Science, Service, Stewardship

Observations of seasonal movement from a single tag release group of Pacific cod (*Gadus macrocephalus)* in the eastern Bering Sea

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Objectives

- We examined Pacific cod tag recoveries for seasonal movement patterns, using the commercial fishery as a proxy for cod distribution

- Tested for seasonal differences in the dispersal of Pacific cod (e.g. measure of distance between release and recovery in the fall and spring)

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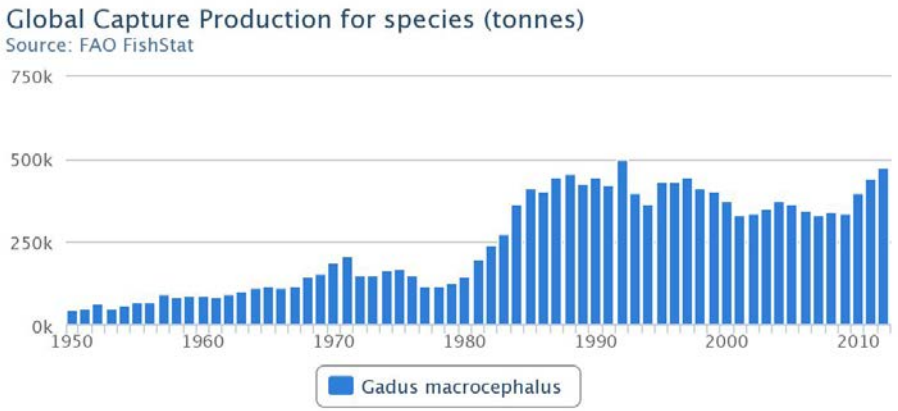
Background

The Pacific cod fishery is the 3rd largest commercial fishery (by volume) in the US and the 2nd largest fishery in Alaska

Two studies on Pacific cod movement in the Bering Sea:

- Shimada and Kimura (1994) studied seasonal movement
- Nichol et al 2013 investigated vertical movement



Global capture of Pacific cod in tonnes reported by the FAO, 1950–2010

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Background

We know there is cod movement between the Bering Sea, Aleutian Islands and the Gulf of Alaska (GOA).

- Genetics supports little exchange between the Aleutians and the Bering Sea.
- The magnitude of cod exchange between the GOA and Bering Sea is unknown.

Until 2015, Pacific cod in the Aleutian Islands and Bering Sea have been managed as a single population.

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Background

- Pacific cod form dense aggregations across the Bering Sea between January and April to spawn.

- Spawning locations in the Bering Sea were identified by Neidetcher et. al (2014)

- 38% of Pacific cod catch in the Bering Sea is caught by trawling (2013)

- 70% of the trawl quota is captured between January and April (2013), during the cod spawning season

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Importance of fish movement

Atlantic cod *(Gadus morhua)*

- several studies showed that even though western Atlantic cod are highly migratory, they showed strong site fidelity (Siceloff and Howell 2013)

- a strong factor that is believed to have contributed to the decline of western Atlantic cod is heavy fishing on spawning aggregations which decreased reproductive potential (through a complete loss of spawning sites)

- vulnerable to over exploitation because of predictability of timing (spawning), fine spatial scales and high density of fish per aggregation.

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Importance of fish movement

North Sea plaice (*Pleuronectes platessa*)

- undergo seasonal migrations but show strong homing capabilities and complete spawning site fidelity (Hunter et al. 2001).

- Management of the species was difficult because a portion of the stock moved in/out of the management area to spawn.

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Importance of fish movement

Why is understanding Pacific cod movement important?

- Direct impact on spatial management of the stock (e.g. what is the movement rate, if any, between the Aleutians and Bering Sea?)

- Impacts on the temporal management of the stock (e.g. effects of long term trawl fishing on spawning aggregations for a species that shows homing/site fidelity?)

