International Ocean Colour Science Meeting 2015

Ocean Color & Fisheries

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What is Fisheries?

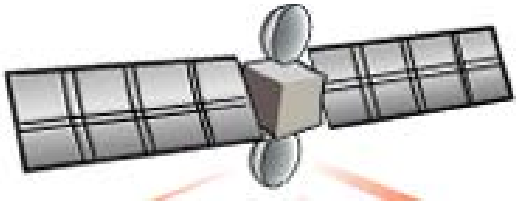
There are three principal aspects of fisheries:

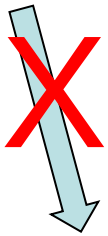
1. Harvesting (catching “fish”)
2. Stock Assessment (counting “fish”)
3. Management & Conservation (saving “fish”)

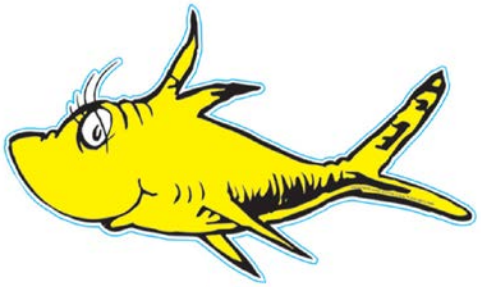
Fisheries is more than just fish, it encompasses all living marine resources (LMRs), i.e. marine mammals, sea turtles and invertebrates.

1. Harvesting

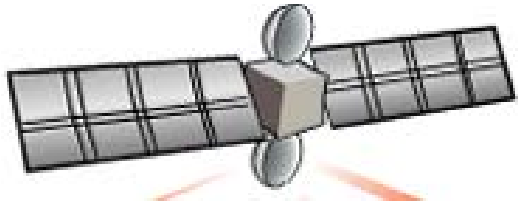
Harvesting

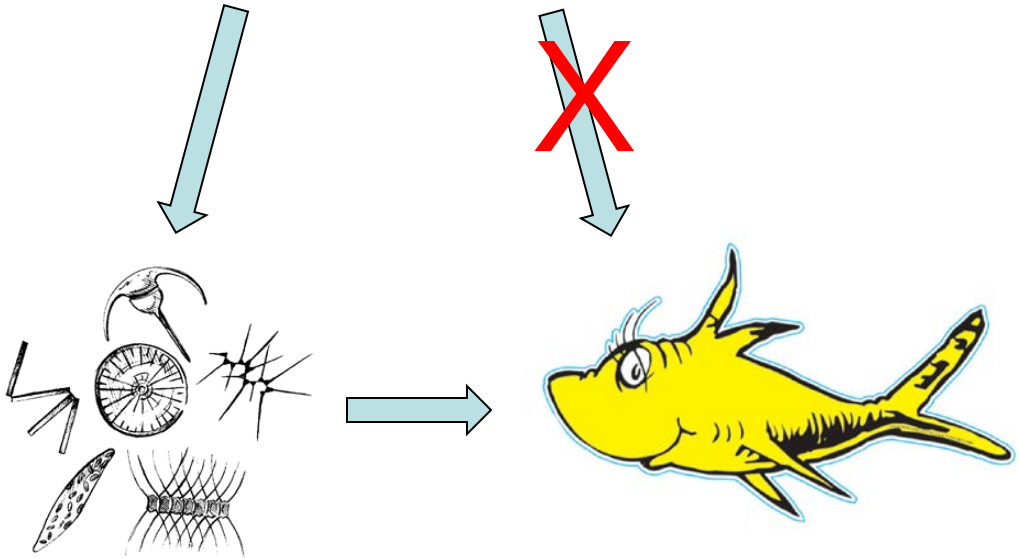






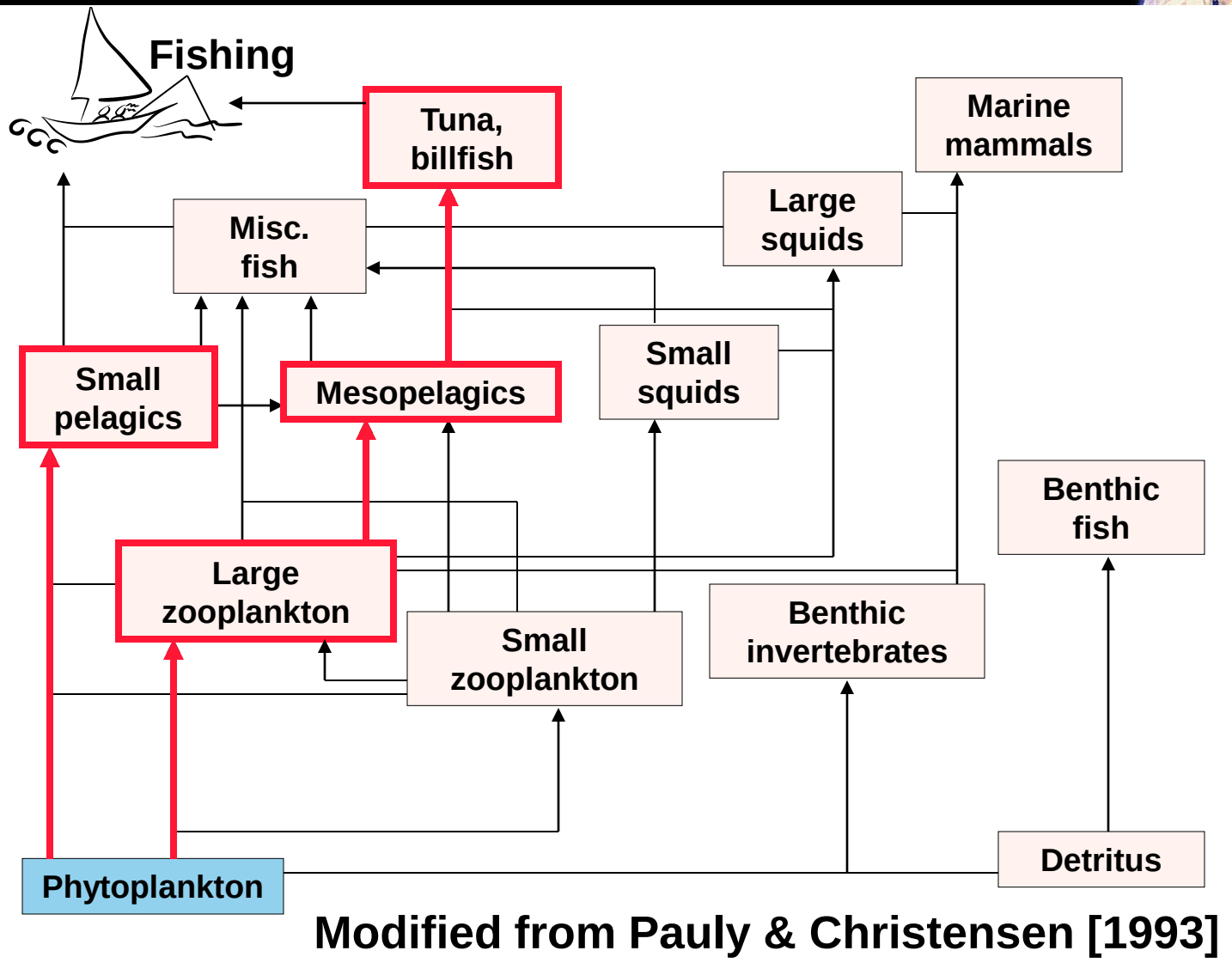
Harvesting





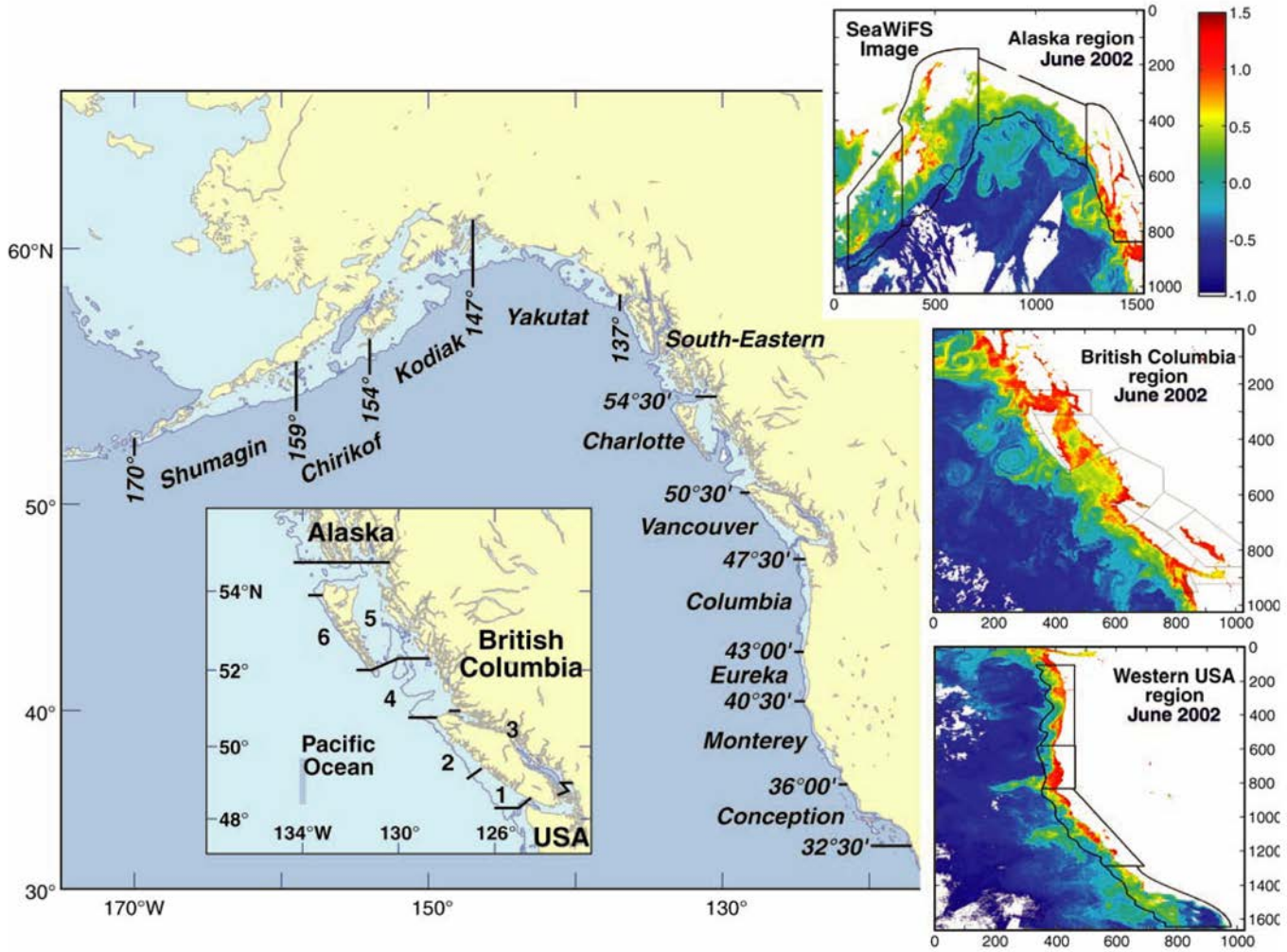
chlorophyll-*a*
in phytoplankton
(different sizes and types)

Oceanic Food Web



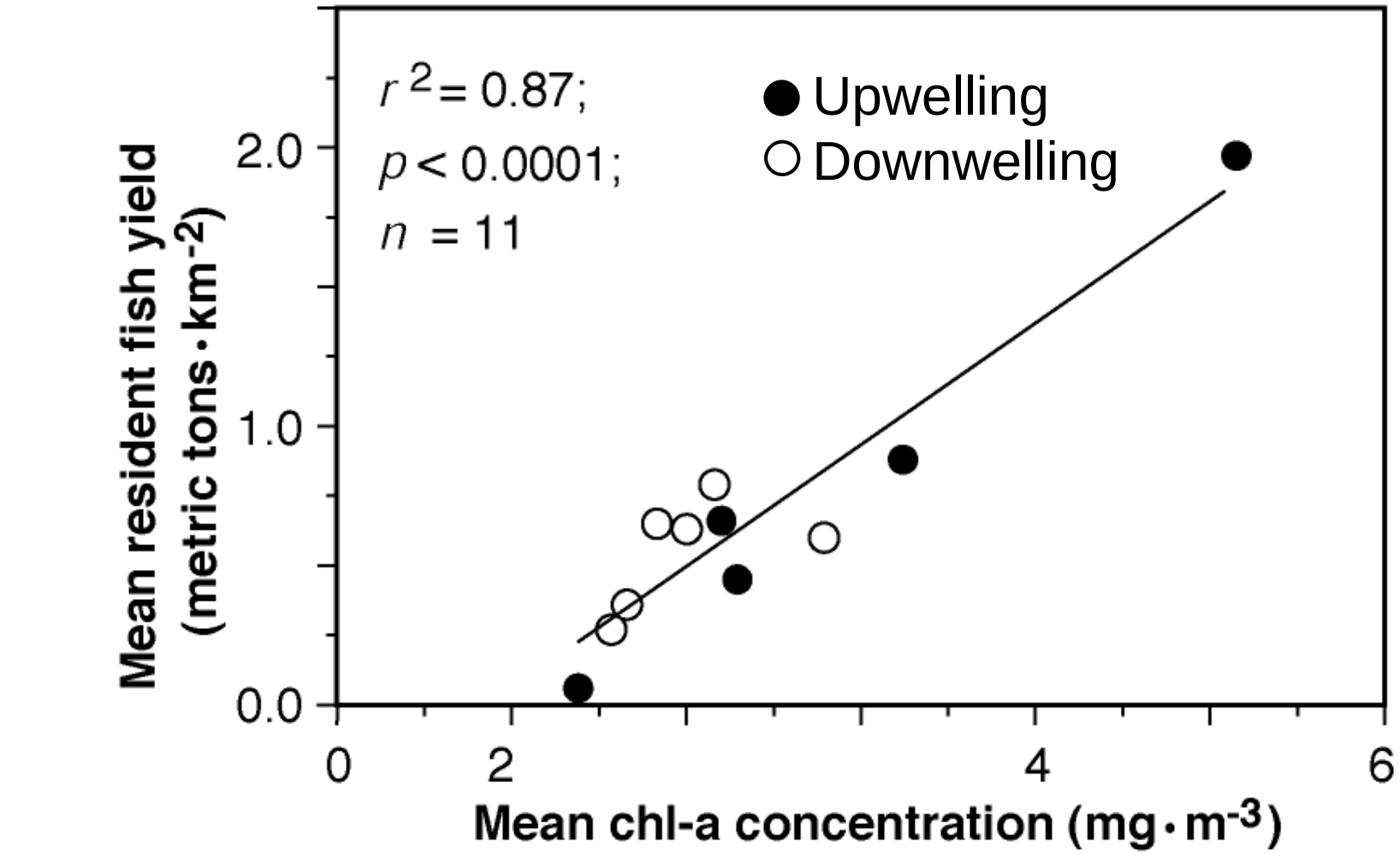
Modified from Pauly & Christensen [1993]

