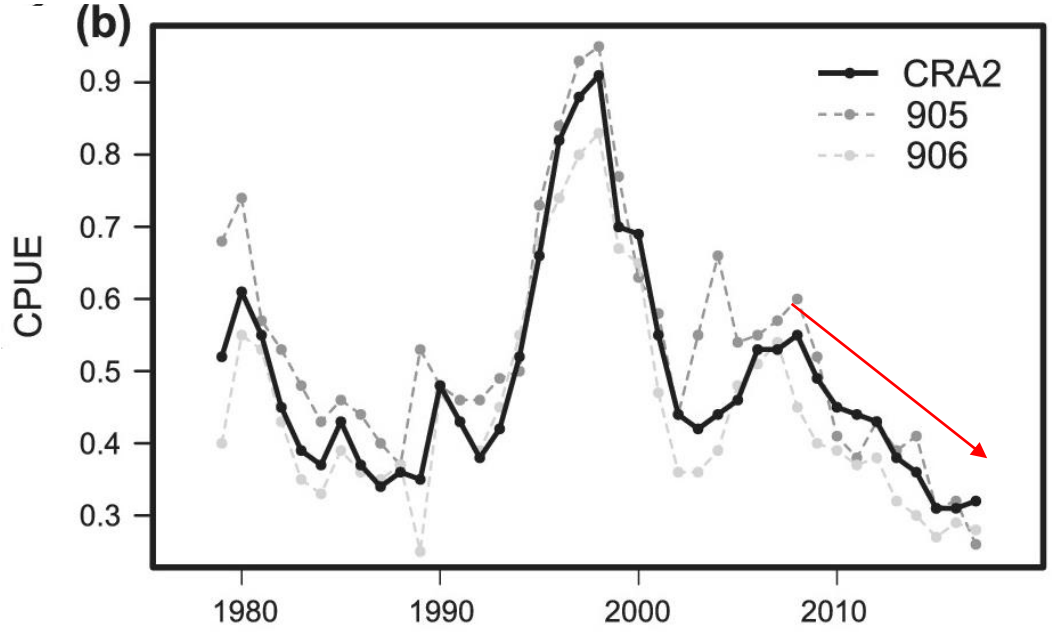
Fishing and North-eastern New Zealand *Jasus edwardsii*

- Present in ancient middens indicating lobster collection well before the eighteenth century
- Quota Management System (QMS), since 1 April 1990
- 10 Quota Management Areas (QMAs)
- Each with annually set Total Allowable Catch (TAC) limits
- Severe declines over the statistical era

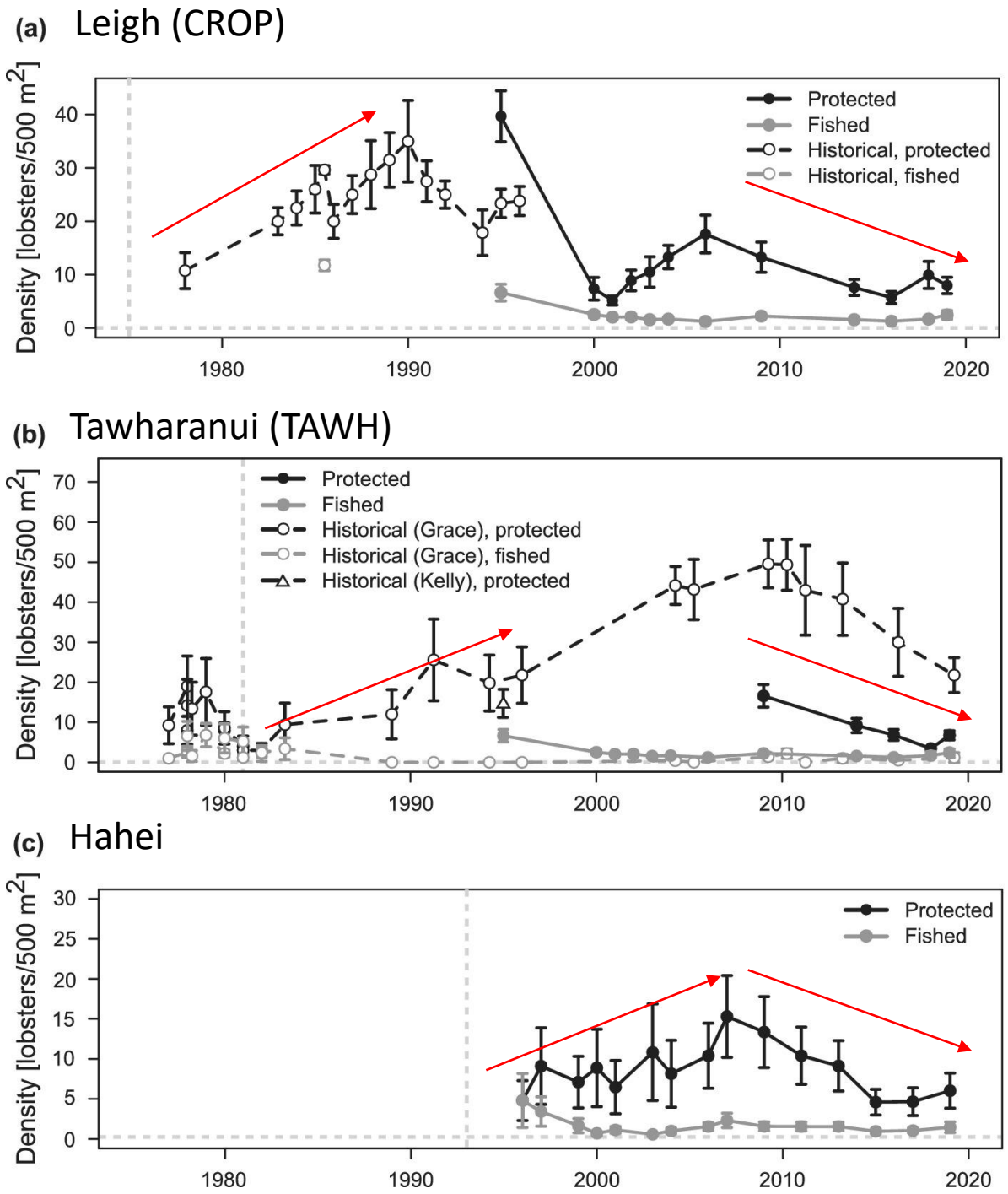


North-eastern NZ marine reserves

- LaScala-Gruenwald et al. (2021) compiled lobster monitoring data from three reserves up to 2019
- All reserves show similar patterns – initial increase, but declines since ~2008
- Same pattern in wider fishery – Efficacy of reserves?



https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/csp2.362



Research aims

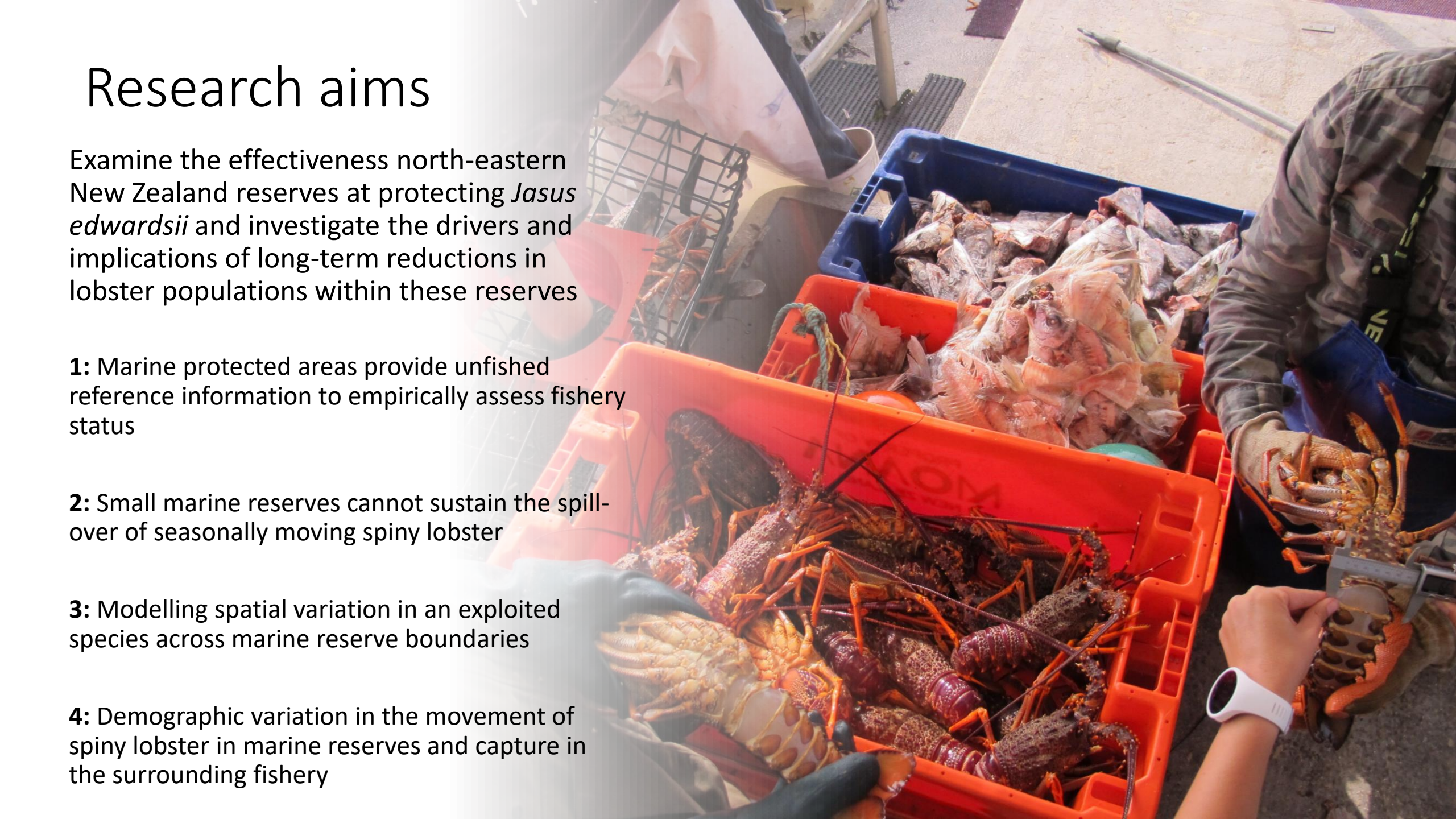
Examine the effectiveness north-eastern New Zealand reserves at protecting *Jasus edwardsii* and investigate the drivers and implications of long-term reductions in lobster populations within these reserves

1: Marine protected areas provide unfished reference information to empirically assess fishery status

2: Small marine reserves cannot sustain the spill-over of seasonally moving spiny lobster

