Habitat Utilization & Ecosystem Connectivity in the Southern Mid-Atlantic Bight

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Chesapeake Bay & Climate Change

Physical Impacts

- **Surface temperatures likely increase 2-6°C by 2100**
- **Frequency & intensity of hypoxia likely increase**

Holland et al. 1987, Kemp et al. 2005, Najjar et al. 2010, Buchheister et al. 2013, Ding & Elmore 2015, Muhling et al. 2018

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Physical Impacts

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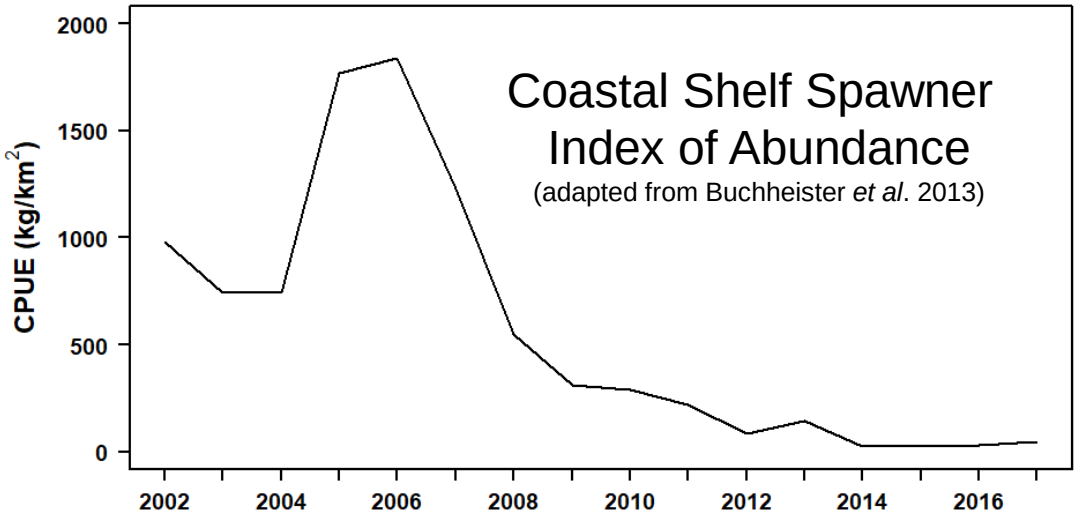


Faunal Impacts (??)

- Decreased use: boreal & cold-temperate species
- Increased use: warm-temperate & subtropical species
- Changes in residence times: trophic impacts
- Impacts to local fisheries: changing opportunities

Holland et al. 1987, Kemp et al. 2005, Najjar et al. 2010, Buchheister et al. 2013, Ding & Elmore 2015, Muhling et al. 2018

