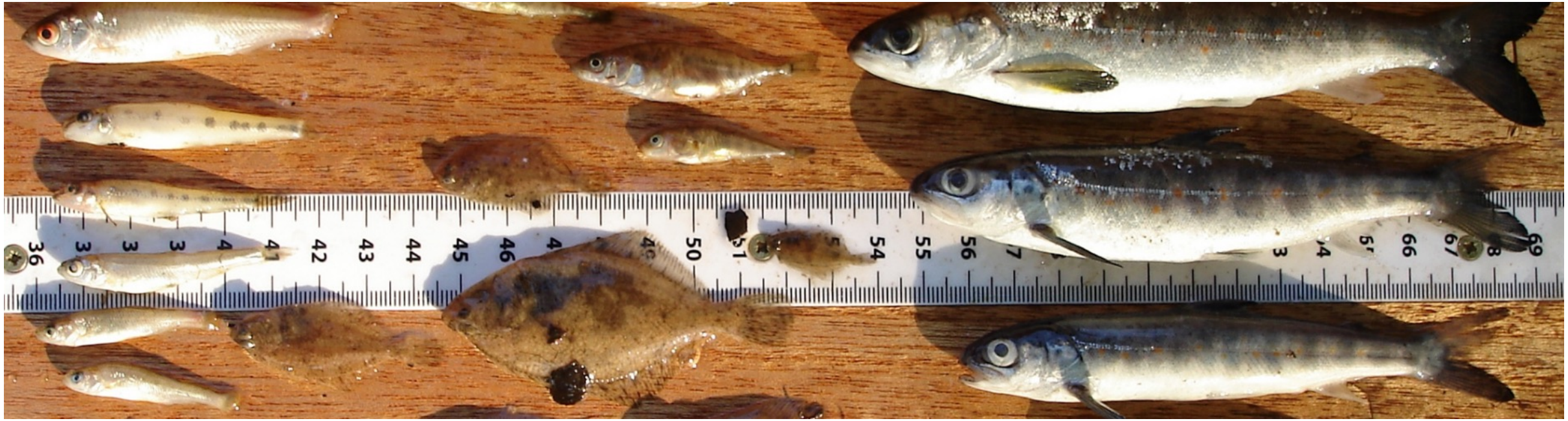

The Fish Entrapment Assessment Cycle for the Power Industry

From Monitoring to Modelling

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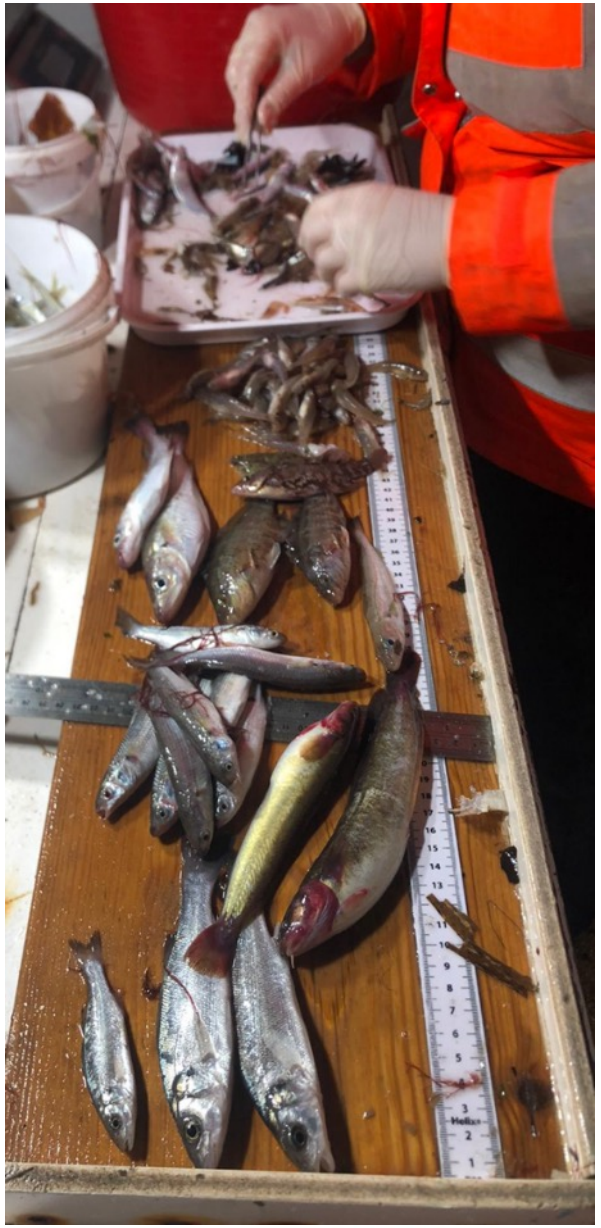
Cooling Water Abstraction

