BIVALVE AQUACULTURE DIALOGUE

Environmental and Social Standards for Bivalve Aquaculture

Draft for 1st Public Comment Period
October 1-November 30, 2009

Table of Contents

Introduction

Aquaculture is the fastest growing food production system in the world. For the past 20 years, global production from aquaculture has steadily increased and this trend is projected to continue. Aquaculture provides significant quantities of fish and other aquatic food sources for human consumption and is a key source of protein. The industry also creates millions of jobs on and off the farm. With appropriate management, aquaculture can be environmentally and socially sustainable, meet the growing need for aquatic foods and contribute to food security, poverty reduction and sustainable economic development.

As with any rapidly growing activity, the growth in aquaculture production has raised concerns about negative social and environmental impacts related to farming and unfair labor practices at farms. It is important that we face the challenge of promoting and spreading practices that contribute to resolving these issues, while reducing those that have a negative impact.

One solution to this challenge is creating standards for responsible aquaculture production, as well as a process for certifying producers who adopt the standards. Standards, when adopted, can help reassure seafood buyers throughout the value chain and at the consumer level that aquaculture products do not have adverse impacts on environmental or social sustainability. One way buyers can support sustainability is by purchasing certified products that have been produced in compliance with these standards.

Through a multi-stakeholder process called the Bivalve Aquaculture Dialogue, measurable, performance-based standards are being created for farmed bivalves (clams, oysters, scallops and mussels). The standards, when adopted, will help minimize the potential negative effects of bivalve aquaculture, while permitting the shellfish farming industry to remain economically viable. Although these standards will be applicable at the farm-level, they are intended to help protect and maintain ecosystem function and ecosystem services in bivalve producing areas, with the recognition that aquaculture operations are not solely responsible for total ecosystem health.

The first draft of the standards, presented in this document, is based on sound science and input from the 300-plus people who have been involved in the Bivalve Aquaculture Dialogue since it began in August 2004. The Dialogue is coordinated by World Wildlife Fund (WWF).

Feedback received during the 60-day public comment period will be used by the Dialogue's Global Steering Committee, the 13-person entity that manages the Dialogue process, to revise the standards. The revised standards will then be posted for a second 60-day public comment period and the GSC will use the feedback to finalize the standards document. In order to encourage continuous improvement, the standards will be revisited and updated periodically (e.g., once every 3-5 years) to ensure that they are based on the most recent scientific knowledge and best available management practices.

Purpose, justification, and scope of the standards

Purpose of the standards

The purpose of the Bivalve Aquaculture Dialogue standards is to provide a means for shellfish farmers to measurably demonstrate the environmental and social sustainability of their farming operations.

Justification for the standards

According to United Nations Food and Agriculture Organization statistics, farmed shellfish make up more than 80 percent of the world's marine aquaculture production. There is growing consumer demand for environmentally certified seafood products and there also is demand from shellfish farmers for a process that will validate their environmental and social sustainability.

Scope of the standards

Issue areas of bivalve aquaculture to which the standards apply

The Bivalve Aquaculture Dialogue created principles, criteria, indicators and draft standards for addressing the following potential negative social and environmental issues related to bivalve aquaculture: ecosystem integrity (organic enrichment, phytoplankton depletion, and ecological carrying capacity), biosecurity, genetics, disease and pest management, multi-user cooperation, and farm maintenance.

Principles are the high-level goals for addressing the issues, criteria are the areas to focus on to address each issue, indicators are what to measure in order to determine the extent of each issue, and standards are the numbers and/or performance levels that must be reached to determine if the issue is being minimized.

Geographic scope and range of activities to which the standards apply

The Bivalve Aquaculture Dialogue standards apply globally to all locations and scales of filter-feeding bivalve aquaculture production systems. Bivalve aquaculture is defined as active husbandry of bivalve shellfish from seed to harvest within a defined area and with defined ownership of the shellfish being cultured.

