PACIFIC COD SATELLITE TAGGING UPDATE 2024

FREEZER LONGLINE COALITION SYMPOSIUM 2024

Susanne McDermott[1], Julie Nielsen[2] Charlotte Levy[3], Kimberly Rand[4], Bianca Prohaska[1], Sean Rohan[1], Jim Armstrong[5]

[1]Alaska Fisheries Science Center, [2]Kingfisher Marine Research, [3]Aleutians East Borough, [4]Lynker Technologies [5]FLC

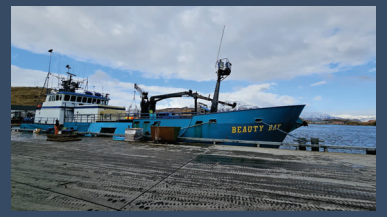
PAcific Cod Tagging (PACT) Collaborators and Funding Sources

Collaborators:

- Pacific Cod Harvesters
- Aleutians East Borough
- Freezer Longline Coalition
- Norton Sound Economic Development Corporation
- Native Village of Savoonga
- Adak Community Development Corporation

Other Funding Sources:

- North Pacific Research Board
- National Cooperative Research Program
- MSA funding
- Pacific States Marine Fisheries Commission

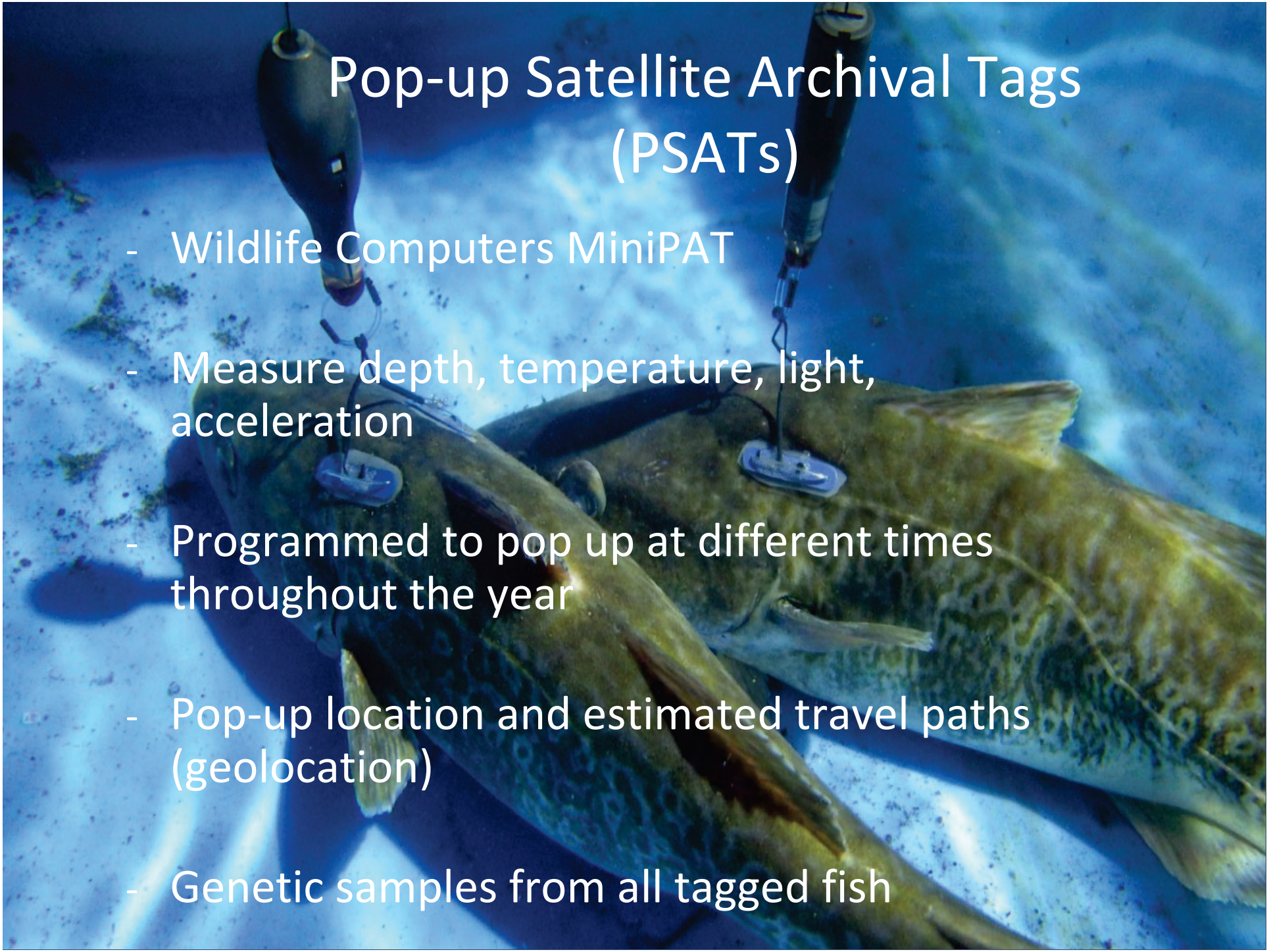


PACT Highest Research Priorities

- Seasonal connectivity between management areas
  - NBS/EBS
  - EBS/GOA
  - Western/Central GOA

Genetics

- Movement out of managed areas
  - Russia/Arctic
- Investigate nature of northward shift to NBS
  - Effects of warming waters on seasonal shifts in distribution
- Fish activity patterns
  - Diel, seasonal, geographic
  - Relate to diet



Pop-up Satellite Archival Tags (PSATs)

- Wildlife Computers MiniPAT
- Measure depth, temperature, light, acceleration
- Programmed to pop up at different times throughout the year
- Pop-up location and estimated travel paths (geolocation)
- Genetic samples from all tagged fish

Geolocation with PSAT data

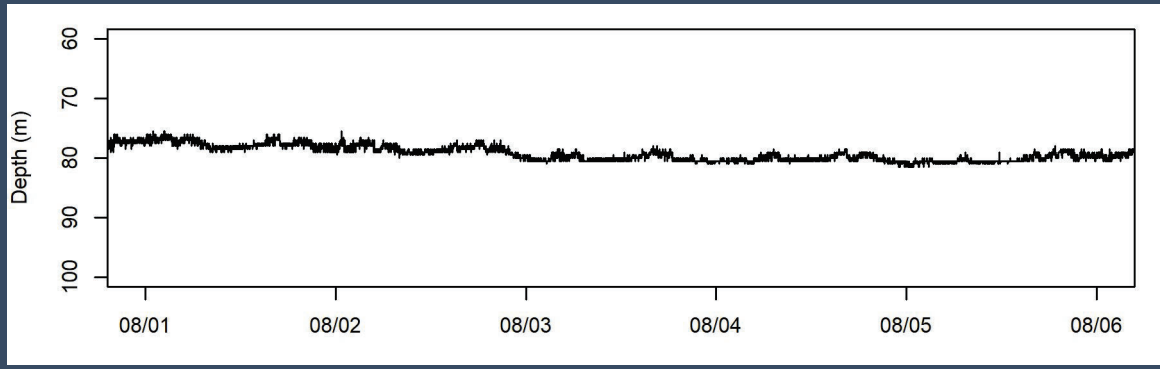
Release

Pop-up

PSAT data "clues"

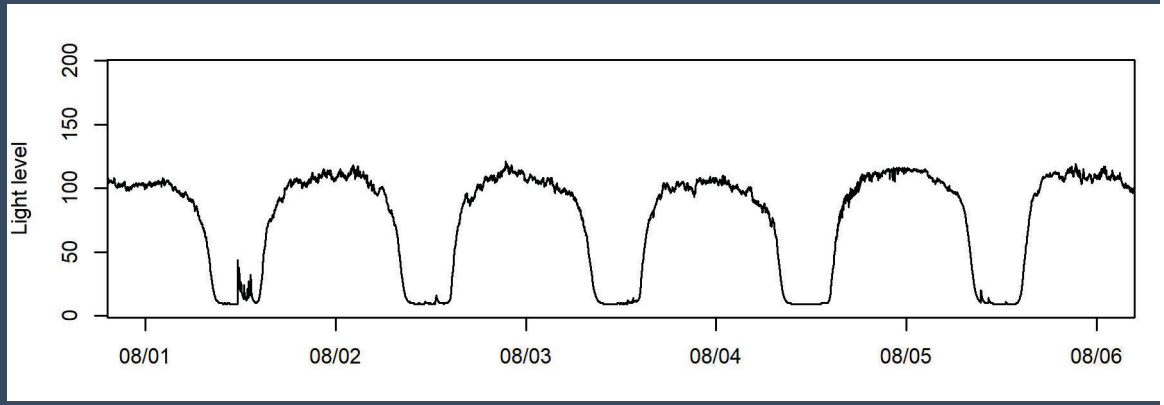
Depth:

- Maximum daily depth = ocean bottom
- Link to bathymetric map



Light:

