Understanding Pacific Halibut Spatial Dynamics in the Northern Bering Sea

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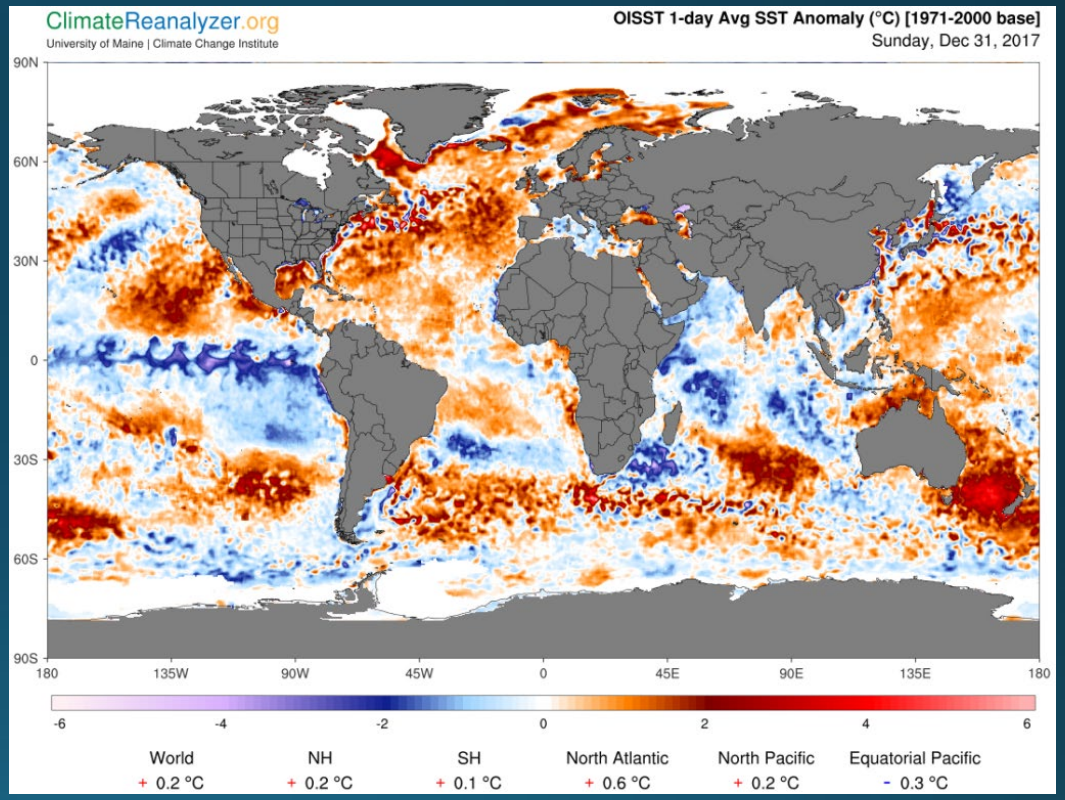
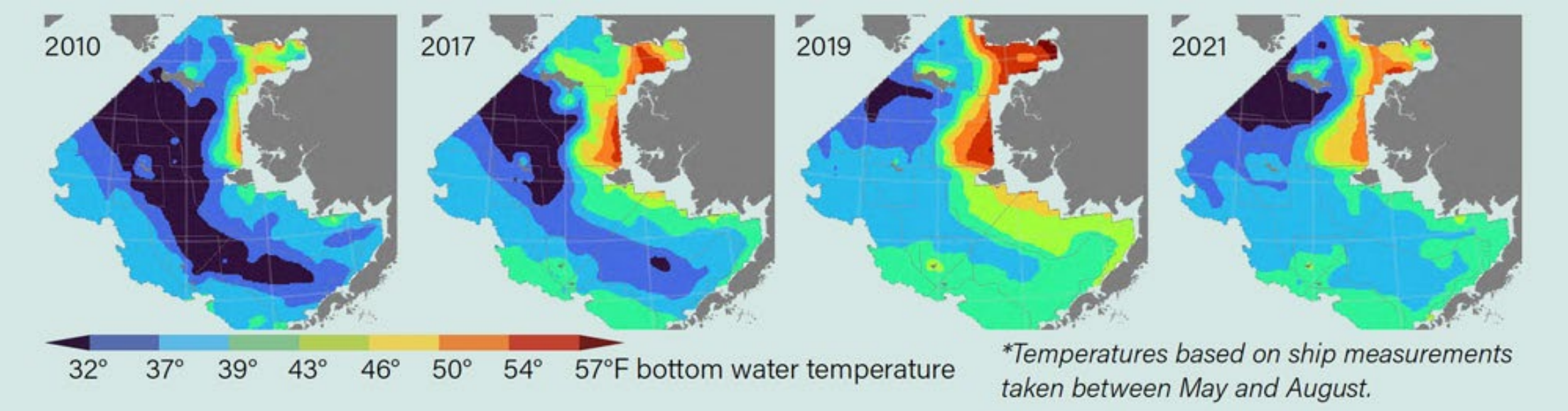
Climate Change