Linkages



From Ware & Thomson, Science, 2003

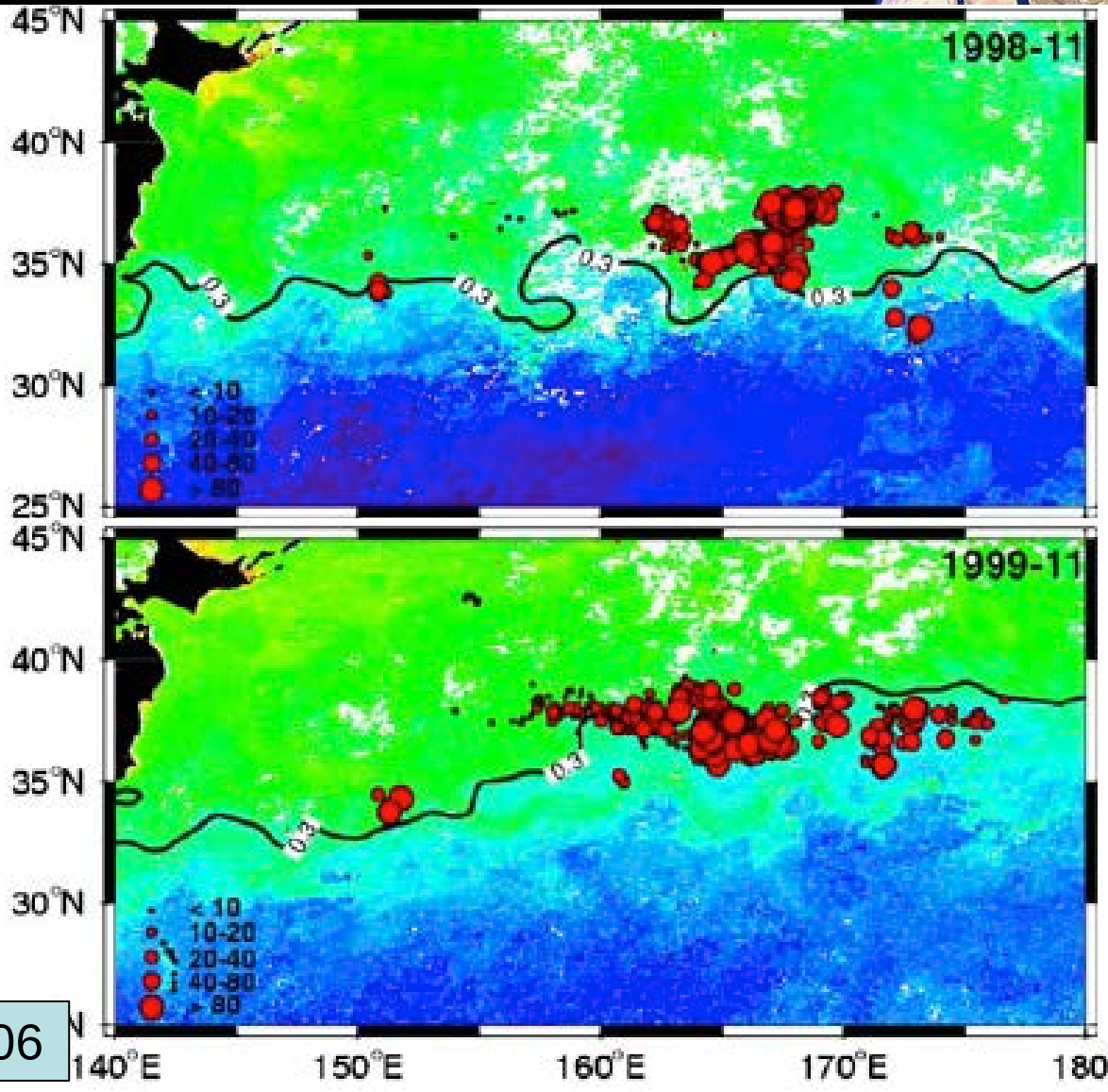
Linkages



From Ware & Thomson, Science, 2003

Frontal Zones

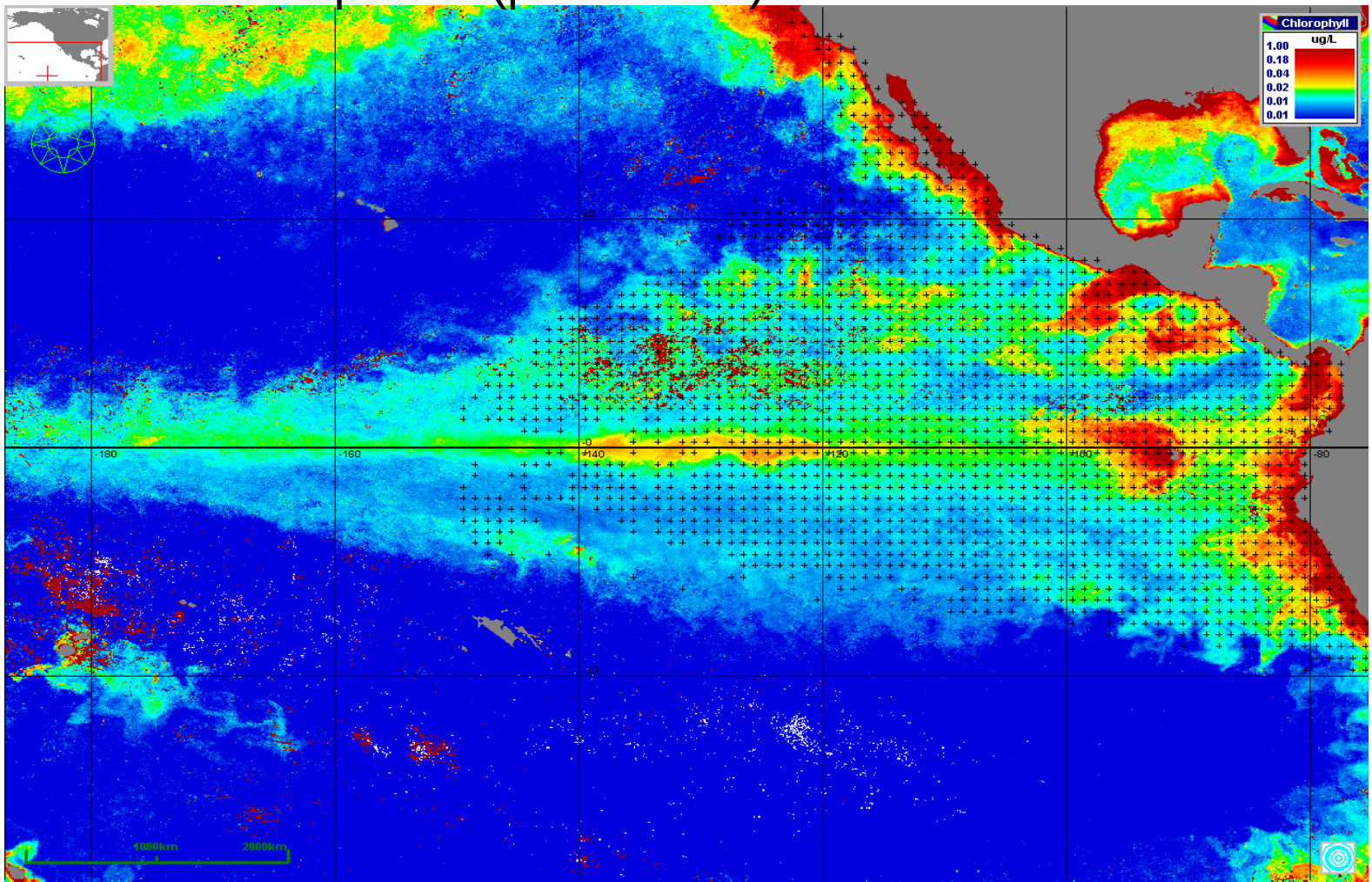
Albacore CPUE (catch per unit effort) overlain on SeaWiFS chlorophyll, showing that the longline fishery largely operates along the transitional zone chlorophyll front (TZCF)



Zainuddin et al., DSR-II, 2006

Upwelling Areas

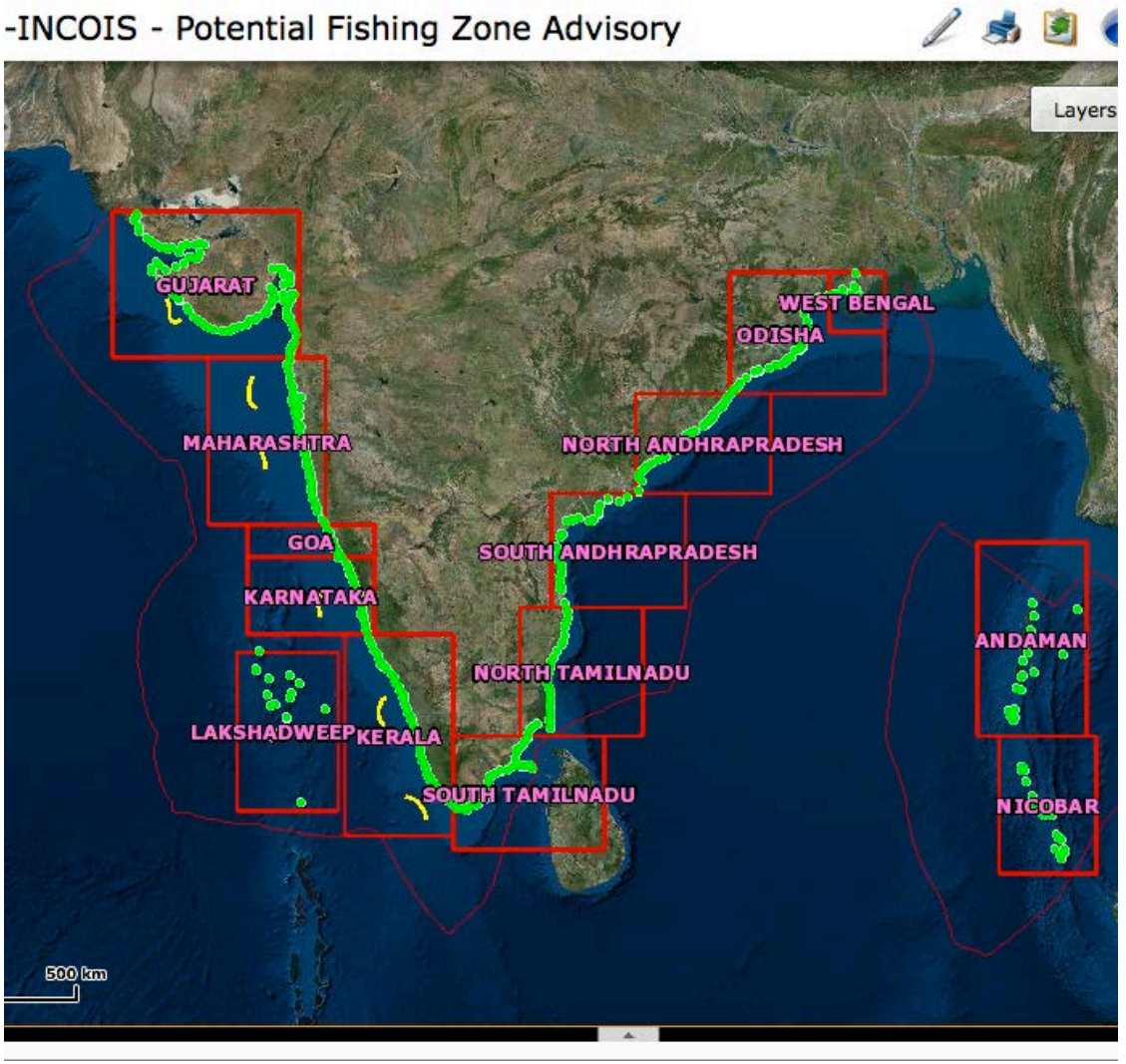
Dots show the distribution of the tuna purse seine fishery in the Pacific. From Dale Kiefer's poster (poster #70)



INCOIS – Potential Fishing Zone (PFZ) Advisories

Indian National Centre for Ocean Information Services (INCOIS) generates and distributes Potential Fishing Zone (PFZ) advisories to the Indian Fishing Community.

The PFZs are generated using SST and chlorophyll data.



http://www.incois.gov.in/MarineFisheries/MarineFisheryAdvisory

INCOIS – Potential Fishing Zone (PFZ) Advisories

GUJARAT

Select Landing Center: Bhada Get Forecast

SATELLITE DATA SHOWS LIKELY AVAILABILITY OF FISH STOCK TILL 18 APR 2015

Distance: kilometers | Depth: Metres | Latitude / Longitude: Degrees Minutes Seconds (D M S) | Get F

From the coast of	Direction	Bearing (deg)	Distance (km) From-To	Depth (mtr) From-To	Latitude (dms)	Longitude (dms)
Mul Dwarka	SW	246	88-93	68-73	20 26 3 N	69 53 47 E
Dwarka	SW	262	86-91	87-92	22 8 12 N	68 8 54 E
Nargol	NW	273	111-116	20-25	20 24 32 N	71 46 48 E
Madhavpur	SW	256	118-123	1057-1062	20 59 22 N	68 52 41 E
Veraval	SW	259	155-160	1633-1638	20 39 3 N	68 55 27 E
Raatadi	SW	238	77-82	82-87	21 21 39 N	68 51 31 E
Chorwad	SW	262	142-147	1756-1761	20 48 49 N	68 54 22 E
Okha	SW	250	82-87	56-61	22 13 43 N	68 20 9 E
Mangrol	SW	260	125-130	1206-1211	20 55 1 N	68 56 44 E
Kadwar	SW	242	84-89	78-83	20 29 35 N	69 44 9 E
Porbandar	SW	240	69-74	64-69	21 18 40 N	69 2 5 E
Gorsar	SW	253	126-131	1524-1529	21 0 19 N	68 45 27 E
Vadodra	SW	242	84-89	58-63	20 27 34 N	69 48 54 E
Kuranga	NW	273	115-120	103-108	22 5 25 N	68 4 57 E
Kachchigadh	SW	258	76-81	66-71	22 11 32 N	68 14 25 E
Umargam	NW	277	98-103	20-25	20 23 49 N	71 51 29 E
Kuchhadi	SW	238	72-77	90-95	21 19 28 N	68 57 15 E
odadar	SW	239	69-74	78-83	21 14 45 N	69 5 31 E
Diu Island	SW	251	104-109	67-72	20 24 26 N	70 3 42 E
Navibandar	SW	242	65-70	66-71	21 15 0 N	69 9 47 E
Navadra	NW	278	130-135	69-74	22 5 32 N	68 1 5 E
Kotda	SW	252	96-101	68-73	20 26 44 N	69 59 38 E
Adri	SW	260	151-156	1675-1680	20 43 33 N	68 53 32 E

http://www.incois.gov.in/MarineFisheries/MarineFisheryAdvisory

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Diu Island	SW	251	104-109	67-72	20 24 26 N	70 3 42 E

INCOIS – Potential Fishing Zone (PFZ) Advisories

Potential Fishing Zone

Languages

- » English
- » हिन्दी
- » తెలుగు
- » தமிழ்
- » ಕನ್ನಡ
- » ଓଡିଆ
- » বাংলা
- » മലയാളം
- » ગુજરાતી

From the coast of	Direct	r)	Latitude (dms)	Longitude (dms)
Mul Dwarka	SW		20 26 3 N	69 53 47 E
Dwarka	SW		22 8 12 N	68 8 54 E
Nargol	NW		20 24 32 N	71 46 48 E
Madhavpur	SW	2	20 59 22 N	68 52 41 E
Veraval	SW	8	20 39 3 N	68 55 27 E
Raatadi	SW		21 21 39 N	68 51 31 E
Chorwad	SW	1	20 48 49 N	68 54 22 E
Okha	SW		22 13 43 N	68 20 9 E
Mangrol	SW	1	20 55 1 N	68 56 44 E
Kadwar	SW		20 29 35 N	69 44 9 E
Porbandar	SW		21 18 40 N	69 2 5 E
Gorsar	SW	9	21 0 19 N	68 45 27 E
Vadodra	SW		20 27 34 N	69 48 54 E
Kuranga	NW		22 5 25 N	68 4 57 E
Kachchigadh	SW		22 11 32 N	68 14 25 E
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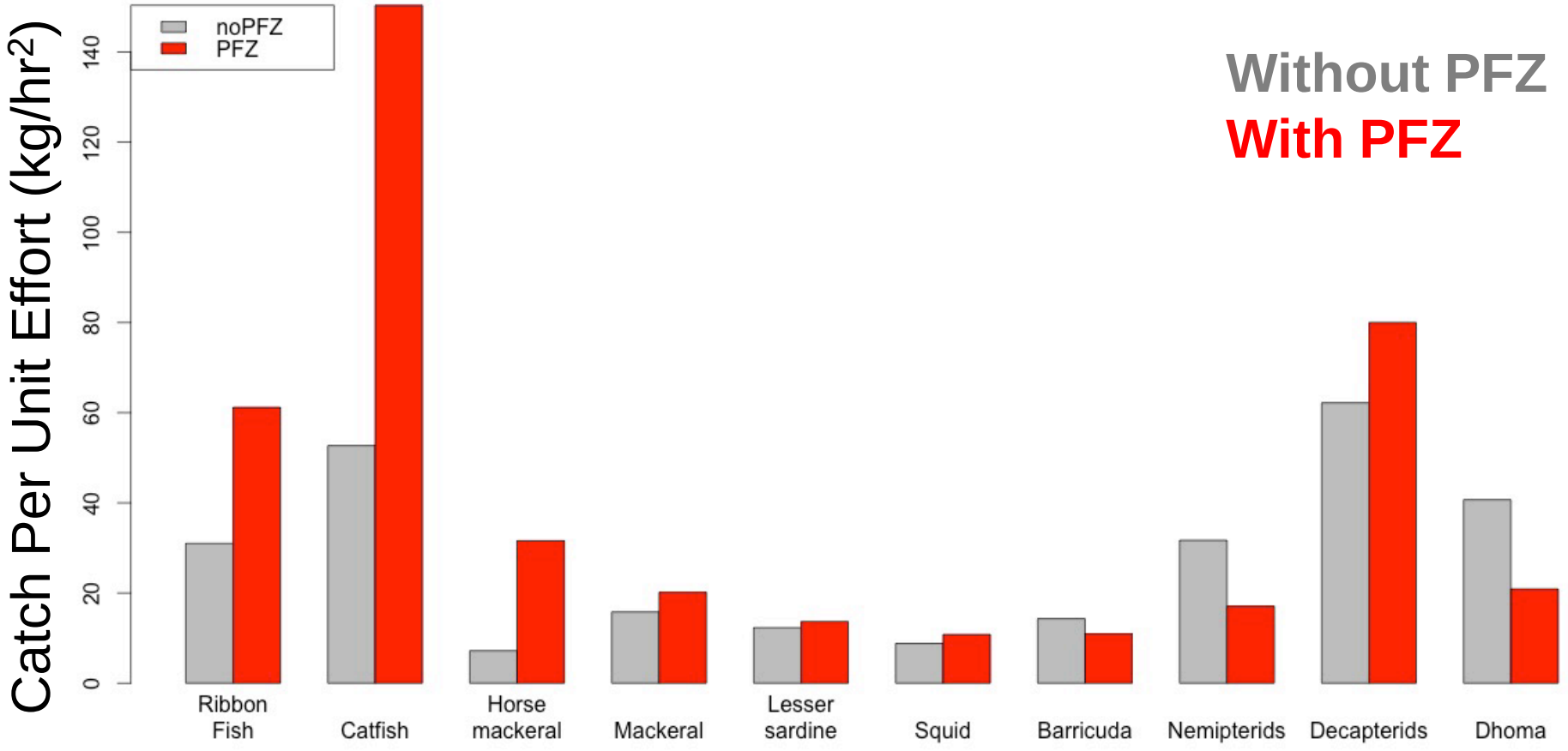
odadar	SW		21 14 45 N	69 5 31 E
Diu Island	SW		20 24 26 N	70 3 42 E

