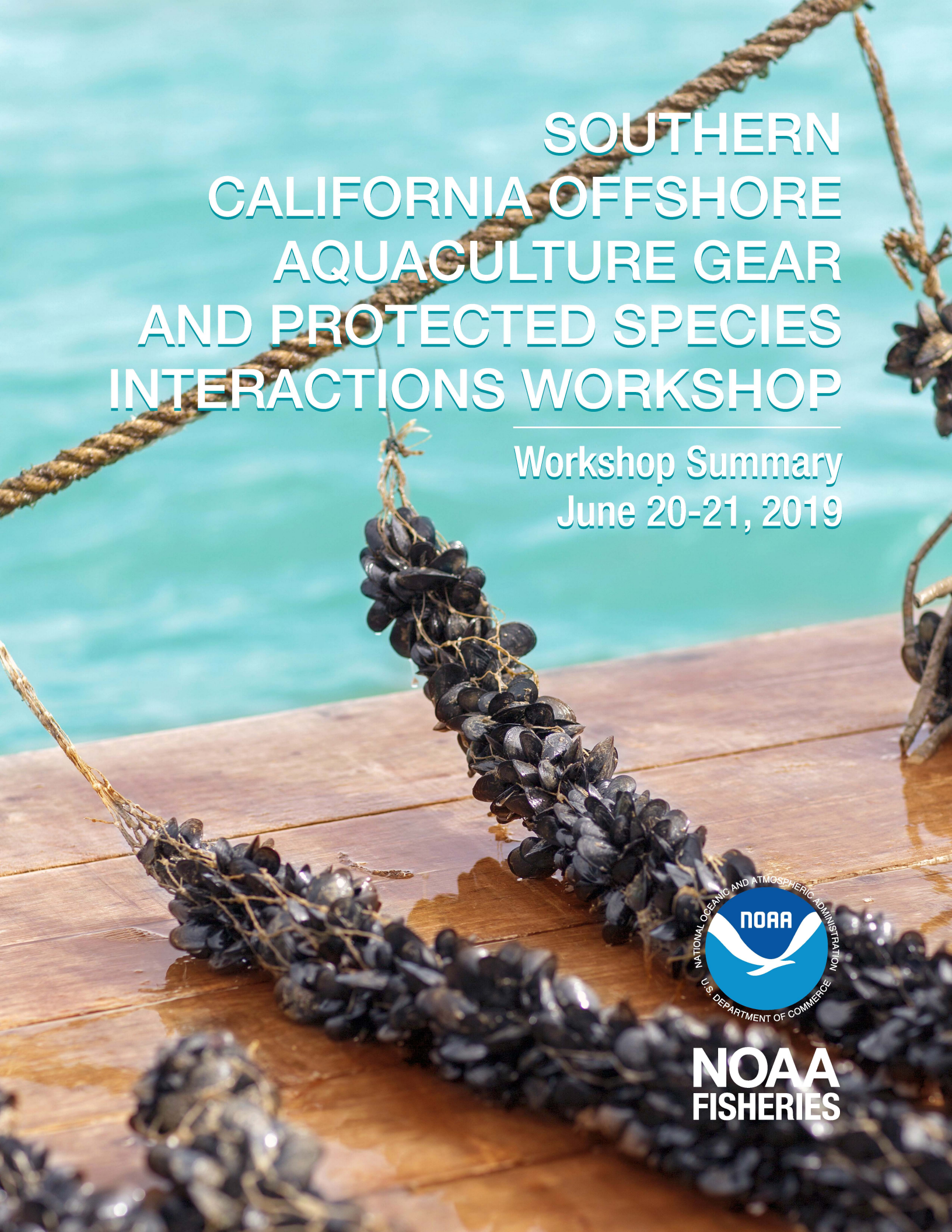

SOUTHERN CALIFORNIA OFFSHORE AQUACULTURE GEAR AND PROTECTED SPECIES INTERACTIONS WORKSHOP

Workshop Summary
June 20-21, 2019

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Southern California Offshore Aquaculture Gear and Protected Species Interactions Workshop Summary

West Coast Region Workshop Summary. 2019. 28 pp.
NOAA Fisheries West Coast Region Office

Southern California Offshore Aquaculture Gear
and Protected Species Interactions
Workshop Summary. 2019. 28 pp.
NOAA Fisheries West Coast Region Office

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West Coast Region

Southern California Offshore Aquaculture and Protected Species Interactions Workshop

Workshop Summary I June 20-21, 2019

U.S. DEPARTMENT OF COMMERCE

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
West Coast Regional Office

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This workshop was hosted by NOAA's Office of Aquaculture and NOAA's West Coast Regional Office's Protected Resources Division.

OFFICE OF AQUACULTURE

NOAA's Office of Aquaculture supports the development of sustainable aquaculture in the United States. Its work focuses on regulation and policy, science and research, outreach and education, and international activities.

PROTECTED RESOURCES DIVISION

NOAA's Protected Resources Division works to conserve, protect and recover endangered and protected marine species under the authority of the Marine Mammal Protection Act and Endangered Species Act.

References:

Price, C.S. and J.A. Morris, Jr. 2013. Marine Cage Culture and the Environment: Twenty-first Century Science Informing a Sustainable Industry. NOAA Technical Memorandum NOS NCCOS 164. 158 pp.

Potential Protected Resources Interactions with Longline Aquaculture Workshop Summary. 2015. NOAA Fisheries Greater Atlantic Regional Office, 14p.

Price, C.S., J.A. Morris, Jr., E. Keane, D. Morin, C. Vaccaro and D. Bean. 2016 in prep. Protected Species and Longline Mussel Aquaculture Interactions. NOAA Technical Memorandum NOS-NCCOS -211. 80 pp.

WORKSHOP SUMMARY

June 20-21, 2019, San Diego, California

EXECUTIVE SUMMARY

As marine offshore aquaculture is positioned to expand in United States waters, there is growing interest to determine how farms can be designed, monitored and managed in a way that minimizes interaction with and harm to protected marine species. Experts in aquaculture, farm design and engineering, and marine science gathered for a multi-day workshop to improve understanding of protected species and aquaculture farm interactions, including gear types and associated function, knowledge gaps, and research priorities (see participant list - Appendix II). This collaborative engagement is expected to inform research and monitoring, future siting and permitting practices, and adaptive management considerations that support sustainable growth of the industry.

The workshop provided a wide range of information to participants on protected marine species in the southern California region, aquaculture farm design and operational management, and both available and desired tools to assess risk, inform the permitting process and develop appropriate monitoring protocols (see workshop agenda - Appendix I). Participants engaged in a series of small group interactive sessions, followed by open group discussion, which identified knowledge gaps and research needs, explored how to assess risk in the absence of data and information, and highlighted challenges and opportunities to using a newly developed species model and farm simulator tool. The workshop culminated with a discussion of key takeaway messages, insights and emerging considerations that will guide future collaboration across agencies and with industry practitioners and experts.

This workshop summary presents an overview of informational presentations, issues of interest and concern held by participants, and proposed next steps put forward at the workshop. Outcomes are expected to guide further exploration and understanding of how to assess risk, advance sustainable farm design and continue learning ways in which regulators and industry practitioners can avoid or mitigate potential aquaculture gear and protected species interactions in southern California. NOAA plans to reengage the Southern California Offshore Aquaculture Interagency Working Group as a forum to continue dialogue on this important issue.

