

# Toothed whale interactions with longline fisheries in Alaska & economic implications



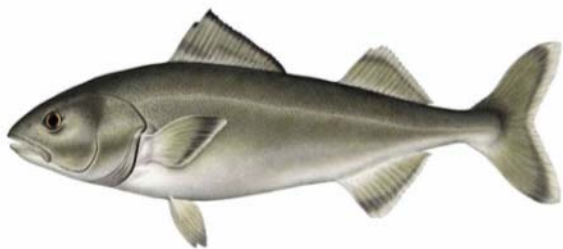
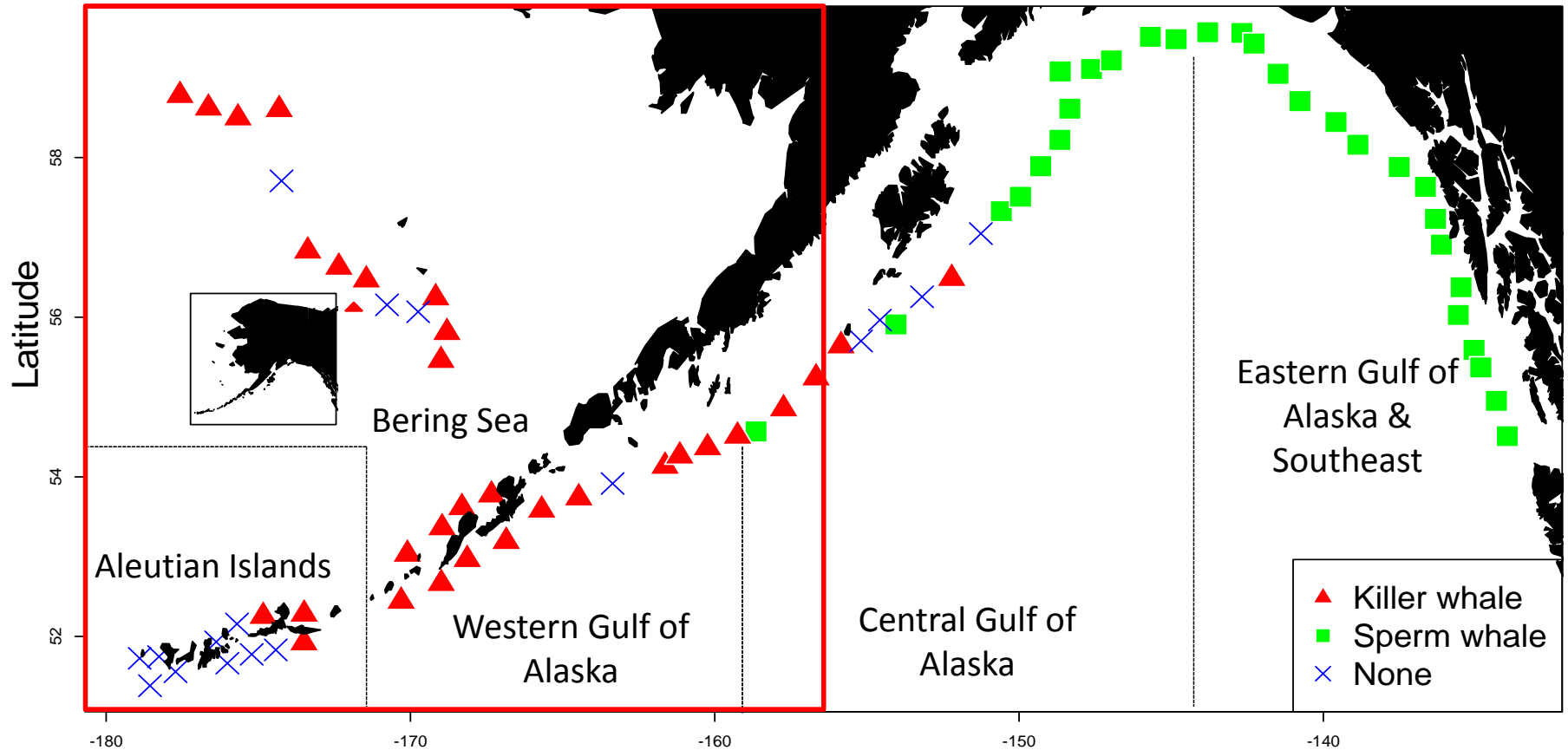
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# Killer whale (*Orcinus orca*) depredation



