

# Improving the estimation of population risk to Hector's and Māui dolphins using carcass data, focusing on toxoplasmosis

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Hector's and Māui dolphin North Island Forum, 27 Oct 2022

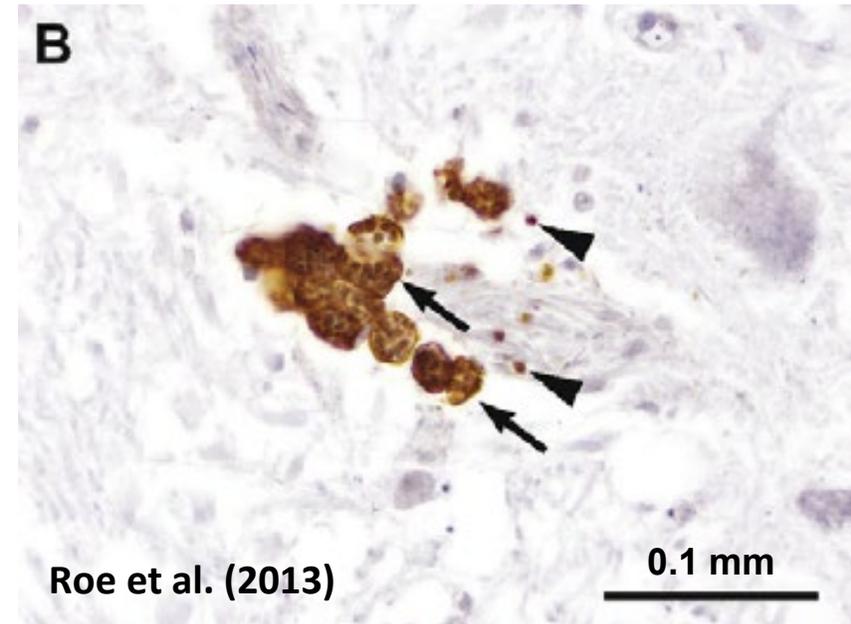
# This project

- DOC-funded desk-based review, completed June 2022
- Specific research objectives:
  - 1) Review factors that might bias estimation of population risk to Hector's and Māui dolphins from toxoplasmosis and other causes of death when using data from necropsies of beachcast dolphins.
  - 2) Indicate probable direction and magnitude of identified potential biases (from 1) for estimating population risk.
  - 3) Guided by 1 & 2, provide recommendations as to how efforts to increase carcass detection rates might best be designed to:
    - a) increase precision of population risk estimates from toxoplasmosis; and
    - b) minimise or account for potential biasing factors for estimating population risk.

# Background

- Roe et al. (2013) first identified potential threat of toxoplasmosis to Hector's and Māui dolphins
- Disease caused by unicellular parasite *Toxoplasma gondii*, for which domestic cat is the only definitive host in New Zealand; capable of infecting all birds & mammals (reviewed for NZ wildlife by Roberts et al. 2020).
- ~60% of Hector's and Maui dolphins found to be infected with *T. gondii* using PCR (greater chance of false negative than false positive), compared with 30–40% of humans in NZ (from serology).
- To date, 9 dolphins determined by formal necropsy to have died from toxoplasmosis, 8 of which were beachcast dolphins (found dead along coastline)

Tissue cysts and tachyzoites in brain of Hector's/Maui dolphin



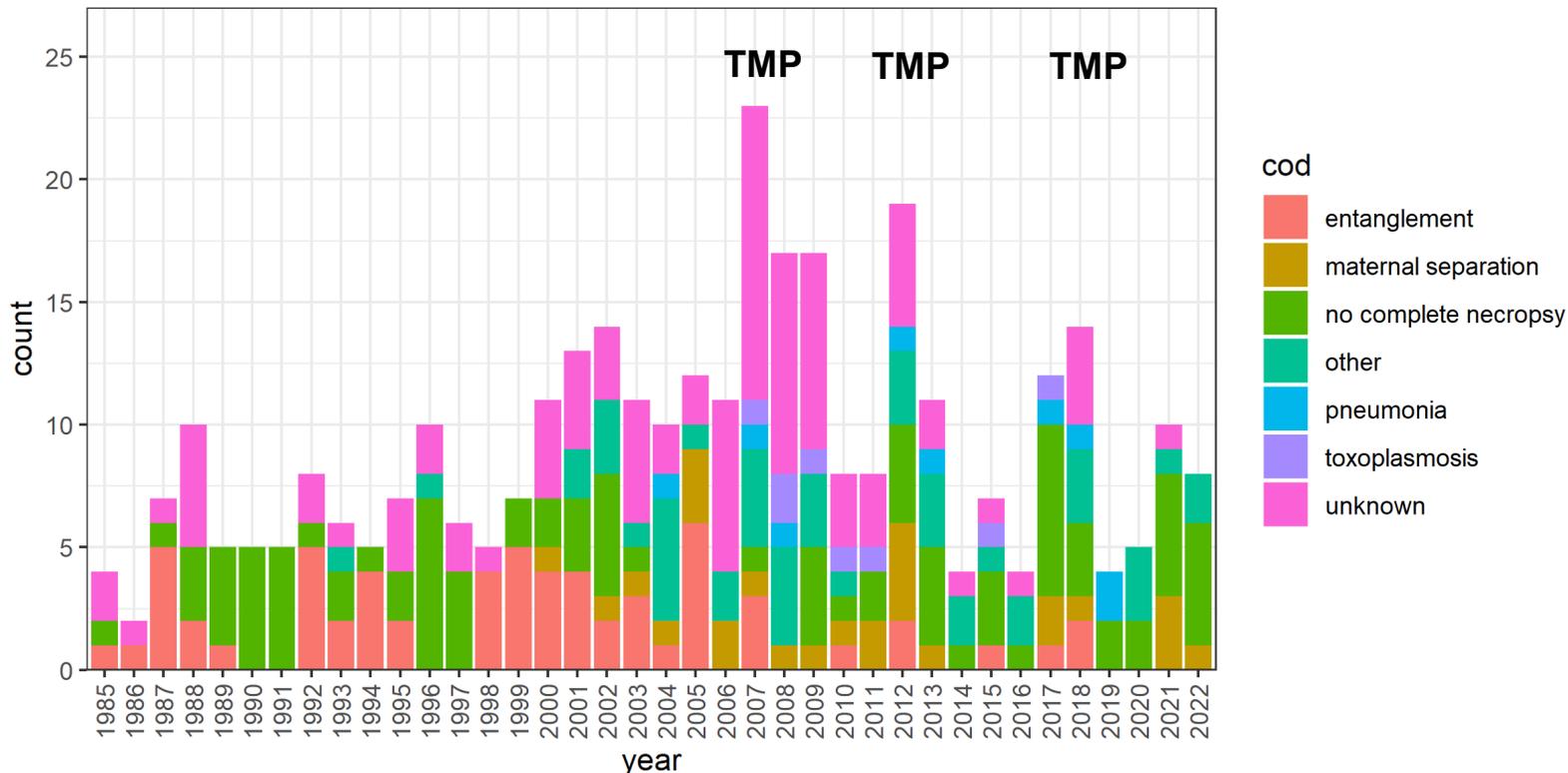
# Background

- Spatial risk assessment informing 2020 TMP for the species used necropsy sample for which primary cause of death attributed ( $N = 55$ ) to partition out non-fishery causes of death, including toxoplasmosis (Roberts et al. 2019)
- Small sample, potentially prone to multiple sources of bias
- Review of available information to identify sources of bias, specifically affecting the estimation of population risk, so also considering risk assessment approach
- Review does not consider necropsy methods
- Addresses following in draft Toxoplasmosis Science Plan 2022 (DOC, in prep.):
  - Research Theme “Importance of the risk of toxoplasmosis in Hector’s and Māui dolphins” and;
  - Priority Research “Improve understanding of the parasite in the dolphins through recovery of dead bodies for necropsy”