Photo courtesy of Jeffrey Seminoff.

BACKGROUND

In recent years a marked increase in the number of whale entanglements in commercial fishing gear -- in particular lines and floats associated with Dungeness crab *(Metacarcinus magister)* -- has been documented along the west coast of the United States. At the same time, NOAA and other agencies with marine aquaculture permitting and regulatory responsibilities are forecasting an increase in permit applications for development of offshore aquaculture farms in state and federal waters in the southern California region (Point Conception to the Mexico border). This has heightened concern among coastal managers and other interested parties about a growing aquaculture industry and the potential interactions that may occur between protected species and farms in this geographic area of interest.

The siting, permitting, monitoring, and operation of offshore aquaculture farms must comply with federal permitting processes and regulatory requirements under the Endangered Species Act (ESA), Magnuson-Stevens Fishery Conservation and Management Act (MSA) for essential fish habitat, and the Marine Mammal Protection Act (MMPA) to avoid, minimize or mitigate any adverse effects on protected species and their habitat. NOAA convened an initial workshop in 2015 in the Greater Atlantic Region that began to explore the nexus of marine aquaculture farms and protected species interactions, with a particular focus on how to assess risk and inform the permitting process. NOAA convened this southern California workshop to further understand the potential risks that aquaculture gear may pose to protected species, identify research and data needs, and develop tools and management strategies that enable sustainable aquaculture development while simultaneously conserving protected marine species and the environment.

WORKSHOP OBJECTIVES

This workshop assembled multiple federal and state agencies, industry representatives, scientists, environmental NGOs and other interested parties to:

- Increase understanding of marine/offshore aquaculture industries and gear types and their function
- Increase understanding of key marine mammal presence, absence and behaviors in the area of interest (Point Conception to the United States/Mexico Border)
- Explore opportunities to develop new tools such as species models and gear/farm simulators to aid in understanding potential cetacean and sea turtle interactions with aquaculture gear
- Identify action items and next steps, including but not limited to potential re-engagement of the Southern California Interagency Offshore Aquaculture Working Group

During the course of the two-day event, participants learned from a wide range of informational presentations, engaged and collaborated with each other in small group discussions, and identified workshop takeaway messages, emerging considerations, and next steps that will foster improved interagency coordination and communication on these important issues.

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Workshop Presentations And Interactive Discussions

FIRST DAY OF THE WORKSHOP

Key staff from NOAA, including the National Marine Fisheries Service (NMFS) Office of Aquaculture, provided introductory remarks and set the stage for collaborative discussions that took place among participants throughout the workshop.

Diane Windham, NMFS West Coast Regional Aquaculture Coordinator, described the rationale and justification for the workshop, highlighted newly emerging tools for assessing risk linked to potential aquaculture farm and protected species interactions, and emphasized NOAA's desire to utilize workshop outcomes as a springboard to reengage the Southern California Offshore Aquaculture Interagency Working Group.

Mike Rust, Science Advisor for the Office of Aquaculture, emphasized NOAA's interest in conducting due diligence regarding aquaculture development in federal waters around the United States. This includes, among other things, risk assessment, identification of research needs, and ensuring appropriate resources are dedicated to addressing priority issues and concerns. He encouraged professional networking amongst workshop participants and noted that lessons learned in California may apply to other parts of the country.

AQUACULTURE TODAY

Early presentations by James Morris, Thomas Noji and Kevin Madley, and Kate Taylor helped frame the focus and direction of the workshop. Collectively, these presenters shared recent NOAA work on aquaculture/protected species interactions, reviewed the current state of the science, and described cross-sectoral collaboration emerging around the country, including in southern California.

State of the Science, Risk Assessment and Collaborative Engagement

James Morris, National Ocean Service (NOS) National Centers for Coastal Ocean Science

James highlighted the challenge that NOAA faces -- as a federal agency embedded within the Department of Commerce -- in meeting its dual conservation and sustainable aquaculture development mandates. NOAA and its partners must play both roles, as they are not mutually exclusive. Perspectives on aquaculture development are variable across agencies and regions, and regional workshops like these, he noted, make a significant contribution to the development of a national aquaculture vision.

In order to better understand the impacts of aquaculture in the marine environment, NOS researchers produced an overview of marine cage aquaculture and the environment in 2013 (Price, C.S. and J.A. Morris, Jr. 2013). NOAA then followed up with a 2017 global literature review of protected species and aquaculture farm interactions (Price et al. 2017). This latter study presents a summary of documented entanglements from around the globe and describes the range of farm types and different marine species considered. The research revealed, among other things, that entanglement events are relatively rare compared to commercial fishing gear but can occur as a result of poor design or operational practices and failure of farms to use best management practices (BMPs).

James reviewed outstanding knowledge gaps on the aquaculture farm/protected species issue, highlighted best operational practices which have been identified, and summarized new insights based on this research. He briefly introduced newly developed species model and farm simulator tools which NOAA intends to further explore to inform risk assessment, permitting and management of offshore farms. He acknowledged the challenges faced by regulators and welcomed workshop participants to partner with NOAA as they work on sustainable aquaculture development in southern California expands and evolves.

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2015 GARFO Aquaculture Workshop Summary and Recent Updates

Thomas Noji, NOAA Northeast Fisheries Science Center and Kevin Madley, Greater Atlantic Regional Fisheries Office (GARFO)

Thomas and Kevin provided an overview of how their respective offices have built on key outcomes and recommendations from the 2015 aquaculture gear/protected species interactions workshop in the Greater Atlantic region. NOAA has since funded an array of research and pilot programs designed to help fill data gaps and further inform how permitting agencies can conduct protected species risk assessments and develop appropriate monitoring protocols in the absence of information. Kevin emphasized the need for a flexible permitting process that enables innovative industry design, consistent monitoring and adaptive management.

Overview of Offshore Finfish Aquaculture in Hawaii

Kate Taylor, NOAA Pacific Islands Regional Office

Kate presented a brief history of the emergence of commercial offshore aquaculture farming in Hawaiian waters. She emphasized the importance of conducting community outreach early and often as a new aquaculture farm was proposed, and ultimately built, off the Big Island of Hawaii. She noted that early community outreach helped both permitting agencies and the permit applicant to better understand and address concerns held by the public. A monk seal mortality at this facility led to needed improvements in operational procedures and BMPs. To date, no entanglements with whales or dolphins have occurred at the facility.

PROTECTED SPECIES IN THE AREA OF INTEREST

Karin Forney and Jeff Seminoff gave presentations designed to increase understanding of key protected species in the area of interest (Point Conception to United States/Mexico border).

Overview of Cetacean Species Presence/Absence, Breeding Grounds, Feeding Grounds, Migratory Pathways, Seasonality, and Behaviors

Karin Forney, NOAA Southwest Fisheries Science Center, Moss Landing, CA

Karin provided an overview of the diversity of cetacean species found within the California Current marine ecosystem. Numerous species live, either seasonally or full time, in areas with permitted or proposed aquaculture farm sites. Cetaceans, she noted, can interact with commercial fisheries and aquaculture facilities in a variety of ways, including attraction, intentional contact to forage, unintentional contact or accidental entrapment or entanglement. Multiple studies demonstrate that some species avoid areas with aquaculture facilities, which may adversely affect critical life functions such as resting or foraging. Karin highlighted biologically important areas in southern California and reviewed risk factors for attracting and potentially entangling cetaceans. She concluded by putting forward key questions and information needs that may guide future research and improve the ability of agencies and industry to assess risk.