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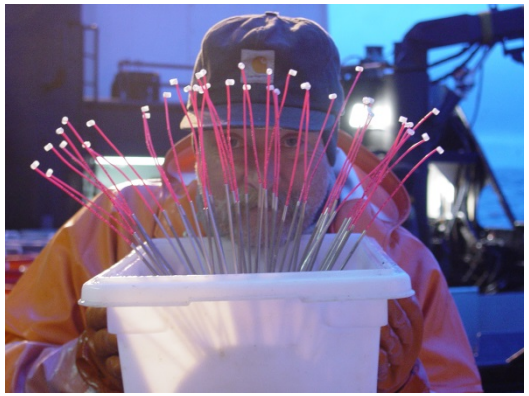
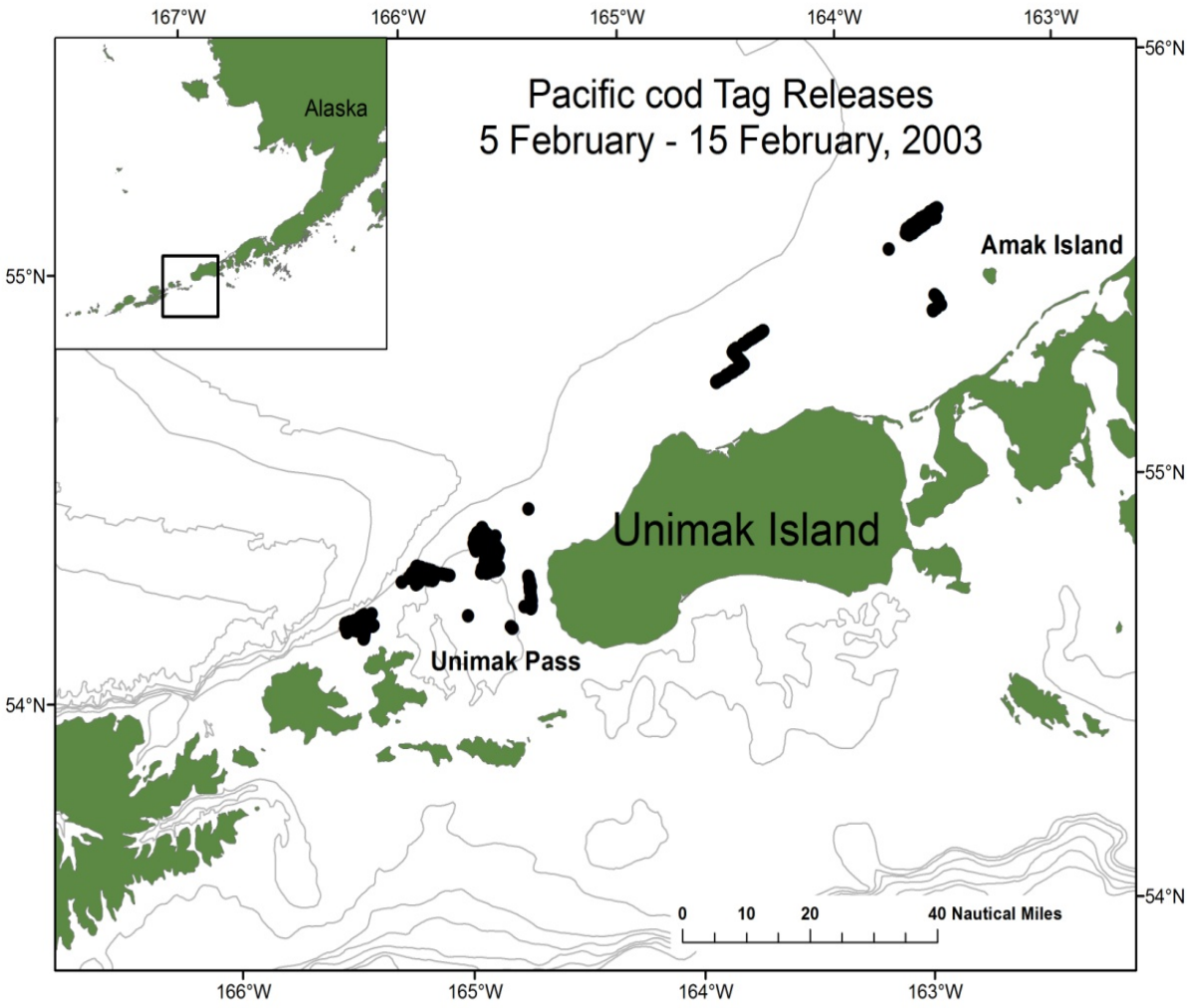
Methods

Over 3,400 Pacific cod were tagged and released near Unimak Pass, Alaska over a 10-day time period in February 2003.





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Methods

- Fish were captured using baited crab pots deployed on the seafloor
- Only tags recovered from freezer longliners and freezer bottom trawlers were used
- Only tags recovered from February 2003-April 2004 were used to capture one complete seasonal cycle of cod movement (*n=693*).