# Inter-annual patterns

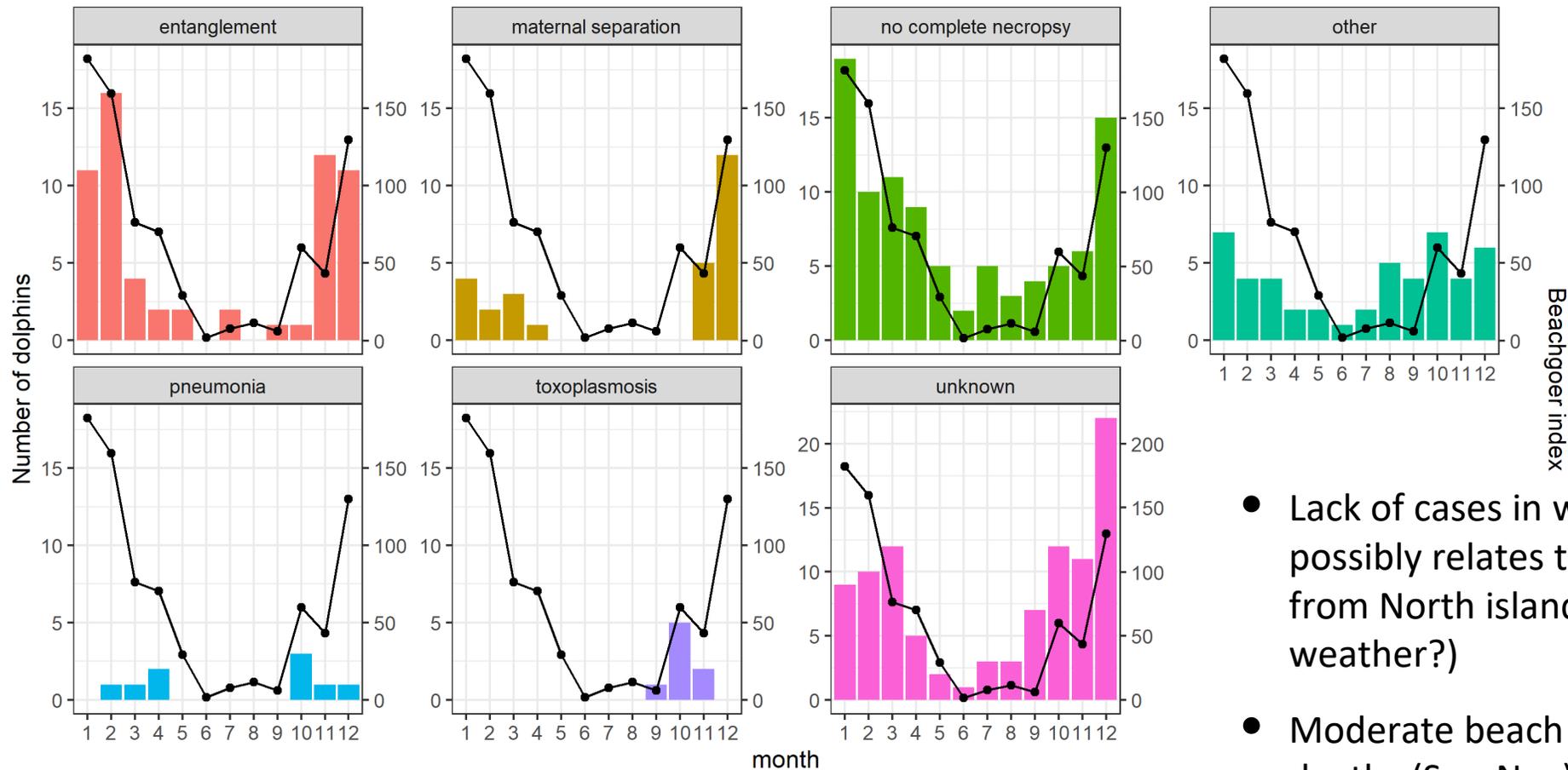
## using DOC incidents database (DOC 2022)

Beachcast dolphins, primarily reported by the public



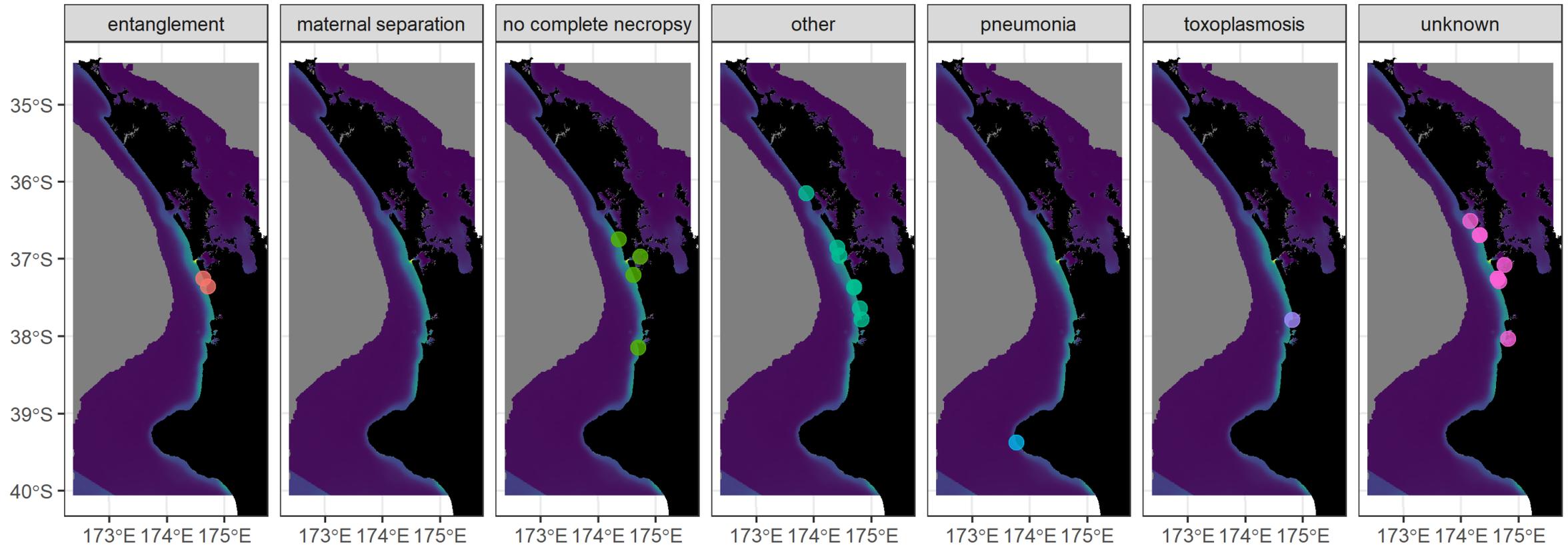
- Changes in number of beachcasts/rate of reporting through time?
- To date, all confirmed toxoplasmosis cases were from 2007 to 2017, although this was not assessed prior to 2002
- Longer time series with increased sampling rate needed to assess for long-term changes in causes of death (may change estimate of risk from toxo)
- More carcass detections during TMPs. Coincidence, or caused by elevated public status?

