Preliminary Evaluation of Oregon Marine Map Data and Information

Prepared by the Oregon Scientific and Technical Advisory Committee
for the Ocean Policy Advisory Council

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Table of Contents

1. Executive Summary and Recommendations 1
2. Background and STAC Procedure 7
3. NEDA Bird and Mammal Review 9
4. NEDA Fish Review 14
5. NEDA Habitat and Ecosystem Review 21
6. NEDA Marxan Review 26
7. Fishing Grounds Mapping Review 29
8. Acknowledgements 38
9. References 39
10. APPENDIX 1: STAC Scope of Work 40
11. APPENDIX 2: Reviewers 41
12. APPENDIX 3: Review Timeline 42
13. APPENDIX 4: List of Acronyms 43

1. Executive Summary and Recommendations

Introduction and Charge

The Scientific and Technical Advisory Committee (STAC) was asked by the Ocean Policy Advisory Council (OPAC) to undertake an independent scientific peer review of the data sets and information used for Oregon's Territorial Sea Plan. STAC members and invited external experts reviewed two basic data sets – (1) the Nearshore Ecological Data Atlas (NEDA) led by the Oregon Department of Fish and Wildlife (ODFW) and (2) the Oregon Fishing Community Mapping Project (OFCMP) led by Ecotrust. The ultimate goal of these mapping projects is to develop an integrated map in *Oregon MarineMap* (oregonmarinemap.org) as a spatial tool for supporting planning and use of Oregon's Territorial Sea. Per OPAC's request, STAC focused its scientific review on key issues of these two programs; 1) assumptions, 2) data validity, 3) sampling design and methodology, 4) data gaps, 5) spatial representation, and 6) strengths and limitations. STAC limited its analyses to scientific questions and did not deal with policy issues. STAC's review is considered a *preliminary* evaluation because of the limited amount of time available to conduct the review and because MarineMap continues to be updated.

Scientific **peer review** is the standard process to evaluate the work of others 'in order to enhance the quality of the work or performance in that field.' Peer-reviewed science is the hallmark that provides robustness for proposed projects as well as data analyses and conclusions drawn by those analyses. It is based on the concept that a separate and independent review will usually find more weaknesses and errors in a body of work which provides guidance to help improve the final product. It is in this light that STAC provides its evaluation. Normally peer review is done at the onset of a project to evaluate the project design or at the conclusion of a project to evaluate data end products, analyses and conclusion. In our case, we are providing an evaluation of a data framework that is under continual development and improvement. As such, we hope that this STAC 'snapshot' evaluation at a point in time will provide some guidance towards future developments and analyses of this 'living document.'

Overarching Conclusions

After undertaking this scientific peer review of Oregon's efforts to map resources and uses in the Territorial Sea to date, STAC review team members were very impressed with the quantity and quality of work that the state and its partners have invested to build and populate Oregon MarineMap. Clearly, Oregon is among a hand full of states in leading the nation in this area. This was a much needed and monumental effort and it was abundantly clear that many people have dedicated substantial time and careful thought to this complicated process, and commendable progress has been made. This was an excellent start to compiling existing data sets into a spatial framework to provide an accessible platform for future management needs. The information here can clearly help inform Territorial Sea planning in a robust way.

While the state's efforts are impressive and there are many notable strengths, STAC notes that there are also weaknesses in both of the reviewed programs which OPAC, managers, and policy makers should be aware of when making site-specific decisions about uses in Oregon's Territorial Sea and when weighing the values of different data and looking for opportunities to invest in further data collection or analyses. In this review, STAC identified and commented on some concerns regarding assumptions, data validity and sampling design, data gaps, and spatial representation. These critiques range from simple, easily-addressable issues (e.g., clearer documentation), to potential questions of interpretation of the data, to more fundamental concerns on the strengths of the underlying data sets. This review includes recommendations on how to alleviate issues and provides guidance on priorities for future investment of time and money. Indeed, certain actions (e.g., release of crab catch data, increased documentation on the Marxan process) have already been taken, in part, as a response to the STAC review.

Review Constraints

This scientific review occurred under a tight timeline (roughly two months) by volunteer efforts, and STAC review team members believe that additional time and information is needed to provide a more thorough assessment of the products. Further, the STAC review team lacked adequate expertise in the modeling tool used by the state (Marxan), limiting their ability to provide a detailed technical review of its application to the Oregon mapping process. Due to these constraints on studying the documentation and analysis techniques for this complex project, some of STAC's questions, critiques and recommendations may be already incorporated and addressed in the state's work.

General Suggestions on Process and Documentation

1) STAC suggests that all information and methodology be clearly and thoroughly documented and catalogued. STAC understands that most of the current documentation was intended for data users but more complete documentation of methods, assumptions, decision-points and rationale will aid in substantiating the validity and usefulness of the data to the user. Currently, much of the rationale, assumptions and some of the accuracy assessments for both the NEDA and OFCMP efforts are in separate documents not yet (to STAC's knowledge) easily or uniformly accessible. Compilation of a synthesis document that includes such information would greatly facilitate users' ability to more fully evaluate the approach. Citations of original method description in reports or publications that were used should be clearly listed. All assumptions and rationale for selections of data should be thoroughly explained. Once this is completed, a more rigorous review of these data should be performed.
2) More care should be taken on terminology. For example, the use of the word 'diversity' should be replaced with a more exact term when referring to only a limited number of fish species. Likewise, the use of the term 'benthic habitat' when referring to a bottom type should just be replaced by the habitat type (e.g., sand, mud) since habitat is normally defined on a species-specific basis.
3) It has been clearly stated that Territorial Sea spatial data are a living record that will be continually upgraded, modified or added to. As such, STAC recommends that a process be discussed on how best to institute regular peer reviews.
4) STAC also recommends that in the future, it would be beneficial and more efficient to have an independent scientific peer review during the proposal stage for projects that will involve substantive monitoring, data collection and mapmaking, such as the state's process to populate Oregon MarineMap.

Overarching NEDA Comments

Strengths

ODFW and their contractors and data contributors accomplished an impressive amount of work in their NEDA efforts to date. The work is particularly impressive given the tight time constraints of the project and the limited financial resources. Oregon MarineMap is a great tool for the state's planning efforts, and the ecological data layers can continue to be improved upon as new data and resources become available. A clear distinction should be made of the underlying data and the Marxan model analyses. The underlying data evaluation largely considers the methods used to collect the data and the analyses and interpretation of what those data represent. The Marxan analysis uses these data and evaluates the consequence of policy decisions or weighting to produce spatial maps. The Marxan analysis is a quantitative policy implementation/management tool that provides near-optimal or 'good' solutions for implementing ecological protection based on a series of policy decisions and goals. It uses the NEDA data layers as input and results depend on 'policy' or management-level decisions. Marxan takes assumed costs into consideration and designates the smallest areas that meet the stated goals.

Limitations and Recommendations

Documentation and Process

- Not all of the explanatory language and method documentation are readily available nor consolidated in one place.

  Recommendation: The NEDA project would be strengthened by increasing accessibility to background rationale and methodology for all analyses and evaluation results used to support certain assumptions, potentially combining these into one synthesis document.

- The state's mapping efforts are an evolving process and must be seen as a work in progress, a living document.

  Recommendation: Measures should be made to ensure that MarineMap (and the Marxan criteria) and runs are updated as future data sets become available. Regular peer scientific evaluation should be included as part of the process.

Data Gaps and Data Set Labels

- NEDA, by design, only includes data that were collected across the entire Oregon Territorial Sea at appropriate spatial scales. Also, by necessity of an Atlas, NEDA only shows static data although the Oregon ocean is very dynamic. Variation in the water column (temperature, salinity, currents, dissolved oxygen, chlorophyll), in the nearshore bathymetry, and in the abundance and distribution of biological organisms is an overarching feature of the Oregon nearshore. A particular limitation is the limited data available for the non-summer seasons, thus important fall, winter, and spring areas that may differ from the summer distributions are not represented.

  Recommendation: Some indication of this seasonal and interannual variability (and precaution in data interpretations) should be given.

- The existing data included in Oregon MarineMap and in Marxan, though possibly the best available at present time, are not representative of species richness or diversity in the Oregon Territorial Sea, particularly because they are largely lacking invertebrates which comprise about 90% of species and the majority of biomass.

  Recommendation: If capturing biodiversity is a goal of the state, then they should work towards adding more data layers, such as invertebrates. A short term solution that the state could consider is to include gravel as a habitat type because gravel provides more useful diverse habitat than 100% rocky reef. .

- The presence of sampling data within the Territorial Sea is low.

  Recommendation: As resources permit, the state should work towards increasing data within the Territorial Sea. Meanwhile, if a Marxan grid cell (or assessment unit, AU) is too far from the collected data (the prediction unit), STAC recommends not making the prediction or, at least, evaluating the consequences of this extrapolation. Otherwise there is a risk of extrapolating too far and introducing error. All such extrapolations and inherent assumptions should be clearly stated to allow a better understanding of what the data mean.

Data Interpretation/Modeling

While the underlying data sets being input into MarineMap can be scientifically evaluated, there were many decisions made in the Marxan modeling (such as, the weighting of different data layers) that STAC believes are based on policy or decision, and were not (or not intended to be) based on strictly scientific considerations.

Recommendation: All policy and choice decisions inherent in the Marxan process should be identified as such up front. More clearly justify why certain decisions were made, such as, why a given model domain boundary modifier was chosen. Where appropriate, run additional Marxan analyses to show how results would differ were other modeling decisions made or parameters used. Additionally, STAC recommends that a panel of outside experts familiar with the application of Marxan be asked to provide a detailed technical review of how this program has been applied to the Oregon maps.

- There is no 'model performance evaluation' for the Marxan output. STAC is concerned that the complexity of the model coupled with the many data layers that went into the modeling scenario, makes it almost impossible to judge the validity of the Marxan output or the relative weight/importance of particular data layers. The scientific implications of policy decisions (e.g., equal weighting of certain biological types and physical measures, definition of boundary modifier) could/should be evaluated.

  Recommendation: One potential solution is to run a series of simpler simulations (e.g., based on far fewer data fields) in which the outcomes are known, and ask whether Marxan is able to recover the solutions. Selectively removing certain data layers may also provide some sense of model sensitivity or robustness to certain data. It would also be useful to see the percent accuracy of the underlying models separated by nearshore and offshore areas.

Other Considerations

- In general, if data were not spatially extensive (i.e. statewide), they were not included in NEDA and the Marxan analysis. Therefore, detailed site-specific information was not used in the analyses. This is deemed a reasonable approach. However, it might be useful to create a separate (meta) database for detailed or site specific data that could be used in permitting in the future or could be used to test overall marine map data generation.
- The data were largely measures of structure (e.g., biological abundance, surface temperature) and not function or processes (e.g., biological productivity, currents and retention). These are generally the type of data that are available. Care should be given when using structural data to infer ecosystem functions.

