A Rapid Assessment of Marine Non-native Species in Harbours and Marinas on the Southwest Coast of Norway and the Northeast Coast of Scotland and the Potential for Coastal Connectivity

Ian Campbell, Thomas P. Adams, Andrew J. Blight, Elizabeth J. Cottier Cook, Vivian Husa, Jennifer Loxton,

20<sup>th</sup> International Conference on Aquatic Invasive Species Fort Lauderdale, Florida 25<sup>th</sup> October 2017 1. Key research aims

2. Methodology

3. Results

4. Next steps

### 1. Key research aims

- Study sites for rapid assessment surveys
  Improves knowledge of NNS presence in areas previous lack of research effort
- Structural characteristics and location of floating wind turbines
   Offers a toolset of methodologies for informing future floating devices
- Number and speed of vessels during the assembly, transport and installation process
   Supports environmental monitoring and a full risk assessment for Developer
- Floating wind turbines as a potential vector and 'stepping stone' for invasion "supports research programmes which increase knowledge about ecosystems and biodiversity"

## 1.1 Study sites

 Many studies investigated fouling species richness and diversity along the same coastline

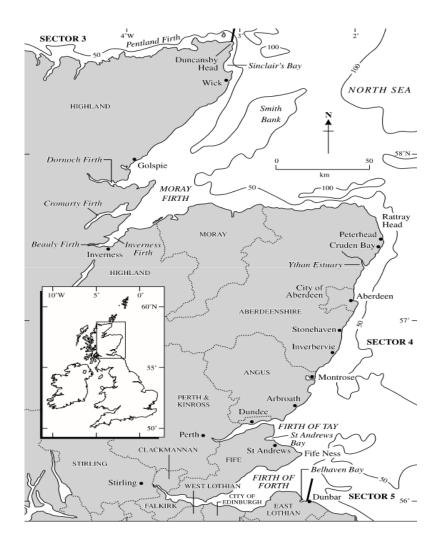
 Few looked at spatial variation between harbours and marinas separated by a seascape and the potential for habitat connectivity.

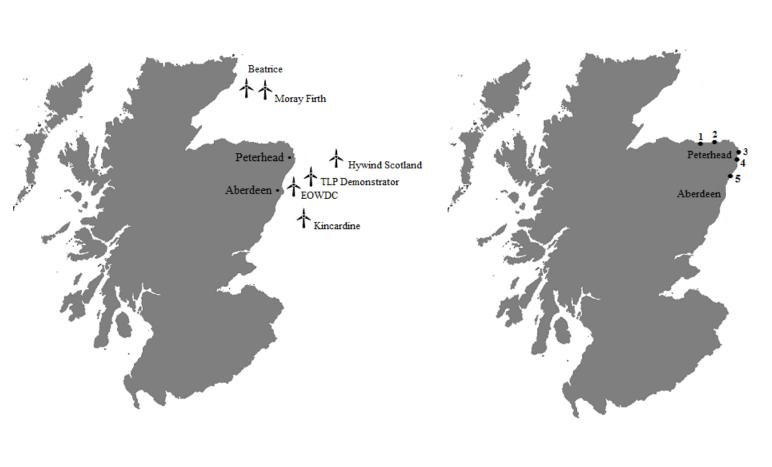
Study focussed on NNS presence on the southwest coast of Norway and northeast coast

