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## 1. Agreed Monitoring Programme as required by licence

### (a) Introduction:

BioAtlantis Aquamarine Ltd. has been licensed to sustainably harvest *Laminaria* sp. in 750 Ha's of Bantry Bay. This is split into a number of different areas, A, B, C, D and E as outlined in the attached map. As part of the licensing agreement, BioAtlantis Aquamarine Ltd. has agreed with the Department of the Environment, Community and Local Government that a baseline study of the area will be conducted prior to commencing harvest. The aim of the survey is to assess the potential environmental effects of mechanical harvesting in areas populated by *Laminaria* over a 3 to 5 year period within the licensed area. Test and control areas, harvested and non-harvested respectively, will be selected and assessed as summarised in Section B below. Table 1 and Figure 1 provide further details relating to the selection of appropriate sites. Table 2 summarises the sampling plan, detailing species/taxa assessed, methodologies employed and years and locations in which assessments will take place.

### (b) Summary of survey plan

#### 1. Selection of representative areas:

The initial step will involve selection of suitable tracts within allocated harvest (test) and unharvested (control) areas. Areas will be chosen on the basis that they provide a good overall representation of the 750 Ha licence area, in terms of depth, substrate, aspect, exposure and natural variations. The tracts will also be representative of the areas where harvesting is likely to occur. Tracts will be relatively homogeneous on the basis of height and density of *Laminaria* Sp.

#### 2. Selection of control tracts (unharvested):

- A total of 5 tracts (10 \* 100 meters each) will be identified in areas A, B, C, D and E. The coordinates will be recorded by GPS and the transects will be allocated as areas that will not be harvested during the 5 year period of the study.
- In year 1 (2016), a single 10M<sup>2</sup> sub-site will be marked within each of the 5 control tracts, with the coordinates recorded by GPS. While a 10m width is proposed for the subsites, this will be increased if necessary. Sufficient buffer zones will be allocated in order to remove "edge" effects. Quantitative measurements of flora and fauna as described in Table 2, will be taken from n=15x1m<sup>2</sup> quadrants located within each of the sub-sites. Fish and bird species will be assessed separately as described in Section C of this document (see 'Methodology employed').
- In years 3 and 5, *Laminaria* sp. density and canopy height will be measured within each of the 5 control tracts. Measurements will be taken from n=15x1m<sup>2</sup> quadrants located within each of the 10m<sup>2</sup> sub-sites. This ensures that natural variations in *Laminaria* sp. over time are measured.

#### 3. Selection of test tracts (harvested):

- A total of 5 tracts (10 \* 100 meters each) will be identified in areas A, B, C, D and E. The coordinates will be recorded by GPS.
- Year 1: Before harvesting takes place (2016), a full assessment of flora and fauna at 5 test tracts will be undertaken, as described above for the control. Once the harvesting device has been commissioned and working correctly in year 1, the 10x100m tracts will be cut soon after.
- In years 3 and year 5, a sub-site (10M<sup>2</sup>) will be marked within each of the 5 test tracts which were cut in 2016. Quantitative measurements of flora and fauna, including *Laminaria* sp. will be taken from n=15x1m<sup>2</sup> quadrants located within each of the 10m<sup>2</sup> sub-sites. Fish and bird species will be assessed separately as described in Section C ('Methodology employed').

- 4. Statistical analysis:** The potential differences between the control data from year 1 and test data generated in years 3 and 5, will be compared statistically using PRIMER or other appropriate statistical methods or software. Potential differences in *Laminaria* sp. density and canopy height over time will be assessed in the control areas. The full analysis of flora and fauna in test areas in year 1, prior to harvest, will facilitate a Before, After, Control, Impact assessment.