Overarching OFCMP Comments

Strengths

The OFCMP mapping process and Open Oceans map software provided a valuable tool and unique opportunity to address an important data gap on the spatial use of commercial, charter, and recreational fisheries in the Oregon Territorial Sea. Further, these data were intended to help assess the potential social and economic value and importance of spatially-defined areas. The data and mapping process engaged a large number of fishing community members in self reporting data, reviewing data, and approving map products.

Limitations and Recommendations

- Documentation – There were significant gaps in documentation of project methods and evaluation.

  Recommendation: More clearly document the entire OFCMP project (data collection, evaluation, and map production) into one report.

- Sampling Design - The data sampling process in the commercial and particularly recreational fisheries was potentially biased due to the non-random nature of the survey design, non-random participation (purposeful sampling), and/or low sector survey participation. Data extrapolation is not valid.

  Recommendation: The potential identified fundamental biases that may exist in the OFCMP data due to the sampling design need to be fully assessed. If the state decides to collect additional fisheries data, STAC recommends that a scientific review of the proposed methods be conducted before the project begins.

- Data Validation - There was no attempt to validate the results, even though data were collected through surveys and self-reported, and self or industry verified.

  Recommendation: Reviewers need access to the raw data for validation, or at minimum, data collection and transformation need to be more clearly documented in order to authenticate the approach.

- Data Verification – STAC has substantial concerns with the data ‘verification’ that was done after the initial maps were created. Researchers then went back to ‘key’ individuals to review the maps to determine if they accurately represented that individual’s fishing sector, and then modified the maps based on the feedback. It is not clear how these individuals were selected, nor is it clear how much the maps were modified based on the feedback from these key individuals. This verification method is not scientifically valid. The original maps are likely to have more scientific validity than the revised maps.

Recommendation: STAC recommends that the pre-verification maps be made available to future reviewers so that the influence of the feedback is clear. One could also derive 'difference maps' that should depict the degree of change in the maps.

- Data Weighting – Inconsistent and inappropriate weighting across fishing sectors and aggregation methods used to produce the OFCMP port maps limit the potential application to define 'importance' or determine economic and social fishery value for specific spatial areas. Lack of access to the data (at the time the STAC review was conducted) and maps also limits the ability of reviewers to evaluate the OFCMP data, mapping process, and sensitivity of alternative weighting schemes, as well as limiting the use of the maps for the Territorial Sea and spatial planning process.

  Recommendation: Consider using non-aggregated maps or more appropriately weighted aggregation maps for planning.

1. Background and STAC Procedure

On January 18, 2012 the Oregon Ocean Policy Advisory Council (OPAC) requested (Appendix 1) that the Scientific and Technical Advisory Committee (STAC) review, to the extent possible, the data sets and information used in Oregon MarineMap that form the foundation for the spatially-explicit Territorial Sea Plan. More specifically, OPAC requested that STAC review the (1) Nearshore Ecological Data Atlas (NEDA) led by the Oregon Department of Fish and Wildlife (ODFW) and (2) the Oregon Fishing Community Mapping Project (OFCMP) led by Ecotrust. STAC limited its analyses to scientific questions and did not deal with policy issues. The timeline for the review was about two months (See Appendix 3).

This scientific peer review is intended to provide a level of robustness to the data framework informing the Territorial Sea planning process. As such, the STAC review should also provide guidance to the state on a data framework that is under continual development and improvement.

To address this charge, STAC recruited additional subject-matter experts and broke into the following five teams (*see Appendix 2 for a list of team members*):

1. NEDA Birds and Mammals
2. NEDA Fish
3. NEDA Habitat and Ecosystem
4. Marxan
5. OFCMP

STAC then held a series of team meetings and a combined open meeting. Agency staff and contractors participated in many of the meetings and provided briefings and answered both written and oral questions to aid in this process.

Evaluation Criteria

To the extent practicable, each team evaluated the data sets and information relevant regarding;

1. Assumptions
2. Data validity and sampling design
3. Data gaps
4. Spatial representation
5. Strengths and limitations

Each of the four NEDA review teams considered the data sets by looking at the use of the data in Marxan, its representation in the Oregon MarineMap, the explanation of the metadata and the ODFW data cross-walk list. In this report, the data descriptions are purposely very abbreviated. If readers want to fully understand the data, they would need to refer to the metadata, the future ODFW NEDA data report (currently in progress), MarineMap abstracts, and published literature about the data (where available).

The OFCMP review team did not have access to the original data due to confidentiality, and therefore reviewed existing documentation of the methods for data collection and map preparation, and used their expertise to evaluate these methods as well as the display and interpretation of the results. As part of their assessment, the OFCMP team reviewed the methodology to create the port maps, including the number of interviews conducted.

3. NEDA Bird and Mammal Review

Team Members

Jan Hodder (team lead), Oregon Institute of Marine Biology, University of Oregon
Dawn Goley, Humboldt State University
Harriet Huber, National Marine Mammal Laboratory, Seattle
Rob Suryan, Hatfield Marine Science Center, Oregon State University

Relevant NEDA Data Sets used in the Marxan Analysis

Seabirds

- United States Fish and Wildlife Service (USFWS) seabird nesting colony data
- Western Snowy Plover Critical Habitat
- Crescent Coastal Research nearshore seabird surveys
- Modeled data from Point Reyes Bird Observatory for the California current

Pinnipeds

- ODFW Pinniped haul–out surveys
- Steller sea lion critical habitat

Cetaceans

- Crescent Coastal Research (CCR) nearshore seabird surveys – data for harbor porpoise and gray whale sightings
- Modeled data from the National Oceanic and Atmospheric Administration (NOAA) cetacean densities in the eastern Pacific Ocean

Strengths, Limitations, and Recommendations

Seabirds

USFWS Colony data – represented in the Oregon MarineMap by point locations ranked high, medium, low

This robust data set uses rankings based on colony size, type (e.g., offshore island), and presence of species of concern. The data are very good for surface nesting species but more limited for burrow nesters. The spatial representation is good.

> Recommendation: One improvement would be for species-specific outputs which would provide more information on regional concerns, e.g., concentrations of nocturnal species that are vulnerable to light pollution.
>
> Data gaps: Little is known about the foraging range and distribution of breeding birds away from the colonies. This is especially true for species that forage beyond the 3 mile, nearshore region. For example, southern Oregon nearshore seabird abundance data (see below) show relatively low abundance despite the presence of some very large colonies of more distant, offshore foraging species. Brown Pelican roosting sites are missing.

Western Snowy Plover Critical Habitat

This is a good data set represented by location in the Oregon MarineMap. Reviewers noted, however, that the USFWS is in the process of updating the critical habitat designation and are currently reviewing public comments, evaluating the economic analysis, and developing the final designation. The deadline for publication is in June 2012.

> Recommendation: The new USFWS designations, once available, should be reflected in the Oregon MarineMap.

Crescent Coastal Research (CCR) surveys used for NEDA Nearshore seabird surveys (2000-2010)

Surveys were conducted for Marbled Murrelets and all other seabirds within 3 km (southern Oregon) - 5 km (northern Oregon) of the shoreline. Data are presented as average absolute density (although abundance is the term used in the Oregon MarineMap), as number of individuals km^{-2}, and as species diversity. The densities of only five species/species groupings - Common Murres, Brandt's Cormorants, Marbled Murrelets and Loons and Grebes - are represented as separate Marxan targets. The Marxan analysis assumes polygons are adequately represented by transects within them. This is a comprehensive data set that covers the very nearshore area where large research vessels cannot survey; it includes multiple years, but is only from May – Sept.

> Data gaps: The outer area of the Territorial Sea south of Coos Bay is less well covered in both extent and number of survey years. It does not include fall, winter, or spring densities and, thereby misses migration periods and ability to identify migration corridors/hotspots. The species composition and abundance of marine birds are often considerably different during winter.

Modeled data from Point Reyes Bird Observatory (PRBO) for the California current – foraging 'hot spots'

The data set for this layer are habitat – association spatial models for 16 species of seabirds in the California Current System collected over an 11 year period (1997 – 2008). Using only the Oregon coast portion of the these modeled distributions for the entire California Current System (Canada to Mexico), the Oregon MarineMap shows modeled PRBO seabird abundance, persistence and importance for Oregon waters, and the top 2.5% of the cell values as indicative of predicted foraging hotspots. Marxan creates a single output using the CCR data for nearshore and PRBO modeled data for offshore.

The PRBO model was developed for the entire California Current and Marxan assumes it adequately predicts bird distribution off Oregon. The PRBO data model however only used one year (2008) of Northwest Fisheries Science Center (NWFSC) data for Oregon so this assumption may not be robust.

> Recommendation: It would more robust for Oregon data to be modeled independently of the rest of the California Current, specific to coastal Oregon hydrography and bathymetry. The

Columbia River plume, a known hot spot, for example, does not show as a hot spot in this analysis, neither do portions of the broad shelf in northern Oregon.

There is no ground truthing of these data and the hot spots strongly represent breeding distributions as evidenced by high density areas in the Oregon MarineMap associated with major seabird colonies. The spatial representations of these data are almost wholly from outside the Territorial Sea, which is not as problematic since CCR data were used for nearshore. The abrupt transition in some instances between nearshore-offshore Marxan output, however, suggests that the PRBO modeled offshore versus CCR observed inshore distributions give inconsistent results.

Data gaps: Modeling of winter data are very limited. More complete data of seabird surveys offshore Oregon are believed to be available for modeling from NWFSC.

Pinnipeds

ODFW Pinniped haulouts – *represented in the Oregon MarineMap by ranked numerical categories by reach (= shoreline segment).*

This robust data set uses rankings based on number of animals present during surveys primarily conducted in the spring and summer and with a lesser number in fall to capture California sea lion peak numbers. Marxan modeled these data by normalizing shoreline segment use for all species on a single scale, then using that value as the 'abundance' for each reach x species combination. This maintains the relative importance of any reach for a species, but also recognizes that a haulout 1000 meters in length is inherently more important than one 10 meters in length. This complicates the interpretation and could, in some cases, misrepresent the data. For example, some harbor seals are found on a long series of rocks in ones or twos totaling perhaps 20 animals. This haulout is less important than a smaller area with more seals where pupping occurs. Although the assumption that harbor seals pup anywhere they are found is valid, there are some concentrated harbor seal pupping locations that could be pulled out from the data set. Despite this concern, a review of what the data looks like in Oregon MarineMap indicates that the pinniped data are well represented. The data presentation in the Oregon MarineMap could be improved however.

