Cheryl Barnes, UAF

Anne Beaudreau, UAF

Martin Dorn, AFSC

Kirstin Holsman, AFSC

Franz Mueter, UAF

Development of a predation index to assess trophic stability in the Gulf of Alaska

POLLOCK CONSERVATION COOPERATIVE Research Center

RASMUSON FISHERIES RESEARCH CENTER

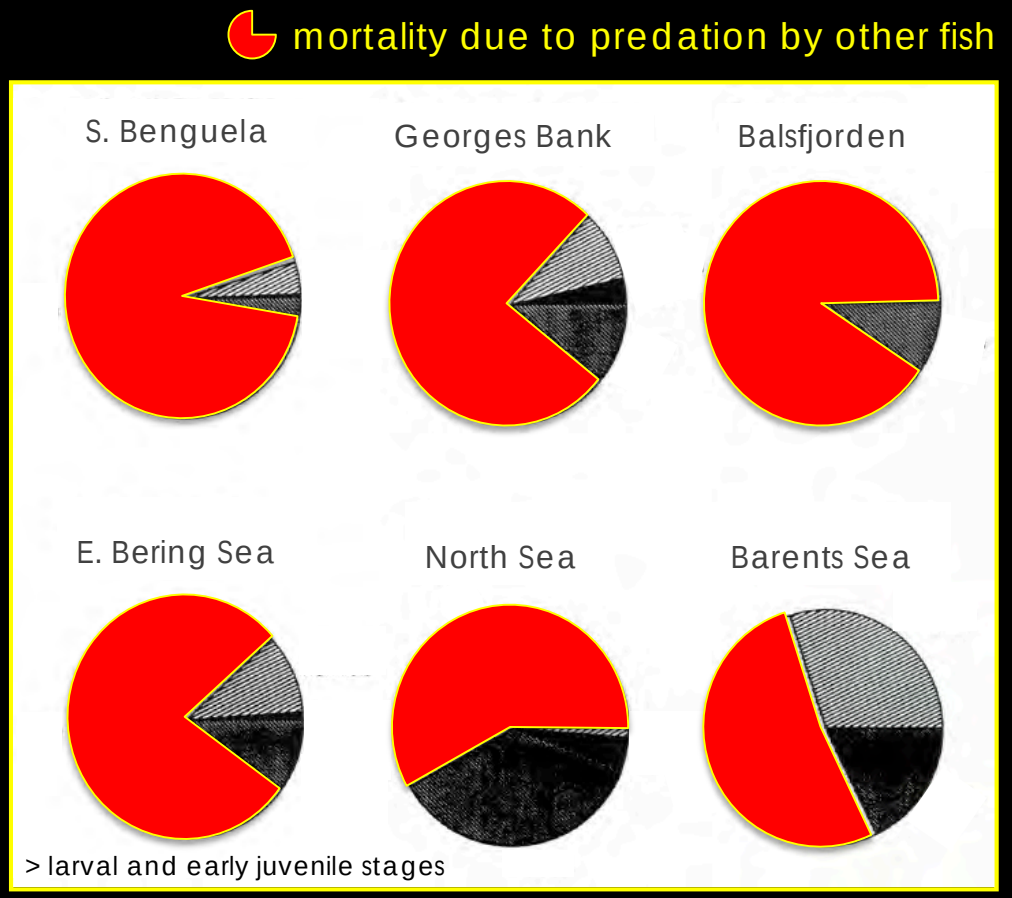
UAF COLLEGE OF FISHERIES AND OCEAN SCIENCES
University of Alaska Fairbanks

UNIVERSITY of ALASKA SOUTHEAST
SITKA CAMPUS

- N. Gulf of Alaska Applied Research Award -


PICES-2019 Annual Meeting:
Connecting Science and Communities
in a Changing North Pacific
Oct 16 – Oct 27, 2019
Victoria, BC, Canada
Hello
my name is
newbie

Predation: important source of mortality for marine fishes

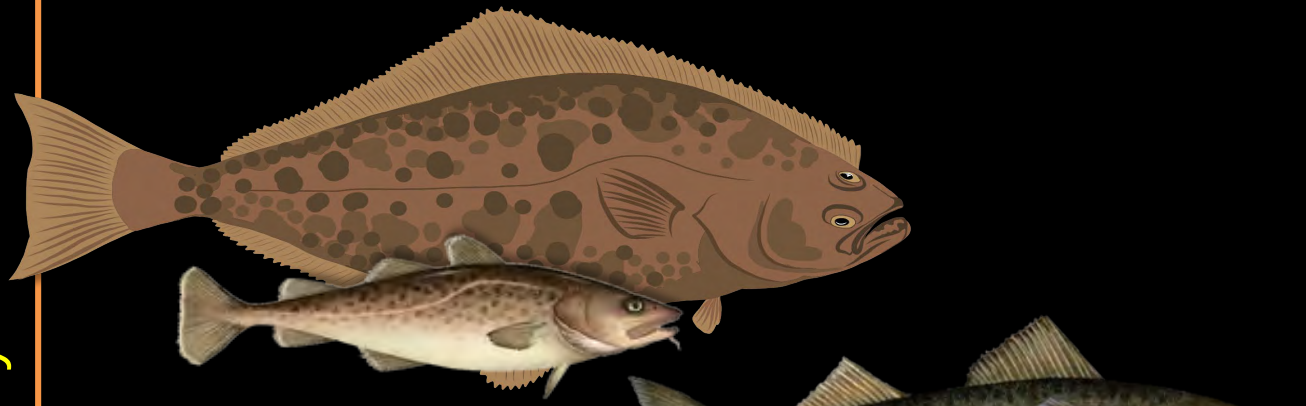


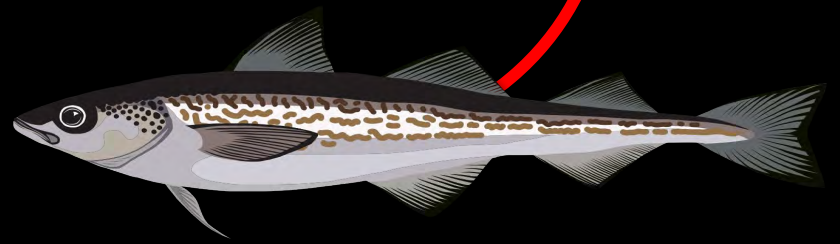
Bax 1991

- shapes size and age structures
- impacts recruitment and survival

predation and trophic stability in the Gulf of AK

Walleye Pollock (*Gadus chalcogrammus*)





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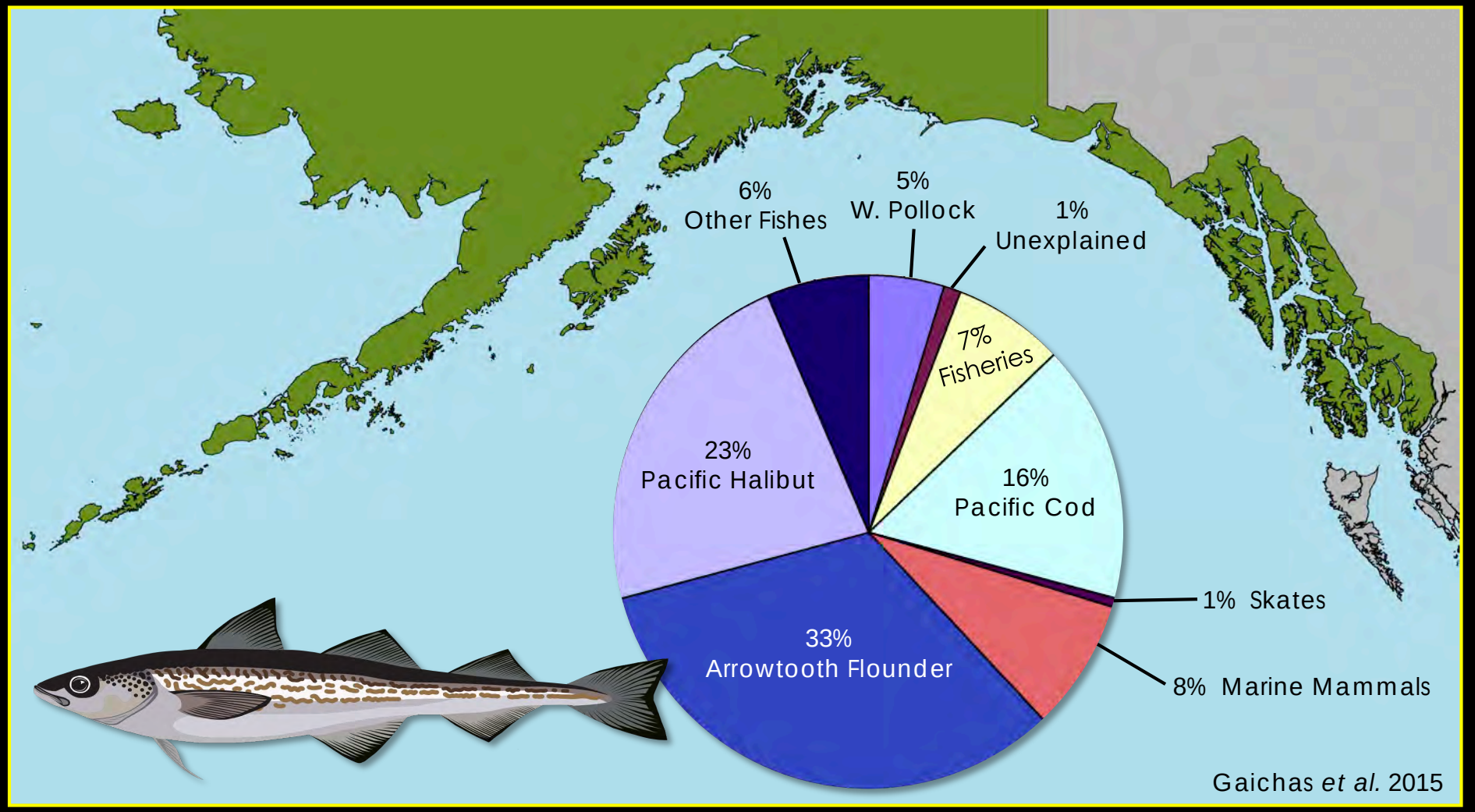

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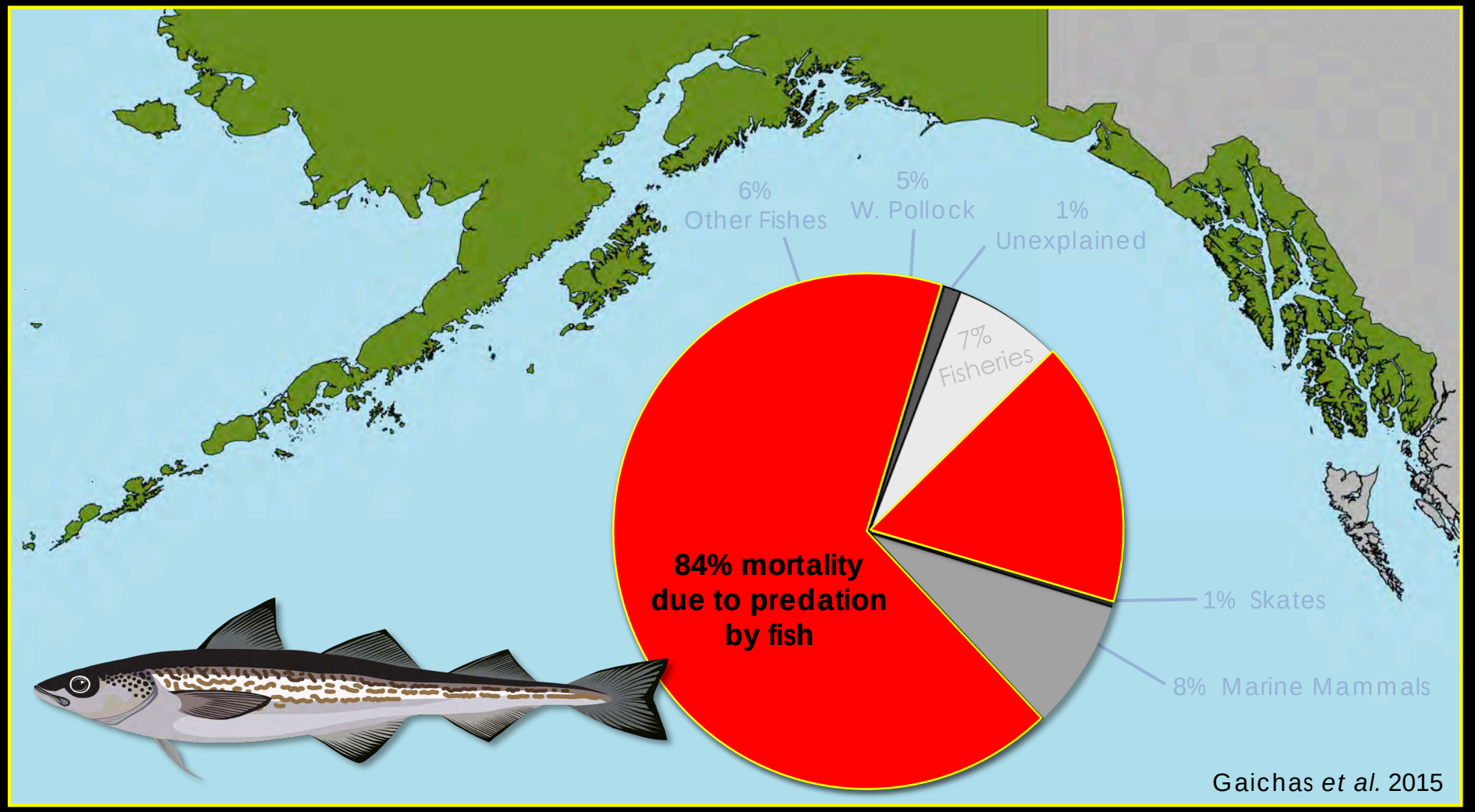
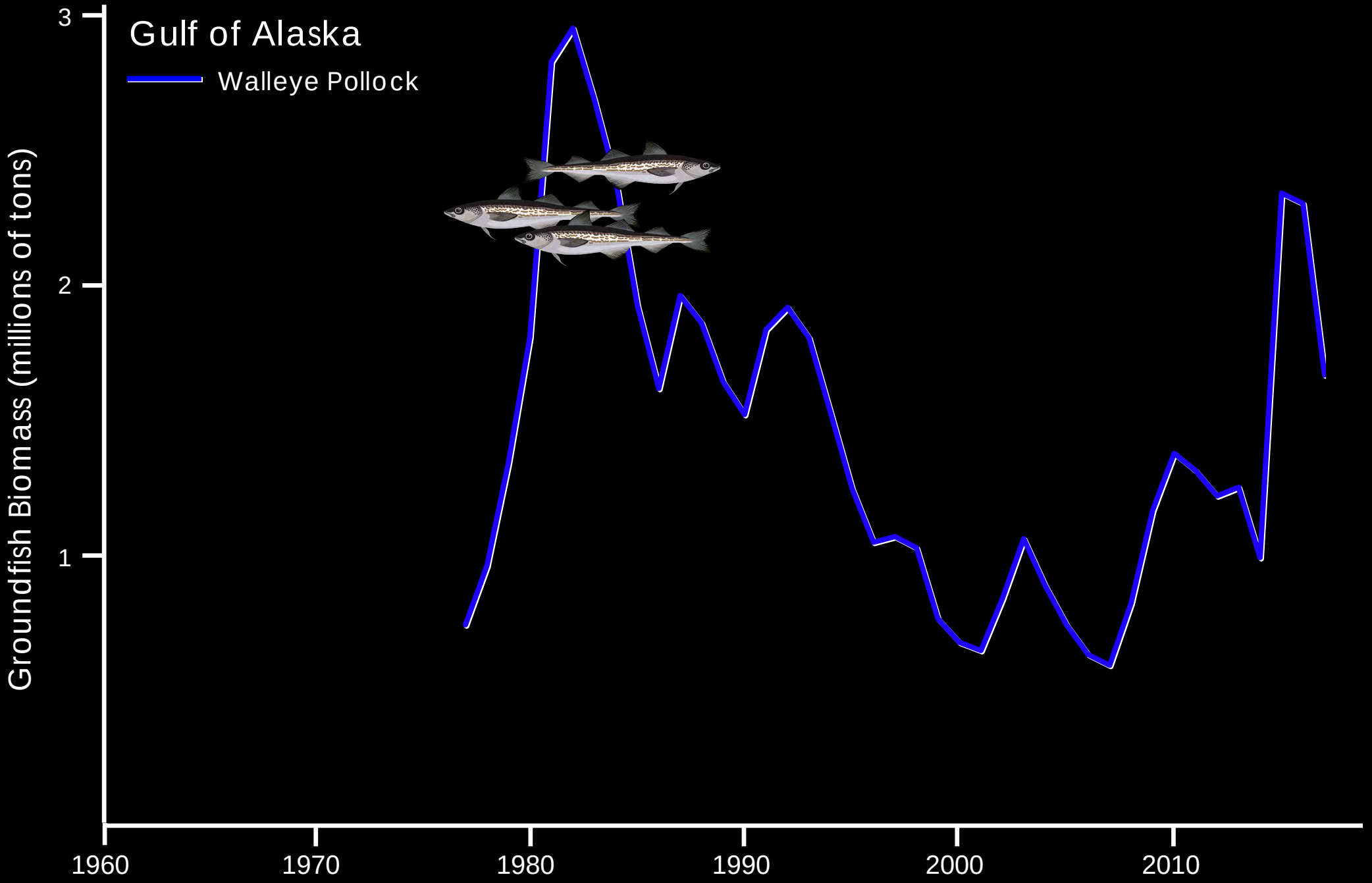


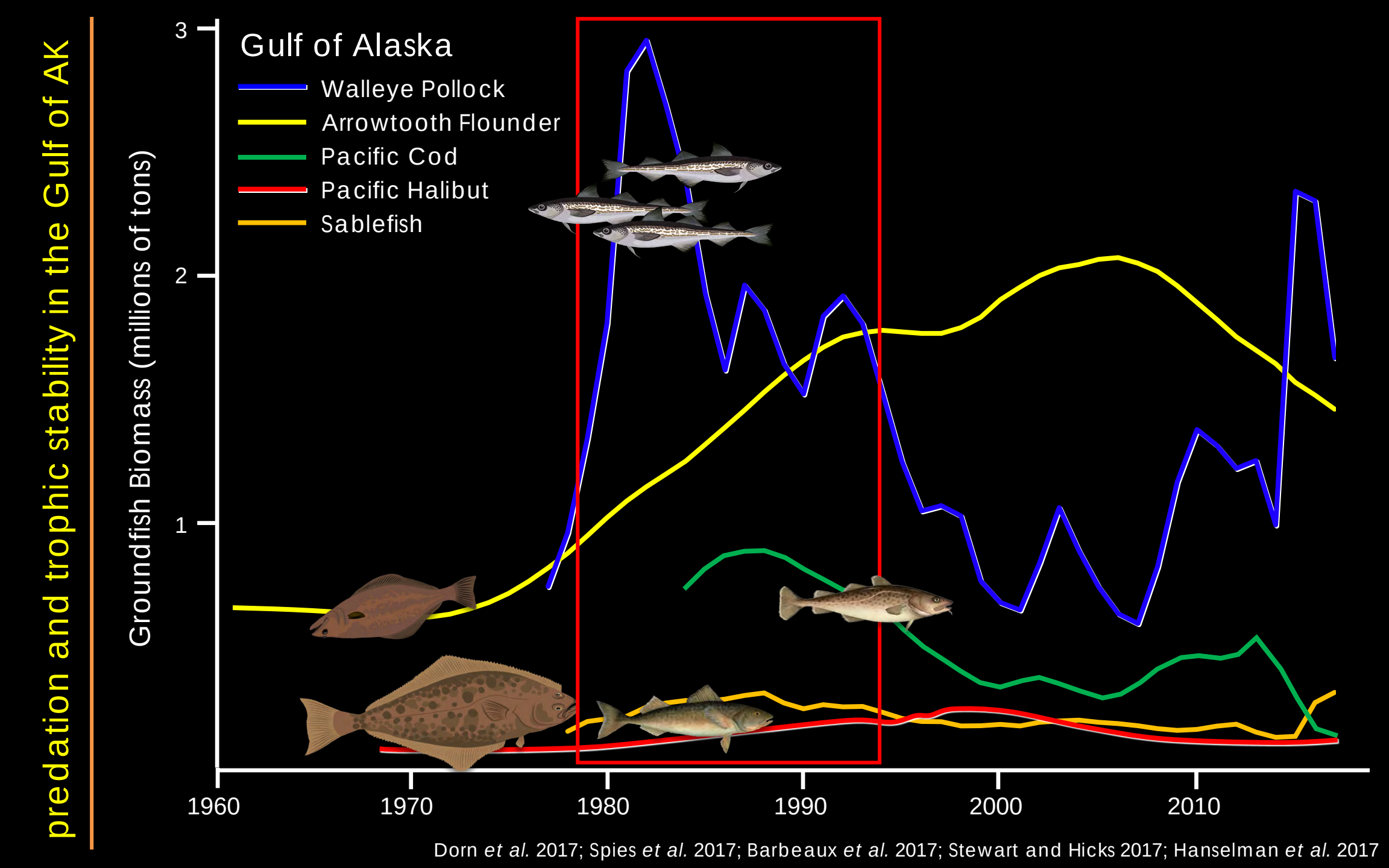
mortality due to predation by other fishes

predation and trophic stability in the Gulf of AK



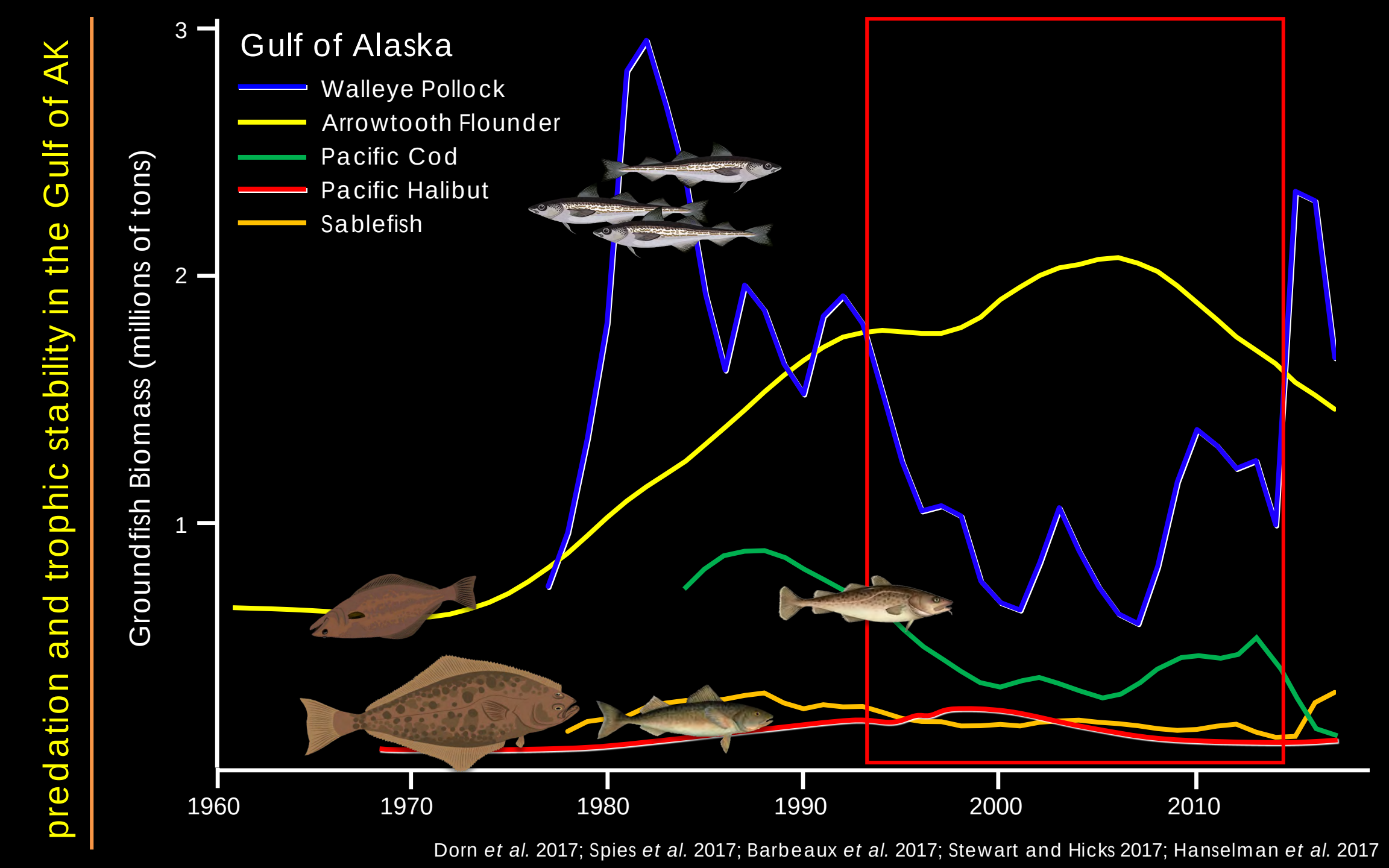
Dorn *et al.* 2017

predation and trophic stability in the Gulf of AK



Dorn *et al.* 2017; Spies *et al.* 2017; Barbeaux *et al.* 2017; Stewart and Hicks 2017; Hanselman *et al.* 2017

