Water Quality and Benthic Environment Monitoring Plan

Prepared Jointly By: *Insert Author*

Insert Month Year

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Attachment 1 – Twofold Bay Mussel Farming Monitoring Program

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1 Introduction

The Water Quality and Benthic Environment Monitoring Plan has been developed to assess and mitigate potential impacts of the INSERT LEASE NAME on water quality and the benthic environment. The Plan includes the Water Quality Monitoring Program, the Macrobenthic Invertebrate Monitoring Program and the Substrate Monitoring Program and has been prepared as a combined document as the three programs are interrelated.

In accordance with consent condition INSERT DETAILS (E.g. D18 of the State Significant Infrastructure Approval SS1-5118), the Macrobenthic Invertebrate Monitoring Program component of this document details the following:

➢ LIST DOT POINTS OF CONSENT CONDITIONS

➢ E.g. Details of the locations at which monitoring of the benthic fauna will be undertaken;

➢ E.g. Details of the parameters to be measured that can be used to identify an effect on the benthic fauna from the operation of the development (including species richness and diversity and functional groups);

➢ E.g. Procedures and protocols for sampling and analyses methodology (including univariate and multivariate analyses);

➢ E.g. A periodic schedule for the sampling of benthic fauna including justification for the frequency;

➢ E.g. A periodic schedule for the reporting of monitoring results; and

➢ E.g. Description of how the locations, parameters, sampling and analyses methodology and frequency of sampling and reporting may be adapted over time in order to interpret and address the effects of the development.

In accordance with consent condition INSERT DETAILS (E.g. D20 of the State Significant Infrastructure Approval SS1-5118), the Water Quality Monitoring Program component of this document details the following:

➢ LIST DOT POINTS OF CONSENT CONDITIONS

➢ E.g. Identification of activities during the deployment and operation of the development, that may have the potential to impact on water quality of potentially affected waters;

➢ E.g. Locations at which monitoring of water quality will be undertaken;

➢ E.g. Details of the parameters to be measured (including, ammonia, nitrate, total Nitrogen, total Phosphorus, chlorophyll *a*) and standards against which any changes to

> water quality will be assessed, having regard to the principles of ANZECC guidelines, and identification of 'trigger points' for further investigation or action to be taken;

> ➢ E.g. Identification of the frequency of water sampling or the quantitative thresholds to be used to determine monitoring events;

> ➢ E.g. A periodic schedule for the reporting of monitoring results; and

> ➢ E.g. Description of how the locations, parameters, sampling and analyses methodology and frequency of sampling and reporting may be adapted over time in order to interpret and address the effects of the development.

The Water Quality and Benthic Environment Monitoring Plan will be supported with relevant policies, protocols, and safe work method statements to promote a comprehensive approach to all farming operations that have the potential to impact negatively on shellfish/finfish health and welfare. The Water Quality and Benthic Environment Monitoring Plan will be continuously reviewed and improvements employed to meet this goal. An "adaptive management" approach will be used to refine the monitoring programs to minimise the potential for broader environmental impacts, streamline monitoring processes and better ensure shellfish/finfish health.

1.1 Sampling Design

The Water Quality and Benthic Environment Monitoring Plan will employ a similar experimental design to that used by the Centre for Research on Ecological Impacts of Coastal Cities (University of Sydney, NSW) to assess the ecological effects of a Snapper farm located in Providence Bay (Underwood & Hoskin 1999; Hoskin & Underwood 2001), albeit with an expanded range of variables being assessed. These studies used a 'Before *vs.* After - Control *vs.* Impact' (BACI) sampling design, which is one means by which causality models can be rigorously tested in environmental investigations (Underwood, 1992; 1994).

The use of multiple control sites coupled with multiple sampling times before and during the aquaculture activities enables an estimate of natural temporal and spatial variation of the environment to be obtained (Green, 1979). Such estimates can then be used to determine if impacts from the INSERT LEASE NAME cause greater variation in the environment than would occur naturally through time (Kingsford & Battershill, 1998). The use of this type of sampling design was strongly advocated in the 1996 guidelines of the United Nations Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) on monitoring the ecological effects of aquaculture (Hoskin & Underwood 2001).

NSW DPI currently requires other marine based aquaculture (finfish and mussel farms) to undertake benthic environment monitoring using a BACI sampling design (See Attachment 1).

1.2 The Adaptive Management Process

Adaptive management is a structured, iterative process of optimal decision making using the best science available with an aim to further improve our knowledge of the system over time using comprehensive monitoring. In this way, decision making simultaneously maximises one or more resource objectives and, either passively or actively, accrues information (e.g. by monitoring and modelling through fluctuating system conditions) needed to improve future management. Through adaptive management rigorous control can be applied that assures sustainable operation and development.

Adaptive management is a tool which should be used not only to change a system but also to learn about the system (**Error! Reference source not found.**). Because adaptive management is based on a learning process, it improves long-run management outcomes. The challenge in using adaptive management approach lies in finding the correct balance between gaining knowledge to improve management in the future and achieving the best short-term outcome based on current knowledge.

