

What effect do changing biotic interactions, if any, have on the distribution shift of cod and pollock? Can the SDM shifts be explained solely by physical conditions?

- There could be biotic components such as changes in the feeding environment. As shown in one of the slides in the presentation, there are changes at the base of the food web, such as the change from lipid-rich to lipid-poor copepods. As such, distributional shifts in cod/pollock could be associated with their search for better prey. This is a very good news piece on these recent events in AK <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/>

Is there a plan to tackle an updated Data Acquisition Plan since the last one is from over 20 years ago and the technological advancements in this field have changed so much during that time frame?

- Yes. We are planning to start in earnest this summer. This will need to be a cross-line office effort, not just NMFS-alone. We will make announcements of workshops and requests for information to keep everyone informed and involved.

Do you think we can manage to increase data acquisition while we are facing all these budget cuts in the world (that might get worse following COVID economic consequences)? I recently read this article about circularities in fisheries science biasing stocks assessment and wonder if this won't become a norm in the future. Do you think some of these innovative techniques will one day be able to replace fishing surveys? Reference to article: Giron-Nava 2020, Scientific Reports.

- The world of data collection is rapidly changing. While there may be times where fewer data are collected (e.g., presently we've had to cancel most of our surveys this year due to COVID-19), the use of unmanned systems, shipboard electronic monitoring systems, etc., can help mitigate the data loss in some areas. Biases might be introduced, and we will have to work to understand these to correct for them. Also, data from other sources might become available and we will have to learn to properly ingest them in our analyses. So, while yes, there is a concern for some data loss, overall there is a very large increase of data collected in the ocean/marine community. This paper offers a very nice description: <https://www.nature.com/articles/d41586-020-01668-z>

Fishermen like stability-stationarity as they try to make a living off the sea day-to-day. Does NMFS have plans for better communication and education regarding variability in a way that they can understand and accept?

- Yes - the changes (stationary or non-stationary) we see are ones we communicate through our participation in Fisheries Management Councils, publications, etc. One example is the development of scenario planning. On July 1, there is a public discussion on "scenarios that describe possible conditions facing West Coast fisheries and communities, over the period 2020-2040", for details please visit <https://www.pcouncil.org/category/news-and-events/>

Mercury (Hg) contamination in fish remains a public health and an ecotoxicology concern, and emerging science suggests Hg may be significantly more toxic than earlier believed. In some cases, fish Hg concentrations are increasing, due to increasing emissions and/or due to climate change. Perhaps I am missing something, but NOAA seems conspicuously absent, in the last decade or more, in aquatic mercury monitoring and science, even in areas that it has stewardship responsibilities for (fisheries, marine mammals, coastal regions, Gulf of Mexico (GOM), Great Lakes, ...). EPA regulates Hg emissions from industry, but doesn't fill monitoring and science roles that NOAA could address. For example, mercury concentration data in Gulf of Mexico fish seems very sparse. NMFS used to carry out surveys of Hg in Gulf of Mexico appears to have diminished or even stopped. Earlier data indicates that many top predator fish in the Gulf cannot be consumed safely by humans, but I don't think we have much if any knowledge about whether fish Hg

concentrations there are increasing or decreasing. Overfishing, population, habitat, food-web structure, and climate-change issues are unquestionably important, but if the fish cannot be consumed, it seems like we are ignoring an important part of the problem? Do you have any thoughts on the relative importance of Hg contamination in fish and NOAA's role?

- Nearly all fish and shellfish contain traces of mercury. For most people, the risk from mercury by eating fish and shellfish is not a health concern. Yet, some fish and shellfish contain higher levels of mercury. The risks from mercury in fish and shellfish depend on the amount of fish and shellfish eaten and the levels of mercury in the fish and shellfish. NOAA Fisheries National Seafood Inspection Laboratory provides analyses, data management, regulatory compliance risk analysis, and technology transfer expertise to meet fishery management and seafood safety responsibilities. They perform a number of analytical tests for clients in the seafood industry on imported and domestic fishery products on a fee-for-service basis. These services include testing products for methyl mercury, heavy metals, bisulfites, histamines, and moisture, as well as species identification and testing for veterinary drug analyses. Additional research was conducted by NOAA's National Centers for Coastal Ocean Science, who published a white paper on Gulf of Mexico Mercury Fate and Transport: Applying Scientific Research to Reduce the Risk from Mercury in Gulf of Mexico Seafood, You can find more details at [https://www.arl.noaa.gov/documents/reports/Evans\\_GOMA\\_Hg\\_White\\_Paper\\_NOAA\\_Tech\\_Memo\\_192\\_orig.pdf](https://www.arl.noaa.gov/documents/reports/Evans_GOMA_Hg_White_Paper_NOAA_Tech_Memo_192_orig.pdf). In terms of public health analysis, our sister agencies the FDA and EPA have provided advice and guidance on what you need to know about mercury in fish and shellfish.

