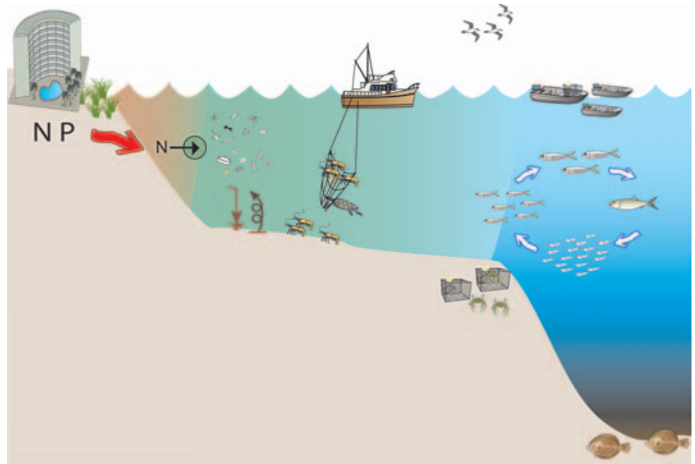
ATLANTIS

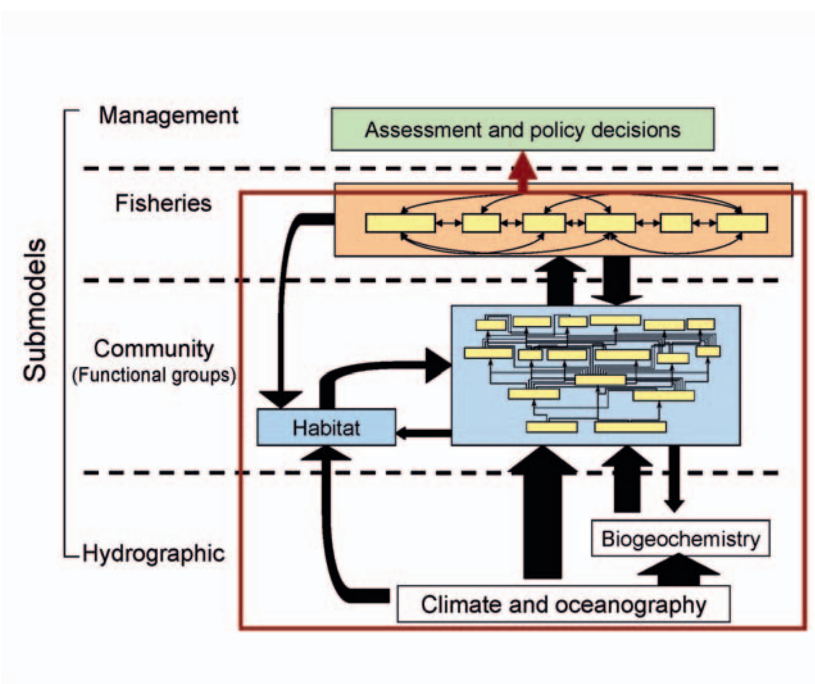
A PROGRAM OF THE SCIENCE FOR ECOSYSTEM-BASED MANAGEMENT INITIATIVE NORTHWEST FISHERIES SCIENCE CENTER. SEATTLE WA.

Atlantis is a simulation modeling approach within the Integrated Ecosystem Assessment framework, capable of testing ecological hypotheses and simulating climatological scenarios.

Atlantis simulates multiple species and fisheries, and can improve our understanding of interactions between species, climate, fishing, and habitat



Ecosystem dynamics are represented by spatially-explicit sub-models that simulate hydrographic processes, biogeochemical factors driving primary production, and food web relations among functional groups. The modular structure allows alternative model formulations that are site specific.



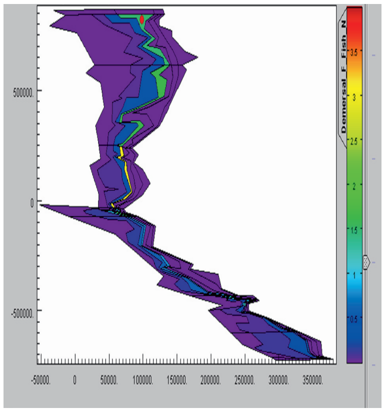
The core of Atlantis is a three-dimensional biophysical module which follows nutrient flows (i.e. N and S) through the main biological groups in the system. The hydrographic model simulates fluxes of water and nutrients driven by temperature and salinity. The fishery submodel considers multiple fleets (target, bycatch, habitat effects, ports, costs, compliance), their impacts (removals, habitat modification) and effort dynamics (CPUE or cost-based, exploration, fisher behavior, social networks).