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Methods

We defined 5 seasonal tag recovery periods:

- **Spring 2003 (February – April)**
- **Summer 2003 (May – July)**
- **Fall 2003 (August – October)**
- **Winter 2003/2004 (November – January)**
- **Spring 2004 (February – April)**

Summer of 2003 time period – alternative observation of cod distribution from NMFS bottom trawl survey

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Methods

Tags recovered and total cod catch were spatially organized on a 20 X 20 km grid

For each grid cell, in each season:

$$\frac{\text{Total number of tagged fish recovered}}{\text{Total number of cod captured by the 2 fleets}}$$

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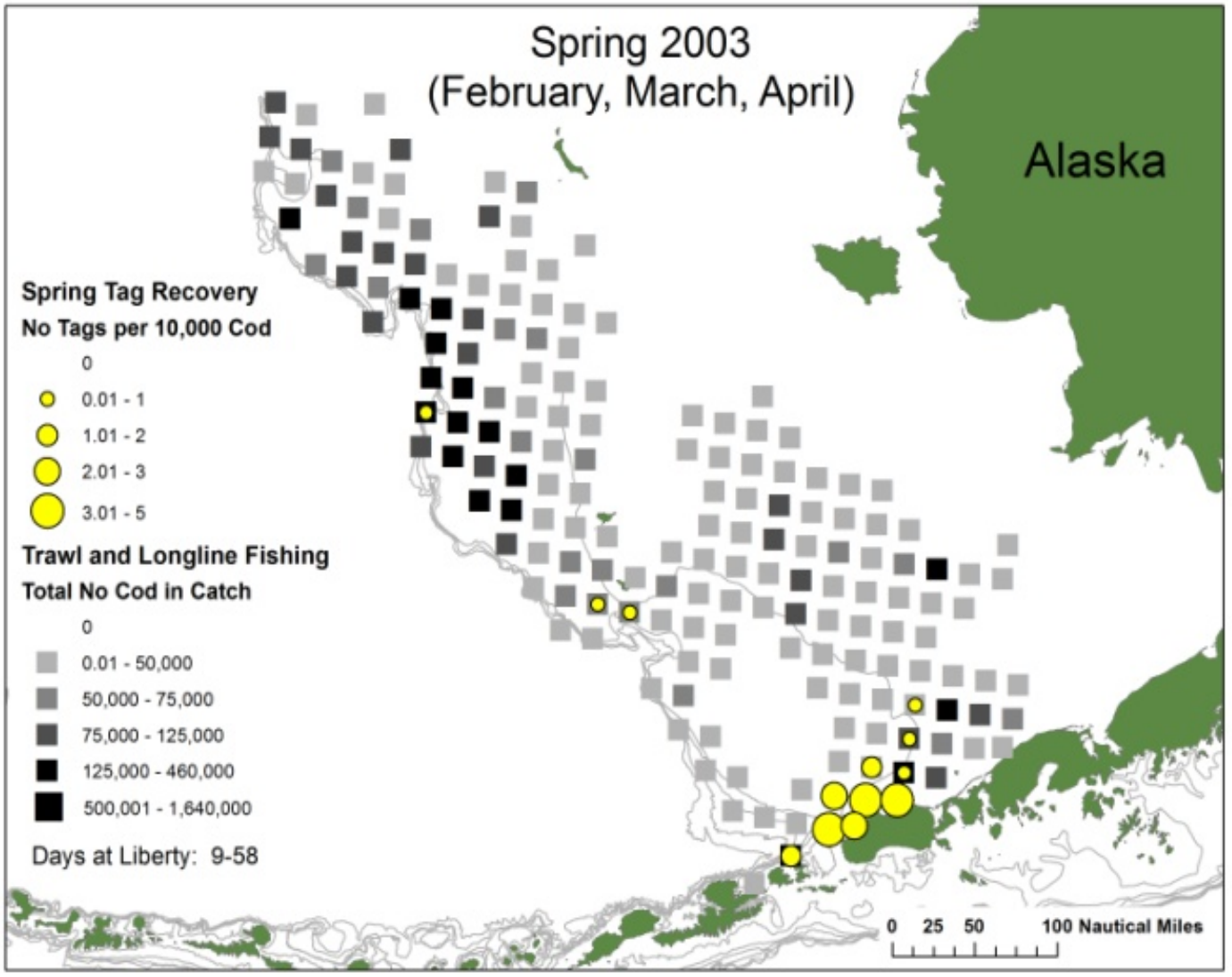
Methods

- The distance (km) between tag release and tag recovery was estimated as a linear distance in ArcGIS (ESRI).