The achievement of adaptive management objectives require an open management process which seeks to include past, present and future stakeholders. Adaptive management needs to at least maintain political openness but usually aims to create it. Adaptive management must therefore be a scientific and social process.
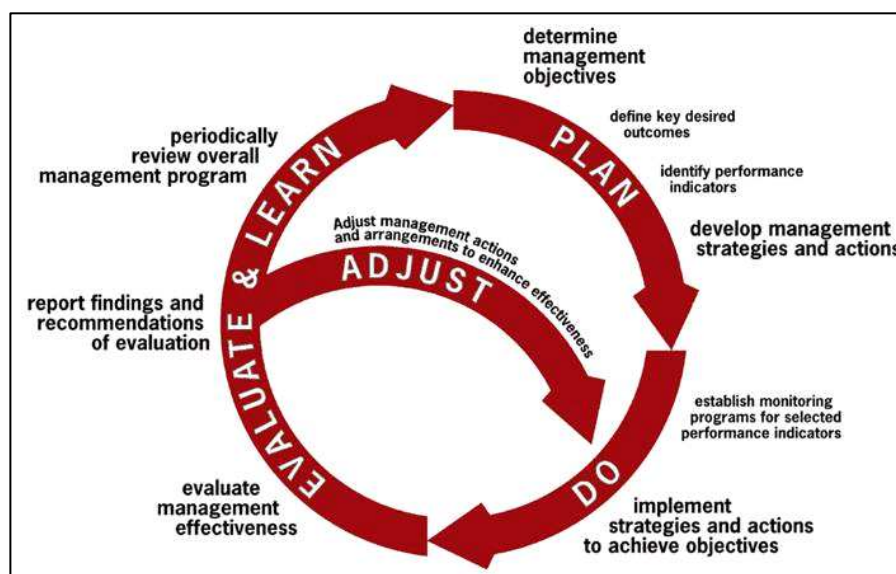
Figure 1: Example of an Adaptive Management Cycle as provided by CSIRO (Source: CSIRO, 2013).

At the core of the adaptive management process is a detailed and targeted environmental monitoring program and a whole-of-environment predictive model. An industry driven environmental monitoring strategy aimed at incorporating both company-specific and statutory monitoring requirements can be developed to optimise future production management and sustainability assessment within farming leases.

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These processes focus on addressing the main risks to the wider aquatic environment and farmed shellfish (shellfish health). The ultimate aim of the adaptive management program is to monitor production over time and increase knowledge in relation to the sustainability and feasibility of farming operations. Monitoring any potential adverse environmental effects will be associated with the application of relevant mitigation measures based on the severity of the observed impacts.

Adaptive management by its nature provides for flexibility, for example:

➢ Sampling frequency can be targeted to high risk periods;

➢ Some parameters may be replaced by others, and/or new ones added;

➢ Some parameters may be removed if they no longer reflect an element of risk; and

➢ The relevance of survey sites may also change with time and some may need to be created, replaced or moved.

As a general rule, monitoring is carried out not simply to accumulate a wealth of data but rather to identify and tackle specific risks and uncertainties.

The prioritised risks are identified through consultation with the regulators, relevant experts and community stakeholders. The risks are managed by the adaptive management process with continued long-term stakeholder involvement. The following risks have been identified by the aquaculture industry:

➢ FOR EXAMPLE

➢ The MARL has potential to have an effect outside their lease area; examples include but are not restricted, to eutrophication and the particular requirements of areas and endangered/threatened species;

➢ Eutrophication of the overall water body will affect water quality on the MARL;

➢ The social licence to operate is jeopardised by not maintaining the water quality and general ecology of the waters we farm, and negatively impacting the local community and other industries in the region;

➢ Environmental conditions may have contributed to or have precipitated a fish health event; and

➢ Neighbouring leases will affect the quality of the water flowing through adjacent farming lease areas.

These risks drive both the strategies (modelling/limits) and implementation plans (environmental monitoring program) of the adaptive management process.

2   Water Quality Monitoring Program

2.1   Activities Impacting on Water Quality

Some activities during the operation stage of the INSERT LEASE NAME could potentially impact on water quality but are largely confined to overstocking. Overstocking could lead to nutrient enrichment of the surrounding waters and accumulation beneath the lease. The following monitoring plan has been designed with these processes in mind and is considered appropriate for the detection of change prior to broader significant degradation.

2.2   Water Quality Monitoring Locations

Water samples will be collected both within and outside the INSERT LEASE NAME and will be sampled before the longlines are stocked at commercial levels and during. XX sites will be monitored, including XX sites within the boundary of the INSERT LEASE NAME, XX compliance sites immediately adjacent to the lease(s) and XX control sites not less than XXX m outside the boundary of the INSERT LEASE NAME (Figure 2).

The compliance sites will be approximately XX m from the edge of the INSERT LEASE NAME, which is consistent with current regulatory practice for shellfish/finfish farming. The compliance sites have been located to the XX e.g. NE and XX e.g. NW of the lease consistent with the dominant current flows for the lease location. Water samples will be collected at XX depths; X m below the surface and X m above the seabed at each of the aforementioned X sampling sites.

