# Potential applications of AUVs and Gliders in Offshore  Windfarm Site Surveys

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*MREKE Internship in partnership with MARS at NOCS*

# Introduction to the Presenter and Presentation

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Project manager and PDRA at NOCS for Arctic Landslide-Tsunami Project

**MREKE Presentation 19/07/2013**

Project rationale
Requirements for windfarm surveys
AUVs and gliders
Applications for initial site surveys
Application during site monitoring
Conclusions

# Rationale for Project

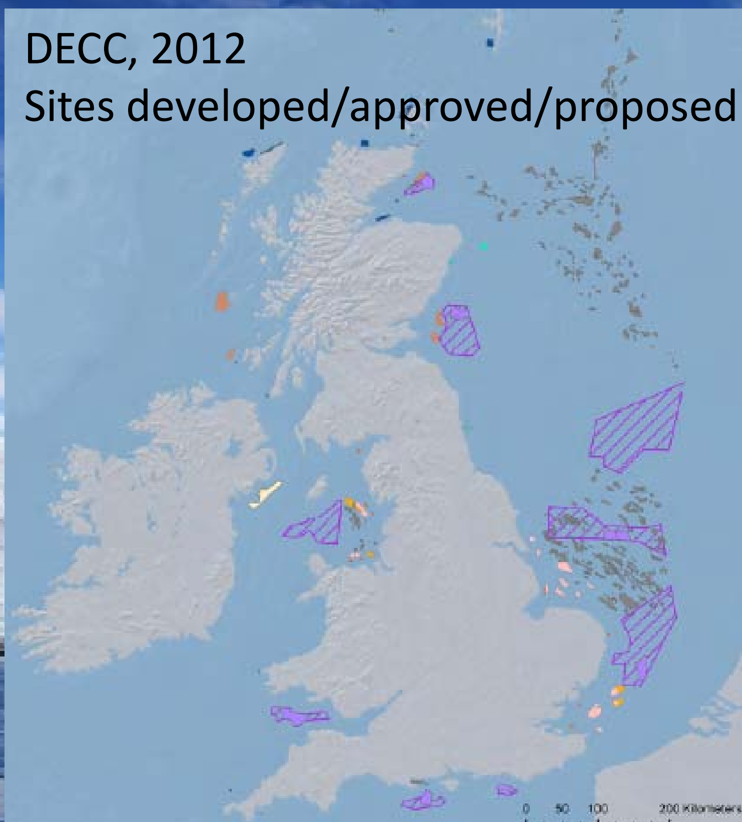
- Offshore wind energy growing in commercial and government interest:
  - UK wind energy 34% capacity increase from April 2011 to July 2012.
  - Offshore wind energy generation increased from 0.95GW to 2.5GW.
  - In that time £12.5bn investment.

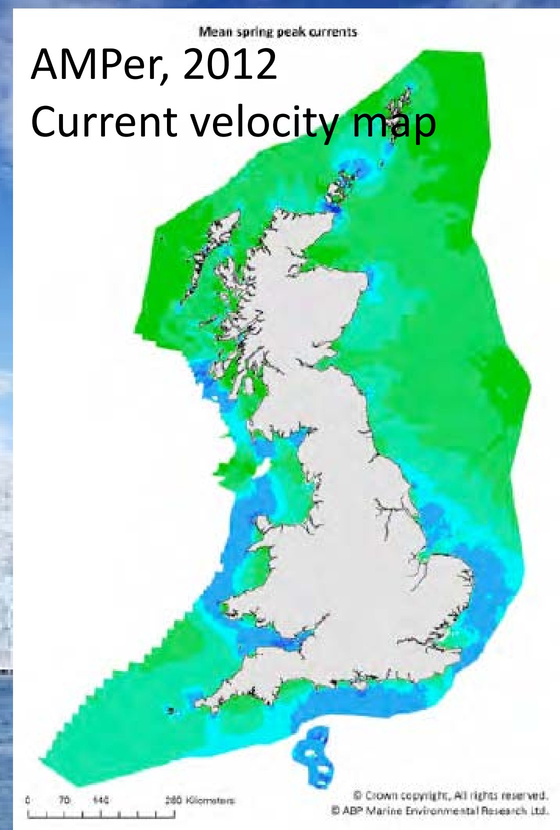
- Energy Act 2004 has resulted in large swaths of offshore marine areas designated as The Renewable Energy Zone.
- However only 26% of UK EEZ has been mapped.
- However this is still at relatively poor resolution and site surveys needed.