Impact of PFZ on CPUE



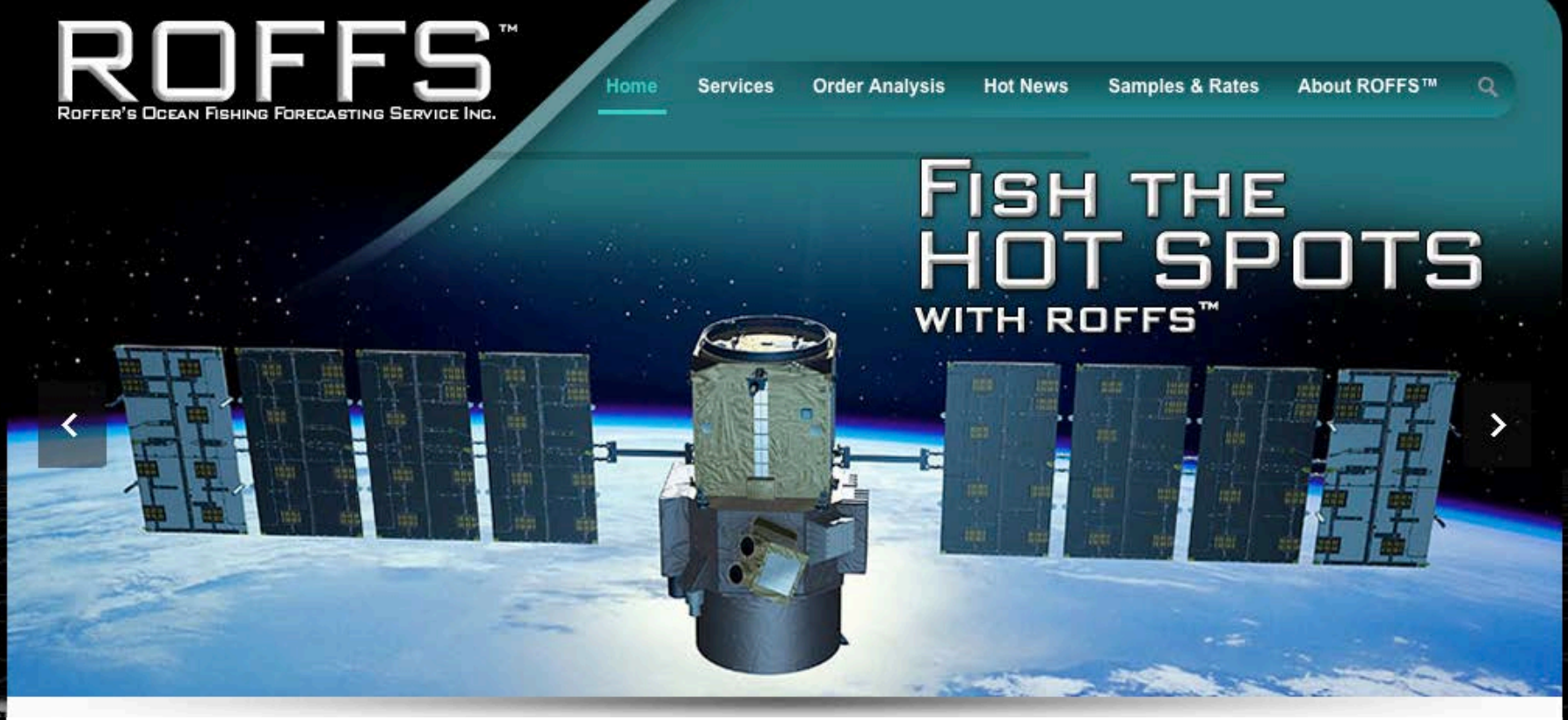
Without PFZ

With PFZ

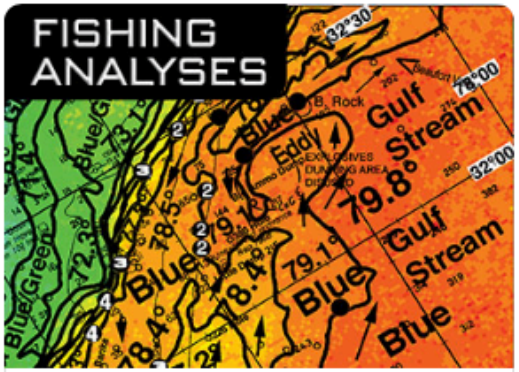
From Solanki et al., CSR, 2005

ROFFS™

ROFFER'S OCEAN FISHING FORECASTING SERVICE INC.



FISHING ANALYSES

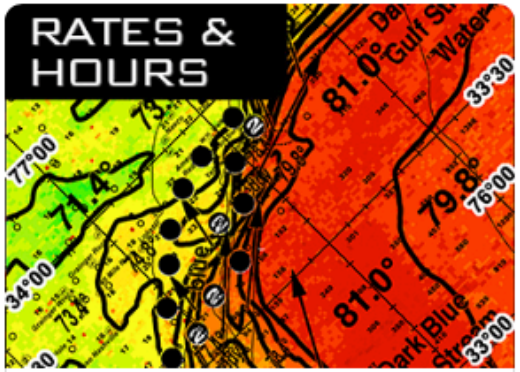


Time and fuel costs are always important considerations when fishing. ROFFS™ will show you where the fish are located before you leave the dock and while fishing by sending you the most

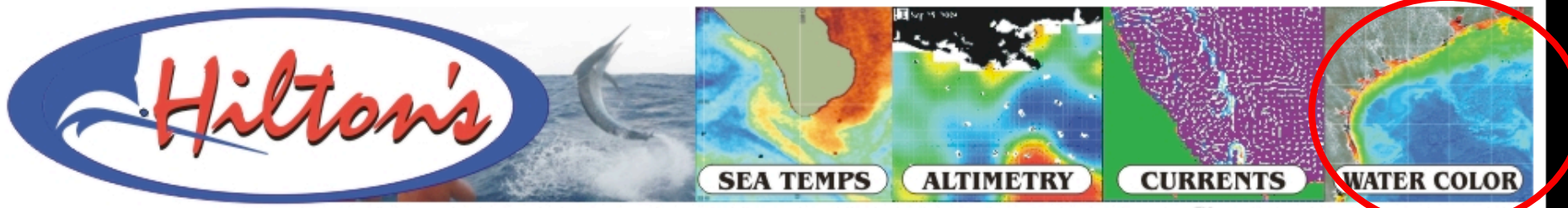
CATCH REPORTS

ROFFS™ loves to talk to clients before, during and after their trips. ROFFS™ tries to update their "catch reports" on a weekly basis and will only report first hand information. No hear-say or dock

RATES & HOURS



ROFFS™ current office hours – September 29, 2014 through March 28, 2015 – Monday through Friday 9 AM – 5PM, Saturday Closed. Please click below for more information on our



CATCH MORE FISH USING LESS FUEL!™

Since 2004, we have provided the highest quality online satellite fishing charts services on the market today – that is why the very best fishermen in the world rely on our product!

REALTIME-NAVIGATOR

Manage Maps | Print Map

04-29-2010 06:30 PM 1day

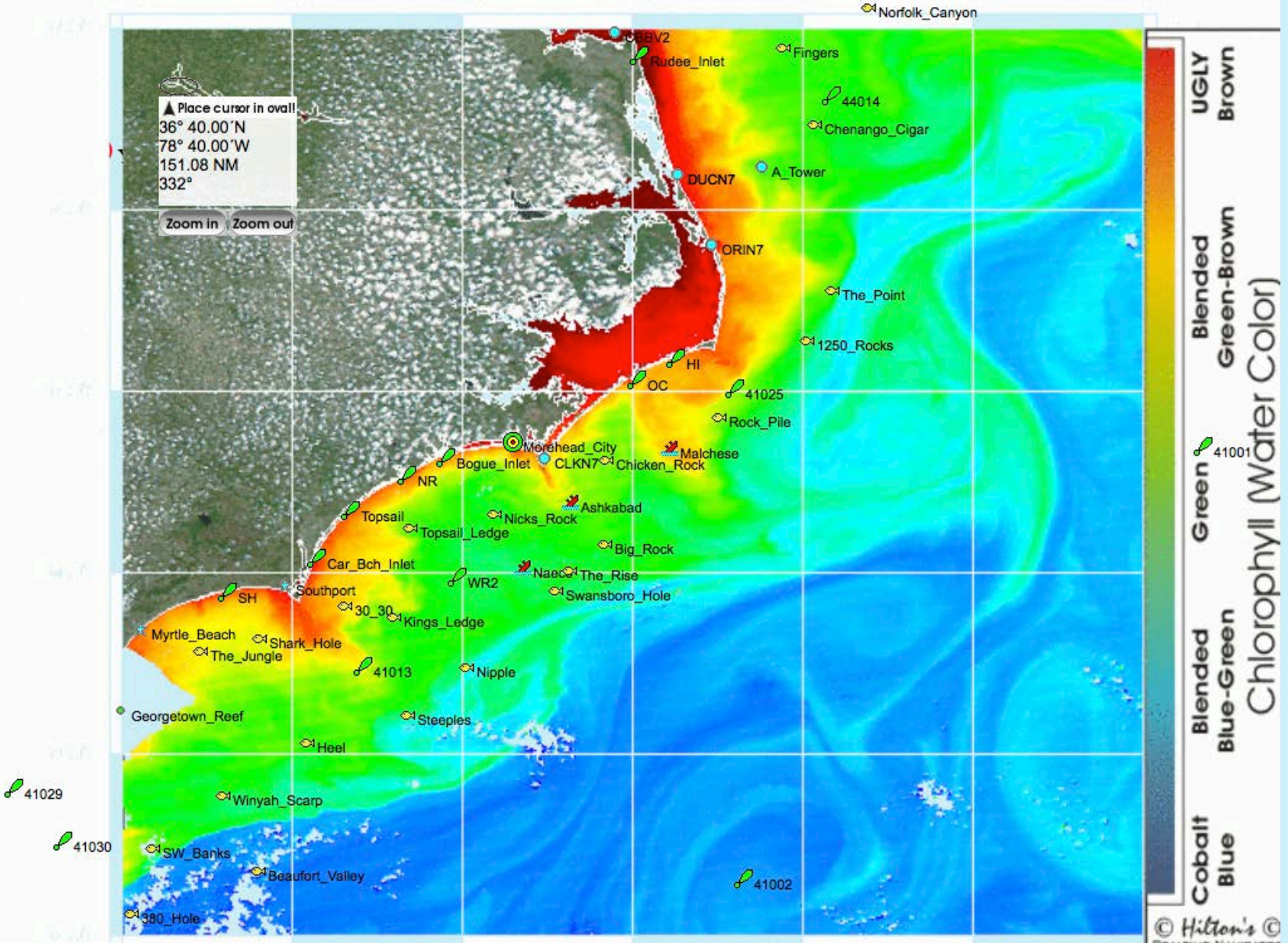
CURRENT MOON

Waning Crescent
1% of Full
Fri 17 Apr, 2015
3:51:26 PM
moon phase

3D Bottom
Sea Temps 2
Altimetry
Chlorophyll
True Color
Currents
Salinity
Radar

IR Loop
Contours On
CONTOURS
Trip Planner
Zoom in | Zoom out

TUTORIAL
LEGEND
MARINE FORECAST



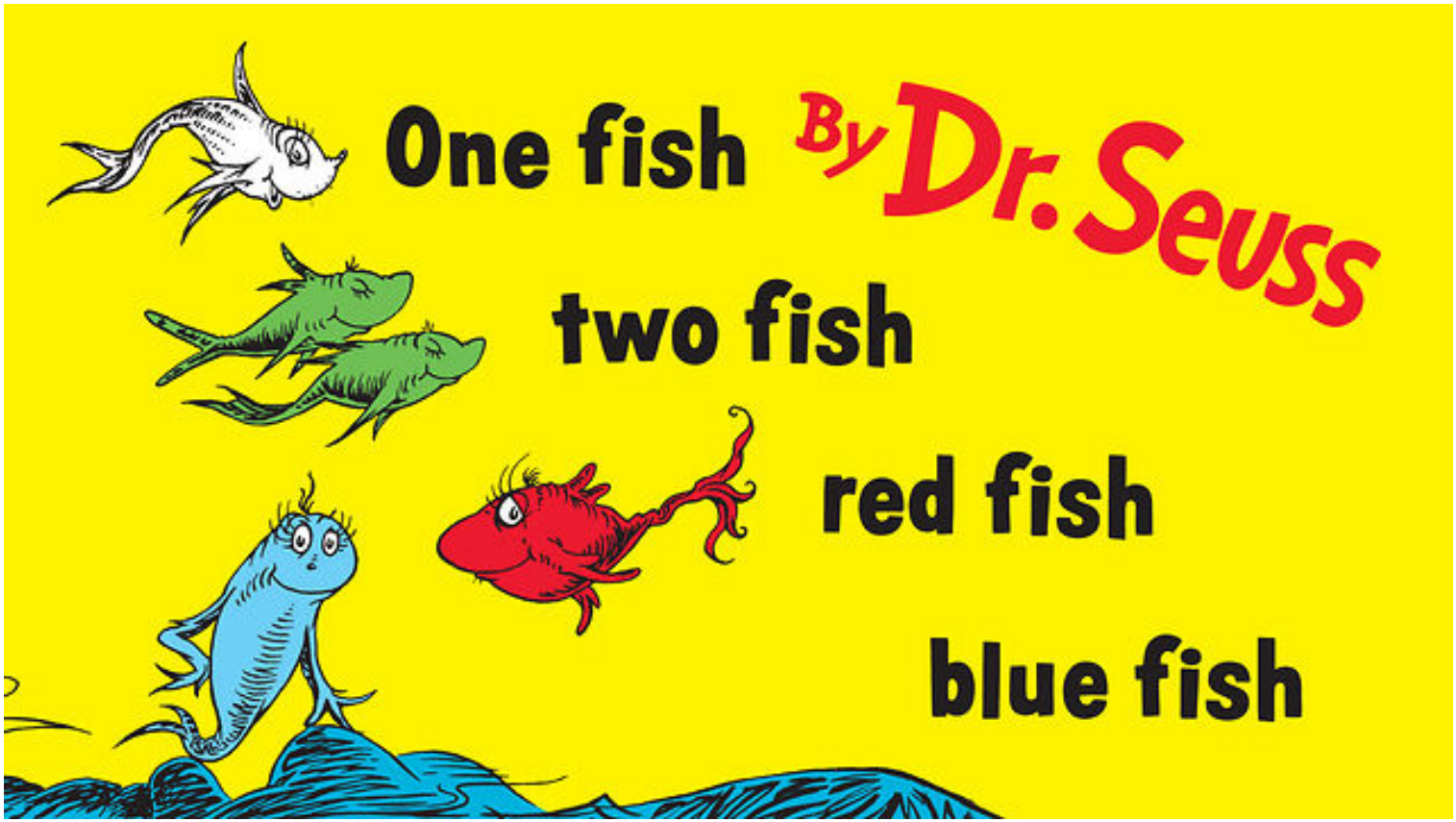
2. Stock Assessment

Stock Assessment?