predation and trophic stability in the Gulf of AK



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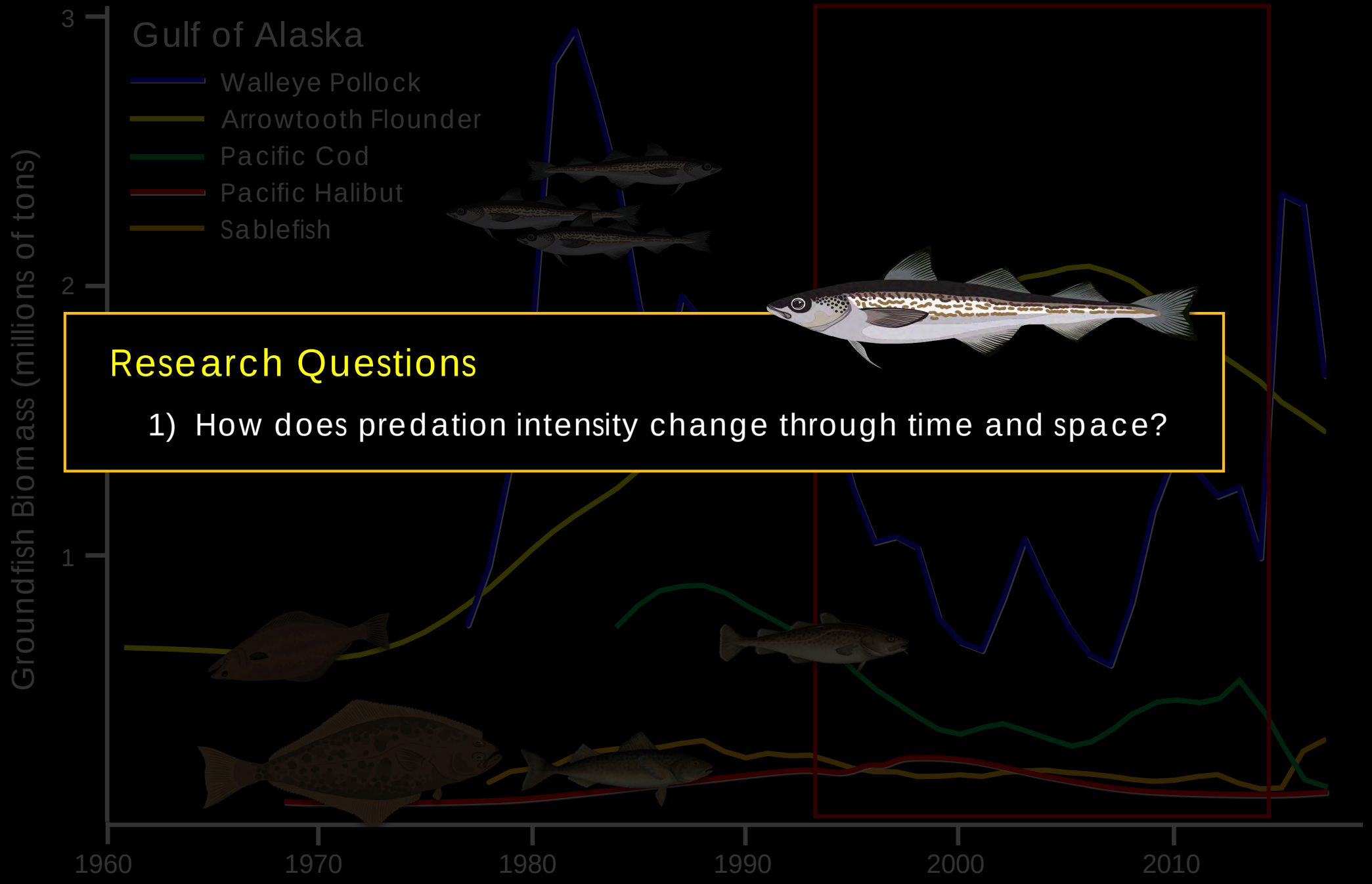
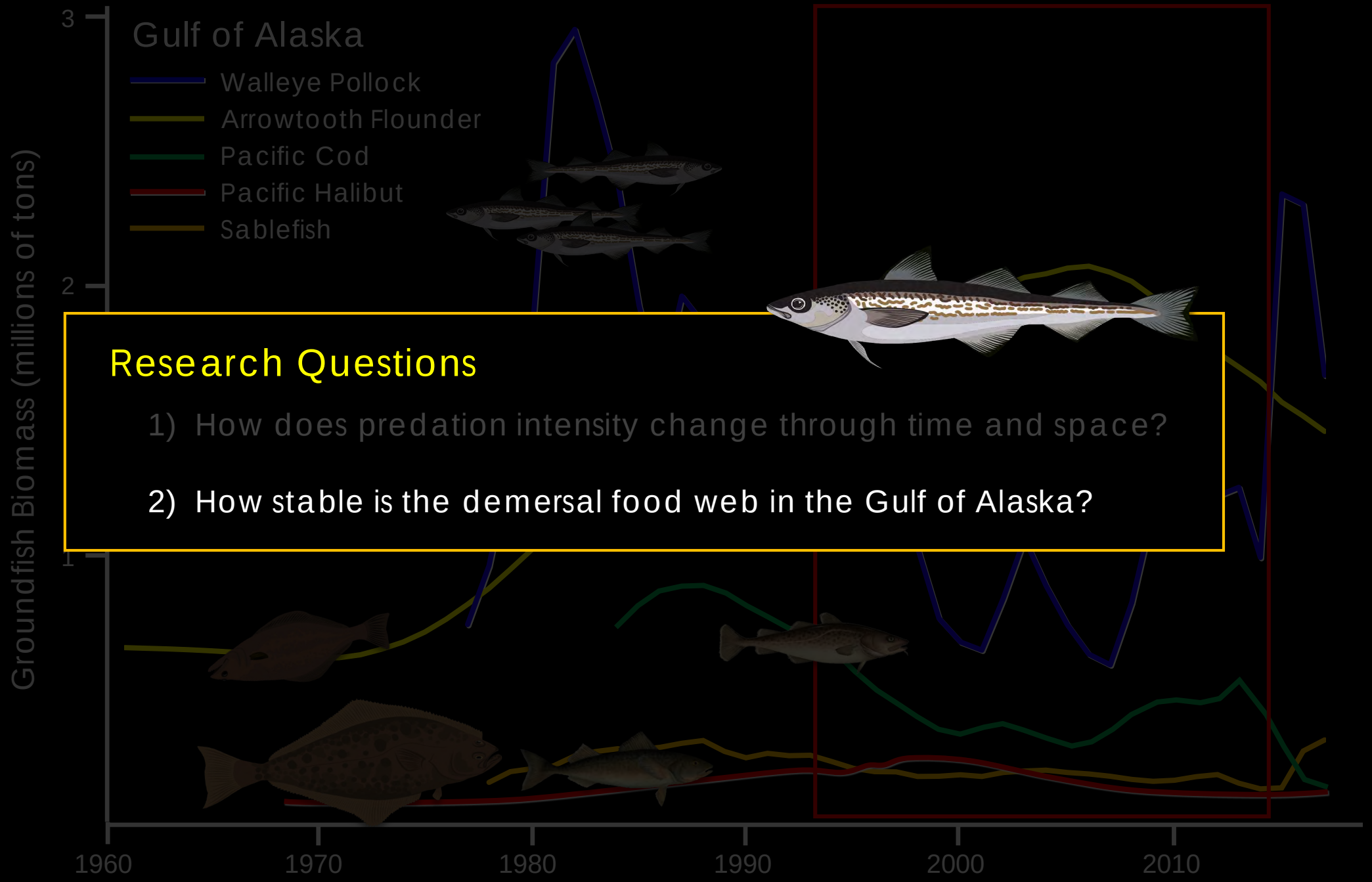


Research Questions

1) How does predation intensity change through time and space?

Dorn *et al.* 2017; Spies *et al.* 2017; Barbeaux *et al.* 2017; Stewart and Hicks 2017; Hanselman *et al.* 2017

predation and trophic stability in the Gulf of AK



Research Questions

1) How does predation intensity change through time and space?

2) How stable is the demersal food web in the Gulf of Alaska?

Dorn *et al.* 2017; Spies *et al.* 2017; Barbeaux *et al.* 2017; Stewart and Hicks 2017; Hanselman *et al.* 2017

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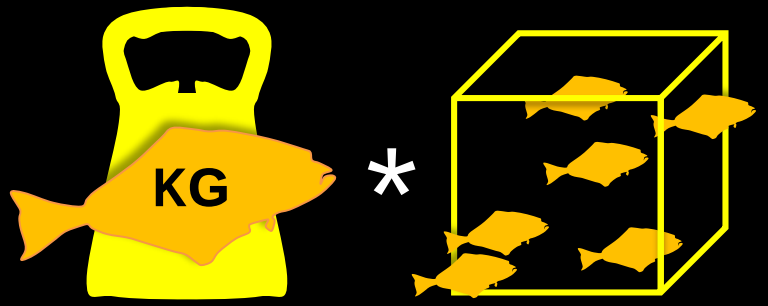
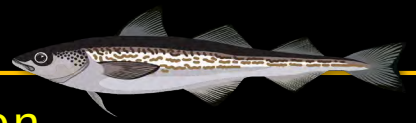


total predator biomass

relative predator density



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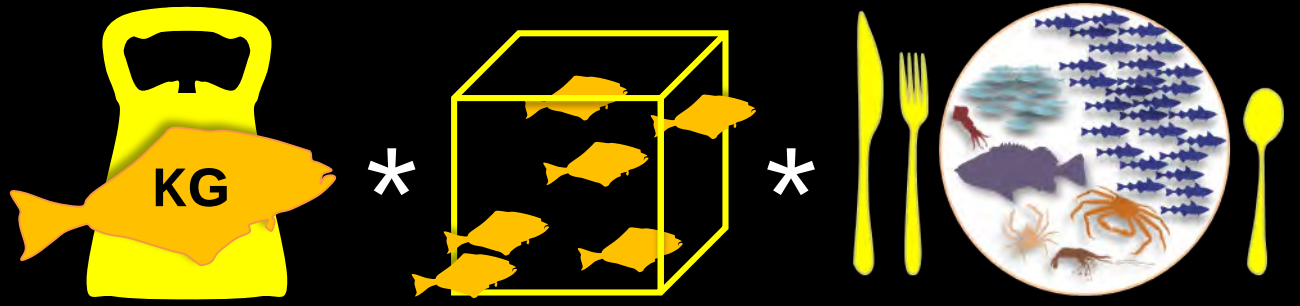
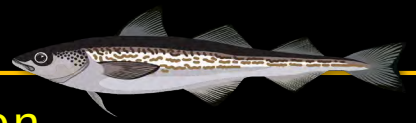


total predator biomass

relative predator density

mean annual ration



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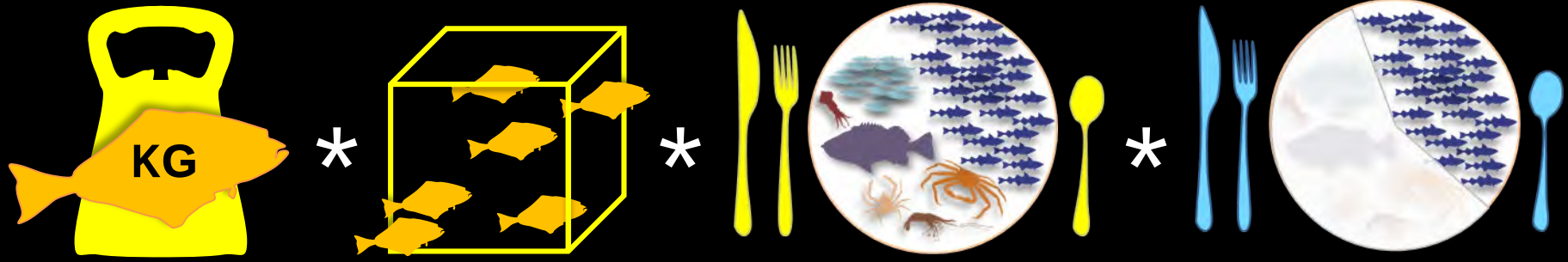
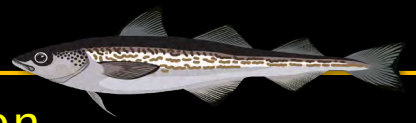


total predator biomass | relative predator density | mean annual ration | proportions of pollock consumed



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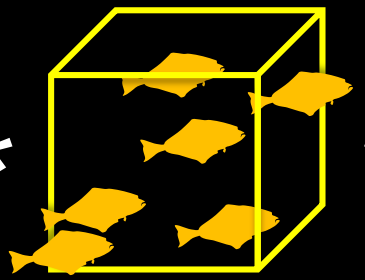

relative predator density

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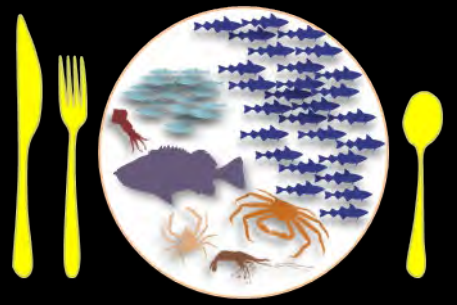
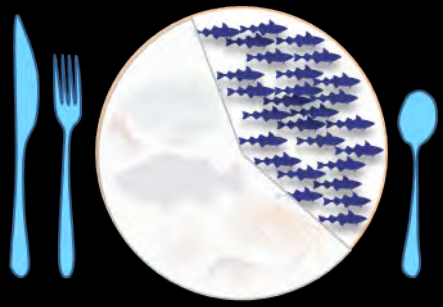


mean annual ration

*



proportions of pollock consumed

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ages of pollock consumed

predation and trophic stability in the Gulf of AK

Research Question

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Kitchell *et al.* 1977
Hanson *et al.* 1997
Harvey 2009
Holsman and Aydin 2015
Holsman *et al.* 2019

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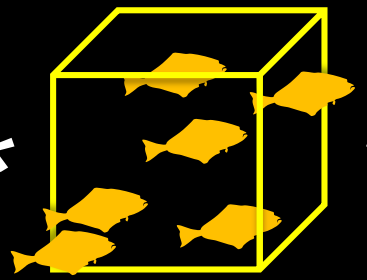

relative predator density

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mean annual ration

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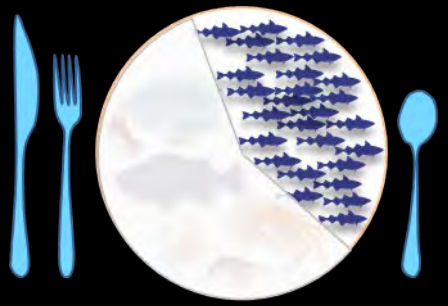

proportions of pollock consumed

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ages of pollock consumed

- Resource Assessment and Conservation Engineering Division
- Marine Ecology and Stock Assessment Program
  Alaska Fisheries Science Center, NOAA
- International Pacific Halibut Commission

- Resource Ecology and Ecosystem Modeling Program
  Alaska Fisheries Science Center, NOAA
  Livingston *et al.* 2017

Barbeaux *et al.* 2017
Dorn *et al.* 2017
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predation and trophic stability in the Gulf of AK

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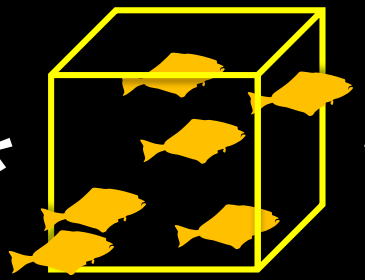

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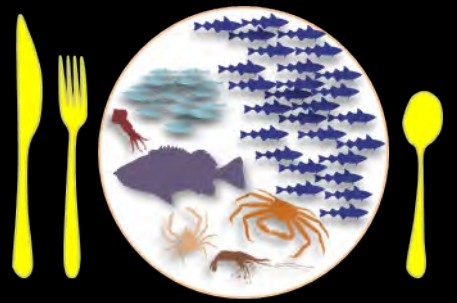

mean annual ration

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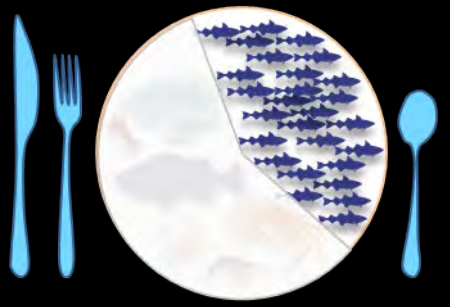

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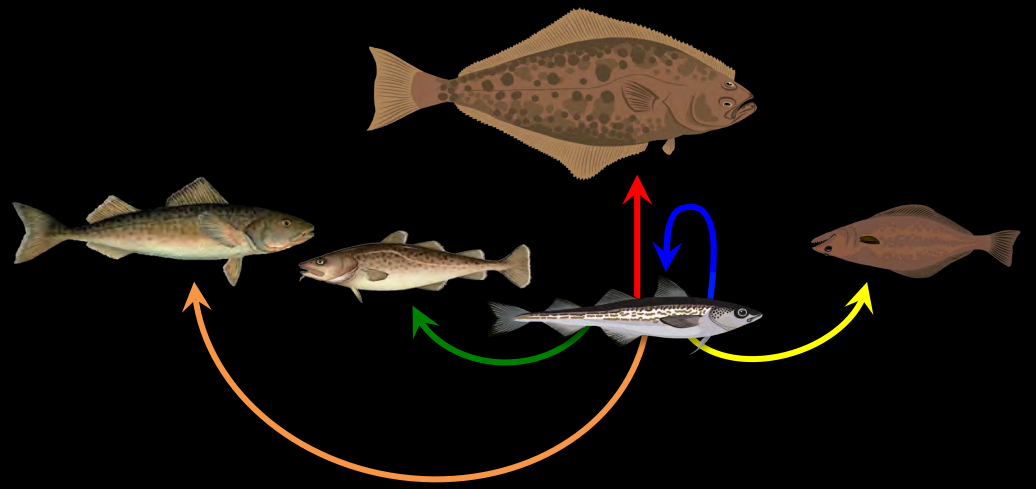
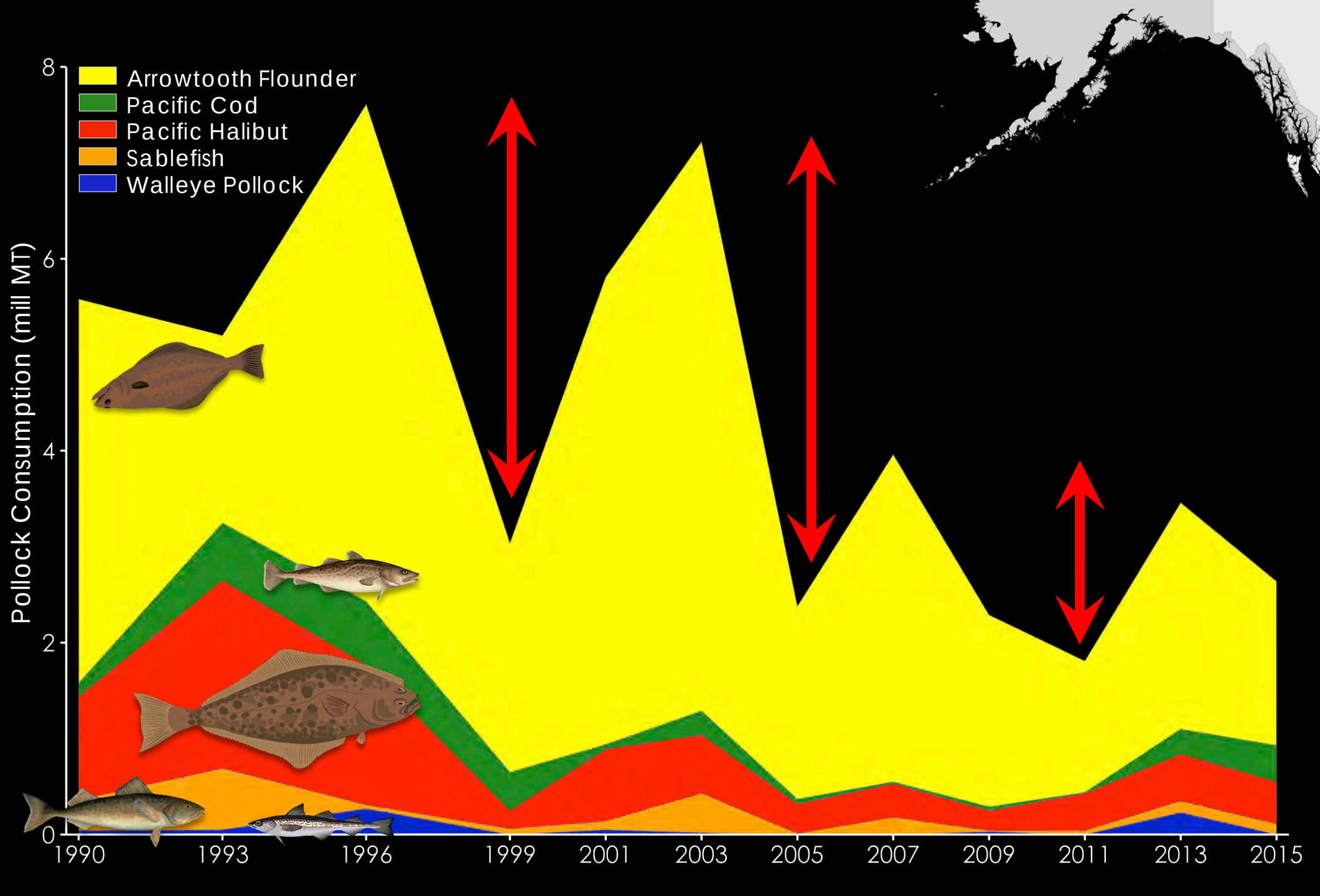
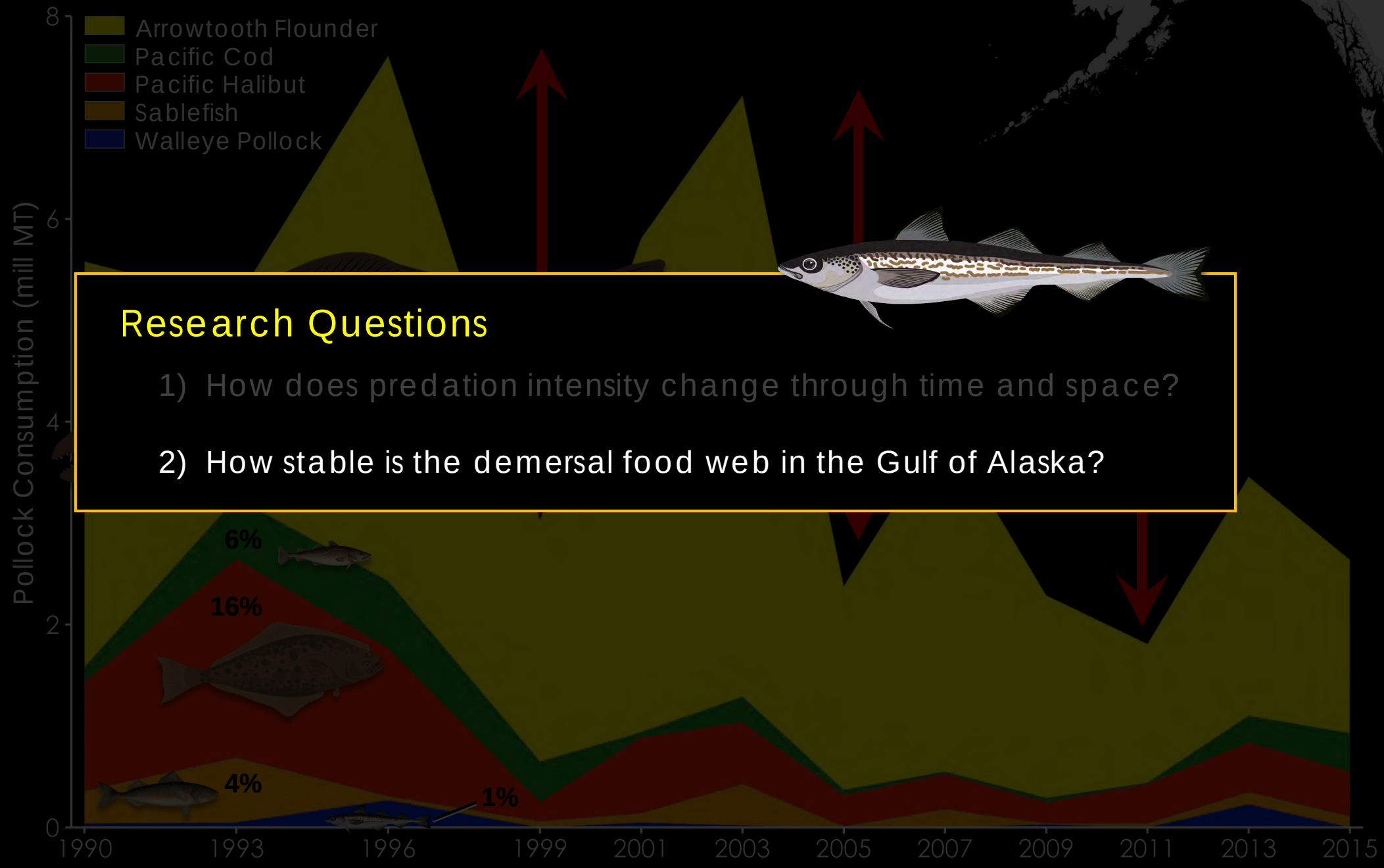


predation and trophic stability in the Gulf of AK



predation and trophic stability in the Gulf of AK



Research Questions

1) How does predation intensity change through time and space?

