FISHING INTENSITY TRIAL – EXPERIMENTAL DESIGN

Overview of the experiment: What are we aiming to achieve and where and when?

The Fisheries and Conservation Science Group of Bangor University is proposing to run an experiment in the Cardigan Bay SAC, as part of their EFF project. The work aims at determining the effect of scallop fishing impact on the seabed in order to advise the Welsh Government on possible sustainable options for the scallop fishery in an ecosystem approach framework. To do so, a gradient of fishing intensities will be applied by scallop fishing vessels in pre-determined, restricted areas and the effect of dredging on the benthic ecosystem will be assessed by sampling the seabed before and directly after scallop dredging with the RV Prince Madog. At least one more scientific survey will be conducted after a few months to monitor recovery.

The "before" scientific survey is planned between the 15th and 31st of March 2014. The experimental fishing is planned to take place between the 1st of April and the 30th of April 2014. The "after" scientific survey is planned between the 1st of May and the 24th of May 2014. We are aiming to conduct another survey to monitor recovery from dredging in October 2014. Ideally, further surveys would be conducted after one year, two years and even later if the seabed had not fully recovered by then. However, this won't be possible within the timeframe of this EFF project but could make the object of another project.

The proposed location of the experiment is a previously exploited scallop bed that has been closed to fishing activities for 5 years (Figure 1). Cardigan Bay was originally selected as an SAC primarily to protect the resident bottlenose dolphin population (*Tursiops truncatus*). Seabed habitats, i.e. stony reefs, were not the primary focus of the designation but were included as quality features of the designated site. Therefore, following previous advice from CCW to the Welsh Government, the area proposed for the fishing experiment lies between 3 and 12nm offshore, avoiding any potential adverse effects between dolphin prey/dolphin habitat and scallop gear interactions within 3nm of the coastline. Furthermore, in order to conduct the fishing experiment proposed within the EFF project, an appropriate assessment had to be conducted to provide evidence of the absence of stony reefs in the area of the SAC that would be impacted by fishing gears during the experiment. A report has been published in June 2013 providing evidence as to the absence of features in the suggested experimental area (Lambert et al. 2013). The habitat in the experimental area is mostly mixed with various proportions of pebble, gravel, fine sediment and shells and the depth range is approximately 35 to 45m. Considering the highly patchy nature of subtidal habitats, this area provides a relatively homogeneous location which is ideal for such an experiment.

In the report (Lambert et al. 2013), we also suggested a design for the experimental fishery. This design was a starting point for discussions amongst scientists and fishers and has since then evolved. The agreed design is presented below, but first, we give a brief overview of the scientific rationale behind the experimental design.

Scientific rationale

The experiment is composed of 14 lanes fished along a gradient of intensities and 3 unfished control lanes, which will be sampled before, straight after (leaving at least 72h for the impacted organisms to die and for the predators and scavengers to feed on them) and again a few months after the experiment. Considering the monthly time scale of the post-impact and recovery survey(s), whether the impact is applied early or late in April will not affect the outcomes. However, to minimize the differences, the effort will be applied first in the high intensity lanes where possible, as those will take a longer time to be created than the low intensity ones. In those fishing lanes, recovery processes will happen through immigration from adjacent areas as well as settlement and growth within the area, which will be representative of fishing grounds where effort is patchy.