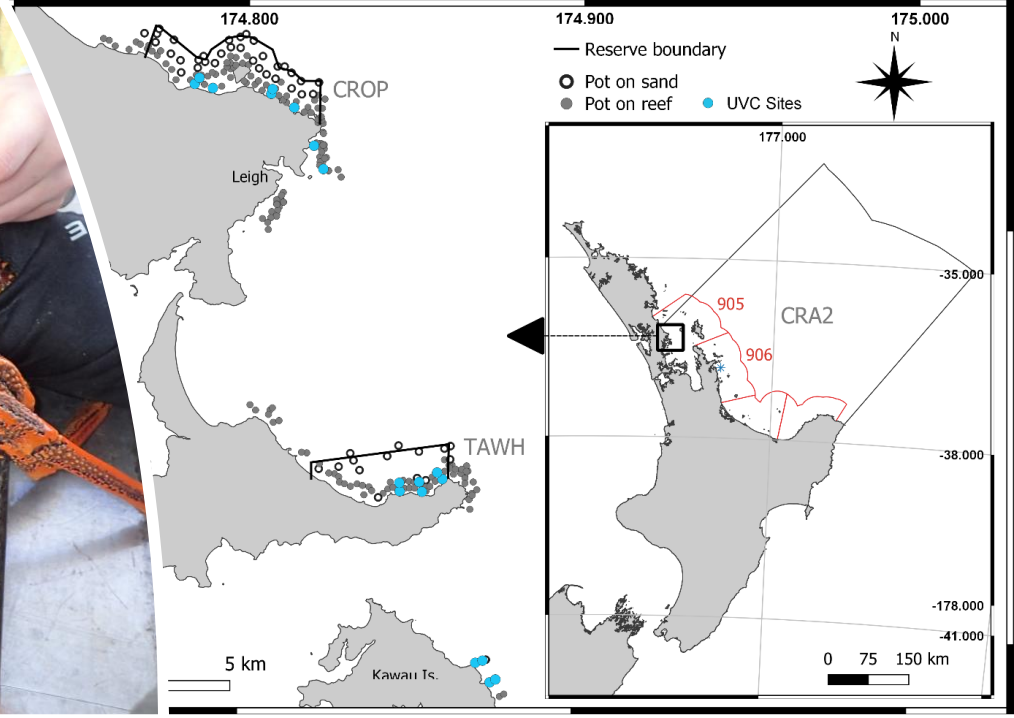
3: Modelling spatial variation in an exploited species across marine reserve boundaries

4: Demographic variation in the movement of spiny lobster in marine reserves and capture in the surrounding fishery



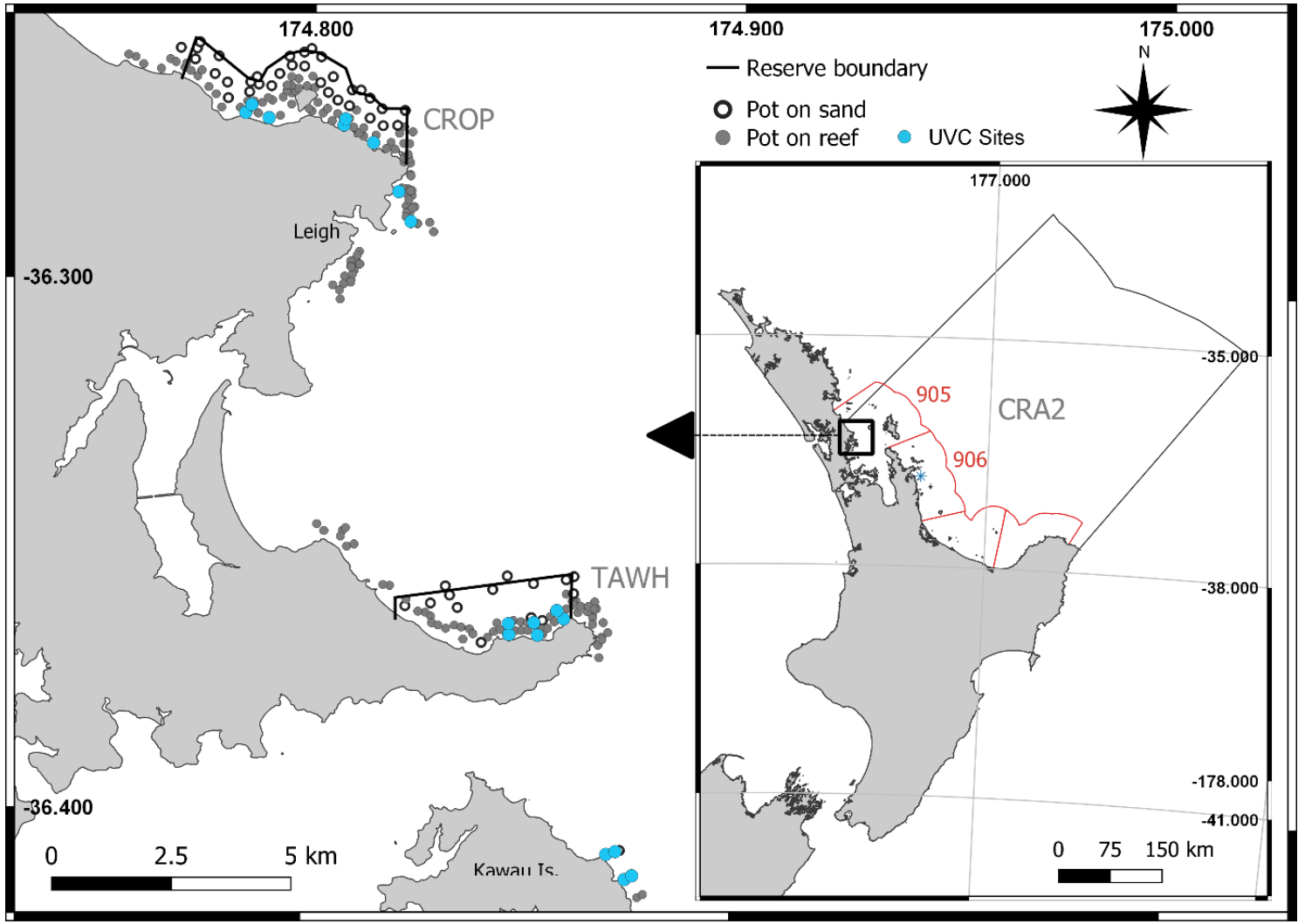
Data: Potting Surveys

- Commercial potting gear used to produce fisheries relevant CPUE data
- Non-reserve potting stations representative of local fishery
- Range of measurements - carapace length, tail width weight
- Spatially explicit data
- Surveys over two years (2018 and 2019)
- Potting with commercial fisher biannually in Autumn and Spring , Winter in only 2019



Data: Diver surveys (UVC)

- Sites inside and outside three reserves
- Diver surveys (50 x 10 m transects) on shallow reef <10 m and 10-20 m
  - Late autumn/early winter
  - Record size and sex
  - “Full” size distribution
    - i.e. not influenced by catchability



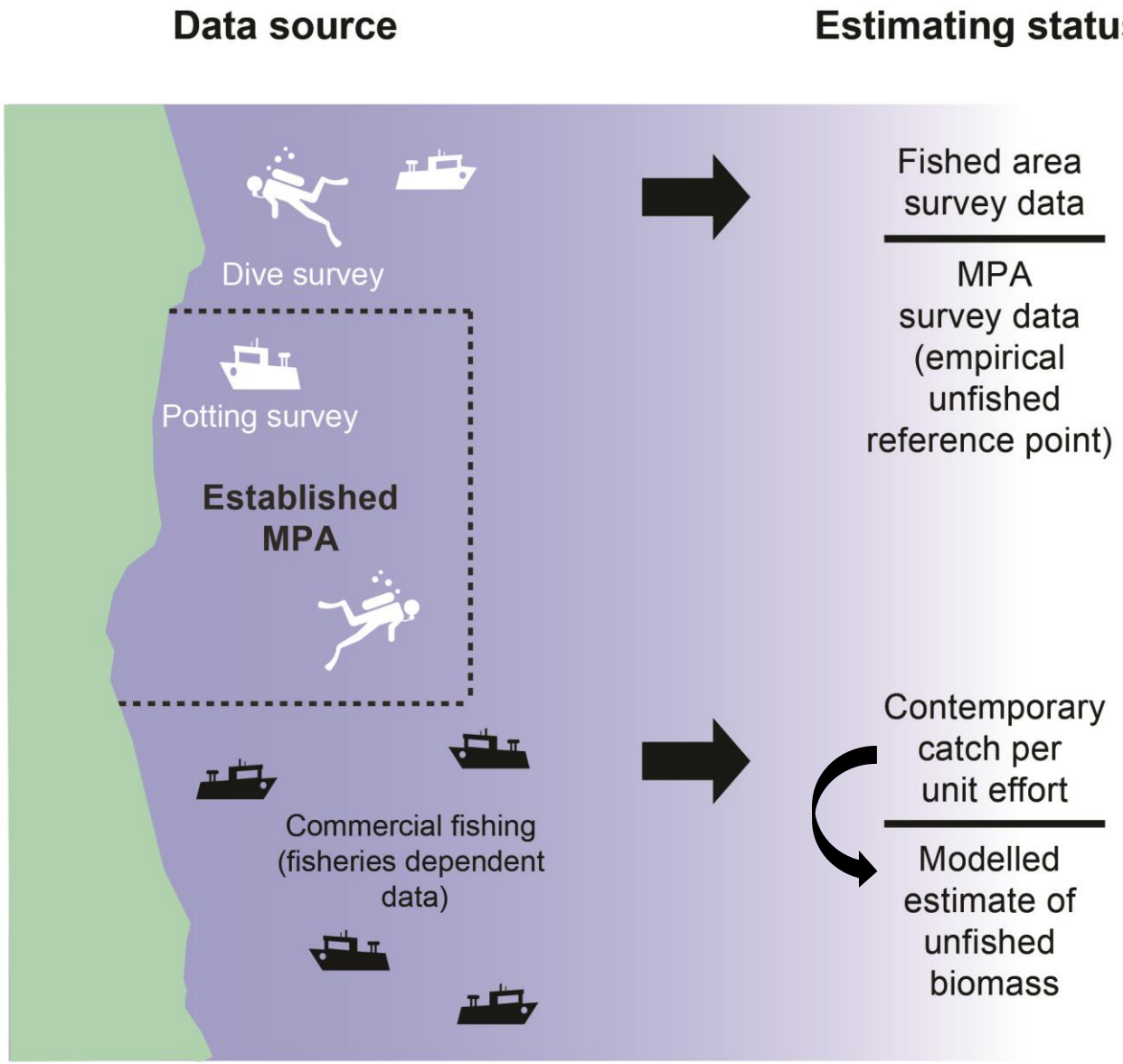
MARINE PROTECTED AREAS PROVIDE UNFISHED REFERENCE INFORMATION TO EMPIRICALLY ASSESS FISHERY STATUS

Fisheries stock assessments reliant on modelled estimates of unfished biomass due to paucity of data prior to industrialised fishing.

Using data from reserves for proxy estimates of unfished catch rates and biomass, this study assesses the status of the fished population.

MPAs provide an 'unfished' population under current conditions	Potting allows collection of fisheries relevant data from reserves	Comparison with survey data types - is CPUE proportional to biomass?

Results compared against performance measures used in New Zealand fishery stock assessments and findings reported in the most recent stock assessment for the north-eastern New Zealand lobster fishery.



