Management of Sustainable Fisheries alongside Marine Renewables: Modelling the Spatial Interactions

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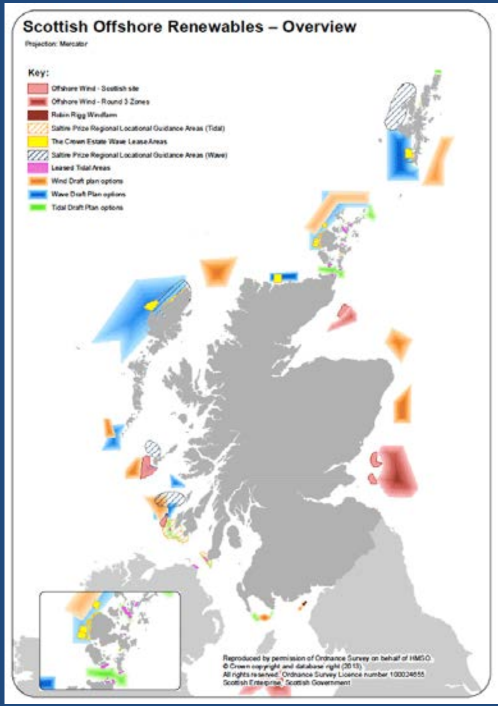
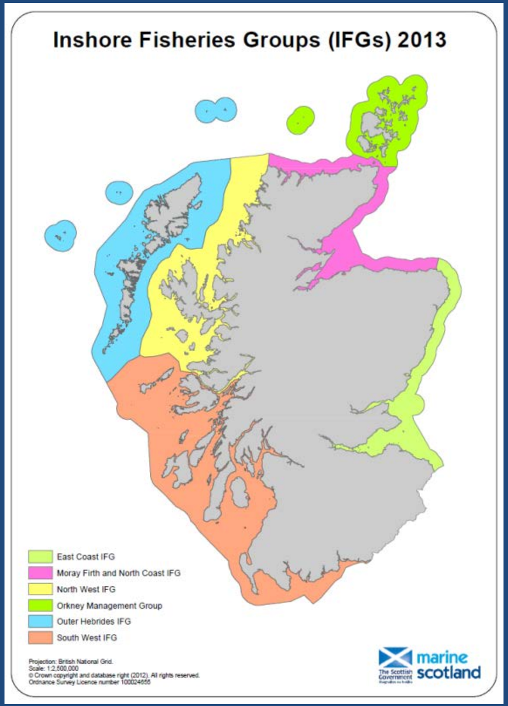
Fisheries and Marine Renewable Energy:

- A traditional and a new user of sea space
- Greatest potential for interaction in inshore areas
- Six Inshore Fishery Groups (IFGs) around Scotland are developing inshore fishery management plans



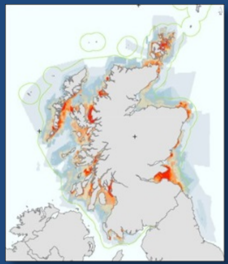
Scotland's Marine Atlas
Marine Scotland

IFG Map
Marine Scotland



Fisheries and Marine Renewable Energy:

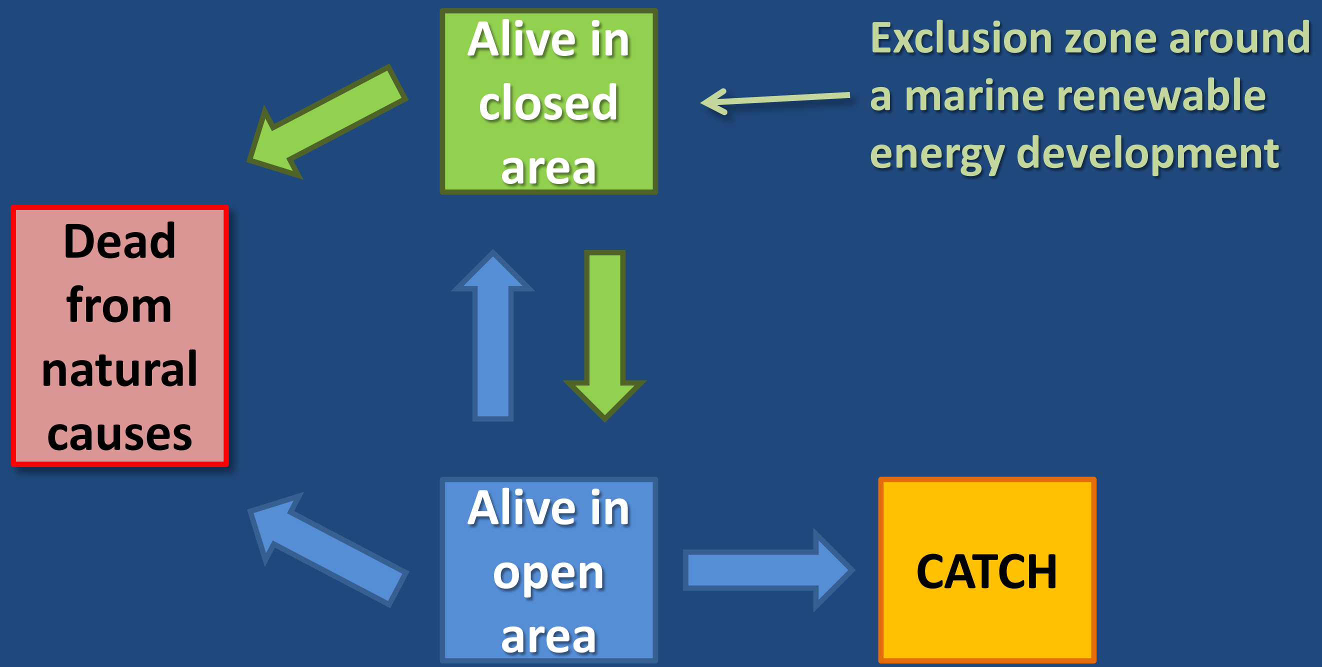
- A traditional and a new user of sea space
- Greatest potential for interaction in inshore areas
- Six Inshore Fishery Groups (IFGs) around Scotland are developing inshore fishery management plans
- Spatial overlap is a first consideration – various initiatives are providing data on this:
  - Marine Scotland's ScotMap
  - Orkney Fishery Project funded by TCE and others



