

# Marine InVEST

natural  
capital  
PROJECT

## A DECISION-MAKING TOOL FOR MAPPING AND VALUING ECOSYSTEM SERVICES PROVIDED BY COASTS AND OCEANS

Coastal and ocean environments provide a number of important benefits and services to people. Unfortunately, a growing variety and intensity of human activities (e.g., energy production, fishing, coastal development, transportation) threaten the sustained delivery of these ecosystem services. Despite their importance, the ecosystem processes that people rely on for food, recreation, coastal protection, and other services, are poorly understood, scarcely monitored, and often only appreciated after they are lost.

The Marine Initiative of the Natural Capital Project is dedicated to using the framework of ecosystem services to inform ecosystem-based management of marine and coastal waters. With funding from the Gordon and Betty Moore Foundation, we are developing and applying a suite of ecosystem service models called InVEST (Integrated Valuation of Ecosystem Services and Trade-offs).

Marine InVEST is highly flexible to accommodate application across multiple scales in coastal and marine regions with diverse habitats, policy questions, and stakeholders. Our approach identifies where ecosystem services are provided and where they are consumed. It reveals how resource management decisions will affect multiple aspects of the economy, human well-being and the environment. Marine InVEST can help answer questions such as:

- What kinds of coastal management and fishery policies will give us the best returns for sustainable fisheries, shoreline protection and recreation?
- Are revenues from activities such as recreational fishing or scuba diving likely to rise or fall under a new fisheries management program?
- What benefits does marine spatial planning provide to society in addition to food from fishing and aquaculture and secure locations for wind or wave-energy facilities?

*Mapping and modeling ecosystem services—their flows and changes under alternative management scenarios—can elucidate the true costs and benefits of natural resource management options, and can lead to improved decision-making and outcomes for both people and the ecosystems on which we depend.*



The aim of the Natural Capital Project is to align economic forces with conservation. Our focus is on ecosystems, earth's living natural capital. If properly managed, natural capital yields a flow of vital "ecosystem services," including the production of goods (e.g., food), life-support processes (e.g., water purification), and life-fulfilling conditions (e.g., beauty, opportunity for recreation), as well as the conservation of options for the future (e.g., genetic diversity to cope with environmental changes).

The Natural Capital Project is a joint venture among Stanford University, The Nature Conservancy, and the World Wildlife Fund

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# Ecosystem Services We Map and Value

## FOOD FROM FISHERIES

Fisheries provide an important source of food and basis for livelihoods, but in some cases overharvesting and loss of supporting habitats threaten fisheries' sustainability. Our models determine how changes in fishing practices and habitat abundance affect amount of landed biomass and its value. We provide both simple models for key species and methods for wrapping around more complex models in areas where they exist. Our next step is to develop approaches to valuing the contribution of nursery habitats to landed biomass.

Outputs: landed biomass and net present value of fish and shellfish, distribution of landings and value to communities

## FOOD FROM AQUACULTURE

Aquaculture is an increasingly important source of food for humans, yet its activities can have detrimental effects on marine environments. Our models show how the location, size and density of aquaculture farms influence the production and value of finfish (e.g., salmon) and shellfish (e.g., oysters), which is a function of farm configuration, water flow and other environmental conditions. We also are developing methods to quantify export of wastes from aquaculture farms and the filtration capacity of suspension-feeding shellfish.

Outputs: harvested biomass and net present value of fish and shellfish, distribution of biomass and value to communities

## COASTAL PROTECTION

Marshes, mangroves and other living habitats can buffer coastlines from storm-induced erosion and inundation. They also can help to regulate natural processes of erosion and sedimentation that are critical to maintaining beaches. Our models predict how the extent and density of living habitat, as well as dunes and other coastline features, influence the area of land eroded or flooded, and alter longer-term patterns of beach formation. The models can help us understand where it is critical to preserve and restore habitats for coastal protection.

Outputs: avoided area of land eroded or flooded, avoided beach nourishment and costs, avoided damages to property and infrastructure, number of people affected by erosion or flooding

## WAVE ENERGY CONVERSION (WEC)

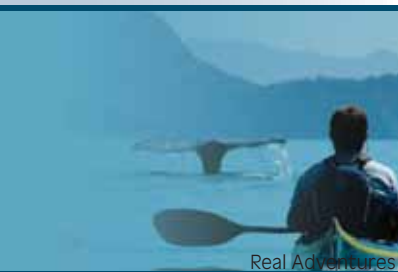
Renewable energy companies, decision-makers and the public increasingly are interested in converting wave energy into electricity. Many hope that ocean waves will be a source for clean, safe, reliable and affordable energy, yet uncertainty exists about the influence of WEC on coastal and marine environments. Our models predict how wave height and period, water depth, and the size, location, and technology of the conversion facility can influence the amount and value of captured power. The models can help decision-makers understand where to install a facility to lead to the greatest captured power and the least effect on coastal and ocean ecosystems and other human uses.