This experiment aims at studying the impact of scallop dredging on habitats and benthic communities. Therefore, during the actual fishing, in April, bycatches will be recorded. Specific monitoring of bycatches in highly fished lanes will constitute depletion experiments where the gear catchability of different species will be assessed. During the pre- and post-surveys, we will use grab, beam trawl and video sampling to study the impact of fishing on all benthic and demersal species that can be sampled using those methods. Such species include polychaetes, molluscs, crustacean, sessile epifauna. This information will be highly valuable to inform the issue of interaction between scallop fishery and bottlenose dolphin populations. Indeed, bottlenose dolphins are expected to prey mostly on bass, mullet, sewin, mackerel and dogfish in the Cardigan Bay SAC (Woolmer 2010). Dogfish is a potential bycatch of the fishery while the other species are more likely to be affected indirectly through their diet. Except for mackerel, the other species feed on small invertebrates and crustaceans, and molluscs and polychaetes for dogfish (Woolmer 2010). In addition to this, considering that the hotspots of dolphin feeding areas appear closer to shore, it has to be noted that most of the highest fishing intensities will be applied further offshore to insure adverse effects are minimised while trying to keep a random design (i.e. there can't be a gradient of fishing intensity from inshore to offshore or it would compromise the outcomes of the experiment).

What will be the extent of the impact of the experiment in the Cardigan Bay SAC?

The total surface area of the Cardigan Bay SAC is approximately 960km^2. We propose to conduct an experiment in the western part of the closed area. This experimental box, in red on the map below (figure 1), is 110km^2 (approximately 8km by 13.5km), corresponding to just under one ninth of the total area of the SAC.

In this experimental box, we propose to impact 14 sites at various intensity levels and keep 3 sites as control sites. Each site is comprised of 3 zones, 2 zones in which the vessels would manoeuvre (haul, shoot and turn) that are situated at either end of a third zone, a lane, which would be impacted a predetermined number of times. The corridor to be impacted is ca. 1700m long by 370m wide, or 0.9nm by 0.2nm, i.e. 630 000m^2 or 0.63km^2. The 2 zones at either end of this corridor are squares of ca. 650m in length, or 0.35nm, i.e. 425 000m^2 or 0.425 km^2. So the total area in which the vessels would be dredging is 14x (0.63+ 2x0.425) = 20.75 km^2, corresponding to <2.2% of the SAC.The fishing intensity gradient to be applied to the fishing lanes varies from the lane being fished 0.25 times to 8 times. The intensities have been set at equal intervals along a $\log_2$ scale: 0.25, 0.35, 0.5, 0.71, 1, 1.26, 1.59, 2, 2.52, 3.17, 4, 5.04, 6.35, 8 (corresponding to $\log_2$ values of -2, -1.5, -1, -0.5, 0, 0.33, 0.66, 1, 1.33, 1.66, 2, 2.33, 2.66, 3). Effectively, this means that the gap between each intensity level

increases along the fishing intensity gradient, with values closer together in the lower end of the gradient. Previous research has shown that the relationship between biodiversity and fishing effort is not linear and this design should allow us to capture the shape of the response, i.e. identify a potential threshold after which increasing fishing intensity do not appear to do any further damage to the seabed.

Along this gradient of 0.25 to 8 times fished, 4 of the 14 impacted lanes will be fished with an average frequency of less than one (mosaic of fish and unfished areas), meaning that less than 20.75km^2 will actually be impacted. If we consider, by precaution, that the 2 "turning zones" at either end of the fishing lanes will be fully covered by dredge tracks, the extent of the area fished will be 10 x 0.63 + (0.25+0.35+0.5+0.71) x 0.63 + 14 x 0.425 = 13.40km^2, corresponding to an area fished of <1.4% of the total area of the SAC. Note however that turning boxes are not necessarily fished.