A)
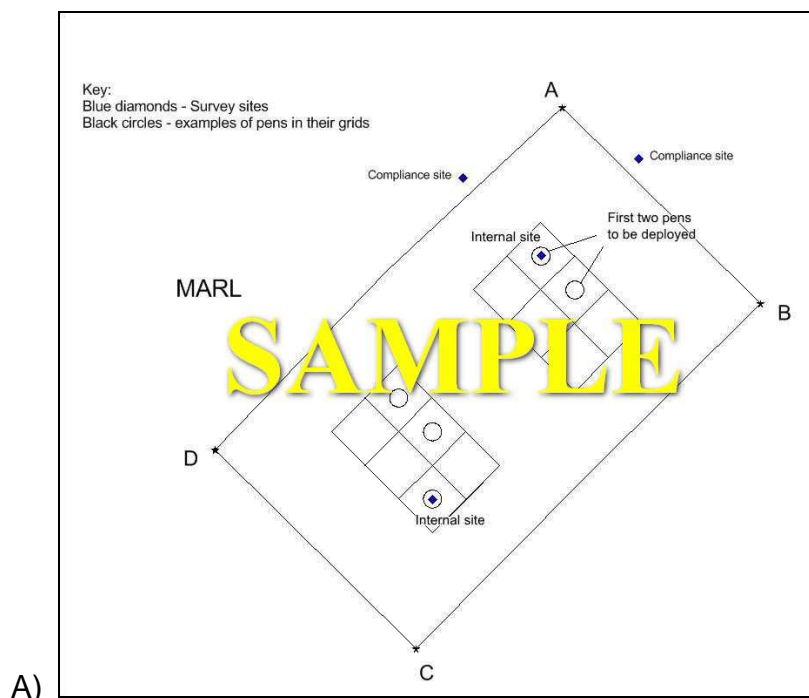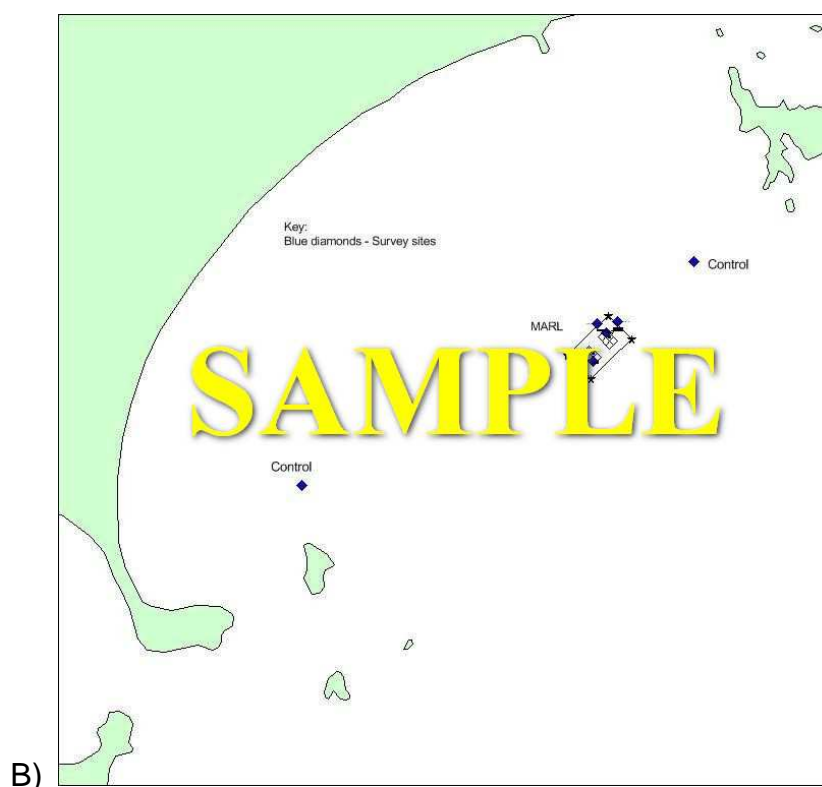
Figure 2: Examples of sampling locations (A) within and adjacent (Compliance: XX m) to the INSERT LEASE NAME and (B) remote (control) to the INSERT LEASE NAME (Source: XXXX, XXXX).

2.3 Water Quality Parameters

Maintenance of water quality is critical to the health of the cultured stock so important culture parameters such as water temperature, salinity, pH and dissolved oxygen levels must be monitored regularly. Parameters such as chlorophyll α and concentrations of nitrogen and phosphorus will be monitored too as required by the monitoring program.

Data loggers will be deployed to assist in recording temporal changes in parameters such as water temperature, while calibrated water quality meters will be used to measure temperature, pH, electrical conductivity and dissolved oxygen. Concentration of nitrogen, specific oxides of nitrogen and phosphorus and chlorophyll α will be determined from samples collected on-site and transferred to laboratories for analysis.

Comparisons of collected water quality data will be made with the recommended trigger values in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* to determine if these parameters are within the acceptable range for marine waters (Table 1).

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Table 1: Example of water quality parameters that will be recorded at each of the X sample sites and the ANZECC & ARMCANZ (2000) default trigger values. DO = dissolved oxygen, TN = total nitrogen, NOx = oxides of nitrogen, TP = total phosphorus, EC = electrical conductivity.

	Temp (°C)	DO (% sat)	pH	TN (µg L^{-1})	NOx (µg L^{-1})	TP (µg L^{-1})	EC	Chl α
ANZECC & ARMCANZ Guidelines		90-110	8.0-8.4	120	25	25		
Lease site 1								
Lease site 2								
Compliance site 1								
Compliance site 2								
Control site 1								
Control site 2								

2.4 Frequency of Water Quality Sampling

The key water quality parameters critical to the health of the cultured stock such as water temperature, salinity, pH and dissolved oxygen levels will be monitored as part of daily operational procedures.

Background water quality data will be collected prior to the installation of the INSERT LEASE NAME and at least annually after the INSERT LEASE NAME is granted, irrespective of whether the lease is stocked with shellfish/finfish. Annual water samples to measure the parameters outlined in Section 2.3 will be collected in INSERT DETAILS (e.g. mid-summer (e.g. February)), a time expected to coincide with maximum growth rates and standing biomass of shellfish/finfish held on the leases.

The maximum standing biomass on the INSERT LEASE NAME will be approximately XX tonnes. Additional water quality measurements, as outlined in Section 2.3, will be taken when the standing biomass reaches certain critical production levels (e.g. XX, XX and XX tonnes).

In the first year of production there will be a pre-deployment sampling, an annual (mid-summer) sampling and depending on the critical production levels being met possibly a further two sampling events. Thereafter sampling will occur annually (mid-summer) and when critical production levels are reached.

The sites sampled within the INSERT LEASE NAME will include samples taken from two stocked longline/sea pen and samples taken at two locations away from stocked longline/sea pen. The samples taken from outside the longlines/sea pens will be taken at a distance of

approximately <mark>XX m</mark> from the lease boundary. The control sites will be no less than <mark>XXX m</mark> from the lease boundary and in locations of similar depth (<mark>approx. XX-XX m</mark>). GPS coordinates of each site will be recorded so that subsequent sampling can be undertaken within the same area. Water samples will be collected at two depths, <mark>X m</mark> below the surface and <mark>X m</mark> above the ocean floor.

Samples to be used for compliance monitoring must be collected in the presence of an independent party for verification (<mark>e.g. University or contractor responsible for undertaking the survey</mark>). All samples that cannot be processed by the University or Environmental/Biological contractor are to be processed by a NATA accredited laboratory.