Stock Assessment

Stock Assessment is a fancy way of saying “counting fish”

Stock Assessment



NOAA Fisheries (National Marine Fisheries Service) is responsible for managing ~450 fish stocks. In addition, NMFS manages ~200 protected or endangered species (marine mammals and turtles).

Stock Assessment

In theory, counting fish seems relatively straightforward.

Stock Assessment

Photo credit: Octavio Aburto

In practice, it’s much more complicated.

Stock Assessment

from http://www.st.nmfs.noaa.gov/stock-assessment/index

Abundance

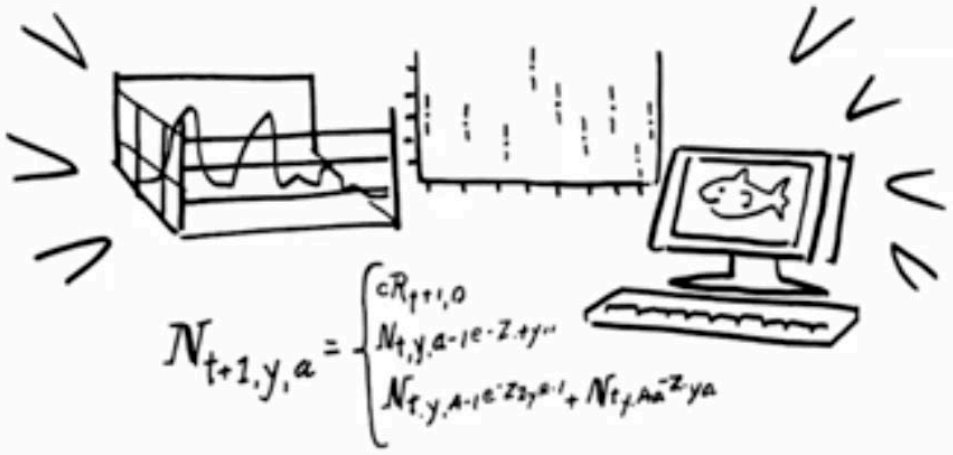
+ Biological Data

+ Catch Data

=

A+B+C=

Stock Assessment

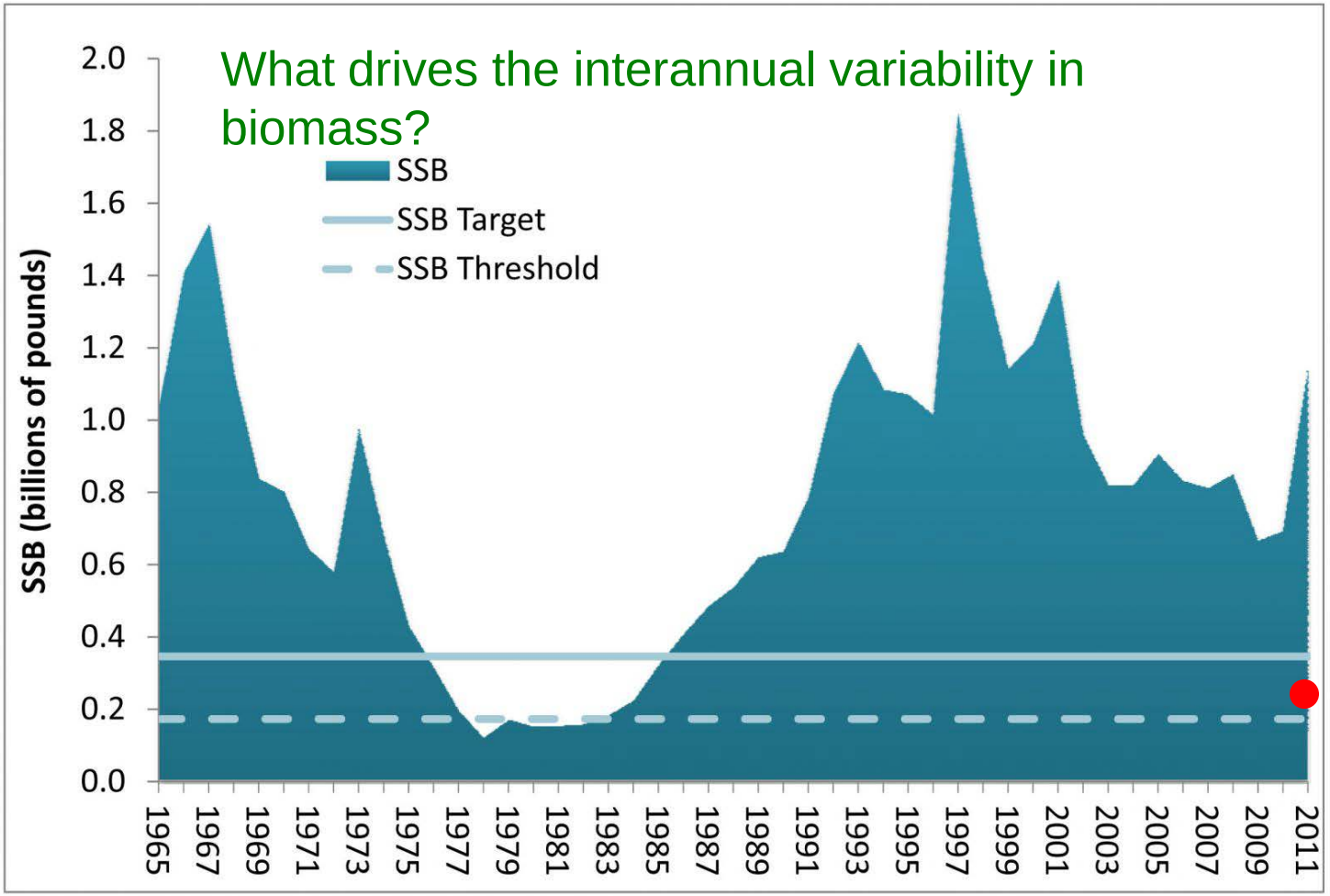


$$N_{t+1,y,a} = \begin{cases} cR_{t+1,0} \\ N_{t,y,a-1}e^{-Z_{t,y}} \\ N_{t,y,A-1}e^{-Z_{t,y,A-1}} + N_{t,y,A}e^{-Z_{t,y,A}} \end{cases}$$

Assessments provide the technical basis for setting annual fishery harvest levels

Stock Assessment

Atlantic Herring Spawning Stock Biomass (SSB)



Annual catch limit (ACL) for 2013-2015 set at 238 million pounds

Source: 54th Northeast Regional Stock Assessment Workshop, 2012

Stock Assessment

from http://www.st.nmfs.noaa.gov/stock-assessment/index

Abundance

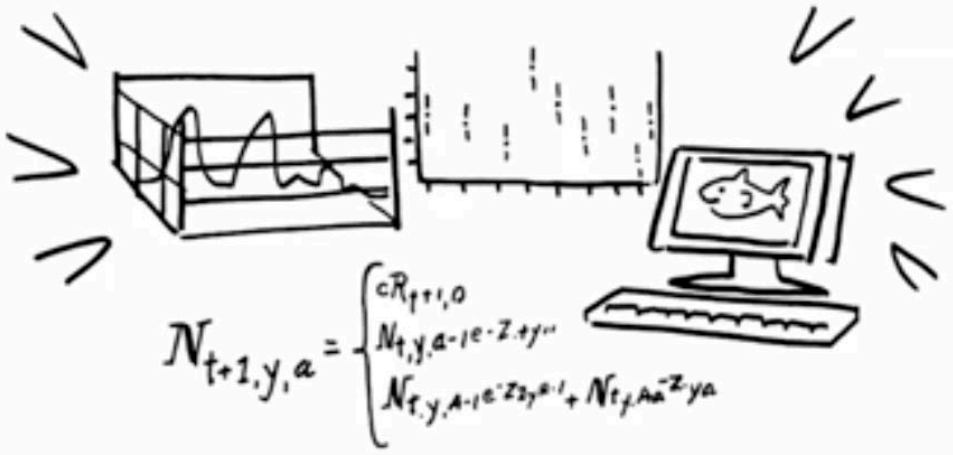
+ Biological Data

+ Catch Data

=

A+B+C=

Stock Assessment

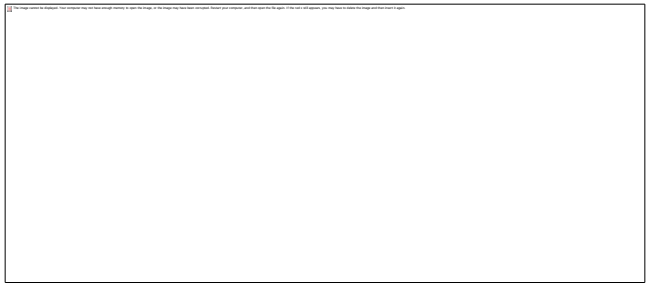


Where's the E (Environment)?

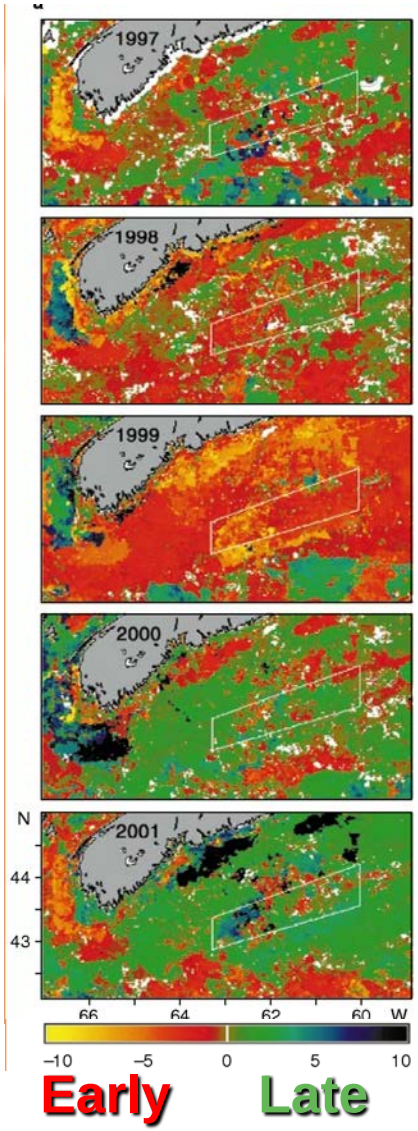
Match-Mismatch Hypothesis

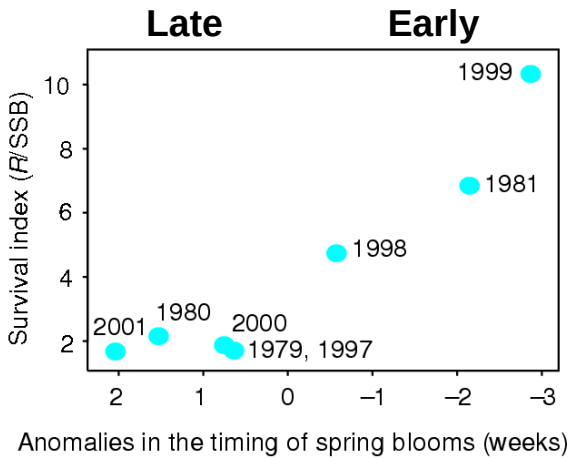
Timing of the spring bloom & Haddock survival

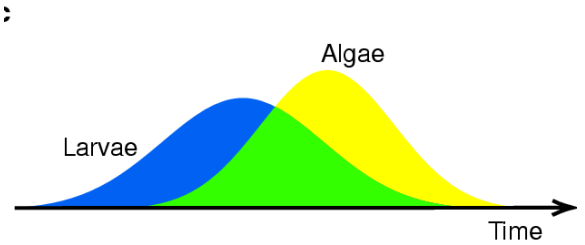
Annual anomaly in the timing of the spring bloom based on SeaWiFS chlorophyll data.



