


Comisión Interamericana del Atún Tropical
Inter-American Tropical Tuna Commission

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LENGTH-STRUCTURED SPATIOTEMPORAL TAGGING MODEL FOR SKIPJACK IN THE EPO

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Background

- Historically, assessing skipjack tuna in the EPO has been problematic due to the lack of a reliable index of relative abundance, the possibility of a dome-shape selectivity, and the lack of age-composition data
- Tagging data is available, but practicalities of tagging make tag non-mixing an issue
- Fine scale spatio-temporal modeling of the tagging data can account for the non-mixing
- An initial implementation of the spatiotemporal tagging model (SAC-13-08) allowed estimation of movement rates based on environmental data and habitat suitability
- A length-structured spatiotemporal population model with movement as an advection-taxis-diffusion process was developed to analyze the tagging data

In fact, the first implementation of the spatio-temporal tagging model (SAC-13-08) allowed estimation of to estimate movement rates based on environmental data and habitat suitability.

Tagging data

- 2000 to 2006
  - six cruises targeted bigeye tuna
  - 3571 SKJ tagged and released with plastic dart tags
  - 566 tags recovered.
- 2011 (30 tags)

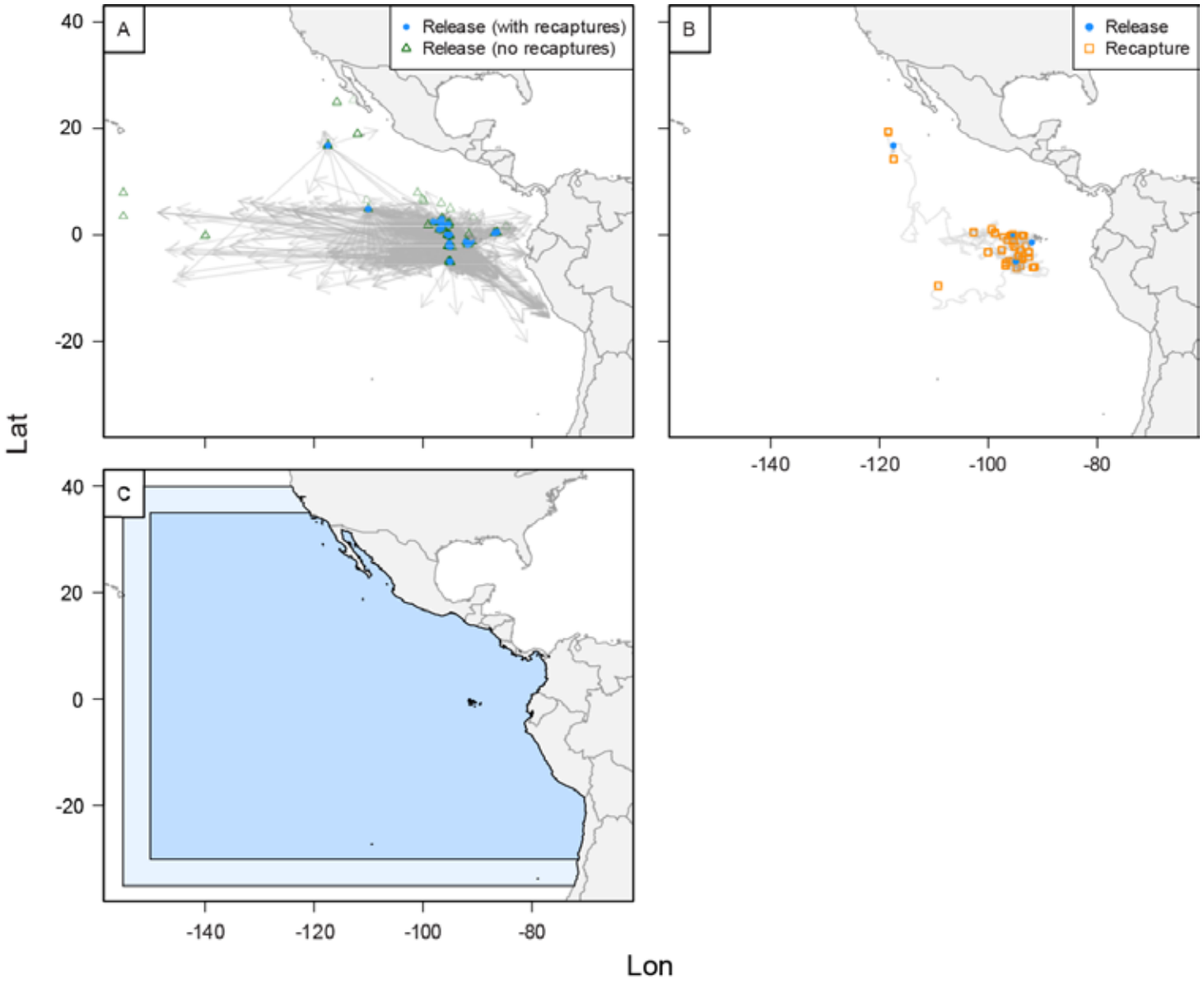
- 2019-2022
  - Three cruises targeting skipjack