- Significant increases in global ocean temperatures
- Large scale impacts on marine ecosystems
- Shifts in species distributions
- The Northern Bering Sea is a region of particular interest



Northern Bering Sea (NBS)



- Traditionally has a deep water cold pool
  - creates a barrier for sub-arctic fishes
- In recent years, this has been significantly reduced, allowing various groundfish populations to shift northward
  - One species is the Pacific halibut

Pacific Halibut

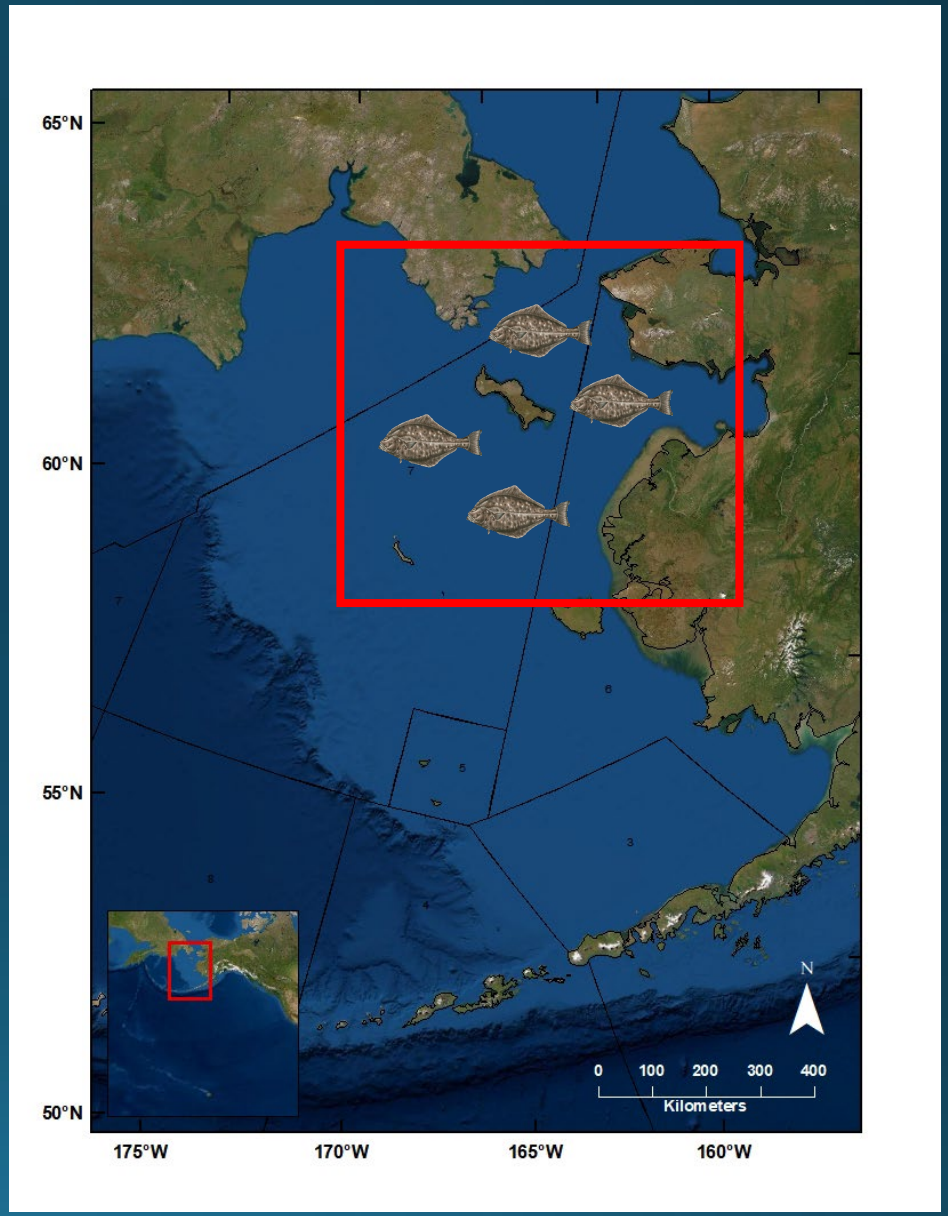
- Large, highly mobile demersal flatfish species
- Valuable to local stakeholders, supporting commercial, recreational, and subsistence fisheries
- Forage in shallow waters during summer months before migrating offshore to spawn in deeper waters during the winter
- Requires informed management to maximize potential stock benefits

