COASTAL FOOD SYSTEMS AND MARINE CONSERVATION

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SITUATION SUMMARY

The College of Agricultural Sciences (CAS) at Oregon State University (OSU) is a global leader in research, education and outreach in a wide range of transdisciplinary sciences related to coastal food systems, sustainable seafood harvest and production, and conservation of marine natural resources. Faculty and staff in CAS have diverse and broad expertise related to marine and coastal environments ranging from aquaculture, biology, ecology, economics and policy, ecosystem services, fisheries, genomics, and seafood production and processing. CAS scientists have active projects in all five of the Earth's ocean basins and engage with policymakers at national and international levels. The importance of this work will continue to grow as global human populations increase and our coastal and marine ecosystems are subjected to multiple anthropogenic impacts and natural disasters.

Internationally Recognized

CAS research, education and outreach programs are collaborative and innovative, many of them known nationally or internationally for their work in coastal and marine systems. Formal institutes and centers include the Marine Mammal Institute, the Translational and Integrative Sciences Center, Food Innovation Center and the United States Geological Survey (USGS) Cooperative Fish and Wildlife Research Unit. CAS has several major research areas with national and international impact. Eight of 12 academic departments in CAS have faculty working on coastal or marine issues supporting both rural and urban economies.

Effectively Collaborative

CAS faculty, students and staff collaborate actively with many OSU colleges and programs also doing work in marine and coastal systems. The College of Earth, Ocean and Atmospheric Science (CEOAS) has substantial expertise in biological, chemical, and physical oceanography, climate and geology. The College of Science also has numerous faculty in at least three departments working in coastal and marine environments. Oregon Sea Grant (OSG) is a national leader in coastal and marine outreach programs. University-wide centers and institutes include the Cooperative Institute for Marine Resources Studies (CIMRS), the Center for Genomic Research and Biocomputing (CGRB), Institute for Water and Watersheds, Institute for Natural Resources and the Pacific Marine Energy Center. Because of this broad interest and expertise in marine and coastal systems, OSU launched the Marine Studies Initiative (MSI) to build upon the excellence in marine programs across OSU and the state, including in Corvallis, Newport and along the Oregon Coast, by amplifying existing efforts and catalyzing new opportunities. CAS plays a major role in this initiative, leading important components such as Food from the Sea and Aquaculture.

World-Class Facilities

Marine, coastal and aquatic sciences at OSU are bolstered by world-class facilities and infrastructural assets. The Hatfield Marine Science Center (HMSC) is OSU's coastal campus and research facility for over 300 scientists, six state and federal agencies including four satellite labs from three National Oceanic and Atmospheric Administration (NOAA) Line Offices, as well as labs in the United States Department of Agriculture Agricultural Research Service (USDA ARS). The Coastal Oregon Marine Experiment Station (COMES) was the first marine experiment station in the nation and today houses facilities for the largest group of tenure-track faculty at HMSC. Hatfield Marine Science Center also includes a visitor center and outreach programs for K-12 and the public. Its seawater system enables live-animal exhibits in the visitor center and marine organism research in several of the buildings on campus, including the NOAA/OSU aquaculture facilities. The Gladys Valley Marine Studies Building is a state-of-the-art research and teaching facility. The CAS Seafood Research and Extension Center in Astoria is the only remaining seafood research center on the West Coast. The Port Orford Station is a small facility providing laboratory, office and meeting space as well as housing for OSU faculty and students. CAS aquatic research programs maintain several state-of-the-art aquatic animal facilities

including the Oregon Hatchery Research Center (OHRC), Fryer Aquatic Animal Health Laboratory (FAAHL), Fish Performance and Genetics Laboratory and the Sinnhuber Aquatic Research Laboratory. Finally, OSU maintains numerous vessels for coastal and marine research, including the RV Oceanus and RV Elakha operated by OSU Ship Ops, the RV Pacific Storm, and a fleet of rigid-hull ,inflatable boats operated by the Marine Mammal Institute.

CAS engagement in coastal and marine sciences, its faculty expertise and its nationally and internationally recognized programs—as well as the extent of university-wide investment in facilities and infrastructure —make CAS and OSU uniquely positioned to be a global leader in the Blue Economy. The college's engagement around this strategic advantage will position it for better collaboration on university-wide Blue Economy and diversity, equity and inclusion initiatives.

Within the broad range of CAS and OSU assets in coastal and marine science, we have five primary focus areas and four cross-cutting focus areas comprising this strategic advantage.

STRATEGIC OPPORTUNITIES

Our marine seafood systems and conservation strengths provide eight key strategic opportunities to make transformative impact on pressing issues and challenges facing the state, nation, and world.