Hanns and Shears (2022) Marine protected areas provide unfished reference information to empirically assess fishery status. *Biological Conservation* https://doi.org/10.1016/j.biocon.2022.109775

Data analysis:

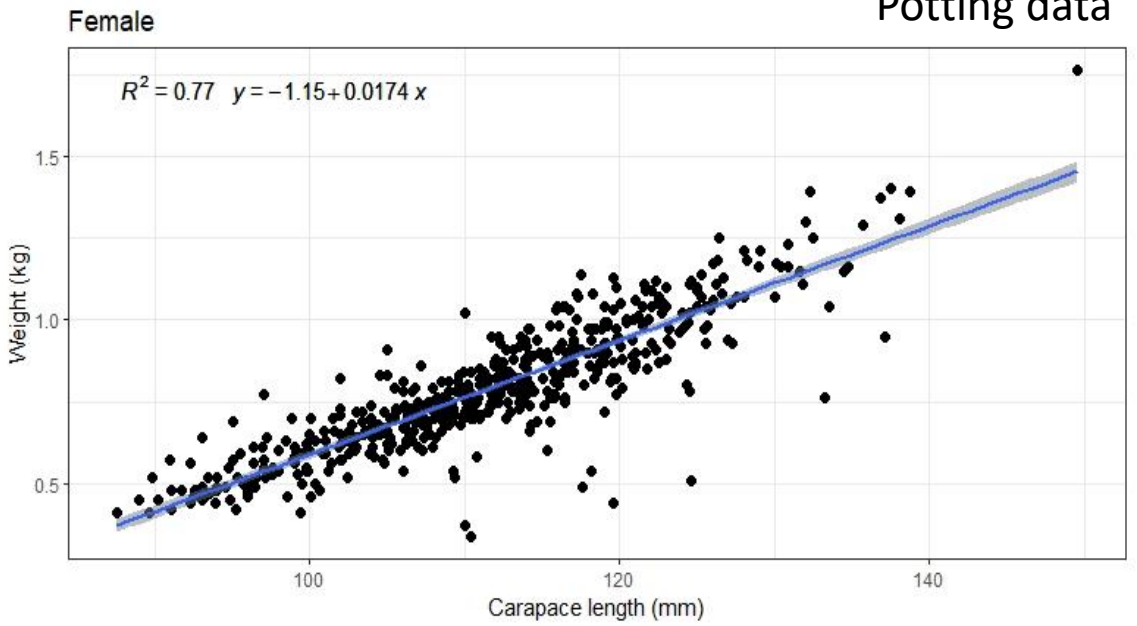
- **CPUE data – weight (kg) / pot**
- Data analysed as “total”, “vulnerable”, and “*SSB”*
- CPUE estimates generated using Bayesian inference with a hurdle mixed model fitted to a gamma distribution in *brms*

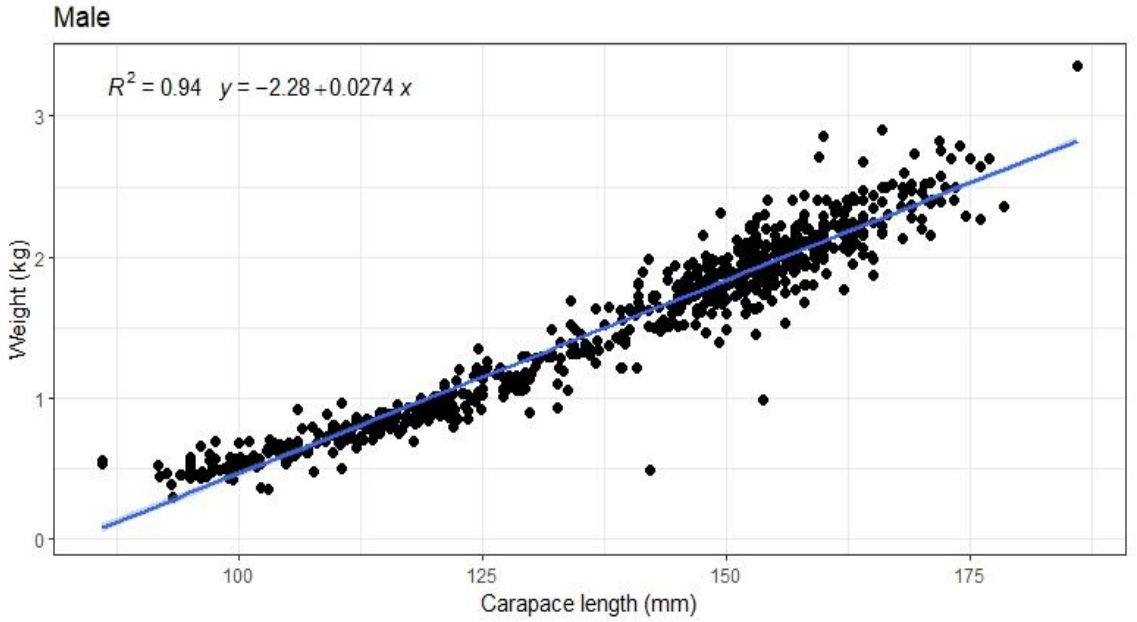
```
CPUE ~ Season+Year+(1|Station)

hu ~ Status
```

- **Biomass per 500 m^2**
- Data analysed “total”, “vulnerable”, and “*SSB”*
- Biomass estimates generated using Bayesian inference with a hurdle mixed model fitted to a gamma distribution in *brms*

```
Biomass ~ Status+Year+(1|Site)

hu ~ Status
```

Potting data



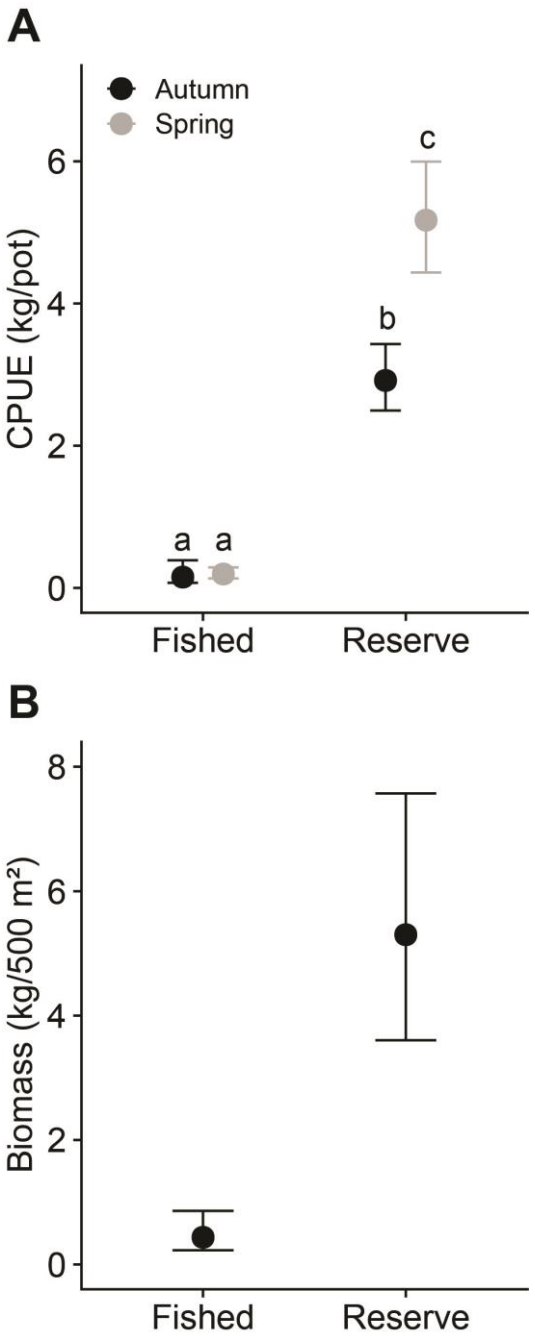


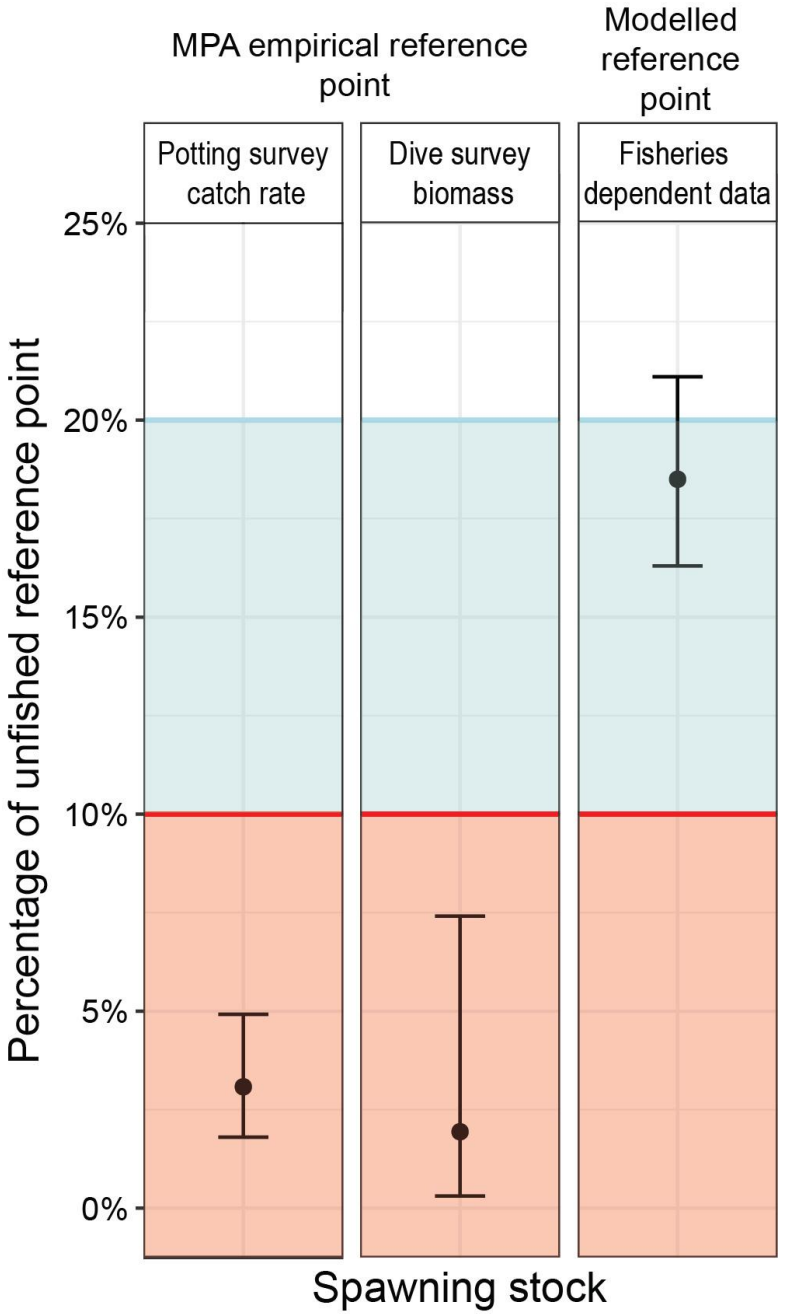
Results

- Both metrics much higher in reserves than fished areas
- Potting and dive survey estimates comparable - validates use of dive survey data to estimate stock status
- Using reserve reference point **fished area *SSB* 3% and 2% of unfished levels**
- Below stock assessment estimate and below hard (10 %) limit
- Conservative?

Overall:

- Demonstrates simplicity of estimating stock status using marine reserve reference information
- Provide information on important metrics of population or stock composition
- Utility of marine reserves beyond conservation within boundaries





SMALL MARINE RESERVES CANNOT SUSTAIN SPILL-OVER

1990s: seasonal offshore movements supported a spill-over fishery

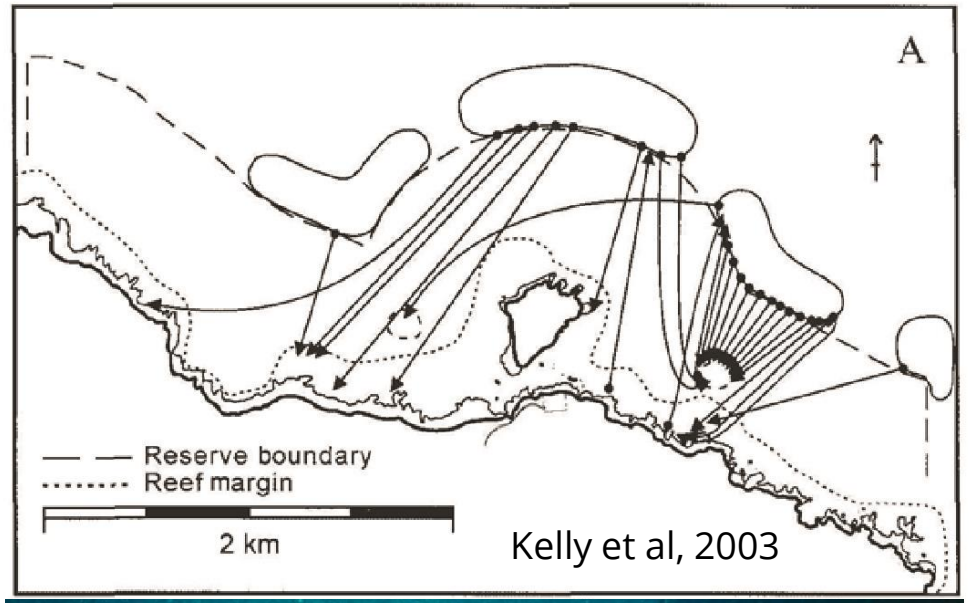
Thought to be density independent feeding movements following the energetic demanding ecdysis and mating periods

During this period large aggregations were observed offshore of reef habitat

Kelly and MacDiarmid (2003) warned sustained and targeted harvest of lobster seasonally moving offshore could reduce population size and rates of growth

Questions: Do seasonal offshore movements still occur and how do they vary with sex and size?