Summer Flounder & Black Sea Bass

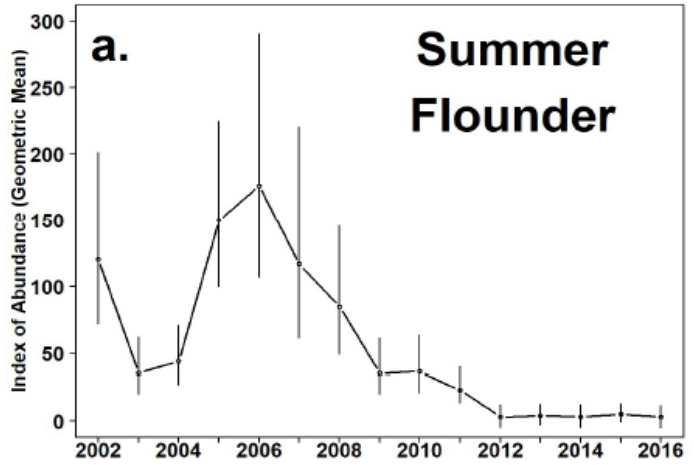
- **Both likely shifting poleward**

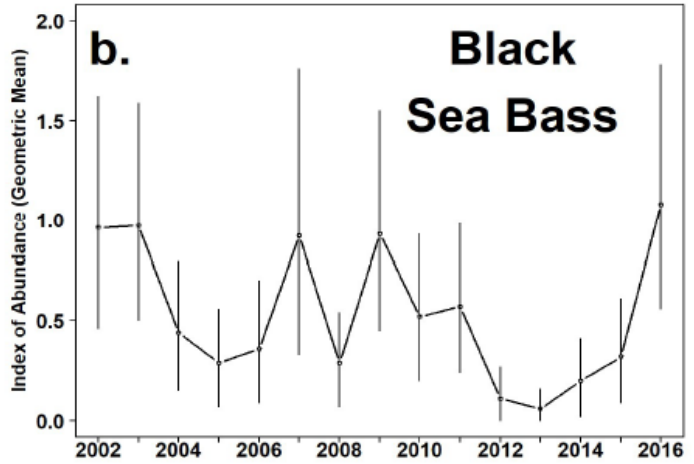
Summer Flounder

- Moderately vulnerable to distribution shifts
- Utilization of Chesapeake Bay has declined

Black Sea Bass

- Highly vulnerable to distribution shifts
- Utilization of Chesapeake Bay has been variable





Quantify habitat preference & 'ecosystem exchange' of LMR: understand possible to responses climate change

Nye et al. 2009, Buchhesiter et al. 2013, Bell et al. 2014, Hare et al. 2016

Objectives

Develop foundation for understanding possible biotic responses to climate change in Chesapeake Bay by:

I. Quantifying habitat preference for summer flounder, black sea bass, & others in Chesapeake Bay, coastal ocean, & Delaware Bay

II. Evaluating the role of Chesapeake Bay environmental conditions in driving use of this estuary relative to the coastal ocean

(Chesapeake Bay / Coastal Ocean Connectivity)

III. Assessing the role of Chesapeake Bay environmental conditions in driving the use of this ecosystem as compared with Delaware Bay

(Chesapeake Bay / Delaware Bay Connectivity)

Species List

Quantify utilization & exchange over a range of taxa representing various life histories:

Benthics

- Black Sea Bass *
- Summer Flounder *
- Atlantic Croaker *
- Kingfishes
- Northern Puffer
- Northern Sea Robin
- Scup *
- Silver Perch
- Spot *
- Windowpane Flounder *

Pelagics

- Alewife *
- Atlantic Menhaden *
- Bluefish *
- Butterfish *
- Striped Bass *
- Weakfish *