IPHC and NSEDC

- Management of the species informed by the IPHC
  - Currently data deficient in the NBS
- Drawn the attention of the Norton Sound Economic Development Corporation (NSEDC)
  - Serves to develop local fisheries and maximize community benefit
- Interested in understanding the Pacific halibut resource

Project Background

- Halibut movements and spatial dynamics are not well known in the NBS
  - Critical information for management
  - Harvest quotas set by regulatory areas
- Seek to address this data gap to inform management and local stakeholders
  - Collaborative satellite telemetry study between NSEDC and UAF

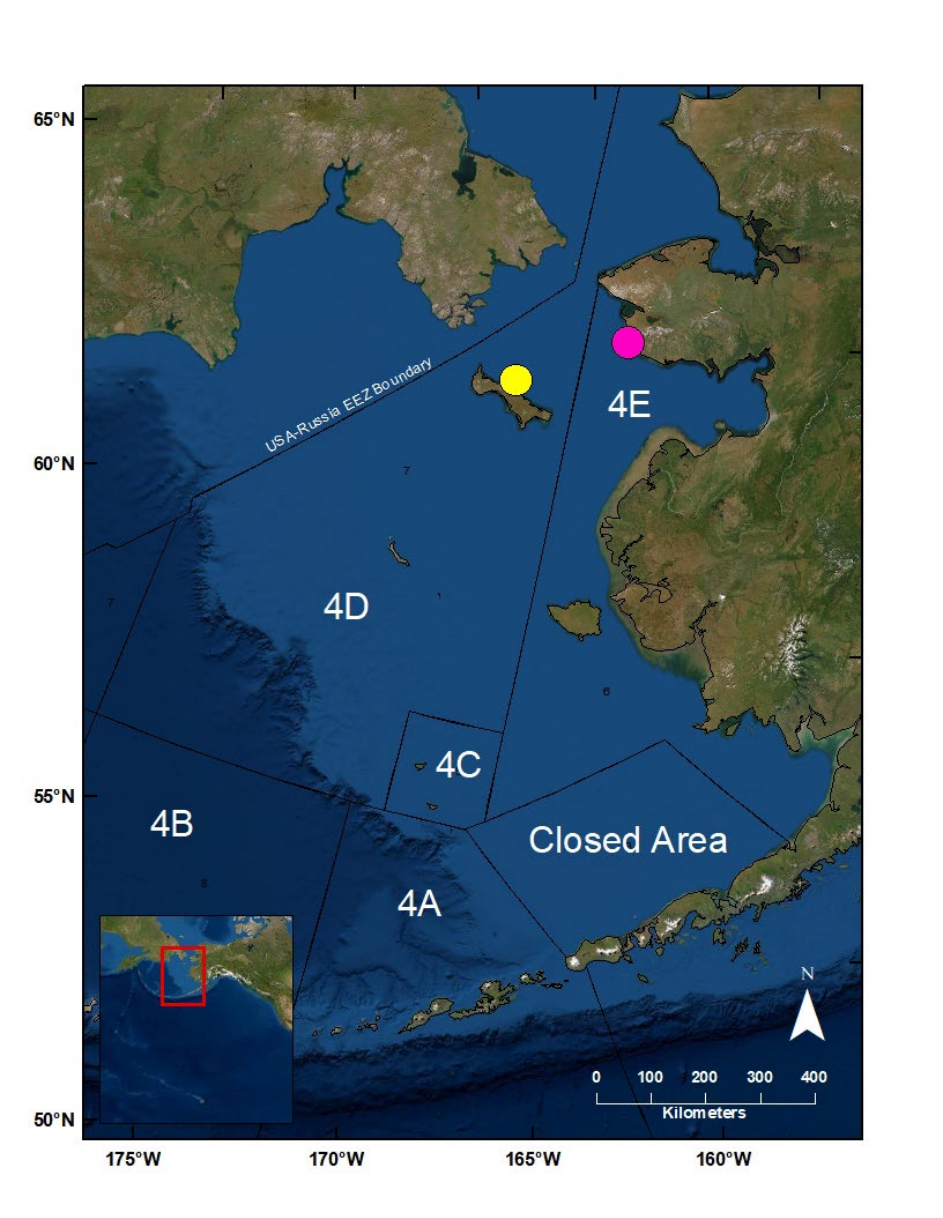


Objectives

1. Characterize occupied depth and temperature of Pacific halibut within the Northern Bering Sea
2. Identify annual movements and migratory timing of Pacific halibut in the region
3. Compare extent of movement to the scale of the current IPHC regulatory areas