- Power stations abstract water for the purpose of cooling with volumes differing depending on whether the station is direct or indirect cooled
- Abstraction of cooling water results in the entrapment of fish into the intake
- Entrapment is collective term for impingement and entrainment
- Impingement is defined as - The abstraction and subsequent capture of fish and other biota on the cooling water screens
- Entrainment is defined as - The abstraction, passage through the cooling water system and subsequent return to their origin waterbody of organisms too small to be captured by the cooling water band screens
- For a new cooling water abstraction application or a non-standard renewal, there is a requirement for an assessment of potential pressures that are associated with marine activities
- For the activity of ‘intake of cooling water’ the following two pressures are identified;
  - Loss of species interest features
  - Deterioration of habitats and food supplies that support species interest features



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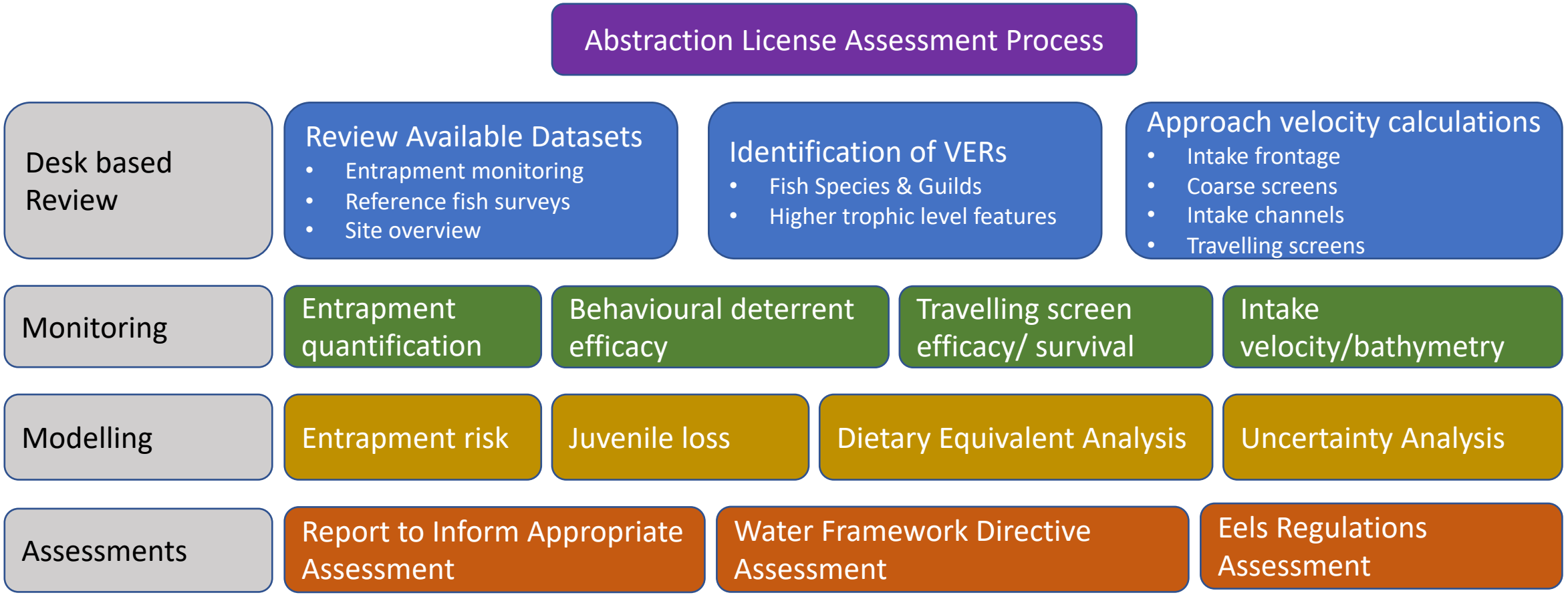
Assessment process



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Review Available Datasets

- Entrapment monitoring
  - Impingement and entrainment monitoring
  - Direct site or a neighbouring site
  - Abstraction simulation monitoring results
  - Targeted species specific monitoring
- Reference fish surveys
- Site overview; screening arrangements, backwash pressure etc.