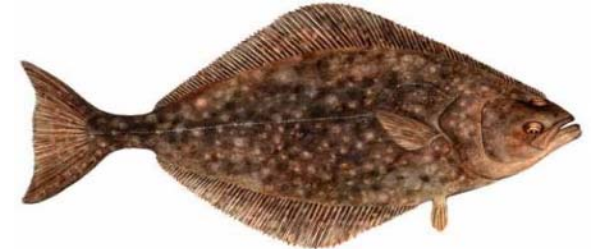
# Depredation on Longline Survey Stations



Sablefish  
(*Anoplopoma fimbria*)



Greenland turbot  
(*Reinhardtius hippoglossoides*)



Pacific halibut  
(*Hippoglossus stenolepis*)

- ↓ Catch per unit effort (CPUE)
- ↑ Operating costs
- ↑ Uncertainty stock assessments
- ↑ Increased risk entanglement / altered foraging strategies

- May be insert slide to document reductions in catch rate from (1) surveys (2) commercial fisheries, (3) fishermen surveys

# Fishing choices and associated costs

Fish through the whales

Drop gear/ extended soaks

Move to a different fishing site

↑ Operation costs  
(fuel, bait)

↑ Opportunity costs

↑ Operation costs,  
Opportunity costs

Previous studies:

**Lost catch \* \$ / lb**

*(Roche et al. 2007, TEC 2009, Tixier et al. 2010)*

But ...

# No 'lost catch'

Because of high value of catch, longline fishermen will fish longer to catch entire quota

To compensate for lower catch rates, effort inputs must increase proportionally to catch same amount of quota (e.g. fuel, bait, crew food, opportunity costs)

 New approach needed to estimate costs!

# Objectives

- Estimate depredation frequency and ↓CPUE for the commercial fleet in western AK
- Estimate increased operating costs (fuel, crew food) and opportunity costs (foregone wages)





# Data & Methods

## 1. Fishing through the whales:

### Commercial Fishery Observer Data (n=15,729 sets)

- Generalized Additive Model (GAM) to estimate **reduction in catch rate** (lost catch per set)

### Trip information from fishermen surveys

- Simple model to estimate additional **fuel consumption**

## 2. Depredation avoidance:

### Fishermen-collected depredation data (n=846 sets)

- Estimating extra effort inputs and opportunity costs

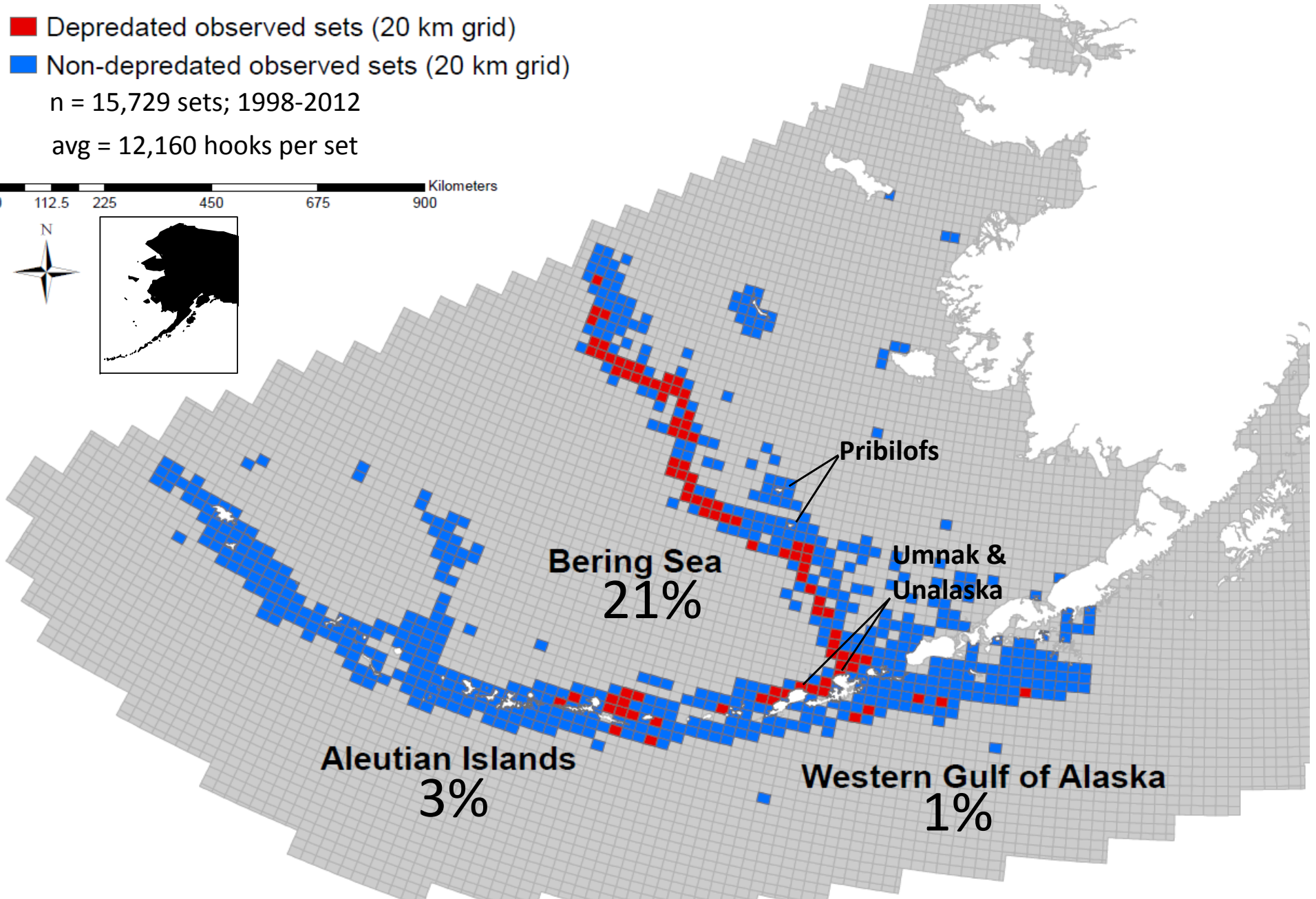
# Fishermen surveys to document avoidance measures