Elasmobranchs

- Clearnose Skate *

Invertebrates

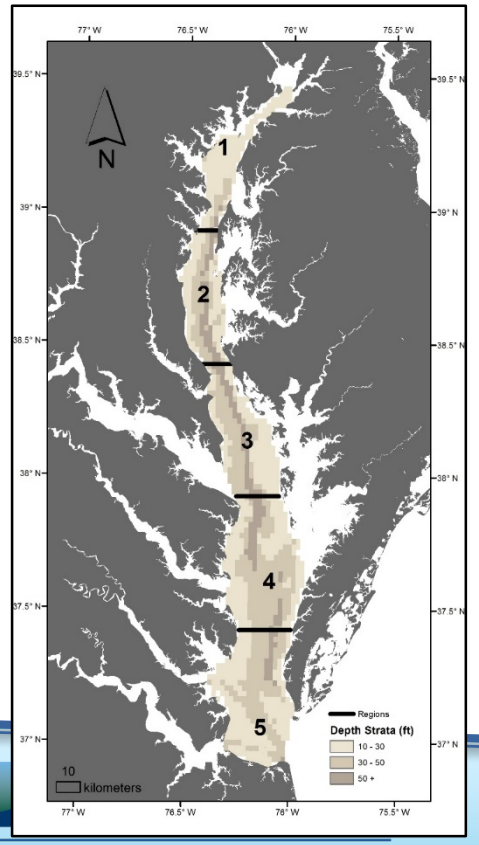
- Brief Squid
- Horseshoe Crab *

Managed Species *

Data Sources

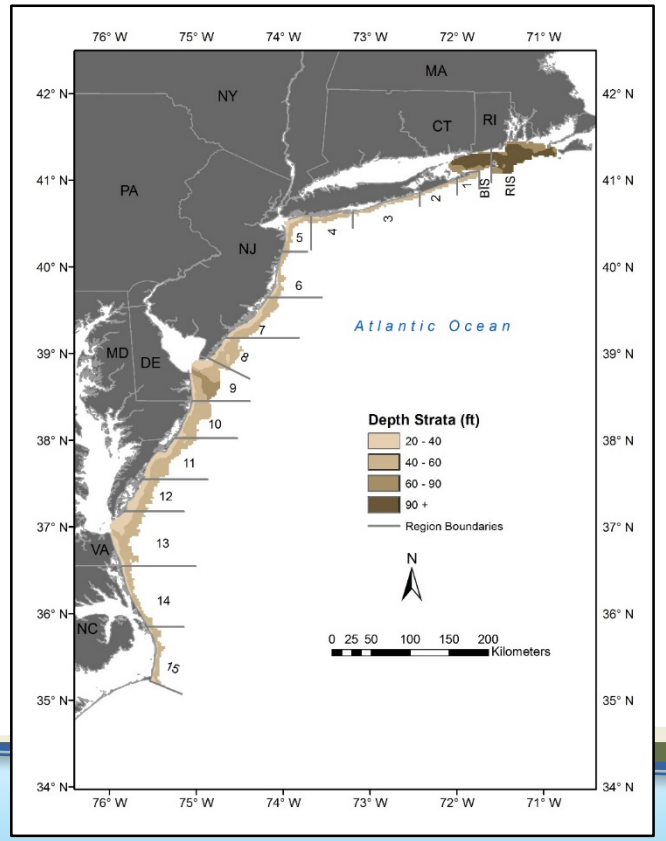
ChesMMAP Trawl Survey

- Bimonthly cruises: Mar-Nov
  - 80 sites/cruise using a strat.-random design



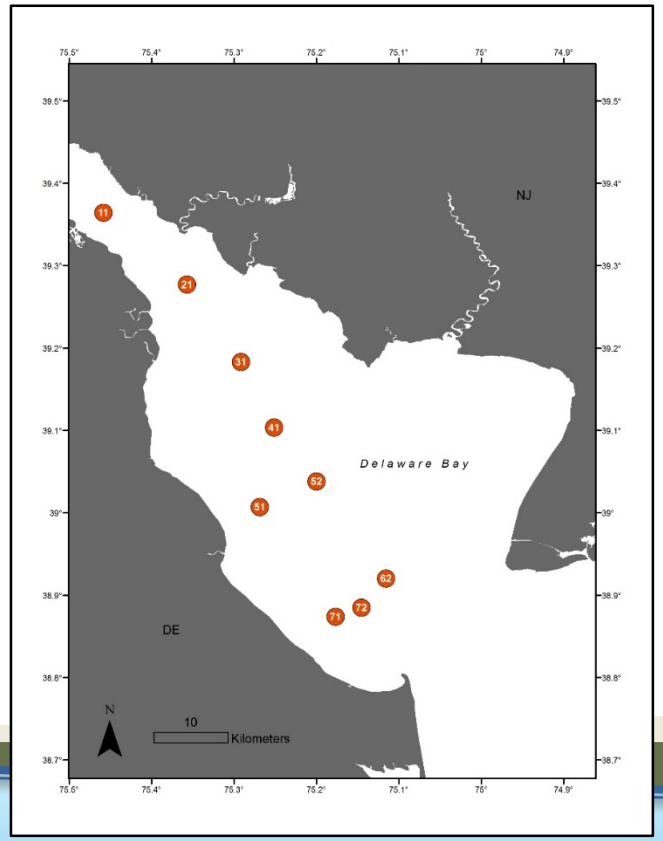
NEAMAP Trawl Survey

- Spring (May) & Fall (Oct)
  - 150 sites/cruise; strat.-random design



DE Bay Trawl Survey

- Monthly; Mar-Dec
  - 9 fixed sites/cruise



Objective I: Habitat Utilization

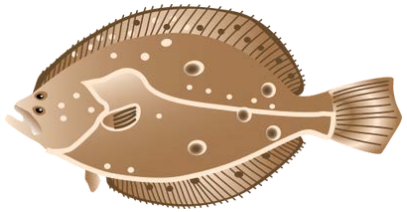
- Generalized linear & additive mixed-effects models (GLMMs/GAMMs)
- Response: catch-per-unit-effort (CPUE) as count/tow

$$y_i \sim NB(y_i|\mu_i,\theta) = \frac{\Gamma(y_i+\theta)}{\Gamma(\theta)y_i!} \cdot \left(\frac{\theta}{\mu_i}\right)^{\theta} \cdot \left(\frac{\mu_i}{\mu_i+\theta}\right)^{y_i}$$