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Identify Valued Ecological Receptors (VER's)

- Fish VER's
  - Categorised into Functional Guilds depending on how they use the site
  - Guilds split by their commercial status, to indicate availability of stock data
    - Marine Migrants with and without Total Allowable Catch (TAC)
    - Marine Adventitious (TAC and no TAC)
    - Estuarine Residents
    - Diadromous Species
  - Species assigned Conservation, Commercial and Ecological Value
- Indirect effects of fish entrapment losses as a food resource for higher trophic level features of designated sites
  - Marine mammals
  - Fish eating birds and fish (relevant protected sites & foraging distances)

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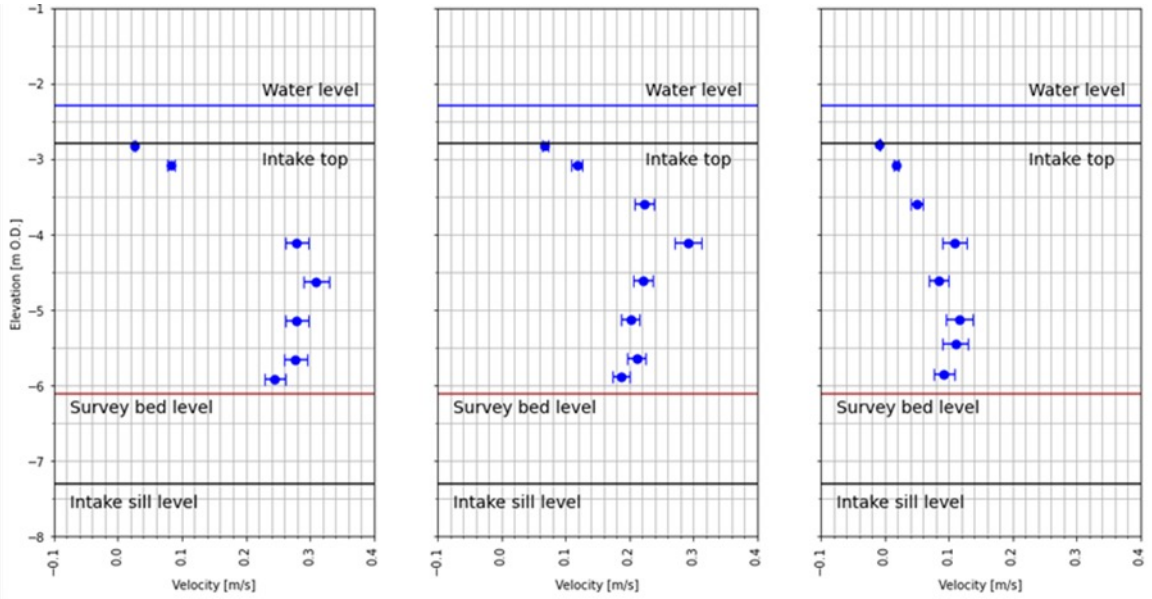
Intake Velocity

- Approach/Escape Velocity

  'velocity in front of the screen measured perpendicular to the screen face, irrespective of the screen angle to flow - i.e. it is the minimum velocity at which a fish would need to swim in order to escape…… by convention, this is measured a short distance (e.g. 10cm) in front of the screen, where a fish might swim, rather than for example between the bars of the screen'

- 'Screen' could be a physical or behavioural screening technology
- For a behavioural technology, 10cm could be from the deterrent system or the behavioural sensor field
- Locations of interest; intake frontage, coarse screens, intake channels, in-front of travelling screens
- Calculated using available information on dimensions and abstraction rates
- May require bathymetry data collection
- Velocity measured in situ