Funding provided by: Gordon and Betty MOORE FOUNDATION; the David & Lucile Packard FOUNDATION

Atlantis is a spatially explicit modeling platform

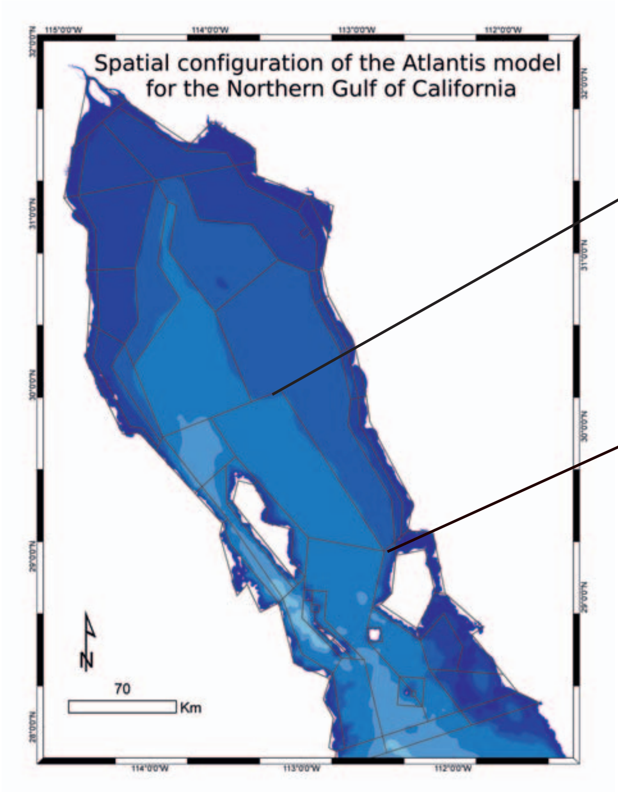
The user can specify the level of complexity needed from few functional groups with simple trophic interactions to complex models with multiple fleets and management options. The model represents key exploited species at a level of detail necessary to evaluate direct effects of fishing, and it also represents other anthropogenic and climate impacts on the ecosystem.

Atlantis was developed by Dr Beth Fulton, an ecosystem modeller at CSIRO Marine and Atmospheric Research in Hobart, Australia

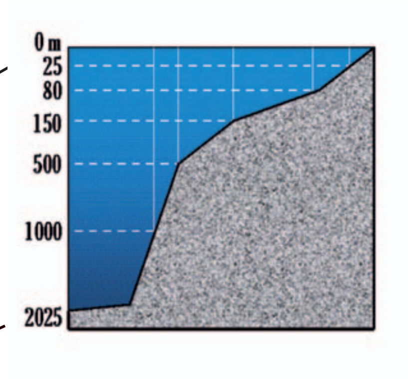


The model can test regional responses to management actions.
Spatial distribution of small flatfish (mg N/m3)

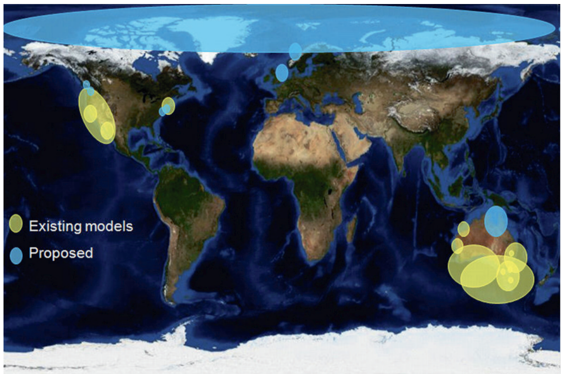
The trophic resolution is at the functional group level. Invertebrate groups are represented as biomass pools, but vertebrates have a specific age structure formulation. An 'availability matrix' describes the rates of flow of material between functional groups, by defining the contribution of each prey type to the diets of predators and considering density dependent effects relating to interaction rates, predator feeding mode, prey avoidance behavior and other factors. The availability matrix is calculated using the percent contribution of prey to predator diet, taken as an annual average over the whole study area. Trophic relations and ecological processes modeled include consumption, production, migration, predation, recruitment, habitat dependence and mortality.



Depth layers



The physical environment is represented explicitly through a series of polygons that coincide with the main geographic and regional characteristics of the marine system. The biological processes are repeated in each of the depth layers within each polygon.

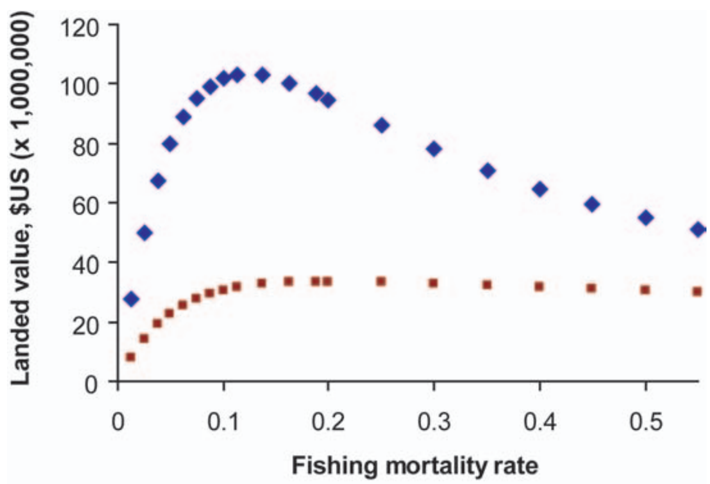


The generic Atlantis code is well developed, and has been parameterized for several systems in Australia. There are currently 13 Atlantis models in use and several others in development. Most recently, it has been used in SE Australia to rank alternative policy scenarios, quantitatively evaluating alternative management packages of quotas, protected areas, closed seasons, and other policy options. At NWFSC we have developed Atlantis Ecosystem Models for Central California and the California Current, we are testing scenarios for the Northern Gulf of California, Mexico and a model for Puget Sound is in development.