- Given spatial overlap, what are the challenges and opportunities for fishery management?
- We develop some simple spatial models…

A simple spatial model…

This is a biological fishery model following the fates of fish in an exploited stock. We model the transitions of fish between four states:



We do this over short time steps (days), and also model biological processes of growth and sexual maturity.

Model Space

- Two types of space are relevant:

1. *Geographical space* – the arena for human activities, i.e. MRE development areas, areas open to fishing
2. *Ecological space* – the arena for fish/shellfish activities, defined in terms of carrying capacity of open and closed areas

- The *first* is a modifier for the harvest rate exerted by the fishery
- The *second* defines rates of exchange of fish between open and closed areas, and also allows us to consider changes in the quality of habitat induced by the presence of a development (reef effect)

Sustainable fishery management

- Harvest Control Rules under the MSY approach are generally based on two types of criterion (biological reference points):
  - a *limit* defined in terms of the lowest acceptable stock biomass
  - a *target* defined in terms of a fishing mortality value that will deliver MSY

Sustainable fishery management

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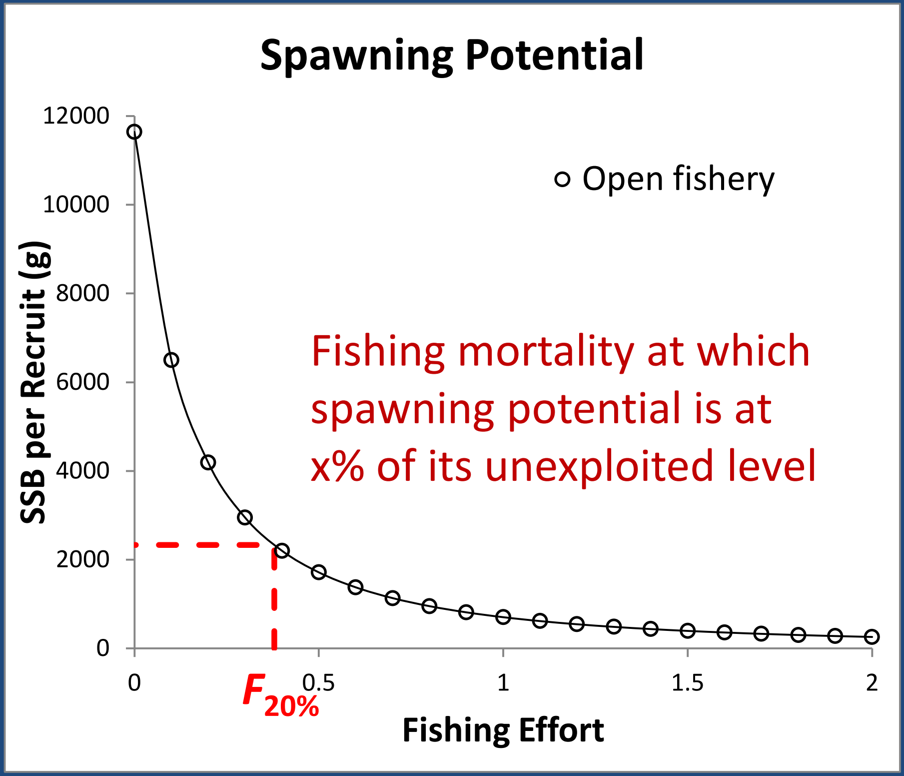
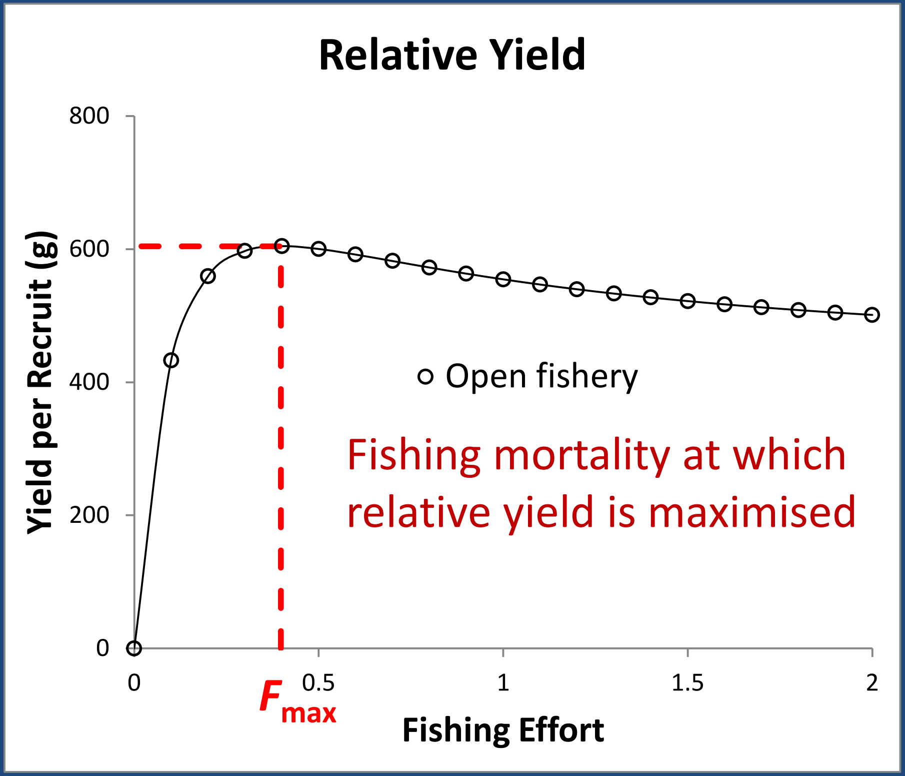
  - a *limit* defined in terms of the lowest acceptable stock biomass
  - a *target* defined in terms of a value or index of fishing mortality that will deliver MSY
- Our simple modelling approach can easily be used to examine effects of closed areas on candidate proxy values for target reference points