From Platt et al., Nature, 2003



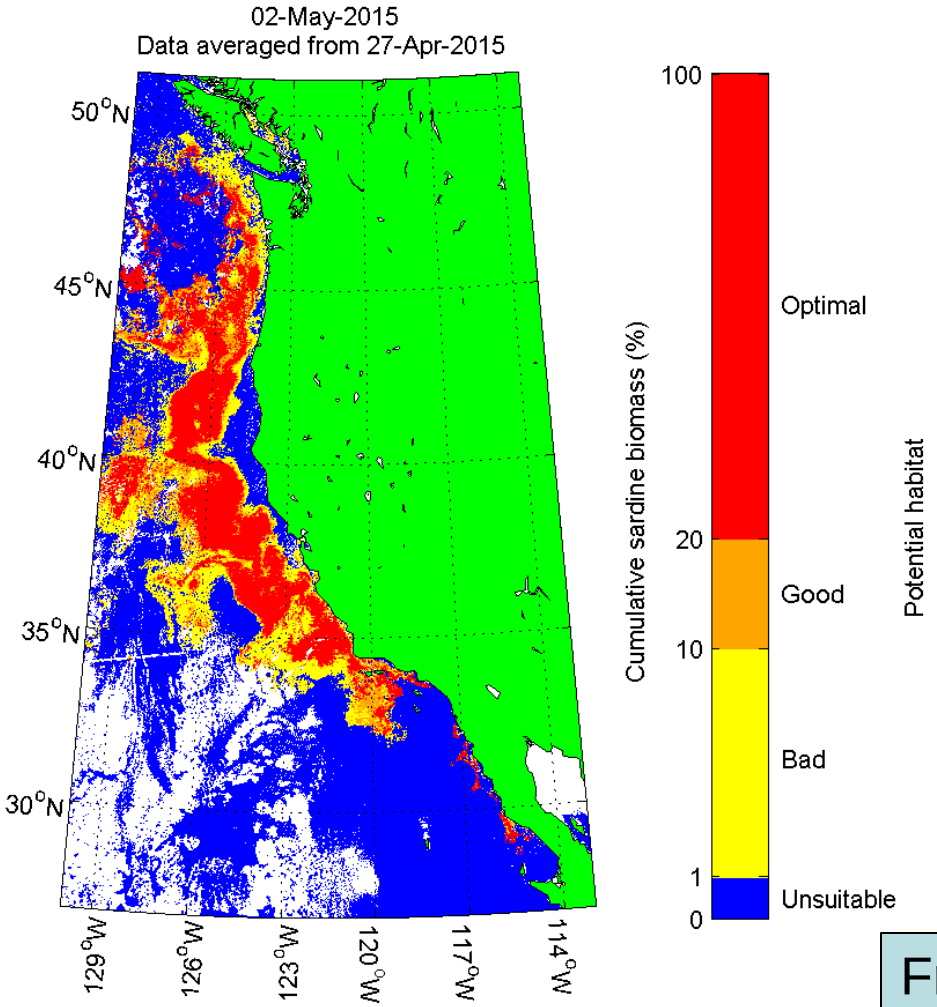




Earlier bloom means more time in the 'green' zone

Habitat Modeling

Potential Sardine Habitat

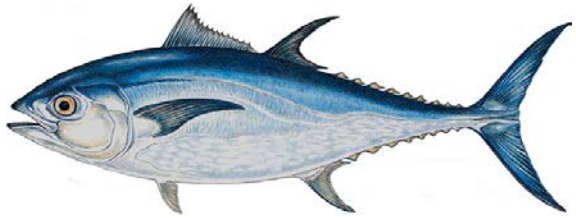


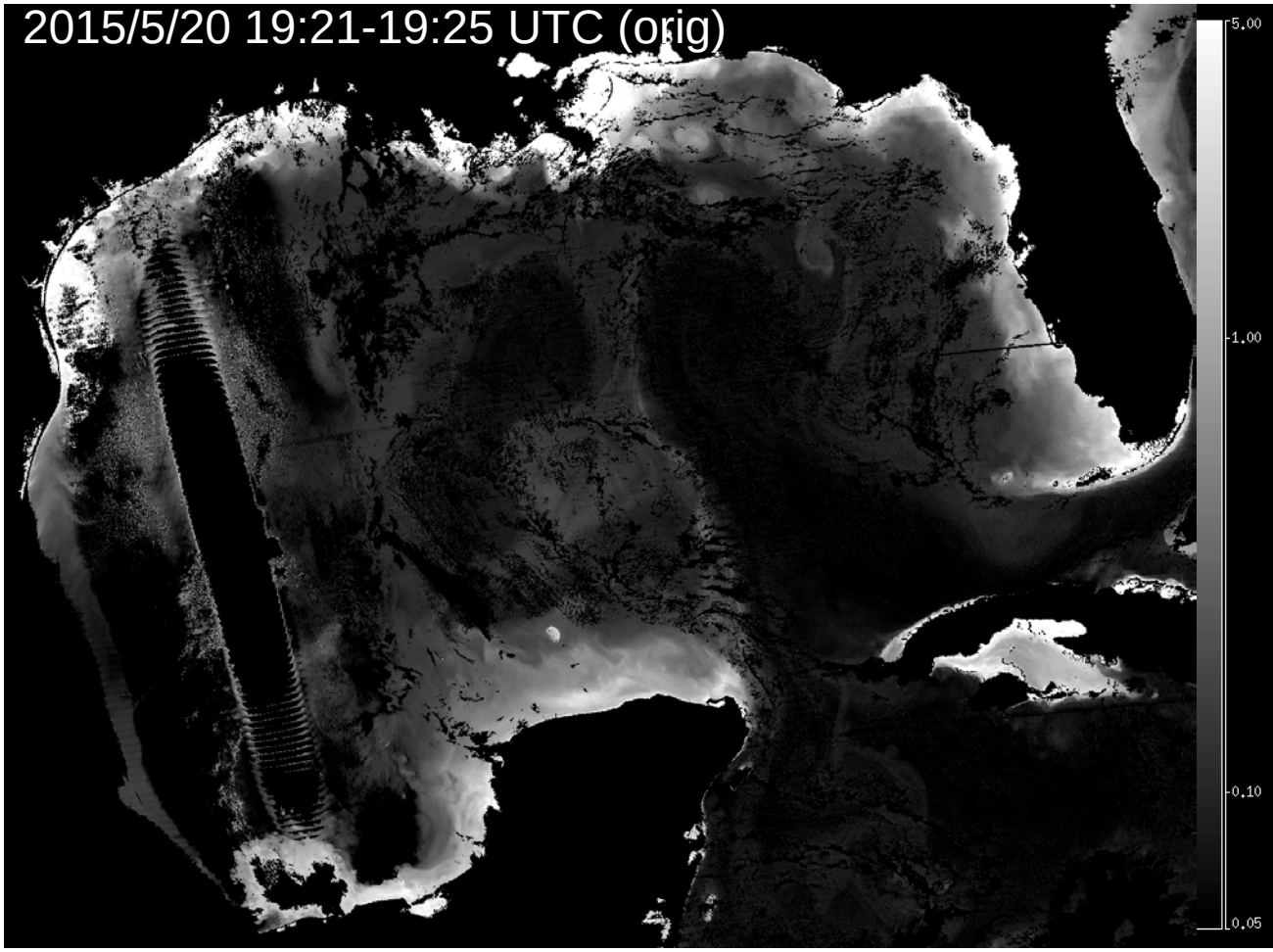
- Model predicts sardine occurrence based on satellite SST, chlorophyll and SSH
- Was developed to optimize the timing and location of ship surveys for sardine stock assessment (i.e., to improve the “A” part of the stock assessment)

From Zwolinski et al., ICES JMS, 2011

NRT Cruise support

- VIIRS chl image generated by NESDIS in support of a SEFSC survey cruise looking for bluefin tuna larvae.
- Images are used to position stations to cover frontal features, small and mesoscale oceanographic features, and to ensure as many different water masses as possible are sampled.
- They requested the images in gray scale.





John Lamkin, NOAA/NMFS/SEFSC

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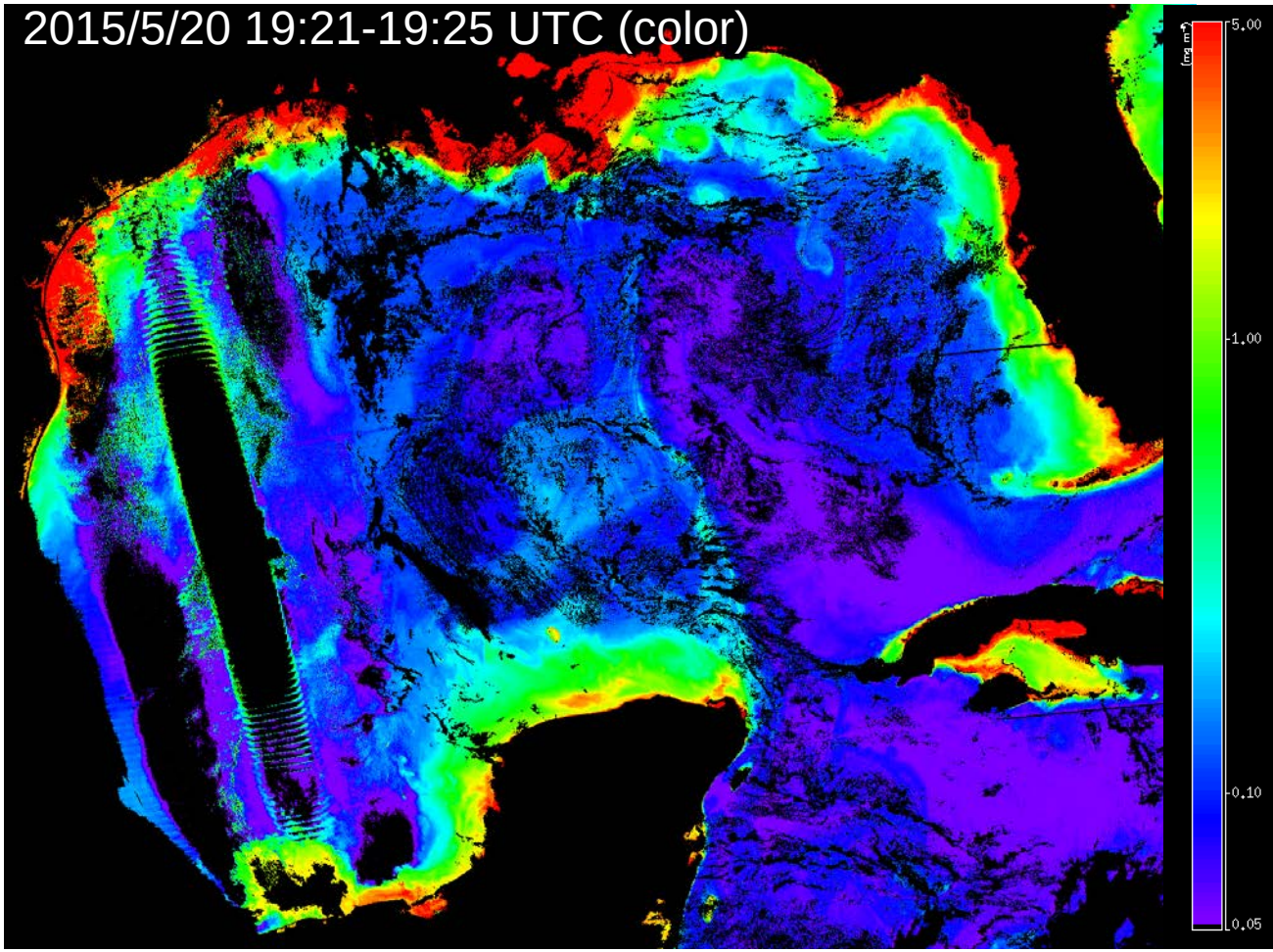
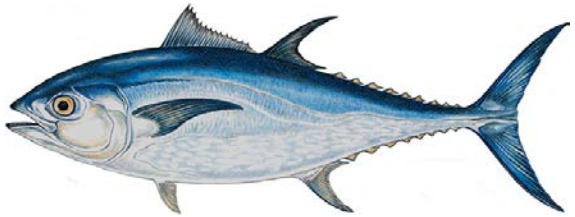




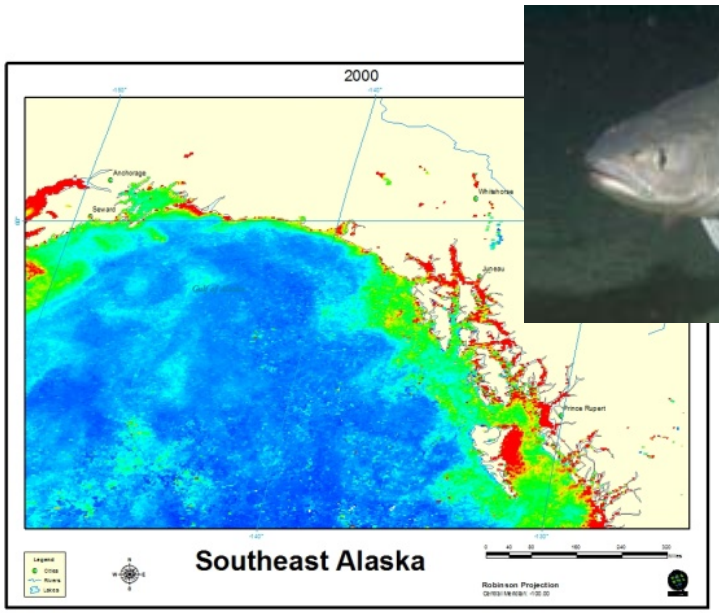
John Lamkin, NOAA/NMFS/SEFSC

Recruitment Variability

Developing ecological indicators for sablefish recruitment

Objectives

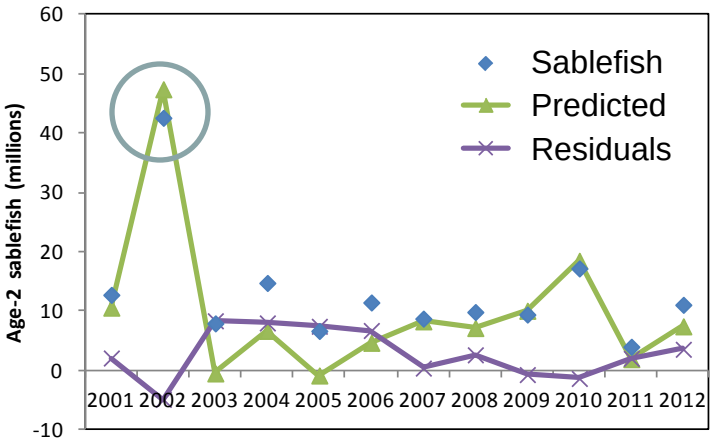
1. Support an ecosystem approach to management
2. $ 142 million fishery for sablefish in U.S.
3. Develop indicators for sablefish recruitment
4. **Use satellite color data to index chl-a, blooms**
5. Quantify blooms in rearing areas
6. Link to future sablefish recruitment



Coastal rearing habitat for young sablefish

Model Prediction

High age-2 recruitment in 2002 was linked to high chlorophyll-a in the late summer in 2000.

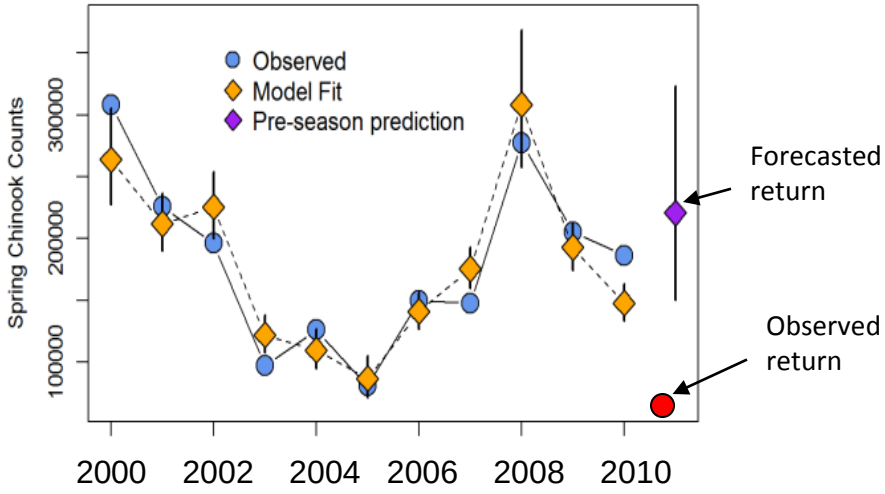


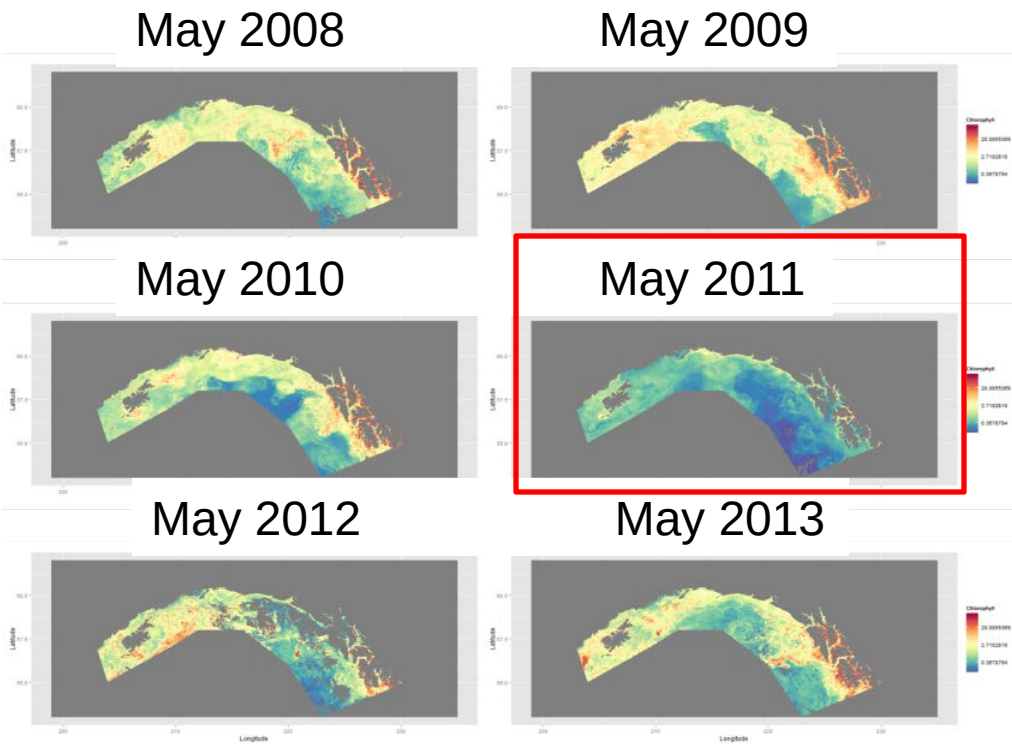
Age-2 sablefish modeled as a function of Chl-a (t-2), sea temperature (ST) (t-2), and age-2 sablefish (t-1) with data collected in situ, 1999-2010 (Martinson et al. 2013).

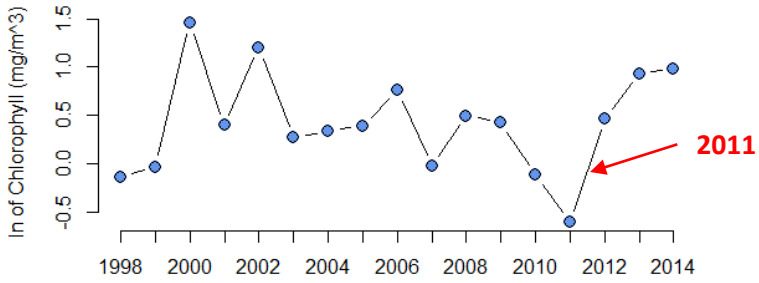
Ellen Martinson, NMFS/AFSC/ABL

Salmon Survival in 2011

Adult Chinook Returns – What happened in 2011?