# Seasonal patterns in beachcast sample (since 1985)



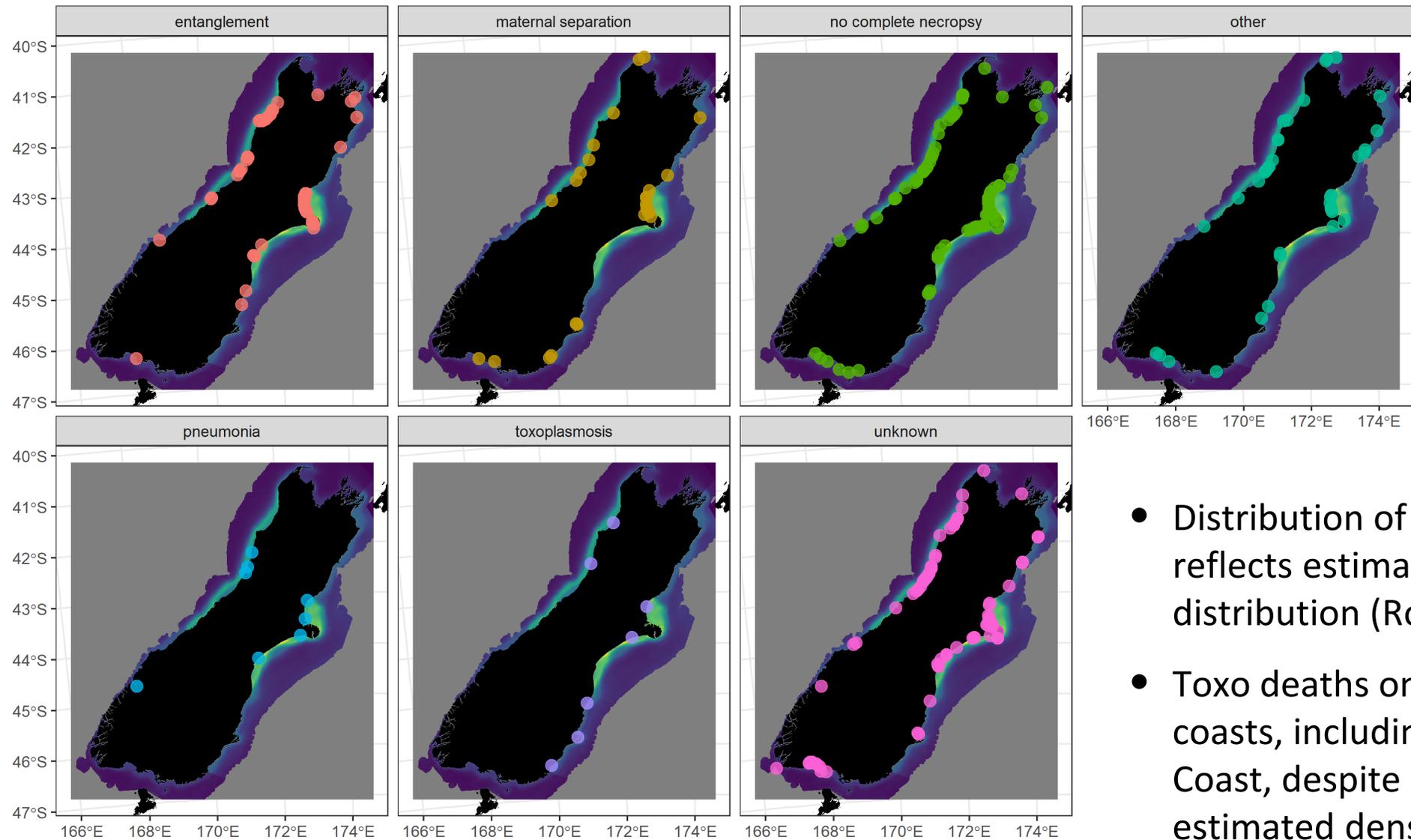
- Lack of cases in winter for any cause of death possibly relates to low beach use (black lines, from North island surveys) (also behaviour & weather?)
- Moderate beach use in period of all known toxo deaths (Sep-Nov)
- Toxo deaths may be under-represented if it kills dolphins in winter period
- Also see Roberts & Hendriks (2020)

# Spatial patterns in beachcast sample



- Distribution of beachcast dolphins reflects estimated at-sea distribution (Roberts et al. 2019)
- Note second toxo death of dolphin found at-sea (not beachcast), also near Raglan

# Spatial patterns in beachcast sample



- Distribution of beachcast dolphins reflects estimated at-sea distribution (Roberts et al. 2019)
- Toxo deaths on east and west coasts, including 3 along Otago Coast, despite relatively low estimated density there

# Spatial patterns in beachcast sample

QUANTITY	WCNI	NCSI	ECSI	SCSI	WCSI	REFERENCES
Population size*	65**	214	9728	332	5482	See Table 2 of Roberts et al. (2019)
Approximate annual deaths***	6.5	21.4	972.8	33.2	548.2	
Number of beachcast carcasses from 2007–2021:						DOC (2022)
all reported	11 (11.28%)	6 (1.87%)	76 (0.52%)	11 (2.21%)	59 (0.72%)	
subjected to formal necropsy	9 (9.23%)	5 (1.56%)	55 (0.38%)	10 (2.01%)	44 (0.54%)	
of which a primary cause of death could be identified	6 (6.15%)	3 (0.93%)	37 (0.25%)	5 (1.00%)	22 (0.27%)	
of which toxoplasmosis was identified as the primary cause of death	1 (1.03%)	0 (0.00%)	5 (0.03%)	0 (0.00%)	2 (0.02%)	