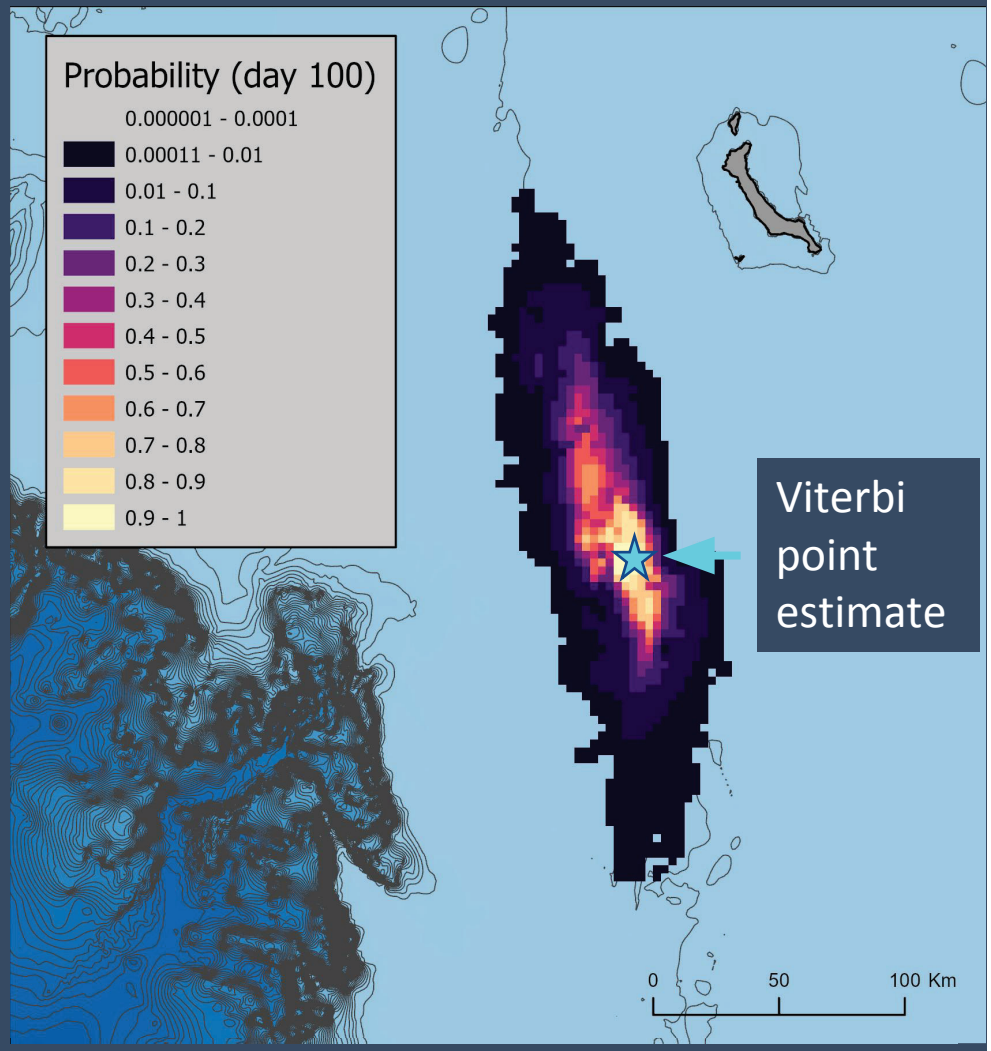
- Time of local noon = longitude
- Time of dusk and dawn = latitude



Geolocation

Hidden Markov model (HMM)*

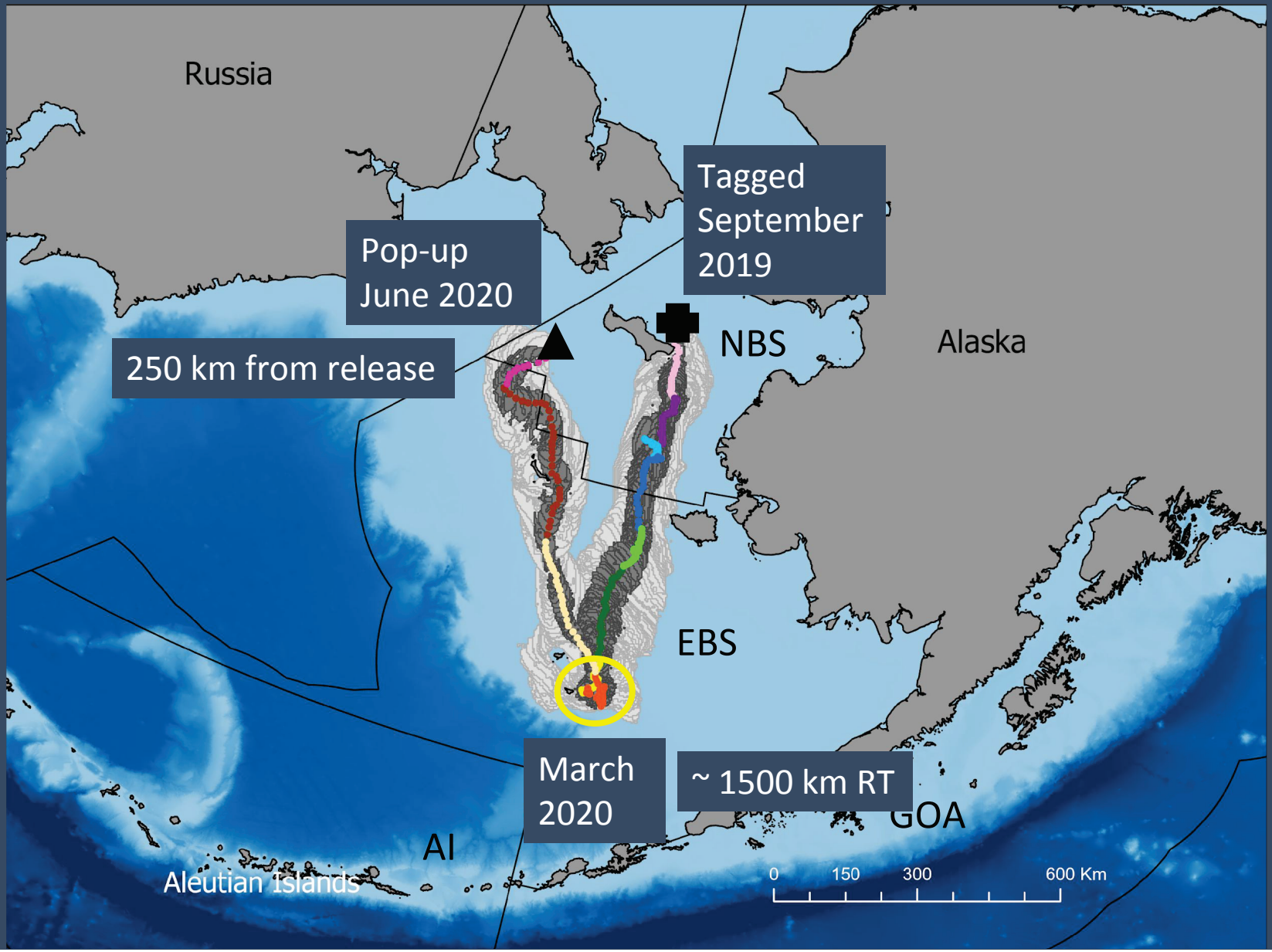
- Geolocation based on maximum daily depth and light-based longitude
- Study area: 3 km grid
- Individuals:
  - Probability in each study area grid cell each day
  - Viterbi point estimates: most probable sequence of grid cells occupied
- All tags: combine probabilities cell-wise for the same time period:
  - Spawning/foraging areas
  - Monthly probabilities by region



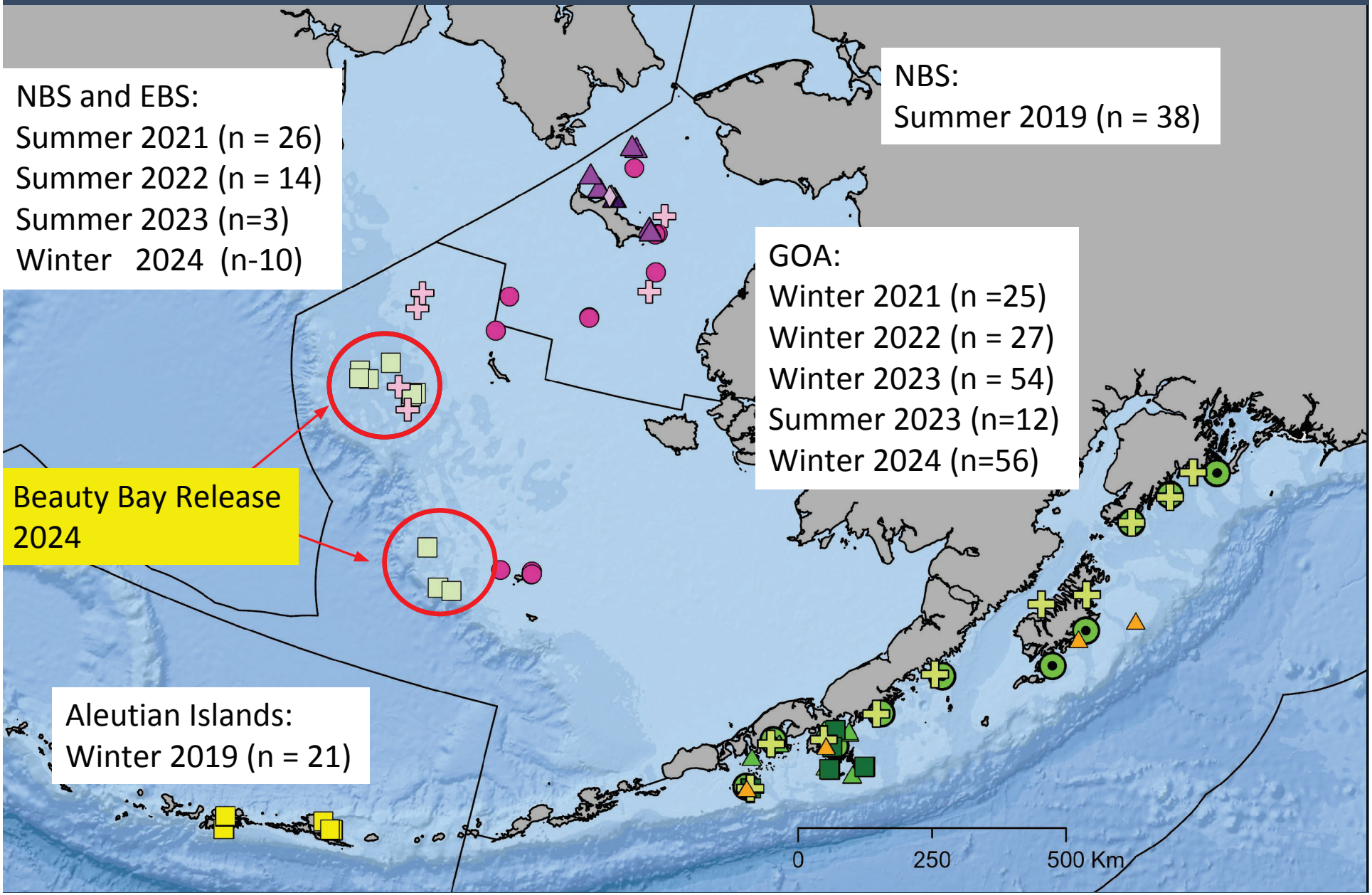
***Pedersen et al., 2008.** Geolocation of North Sea cod (*Gadus morhua*) using hidden Markov models and behavioural switching. Canadian Journal of Fisheries and Aquatic Sciences **65**:2367-2377.