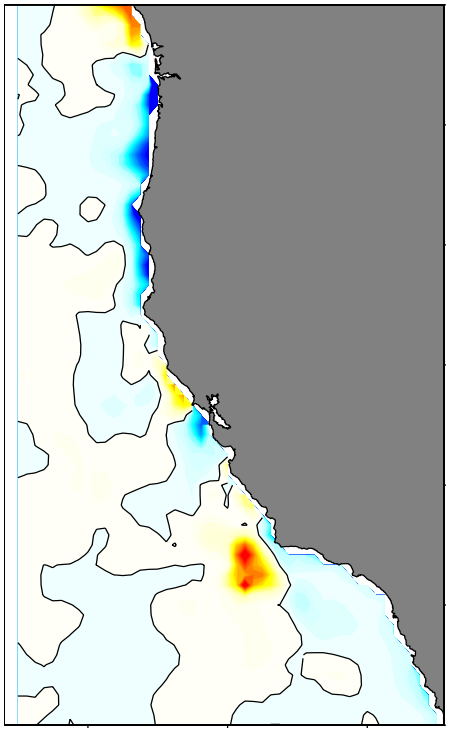


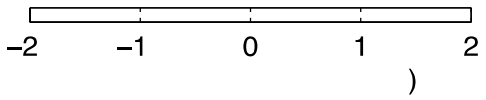


Time series of average April-May chlorophyll concentrations in coastal Gulf of Alaska. The lowest value (2011) suggests that low productivity could have negatively influenced salmon survival that year.

Brian Burke
Fish Ecology Division
NWFSC, NOAA Fisheries

CA Current
Integrated Ecosystem Assessment (IEA)



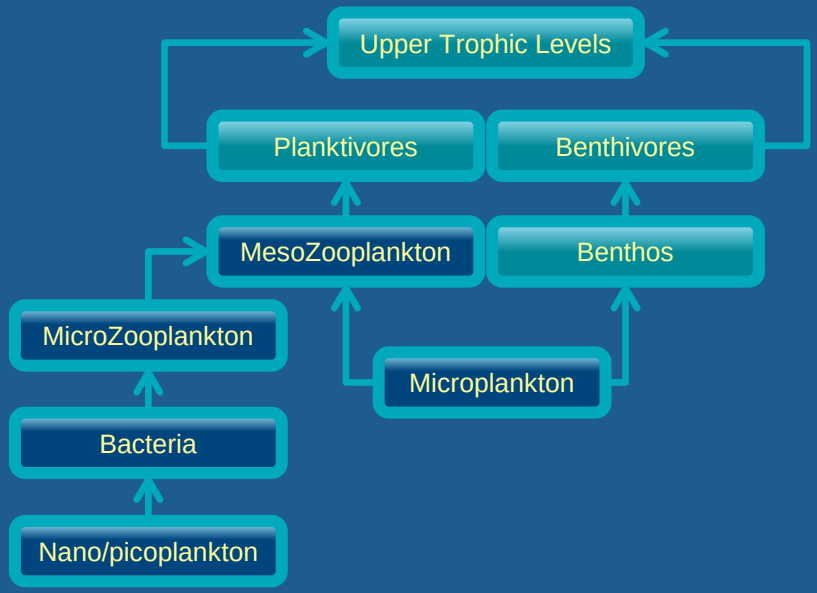


From the 2013 California Current System IEA report

Ecosystem Production Potential Modeling

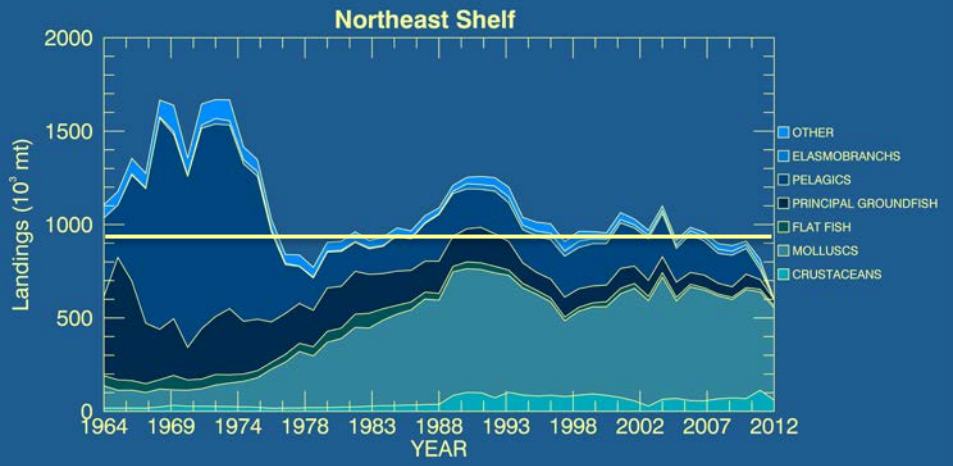
Northeast Fisheries Science Center - Kimberly Hyde & Michael Fogarty

The NEFSC is using a (satellite derived) bottom-up approach to determine fisheries production potential and exploitation for various ecosystem components.



Trace size fractionated primary production through the food web to determine the amount of upper trophic level production that can be extracted at sustainable levels.

The proposed ecosystem limit reference point is that the exploitation rate should not exceed the fraction of microplankton production (~20-30%).



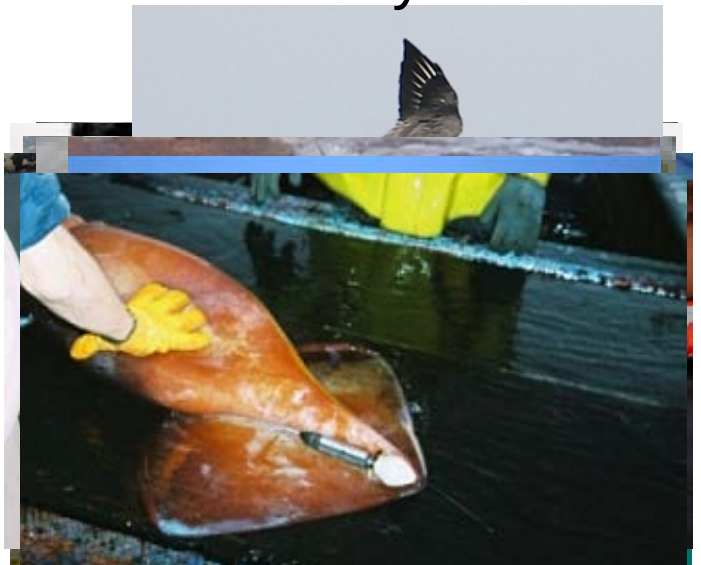
Fishery removals exceeded recommended levels (~935,000 t) in the past, but are now close to estimates of sustainable extraction rates.

3. Management & Conservation

Tagged Species

Electronic tagging is a key methodology used by NOAA Fisheries to gather information on stock productivity and recruitment, fish behavior, feeding ecology and habitat selection– information needed for accurate and responsible fisheries management.[1]

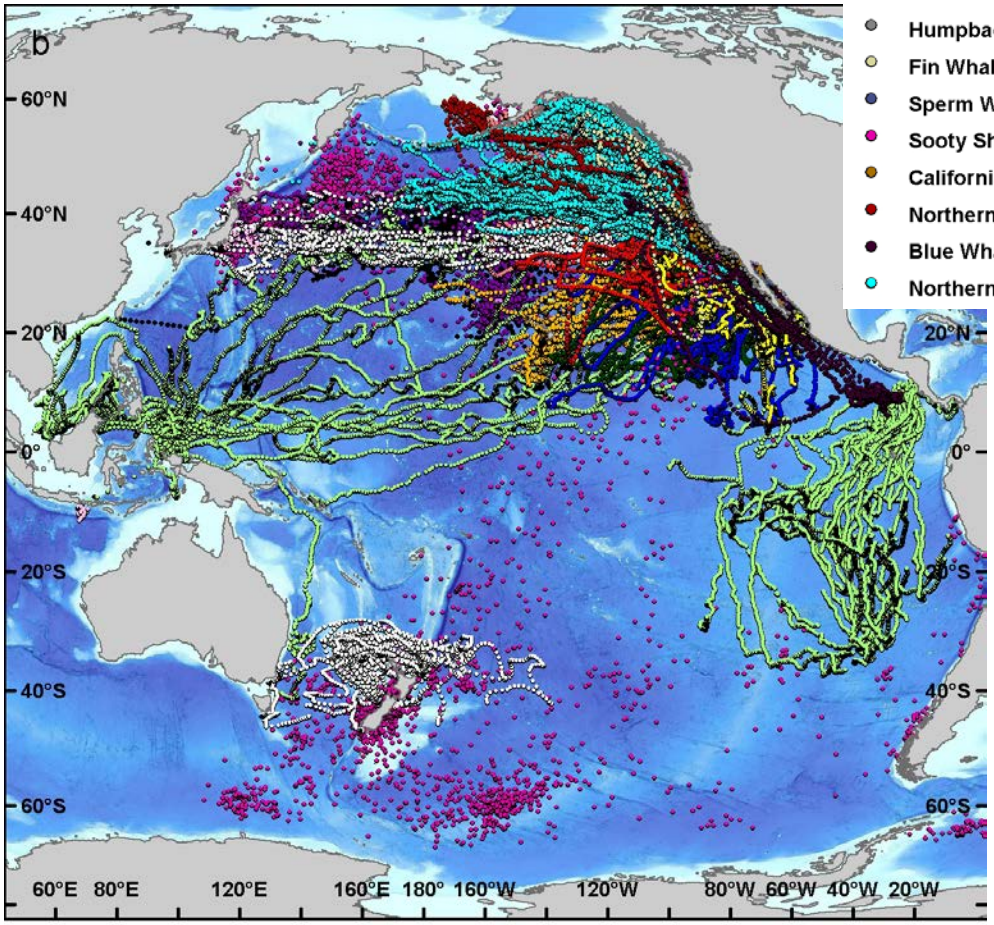
Satellite data, such as ocean color, SST, SSH and SVW, are necessary to place the telemetric data from tags in an environmental context as part of the transition to an ecosystem approach to management.



[1]Report of the NMFS Workshop on advancing electronic tag technologies and their use in stock assessment. NOAA Tech. Memo. NMFS-F/SPO-82, 82 pp, 2007.

http://spo.nmfs.noaa.gov/tm

Top Predator Exploration of the Pacific Ocean



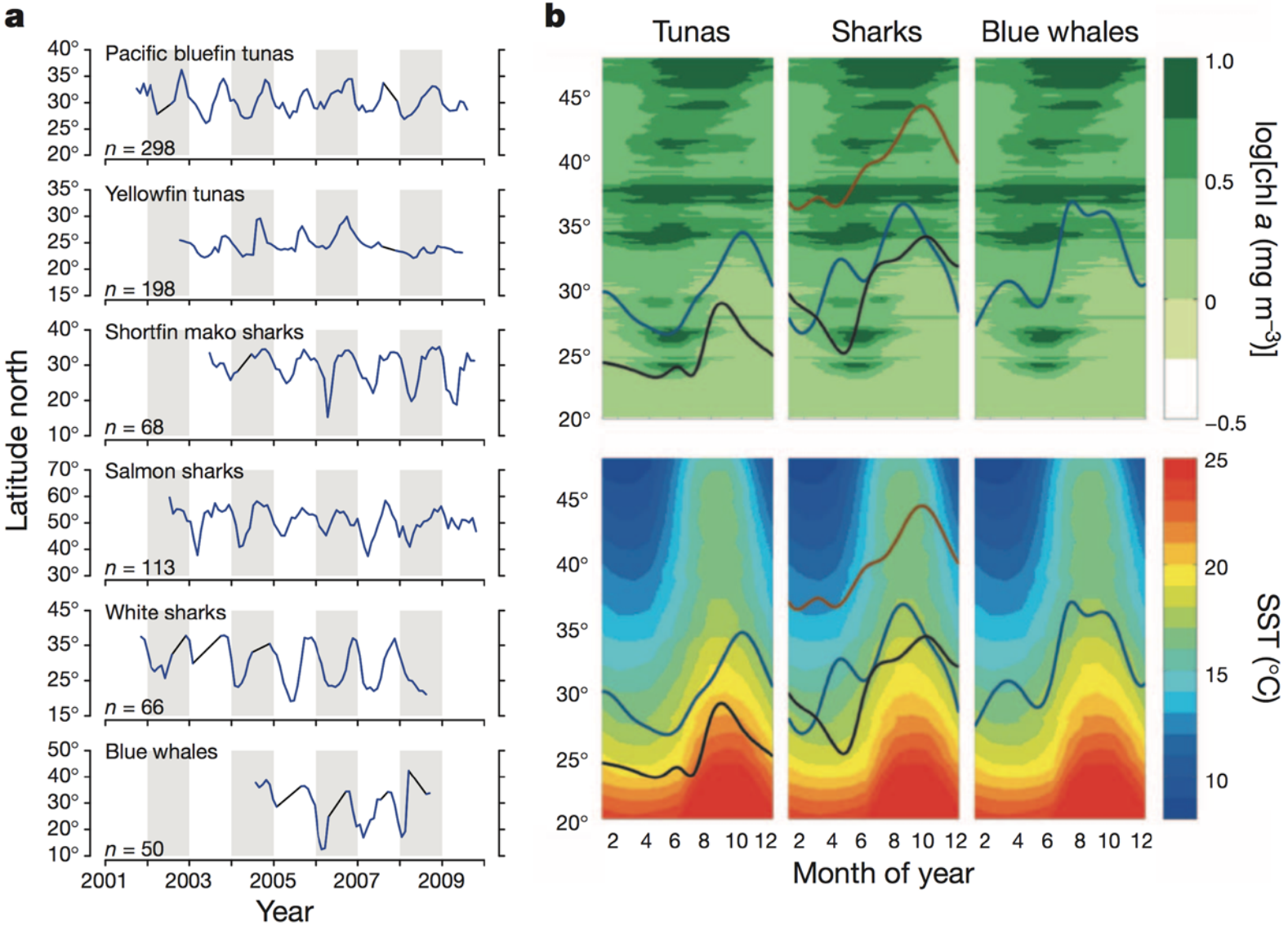
- Humpback Whale
- Fin Whale
- Sperm Whale
- Sooty Shearwater
- California Sea Lion
- Northern Fur Seal
- Blue Whale
- Northern Elephant Seal
- Thresher Shark
- Yellowfin Tuna
- Albacore Tuna
- Blue Shark
- Mako Shark
- White Shark
- Loggerhead Turtle
- Mola mola
- Pacific Bluefin Tuna
- Leatherback Turtle
- Salmon Shark
- Laysan Albatross
- Black-footed Albatross
- Humboldt Squid

TAGGING OF PACIFIC PELAGICS

- 23 species; 4,000 tags; >1 Million profiles
- Tracking, conservation, ocean observation

From Block et al, 2011, Nature **475**, 86–90

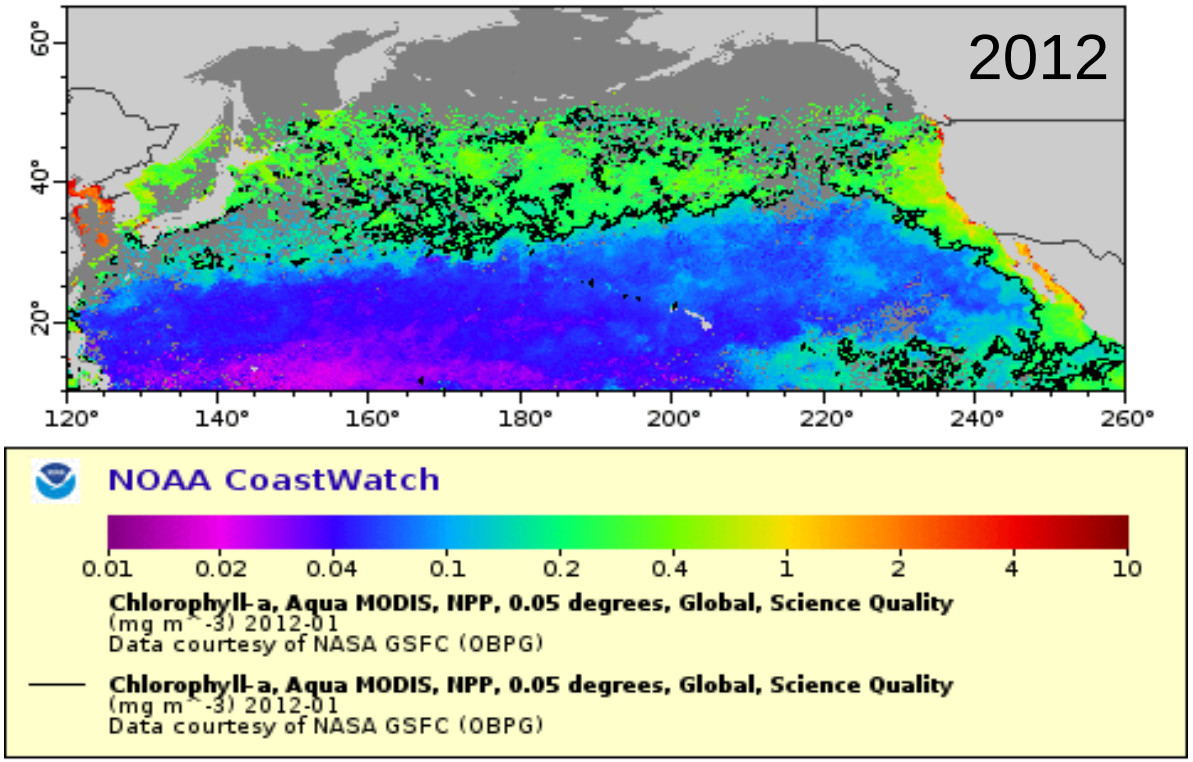
TOPP Synthesis: Marine Predator Migrations