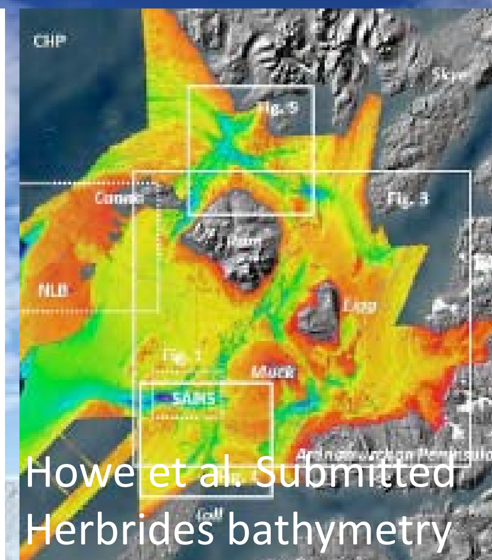
- **Ship-board surveys are becoming costly due to fuel price increases and increases in additional overheads.**
- **Autonomous surveys are cheaper and less intensive alternatives.**
- **How viable is this proposition?**

# Requirements of Offshore Wind Energy

1. **Initial sea bed maps and current data on which to aid selection of license blocks for development.**
   - Coarse swath bathymetric maps.
   - Oceanographic maps including current direction and speed.