Results: 2019 NBS (summer to winter and annual movement)

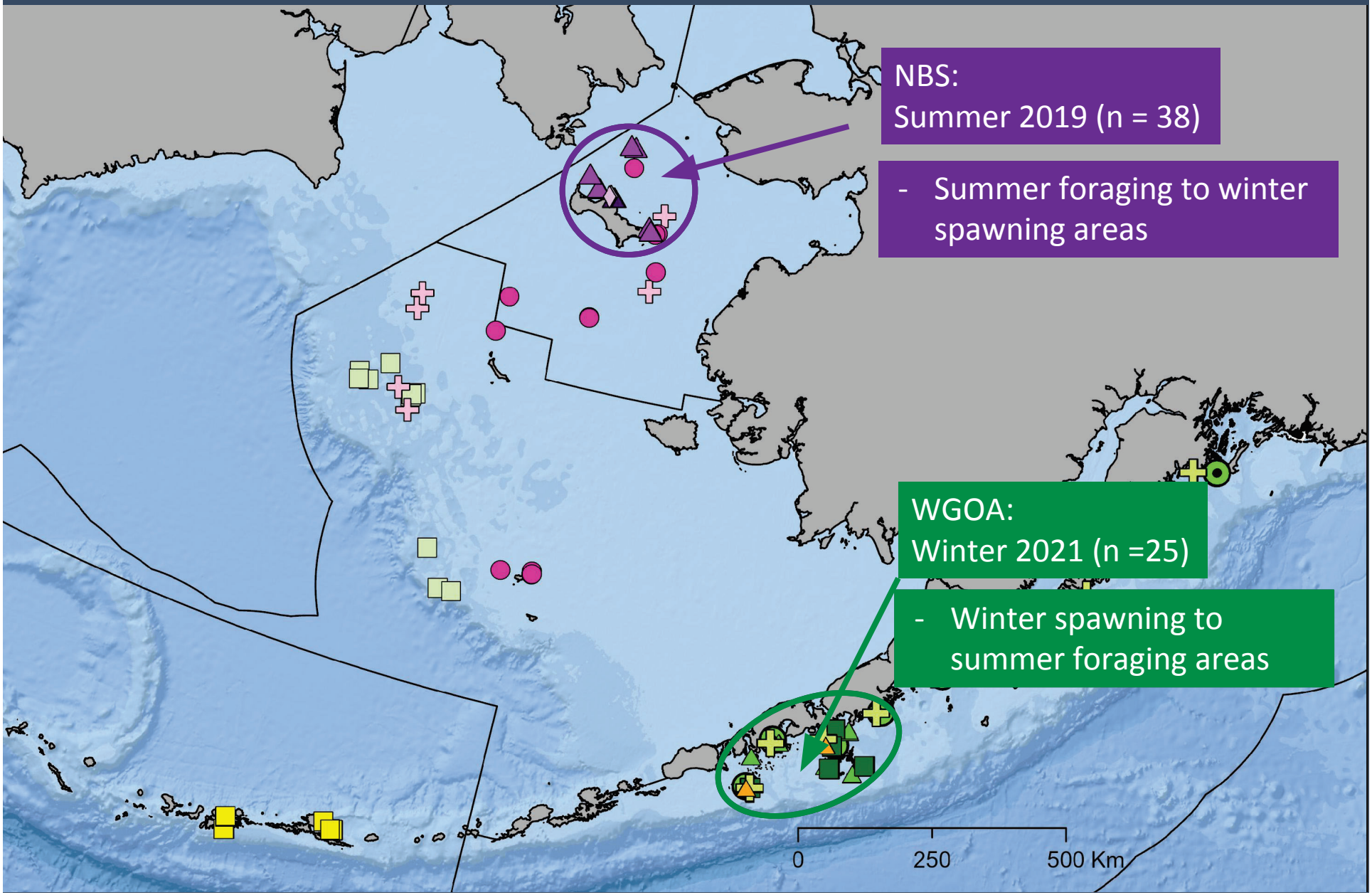
Estimated pathways



Pacific cod PSAT releases to date: n = 288



Pacific cod seasonal movement examples



Northern Bering Sea (NBS) capture and tagging

(Summer foraging to winter spawning)

August/September release

NOAA summer survey:
F/V Alaska Knight
F/V Vesteraalen

- Capture by rod and reel
- n = 30

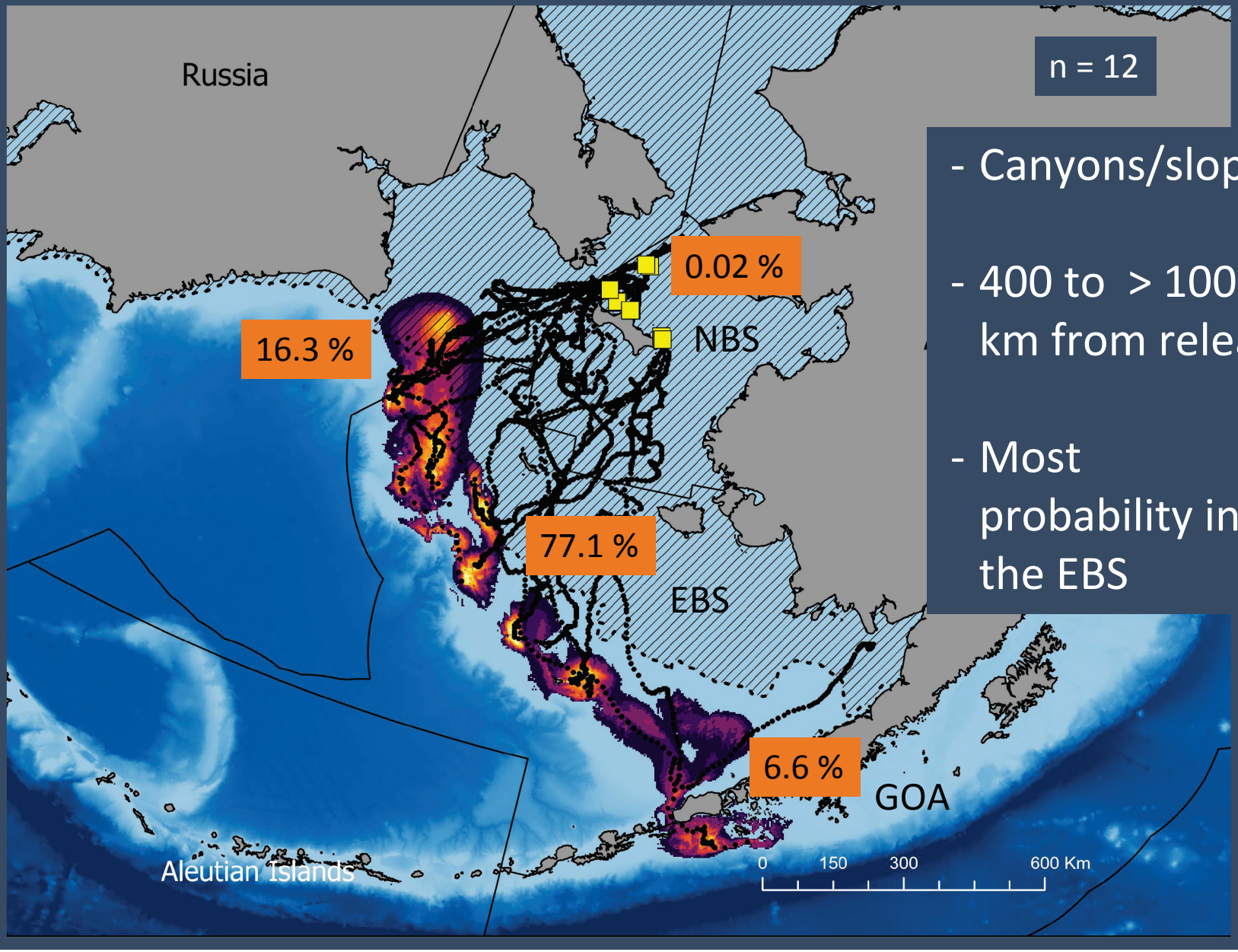
Native village of Savoonga:
Skiffs launched from shore