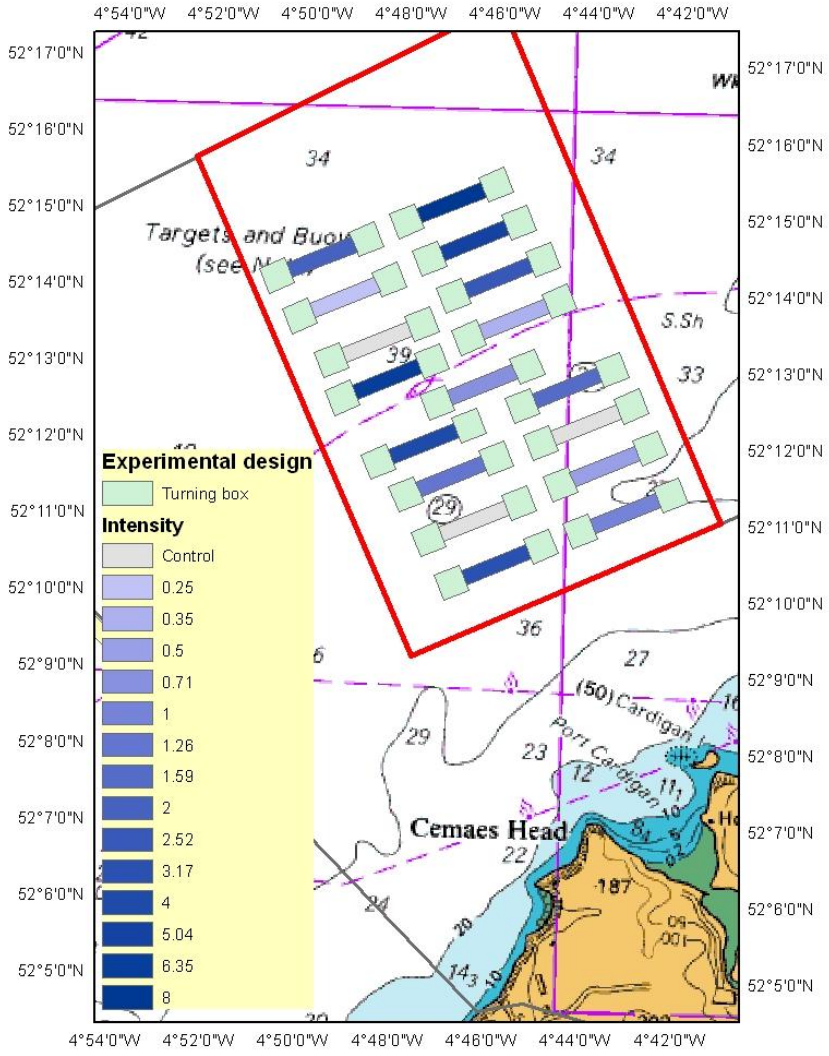

Figure 1. Experimental area and proposed design. Treatments are randomised. Sites are concentrated in the south, closer to the coast, not to prevent smaller vessels to participate in the

experiment and to prevent potential biases in the results if there was to be a divide between small vessels inshore/large vessels offshore. This way it is expected that smaller vessels can fish at each site.

How much fishing is needed to cover the gradient of intensities required?

Each intensity level, 0.25 to 8, corresponds to a certain number of dredge-passes through the fishing lane. A dredge-pass is defined as a tow along the lane, of 1700m long, with a single dredge. With a dredge of 0.76m wide, for a whole lane to be fished once, there needs to be 491 single dredge-passes. This corresponds to 61 tows across the area for a 4 dredges a-side vessel and 35 tows across the area for a 7 dredges a-side vessel.

A vessel with 4 dredges a-side, fishing at 2.2knots during 12h (12h of contact of the gear with the seabed in the fishing lane), will do 28 tows across the area in a day. One tow would take 25minutes. It would therefore need just over 2 days to completely fish one of the lanes once. A vessel with 7 dredges a-side, fishing at 3knots during 12h, will do 39 tows across the fishing lane in a day. One tow would take 18minutes. It would therefore need less than a day to completely fish one of the lanes once.

See table below for details of fishing effort required and examples of how long it would take for vessels of 4 or 7 dredges a-side to complete the experiment.

Table 1. Description of fishing effort needed for the experiment and example of distribution of single dredge-passes.