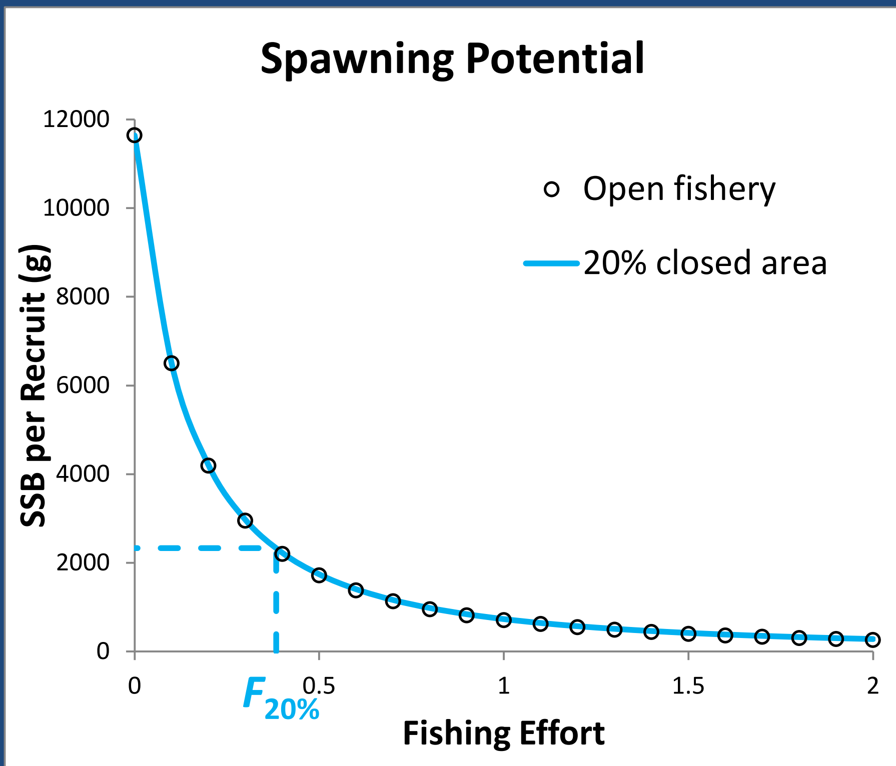
‘Per recruit’ analyses used to derive fishery management criteria