From Block et al, 2011, Nature **475**, 86–90

TZCF

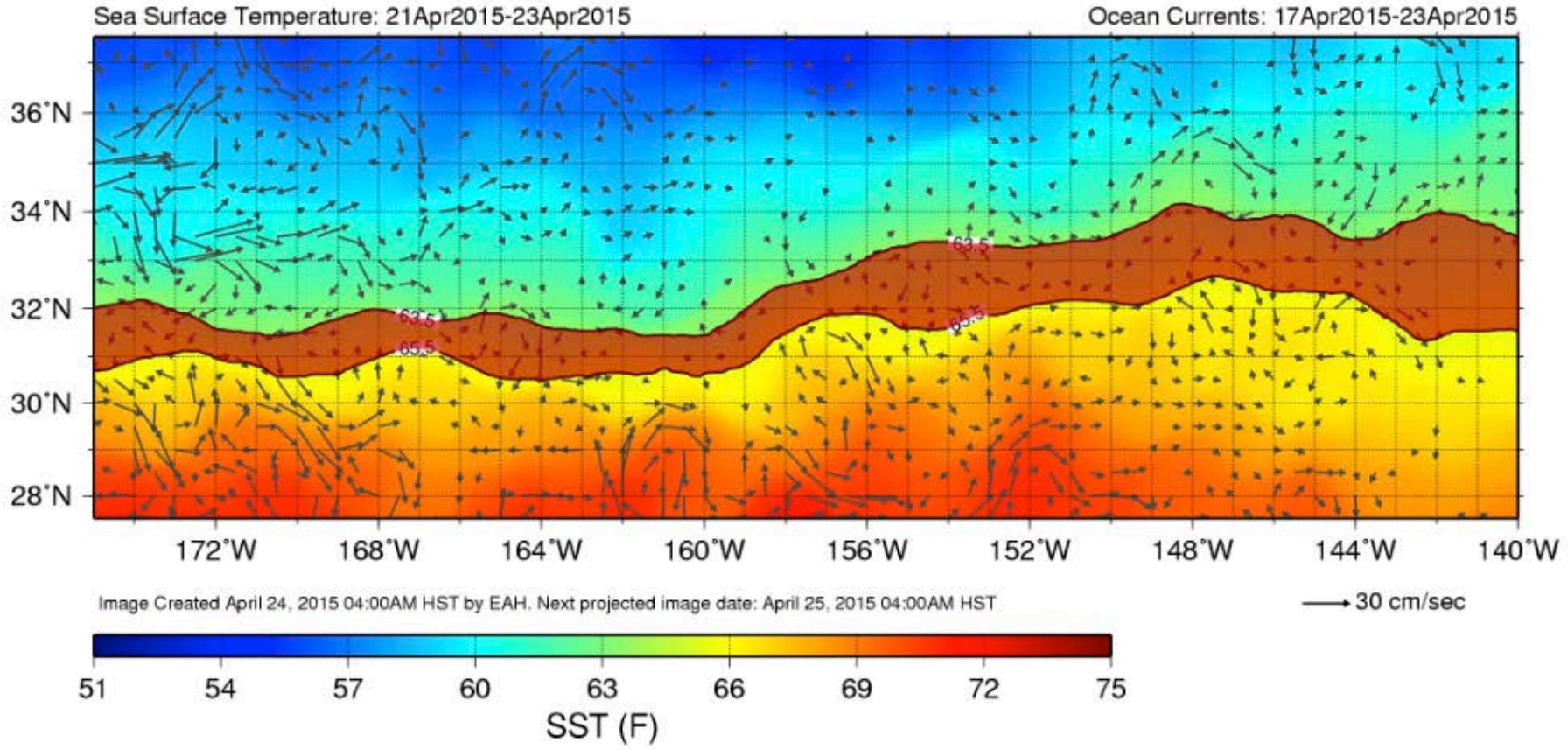
Transitional Zone Chlorophyll Front



- Migration route for sea turtles, squid and tuna (Ichii et al, 2009, Polovina et al, 2015, Zainunddin et al, 2008)
- It's interannual variability affects the population of the endangered monk seal in the Hawaiian islands (Baker et al., 2007, 2012)

EXPERIMENTAL PRODUCT

avoid fishing between solid black 63.5°F and 65.5°F lines
to help reduce loggerhead sea turtle interactions



PACIFIC ISLANDS FISHERIES SCIENCE CENTER
ECOSYSTEMS AND OCEANOGRAPHY DIVISION
2570 Dole Street, Honolulu, HI 96822
http://www.pifsc.noaa.gov/eod/turtlewatch.php
contact: Evan.Howell@noaa.gov

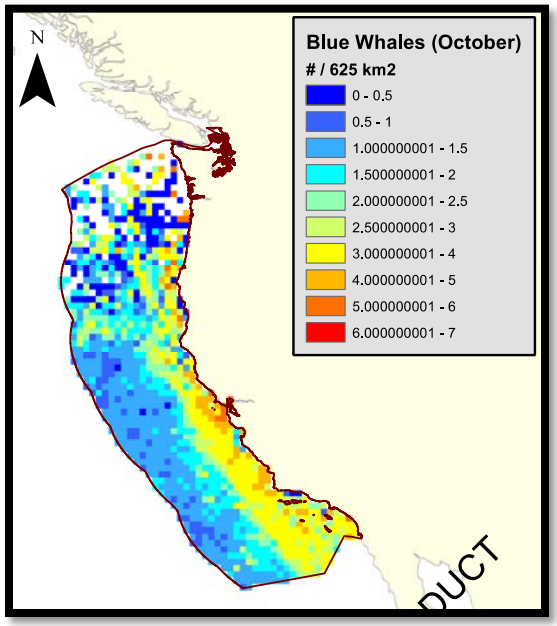
Data provided by Central Pacific CoastWatch node

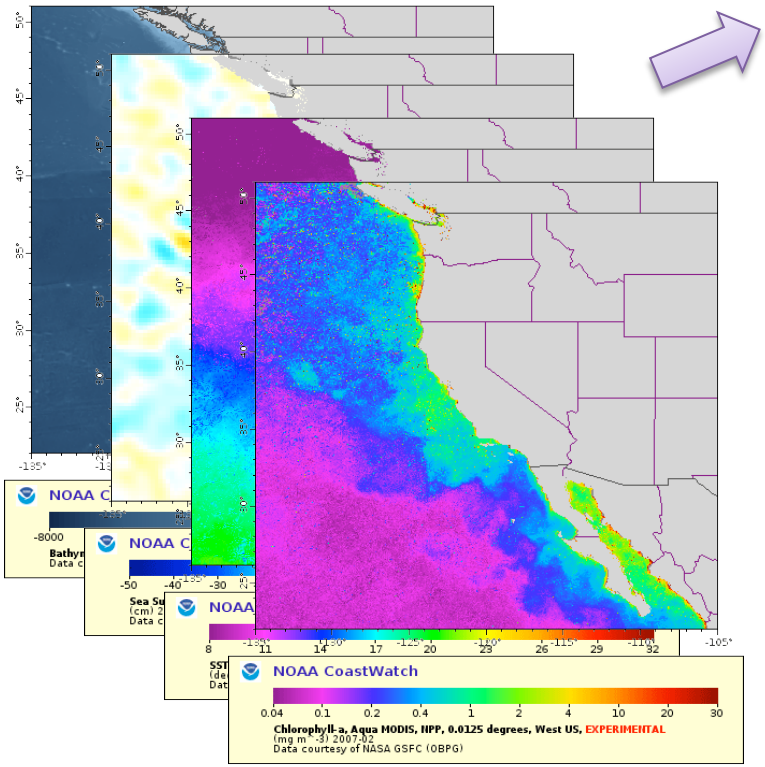
TURTLEWATCH

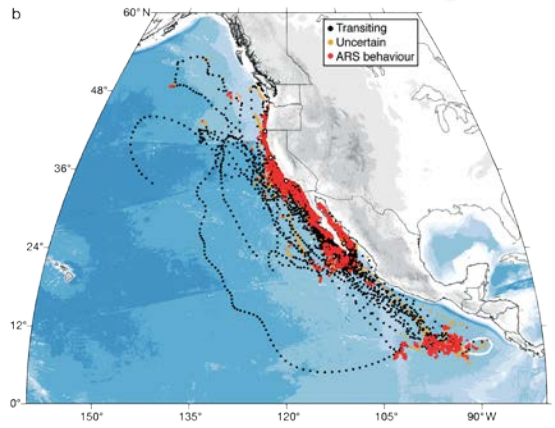
http://www.pifsc.noaa.gov/eod/turtlewatch.php

Whale Watch

- Use satellite data to model blue whales & ship strike risk in near real time
- 104 OSU Blue Whale tracks
- NASA funded





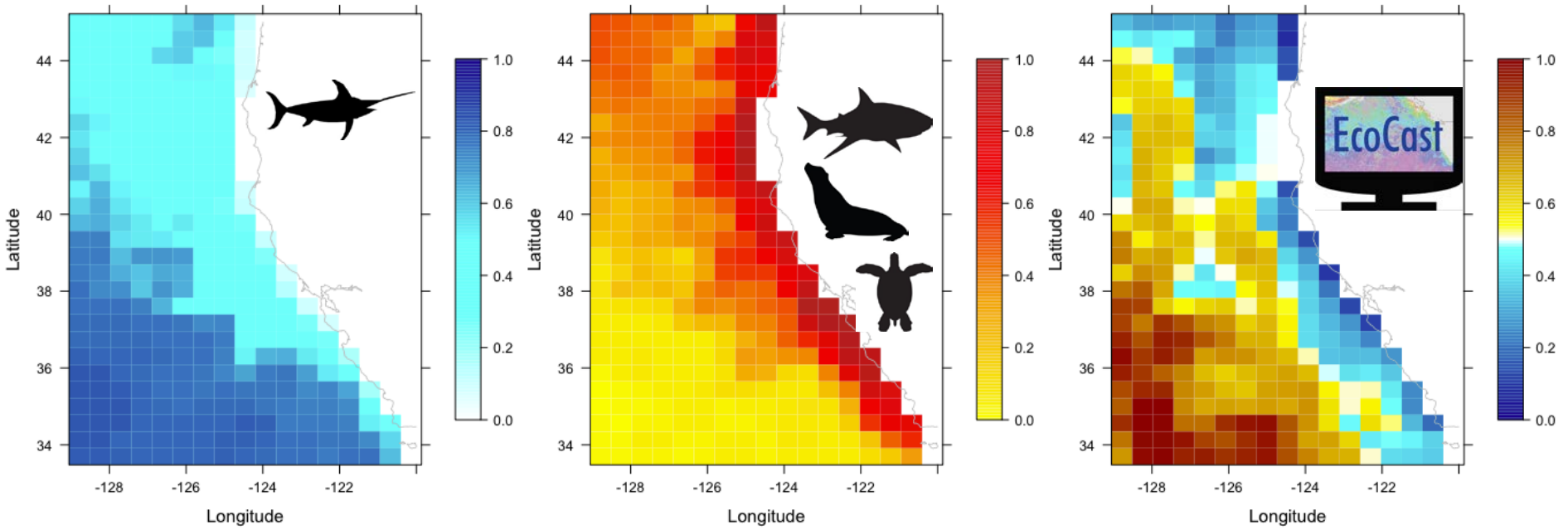


Elliott Hazen et al., NMFS/SWFSC

EcoCast

Predicting fishery bycatch for management

Predicted catch + **Predicted bycatch** ➔ **EcoCast**

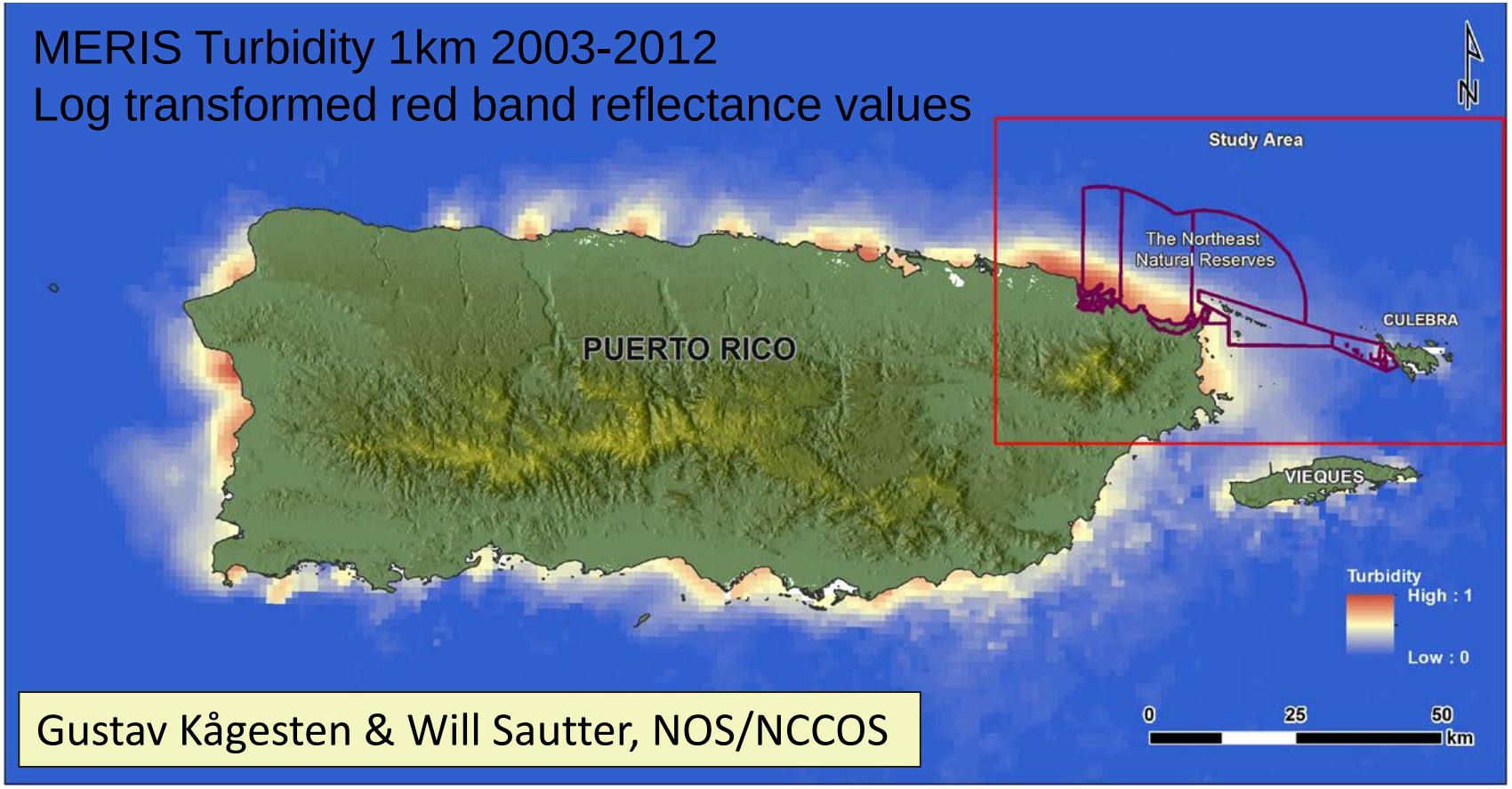


Using remotely sensed products, these surfaces can be predicted in near-real time for use by managers and fishers. A NASA funded project.

