Marine renewable energy systems:

Economic effects on industry and ecosystem

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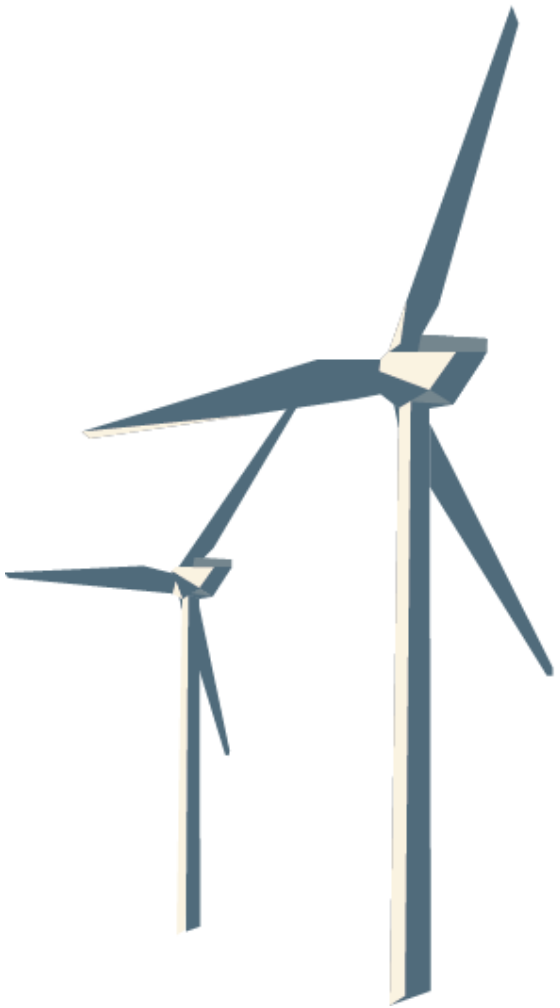
Introduction to my work

- Developing a model which links **marine ecosystem** to economic production.
- Main application is to **offshore wind energy in** the UK.
- Aim to provide **socio-economic evidence** for the **Marine Management Organisation** (PhD CASE partner).
- Supervisory team: Xiaoyu Yan (ESI), Eleni Papathanasopoulou, Tara Hooper & Mel Austen (PML)

Topics in this seminar



Reasons for building a model that the links the U.K. economy and ecosystem…

and some pieces of the puzzle…

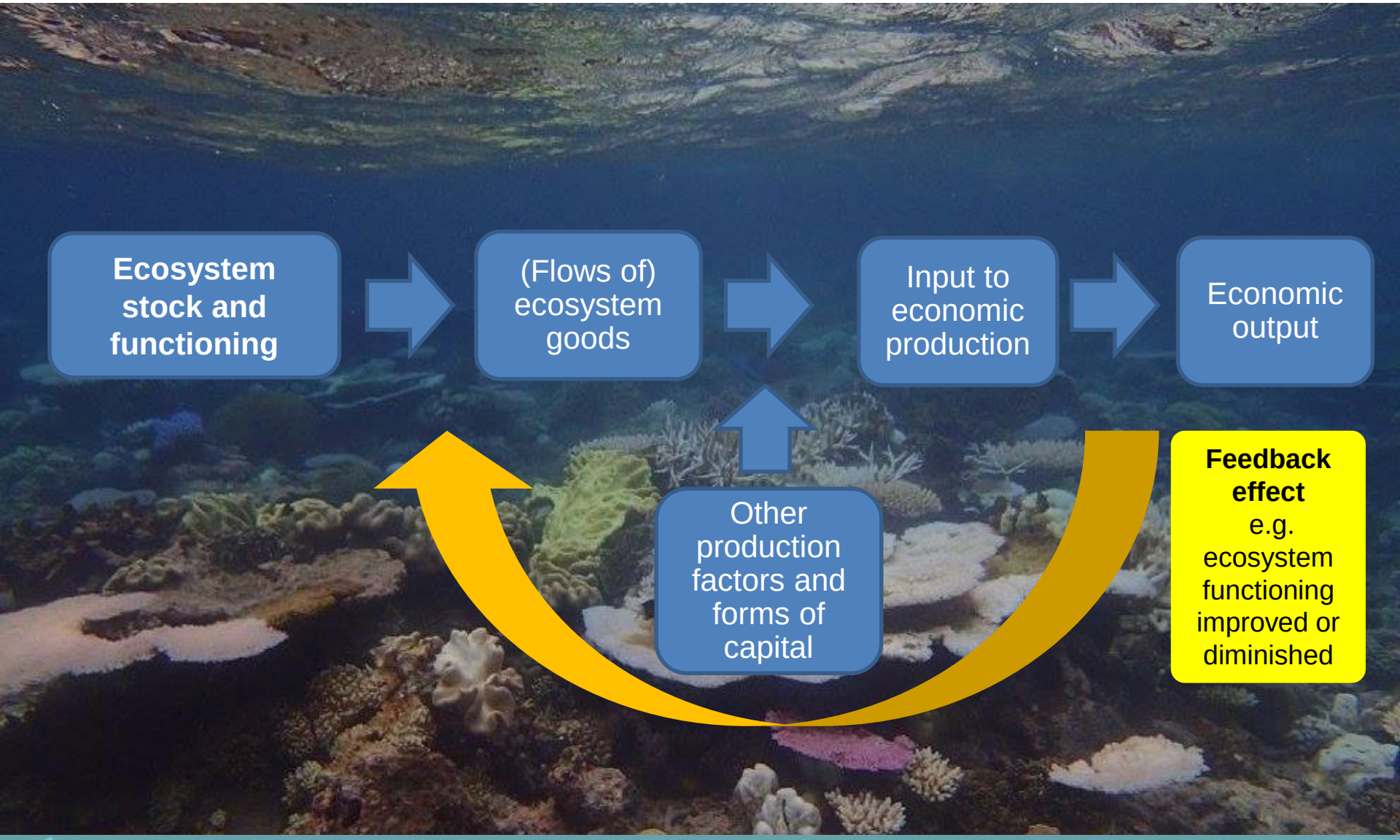
1. Defining **feedback loops** between marine renewables, other industries, and the ecosystem.
2. The **marine economy** and marine energy industries

