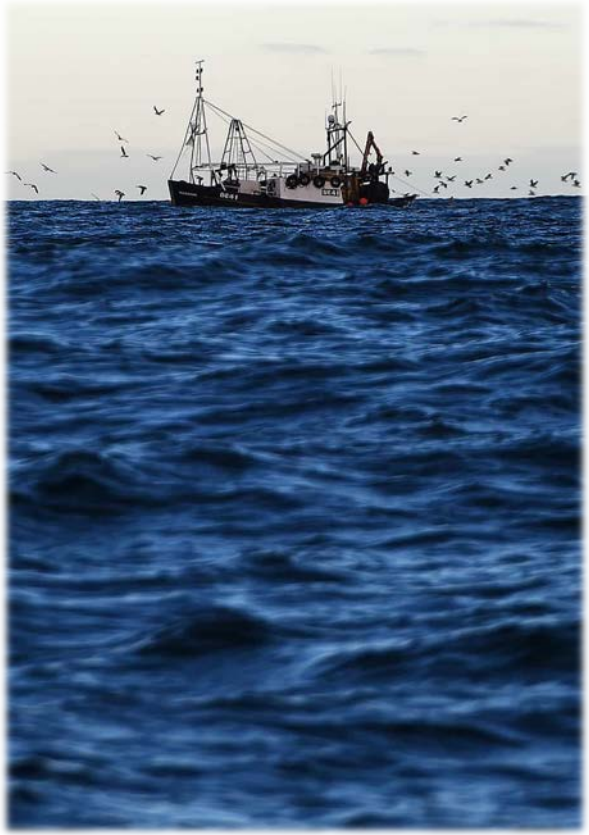
Science Enterprise Updates

Cisco Werner
NMFS Chief Science Advisor

CCC
Washington, DC
November 2019

Topics

1. Science & Technology Initiatives
    - UxS
    - ‘Omics
    - Artificial Intelligence (AI)
2. Movement/species’ shifts
3. Next-Gen Data Acquisition Plan (DAP)
4. Modeling (S2S)
5. ER for Rec Fisheries
6. Concluding thoughts

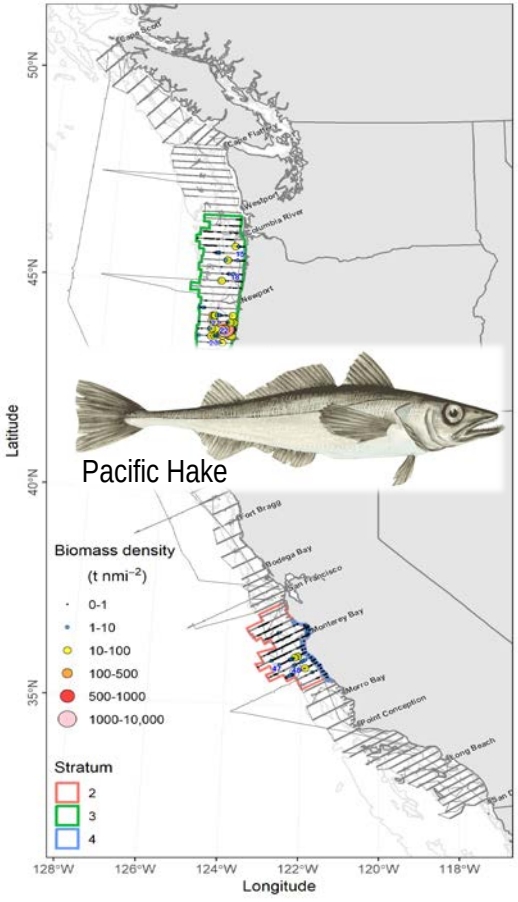


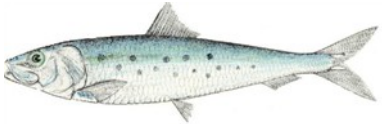
Coastal Pelagic Species & Hake survey 2019

Instruments

- Calibrated* 38/200 kHz WBT-Mini
- Environment (Temperature, light, salinity, wind, etc.)