- Capture by hand line
- n = 8

Average depth = 30 m

Results: 2019 NBS (summer to winter and annual movement)

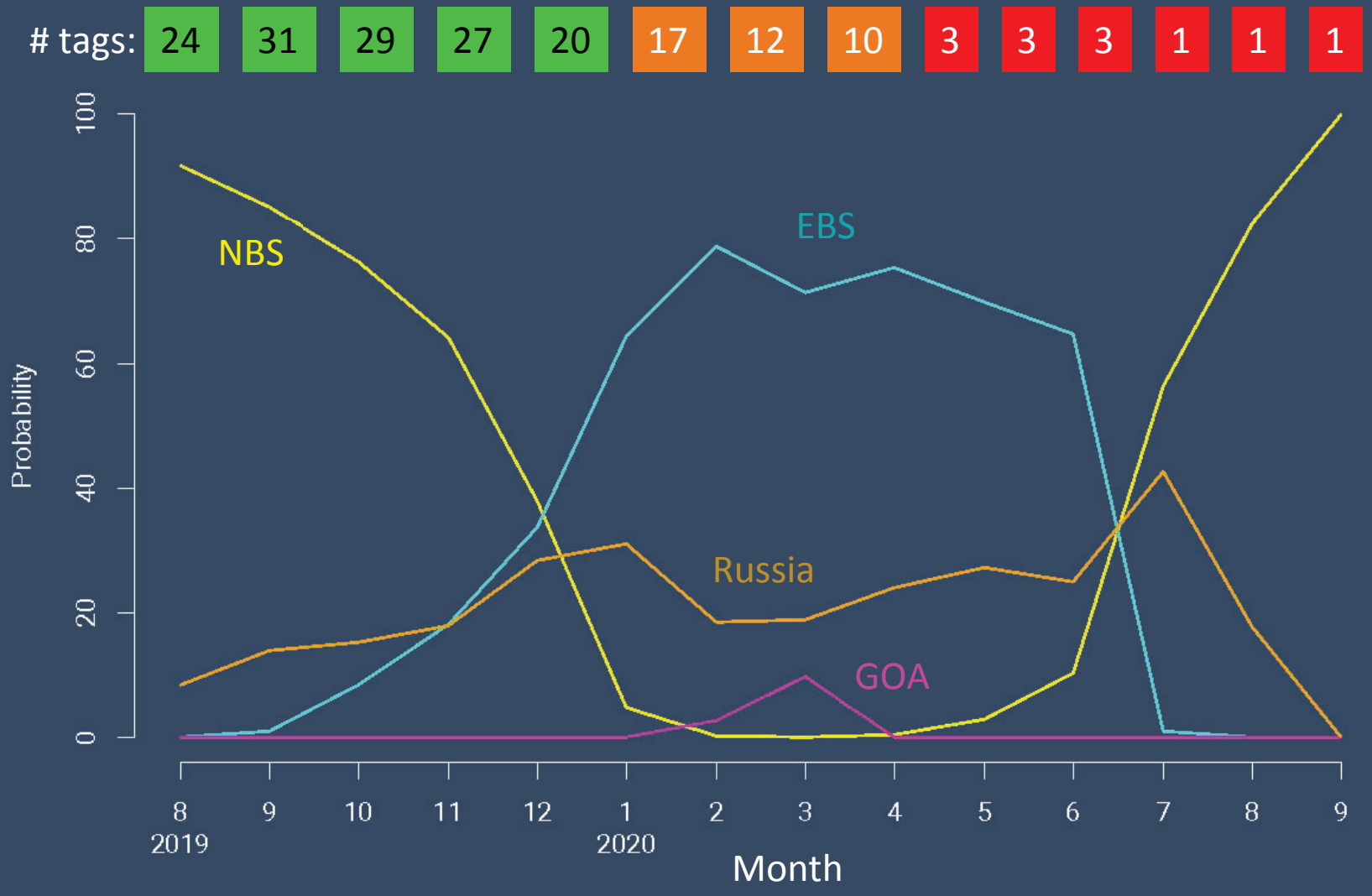
Probability during spawning (Feb 14 – March 31)



- Canyons/slopes
- 400 to > 1000 km from release
- Most probability in the EBS

Results: 2019 NBS (summer to winter and annual movement)

Monthly probability by region



Summary: 2019 NBS (summer to winter and annual movement)

- No evidence of cod overwintering in the NBS
  - Tagged fish moved out ahead of sea ice
- Substantial seasonal connectivity with EBS
  - Traditional spawning areas
- Some seasonal connectivity with GOA
- Some connectivity with Russia year-round
- 2021/2022 preliminary results similar

Western GOA capture and tagging

(Winter spawning to summer foraging)