    6431 SKJ were tagged with plastic dart tags

    1682 tags recovered
- 33 archival tags

In fact, the first implementation of the spatio-temporal tagging model (SAC-13-08) allowed estimation of to estimate movement rates based on environmental data and habitat suitability.

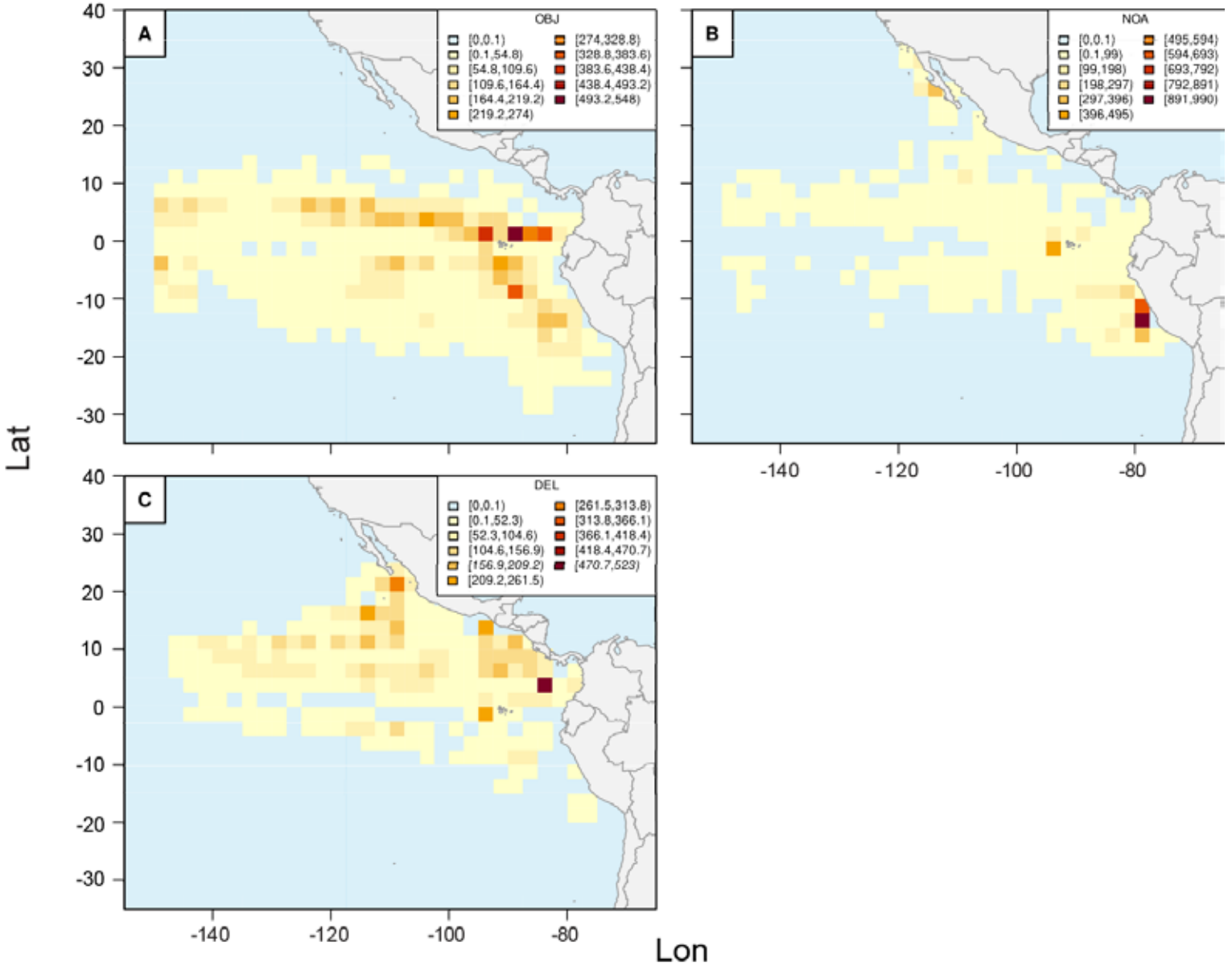
Tagging data



Improvements

- Faster algorithm to estimate fine-scale movement rates for a large spatial domain
- Incorporating archival tags
- Incorporating fishing effort data
  - Number of sets (1°x1° per day) by fleet (OBJ, NOA, DEL) and vessel size (class)
- Including additional environmental variables
  - Advection
    - Ocean currents
  - Habitat preference/ taxis
    - Sea surface temperature
    - Dissolved oxygen
    - Mixed layer depth
- Accounting for the length of tagged fish