Unit of certification to which the standards apply

The unit of certification refers to the extent of the specific aquaculture operation to be assessed and monitored for compliance with the standards. The size of the production operation can vary considerably and needs careful consideration when determining the entity that will seek assessment for compliance. As the focus of these standards is on production, the unit of certification will typically consist of a single farm or other production unit.

The unit of certification may also encompass a group of operations that should be considered collectively as the aquaculture operation under consideration, especially in the case of small-scale farms involving the same species and similar management regime. For example, they may be in close proximity to each other, share resources or infrastructure, share a landscape unit (e.g. a bay or water body), and/or have the same production system. Farms will also have cumulative effects, which will often be the main environmental issue. Determining the unit of certification requires that an appropriate spatial scale and level of potential cumulative effects be considered. The certification body will determine the ultimate unit of certification and procedures for auditing.

<u>Process for creating the standards</u>

The draft Bivalve Aquaculture Dialogue standards were developed through transparent, consensus-oriented discussions with a broad and diverse group of stakeholders (e.g., producers, NGOs, researchers, government representatives, scientists, buyers and allied businesses). The process included the following steps:

- WWF notified the International Social and Environmental Accreditation and Labeling Alliance (ISEAL) of the intent to apply ISEAL's "Code of Good Practice for Setting Social and Environmental Standards" to the Bivalve Aquaculture Dialogue. ISEAL approved this step and accepted WWF as an associate member on behalf of all of the Aquaculture Dialogues.
- Participation in the Bivalve Aquaculture Dialogue is a voluntary process and anyone with an interest can be involved. To maximize involvement, the inaugural meeting of the Bivalve Aquaculture Dialogue – as well as later Bivalve Aquaculture Dialogue meetings – was publicized on the Aquaculture Dialogues website, in seafood trade publications, and in several other publications read by key stakeholders. Key stakeholders were contacted directly by WWF and others to participate in the Bivalve Aquaculture Dialogue in order to ensure its credibility.

- A total of eight Bivalve Aquaculture Dialogue meetings were held in the three initial target regions: North America, Europe and New Zealand.
- Bivalve Aquaculture Dialogue participants agreed on seven key environmental and social issues associated with bivalve aquaculture and on the principles to address each issue.
- Bivalve Aquaculture Dialogue participants agreed on the objectives of and justification for the Dialogue, as well as the process for creating the standards.
- Bivalve Aquaculture Dialogue participants agreed on a governance structure for the development of the standards. This includes the following:
    - Regional Advisory Groups made up of a range of stakeholders representing different sectors from the different regions interested in bivalve aquaculture: North America, Europe and New Zealand. The groups were responsible for selecting Global Steering Committee (GSC) members, consulting with the GSC on issues relevant to the Dialogue and commenting on draft standards produced by the GSC.
    - The GSC is the primary decision-making body of the Bivalve Aquaculture Dialogue. The GSC is made up of three to four representatives selected from each of the regional advisory groups (please see **Appendix).** Additional members can be added as the Bivalve Aquaculture Dialogue continues to reach out to new regions involved in bivalve aquaculture production
    - GSC decisions are informed by the full Dialogue, the Regional Advisory Groups they represent, technical experts and external stakeholders.
- The GSC drafted environmental and social standards for bivalve aquaculture, incorporating the information and input that was provided by Bivalve Aquaculture Dialogue participants
- The GSC finalized an outreach plan to ensure that new stakeholders are continually engaged in the process. Outreach with small-scale farmers was conducted in Vietnam. Also, a workshop was held in Qingdao, China to receive input on the draft standards and request greater involvement in the Bivalve Aquaculture Dialogue from additional stakeholders and stakeholder groups.

Content of the standards

Principle 1: Obey the law and comply with all applicable legal requirements and regulations

Bivalve aquaculture operations must, at a minimum, adhere to national and local laws. The Bivalve Aquaculture Dialogue may develop sustainability standards beyond those required by law but the baseline requirement for any aquaculture operation must be compliance with the legal obligations of the producing country.

