SIMBIOSYS

Sectoral Impacts on Biodiversity and Ecosystem Services

Assessing and reducing impacts of aquaculture on marine biodiversity and ecosystem functioning

Tasman Crowe
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Environmental Protection Agency
NDP
SSTI
Funded as part of the Strategy for Science, Technology and Innovation

Strategic overview of influences of aquaculture on biodiversity and ecosystems services in Ireland

- Myriam Callier, Tasman Crowe, Dannielle Green, Judith Kochmann Francis O'Beirn & Grainne O'Brien

EPA STRIVE Project

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SECTORAL IMPACTS ON BIODIVERSITY AND ECOSYSTEM SERVICES

Aquaculture

World aquaculture now produces half of the fish and shellfish consumed by humans. Aquaculture is a significant industry for Ireland, particularly in remote coastal communities. Industry output in Ireland is focused on high quality, low volume niche markets, such as organic or eco-certified products. To ensure the sustainability of this industry, it is essential to better understand the interactions between aquaculture, biodiversity, ecosystem services and society. Changes to biodiversity can affect the functioning of ecosystems, altering rates of production, nutrient cycling, etc., which in turn can influence the benefits to society that ecosystems provide. The aim of this review is to highlight some of the ways in which aquaculture can interact with biodiversity, emphasise possible consequences for society and suggest key areas for future research and policy development.

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Key Messages

- Ireland's aquaculture is mostly less intensive than in many other nations.
- Sustainability is supported by a number of successful national voluntary programmes that focus on best practise. These do not necessarily require environmental benefits to be assessed or enforced.
- Aquaculture can influence biodiversity and ecosystem functioning and services in a number of ways, including: interactions with wild fisheries resources, physical damage / replacement of habitat, organic and nutrient enrichment, vector for invasive species and via interactions with seals and birds. The relative importance of impacts varies with context.
- A key unresolved issue is the extent to which aquaculture is compatible with maintaining favourable conservation status in Natura 2000 sites.
- Coordinated monitoring programmes and research are required to understand (a) changes to communities and ecosystem processes in the water column; (b) extent of influence of individual aquaculture installations and how this combines and interacts with other local and global pressures; (c) the resistance and resilience of coastal ecosystems and the carrying capacity of Irish embayments and (d) how ecological changes induced by aquaculture translate into changes in provision of ecosystem services.

epa

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UCD DUBLIN

Marine Institute

Marine ecosystem services & sectors

- Provision of food
- Provision of other biol. resources
- Climate regulation
- Erosion control
- Pollution control
- Aesthetic & cultural value

- Aquaculture
- Fisheries
- Recreation & tourism

Supporting industries

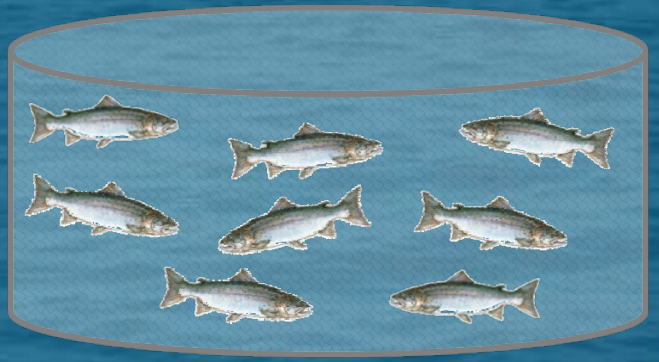
- Vital to economy and society, particularly of remote coastal communities.

MEA 2005; Govt. of Ireland 2008

Aquaculture in Ireland

- Global fisheries in decline, aquaculture expanding: now provides >50% of seafood

- Aquaculture in Ireland dominated by oysters, mussels and salmon
  - focus on high value, organic/eco-certified products
- Valued at €105 million in 2007
- 2000 jobs, many in rural coastal communities



FAO 2009; Browne et al 2008

Aquaculture in Ireland

- Key challenge: finding balance between benefits of aquaculture and maintaining conservation status in coastal SACs and SPAs

- Requires good understanding of how aquaculture interacts with the environment
- Evidence from overseas not always applicable
  - Often lower intensity production
  - Higher flow than, e.g. Scottish lochs

Influences on ecosystems

- Interactions with wild-fisheries resources
  - capture of seed mussels
  - fish capture for feed production
- Physical changes to the habitat
  - addition of structures
- Organic and nutrient enrichment
- Invasive species
  - escapes, vectors, facilitation
- Interactions with seals and birds
  - positive and negative