Currents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OBJ
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[219.2,274)
[274,328.8)
[328.8,383.6)
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[438.4,493.2)
[493.2,548)
B
NOA
[0,0.1)
[0.1,99)
[99,198)
[198,297)
[297,396)
[396,495)
[495,594)
[594,693)
[693,792)
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[891,990)
C
DEL
[0,0.1)
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[52.3,104.6)
[104.6,156.9)
[156.9,209.2)
[209.2,261.5)
[261.5,313.8)
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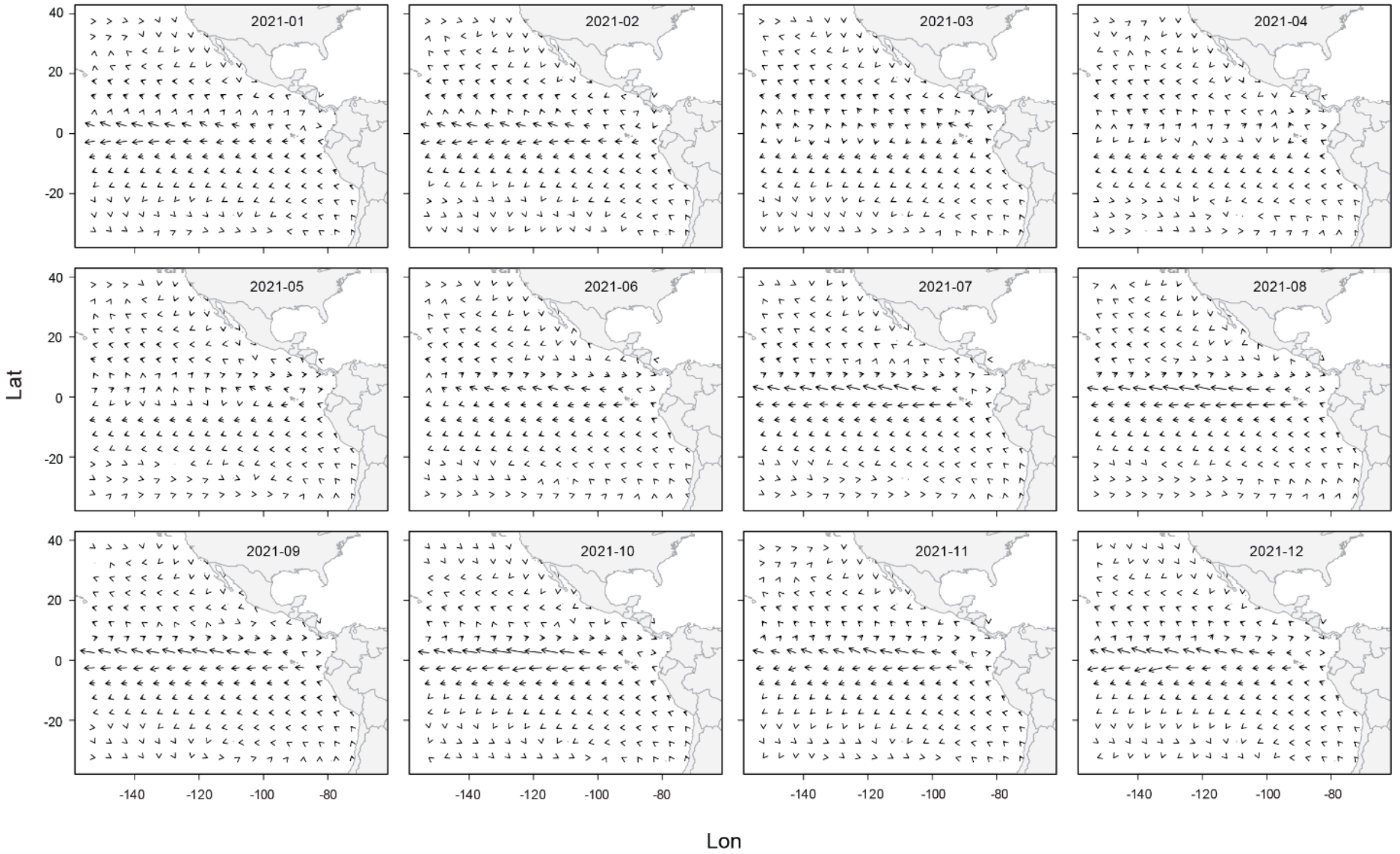
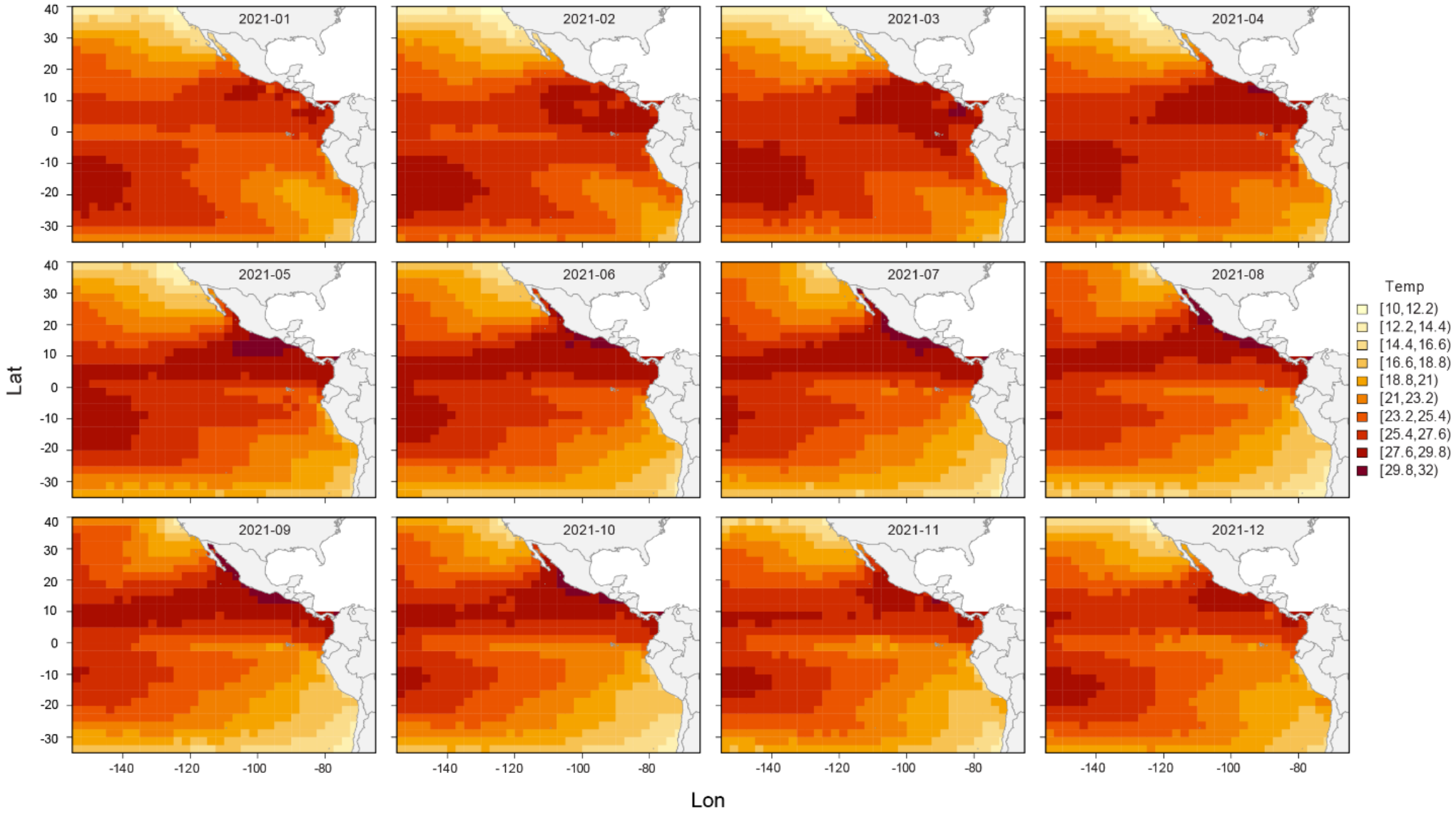
[418.4,470.7)
[470.7,523)
40
30
20
10
0
-10
-20
-30
-140
-120
-100
-80
Lat
Lon