- Nonparametric Kolmogorov-Smirnov test was used to determine if the cumulative distribution of the distance between release/recovery was different between the Fall 2003 and Spring 2004 time periods

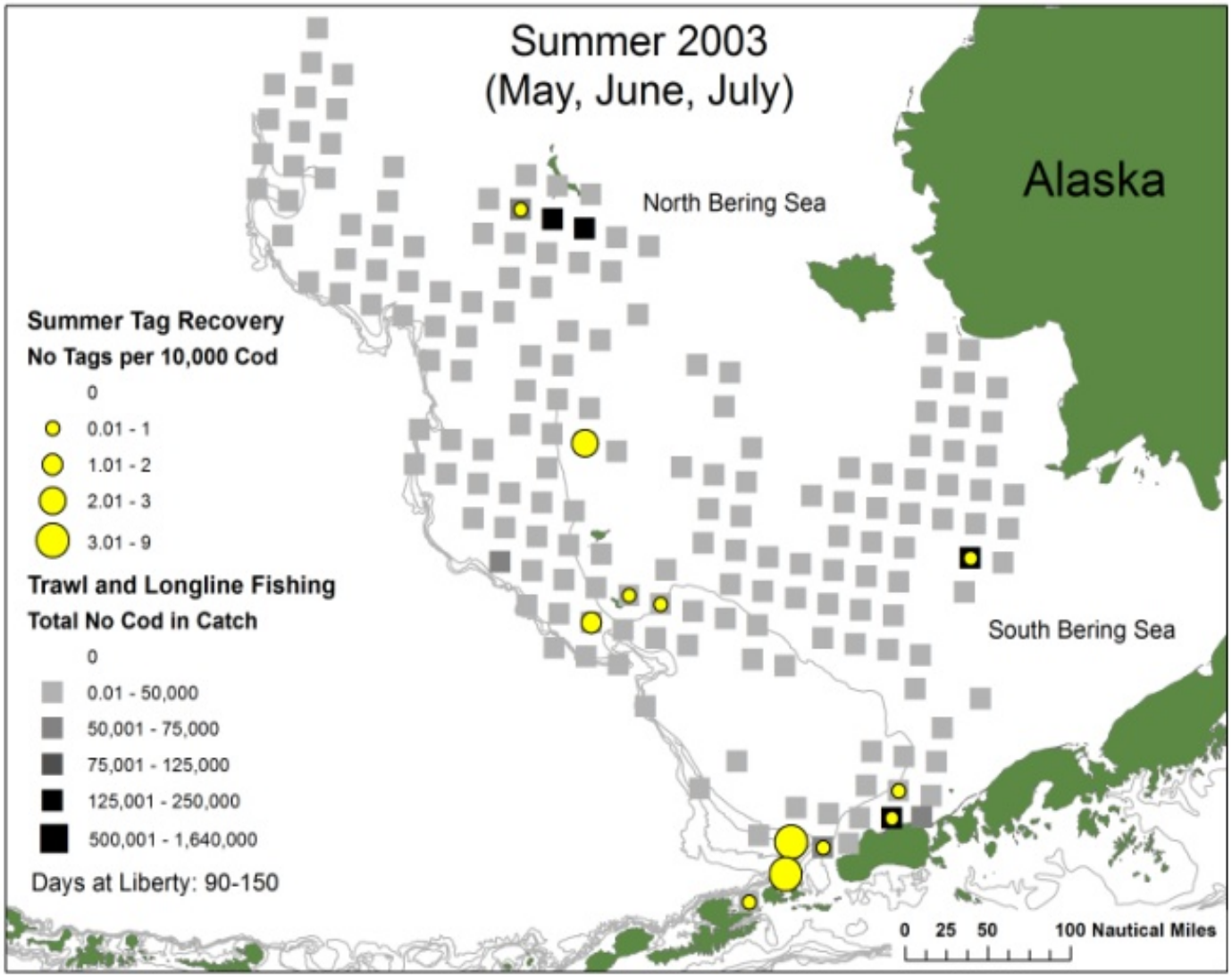
Results