Elliott Hazen et al., NMFS/SWFSC

MPA Development

Biogeographical assessment of new MPA (marine protected area) in Puerto Rico

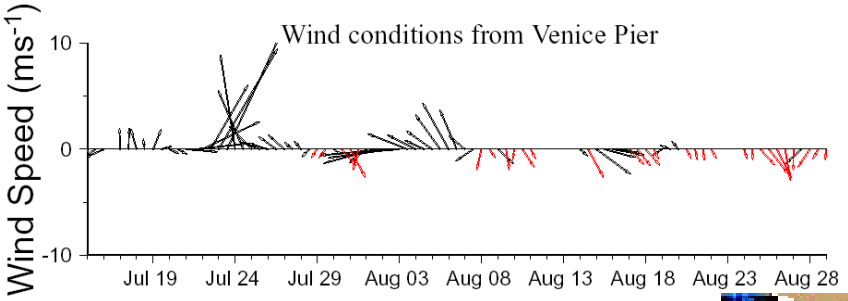


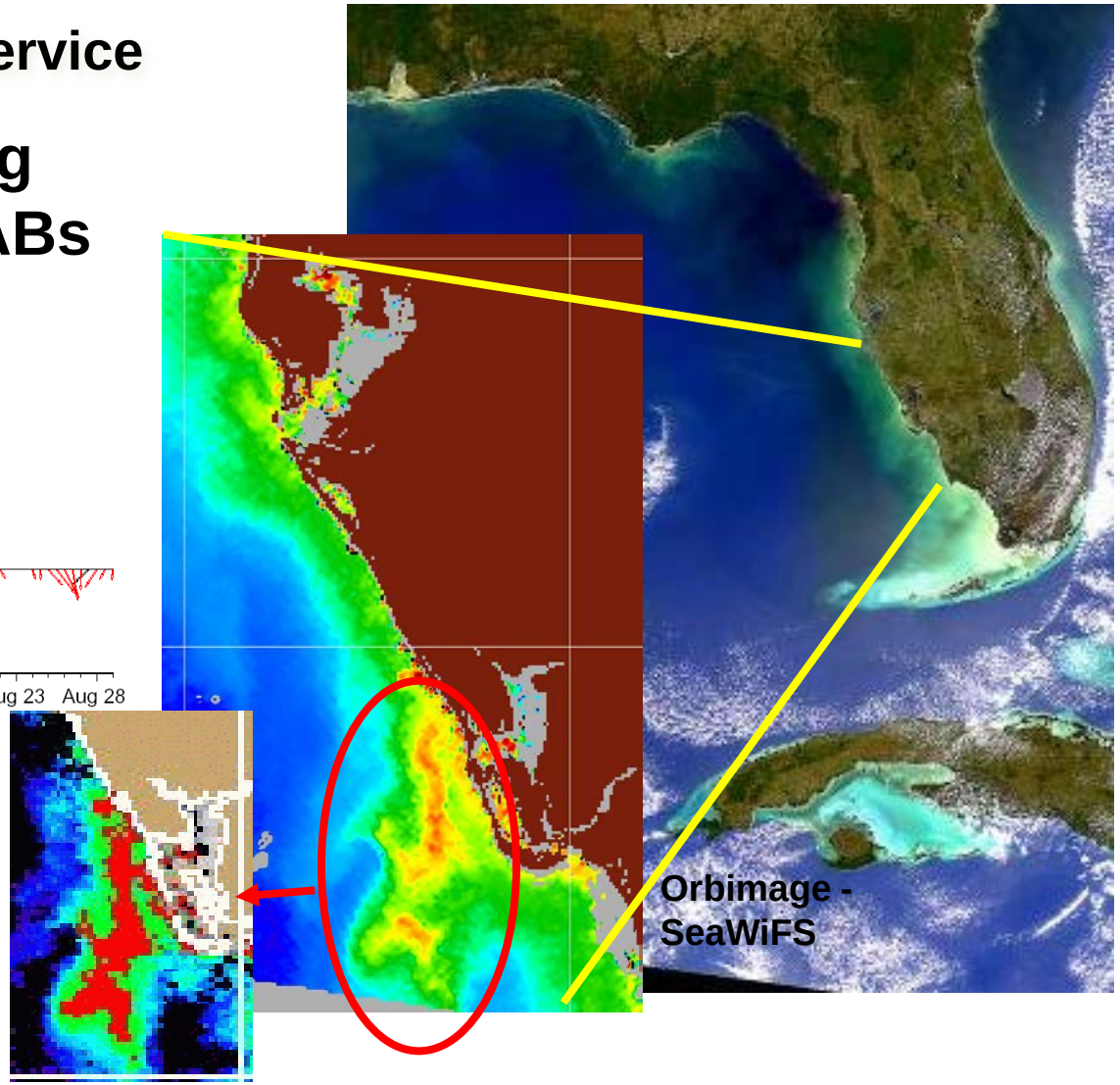
- High resolution (750m) ocean color and SST data from VIIRS will be extremely useful
- Need data in a format that is easy to pull into ArcGIS

Harmful Algal Blooms (HABs)

NOAA National Ocean Service

Operational Monitoring and Forecasting of HABs in the Gulf of Mexico

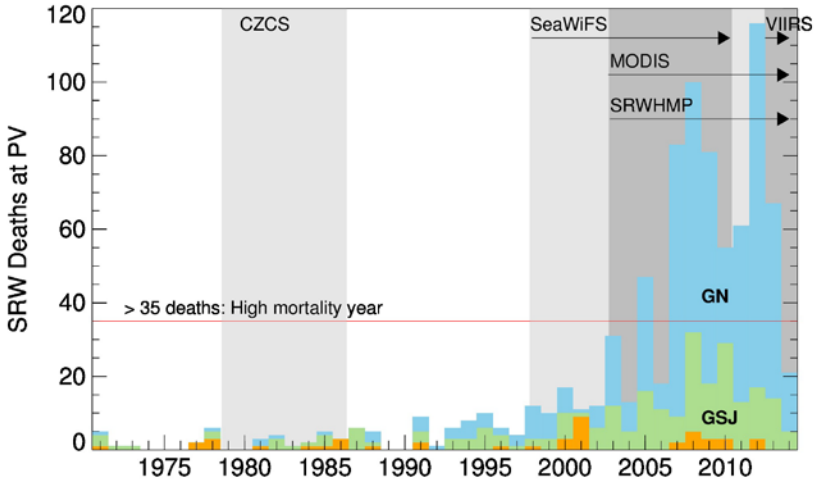




Courtesy of Rick Stumpf, NOS

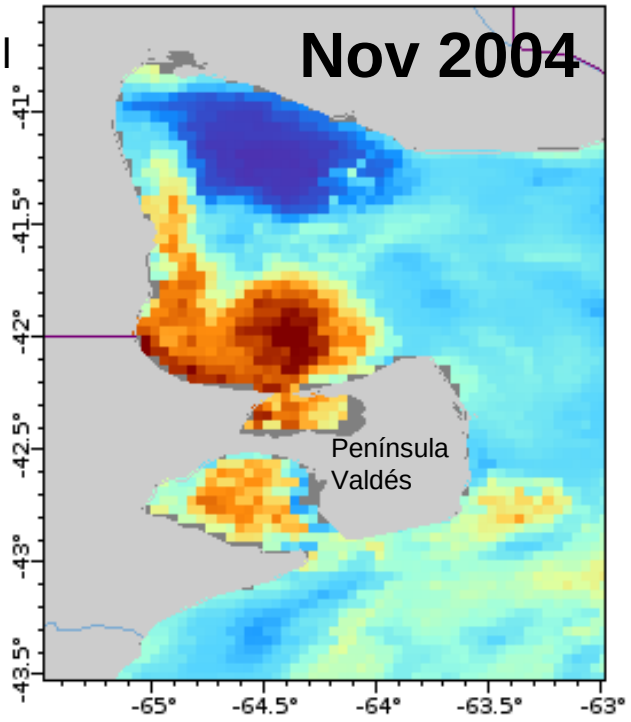
HABs & mortality events

Are southern right whale calf deaths at Península Valdés caused by HABs?



In the past 10 years there has been a dramatic increase in the number of SRW deaths at their calving ground in Argentina. Most of the deaths (~90%) are calves less than 3 months old.

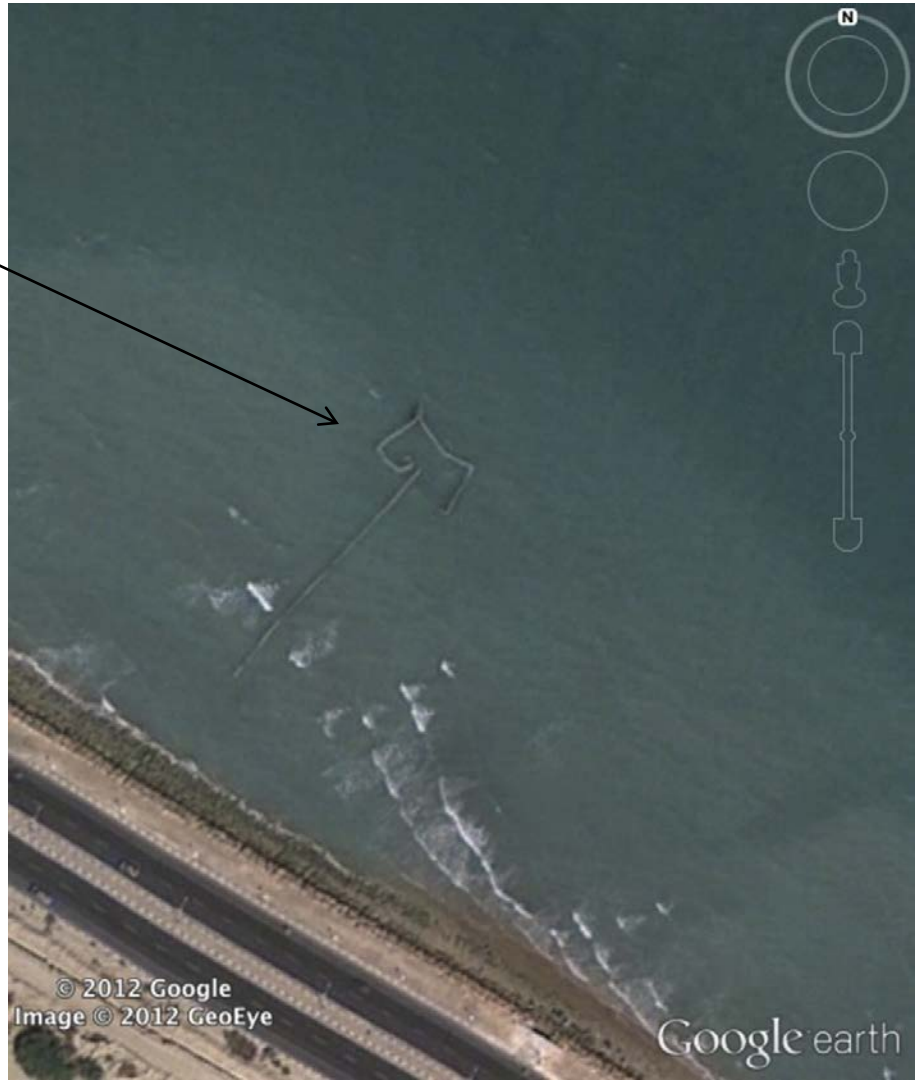
The chlorophyll maximum of the spring phytoplankton bloom at PV has increased by an order of magnitude in the past 10 years.



See Wilson *et al.* poster
under review for
Marine Mammal Science

Estimate Harvesting from Space

- Used Google Earth imagery to identify intertidal weirs in the Persian Gulf.
- Estimated the 19,000 visible weirs catch > 30,000 tons of fish per year, six times greater than the official reported catch of 5,000 ton/year.
- Observed weirs in areas where they have been banned (Qatar).

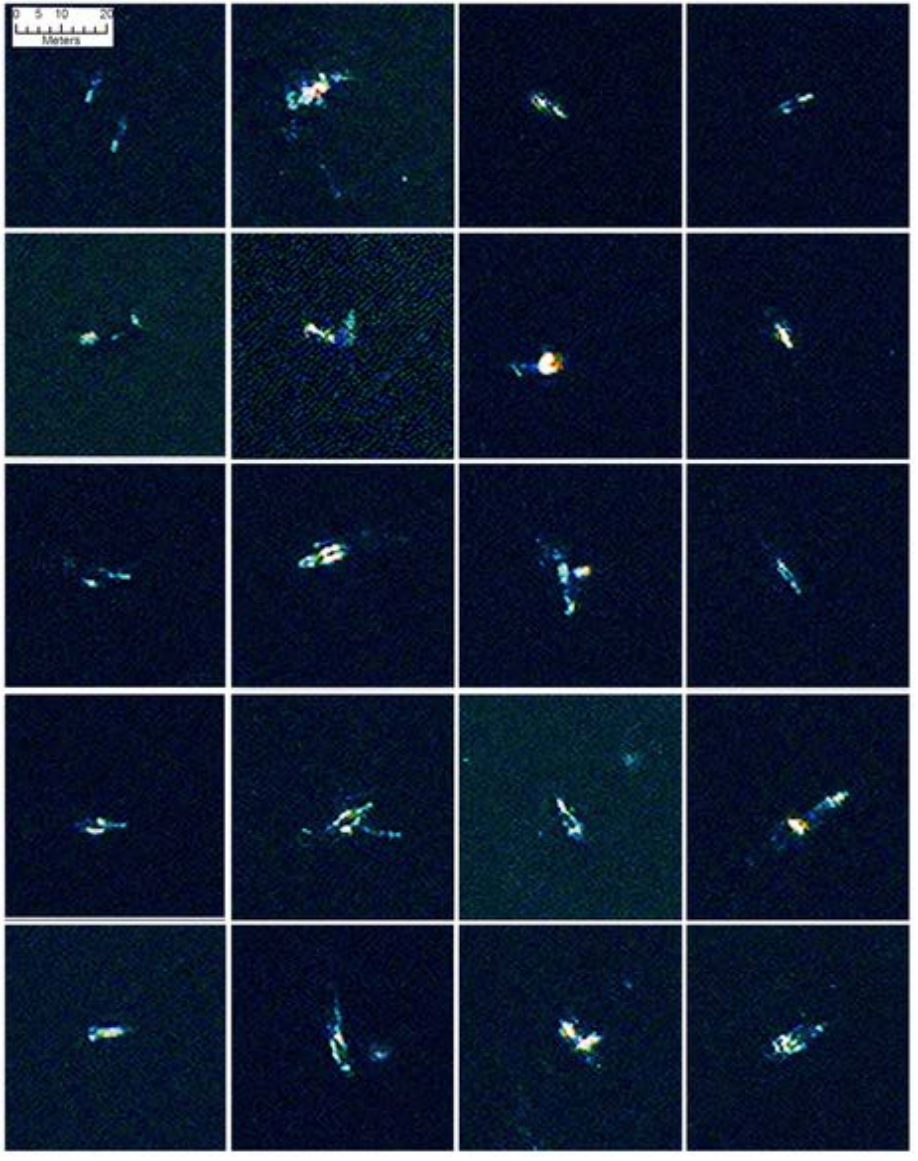


Al-Abdulrazzak & Pauly, ICES J. Mar. Sci. 2013

Whales from Space

- A selection of 20 comparable false color image chips from the WorldView2 satellite of probable whales found by automated analysis.

- This study was done in Península Valdés, Argentina, which is a calving ground for Southern Right Whales (see Wilson et al. poster).



Fretwell PT, Staniland IJ, Forcada J (2014) Whales from Space: Counting Southern Right Whales by Satellite. PLoS ONE 9(2): e88655. doi:10.1371/journal.pone.0088655
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0088655

PLOS | ONE

Take Home Points

- “Fisheries” is more than just catching fish; stock assessment, management and conservation are important aspects to fisheries, which encompasses all living marine resources.
- NRT ocean color data are needed for optimizing harvesting and assessment surveys, detecting and monitoring HABs and making forecasts.
- Long-term Climate Quality ocean color data are needed for use in stock assessments, ecosystem assessments, and management and conservation applications.


Thank you !