2.5   Reporting

Results for all sites will be reported on the <mark>INSERT PROPONENT</mark> websites within <mark>XX week</mark> of the data being obtained from third party monitoring contractors.

2.6   Adaptation of Monitoring Program

The proposed monitoring program has been designed to identify if any significant changes to the marine benthic environment immediately adjacent to the lease are occurring due to the presence of the farm and will provide the baseline conditions/parameters against which future fallowing and recovery can be assessed. The water quality monitoring program will utilise temperature, pH, electrical conductivity, dissolved oxygen, nitrogen, specific oxides of nitrogen and phosphorus and chlorophyll α next to the lease areas, at control sites and within the lease to monitor changes that may occur.

This monitoring program will be reviewed after a period of time (<mark>E.g. two years or three sampling events)</mark> has elapsed to permit sufficient samples to be collected to provide a high degree of certainty that there are no significant long term impacts resulting from the aquaculture farming activities. If however, during the monitoring program significant impacts in water quality are found between the compliance and control sites then further analysis of the invertebrate samples. If significant change is observed among invertebrates, appropriate management regimes (e.g. fallowing) will be employed to ameliorate these impacts.

Each site beneath and adjacent to the lease (Figure 2-A) will constitute the compliance sampling locations. At these compliance sites all benthic (sediment and fauna) parameters will be sampled in triplicate. The <mark>INSERT LEASE NAME</mark> is to have two control sites associated for assessment (Figure 2-B). Each of the control sites is also to have all benthic samples taken in triplicate. These control samples are to be collected concurrently (annually) with the lease monitoring samples.

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INSERT PROPONENT will have all triplicate benthic samples analysed at baseline. For the annual surveys chemical and physical samples are to be analysed. If a significant impact is found at the compliance sites at the lease boundary then the benthic fauna samples (Section 3.1) from each site are to be analysed and a repeat remotely operated vehicle (ROV) survey is to be undertaken at all transect sites within a month of the initial survey. If it is determined from the analysis of the ROV footage and/or the benthic fauna samples that a significant impact has occurred then appropriate management regimes (e.g. fallowing) will be employed to ameliorate these impacts (Figure 3).
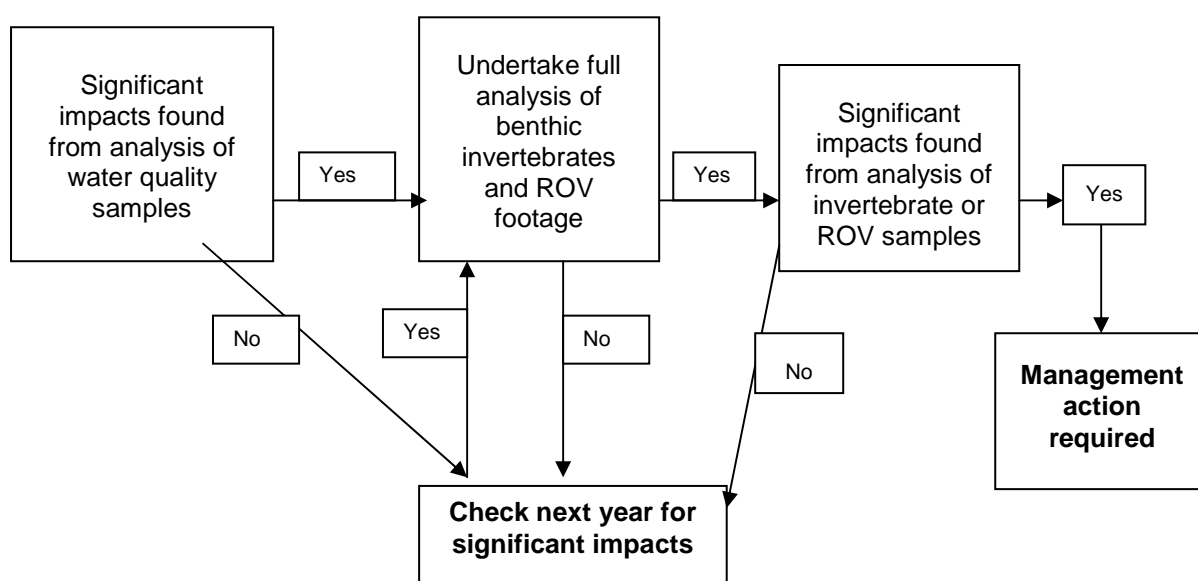
Figure 3: Management process in response to compliance site monitoring.

3 Benthic Environment Monitoring Program

The benthic environment beneath and surrounding the longlines will be monitored biologically (e.g. benthic invertebrates), chemically (i.e. the composition of elements in sediment) and physically (e.g. the particle size of sediment and video footage/photo comparisons).

Sediment samples will be collected for determination of particle size, total organic carbon (TOC) and macroinvertebrate communities. Samples will be analysed using a simplified BACI sampling program similar to that outlined in Hoskin & Underwood (2001) and that is currently required for other marine aquaculture activities in NSW (See Attachment 1).

3.1 Macrobenthic Invertebrate Monitoring Program

Observing benthic fauna is a common environmental monitoring tool worldwide (de Jong & Tanner, 2004). Many studies have demonstrated that benthic fauna is a reliable indicator of environmental changes that are induced by increased nutrient and sediment loads (Ritz *et al.*, 1990; Weston, 1990).

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A range of factors that may affect the abundance and species diversity of macrofauna within Jervis Bay were identified from available literature, such as depth, sediment size, organic content of sediment, salinity, habitat type, temporal variation, temperature and nutrients (Table 2). These factors were taken into account when developing the sampling design.

Table 2: Important factors that may affect the abundance and species diversity of macrofauna within Jervis Bay and how this study will address them.