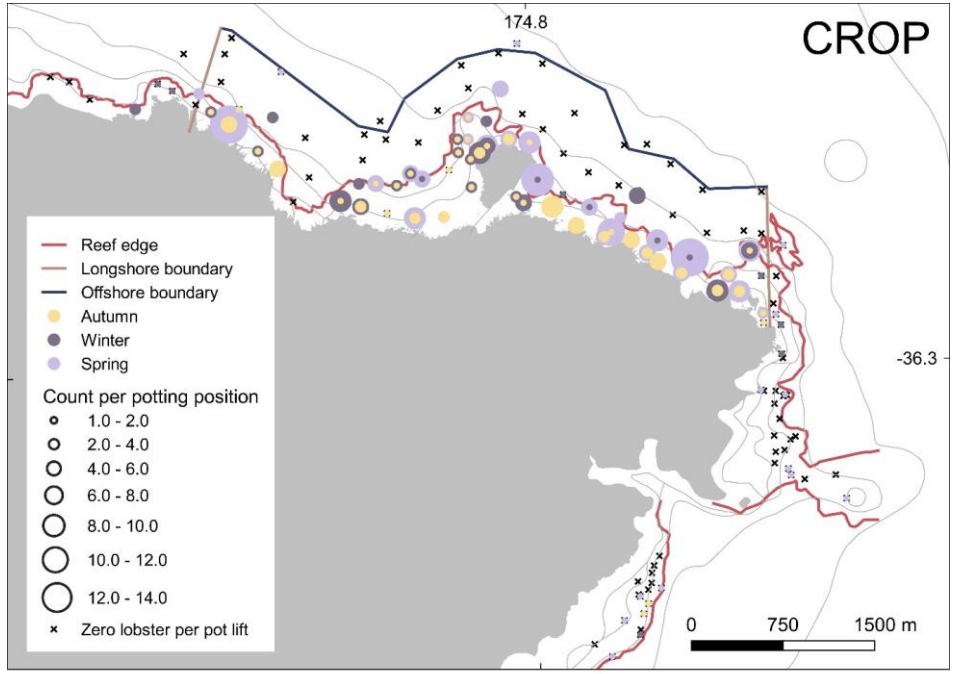
How do contemporary distributions compare with historic (1990s) distributions?