Recommendation: Reviewers suggest that ODFW use the same types of icons as for the seabird colony locations. Colors for the numerical categories are difficult to distinguish as they are too close to each other in shade and if you were color blind you would never be able to see the differences. On Oregon MarineMap, in the Help section, under navigating, there is a video demonstration of how to use the marine mammal data layer. It shows different icons for each species at each haulout and when a species is clicked on, it gives real data on numbers and age classes present. This is much more useful than what is presently on the Oregon MarineMap. There are otariid tracking data and brand resight data that may be of use for future Oregon MarineMap layers.

Data gaps: At sea use – foraging hot spots and winter distributions – are missing, especially for California sea lions. Harbor seal pupping ’hot spots’ are also lacking.

Steller sea lion critical habitat

This is a good data set represented by location in the Oregon MarineMap.

Cetaceans

Crescent Coastal Research surveys for nearshore cetacean relative abundance - harbor porpoise and gray whale Pacific coast feeding group

The data set comes from nearshore surveys conducted principally for Marbled Murrelet censuses. Cetaceans were a secondary target. This data set has the same spatial representation details as that for the nearshore seabirds in that the outer areas of the Territorial Sea south of Coos Bay are less well covered. For harbor porpoises, this is a visual survey using a line transect method and numbers are per unit effort (Average number of individuals/linear km of transect). The data set for harbor porpoises covers multiple years (1992-1995 and 2000 – 2010) but is only from May – September. Visual surveys are probably not the best for harbor porpoise due to their size and poor delectability at the surface. Hydrophone surveys are a more precise way to detect these animals.

Gray whales that were sighted during these surveys were not recorded with line transect measure, distance or bearing estimations. Without these data, the encounter rates cannot be converted to densities. The data set for gray whales covers multiple years (1992-1995 and 2000 – 2010) but is only from June – September. Gray whale survey data were modified to exclude encounter rates from May to eliminate the possibility of including migrating gray whales in the analysis.

> Data gaps: October – April distributions and densities for harbor porpoise are missing. Additional data on harbor porpoise numbers for the southern part of the state are available from the US Forest Service Redwood Sciences Lab. Additional data for the gray whale Pacific coast feeding group includes telemetry and photo identification available from several research groups.
>
> Recommendation: Convert data for harbor porpoise into densities rather than numbers per unit effort. Support efforts to consistently document year-round habitat use of cetaceans throughout the Oregon Territorial Sea.

Modeled abundance data from NOAA - cetacean densities for 12 species in the eastern Pacific Ocean.

Data is represented in the Oregon MarineMap by four abundance categories of low to high abundance that differs in numbers between species. The data are from ship-based cetacean and ecosystem assessment surveys used to develop habitat models to predict density for 12 cetacean species in the California Current Ecosystem. All data were collected by NOAA's Southwest Fisheries Science Center from 1986-2006. Note that the Oregon MarineMap data information says, 'Data include over 17,000 sightings of cetacean groups on transects covering over 400,000 km.' The original report indicates that this large data set also includes a large number of sightings from the Eastern Tropical Pacific. Reviewers have assumed these were not used in the Marxan modeling.

The NOAA model was developed for the eastern Pacific Ocean and Marxan thus assumes it adequately predicts cetacean distribution off Oregon. There is no ground truthing and many of the species are unlikely to occur in the Territorial Sea. The spatial representations of these data are almost wholly from outside the Territorial Sea. Relative abundance km^{-2} is modeled and then distributed amongst four broad categories of low to high abundance. These categorical data are very coarse and thus distinctions between the four categories are not necessarily supported well by biology. The north/south components of the model however are likely valid, based on biological knowledge of the animals represented, whereas the offshore/nearshore components may not be so well supported.

Data gap: Lacking information from the Territorial Sea.

Recommendation: Focus efforts on species likely to be observed in the Territorial Sea. These include Gray whales, Humpback Whales, Blue Whales and harbor porpoise.

4. NEDA Fish Review

Team Members

Jeff Feldner (team lead), Oregon Sea Grant, Oregon State University
Lorenzo Ciannelli, College of Earth, Ocean, and Atmospheric Sciences (CEOAS), Oregon State University
Jessica Miller, Department of Fish and Wildlife, Oregon State University
Bill Pearcy, CEOAS Professor Emeritus, Oregon State University

Relevant NEDA Data Sets

Fishery Independent Trawl Data

- ODFW flatfish trawl data (1971-1974)
- NWFSC shelf and slope surveys (annual slope trawl survey, 1998-2002; slope and shelf trawls, 2003-2010)
- AFSC shelf and slope surveys (triennial shelf – slope and shelf, 1977-2004)

Fishery Dependent Data

- ODFW groundfish trawl logbook data
- Oregon Enhanced Data Collection Program
- ODFW Dungeness crab logbook data (2007/08 and 2009/10)
- NOAA and TNC MaxEnt fish and Dungeness crab model output

Summary of Data Sets and Modeling Methods

Fishery Independent Trawl Data

ODFW worked with the NOAA Biogeography Branch to map the fishery independent trawl data. Their approach used binary logistic regression tree methods to derive the final outputs in their fish modeling.

Spatial predictive models for six fish assemblage metrics were developed for waters offshore of Oregon. Three data sets of fishery-independent trawl data were used. These included ODFW's nearshore trawl data and NMFS Slope and Shelf trawl survey information. The goal of this analysis was to identify 'hotspots' for species abundance and diversity. The development of the model used 7,671 research survey trawls, of which 141 occurred in Oregon's Territorial Sea (TS).

Boosted regression trees (bootstraps) were used for cross validation wherein the modelers held back 20% of the data to use as secondary validation/accuracy assessment. The validity of model results in nearshore (<3nm) and offshore areas (>3nm) were made available in the materials provided to STAC.

Abundance, biomass and taxonomic data were obtained from three data sources, all of which collected data using benthic trawls: ODFW flatfish trawl data, NWFSC shelf and slope surveys, and AFSC shelf and slope surveys. According to the metadata, predictive models were developed for: 1. All species – biomass; 2. All species - count / abundance; 3. All species - number of species / species richness; 4. All species – diversity; 5. Nearshore species – biomass; 6. Nearshore species -count / abundance.

The following list includes Marxan targets (TS = Territorial Sea)s:

- Abundance (in TS)
- Abundance (outside TS)
- Biomass (in TS)
- Biomass (outside TS)
- Species richness (in TS)
- Species richness (outside TS)

Biomass of nearshore group (Nearshore Group included: Sand Sole, English Sole, Pacific Sand dab, Speckled Sand dab, Petrale Sole, Starry Flounder, Butter Sole)

Models used eight distinct spatial layers to derive 42 environmental predictors. Fish metrics were predicted to all grid cells in the spatial analysis grid using fish-environment relationships modeled using boosted regression trees for continuous variables and binary logistic regression trees for categorical data (High/Low classes). High values (hotspots) were defined as the top 10% of values (=>90th percentile). For all assemblage-level fish metrics, the binary classification outperformed continuous predictions. Due to poor performance and high uncertainty/error for continuous metrics, only hotspot maps were produced and assessed with an independent data set (random 20% of nearshore & offshore trawl samples held back n=1,534).

The following layers were not incorporated in the Marxan modeling efforts but are included in the NEDA;

- Green Sturgeon ESA Critical Habitat (NOAA, 2009): not in marine map & not a Marxan target
- Oregon Coast Coho Salmon ESA Critical Habitat: in MarineMap but not a Marxan target
- The locations of NMFS and ODFW trawl locations: a layer in MarineMap but not a Marxan target

Additional information can be found in the ODFW produced *STAC fish briefing report* (located on the oregonocean.info website listed in the reference section of this report).

Fishery Dependent Data

ODFW worked with The Nature Conservancy (TNC) to model fishery dependent data using MaxEnt (maximum entropy). This technique was used to analyze trawl logbook data and Oregon Enhanced Data Collection Program (EDCP) trawl information.

<u>Groundfish trawl and EDCP data</u>
There were a total of 53,393 groundfish trawls and/or EDCP observer samples, of which 913 were in the Oregon Territorial Sea.

There were 9 predictor variables (e.g., SST, chlorophyll, bottom depth). Presence-only data were used and MaxEnt is built to deal with presence-only data. The model product outputs are probabilities of occurrence.

TNC modeled presence data for petrale sole, sane sole, dover sole, sablefish, lingcod, and pacific sandabbut the information is not in MarineMap due to confidentiality concerns. The following list includes the Marxan targets:

- Petrale sole (inside TS) & Petrale sole (outside TS)
- Sand sole (inside TS) & Sand sole (outside TS)
- Dover sole (inside TS) & Dover sole (outside TS)
- Sablefish (inside TS) & Sablefish (outside TS)
- Lingcod (inside TS) & Lingcod (outside TS)
- Pacific sand dab (inside TS) & Pacific sand dab (outside TS)

<u>Dungeness crab data</u>
Analysis of crab data included two years of recently implemented data (2007/08 and 2009/10). The data covered a relatively narrow bathymetric range and clearly represent a snapshot in time. Crab populations and distribution can and do vary on temporal scales.

Modeled presence of Dungeness crab were developed but are not included in MarineMap due to confidentiality concerns. Marxan targets include Dungeness crab inside and outside of the TS.

<u>Difference between fish and crab analyses</u>
Crab were represented by the centroid of the end points of the pot string and fish data are represented as the centroid of each trawl line.

Strengths, Limitations, and Recommendations

Initiating a process to compile existing information on some of the state's commercially and recreationally important marine species is a substantial step forward and will facilitate future management and spatial planning efforts in the state and region. Additionally, the future use of the data products is relatively wide-open, e.g., for assisting with future spatial planning and permitting. However, the spatial scales and temporal resolution of the various data sets vary and the methods associated with the original data collection and derived products are in several different files or on-line locations or not yet summarized – which made the data sets and interpretation challenging to review. Given these aspects and the fact that the documentation process is still ongoing, an overall conservative approach in terms of reliance on these derived products, at least in terms of the fish data, appears to be warranted.

Assumptions

- Overall, it was challenging to understand all of the assumptions associated with these data sets. The documentation is in a number of files and much of the final product is based on derived products. Based on initial conversations with TNC and NOAA, it appears that some of the assumptions of concern (such as the validity of combining nearshore data from the early 1970s with a 30-year dataset that includes deeper waters) may have been explicitly evaluated but the results of those evaluations are not yet accessible to the reviewers.

- It was assumed that logbook and ODFW data were representative of the distributions, abundances (NOAA-7 flatfishes, ODFW-5 flatfishes, lingcod and Dungeness) and biomass, counts of the best ecological areas for fishes off Oregon. This also assumes that these distributions have not changed over time because of over fishing past hot spots, that they are robust in light of seasonal, interannual and decadal variability and migrations, winter distributions, and that they include critical spawning and nursery areas for fishes including rare and keystone species or those with limited ranges, and species not included (e.g., canary rockfish was more abundant in ODFW surveys than all flatfishes except English and Dover sole).
- The use of MaxEnt to model fishery-dependent logbook data was discussed at length. MaxEnt operates on 'presence-only' data. These data are typical of spatial occurrences that lack a systematic biological sampling. However, the logbook fishery data does not share similar features. The fact that certain species are not always recorded on fishermen logbooks even when they are actually caught (e.g., the discard issue) is a feature that questions the validity of the data, rather than the choice of the modeling technique. The rationale for why the fishery-dependent data are modeled using presence only records is unclear. STAC recommends the comparative use of other modeling techniques that can account for presence and absence records be attempted.