Given the fishing moratorium in the Arctic Ocean, per the recent agreement within the Arctic Council, how will NMFS and other international fisheries organizations obtain the necessary data to determine what fish are actually there?

- This is indeed a very important undertaking. The U.S. is one of the nations that has ratified the agreement <https://www.state.gov/the-united-states-ratifies-central-arctic-ocean-fisheries-agreement/>. The assessment of the CAO fisheries will be an international effort involving the US, Canada, Norway, the EU, Russia, Japan, Korea, China, etc. Planning is underway through various international committees such as FISCAO. An example of a report is [https://archive.fisheries.noaa.gov/afsc/Arctic\\_fish\\_stocks\\_fifth\\_meeting/pdfs/Final\\_report\\_of\\_the\\_5th\\_FISCAO\\_meeting.pdf](https://archive.fisheries.noaa.gov/afsc/Arctic_fish_stocks_fifth_meeting/pdfs/Final_report_of_the_5th_FISCAO_meeting.pdf)

May I get a copy of your Presentation? How sensitive are unmanned systems now compared to 20 years ago?

- Yes, of course - a PDF version is available: [ftp://ftp.library.noaa.gov/BrownBags/NOAA%20Environmental%20Leadership%20Seminar%20Series/Werner/060920\\_CWerner\\_NOAA%20Env'l%20Leadership%20Webinar\\_Evolving%20Challenges%20in%20Fisheries%20Science,%20and%20How%20We%20are%20Tackling%20Them.pdf](ftp://ftp.library.noaa.gov/BrownBags/NOAA%20Environmental%20Leadership%20Seminar%20Series/Werner/060920_CWerner_NOAA%20Env'l%20Leadership%20Webinar_Evolving%20Challenges%20in%20Fisheries%20Science,%20and%20How%20We%20are%20Tackling%20Them.pdf)  
In terms of the sensitivity of the unmanned systems - do you mean durability? They are quite robust and are routinely at sea for months at a time.

You mentioned citizen science. Do you see citizen science data sources growing to complement traditional methods as well as the 'omics and remote sensing data that was explicitly mentioned?

- Yes, very much so. Here is info on how we are already engaging citizen science <https://oceanservice.noaa.gov/citizen-science/>, <https://www.noaa.gov/office-education/citizen-science-crowdsourcing>, <https://www.noaa.gov/education/news/white-house-report-showcases-noaa-citizen-science-efforts>.

Thank you for a nice overview. It is good to see it all in perspective. Can you talk about plans to modify the East Coast sampling strategy as all the offshore development goes forward? Will you be able to make the data match up from the past to the future?

- Thank you for your kind comment. Offshore wind development is a very important topic that is affecting the NE now, and will be affecting other regions in the coming years. This presentation [https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/5d5d8febbf55c300017b65be/1566412785315/NOAA+Fish+Wind.8.21.2019\\_new.pdf](https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/5d5d8febbf55c300017b65be/1566412785315/NOAA+Fish+Wind.8.21.2019_new.pdf) I believe answers most of your questions. Additionally, The NE Fisheries Management Council held a special session on Offshore Wind in April of 2019. Please see: <https://www.nefmc.org/library/april-2019-offshore-wind-in-the-northeast-region-special-session> for additional information.

Thinking about the benefits of ground-truthing and the increased need for consistent data - how is NMFS incorporating "citizen science" or actively engaging communities that might be witnessing ecosystem shifts?

- Please refer to my answer and links above to a related question on citizen science above.

The point about communication between researchers, managers, and stakeholders/communities is really important. Would you share examples of when this has been done successfully? Especially as we get into more complex analyses, being able to communicate this clearly to the affected communities is important! As well as to resource managers who are making management decisions and need to find ways to build in adaptive management.

- There are several examples of how we are learning to communicate better. One of these is through "Management Strategy Evaluations" (MSEs). A very good example is the recent Atlantic Herring MSE. A very good description is given in this paper: <https://www.nrcresearchpress.com/doi/full/10.1139/cjfas-2018-0125#.Xuz-MZNKhp8>

Given the need for continued and increasing and increasingly complex modeling, what planning has been done to ensure the training and development of mathematical modelers to develop this work?

- Mathematical modelers are an integral component of our science work force. Stock assessors, climate modelers, weather forecasters, are all trained in mathematical/computational skills. One example of the recognition and planning of the importance of mathematical skills is in this document [https://spo.nmfs.noaa.gov/sites/default/files/TM\\_91.pdf](https://spo.nmfs.noaa.gov/sites/default/files/TM_91.pdf). NMFS has worked with academic partners to strengthen degree programs in certain areas, see overview in [https://www.st.nmfs.noaa.gov/Assets/quest/documents/QUEST\\_FactSheet\\_040314.pdf](https://www.st.nmfs.noaa.gov/Assets/quest/documents/QUEST_FactSheet_040314.pdf)

To support community research efforts, how are the collected data made available? Are there barriers or challenges in data availability and access?