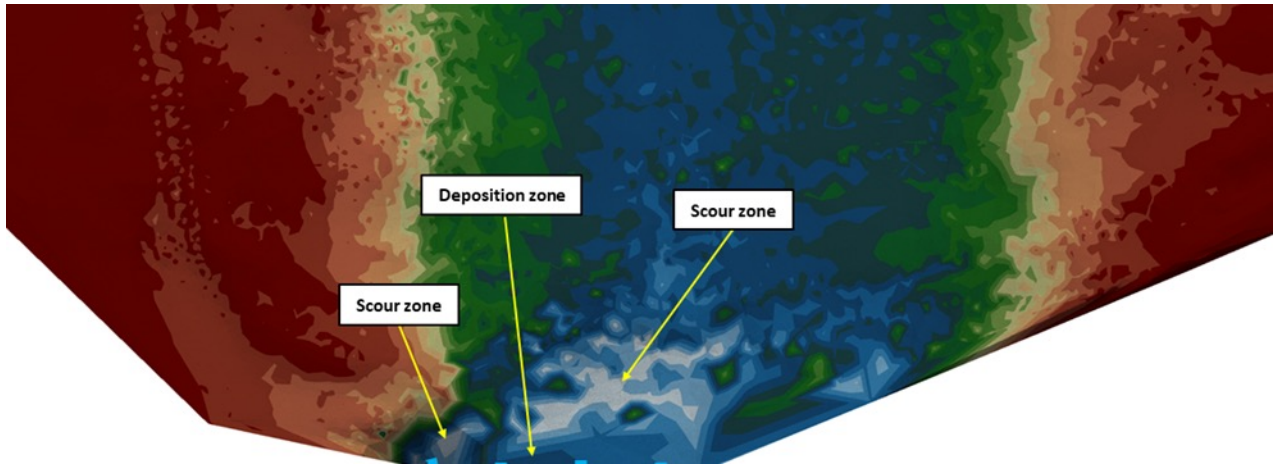


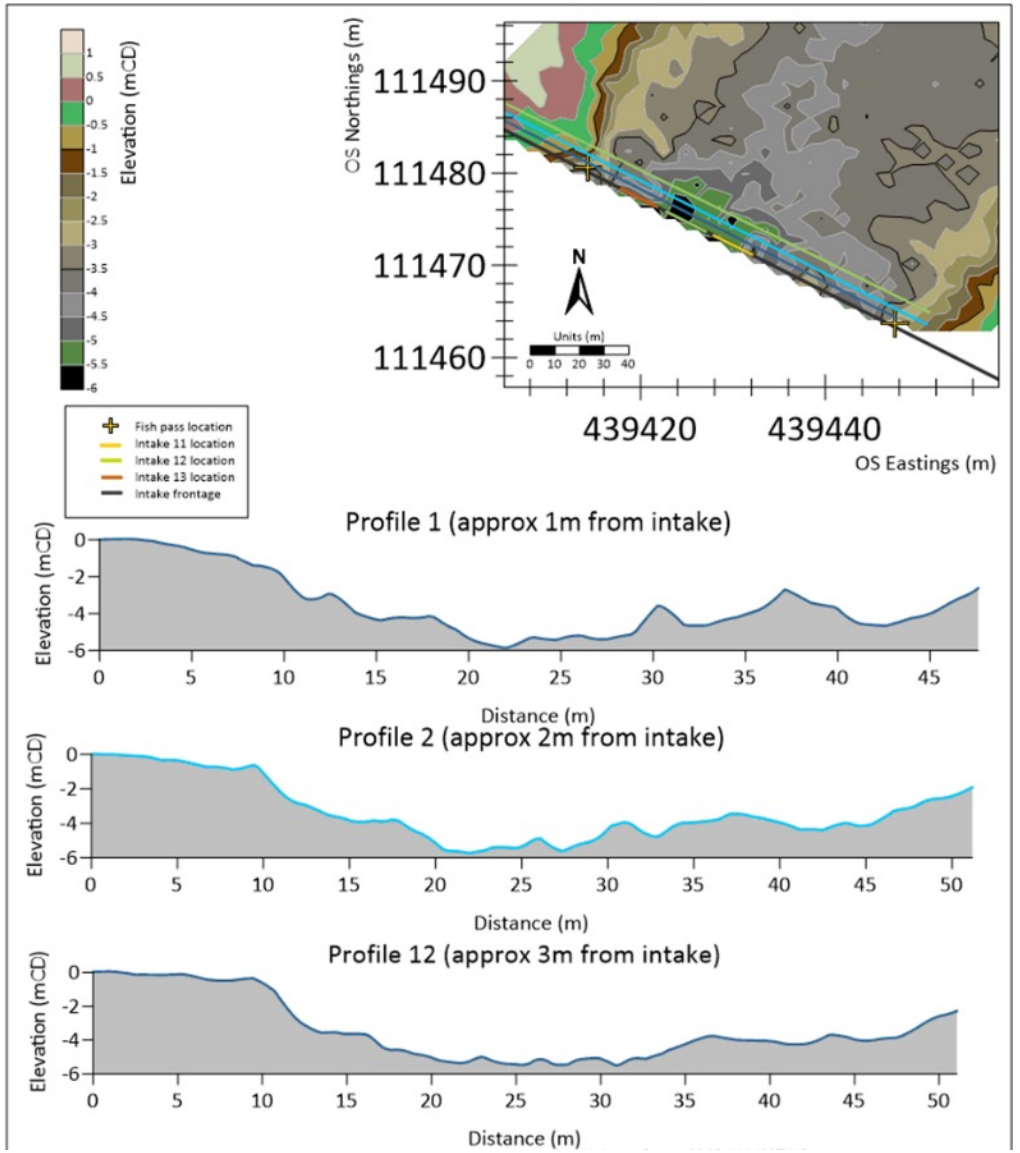
Intake Velocity

- Different technologies required depending on the individual site characteristics
- Acoustic Doppler Current Profiler in vertical profile
- Doppler
- Impellor
- Site considerations;
  - Presence of physical structures for multi-beam sensors
  - GPS and sensor interference
  - Travelling screens; confined spaces, located at depth, turbulent non-laminar flow, health and safety risks from moving screens, dual flow operation
- Calibration required if operating different sensors at the different locations

Intake Velocity

- Bathymetry surveys may be required to validate bed topography and siltation state
- Profiles can be taken at set transects to assist with escape velocity calculations
- Comparison with historical surveys to understand scour and deposition impacts





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Entrapment Monitoring