March release

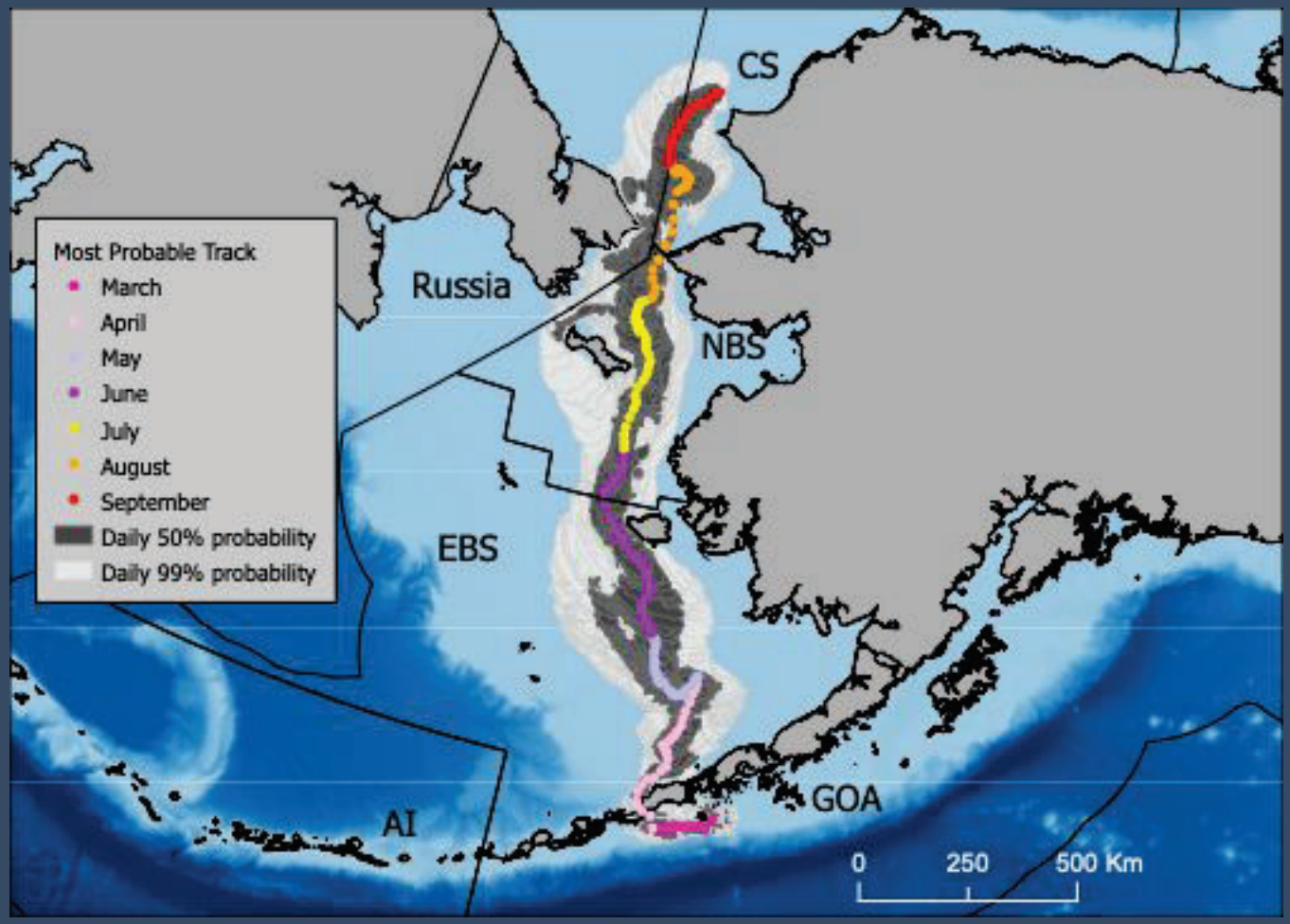
Chartered survey:
F/V Decision

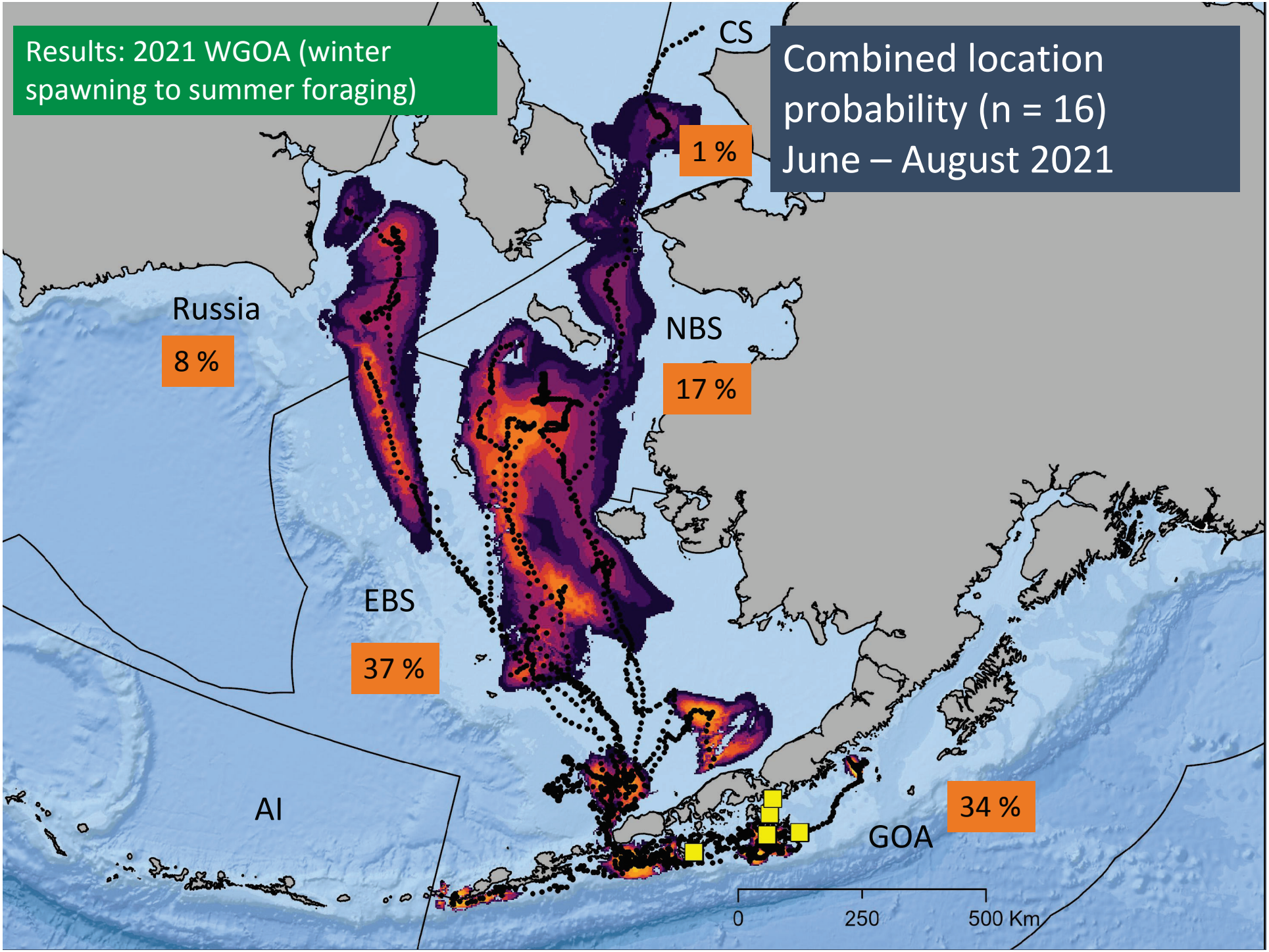
n = 25

- Capture in pots
- Allowed to off-gas
- Depths < 100 m
- Released with descender
- Biological samples collected
- Conventional tags released

Results: 2021 WGOA (winter spawning to summer foraging)