Study Site

- All individuals were captured and tagged in waters near two Northern Bering Sea locations:
- Nome, located in Norton Sound (pink dot)
  - IPHC regulatory area 4E
- Savoonga, located on Saint Lawrence Island (yellow dot)
  - IPHC regulatory area 4D



Fish Capture

- Fishing efforts in July, August, and September
- All boats captained by local fishermen
  - Commercial longlining vessel for Nome tagging
  - Small subsistence and CDQ vessels in Savoonga
- Healthy, mature females (>100 cm FL), selected for tagging

Tagging Procedure

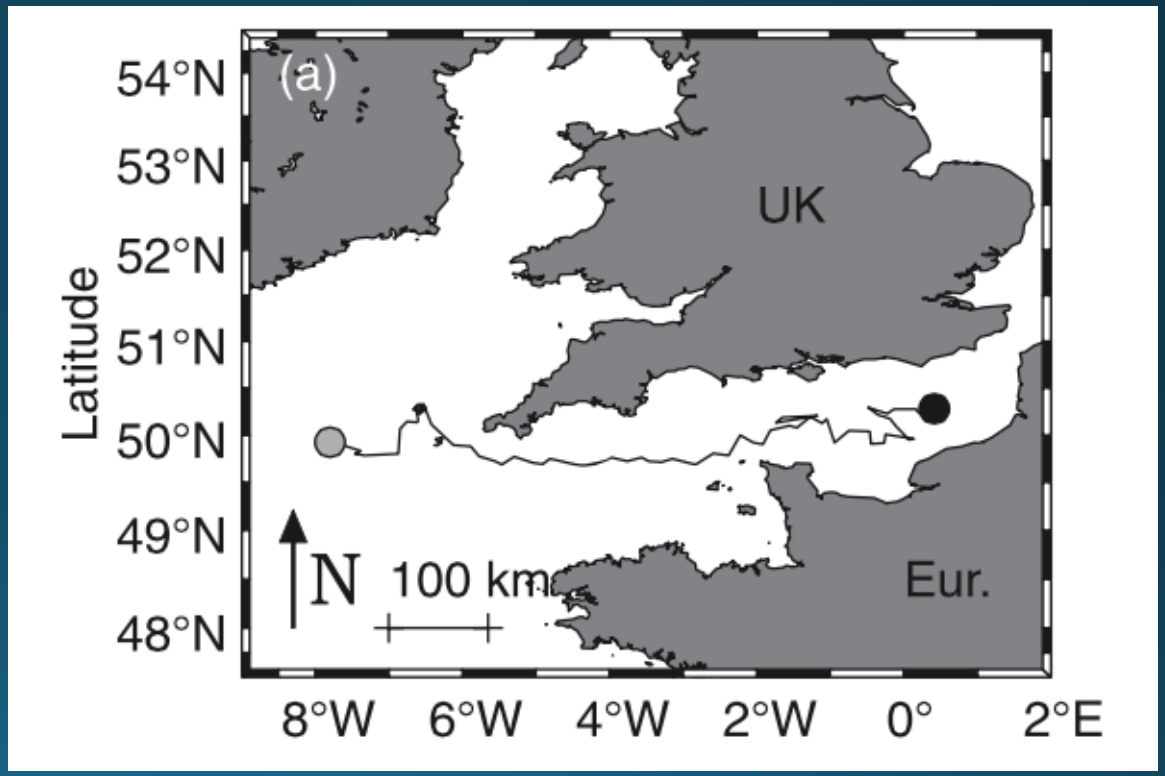
- Fork length measured
- Fish tagged using Wildlife Computers miniPATs
  - Pop-off satellite tags
  - Record depth, temperature, light intensity, and pop-off location
- Deployment schedules for winter spawning and summer foraging season pop-offs

Analysis: Habitat Occupancy

- Habitat occupancy evaluated through daily time series data
  - mean daily values by individual
- Aggregated across tagged individuals to assess population wide trends
- Identify movement states
  - Migratory/residency
- Pop-off locations will also be used to evaluate fish location 6-12 months at liberty
  - Calculate movement distance from deployment location