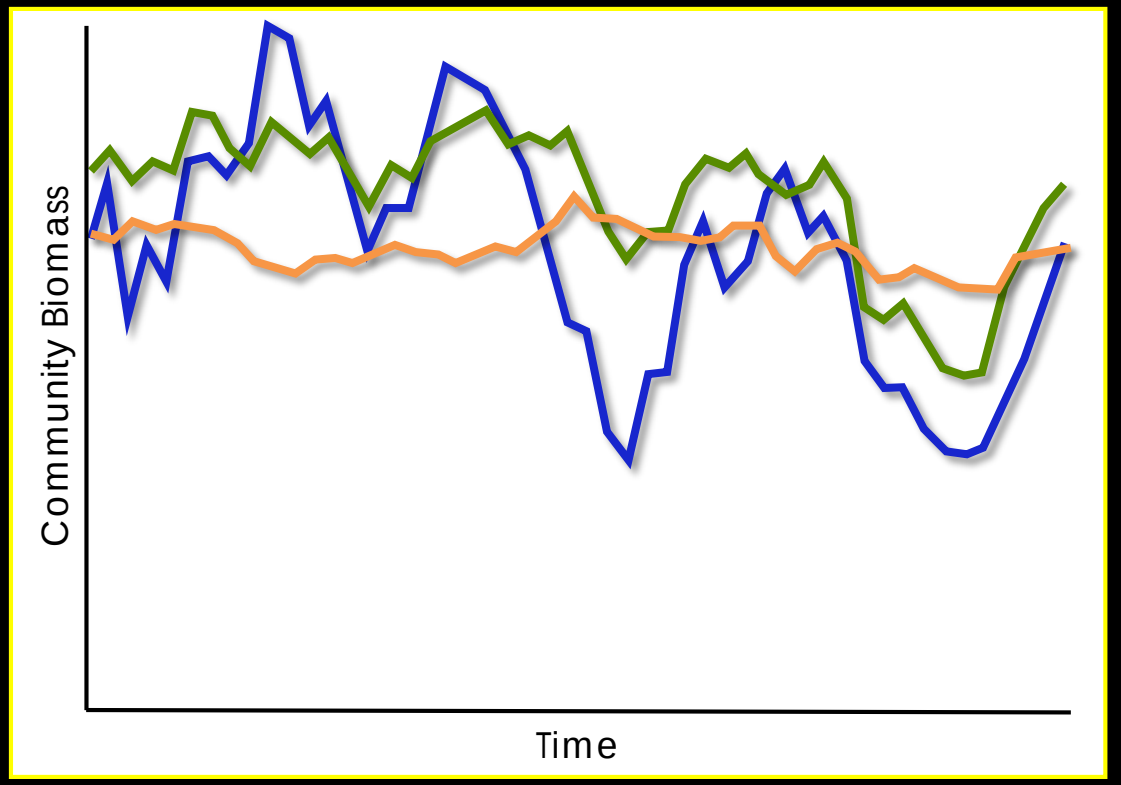
2) How stable is the demersal food web in the Gulf of Alaska?

the portfolio effect

the portfolio effect

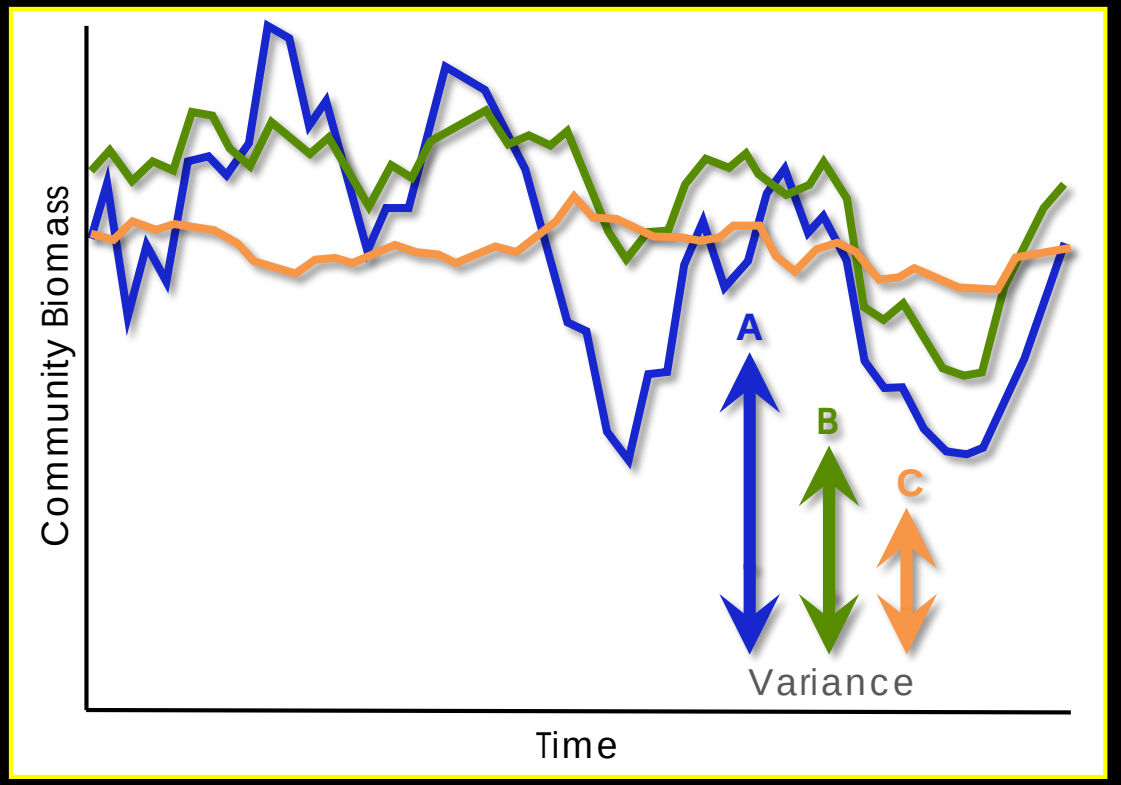
diversity ∝ stability

the portfolio effect



Adapted from Oken *et al.* 2018

the portfolio effect



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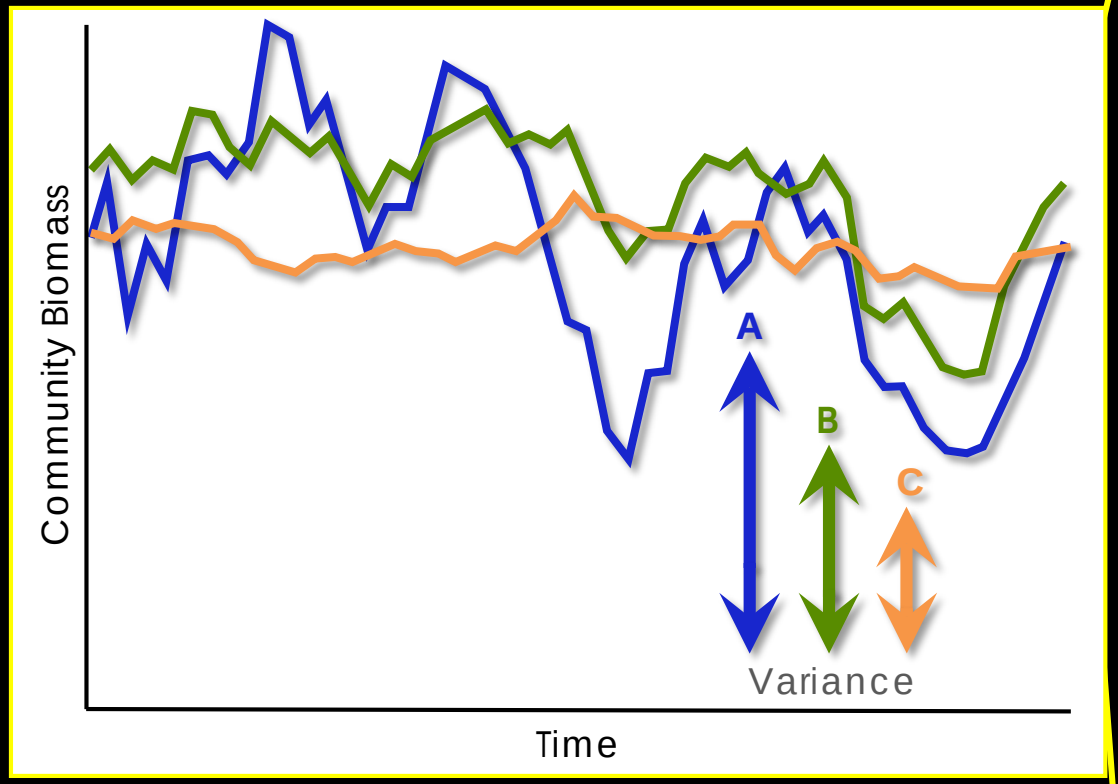

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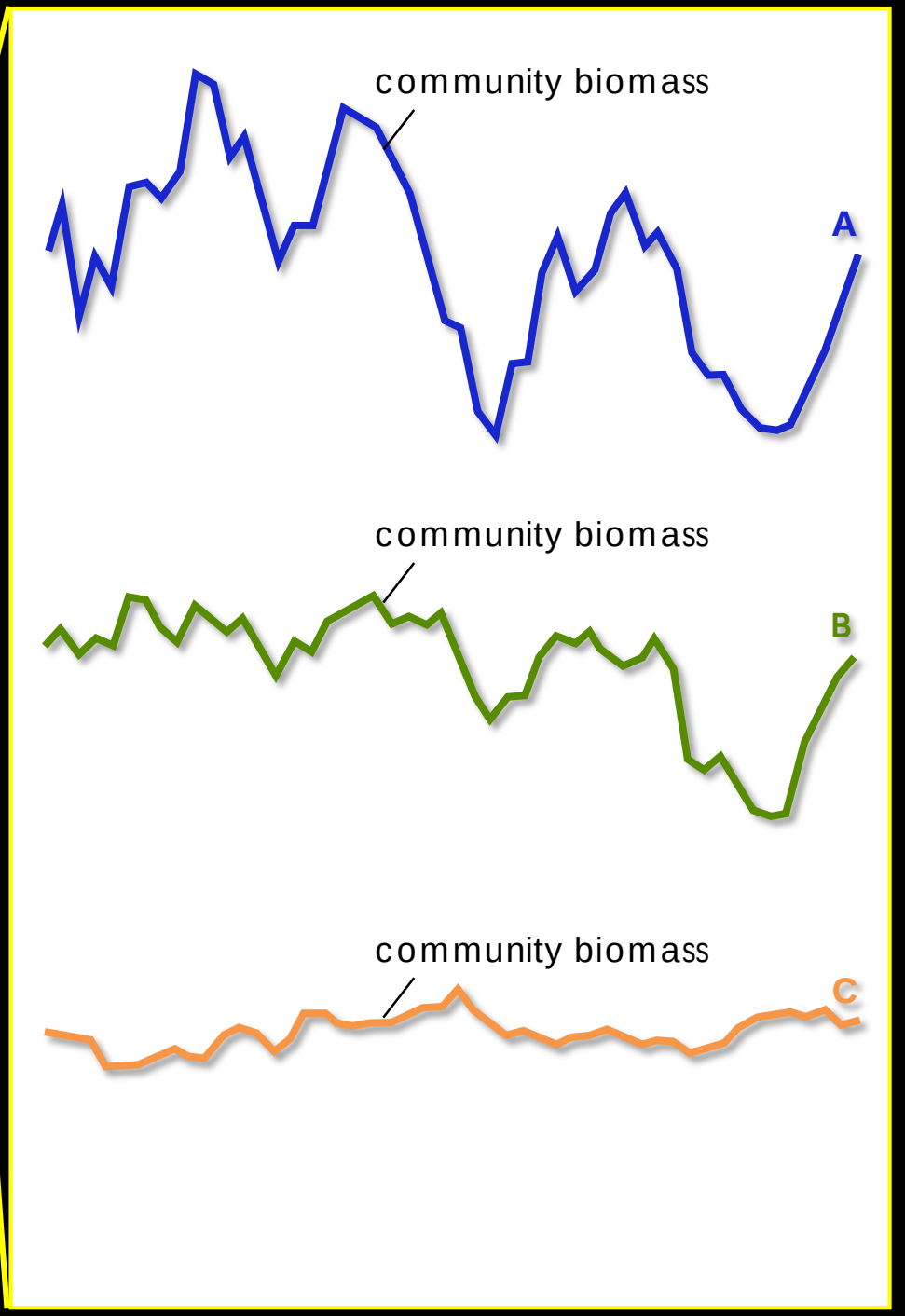

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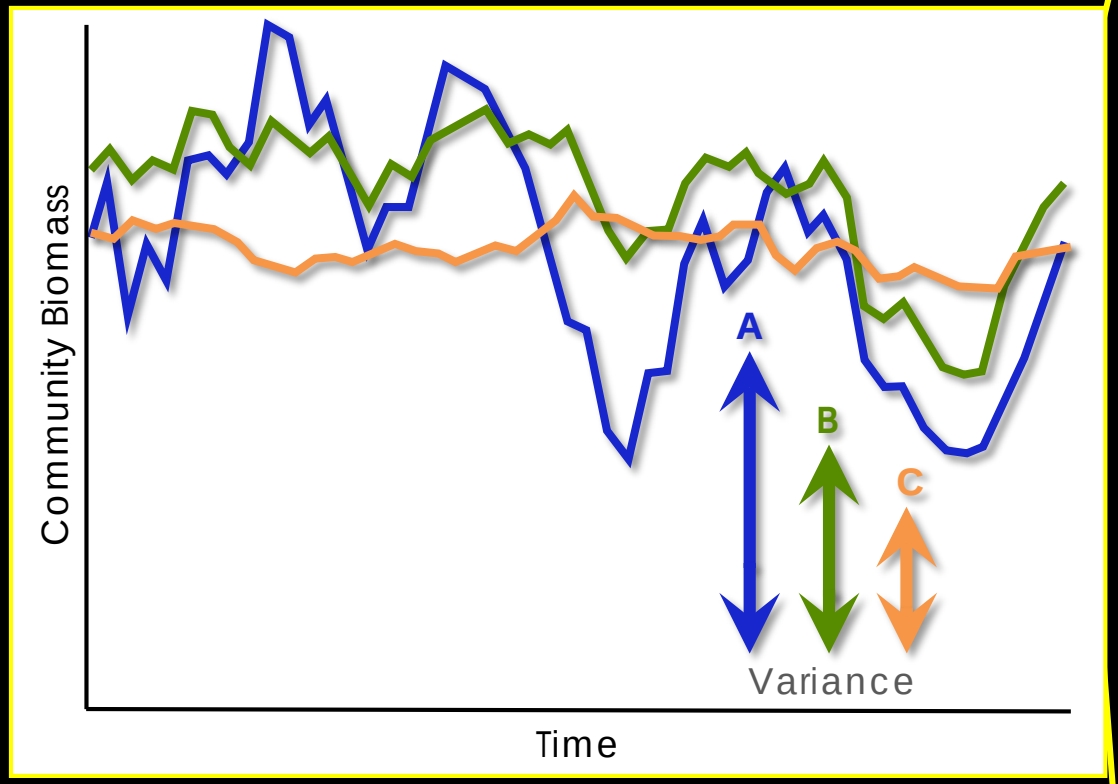

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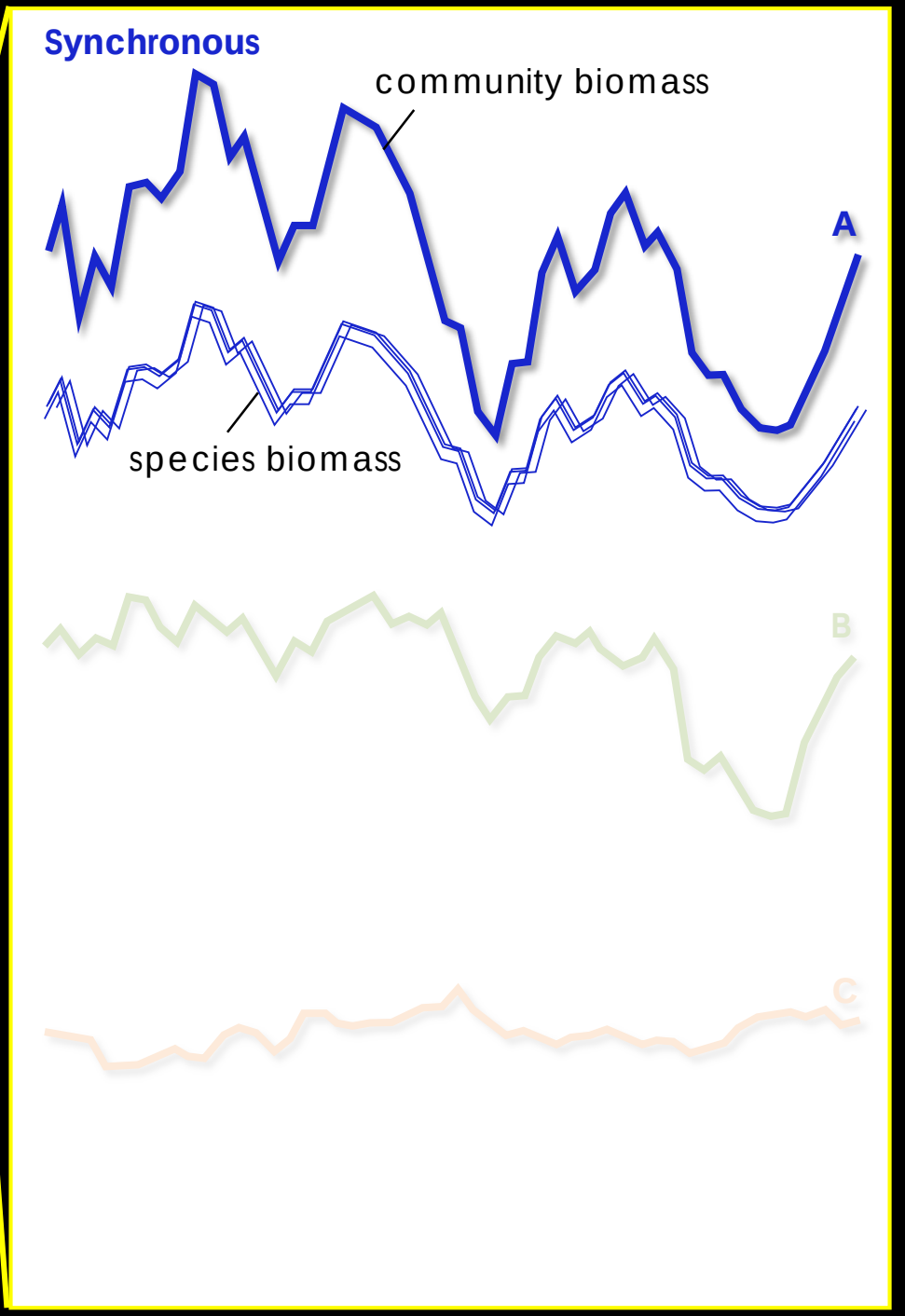

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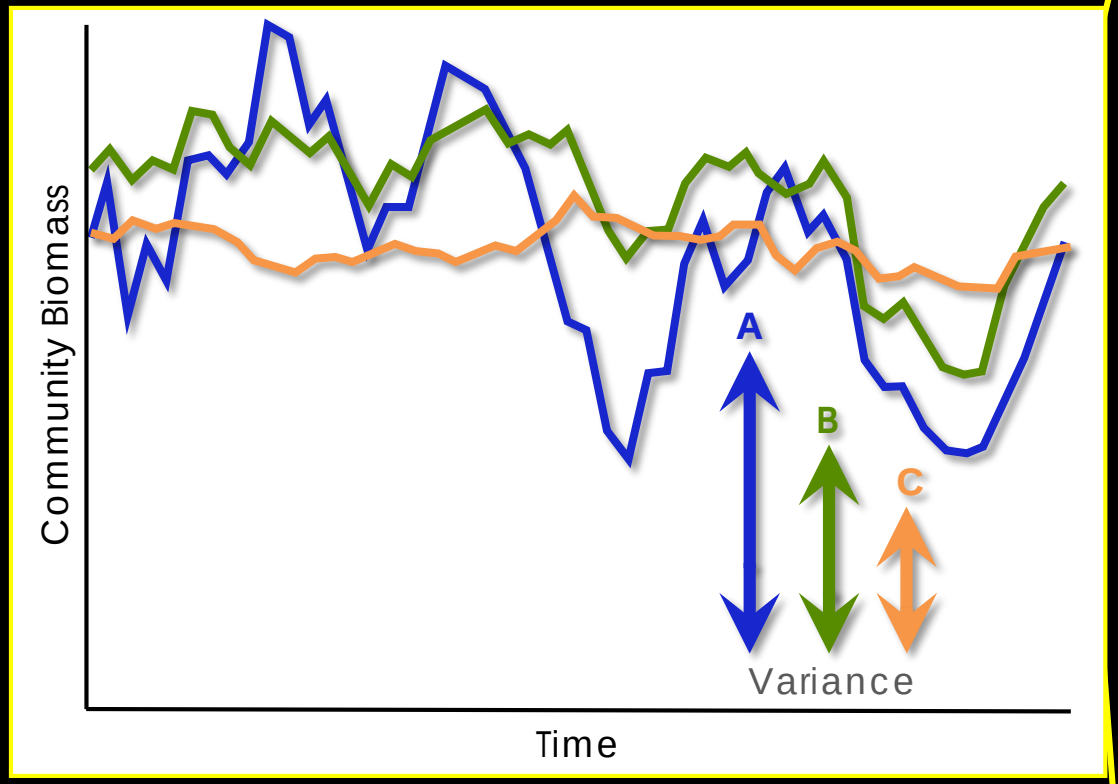

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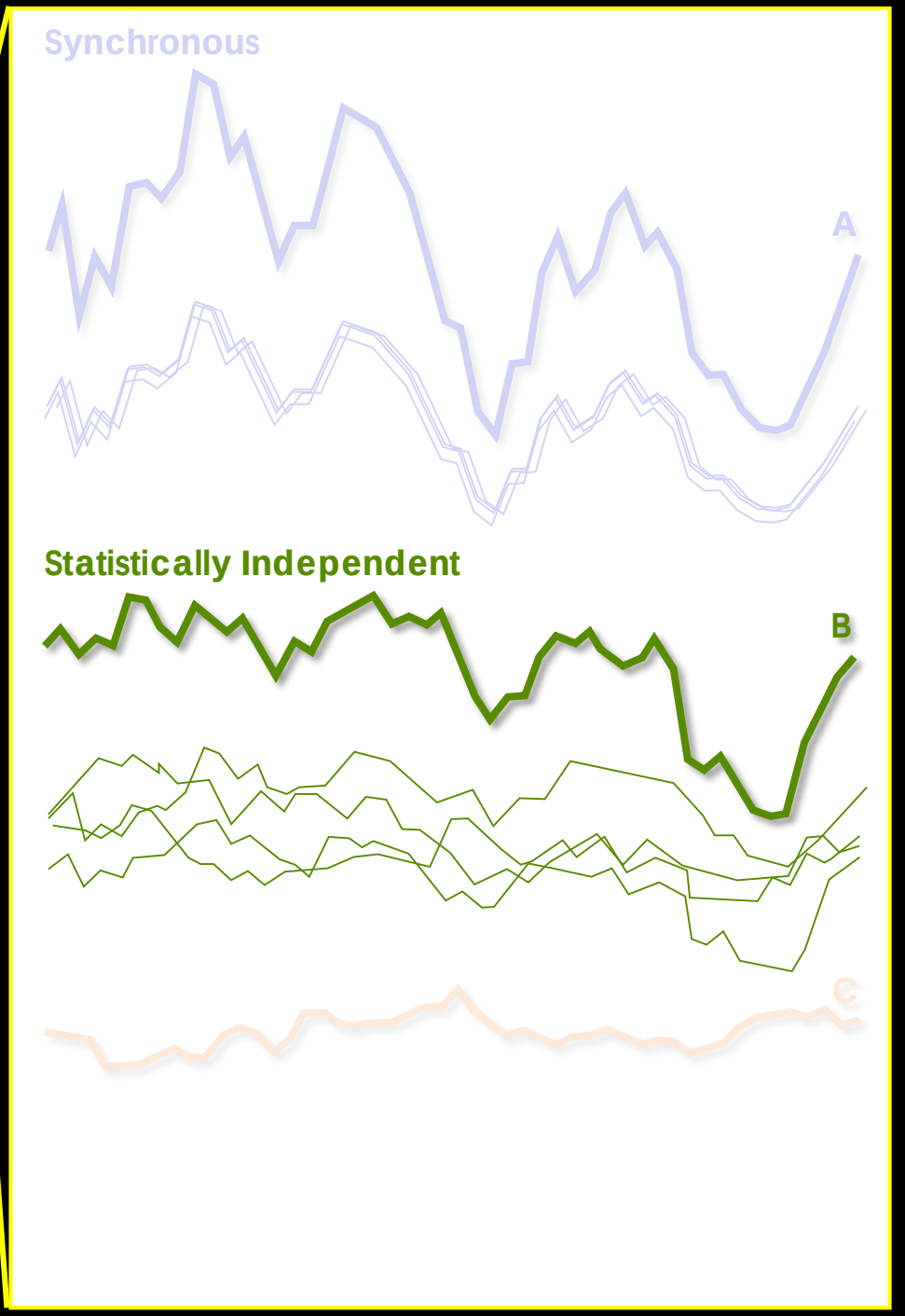

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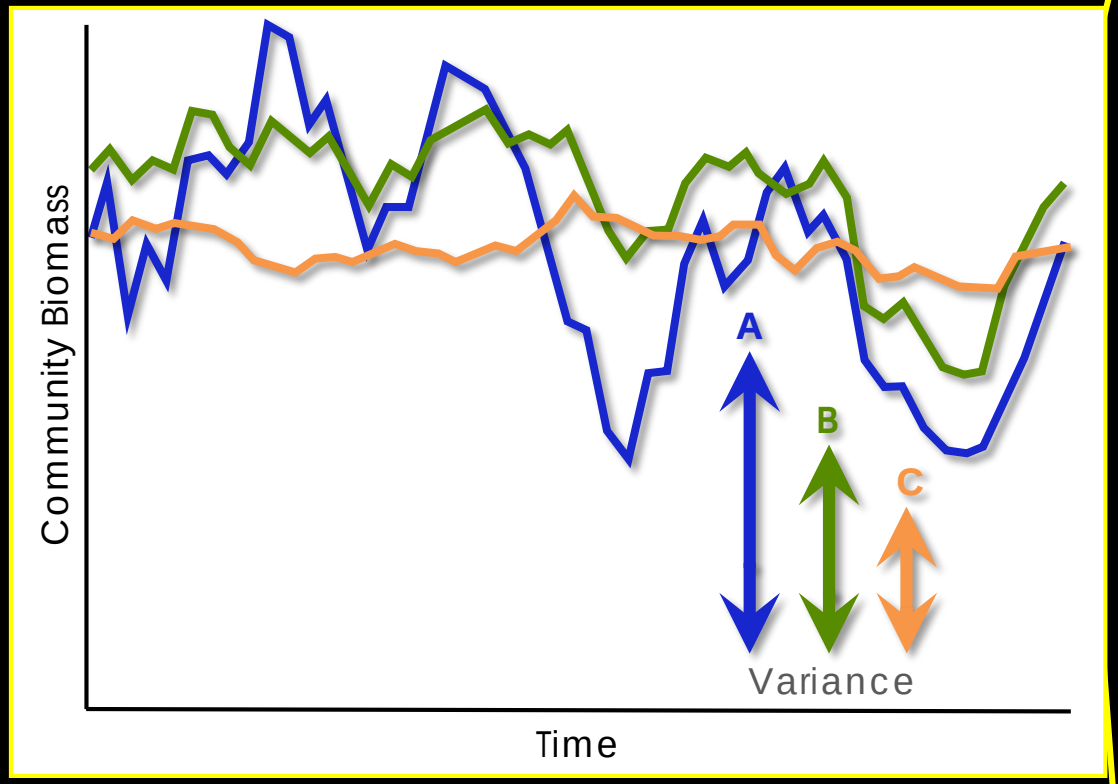