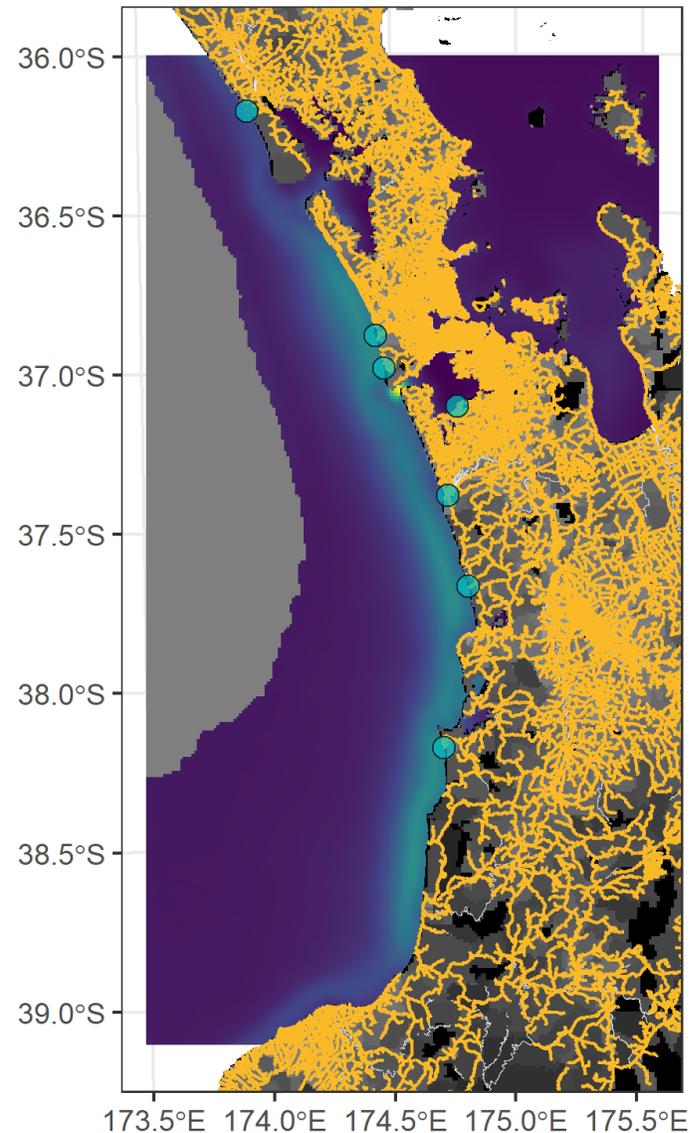
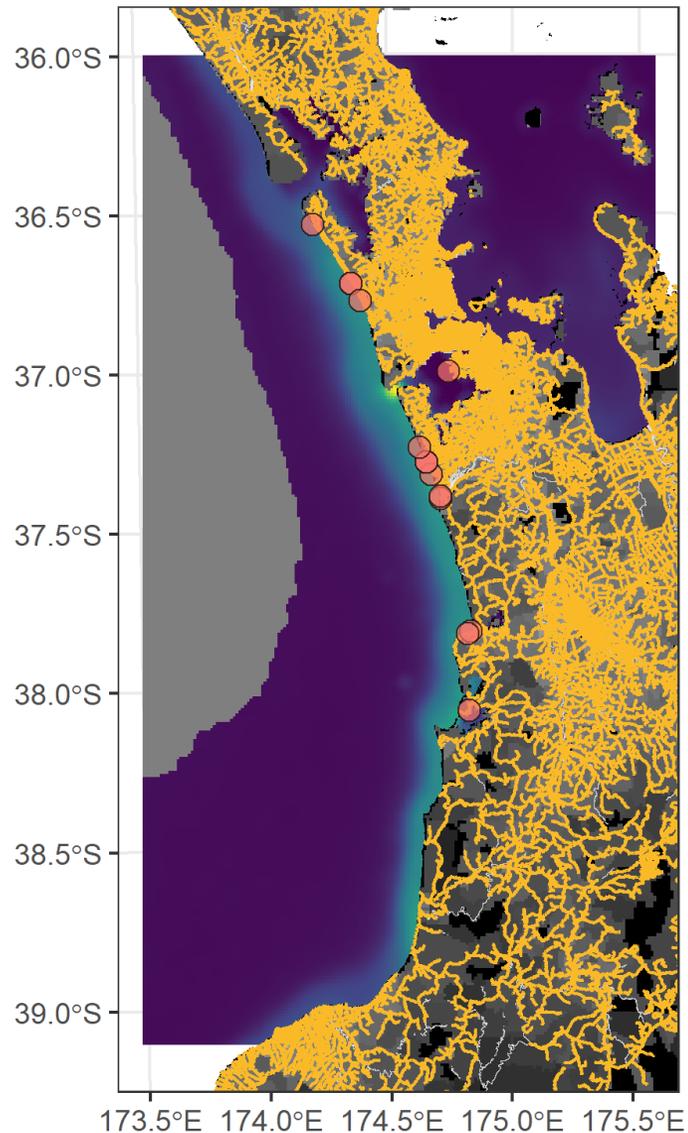
\*Values used for population size rescaling strata used by Roberts et al. (2019).

\*\*2015–2016 population estimate of Māui dolphin used (63 individuals), which was near the middle of the time series of beachcast dolphins used in this table. This includes two South Island Hector’s dolphin migrants identified from genetic analysis of biopsy samples (Constantine et al. 2021).

\*\*\*Calculated as the total population size multiplied by 0.1 (approximating the annual proportion of dolphins dying each year)

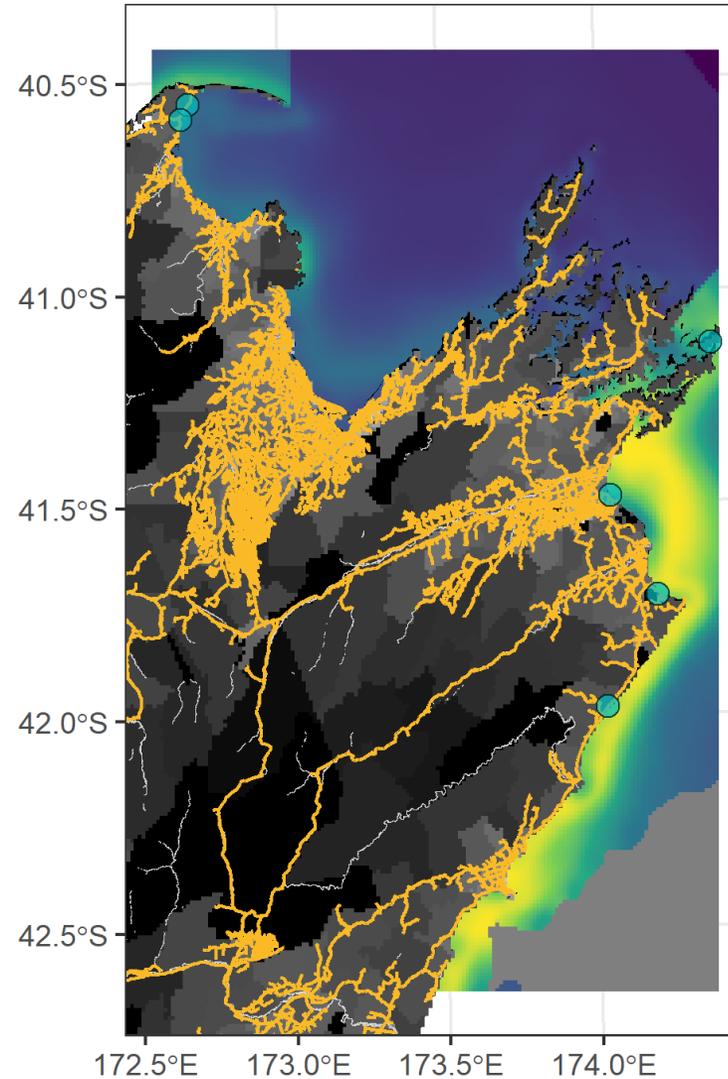
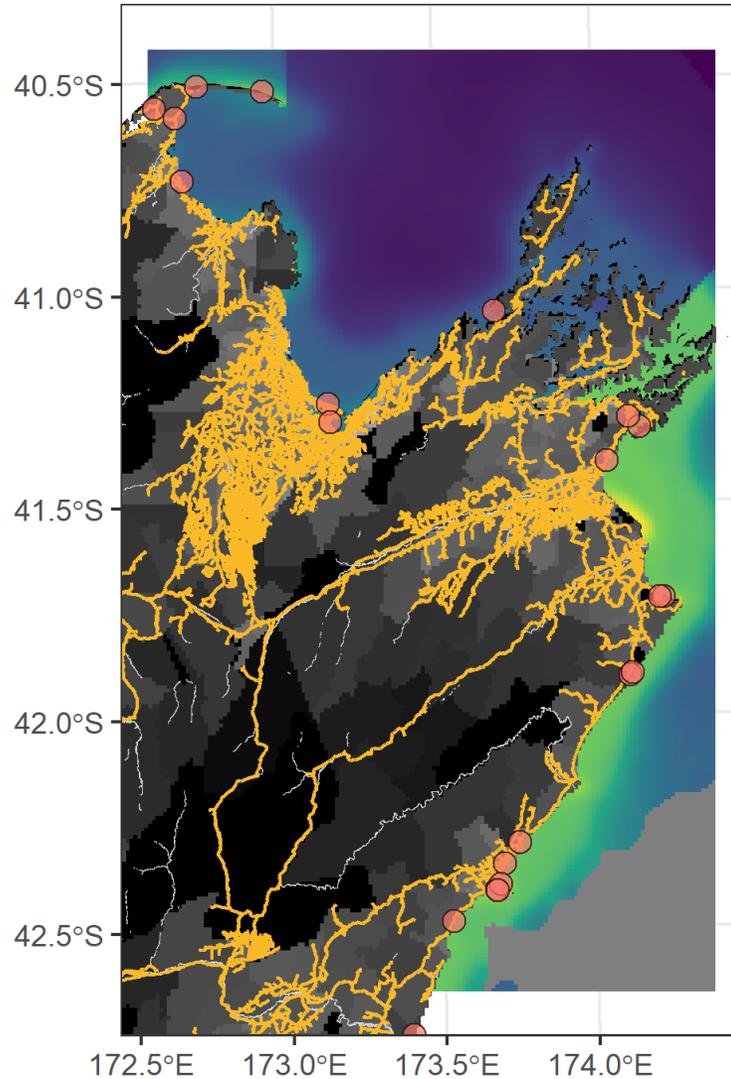
- Percentages are numbers presented as % of inferred annual deaths (10% of pop size)
- Inferred reporting rate an order of magnitude higher along WCNI (~10% of all annual deaths), than around South Island (0.5 to 2.2%)
- Difference driven by elevated public status of Maui dolphin?
- South Island reporting rate is low, but the regional distribution of these is near-optimal