Lasker's and/or *Shimada*'s & Saildrones' Transects





Pacific sardine

Northern anchovy

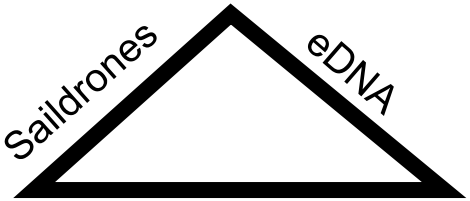
Pacific herring

Pacific mackerel

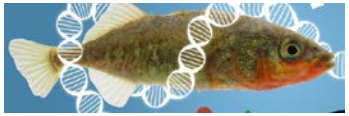
NOAA FISHERIES

*Renfree et al., 2019. NOAA-TM-NMFS-SWFSC-608

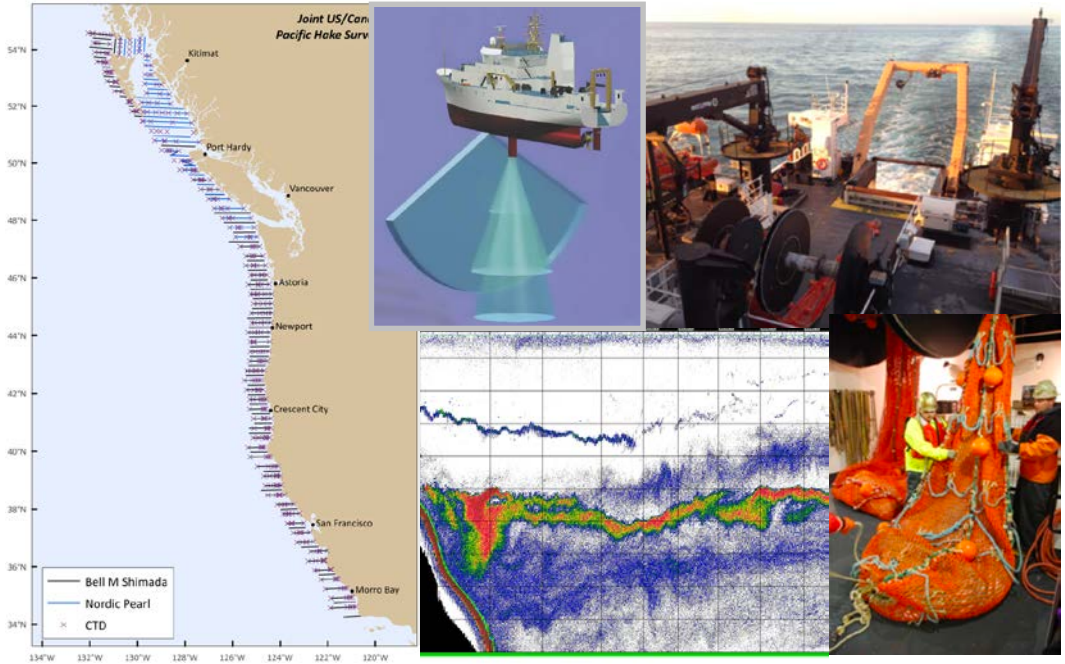
Summer of 2019

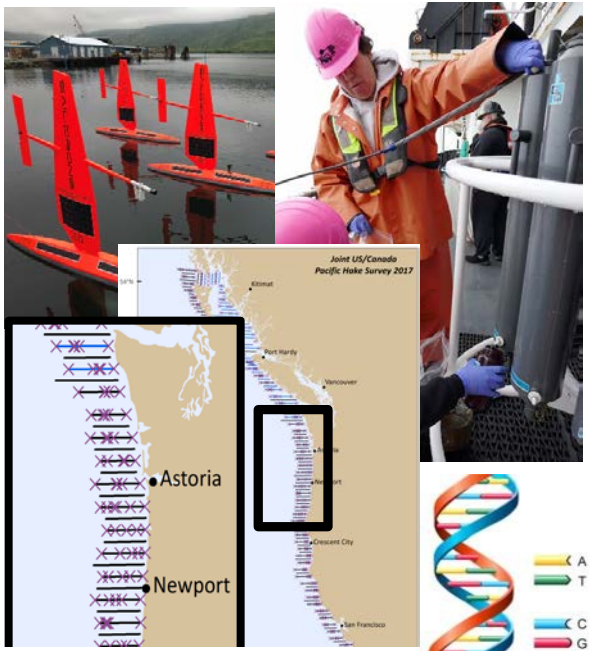


Acoustic trawl survey



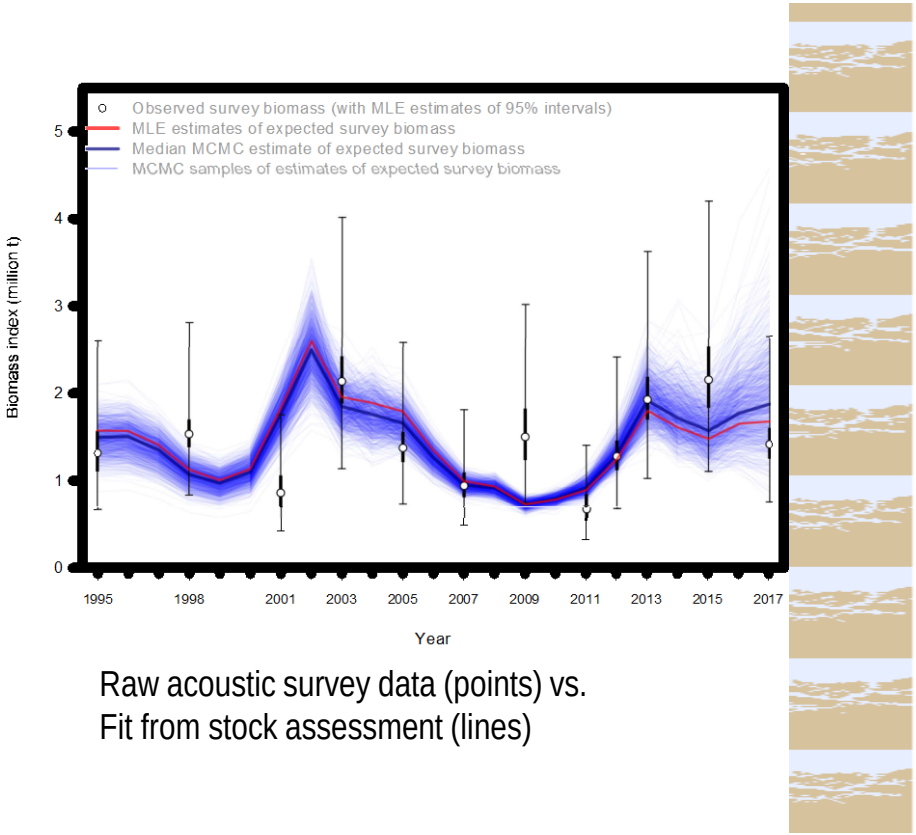
eDNA to detect and support estimate of Pacific Hake





Acoustic transects (▬)
CTD stations (✕)

Target: develop indices of abundance for hake from eDNA



Raw acoustic survey data (points) vs.
Fit from stock assessment (lines)

Edwards, A.M. et al. 2018. Status of the Pacific Hake (whiting) stock in U.S. and Canadian waters in 2018.

DNA likely integrates signal over a larger spatial and temporal scale than acoustic surveys.

- Acoustics detect fish that are present during the survey.
- eDNA can last hours to days in the water

Questions

Are indices developed from eDNA comparable to acoustic estimates?

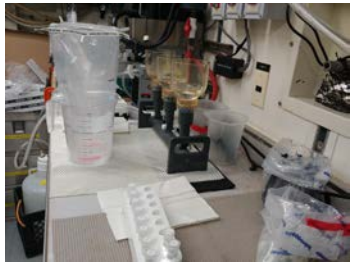
- Local scale
- Regional scale
- Coastwide scale

Does eDNA data mirror, complement, or contradict acoustic information?

Note: it will be important to have an archival strategy for samples for future analyses.

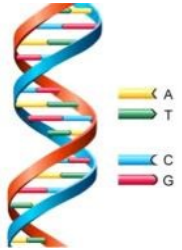
2019 eDNA collection at sea & lessons learned

Water collected from CTD



Samples filter to capture eDNA

Filters inserted into lysis buffer

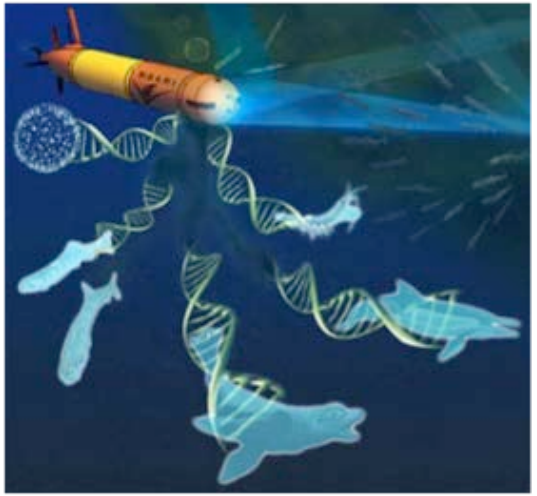


- Approximately 1,000 samples collected in US for eDNA processing
- Fully optimize eDNA techniques and use survey to detect and track other species of interest, e.g., invasive species, endangered species & microbial communities
- Design and validate primers specific to other species of interest in laboratory experiments.
- Recruit more scientists for field work and bioinformatics.

Courtesy Jeanette Davis

Fisheries Genomics Strategic Initiative (SI)

- eDNA and **abundance indeces** of hake
- Population genomics (e.g., to reveal **population structure**) of rockfish, hake, and cod
- Metagenomics (e.g., to reveal **differences in diet between** populations that might influence patterns of growth and survival)
- **Bioinformatics** investments
  - Installation of ‘omics tools and computational needs
  - Information sharing and training via webinar
  - In-person training of data processing
  - Workshops to assess progress, standardize protocols, and make improvements



NOAA S&T Focus Areas

‘Omics

UxS

AI

NOAA's *'Omics, UxS & AI* Vision & Strategies(*)

Vision statements include:

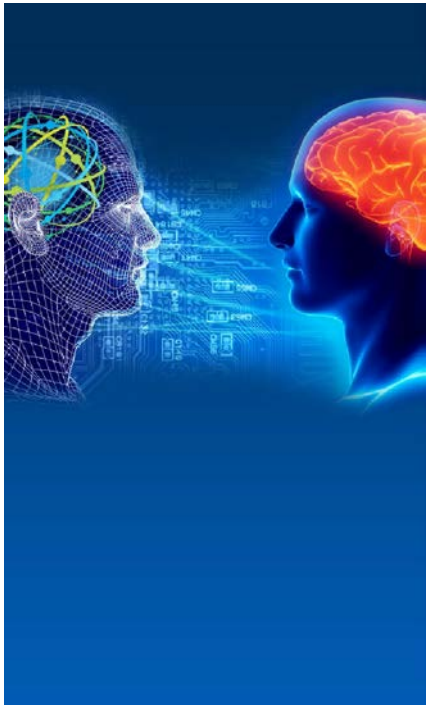
NOAA will integrate modern **'omics** technologies across the agency, transforming its approach to biological investigation

Accelerate and expand the transformative use of **unmanned systems (UxS)** to the benefit of NOAA, the nation, and the global earth science community.

The NOAA **AI** Strategy is to transform how Earth Science is conducted by integrating AI to advance NOAA's science and requirements-driven mission priorities.