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Work package 3

Assessing and reducing impacts of aquaculture on marine biodiversity

1. Test potential impacts of introduced Pacific oysters

2. Assess impacts of fish cages and test mitigation strategies

3. Provide management recommendations

Tasman Crowe, Myriam Callier, Dannielle Green, Judith Kochmann, Francis O'Beirn, Grainne O'Brien

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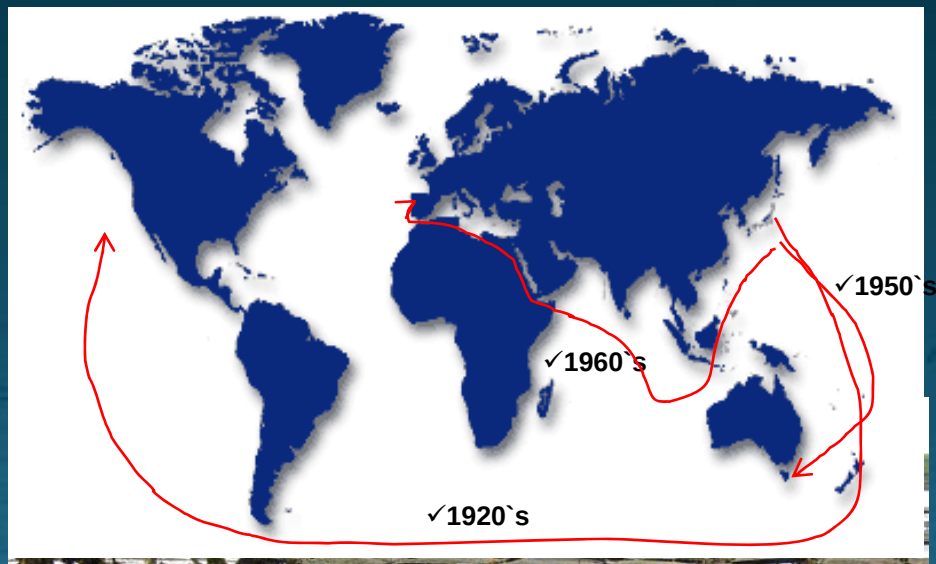
Pacific oysters



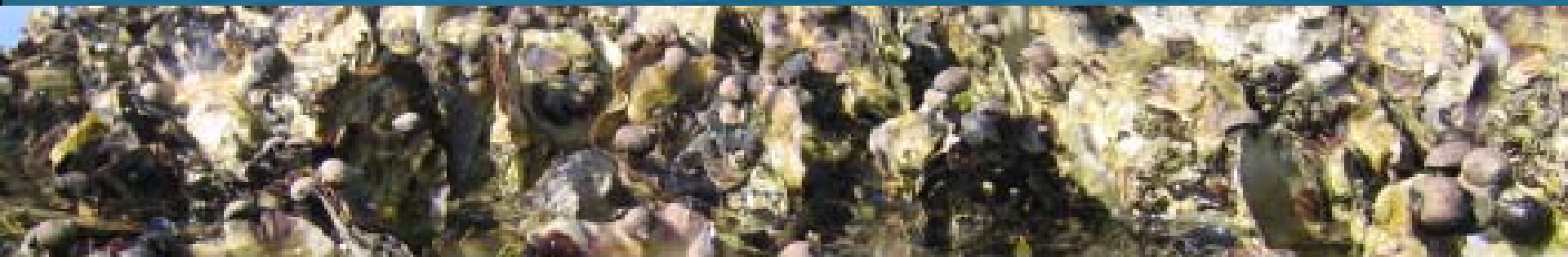
- Widely introduced for aquaculture
  - in Ireland since 1970s
- Invasive in many places

