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PUTTING LIFE INTO ECOSYSTEM-BASED MANAGEMENT THEORY: A PLANNING APPLICATION USING SPATIAL INFORMATION ON MARINE BIODIVERSITY AND FISHERIES

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INTRODUCTION

Worldwide, the ever-increasing demands on natural resources require society to make important decisions about resource use and conservation. The fate of marine fish species is among the top issues our society faces. To begin to address this planners and managers must take an ecosystem approach while accounting for marine fish diversity, production, and sustainability. However, traditional stock assessments and management actions have largely focused on single species without regard to habitat requirements or conditions.

This Ecosystem-Based Management (E-BM) case study explicitly links two different objectives, biodiversity conservation and fishery production. These explicit links were established with Geographic Information System (GIS) technology and two spatial analysis tools; an optimized site selection tool, Marxan (http://www.ecology.uq.edu.au/index.html?page=27710), and a fisheries modeling tool, Ecopath with Ecosim (EwE, www.ecopath.org). These are commonly used tools worldwide for marine biodiversity and fisheries planning, respectively. Both offer a tremendous amount of flexibility and transparently in designing decision support scenarios, and continue to be developed to better serve the planning community. This case provides an introduction to how biodiversity and fishery objectives can be incorporated together into an integrated E-BM planning approach.

The information presented here offers an example of how biodiversity and fisheries considerations can be jointly addressed; this is not intended to be the optimal or single approach when considering these objectives.

In specific this study aims to

a) illustrate how biodiversity and fishery objectives can be combined using spatial tools, and

b) examine the relationships between marine ecosystem characteristics and specific fishery production metrics.

Two approaches are illustrated for combining these objectives. In the first approach, Marxan solutions are developed with and without data on marine fish. In the second approach, Marxan solutions are directly linked to EwE models through the Ecospace module to evaluate the effects of selecting areas for the conservation of representative biodiversity on fishery production.

BACKGROND

Conservation assessments serve as a guide for planners and decision-makers, and have no regulatory authority. These assessments are conducted in a transparent manner and are made accessible to the widest range of users possible. They should be treated as a first approximation, and the gaps and limitations described within these regional assessments must be taken into consideration.

The Pacific Northwest Coast ecoregion is a narrow, elongated landscape lying to the west of the Coast Range mountains and stretching from the southern border of Oregon to the northern tip of Vancouver Island. The ecoregion includes nearly all of the Olympic Peninsula and most of Vancouver Island, British Columbia encompassing some 8,170,260 ha (30,900 square miles) of temperate rainforests, beaches and rocky intertidal zones, bays and estuaries, and coastal rivers. The outer coasts of Oregon, Washington and the West Coast of Vancouver Island in British Columbia offer a wide range of intertidal and subtidal marine diversity. From exposed rocky shores of the Pacific Ocean to protected estuarine systems, the Pacific Northwest Coast ecoregion encompasses over 9,000 kilometers of shoreline. In general, the region is characterized by large amounts of rain in places along the coast which contribute freshwater run-off and land-derived nutrients to the marine environment. This case study examines the U.S. portion of this ecoregion.

Historical management of fisheries has generally been crisis-based rather than proactive. However, there is a growing national and international recognition of the need to develop an Ecosystem-Based approach to Fisheries Management (E-BFM) in response to the challenges and shortcomings of traditional resource management approaches in sustaining marine ecosystems. While E-BFM is a laudable goal for fishery management the purpose of the cases illustrated here is ultimately to go beyond single objective or sector management (e.g., fisheries) to consider multiple objectives in a more holistic management context.

METHODS

In setting the context for fisheries in the Pacific Northwest region we first assessed diversity and production by constructing spatial data on marine fish targets and included them within a Decision Support database. We designed multiple Marxan scenarios to examine the influence marine fish targets had on priority conservation site selection.

In order to better address fisheries and multiple trophic relationships, we have examined the use of Ecopath with Ecosim (EwE) . EwE is regarded as a widely used and acknowledged fisheries modeling tool around the globe. EwE software analyzes exploited aquatic ecosystems, combining software components for ecosystem trophic mass balance analysis (Ecopath) with a dynamic modeling capacity (Ecosim) for exploring past and future impacts of fishing and environmental disturbances. Ecosim models can be replicated over a spatial map grid (Ecospace) to allow exploration of policies such as marine protected areas, while accounting for dispersal and migration of fishes. This toolkit provides a brief overview of the Ecopath with Ecosim model but focuses primarily on Ecospace.

An Ecopath model has been developed in the Northern California Current (NCC) ecosystem, extending from Cape Mendocino in California to Cape Flattery, Washington (Field 2005). This case study utilizes the NCC Ecopath model and extends its utility to include an Ecospace component.

We report on two cases or examples. For the first case we utilized ecoregional planning methods to run Marxan scenarios with and without marine fish targets or fishing effort. Most marine regional assessments have not incorporated marine fish targets except some limited life stage data such as spawning beaches or aggregation sites just off shore. Therefore including marine fish targets offers a new perspective to regional conservation priority setting.