of Scotland

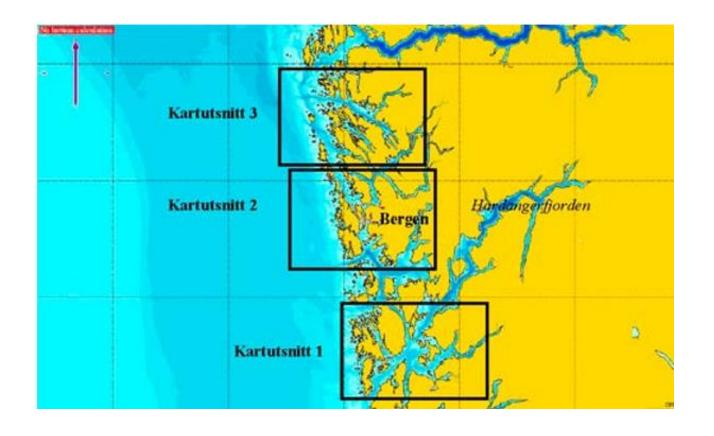


### 1.2 Scotland



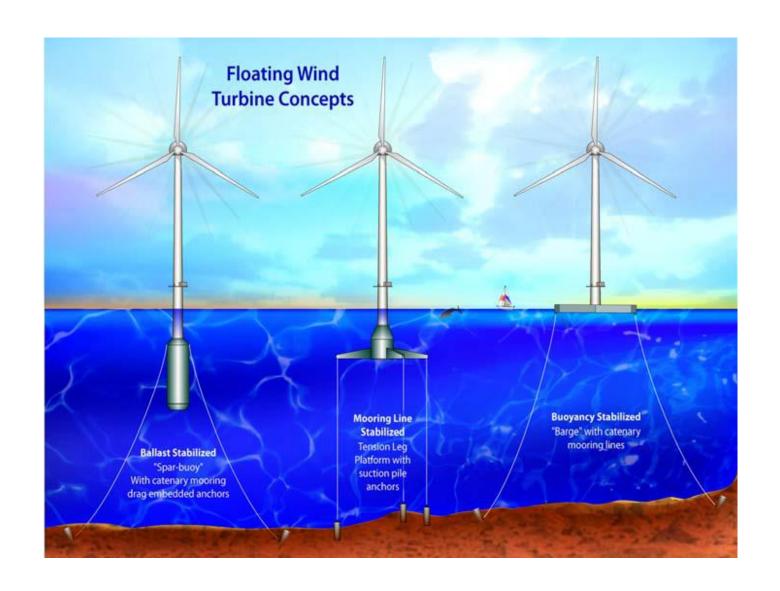


# 1.3 Norway

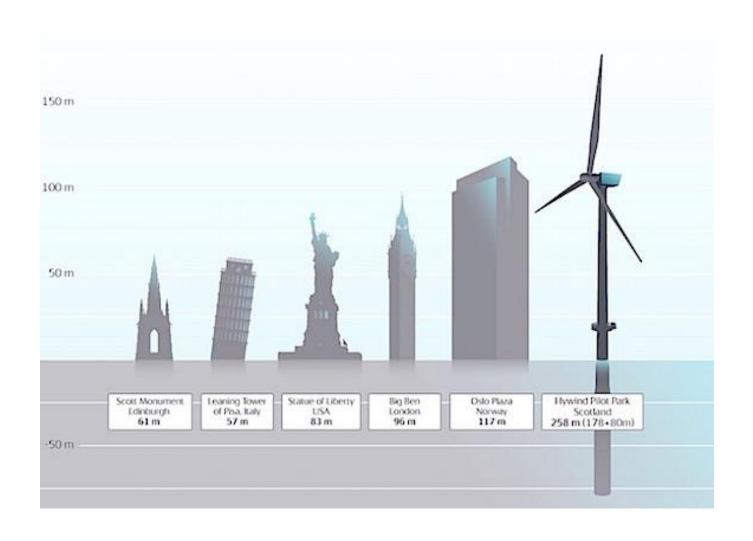




## 1.4 Floating design concepts

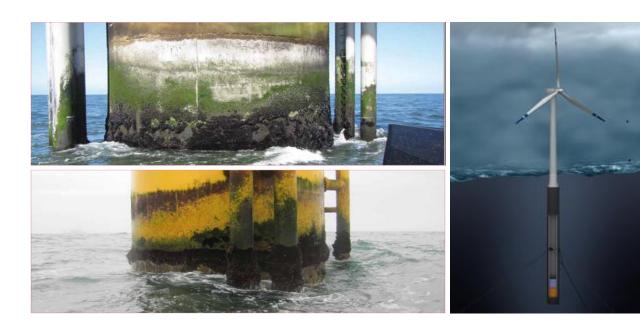


# 1.5 Hywind Scotland

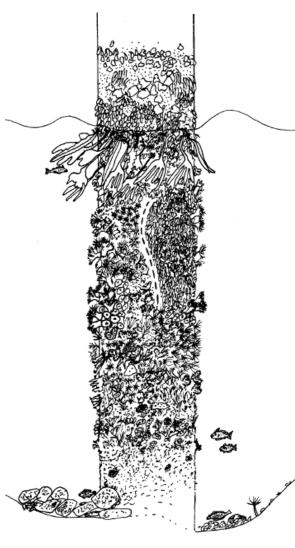


## 1.6 Deep water locations

- Hydrodynamic conditions deep water very different near shore shallow coastlines
- High tidal environment
- Different flow regime
- Foundations permanently submerged
- Difficult to access
- No analogues for deep water floating devices



## Why should we care?



### Intertida

Predominantly barnacles and ephemeral algae including: the barnacles Semibalanus balanoides and Elminius modestus, sea lettuce Ulva lactuca, gut weed Enteromorpha intestinalis, and laver, Porphyra spp.

### Kelp zone c+.1-2 m

Kelps, foliose red seaweeds, barnacles, encrusting sea mats. Mussels sometimes dominant below kelps. Foliose algae (including *Palmaria* palmata and *Polysiphonia* spp. especially) may extend deeper

### Shallow subtidal c+. 2m-6m Two alternative are illustrated:

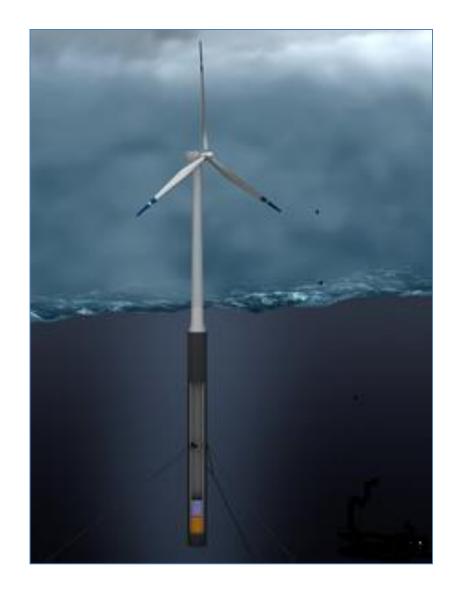
- (Left-side of illustration.) Plumose and other anemones, sponges, possibly hydroids. Large individuals of the plumose anemone Metridium senile, with groups of sagartia anemones Sagartia elegans and patches of hydroids, Tubularia larynx and sponges, Halichondria panicea. Occasional red seaweeds especially filamentous species.
- (Right-side of illustration.) Dominated by mussels, Mytilus edulis with scattered elements of the above and starfish (Asterias rubens) predators.

### Main column to scoured area.

Likely to be dominated by plumose anemones Metridium senile, sagartia anemones Sagartia elegans, soft corals Alcyonium digitatum, hydroid sea firs including Obelia spp., Kirchenpauria pinnata, Tubularia indivisa, sponges such as Amphilectus fucorum and solitary sea squirts Ascidiella spp. Patches of feather stars (Antedon bifida) may be present as well as areas of the colonial sea squirt Diplosoma listerianum and the sponge Polycarpa spp. Scoured area Dominated by keeled tubeworms, Pomatoceros triqueter, and barnacles Balanus crenatus, with encrusting bryozoan sea mats near the top of the zone. May be dominated by ross worm Sabellaria spinulosa. Large amounts of bare substratum likely to be present.