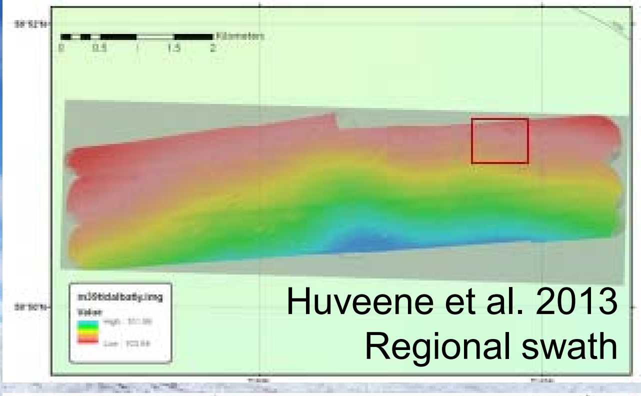



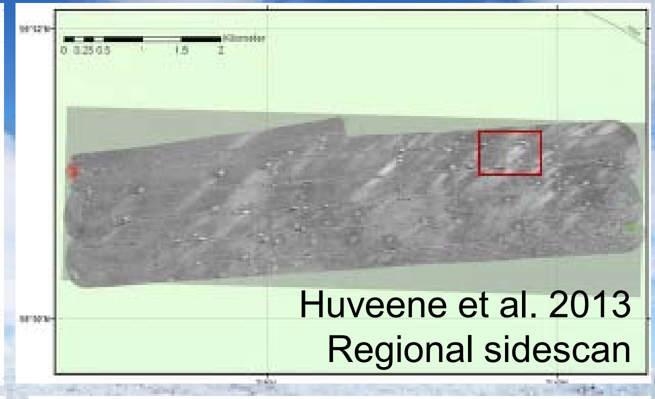



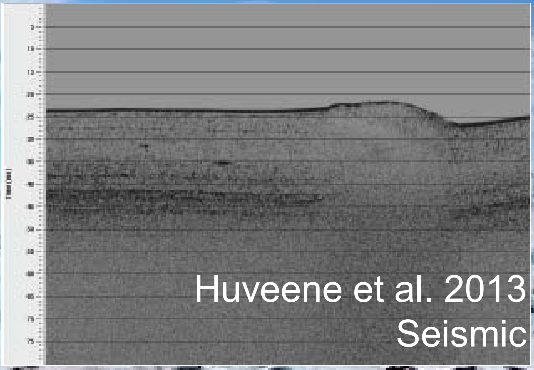
# Requirements of Offshore Wind Energy

**2. High resolution site surveys prior to infrastructure emplacement.**

- High resolution swath bathymetry.
- Sidescan sonar mapping spatial sediment properties.
- Sub-bottom acoustic profiler (seismic reflection) for depth distribution of sediment properties and structures.
- Bottom water current strength and particulate concentration.