We have used Atlantis models to:

Identify food web effects of ocean acidification

We identified the food web effects of declines in shelled plankton and benthos along the US West Coast, as are likely under ocean acidification caused by projected increases in atmospheric CO2 levels. Our results demonstrate that predators dependent on shelled invertebrate prey, such as the flatfish English sole (*Pleuronectes vetulus*), are particularly vulnerable to acidification and could show tenfold declines in abundance and sustainable harvest. In contrast, other groups (e.g. jellyfish) are likely to increase in biomass.



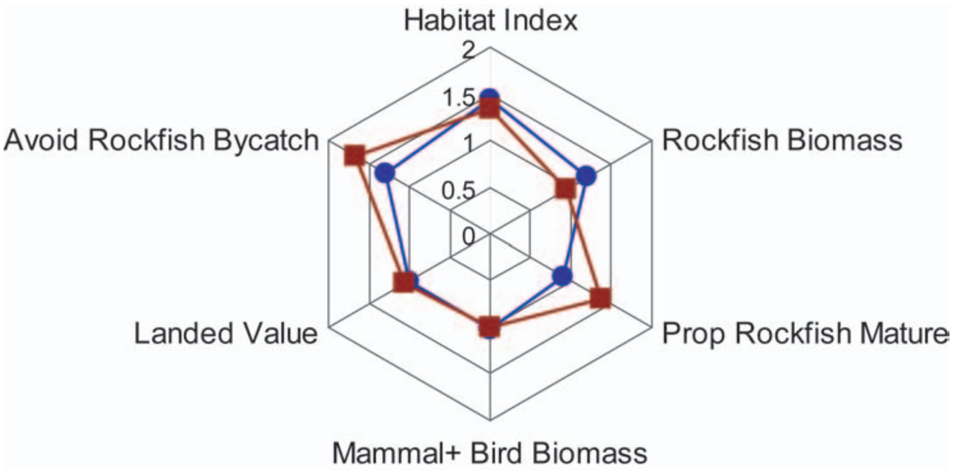
Ladings of English sole under current ocean conditions (top line) vs. conditions with strong effects of acidification on shelled benthos (bottom line)

Incorporate a range of ecosystem properties

Two Atlantis models have so been built for the Northern Gulf of California, representing the ecosystem as it appeared in 1985 and in 2008. Atlantis can represent persistent oceanographic influences important to this region like the strong latitudinal gradient of turbidity, the natural stratification of salinity and temperature, and reversible seasonal gyres. The function of biogenic habitats such as seagrass and rhodolith beds as fish rearing habitat and refuge space is also represented. Incorporating these features increases the useful range of ecological and management scenarios that can be tested using Atlantis.

Identify tradeoffs between economic and ecological objectives

We identified five broad options for managing human impacts on the marine system of in the US West Coast, both coastwide and in Central California. This model specifically addressed the scientific and management needs of the National Marine Sanctuaries (NMS), the California Department of Fish and Game, and the California Ocean Science Trust Monitoring Enterprise. We worked with NMS staff to develop 5 major alternative scenarios for fisheries management, and several additional variations within these. Overall, the scenarios captured a range of options for spatial management and shifts in prevalence of particular fishing gears. We simulated the impact of each of these scenarios for 20 years.



Example of tradeoffs between performance of Gear Switch vs. Spatial Management Scenarios

Our results show that no single scenario maximized performance in terms of all desired attributes. There were tradeoffs between economic and ecological objectives when comparing spatial management, gear switching (from trawl to pots and longlines) and effort control scenarios. For instance, there were direct impacts of the scenarios on fleets (e.g. on trawl and longline+pot fleets), as well as indirect effects such as halibut longline fisheries that gained revenue when trawl effort declined. Overall, fleets were differentially affected by the scenarios (some suffer significant economic declines while others see substantial increases). We found that switching gears to minimize bycatch and habitat destruction does not restore the age structure of rockfish populations, but spatial closures can.

Further reading

Kaplan, I.C. & Levin, P. 2009. Ecosystem-Based Management of What? An Emerging Approach for Balancing Conflicting Objectives in Marine Resource Management. In: The Future of Fisheries Science in North America. (eds R.J. Beamish & B. Rothschild), pp. 77-95.

Fulton, E.A., A. D. M. Smith and D. C. Smith. 2007. Alternative Management Strategies for Southeast Australian Commonwealth Fisheries: Stage 2. Quantitative Management Strategy Evaluation. Australian Fisheries Management Authority. CSIRO, 372 pp.

For more information please contact: Phil Levin phil.levin@noaa.gov