# Spatial patterns in beachcast sample



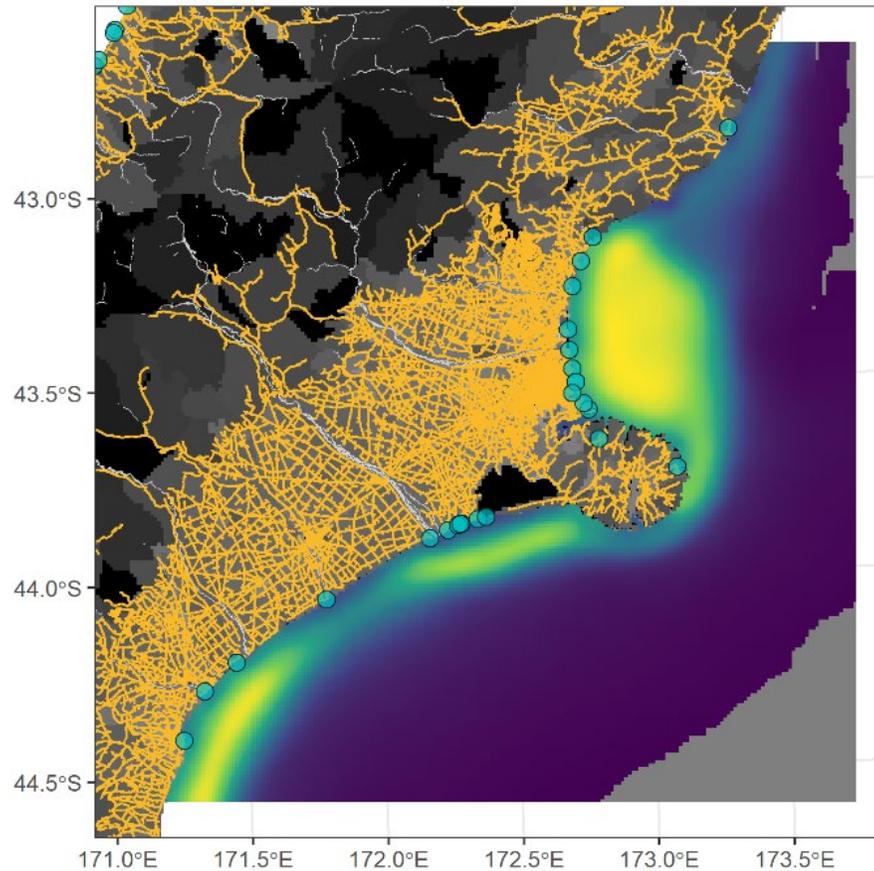
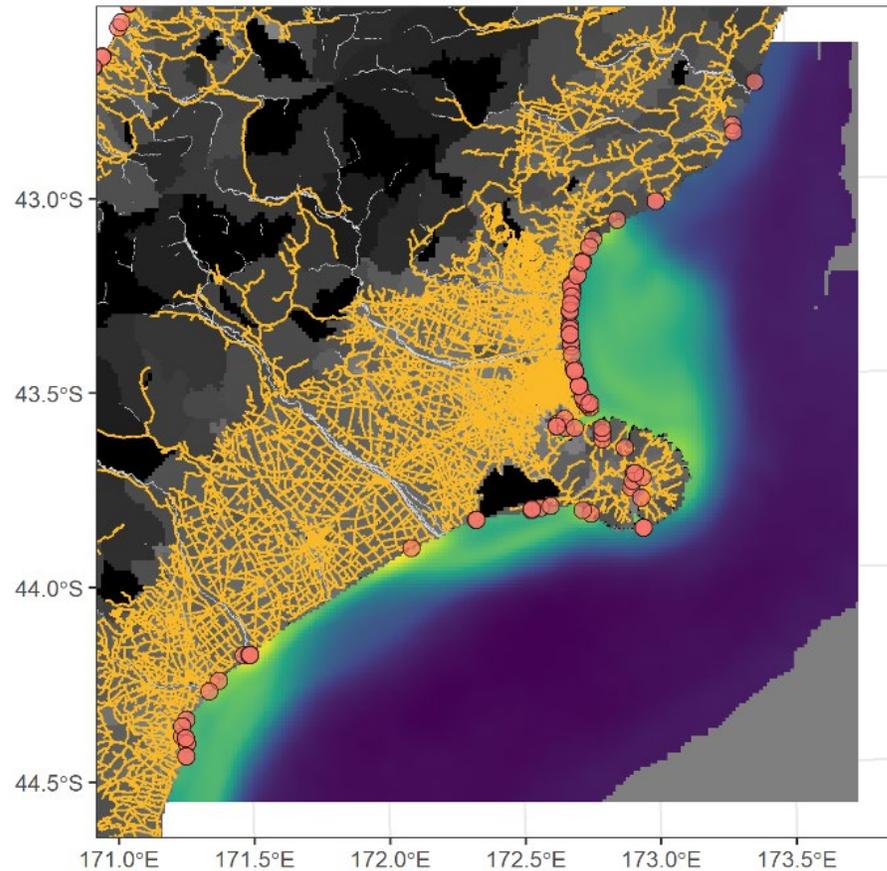
- Fine-scale distribution of beachcast dolphins in **summer** and **winter**
- Looking for causes in potential holes in sampling (no beachcasts where there should be dolphins)
- Roads = orange lines, low human density = black regions
- For WCNI, few south of Raglan, which may reflect lack of dolphins as well as relatively poor public access?