Huveene et al. 2013
Regional swath


Huveene et al. 2013
Regional sidescan


Huveene et al. 2013
Seismic

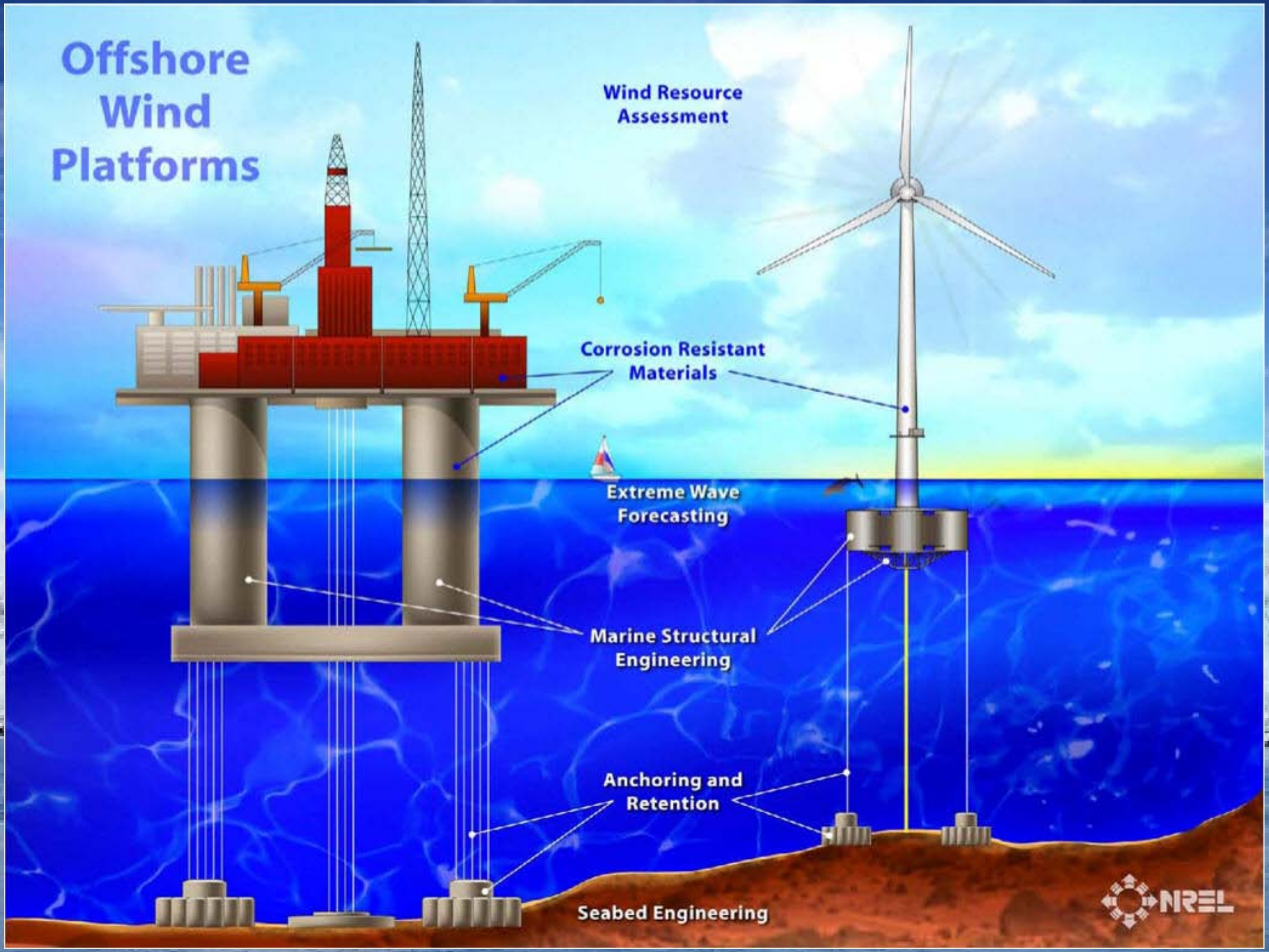

Huveene et al. 2013
Local swath of Darwin seamount


Huveene et al. 2013
Local sidescane

# Requirements of Offshore Wind Energy

**3. Site monitoring around installed infrastructure.**

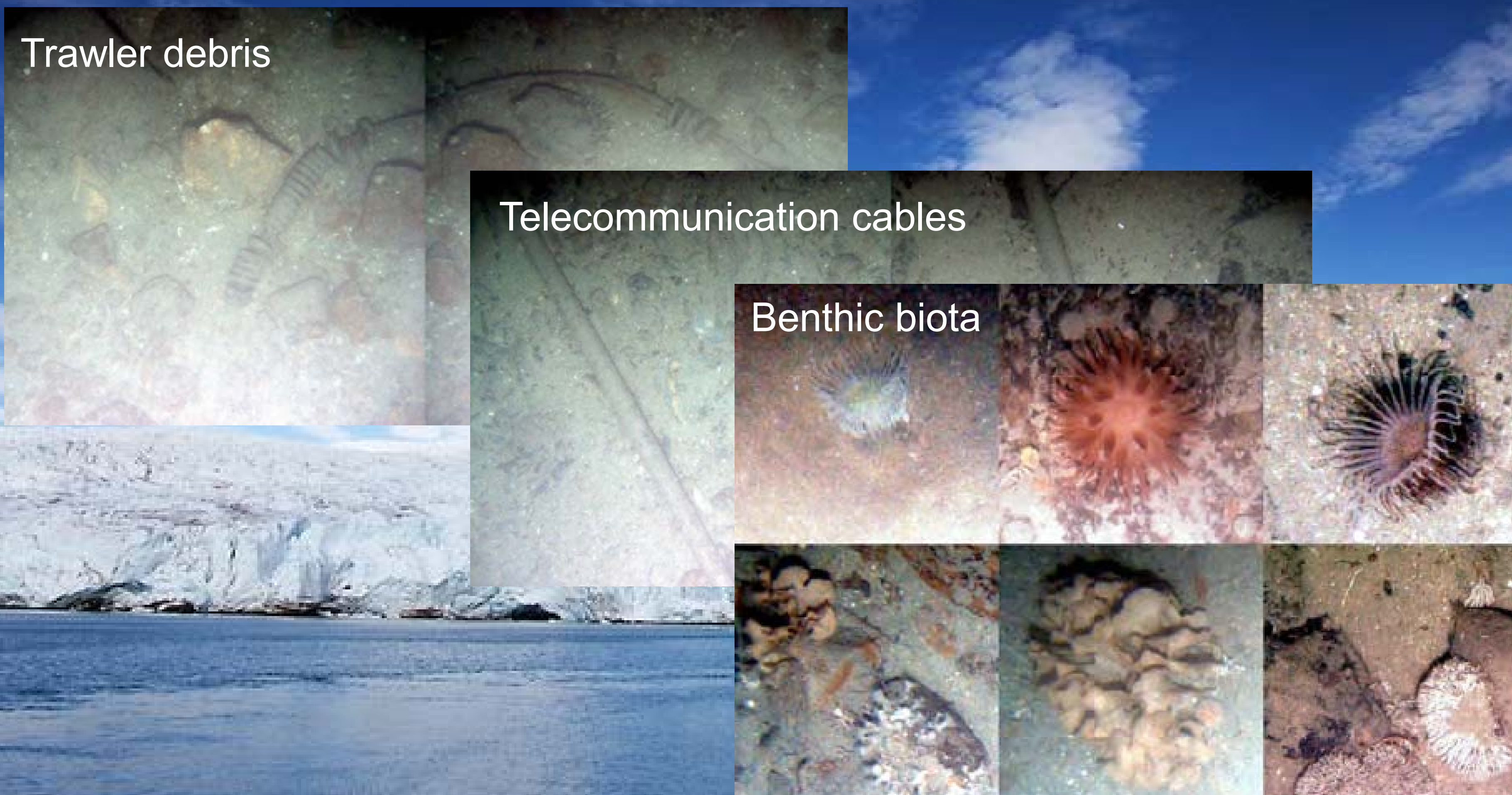
- Reaction of seafloor to infrastructure installation monitored by acquisition of repeat surveys.