Analysis: Movement Tracks

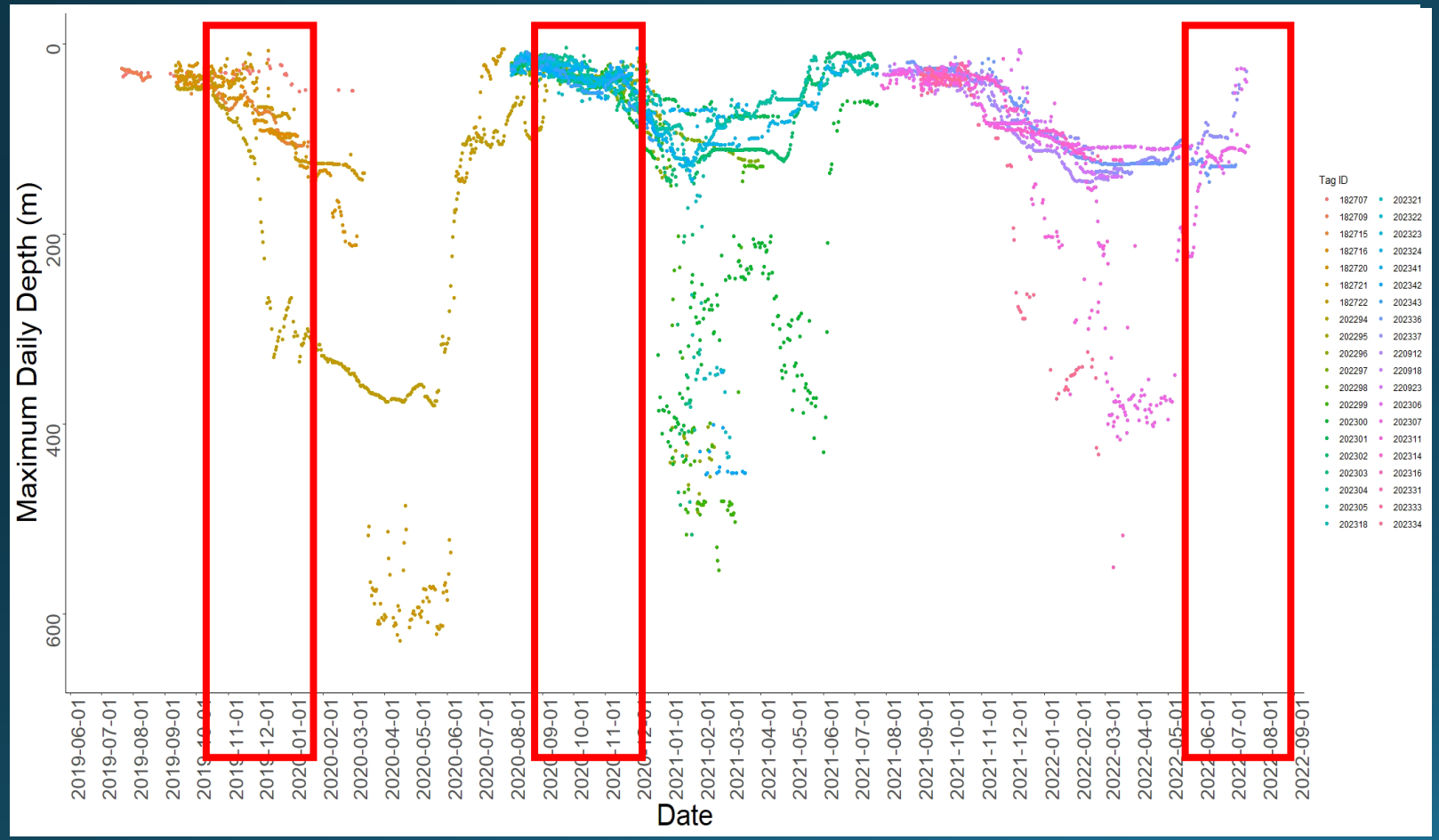
- Most likely daily locations were found from a Hidden Markov state-space model (HMM)
  - Pair observed data to environmental conditions
- Modified for use on demersal fishes in the Bering Sea
  - Constructs likelihood using maximum daily depth and longitude estimates from light intensity curves