Spring 2003 tag recovery distribution and cod catch

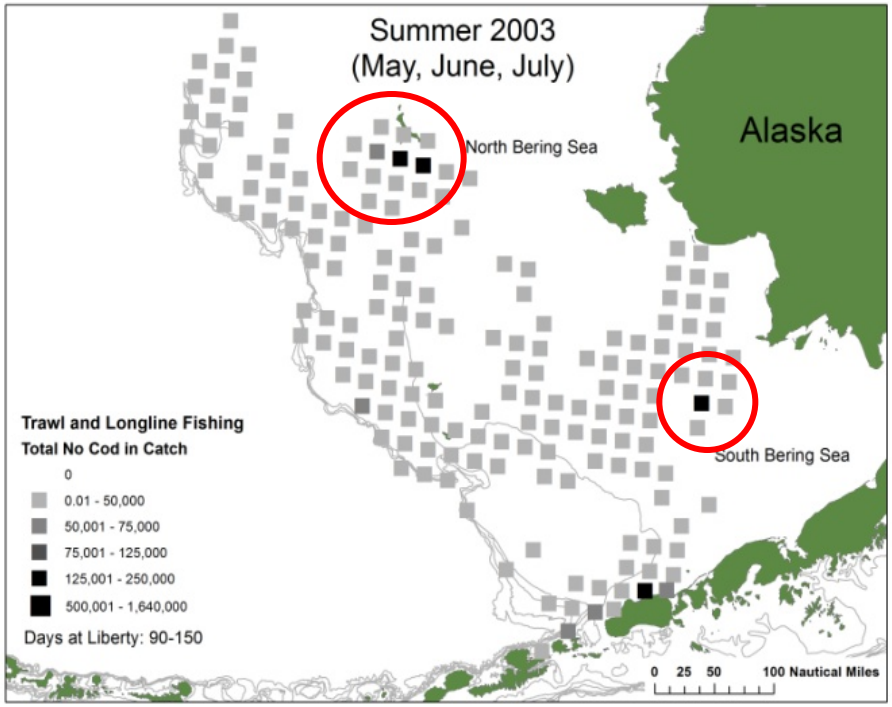


Results

Summer 2003 tag recovery distribution and cod catch



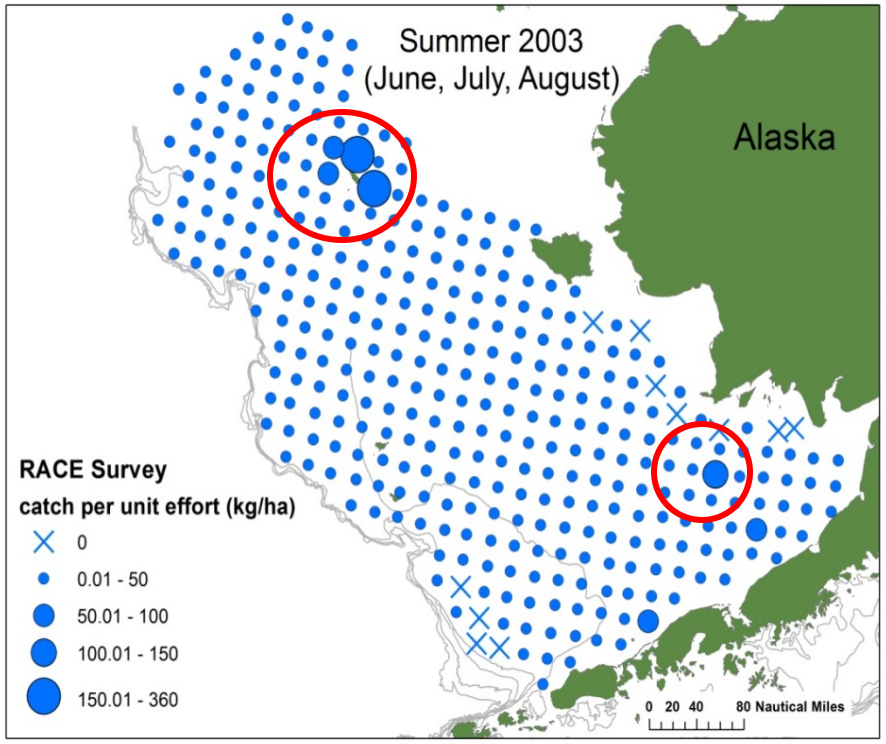
Results



Cod catch

(freezer longliners/trawlers)

