

FUTURE DIRECTIONS IN FISHERIES MANAGEMENT: AN ECOSYSTEM-BASED APPROACH

Ecosystem-based fisheries management (EBFM) uses a holistic approach to fisheries management, characterizing a greater number of ecosystem components, including the physical and chemical properties of systems. This newsletter explores the current and potential applications of the ecosystem-based approach.

Broader horizons in fisheries management

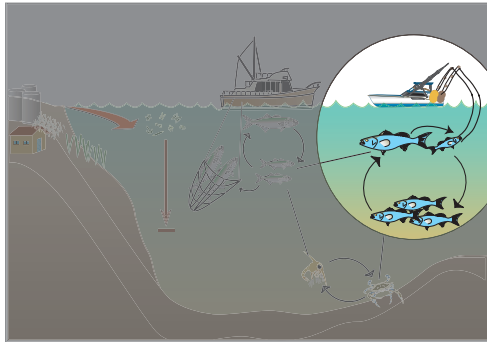
The standard approach to fisheries management has been to focus on one species at a time, using parameters such as catch level, life history, and economic yield in order to determine a management plan for the fishery (Figure 1). The use of targets and thresholds to trigger management actions allows for a focused, efficient regulation of a single fishery. However, with the single-species approach, habitat characteristics, interactions between species, and natural variability are not incorporated, contributing to scientific uncertainty and potentially masking factors affecting the health of all fisheries. The challenge at hand is to reflect these factors successfully using an ecosystem-based approach.



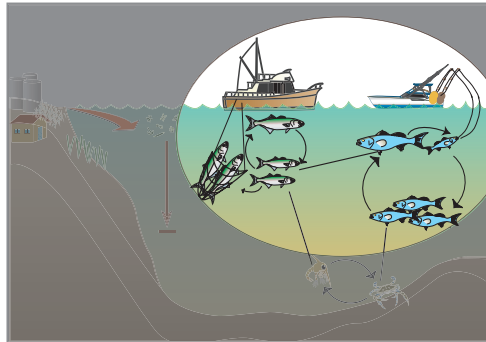
Boats rigged for commercial fishing in Chincoteague Bay, Maryland.

T. Caruthers, UNCES

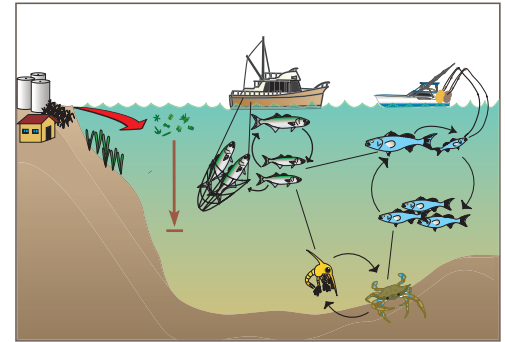
Single-species



Multi-species



Ecosystem-based



Major research & assessment required:

- Species' life history
- Catch data (e.g. biomass, fishing effort)
- Stock assessment
- Fisheries-independent monitoring

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- In addition to the requirements of single-species management:
- Diet composition and ecological interactions
 - Bycatch and fleet monitoring
 - Assessment of value

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- In addition to the requirements of multi-species management:
- Analysis of the relationships between habitat, land use, fishing effort, distribution and population, and water quality/physical-chemical properties

Major management options & tools:

- Quotas, maximum sustainable yield
- Fishing mortality thresholds
- Biological reference points as a means of determining targets and quotas
- Licensing and seasons

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- In addition to those used in single-species management:
- Bycatch limits
 - Multi-species committee meetings to analyze management options
 - Multi-species assessment models

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- In addition to those used in multi-species management:
- Ecosystem models linking living resources and habitat characteristics listed above
 - Integrative ecosystem committees
 - Habitat restoration, reducing nutrient loads

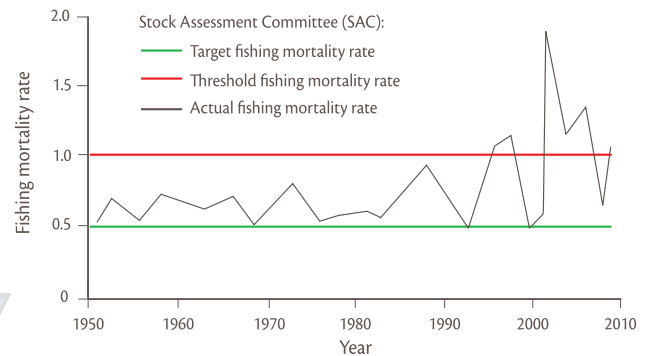
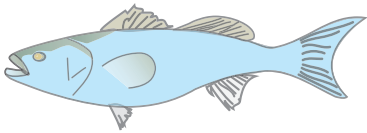
Figure 1: The evolution from single-species to ecosystem-based fisheries management involves a widening of scope toward our current position - on the verge of implementation.