Preliminary Results

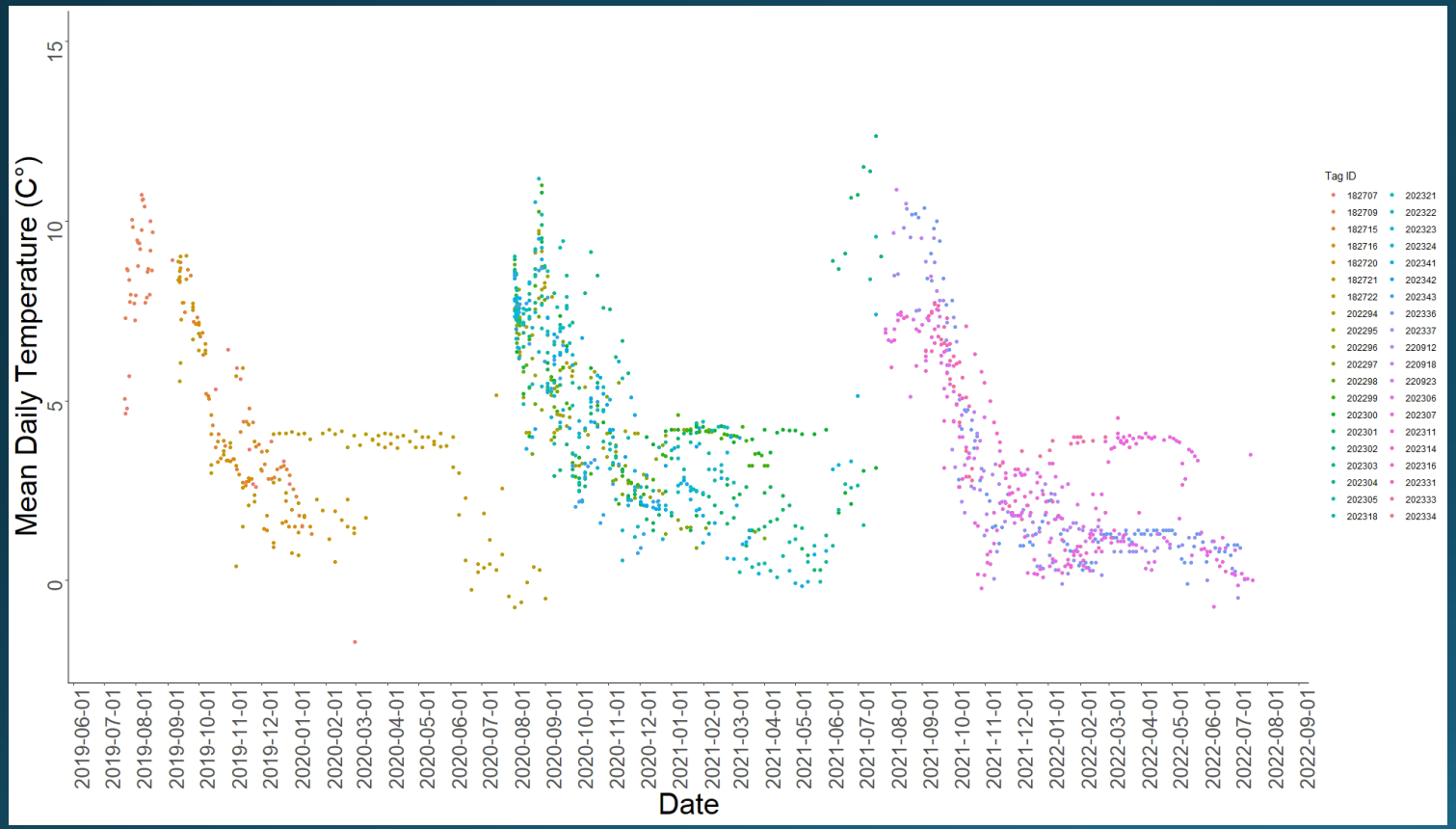
- A total of 59 satellite tags have been deployed
- 45 tags reported to satellites, transmitting variable amounts of usable data
  - Abnormally large number of tag failures, premature pop-offs, and poor data transmission likely due to faulty tag batteries and Bering Sea conditions

Depth Occupancy



- Individual mean daily depth records for all tags that transmitted time series data (n=40)
  - Highly variable during the winter and spring
- Aggregated mean daily depth indicates migration timing
  - Depart shallow waters in November
  - Reach deeper waters by February
  - Begin to return in May
  - Reach foraging grounds by August