# Spatial patterns in beachcast sample



- Recall spatial distribution layers being updated for PMM2020-09 (not shown here), which has highest density in NCSI at Golden Bay
- This is where most beachcast dolphins were located
- Road along northern Kaikoura Coast, though low human density

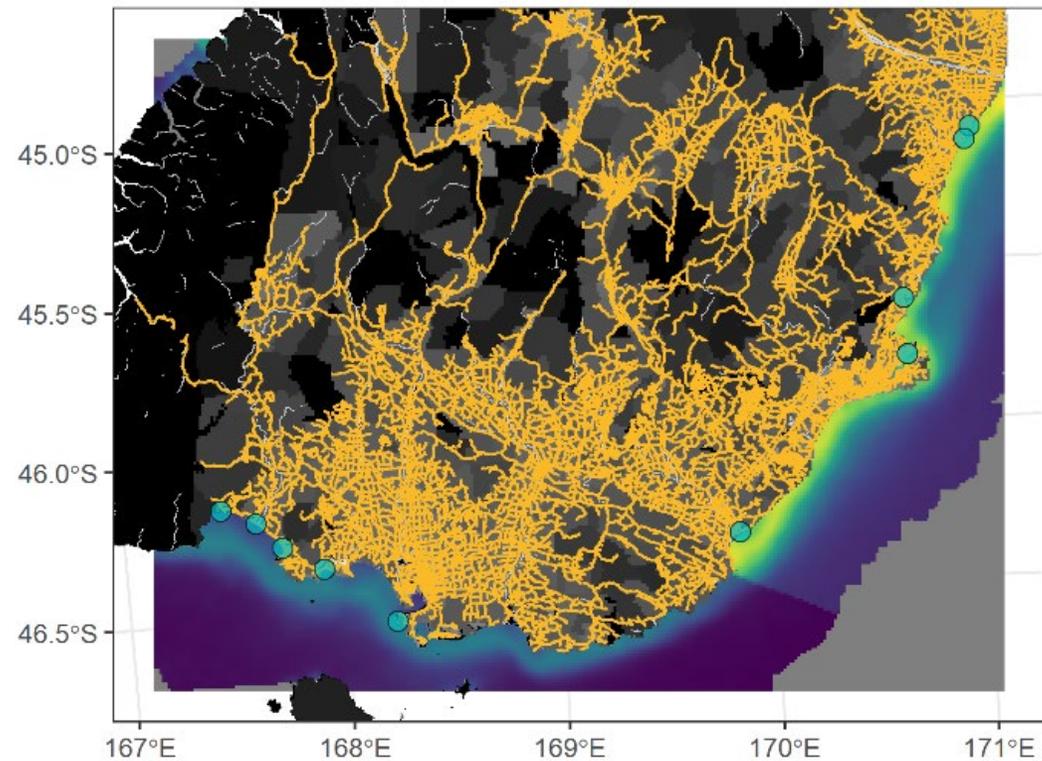
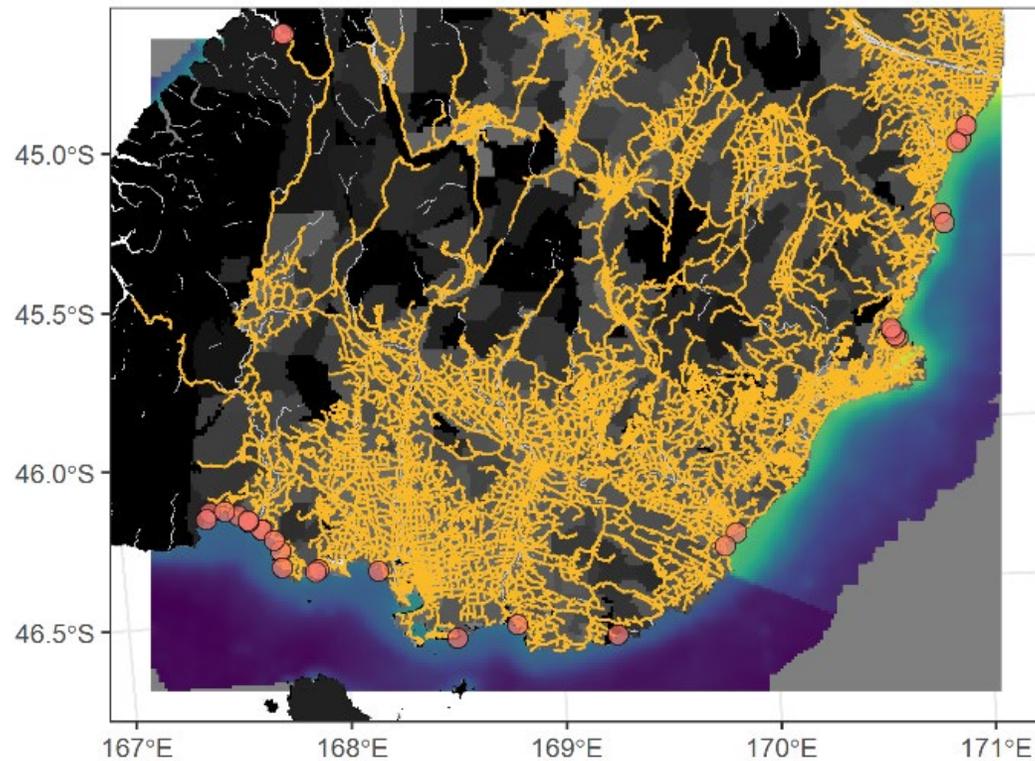
# Spatial patterns in beachcast sample