Data validity and sampling design

- The spatial and temporal sampling design varies among the empirical data sets used, as well as between the two modeling approaches (NOAA and TNC). These issues were not evaluated by STAC and additional information to do so may be required.
- With the exception of Dungeness crab logbook data, most of the fish data inputs have sample locations outside of the nearshore area of interest. This can be a problem because model predictions are extrapolated on a regular grid that includes the entire modeling domain (inshore and offshore regions). It was unclear whether any attempt had been made to check whether there is a consistent spatial bias in the prediction error. It is possible that the errors associated with the predictions in the less sampled inshore regions are consistently greater due to the reduced sample sizes. If that were the case, then it may be appropriate to recommend limiting the extent of the predictions in the inshore regions, for example by limiting predictions to pixels that are only within a limited distance from an observation, or by increasing the pixel size of the modeling domain.
- For the Marxan fish analysis, the following was reported in the available metadata, "while there were species-specific differences, in general, depth and distance to shore provided the most information for predicting the probability of priority species presence in the project area. 'Upwelling' and/or distance to shelf also provide important information for most species." The model evaluation criteria included in the metadata indicated relatively poor performance for Dover sole although it was included in the analysis. It is not clear why this species remained in the analysis or if the inclusion of this species substantially altered the final output.
- Also noted in metadata for the Marxan analysis, 'Novel grids' were then produced, indicating areas where modeled values existed outside the range in covariate space of the predictor inputs. These areas of 'novel' values were subsequently masked out of the

prediction surfaces." It is not clear how prevalent these 'novel' values were.

After completing the review, some questions remain about data validity and sampling design. Therefore, it is recommended that, if possible, ODFW address these questions in future documentation of the NEDA process:

a) Are the logbook data biased around fishing ports? Is this considered?
b) How are recreational fisheries evaluated as important areas?
c) MaxEnt: How were environmental predictors used in the modeling in the NOAA and logbook models? Is it assumed that these predictor variables and fish data have equal weights?
    - In Table 1 the highest correlations--between chlorophyll and distance from shore (-) and depth (+) seem contradictory and illogical. Why are chlorophyll and upwelling negatively correlated? Are these relationships linear or curvilinear?
    - Depth or distance from shore had the highest gains in the jackknife plots. Does this mean that based on the logbooks that they increased or decreased linearly with depth, associated with a specific sediment type, or that trawls were all made along a specific depth contour?

Spatial representation

- Derived products may be biased by distribution of sampling effort. STAC received a preliminary explanation into how '0s' and no data stations are incorporated into analysis but this topic needs further consideration.
- The effect of incomplete (no haul location, zero fish reported, etc.) hauls in the logbook data on modeling results may not be fully considered by MaxEnt modeling- e.g., a very large number (over 300,000) of samples were removed because there were no data for the end of the haul. Using the mid-point of trawl requires information on both beginning and end location. This choice eliminates a large number of hauls that are missing either point. One possibility for incorporating these data would be to use only the start location of a tow. STAC discussed the possibility that those hauls could have been biased towards large samples since that is sometimes an explanation of why the trawl end or catch is not recorded. Also, are certain types of fishing (e.g., when beginning and end locations are the same) being left out of the analyses? Hauls are usually along a depth contour, so useful data may still be obtained from without end locations. Consideration should be given to including these data to test for significant differences in results.
- STAC discussed the issue of aggregation of data (i.e., boundary modifier in Marxan). Choice of this value may (or may not) substantially alter spatial distribution of priority categories I, II, and III. Additional information on feasibility of explicitly evaluating this issue would be useful.
- The current boundary of protection around estuaries seems rather small. Can more scientific validity be given to this value? It ranges from 1,000 m to 20,000 m. Estuarine influence in both pelagic and benthic environments is likely to go beyond that. What is the status of the Estuary Salmon Index and protection to areas outside estuaries that are important as migratory corridors for salmonids, sturgeon and other species? These radial areas need to be shown on maps.
- STAC suggests conducting a sensitivity analysis to evaluate how the final output varies with grid size. STAC understands that there is only a limited scope to increase grid-cell

size (3 nautical miles from shore) but pixels do not have to be squares. They can be rectangles, with longitudinal bins shorter than the latitudinal ones.

- Grids that are adjacent to the coast and that will thus likely have smaller wet areas will have a unequal treatment a priori in the analyses. This should be reflected in data interpretation and inherent assumptions.
- For the Marxan fish analysis, the lack of detectable latitudinal variation within the nearshore zone referenced in the metadata may well be, as noted, due to low sample size within this zone. However, this does not necessarily mean that the true nearshore latitudinal (or longitudinal) variation will be well characterized by a combined model. Given that the region most likely to be assessed in future planning efforts is the nearshore region, there may be greater risk associated with inaccurate representation of this area. The validity of combining these data sets into a single modeling effort is still questionable if the primary reason for this approach was the lack of variation within the nearshore due to low sampling effort. Perhaps accuracy assessments split out by region, if not already completed, would shed some light on this area.

Data gaps

- There are substantial data gaps, particularly in terms of distribution of spawning and nursery habitats. Some of the gaps could be filled with analysis of existing data whereas others require new data collection. Our understanding is that funding is very limited but developing a prioritization of data gaps to be addressed may be a good starting place. What protocols will be used to incorporate other data on spawning/nursery or retention areas of nearshore fishes in the future? It is critical to establish a process to incorporate new/additional information as this becomes available. Hopefully, output from the regression tree and MaxEnt analysis, combined with Marxan can also be used to identify data gaps.
- When ODFW can get access to the data, they should consider including NMFS observer data in the data sets. Since implementation of the Trawl Rationalization program, these data are now much more complete than before due to the requirement of 100% observer coverage in the fishery and reporting of all species caught.
- There have been small mesh beam trawl surveys conducted in the late 1970s and early 1980s in certain shallow water areas. These surveys can offer valuable information for the fish modeling component. Currently these data are not available in electronic format, but are nevertheless available in large binders (Doug Markle, Department of Fish and Wildlife, OSU) and published literature. More recently there have been focused samples near the Yaquina Head and Reedsport (Lorenzo Ciannelli and Sarah Henkel). Previous studies with fine-meshed beam trawls reveal that the sandy sediments off Moolack Beach are a nursery area for juvenile English Sole.
- The nearshore flatfish survey occurred from 1971-1974. This study was completed nearly 40 years ago prior to the 1976/77 regime shift. Additionally, the abundance estimates were reportedly driven by high recruitment years (1961, 1966, and 1968). This data set would be very useful for a change analysis or temporal comparison, but caution should be taken when using to represent current conditions.
- The Columbia River plume, as well as other smaller river plumes, are not apparent on the maps.

- There is no process to include ‘scientific expert knowledge’. This is a severe data gap, considering that the availability of spatially resolved data that span the entire coastline is very limited. Scientific expert knowledge can be incorporated adopting a process analogous to the one used to indentify fishing grounds.

Additional Recommendations

- Data gaps: use output from the regression tree and MaxEnt analysis, combined with Marxan can be used to identify data gaps.
- ODFW should be very clear in labeling what species are included in datasets (e.g., list the species rather than saying ‘fish’)

5. NEDA Habitat and Ecosystem Review

Team members:

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Relevant NEDA Data Sets

- Benthic Habitats, version 3.6.1
- Rocky and Sandy Shorezone Habitat
- Maximum Canopy Extent from Composite of all Kelp Surveys (1990, 1996-99, 2010)
- Chlorophyll-a in the Pacific Northwest Marine Ecoregion (1998-2005)
- Upwelling in the Pacific Northwest Marine Ecoregion (1998-2004)
- Historical Dissolved Oxygen Data off Oregon, (1950-80)
- Proxy for Estuary Influence on Nearshore Habitat
- [Fishery-dependent Models of Presence of Selected Invertebrate Species off Oregon (2011)] – considered elsewhere

Strengths, Limitations, and Recommendations

Benthic Habitats, version 3.6.1

With respect to the classification of benthic habitats, the available information on methodology is inadequate to judge the validity of the data. Substrata are grouped into four categories: rock, sand, mud, and mixed. Although ODFW has provided some clarification of the 'mixed' category (it is a composite category that includes many of the categories in standard classifications of essential fish habitat), the data used for the present analysis are not clearly explained. Multiple questions remain after completing this review:

- If an assessment unit included both rock reef and sand, was the entire unit classified as 'mixed' or were the areas of bedrock and sand broken down in some way? Were cobble fields classified as rock or as mixed?
- Metadata files were lacking information on how many grab samples were used to determine the classifications, what sort of spatial arrangement was used for sampling, or how particle sizes were delimited.
- What kind of sampling device was used? If it was a grab, was this grab equally efficient at collecting all particle sizes?
- Was there any possibility of wash-out of fine sediments on the way to the surface?
- How well can multibeam returns differentiate among rocky bottoms of various particle sizes?
- Were bottom samples always the same when they came from bottoms with a particular kind of sonar profile? Surely there was some variation here.
- If 'rock' includes pebbles, cobbles and other loose stones larger than sand grains, why were these not broken out into one or more additional categories?

Although the implication of referring to bottom type as a 'habitat classification' is that geological attributes of the bottom are to be used as surrogates for organismal habitat, it appears that any fauna collected in grab samples were not analyzed or retained. This is unfortunate, since habitat data are of limited value without ground truth studies that indicate what animals actually use the putative habitats. This is a potentially large issue because existing data indicate major differences in animal diversity and species composition among unconsolidated sediments of various sizes (e.g., gravels vs. small cobbles). The amount and type of infilling by smaller particles is also critical in determining the suitability of the habitat for various species. Finally, where benthic invertebrates are concerned, substratum type is not the only important dimension of benthic habitat quality. For example, current speed in the benthic boundary layer, which can be influenced by depth and by nearby topographical features, is expected to be a strong predictor of animal communities on the ocean floor.

> Recommendation: The existing data layers on habitat classification for the benthos are based on very preliminary data. The information should be used with great caution until at least some studies have been conducted to calibrate the geological classification scheme in a way that actually predicts biotic communities. At best it might be best to refer to these data as bottom types.

Overall, the methods used to categorize benthic habitats are unclear. In addition, it seems that the number of substrate categories is insufficient to capture the diverse types of rocky subtidal habitat found in Oregon waters. Since different rocky habitat types will host different suites of species, without more specific categories, certain habitat types may be left out of the prioritization process.