Site Name	Licensed area (Ha)	Control (unharvested)			Test (harvested)		
		Tracts <sup>†</sup> (Number x Area, m <sup>2</sup> )	No. Subsites <sup>‡</sup>	No. Quadrants*	Tracts <sup>†</sup> (Number x Area, m <sup>2</sup> )	No. Subsites <sup>‡</sup>	No. Quadrants*
A	35	1 x 1000	1	15	1 x 1000	1	15
B	64	1 x 1000	1	15	1 x 1000	1	15
C	100	1 x 1000	1	15	1 x 1000	1	15
D	183	1 x 1000	1	15	1 x 1000	1	15
E	368	1 x 1000	1	15	1 x 1000	1	15
<b>Total</b>	750	5 x 1000	5	75	5 x 1000	5	75

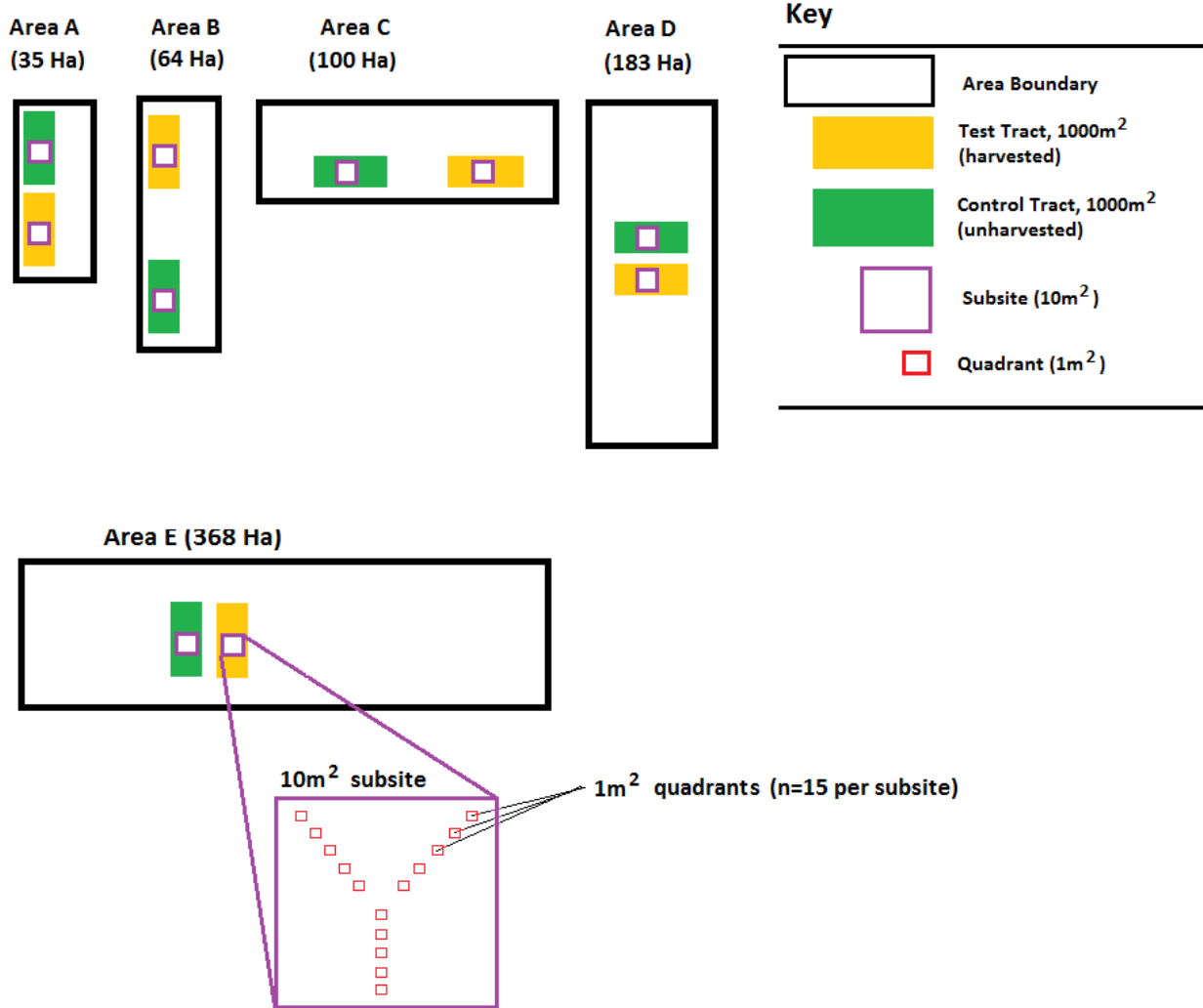
**Table 1: Selection of control and test tracts**