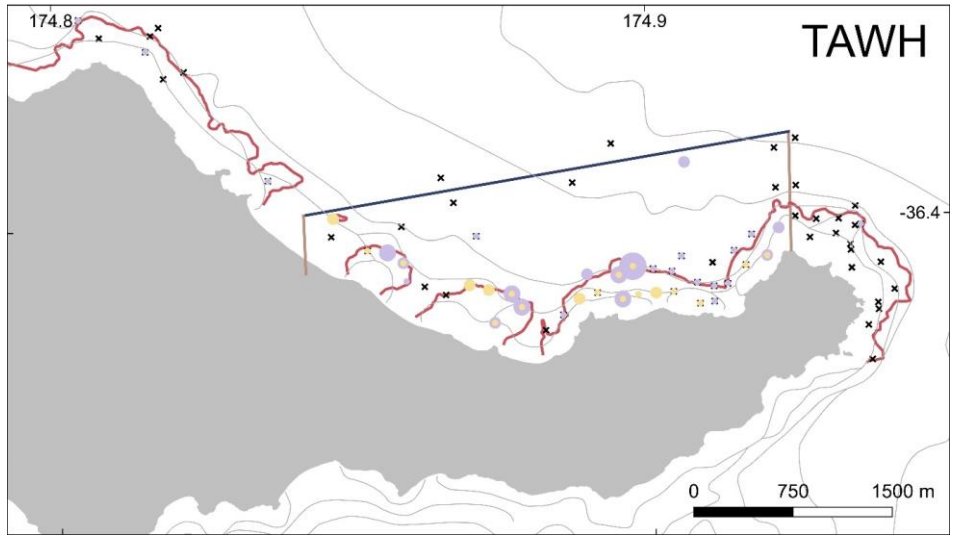


Kelly et al, 2003

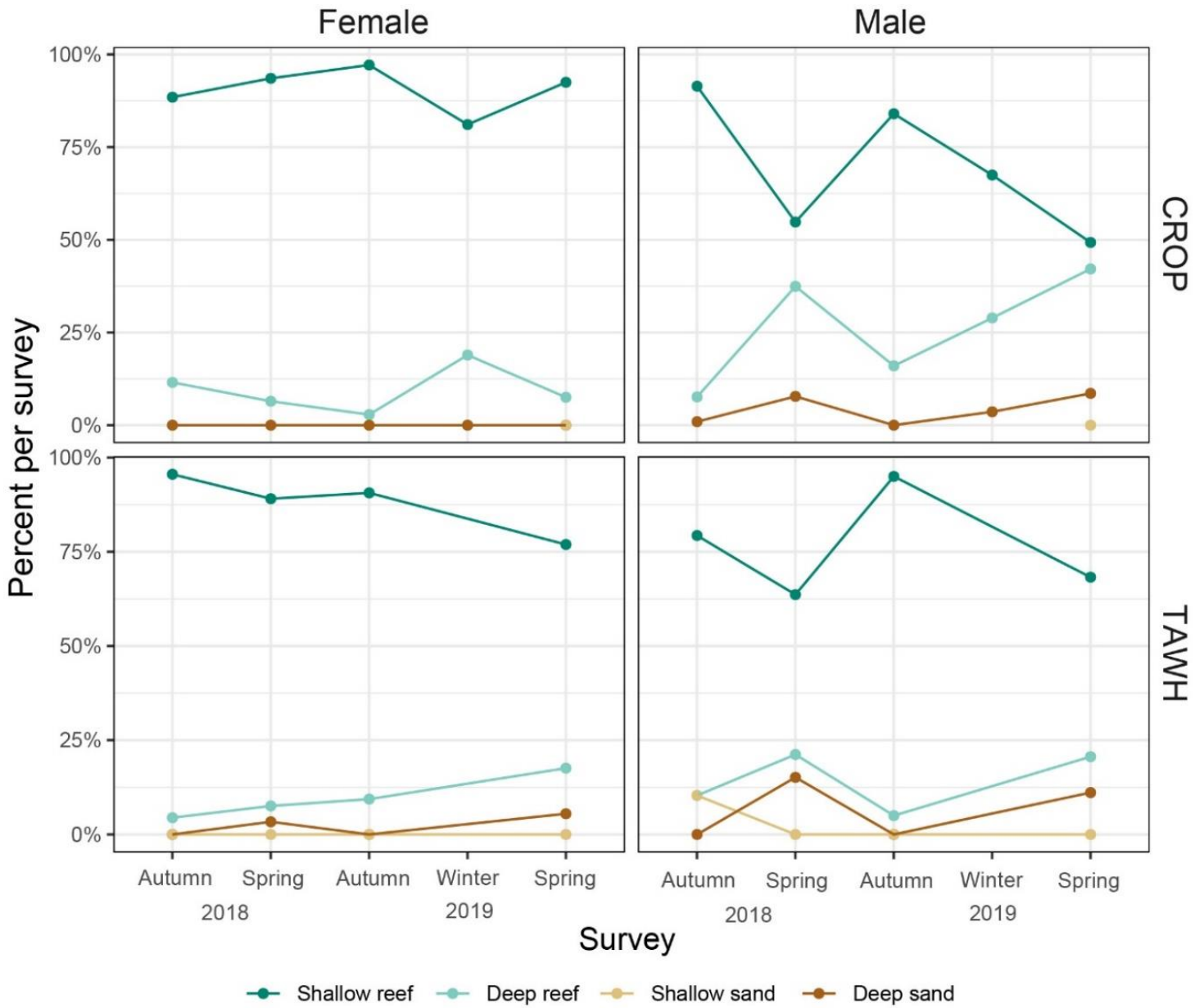

Kelly et al, 1999

SMALL MARINE RESERVES CANNOT SUSTAIN SPILL-OVER

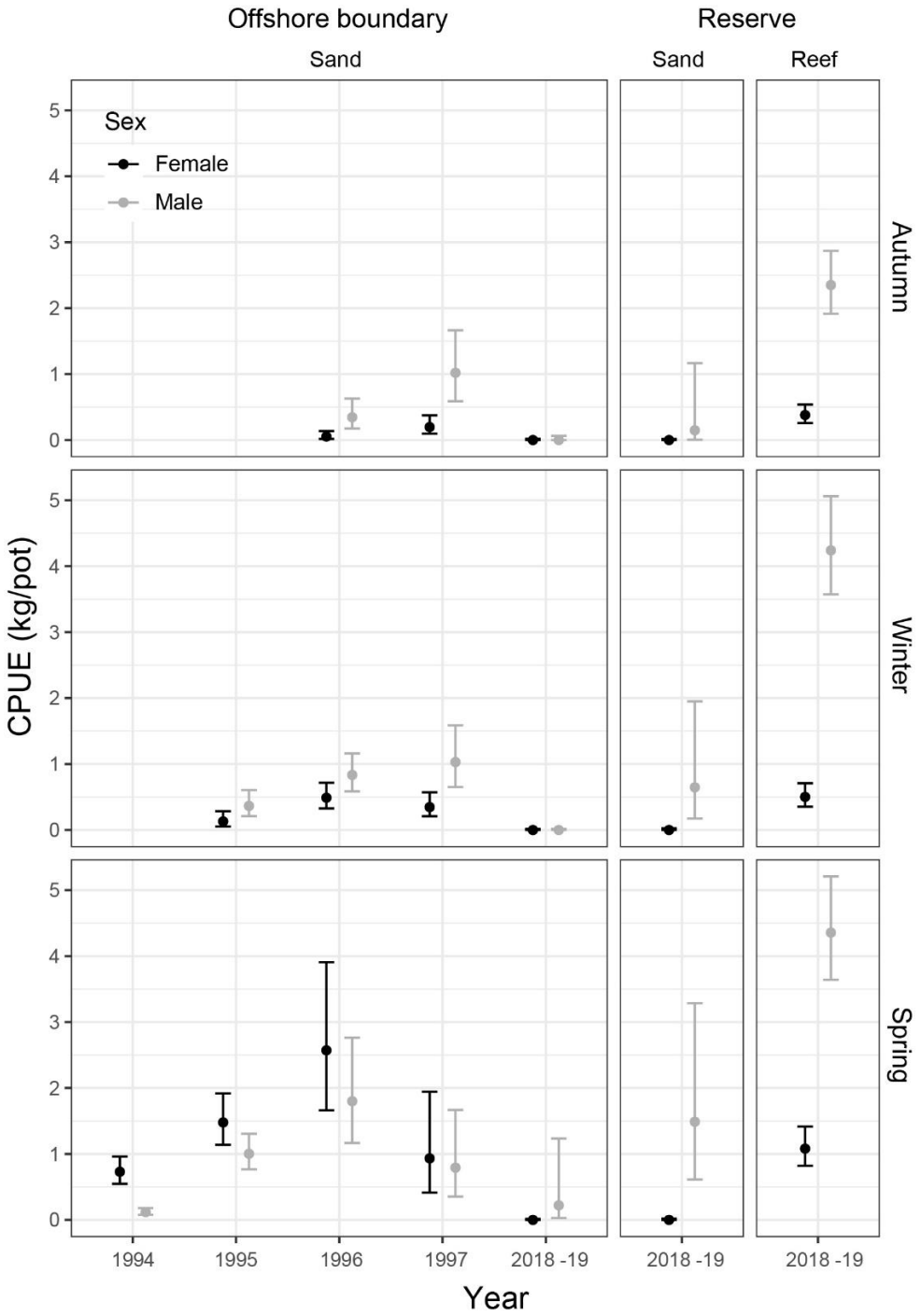


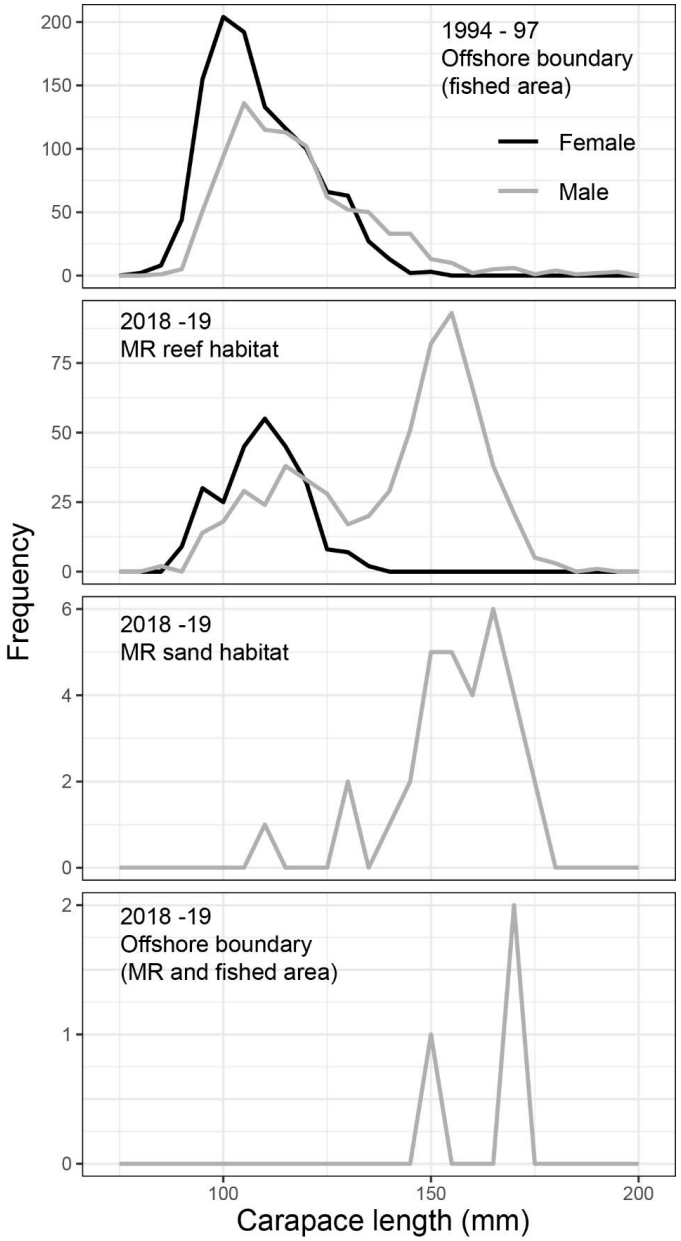


Results: Potting survey catch distribution



Results: Comparison with historical catch data



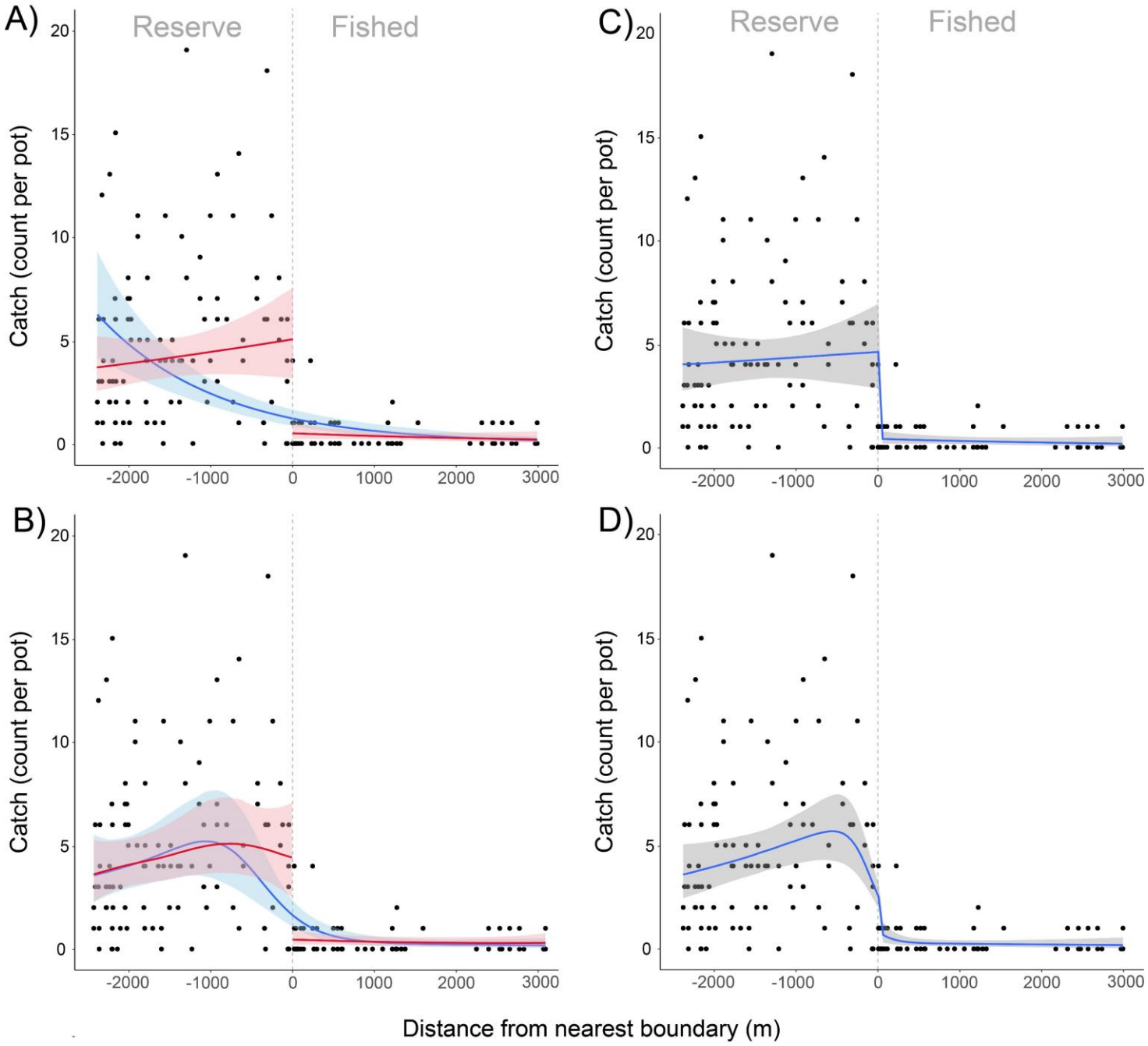


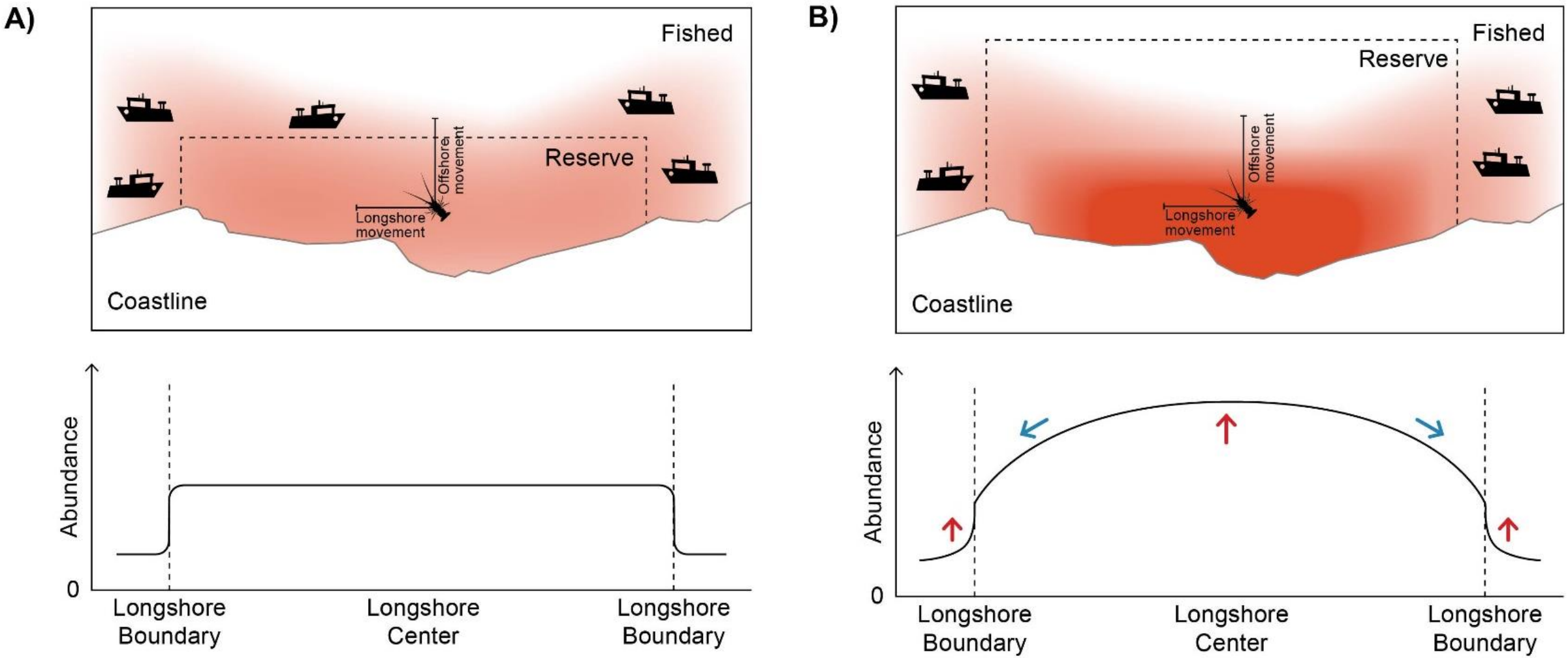
Conclusions

- Following population declines:
  1. Composition of lobster moving offshore of reef habitat has changed
  2. Frequency and abundance of lobster moving offshore has reduced
  3. Distances travelled from the reef edge have declined.
- Seasonal offshore movements are now unlikely to support the spill-over
- Density-dependent mechanisms have impacted aspects of density-independent movements through changes to beneficial intraspecific interactions
  - Defensive aggregations
  - Aggregation formation hindered by Allee effects?

MODELLING SPATIAL VARIATION IN EXPLOITED SPECIES ACROSS MARINE RESERVE BOUNDARIES

- Several modelling approaches applied
- Edge-effects and spill-over varied between approaches
- Limited evidence of edge-effects or spill-over
- Reflect efficacy issues associated with historical offshore harvest?