Broader horizons lead to increasing complexity

During the transition from a single-species to an ecosystem-based approach, the level of complexity is magnified. This transition does not imply doing away with single- and multi-species approaches. Ecosystem-based management is a synthesis of traditionally single- and multi-species information and tools, with the new additions of trophic interactions and habitat.

Single-species

The premise of the least complex approach, single-species management, is largely based upon assessing the population in relation to fishing mortality rate targets and thresholds. The goal of this process is to achieve a maximum sustainable yield (Figure 2A). Though it is the least complex of the three approaches, single-species management requires substantial research and monitoring effort even before a management plan may be developed.



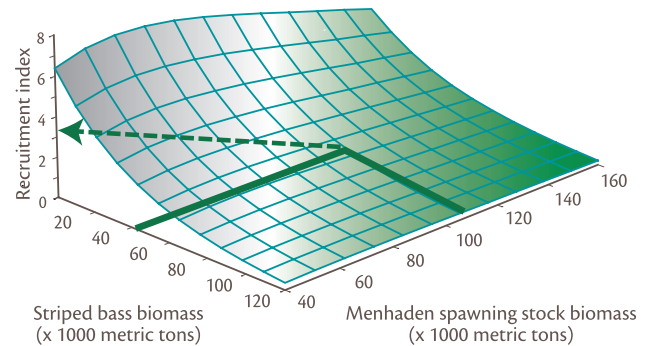
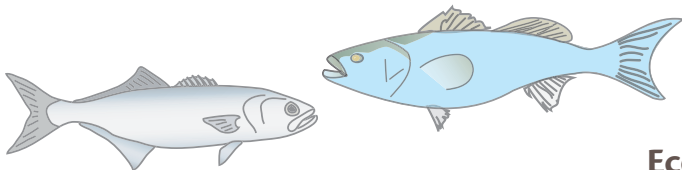
A. Single-species target and threshold system, where fishing mortality rate (F) is used to alter harvest regulations when numbers approach threshold levels.

Adapted from the 2005 Chesapeake Bay Blue Crab Advisory Report, Fisheries Steering Committee

Multi-species

The multi-species approach adds a new level of information by addressing species interactions. The multi-species approach relies mainly upon diet composition (trophic structure) and recruitment data (amount of fish added to the exploitable stock each year) to predict the consequences of varied fishing effort (Figure 2B).

The inclusion of trophic interactions allows managers to observe the effects of varied fishing effort upon different species. However, the inability to reach target biomass of multiple species by regulating fishing effort alone has demonstrated the need for an approach that includes factors affecting all species (e.g. habitat availability and quality, primary production).



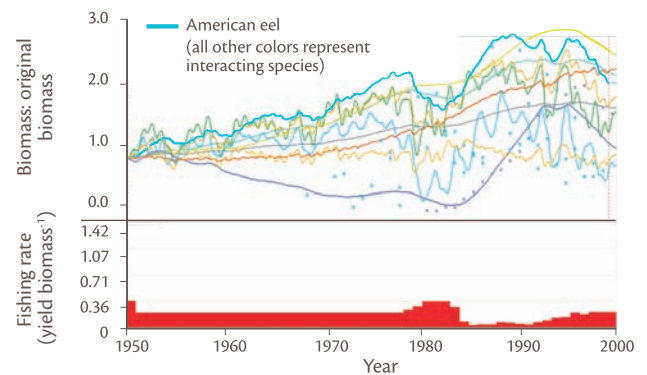
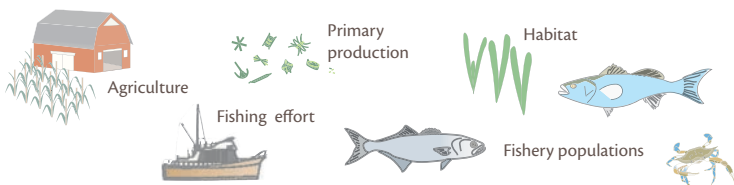
B. Multi-species theoretical model, using menhaden spawning stock and striped bass biomass in the beginning of the year to predict menhaden recruitment (number of young produced) for the fall. The multi-species approach allows for simultaneous observation of the effects of fishing effort on numerous species.