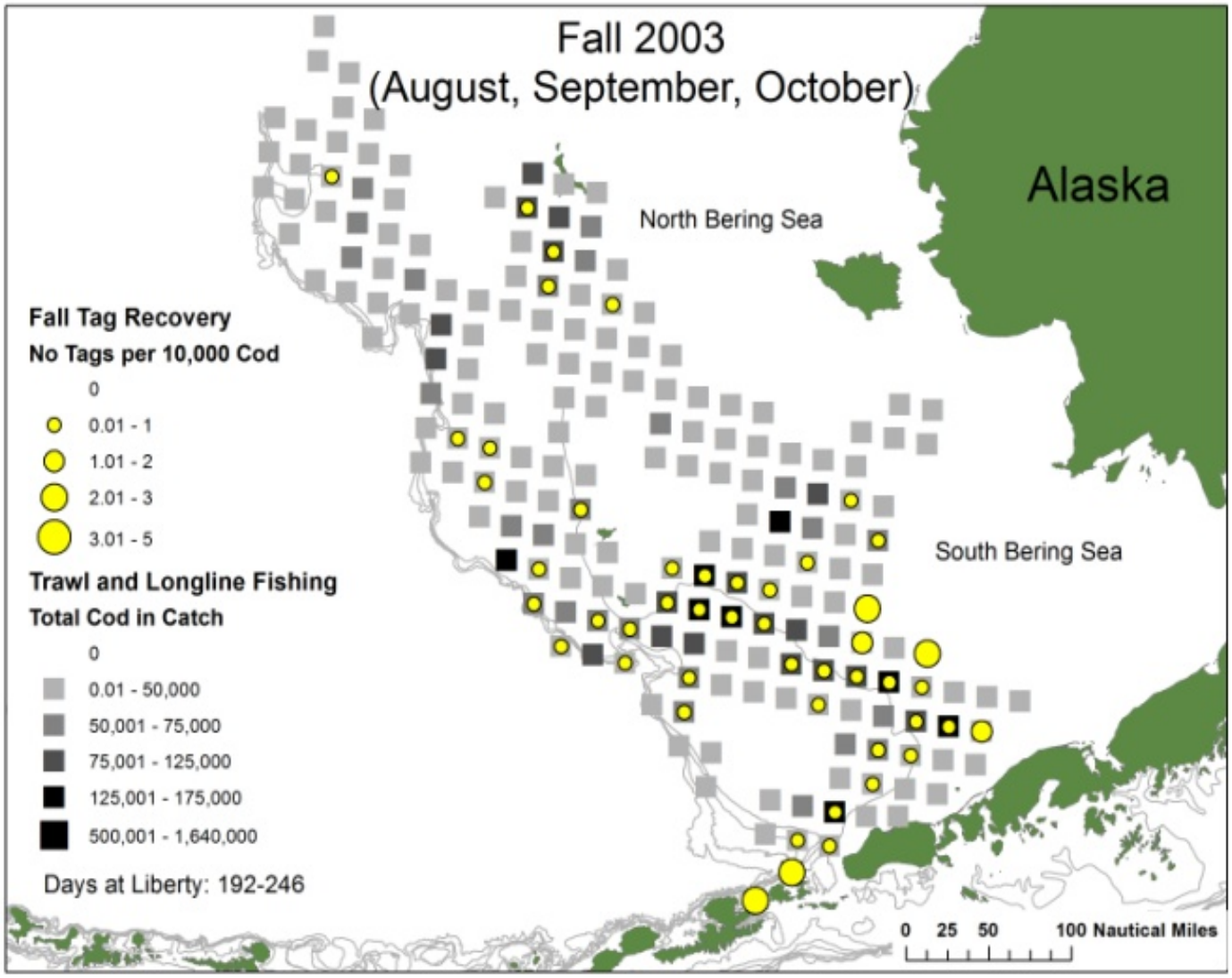
Summer 2003



NMFS Bottom Trawl Suvery

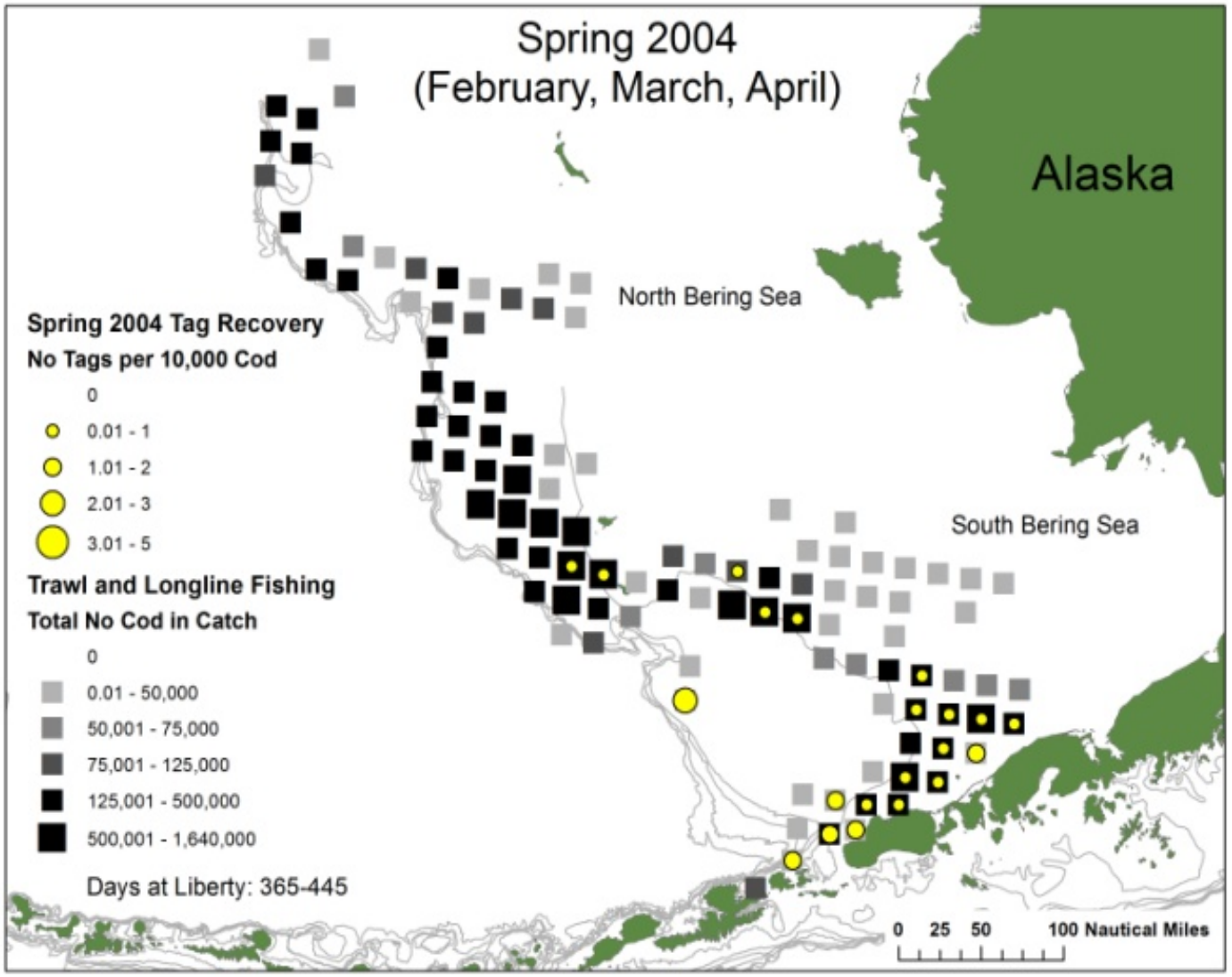
Results

Fall 2003 tag recovery distribution and cod catch



Results

Spring 2004 tag recovery distribution and cod catch

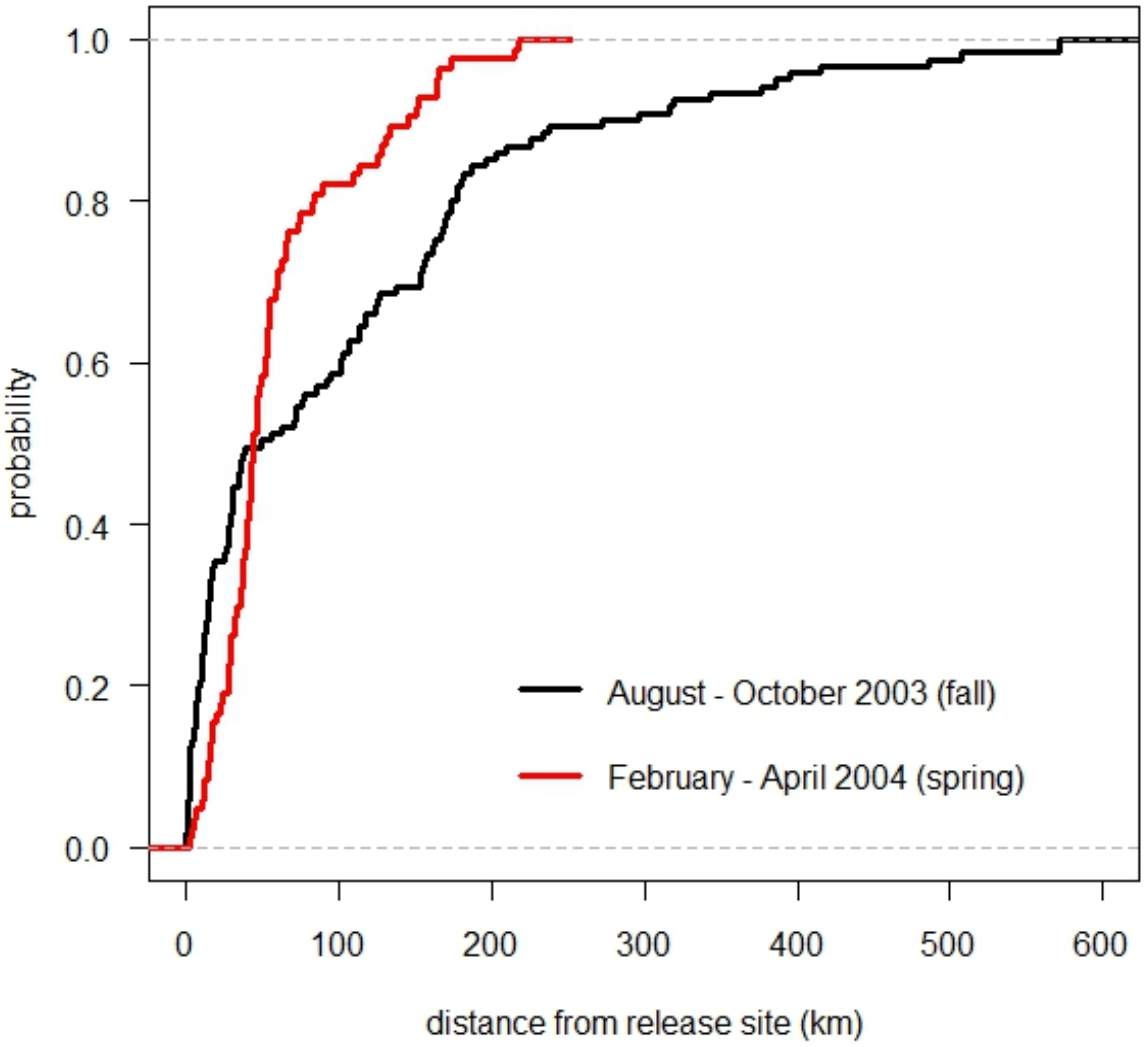


Approximately 1 year at liberty

Results

Kolmogorov-Smirnov test: P = 0.003

- Fall 2003, 56% of the tag recoveries occurred <100 km from the release site (black line)
- Spring 2004, 85% of the tag recoveries occurred <100 km from the release site (red line)



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Conclusions

- Cod from this tag release group were distributed across the entire Bering Sea during Fall 2003, possibly to feed on the shelf.

- Cod from this tag release group returned to their release site after 1 year (Spring 2004), presumably to spawn (site fidelity and homing tendencies)

- Regardless of the season, there is a continual capture of tagged cod within the vicinity of their release, suggesting a portion of the population may be residents of the area.