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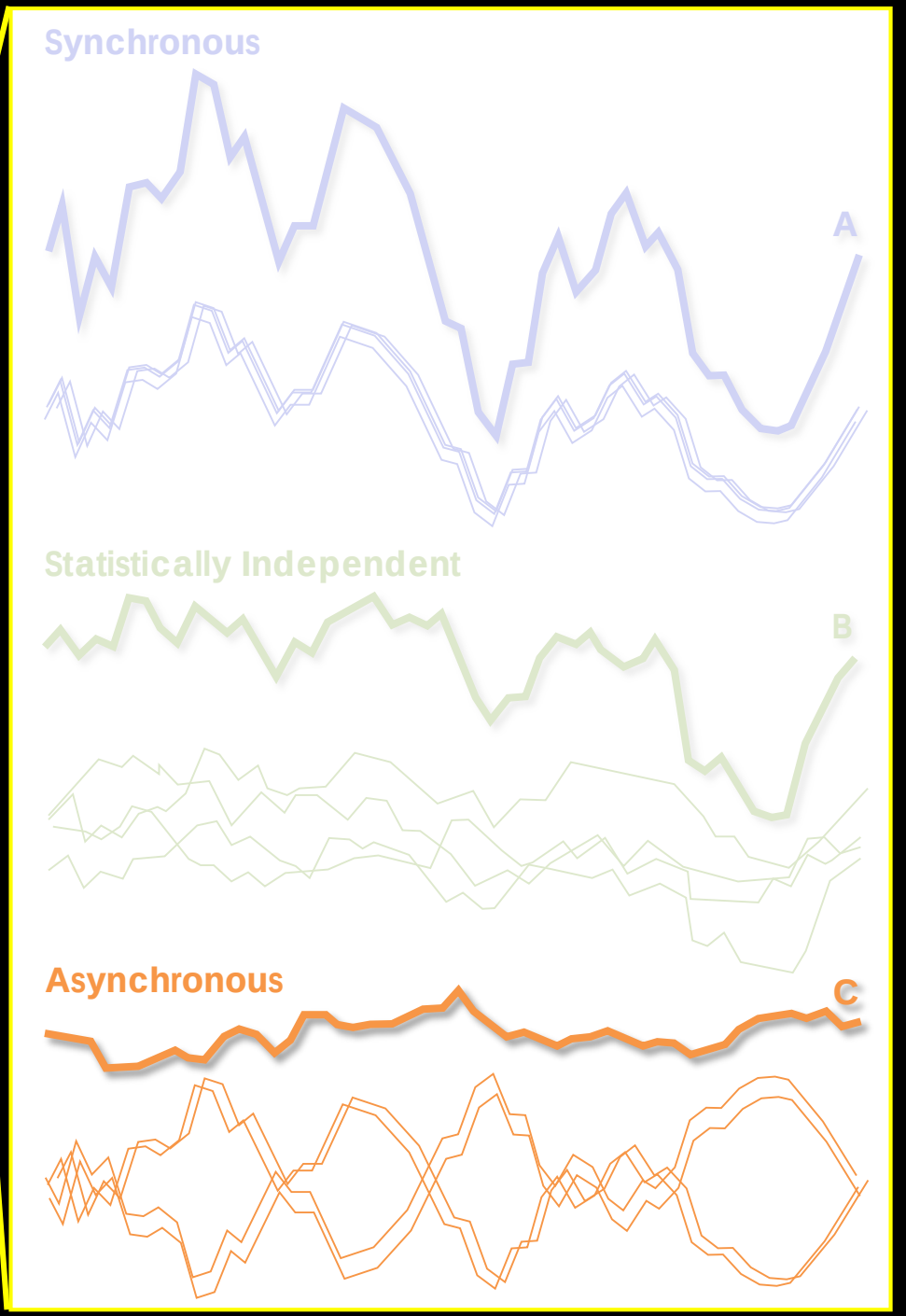

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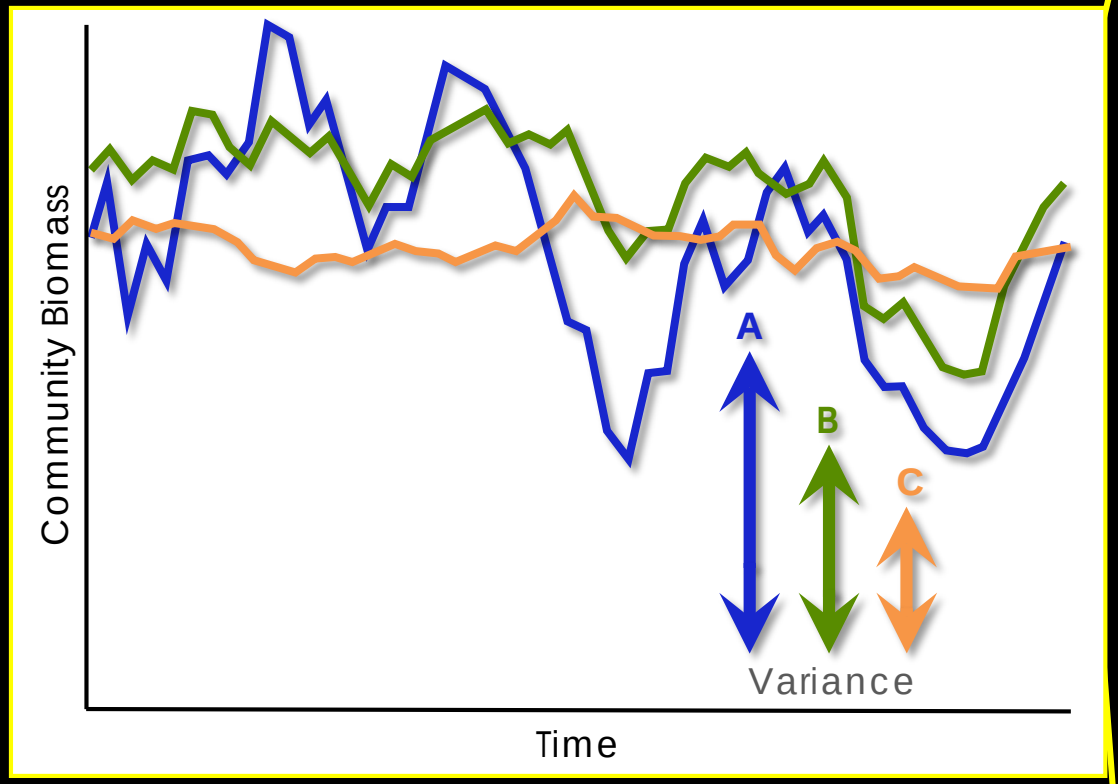

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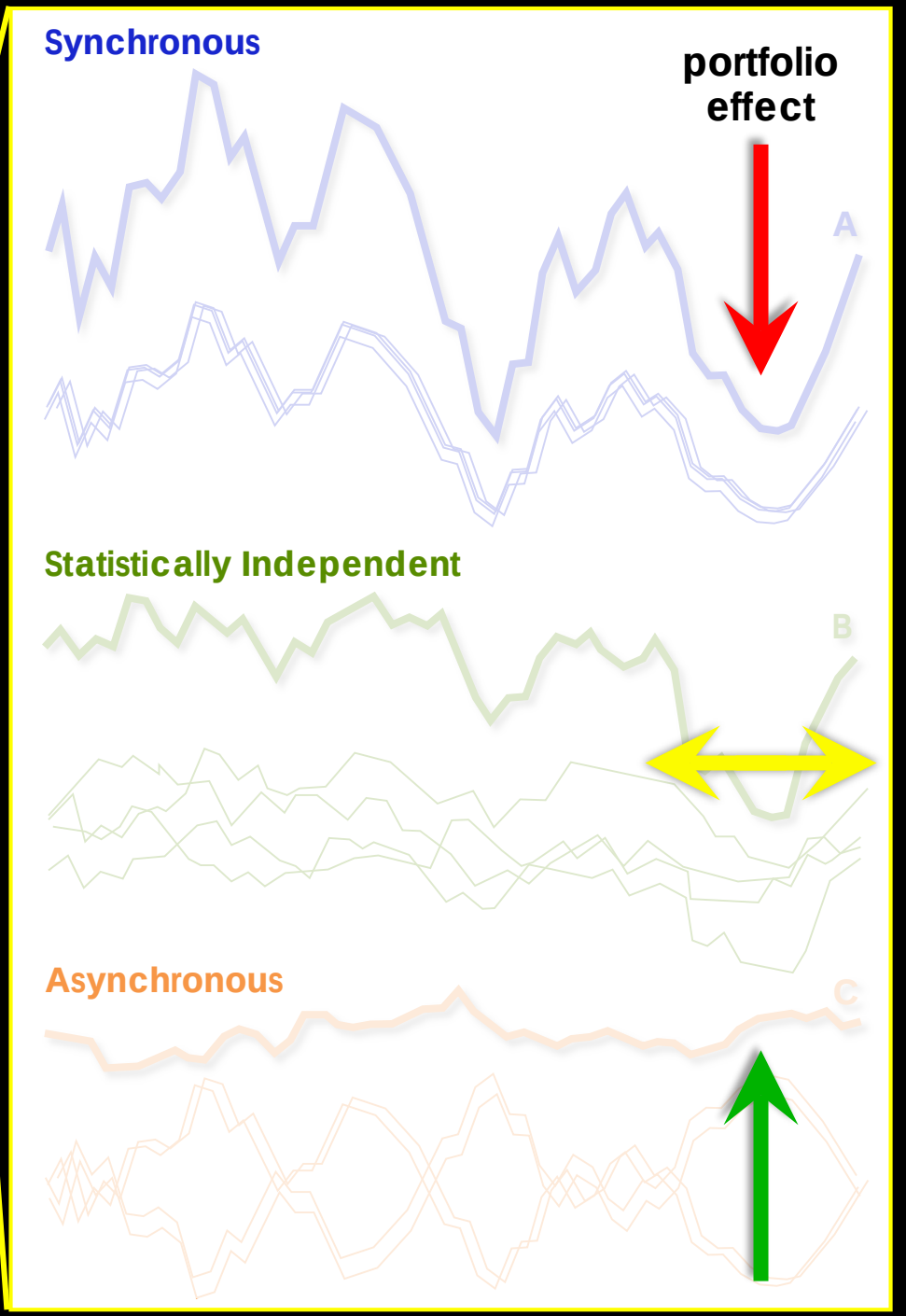

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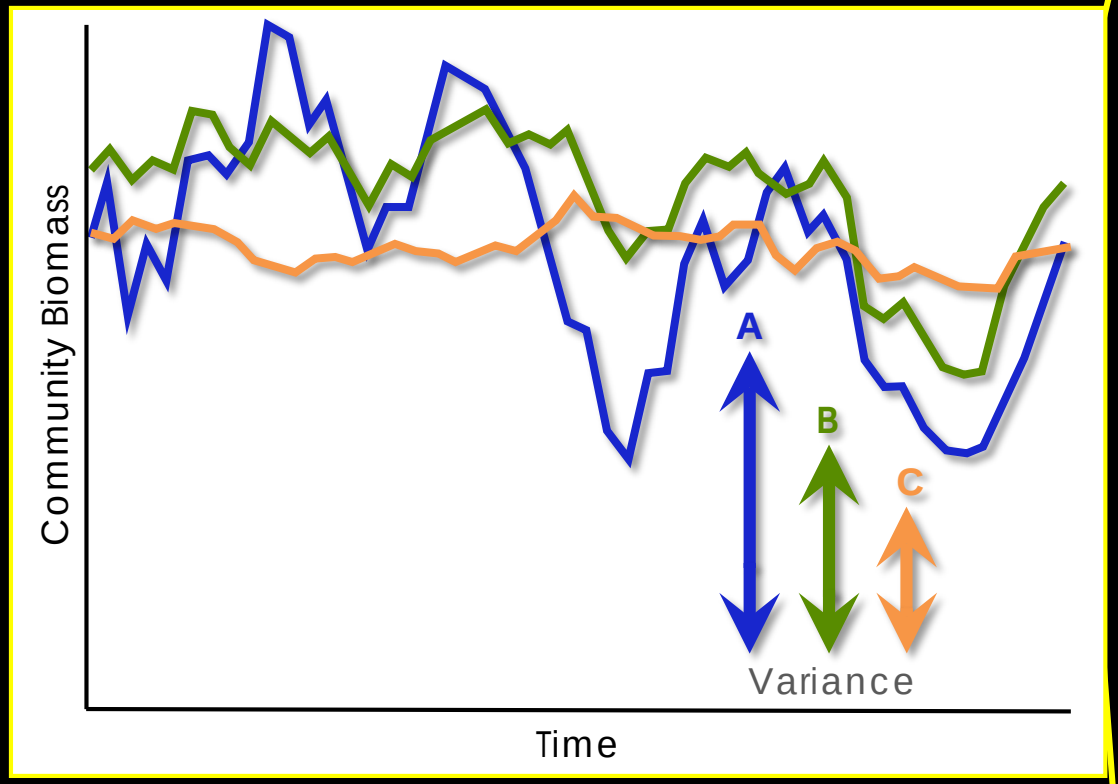

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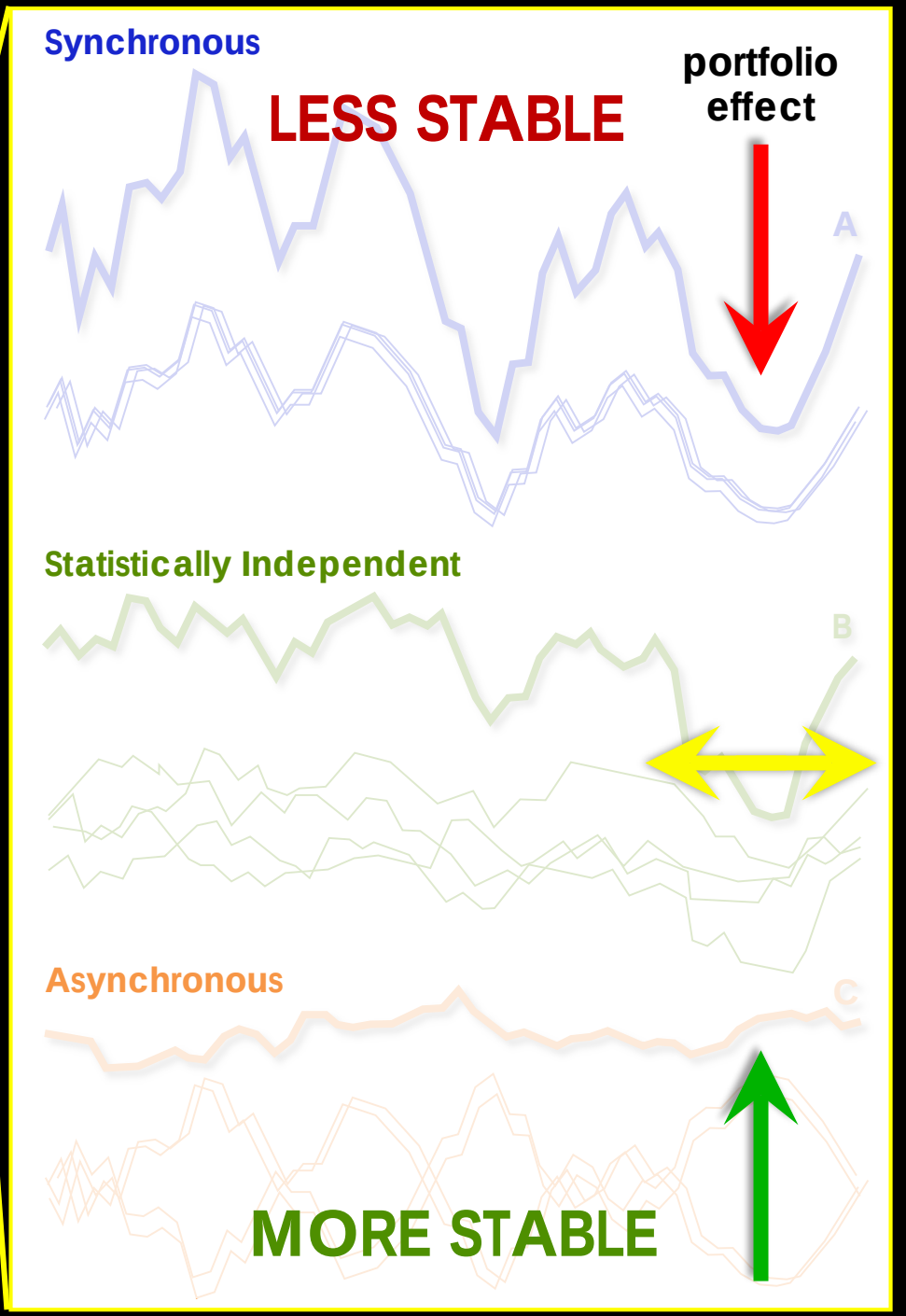


the portfolio effect


Sports Illustrated

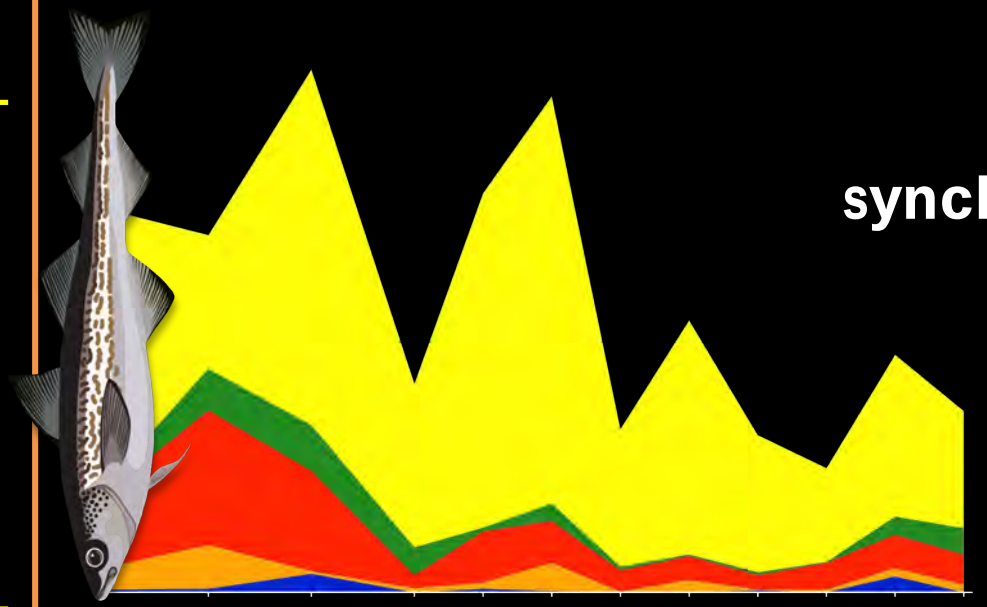

YouTube

predation and trophic stability in the Gulf of AK

Time Series: 1990 to 2015

Spatial Scales:

- Basin
- Pollock Stock Assessment Area
- Subregion
- INPFC Statistical Area



$$\textbf{synchrony} = \frac{\text{variance in total consumption}}{\text{sum of predator-specific variances}}$$

portfolio effect = 1 - synchrony

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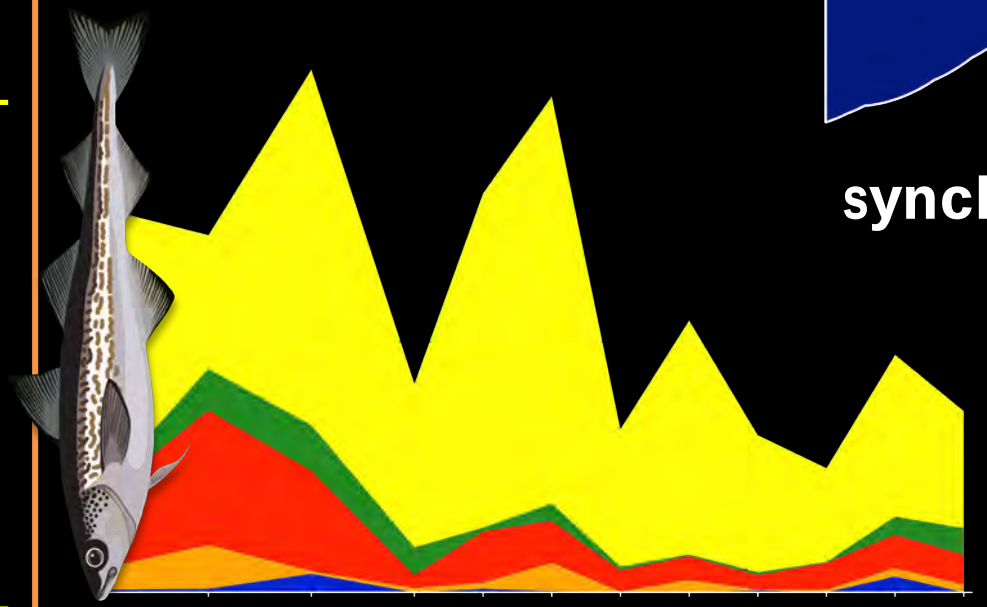

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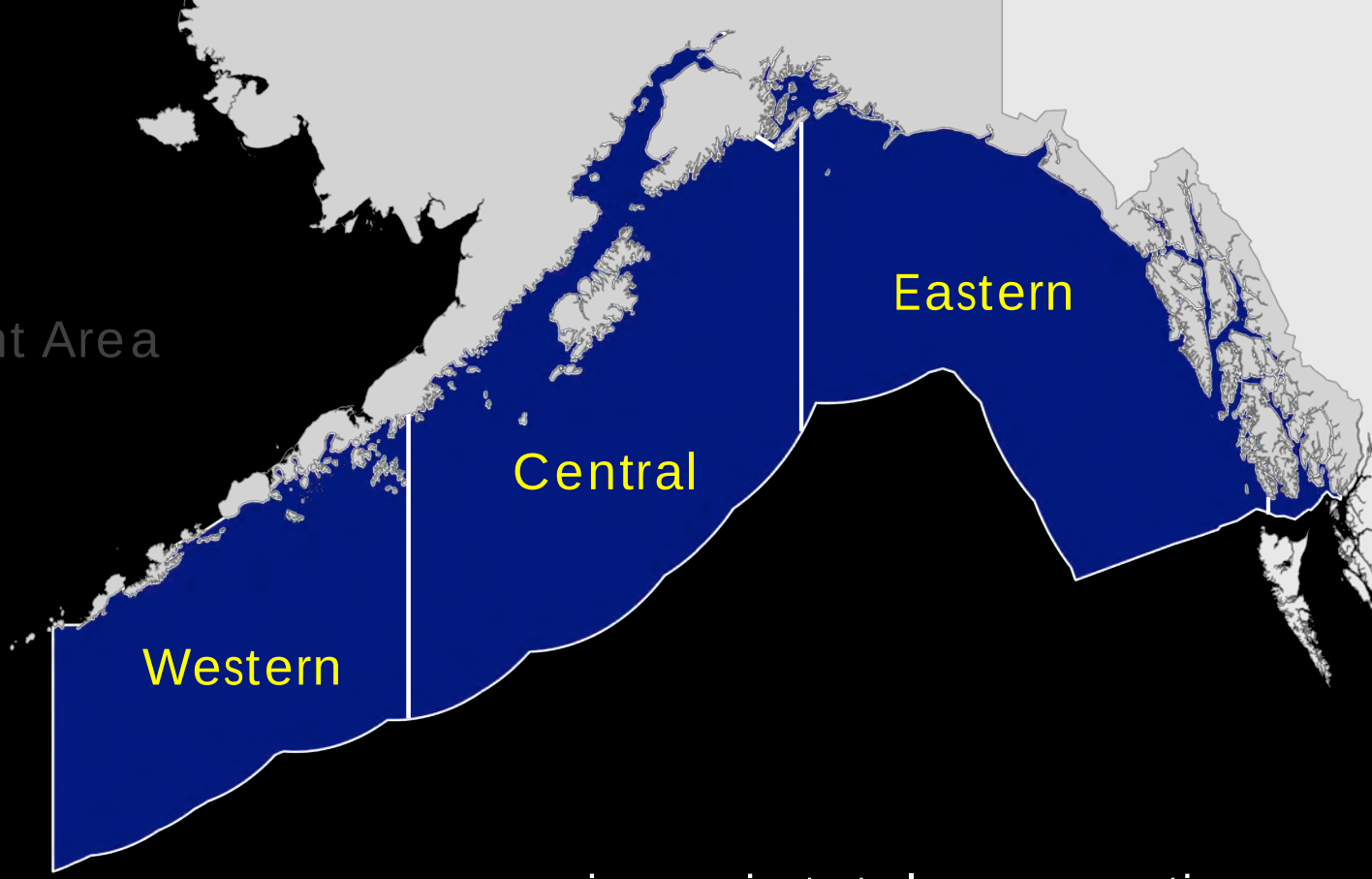