Zhang et al., in prep.

Ecosystem-based

An ecosystem-based approach addresses important factors not included in the above approaches. The researchers and managers involved consider new management options, such as habitat restoration and land zonation. Using a time-dynamic simulation and accounting for nutrient inputs and habitat parameters, ecosystem-based models further support a comprehensive look at the entire system, rather than a narrow representation of one species at a time. In this manner, both sensitive and more resilient species may be more fully represented (Figure 2C).

With a balance of research, modeling, and time invested in adaptive management, the goal of these additions is to lead to an improved characterization and optimum sustainable yield for each fishery.



C. Ecosystem based models such as this may be used to help managers examine the influence of multiple factors, including nutrient loading, fishing pressure, and food web dynamics upon species of interest. Dynamic modeling approaches allow managers to interactively examine these influences.

Adapted from EwE output by H. Townsend NOAA

Figures 2A-C: Examples of modeling tools used or in development for single-species, multi-species, and ecosystem-based management.

The process behind sound management

Sound management is an adaptive process, reducing costs and enabling feedback by continual evaluation and refinement of the plan's effectiveness. The first planning stages require an integrative ecosystem committee comprised of managers, researchers, and stakeholders.

In order to implement an ecosystem-based management plan, the **assessment** stage requires a framework of research, monitoring, and modeling. This research includes analysis of fleet dynamics, ecological interactions, nutrient loading, physical and chemical properties of aquatic systems, and the effects of changing land use practices on water quality. Mapping species' habitat using information such as salinity, dissolved oxygen, and bottom type is also a large part of this process.



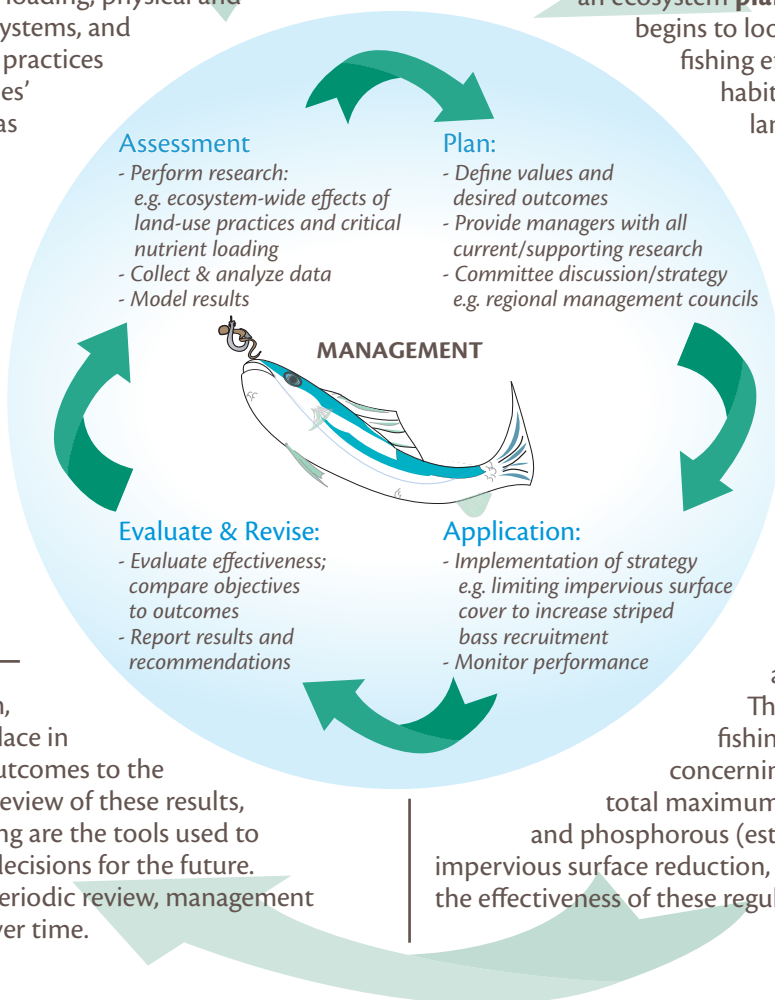
M. Matsche, MD DNR

Species are dissected to determine diet composition. This data will be used to contribute life history information for modeling trophic interactions.