For the second case The Nature Conservancy worked with the Science for Ecosystem-based Management Initiative (SEMI) at NOAA Fisheries who developed an initial Ecospace component from the Northern California Current Ecopath model to examine different potential Marine Protected Area designs. The Nature Conservancy worked with SEMI to extend the utility of their Ecospace model to incorporate information from Marxan. Together we developed a spatial information exchange where Marxan solutions could be imported into Ecospace. This information exchange set the groundwork for establishing the multiple objective Decision Support System. In doing so we were able to leverage the spatial efficiency provided by Marxan site selection as well as the trophic interactions displayed over time and space with Ecosim and Ecospace. Here we illustrate that this method of linking objectives can have significant biodiversity, fishery, and zoning implications.

RESULTS

The results of the first case or example

This initial examination calculated a 70% shift in site location when these factors were considered within the biodiversity conservation planning framework. It should be noted that Marxan can output a significant shift in site location when the same scenario is run twice. This is especially true of scenarios that heavily rely on representative targets lacking quality or viability assessments for each target, or have goals of representation under 100%. Even with this variability the shift in site location represents important considerations to recognize when designing potential reserve networks across multiple objectives. These and all decision support system results need to be ground-truthed and verified with site-scale information and expert review panels; these outputs are best used to inform decision making processes, and again should not be mistaken as “answers” in meeting these objectives.

The results of the second case

We ran Marxan in multiple scenarios in order to identify potential conservation priority areas across various-sized total area designs (0 – 44%). Imported Marxan solutions were informed by both marine fish targets and fishing effort. Every solution was imported into Ecospace with Ecosim running over a 21-year trajectory starting in 2002. Ecospace mapped biomass dispersal rates and distribution, migration, habitat preferences, and fishing pressure for all groups over that timeframe. Results are reported at the end of this 21-year period, which we term "biomass returns," for each subregion of the study area.

In order to begin answering the above questions we compiled quantitative results of specific biomass groups. Specific groups were chosen to illustrate this where species were also identified in the marine ecoregional assessment process as a marine fish target. Of the 17 fisheries targets included Decision Support System database, we chose 6 species as indicative of general patterns: Sablefish, Yellowtail Rockfish, Lingcod, English Sole, Rex Sole, and Dover Sole.

Ecospace results were examined both in and outside of the potential conservation priority areas in order to explore the implications for how biomasses were captured. It is assumed that these potential conservation areas will preserve higher amounts of biomass relative to the assigned fishing pressure from outside, but we wanted to test this assumption quantitatively. Our initial look at biomass returns illustrates that most biomass groups were more abundant inside the potential conservation areas, but this was not always the case. English Sole, for example, were more abundant inside the Marxan solutions up to 25% of the Cape Blanco subregion, which then dropped off until biomasses were reported to be the same as the total conservation area reached 44%.

IMPLICATIONS

Implications for the first case

Notice the shift in site location in the Olympic Coast National Marine Sanctuary (OCNMS - just south of Cape Flattery). With the inclusion of marine fish and fishing effort data this area is highlighted relative to when these factors are not included. The Olympic peninsula contains high levels of biodiversity in both terrestrial and marine environments, and the Sanctuary itself contains relatively high amounts of marine fish diversity; it is also a place where fishing effort is lower than other areas in the ecoregion. This implies the need for appropriate management in OCNMS where boundaries and a management scheme have been established.

Implications for the second case

The Ecospace results using Marxan solutions are beneficial in decision making processes where different assumptions including the size of proposed reserve designs, their affects outside these areas, and the amount of fishing pressure around them are all important issues in addressing Ecosystem-Based Management. By importing these solutions that have been informed by spatially-explicit biodiversity conservation, marine fish, and fishing effort data, there is an implied spatial efficiency in these areas representing marine ecosystems. This work needs to be further tested, but has laid the groundwork for future effort in advancing joint biodiversity and fishery objectives.

Both Lingcod and Dover Sole showed more biomass inside the potential conservation areas than outside in all cases. This is perhaps a verification of the literature stating the benefits of reserves for marine fish production. But why did biomass returns for English Sole decline after 25% total area in the Cape Blanco subregion was depicted as potential conservation sites? Perhaps the amount of preferred habitat for English Sole was reached around 25%, which then production dropped because the larger areas were not able to capture more preferred and/or higher quality habitat. This could also imply that fishing effort outside that 25% area of the Cape Blanco subregion had degraded their preferred habitat. A detailed analysis needs to be conducted that spatially aligns marine fish targets with habitat types as well as a current condition analysis to update the fishing effort information. With this updated information, which indeed may be better collected and assessed at site or subregion scales, the user community will be able to more accurately account for species-habitat preferences and fishery production in and outside of priority conservation areas.

By understanding the complex ecological relationships within which exploited fishes exist, researchers can better anticipate the effects of the ecosystem on fisheries and the effects of fishing on the ecosystem. In this way the science of E-BM can help inform decision makers on the intricate relationships that revolve around biodiversity conservation and fishery production.

LITERATURE CITED

Field, J.C., R.C. Francis, K. Aydin 2006. Top-down modeling and bottom-up dynamics: Linking a fisheries-based ecosystem model with climate hypotheses in the Northern California Current. Progress in Oceanography 68, 238-270.

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