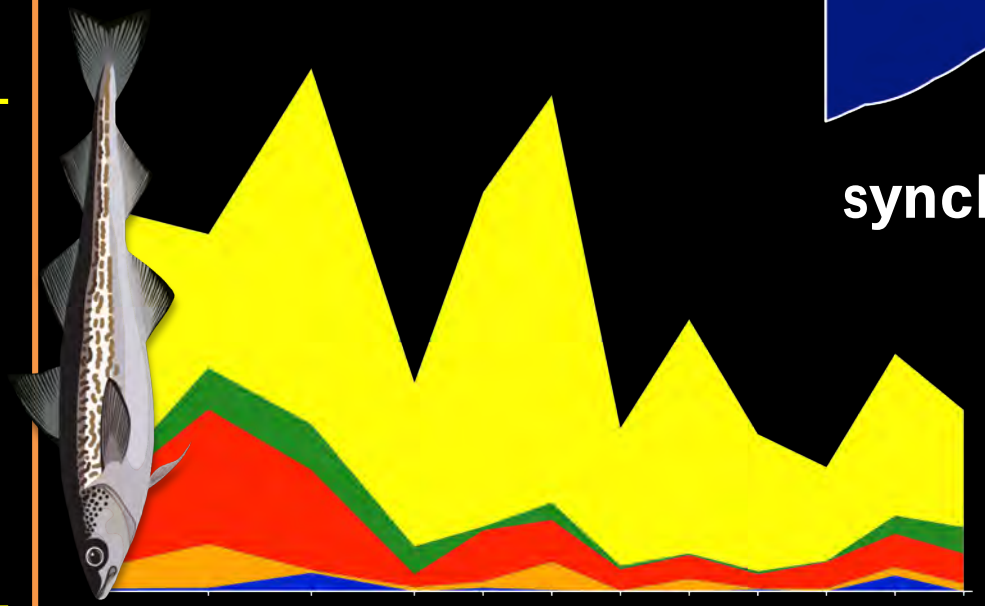

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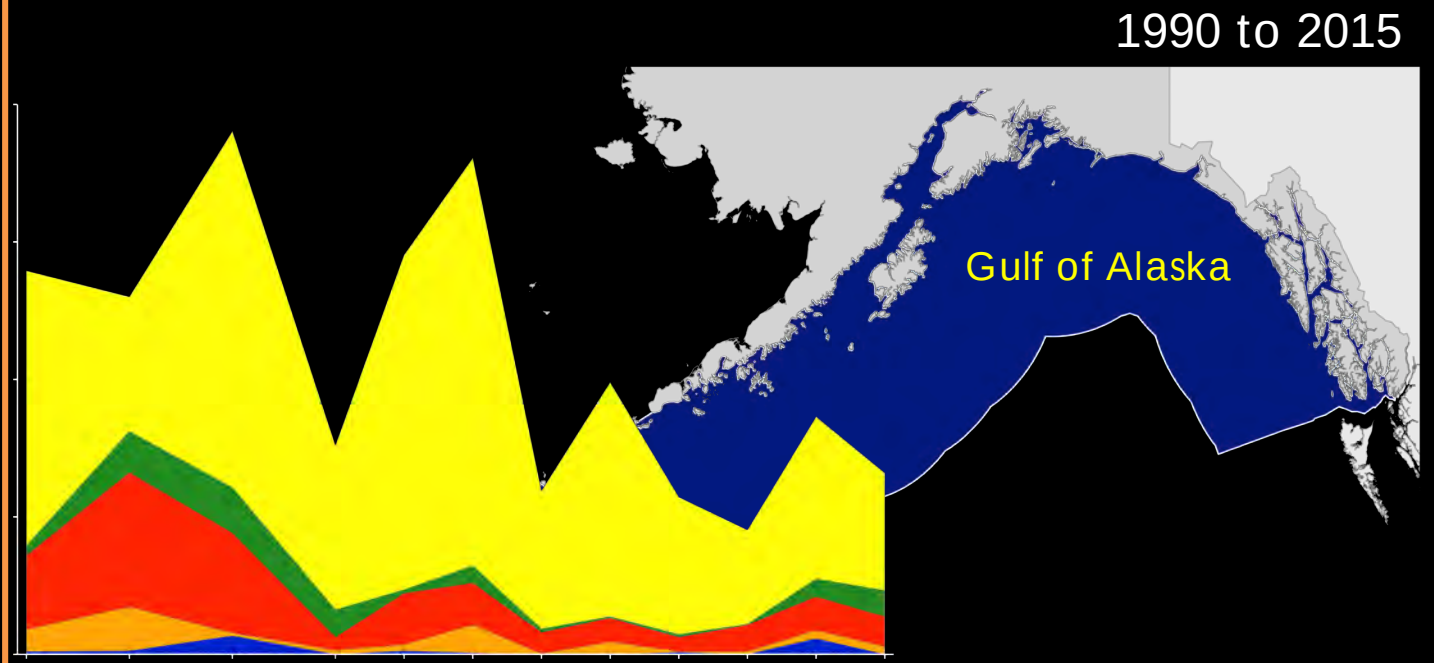
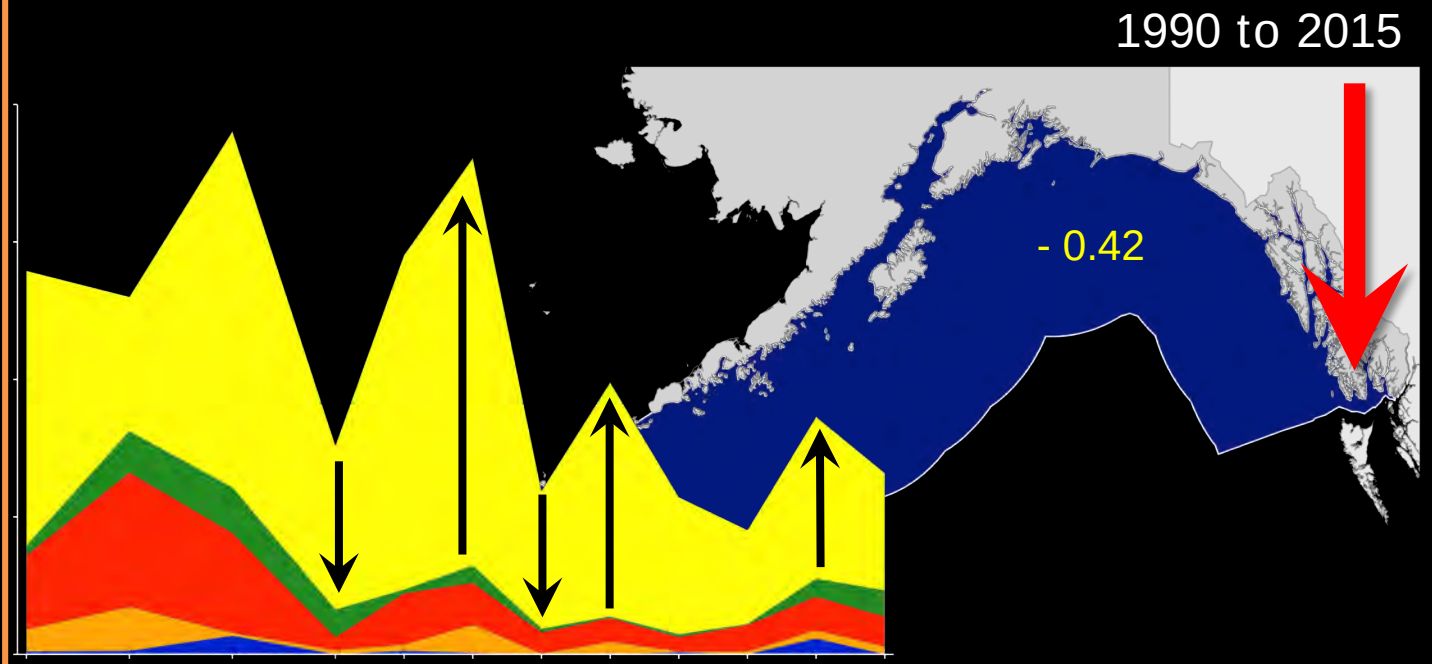
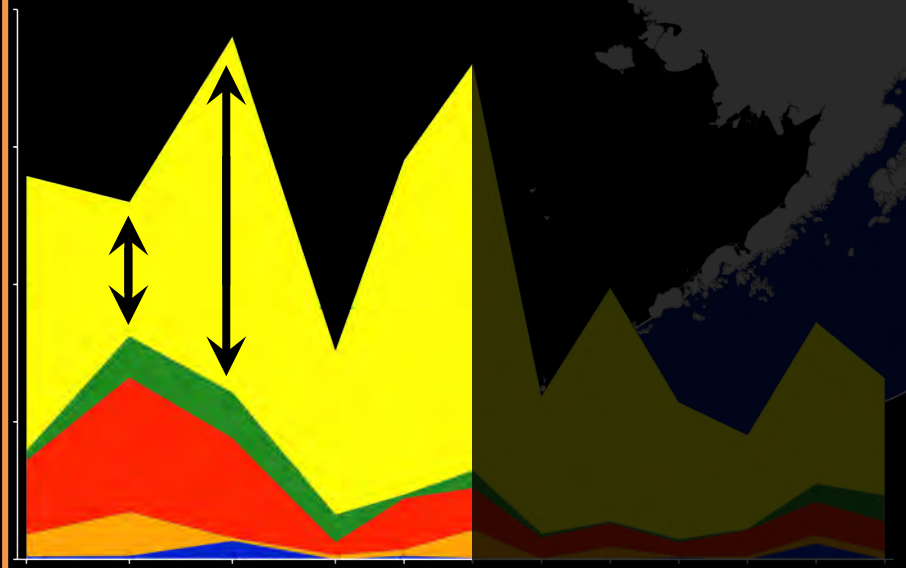


predation and trophic stability in the Gulf of AK

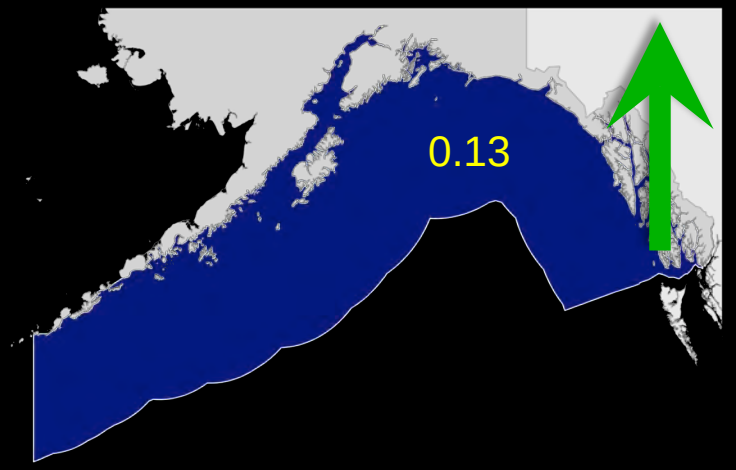


predation and trophic stability in the Gulf of AK



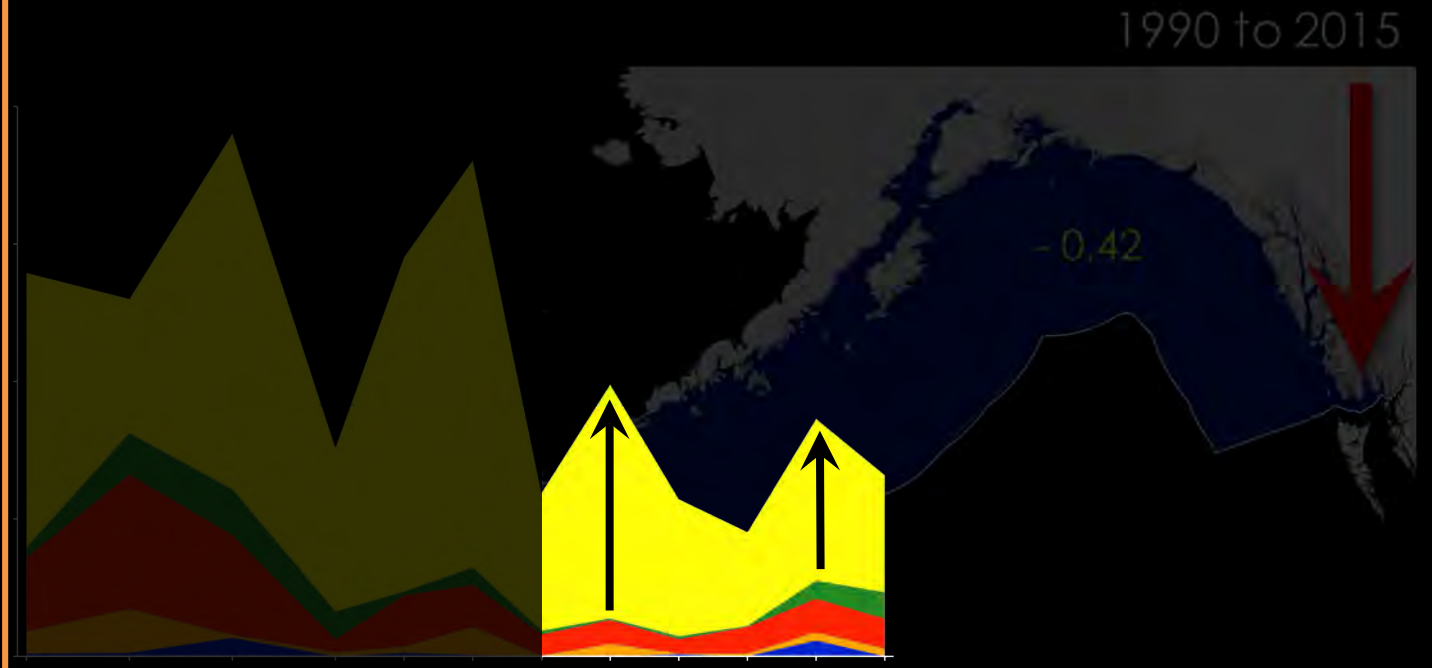
1990 to 2015

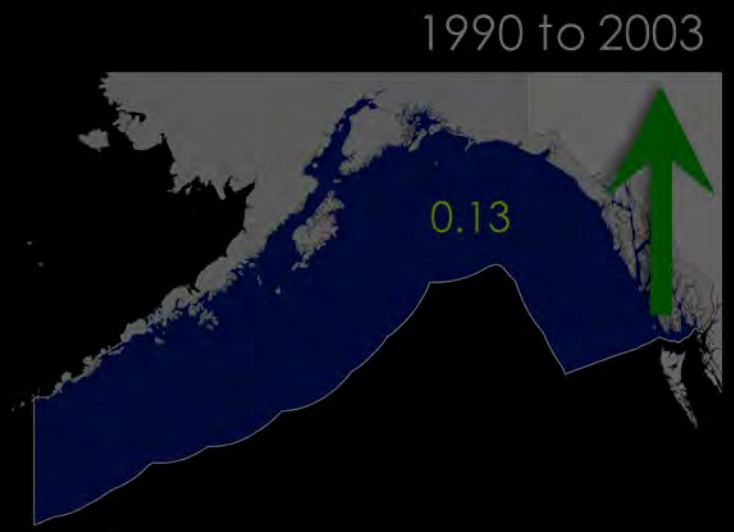
1990 to 2003

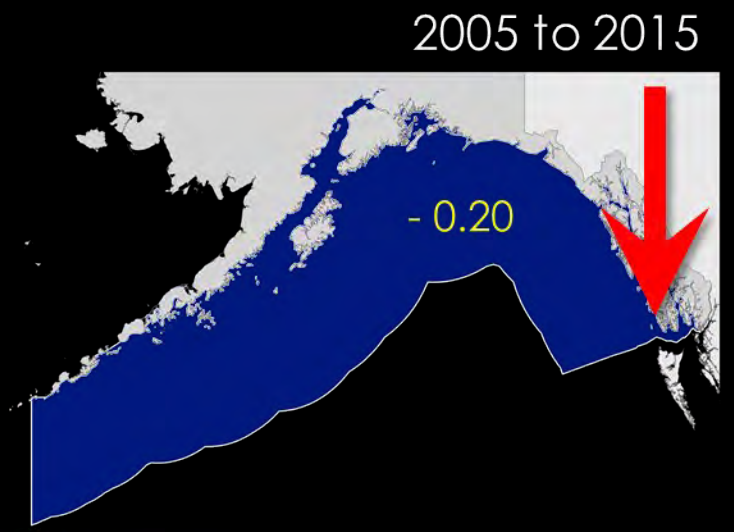


2005 to 2015

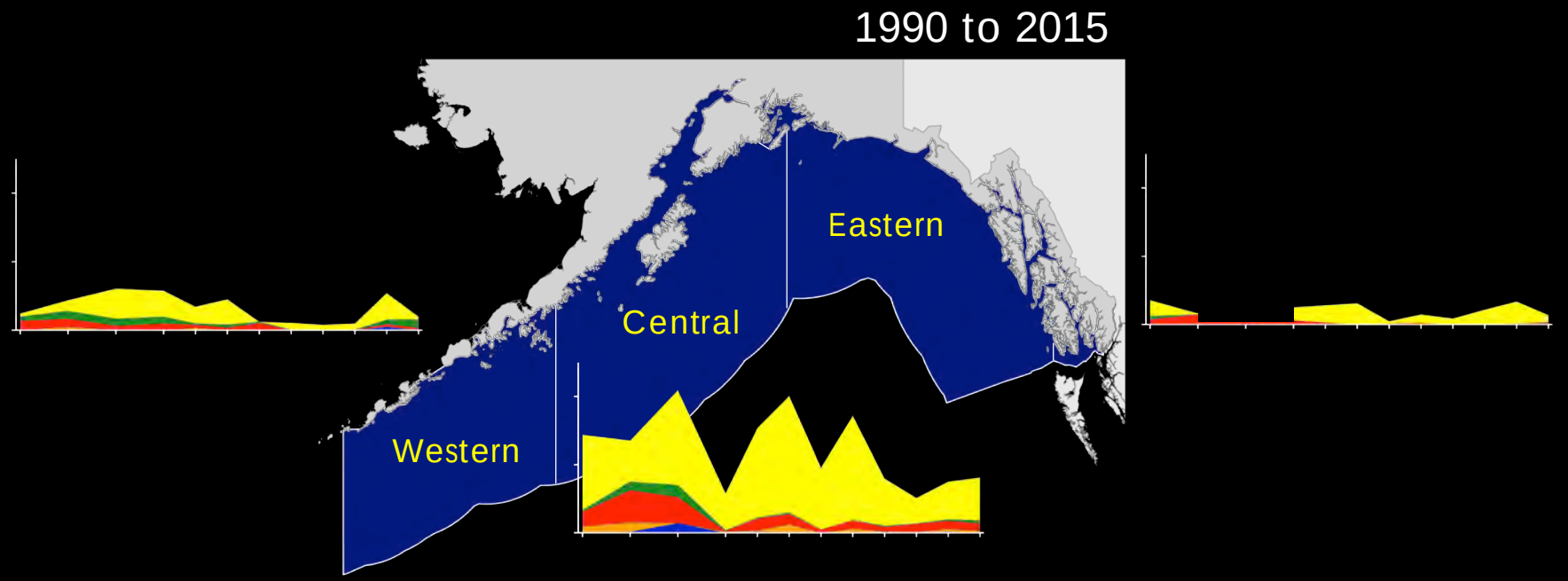
predation and trophic stability in the Gulf of AK



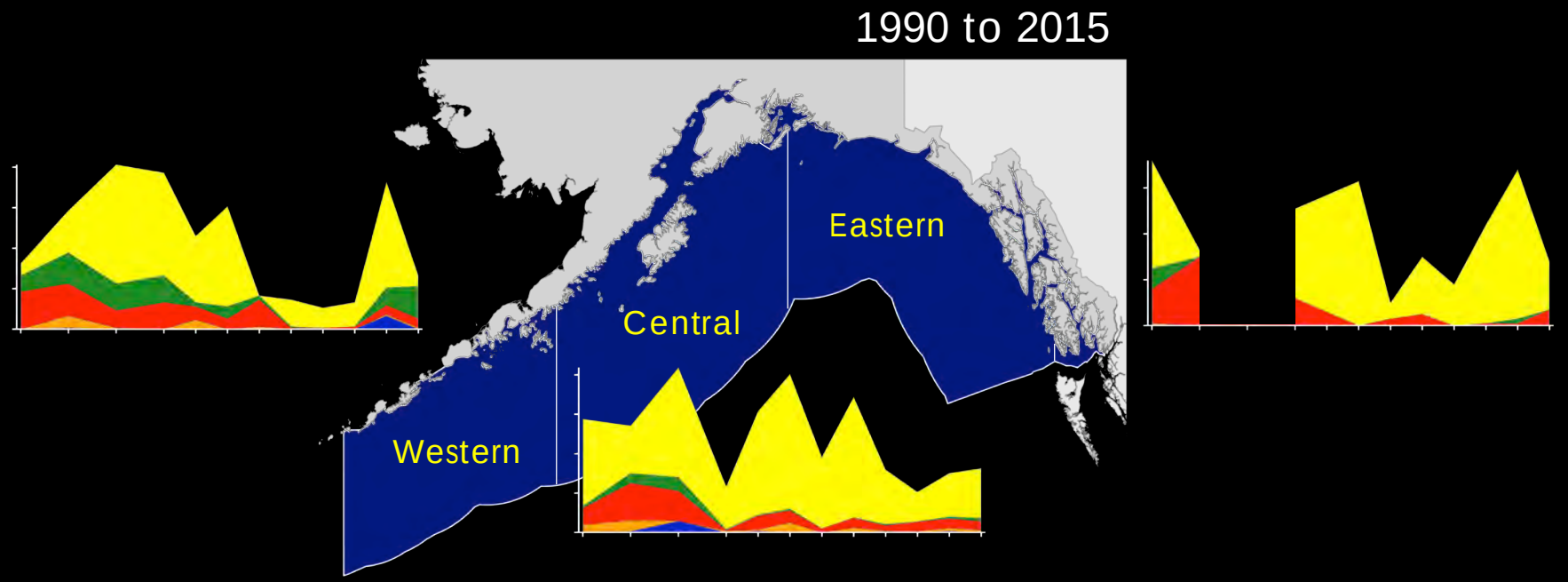




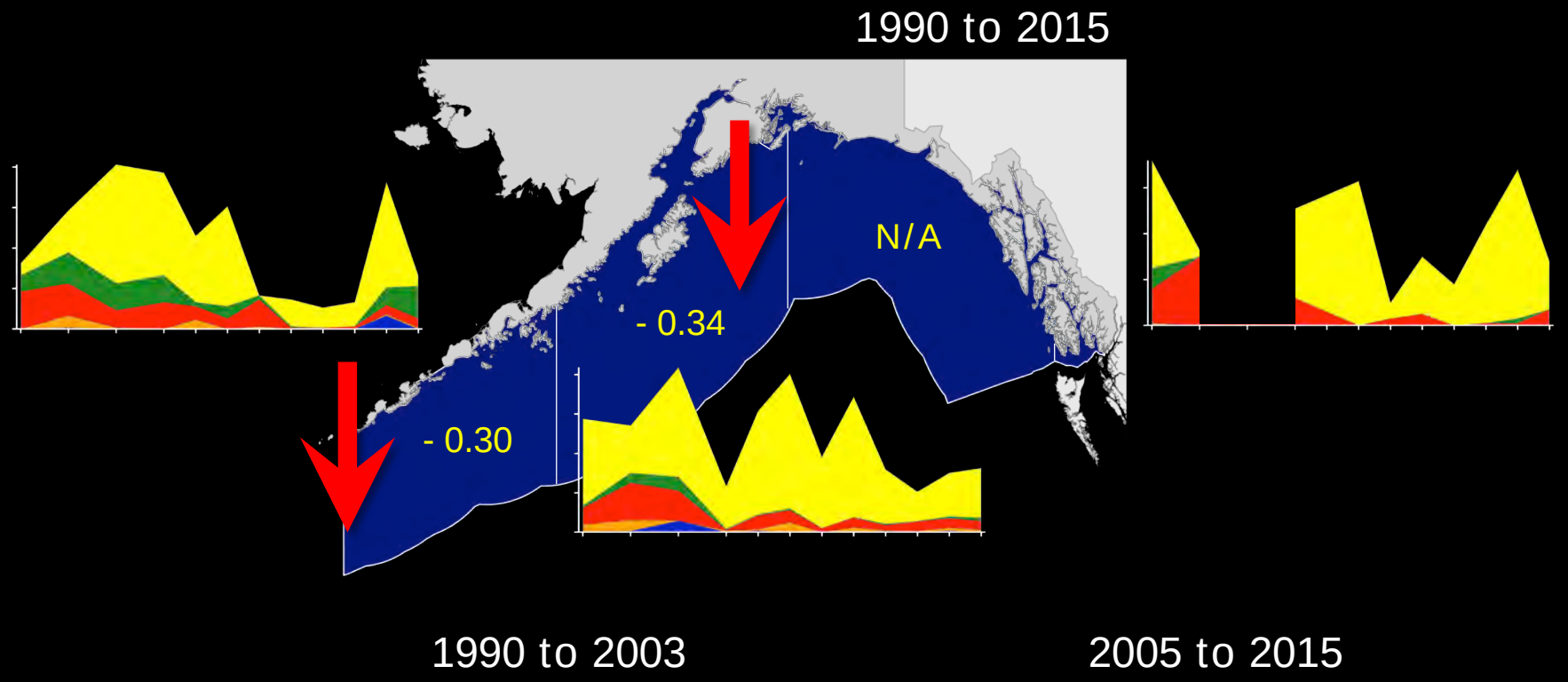
predation and trophic stability in the Gulf of AK