Potentially significant impacts

Pacific oysters in Ireland

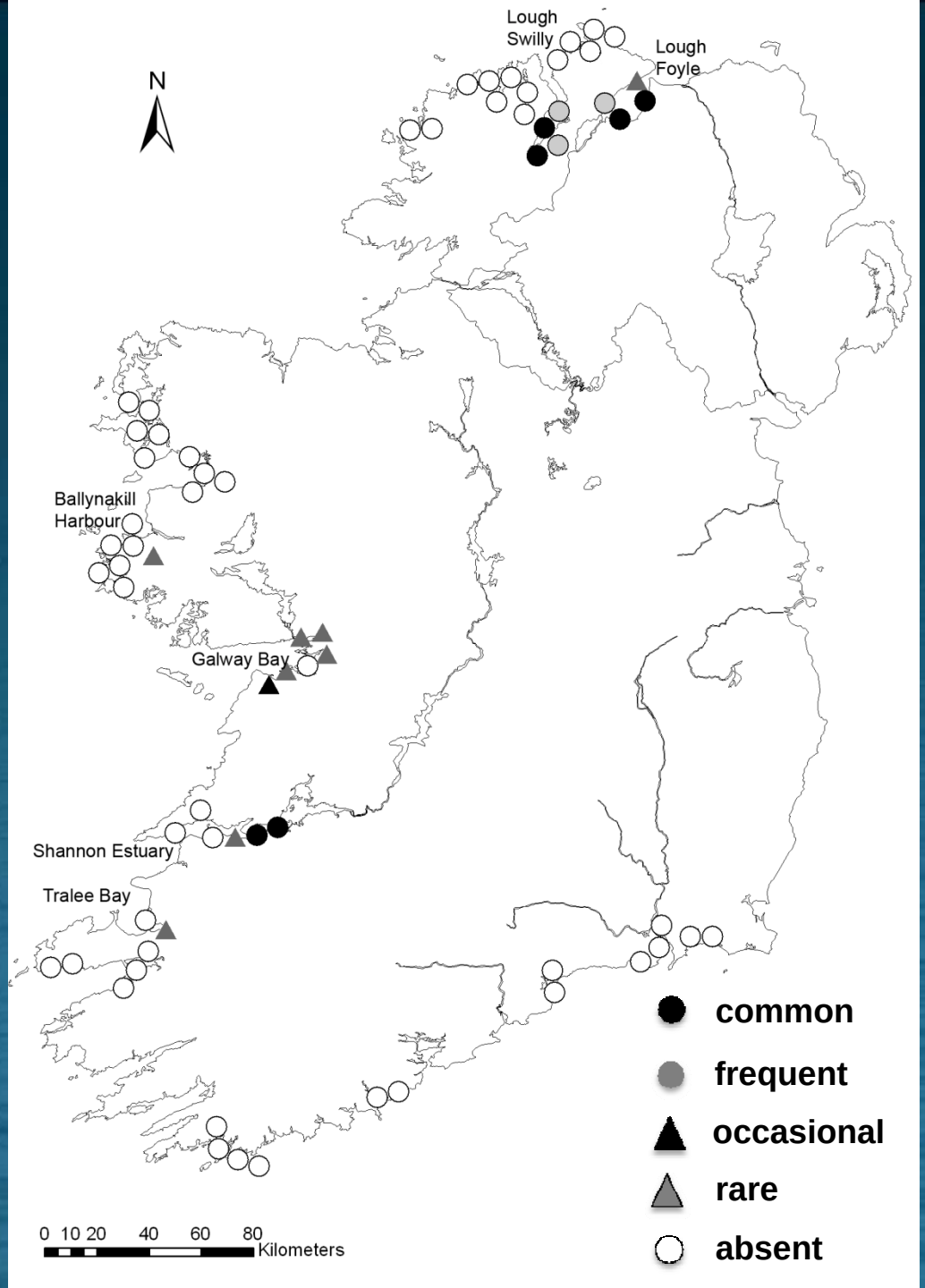
Wild oysters now at some sites, therefore research to:

1. document and predict spread
   - Judith Kochmann (UCD GREP funded by IRCSET & IRCHSS)
2. assess potential impacts on ecosystems
   - Dannielle Green (SIMBIOSYS)



Spread of Pacific Oysters

- Worked with BIM, Marine Institute, Loughs Agency and QUB
- Surveyed 69 intertidal sites with range of characteristics
- Experimentally tested influence of macroalgae and predators
- Genetically tested origins of wild populations and whether self-sustaining


Lough Swilly
Lough Foyle
N
Ballynakill Harbour
Galway Bay
Shannon Estuary
Tralee Bay
0 10 20 40 60 80
Kilometers
common
frequent
occasional
rare
absent

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Spread of Pacific Oysters

- Establishment of wild populations limited at this stage
  - a degree of control may still be possible

- Developed rigorous methodology for sampling and identified factors associated with oyster establishment
- Found that crabs can eradicate post-recruits in some areas and algae can slow growth, but effects variable
- Evidence for multiple recruitment events and decoupling of establishing populations from local aquaculture
  - need to manage establishing populations plus aquaculture
- Recommend triploid oysters to reduce reproduction

Kochmann et al in press *Journal of Heredity*
Kochmann et al in review *Biological Invasions*

Impacts of Pacific Oysters

- Experimental tests of potential impacts on biodiversity and ecosystem functioning in a range of habitats and at a range of densities