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Conclusions

What remains unknown about Pacific cod movement in the Bering Sea:

- The portion of the population that is resident to certain areas
- The portion of the Bering Sea population that exchanges with the Gulf of Alaska and/or Aleutians
- The effects of fishery localized depletion of cod and the burden on foraging Steller sea lions is unknown because movement of cod is unknown.

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Conclusions

What remains unknown about Pacific cod biology as it relates to movement in the Bering Sea:

- Effects of fishing on spawning aggregations (i.e. does it reduce reproductive potential over time?)
- Are all spawning aggregations in the eastern Bering Sea available to all fisheries during the spring?
- The size and duration of spawning aggregations
  (Neidetcher et al. 2014 has identified spawning locations in the eastern Bering Sea)

Acknowledgments

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- Libby Logerwell, the FIT Team Leader
- Thank you to the tagged Pacific cod and the little insight we were able to glean from their time at liberty.

Observations of seasonal movement from a single tag release group of Pacific cod in the eastern Bering Sea. In Press. Kimberly M Rand, Peter Munro, Sandra K. Neidetcher, and Daniel G. Nichol. Marine and Coastal Fisheries.

Photo by Sandi Neidetcher

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Results

	Spring 2003	Summer 2003	Fall 2003	Winter 2003/2004	Spring 2004
All recoveries (number of tagged cod)	360	69	121	59	84
Recoveries **<100 km** from release	353 (98%)	62 (90%)	68 (56%)	36 (61%)	71 (85%)
Recoveries **>100 km** from release	7 (2%)	7 (10%)	53 (44%)	23 (39%)	13 (15%)
Mean distance (km) between release and recovery **(<100 km)**	58	26	42	79	80
Mean distance (km) between release and recovery **(>100 km)**	424	425	403	471	290
Mean distance (km) between release and recovery **(all)**	65	66	201	232	112