These include:

1. Aquaculture
2. Coastal Communities and Food from the Sea
3. Sustainable Aquatic Food Systems
4. Workforce Training
5. Understanding Marine Ecosystem Changes
6. Genomics and Big Data
7. Social, Economic and Political Impacts
8. Land-Sea Connection

1. Aquaculture

Global aquaculture is the fastest growing agriculture sector and accounts for about 50% of seafood production. This trend is expected to continue due to the limited capacity of wild-capture fisheries to meet demands of an increasing global human population. The U.S. imports more than 80% of its seafood and about 50% of these imports are aquaculture products. Aquaculture also plays an important global conservation role in relieving fishing pressure on depressed fishing stocks.

On the West Coast, shellfish farming is the most important form of marine aquaculture, with an annual production valued at more than $125 million and employing about 2500 coastal community members. OSU has led in developing and transferring technology to shellfish farmers since the mid-1970s. An expanded USDA/ARS research program, based at HMSC, also helps shellfish farmers address ocean acidification and disease threats associated with global warming. OSU has also led substantial USAID-funded projects supporting freshwater and marine aquaculture in developing countries where food insecurity is an increasingly serious problem due to population increase and environmental impacts of global warming.

In addition, West Coast state and federal agencies operate large salmonid hatchery programs supporting conservation efforts as well as commercial and recreational fisheries. OSU works with these agencies to improve salmonid hatchery and broodstock management practices through research at the Oregon Hatchery Research Center, COMES genetics programs, as well as disease studies conducted at the FAHHL. Over 50 scientists across OSU recently participated in the preparation of a white paper on the future of freshwater and marine aquaculture.

New approaches are needed to enhance sustainable aquaculture on state, regional and national scales in order to meet increasing domestic and global demands for healthy, sustainably produced seafood and other bio-products. OSU is well suited to capitalize on its resources and reputation to help develop robust and environmentally sustainable aquaculture systems. The availability of wind,

wave and geothermal energy sources, coupled with Oregon's moderate climate and largely pristine environment, provide additional advantages in the development of "energy-neutral" sustainable aquaculture. Aquaculture facilities offer a great opportunity to support rural economies but will likely lead to conflicts with other marine-related industries. CAS is uniquely positioned to help stakeholders resolve these conflicts.

2. Coastal communities and food from the sea

Total food production will need to increase by 70% by 2050 in order to feed a projected global population of 9.7 billion. Innovations to all food systems will be critical in meeting this pressing challenge. The aquatic foods harvested and produced in the U.S. are sources of some of the planet's healthiest and most sustainable proteins, fats and fibers (macroalgae), while supporting rural and coastal economies. Harvest and production of aquatic food products is a critically important component of the U.S. food supply chain, supporting >1.2 million jobs, generating >$144 billion in sales, and contributing >$61 billion to U.S. gross domestic product. The West Coast is a major finfish and shellfish producer. About 9.4 billion pounds of edible seafood products with a dockside value of $5.6 billion were landed on the West Coast in 2018. The majority (> 80%) of this catch was finfish. In 2018, West Coast landings, including Alaska, accounted for >70% of the total catch of U.S. fisheries. Most aquatic-derived food harvesters, producers and processors are small to mid-sized companies when compared to their terrestrial counterparts. Like other U.S. food sectors, the aquatic-derived food distribution channels are global and dominated by a few companies that buy unprocessed product from large numbers of small- to moderate-scale fish harvesters and aquaculturists. As a result, the aquatic food sector is an important economic base and an important source of employment and earnings for Oregon's rural coastal communities.

Aquatic food products harvested from the wild or farmed in marine or fresh waters face similar challenges to terrestrially grown food products. CAS has a long history of leadership supporting Oregon's diverse food production and processing systems and will play a growing role in accelerating the flow of information and pace of innovation, addressing science and engineering challenges that limit the competitiveness of the U.S. aquatic food industry.

The U.S. aquatic food industry faces significant challenges to remain resilient and economically viable and competitive. Current challenges include rapidly changing climate and oceanic conditions; harmful algal blooms; marine plastic pollution; illegal, unregulated and unreported fishing; changes in governmental policies and permitting (such as fishery and environmental quality); and the global pandemic. While the USDA has a long history of working with farmers and meat and dairy producers to improve yields, enhance product quality, ensure food safety, and foster cooperative research and market development, its mission has not encompassed all aspects of the aquatic food production system.

The Fisheries Division of NOAA has responsibility for promoting sustainable fisheries but focuses primarily on assessment of fish populations and managing catches. As a result, industries focused on aquatic food production have fallen through this gap in agency missions and have not benefited from the level of industry-university cooperation that has served other food sectors in enhancing resiliency and capacity building. This is particularly troubling because aquatic food industry harvesters, producers and processors are small to medium-sized businesses with a lack of infrastructure and labor pool constraints due to rural location, transportation barriers and limitations related to high perishability of food products, variable harvest allowances and seasonality. As a result of these factors, the U.S. aquatic food industry is under significantly more stress than many of its larger terrestrial counterparts. Consequently, the U.S. aquatic food sector has not evolved as rapidly as other U.S. food sectors in terms of technological innovation. CAS leadership in this sector offers substantial opportunity to increase industry partnerships and help guide policy development for seafood processing.