This table outlines the planned distribution of tracts within the licensed areas. In the case of the control category, harvesting within the tracts will not occur. Depending on site suitability, the control tracts will be located inside the licensed area. In the case of the test category, harvesting will take place within the tracts. At year 1, flora and fauna (inc. *Laminaria* sp.), will be measured quantitatively within a single subsite selected from each of the 5 control tracts. In years 1 (pre-harvest) and 3 and 5 (post-harvest), flora and fauna (including *Laminaria* sp.) will be measured quantitatively within a single subsite of each of the 5 harvested test tracts. This will facilitate statistical comparison between both test and control. In years 3 and 5, *Laminaria* density alone will be assessed in the control subsites, to ensure that natural variations in density over time are measured (see Table 2 for more details).

<sup>†</sup> Distribution of tracts within licensed areas may be subject to change, depending on suitability of individual areas.

<sup>‡</sup> There will be one subsite per tract. The area of each subsite will be 10m<sup>2</sup>.

\*There will be 15 quadrants per subsite. The area of each quadrant will be 1m<sup>2</sup>.



**Figure 1: Planned distribution of test and control tracts and allocation of sub-sites and quadrants**  
 This figure illustrates the proposed distribution of test and control tracts, along with assigned sub-sites and quadrants therein. Please note, the figure is not to scale and allocation of control and test tracts may be subject to change, depending on the suitability of individual areas.