Factor	Approach
Depth	Controlled (35 to 45 m)
Sediment size	Controlled (sand and coarse sand) / measured
Organic content of sediment	Measured
Salinity	Controlled/measured (equivalent areas)
Habitat type	Controlled (all soft sediment)
Temporal variation	Small scale (animal activity) – Controlled (samples collected at same time of day) Medium scale (season) – Controlled (sites sampled in all seasons) Large scale (annually) – Controlled (sites sampled each year)
Temperature	Measured
Nutrients	Measured (both for sediment samples and water)

3.1.1 Invertebrate Monitoring Locations

Sites will be monitored within the leases, adjacent to the leases (compliance site) and at two control sites. The compliance sites will be located approximately XX m from the boundary of the lease, consistent with current regulatory practice for fish farming in Tasmania (Figure 4). The compliance sites have been located to the XX (E.g. NE) and XX (E.g. NW) of the lease consistent with the dominant current flows for the lease location. The control sites will be located not less than XXX m from the lease boundary.

The minimum distance of XXX m from the INSERT LEASE NAME is considered to be sufficient for the control sites to be independent of the lease based on the results of previous studies on more intense nutrient producing activities such as sewage outfalls. A 10 ML daily discharge of secondary treated sewage for example, is generally limited to within 300 m of an

outfall for the majority of variables (Smith, 1996; Smith, 2000). GPS coordinates of each site will be recorded so that subsequent sampling can be undertaken within the same area.
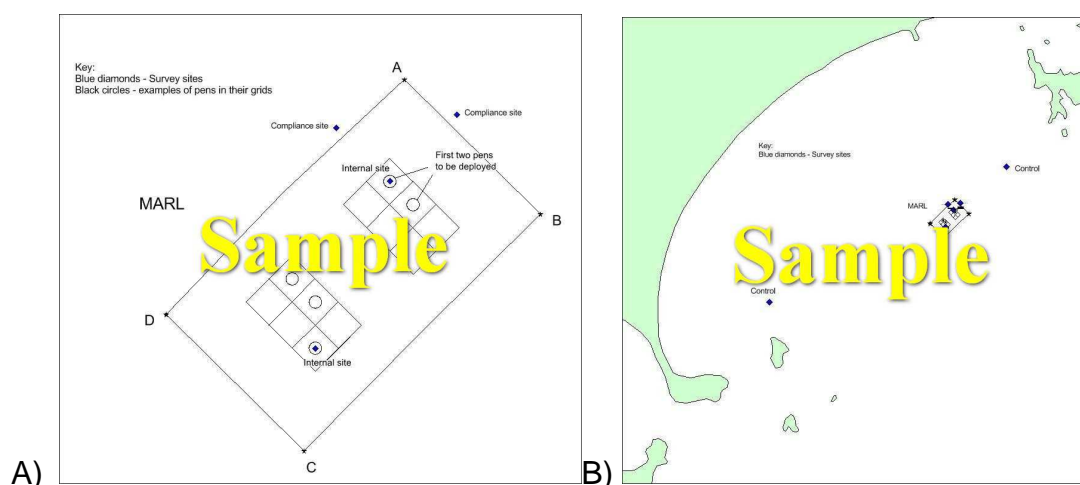
Figure 4: Examples of sampling locations (A) within and adjacent (compliance: XX m) to the lease and (B) remote (control) to the lease.

3.1.2 Sampling Parameters

Data on the abundances and species diversity (e.g. richness, Shannon-Wiener, evenness) of benthic macroinvertebrate taxa will be subjected to both univariate and multivariate analyses to determine whether any impacts are present. Thus, the overall abundance of individuals and the different measures for species diversity will be subjected to ANOVA (factors of site and time) with data transformations undertaken as appropriate. The presence of significant differences between sample sites (and any interactions with times following subsequent sampling events) will be used to infer whether impacts are present. If appropriate, taxa will be allocated to functional groups, such as feeding guilds or "pollution-tolerance" guilds, and similar univariate analyses undertaken. If certain taxa are ubiquitous and sufficiently abundant, then they may be also subjected to ANOVA.

For multivariate analyses, data on the numbers of individuals of each of the different taxa will be subjected to the Bray-Curtis similarity measure (following appropriate transformation) and non-metric multidimensional scaling (nMDS) ordinations used to visualise any trends in the data using PRIMER 7 (Clark *et al.*, 2014).

Permutational Analysis of Variance (PERMANOVA - Anderson *et al.*, 2008), will be used to detect whether there are any significant differences between sample sites (and any interactions with times, following subsequent sampling events), with these being used to infer whether impacts are present.

Analysis of Similarities (ANOSIM - Clarke & Green, 1988), and the accompanying R-statistic value, will also be used to determine the extent to which the benthic macroinvertebrate

assemblages are related to sample site or time. Similarity Percentages (SIMPER - Clarke, 1993) were used to determine the taxa which typified the benthic macroinvertebrate assemblages in each sample site and/or time and which distinguished between those *a priori* groups, taking any interactions into account.

3.1.3 Sampling and Analysis

Three sediment samples will be collected at each sampling location by using an appropriate sample grab. Macrofauna (animals greater than 1.0 mm) will be extracted from the core samples by various methods which may include sieving or vigorously swirling the sediment in a container of water and magnesium chloride (a relaxant), and pouring floating animals onto a 1.0 mm sieve-mesh (Underwood & Hoskin, 1998).

Identification and counting of macrofauna in each sample may be aided by staining the animals and through the use of a dissecting microscope. Macrofauna will be identified to intermediate levels (i.e. class, order or family) and the measures of abundance and species diversity will be recorded. These two variables have been chosen as they have been successfully used in many studies investigating the ecological effects of nutrient producing activities (e.g. sewage pollution) by the means of examining community structures (Underwood & Peterson 1988; Roper, 1990; Underwood & Chapman, 1995). Macrofauna samples will be preserved in buffered formalin in seawater (Underwood & Hoskin, 1999).

Samples to be used for compliance monitoring must be collected in the presence of an independent party for verification (e.g. University or contractor responsible for undertaking the survey). All samples that cannot be processed by the University or Environmental/Biological contractor are to be processed by a NATA accredited laboratory.