Terrestrial food systems have already gone through a "green revolution" and enhancements in production are projected to be incremental at best. Aquatic food systems, however, are poised for a "blue revolution." Innovative marine and freshwater aquatic food systems promise a high potential for more sustainable and abundant future food production.

CAS has recognized the importance of aquatic foods to Oregon's coastal communities by investing in and providing research and outreach expertise for the aquatic food industry through COMES since the 1940s. This depth of investment in Oregon's coastal communities in partnership with entities such as the Food Innovation Center; departments of FW, FST, Biological and Ecological Engineering; and Applied Economics is unique in the nation and places OSU as a leader in aquatic food systems research and outreach. Given CAS's history of success in food systems of all types, continued engagement with and support of aquatic food systems will be critical to helping the state of Oregon and the nation meet the food, fiber, fuel, feed and climate demands of the 21st Century.

3. Sustainable Aquatic Food Systems

The U.S. government advises doubling seafood consumption (8 or more ounces per week vs. current level of 4.5 oz.) for health reasons (2015 Federal Dietary Guidelines for Americans). Meanwhile, nearly half of the U.S. aquatic food supply is wasted across the supply chain, and almost one-third of this loss occurs post-harvest. As we change these statistics by increasing the supply of aquatic foods, we also must improve our stewardship in terms of sustainable utilization. USDA's Agriculture Innovation Agenda for the next 20-30 years seeks to align public and private sector research around themes of productivity, food loss and waste, carbon sequestration and greenhouse gas mitigation, water quality and renewable energy, and these themes are also important in meeting current challenges for aquatic food systems. CAS is particularly well-positioned to lead OSU in developing innovations that support these themes, especially in terms of sustainable aquatic food systems and production and use of other marine-related bio-products. Finally, CAS has an important responsibility as well as capacity for educating seafood consumers regarding sustainable use of aquatic foods.

4. Workforce Training

Oregon has taken action to understand and address the needs of the maritime sector workforce in House Bill 2181. The marine food sector is global in nature and, as a result, is more integrated than other food sectors with third-party auditing systems. Over the past 10 years, company participation in third-party auditing schemes developed through the Global Food Safety Initiative (GFSI) has increased and standards based on GFSI require employees to demonstrate competency in their position. This has increased the number of employees seeking professional development and training opportunities. Furthermore, the marine food sector employs a highly diverse workforce with special training needs. CAS has a history of meeting these needs through regional, national and international trainings. The OSU Surimi School and Forum is an international training program that has helped businesses over the last 25 years provide basic training for new employees in surimi processing. The Better Seafood Processing School, another training program, is focused on introducing new employees to seafood processing and its challenges. The Seafood Wastewater and By-Product Recovery Conference is a third offering, focused on helping companies learn what is new in environmental regulatory requirements, wastewater recovery and by-product utilization. Seafood Hazard Analysis Critical Control Points (HACCP) and Seafood HACCP Train-the-Trainer are offered regionally, nationally and internationally to help employees from processors obtain the credentials needed to develop food safety plans in accordance with the U.S. Food and Drug Administration's (FDA) regulatory requirements. These trainings are conducted regionally in collaboration with the Oregon Department of Agriculture, nationally in collaboration with the National Seafood HACCP Alliance and Association of Food and Drug Officials, and internationally in collaboration with the FDA, Joint Institute of Food Safety, and USDA.

5. Understanding Marine Ecosystem Changes

An urgent question today is not whether marine ecosystems will change in response to the warming climate and increasing pollution, but how they will change so that effective management strategies can be implemented. From phytoplankton and kelp at the base of the food web through to fishery stocks and apex predators, such as seabirds and marine mammals, the evidence is overwhelming that ocean ecosystems are changing and becoming less predictable in ways that threaten their sustainable management. At the intersection of land and sea, the Oregon Coast is home to a rich and diverse, yet delicate ecosystem. Its complex physical and chemical features interact with biology to impact food production and ecosystem health. The pace of some aspects of climate change, such as hypoxia and ocean acidification, is more rapid in Oregon's coastal ecosystems than in other places in the world. This is cause for concern, but also opens opportunities for leadership.