Intensity (= number of times the lane is fished)	**Number of single dredge-passes**	**Number of tows across the lane for a 4 a-side**	**Number of tows across the lane for a 7 a-side**	**Number of 12h* days with 4 a-side (2.2kn)**	**Number of 12h* days with 7 a-side (3kn)**	**Number of 8h* days with 4 a-side (2.2kn)**	**Number of 8h* days with 7 a-side (3kn)**
0.25	123	15	9	0.5	0.25	0.75	0.5
0.35	172	21	12	0.75	0.25	1	0.5
0.5	245	31	17	1	0.5	1.5	0.75
0.71	348	44	25	1.5	0.5	2.25	1
1	491	61	35	2	0.75	3.25	1.25
1.26	619	77	44	2.75	1.25	4	1.75
1.59	781	97	56	3.5	1.5	5	2.25
2	982	123	70	4.25	1.75	6.5	2.75
2.52	1237	155	88	5.5	2.25	8	3.5
3.17	1556	195	111	6.75	2.75	10	4.25
4	1964	245	140	8.5	3.5	12.75	4.25
5.04	2474	309	177	10.75	4.5	16.25	6.75
6.35	3117	390	223	13.5	5.75	20.25	8.5
8	3928	491	280	17	7.25	25.5	10.75
Total	**18 037**	**2 254**	**1 287**	**78.25**	**32.75**	**117**	**48.75**

				(or 6 vessels - 13days each)	**(or 3 vessels -11days each)****	**(or 6 vessels -19 to 20 days each)**	**(or 3 vessels -16days each)****

* A 12h or 8h day means 12hours or 8hours of gear contact with the seabed in the fishing lane
** See regulations below – a vessel with 7 dredges a-side would not be allowed to fish between 3 and 6nm, only between 6 and 12nm.

What instructions will be given to the participating fishing vessels?

There will be 18037 single-dredge passes to distribute amongst participating fishing vessels, ideally corresponding to a maximum 6 vessels to be logistically manageable by a small team of scientists and enforcement officers as observers will be on board each vessel, if possible. There will be no more than one fishing vessel per site and each participating fishing vessel will be attributed one or more sites. A fixed number of single dredge-passes is associated to each site (as described in the above table and in figure 2). Based on this number of single dredge-passes and the number of dredges a-side of the vessel selected for the experiment, the skipper will be attributed a number of tows to be conducted in each of his lanes. For example, if a vessel can fish with 7 dredges aside and is attributed the lane where an intensity of 8 is required, then the vessel will have to tow its gear 280 times across that box. The skipper will therefore be asked to go back and forth 140 times (or 280 times one way). This should take around 8 days (see table 1 above).

The 2 “turning zones” will be used to position the vessel, shoot and haul. If the first hauls show that the dredges are less than half full after a tow across the lane, then the vessels will be allowed to leave the gear down in the “turning areas” and fish back and forth before hauling. If the dredges are more than half full after fishing across the lane once in one direction, then the gear will have to be hauled each time before turning back.