ROVs may be used to obtain video footage of the seabed along transects that extend from beneath the lease to the compliance monitoring site. This footage can illustrate changes in floral and faunal assemblages that are indicative of impact and are now commonly used in Tasmania for fish farm compliance monitoring. ROVs are cheaper and easier to use than traditional sampling approaches and are now used more frequently by fish farmers to monitor changes and implement management strategies before significant impacts occur.

3.1.4 Invertebrate Sampling Frequency

Background invertebrate sampling will be collected prior to the installation of the INSERT LEASE NAME and at least annually after the lease is granted, irrespective of whether the lease is stocked with shellfish/finfish. Annual invertebrate sampling as outlined in Section 3.1.3 will be undertaken in XXXXX (E.g. mid-summer (e.g. February)), a time expected to coincide with maximum growth rates and standing biomass of shellfish/finfish held on the leases.

The maximum standing biomass on the INSERT LEASE NAME will be approximately XXX tonnes. Additional invertebrate sampling, as outlined in Section 3.1.3, will be taken when the standing biomass reaches certain critical production levels (e.g. XX, XXX, XXX tonnes).

UPDATE In the first year of production there will be a pre-deployment sampling, an annual (mid-summer) sampling and depending on the critical production levels being met possibly a further two sampling events. Thereafter sampling will occur annually (mid-summer) and when critical production levels are reached. This sampling will be conducted concurrently with water quality and substrate sampling.

This frequency is consistent with sampling conducted previously for mussel and snapper farming in NSW and exceeds that currently required for salmon production in Tasmania. Annual samples are likely to be collected in mid-summer (e.g. February), a time expected to coincide with maximum growth rates and standing biomass of shellfish. Additional invertebrate sampling will be conducted for experimental purposes at the discretion of the proponent and in accordance with needs for the development of the adaptive management approach.

3.1.5 Reporting

Results for all sites will be reported on the INSERT PROPONENT website within XX week of the data being obtained from third party monitoring contractors.

3.1.6 Adaptation of Monitoring Program

The proposed monitoring program has been designed to identify if any significant changes to the marine benthic environment immediately adjacent to the lease are occurring due to the presence of the farm and will provide the baseline conditions/parameters against which future fallowing and recovery can be assessed. The monitoring program as a whole will utilise total organic carbon (TOC), particle size analysis (physical) and benthic fauna through sampling and visual means (ROV) of the sediments next to the lease areas, at control sites and within the lease to monitor changes that may occur. This monitoring program will be reviewed after a period of time (two years or three sampling events) has elapsed to permit sufficient samples to be collected to provide a high degree of certainty that there are no significant long term impacts resulting from the aquaculture farming activities. If however, during the monitoring program significant impacts are found then appropriate management regimes will be employed to ameliorate these impacts (e.g. destocking or fallowing).

Each site at the start and end of each transect (Figure 4-A) will constitute the compliance sampling locations. At these compliance sites all benthic parameters will be sampled in triplicate. Each active lease area is to have two control sites associated for assessment (Figure 4-B). Each of the control sites is also to have all samples taken in triplicate. These

control samples are to be collected concurrently (annually) with the lease monitoring samples. The aquaculture permit holder is to have all triplicate samples and ROV footage analysed at baseline. For the annual surveys all ROV, chemical and physical samples are to be analysed and the benthic fauna samples preserved for subsequent analysis should that be required at both the compliance and control sites.

If a significant impact is found at the compliance sites at the lease boundary from the initial analysis then the benthic fauna samples from each site are to be analysed at the expense of the permit holder and a repeat ROV survey is to be undertaken at all transect sites within a month of the initial survey (Figure 5). If it is determined from the analysis of the ROV footage and/or the benthic fauna samples that a significant impact has occurred then appropriate management regimes will be employed to ameliorate these impacts.
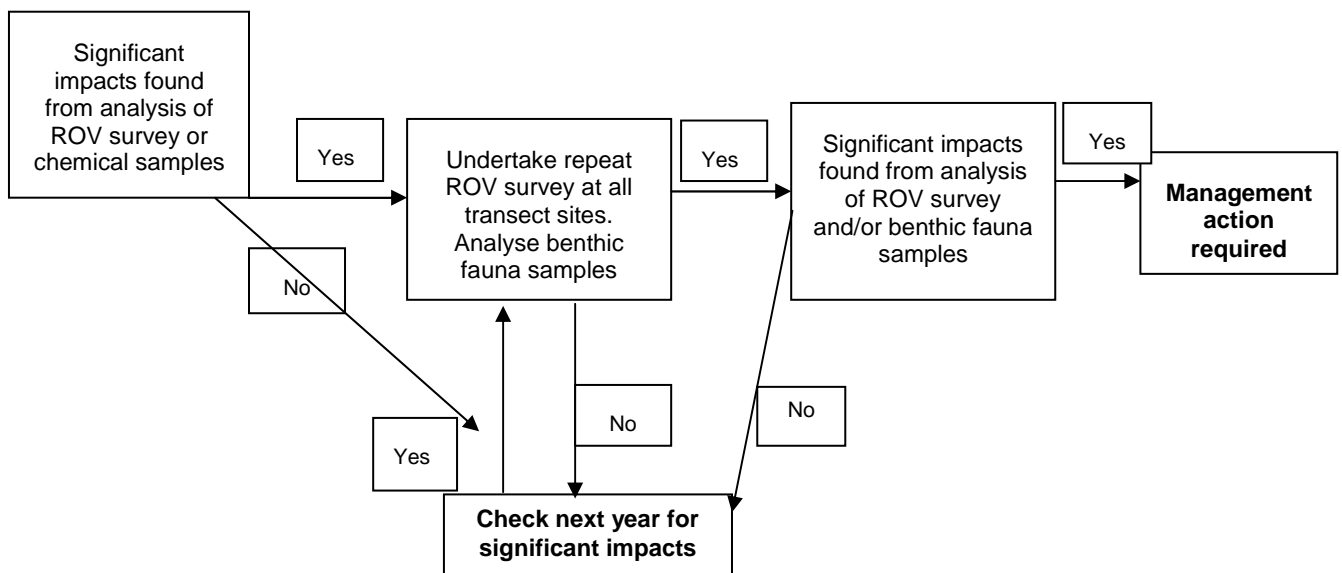
Figure 5: Management process in response to compliance site monitoring.