# Requirements of Offshore Wind Energy

**4. Potential government requirements for environmental monitoring.**

- Habitat mapping predominantly by photography.
- Passive monitoring using acoustics.



# Gliders

Gliders utilise buoyancy through an external bladder in addition to manoeuvrable wings to propel the vehicle forward in saw-tooth geometry.

Gliders designed for endurance, therefore power to instruments is a premium. Therefore instruments are passive including:

- CTD
- Dissolved oxygen
- Optical backscatter
- Chlorophyll fluorescence sensors
- **ADCP current measurements**
- **Turbulence sensory**

# Autonomous Underwater Vehicles

AUVs utilise an electric motor with direct drive to small propellors for forward propulsion, with maneovreability from tail fins.

AUVs designed short 12-24 hour surveys using active acoustic sources:

- **Swath bathymetric sonar**
- **Sidescan sonar**
- **High frequency seismic**
- **ADCP velocity profiler**
- **HD photography**


AUVs have depths rating of 1000-6000m water depths.

# Application to Site Surveying

**Initial Findings**
AUVs have the greatest potential for application within site surveying for the Marine Renewable Energy sector.

Geophysical data (as mentioned) can be gathered by AUVs and shown to be of similar or better quality than ship-based surveys.

Science cruises have already utilised multidisciplinary methods; surveying using AUVs whilst coring elsewhere.

**Further Findings through Company Meetings**
In consultation with **Gardline Marine** and **Kongsberg**.
Alternate consultation informally from **Fugro**.

# Application to Site Surveying

**Pre-installation Survey _Findings_ (water depths >200m)**

In deeper off-shelf waters AUVs can be programmed to fly 10-30m above the sea bed. Depths not obtained by ship-board instruments or towfish.
**This gives higher resolution data and removes problems with noise.**

Coring in off-shelf waters takes longer.
**This promotes use of AUVs for multidisciplinary cruises. Time in deep-water is also more costly and higher risk.**

**However a predominance of wind farm installations are on the shelf, and primarily within 0-50m water depths.**

# Application to Site Surveying

**Pre-installation Survey _Findings_ (water depths <150m)**

Issues of noise on ship-based instruments in storms. AUVs operating independently at depths will remove this.
**This is true but other issues arise.**

Ship present only for near-shore L&R reduces costs.
**L&R is most risky operation during rough seas or not. Vehicle failure still requires ship presence, and rapid mobilisation is costly.**

Unmapped geological and articficial obstructions cannot be accounted for leading to vehicle loss in shallow waters.
**Ship surveys avoid obstacles due to ship-board swath bathymetry informing towfish operators.**

# Application to Site Surveying

**Pre-installation Survey *Findings* (water depths <150m)**

Multidisciplinary functionality reduced.
**Due to proximity to port additional coring (or other) expeditions are not as expensive as in deep water.**