Overview of Sea Turtle Species Presence/Absence, Breeding Grounds, Feeding Grounds, Migratory Pathways, Seasonality, and Behaviors

Jeff Seminoff, NOAA Southwest Fisheries Science Center, La Jolla, CA

Jeff presented the life cycle and spatial distribution of three protected sea turtle species that live off the coast of California -- the endangered Leatherback *(Dermochelys coriacea)*, threatened Loggerhead *(Caretta caretta)* and threatened Green Sea Turtle *(Cheloniamydas)*. He stressed that tools must also be developed which help prevent turtle interactions with marine fisheries, including aquaculture. He identified potential interactions that could occur with aquaculture farms and described knowledge gaps identified at the 2015 GARFO workshop. He emphasized the need to conduct future research in a step-by-step manner to improve understanding of sea turtle behavior and then make gear modifications as needed or appropriate.

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KNOWLEDGE GAPS AND RESEARCH NEEDS

Following the presentations, workshop participants gathered in small groups to identify and discuss knowledge gaps, information needs and ways to analyze the effects of aquaculture farms in the absence of information. Once back together as a full group, participants shared priority topics and associated knowledge gaps, posed a number of questions that may guide future research, and recommended steps forward for agencies, researchers and industry.

Animal Behavior/Gear Interactions

- Lack of information on protected species behavior and interactions around aquaculture gear represents a big knowledge gap.

- Need better understanding of physical interactions between protected species and aquaculture gear before, during and after interaction; this will inform whether engineers and farm operational/management plans can design or alter structures, and also help determine whether resource managers or industry have any control over these interactions.

- Need more data and better understanding of how animals get in trouble and what this means for development of tools that reduce the likelihood of entanglement. What are the consequences of an interaction between a farm and a protected species and what implications does this have for permitting and management?

- Need data on how animals perceive and react to different visual/auditory stimuli in order to guide future farm development.

- Need to better define the context of positive interactions or negative interactions, perceptions of gear in the water and animal response.

- Link specific types of equipment with specific types of animal interaction. How can this information be acquired?
  - Can we monitor interactions other than entanglements?
  - Can we focus on specific gear?
  - Can this help narrow down concerns?
  - Combine data sets of animal abundances with self-identification/ suitability models
  - Specific investigations will be most informative

- Need more information on protected species migratory routes, distribution of food sources, and finer scale species distribution. Acquiring information on endangered species is difficult yet also important.

- Network with international players to acquire available data and lessons learned from around the world (e.g. proxy data from farms already in place in other locations).

Photo courtesy of Rich Wilson.

Risk Assessment

- Need to define the problems associated with interactions and entanglement better in order to properly assess the real level of risk.

- How can we cope with the effect of concentrating resources at farm sites (e.g. Finfish)?
  - Farms represent an attractive nuisance that may have consequences
  - Potential mitigation for habitat/prey limited species
  - Disease in wild animals

- What level of risk/uncertainty is acceptable for making permitting decisions?
  - How can we guide research to benefit decision-making and address the needs of the regulatory customer?
  - How much information is sufficient to make informed decisions and allow permitting to go forward responsibly (e.g. monitoring, BMPs)?

- How do we integrate limited examples of entanglement into a risk assessment?

- How do we assign relative risk to different types of interactions (e.g. mooring line versus vertical buoy line)?

- Need to define acceptable amount of allowable take per protected species. Should take rates be similar or different from wild caught fisheries?

- Quantify risk by hazard, species, amount of production, gear type and amount of gear.

- Need to visualize protected species interaction events/entanglement to identify risk factors.

Permitting/Regulatory Requirements

- How can regulatory oversight be provided and enhanced for open ocean facilities? Other than through self-reporting by operators, how would regulatory agencies know if marine mammal entanglement, injury, or mortality occurs at an open ocean facility?

- What are the reporting requirements for entanglement? Unreported incidents mean no data to inform permitting, monitoring and management. And what happens after reporting?

- Need small scale example farm in the water to collect data and inform development of future permitting, monitoring and management requirements.

- Connect monitoring requirements to gear development to improve interaction data and help industry meet permitting requirements.

- How do we quantify different types of gear used for the same purpose?

- Consider potential gear modifications in geographic areas where farms and protected species overlap.

- Define gear design constraints for engineers and create consistent and standardized guidelines for industry.

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Monitoring/Scientific Modeling

- Develop meaningful monitoring requirements and associated data management/quality assurance protocols. Better define what needs to be monitored and why.
- Need more observation data to inform development of appropriate monitoring approaches and needed level of monitoring effort (e.g. bycatch monitoring).
- Use GoPro cameras, acoustics and drone/satellite imagery.
- Improve collection of interaction data from pilot NOAA grant-funded projects (scaling up now); information collected on existing projects could be more robust.
- Develop a pilot project in southern California to test how animals perceive gear in water; apply information to future permitting and adaptive management.
- Leverage passive monitoring to better understand behavior without risk(may benefit farmers; can compare to non-farm sites).
- Need more case studies and in-situ experiments.
- Simulate protected species interaction; this will help generate data and scenarios that provide insights on how physical interactions occur (i.e. when and how entanglement occurs versus no entanglement) and possibly also how animals perceive gear.
- Start validating recently developed models (e.g. whale interaction simulator).
- Get information published, available and endorsed or validated in some way.

Industry Best Management Practices

- Improved understanding of animal behavior can and should inform gear modifications and development of BMPs.
- Need to research and compile information on what industry tools and BMPs have already been developed to reduce the likelihood of entanglement.
- Need industry to develop operational plans; this will inform standard operating procedures, monitoring and application of BMPs.
- If one of the best ways to minimize entanglement risk is for the facility to reduce or eliminate loose and broken lines in the water column, what assurances can be developed or established to make sure the facility is operated and maintained in that way? How will regulators be alerted if it is not and what steps will be taken in those cases?

HOW TO ANALYZE EFFECTS OF FARMS IN THE ABSENCE OF INFORMATION

Networking/Use of Proxy Data

- Share experiences from different regions and acquire monitoring data from international partners and experts (e.g. existing farms; monitoring processes/ requirements; proxy data).
- Acquire information from international research partners (e.g. Ensenada Center for Scientific Research and Higher Education).
- Acquire information from similar ocean-uses (e.g. oil rigs, piers, lobster industry). Assess or infer by analogy to these other industries, however, do this with care as not all structures, lines or nets are equal.
- Develop cross-sectoral relationships:
  - Work with farms willing to conduct monitoring and share information
  - Build a robust database from known sources and develop/apply the model to fill gaps
  - Collaborate on research, learn about monitoring protocols/gaps, and transfer knowledge
- Conduct outreach with stakeholders, including coastal communities, to gauge direct and indirect effects of farm operations.
- Create incentives for information sharing.