General shared goals:

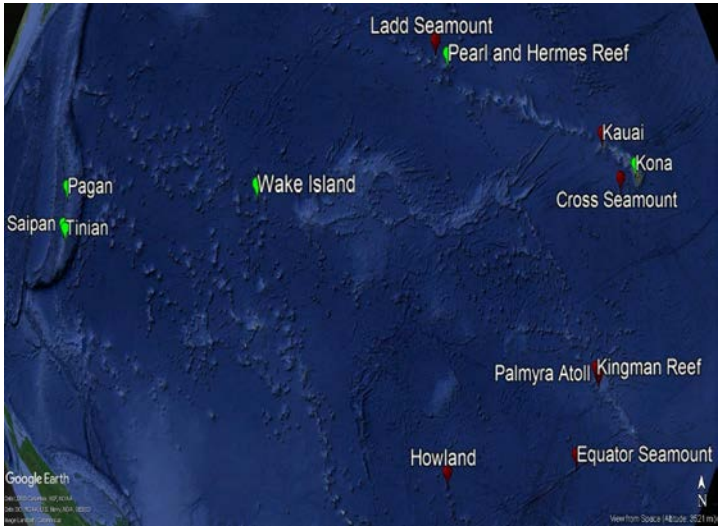
- Establish efficient organizational structures
- Advance research and innovation in support of NOAA's mission.
- Accelerate the transition of research to operational capabilities.
- Strengthen and expand partnerships.
- Promote proficiency in the workforce.



* NOAA Strategies still in draft form; target completion: calendar 2019.

PIFSC Marine Mammal Survey

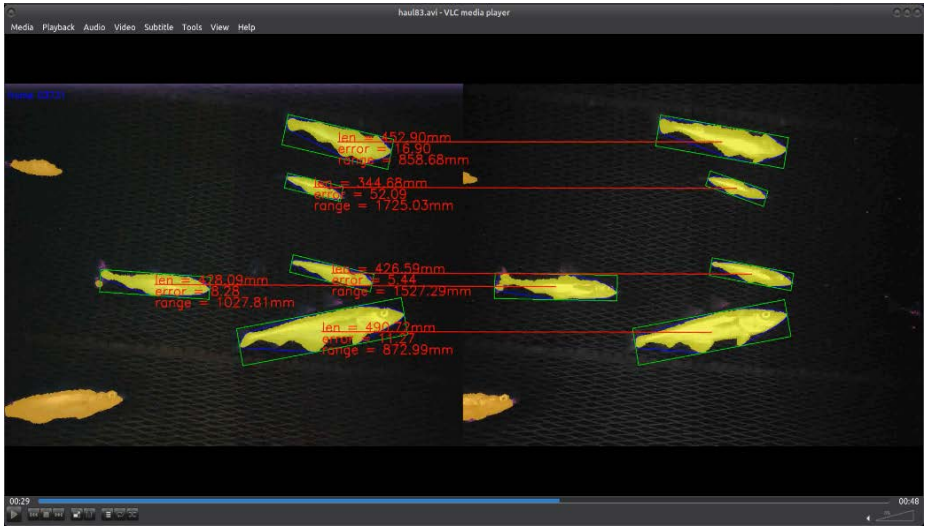
NOAA Pacific Islands Fisheries Science Center's Cetacean Research Program surveys marine mammals, and collected >170,000 of passive acoustic recordings from monitoring instruments throughout the Pacific Islands.



Google Artificial Intelligence (AI) to develop machine learning model to recognize and annotate humpback whale songs. Significant savings in processing with 90% in precision and recall.
[Contacts: Ann.Allen@noaa.gov & Erin.Oleson@noaa.gov]

AFSC Bering Sea pollock survey

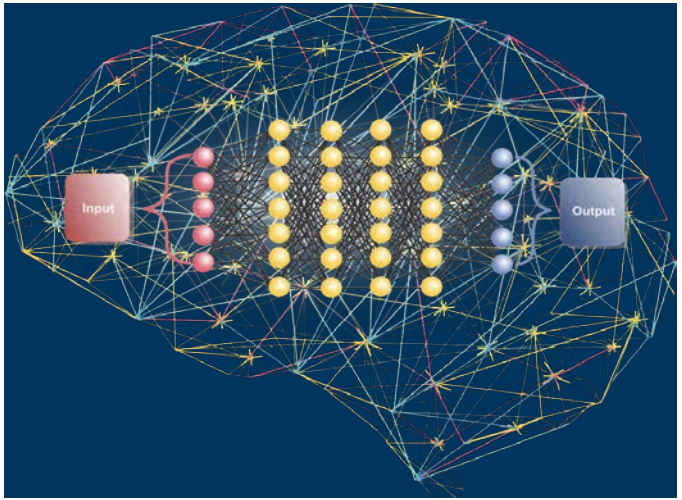
NOAA Alaska Fisheries Science Center utilizes VIAME to automate the processing of video images of pollock, and recent upgrades include improved precision with classification, stereo measurements, and >4x faster processing. [Contact: Kresimir.Williams@noaa.gov]



Data, data, data…

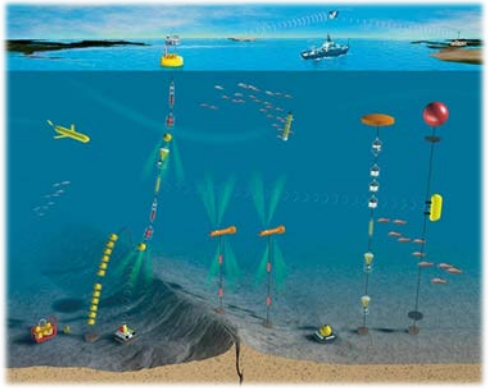
Evolving approaches in Artificial Intelligence and Machine Learning:

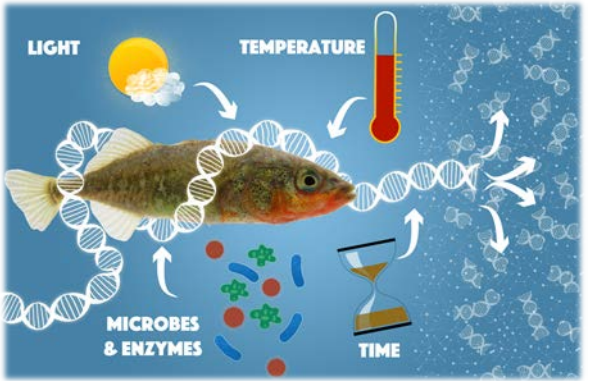
"Data-driven science"



Supporting technologies (now broadly available)

- Continuous data collection on numerous platforms
- Profile distributions of marine animals in the water column
- Opportunity to study marine ecosystems at scales not possible before

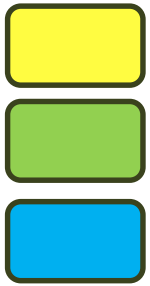




New (and more) data bring advantages and also many challenges

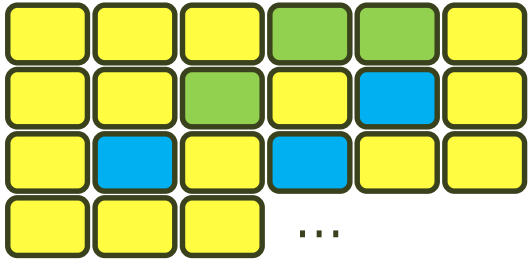
It used to be…

days,
weeks



But now…

weeks,
months,
years



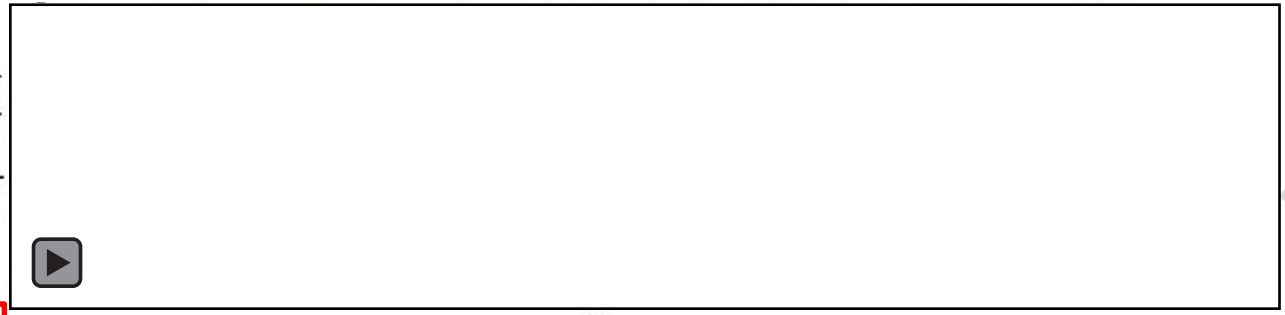
- Careful calibration
- Net/video ground truth
- Hypothesis-driven:
  we (kind of) know what to look for

- Limited calibration
- Limited ground-truth
- Data-driven:
  where/what should we look?