Shallower water around rivers/estuaries/headlands have stronger currents (>2m/s) that cause vehicle crabbing and poor resolution data.
**Science studies in Sea of Hebrides show crabbing in ~1m/s and not a problem to navigation or data quality.**

**Experience of industry is that in velocities above 2m/s (or faster than vehicle speed) ship-based data is better.**

Shallower water depths are often turbulence ruling out photography.
**Ecology studies in these waters would be difficult using any method.**

# Application to Site Surveying

**Pre-installation Survey _Conclusions_ (water depths 0-6000m)**

- In water depths **above 700-800m AUVs are used in combination** with ship-based surveys. Multidisciplinary surveys are cost-effective and ship is in proximity for vehicle failures.

- Cost benefit between staying with vehicle and returning to port debated.

- In water depths 700-800m (especially >3000m) AUV data is beneficial as vehicle can fly close to sea bed. **Shallow water has no benefit in data**.

- **High risk due to loss of vehicle**: deep waters due to depth and high seas and shallow waters due to obstacle avoidance and shipping/fishing.

# Application to Site Surveying

**Installation Monitoring Survey *<u>Findings</u>* (water depths <150m)**

Increased turbulence and obstacles (i.e. pilings) negate application.
**With infrastructure comes risk of AUV collision.**
**Risks are too great considering cost of vehicle and data value. Ship-based surveys have reduced risk.**

Increased turbulence and suspended sediment concentration negate most opportunities to monitor ecology.
**Photography is primarily used for ecology studies, which is difficult in high turbulence areas.**
**Monitoring of ecological impact is not required by Government.**

# Application to Site Surveying

**Installation Monitoring Survey *Findings and Conclusions***

Increased turbulence and obstacles (i.e. pilings) negate application.
**Risks are too great when considering cost of vehicle and value of data being collected.**

Kongsberg suggest future having fully autonomous vehicles present in larger windfarms with docking stations for charging and data collection.
**Vehicles are currently too expensive to assign to a single windfarm. Issues remain over obstacle avoidance. Ship assistance still required for vehicle failure.**

# Key Findings

- Deep water (>700-800m) site surveys utilise AUVs in combination with multidisciplinary surveys (i.e. coring).

- Shallow water surveys primarily to use ship-based methods due to:
    - Risk of vehicle collision/loss.
    - No benefit to data quality.
    - No cost-benefit.

- Site monitoring is seen as a benefit, but due to risk, ship-based surveys will continue until risk reduced or cost of vehicle reduces.

- Ecological surveys are not currently required, but potentially will be. Currently pre-installation surveys can be done, but Government drivers need to be present to promote this.

- **At present shallow water surveys, primarily where windfarms are located, have little cost benefit compared to ship-based surveys when considering: vehicle cost, risk and data quality.**

**Figure Captions**

Figure 1 – Autosub3 NOC on recovery
Figure 2 – Autosub6000 NOC before deployment
Figure 3 – Autosub Long Range in tank tests
Figure 4 – MARS Teledyne glider being deployed
Figure 5 – Autosub6000 sidescan sonar of Darwin Seamounts
Figure 6 – Autosub6000 sub-bottom profiler scan-line through a seamount
Figure 7 – Autosub6000 (right) verses ship-board (left) monochrome seabed photography mosaic used for sea floor classification. Showing similarity between datasets.
Figure 8 – Autosub6000 ADCP data from the Black Sea showing saline flow velocity profiles over a channel with a hydraulic jump.
Figure 9 – CTD data from glider transects across the Western Irish Sea
Figure 10 – High resolution anchor plough marks in sea floor acoustic survey using Bluefin21
Figure 11 – High resolution ship wreck image produced from sea floor acoustic survey using Bluefin12D.
Figure 12 – OceanServer AUVs fitted with ADCP and swath bathymetry payloads.
Figure 13 – WHOI Sentry AUV with chemical spectrometer to detect dissolved chemicals above vent systems.
Figure 14 – Exocedus coastal glider