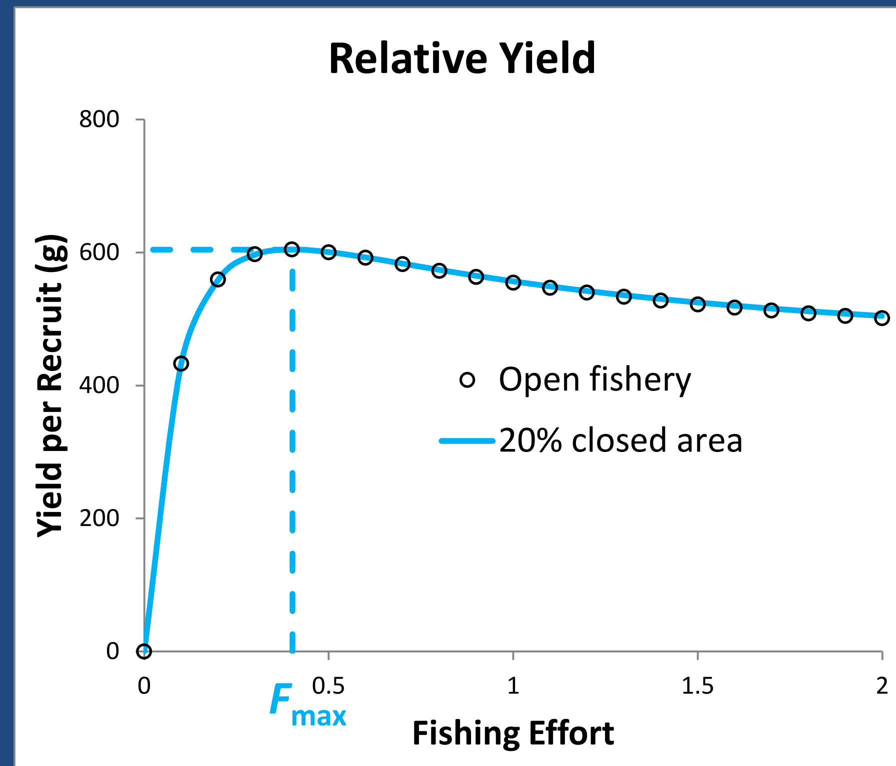




Example using biological parameters for Orkney lobsters

What happens if fishery is displaced from 20% of its grounds?