Rocky and Sandy Shorezone Habitat

The substrate categories currently used for Rocky and Sandy Shoreline Habitats are insufficient to capture the diversity of habitat substrates found along the Oregon coast.

> Recommendation: STAC recommends separating out rocky habitat into more categories to include bedrock, cobble, pebble or similar.

The data used for subtidal habitat map layers may be the best available at this time, but it is unclear why data on intertidal organisms were excluded. PISCO and other groups have collected intertidal survey data for many years. Intertidal habitats were classified as merely rock and sand on the basis of aerial photos. Within a given rocky site, however, there is invariably a rich diversity of habitats consisting of pools, cobbles, vertical surfaces, etc. All of these support different communities of invertebrates, fishes and algae.

> Recommendation: Given that the intertidal data in Oregon may be among the most comprehensive available, include them in NEDA if spatially extensive. If not spatially extensive create a separate (meta) database for detailed or site-specific data that could be used in permitting in the future or could be used to test overall marine map data generation.

Maximum Canopy Extent from Composite of all Kelp Surveys (1990, 1996-99, 2010)

The only algae considered in the analysis are two species of canopy-forming kelp, which are not separated, despite the rarity of *Macrocystis* in Oregon.

> Recommendation: Separate the two species of algae included in the analysis, or explain why they were lumped together.

Upwelling in the Pacific Northwest Marine Ecoregion (1998-2004)

The Advanced Very High Resolution Radiometer (AVHRR) satellite imagery was used to produce data (and maps) of upwelling and sea surface temperature. If reviewers are reading the meta data correctly, as shown in the file, (NEDA_layers_metadata), for the three files (upwelling_binned, upwelling_continuous; and sea_surface_temperature_continuous), the authors only used 11 of a possible 21 monthly composite satellite images over the period 1998-2004 to create their ‘map’ of upwelling and sea surface temperature. They state that they eliminated any monthly composite that had cloud cover. As a result of using only 11 images collected over 7 years (when in fact, thousands of images are available for study), the authors have not done a comprehensive job in representing the climatological upwelling or sea surface temperatures.

> Recommendation: STAC recommends working with the academic satellite oceanography community to produce a data layer with better temporal coverage. In the profession of ‘satellite oceanography’ it is true that clouds can be a problem; however, there are many ways to deal with clouds – corrections can be applied and composite images produced by combining several images collected close in time. It is not uncommon to use 8-day composites in descriptions of upwelling and sea surface temperatures.

Chlorophyll-a in the Pacific Northwest Marine Ecoregion (1998-2005)

The same problem exists for the chlorophyll data whether it is the ‘binned’ or ‘continuous’ files. In this case, the authors used only 21 monthly composite satellite images out of a total of 32 possible (8 years, June-Sep).

> Recommendation: As stated above, STAC recommends producing a data layer with better temporal coverage - most scientists are accustomed to working with 8-day composites.

Historical Dissolved Oxygen Data off Oregon, (1950-80)

Okay. Need to get updated data set.

Proxy for Estuary Influence on Nearshore Habitat

STAC understands the interest in including a measure of the influence of estuaries on the nearshore habitat. The measures of estuary size (estuary area and watershed area) seem reasonable. However, the choice of the radius metric is not clearly rationalized: it does not account for the influence of the tidal jet leaving the estuary on ebbs (could be ~10 km); it does not take into account the level of estuarine mixing (mostly by tides) that dictates how much the river input is amplified to become the estuarine outflow to the coastal ocean; and it does not account for the range of influence of the freshwater discharge that could extend large distances along the coastal ocean, e.g., hundreds of km for the Columbia River plume, not 20 km. This distance will be dependent on oceanic forcing. The ‘Estuary Influence’ appears to be missing from the Target List in the NEDA Marxan Analysis document. In summary, even with these shortcomings, the presence/absence of estuary influence may have resulted in a useful indicator of estuary locations. The Oregon MarineMap does not show this presence/absence information.

Data gaps

Algal and invertebrate diversity and structure formers
A fundamental problem with this analysis is the lack of important data on invertebrates and algae. The only algae considered in the analysis are two species of canopy-forming kelp, which are not separated, despite the rarity of *Macrocystis* in Oregon. The only invertebrate species included in the analysis is Dungeness Crab because of its fishery importance. All other existing data on invertebrate density, occurrence and diversity are not used, including fishery data on shrimp, urchins and razor clams. STAC recognizes that non-existent data cannot be included and also understands that data with narrow geographic coverage are difficult to include in the analyses. Nevertheless, it is important to recognize that the data used for these maps, though possibly the best available at the present time, do not represent species diversity in the Oregon Territorial Sea in even an approximate sense. The latest edition of the Light and Smith Manual (Carlton, 2007) identifies about 3700 species of intertidal invertebrates in the intertidal zone, and the limited data on subtidal ecosystems in Oregon suggests that there are at least hundreds of additional species never found in the intertidal. There are currently no data on invertebrate species subtidally (or intertidally) included in the dataset.

These data are necessary for a comprehensive assessment of ecosystems. For example, there may be sufficient data in the current Marxan analysis to identify that specific areas have high abundance and diversity of commercial fish and crabs and thereby identify such areas as high priority for protection. However, there are seemingly no data currently included in the analysis to identify areas of high diversity of algal and invertebrate species.

There are multiple data gaps in Oregon MarineMap/the NEDA database for which data currently exist but were not included in the Marxan analysis because they did not meet ODFW’s criterion of being spatially extensive. For instance:

- Survey of benthic communities near potential renewable energy sites offshore the Pacific Northwest (Henkel, Boehlert)
- Invertebrate data from NMFS annual (2004-2009) and triennial (1974-2004) trawl surveys
- Commercial shrimp fishery logbook data
- Commercial urchin fishery logbook data
- Commercial razor clam fisheries logbook data, Razor clam biological surveys
- PISCO (Partnership for Interdisciplinary Studies of Coastal Oceans) rocky intertidal community data
- Zooplankton data-OSU from NMFS research cruises.

Recommendation: Given the points raised above, STAC recommends that these data should be prioritized for inclusion in a separate (meta) database for detailed or site specific data that could be used in permitting in the future or could be used to test overall marine map data generation. For example, the rocky intertidal habitat is known quite well (e.g., PISCO), so relatively easy to fill out and use.

Missing species: mysids and fall Chinook salmon

Two key species identified in *The Oregon Shelf/California Current System's Ecological Setting* for the report *Ecological Effects of Wave Energy Development in the Pacific Northwest* (2008) were not considered in the NEDA documents – mysids and fall Chinook salmon. Both are common in the nearshore zone; mysids are a major prey for Gray Whales, and juvenile fall Chinook salmon spend their first summer at sea in a narrow band between the surf zone and a few km from shore. There are virtually no data on mysids but their importance is well known; there are data on fall Chinook distributions that could be included in the report, from surveys done from Newport north to LaPush, Washington, in June and September 1998-2011. Bill Peterson could produce a climatology of the catches if ODFW would like this as an addition to NEDA.

Comment on time series

STAC recognizes that the intent of the NEDA process was to produce maps, based on spatial data. However there are a number of time series of oceanographic data that could be useful in the NEDA process that were collected at a single point or along a single transect, that likely represent a larger spatial area than the single point might suggest. Of course one cannot produce a 'map' from 'point' data, however, these data may be useful for providing some measure of temporal (seasonal or year to year) variability.

6. NEDA Marxan Review

Team Members

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Overview

Marxan is a management tool that provides near-optimal or 'good' solutions for ecological protection based on a series of policy goals, taking estimated costs into consideration and designating the smallest areas that meet the stated goals. The inputs require *a priori* policy decisions, so the output cannot be evaluated from a strictly scientific perspective. Because the STAC reviewers were not expected to comment on policy and because other teams of STAC reviewers were charged with evaluating the raw data inputs to the various layers, the Marxan review was restricted to the analysis of two basic questions:

1) Does Marxan provide the most appropriate algorithms for making decisions about ecological protection in the Oregon Territorial Sea?
2) What is the level of confidence that the Marxan program has been applied in the most unbiased and appropriate way to the available data sets?

Suitability of the Marxan Program

Marxan originated with the dissertation of a graduate student working under the supervision of Professor Hugh Possingham, who has a strong reputation as one of Australia's most talented quantitative ecologists. Since it was first introduced, the program has been applied to numerous marine and terrestrial systems worldwide, and the program has been updated and improved on a regular basis. It appears to be the only widely accepted program that uses an iterative mathematical algorithm to recommend optimal solutions to the marine reserve problem. An ever-growing literature testifies to its usefulness in circumstances where policy goals can be properly articulated.

Marxan effectively tries to find the best solution to minimize:

- The total cost of AUs (number of hectares)
- A species penalty factor (i.e., for not meeting conservation/abundance goals)
- The perimeter of the selected AUs

Marxan finds the solution through one of three algorithms. Simulated annealing was selected as the algorithm for the Oregon analysis and appears appropriate. This algorithm finds a random location in the possible solution space and determines its overall 'score'. Then, a new location is randomly chosen within a large distance from the last location and its score is computed. The location with the best score is retained and the process continues. Over time, the maximum distance between each new location is reduced until the distance is near zero. This algorithm will find a 'good' solution but not the optimal one. There is a tradeoff between finding the best solution with an exhaustive search and finding a good solution with a much faster search. One characteristic of the algorithm is that it may produce different results with exactly the same parameters, thus the need to run it repeatedly.

Because Marxan produces one method based on a suite of data inputs, the analysis is only as good as the data used. Any gaps in the data will therefore limit the program's usefulness. A strength of the program is that near-optimal ecological and socio-economic outcomes are readily determined from this single algorithm based on goals articulated at the front end.

MarineMap is an alternative program developed in the lab of Will McClintock and currently used in the California marine reserve and Marine Life Protection ACT (MLPA) process. It allows stakeholders to view all layers of the map then create polygons that represent various zoning schemes they might imagine. MarineMap has the advantage of giving ownership to stakeholder groups who can propose various schemes based on their own goals and to incorporate local or individual knowledge into the process. There is no automated algorithm in MarineMap. Sea Sketch, a companion program now under development and scheduled for release this summer, will have the ability to analyze the consequences of the zoning schemes that stakeholders have proposed. Because it incorporates local knowledge in addition to larger data sets, MarineMap may help fill in gaps in the map data.

The Marine Map program used in California is similar to the mapping tools that encouraged stakeholder involvement in the earlier marine reserve designation process in Oregon. Marxan and MarineMap have two different philosophies. It is the opinion of STAC that Marxan is a more appropriate management tool for circumstances where data sets are too large and complicated for humans to determine near-optimal solutions.