Modeling/Applied Research

- Conduct model simulations of specific areas and potential protected species interactions.
- Acknowledge uncertainties in modeling and leverage existing data to model for unknowns.
  - Uncertainties can be explored most effectively if the sensitivity of the model to variations in parameters is known
  - Even with a lot of unknowns, models can inform work to get better data; what parameters have the greatest influence on outcomes?
- Find and allocate resources to look at interactions regulators are unable to analyze in the absence of information.
- Conduct science-based research to support analysis and inform industry management (i.e. social license).
- Conduct strategic and defensible monitoring not kitchen sink efforts.
- Incentivize monitoring: give growers positive incentives for providing data and best practices, thereby sharing information that becomes public data.
- Conduct review of habitat-related behavioral effects, especially over time, to see what happens (e.g. farm as fish aggregation device for prey species).

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Modeling/Applied Research

- Gather data on materials used and have experts quantitatively rank possibilities, feed this information into risk assessment models or utilize as available data.
- Use gear/physical characteristics and animal morphology/speed to estimate the parameters of the problem (e.g. large whale swimming at 2 km).
- Seek out expert opinions when conducting research/risk assessment.
- Use best available species tracking data to inform farm siting.
- Conduct forensic analysis of known cases and incentivize grower cooperation -- look at how and why the animal got in trouble.
- Consider incidental take as a buffer for uncertainty versus finding of no significant impact target.
- Analyze bias in reports (e.g. non-reporting).

Gear Specifications/Pilot Projects

- Place a small-scale example farm in the water, conduct strategic monitoring, then utilize data to inform future permitting processes and requirements.
- Acquire specifications on gear being used.
- Improve understanding of how animal physical interaction affects gear.

Photo courtesy of Rich Wilson.

OFFSHORE AQUACULTURE GEAR TYPES AND FUNCTION

Tyler Sclodnick, Federico Rotman, Scott Lindell and Paul Dobbins gave presentations designed to increase participant understanding of different marine aquaculture gear types and functions. The presenters then fielded a range questions and comments which enabled further clarification on specific gear types and associated risks, the need and importance of operational plans, farm design and engineering certifications, and how to develop standardized monitoring protocols which are mutually beneficial to industry and regulators. Samples of gear were provided by the speakers, and an interactive hands-on discussion followed these presentations.

Fin Fish Gear: Cages, Pens, Anchoring Systems and Feed Systems

Tyler Sclodnick, InnovaSea and Federico Rotman, Hubbs Seaworld Research Institute

Tyler described artisanal, coastal and open ocean aquaculture farm designs from around the world. He reviewed design considerations for net pen, surface pen and submerged pen systems. He focused on the InnovaSea grid systems and noted that wave energy is a core consideration for how these systems are designed and deployed in the marine environment. Tension loggers may be strategically placed on the grid and help operators detect any aberrations in the system, such as potential contact with a whale or other protected marine species. He suggested linking risk to the level of aquaculture farm production and shared that no InnovaSea system operators have to date reported any whale entanglements.

Federico presented on behalf of Tyler Corte of Blue Ocean Mariculture. He gave a presentation on submerged net pens installed in 2005 off the west coast of the Big Island of Hawaii. The original system consisted of five pens but was replaced in 2016 by a new system of nine pens. Blue Ocean Mariculture maintains daily visual records of marine wildlife observations at this facility and, whenever a change is made to the permit, conducts a biological evaluation to assess impact of those changes on the surrounding ocean ecosystem. Federico concluded by reviewing the range of BMPs the company has integrated into its standard operating procedures in order to maintain a safe and sustainable farm system.

Shellfish and Seaweed Gear: Mussels on Longline, Seed, Floats/Buoys, Other Species Gear, and Anchoring Systems

Scott Lindell, Woods Hole Oceanographic Institution and Paul Dobbins, World Wildlife Fund

Scott presented a typical mussel longline farm configuration and showed in-water examples from New Zealand and Korea. Mussel farms typically have a trapezoidal architectural design, anchored with screw anchors and supported by submerged or surface buoys. Vertical grow and spat lines are commonly located in the center of the structure. Buoys, Scott noted, can be extended to minimize interactions with protected marine species. Moreover, engineers can design grow ropes to break away from horizontal lines in the event of an interaction or entanglement. Scott is currently working on a project focused on reducing the footprint of seaweed farm operations.

Paul shared the World Wildlife Fund (WWF) view that aquaculture's impact on wild fish populations, marine habitats, water quality and society can be significantly and measurably reduced. At the same time, WWF believes aquaculture has great potential to serve as a sustainable source of seafood around the globe. He noted, like others who presented on farm design, that taut lines not only help anchor a farm in rough ocean conditions, but may help reduce the potential for entanglement. He has yet to find documentation in the literature, or in the field, of seaweed lines entangling marine mammals or turtles.

Photo courtesy of Rich Wilson.

BUILDING AND MAINTAINING OFFSHORE FARMS

Dave Fredrikkson and Ann Bowles gave presentations designed to increase participant understanding of engineering and design considerations that aid regulatory agencies and industry proponents in addressing potential aquaculture gear/protected species interactions.

Overview of Aquaculture Gear Engineering Considerations

Dave Fredriksson, US Naval Academy

Dave provided a look at the complex numeric models, physical models and field measurements that inform design and engineering of open ocean aquaculture systems. He showed various types of marine aquaculture farms and described how engineers apply models at the United States Navy's hydrodynamics lab in order to analyze and test aquaculture system design. He suggested that regulators and industry proponents define protected resource design criteria at the outset of the farm development process, and provided examples of criteria identified at the 2015 GARFO workshop. At the same time, he noted that a body of work still needs to be developed that quantifies farm design specifications to satisfy both system survival and protected resource criteria.

Outputs of the Hubbs SeaWorld Research Institute Workshop

Ann Bowles, Hubbs SeaWorld Research Institute

Ann reported out on science and engineering considerations identified and discussed at the Hubbs SeaWorld Research Institute (HSWRI) workshop which took place in the days before this NOAA workshop. HSWRI secured a Saltonstall-Kennedy grant to aggregate, summarize and review information on protected species entanglement and the measures used to prevent it. Ann summarized key takeaways and outstanding questions that surfaced at the workshop. Under this project HSWRI will produce an in-depth review of available information, the effectiveness of current mitigation measures, and engineering and monitoring tools likely to help reduce risks.

Open group discussion following the presentations enabled exploration of how regulators can work with industry to strike the right balance between over and under-engineering aquaculture farms to both ensure safety and minimize risk to protected species and the marine environment. Dave Fredriksson noted that once an offshore farm is placed in southern California waters, it needs to be monitored, with collected data then utilized to validate the simulator model. This will allow the safety factor to be quantified and assessed. His lab is starting work that will help engineers integrate both safety and protected species criteria into future farm design.

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Development and Applicability of a Species Model and Farm Simulator Tool

SECOND DAY OF THE WORKSHOP

James Morris opened the second day of the workshop with a "Let's Talk about Tools for Rules" session in which participants brainstormed both currently available and still desired tools and resources that help regulators and industry practitioners make informed decisions about offshore aquaculture. Building communication and collaboration between tool builders and tool users is a common challenge facing ocean and coastal resource management professionals.