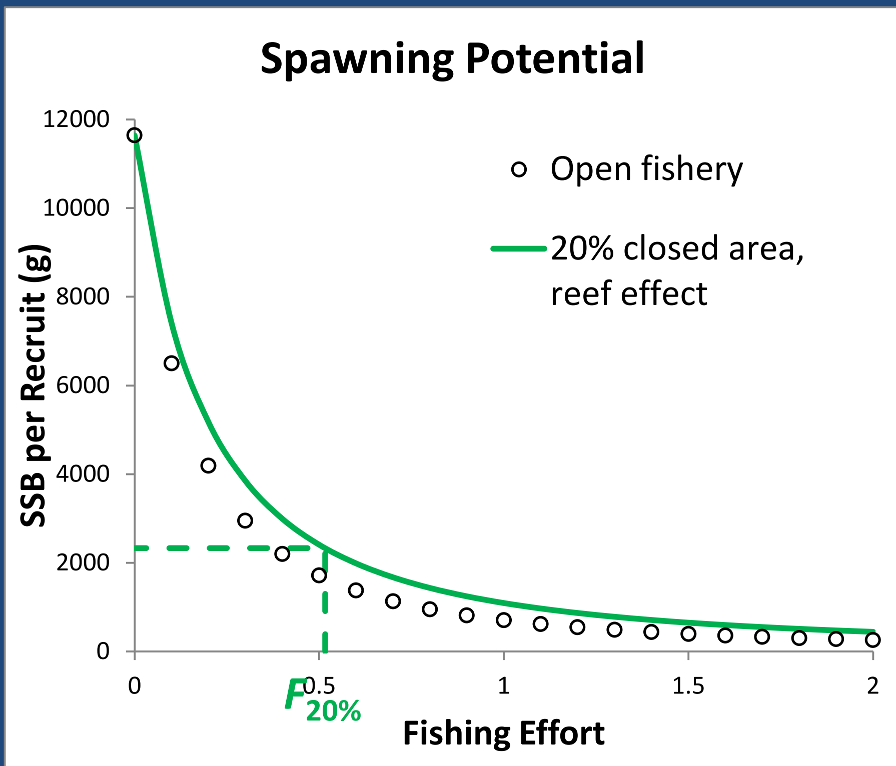


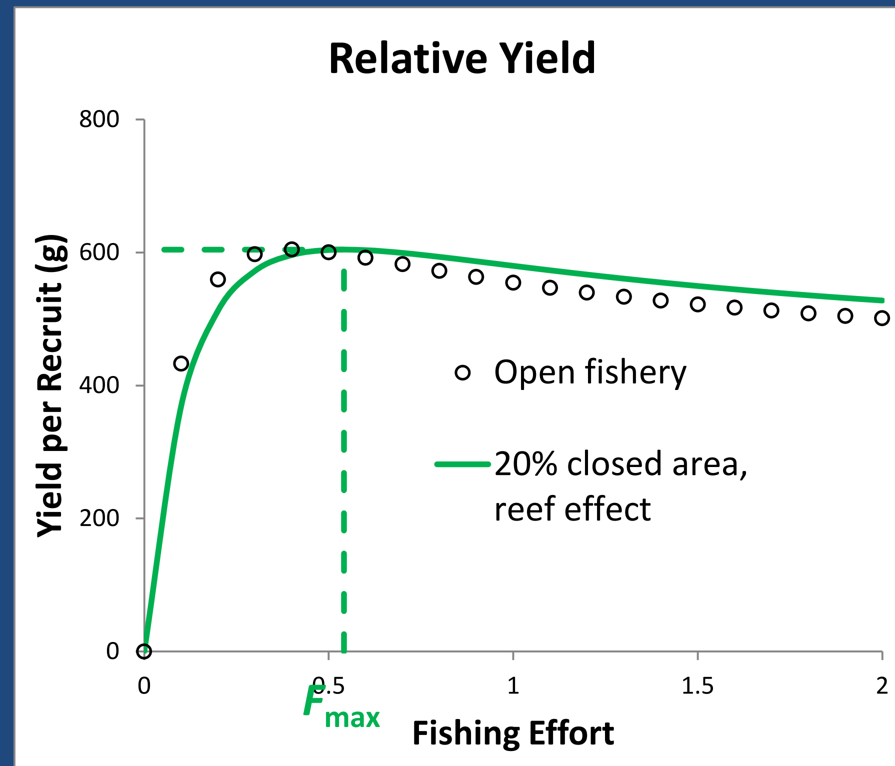


Assuming 99% fidelity to the closed area on a daily basis, i.e. 1% emigration

Almost no effect on curves or criteria, even at this low rate of movement

What if the carrying capacity of the closed area is increased – a reef effect?

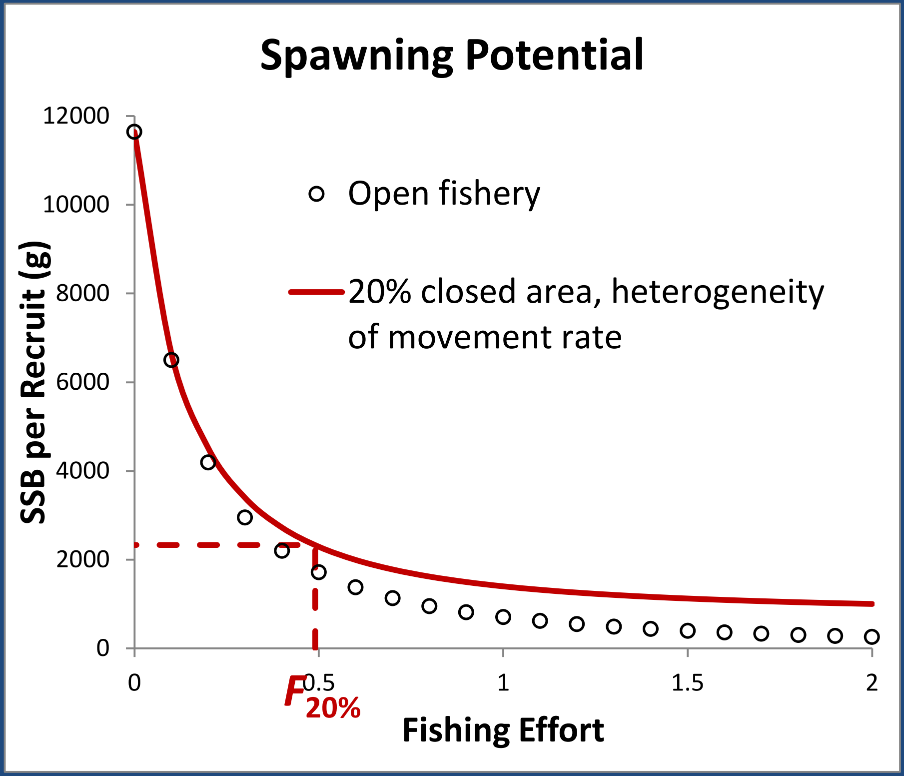


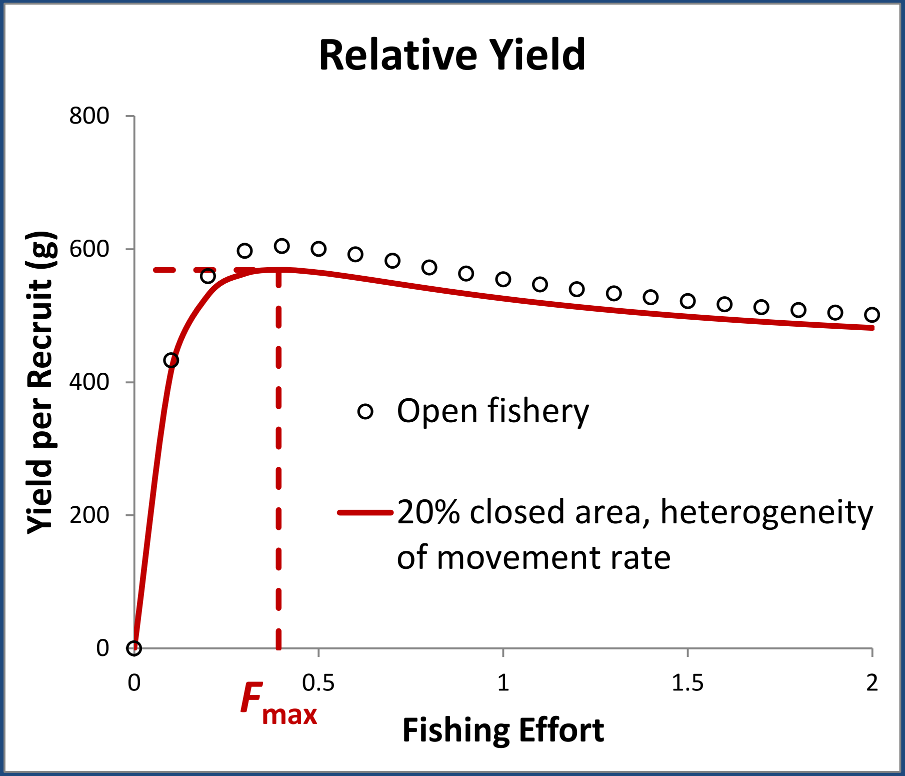


Habitat value per unit area 2x greater inside closed area

Increased values of criteria indicate increased resilience of the fishery

All lobsters are not equal – what if some move more than others?