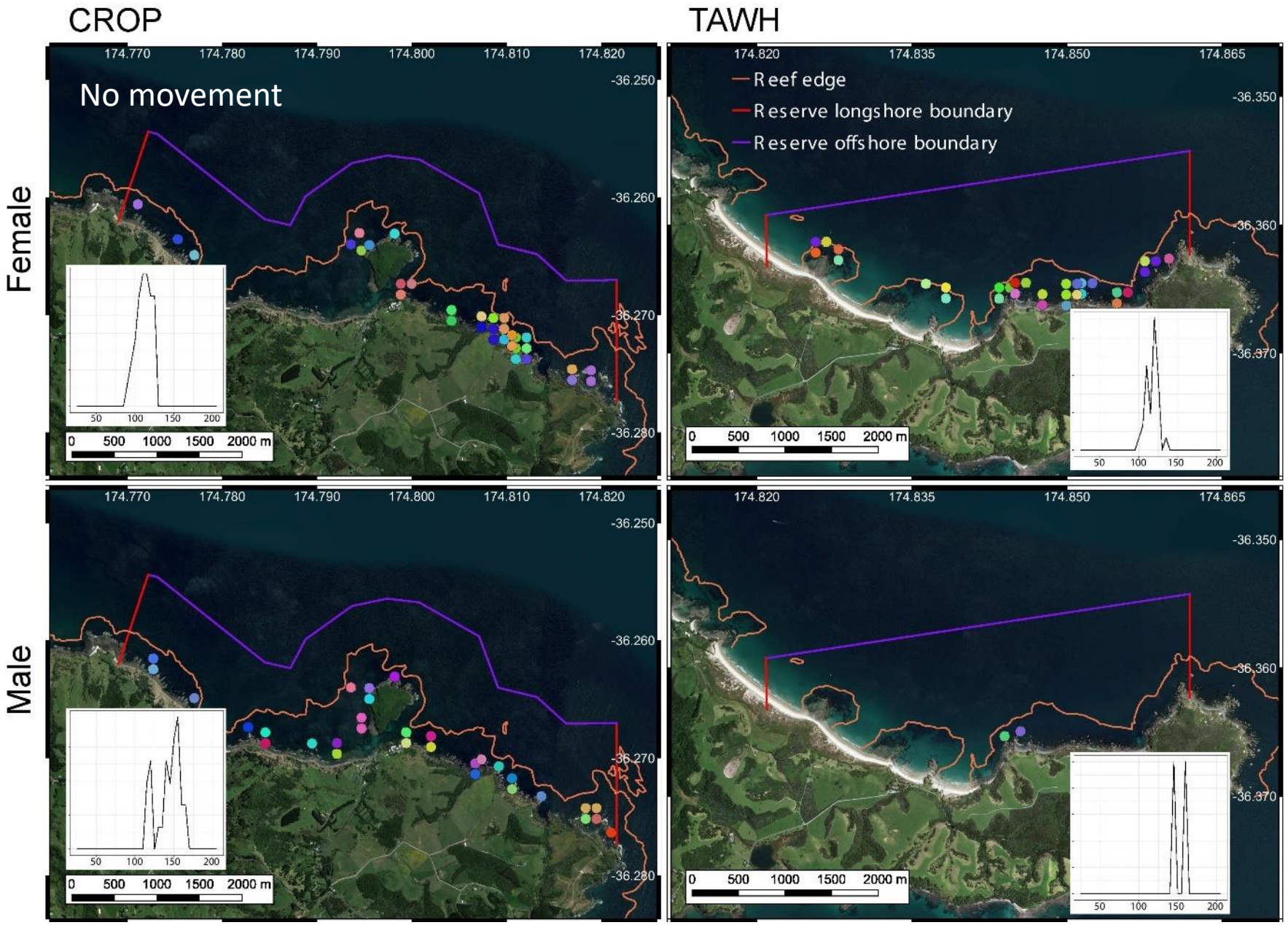

A)
Fished
Reserve
Offshore movement
Longshore movement
Coastline
Abundance
0
Longshore Boundary
Longshore Center
Longshore Boundary
B)
Fished
Reserve
Offshore movement
Longshore movement
Coastline
Abundance
0
Longshore Boundary
Longshore Center
Longshore Boundary

DEMOGRAPHIC VARIATION IN THE MOVEMENT OF SPINY LOBSTER IN MARINE RESERVES AND CAPTURE IN THE SURROUNDING FISHERY

- What lobster are now entering the fishery from these marine reserves
- Due to boundary fishing, mechanisms driving movements out of reserves can influence the structure of protected populations.
- Using tag-recapture information this study investigated relationships between sex, size, movement and capture in the fishery.

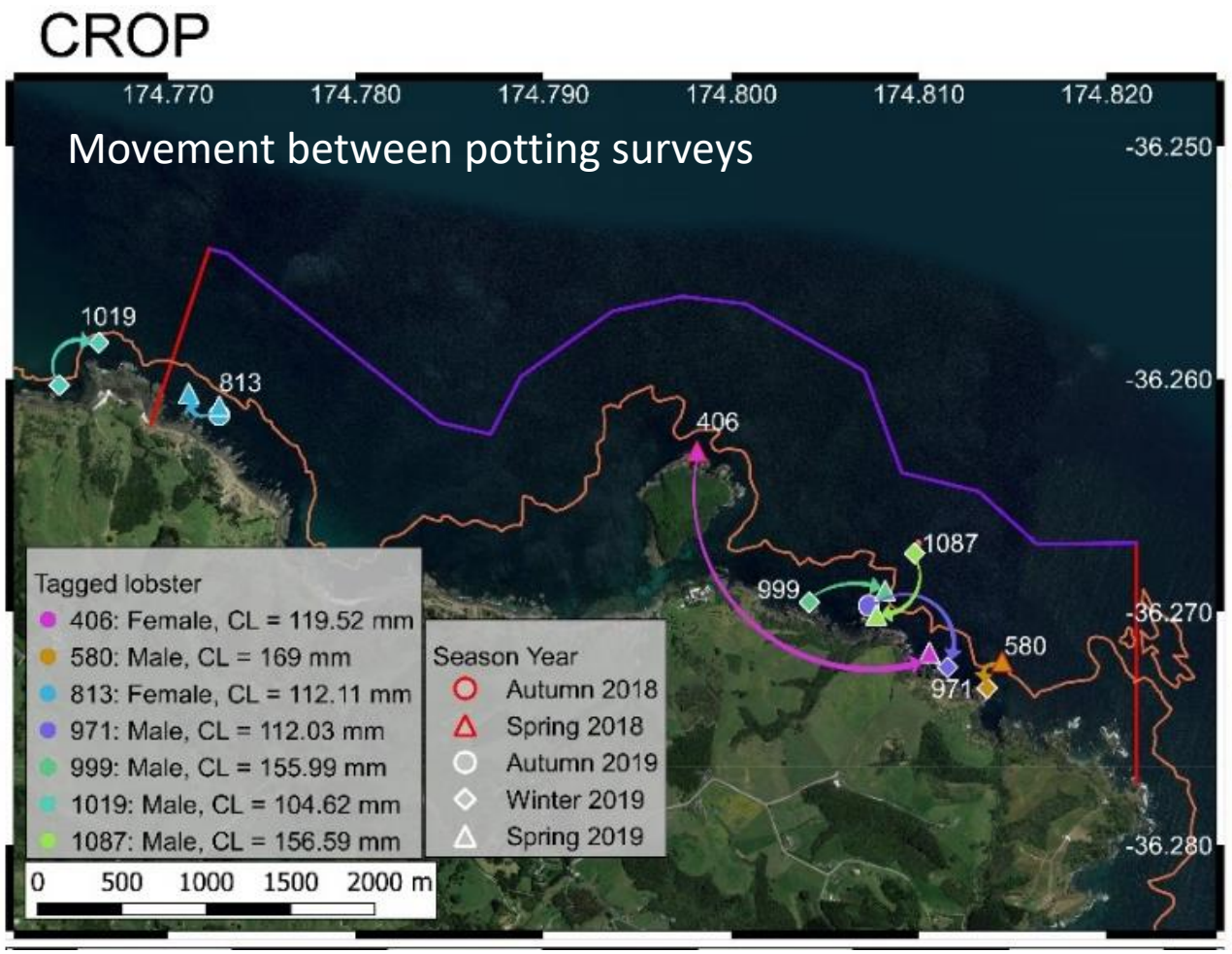
Recaptures

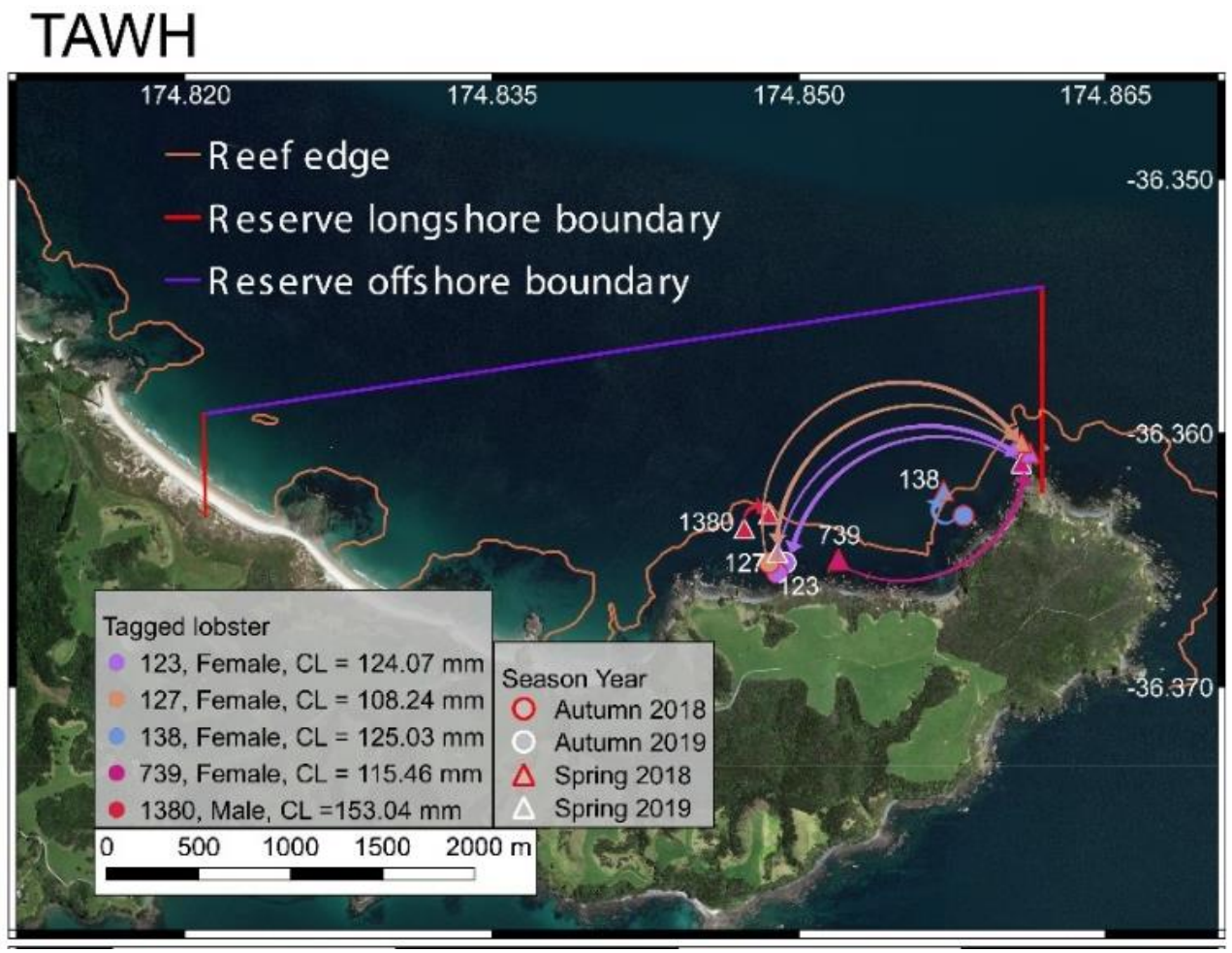
- 1386 lobster (862 male, 525 female) were tagged during potting surveys
- 198 lobster re-caught (~14%)
- 60.6% retained tags
- 18 re-caught at least twice
- 112 re-caught during potting surveys
- 97 (86.6%) were re-caught at the location of original tagging



Recaptures during potting surveys

- Two female lobster (123 and 127) undertook large longshore movements in TAWH
- Both tagged near the TAWH's center in autumn 2018, re-caught near the eastern boundary in spring 2018 and re-caught again at position of initial tagging at reserve center
- Movement associated with egg release?