Outputs: captured wave energy, value of captured wave energy, environmental impact

## RECREATION

Marine and coastal recreation activities generate significant economic value. This value depends on the quality and availability of marine resources over time, as well as the geographic location of activities. Our models will provide users with the ability to assess how economic values or user groups associated with different recreational activities change as the quality and quantity of marine resources is altered through different management scenarios.

Outputs: economic value of recreational activities, visitation rates, community access to activities





## A Scenario Assessment Tool

Our process begins by identifying critical management choices being considered by decision makers or other stakeholders. From these, we develop alternative scenarios that either show present delivery of services or how they look in the future under different policies or a changing climate. Marine InVEST is used to model how these alternative futures influence ecosystem structure and function, and how such changes affect the flows and values of ecosystem services and biodiversity. Model outputs are maps, balance sheets and tables.

## The Models

Marine InVEST incorporates ecosystem services and valuation approaches into planning. Our models show how various sectors—from aquaculture to energy—are affected by how humans choose to interact with the marine environment. Marine InVEST also provides biodiversity outputs to look at trade-offs and synergies between ecosystem services and other conservation objectives.

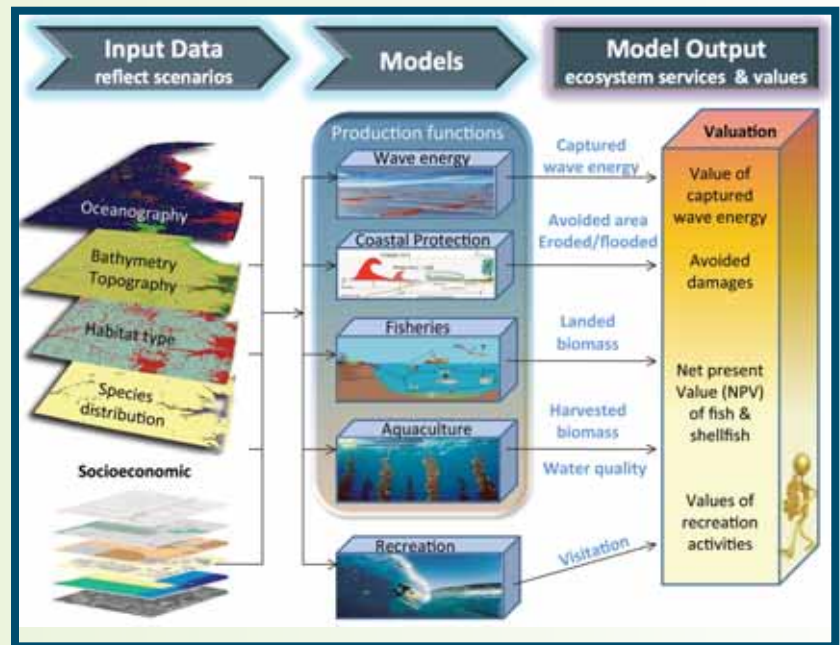
Our models are based on production functions that define how an ecosystem's structure and function affect the flows and values of ecosystem services. Previous focus on the patterns of service supply (e.g., living habitats as buffers for storm waves) did not account for the potential uses, or demand, of the service. For example, are there people and infrastructure that would be affected by coastal storms?

Marine InVEST meets this need by providing:

- biophysical outputs (e.g., reduction in height of storm waves by living habitats)
- ecosystem service outputs (e.g., reduction in flooding of property)
- economic or social outputs (e.g., avoided costs from flooding, number of people affected)

Marine InVEST is spatially explicit to account for differences in the delivery of and demand for services across land- and seascapes. Since data are often scarce, we initially offer relatively simple models with few input requirements. These models are best suited for identifying patterns in the provision and value of ecosystem services and to inform marine spatial planning. We are developing more complex, data intensive models that may be more appropriate for informing payment for ecosystem services or other programs that require more certainty and specificity in results.

## Our Approach



Models for different services are linked through input data layers that reflect scenarios about management actions (e.g., restoration of eelgrass, increase in aquaculture) and climate change (e.g., sea-level rise, water temperature).