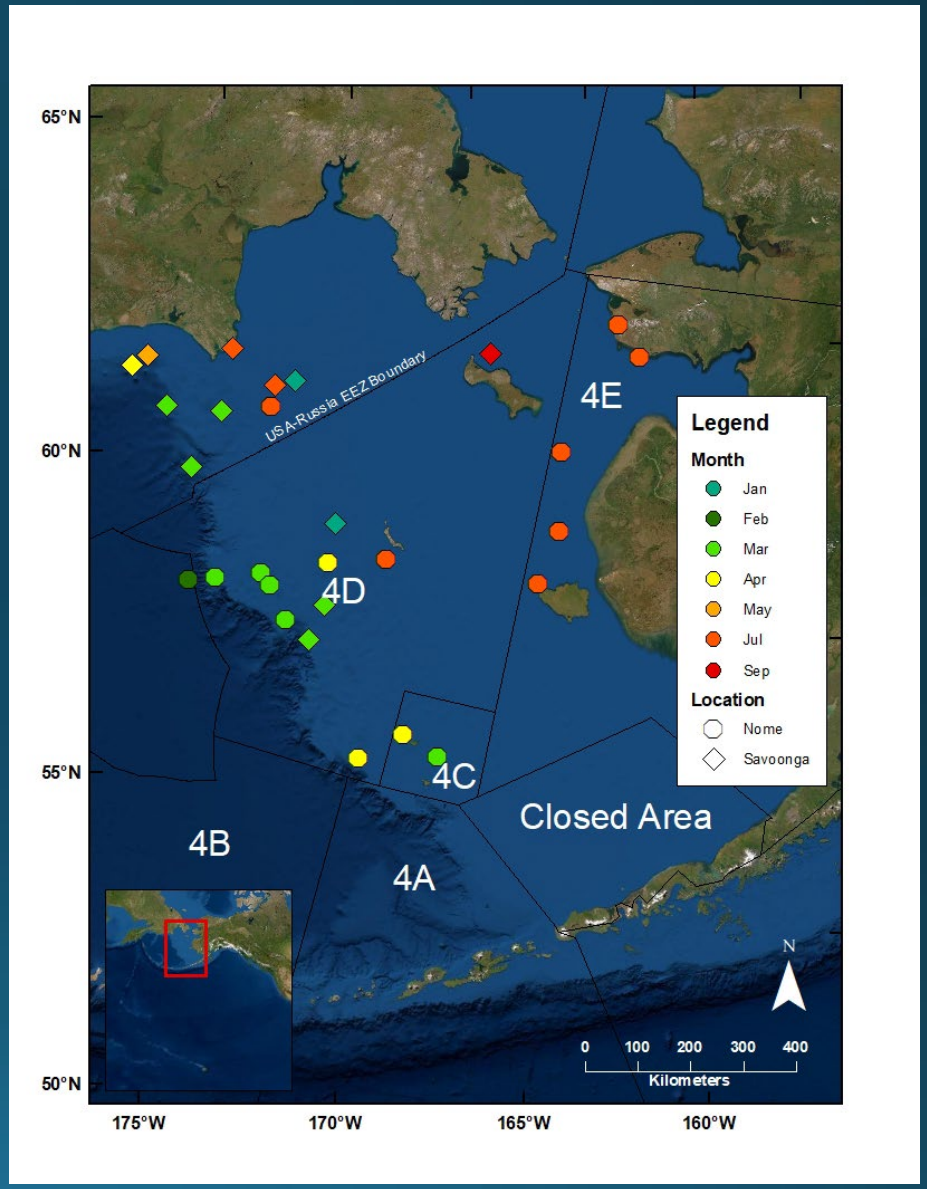
Temperature Occupancy



- Individual mean daily temperature records
  - Highly variable during the winter and spring
- Aggregated mean daily temperature
  - Cold water (<2°C) occupation during the winter and spring
  - Reach warmer shelf waters in July