STAC also investigated several other programs used in ecological spatial planning. Several of these (ARIES, ATLANTIS, INVEST, MIMES) are used to model ecosystem services, including but not limited to fisheries. All of these require temporal inputs. Other programs (Coastal Resistance, Cumulative Impacts) are used for modeling the vulnerabilities of coastal human populations. While any of these programs might prove useful for specific problems in Oregon, they are not suitable alternatives to Marxan.

Confidence in the Present Application of Marxan

Because the reviewers were given very little time to examine the details of program operation and had nobody with prior expertise in Marxan and its application, it was virtually impossible to determine the appropriateness of the various protocols used.

STAC noted that virtually every data layer involved decisions about how to reclassify the information in a way that could be used by the program. Over-arching decisions such as where to set boundary modifiers and abundance goals, and how many iterations to perform were determined analytically. The boundary modifiers where analyzed for how they affected the model but it was unclear how the goal of 60% for abundance levels could be applied to all datasets. The status values used to 'lock' AUs in (mouths of estuaries) and AUs out (those outside the analysis area) of the final output appear appropriate.

The weighting of different data layers and apriori decisions such as types of habitats having 100% protection are made prior to the Marxan model runs but will affect the final maps produced. The choice of the boundary modifier will also affect final results. A detailed evaluation of how this value was selected is needed (and recently provided) and more importantly, how the choice of the boundary modifier affects final model output. In essence this modifier can affect how wide a range a particular attribute has on neighboring cells. STAC recommends that FINAL output be evaluated at a range of boundary modifiers.

STAC noted that continuous data sets were often collapsed into categorical data or otherwise simplified. The reasons for this were not always clear, but there was concern that useful information might be lost by these simplifications. The use of zeros in representing presence data was also questioned.

Recommendations:

- STAC recommends performing sensitivity analysis, especially to understand the effect of categorical variables and boundary modifiers on the model outputs. This will be a challenge with the number of datasets that are included. It may be possible to reduce the number of datasets by creating ‘surrogate’ datasets for groups of species to reduce the number of iterations during sensitivity analysis. One potential approach is to run a series of simpler simulations (e.g., based on far fewer data fields) in which the outcomes are known, and ask whether Marxan is able to recover the solutions. Selectively removing certain data layers may also provide some sense of model sensitivity or robustness to certain data. It would also be useful to see the percent accuracy of the underlying models separated by nearshore and offshore areas.
- STAC has informally looked at how each of the individual datasets related to the final output to understand which ones were contributing the most to the models. This analysis could be formalized and added to the final product.
- STAC recommends that an outside team familiar with the application of Marxan be asked to provide a detailed technical review of how this program has been applied to the Oregon maps.

7. Fishing Grounds Mapping Review

Team Members

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Relevant Documents, Data Sets, and Maps

This review was conducted with reference to key supporting and background documents:

Fishing Grounds Maps Review

- Fishing Grounds Maps 1- STAC Marine Reserves Economic Assessment, 2009
- Fishing Grounds Mapping Project Report, Ecotrust, Nov 2010
- Fisheries Grounds Maps and Report, Ecotrust, Nov 2010
- Fishing Grounds Maps, Ecotrust, Scholz et al., 2011
- FISHCRED Report http://www.oregonwave.org/fishcred/

STAC framed their scientific review with respect to the request from OPAC as well as the goals, intended uses, and associated guidelines for the OCFMP data and maps. OFCMP project goals and objectives (Ecotrust 2010) were:

- *Comprehensively describe Oregon's commercial, charter, and recreational fishing community and incorporate fishermen's knowledge into the deliberations of the TSP…*
- *Develop accurate maps depicting the extent of local fishing grounds and their stated and economic importance to the local fleets*
- *Analyze areas of high or valuable use in relation to existing or prospective ocean uses*
- *Collect baseline data for the future analyses of economic contribution of the recreational fishing sector to the coastal economy*
- *Integrate data into Oregon's Coastal Atlas and Oregon MarineMap to inform the TSP.*

Background and General Approach Used by the OFCMP

Ecotrust was contracted by the State of Oregon to help collect information on the distribution and spatial extent of commercial, charter, and recreational fisheries consistent with Goal 19 objectives and the amended Territorial Sea Planning process. This need reflected a 'data gap' due to the need for more **spatially-explicit fisheries data**. The 'OCEAN Open Map' software, which is a stakeholder-driven decision-support tool that combines fisheries 'importance' mapping with other potential economic valuation and weighting techniques was employed. The mapping technique software had been applied in California in the siting of marine sanctuaries but had not been used previously in the state of Oregon (Scholz et al. 2011).

The survey process involved identifying key fisheries with their component fishing strategies (practices or gear configurations), the stratification of the study area into port complexes, and the effort to represent greater than 50% of total landings and at least three fishermen for each fishery. Data collection was accomplished through both desktop computer (commercial and charter fisheries) and online (recreational fisheries) applications. All interviews followed a shared protocol for each fishery in which the interviewee participated. Fishers were asked to identify all fishing areas/locations that are of economic importance over their cumulative fishing experience, and to rank these using an imaginary 'bag of 100 pennies' that they distribute spatially over the fishing grounds. Fishers were allowed to review their individual results and adjust them if they did not accurately represent their intentions. Attempts were also made to collect non-spatial information pertaining to demographics and revenues, costs, or expenditures, but this was not done consistently or successfully across all fishery sectors.

The datasets were aggregated in each port to create a 'cross-sector value map' combining the results from the commercial, charter, and recreational sectors. Maps were reviewed by industry groups through a process coordinated by FISHCRED (Fishermen's Information Service for Housing, Confidential Release and Essential Distribution), (an industry organization developed to coordinate review of the OFCMP maps; http://www.oregonwave.org/fishcred/). Because of the confidential nature of the fishing data, maps could not be released to state agencies or the public unless first reviewed and approved by the fishing industry. The port based maps approved by industry and provided to DLCD (and now housed in Oregon MarineMap -- Oregon.marinemap.org) combine commercial, charter boat, and non-guided recreational angler sector data. While individual commercial and charter boat fishermen surveys were weighted by vessel gross revenue, individual recreational data were not weighted by any economic or social criteria. In addition all fisheries and all sectors were weighted equally, regardless of their size or economic value. The resulting port-based maps represent spatially-explicit information on the self-stated 'importance' of fishing areas combined across all sectors. The color contour 'heat' maps illustrate the aggregate cross-sector fishing 'importance' for each port, but not for any specific sector or fishery. The maps present this information as a range of concentric light to dark color contours, with the darker contour areas representing the highest spatial concentrations of relative fishing 'importance'.

The combined-sector maps for each port incorporate aggregated data on fishing grounds for commercially and recreationally caught species such as crab, salmon, halibut and groundfish. Data collection occurred in two stages: March-May 2009 and December 2009–September 2010. Data were collected from 244 commercial fishermen, 63 charter operators/owners, and 237 recreational fishers. The ports included were Astoria, Pacific City, Garibaldi, Depoe Bay, Newport, Florence, Winchester Bay/Reedsport, Coos Bay/Charleston/ Bandon, Port Orford, Gold Beach, and Brookings. The charter port fisheries analysis also used the same port groups as commercial with the exclusion of Garibaldi, whose charter sector did not participate, and Port Orford, which did not have any charter boats. The recreational fisheries analysis included the same port groups as commercial with the addition of Salmon River. Not all user groups or fisheries are represented in all ports. For additional information on the sampling process used see the discussion in the Sampling Section of this report as well as Ecotrust 2010, and Sholz et al. 2011.

Key Issues

The following section summarizes key issues associated with the OFCMP data and map products – especially with respect to their application to the Territorial Sea Planning process. Where relevant, the issue-based discussion highlights assumptions, data validity, sampling design, methodology (including the design of port maps and interview numbers), data gaps, and spatial representation.

Sampling Design

An interactive, computer mapping tool, called Open OceanMap was used to collect spatial information from Oregon fishers. The raw data, at the level of the individual fishers, consisted of spatial polygons that delineate fishing locations and measures of their relative importance. From these raw data, aggregated maps of the relative importance of different fishing grounds off the Oregon coast were developed. This section describes and discusses the process used for collecting the raw data.

<u>Collecting the fishing grounds raw data</u>

A stratified survey sampling approach was used for selecting the fishers from whom they obtained data on fishing locations as well as basic demographic information. The strata were defined in terms of three primary fishing sectors: commercial fishing boat operators, charter-boat operators, and recreational anglers with boats. Within each fishing sector, study fisheries, defined in terms of the major target fish species and the primary gear employed were identified. The sets of study fisheries were developed in consultation with the ODFW and other experts. In the commercial fishing sector there were 19 study fisheries, including ones for Dungeness crab using traps, for pink shrimp using trawl, and for sea urchins by diving. In the charter-boat fishing sector there were five study fisheries, including ones for albacore tuna, for rockfish, and for salmon. In the recreational fishing sector, there were 12 study fisheries, including boat fishing for Dungeness crab and for bottom fish, and dive fishing for flatfish and for abalone. The fishing sectors and study fisheries were further categorized geographically by port-groups: Astoria, Pacific City, Garibaldi, Depoe Bay, Newport, Florence, Winchester Bay/Reedsport, Coos Bay/Charleston/Bandon, Port Orford, Gold Beach, and Brookings. For the recreational anglers there was an additional geographic category for the boat launch ramp located near the mouth of the Salmon River, north of Lincoln City. The various study fisheries did not all operate from all the port-groups.

For the commercial fishing sector, data from PacFIN for the period 2004-2008 were tabulated to indicate the ex-vessel values of the landings for all the port / fishery strata. Survey participants were selected using a purposive sampling approach, with the goal of choosing for each port / fishery stratum participants whose fishing revenues from that fishery represented at least 50% of the total landed value for that port / fishery stratum, with the additional goal of having at least three participants from each port / fishery stratum. (The Ecotrust report incorrectly stated that there had to be at least five participants.) For the charter fishing sector, which has a relatively small number of operators, almost the entire state-wide population of charter-boat operators participated in the survey. For the recreational fishing sector, staff conducted a mailing to individuals identified from an ODFW list of recreational fishing permit holders, cross-referenced against an Oregon Marine Board list of individuals with registered boats. They obtained response cards from 232 individuals (7.9% response rate), but only some of these individuals indicated willingness to participate in the survey (e.g., 64% from coastal counties and only 33% from valley counties).

The raw data collection with the computer mapping tool was generally conducted by means of one-on-one interviews with individual fishers, but about one third of the participants from the recreational fishing sector completed the survey process using an on-line version of the mapping tool. For each study fishery, the survey participants identified the maximum extent of the locations where they would fish. Then, within this maximum area participants identified specific fishing grounds, based on their cumulative fishing experience, by drawing polygons on the digital map. They then ranked the relative importance of the different fishing grounds by distributing '100 pennies' across the fishing grounds. Finally the participants provided information on their demographics and basic fishing operations.

