Assessing the impact of introduced infrastructure at sea with cameras:
A case study for spatial scale, time and statistical power

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Baited remote underwater video (BRUV)

Main taxon
Teleosts, crustaceans, elasmobranchs & echinoderms

Example metrics
Species richness
Fish length frequencies (stereo)
First arrival time
Biomass estimates

\[ N_{\text{max}} = \text{relative abundance} \]
Ecological/environmental marine monitoring requirements and challenges

Data requirements:
- Baseline data characterising spatial and temporal variability
- Continued monitoring (data collection) over relevant scales

Data challenges:
- Detect the potential effect from the natural ‘background noise’
- Recognize whether any detected change is biologically, ecologically or functionally ‘meaningful’

Overarching challenges:
- Funding (salaries, equipment, boat hire etc.)
- Dynamic weather and sea state
New site and survey

Ideal scenario to design monitoring program:

✓ Familiar with study site

✓ Prior knowledge of spatial & temporal variability (system/receptor)

✓ Conduct power analysis to determine sample size to detect (‘meaningful’) change

✓ No infrastructure in place to allow baseline pre-installation data to be collected
BRUV survey at MRE site

Actual scenario to design monitoring program:

- Unfamiliar with site
- No prior data on spatial or temporal variability
- Some infrastructure was already installed

Resulting survey design was a compromise between:

a) Experimental and statistical theory; e.g.
   1. $\uparrow$Sampling(precision) = $\uparrow$Power
   2. $\uparrow$Effect size = $\uparrow$Power
      ($\uparrow$Variance = $\downarrow$Power)

b) Available resources; money, people, time etc.
Survey location

16-20 km offshore

8km² zone

Medium to fine sediment habitats

Rocky reef and large boulder habitats

40-55m depth

25-45m depth

Wave Hub offshore renewable energy test site

Cable with rock berm (0.3m) & concrete matressing at 120m intervals
No permanent energy devices were deployed during the survey period

Focus of the study:

1. BRUV systems utility to provide baseline & monitoring data for impact assessments

2. Investigate the power to detect change in ecological metrics given the variation observed and sample size

3. Could any effects of the MREI infrastructure on the mobile epi-benthic community be detected?
Survey design

Wave Hub Study Area

Cable Route Study Area

- Cable
- Wave Hub Zone

5 km
Survey design

Three drops at each location

 Attempted 2 surveys a year to incorporate seasonality (spring/autum)
1. BRUV survey

Deployments:

- Survey effort was reduced by ~50% due to weather, time and money limitations
- ~300 deployments were completed
- ~70% provided 30 minutes footage of acceptable quality

- Wave Hub area total = 91 (42 Trt / 49 Ref)
- Cable route area total = 107 (55 Trt / 52 Ref)
1. BRUV survey

Recorded:
- > 5000 individuals
- 67 species
- 46 families

- 80% teleost

- Weather was main limiting factor
- ...but BRUV provided the required data for baseline site characterisation & impact assessment
2. Power analyses for survey design (method)

- SIMR package in R (Green & MacLeod, 2016. Methods in Ecology and Evolution 7, 493-498)
  - Power analysis for mixed effect models

- Spring data only for:
  - Overall species richness ($S$)
  - Teleost relatively abundance ($N_{\text{max}}$)

- Conducted with years combined (and separate)
- Range of effect sizes investigated
2. Power analyses (years combined)

Species richness (both study areas)

- To detect 10% change with >0.8 power would require >200 samples
- To detect 20% change with >0.8 power would require ~40-50 samples

- Detection power varies with metric & study area
- No impact for abundance should be viewed with caution
  - ...........but what level of change is meaningful?
  - Requires >100 samples

- There was low power (<0.8) to detect any level of change at the cable route study area
3. Detecting impact on the epi-benthic community

Mixed effect models (PERMANOVA)

**Species richness ($S$)**

- High yearly variation in $S$, $N_{\text{max}}$ and assemblage data
- No impact of infrastructure detected for phylum data

*Year was the only significant effect found within cable route area*

**Yearly variation was also found to be the main effect in assemblage composition analyses, with no infrastructure effects found**
Summary

1. Weather was a limitation but BRUVS demonstrated their value in gathering epi-benthic species data

2. Power to detect change varies with:
   - Ecological metric – caution should be taken with abundance data
   - Site location – even within development sites

3. No effect of the infrastructure at the MRE test site could be detected for phylum data

   High inter-annual variation (‘noise’) effects the ability to detect change
Thank you. Any questions?
BRUV footage from Billia Croo site
(courtesy of CEFOW project survey)

Common/flapper skate *Dipturus batis*
Species richness by year (power)

Smaller sample sizes in the yearly models

Wave Hub
20% change

Cable route
20% change
Fish abundance by year (power)

Smaller sample sizes in the yearly models

- Inter-annual variation could lead to over- or under-estimation of survey effort if using single year data.

Wave Hub
50% change

Cable route
50% change
Effective area of attraction (AR) – (Cappo et al. 2004. JMBE)

\[ AR = 60 \times (S_t) \times \left( \frac{(V_f \times V_c) - V_c}{V_f} \right) \]

Current speed of 0.23 m s\(^{-1}\) and a maximum (endurance) fish speed of 0.6 m s\(^{-1}\) used in calculation