Estimated pathways

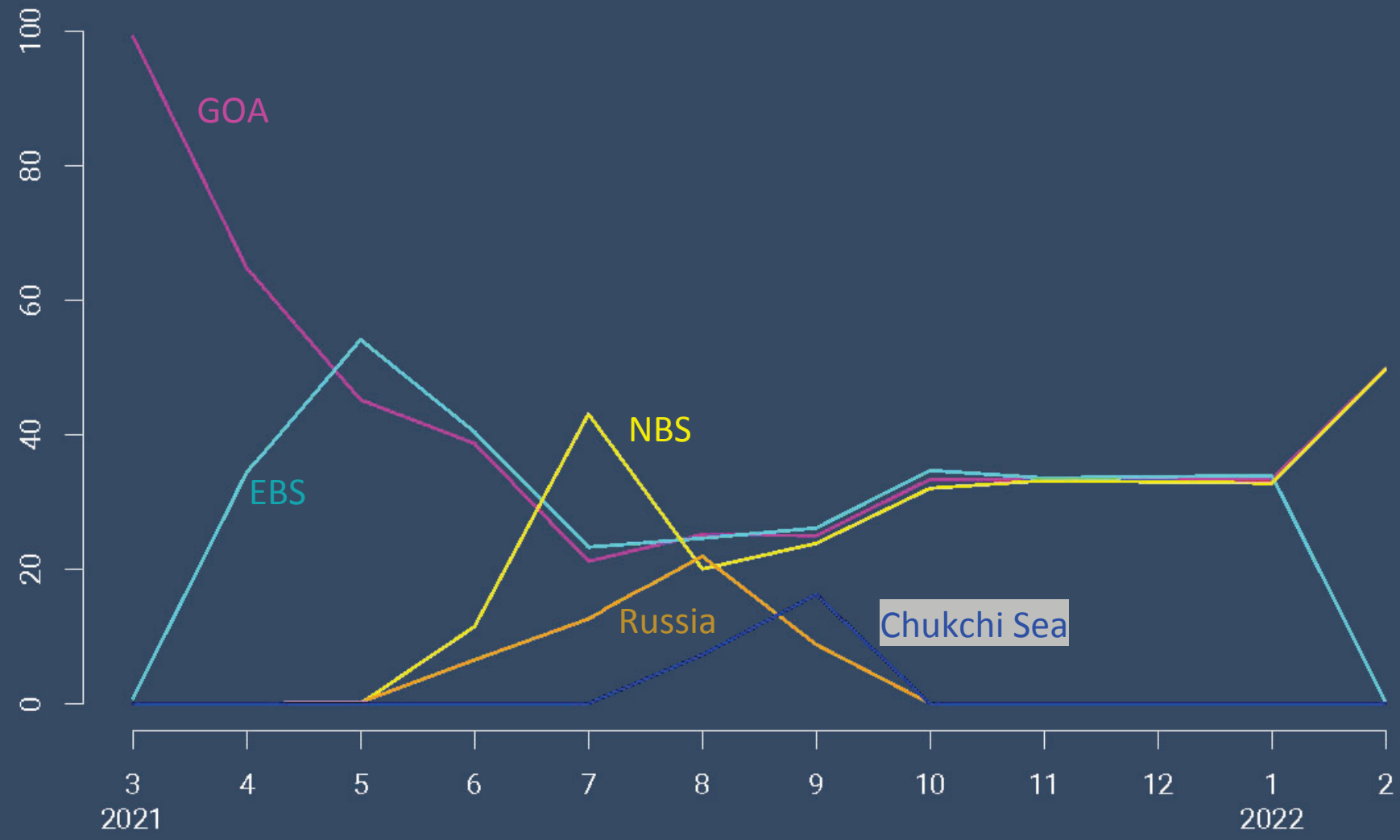


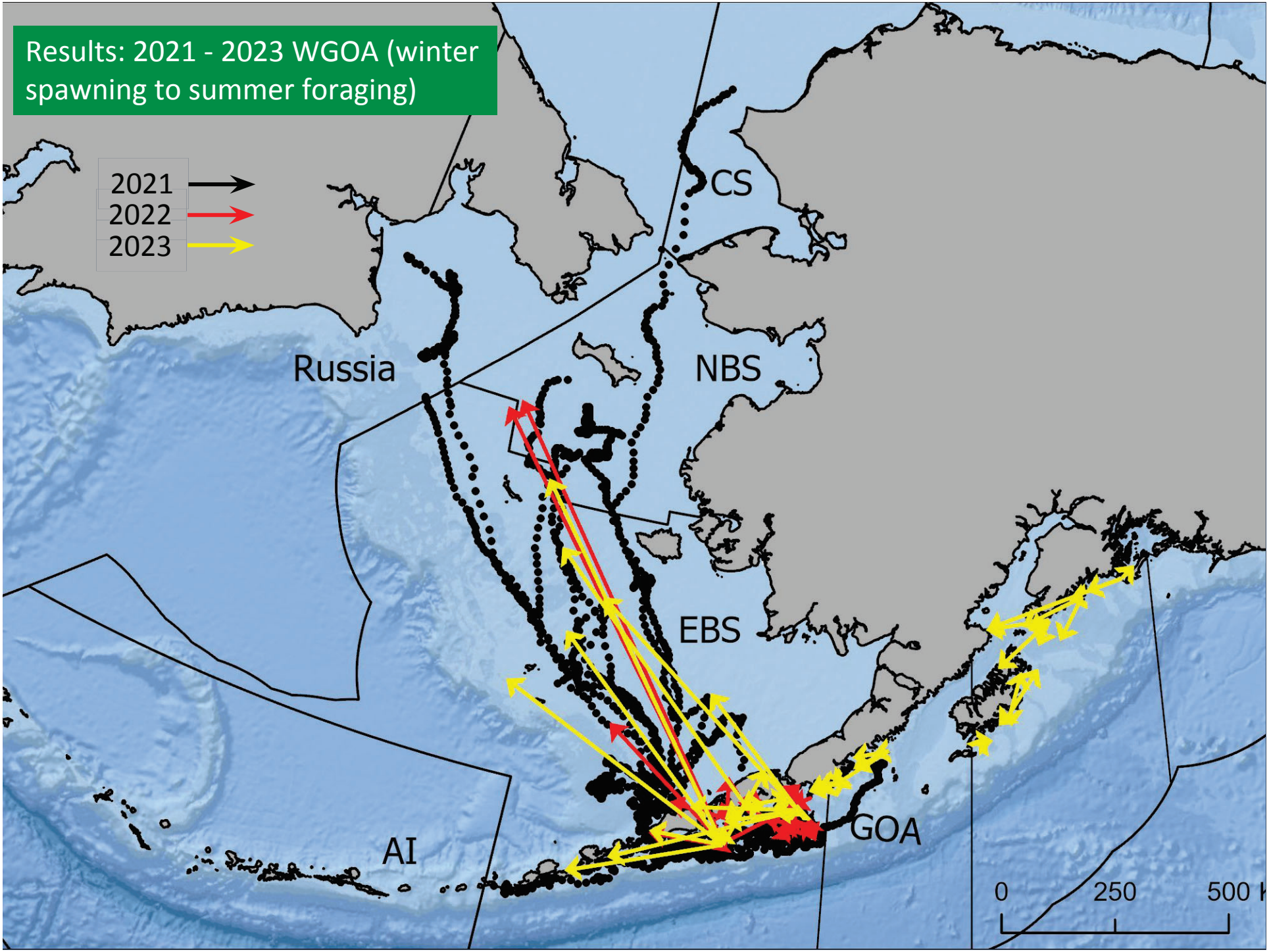

Results: 2021 WGOA (winter spawning to summer foraging)
Combined location probability (n = 16) June – August 2021
CS
1 %
Russia
8 %
NBS
17 %
EBS
37 %
AI
34 %
GOA
0
250
500 Km

Results: 2021 WGOA (winter spawning to summer foraging)

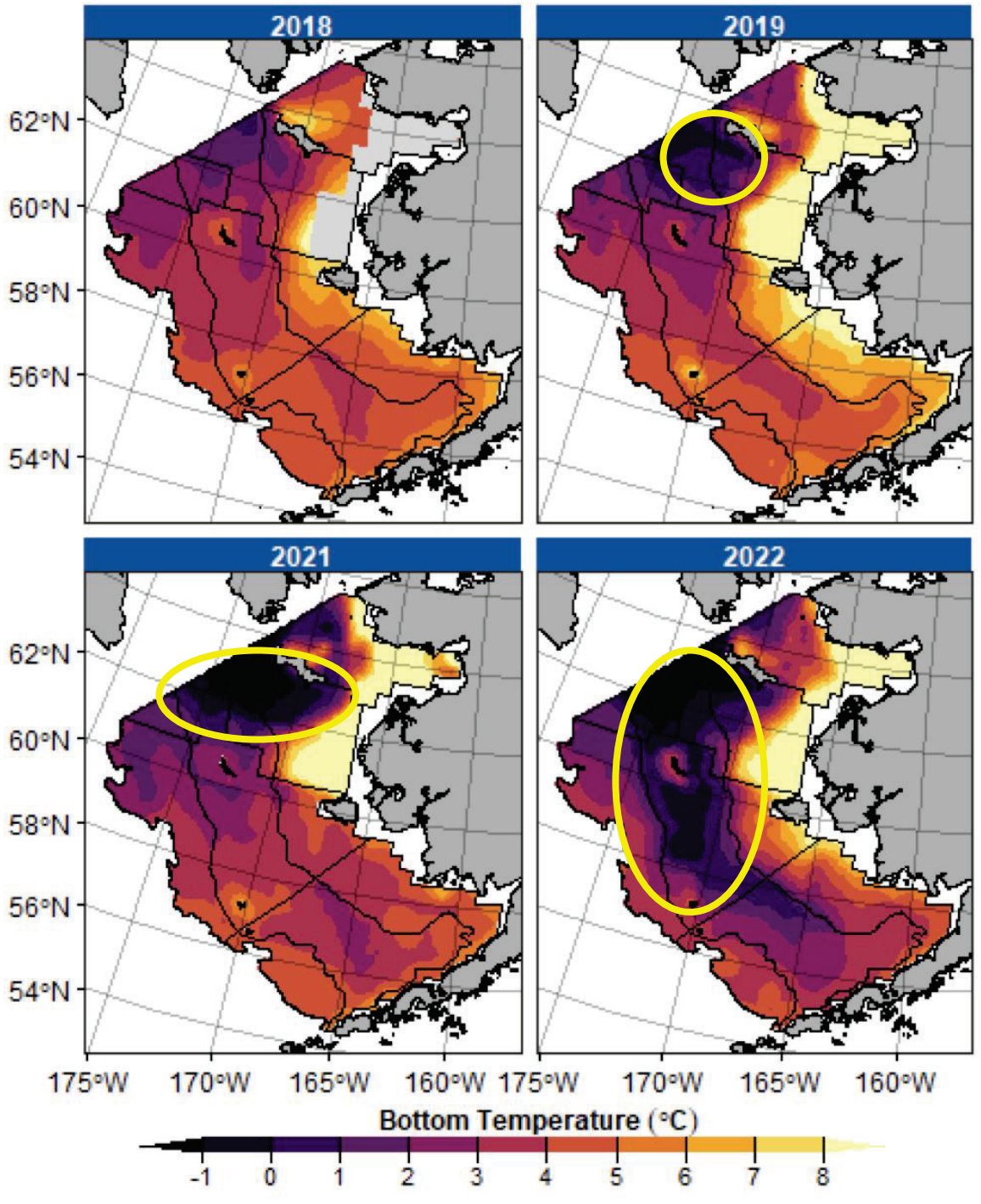
Monthly probability by region

# tags:	23	22	20	16	8	6	4	3	3	3	3	2




Results: 2021 - 2023 WGOA (winter spawning to summer foraging)
2021
2022
2023
CS
Russia
NBS
EBS
AI
GOA
0
250
500