predation and trophic stability in the Gulf of AK

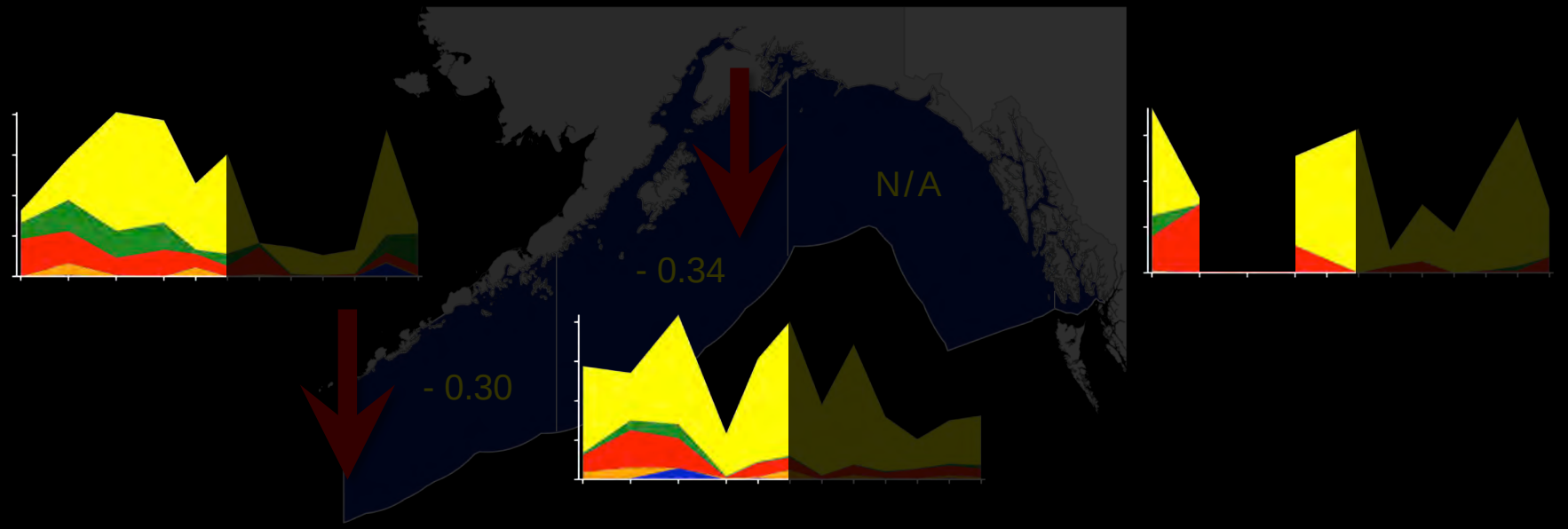


predation and trophic stability in the Gulf of AK

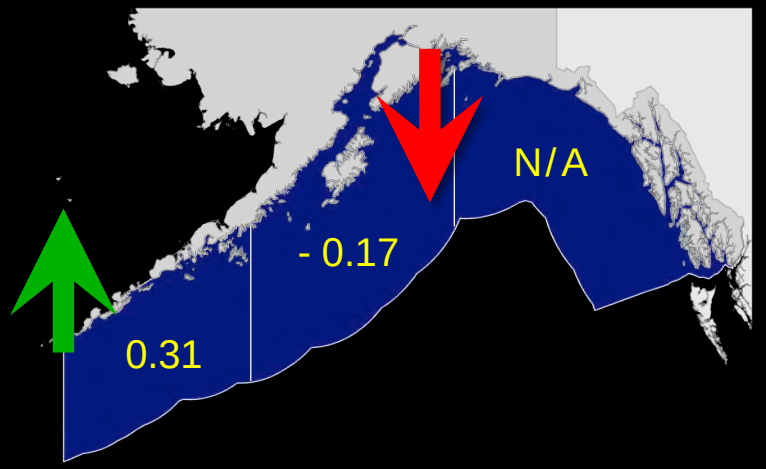


predation and trophic stability in the Gulf of AK

1990 to 2015

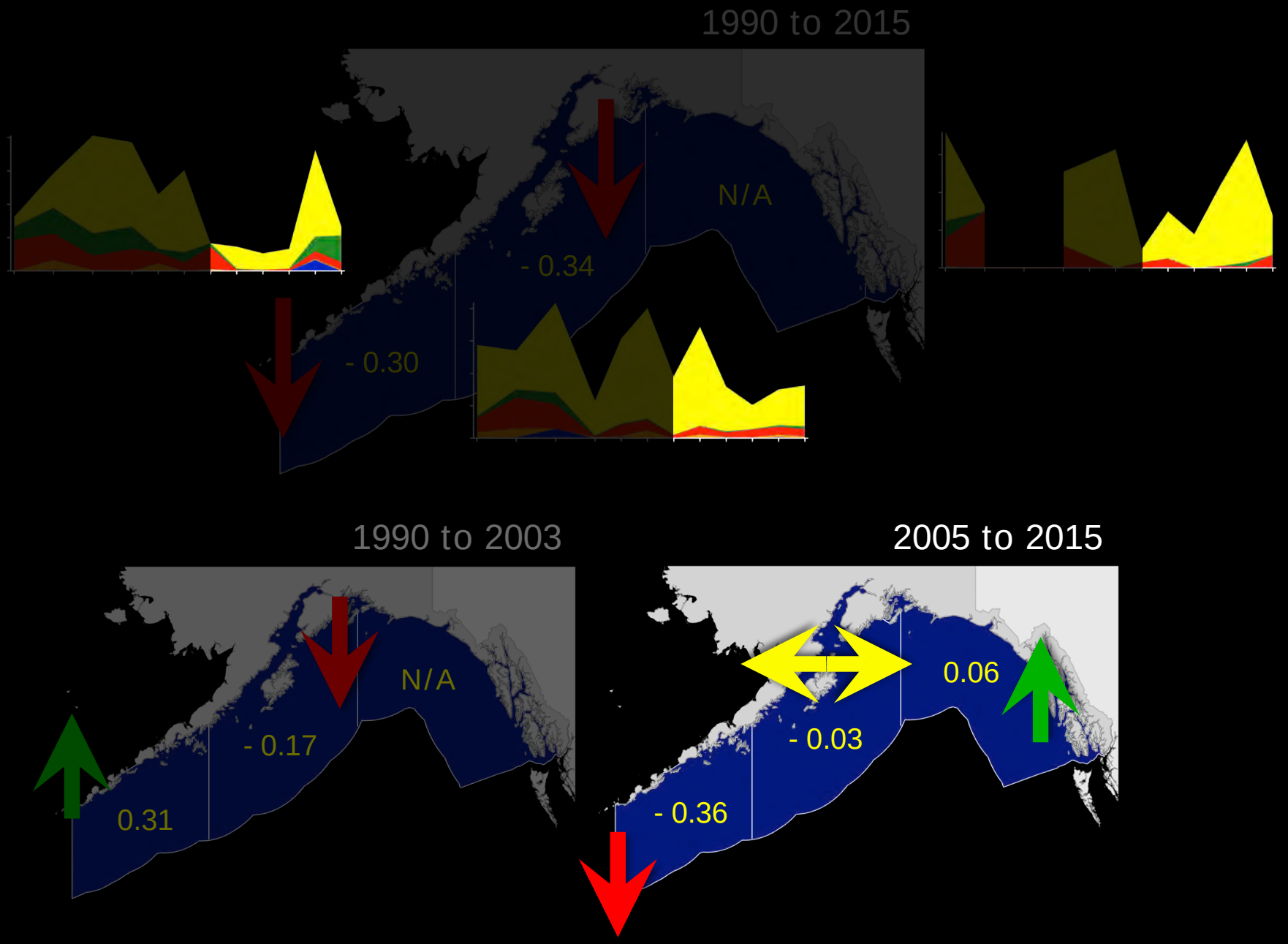


1990 to 2003



2005 to 2015

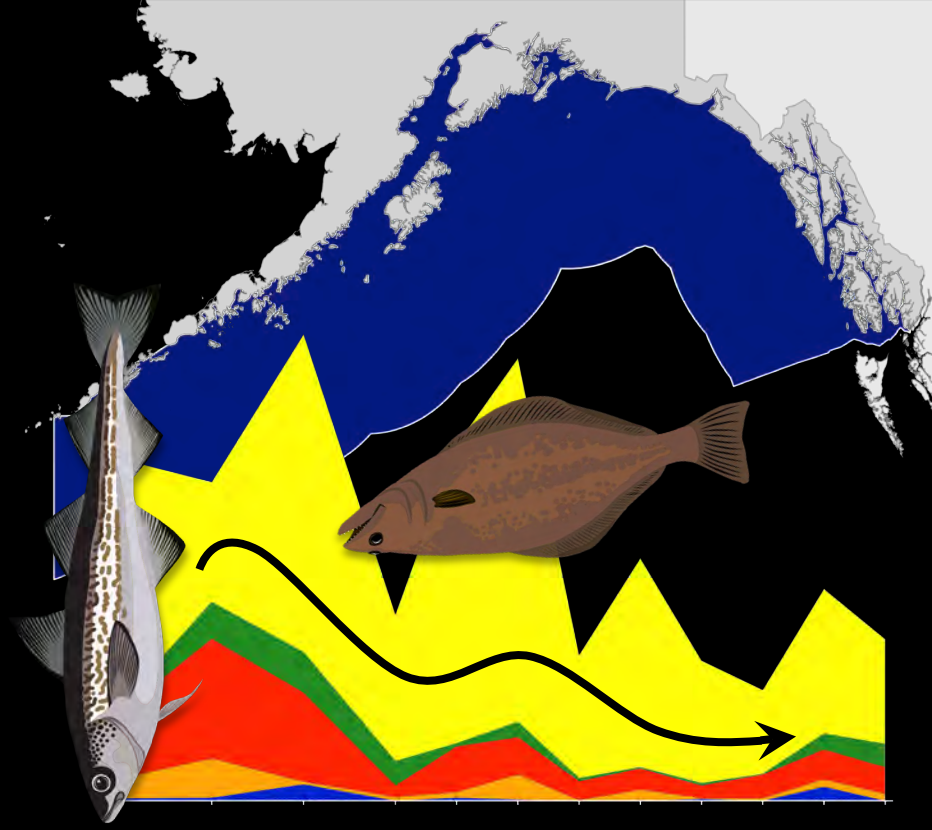
predation and trophic stability in the Gulf of AK



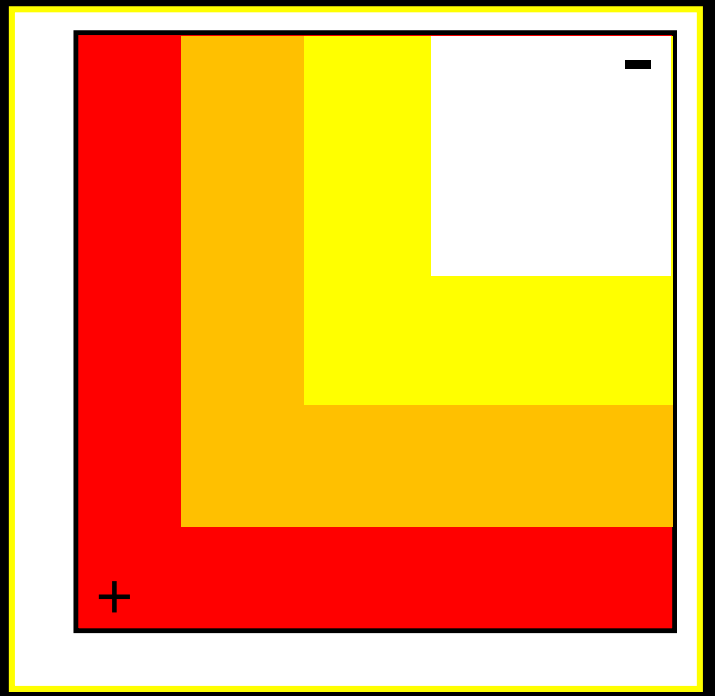
predation and trophic stability in the Gulf of AK

Key Findings

- intense and highly-variable predation
- Arrowtooth Flounder = dominant predator
- synchronous consumption dynamics
  - increased through time
    - dep. on scale/location



Potential for Top-Down Control



Adapted from Oken *et al.* 2016

Ecological Inferences

- trophic instability in the Gulf of Alaska

predation and trophic stability in the Gulf of AK

Key Findings

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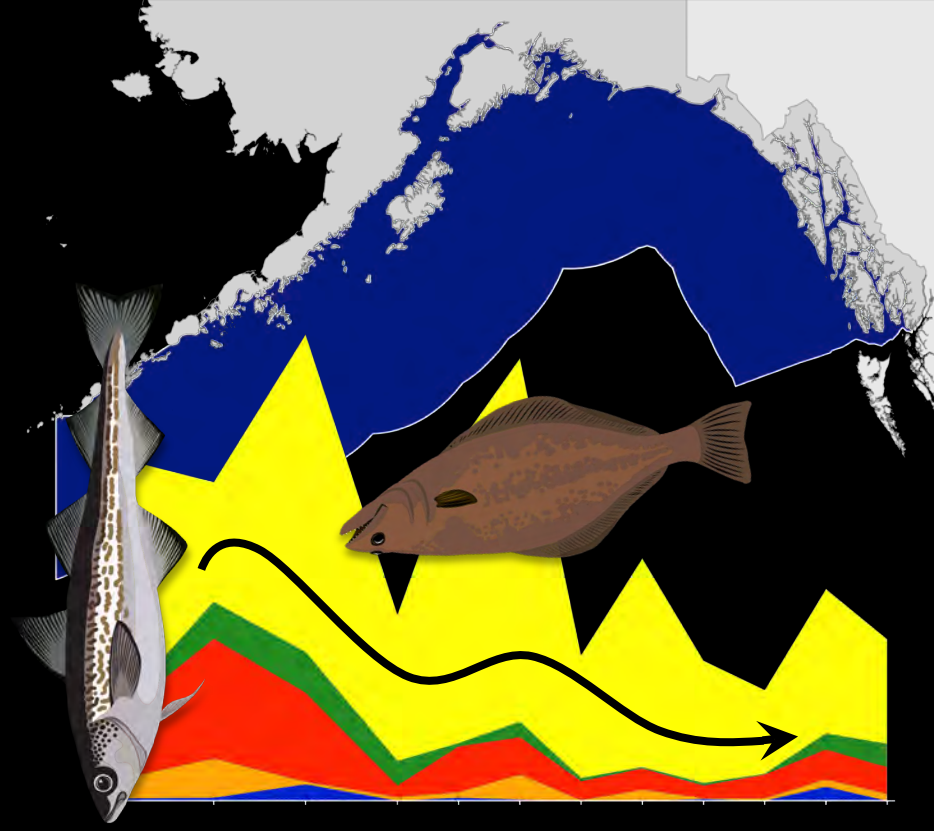

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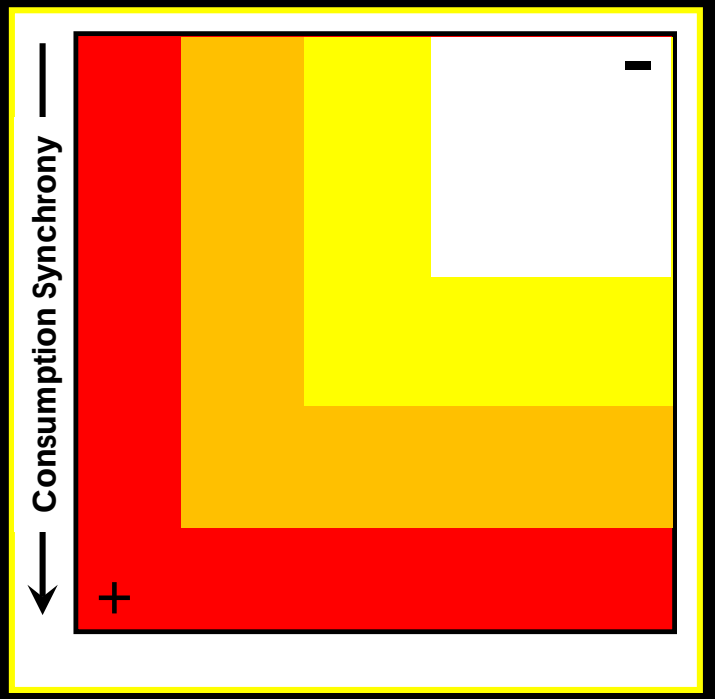

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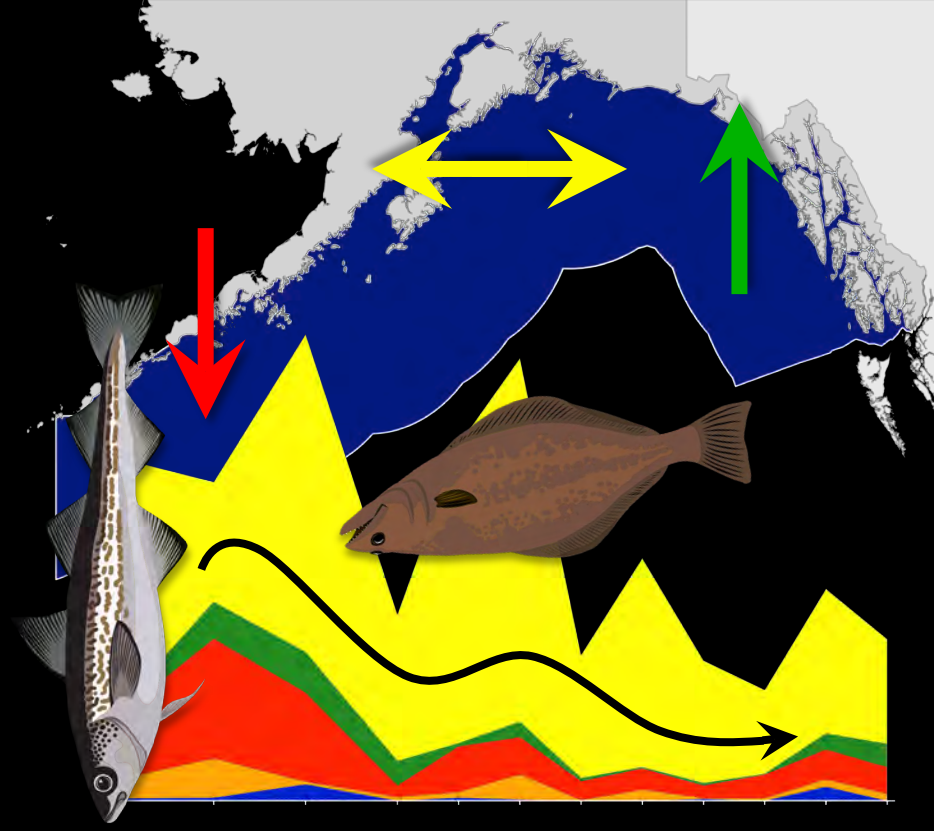
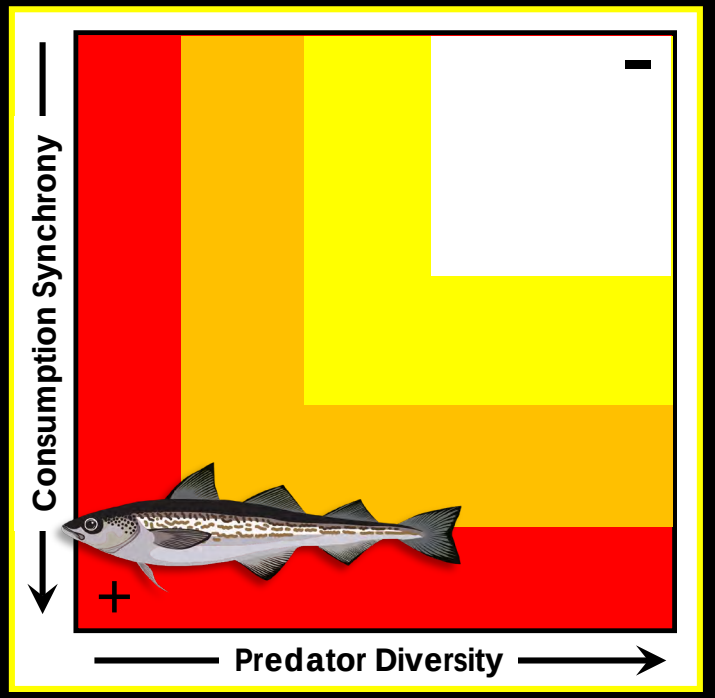


Potential for Top-Down Control



Adapted from Oken *et al.* 2016

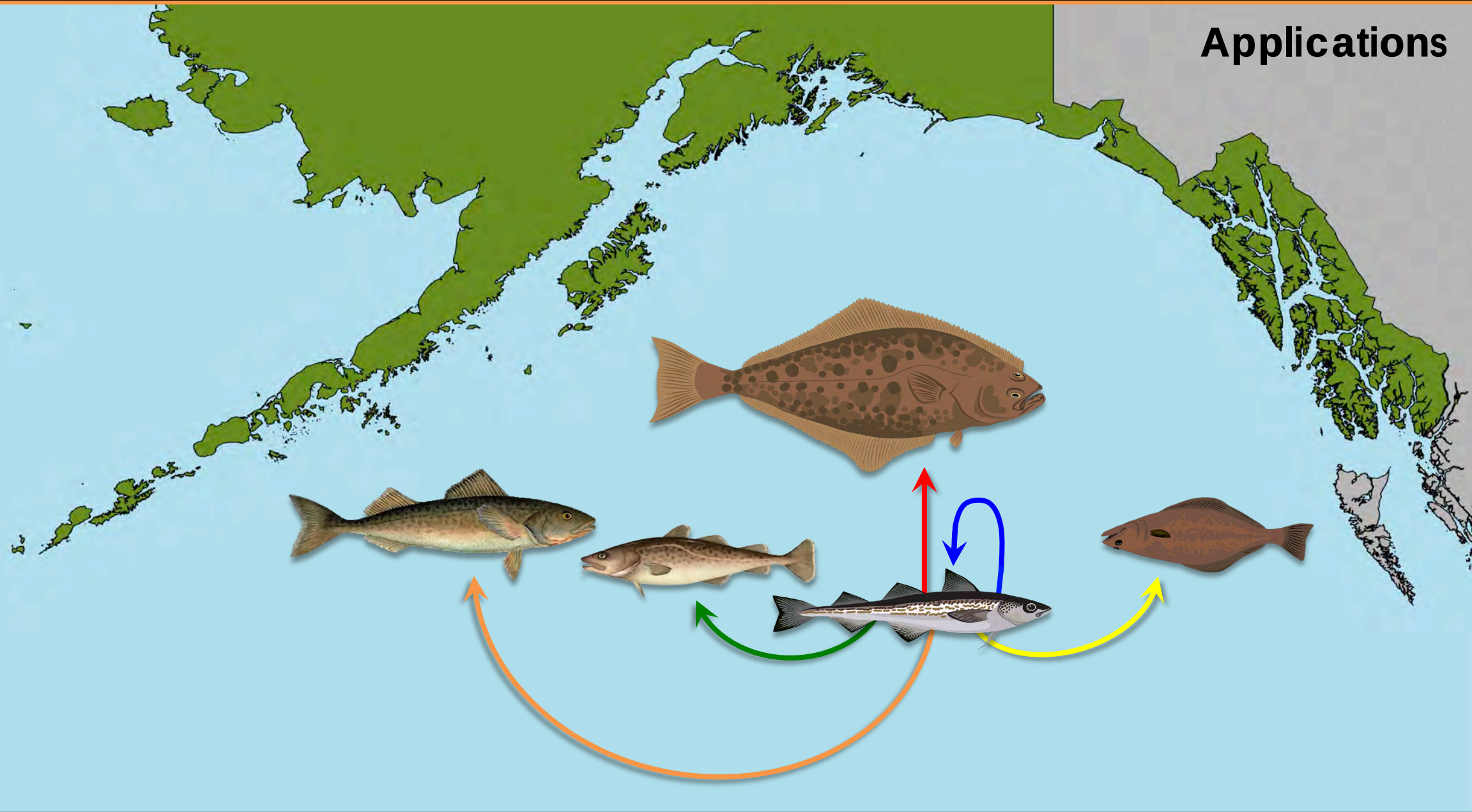
Ecological Inferences

- trophic instability in the Gulf of Alaska
- strong top-down control over pollock

  - spatial heterogeneity: buffer

e.g., Thorson *et al.* 2018

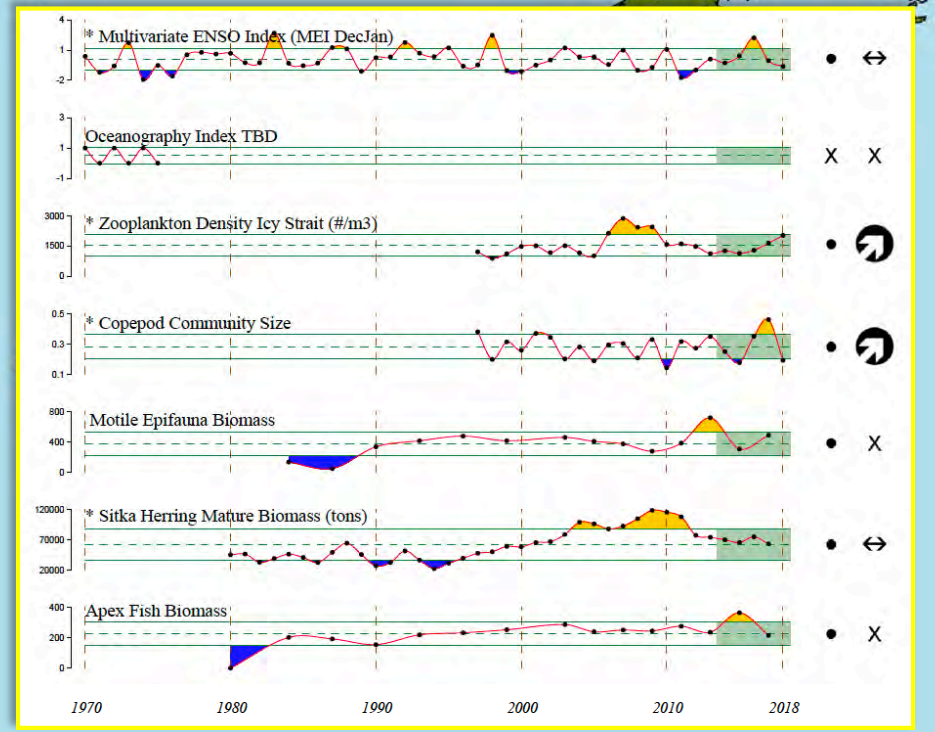
Development of a predation index to assess trophic stability in the Gulf of Alaska