(Courtesy Wu-Jung Lee, APL-UW; OCEANS ‘19)

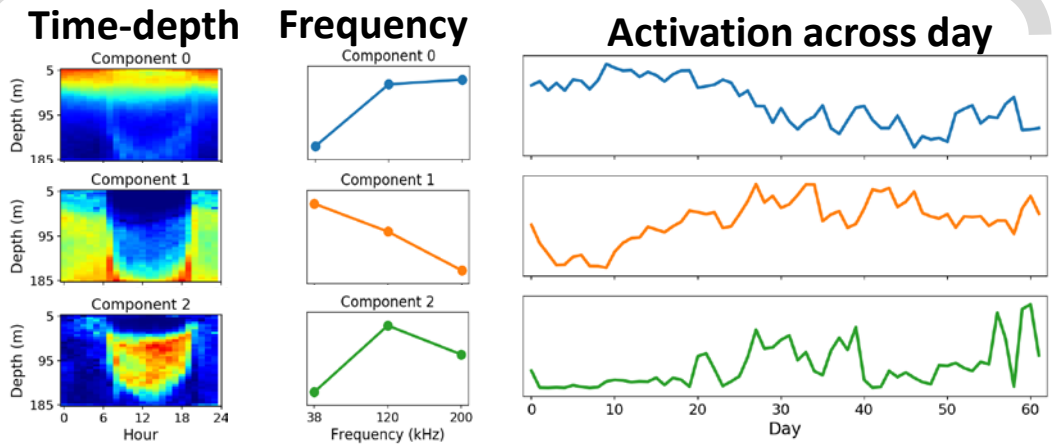
Decomposition results

OOI cabled node:
Upward-looking at 200 m



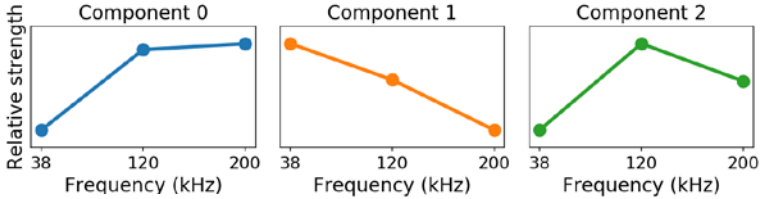
Day

- Unsupervised machine learning
- Dimensionality reduction

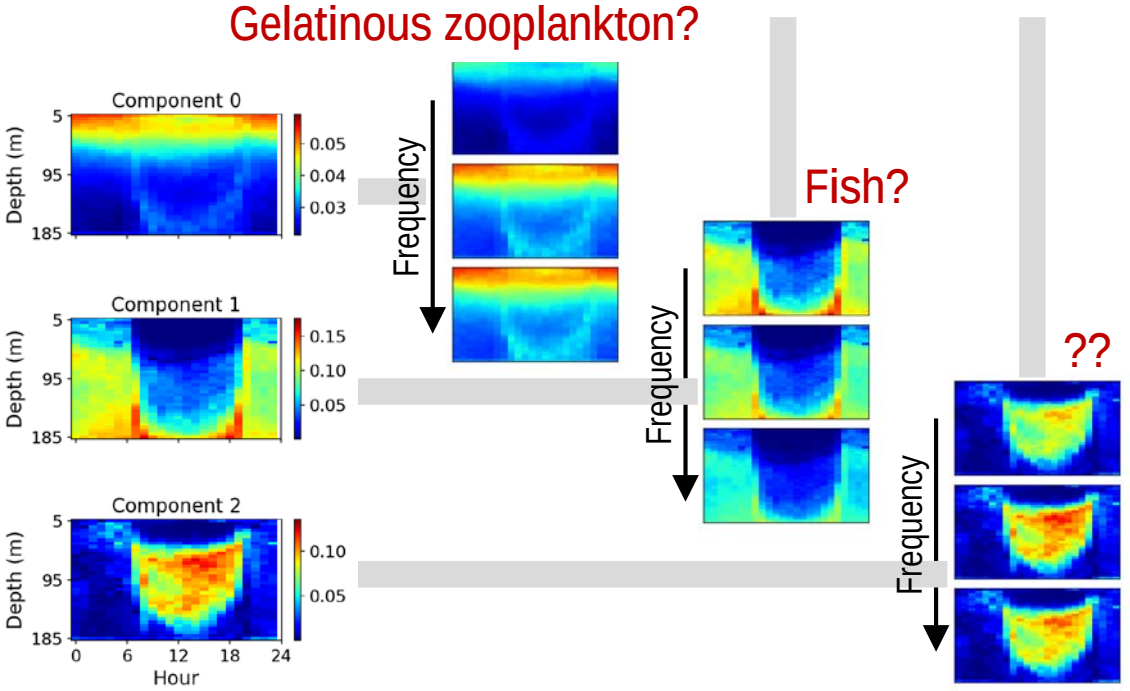


(Courtesy Wu-Jung Lee, APL-UW; OCEANS '19)

The components may be biologically meaningful

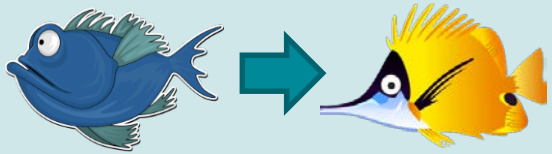


"It's conceivable that a machine-learning approach will soon enable us to make accurate predictions of 'how a protein will fold' [substitute: movement patterns] and this may be very useful to know. But it won't be *scientific knowledge*. After all, [the computer] knows nothing about 'biochemistry' [substitute: fisheries oceanography]."



https://www.theguardian.com/commentisfree/2019/aug/24/douglas-adams-was-right-knowledge-without-understanding-is-meaningless

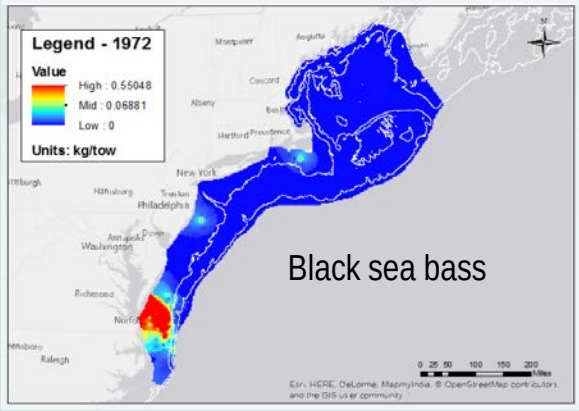
(Courtesy Wu-Jung Lee, APL-UW; OCEANS '19)

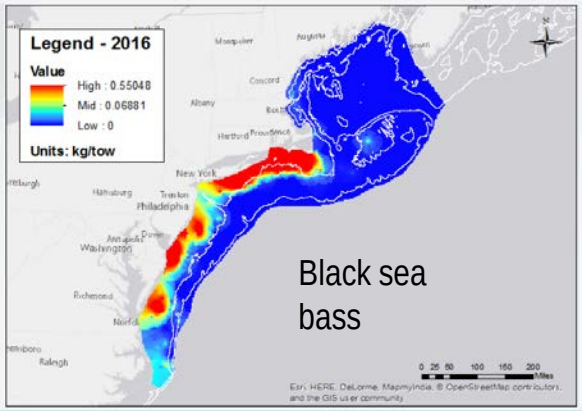


Impacts on Fish and Fisheries: geographic shifts and changes in productivity

Potential to significantly impact management

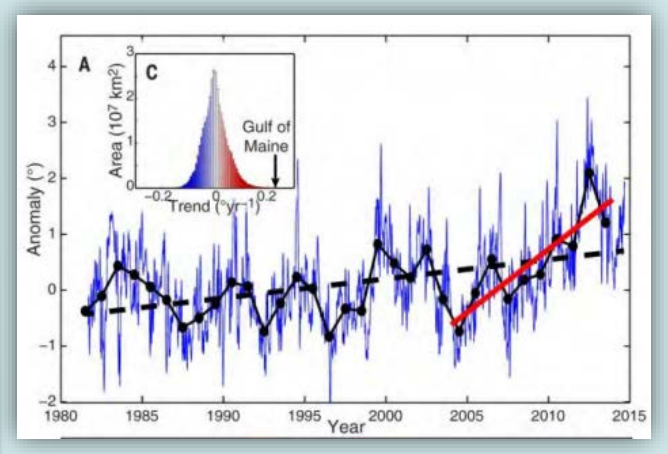
- Allocation issues
- Spatial & temporal management
- Estimates of spawning biomass and biological reference points