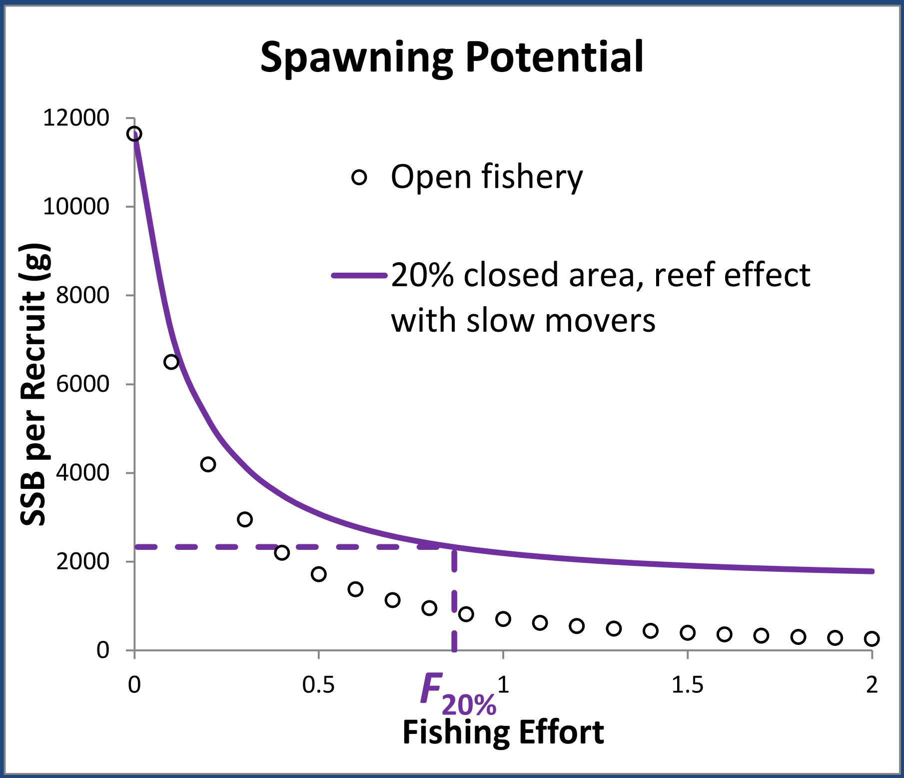


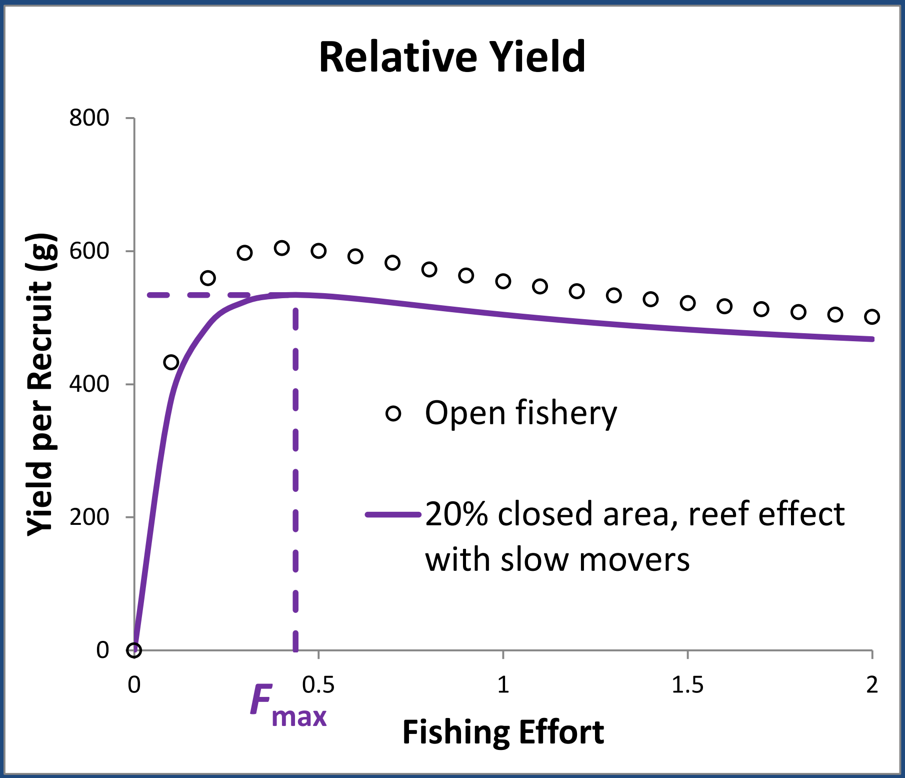


Same average site fidelity, but stock split between fast and slow movers

Enhanced protection of spawning potential at the expense of some loss in yield

What if a reef effect makes lobsters more sedentary inside the closed area?