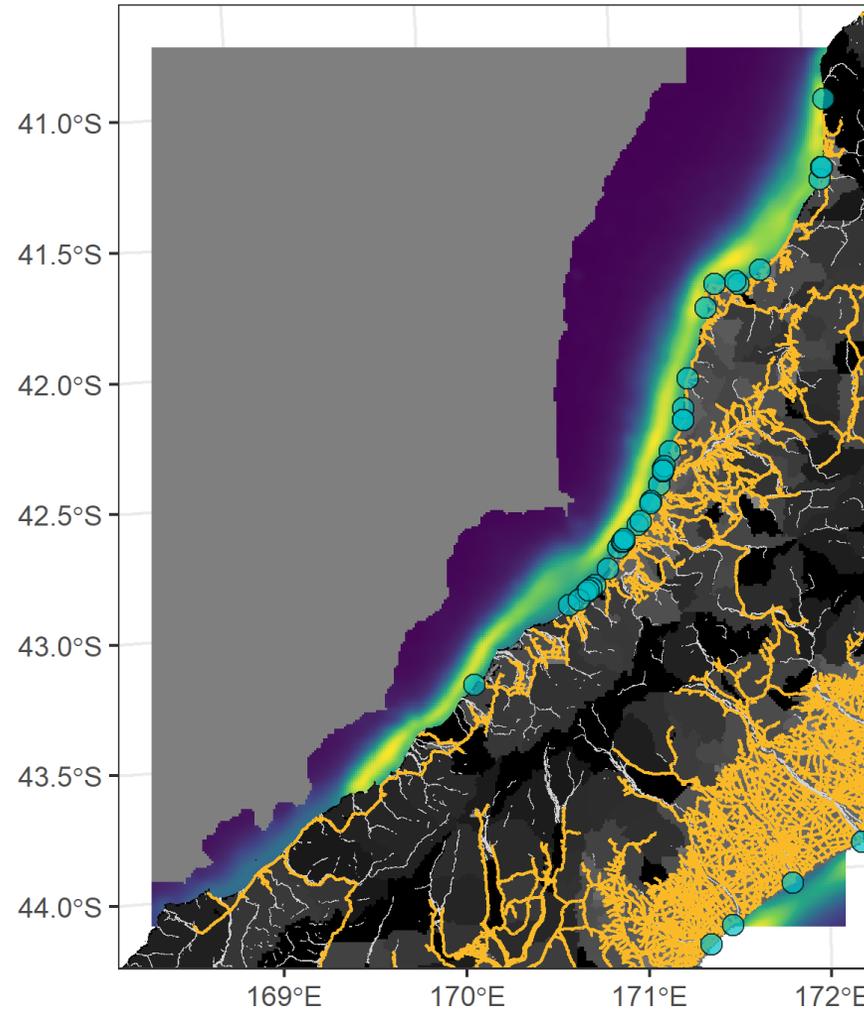
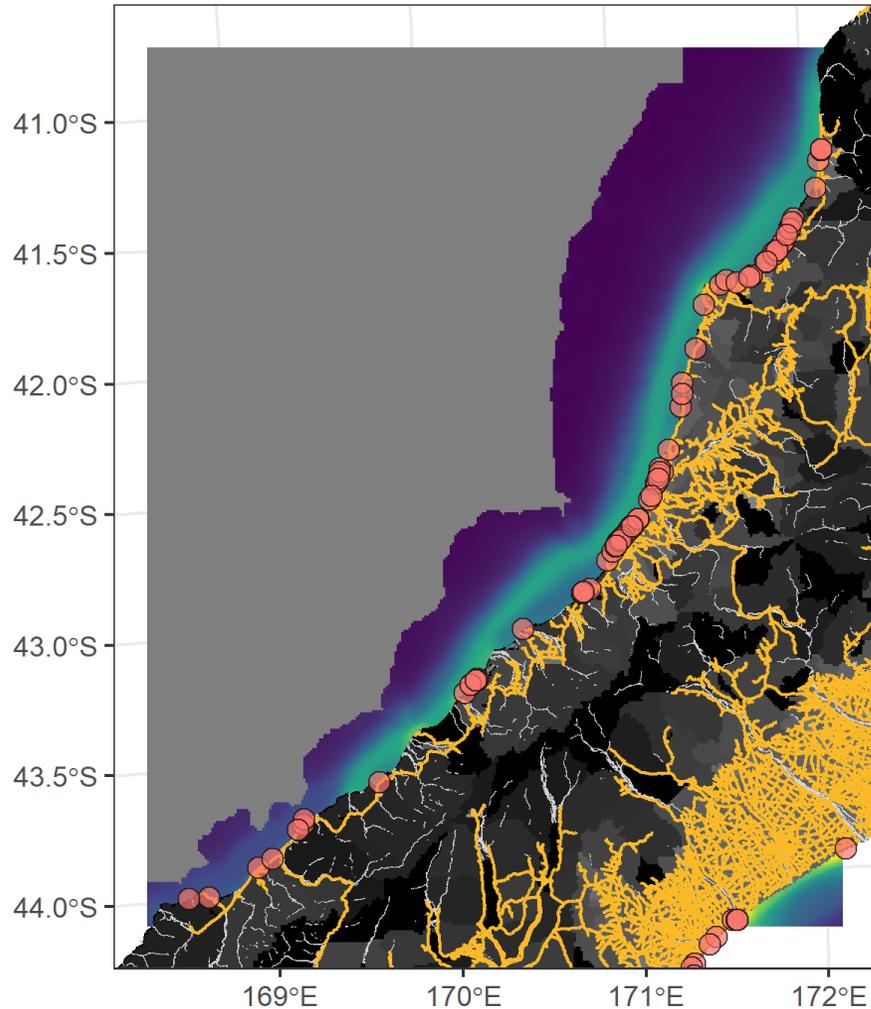
- Canterbury Coast plots highlight more offshore distribution of dolphins in winter
- Another driver of lower carcass recovery rate in winter?

# Spatial patterns in beachcast sample

- Few holes in public access along this coastline between Te Waewae & northern Canterbury