- Model CPUE as a function of fixed & random effects
  - Fixed effect habitat variables: temperature, salinity, dissolved oxygen, & depth
  - Year as random effect (random intercept model)
  - Trawl area swept as offset variable

Evidence of spatial autocorrelation → fit models using INLA (Bayesian Framework)

Objective I: Summer Flounder, Chesapeake Bay



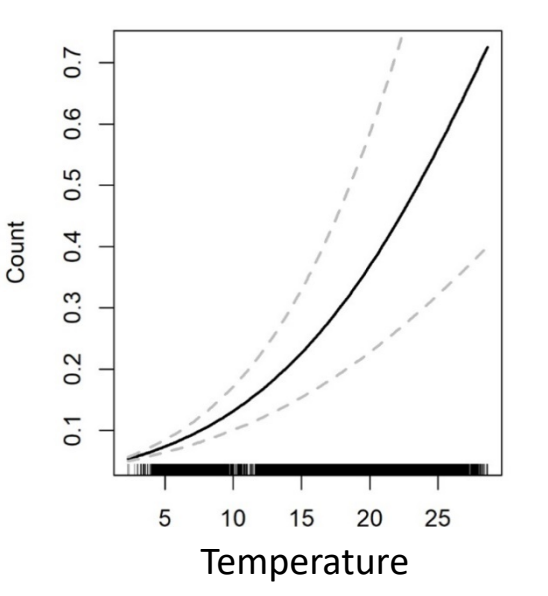
Zero-Altered, GLMM (Neg. Bin.)

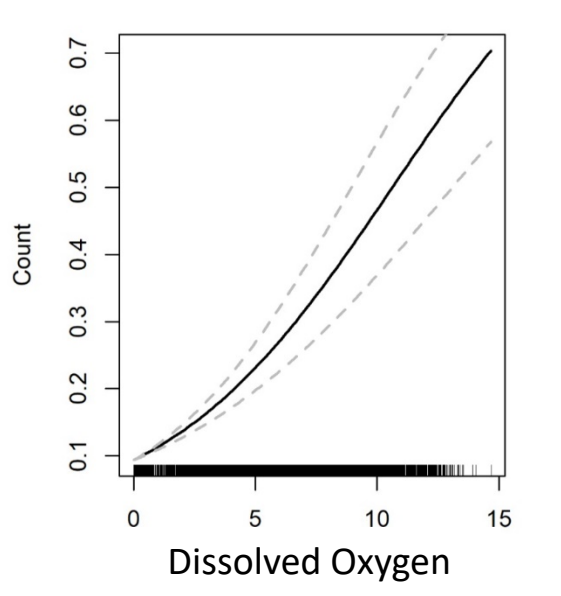
Binomial

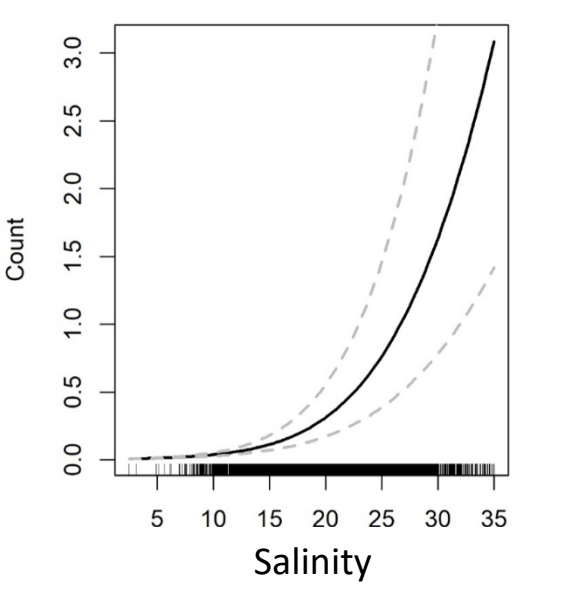
Presence/Absence ~ Temp + DO + Salinity + Depth + (1|Year) + offset(ln.area)