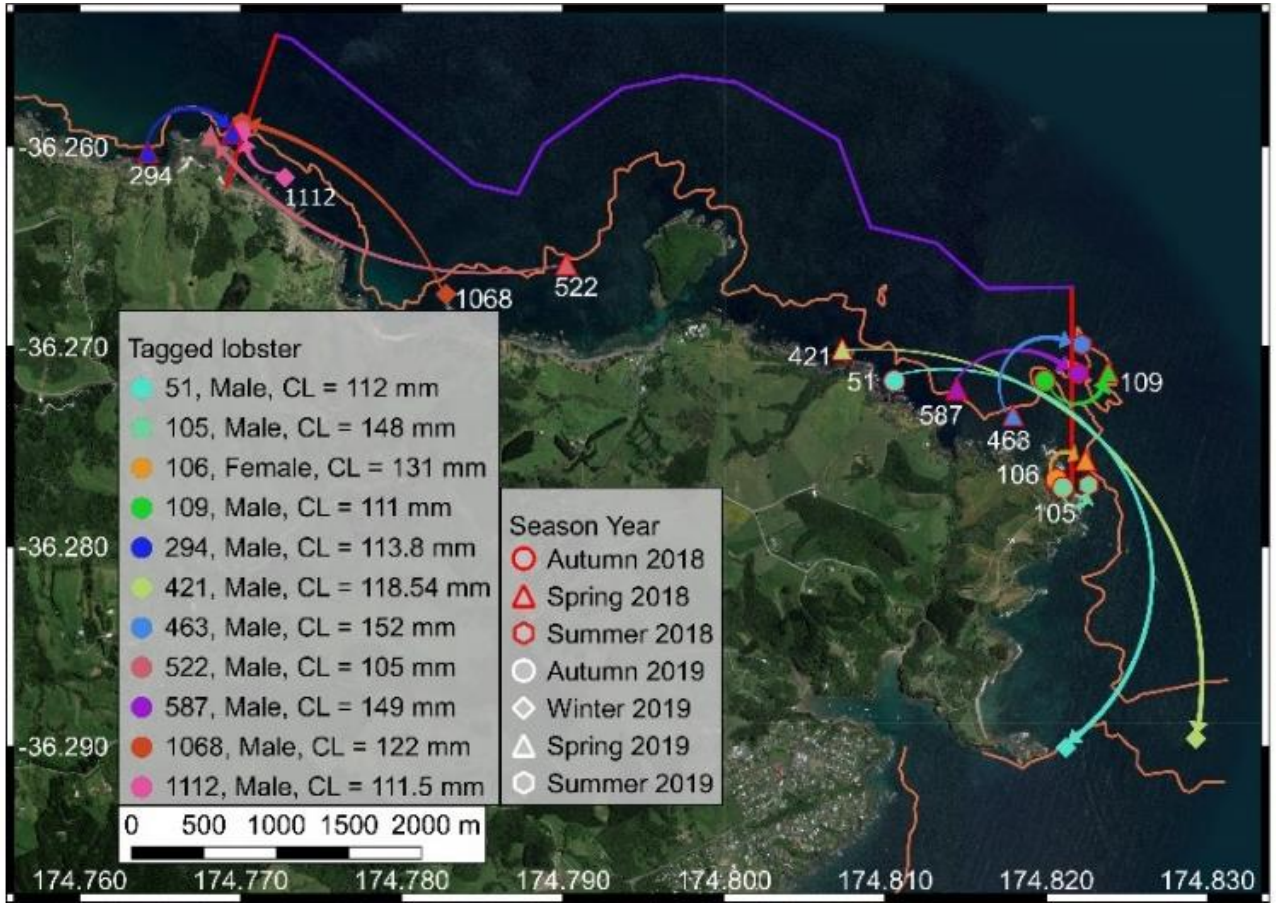


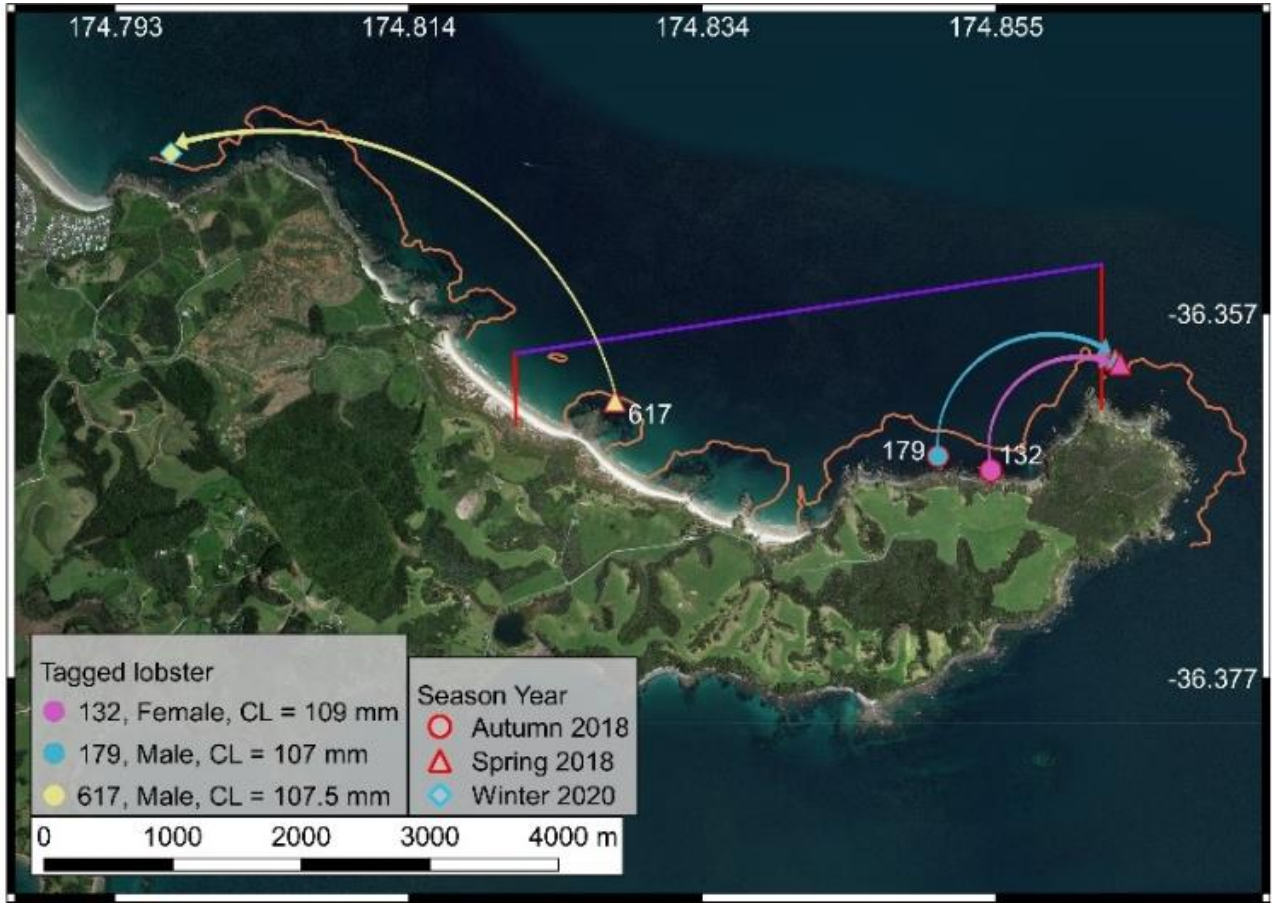


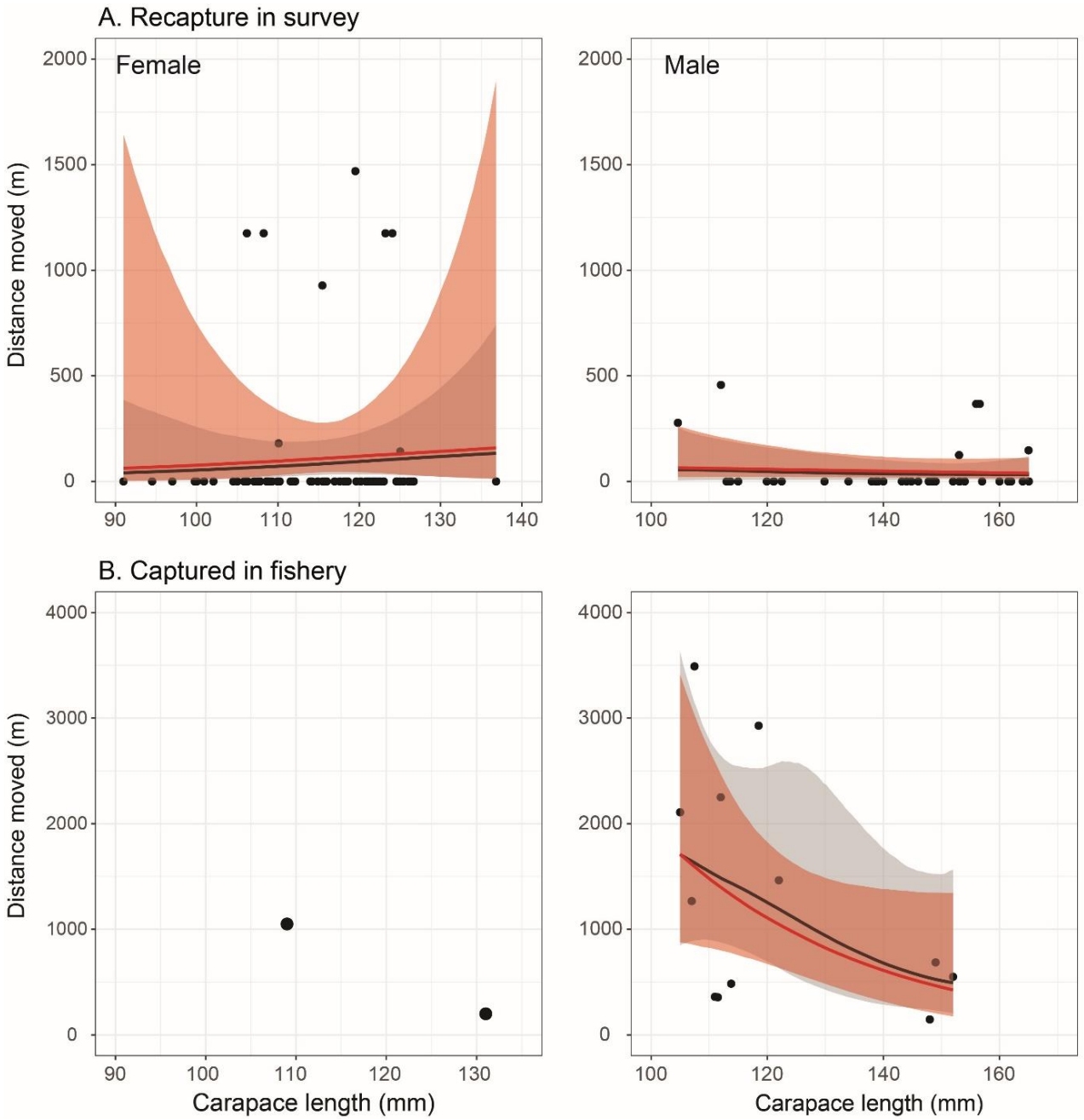
Re-caught in fishery

- Commercial potting and recreational diving

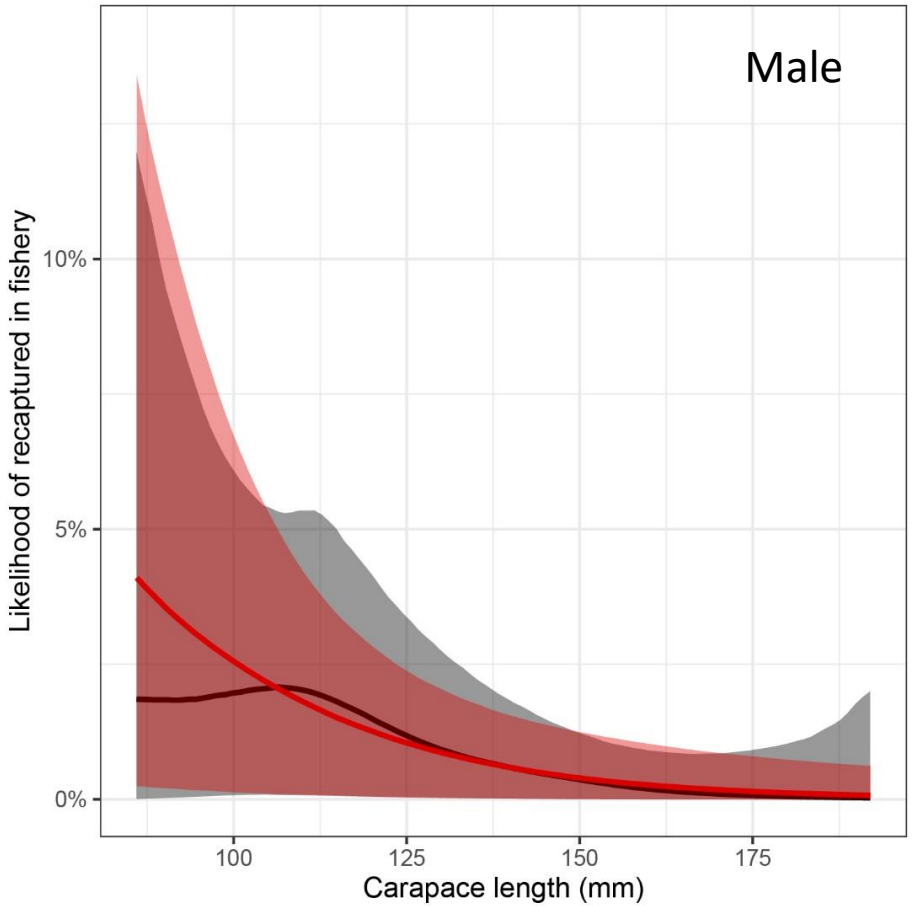
- 14 (1.1%) caught in the adjacent fishery (2 female, 12 male)
- The largest movements by ‘young’ adult males (CL’s 105 – 120 mm)
  - No clear direction or relationship with season
  - ‘Nomadic’
- Female TAWH movement may be associated with egg release activity





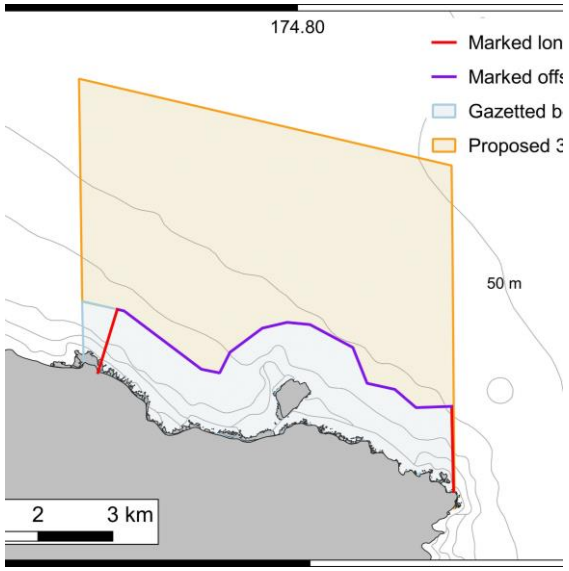


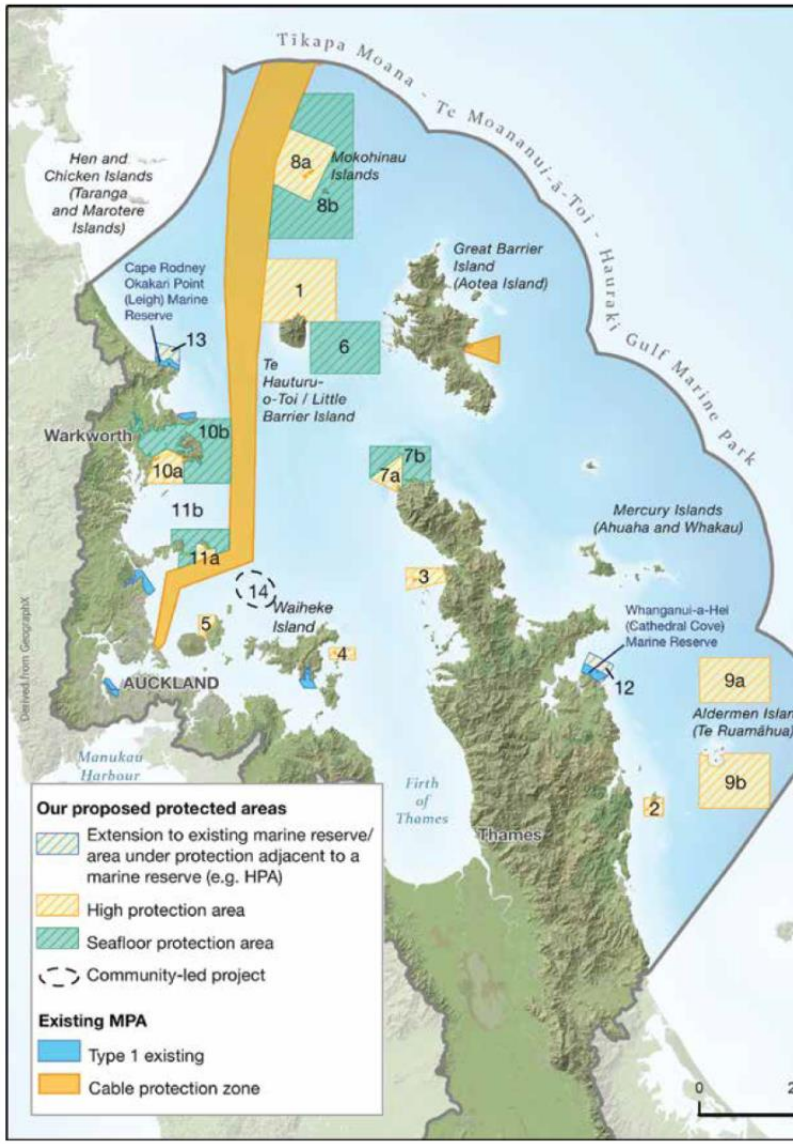
- Negative relationship between size and distance moved in male fishery caught recaptures and likelihood of capture in fishery
- Movements beyond boundaries differs between sexes and across ontogenies.