Source: OceanAdapt https://oceanadapt.rutgers.edu/
https://www.fisheries.noaa.gov/species/black-sea-bass

Black sea bass *(Centropristis striata)*

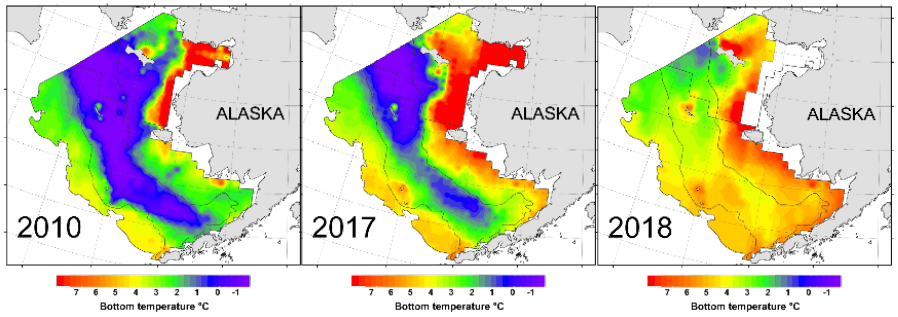


Temperature expected to increase by 2-4°C by end of century

(IPCC, 2014; Pershing et al. 2015, Science)

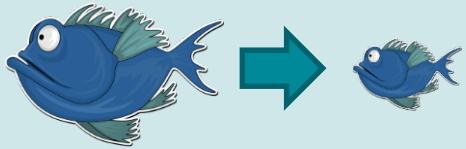
Some population shifts occurring faster than anticipated

Pacific cod and pollock distribution moved shoreward and northward as cold pool (<2°C) was reduced.



https://www.seattletimes.com/seattle-news/as-bering-sea-ice-melts-nature-is-changing-on-a-massive-scale-and-alaska-crab-pots-are-pulling-up-cod/?utm_source=twitter&utm_medium=social&utm_campaign=article_inset_1.1

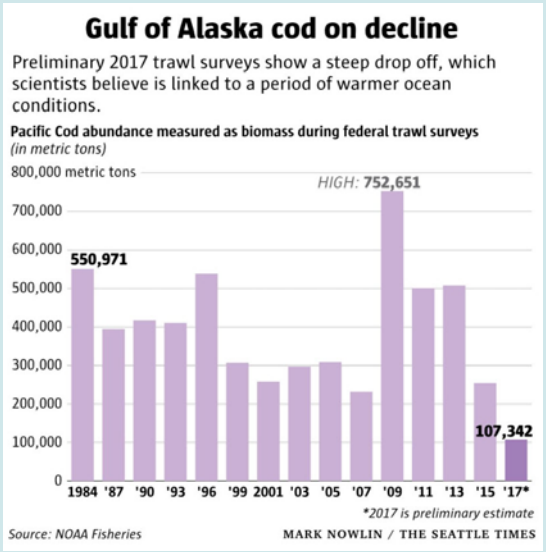
(Courtesy of B. Foy, S. Barbeaux, K.Holsman, B. Lauth, L. Britt, S. Zador; AFSC, 2019)



Impacts on Fish and Fisheries: geographic shifts and changes in productivity

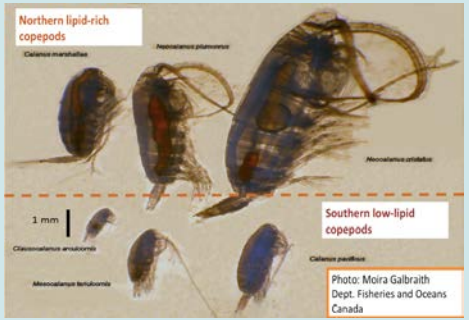
Potential to significantly impact management

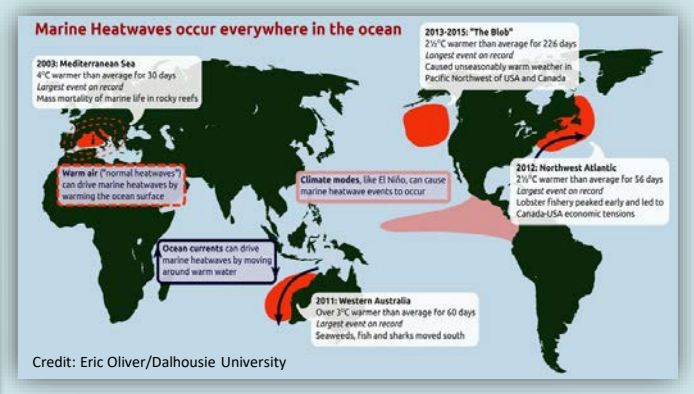
- Allocation issues
- Spatial & temporal management
- Estimates of spawning biomass and biological reference points



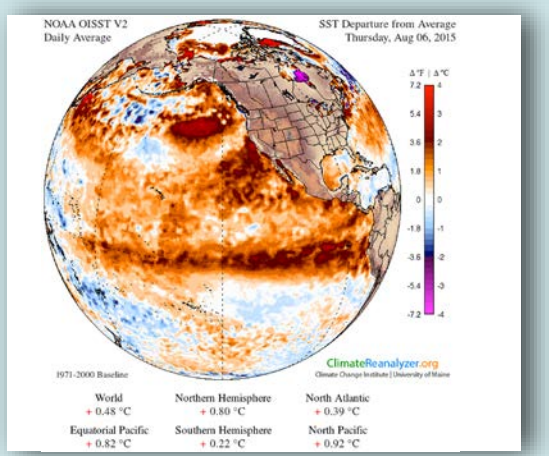
Pacific Cod
(Gadus macrocephalus)

https://www.fisheries.noaa.gov/species/pacific-cod





Credit: Eric Oliver/Dalhousie University

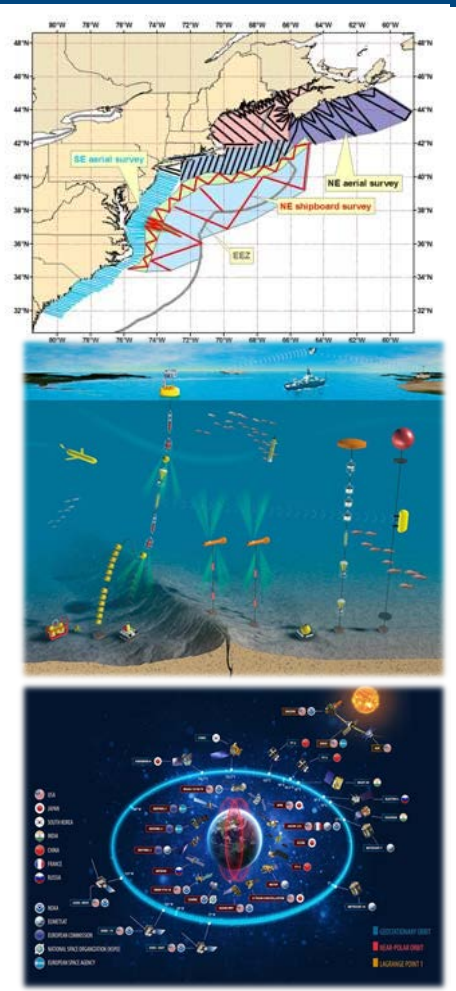


Next Generation Surveys (update)