- Entrainment and impingement data is required to assess both direct and indirect impacts from the abstraction
- Data may be available from the direct site or a neighbouring site for a new abstraction licence or may need to be collected
- For new sites entrapment simulation monitoring through pumping a sample of water from the receiving environment may be suitable depending on abstraction volume and proposed intake arrangement
- BEEMS guidance is available for the design of the measurement of impingement and entrainment at coastal and estuarine power stations
- Sampling must consider influential environmental factors; season, diurnal and spring-neap cycles – 24 hour samples recommended over 14 day tidal cycle
- Sampling nets must be the same mesh size as screens or smaller
- Entrainment sampling must consider ratio of abstracted water sampled

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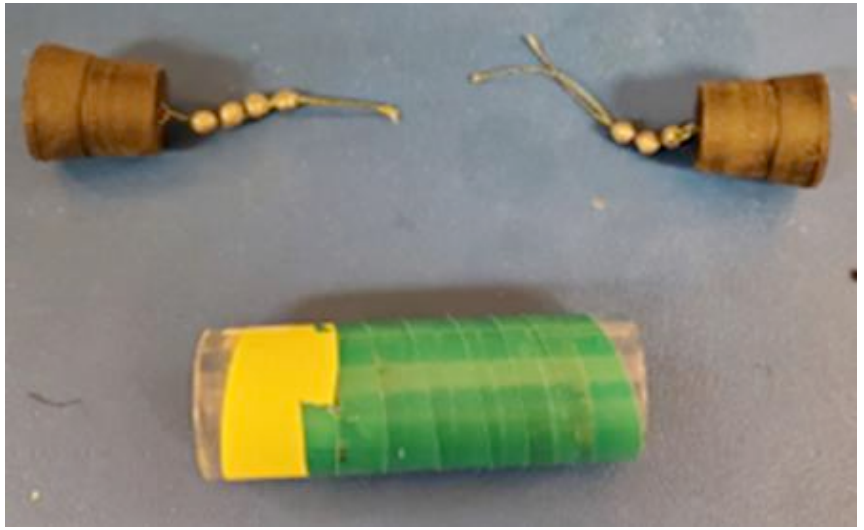
Behavioural Deterrent Efficacy Monitoring