Currents


2021-01
2021-02
2021-03
2021-04
2021-05
2021-06
2021-07
2021-08
2021-09
2021-10
2021-11
2021-12
Lat
Lon
40
20
0
-20
-140
-120
-100
-80

Sea surface temperature



Model: Movement

- Diffusion
  - Constant in space and time
  - Sea surface temperature
- Advection
  - Scalar of the ocean currents in north-south and east-west direction
- Taxis
  - Directed movement towards suitable habitat
    - Sea surface temperature
    - Dissolved oxygen
    - Mixed layer depth
- Kalman filter used for the definition of the model likelihood
- Archival (more location data) and conventual tags treated the same

Model: Mortality

- The probability of the recovery depends on
  - Movement
  - Probability of the survival
  - Probability of capture
- $F = \lambda.E$
  - Location, time, length, fleet
- Adjustments
  - Ratio of excluded recovered tags
  - Immediate shedding and non-reporting rate
  - Continuous shedding rate

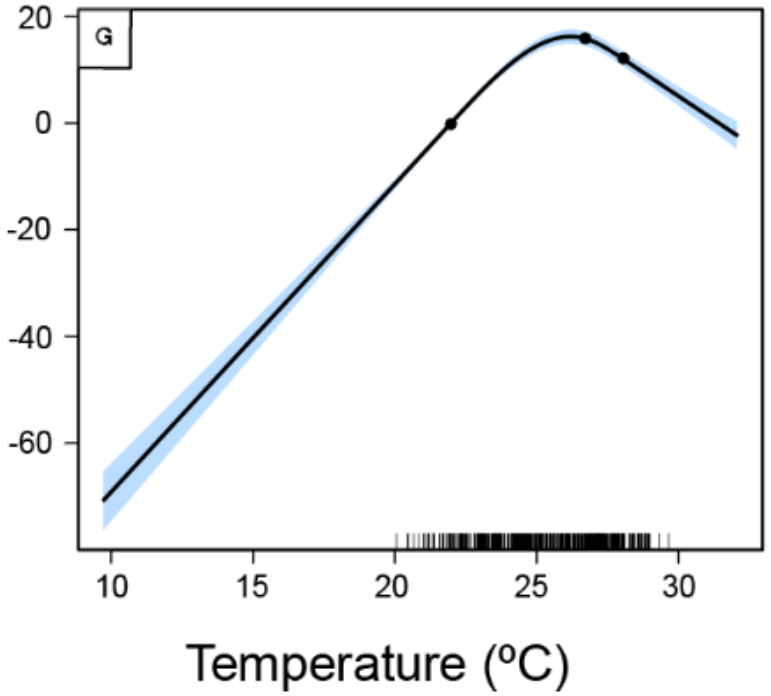
Model: Mortality

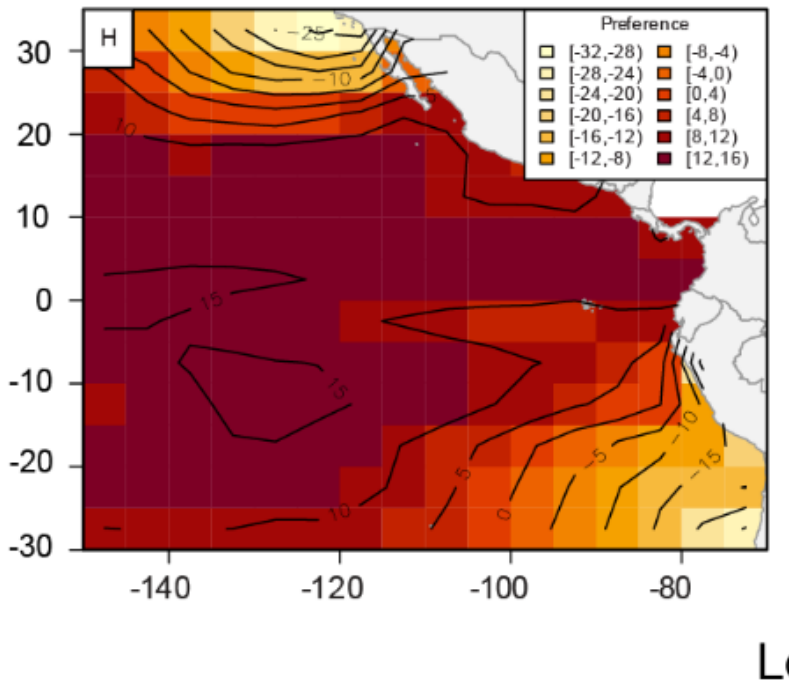
- Length classes
  - Natural mortality – 12
  - OBJ -12
  - NOA - 5
  - DEL - 3

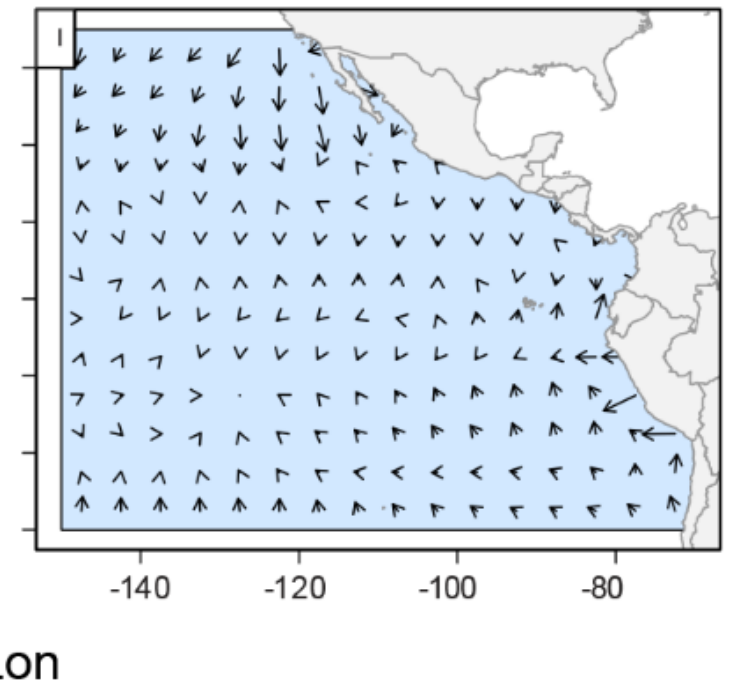
Results: Movement

- Advection
  - Relationship with ocean currents is negative (-1.7) and directed in the opposite direction to the currents.
- Taxis
  - SST was the most robust environmental field for taxis
    - Preferred temperature window around 25°C
  - O2 and MLD dependent on model settings