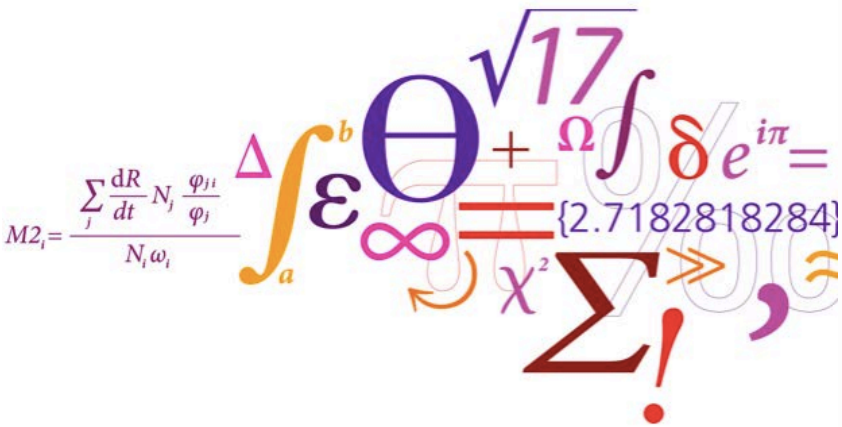
- Last comprehensive evaluation of our surveys was the 1998 publication of the *NOAA Fisheries Data Acquisition Plan*. Initiate formation of a Working Group to develop a plan to accomplish our future survey and data collection needs.

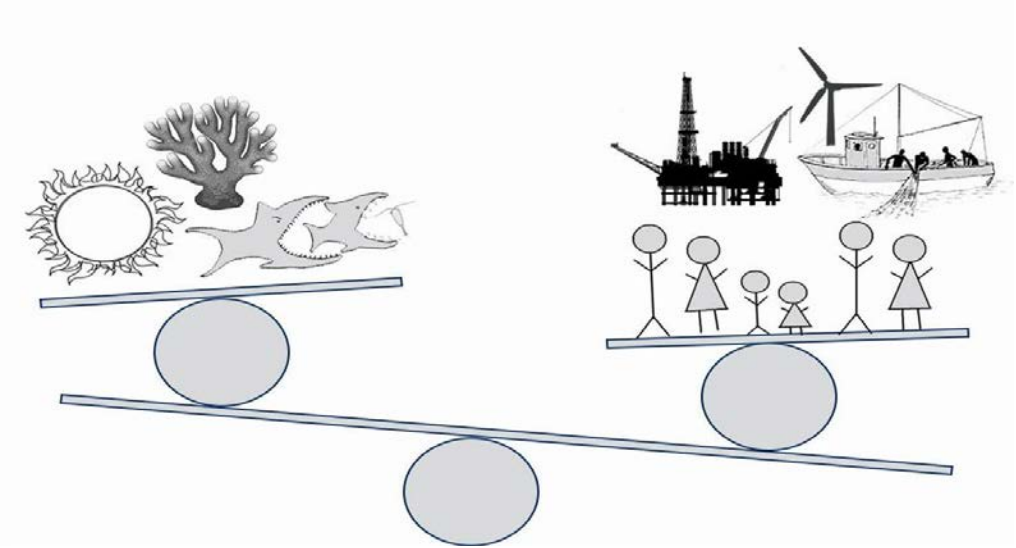
- There is a need to re-visit our data-collection needs and strategies (in collaboration with other Line Offices) in view of:

  - Changes in “questions”… fish stocks’ distributions, vital rates, etc.
  - Need to include ecosystem considerations
  - Changes in fleet composition (ships)
  - Partnerships with industry
  - New technologies & new analytical capabilities

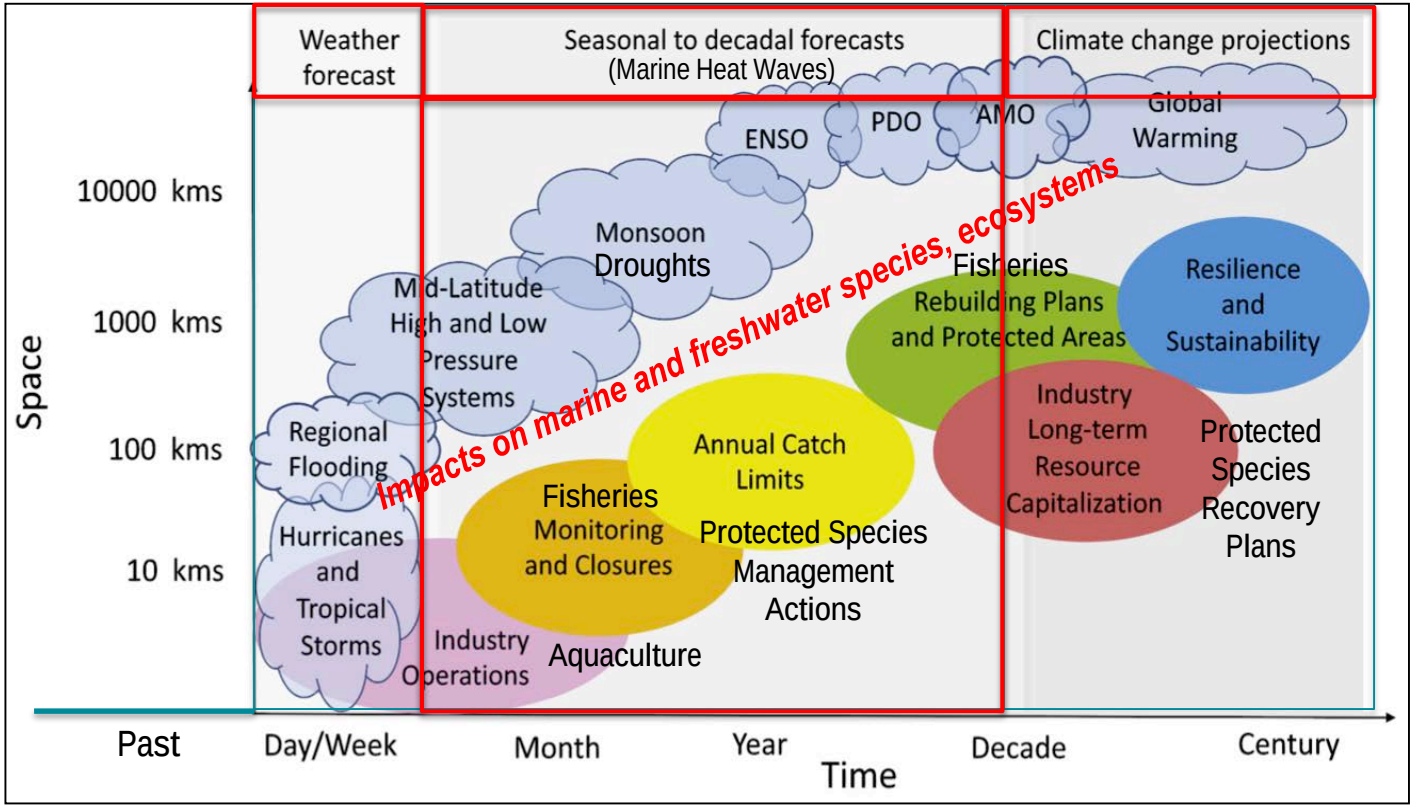


Models...