No.	Taxa/species†	Functional group/ characteristics	Justification/ requirement	Assessment Method (e.g. Semi-quantitative, Presence/absence, etc.)	No. subsites and quadrants	Schedule
<b>Flora</b>						
1	<i>Laminaria</i> sp.	Target species for harvesting	Assessment required by Dept. of Environment (licence No- FS 6061).	<ul style="list-style-type: none"> <li>Quantitative measurement of: <ul style="list-style-type: none"> <li>➢ Number of <i>Laminaria</i> plants</li> <li>➢ Density of <i>Laminaria</i> plants.</li> <li>➢ Height of canopy</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Control (unharvested): <ul style="list-style-type: none"> <li>➢ Measurements taken in n=5 subsites: 15 x 1m<sup>2</sup> quadrants per subsite, i.e. 75 quadrants total.</li> </ul> </li> <li>Test (harvested): <ul style="list-style-type: none"> <li>➢ Post harvest measurements taken in n=5 subsites: 15 x 1m<sup>2</sup> quadrants per subsite, i.e. 75 quadrants total.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>Control (unharvested): <ul style="list-style-type: none"> <li>➢ Year 1 prior to harvest (date: Mar-Apr 2016)</li> <li>➢ Year 3 post harvest (date: Mar-Apr 2019)</li> <li>➢ Year 5 post harvest (date: Mar-Apr 2021)</li> </ul> </li> <li>Test (harvested): <ul style="list-style-type: none"> <li>➢ Year 1 prior to harvest (date: Mar-Apr 2016)</li> <li>➢ Year 3 post harvest (date: Mar-Apr 2019)</li> <li>➢ Year 5 post harvest (date: Mar-Apr 2021)</li> </ul> </li> </ul>
2	<i>Saccorhiza</i>	Opportunistic species	Opportunistic species which may occur where <i>Laminaria</i> stypes are lost.	Quantitative measurement of: <ul style="list-style-type: none"> <li>Number of <i>Saccorhiza</i> plants</li> </ul>	As per point 1 above	As per point 1 above
3	Epiphytic flora (e.g. red algal species, <i>Polysiphonia</i> , <i>Ceramium</i> , <i>Lithothamnion</i> )	Species that grow on <i>Laminaria</i> holdfast, stipe and/or blade	Assessment of epiphytes required by Dept. of Environment (licence No- FS 6061).	Semi-quantitative measurements of presence of epiphytes on <i>Laminaria</i> holdfast, stipe and blade.	As per point 1 above	As per point 1 above
<b>Fauna (Invertebrates)</b>						
4	<b>Sponges</b> (e.g. <i>Pachymatisma</i> , <i>Cliona</i> )	<ul style="list-style-type: none"> <li>Epifaunal</li> <li>Filter feeders</li> </ul>	Potential candidates for long term monitoring. Assessment required by Dept. of Environment (licence No- FS 6061).	<ul style="list-style-type: none"> <li>Quantitative measurement: <ul style="list-style-type: none"> <li>➢ Inventory</li> <li>➢ Relative Abundance</li> </ul> </li> </ul>	As per point 1 above	<ul style="list-style-type: none"> <li>Control (unharvested): <ul style="list-style-type: none"> <li>➢ Year 1 prior to harvest (date: Mar-Apr 2016)</li> </ul> </li> <li>Test (harvested): <ul style="list-style-type: none"> <li>➢ Year 1 prior to harvest (date: Mar-Apr 2016)</li> <li>➢ Year 3 post harvest (date: Mar-Apr 2019)</li> <li>➢ Year 5 post harvest (date: Mar-Apr 2021)</li> </ul> </li> </ul>
5	<b>Decapods</b> (e.g. <i>Cancer</i> )	<ul style="list-style-type: none"> <li>Mobile</li> <li>Predatory or scavenging</li> </ul>	Potential candidates for long term monitoring. Assessment required by Dept. of Environment (licence No- FS 6061).	As per point 4 above	As per point 4 above	As per point 4 above
6	<b>Echinoderms</b> (e.g. <i>Echinus</i> , <i>Asterias</i> and <i>Holothuria</i> )	<ul style="list-style-type: none"> <li>Epifaunal</li> <li>Sessile or limited mobility</li> <li>Grazers, predatory or detritivorous</li> </ul>	Potential candidates for long term monitoring. Assessment required by Dept. of Environment (licence No- FS 6061).	As per point 4 above	As per point 4 above	As per point 4 above

Fauna (Fish)						
7	Under Canopy species (e.g. Gobies, <i>Gobiusculus flavescens</i> ).	<ul style="list-style-type: none"> <li>• Mobile</li> <li>• Permanent</li> </ul>	Assessment required by Dept. of Environment (licence No- FS 6061).	<ul style="list-style-type: none"> <li>• Quantitative measurement: <ul style="list-style-type: none"> <li>➢ Inventory</li> <li>➢ Relative Abundance</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Control (unharvested): <ul style="list-style-type: none"> <li>➢ Kelp area: Measurements taken from two strings of fyke nets (gangs of 3 nets) per n=4 control sites. Fyke nets will be placed on seabed for 48hours. Species will be identified, enumerated and measured prior to release.</li> <li>➢ Non-kelp area: as above</li> </ul> </li> <li>• Test site (harvested): <ul style="list-style-type: none"> <li>➢ Kelp area: The same procedure will be followed at 4 test site locations, post harvest.</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• Control site (unharvested): <ul style="list-style-type: none"> <li>➢ Year 1 prior to harvest (date: Mar-Apr 2016)</li> </ul> </li> <li>• Test site (harvested): <ul style="list-style-type: none"> <li>➢ Year 3 post harvest (date: Mar-Apr 2019)</li> <li>➢ Year 5 post harvest (date: Mar-Apr 2021)</li> </ul> </li> </ul>
8	Over-canopy species within the pelagic zone.	<ul style="list-style-type: none"> <li>• Mobile</li> <li>• Transient</li> </ul>	Assessment required by Dept. of Environment (licence No- FS 6061).	As per point 7 above	<ul style="list-style-type: none"> <li>• Control (unharvested): <ul style="list-style-type: none"> <li>➢ Kelp area: Trawl above kelp canopy in the pelagic zone (10mm net mesh). Four hauls will be made in 4 control locations. Species will be identified, enumerated and measured.</li> <li>➢ Non-kelp area: as above</li> </ul> </li> <li>• Test site (harvested): <ul style="list-style-type: none"> <li>➢ Kelp area: The same procedure will be followed at 4 test site locations, post harvest.</li> </ul> </li> </ul>	As per point 7 above
Fauna (Birds)						
9	Various species	<ul style="list-style-type: none"> <li>• Mobile</li> <li>• Transient</li> </ul>	Assessment required by Dept. of Environment (licence No- FS 6061).	Semi-quantitative records of seabird species occurrence will be made from the survey vessel during the underwater surveys.	<ul style="list-style-type: none"> <li>• Control (unharvested): <ul style="list-style-type: none"> <li>➢ Species will be identified and enumerated from the survey boat while survey is underway.</li> </ul> </li> <li>• Test site (harvested): <ul style="list-style-type: none"> <li>➢ The same procedure will be followed at test locations, post harvest.</li> </ul> </li> </ul>	As per point 7 above