- PARR (Public Access to Research Results) requires that we make all our data available. Some data are proprietary and we have some restrictions apply. But, by and large, our data is publicly available. See [https://www.st.nmfs.noaa.gov/Assets/data/edm/documents/NOAAPARRPlan\\_v5.04\(final\).pdf](https://www.st.nmfs.noaa.gov/Assets/data/edm/documents/NOAAPARRPlan_v5.04(final).pdf) for a description of our (NMFS') strategy to make the data public.

Has solar activity ever been incorporated in these models?

- On long enough (e.g., climate) time-scales yes. See for example this article: <https://eos.org/science-updates/better-data-for-modeling-the-suns-influence-on-climate>

How will the new data be realistically used in management forums when these management bodies, e.g., regional fishery management councils and commissions, are having difficulty being able to use the current data

sources (stock assessments) in a timely manner for their decisions? Are there plans to integrate this new paradigm?

- The new data has to undergo a thorough review process before it can be incorporated into new management actions. The review takes place at the Fisheries Councils through their SSCs (Statistical and Scientific Committees) and other bodies that report to the SSC. As such, it's a very deliberate process that while "slow" also ensures that it's properly checked/reviewed and understood by all.

Can you foresee any ability of acoustics and optical measurements to automatically get stock assessments how many years out may this be?

- To a degree, yes, but there will always need to be some biology (fish) collected to determine age, sex, and condition of the individuals. So, while the acoustic and optical data can and will give us much of the info we need, we will always need to "put our hands" on some of the fish themselves. A good example of assessment with optical measurements is here:

<https://www.fisheries.noaa.gov/feature-story/how-underwater-cameras-can-help-protect-hawaii-deep-7-bottomfish>

Do scientists have a suite of collaborations regarding the qualitative and quantitative data currently required for better decision making?

- Yes - we collaborate with industry, recreational anglers, other agencies, citizen scientists, etc. At the same time we need to understand how the data was collected, possible biases to correct for them, sources of errors to weight them appropriately, etc. It's a slow process going through the various steps of collecting the data, QA/QC-ing it, etc., until it's finally used in decision making.

When you think about the social aspect of science, are you thinking "democratization of science," ...how do we interact with parties that do not share our scientific narrative/values, etc

- I was thinking about the evolving structure of science, the creation of broader networks, citizen science, etc. The two papers I referenced in the PPT [by Barabási (2005) in Science magazine's 29 April issue, and by Fortunato et al. (2018) in Science magazine's March 2nd issue]. Excerpting from Fortunato et al. "Contemporary science is a dynamical system of undertakings driven by complex interactions among social structures, knowledge representations, and the natural world. Scientific knowledge is constituted by concepts and relations embodied in research papers, books, patents, software, and other scholarly artifacts, organized into scientific disciplines and broader fields. These social, conceptual, and material elements are connected through formal and informal flows of information, ideas, research practices, tools, and samples. Science can thus be described as a complex, self-organizing, and constantly evolving multiscale network."

During my PhD thesis, we partnered with a fishing fleet to retrieve fish and used them to study diet. We did take into account sampling bias while analyzing our data but it's 4 years now and this is still a paper that gets rejected because of the problem of biased data collection (quoting reviewers/editors). Do you think fishery sciences are ready to really partner with the industry?

- We partner with industry very closely and continuously. I assume (not having seen the manuscript in question) that the objections you mention refer to a flaw in the way the data were collected (irrespective of who collected them), and not because it was collected by industry partners. Sampling schemes are of course essential to the interpretation of the data collected.

A lot of these new technologies are obviously amazing, but a lot of it seems quite expensive. I'm curious how realistic some of these technological goals are with the average NOAA/NMFS budget. Are you expecting NMFSs future budget needs to be limiting or is that not an issue?

- Indeed - some of the technologies can be costly, particularly during the initial phases of research and development. Additional costs are incurred in that -- even if the new technologies work -- we need to calibrate across measurement approaches. As such, for a number of years there will be a need to conduct measurements in parallel (the way we currently take measurements and with the new technologies). This may not be twice the cost, but it is an added cost. So yes, you are right -- resources to move into the "next generation" technologies and assessments can be challenging, but we have to think we will find ways forward.

How much impact has the surveying activity for offshore wind made on the assessment? - geophysical and geotechnical surveying

- Please refer to my answer above to the previous offshore wind related question and please see the links therein.