- Important to understand the efficacy of any in-situ or planned behavioural deterrents
- Planned deterrent efficacy must be determined through desk based studies
- For existing deterrents ‘on-off’ control experiments can be undertaken
- 24hr on-off cycles recommended to account for diurnal and daily tidal changes
- Need to understand fish residence times in the abstraction system to ensure clear datasets for on and off cycles – use of ‘dummy’ fish
- All other variables must stay consistent e.g. abstraction rates, screens operating, travelling screen speed etc.
- Requires representative species with differing sensory responses



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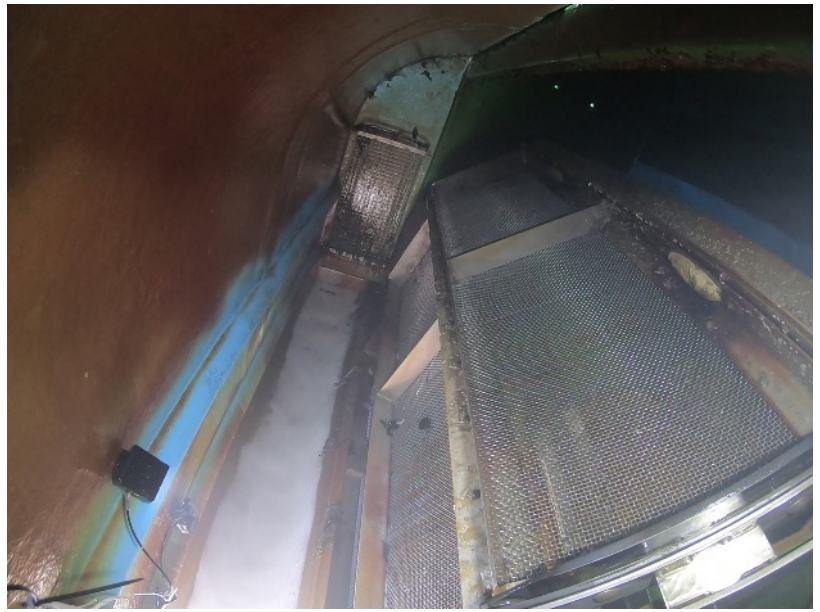
Travelling Screen Efficacy/Survival Monitoring