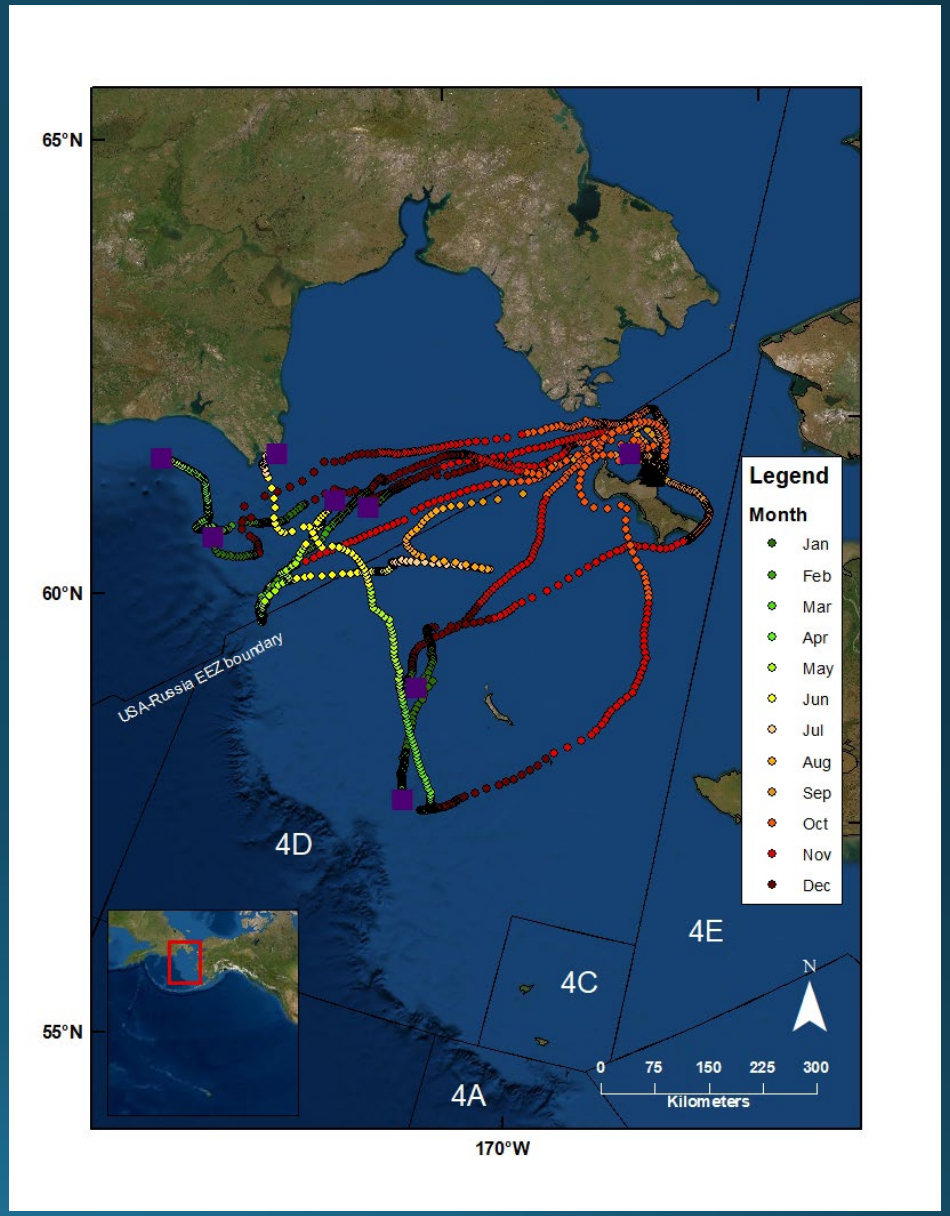
Pop-off Location

- A total of 28 usable locations
  - 16 from Nome
  - 12 from Savoonga
- Fish occupied the shelf edge from the Pribilof islands to the Russian maritime border
  - Winter linear displacement mean ± SD distance of 705.7 ± 158.9 km
- Fish return to approximate tagging location
  - Some pop-off locations indicate individuals were still in transit



HMM Tracks

- Weighted mean daily locations from HMM (n=24)
  - Color coded by month
- Nome fish occupy regulatory areas 4C, 4D, and 4E
- During the fall migration all Nome (4E) fish crossed into 4D
  - Some also entered 4C or Russian waters
- Most Savoonga (4D) fish entered Russian waters (75%)
  - The rest remained within 4D
- Movements occur during the commercial fishing season
- Fishery dynamics in Russia are unknown



Conclusions

1. Pacific halibut in the NBS exhibit large scale annual movements, but show fidelity to summer foraging grounds
2. NBS Pacific halibut winter across a wide range of the Bering Sea shelf edge
3. IPHC regulatory areas are not reflective of fish movements, where Pacific halibut annual migrations cross multiple management boundaries during the commercial fishing season
    A. Large proportion of fish display movements into Russian waters where exploitation rates and stock dynamics are not understood

Future Work

- 25 tags were deployed this past summer and will be analyzed following data transmission
- Results will be compared to findings from tagging work in the southern and central Bering Sea
- Following all data analysis, results will be used to inform a Management Strategy Evaluation for the Bering Sea