CAS is perfectly positioned to lead transdisciplinary investigations on ecosystem function that span broad temporal and spatial scales. Oregon's coastal system experiences predictable upwelling and downwelling seasons that cause wide variations in temperature, oxygen and pH, offering a natural laboratory to our scientists. New technologies enabling continuous, high-resolution observations from the surf-zone to the open ocean provide near-real-time information that helps us understand how physical, chemical and biological mechanisms interact to alter biological activities and production. By partnering with faculty who have oceanographic and biogeochemical expertise in CEOAS and COS, CAS faculty are able to link these physical changes to biological effects that drive shifts in population, community and ecosystem dynamics using both empirical data and dynamic mathematical models. While other entities at OSU are focused on describing the basic science of these processes, research in CAS typically embraces the land/sea grant mission of linking our understanding of those ecosystem

changes to the effects they will have on our ability to conduct sustainable management. Hence, research on global change is informed by the needs of end-user management agencies and industry. Our strong partnerships with NOAA, EPA, USFWS, USGS, ODFW, and other agencies are a financial and intellectual asset, promoting actionable science that directly affects policy.

Opportunities abound for establishing state-of-the-art infrastructure for long-term monitoring on the Oregon Coast. OSU's scientists are leaders in data integration and innovative statistical applications needed to analyze environmental variables and develop a predictive understanding of our valuable marine ecosystems. Real-time in-water and above-water sampling enables detection of known and unknown factors that interact to effect change.

In the context of climate change, another issue of both global and local concern is the emergence of new epizootic diseases, both in natural populations (e.g., sea star wasting syndrome) and cultivated stocks (e.g., oyster herpesvirus). These potentially catastrophic diseases are likely exacerbated by climate factors and the nature of global commerce. OSU faculty are renowned for the vision and experimental expertise needed to conduct and exploit basic science to identify disease entities and the organismal behaviors responsible for perpetuating or mitigating detrimental ecological processes. Continued investment in and promotion of these activities could be enhanced by new initiatives focused on epizootics, ecological modeling rooted in biochemical function, and management of crosscutting arenas such as fisheries and wildlife conservation.

In the context of marine ecosystems important to the Pacific Northwest, it is crucial to acknowledge that the iconic Pacific salmon spend the first months to years of their lives (and the last months as well) in freshwater ecosystems. These systems are also changing due to increased human demand on freshwater and rivers becoming generally warmer, slower and lower in oxygen, all with detrimental consequences for salmon. Human alteration of freshwater flows using dams exacerbates these issues and creates human-wildlife conflicts as marine mammals congregate to depredate migrating adult salmon. CAS has a huge research presence ranging from salmon navigation on the final journey upstream to the effects of warming waters on successful downstream migration, and the role of invasive species competing with salmon in their native streams. Recent federal policy changes have brought the mammal-salmon conflict to the forefront, and there is considerable opportunity for CAS leadership in that area, where behavioral ecology intersects with fishery management and human dimensions.

While climate change is certainly the greatest effect that humans are exerting on the global ocean, pollution remains both a local and global concern. Pollution from contaminants of emerging concern, such as many next-generation pesticides, could threaten coastal fisheries, particularly those species that utilize estuaries during part of their life cycle. The issue of marine plastic pollution has also arisen as a global concern in the last decade. While the threats to some sea life are clear (e.g., seabirds), the potential for persistent sub-lethal effects on fishery species – and the transmission of plastics from seafood to human consumers – is an active area of research. CAS has the capacity to expand on existing research in this area, for both aquaculture and wild-catch fisheries, in order to quantify the scope of the problem and the associated risk to humans and fishery economies.

6. Genomics and Big Data

Access to large and increasingly continuous marine data from satellites, hard-wired transects and gliders combined with substantial reduction in cost of high-throughput genotyping and other 'omics technologies is markedly increasing availability of Big Data, including completely sequenced genomes available across broad marine taxa. These advances offer expanding resources to enhance management and harvest of aquaculture and wild fish stocks, in concert with the need to protect endangered species and address other environmental and social issues.

OSU faculty in CAS and across multiple colleges, institutes and centers (CIMRS and CGRB) provide leadership in developing these tools and analyzing findings to model and form predictions that address complex management problems (for example, hypoxia, ocean acidification, marine heat waves, toxic harmful algal blooms, etc.). Our expertise ranges from basic to applied science, enabling us to translate 'omic-environmental information into policy-relevant findings. Although a relatively young field, in CAS we are also among national university leaders developing transdisciplinary training environments that integrate social, math, statistics, computing, environmental (including climate), behavioral, epigenetic, genetic and genomic aspects of marine organisms, their ecosystems (including humans) to best resolve resilient futures for all.

We have substantial need for increased human and infrastructural capital to turn these potentials into socially and environmentally meaningful outcomes. Oregon's center stage location among West Coast states positions us well to continue leadership in these areas.

7. Social, Economic and Political Impacts

Marine resources are public resources, and policy and management are critical in determining the benefits that can be achieved in their use and conservation. Understanding the behavior of resource users in response to the incentives, disincentives and constraints imposed by regulatory policies is critical for estimating benefits, impacts and trade-offs among competing social values. Whether it is the armoring of private coastal property, the protection of endangered species, the management of fishery resources, or the control of effluents from seafood operations, policy design and analysis is critical for improving social welfare. The challenge is especially complex due to managing diverse but scarce resources in dynamic marine environments with limited information and significant risk and uncertainty. The seafood system reflects this complexity and public or private policy changes affecting any node in a supply chain can result in major upstream and downstream market and community impacts. Exploiting the intellectual and public policy tension between concepts such as full utilization and conservation creates significant opportunities for creative research and education. Addressing complex marine problems requires transdisciplinary and systems thinking. Social sciences including economics, sociology and resource management are important disciplines for developing integrative approaches to address marine issues.