$M2_i = \frac{\sum_j \frac{dR}{dt} N_j \frac{\varphi_{ji}}{\varphi_j}}{N_i \omega_i}$
$\Delta \int_a^b \varepsilon \Theta^{\sqrt{17}} + \Omega \int \delta e^{i\pi} =$
$\infty = \{2.7182818284\}$
$\chi^2 \sum ! \gg$



Decisions and Information Needs Across Time and Space (S2S2D)

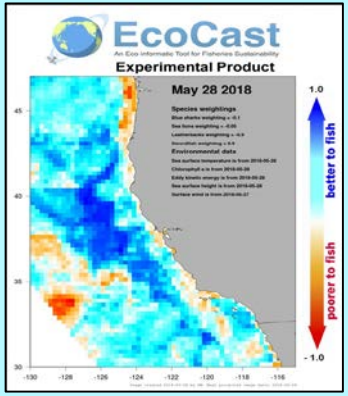


NOAA FISHERIES

Adapted from Tommasi et al., Progress in Oceanography, 2017

Requirements and Applications

Near-term Forecasts



- Early warnings
- By-catch avoidance
- Aquaculture
- Stakeholder actions

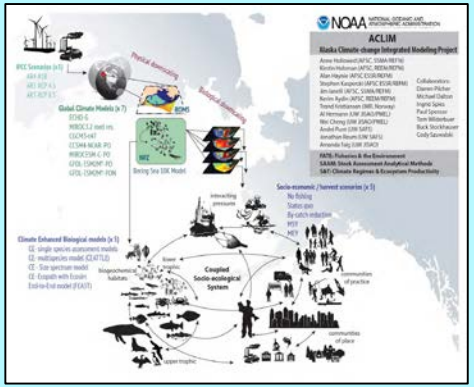
S2S Forecasts

- Surveys
- Stock assessments
- Harvest levels
- Allocations
- Stakeholder actions

S2Decadal Forecasts

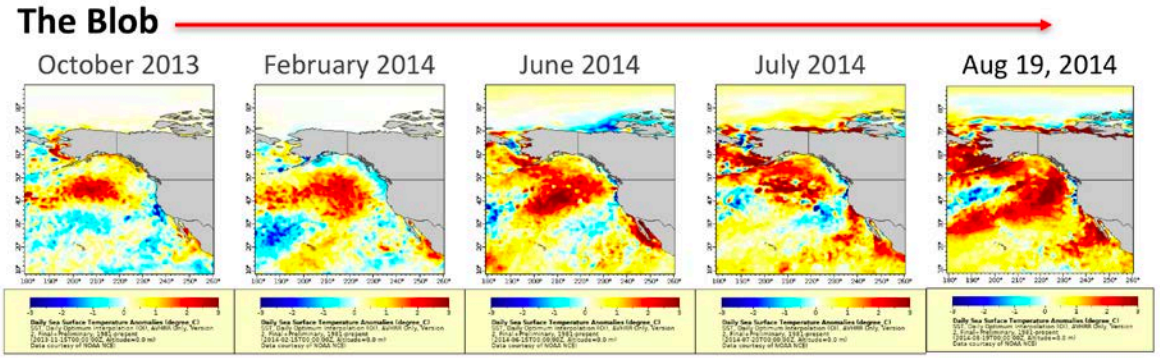
- Future scenarios
- Evaluate management strategies
- Inform rebuilding & recovery plans
- Conservation

Longer-term Projections



Could we have predicted the “Blob”?

So that *if* it happens again…

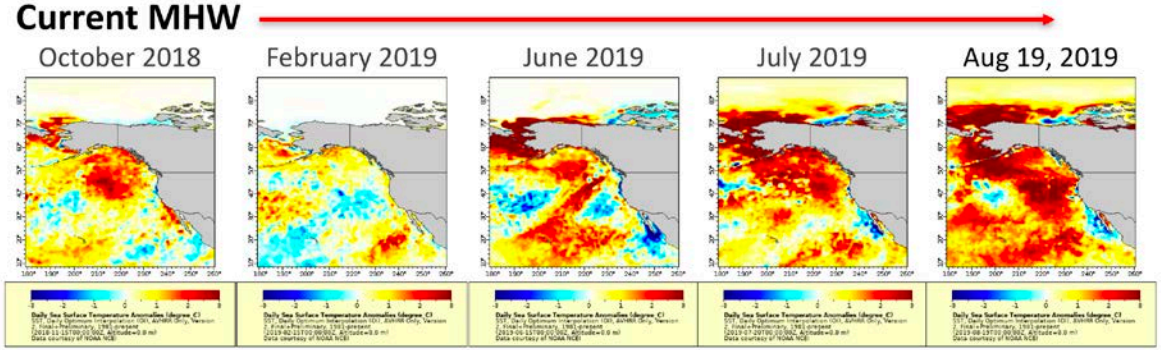


San Francisco Chronicle
(10 Sept 2019)

‘Blob’ of warm Pacific water is back —

???

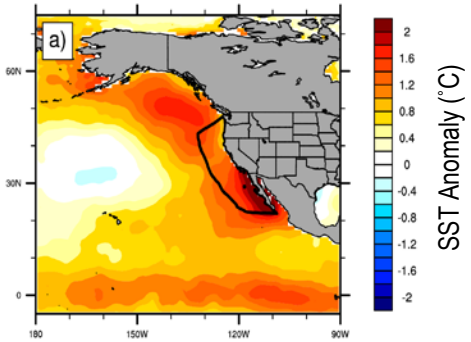
https://www.sfchronicle.com/environment/article/Blob-of-warm-Pacific-water-is-back-14426451.php



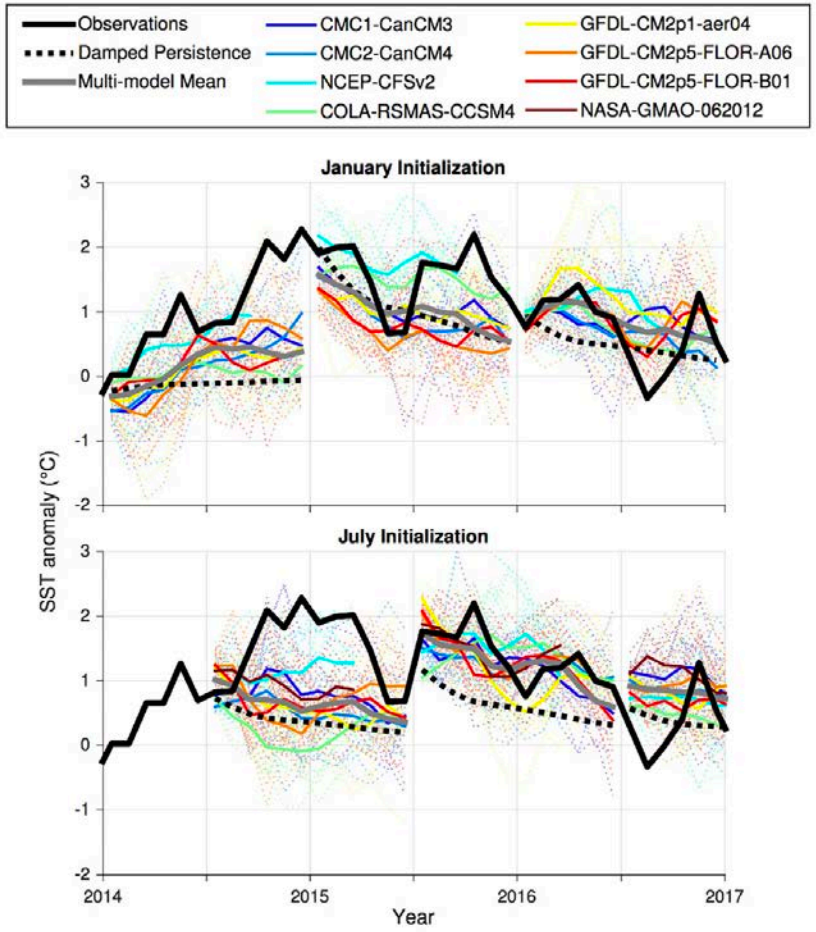
(Adapted from T. Garfield, N. Mantua, A. Leising, C. Harvey, M. Jacox, et al.; presented at 2019 NOAA West Watch)

Marine Heat Waves (S2S) forecast skill

(could we have predicted the the 2014-16 NE Pacific warming?)



Thus far, results suggest that different types or aspects of marine heatwaves are **more or less predictable depending on the forcing mechanisms at play**, and events that are consistent with predictable ocean responses could inform ecosystem-based management of the ocean.