Context: change in energy systems

- Installed capacity of offshore wind increased by **77%** [1] between 2012 and 2016 in the U.K. – great for climate!
- Energy systems affect **marine ecosystems** in lots of different ways [2].
  - E.g. fish aggregation, marine mammal behaviour, aesthetic traits, change in spatial use
- Affect **other marine industries** already in the vicinity.
- Change in energy systems and their effect on ecosystems can be better understood with an **integrative model**.
- Use a model that includes **feedback loops** to examine link between economy and ecosystem [3-4].

[1] DBEIS (2018) *DUKES Chapter 6*
[2] Papathanasopoulou et al (2015*) Renewable and Sustainable Energy Reviews*
[3] Kelble et al (2013) *PLoS ONE*
[4] Braat & de Groot (2012) *Ecosystem Services*

Economy in the marine ecosystem

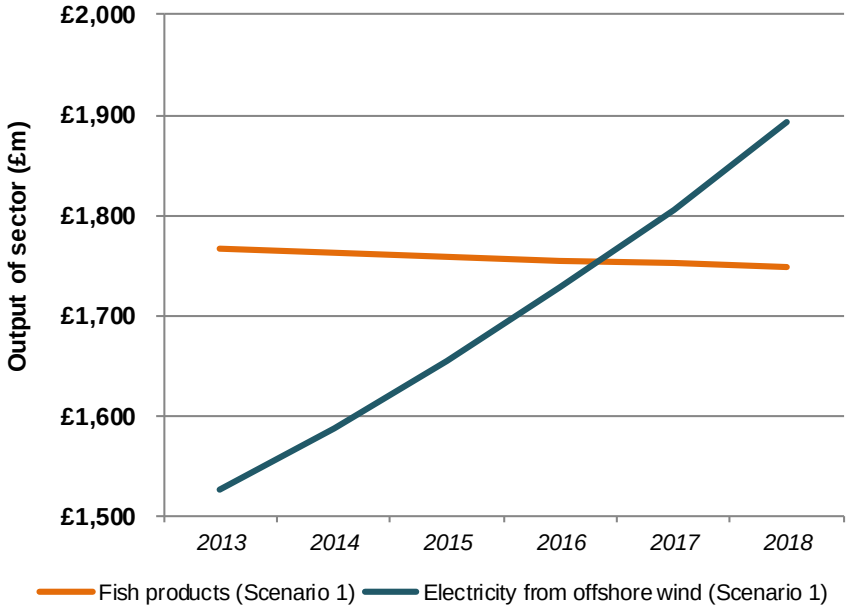


Change in energy systems

- **One feedback loop example**: Construction of offshore wind farms changes the behaviour of people in the fishing industry, and the aggregation of fish surrounding the turbines [6-8].
- **Illustrative scenario**: Expansion of offshore wind farms in the U.K. by 12.6% [5] reduces fishing activity due to exclusion (by 0.02%) in 2013.
- **Model outputs**: output of fishing sector and its related ecosystem stock, versus the output of offshore wind sector.