CAS has a strong tradition and reputation in conducting integrative natural resource and marine research. Teams of researchers from AEc, COMES, FST, and FW together with colleagues from other OSU colleges have worked on a broad range of marine economic and policy issues. Much of this work has required integrative modeling across ecological and economic systems for evaluating trade-offs between market and non-market goods, alternative user groups and ecosystem services. The work has been policy-relevant and applied for improving coastal resource management, fishery/aquaculture management, and seafood industry management associated with improving production and marketing systems. With CAS's extensive food systems-related assets and tradition in policy-relevant research, it is well positioned to increase integration of social scientists and natural scientists in tackling policy-relevant marine research and discovering and analyzing policies that can expand marine resource food production while also conserving and protecting marine resources.

8. Land-Sea Connection

Estuaries are essential ecosystems that link land and sea, supporting marine life, commerce, aquaculture and coastal communities. Increases in ship transport and coastal development have increased pressures on estuaries, including dredging, pier construction, plastics and run-off pollution, and shore stabilization as sea level rise impacts also increase. Future impacts may also include liquid natural gas terminal construction or other large-scale industries. Coastal estuaries in the Pacific Northwest are also adjacent to agricultural and forest lands, where their management practices affect water quantity and quality upstream from an estuary.

Evaluation and management advice for these human-ecological systems requires strong integrative science that is transdisciplinary, linking biology, engineering, aquaculture, economics, social science, and other fields. Agencies at the HMSC, including EPA, ODFW, and USFWS, have scientists doing important research in estuaries, providing a valuable resource for collaborations. While there is expertise across OSU to address specific issues, there is an opportunity for CAS to become a hub for research on estuaries and resource sustainability problem-solving. This focus area also provides a key linkage to other CAS Strategic Advantages, most notably, Working and Natural Landscapes. Likewise, the location of HMSC on the Yaquina estuary provides an excellent platform for experiential learning opportunities.

CROSS-CUTTING OPPORTUNITIES

In addition to the broader strategic opportunities in marine seafood systems and conservation, there are some cross-cutting opportunities that run through them all.

These include:

1. Transdisciplinary Problem Solving
2. International Engagement
3. Science Communication
4. Education

1. Transdisciplinary Problem Solving for 21st Century Coastal Systems

By its very nature, the marine realm embodies transdisciplinarity. Using, studying and preserving marine ecosystems involves a wide array of natural, physical and human sciences, as well as disciplines outside of the sciences (law, policy, arts). Transdisciplinarity, efforts by individuals or groups from different disciplines working jointly to create new conceptual, theoretical, methodological and translational innovations to address common problems is increasingly important, even critical, as we address increasingly complex challenges in the marine sciences. Catastrophic failures in marine sustainability and conservation (e.g., species extinction) can be attributed to efforts that have proven, in retrospect, to have excluded critical perspectives. Transdisciplinarity offers the promise of a better future.

Expertise in the marine sciences and human dimensions within CAS, coupled with broader OSU expertise provide exciting opportunities for significant advances in transdisciplinarity and foci for centers of excellence. One of the primary lessons resulting from an NSF-funded transdisciplinary program and a cross-nation summit hosted at OSU showed the effectiveness of disciplinary and transdisciplinary approaches to address stakeholder needs. Essential to this process was the cross-college, and indeed, cross-nation composition of this transdisciplinary reach. Notably a number of CAS faculty engaged and assisted with these advances and realizations.

In addition to being a focus area itself, transdisciplinarity represents a tool for increasing science impacts. Aquaculture and Food from the Sea are two focus areas currently considered within MSI provide flagship opportunities for growing the practice of transdisciplinarity (see above). Others include ecosystem-based fisheries management, marine species conservation, ocean energy, potential for use of marine microbes (phytoplankton and bacteria) to produce pharmaceuticals, nutraceuticals and chemicals from marine organisms, and human wildlife conflict issues. In these and countless other scenarios, transdisciplinarity provides opportunities for enhancing understanding and science impacts, even as we develop the tool itself in ways that are crosscutting.