**Table 2: Sampling plan, methodology, timing and duration involved.**

† See section C (ii) 'Flora and Fauna' for details how species and taxa will be selected.

**(c) Methodology Employed:****(i). Survey areas****Mar-Apr 2016 (Year 1): Assessment of the control and test areas.**

In Mar-Apr 2016, ecologists will determine the most appropriate locations in which to assign control and test tracts. Ecologists will take quantitative measurements of flora and fauna from the control tracts and test tracts (prior to harvest) in year 1. Ecologists will begin at the centre of each subsite (10m<sup>2</sup>) assigned within each tract, laying down a 1m<sup>2</sup> quadrant marker, approximately 2 meters from the central point. Direct measures relevant to the survey, as described in the next section, will be taken from this quadrant (i.e. quadrant 1). When complete, the ecologists will proceed in a sequential manner, taking quantitative measurements from quadrants 2, 3, 4 and 5, etc. For each dive, GPS will be used to log diver entry and exit points. The procedure for measuring fish and bird species is described separately in sections (iv) and (vii).

**Mar-Apr 2019 and 2021 (Year 3 & 5 post-harvest): Assessment of the test areas**

Quantitative assessments of flora and fauna will take place in the test areas in 2019 and 2021, in a similar manner as described above in 2016. In 2019 and 2021, assessments in the controls areas will be limited to assessment of *Laminaria* sp., in order to assess the potential for natural variations in density or canopy height over time, in non-harvested areas.

**(ii). Measurement of *Laminaria* density and recovery****Mar-Apr 2016 (Year 1): Assessment of the control and test areas.**

Surveys will take place in the control and test sections prior to harvest in Mar-Apr 2016 (i.e. year 1). Assessment of *Laminaria* forest structure will involve the following measurements:

- *Laminaria* plant height: young and adult sporophytes at different stages of growth.
- *Laminaria* canopy height.
- Density: number of *Laminaria* plants per quadrant.

Fronde length will not be measured.

**Mar-Apr 2019 and 2021 (Year 3 & 5 post-harvest): Assessment of the test area**

The same assessment above will be performed on both control and test areas in year 3 and 5 post-harvest. This will allow for statistical comparisons to be made between unharvested control sites and test sites, 3 and 5 years post harvest. It will also allow for assessment of *Laminaria* sp. parameters in the undisturbed control site between 1-5 years.