- Greater protection afforded to large males which maintain long-term site affiliations.
- Young adult male lobster more likely caught in the fishery due to large, long-shore nomadic movements.



Overall Conclusions

- Research highlights the poor state of the wider fishery and
- Suggests that while the reserves examined play a role in protecting lobster, they are too small to fully protect lobster populations.
- Show how fishing impacts on protected populations not only vary in space and time but will change as the protected population's density changes.
- Results and methods developed provide important information that can inform both future marine reserve design and fisheries management.





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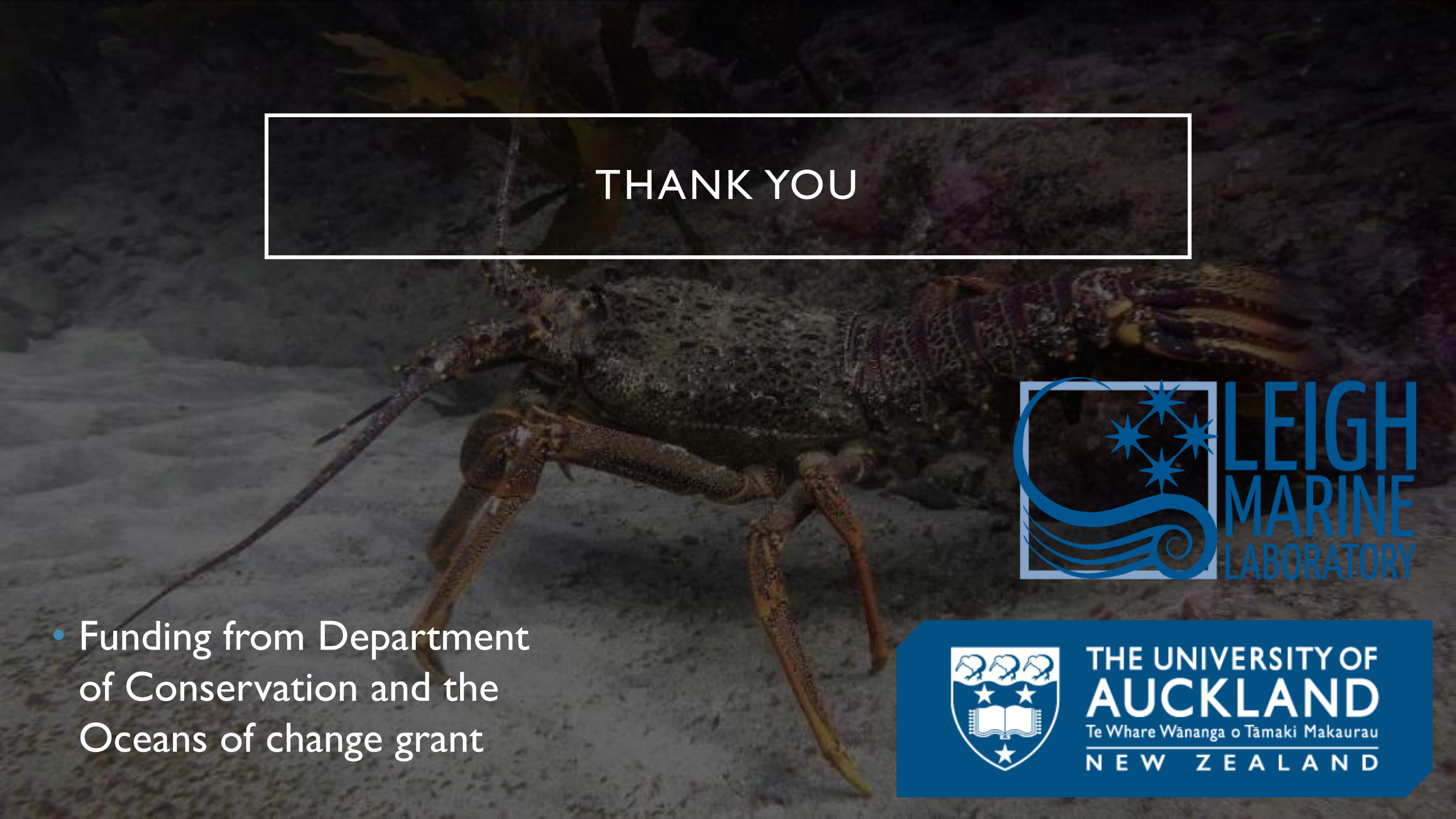

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