Sampling Issues

Except for the fishers in the charter fishing sector, for which there was almost full participation in the survey process, information was obtained for only a sample of the complete populations of commercial and recreational fishers. With any form of subsampling there will be uncertainty regarding whether the sample data are representative of the population that was not sampled. When samples are taken randomly there is a theoretical basis for drawing inferences about the full population from the sample data. Further, the data provide a measure of the uncertainty associated with observed average (described as the standard error).

With the purposive sampling of the commercial fishers conducted, there is no theoretical basis for asserting that the results from the sample are representative of the broader population of fishers. The Ecotrust report states that their sampling process was 'designed to be representative of the spatial value' but there is no supporting evidence that the collected data are representative. Although the goal of sampling fishers whose activities represented at least 50% of the total landed value for a sector / port / fishery stratum was achieved, the question of where the residual landings were caught remains unanswered. Also, because it is generally true that a small proportion of fishers are responsible for a large proportion of the landings in any fishery, sampling process will likely end up missing the majority of the fishers operating in any fishery (because the goal of sampling 50% of the landed value can be achieved by sampling a much smaller percentage of the fishers). In contrast, it may represent the majority of fish caught.

For most of the commercial fishing / fishery strata, the sampling process achieved its goal of sampling from fishers who accounted for at least 50% of the total statewide landed value for each particular study fishery. However, the sampling process was deficient at meeting its statewide goal for five of the 19 study fisheries (26%): rockfish–hook and line (dead), rockfish–longline (dead), salmon–troll, tuna–troll, and sardine–net (seine). At the port level of stratification the sampling process was slightly worse. Table 4 of the Ecotrust report indicates that the 50% target was missed for 28 of the 101 port / study fishery strata having non-zero landings.

A related problem is that the larger catches in a commercial fishery are often taken by the larger vessels. The fishing grounds that support these vessels may be inaccessible to smaller vessels, for example, because the smaller vessels may not be equipped with the needed fishing gear. In this case the fishing grounds that are important to the operator of a large vessel may not match those of the operator of (the more numerous) smaller vessels.

For the recreational fishing sector, potential survey participants were identified from a list of licensed recreational anglers who also had registered a boat. Although this seems a reasonable approach, the response level that was achieved was low which reduces the level of confidence in how well the data represent the entire fishery.

Due to concerns for confidentiality of the participants' information, raw data from any sector / port / fishery strata having less than three participants was excluded (at the time this review was being done). STAC cannot therefore access how well fishing grounds from sector / port / fishery strata with few fishers were represented.

Data Validation

Data collected in any survey (or by means of logbooks or other forms of self-reporting) are liable to the vagaries of memory, subjective judgment, and possible deliberate falsification. This is one reason why surveys often include a suite of auxiliary questions on the demographic characteristics of the respondents or on topics unrelated to the focus of the survey. The responses to these secondary questions can be compared to independent information, with the aim of demonstrating that the results are consistent and therefore plausible. We could not find information on what was done specifically to help validate the accuracy of the information collected in this study.

Further, some of the basic information that was collected from the recreational fishing sector seems questionable. For example, results show that 70 of the 208 recreational anglers with a private boat were fishing from the Salmon River location. It seems likely that the actual statewide percentage of marine recreational anglers operating from the Salmon River is considerably lower than 33%. Results also show that that recreational anglers with a private boat on average fished for 55 days per year (more than one day every week). Again, this seems like an extraordinarily high number. These data suggest that the respondents were either misreporting their information or were exceptional anglers rather than average ones.

There were no similarly striking results for either the commercial or charter fishing sectors. However, several analyses could have been conducted to provide some independent validation of the summary results. For example, for the commercial fishing sector tabulated PacFIN landings revenues by fishery, port and individual were used to identify the list of top-producing fishermen to target for the survey. These same PacFIN data on landings revenues could have been converted to percentage values by study fishery, relative to each individual's average annual fishing earnings. These calculated percentage-income-by-fishery values could then have been directly compared to similarly calculated values based on each respondent's self-reported fishing income values (summarized in the Ecotrust report across all respondents in Tables 7-17 in the column labeled 'Income from fishery (%)'). The PacFIN landings receipts also could have provided information on the number of days of landings, which could be compared with the fishers' reported number of days of fishing. However, this is a much cruder comparison because many fishing trips take several days to complete.

In addition, the charter fishing sector does not have any information source comparable to PacFIN to provide independent corroborating information, but the data collected by ODFW's Ocean Recreational Boat Survey may have provided information that would indicate the relative scale of the operations of the different charter vessel operators. Also, the percentage of trips in the five different fisheries could be compared with the information summarized in Table 19 of the Ecotrust report.

Documentation

A hallmark of the scientific method is that the results from experiments or other processes for collecting data can be replicated. Any report on a scientific study should provide sufficient information (or references to sources of such information) so that other investigators could repeat the study, and thereby verify or refute the validity of the original study results. The report on this study does not provide adequate documentation on several aspects of the work for full peer review.

Although the process used for collecting the raw data was reasonably well described, the method used for building the aggregated 'heat maps' was not well documented. In particular, it was unclear how the heat maps from the different fishing sectors were combined into the aggregated maps. The report referenced an 'In press' publication that was not provided to STAC by the time of the review. The methodology used in connection with the California MLPA Initiative, described in the Scholz et al. (2011) paper published in *Conservation Biology*, appeared to differ from the methods used in the Oregon study. Further, the *Conservation Biology* study only described the process of collecting and mapping information from the commercial fishing sector, whereas the Oregon study involved two additional fishing sectors.

Also, the Oregon study included a process for refining the fishing maps, but this process was poorly documented. The report briefly mentioned that a four-step process was used to provide quality assurance and quality control of the data collection and mapping process. In responses to questions from the reviewers, however, it was discovered that the map products were 'refined' in consultation with some fishery experts. The details of this process were not well documented, and it was unclear whether the process made substantive or inconsequential changes to the aggregated maps.

Data 'Weighting'

A key part of the intended process in developing the OFCMP maps is the use of 'weights' that represent economic or social criteria/value (profits, catch, revenue, vessel size, etc) to provide context and meaning for the self-reported spatial measures of relative 'importance.' These weights would be applied to the spatial measures of relative importance to create a spatial map representing economic and social values. However, the aggregate maps did not apply these weights to individual fisheries or the fishery sectors. Without the use of such weights, each fishery and sector is given an equal weight regardless of the size of the fishery or its economic or social importance to the region and state. The actual port maps produced by the OFCMP process represent aggregate maps across the three major fishery sectors. Maps for individual commercial and charter vessel operators are weighted by gross revenues, but no value is used to weight the individual recreational fishermen data. While such a weighting scheme may be consistent with the approach to focus on individual commercial/charter fishermen that generate higher revenues -- while also generating maps acceptable by the fishing industry for public use - the lack of consistent and economically/socially relevant weights creates a number of challenges in evaluating the meaning and quality of the maps as well as their application for public policy.

These challenges are summarized as follows:

- Data omissions and inconsistent use of weights for a single set of port maps: The maps produced by the OFCMP used an inconsistent weighting approach across sectors; while individual data were weighted by revenue (an economic criteria) for the commercial and charter boat operators sector, no comparable economic data was used for the self-guided recreational sector. These omissions and inconsistent weighting makes it difficult to interpret the meaning of the aggregated map and makes it less credible and valid for public policy. As a general rule, all fisheries and/or sectors should be weighted by the same or comparable criterion within an individual map. For example, the map could have used a criterion such as proportion of the total catch within the sector or the relative amount of effort (such as 'days fishing'). Although a map with this weighting may not be directly useful for some purposes, it would result in easier interpretation and provide greater spatial understanding of catch and or effort across sectors. Moreover, in the case of weights based on 'days fishing', additional subsequent uses of the data and maps might be possible by imputing economic values to 'days fishing' across fisheries and sectors.
- Inadequate and inappropriate economic and socially relevant weights: The port maps produced by the OFCMP process have a second flaw which is the lack of socially-relevant weights. The fishery sector and fleets are not weighted by metrics that are commonly recognized as representing economic and social values to the region, state, or nation. Although there are a variety of economic and social measures that could be used, a standard starting point would be to collect estimates of the costs and benefits associated with each sector and fishery. For commercial fishermen and charter boat operators, estimates of revenues and costs make it possible to use net revenue (profit) as an indicator of value. In the case of recreational fishermen (both charter clients and boat owners), cost data can be collected whereas measures of (non-market) benefits would require other methods. Other weighting criteria could be used based on revenue and expenditure data in order to evaluate regional economic impacts. Additional kinds of assessments might focus on percentage of total household income, or even expenditure or gross revenues. But because the OFCMP port maps do not represent a consistent set of core economic metrics within and across each sector, they cannot be compared within a single state-wide map (this is in contrast to the other Oregon MarineMap products). For example, one port may have 'high importance' contour lines containing the same sized area as a second port's 'high importance' area. But based on a standard economic or social weighting criterion these areas may represent vastly different social or economic values. For example, the OFCMP port maps give equal weight to a crab fisherman who generates $1 million in net income and a recreational fisher who spends a few days each year fishing from a kayak. This approach stands in contrast to the Scholz et al. (2011) application of the Ocean Open Map which used weighting criteria based on net economic value. These values were used to determine potential loss of economic benefits if fishing grounds were closed in order to create marine reserves (or potentially any other use of the space). Consistent with this approach, an OFCMP aggregate map could be produced that was weighted by a net economic benefit criterion for: 1) each commercial

fishery based on net revenues (e.g., net income or profits); 2) the charter boat sector which includes net revenue produced by the charter operators plus net economic benefits for their clients (based on the value of the recreational fishing experience net of its costs, e.g., their 'willingness to pay'); and, 3) net economic benefits for the recreational non-guided sector and fisheries (based on 'willingness to pay'). Such a map would be 1) consistent across ports, 2) could be 'added up' and used to 'avoid, minimize, or mitigate adverse impacts,' and 3) would meet national and professional social science standards. In similar ways other aggregate maps could also be produced to evaluate regional impacts or other aspects of economic/social benefits important to the state of Oregon and consistent with Goal 19.

- Inability to analyze maps by individual fishery, sector, or alternative weighting criteria: The single set of OFCMP port maps available for review limited our ability to explore the sensitivity of the maps to different weighting criterion. Reviewers were unable to determine if the map contours were 'robust' to different weighting standards, or conversely, extremely sensitive to weighting. Reviewers could not determine whether the map boundaries and importance contours would dramatically alter depending on the weighting scheme within or across sectors, fisheries, or port areas. This limitation significantly constrained the ability to evaluate how the maps work, their performance and quality, and the 'tensions' between alternative fisheries relative to weighting criteria. In contrast, the NEDA maps found in Oregon MarineMap provided reviewers with the opportunity to explore the map and evaluate the sensitivity to various criteria and mapping alternatives. If OFCMP maps are sensitive to weighting criteria (which is not an unreasonable expectation given the diversity of fisheries and their wide range of expenditures, landings, revenues, and costs) they will be more challenging to approve and use within the Territorial Sea Planning Process. However, they may also be potentially more valuable for resolving complex spatial decisions involving multiple fleets and sectors as well as other ocean uses.