Mixed results

Models exhibited forecast skill for the

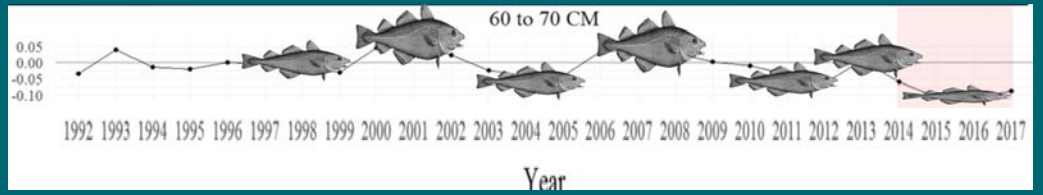
- the initial onset of anomalous warming in early 2014, and
- another anomalous warming event in early 2016,

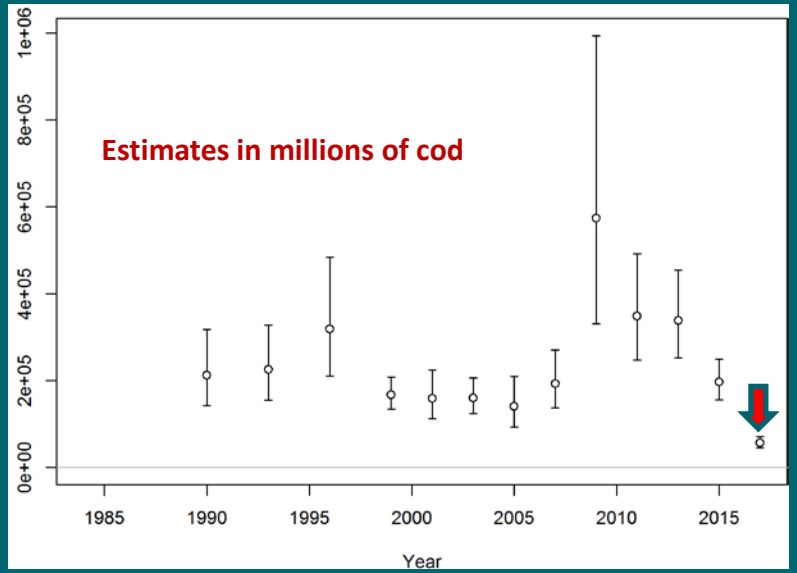
but not

- a second rapid SSTa increase in late 2014, or
- a sharp reduction and subsequent return of warm SSTa in mid-2015.

Jacox et al. (2019) Predicting 2014–2016 CCS Marine Heatwave. Frontiers in Marine Science. doi: 10.3389/fmars.2019.00497

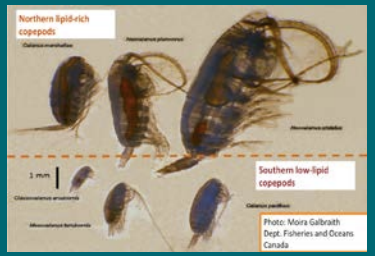
GOA Pacific cod 2017 Bottom trawl survey

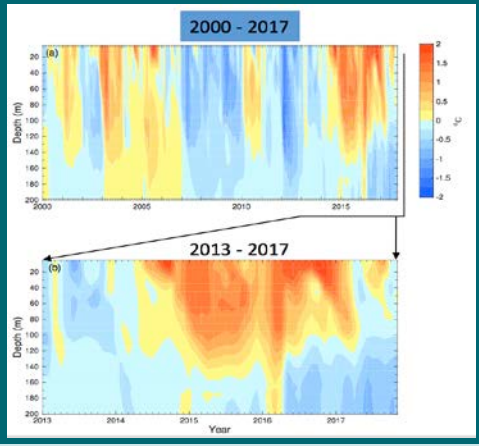




- Lowest estimate ever 1.96×10^8 fish and 107,324 t
- 71% decline in abundance since 2015 (83% since 2013)
- 58% decline in biomass since 2015 (78% since 2013)

- Higher Pacific cod natural mortality
- Warmer temperatures throughout the year
- Higher metabolism in warmer
- Lower forage in 2015-2016





NOAA FISHERIES

(Courtesy Steve Barbeaux, Anne Hollowed, and others; NOAA/AFSC)

“Shadow assessments”…

Running "shadow assessments" in parallel to present stock assessments:

- establishes partnerships between the ecosystem modeling groups and the assessment teams, and
- links the ecosystem modeling teams with analysts to jointly establish annual biological reference points.

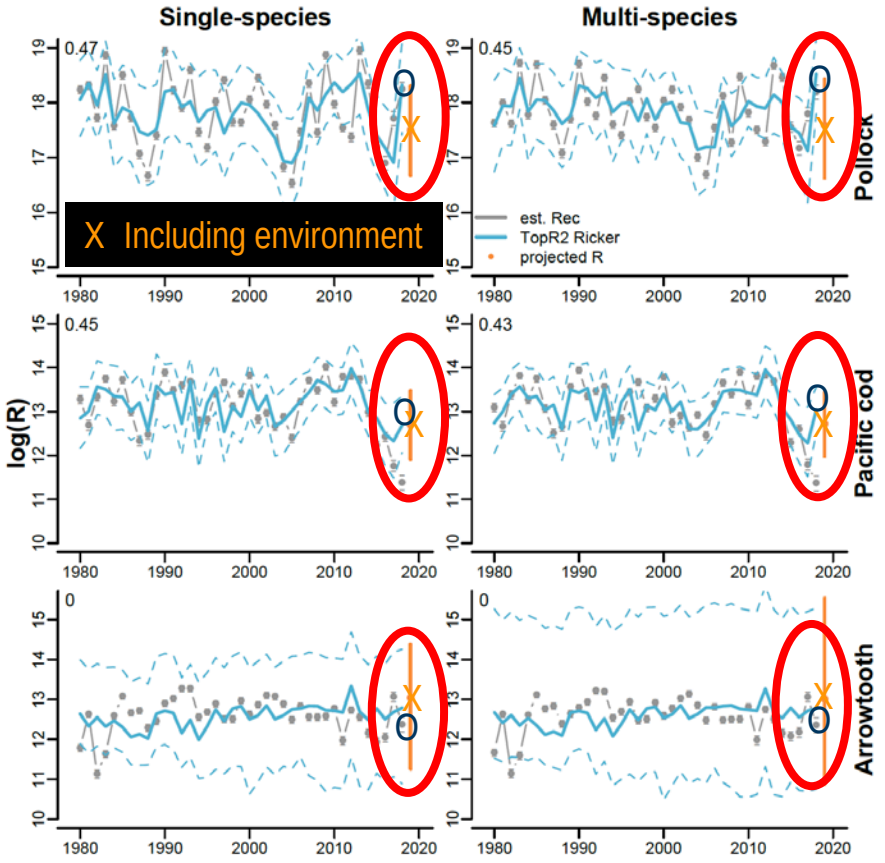


Figure 21: Climate-enhanced recruitment (log) fits and 2019 forecasted recruitment given 2018 SSB and environmental conditions.

2018 Climate-enhanced multi-species Stock Assessment for walleye pollock, Pacific cod, and arrowtooth flounder in the Eastern Bering Sea

Kirstin K. Holsman, James N. Ianelli, Kerim Aydin, Ingrid Spies, Grant Adams, Kelly Kearney

Recreational fisheries – Electronic Reporting

- NOAA Fisheries supports continuing development of ER for non-for-hire recreational anglers.
- As a data collection tool, ER presents opportunities as well as presenting some challenges.

Proposed MAFAC Rec Fisheries ER Task Force

Purpose

Provide expert advice to MAFAC and NOAA Fisheries on generation, delivery, and use of ER to help us fulfill our mission.

Objectives

- Assist NOAA Fisheries in fulfilling its role in providing useable high quality, accurate data on recreational fisheries.
- Provide input and guidance that contributes to the development of an Agency roadmap to guide implementation of electronic data collection in non-for-hire recreational fisheries, where appropriate.

Proposed MAFAC ER Task Force

Proposed Tasks

- **Identify and prioritize data gaps** that could be addressed through the use of mandatory or voluntary angler ER.

- **Identify practical goals and challenges to overcome** for voluntary and mandatory ER for recreational private boat and shore anglers.

- **Provide recommendations** on how these goals could be achieved by NOAA Fisheries

Summary remarks/thoughts

1. UxS, eDNA & AI
2. Movement species' shifts and changes in productivity
3. Next-gen surveys
4. Developing S2S modeling capabilities
5. ER in Recreational Fisheries

Thank you

Questions or comments?