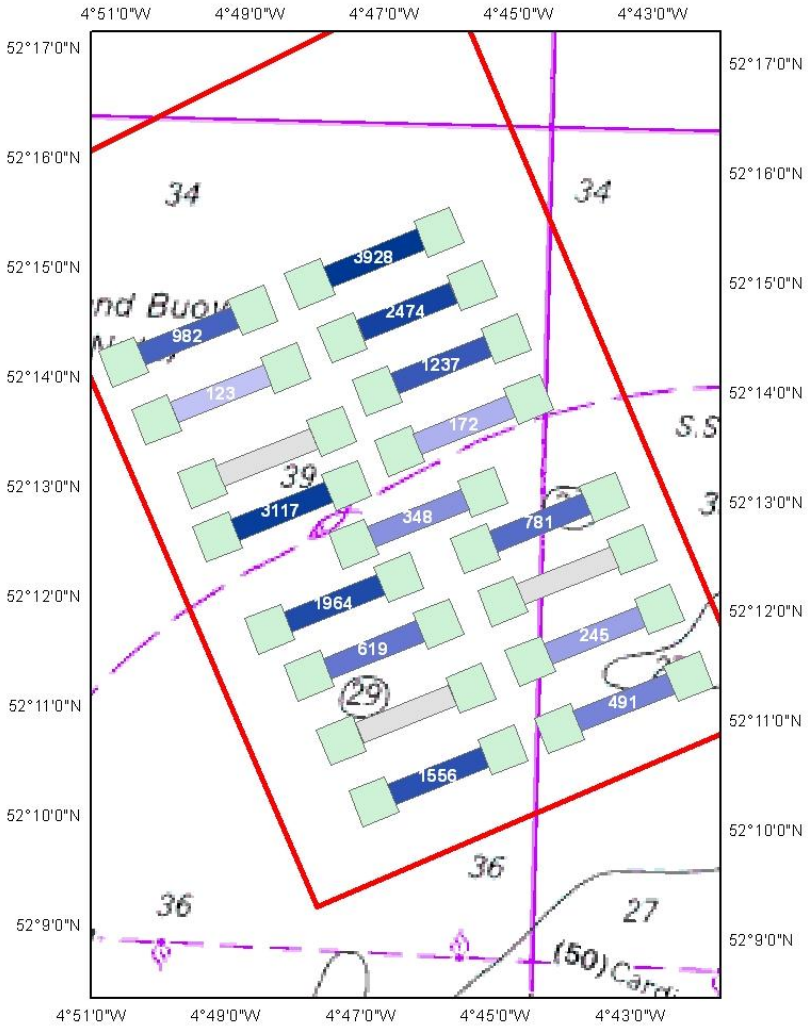

Figure 2. Experimental design and number of single dredge passes to be distributed to participating fishing vessels in each impact site.

Example of instructions to Skipper A in box X

- You will fish exclusively in the lane of site 2 (coordinates attached)
- You will always fish with 4 dredges a-side
- Site 2 has a target intensity of 3.17. This corresponds to 1556 single dredge-passes. With your 4 a-side vessel, this corresponds to 195 tows across the lane. You will therefore have to go along the lane 195times (which, as an indication, should take around 7 days of 12h of gear contact with the seabed at a fishing speed of 2.2kn).
- You will always shoot and haul in the 2 “turning zones” at either end of the fishing lane. Those 2 boxes are not for fishing but exclusively for shooting, hauling, turning and positioning the vessel.
- Try as much as possible to spread the effort equally across the width of the lane by following the instructions given by corridor (coordinates attached, see figure 3). One corridor is

approximately 92m wide (ca. 0.05nm), for a total width of the lane of 370m (ca. 0.2nm). There are therefore 4 corridors in each of which the aim is to conduct 48 or 49 tows (see figure 3).

- During the first day, you will always haul to check the content of the dredges after a single tow in one direction through the lane.
- If the dredges are less than half full each time you haul them up, then you can contact the scientist in charge to ask for authorisation to haul less often (i.e. after going back and forth once or more).
- Keep record of the coordinates of each tow by filling in the logbook provided (start and end time, latitude and longitude) and by mapping out your tracks on your plotter and share them with the scientist in charge at the end of the experiment.
- Record the catch and bycatch per tow in the logbook provided (i.e. number of baskets of scallops for landing, number of baskets of scallops discarded and number of baskets of bycatches)
- […] *Further details on landing port, catch sharing, onboard observers, etc, to be determined in the tender document*