Other Issues

- The OFCMP report and the associated aggregate fishing maps provide no measures of the variability inherent in the raw data. STAC considers this to be a serious deficiency. In general, if raw sample data are highly variable, then there will be greater uncertainty surrounding the average value, compared to having raw data that are not variable. In the context of the fishing maps, it is important for decision-makers to be aware of whether or not the sampled fishers were consistent or inconsistent in their identification of important fishing grounds. If there is a high degree of consistency, this provides some assurance that raw data from a different sample of fishers would produce similar results. Inconsistency in the data, however, implies that raw data from a different sample of fishers could produce different results, which, in turn, implies that a decision based on such results could be controversial.
- The data provides a snap-shot in time of the important fishing grounds. However, the report provides no perspective on the potential for year-to-year variation in the location of important fishing grounds. If there is a high degree of variability, then raw data collected during 2008, for example, might produce a different view of the situation compared to data collected during 2004 or 2012. Consistency in data from different years gives some assurance that the information provides a stable basis for a decision.
- As in all such studies, the lack of validation and gaps in documentation raise questions about the possibility of 'gaming' by some participants. This was noted in the STAC

report on the Economic Review of Marine Reserves (Hanna and Sampson 2009). Wilen and Abbott (2006) attempted to verify the Ecotrust Open Ocean Maps project in California using logbook data, with only partially successful results. However, the incentives for 'gaming' (deliberately misrepresenting the importance of a location) may be few once aggregate maps are shown to the fishing community for validation (Wilen and Abbot 2006; McCay et al. 2006). Although there is absolutely no evidence of deliberate 'gaming' in the OFMPC process, validation of the data and mapping process would be important for improving confidence in the data and the map products.

Strengths, Limitations, and Recommendations

Strengths

The OFCMP mapping process and Open Oceans map software provided a valuable tool and unique opportunity to address an important data gap on the spatial use of commercial, charter, and recreational fisheries in the Oregon Territorial Sea, and to use these data to determine social and economic value and importance of spatially-defined areas. The data and mapping process engaged a large number of fishing community members in self-reporting data, reviewing data, and approving map products. The single set of port maps produced by the process may correlate with some of the Goal 19 definitions describing 'important' fishing areas.

Limitations

As summarized in this review the OFCMP data and mapping process had a number of problems and limitations. The data sampling process in the commercial and particularly recreational fisheries was potentially biased due to the non-random nature of the survey design, non-random participation, and/or low sector survey participation. There was no attempt to validate the results, even though data was collected through surveys and self-reported, and self or industry verified. This problem was compounded due to gaps in documentation. Inconsistent and inappropriate weighting and aggregation methods used to produce the OFCMP port maps limit the potential application to define 'importance' or determine economic and social fishery value for specific spatial areas. Lack of access to the data and maps also limits the ability of reviewers to evaluate the OFCMP data, mapping process, and sensitivity of alternative weighting schemes.

Recommendation

In the absence of other comprehensive spatial information describing fishing use and location, the OFCMP data and maps are potentially important tools for marine spatial planning and for 'avoiding, minimizing, or mitigating the adverse effects' of alternative uses of Oregon's Territorial Sea. However, any potential user of the OFCMP products must recognize the problems, assumptions and limitations. Validation and improved documentation may address some of these concerns.

Acknowledgments

STAC greatly appreciates the tremendous amount of support by ODFW, DLCD, Ecotust, The Nature Conservancy and FISHCRED in this STAC review. Members of these groups provided briefs to STAC, answered a host of written questions and attended a number of meetings at STAC request to answer additional questions. We thank them for all of their help. We also thank Jenna Borberg (Sea Grant) who helped coordinate all meetings, gather references and helped edit this report.

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Other background documents and review materials are available at http://oregonocean.info/index.php?option=com_content&view=article&id=480:stac-review-of-oregon-marine-planning-data&catid=15:stay-up-to-date-on-ocean-alternative-energy&Itemid=12

APPENDIX 1: STAC Scope of Work

Approved by OPAC Executive Committee: January 18, 2012

OPAC requests that STAC review, to the extent practicable, the data sets and information used in Oregon MarineMap (OMM) that form the foundation for the spatially-explicit Territorial Sea Plan. In particular, STAC should review the assumptions, data validity and sampling design, data gaps, spatial representation and strengths and limitations associated with 1) the Nearshore Ecological Data Atlas (ODFW) and 2) the Fishing Grounds maps (Ecotrust). STAC should also explore scientific aspects of the data sets and information used in map/s, if available, to be submitted by the Oregon Wave Energy Trust (OWET), or its contractor, during the TSP process.

For the Nearshore Ecological Data Atlas, STAC analyses will include both data set review and Marxan analysis. STAC should also review conclusions drawn from the (September 2011) scientific workshop. This review will require full access to the database and sampling procedures and include:

- full list of datasets (individual datasets and Marxan output maps with OMM link and/or name)
- explanation of how Marxan contours were developed for inclusion in resource levels
- summary of Marxan 'performance' (percent of resources captured at various marxan levels).

For the Fishing Grounds maps, STAC analyses will include review of the methodology to create the port maps, including the number of interviews conducted. Access to the database is not possible, due to the confidential nature of the data.

STAC will limit analyses to scientific questions and not deal with policy issues (e.g., what is included in Level 1 or Level 2 designation).

At this time, STAC will not be asked to review other projects or submitted spatial comments from sources other than from OWET or its contractor. At some point in the future, STAC may be requested to review some of these other projects (e.g., Shoreside Economic Analysis report) or spatial comments (e.g., Pacific City Dorymens' fishing map; Ocean Power Technologies' (OPT) proposed areas).

APPENDIX 2: Reviewers

STAC Members

Stephen Brandt, Oregon Sea Grant, chair

Jack Barth, Oregon State University, College of Earth, Ocean and Atmospheric Sciences (CEOAS)

Veronica Dujon, Portland State University, Department of Sociology

Jeff Feldner, Oregon Sea Grant

Elise Granek, Portland State University, Environmental Science and Resources

Jan Hodder, University of Oregon, Oregon Institute of Marine Biology

William Jaeger, Oregon State University, Agricultural and Resource Economics

Gil Sylvia, Oregon State University, Coastal Oregon Marine Experiment Station/Agricultural and Resource Economics

Craig Young, University of Oregon, Oregon Institute of Marine Biology

External Experts

Lorenzo Ciannelli, Oregon State University, CEOAS

Dawn Goley, Humboldt State University, Department of Biological Sciences

James Graham, Oregon State University, CEOAS

Harriett Huber, NOAA, National Marine Mammal Laboratory, Seattle, Washington

Jessica Miller, Oregon State University, Hatfield Marine Science Center

Bill Pearcy, Oregon State University, CEOAS emeritus

Bill Peterson, NOAA, Northwest Fisheries Science Center, Newport, Oregon

Rob Suryan, Oregon State University, Department of Fisheries and Wildlife

Review Team Members:

	NEDA				OFCMP
STAC Review Groups	**1. Birds & Mammals**	**2. Fish**	**3. Ecosystem**	**4. Marxan**	**5. Fishing Grounds Maps**
Group Lead	Jan Hodder	Jeff Feldner	Jack Barth	Craig Young	Gil Sylvia (co-lead) Bill Jaeger (co-lead)
STAC Members			Elise Granek Craig Young	Elise Granek Jan Hodder	Veronica Dujon
External Experts	Dawn Goley Harriett Huber Rob Suryan	Lorenzo Ciannelli Jessica Miller Bill Pearcy	Bill Peterson	James Graham	David Sampson

APPENDIX 3: Review Timeline

January 18, 2012 **-** OPAC approved the Scope of Work for STAC's review (Appendix 1).

January 27 - STAC had their first Conference Call to discuss OPAC's charge.

January 28 –March 19 - Each of the five groups of STAC plus external experts convened by numerous conference calls and in-person meetings to review different areas of Oregon's marine planning data. Staff from DLCD, ODFW, TNC, Ecotrust and FISHCRED participated in some of these meetings to give presentations and answer clarification questions. Background materials and review documents were posted to the DLCD hosted ocean website (http://oregonocean.info) in order to have everything in one easy to access location.

March 20 - STAC all-hands meeting for the five groups to present draft reports and all members to discuss the review. Staff from DLCD, ODFW, TNC, and Ecotrust attended to answer remaining clarification questions.

March 21 – April 8 – Each team drafted their report, these were compiled and then the entire comprehensive report was reviewed by all of the STAC review team members.

April 9 – Stephen Brant, the Chair of STAC, presented a summary and highlights of the STAC review to OPAC.

April 24 – STAC submitted a draft report to OPAC, giving them an opportunity to provide comments. STAC requested that OPAC limit comments to corrections and points of clarification.

May 9 – June 20 - OPAC submitted corrections and points of clarification to the STAC chair. Comments were distributed to Review Team leads and they, along with their Teams, made edits to clarify or correct text as appropriate.

APPENDIX 4: List of Acronyms

AFSC	Alaska Fisheries Science Center (part of NOAA)
AU	Assessment Unit
AVHRR	Advanced Very High Resolution Radiometer
CCR	Crescent Coastal Research
CEOAS	College of Earth, Ocean, and Atmospheric Sciences (at Oregon State University)
DLCD	Department of Land Conservation and Development
EDCP	Enhanced Data Collection Program
ESA	Endangered Species Act
FISHCRED	Fishermen's Information Service for Housing, Confidential Release and Essential Distribution
MaxEnt	Maximum Entropy
MLPA	Marine Life Protection Act
NEDA	Nearshore Ecological Data Atlas
NMFS	National Marine Fisheries Service (part of NOAA)
NOAA	National Oceanic and Atmospheric Administration
NWFSC	Northwest Fisheries Science Center (part of NOAA)
ODFW	Oregon Department of Fish and Wildlife
OFCMP	Oregon Fishing Community Mapping Project
OIMB	Oregon Institute of Marine Biology
OMM	Oregon MarineMap
OPAC	Ocean Policy Advisory Council
OPT	Ocean Power Technologies
OSU	Oregon State University
OWET	Oregon Wave Energy Trust
PacFin	Pacific Fisheries Information Network
PISCO	Partnership for Interdisciplinary Studies of Coastal Oceans
PRBO	Point Reyes Bird Observatory
PSU	Portland State University
SST	Sea Surface Temperature
STAC	Scientific and Technical Advisory Committee
TNC	The Nature Conservancy
TS	Territorial Sea
UO	University of Oregon
USFWS	United States Fish and Wildlife Service