3.2   Substrate Monitoring Program

3.2.1   Substrate Monitoring Locations

To coincide with the invertebrate monitoring program, substrate monitoring will occur within the   , adjacent to the lease (compliance sites) and at two control sites (Figure 4). The compliance sites will be located approximately   from the boundary of the   , consistent with current regulatory practice for   . The compliance sites have been located to the   ) and XX (   ) of the lease consistent with the dominant current flows for the lease location.

The control sites will be located not less than 500 m from the   boundary. The minimum distance of 500 m from the   is considered to be sufficient for the control sites to be independent of the lease based on the results of previous studies on more

intense nutrient producing activities such as sewage outfalls. A 10 ML daily discharge of secondary treated sewage for example, is generally limited to within 300 m of an outfall for the majority of variables (Smith, 1996; Smith, 2000). GPS coordinates of each site will be recorded so that subsequent sampling can be undertaken within the same area.

3.2.2 Sampling Parameters

Sediment samples will be collected for determination of particle size and total organic carbon (TOC).

3.2.3 Sampling and Analysis

Three sediment samples will be collected from each sampling location using a suitable grab sampler. The same sites and plots used to collect the cores for macrofauna analysis will be used to collect these samples. The cores of sediment will be refrigerated or frozen until analysed in order to prevent microbial degradation.

The amounts of carbon, hydrogen and nitrogen in the sediments will be estimated using appropriate analytical techniques such as automated CHN analysis (e.g. Perkin Elmer 2400 Series CHNS/O analyser). The rationale for the use of this device is based on its good record of providing accurate measurements, as well as its convenience and the fact that it is cheaper than most alternative methods (Kingsford & Battershill, 1998). The concentrations of nitrates, nitrites and phosphorus of the sediment at each site will be measured at regular intervals using an autoanaylser.

Grain size will be assessed through appropriate analytical techniques such as microscopic observation of sediment samples or via coulter counter analysis (Kingsford & Battershill, 1998). Video and photo documentation of the seafloor beneath the longlines/sea pens may also be used to assess the impacts of the LEASE NAME on the benthic environment at various stages. Recovery rates fallowing for example, may be assessed using this technique. These results will also be used to monitor and assess the impact of *in situ* cleaning of biofouling.

Samples to be used for compliance monitoring must be collected in the presence of an independent party for verification (e.g. University or contractor responsible for undertaking the survey). All samples that cannot be processed by the University or Environmental/Biological contractor are to be processed by a NATA accredited laboratory.

3.2.4 Substrate Sampling Frequency

Substrate sampling beneath the longlines/sea pens, at the compliance and at the control sites will occur prior to the commencement of activities and will be conducted concurrently with water quality sampling.

Background substrate sampling will be collected prior to the installation of the LEASE NAME and at least annually after the lease is granted, irrespective of whether the lease is stocked with shellfish. Annual substrate sampling as outlined in Section 3.2.3 will be undertaken in mid-summer (e.g. February), a time expected to coincide with maximum growth rates and standing biomass of shellfish/finfish held on the LEASE NAME.

The maximum standing biomass on the LEASE NAME will be approximately XXX tonnes. Additional substrate sampling, as outlined in Section 3.2.3, will be taken when the standing biomass reaches certain critical production levels (e.g. XX, XXX, XXX tonnes).

UPDATE In the first year of production there will be a pre-deployment sampling, an annual (mid-summer) sampling and depending on the critical production levels being met possibly a further two sampling events. Thereafter sampling will occur annually (mid-summer) and when critical production levels are reached. This substrate sampling will be conducted concurrently with water quality and invertebrate sampling.

This frequency is consistent with sampling conducted previously for mussel and snapper farming in NSW and exceeds that currently required for salmon production in Tasmania. Additional substrate sampling will be conducted for experimental purposes at the discretion of the proponent and in accordance with needs for the development of the adaptive management approach.

3.2.5 Reporting

Results for all sites will be reported on the INSERT PROPONENT website within XX week of the data being obtained from third party monitoring contractors.

3.2.6 Adaptation of Monitoring Program

The proposed monitoring program has been designed to identify if any significant changes to the marine benthic environment immediately adjacent to the leases are occurring due to the presence of the farm and will provide the baseline conditions/parameters against which future fallowing and recovery can be assessed.

The benthic monitoring program will utilise benthic fauna and total organic carbon (TOC) next to the lease areas, at control sites and within the lease to monitor changes that may occur. This monitoring program will be reviewed after a period of time (two years or three sampling

events) has elapsed to permit sufficient samples to be collected to provide a high degree of certainty that there are no significant long term impacts resulting from the aquaculture farming activities. If however, during the monitoring program significant impacts are found then appropriate management regimes will be employed to ameliorate these impacts.

Each site at the start and end of each transect (Figure 4-A) will constitute the compliance sampling locations. At these compliance sites all parameters will be sampled in triplicate.

Each active lease area is to have two control sites associated for assessment (Figure 4-B). Each of the control sites is also to have all samples taken in triplicate. These control samples are to be collected concurrently (annually) with the lease monitoring samples.