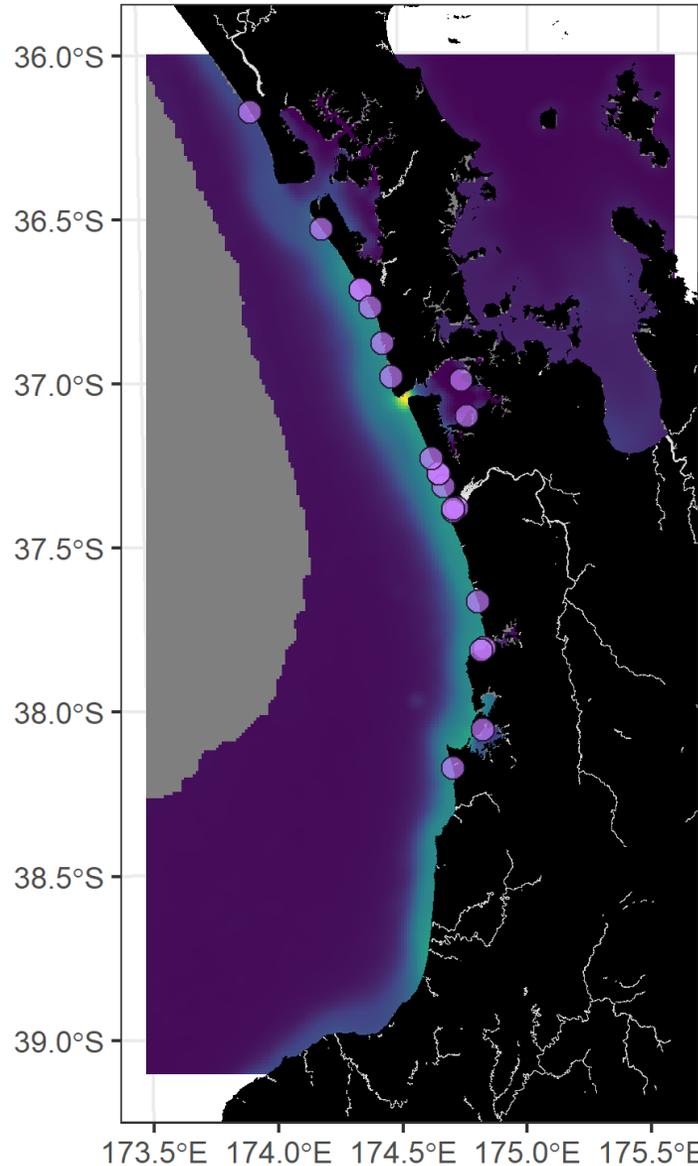


# Spatial patterns in beachcast sample

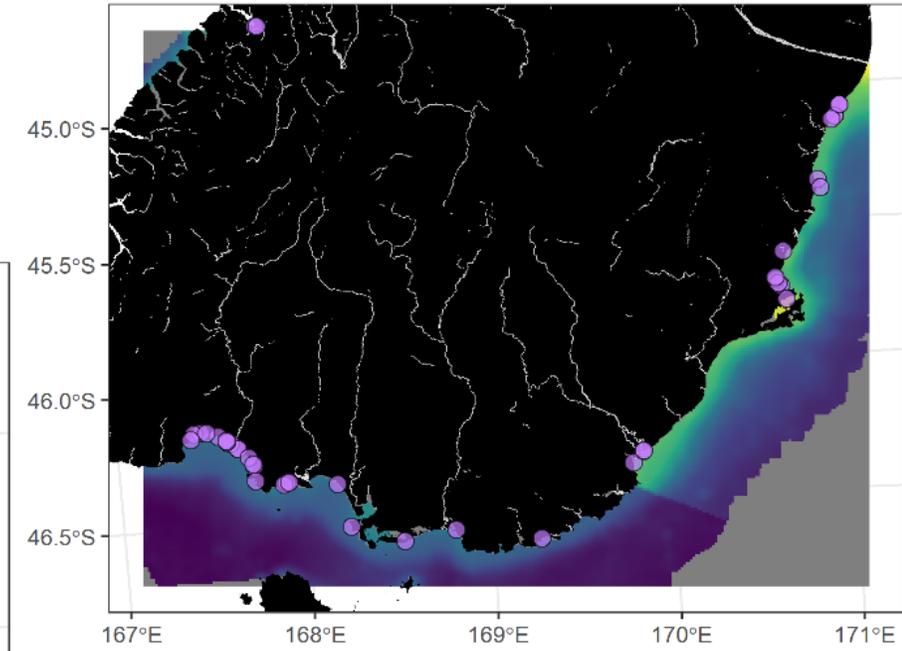
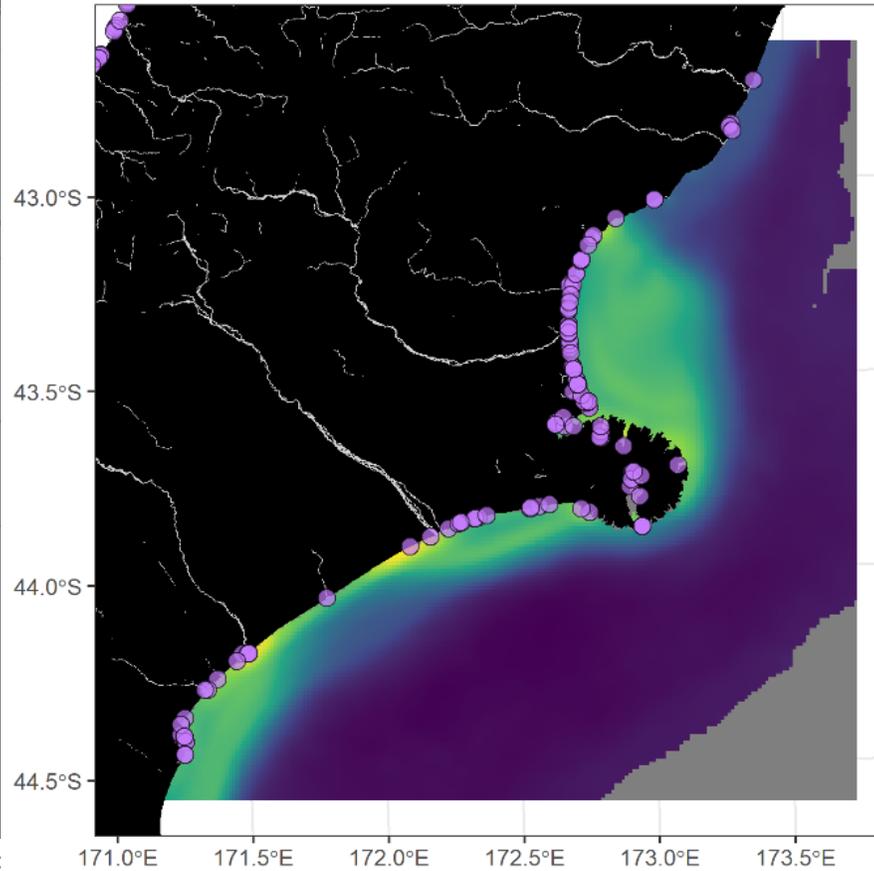


- Poorer inferred carcass recovery rate in southern part of WCSI?
- Would probably relate to much poorer public access and low human density
- Can the public increase carcass reporting rate here by much?

# Increased carcass detection rate near river mouths?



- Perhaps in some locations
- Would this cause toxo deaths to be over-represented?



# Demographic patterns (sex ratio)

- 7 out of 9 toxoplasmosis deaths (including 1 found at-sea) were females, of which 6 were reproductive
- Roe et al. (2013) highlighted presence of *T. gondii* in uterine tissues of multiple Hector's and Māui dolphins. Also, one case of fatal toxoplasmosis in a pregnant female that had *T. gondii* in foetal, uterine and placental tissues
- Roe et al. (2013) deduced that toxoplasmosis may be a cause of neonatal loss
- TMP risk assessment (Roberts et al. 2019) did not account for potential sex skew and affect on offspring (a negative bias?)

# Demographic patterns (age)

- Four of the cases of disseminated toxoplasmosis were aged from tooth sections, including: three females (estimated to be ages 9, 14 and 15) and one male (estimated age 4) (Roberts et al. 2019).
- Probability of previous infection with *T. gondii* increases with age (tentatively shown for Hector's and Maui dolphins specifically) (Roe et al. 2015)
- Beachcast sample might not be representative if more young or old dolphins in sample
- Of all beachcast dolphins that were aged, the mean age was 8.2.
- This is slightly above the estimated age at first maturity for females of this species (6.91; 95% credible interval = 5.82–8.24) (Edwards et al. 2018).
- This would not suggest a bias.
- A skew towards catching subadults (Davies et al. 2008) would complicate the use of bycatch carcasses to make inferences about toxo infection rate

# Summary of potential biases for estimating toxoplasmosis risk

PROBABLE SOURCE OF BIAS	PROBABLE DIRECTION OF BIAS	PROBABLE MAGNITUDE OF BIAS
Small population size	Neutral, though may depend on risk assessment approach.	Increasing probability of bias with decreasing sample size
Seasonality in carcasses being beachcast and reported	Negative, since all toxoplasmosis deaths to date were in spring months when beach activity is low to moderate.	Moderate
Spatial distribution of carcass detection rate	Positive, based on beachcast carcasses being predominantly found near to river mouths in some, but not all regions.	Moderate in some regions
Sex skew in toxoplasmosis deaths	Negative, since most confirmed cases to date were reproductive females, although depending on risk assessment approach used.	Strong, if the current sex skew is representative
Long-term changes in the proportion of mortality from toxoplasmosis	Unknown, given lack of longer-term monitoring required to assess this.	Unknown, though potentially large.

# Conclusions & recommendations

- Some potential negative biases (seasonality of carcass reporting & female skew) that could be countered by increasing carcass reporting in winter/spring
- Some potential positive biases (e.g., higher spatial carcass reporting rate near river mouths in some regions) that could be countered by targeting increasing sampling elsewhere
- Uncertainty about longer-term patterns in importance of toxo. Is 2007-2018 (latest risk assessment) representative of before & after? Need a bigger long-term sample!
- However, low carcass reporting rate around South Island relative to North Island indicates potential to increase number of carcasses for estimating the population risk from toxoplasmosis (and other causes of death)
- Apparent holes in beachcast reporting in regions with low human density & poor access. Will public effort alone be sufficient in these locations?

# Acknowledgements

- Thank you specifically to Hannah Hendriks (DOC), who maintains the DOC incidents database
- This research was funded by the New Zealand Department of Conservation

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