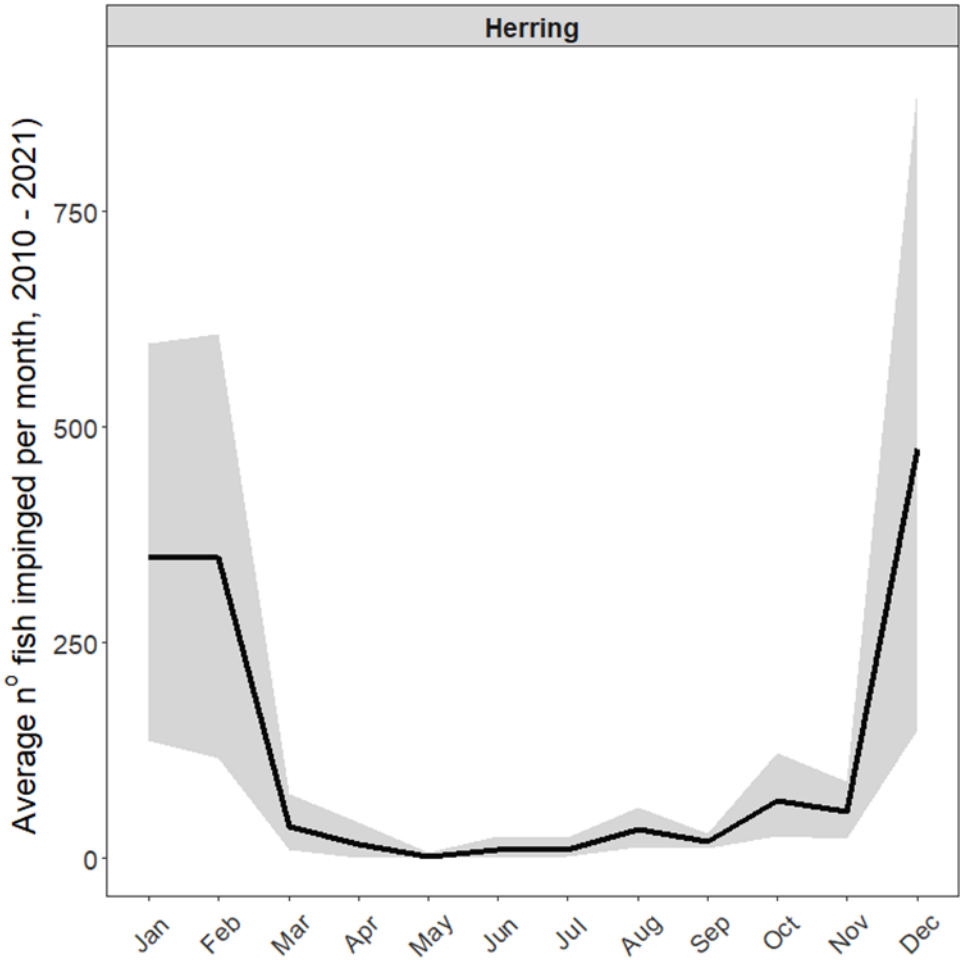
- Survival rates and efficiency from passage on travelling screens is important to understand fish entrapment losses
- Survival can be monitored alongside standard entrapment monitoring with retention of fish for 24, 48 and 72 hrs
- Other aspects of screen efficiency such as spraybar removal can be monitored through camera observations
- Fish mark recapture can be used to monitor recycle rates from outfall and specific injury mechanism points



Entrapment Risk Assessment

- A stepped approach to determining the number of fish predicted to be lost annually due to entrapment

1. Extrapolation/Interpolation
    a) CPUE – m^3s^{-1}
    b) Interpolation to full 24 hr period & for days not sampled
    c) Species vulnerable periods
    d) Bootstrapped means – uncertainty analysis
2. Survival rates (impingement & entrainment) – species, lifestage & screen specific
3. Behavioural deterrent efficacy rates
4. Uncertainty analysis – standard errors, confidence intervals and parameter ranges included in Monte Carlo analysis



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Juvenile Loss Assessment

- Fish losses often involve the juvenile part of a population – presence in inshore nursery areas, small size & swimming ability
- Due to natural juvenile mortality, juvenile loss has a lesser impact to the population than adult losses
- Requirement to contextualise impact of juvenile losses to future populations
- Contextualisation method used depends on species, life history data availability & ecological question being answered (loss to species population or loss to ecosystem/other trophic level)
  - EAV / FH - Equivalent Adult Values / Fecundity Hindcasting
  - SSB / R – Spawning Stock Biomass per Recruit
  - PF / BLM - Production Foregone / Equivalent Biomass Lost Model
  - EALP - Equivalent Area of Lost Production
- Uncertainty considered in all methods

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Dietary Equivalent Analysis

- Indirect effects of fish entrapment losses as a food resource for higher trophic level features
- Bioenergetic modelling and dietary and demographic information to convert fish entrapment losses to the potential number of marine predators, or proportion of a population, that could have been sustained by the biomass of the fish prey
- Not to say that these individuals would be lost, rather they have the potential to be lost should no other food sources be available
- Key parameters required from literature;
  - Proportion of prey species in diet
  - Energy value of prey species
  - Predator daily energy expenditure
  - Energy transfer – proportion of food energy used for predator to live
- Uncertainty analysis

Environmental Assessment Requirements

- Report to Inform an Appropriate Assessment for designated sites
  - Potential to present ‘A Likely Significant Effect’ and ‘Adverse Effect on Integrity’
- Water Framework Directive Assessment
  - Clearing the Waters for All Guidance
  - Transitional and fresh waterbodies
  - Cause a deterioration from its current status or potential (No Deterioration Assessment)
  - Prevent future attainment of Good status, or potential (Future Status Objectives)
  - Classification element – Biological - Fish
- Eels Regulations Assessment
  - To assess risk to eels if non-compliant with the Regulation requirements

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Thanks

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