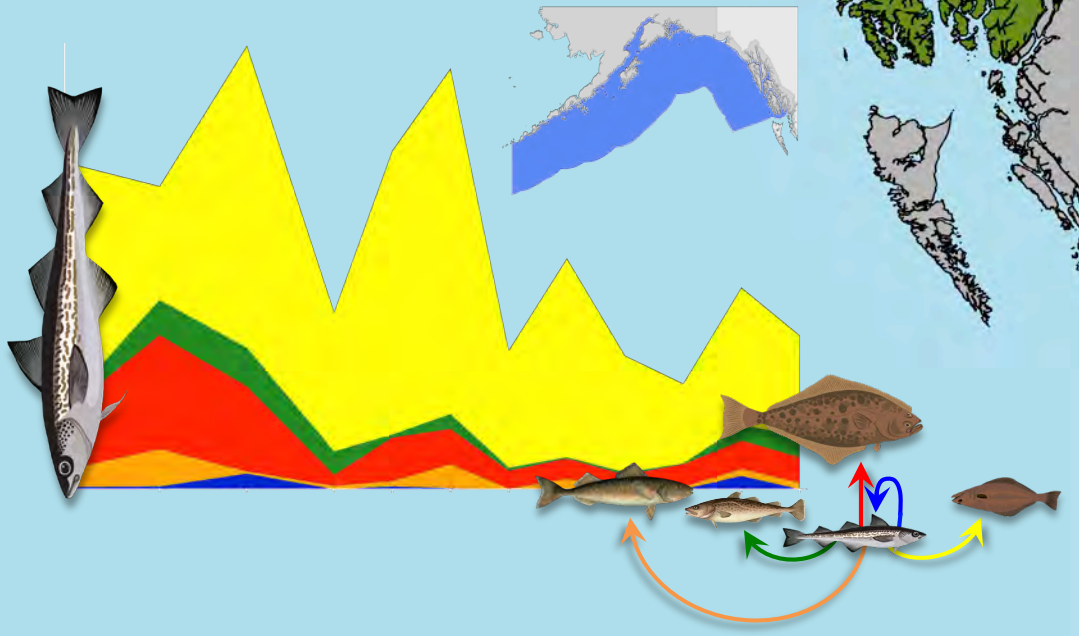
Development of a predation index to assess trophic stability in the Gulf of Alaska

Applications

GOA: Ecosystem Status Report



- temporal variation in portfolio effects



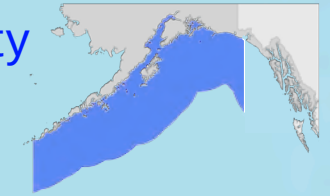
Zador and Yasumiishi 2018

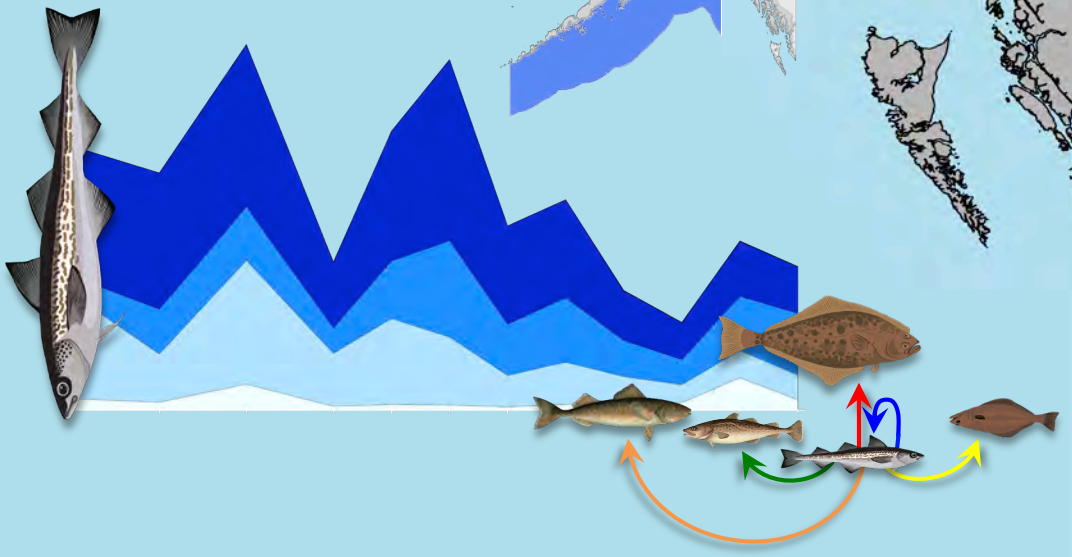
Development of a predation index to assess trophic stability in the Gulf of Alaska

Applications

Martin Dorn
AFSC, NOAA

- spatially-explicit, time-varying, age-specific estimates of predation
- modifier for constant natural mortality

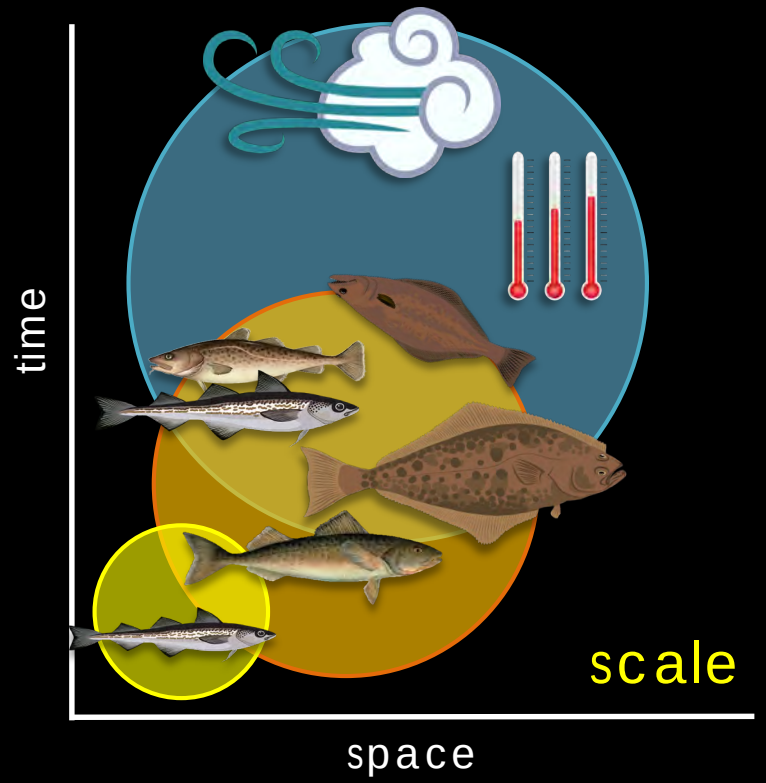


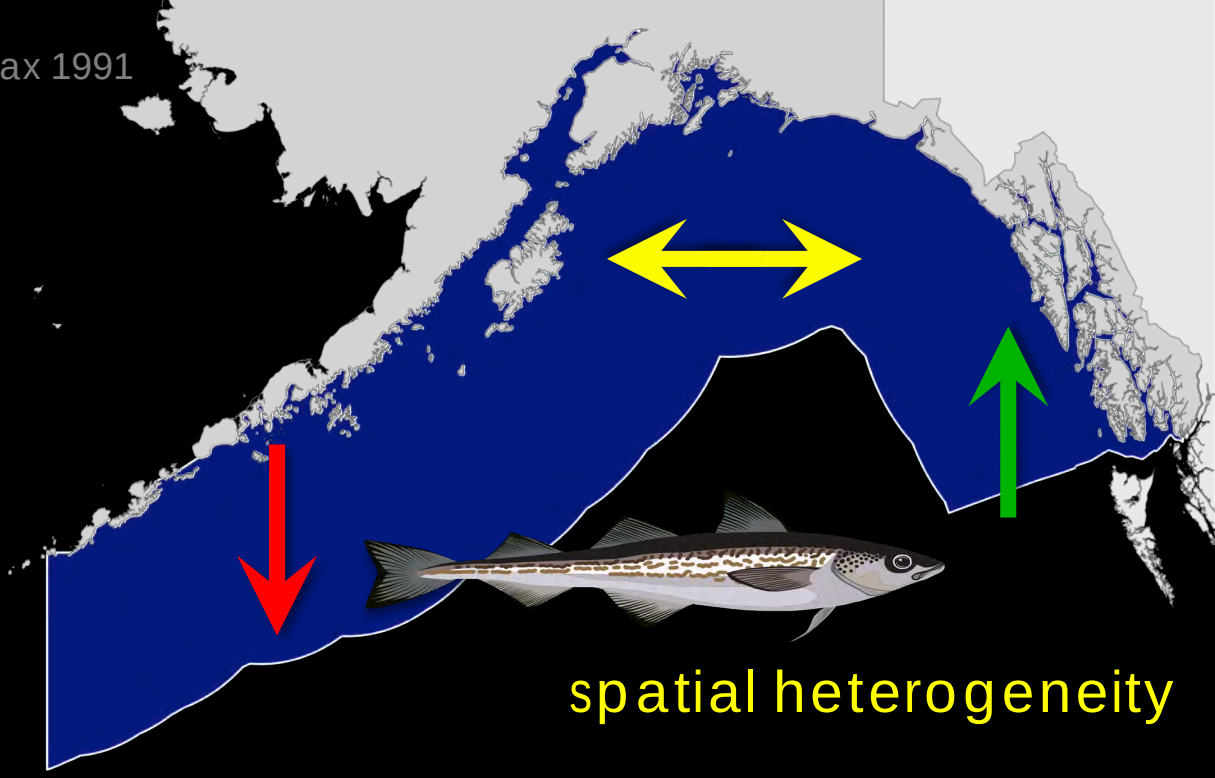


GOA: Ecosystem and Socioeconomic Profile (ESP)
- appendix to SAFE Report

“gross caricatures of complex natural systems” – Nicholas J. Bax 1991

"gross caricatures of complex natural systems" – Bax 1991





Acknowledgments

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N. Gulf of Alaska Applied Research Award (2018, 2019)

Fish Art

Nick Ingram

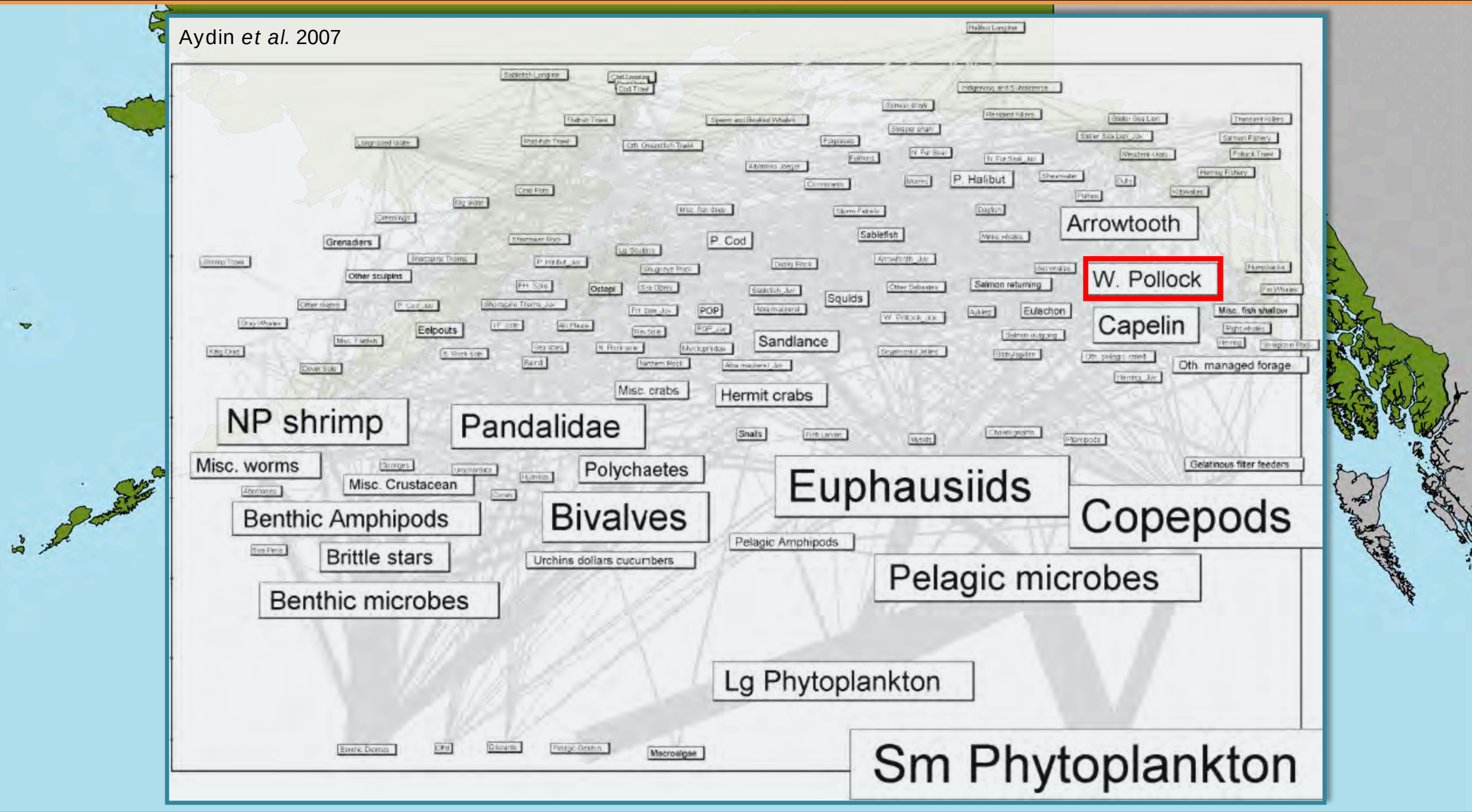
Subsurface Style

Data provided by:

NOAA Fisheries | Alaska Fisheries Science Center
National Oceanic and Atmospheric Administration

International Pacific Halibut Commission

Gulf of Alaska Food Web



Top down control in the Gulf of Alaska

NOAA Technical Memorandum NMFS-AFSC-178

A Comparison of the Bering Sea, Gulf of Alaska, and Aleutian Islands Large Marine Ecosystems Through Food Web Modeling

by
K. Aydin, S. Gaichas, I. Ortiz, D. Kinzey, and N. Friday

Comparative methods for evaluating climate change impacts on the foraging ecology of Alaskan groundfish

Kirstin K. Holsman[1,*], Kerim Aydin[2]

[1]University of Washington Joint Institute for the Study of the Atmosphere and Ocean, Alaska Fisheries Science Center NOAA Fisheries, 7600 Sand Point Way NE, Seattle, Washington 98115, USA
[2]Alaska Fisheries Science Center NOAA Fisheries, 7600 Sand Point Way NE, Seattle, Washington 98115, USA

What drives dynamics in the Gulf of Alaska? Integrating hypotheses of species, fishing, and climate relationships using ecosystem modeling

Sarah K. Gaichas, Kerim Y. Aydin, and Robert C. Francis

A multispecies age-structured assessment model for the Gulf of Alaska

Kray F. Van Kirk, Terrance J. Quinn II, and Jeremy S. Collie

Using food web model results to inform stock assessment estimates of mortality and production for ecosystem-based fisheries management

Sarah K. Gaichas, Kerim Y. Aydin, and Robert C. Francis

Quantifying food web interactions in the North Pacific – a data-based approach

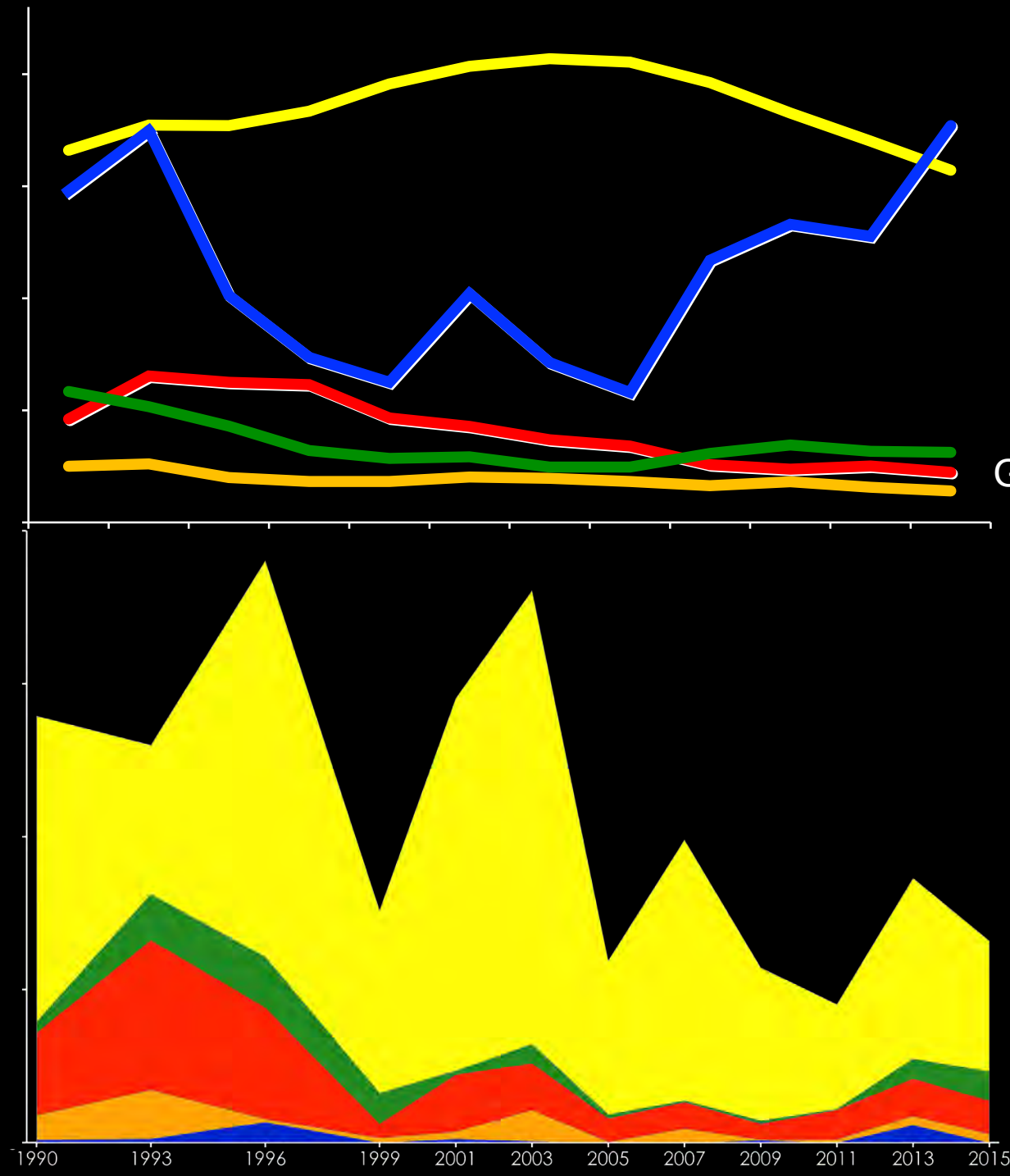
Patricia A. Livingston · Kerim Aydin · Troy W. Buckley · Geoffrey M. Lang · Mei-Sun Yang · Bruce S. Miller

Wasp waist or beer belly? Modeling food web structure and energetic control in Alaskan marine ecosystems, with implications for fishing and environmental forcing

Sarah Gaichas [a,*], Kerim Aydin [b], Robert C. Francis [c]

[a]NOAA, National Marine Fisheries Service, Northeast Fisheries Science Center, Ecosystem Assessment Program, Woods Hole, MA 02543, United States
[b]NOAA, National Marine Fisheries Service, Alaska Fisheries Science Center, Resource Ecology and Fisheries Management Division, Seattle, WA 98115, United States
[c]University of Washington, School of Aquatic and Fisheries Sciences, Seattle, WA 98115, United States

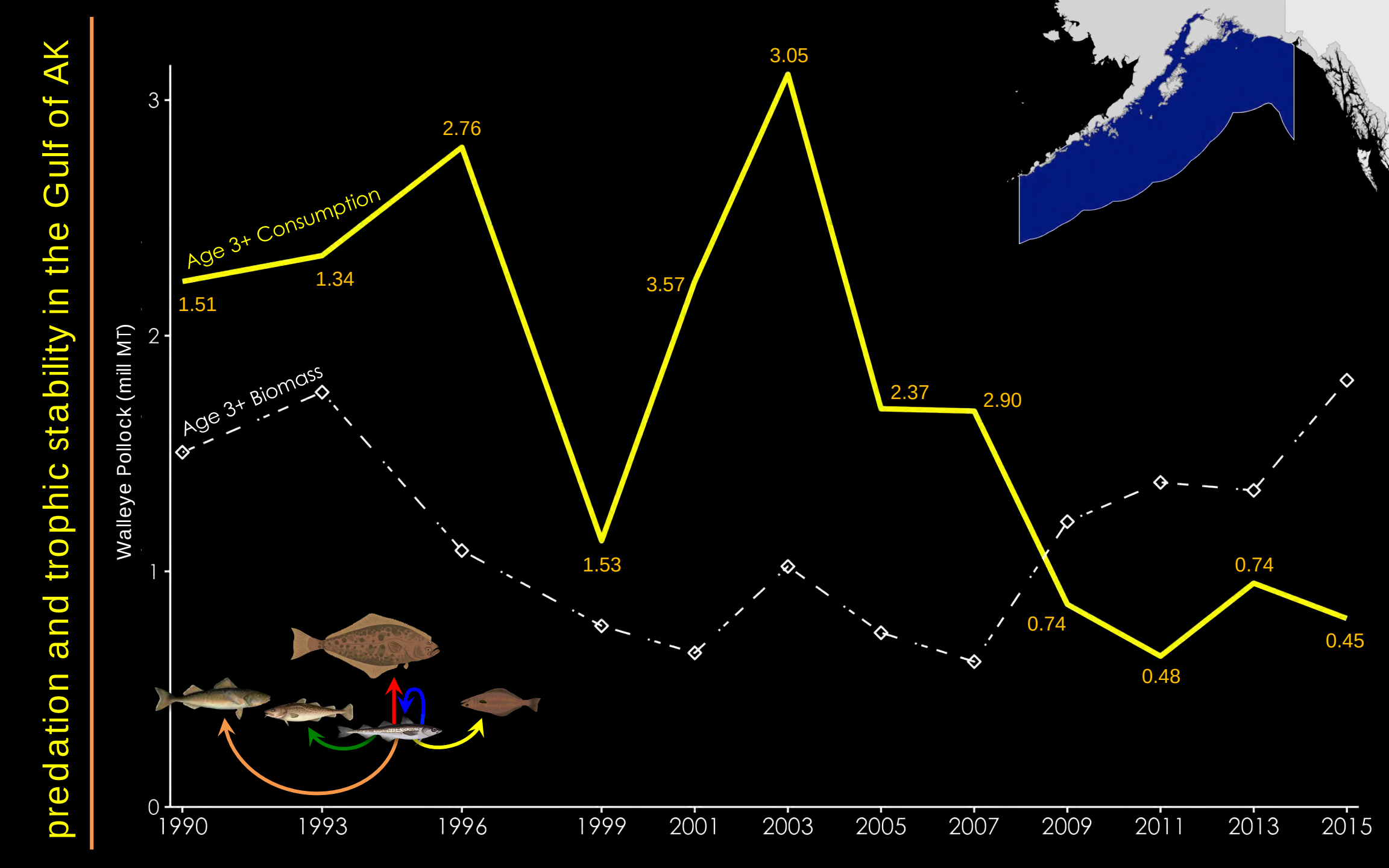
predation and trophic stability in the Gulf of AK