**(iii). Fauna and Flora assessed**

The presence of ~10 sentinel taxa (fauna and flora) will be measured in each quadrant, selected on the basis of their suitability as markers of change within the ecosystem. Suitability will be determined via desk study on the basis of range of parameters, including:

- Presence of Taxa/species within the *Laminaria* biotope,
- Importance of the *Laminaria* biotope to life cycle requirements of the Taxa/species,
- Sensitivity to alterations of disturbance to *Laminaria* sp.,
- Duration of life cycle,
- Overall importance within the *Laminaria* biotope.

Presence of the Taxa/species within Bantry Bay will be determined during a number of preliminary dives, prior to beginning the survey. Additionally, standard MNCR phase 2 survey techniques will be carried out. Digital photographic and video records will be taken at each site during the survey.

**(iv). Birds**

A semi-quantitative assessment of seabird occurrence will be undertaken from the survey vessel while dives and survey is being carried out (seabird identification and enumeration).

**(v). Statistical analysis**

Statistical analyses will be carried out using appropriate statistical software such as Primer which will be used to analyse community structure as well as to describe species assemblages and biotopes at control and harvest sites. Statistical comparisons will be made between the control (unharvested) and data generated in year 1 with data from the harvested areas generated in year 3 and 5 post harvest. The statistical analysis will include tests such as analysis of variance (ANOVA), univariate, multivariate analysis or other statistical methods deemed appropriate when assessing and comparing species abundance/relative abundance in test versus control. In addition, potential natural variations in *Laminaria* density and canopy height over time will be assessed in the control sites. Comparisons will be made between the test areas pre harvest (year 1) and post harvest (years 3 and 5).

**(vi). Survey Schedule**

**Mar-Apr 2016 (pre-harvest):**

Day 0: Organization and travel to site.

Day 1: preliminary assessment of site suitability

Days 2-4: Survey; Assessment of flora and fauna (inc. *Laminaria* sp.) – **Control & test (unharvested)**

Days 1-4: transfer of raw datasets and creation of database.

**Mar-Apr 2019:**

Day 0: Organization and travel to site.

Day 1: Survey; Assessment of flora and fauna (inc. *Laminaria* sp.) – **test (post harvest)**

Day 2: Survey; Assessment of flora and fauna (inc. *Laminaria* sp.) – **test (post harvest)**

Day 3: Survey; Assessment of *Laminaria* sp. density and canopy height – **Control (unharvested)**

Days 1-3: transfer of raw datasets and creation of database.

**Mar-Apr 2021:**

Day 0: Organization and travel to site.

Day 1: Survey; Assessment of flora and fauna – **test (post harvest)**

Day 2: Survey; Assessment of flora and fauna – **test (post harvest)**

Day 3: Survey; Assessment of *Laminaria* density and canopy height – **Control (unharvested)**

Days 1-3: transfer of raw datasets and creation of database.

**(vii). Reporting Schedule**

Analysis of data: 0-4 weeks post survey.

Writing and submitting report: 4 weeks.

**(viii). Fish species:**



**Objectives:**

Specific sampling work objectives of fish community studies are to:

1. Year 1 (control):
  - Kelp area: generate baseline data for under canopy and over canopy areas. This will include identification of species, enumeration and determination of size frequency.
  - Non-kelp area: repeat the above.
2. Year 3 and 5 (test):
  - Kelp area: as above.

Sampling design will aim to collect data in relation to:

- Under canopy species (e.g. Gobies, *Gobiusculus flavescens*).
- Over canopy species within the pelagic zone.

**Timing of sampling:**

Sampling of fish will take place once in Mar-Apr of year 1 (control - forested, unharvested), once in Mar-Apr of year 3 (test - forested, harvested) and once Mar-Apr of year 5 (test - forested, harvested). Statistical comparisons will be made to assess the potential for changes in fish numbers over a 5 year period.

**Methodology:**

Sampling of fish will take place in clearly defined harvested and non-harvested areas, using non-destructive methodologies where possible/feasible. Sufficient buffer zones will be applied between harvested and non-harvested areas (e.g.  $\geq 30$  meters). Where necessary, test and control tracts may be increased in size to ensure that the distance to be travelled for each trawl is sufficient to ensure that trawls operate effectively. Additionally, sampling may take place within larger representative harvested and unharvested zones if deemed necessary.