## Marine InVEST in Practice

Marine InVEST can inform a variety of policy, management and conservation approaches.

**Ecosystem-based management (EBM) and Marine Spatial Planning (MSP)** are integrated approaches to management that aim to achieve specific ecological, social and economic objectives. Marine InVEST can inform EBM, MSP, and associated adaptive management and **marine conservation agreements**, by assessing the current and potential status of ecosystem services under alternative, spatially-explicit future scenarios.

**Markets and payments for ecosystem services (PES)** are contractual and voluntary transactions for the delivery of an ecosystem service, or implementation of management practices likely to secure that service (e.g., **fisheries catch share programs**). Marine InVEST can support the design and implementation of PES programs by identifying how payments can meet multiple goals, where to distribute payments or establish new programs, and how to improve efficiency of investments.

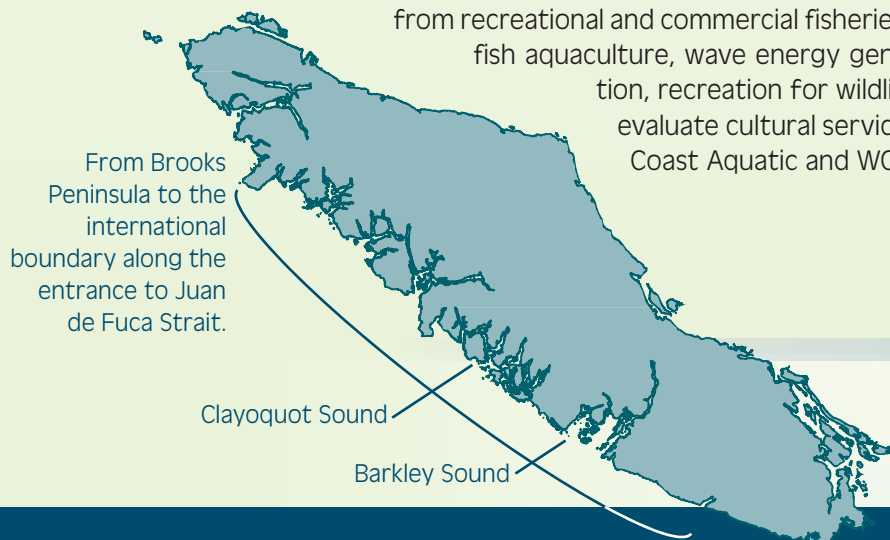
**Ecosystem-based climate adaptation** aims to preserve and restore natural ecosystems so they can provide cost-effective protection against adverse effects of climate change and continue to provide a full-suite of ecosystem services. Marine InVEST can inform adaptation strategies by showing how future changes in ecosystem structure and function will influence the delivery of services needed to maintain human well-being under future climate conditions.



## Marine InVEST informs spatial planning along the West Coast of Vancouver Island

Our initial application of Marine InVEST is underway along the West Coast of Vancouver Island (WCVI) in British Columbia, Canada. The 460 km shoreline of inlets, fjords, sounds and open beaches is fed by an extensive network of rivers and lakes from temperate rainforests. The region is home to thousands of fish, bird, plant and animal species, and local communities that rely on these resources for sustenance and livelihood. In spite of the impressive natural beauty of the area, the Vancouver Island ecosystem faces great challenges. Salmon populations have decreased dramatically in recent years, levels of toxics in local food sources are abnormally high, the influence of logging, transportation, and aquaculture is increasing pressure on the system, and there is uncertainty about emerging activities such as wave energy.

We are partnering with West Coast Aquatic, a government and non-government co-management body for aquatic resources in WCVI, to use Marine InVEST to inform a more transparent and integrated approach to management of the region. The goal is to create a framework and marine spatial plans in Barkley and Clayoquot Sounds, and waters offshore of the WCVI, agreed upon by all levels of government, First Nations, coastal communities, and private entities. Marine InVEST will be able to advance planning beyond compartmentalized, sector-specific issues, providing a platform for stakeholder discussions and negotiations around trade-offs. Our models for the provisioning of salmon from recreational and commercial fisheries, food from salmon net pen and benthic shellfish aquaculture, wave energy generation, protection from erosion and inundation, recreation for wildlife viewing and our work with collaborators to evaluate cultural services, are all highly relevant to issues facing West Coast Aquatic and WCVI stakeholders.



### The Marine Initiative of the Natural Capital Project

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A joint venture among:



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