Results: Taxis

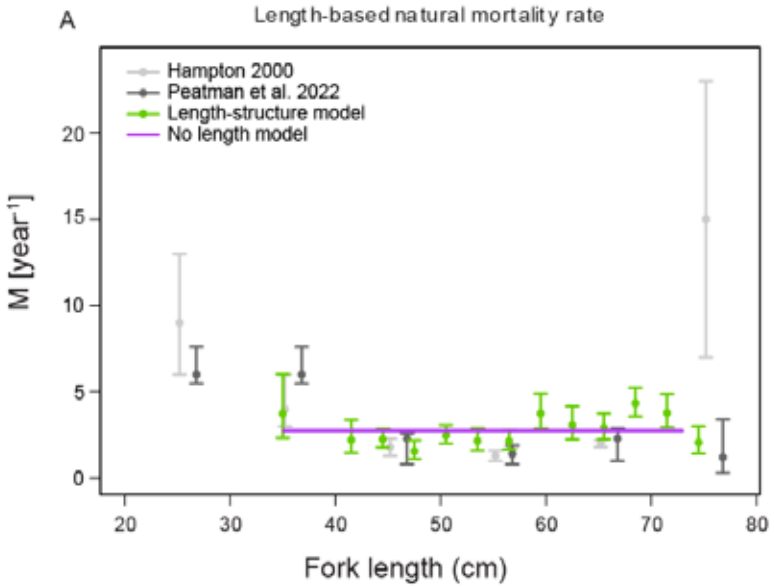


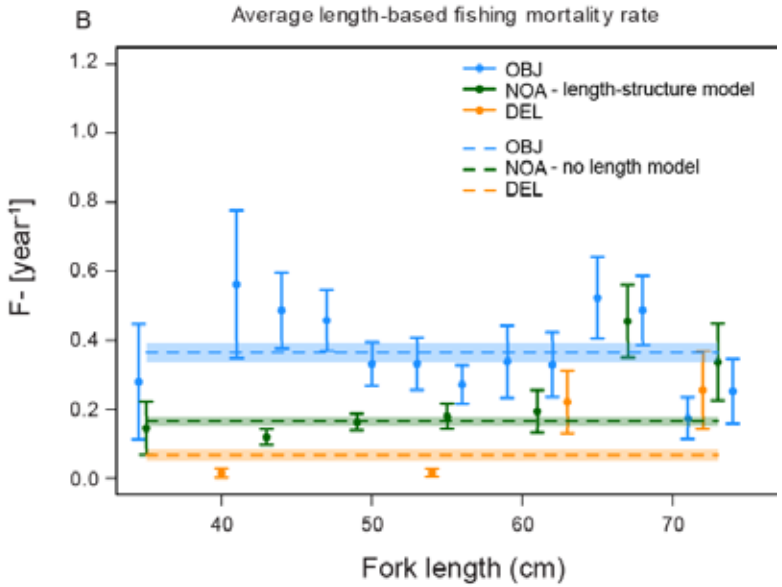


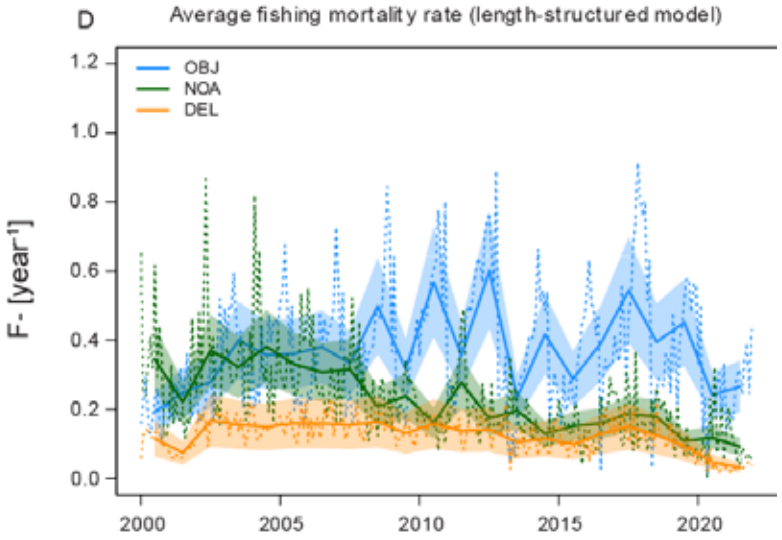


Length-structured model

Results: Natural and fishing mortality







Next steps: Potential improvements

- Explore more flexible relationships between fishing mortality and effort
- Adding additional covariates to the spatial effort data
- Inclusion of spatial catch data along with a spatiotemporal model of abundance
- Parameterized function for the natural mortality by length by assuming e.g., the Gislason et al. (2010) or Lorenzen et al. (2022) function
- Assuming a parameterized function for the capture probability at length (selectivity curve) for each fleet.
- Estimation of seasonally varying movement rates and mortality parameters
- Explore estimating or fixed values of Immediate and continuous shedding and non-reporting rates
- Development of model diagnostics and further sensitivity testing of the estimation of movement and mortality rates

Ultimate goal

- Provide useful input to the interim assessment model
- Develop a standalone length-structured assessment model to estimate stock abundance, exploitation rates, and biological reference points

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