Participants were initially tasked to brainstorm currently available resources and decision-support tools. The group put forward the following:

- General habitat data and location-specific data.
- Sea turtle and marine mammal distribution tools, including increasingly predictive models (e.g. Turtle Watch website).
- Various tools used by the Navy and the Bureau of Ocean Energy Management (BOEM) to understand the location of marine animals.
- Endangered Species Act (ESA) consultations on similar types of projects.
- Regional fishery observer program data.
- Marine mammal stranding data and conditions of entanglement (e.g. species, season).
- Environmental assessments from past projects that were rejected.
- Local knowledge from scientists and naturalists that work in the area of interest.
- Data portals (e.g. West Coast Coastal Alliance).
- Environmental consultants who regularly interact with experts.
- Stakeholder and political influence on decision-making.

Participants then brainstormed tools they would like to see built -- a kind of "wish list" of highly useful tools in the toolbox. Responses included:

- A central clearinghouse of information on aquaculture gear types and function.
- A community of practice that includes resource agencies, planners and regulators, scientists and stakeholders.
- Information/reports associated with NOAA grant funded aquaculture projects reviewed, funded, denied or approved, and projects that triggered NEPA/ESA processes.
- Ways to collect and store detailed data on individual animal/farm interactions (e.g. visual and acoustic data).
- A risk assessment tool that focuses on an entire operation, nearby stressors from other ocean uses, and impacts that affect analyses at different spatial scales.
- Something adapted from the Army Corps of Engineers tool that enables ESA analysis for dredging projects.
- Standardized monitoring framework, so industry knows what to expect and regulators can monitor multiple projects. ICES aquaculture working group could assist this effort.

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- Expanded research on biologically important areas that brings experts together and helps identify and characterize certain areas as sensitive.
- International reporting of interactions -- better information exchange and collaboration.
- Comparative analysis of similarities between international offshore aquaculture operations and functional or emerging operations in the United States.

James summarized and acknowledged the group's input, then described a partnership between NOAA, Duke University, the New England Aquarium and Bellequant Engineering to build a species model and farm simulator tool to better understand aquaculture gear and animal interactions. The tool will soon be used to simulate interactions between offshore windfarms and protected species along the Atlantic coast. NOAA is also interested to work with partners on the west coast of the United States to determine the applicability and benefits of applying this tool to inform potential offshore wind farm development in southern California.

Dr. Lars Howle of Duke University, one of the model's architects, provided an overview of the model design, function and its potential applications. The tool was originally designed to simulate and help predict entanglements of the endangered North Atlantic Right Whale *(Eubalaena glacialis)* with lobster trap gear. Dr. Howle reviewed the methods and computational needs used in developing the tool and demonstrated various simulations showing animal/gear interaction. He summarized the challenges, opportunities and potential next steps for adapting the tool to inform aquaculture development, and welcomed input from workshop participants.

NOAA and its partners on this project, both James and Lars noted, are now seeking input from experts and interested parties in order to determine the applicability and potential benefits of the simulator to offshore aquaculture development. Building on Dr. Howle's presentation, workshop participants gathered in small groups to identify and define the challenges and opportunities to using a species and farm simulator tool in southern California waters. Once participants came back together as a full group, the discussion centered around the following responses (see Appendix II for full small group outputs):

Challenges

- How to prioritize monitoring/investigations of gear and species. Need links to:
  - Endangered Species Act and Marine Mammal Protection Act
  - Industry investments
  - Farm development stages
- Need specific information on number/type of species, gear, site and region. Also focus on:
  - Whale momentum and orientation entering farm
  - Documented global example of shortest line entanglement
  - Tools needed to record and document interactions
- Keeping gear and species information up-to-date and regularly feeding new information into the model.
- Recognizing that the model is only one tool in the toolbox.
- How to parameterize the model for species specificity (e.g. life stages) and generate realistic outputs.
- How to incorporate gear diversity and design considerations into the model.
- How to define desired decision before prioritizing model inputs.

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- How to incorporate data into the consultation process, including accessibility and usability
  - Limited experience with aquaculture
  - Hope to increase confidence of risk assessment in permit applications
  - BOEM plans to use the simulator as a predictive tool to help with siting, reference and informed decision-making about offshore wind farms

- How to get in the ballpark of reality? What if simulator approach is wrong,determination is made, and whale gets entangled? May reduce confidence. What if the model approach is too conservative? Will high numbers of entanglement scenarios deter any development?

- When agencies rely on models there is a learning process for deciding how and when to use a simulation to support decision-making.

- Many other components to assessing gear configurations, siting and farm operations, simulator is only one part of process. Simulator is a tool but not the decision-maker.

- Model needs validation.

- Regional specificity of data inputs.

- Variation in animal behavior data.

- Stochastic nature of events.

Opportunities

- Explore the potential application of the model in southern California more deeply with partners, regulators need accurate prediction of risk.

- Wide range of possible outcomes when integrating physics and animal behavior.

- Data on rope tension/friction already exists and can be integrated into the model.

- More data input and bigger training sets will lead to higher accuracy of results and improve confidence in the model over time.

- Running simulations will help decision-makers characterize confidence intervals of results and thereby make the model more reliable.

- ESA consultations require ground-truthing data for legal defensibility of decision-making.

- Reverse engineer the simulation process: Start with entanglement, run the model in reverse, then identify most likely animal behaviors that contribute to entanglement.

- Look at the conditions surrounding different entanglement scenarios documented in the literature, input this information into the model, then see if these parameters result in an entanglement.

- Draw lessons from existing models that look at species behavior and interactions with human structures (e.g. methods, stakeholder communication and collaboration).

- Potentially crowd source the tool and let the public simulate entanglement behavior. This may simultaneously improve scenario development, inform gear adjustments and educate the public on the issue.

- HSWRI has access to some species of interest with the possibility of conducting controlled experiments around auditory stimulation, animal speed, interaction events and tension of vertical and horizontal lines.

- Models are good for exploring and clarifying the stochastic nature of events.