Greater gains in spawning potential, but also greater losses in yield per recruit

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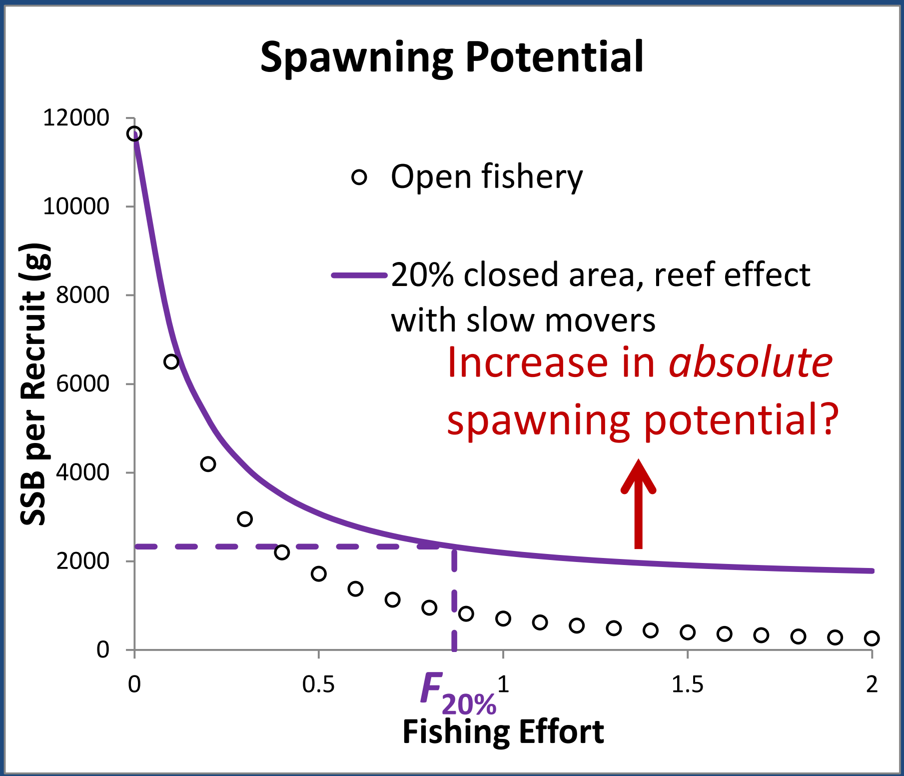
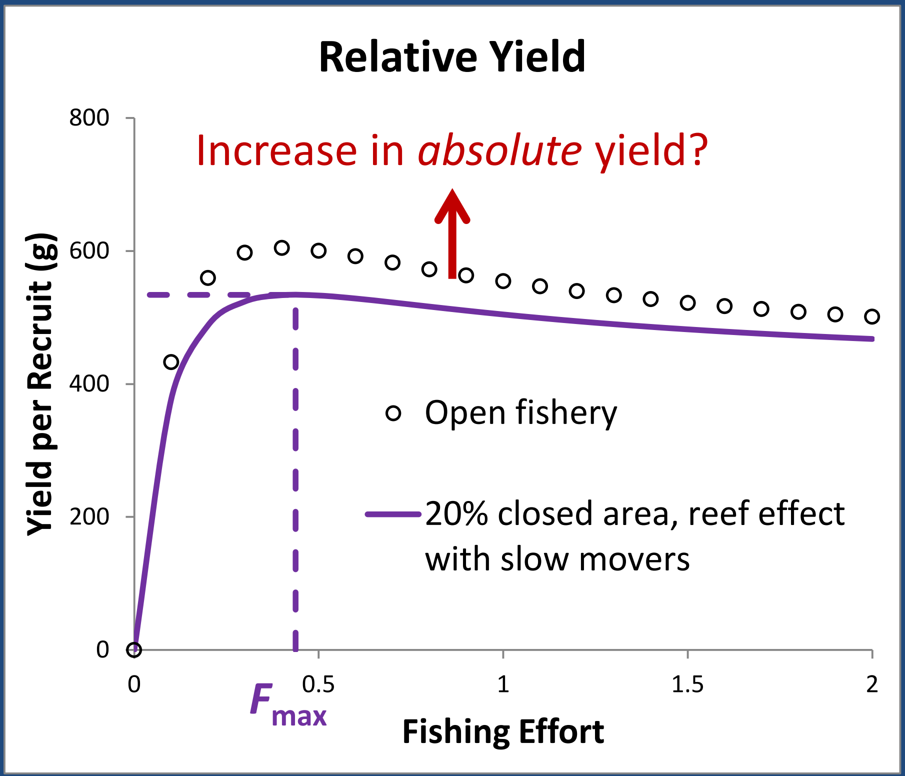




BUT… per recruit analyses are relative and take no account of numbers of juveniles added to the stock. Absolute increases are possible if the reef effect eases habitat bottlenecks.