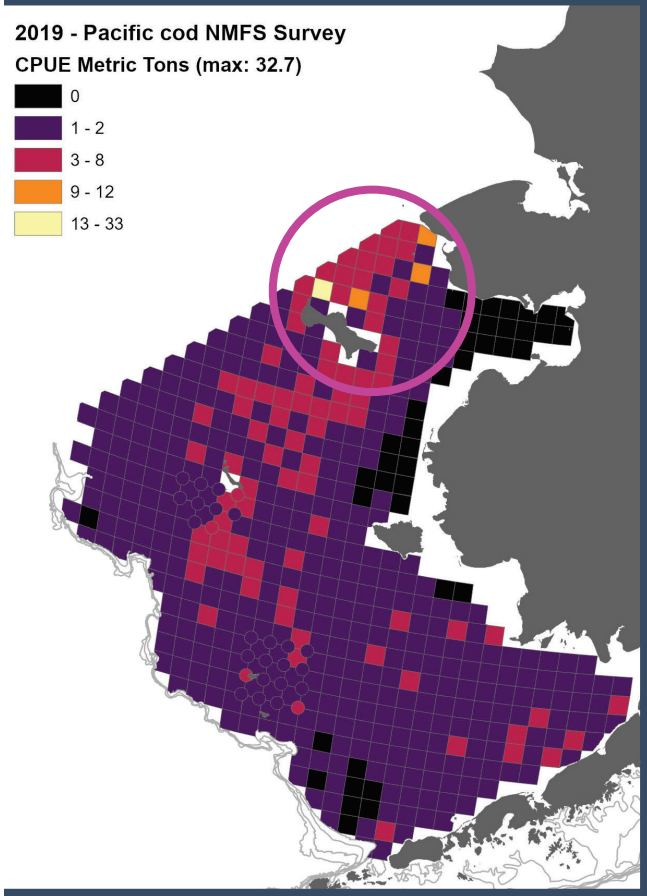
Bering Sea bottom temperature



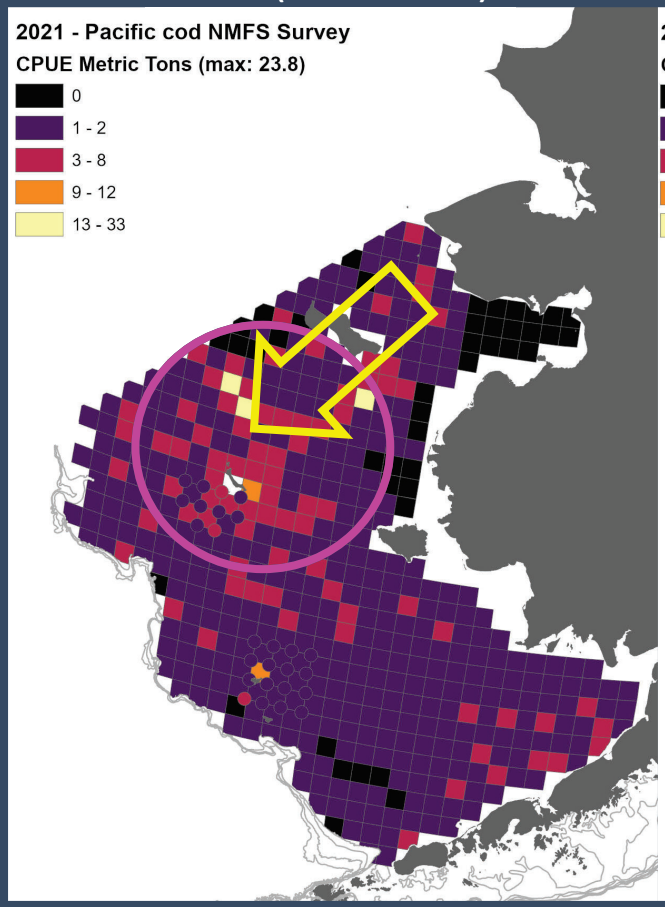
Courtesy of Sean Rohan, NOAA AFSC

Pacific cod distribution in summer survey

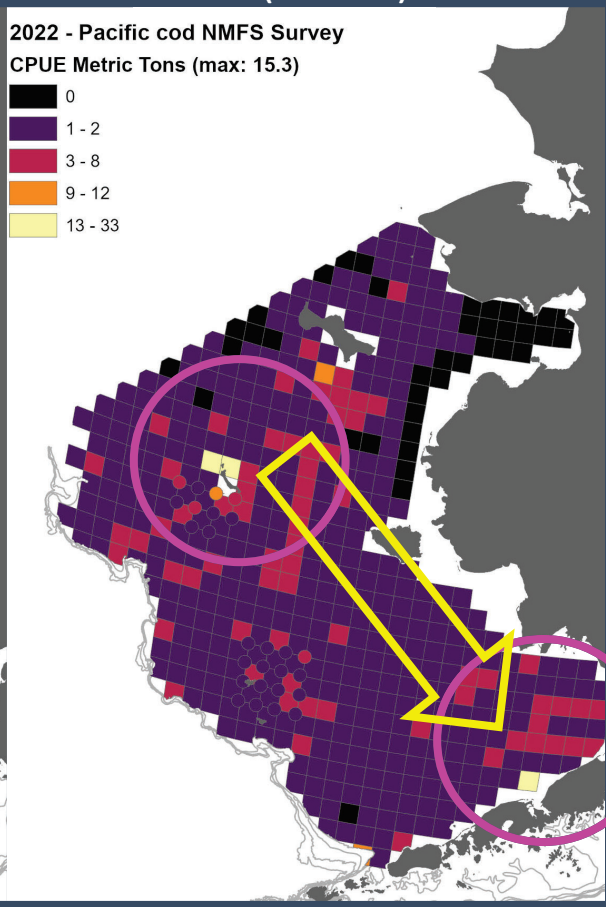
2019 (very warm!)



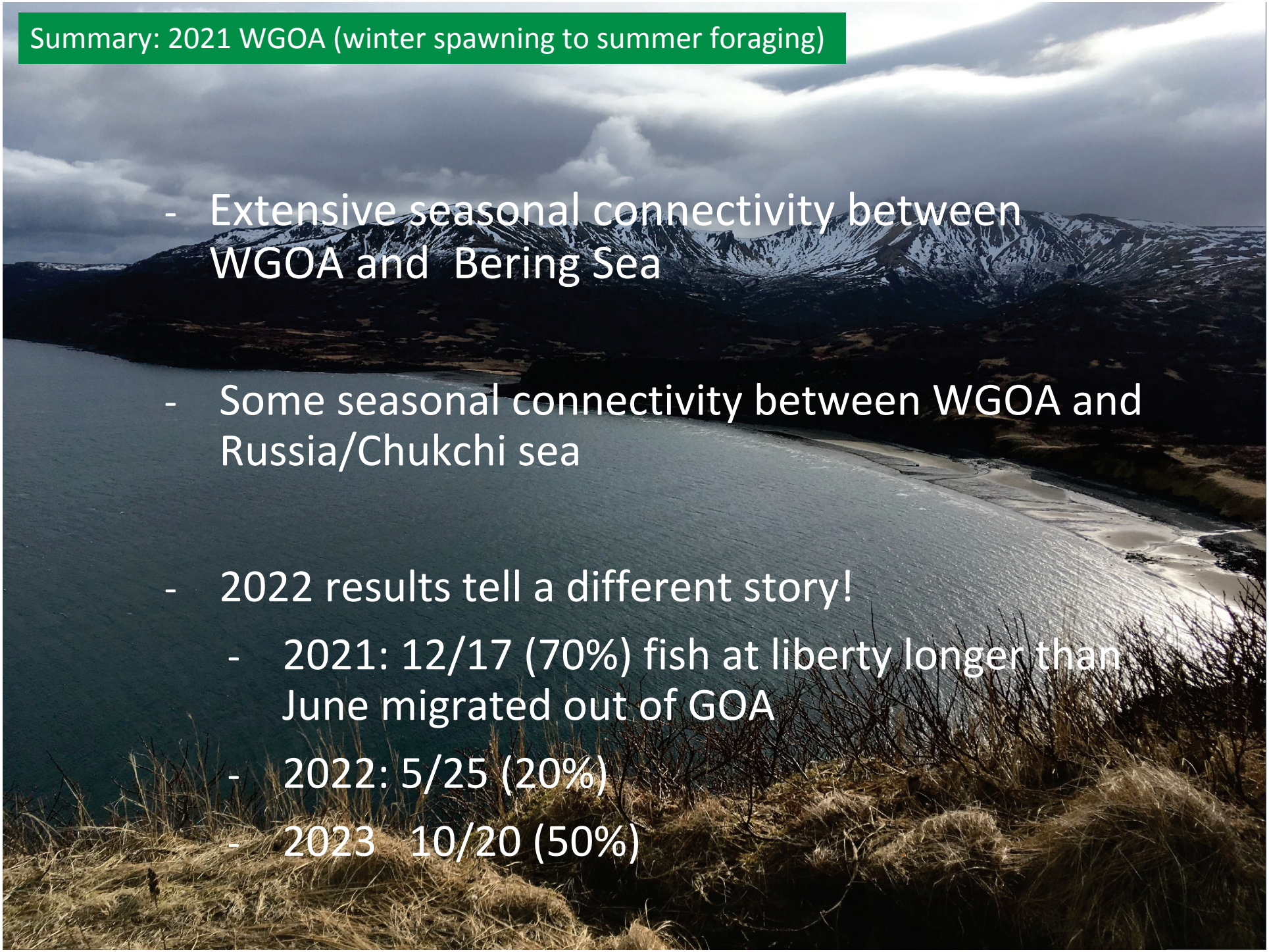
2021 (still warm)



2022 (colder)

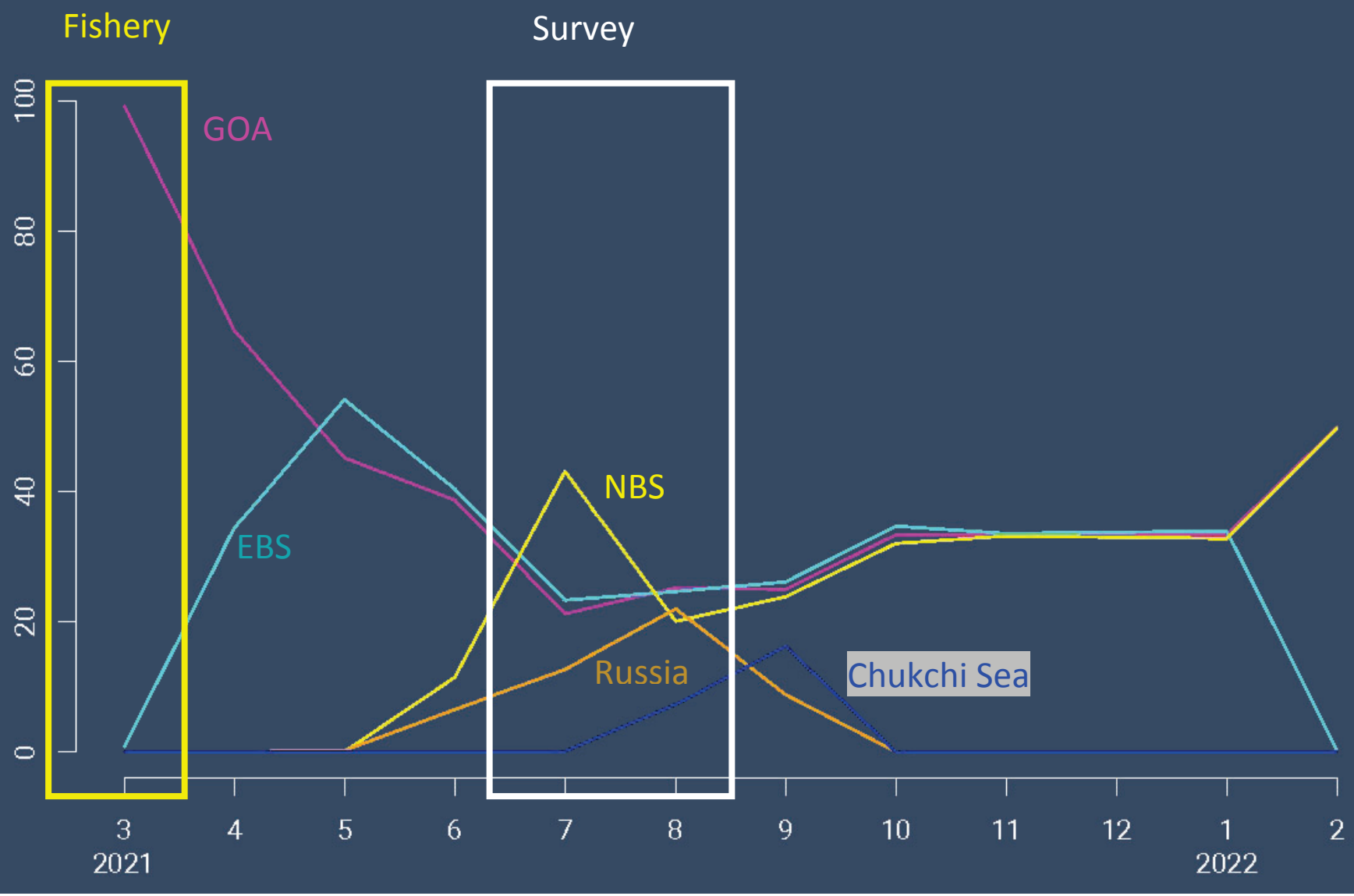


Summary: 2021 WGOA (winter spawning to summer foraging)