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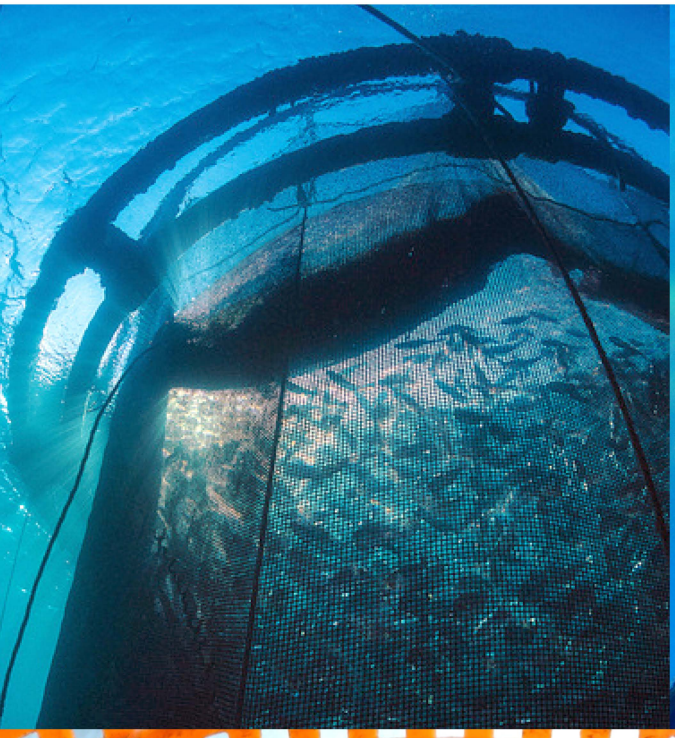
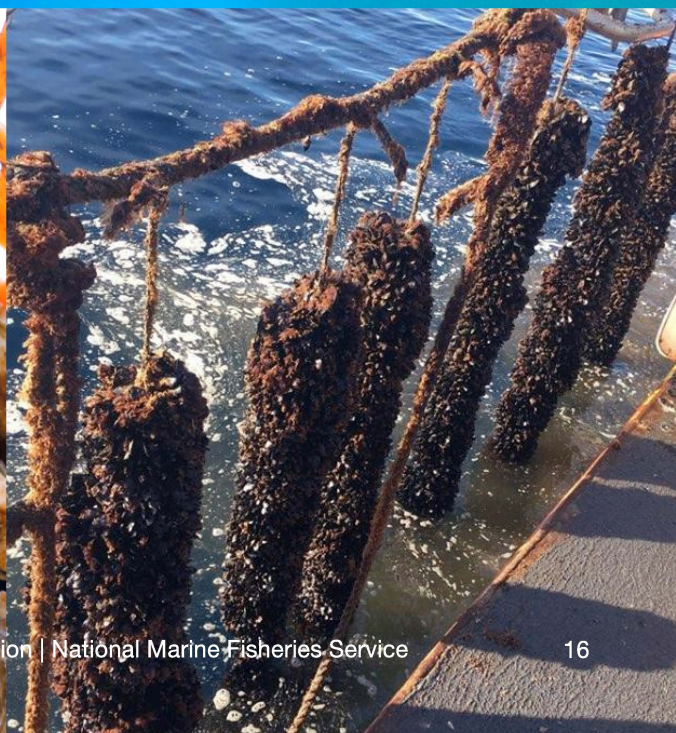
As the simulator discussion wrapped up, Dr. Howle asked the group to identify other useful purposes the tool might serve. Participants suggested the following:

- Ship strike interactions.
- Understanding line tension and cutting impacts to whales.
- Source of information for disentanglement teams:
  - Where and how to cut lines
  - Visual techniques for disentanglement training
- Forensics on entanglement events.
- Education for managers, industry and the wider public.





KEY TAKEAWAYS, INSIGHTS AND EMERGING CONSIDERATIONS

At the outset of the workshop, participants were asked to identify issues of interest they wanted to explore and better understand during the course the presentations, interactive sessions and open group discussion. At the conclusion, participants identified and briefly discussed key take away messages, insights and emerging considerations. It is important to note that none of the insights listed below has yet been ranked or prioritized for action. Each item, and the overall content of this workshop summary, should be considered moving forward.

- The species model and farm simulator present a new learning opportunity around aquaculture gear/protected species interactions. Key questions:
  - Can a Community of Practice come together and inform development of a useful species model and farm simulator tool for southern California?
  - Can the simulator be designed well enough to assess risk and support effective decision-making?
  - How can the model build confidence in the evaluation and determination of risk?
  - How can predictive information inform ESA consultations and public comment?

- Empirical data is lacking, especially cetacean behavioral data (e.g. how animals perceive and react to gear, environmental influences on behavior, interactions around gear).

- Moving forward, effective data management, quality assurance/control, and accessibility are of paramount importance.

- Guidance for setting monitoring requirements is limited. Industry and regulatory agencies need to better understand how to design, execute, and report on monitoring efforts and results in order to effectively permit farms and manage adaptively.

- Regulatory agencies should continue acquiring as much information as possible from NOAA granted funded aquaculture research projects already in the water. Integrate lessons learned into the grant-making process in order to design future research and data collection protocols. Many also believe new pilot projects are needed, including in southern California.

- Presentations and follow-on discussion revealed there is much to learn from how industry is operating and advancing BMPs. Operational management and maintenance protocols are critically important. BMPs should be linked to the agency consultation process.

- Industry, regulators and interested parties are not working in a vacuum. It is critical to capitalize on an international network of peers, available standards and BMPs, and lessons learned that could inform aquaculture development in the United States.

- Industry representatives at the workshop expressed strong interest to share practiced and emerging BMPs, reflecting a significant opportunity for public/private sector collaboration, information sharing and networking. Industry remains interested to learn more about what regulators want to see regarding needed information and permitting requirements.

- Future engineering will require innovation, early integration of protected species design criteria, flexibility and sensitivity to costs, and links to established international standards. Competent authorities are needed to support trainings, inform farm design and testing, and help the industry advance and promote sustainable practices.

- Challenges exist in comparing aquaculture gear to traditional fishing gear, yet similarities can still provide useful information and insights.

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- A central clearinghouse of information on marine aquaculture gear types and function is needed. Information sharing is encouraged across agencies, with policymakers and with the public (e.g. data, tools, experiences). An opportunity exists to improve public perception of the aquaculture industry.

- Development of an aquaculture gear guide, as well operational plans that incorporate international standards and BMPs, would be broadly useful.

- There is broad support for reengaging the Southern California Offshore Aquaculture Interagency Working Group as a forum to further explore the topics addressed at this workshop. Many expressed interest in participating. Workshop outcomes should inform early working group discussions.

Photo courtesy of Rich Wilson.

NEXT STEPS

Closing comments by James Morris and Diane Windham focused on next steps.

James shared that NOAA and BOEM collectively have resources to develop 4-5 model simulators for application on the east and west coast of the United States. In the southern California region the first models will look at mussel longlines and potential interactions with Humpback whales *(Megaptera novaeangliae)*. NOAA plans to put together a core team of programmers, designers and animal behavior specialists to further refine the model and is looking for west coast participants to join the team. In time, the work will be shared for public review and input.

Diane emphasized the need to build on workshop outcomes and continue the dialogue. In the near-term, NOAA plans to reengage the Southern California Offshore Aquaculture Interagency Working Group. This group will serve as a forum to continue bringing key parties together to look at model development and other aspects of aquaculture planning. Discussions ahead will also consider working group membership, governance and priority topics for discussion at future meetings. Diane concluded by thanking everyone and welcoming greater communication and collaboration on aquaculture in the future.

CONCLUSION

This workshop brought together a diverse assemblage of experts in aquaculture farm design, engineering and marine science to work closely with regulatory agencies to improve understanding of the potential interaction between protected marine species and offshore aquaculture in the southern California region. Participants identified knowledge gaps and research needs, discussed how to analyze the effects of farms in the absence of information, and were introduced to a species model and farm simulator tool which may help improve understanding of aquaculture gear and animal interactions. Workshop outputs set the stage for ongoing collaborative engagement, information sharing and innovative work ahead that advances sustainable aquaculture farm design and operations while simultaneously minimizing interaction with and harm to protected species and the marine environment.

