

6

MARINE ECOSYSTEMS RESEARCH PROGRAMME — UNDERSTANDING TRADE-OFFS



Marine Ecosystems
Research Programme

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Management of marine activities is increasingly taking a more integrated approach which recognizes the potentially conflicting demands of multiple industries and stakeholders. Marine spatial planning is an attempt at resolving some of the direct interactions between competing interests, but the indirect interactions which arise as a result of the ecological responses of the system are far from being accommodated. These are the basis for a so called Ecosystem Approach. A sub project of MERP, led by the University of Strathclyde, aimed to integrate social, economic and ecological research that will be needed to support such an approach.

The overall goal was to expose the 'big-picture' outcomes of the collective

application of a range of shelf-sea management measures spanning fisheries, aquaculture, and conservation in terms of ecological properties and both monetary and non-monetary values. The research involved computer simulations of the consequences of four strongly contrasting societal 'worldviews' developed from UK National Ecosystem Assessment scenarios, each accompanied by narratives around the range of marine management measures. These were partly co-developed with stakeholders. The simulations were supported by social and economic field-work to document the spectrum of values and aspirations held by individual stakeholders and their expectations for the outcomes of the management regimes represented by the four

worldviews. Finally, the results of the computer simulations were shared with the stakeholders in a workshop situation to gauge the effectiveness of the various management measures at delivering outcomes that satisfy their values as a group.

The main geographic focus of the research was the west of Scotland continental shelf, a region with co-existing industries and reputations based on wild finfish and invertebrate fisheries, aquaculture, wildlife and cultural attributes. However, the stakeholder consultation also gathered data on values and attitudes in the southwest of the UK.

Goal setting and scoping with stakeholders

A 'stakeholder landscape' mapping exercise was carried out early in the project to assess who had an operational interest in the research, and how much power and influence they had over policy and future engagement. Three areas: the west of Scotland, Cardigan Bay (west Wales) and the south-west of the England, were analysed.

During April-May 2017 stakeholder 'scenario defining' workshops were held in the study areas involving representatives from the fishing industry, recreational businesses and groups, NGOs, policy and management agencies. The workshops captured stakeholder expectations and ambitions for directions of change of a range of attributes in their respective marine regions. Stakeholders were provided with four marine management narratives for contrasting socio-political systems ('worldviews'), which provided a framework for contemplating a range of management measures that might be employed. The management measures included different approaches to fisheries management, conservation measures, and aquaculture development.

The marine management narratives were then further developed by the research team to correspond with the high-level socio-political descriptions of four of the worldview scenarios contained in the UK National Ecosystem Assessment – referred to as 'National

Security', 'World Markets', 'Nature at Work' and 'Local Stewardship'. These provide a basis for considering how the economic and political driving forces which ultimately affect ecosystem services and human well-being might evolve under a range of possible futures, for example under a system governed by protectionism as opposed to globalization, or devolution of management to a local level as opposed to national control.

Making MERP models work

Two of the MERP suite of models (Ecopath with Ecosim (EwE), and StrathE2E) were used to explore the interacting ecological and economic consequences of the measures embedded within the worldviews. EwE is a food web model representing small groups or individual species ranging from benthos to fish and top predators, and how they are inter-connected as prey and predators. StrathE2E is also a food web model but based on bulk categories of species defined by their feeding preferences, eg. planktivorous fish, and not individual species. In addition, StrathE2E also represents some key spatial processes, biogeochemistry, nutrient inputs and seabed habitats. Environmental driving data for both models came from another MERP model – ERSEM. Data on fishing gear effort, selectivity and discard rates, and profit margins were extracted from EU and UK national databases. Data on by-catches of non-target species such as seabirds and marine mammals in different fishing gears were derived from observer programme and strandings databases.

Valuing provisioning service

Digital data on first-sale market prices for fish are openly available only since 2000 so print-published data back to 1965 were digitized to produce a coherent record of UK annual average prices of 81 fish and shellfish species from 1965 - 2017. When corrected for inflation using the Consumer Price Index, prices for some species were shown to vary inversely with the quantity landed,



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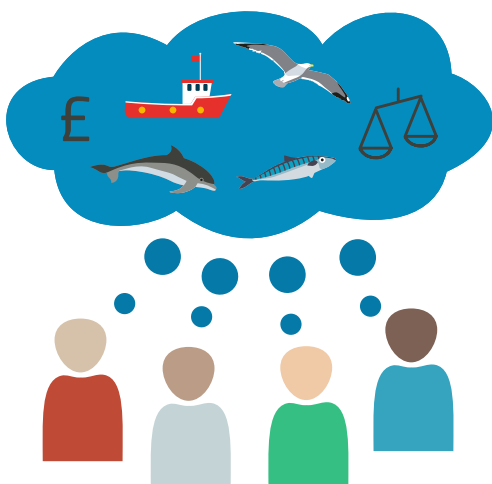
indicating supply dominated markets; others showed synchronization across groups of species; pelagic fish such as herring showed demand-driven fluctuations correlated with prices of other foods such as chicken. The results of these analyses provided a standardised set of prices for each species in EwE and each harvested group in StrathE2E.