2. International Engagement

Marine systems tend to be transboundary – geopolitical boundaries are artificial constructs in ecosystems where the habitat is largely defined by characteristics of water masses that move around in space through time. Many of the organisms in marine systems are themselves highly migratory. Marine mammals, seabirds, marine turtles, tunas, billfish, salmon and sharks are a few examples of marine organisms that travel thousands of miles, some crossing entire ocean basins during migration or through life cycles that require vast areas (Figure 1). Humans extract marine resources in waters governed not only by the jurisdiction of a single country, but also on the high seas – the commons— where management occurs through international agreements. Regulatory requirements differ across nations and the high seas and 'transfer effects' — resource extraction in regions where regulation is less constrained— can have significant impacts on the sustainability of these resources, and the health of marine ecosystems in general. Marine ecosystems, therefore, by their very nature, are conducive to science that embraces an international perspective.

CAS is well-placed to further advance an international approach to our research, education and outreach. We are already internationally recognized as leaders in many marine fields (e.g., aquaculture, fisheries management, marine genomics, marine mammal biology and marine conservation). We have mechanisms in place to facilitate and catalyze greater international collaboration and education. OSU's reputation for the rigor and effectiveness of its Ecampus programs is a good example, providing an existing and successful model that can increasingly be extended to an international context. And, we have a vision of increasing our international footprint, through enhanced engagement with students and colleagues. CAS involvement with OSU's MSI is an example, with MSI's mission of creating a healthy future for our ocean and the planet through transdisciplinary research and teaching.

3. Science Communications

The commitment to extension and outreach shared by all units in CAS integrates with our research and educational programs and the growing need for strong communication of science topics to the public. Along the Oregon Coast, CAS has substantial linkage among coastal agriculture, fisheries, seafood production and distribution, coastal ecosystem monitoring and conservation. However, the economic health and resilience of coastal communities needs to be more broadly united, branded and better advertised. This communication can be enhanced through our close association with OSG Extension and our faculty and affiliates posted in Port Orford, Coos Bay, Newport and Astoria. The HMSC Visitor's Center provides an excellent platform for outreach and science communication and a training ground for students seeking careers in these fields.

We need to improve and focus our messaging regarding CAS contributions to science in support of sustainable marine ecosystems. Skills in communication are important at all levels –– faculty, leadership and students — and essential for reaching our diverse stakeholder groups. OSG and our many faculty with communications training are important resources that can be better supported.

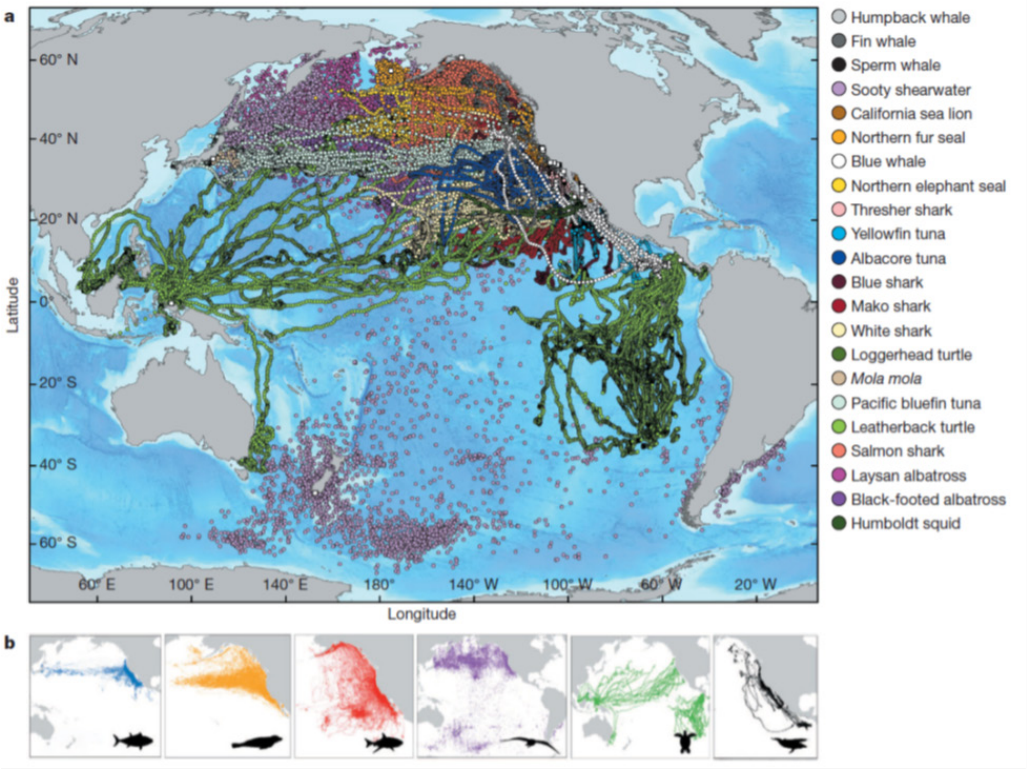

Figure 1. Daily positions of (a) 22 marine species fitted with satellite tags, and (b) six individual species, showing the transboundary nature of their movements. From Block et al. 2011.