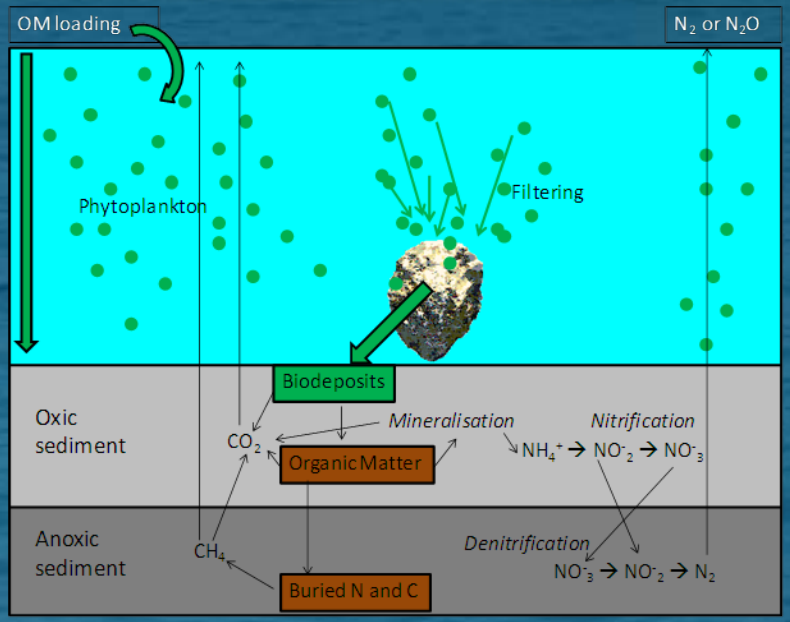
Impacts of Pacific Oysters

- Showed negative effects on protected habitat (*Sabellaria* reefs) and changes to biodiversity (including apparent facilitation of other introduced species)
  - control of spread should be a high priority
- Dead oyster shells also influential
- Effects varied with habitat and density

Green et al. in revision
Marine Ecology Progress Series

Impacts of Pacific Oysters

- Oysters can alter nutrient cycling and decomposition rates and potentially affect primary productivity.
- Could affect ecosystem services, e.g. by reducing carrying capacity for aquaculture.



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Dr Myriam Callier

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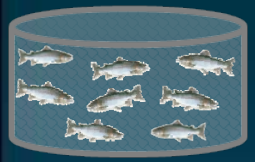
Influence of salmon cages

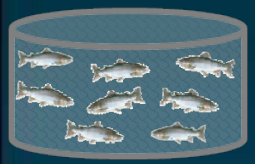
- Tested extent of influence on benthic communities using sampling and stable isotopes
- Assessed possible mitigation approach



Influence of salmon cages

- Low diversity under cages and high abundance of opportunistic species
- Effects on communities extended 25-200 m downstream, but <25 m perpendicular to flow
- Uptake of fish farm waste by benthic organisms demonstrated + some evidence of dietary switches

Callier et al. in revision *Marine Ecology Progress Series*



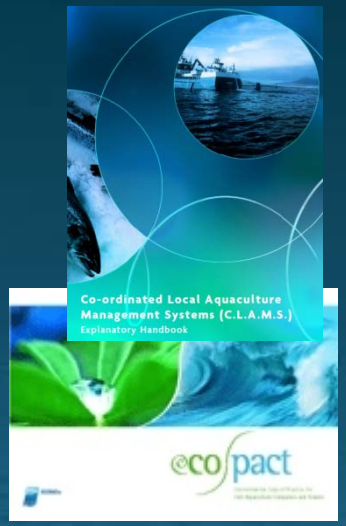
Influence of salmon cages

- Increased biomass of suspension feeders could decrease levels of particulate and dissolved material
- Potential mitigation strategy?
- Substrates for suspension feeders could be deployed in sensitive environments, where a small reduction in nutrients could be critical

Callier et al. in revision
Marine Ecology Progress Series

Approaches to reducing impacts

- Statutory measures
- ECOPACT: Environmental Management System for aquaculture
- CLAMS: Co-ordinated Local Aquaculture Management Systems
- Mitigation measures include:
  - Ongoing improvements in feeding efficiency
  - Fallowing, rotation of cages, reduction of culture densities
  - Bioremediation, polyculture
  - etc.



Future research needs

- influence on pelagic communities
- influence on ecosystem functioning & services
- spatial extent of influence and duration of impacts - larger scales in space and time
- cumulative effects of separate farms
- synergistic effects with other stressors
- resistance and resilience of ecosystems
- carrying capacity of bays
- compatibility of aquaculture with conservation objectives of SACs

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www.ucd.ie/marbee

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