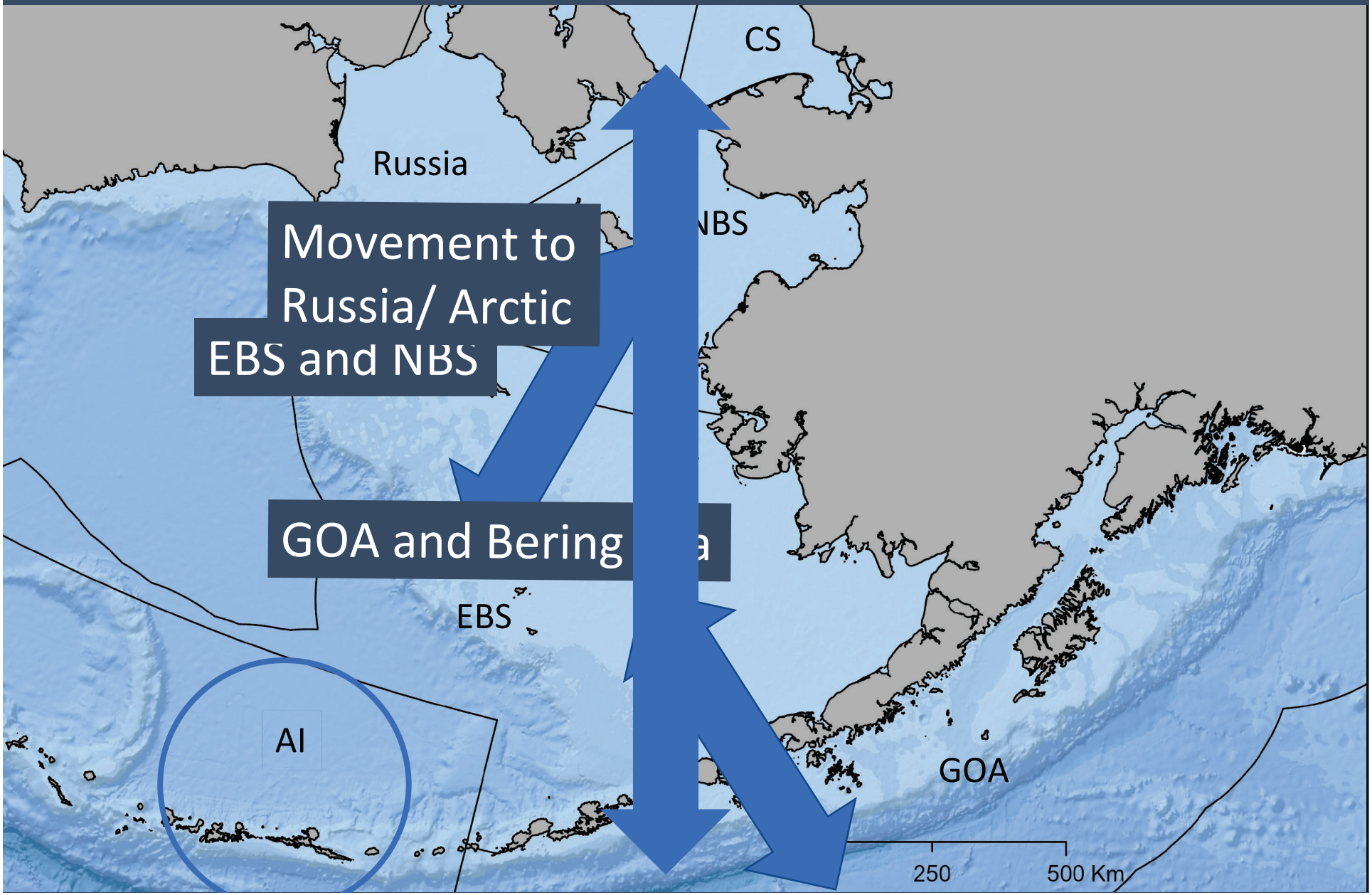


- Extensive seasonal connectivity between WGOA and Bering Sea
- Some seasonal connectivity between WGOA and Russia/Chukchi sea
- 2022 results tell a different story!
  - 2021: 12/17 (70%) fish at liberty longer than June migrated out of GOA
  - 2022: 5/25 (20%)
  - 2023 10/20 (50%)

Management implications: seasonal change in distribution



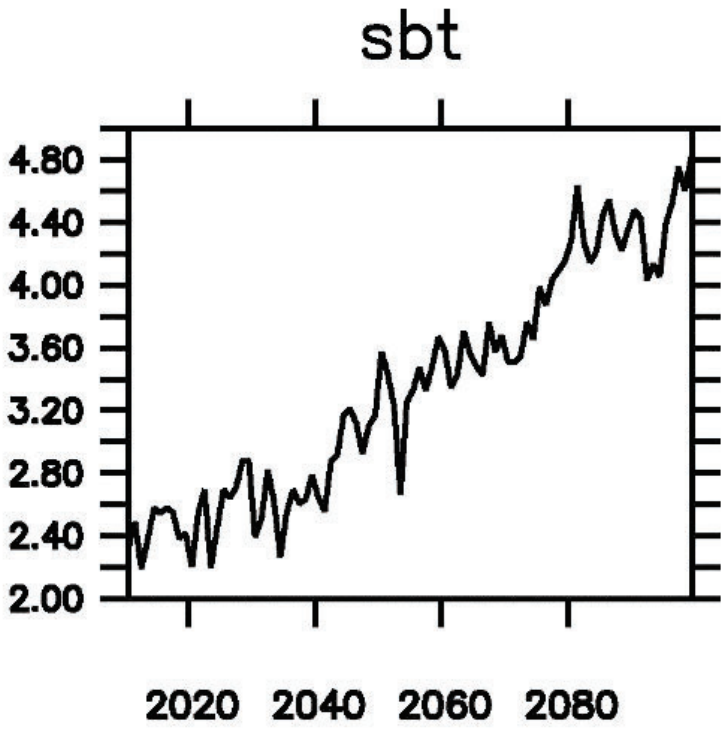
Management implications: seasonal connectivity



Management implications: connectivity may vary with temperature regime

- Increasing temps = increasing connectivity with Russia and Arctic?
  - Trans-boundary stock issues
  - Movement out of surveyed areas
- More research in different years to determine mechanisms and predict connectivity under different scenarios
  - Sea ice extent?
  - Prey distribution?
  - Cold pool temps not a physiological barrier….

Bering Sea bottom temperature predictions under “no change” scenario



JOURNAL ARTICLE

Projected biophysical conditions of the Bering Sea to 2100 under multiple emission scenarios

Albert J Hermann ✉, Georgina A Gibson, Wei Cheng, Ivonne Ortiz, Kerim Aydin, Muyin Wang, Anne B Hollowed, Kirstin K Holsman

ICES Journal of Marine Science, Volume 76, Issue 6, November-December 2019, Page 1937, https://doi.org/10.1093/icesjms/fsz111
Published: 09 June 2019

Current and Future Research

- Current:
  - Annual movement (site fidelity)
  - Behavior
  - Genetics
  - Diet
  - Spawning phenology
  - Movement modeling with habitat preference
- Future:
  - GOA releases during summer
  - More summer releases in Bering 2024
  - Winter releases in the Bering with industry collaboration
  - Collaboration with stakeholders to answer cod related questions

Thank you!

AFSC survey charter vessels and crew (F/V Vesteraalen and F/V Alaska Knight)

Savoonga fishermen and plant personnel
F/V *Decision* (Capt. Kiley Thompson and crew)
F/V *Beauty Bay* (Capt. Scott Hansen and crew)

Cooperative Partners:
Aleutians East Borough
Norton Sound Economic Development Corporation
Freezer Longline Coalition
Pacific Cod Harvesters

NMFS Scientific personnel:
Duane Stevenson
Cecilia O'Leary
Ned Laman
Adriana Meyers
Nicole Charriere
Jennifer Gardner
Cynthia Yeung
Reyn Yoshioka
Lukas DeFilippo
Chris Long
Emily Ryznar

Comments? Questions?
Susanne.McDermott@noaa.gov

Spawning Phenology