4. Education

There is great potential for better integration of curricula across campus in these interdisciplinary areas, including potential for an integrated minor for HMSC. Numerous programs are poised to expand student engagement: Ecampus programs could have much broader impacts internationally; the U.S. Coast Guard educational support program is increasingly popular; CAS undergraduate research and experiential learning could integrate with MSI efforts. In addition, there are opportunities to meet growing interests and improve access to education as programs evolve, including FST's sustainability efforts, potential community college agreements, and additional courses that may align with MSI's Marine Studies degree (such as FW 324 Food from the Sea (Bacc Core CGI) not to mention collaborations with other universities (i.e., UO's marine biology program, PSU CIMRS & CGRB) are just some examples. There are also opportunities to build connections to community colleges in the state, especially with social justice issues that incorporate human dimensions with conservation. However, many students do not know these programs exist, although employers want people trained in these areas. Furthermore, students don't look to CAS for their education if they are interested in marine science, and advances in this focus area may attract non-CAS students to CAS academic programs. These outreach efforts also have the potential to significantly increase the diversity of our student body. We need to increase our visibility.

The convergence of MSI and CAS with the university's expertise in distance education and the reputation of our academic programs provides an unprecedented opportunity to expand national and international participation in our educational and outreach activities. Developing new curricular cross-college options, certificates or minors could be integrated with creative advertising/marketing that would result in greater participation in CAS educational programs centered on the coast (HMSC, Astoria Seafood Lab, Port Orford Field Station). Improved technologies for synchronous distance delivery of seminars and lectures will also help us connect with coastal communities and colleagues.

GOALS

It is not enough to have defined opportunities without detailing some specific goals connected to those opportunities.

For example:

- Build a nationally recognized research and academic aquaculture program known for its innovative and diversified research approach, focus on sustainability and ecosystem compatibility, applied experiential education, and creative engagement with stakeholders and external partners. (from our Aquaculture white paper)
- Increase CAS faculty engagement, visibility and impact on national and international policy-making bodies related to coastal and marine sciences.
- Increase college engagement in MSI's MAST degree and programs by diversifying CAS degrees and certificate offerings in order to increase the number of students in our courses, degree programs, minors and certificates.
- Establish and support transdisciplinary teams to address complex coastal and marine sustainability challenges and increase connectivity of our faculty across terrestrial, coastal and marine systems.
- Launch Food from the Sea research, education and community engagement initiatives with an emphasis on sustainable use of aquatic food systems and workforce training.
- Position CAS to build resiliency in our stakeholders and to address the many accelerating challenges our society faces in coastal and marine environments.
- Increase the level of CAS international research collaborations in coastal and marine sciences by engaging both students and scholars.
- More broadly engage colleagues in other colleges and institutes across OSU in high-quality transdiscipilinarity and develop better links for use of existing infrastructure.
- Encourage additional sources of regional, national and global funding around sustainable food systems and conservation.
- Link up and work with OSU's NOAA Strategic Working Group to more closely dovetail CAS efforts pertaining to this theme with OSU's higher-level efforts to strengthen existing partnerships and create new ones with NOAA in the next decade.

ADDITIONAL RESOURCES + STRATEGIES

There are a number of strategies that are already identified to achieve these goals. They include:

- Encourage/facilitate/support faculty engagement in with other collaborative research programs and organizations (e.g. CIMERS/USDA/USGS, etc.) and.
- Engage leadership in cross-college discussions regarding transdisciplinary research.
- Help junior faculty make connections across areas of interest among faculty and agencies via ignite sessions, ambassador programs or a university-wide research engine.
- Facilitate/create/support a cross-college policy institute focused on translation of marine science to actionable policies.
- Engage/empower a group of education innovators within the college to develop new cross-college integrated curricular options, certificates or minors.
- Encourage teaching faculty to develop transdisciplinary/crosscutting courses or course materials with transdisciplinary science as a learner outcome.
- Provide incentives for faculty/units from the college to lead efforts to support students who may require a longer time to degree completion.

- Recognize and enhance opportunities that already exist for transdisciplinary activities: MSI, MMI, Sustainability B.S. Degree, etc.
- Rely on senior faculty for leadership in these areas to reduce potential risks.
- Consider barriers to faculty and student participation and how they can be reduced.
- Ensure credit/recognition for transdisciplinary and collaboration efforts.
- Recognize effort/time and resources needed to execute these plans.
- Provide mentoring that recognizes need for faculty to maintain discipline-specific research in tandem with collaborative efforts.
- Increase CAS-level outreach to foundations and nonprofits that support overarching program efforts (food sustainability and marine conservation).
- Provide seed-grants focused on collaboration/transdisciplinary activities by building teams or Hubs of Action.
- Develop and support seafood processing and culinary centers (linking MSI and Astoria, Port Orford, labs and housing).
- Develop the capability to think rationally and bravely into the future by engaging panels for futurist engagement and development of appropriate proactive strategies.