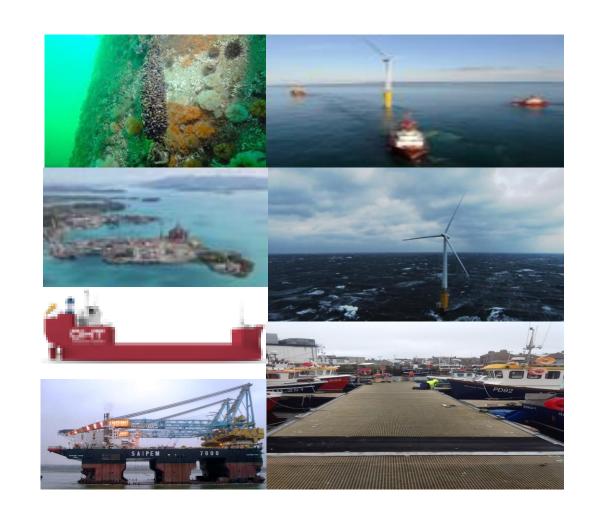
### Base of structure Two alternatives are illustrated:

- (Left-side of illustration.) No or few mussels on structure above and antiscour in the form of small boulders installed. Boulders colonised by same species as scoured structure although sheltered intertices may attract solitary sea squirts and other species. Reef species such as wrasse, Labrus bergylta, swreck fish Trisopterus luscus, lobster Homarus gammarus, crab Cancer pagurus, and conger Conger conger attracted.
- (Right-side of illustration.) Mussels dominant on structure above and no anti-scour. Live and dead mussels accumulate at base. Possibly peacock worms. Sabella pavonina present. Scavengers such as crabs and flat fish attracted.



### 2. Methodology

- 1. Full literature review of biofouling and INNS on offshore artificial structures and study sites in Norway and Scotland
- 2. Baseline NNS at ports adjacent to assembly and deployment
- 3. Scrape sample ATI vessels
- 4. Attach in-situ panels to Hywind Scotland prior to wet towing to Scotland
- 5. Operational monitoring of Hywind Scotland foundations
- 6. Final RAS at ports of assembly and deployment



## 2.1 Methodological challenges

### "Everyone has a plan till they get punched in the mouth" Mike Tyson

- ✓ Comprehensive literature review
- ✓ RAS at ports of assembly and deployment
- Scrape sample all ATI vessels
- Attach in situ panels to HywindScotland prior to wet towing to Scotland
- Operational monitoring of Hywind Scotland foundations
- ✓ Final RAS at ports of assembly and deployment









## 3. 1 Results Scotland



















# 3. 2 Results Norway







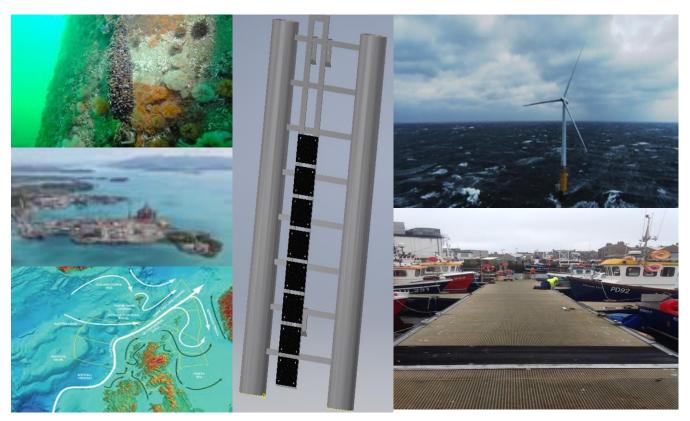






## 4. Revised methodology

- ✓ Full literature review of bio-fouling and INNS on offshore artificial structures
- ✓ Baseline NNS at ports adjacent to assembly and deployment
- + Assess physical characteristics of each of the study sites in Norway and Scotland
- + Create a coupled biophysical model to quantify non-anthropogenic dispersal of two non-native cirriped species from the port of assembly
- + 2<sup>nd</sup> proof of concept for operational monitoring of Hywind Scotland
- ✓ Final RAS at ports of assembly and deployment











# Acknowledgements









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