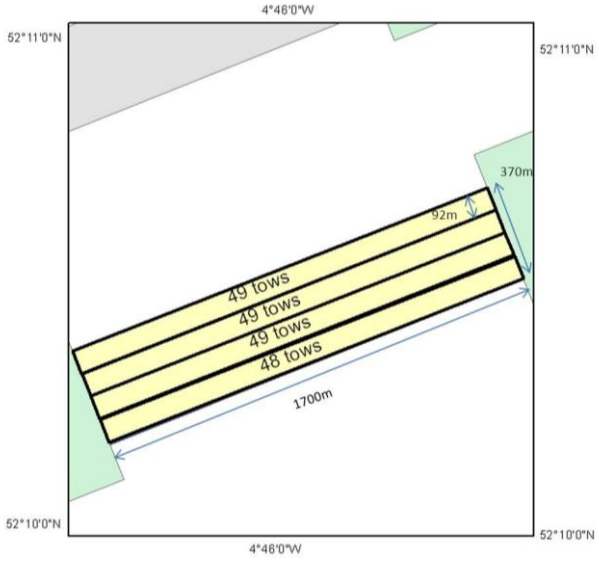

Figure 3. Objective effort allocation in site 2. Each corridor is approximately 92m wide. The number represents the number of passes a vessel fishing with 4 dredges a-side should aim for.

What will be the vessel and gear restrictions?

The specifications of the vessels entering the experiment will have to comply with the Welsh waters legislation for scallop dredging (Scallop Fishing (Wales) (No.2) Order 2010). Further requirements will be determined at a later stage and will be included in the tender document, such as having had installed the Succorfish gear in-gear out technology.

The experiment is planned for the open season between the 1st and 30th of April 2014 and will take place between 3nm and 12nm. Therefore the following regulations on the vessels and gear specifications apply to the participating fishing vessels:

3. No British fishing boat is permitted, at any time, to fish for, take or kill scallops using a scallop dredge in Welsh waters, unless that boat's engine has a power output not exceeding 221 kilowatts.
6. No British fishing boat is permitted, at any time, to fish for, take or kill scallops using a scallop dredge—
(b)in any part of Welsh waters which lies beyond 3 nautical miles and within 6 nautical miles of baselines, unless that boat is towing no more than 8 scallop dredges in total; and
(c)in any part of Welsh waters which lies beyond 6 nautical miles and within 12 nautical miles of baselines, unless that boat is towing no more than 14 scallop dredges in total.
8. (2) No British fishing boat is permitted, at any time, in any part of Welsh waters which lies beyond 3 nautical miles and within 6 nautical miles of baselines, to use a tow bar in connection with fishing for, taking or killing scallops, unless that tow bar–
(a)does not exceed 4 metres in length; and
(b)is not constructed in a way which enables more than 4 scallop dredges to be attached to it at the same time.
8. (3) No British fishing boat is permitted, at any time, in any part of Welsh waters which lies beyond 6 nautical miles and within 12 nautical miles of baselines, to use a tow bar in connection with fishing for, taking or killing scallops, unless that tow bar–
(a)does not exceed 6.8 metres in length; and
(b)is not constructed in a way which enables more than 7 scallop dredges to be attached to it at the same time.
9. No British fishing boat is permitted at any time, in any part of Welsh waters to use any tow bar in connection with fishing for, taking or killing scallops, which exceeds 185 millimetres in external diameter.
10. (1) Subject to the provisions of this article, no British fishing boat is permitted to tow any scallop dredge within Welsh waters unless in relation to such a dredge—
(a)no part of its frame is greater than 85 centimetres wide;
(b)it includes a functioning, operational and moveable spring loaded tooth bar;
(c)it does not contain any attachments to the rear, top or inside of the dredge;
(d)it does not contain a diving plate or any other similar device;
(e)the total weight of the dredge including all fittings does not exceed 150 kilograms;
(f)the number of belly rings in each row suspended from the belly bar does not exceed 7;
(g)the number of teeth on the tooth bar does not exceed 8; and
(h)each tooth on the tooth bar measures no more than 22 millimetres in diameter and 110 millimetres in length.
(see definitions in the Scallop Order)
11. (1) For the purposes of section 1(3) of the Act, the minimum size of scallop that may be carried by a British fishing boat in Welsh waters is 110 millimetres.
(2) For the purposes of paragraph (1), the size of a scallop is to be measured in accordance with paragraph 6 of Annex XIII to Council Regulation (EC) No 850/98 for the conservation of fishery resources through technical measures for the protection of juvenile marine organisms(1) as amended from time to time.