After the application of the plan, **evaluation and revision** take place in order to compare the desired outcomes to the monitored results. Committee review of these results, research, and predictive modeling are the tools used to refine and adapt management decisions for the future. As changes are made through periodic review, management decisions are able to improve over time.

After research has been synthesized, an integrative ecosystem committee (watershed and system stakeholders, researchers, and managers) works together to define desired outcomes for an ecosystem **plan**. This integrative approach begins to look outside the realm of regulating fishing effort to other factors such as habitat quality restoration, land use/impervious surfaces, and critical nutrient loads. Including both resident and migratory species, this process is extensive, requiring the cooperation of many interested parties. Migratory species are particular management challenges, as habitat and range may extend across jurisdictional zones, depending upon a species' life stage and the time of year (Figure 3).

The **application** of an ecosystem-based plan varies according to a system's attributes. The strategy used may reach beyond fishing effort to include regulations concerning essential habitat protection, total maximum daily loads (TMDLs) of nitrogen and phosphorous (estuarine and coastal systems), impervious surface reduction, zoning laws, etcetera. Monitoring the effectiveness of these regulations is also part of the process.



Distribution and migration ranges of Atlantic striped bass populations

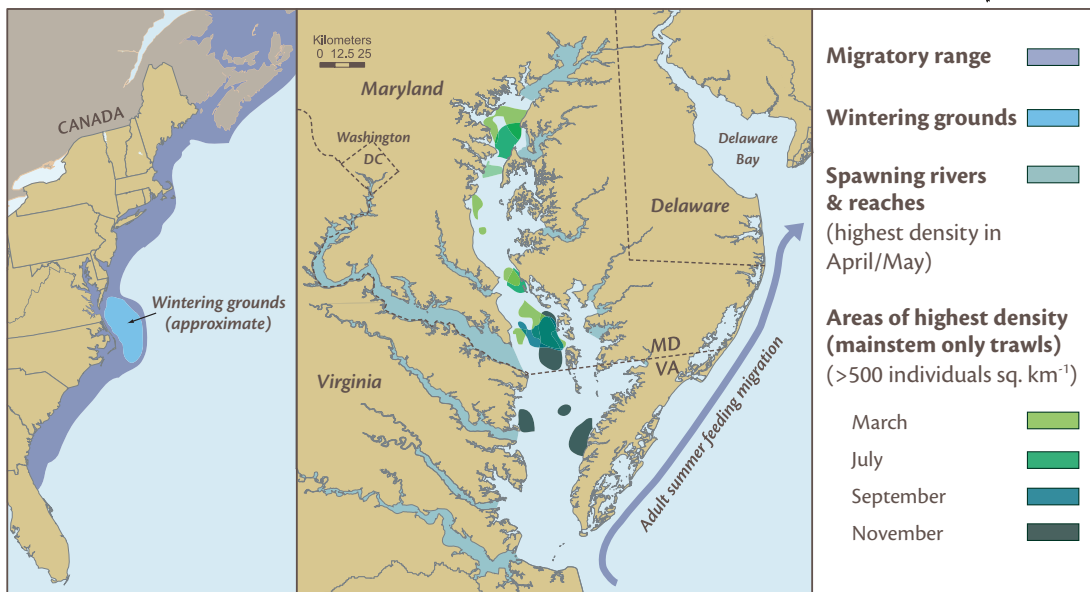
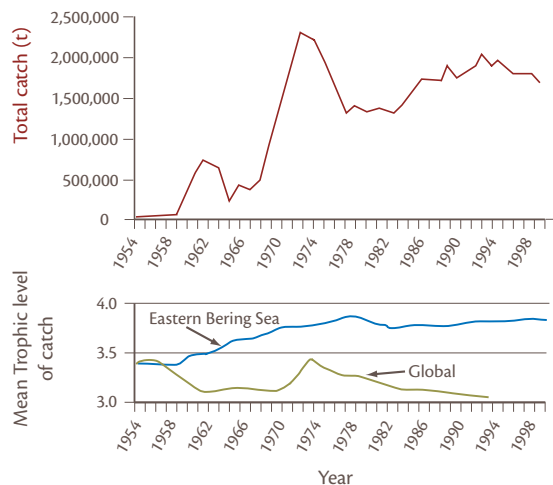


Figure 3: Map of spawning rivers and reaches and high-density distribution (mainstem only) of striped bass in Chesapeake Bay. Migratory species are a management challenge, ranging across jurisdictional zones. The variability of certain habitat characteristics (e.g. dissolved oxygen) further compounds the difficulty of managing species. Spawning areas are adapted from Habitat Requirements for Chesapeake Bay Living Resources (Funderburk 1991); distribution/abundance data are adapted from Virginia Institute of Marine Science's ChesMMAP trawl surveys for the year 2001.