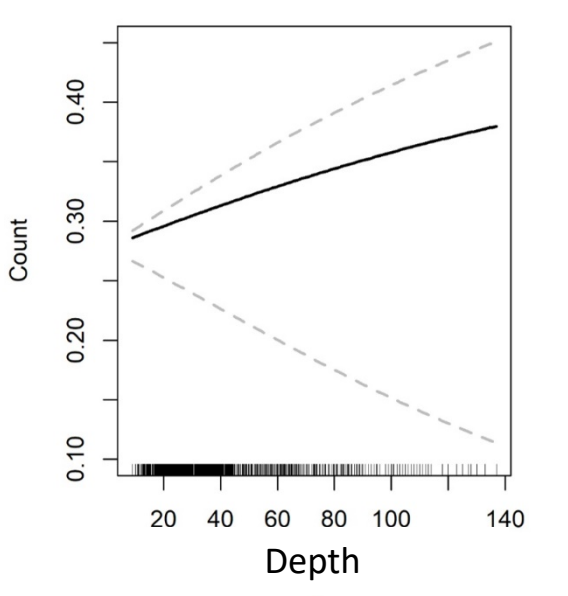
Zero-truncated neg.bin

Zero-truncated Count ~ Temp + Salinity + Depth + (1|Year) + offset(ln.area)