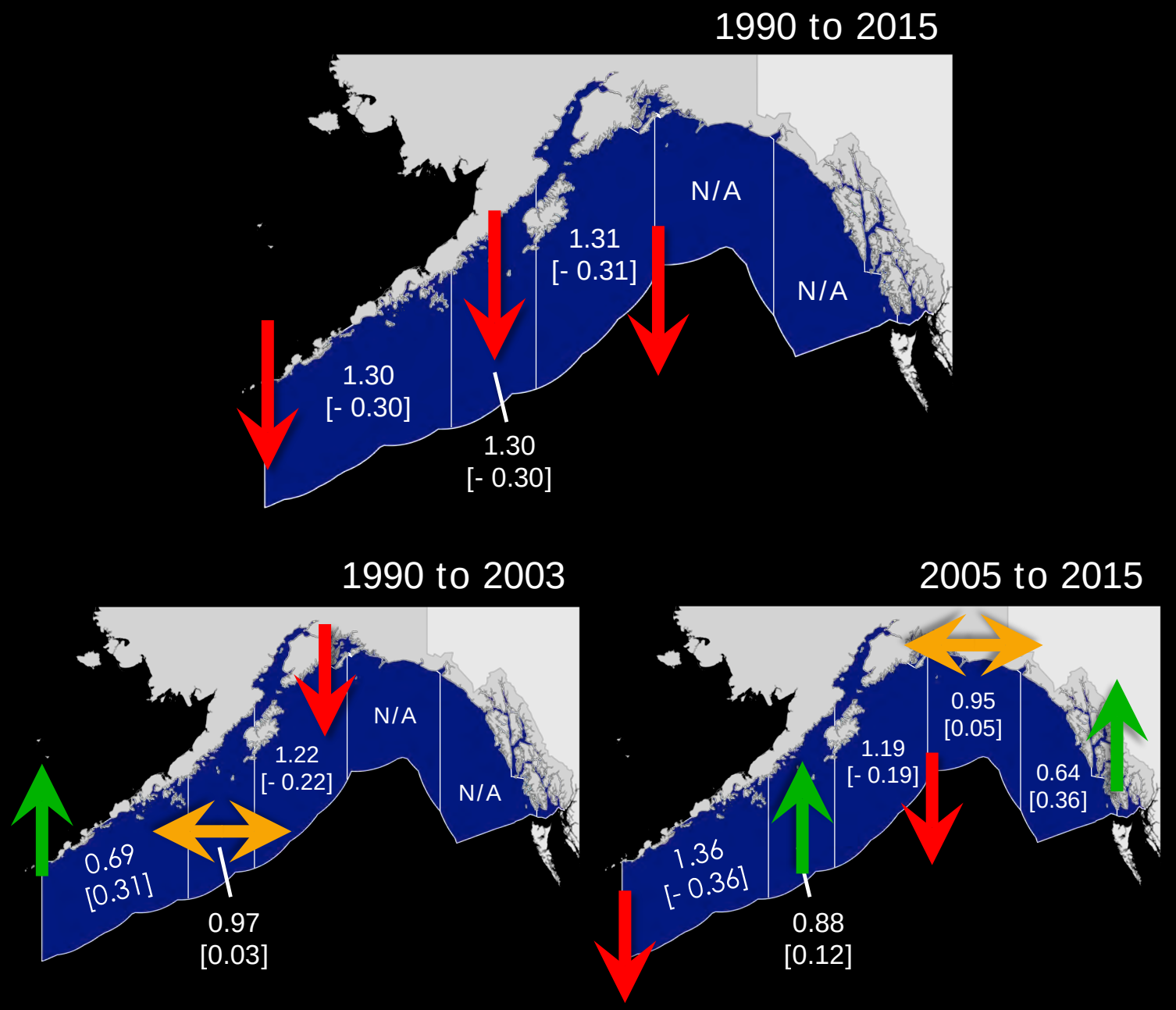
Gulf of Alaska

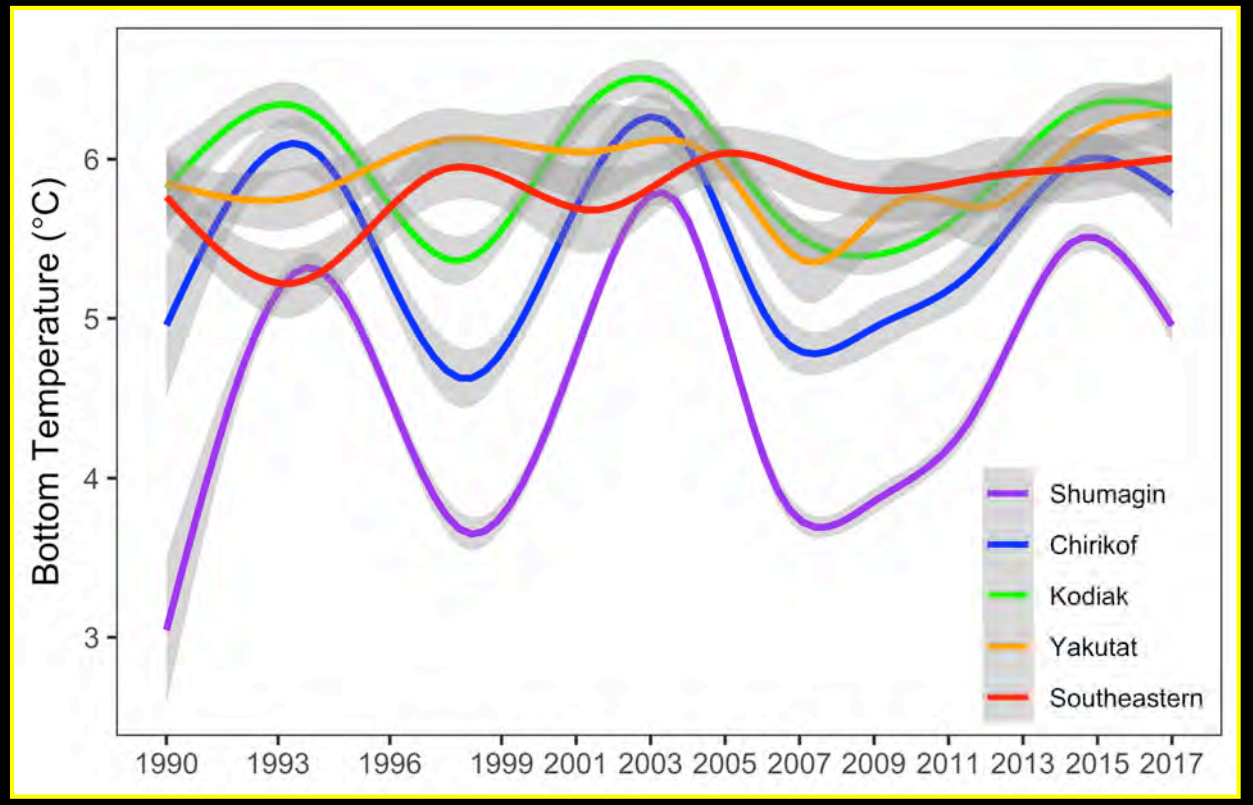
- Arrowtooth Flounder - Spies et al. 2017
- Walleye Pollock - Dorn et al. 2017
- Pacific Halibut - Stewart and Hicks 2017 +
- Pacific Cod - Barbeaux et al. 2017
- Sablefish - Hanselman et al. 2017

predation and trophic stability in the Gulf of AK

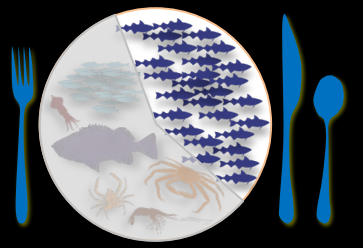


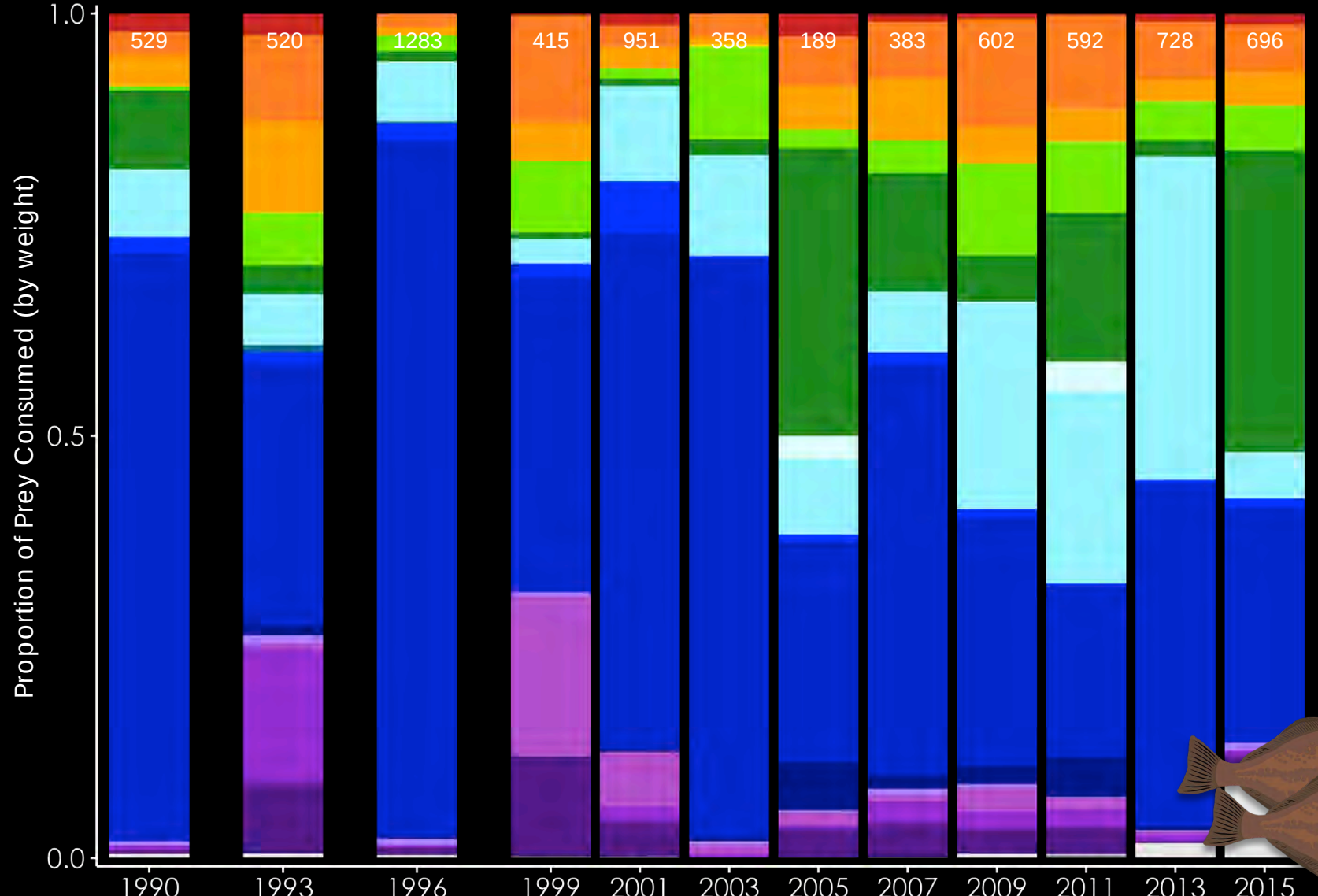
predation and trophic stability in the Gulf of AK




Bottom Temperature (°C)
6
5
4
3
1990
1993
1996
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
Shumagin
Chirikof
Kodiak
Yakutat
Southeastern

predation and trophic stability in the Gulf of AK

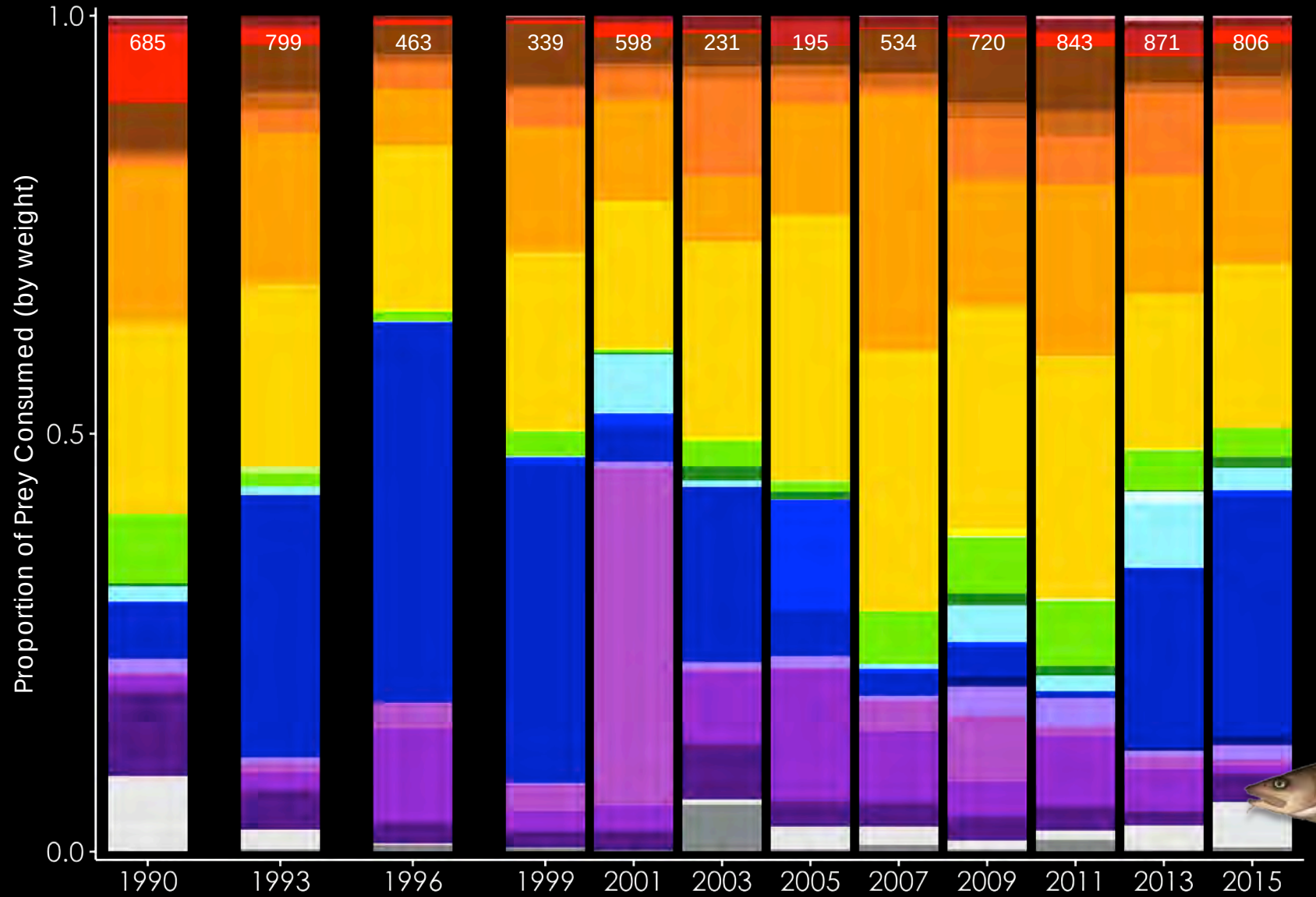


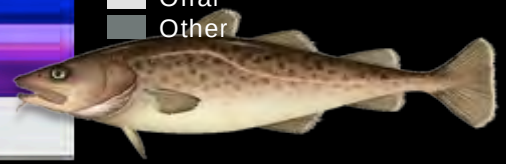


1+ yr, ≥ 19 cm

predation and trophic stability in the Gulf of AK

$$P_{s,a,i,j} = B_{s,i} * rD_{s,i,j} * \bar{C}_{s,i,j} * \bar{p}_{s,i,j} * \propto a_{s,a,i}$$

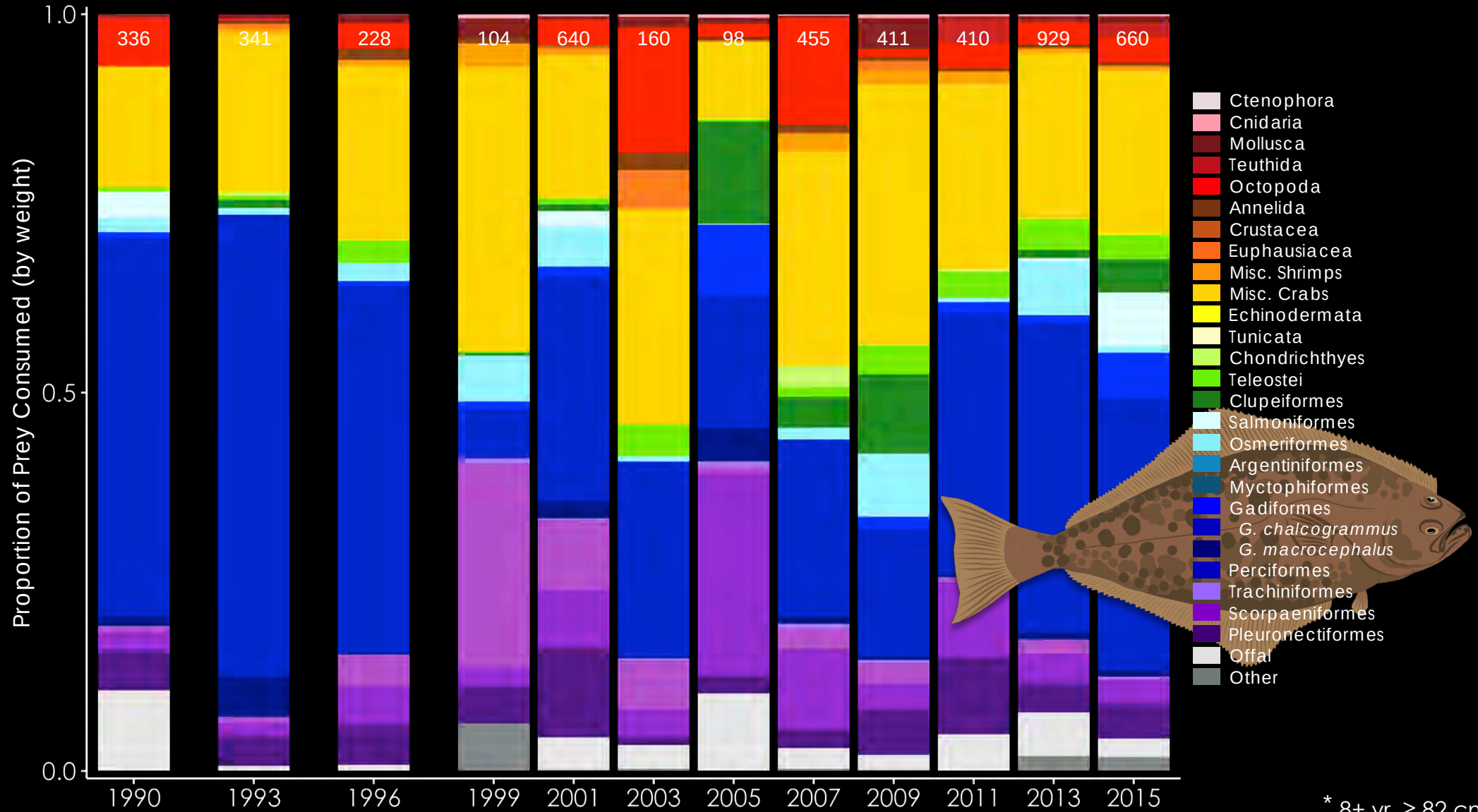




0+ yr, ≥ 0 cm

predation and trophic stability in the Gulf of AK

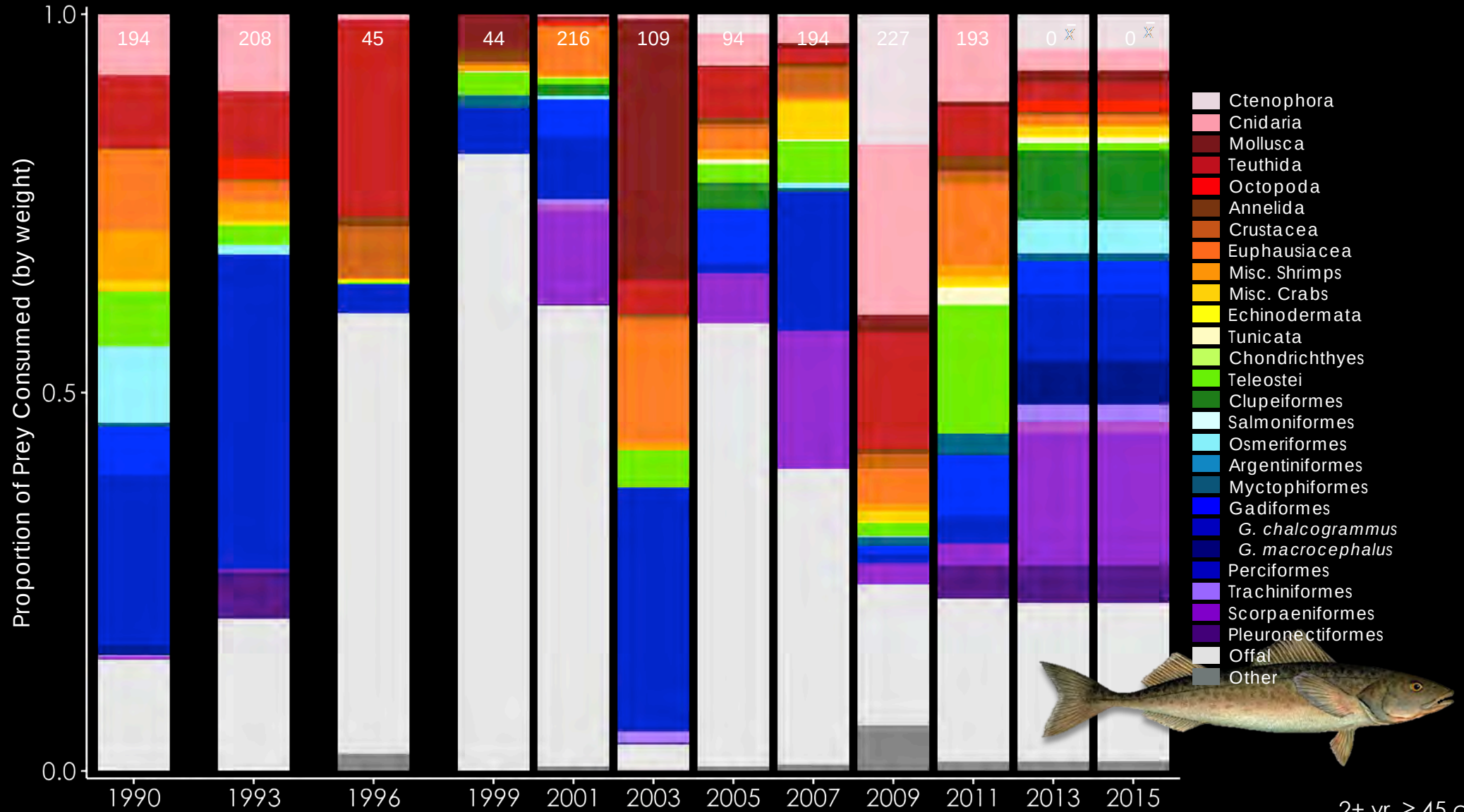
$$P_{s,a,i,j} = B_{s,i} * rD_{s,i,j} * \bar{C}_{s,i,j} * \bar{p}_{s,i,j} * \propto a_{s,a,i}$$



* 8+ yr, ≥ 82 cm

predation and trophic stability in the Gulf of AK

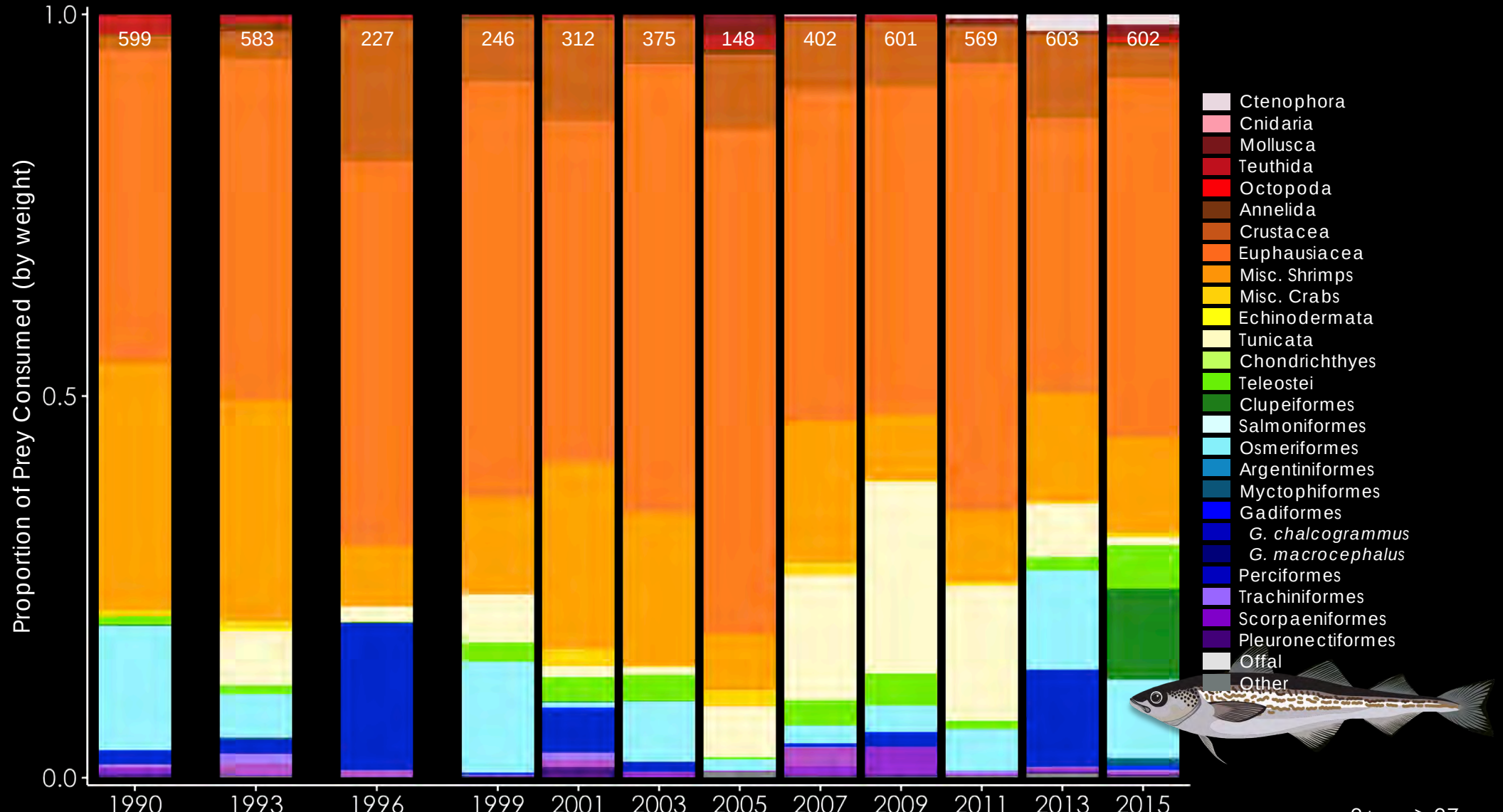
$$P_{s,a,i,j} = B_{s,i} * rD_{s,i,j} * \bar{C}_{s,i,j} * \bar{p}_{s,i,j} * \propto a_{s,a,i}$$



2+ yr, ≥ 45 cm

predation and trophic stability in the Gulf of AK

$$P_{s,a,i,j} = B_{s,i} * rD_{s,i,j} * \bar{C}_{s,i,j} * \bar{p}_{s,i,j} * \propto a_{s,a,i}$$



3+ yr, ≥ 37 cm