- 6 vessels fishing in western Alaska in 2011 and 2012 (n=846 sets, 262 days fishing) recorded:
  - number of sets
  - number of sets affected
  - avoidance measures (distance traveled, hours waited, etc.)
- Estimate direct costs:
  - increased fuel use
  - crew food / supplies
  - opportunity costs in lost time

# Observed commercial fishery depredation

- Depredated observed sets (20 km grid)
  - Non-depredated observed sets (20 km grid)
- n = 15,729 sets; 1998-2012  
avg = 12,160 hooks per set

0 112.5 225 450 675 900 Kilometers



# Modeling groundfish CPUE reductions

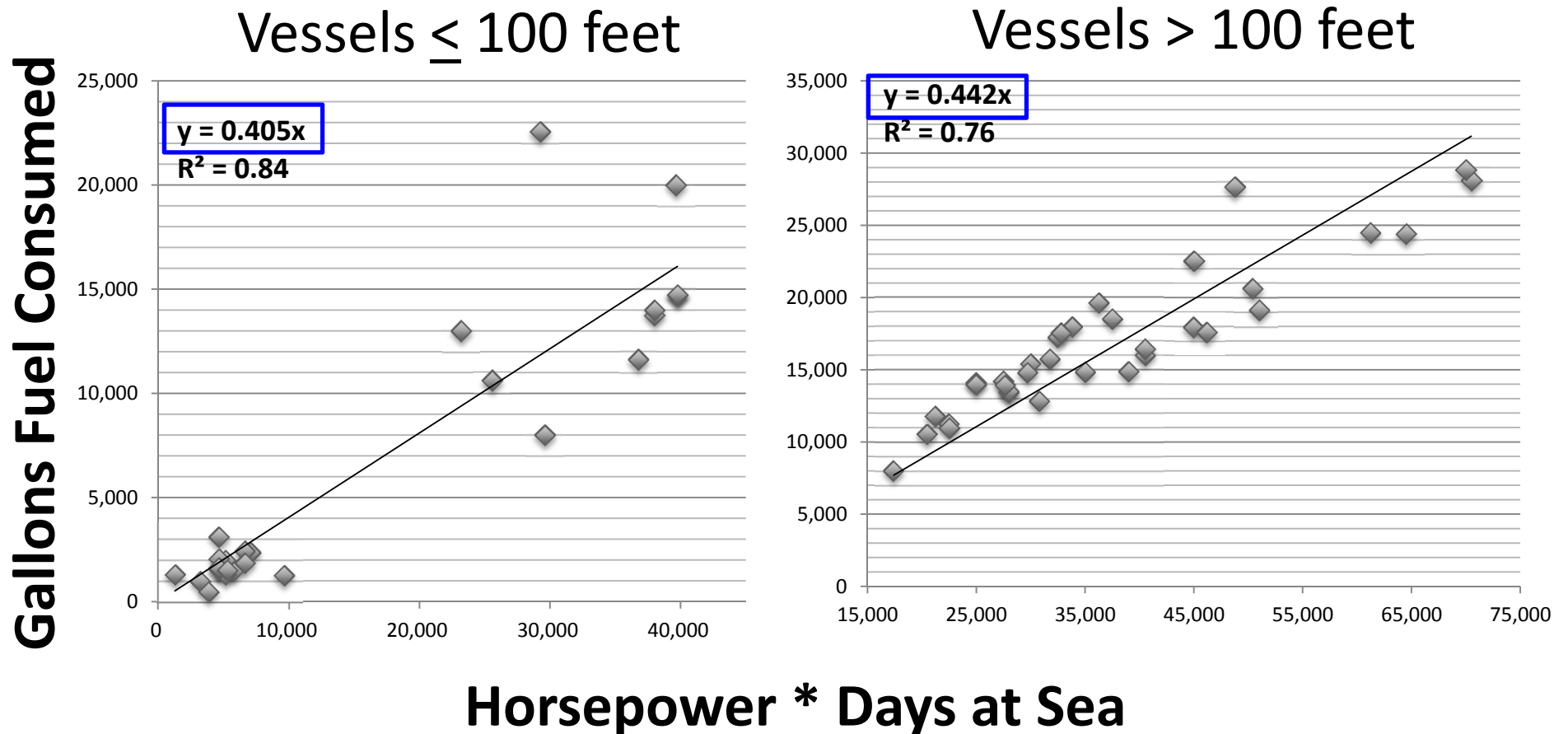
$$\log(\text{cpue}) = \beta_0 + f_1(\text{lat}, \text{long}) + f_2(\text{depth}) + \text{year}_i + \text{vessel}_j + \text{depredation}_k + \varepsilon$$

## Predicted Reductions (GAM)

	Commercial data
Sablefish	55 – 69%
Pacific halibut	35 – 57%
Greenland turbot (BS and AI only)	54 – 67%

# Estimating fuel consumption

Detailed trip information from 60 longline fishing trips in western Alaska (Tyedmers 2001)



# 1. Costs of fishing through the whales

*fuel consumption rate* \* *days at sea* \* *average vessel horsepower* = *gallons fuel consumed*

Estimated fuel per set			
	Fuel consumption rate	Estimated gallons	95% CI (gallons)
≤100 ft	0.405	199	±23
>100 ft	0.442	427	±30



# 1. Costs of fishing through the whales

$$\text{Gallons per set} * CPUE \downarrow_{\text{area, target}} = \text{additional fuel needed} * \$/\text{gallon}$$