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APPENDIX I. WORKSHOP AGENDA

WORKSHOP OBJECTIVES

- Increase understanding of marine/offshore aquaculture industries and gear types
- Increase understanding of key marine mammal presence, absence and behaviors in the area of interest (Point Conception to the US/Mexico Border)
- Explore opportunities for development of new tools such as species/gear simulator to aid in addressing potential cetacean and sea turtle interactions with offshore aquaculture gear
- Identify action items and next steps, including but not limited to potential re-engagement of the Interagency Offshore Aquaculture Working Group

DAY 1 - June 20th	
9:00	**Welcome, Introduction and Overview of Workshop Need and Purpose** *Diane Windham, NOAA Fisheries – West Coast Regional Aquaculture Coordinator* *Dr. Mike Rust, NOAA Fisheries – Science Advisor for the Office of Aquaculture* **Objective:** Welcome all participants, describe the workshop rationale and need, and set the stage for all follow-on discussions.
9:15	**Agenda Review and Workshop Guidelines** *Rich Wilson and Meagan Wylie, Seatone Consulting*
9:30	**Aquaculture Today: Recent NOAA Work and State of the Science Regarding Offshore Aquaculture Gear and Protected Species Interactions** • State of the science, risk assessment and collaborative engagement *James Morris, National Ocean Service (NOS)* • 2015 GARFO aquaculture workshop – summary and recent updates *Kevin Madley, GARFO, and Thomas Noji, NOAA NEFSC* • Overview of offshore finfish aquaculture in Hawaii *Kate Taylor, NOAA PIRO* • Q&A period **Objective:** Present recent NOAA/NOS work on aquaculture/protected species interactions, review the state of the science, and consider emerging collaboration.
11:00	**BREAK**
11:15	**Protected Species in the Area of Interest** • Overview of cetacean species presence/absence, breeding grounds, feeding grounds, migratory pathways, seasonality, and behaviors *Karin Forney, NOAA SWFSC* • Overview of sea turtle species presence/absence, breeding grounds, feeding grounds, migratory pathways, seasonality, and behaviors *Jeff Seminoff, NOAA SWFSC* • Q&A period and interactive group discussion **Objective:** Increase understanding of key protected species in the area of interest (Point Conception to US/Mexico border).
12:30	**LUNCH**

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DAY 1 - Continued	
1:30	**Marine/Offshore Aquaculture Gear Types and Function** • Fin fish gear: cages, pens, anchoring systems, feed systems, etc. *Tyler Sclodnick, InnovaSea and Federico Rotman, HSWRI* • Shellfish and seaweed gear: mussels on longline, seed, floats/buoys, other species gear, and anchoring systems *Scott Lindell, Woods Hole Oceanographic Institution and Paul Dobbins,World Wildlife Fund* • Q&A period and interactive group discussion **Objective:** Increase understanding of different marine/offshore aquaculture gear types and functions.
3:00	**BREAK**
3:15	**Building and Maintaining Marine/Offshore Aquaculture Farms** • Overview of aquaculture gear engineering considerations *Dave Fredriksson, US Naval Academy* • Outputs of the Hubbs Sea World Research Institute workshop *Ann Bowles, HSWRI and facilitator Rich Wilson* • Q&A period and interactive group discussion **Objective:** Increase understanding of engineering and design considerations to aid in addressing potential protected species interactions with offshore aquaculture gear.
4:45	**Summary of Day 1 and View Towards Day 2** • Key day 1 insights, themes and outputs • Review of day 2 agenda
5:00	**Workshop Adjourns**

DAY 2 - June 21st	
8:30	**Development and Applicability of a Species Model and Farm Simulator Tool (part 1)** • Session framing: *James Morris, NOS* - Discuss the importance of tools in the permitting process - Brainstorm existing tools and approaches - Set up the opportunity to build a simulator-type tool for use in data limited situations such as the southern California context • Species model and farm simulator concept and California protected species of concern/interest *Lars Howle, Duke University* • Q&A period and interactive group discussion **Objective:** Introduce a cetacean model and offshore mussel longline farm simulator and discuss its potential applicability in southern California waters
9:45	**BREAK**
10:00	**Development and Applicability of a Species Model and Farm Simulator Tool (part 2)** • Building collaborative engagement in southern California waters *James Morris, NOS* • Interactive group discussion: - Challenges and opportunities to using the simulator tool - Other considerations for analyzing potential interactions and determining appropriate monitoring • Identification of next steps **Objective:** Map out challenges and opportunities to analyzing and understanding potential protected species interactions with offshore aquaculture gear, and determining appropriate monitoring protocols.
12:00	**LUNCH**
1:00	**Workshop Outputs, Action Items and Next Steps** • Summary of key outputs, action items and next steps *Facilitators Rich Wilson and Meagan Wylie* • Assess the potential for re-engagement of the Southern California Interagency Offshore Aquaculture Working Group - Discussion/scheduling • Review “parking lot” items • Closing comments/questions *Diane Windham, NOAA Fisheries* **Objective:** Establish a pathway forward that supports continued collaboration, communication and problem-solving amongst agencies and interested parties.
3:00	**Workshop Adjourns**

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APPENDIX II. WORKSHOP PARTICIPANTS

NAME	AFFILIATION
Jeff Bash	NOAA Fisheries/Policy and Planning/WCR
Gretchen Bath	NOAA/NOS
Ann Bowles	Hubbs SeaWorld Research Institute
Bryant Chesney	NOAA Fisheries/PRD/WCR
Paul Dobbins	World Wildlife Fund
Tina Fahys	NOAA Fisheries/PRD/WCR
Karin Forney	NOAA Fisheries/SWFSC
Dave Fredriksson	US Naval Academy - Annapolis
Luke Gardener	CA Sea Grant - AQ Extension Specialist
J.P. Garofalo	Malibu Oyster Company
Bob Gordon	Pacific6
Vince Guida	NOAA Fisheries/NEFSC
Lars Howle	Duke University/Bellequant
John Hyde	NOAA Fisheries/SWFSC
Kate Kauer	The Nature Conservancy
Don Kent	Hubbs SeaWorld Research Institute
Steve Leathery	NOAA Fisheries HQ - NEPA
Jennifer Lee	NOAA Southeast Regional Office (SERO)
Scott Lindell	Woods Hole Oceanographic Institution
Randy Lovell	CA Department of Fish and Wildlife
Kevin Madley	NOAA Fisheries/AQ/GARFO
Eric Matzen	NOAA Fisheries/NEFSC
Laura McCue	NOAA Fisheries/PRD/WCR

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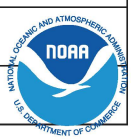
NAME	AFFILIATION
Lisa Methratta	NOAA Fisheries/HQ - OPR/AQ Liaison
Lisa Milke	NOAA Fisheries/NEFSC
James Morris	NOAA/NOS
Chi Mori	NOAA Fisheries/AQ/GARFO
Mackenzie Nelson	Aquarium of the Pacific
Thomas Noji	NOAA Fisheries/NEFSC
Jessica Powell	NOAA Fisheries/SERO PRD
Catherine Purcell	NOAA Fisheries/SWFSC
Desray Reeb	Bureau of Ocean Energy Management
Bonnie Rogers	Army Corps of Engineers (now EPA)
Federico Rotman	Hubbs SeaWorld Research Institute
Madelyne Roycroft	Port of San Diego
Mike Rust	NOAA Fisheries/HQ/Office of Aquaculture
Julie Scheuer	NOAA Fisheries/PRD/AK
Tyler Sclodnick	InnovaSea
Jeff Seminoff	NOAA Fisheries/SWFSC
Sean Suk	US Navy, San Diego
Paula Sylvia	Port of San Diego
Jaclyn Taylor	NOAA Fisheries HQ/OPR
Kate Taylor	NOAA Fisheries/AQ/Pacific Islands
Kim Thompson	Aquarium of the Pacific
Russ Vetter	NOAA Fisheries/SWFSC
Rich Wilson (Facilitator)	Seatone Consulting
Walt Wilson	US Navy, San Diego
Diane Windham (Convener)	NOAA Fisheries/AQ/WCR
Meagan Wylie (Facilitator)	Seatone Consulting
Chris Yates	NOAA Fisheries/PRD/WCR



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APPENDIX III. CHALLENGES AND OPPORTUNITIES TO APPLYING A SPECIES MODEL AND FARM SIMULATOR TOOL TO OFFSHORE AQUACULTURE DEVELOPMENT

The text below includes unedited information from all small group worksheets collected on the second day of the workshop. Group numbers are arbitrary and used solely to illustrate clusters of comments generated from each individual small group. Open group discussion which followed is described in the main body of this workshop summary.