Conclusions so far:

- *Assuming that fishing effort displaced from MRE development areas can be freely distributed across the fishery…*
- Appreciable mobility of the target stock between open and closed areas will mean that the closure will have very little effect on long-term yield, spawning potential or management criteria
- Significant differences in mobility between individuals creates a pool of stock inside the closed area that is less accessible to the fishery, increasing the resilience of the fishery at moderate levels of fishing effort and allowing higher values of the target ref. point
- Enhancement of habitat quality within the closed area, e.g. through increased structural complexity around a development, can increase the effective size of the closed area, with gains in spawning potential at the expense of reduced yield…
- …but if this 'reef' effect can release population bottlenecks, absolute yield may in fact be increased

Final thoughts…

- Inshore fishery managers need to understand the implications of exclusion zones for economic and biological sustainability

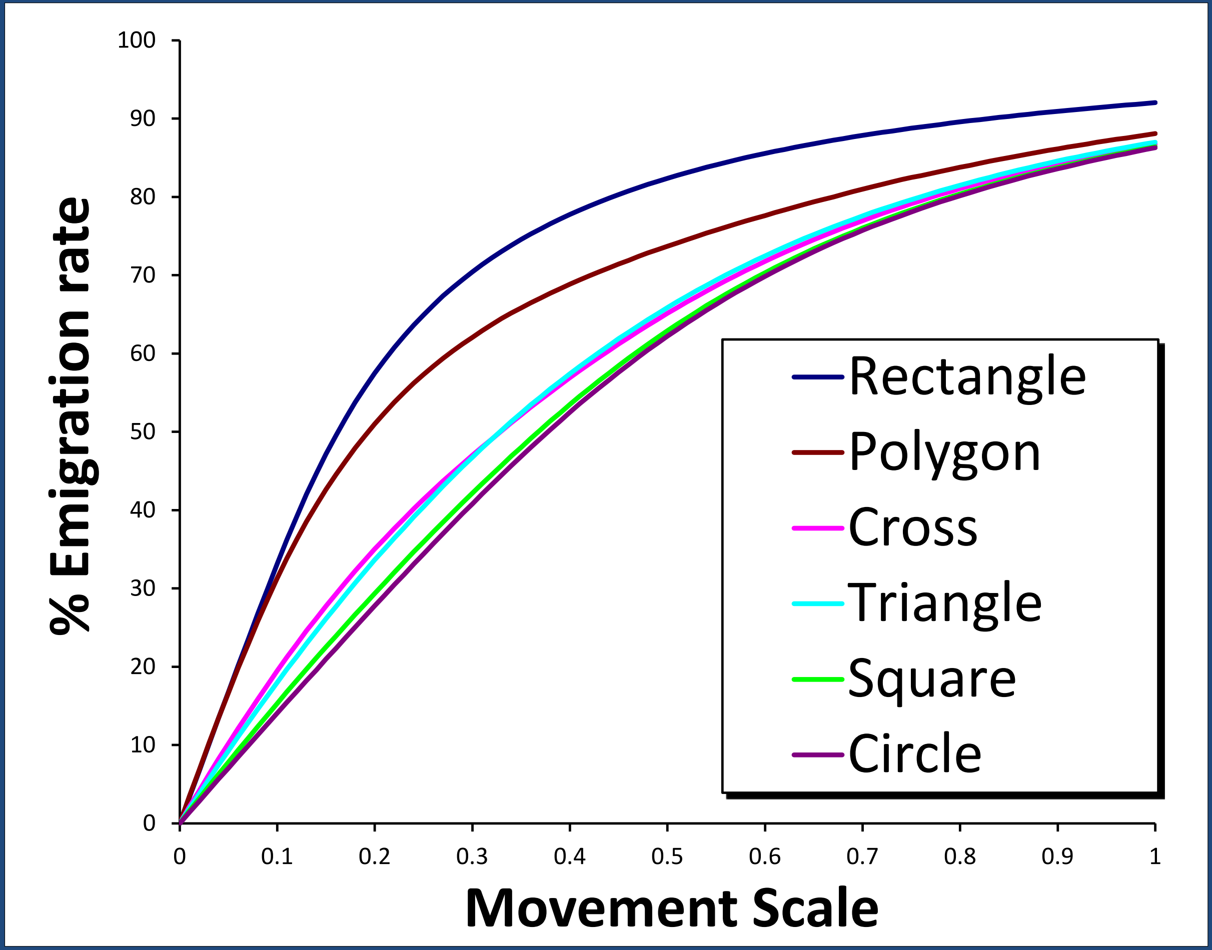
- More research into fish and shellfish movement patterns is needed to develop this understanding

QBEX NERC/Defra-funded, led by David Sims, MBA

- Habitat enhancement offers an opportunity for positive interaction with MRE developments

Orkney Sustainable Fisheries is about to start research into habitat enhancement for juvenile lobsters

All closed areas are not equal…



- Emigration rates from different shapes of the same area
- Sum of emigration from multiple closed areas is likely to be greater than the emigration from a single closed area of the same total size
- Directed movements (e.g. migration) may increase or decrease emigration rates in the short term, and will decrease residency over the longer term