How will scientific sampling will be conducted?

Scientific sampling will be conducted between the 15th and 30th of March 2014 and between the 1st and 16th of May 2014 onboard the RV Prince Madog.

The first part of both cruises will be dedicated to side scan or multibeam over the fishing lanes (i.e. at the 14 impacted sites and 3 control sites) in order to record the distribution of different habitats and record the distribution of dredge tracks.

Each one of the 17 lanes will be sampled using 3 different sampling gears: 0.1 m^2 Hamon grab, 2m-beam trawl and video sled. The Hamon grab bucket (28.5 litres) is mounted on a frame measuring 1.34 x 1.31 m. The beam trawl that will be used for sampling is a 2-m-beam trawl fitted with a chain mat and a 2-mm-mesh liner, and 12mm outer mesh. The video sled is 1.36m wide and on 2 skids of 1.45m in length, each being 10cm wide.

In each lane, and during each survey, a total of 9 grab samples will be taken, 3 beam trawl tows of 5minutes at 1.5knots and 1hour of video tow at 0.8knots will also be conducted at haphazardly selected and spread out locations within the lane. Sediment samples and all infauna from grab samples will be kept in formalin for weighing and identification to the lowest identifiable taxon in the lab while the rest will be analysed onboard and thrown back at sea straight after (with exception of a few specimen when needed for further identification in the lab). We will use a 1mm sieve for the fauna. Granulometry samples will be sufficiently large for the often coarse nature of the seabed and particle size analysis will be resolved to 1 or ½ phi bands. This protocol will be the same for the 'before' and 'after' research vessel surveys.

The impact of each 2m-beam trawl tow will be 463m^2 (or 0.000463km^2). There will be 3x17 tows (i.e. 3 per site), before and after the experimental fishery, which corresponds to 102 tows in total, covering an area of 0.047km^2. One hour of video sled corresponds to an impact of the skids of 296m^2, or 0.0003km^2. There will be 17 1h-video tows, before and after the experimental fishery, which corresponds to 34 tows in total, covering an area of 0.01km^2. However, since the scientific sampling will occur on the fishing lanes, it will not add to the extent of the impact of the experiment (or potentially marginally in the 4 lanes where the fishing intensity will be less than one, i.e. in the lanes that will not be entirely fished during the experimental fishery).

See photographs of sampling gear below.

2m- beam trawl

Video sled

Hamon grab

Timetable

It is planned that the fishing intensity study will be undertaken to the below timetable. The project is dependent on permission being issued for the research vessel cruises and the fishing activity, as well as the participation of fishers.

Date	Task	Notes
16/10/2013	Experiment plan submitted	
16/10 /2013 to 31/01/2014	Additional information provided by BU to NRW and WG as necessary	
16/10 /2013 to 25/122014	BU, WFA and WG to prepare tender document to select fishers to participate in the experiment	
31/01/2014	Deadline for decision to be received by BU team from NRW and WG on permission to undertake the fishing intensity study	The experiment will not go ahead to this schedule if a decision is not reached by this date
01/2014	Commence tender process to select fishers to participate in the experiment	
28/02/2014	Complete tender process	
10/03/2014	Notify fishers and other stakeholders of outcome of tender process	
16/03/2014	Commence research vessel 'before' survey	
31/03/2014	Complete research vessel 'before' survey	

1/04/2014	Commence experimental fishing	
30/04/2014	Complete experimental fishing	
1/05/2014	Commence research vessel 'after' survey	
24/05/2014	Complete research vessel 'after' survey	
10/2014	Undertake research vessel survey to monitor recovery	Exact date to be determined

References

Lambert, G. I., Murray, L.G., Bennell J.D. & Kaiser, M.J. (2013). Habitat assessment of the area of the Cardigan Bay SAC proposed for a fishing intensity experiment. Fisheries & Conservation report No. 23, Bangor University. Pp.51