What are the challenges to using a species model and farm simulator tool as it relates to analyzing and understanding potential protected species interactions with offshore aquaculture gear, and determining monitoring protocols?

Group 1

- What is the return on investment for level of detail (e.g. managed species, gear configurations, oceanographic conditions)?
  - Most useful for design
  - Most useful as open source simulator so lots of people can use
- Nice to see a species model/farm simulator for humpbacks.
- How do we convert real world data on behavior into a form useful for simulation (e.g. 3D accelerator and video)?
- How do you calculate fit to reality % needed?

Group 2

- Challenge to determining species behavior (region/site, gear-specific)
  - Need a grid.
  - How compliant is gear, how does [gear] do through impact interactions?
  - Is the response of the farm gear dependent on oceanic conditions and where the gear is in terms of farm production phase/growth cycle? Have to make a lot of assumptions
  - What part of the gear is the animal interacting with?
  - What is the forward momentum of the animal? How is the animal approaching the farm?
  - Suffering from mussel abrasions?
  - Weakness: We don't know what whales see?
  - Unfamiliar with how whales interact with horizontal line?
  - What is the shortest documented line an animal has been entangled in?
  - Inform: farm configuration/gear types.
  - Sensor/identifier that indicates interaction occurred

Group 3

- Concern: Model is data poor when it comes to behavior.
- Need more observational information of gear interactions to help with model (but there are not many examples).
- How will behavior change with an aquaculture operation in comparison to fishing gear operations?
- Difficult to communicate underpinning of models to the public.

Group 4

- Lots of assumptions.
- Behavior unknowns.
- Environmental variables, seasonal .
- Abundance of species/gear combinations.
- High cost of development
- Usability for untrained.
- Differences by life stage.

Group 5

- Detection technologies.
- More information needed for species-specific behavior - life stage specific.
- Parameterizing the model.
- Could lead to unrealistic expectations.
- Gear diversity modeled.
- How do you convert model to estimate risk and inform monitoring

Group 6

- Incorporate all potential scenarios over many species to be a realistic assessment tool.
- Incorporate engineering models with whale models.
- Keeping data input up to date with monitoring results.
- Test new designs or species.
- Secure whale behavior expert opinion input to model refinements.

Group 7

- Animal behavior largely unknown around different configurations.
- Other species.
- Simulator out of context visually, could be used to restrict aquaculture visuals are powerful.
- Differences in offshore aquaculture gear.
- Funding to keep up to date.
- Feels like you are removing more uncertainty than you might be.
- How to incorporate into consultation process? Legally defensible?

Group 8

- Resources very expensive and time-intensive, plus where does the money come from?
- Prioritizing gear, animals.
- Refining animal morphology/behavior for each species of consideration (parameterizing)
- As far as prioritizing, what determines priorities?
  - ESA concerns, funder priorities (where money comes from), industry development stage (who is next in the docket)
- Timing/planning up front critical.

Group 9

- What goes into the model? Relevant inputs.
- Unknown behavior inputs.
- How do you change gear to break away from animal but not break away in storm? Totally dependent on different types of lines plus gear.
- Difficult to have relevant information for parameters without cages in the water.
- Again for southern California, Baja, California, Mexico needs to be included as part of the picture. Limited access to data at present.

What <u>opportunities</u> does using a species model and farm simulator tool present as it relates to analyzing and understanding potential protected species interactions with offshore aquaculture gear, and determining appropriate monitoring protocols?

Group 1

- Crowd sourcing and citizen engagement could be promoted using these tools (people develop familiarity with processes and issues, including farmers).
- Planner, manager, grower engagement.

Group 2

- Informs farm development, tests new farm design, increases certainty (better information for investors), assess new impacts of farm designs/innovations.
- Most utility in regulatory process, permitting reviews, start with small acreage, demonstrate success, then scale up.

Group 3

- Could use it for multiple species.
- Could allow for proactively redesigning gear.
- Could help with development of new policies/regulations and engineering.
- Have some monitoring system in place to ground-truth the model.
- Question the science.

Group 4

- Testing line strengths, weak link strengths.
- Development of gear.
- Allows farmers and the public to visualize potential effects, whale's eye view.
- Opportunity for decision makers to let developers/researchers know what information is needed.

Group 5

- Help influence public perception/education.
- Inform gear configurations, siting to avoid.
- Inform where the data gaps are.

Group 6

- Analyze different alternatives.
- Discover gear configurations with less risk (linked to test new designs or species above).
- Dynamic Dave model with tensions, etc. inputting into whale model (engineering and whale combined) to reduce; it depends answer.
- Develop standards for industry.
- Use monitoring to validate model output for validation

Group 7

- Offshore aquaculture gear is different from fishing gear, and that can be shown, especially in comparison to lobster gear.
- Tool to force regulators to vocalize/have deeper conversations on what is needed to allow offshore aquaculture.
- Inform changes in gear configuration.
- Help to prioritize where funding for monitoring tools, such as tension loggers (15K each).

Group 8

- Provides critical information for policies, permitting, consultations and communication.
- Building teams of experts for this purpose but then they could also serve as a resource body for other issues, questions, etc. moving forward.
- Tool is continually evolving, opportunities for data expertise to weigh in, refine model(s) (both challenge and opportunity).

Group 9

- Model different gear set ups.
- Set up gear-loss versus species-loss type of evaluations.
- Make decisions on farm orientation based on simulations.
- May be opportunities to use data (collected for other purposes) to populate model parameters whale tracks in a given area, how they interact with other, pre-existing non-manmade structures.
- Letting people see perspective (improve aquaculture perception) is an important socioeconomic tool.

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Other identified considerations for analyzing potential interactions and determining appropriate monitoring protocols.

Group 1

- Return on investment could be a challenge, gear interaction damage really low. We still don't have a lot of input data.

Group 2

- The science of deterrents; could this be worked into the models.

Group 3

- Multiple lines, such as kelp arrays.
- Questions: Available training opportunities? Could Alaska stranding program help collect friction co-efficients?

Group 4

- Life stage specificity.
- Migratory routes, species. Species biology.
- Group versus individuals.
- Behavioral attributes, whale detectability.
- Focused on entanglements.

Group 5

- Can we use the model to reverse engineer actual entanglements to understand animal behavior and the possible ways to get to that specific entanglement?
- Are there other models attempting to incorporate animal behavior and how are they dealing with behavior uncertainty?

Group 6

- Building trusting relationships with farms to collect data.
- Consolidation of operations by all industries.
- Reactions to different densities of gear within a given area (e.g. sparse lines on periphery versus more dense inside).

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