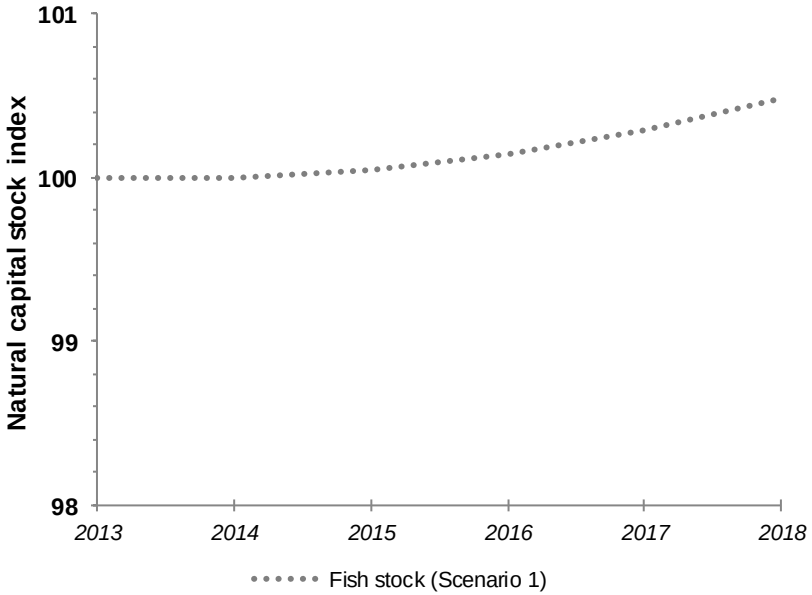
[5] DBEIS (2018), *Digest of United Kingdom Energy Statistics 2017*
[6] Gray, Stromberg &Rodmell (2016)
[7] Wilhelmsson, Malm & Öhman, (2006) *ICES J. Mar. Sci*
[8] Bergströmet al (2014) *Environ. Res. Lett.*

Illustrative results



Offshore wind output grows year on year, decreasing fishing sector

Decreased output/demand in fishing sector allows ecosystem stock to grow/recover



Source data: UK IO Analytical tables 2013 (ONS, 2017), Digest of UK Electricity Statistics (DBEIS, 2017), UK Sea Fisheries Statistics (MMO, 2013-2017)

Layering feedback effects

- However, there are many different feedback effects, layered with one another in a complex way;
  - Between different industries
  - Interacting with different ecosystem resources
  - Working with and against one another
- As the basis of the model we need to define a **marine economy**, with sectors which **rely on** the marine ecosystem to produce goods and services.
  - Resource based, e.g. aggregates, oil, seaweed, fish
  - Service based, e.g. ship building, ports, sport, recreation
- Can then link marine resources to these sectors with more confidence.