OTHER NEEDS

To maximize the ability to deploy these strategies and meet defined goals within marine seafood systems opportunities, some investment is necessary.

Many of the goals and outcomes for this theme can be achieved with minor investment, realigning internal resources or by hosting and facilitating teams to work together to develop research proposals or curricula. Some of these goals and outcome, however, are likely to require significant investment, primarily in the form of faculty appointments to lead or participate in research in specific areas and fund-raising initiatives.

We have identified eight positions (Appendix A) that will be required if CAS is to make significant progress on some of these goals. We acknowledge that CAS has a long-standing priority staffing process by which faculty positions are vetted first within units and then at the college level. Some of these positions have been vetted at the unit and college levels and two have been approved but are currently subject to a hiring freeze. In addition to this human capacity, we identified significant infrastructure needs in the form of a new marine aquaculture facility. The seawater system at HMSC is a unique attribute, but currently possibilities to expand marine aquaculture are limited. The NOAA Aquaculture Lab is at capacity and OSU does not have its own marine aquaculture facilities. Funding for a new aquaculture facility could be accomplished during the new Campaign for OSU or via federal appropriations to NOAA or USDA, supported by a cooperative agreement.

External Support

Another means to maximize the realization of the many opportunities within Marine Seafood Systems and Conservation is to connect with external support and resources.

External support and resources to pursue this theme would come from three primary sources. CAS sponsored research assistant, Cody Hess, conducted a search of current RFPs with multiple keywords such as aquaculture, seafood, marine, coastal and conservation on September 3, 2020. Primary funding for initiatives identified under this theme would come from federal agency support. Search of RFPs identified 15 federal programs within NOAA, NSF, USDA, USFWS, Smithsonian Institution and Sea Grant current solicitations.

The RFP search also identified five foundations or nonprofit organizations currently offering support of coastal and marine-related programs. Direct solicitation of seafood processors and other coastal and marine business or development efforts specifically targeting such programs can identify industry partners supporting initiatives under this theme.

Finally, we believe that substantial additional federal resources may be available by engaging OSU's Director of Federal Government Relations and peer institutions in coastal states in an effort to broaden research programs of both USDA and NOAA to include seafood-related research. Currently, USDA supports some aquaculture-related research, but otherwise has not supported seafood-related programs. Likewise, NOAA supports research related to sustainable fisheries and aquaculture, but does not support seafood processing research.

The OSU Foundation could also engage faculty and unit leaders in identifying donors who would support this theme. Finally, there is the opportunity to increase fee for service/designated operations activities in many areas such as marine genomics, workforce training, RV Pacific Storm operations, etc.

Appendix A. Positions needed to build capacity to achieve some of the goals and outcomes of the Marine Food and Conservation strategic advantage.

- Ecosystem, Stock Assessment Scientist—This position would be jointly funded by CAS and Oregon Department of Fish and Wildlife and would replace the position that David Sampson vacated on retirement. This position was approved during the 2019 priority staffing process.
- Seafood Microbial and Human Health Biologist—This 1.0 FTE position replaces the position vacated by Yi-Cheng Su (now deceased). This position was approved during the 2019 priority staffing process.
- Human Dimensions Scientist (COMES/FW or AEC)—1.0 FTE position in human dimensions will add critical components to transdisciplinary programs in coastal and marine environments; many federal RFPs call for human dimensions expertise.
- Coastal/Marine Economist (COMES/AEC)—This 1.0 FTE position would replace expertise formerly provided by Gil Sylvia. The position would conduct analyses of coastal and marine seafood and conservation sectors, or conduct trade-off analyses or develop impact assessments among competing opportunities in coastal and marine environments. Many federal RFPs seek to support teams that might include an economist.
- Director, Center of Excellence in Aquaculture—0.5 FTE position to provide leadership and coordinating focus for a new Center of Excellence in Aquaculture as proposed in an Aquaculture Investment in Seafood Security faculty proposal. This would be a two-year investment designed to coordinate the considerable expertise OSU currently has in aquaculture. This investment might come from the Research Office, via contributions from CAS, federal funds or a combination of these sources. The Center of Excellence in Aquaculture would also need some administrative support.
- Senior Policy Director of a cross-college marine policy institute. This is a 0.5 FTE leadership position for a yet-to-be-funded marine policy institute. This investment might come from the Research Office, via contributions from among multiple colleges (CAS, CLA, COS, COEAS), federal funds or a combination of these sources. The policy institute would also need some administrative support.
- Marine Seafood and Conservation Futurist—Coastal and marine environments are complex and rapidly changing. CAS would benefit from a faculty member who specifically focuses on envisioning the future status of marine seafood systems and conservation.
- Sustainable Seafood and Surimi Processing Scientist—This position will be needed in the near future to replace Jae Park, who has retired, if CAS is to retain its national prominence in surimi development.