Beyond the theory: success is possible

Despite still being in its infancy, the ecosystem-based strategy is increasingly being evidenced in international and national documentation (e.g. Sustainable Fisheries Act, 1996; Ecosystem Principles Advisory Report, 1999).



Bering Sea figure adapted from P. Livingston, Alaska Fisheries Science Ctr. global trophic trends from Pauly et al. (1998)

Figure 4: Total catch and mean trophic level of the Eastern Bering Sea fishery compared with global trends in mean trophic level of landings. The Sea's relative trophic level stability is unique among most fisheries, indicating that higher level consumers (e.g. pollock, Pacific cod, yellowfin sole) are not being overfished while many current fisheries are depleting the larger, spawning-age fish populations.

Given the complex nature of EBFM, the greatest challenges lie in defining the desired outcomes and coordinating multiple stakeholders and government agencies.

While few examples of EBFM currently exist, the Bering Sea has had some success using the approach. Groundfish population and mean trophic levels of the catch (an indicator of ecosystem sustainability) are relatively stable.

In this case, success can be attributed to annual trawl surveys providing vital population data (Figure 4), and a network of Marine Protected Areas providing essential habitat. The stability of the fishery may also be in part due to the nature of an open-ocean system, in which variability may not be as pronounced as within an estuary or coastal ecosystem. While the concept of EBFM has made its way into research and planning efforts, its implementation is still in the early stages worldwide.



Pacific trawl surveys aboard the research vessel Miller Freeman

Captain R. A. Pawlowski, NOAA Image Library

Progress in Chesapeake Bay

Currently in Chesapeake Bay, a fisheries ecosystem plan (FEP) has been published, serving as a guide for ecosystem-based fisheries management. The FEP addresses many issues particular to managing an estuary, from habitat management requirements and current state of fisheries to population history and predictive modeling. Ecosystem-based modeling efforts may help to account for new parameters, such as the effects of habitat restoration or varied nutrient loading into the Bay. A recent estimate of effort toward implementing a plan ranged from 41-67% for each of five species (Figure 5).

Recommendations for Chesapeake Bay include defining essential habitat and areas of particular concern for species as well as considering how the population of each individual species affects the ecosystem as a whole. These new steps are the beginnings of a shift toward ecosystem-based management in an estuarine system.

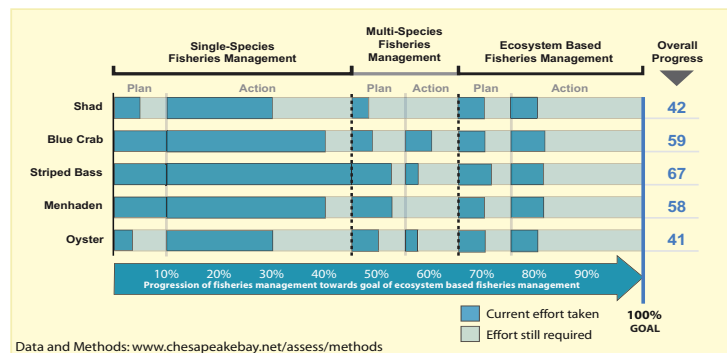
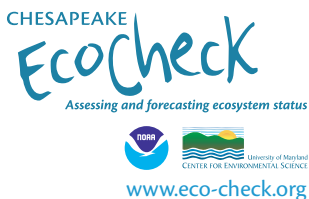


Figure 5: An index of fisheries management effort in the Bay according to the Chesapeake 2000 Agreement.

EcoCheck/Chesapeake Bay Program (2006)

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Further Information:

- EBFM at NOAA Chesapeake Bay Office: <http://noaa.chesapeakebay.net/fisheriesecosystem.aspx>
- Amy Matthews Amos' "Moving forward: a snapshot of U.S. activities in ecosystem-based fisheries management," <http://www.lenfestoccean.org/publications.html>

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