*Under Canopy species*

In year 1, under canopy species (e.g. Gobies, *Gobiusculus flavescens*) will be assessed. The sampling method will involve fyke sets positioned on the seabed for 48 hours at a total of 4 control locations. Species will be taken from the nets identified and enumerated before release. In year 3 and 5, this assessment will also be carried out in the post harvested test area.

*Over Canopy species*

The following procedures and equipment to be employed may be subject to change if deemed necessary in the course of the survey:

- Over kelp canopy species will be assessed by trawling fish nets (~10mm mesh) above the kelp canopy, within the pelagic zone.
- Trawl net length: 1.0-5.0 meters.
- Trawl mouth width: 1.0-5.0 meters.
- Trawl duration: 4-20 minutes
- Distance travelled for each trawl: 50-200m.
- The trawling period will be long enough and at appropriate speed to capture fish.
- In year 1, there will be 4 hauls in each of the n=4 control areas. On retrieval of nets, specimens will be identified, measured and enumerated. In year 3 and 5, this procedure will also be carried out in the n=4 post-harvested test areas.

**Replicate numbers:**

The protocol includes n=4 control sites and n=4 test sites:

- Control site 1 (forested, unharvested):
  - Located in a single subsite selected from Area A, B, C, D or E.
  - Assessed in year 1.
  - Under canopy species: two strings of fyke nets (gangs of 3 nets)
  - Over Canopy species: n=4 hauls of pelagic trawl (~10mm mesh).
- Control site 2 (forested, unharvested):
  - Located in a single subsite selected from Area A, B, C, D or E.
  - Assessed in year 1.
  - Under canopy species: two strings of fyke nets (gangs of 3 nets)
  - Over Canopy species: n=4 hauls of pelagic trawl (~10mm mesh).
- Control site 3 (forested, unharvested):
  - Located in a single subsite selected from Area A, B, C, D or E.
  - Assessed in year 1.
  - Under canopy species: two strings of fyke nets (gangs of 3 nets)
  - Over Canopy species: n=4 hauls of pelagic trawl (~10mm mesh).
- Control site 4 (forested, unharvested):
  - Located in a single subsite selected from Area A, B, C, D or E.
  - Assessed in year 1.
  - Under canopy species: two strings of fyke nets (gangs of 3 nets)
  - Over Canopy species: n=4 hauls of pelagic trawl (~10mm mesh).
- Test site 1 (forested, harvested):
  - Located in a single subsite selected from Area A, B, C, D or E.
  - Assessed in year 3 and 5.
  - Under canopy species: two strings of fyke nets (gangs of 3 nets)
  - Over Canopy species: n=4 hauls of pelagic trawl (~10mm mesh).
- Test site 2 (forested, harvested):
  - Located in a single subsite selected from Area A, B, C, D or E.
  - Assessed in year 3 and 5.
  - Under canopy species: two strings of fyke nets (gangs of 3 nets)
  - Over Canopy species: n=4 hauls of pelagic trawl (~10mm mesh).
- Test site 3 (forested, harvested):
  - Located in a single subsite selected from Area A, B, C, D or E.
  - Assessed in year 3 and 5.
  - Under canopy species: two strings of fyke nets (gangs of 3 nets)
  - Over Canopy species: n=4 hauls of pelagic trawl (~10mm mesh).
- Test site 4 (forested, harvested):
  - Located in a single subsite selected from Area A, B, C, D or E.
  - Assessed in year 3 and 5.
  - Under canopy species: two strings of fyke nets (gangs of 3 nets)
  - Over Canopy species: n=4 hauls of pelagic trawl (~10mm mesh).

**Data analysis and reporting**

Parameters to be analyzed will include species type, abundance, size and catch per unit effort. Control and harvest areas will be compared statistically using methods such as multivariate analysis. The results of the analysis will be provided with the overall report.