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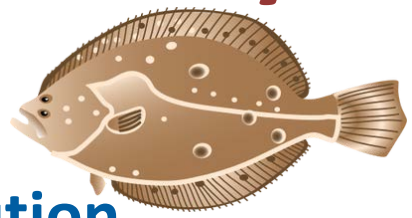
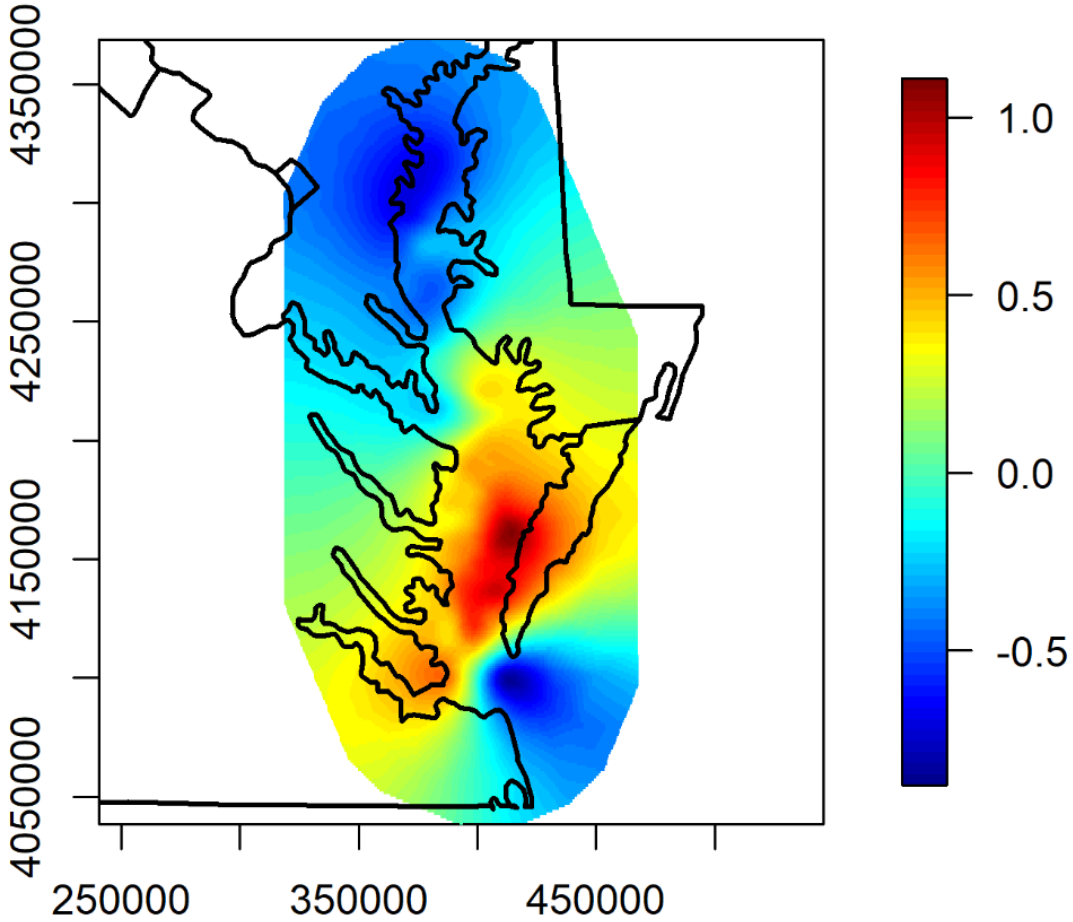
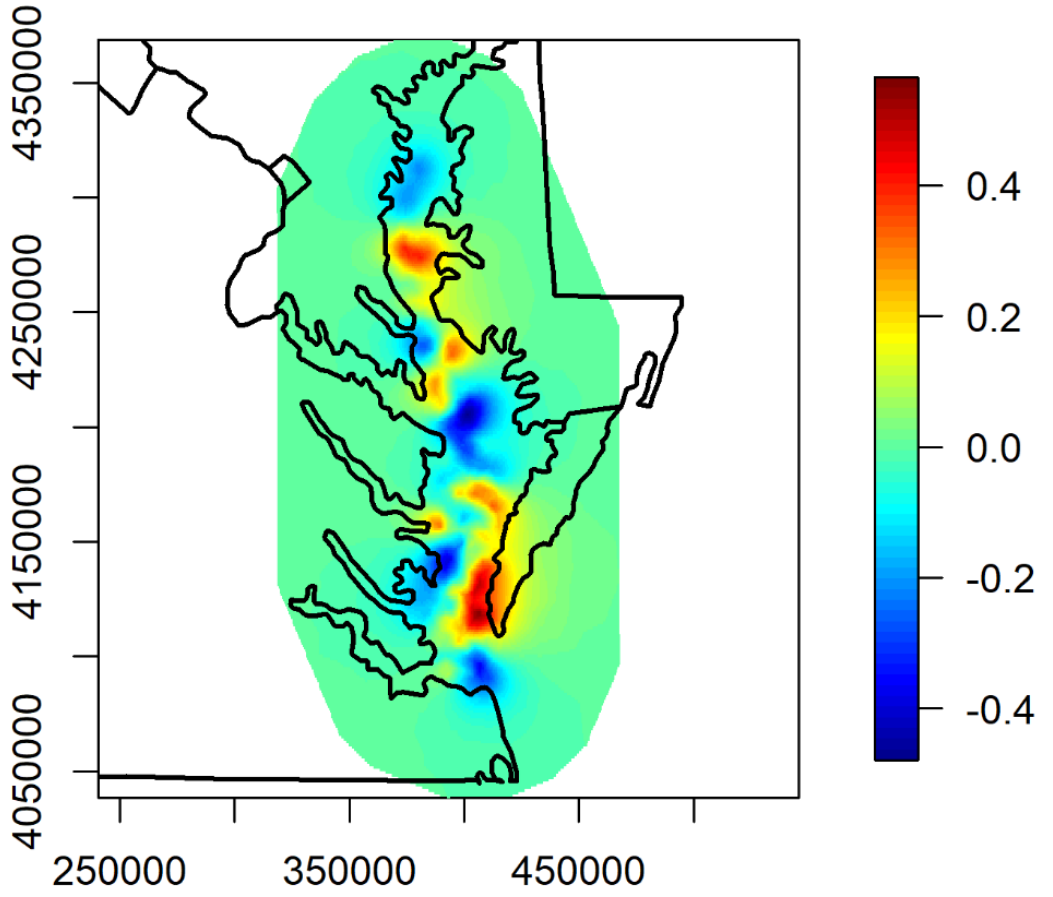
Spatial Random Field



Presence/Absence
Binomial Distribution



Conditional Distribution
Zero-Truncated Negative Binomial



Next Steps

- Explore generalized additive mixed-effects models (GAMMs) using INLA framework for summer flounder

- Repeat this approach to quantify habitat utilization for 18 other species (including black sea bass)

- Move on to Objective 2: quantify connectivity between Chesapeake Bay & coastal ocean

Thank You