INSERT PROPONENT is to have all triplicate samples analysed at baseline. For the annual surveys chemical and physical samples are to be analysed. If a significant impact is found at the compliance sites at the lease boundary from the initial analysis then the benthic fauna samples from each site are to be analysed at the expense of the permit holder and a repeat ROV survey is to be undertaken at all transect sites within a month of the initial survey (Figure 6). If it is determined from the analysis of the ROV footage and/or the benthic fauna samples that a significant impact has occurred then appropriate management regimes will be employed to ameliorate these impacts.
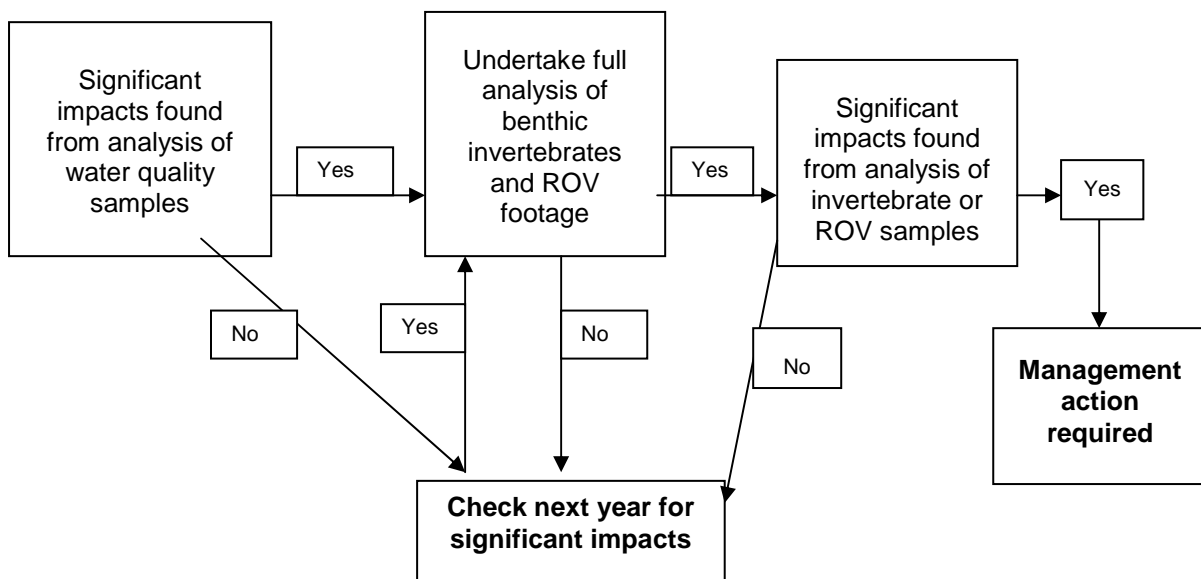
Figure 6: Management process in response to compliance site monitoring.

4 Consultation

In the preparation of the Water Quality and Benthic Environment Monitoring Plan the following personnel were consulted.

- E.g. Name, School of Environmental and Life Sciences, University of Newcastle;

- E.g. Name, Environmental and Life Sciences, University of Newcastle;

- E.g. Institute for Marine and Antarctic Studies (IMAS), University of Tasmania;

- E.g. Name (*Research Scientist),* NSW Department of Primary Industries; and

- E.g. Name (*Manager, Marine Park*), NSW Department of Primary Industries.

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6   Attachments

Attachment 1 – Twofold Bay Mussel Farming Monitoring Program

Attachment 1

Twofold Bay Benthic Monitoring Program

The monitoring program provided below has been designed to identify if there are any significant changes to the marine benthic environment due to the presence of the mussel farms. The monitoring program utilises the parameters of Total Organic Carbon (TOC) and benthic fauna in sediments under lease areas and at control sites to monitor any changes that may occur. This monitoring program is reviewed after a period of time that enables a sufficient number of samples to be collected to provide a high degree of certainty that there are no significant long term impacts resulting from the mussel aquaculture activities. If however, during the monitoring program significant impacts are found then appropriate management regimes will be employed to ameliorate these impacts.

Sampling regime

Within Twofold Bay there are three lease areas which have two associated control sites. Six samples are collected at each site for both TOC and benthic fauna, which results in a total of 12 samples per site. Thirty six samples are collected per lease area and the associated control sites (i.e. 18 TOC samples and 18 benthic samples). These samples are taken annually at a nominated time of the year and in accordance with methods approved by NSW DPI. Aquaculture permit holders are required to provide appropriate facilities to fix, label and store all samples in a secure location approved by NSW DPI.

Processing of samples

Prior to the processing of any samples the aquaculture permit holder has to provide details of the laboratory/s to be utilised for processing of samples, for approval by NSW DPI.

The aquaculture permit holder is to have three of the six lease samples and three of the samples from each of the two control sites analysed for TOC annually. The result of this analysis is to be forwarded to NSW DPI for consideration. If a significant impact is found from the initial analysis then the remaining three samples from each site are to be analysed for TOC by the permit holder. If it is determined from the results of this further TOC analysis that a significant impact has occurred then the fauna benthic samples are required to be analysed and the results provided to NSW DPI. If it is determined from the analysis of the benthic fauna samples that a significant impact has occurred then appropriate management regimes will be employed to ameliorate these impacts. The diagram below outlines the process above.

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┌─────────────────┐         ┌─────────────────┐          ┌─────────────────┐
│ Significant      │         │  Significant     │         │  Significant     │
│ impacts          │   Yes   │  impacts found   │   Yes   │  impacts found   │   Yes
│ found from       │ ──────► │  from analysis   │ ──────► │  from analysis   │ ──────►
│ analysis         │         │  of remaining 3  │         │  benthic fauna   │
│ of initial 3 TOC │         │  TOC samples     │         │  samples         │
│ samples          │         └─────────────────┘         └─────────────────┘
└─────────────────┘
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┌──────────────────┐
│ Management   │
│ action   │
│ required   │
└──────────────────┘

┌──────┐   ┌──────┐   ┌──────┐   ┌──────┐
│ No │   │ Yes │   │ No │   │ No │
└──────┘   └──────┘   └──────┘   └──────┘

┌─────────────────────┐
│ Check next year for │
│ significant impacts │
└─────────────────────┘