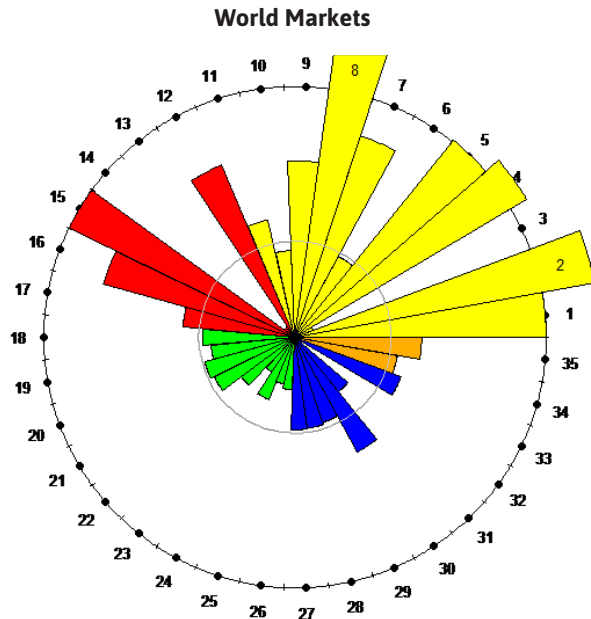
Seaweed harvesting has a long history in the west of Scotland, although there is debate around permitting future mechanical harvesting which was factored into the management measures included in the worldviews. Established industries in France and Norway harvest 18000t and 27000t of seaweeds respectively per year.

Economic data on salmon aquaculture were also derived from market analysis and used to estimate price variations arising from changes in UK production and consumption which were anticipated in each of the worldviews. Interestingly the variations in demand for farmed salmon brought about by wild fish substitution ranged widely from a reduction of 55000t to an increase of 43000t over a baseline production of 135000t/year.

Putting a value on tourism, leisure and recreation (TLR)

The project analysed monetary values arising from recreational uses of living marine resources such as wildlife watching, sea angling and diving. Sea angling and diving monetary values were obtained integrating data from the ecological model and an existing preference model of recreation. New field work was carried out to determine





Label	Description	Label	Description
1	Mobile pelagic effort	18	Winter surface nitrate
2	Mobile demersal effort	19	Mud porewater ammonia
3	Static gear effort	20	Total PP inc kelp
4	Shellfish landings	21	Benthos biomass
5	Demersal fish landings	22	Finfish biomass
6	Planktivorous fish landings	23	Planktivorous/total fish biomass
7	Migratory fish landings	24	Seal biomass
8	Fishery revenue	25	Bird and cetacean biomass
9	Fishery profit margin	26	Top-predator prodn/Primary prodn
10	Fishery profits	27	Number of anglers
11	Seaweed profits	28	Number of divers
12	Total discards	29	Number of wildlife watchers
13	Cetacean catch ratio	30	Welfare of anglers
14	Seal catch ratio	31	Welfare of divers
15	Bird catch ratio	32	Welfare of wildlife watchers
16	Seabed abraded area ratio	33	TLR consumer surplus change
17	Inshore/total area abraded	34	Consumption of aqua products
		35	Aquaculture profits

Segment lengths are proportional to the ratio of scenario : baseline values. Inner grey circle represents the baseline (scenario:baseline ratio = 1)

willingness to pay from wildlife watchers per unit change in abundance of target species, as a means of assessing values of wildlife such as whales, dolphins, porpoise, seals and seabirds for the west of Scotland and the Celtic Sea.

Stated-Preference Choice Experiments were conducted in Scotland and south-west England. Contingent behavior models were then used to analyse the results and predict the changes in probability of choosing one of the marine regions in the West of Scotland, rate of participation and economic measures of well-being, per unit changes in fish and wildlife biomasses. Results were applied to differences in fish and top-predator abundances between the baseline and worldview simulations

using EwE and Strathe2E, to estimate the change in recreational value from present-day as a result of each scenario.