## Cost of additional fuel per depredated set

	Cost per set	95% CI	AVG
≤100 ft	\$231	±\$107	<b>\$433 ± 147</b>
>100 ft	\$462	±\$148	

## 2. Costs of depredation avoidance

- Detailed study with 6 vessels 2011 and 2012 (n=846 sets)
  - Recorded # sets affected, avoidance measures (distance traveled, hours waited, etc.)





## Depredation Avoidance Costs (Average per set)

Additional Fuel	Additional Crew Food	Opportunity Costs	TOTAL
\$289	\$58	\$217	<b>\$564</b>

### Costs to fish through (Average per set)

Additional Fuel  
**\$433 ± \$147**

Doesn't take into account

Bait

Crew food

Opportunity costs

# Sets per day

Whales reinforced/ spreads behavior

# Conclusions

- Catch rate reductions high (55-70%), % sets affected variable (increases over time)
- Depredation avoidance measures costly ~\$564/ set



- Fishing through the whales expensive ~\$433/ set
- Depredation avoidance preferred long-term solution



# Closing thoughts

- Depredation changing the nature of fisheries in western Alaska
  - Season timing
  - Pot gear in the BS, AI (GOA?)
  - Costly avoidance measures
- Killer whale distribution / social learning could facilitate the spread of depredation behavior
- Cooperative research and proactive mitigation are needed
- Need for economic data!

# Thanks!

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Thank you!