Marine economy

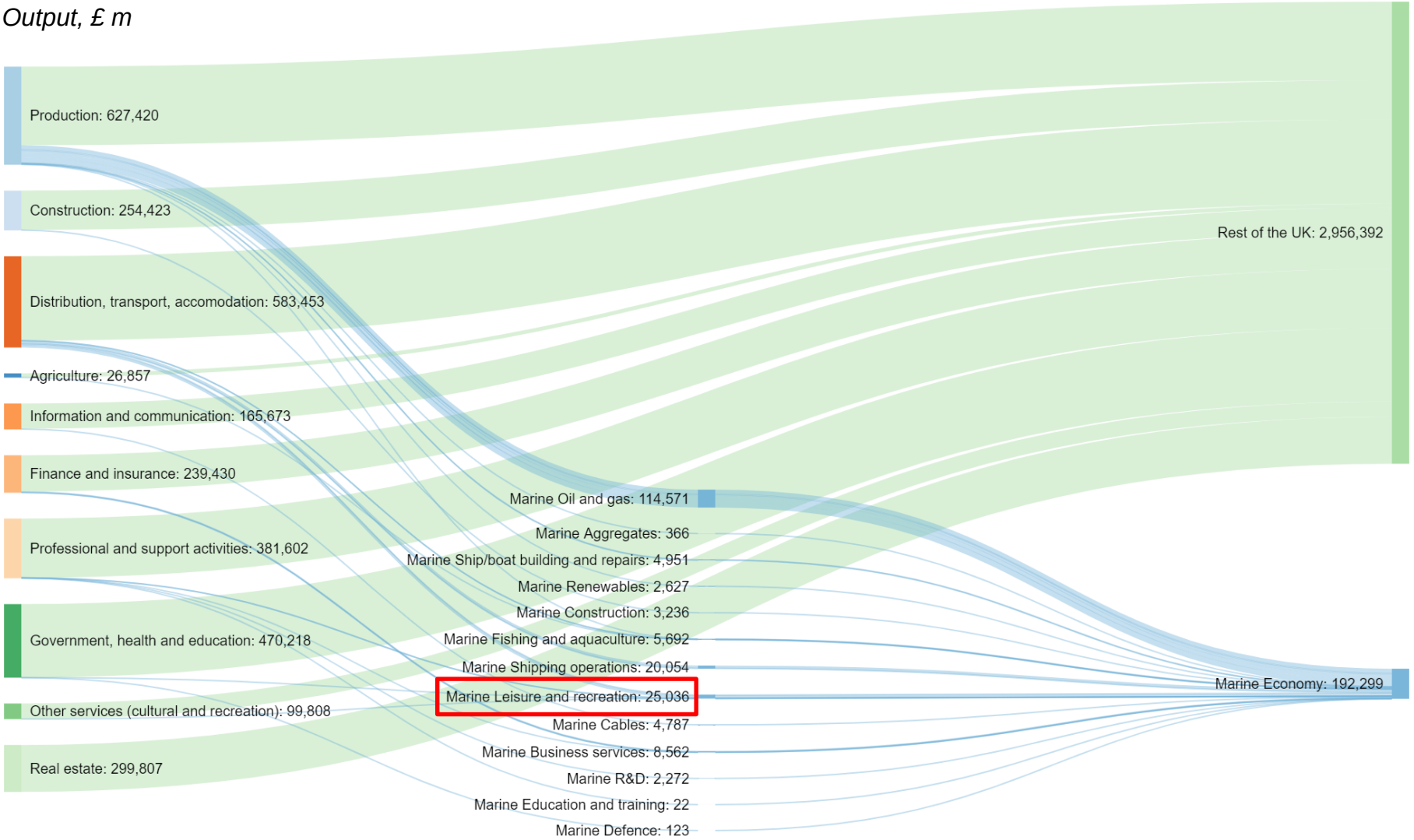
- National accounts published at an aggregated level.
- No **recent** valuation of **all** sectors in the UK that rely on marine environment – emphasis has been on maritime sub-sectors (e.g. Pugh, 2008; Morrissey, 2014).
- No **input-output table (IO)** for U.K. 'marine economy' – approaches focus on size of the economy but not the structure of it. *Need an IO table for my model…*
- Electricity products **grouped together** in one sector – renewables are included with gas turbines, nuclear etc.
- Cultural, recreation and leisure activities have been continually **under-represented** in estimates of marine economy.

Marine economy: key results

- Marine economy represented 7.2% of GDP in 2014 – larger than previous estimates.
- Marine renewables contribute £2 billion (0.1%) in GVA.
- Oil and gas contributes £71 billion (3.6%), including electricity, gas distribution and refining.
- Leisure and recreation represent the second largest marine sector - £20 billion (1.1%).

Marine economy in the U.K.

Output, £ m



Results based on 2014 data

Marine economy: multipliers

- Multipliers – for each additional unit of demand, how much additional output is generated in the economic system? And how much value added?
- Offshore wind has a **lower** output multiplier (2.19 vs 2.39 for total electricity). It "causes" less output in other industries, e.g. it doesn't use coal, oil, gas as an input.
- Offshore wind has a **higher** value added effect (0.74 vs 0.63). The proportion of value adding elements is higher, e.g. more labour used and so more money goes back to the household.
- Why these results specifically – more work needed…
- Why is it significant – these recalculated multipliers mean that investment in offshore wind has a **different effect** on the wider economy than first thought.

To conclude

- Change in electricity production may affect **other marine industries** as well as the **ecosystem**.
- Systems thinking can capture **wider effects** of these changes.
- Renewable energy sectors can be defined as industries in their own right, as can other marine sectors which rely on the environment.
- Feedback loops between marine sectors, and links with ecosystem resources can now be defined more clearly.

Links to other research

- Trade-offs could be used in sustainable management of the marine area.
- Economic significance of emerging energy systems can be better understood.
- A marine input-output table can be used for exploring feedback effects in integrated model, or re-purposed for life-cycle analysis (LCA).
- Environmentally Extended IO analysis – linking consumption to emissions – could follow on particular industries which were not well defined in the national accounts, e.g. shipping.

Acknowledgements

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All graphics author's own, except where stated.

Questions?
Thanks for listening!

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Quick glossary

- Output – value of all goods and services produced in a sector, or the whole economy.
- Input-output table – describes inputs required by sectors, and the goods they produced → adds to GDP.
- GVA – contribution to the economy (after taxes, intermediate consumption etc.).
- Ecosystem services – the benefits that people or society get from the ecosystem.
- Natural capital – the ecosystem 'stock' that provides ecosystem services and functioning.