Cultural values

Cultural properties of the ecosystem defy quantification but are nevertheless very important to people. These include experiences, sense-of-place and identity, and enabling capabilities. The project used state-of-the-art Community Voice methodology involving filmed interviews with individuals from key stakeholder groups in Scotland and south-west England to gather data on intangible, non-monetary values. Analysis of the data revealed reinforcing feedbacks between nature and culture. A 40 minute documentary film ([http://](http://sharedvaluesresearch.org/merp-marinevalues/)

sharedvaluesresearch.org/merp-marinevalues/) highlights the range of stakeholder views, and extracts from this were used in workshops and distributed back to participants for dissemination among their local communities.



Bringing models together

EwE and Strathe2E involve linked sub-models of ecology and fishing fleets, but typically the connection is only one-way, so that there is no automatic feedback between the behaviours of fishing fleets and ecological conditions. During MERP a new approach was developed for Strathe2E which represents these feedbacks, and allows dynamic control of the overall activity and spatial distribution of each gear type. For example, if profit margins for a particular gear are positive then activity increases and vice versa – simulating a so-called ‘open access’ fishery in which participation is driven purely by market forces. Alternatively, gears could be programmed to be constrained by catch, effort, or stock biomass limits set by ‘management’. This approach allowed



for a range of regulatory regimes to be simulated with the model.

Both EwE and the new StrathE2E development was used to simulate the west of Scotland ecosystem and economy under the actual environmental, fishery and aquaculture conditions during the period 2003-2013. These results formed a baseline against which further model results for each of the worldviews were compared. Graphical visualizations of the results were developed to aid discussions at the final stakeholder workshop. Model simulations and accompanying narratives for each worldview are shown for the west of Scotland in Appendix 1 of the MERP Final Science report, available on the MERP website.

Key findings from the stakeholder workshop

There was convergence of views on the need for more selective fishing gears to minimize the effects of unwanted by-catch, reinforced by the model results. However, views differed on whether the goal of harvesting at Maximum Sustainable Yield (MSY) as opposed to Maximum Economic Yield (MEY) was favored, and whether effort controls were preferable to catch controls. Nevertheless, there was universal agreement that fishery controls were necessary and that the simulations representing 'World Markets' in which fishing was controlled only by market forces led to a highly undesirable outcome.

The role of MPA's as a means to protect key features, as opposed to no-take zones as a form of set-aside or 're-wilding' was extremely contentious, and one of the main points of conflict between the differing objectives of conservation and fisheries management. While there was support for limiting or eliminating the damaging impact of fishing, especially seabed impacts in sensitive habitats, there was little consensus on the value arising from no-take-zones, and concern at the lack of baseline data and monitoring of effectiveness in some cases.

There was no widespread support for the current targets on expanding salmon aquaculture activity, which were seen as both unattainable and unsustainable, notwithstanding the minimal impacts of nutrient emissions predicted by the models, and the economic benefits for local communities. Concerns arose from a variety of issues including effects of medicines, competition for space, and visual concerns.

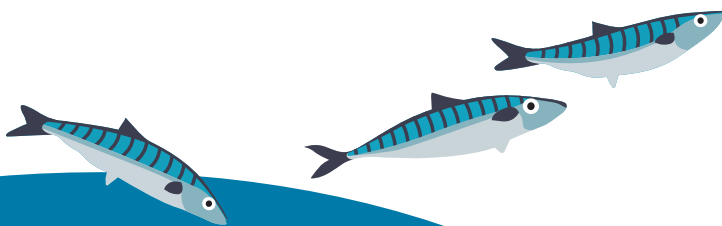
There was a widespread concern regarding the effectiveness of regulations due to levels of compliance, especially in relation to discarding and MPA incursions. The combination of quota-uplift to facilitate the Landing Obligation, and non-compliance with the discarding restrictions was regarded as particularly problematic in the light of the model simulations.



Impacts

The primary purpose of the project was to develop the science which will underpin future advice on implementation of management approaches seeking to find cross-sectoral compromises between diverse societal expectations on conservation, economic yield and human wellbeing. The results are being published in peer-reviewed journals and the model outputs made available to policy makers and UK and European working groups through the CEFAS CefMAT application. MSFD and OSPAR assessments have already benefited from this work through inputs to UK reports and policy perspectives.

MERP Science reports detailing the research undertaken across the programme are available from www.marine-ecosystems.org.uk/Resources/Reports



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