CRITERIA

1.1 All applicable legal requirements and regulations where farming operation is located

INDICATOR

1.1 Documentation of compliance with all applicable legal requirements and regulations where farming operation is located

STANDARD

1.1 Evidence of compliance with all applicable regulations (e.g. regulations permitting the farming activity, licenses, evidence of lease, concessions, and rights to land and/or water use)

Principle 2: Avoid, remedy or mitigate significant adverse effects on habitats, biodiversity, and ecological processes

Relevant issues: organic enrichment, phytoplankton depletion, ecological carrying capacity, ecosystem integrity

One of the main areas of potential environmental concern associated with bivalve aquaculture is the intensity of production and its effect on the ecological communities in close proximity to farming operations. Given that shellfish are farmed in dynamic coastal environments, the ecosystem effects of farming are hard to measure in a way that can be applied consistently from farm to farm. To overcome this challenge, the Dialogue developed a tiered approach based on initial risk assessments, followed by increasing levels of monitoring dependant on localized site-specific conditions. In addition, it was agreed that, in order to truly verify environmental sustainability, the standards must also address the cumulative impact of multiple farms in a given area. In other words, in order to ensure that the ecological carrying capacity of a given bay or body of water is not exceeded, the impacts of one farm must be tied to the additional and corresponding impacts of farms in the same water body.

Organic Enrichment

Suspended or off-bottom bivalve aquaculture may result in increased biodeposition underneath and adjacent to farms. The accumulation and mineralization of this excess organic matter in sediments can cause stress on benthic organisms through oxygen depletion and the toxic effects of hydrogen sulfide (H_2S). The impacts on benthic communities due to increased organic matter sedimentation are well known (e.g. Pearson and Rosenberg 1978, Hargrave et al., 2008b). Total 'free' sulphide (S^{2-}) in surficial (0-2 cm) sediments is a cost-effective indicator of the organic enrichment effects of shellfish aquaculture on benthic communities (Hargrave et al., 2008a, Cranford et al. 2009). Other metrics (e.g. redox potential, sediment oxygen demand, sediment organic content and benthic diversity indices) were also considered, but they were rejected because of measurement challenges, costs and/or inherent variation. More information on the rationale behind the total 'free' sulfide measurement can be found in the **Appendix.**

In addition to measuring levels of total 'free' sulfide, bottom video/imaging is also a relatively cost-effective way to quickly determine whether sediments underneath a farm have already become hypoxic or if the benthic conditions underneath or adjacent to a farm may be especially sensitive to increased organic loading from biodeposition. If bottom video/imaging reveals non-depositional substrate and the absence of sensitive benthic habitat, there is a lower risk of adverse benthic effects from bivalve aquaculture operations.

Phytoplankton Depletion

There is potential for bivalve farming operations to exceed the ecological carrying capacity of the body of water in which they are located. Ecological carrying capacity has been defined as the stocking or farm density above which unacceptable ecological impacts begin to manifest (Inglis et al. 2000). This happens when the removal of phytoplankton by all bivalve farms in a water body, including the applicant site, outstrips the capacity of the ecosystem to replenish the supply, resulting in adverse conditions for wild and cultured populations. The Dialogue addresses this issue using relatively simple calculations that compare how long it takes a population of bivalves to clear a body of water (clearance time - CT) with how long it takes for tides to flush that body of water (retention time - RT). Please refer to the **Appendix** for the rationale and specific formulas for the carrying capacity measurement, including a protocol for defining applicable water body boundaries. When carrying capacity is exceeded, farmed areas should have or be part of a bay-scale management plan for addressing potential cumulative pelagic effects from multiple farms.

Benthic Disturbance

Some bivalve shellfish farms are situated in areas with native critical habitat and/or resident endangered species. In order to preserve local biodiversity it is important that the Bivalve Aquaculture Dialogue standards take into account potential risks that bivalve aquaculture poses to critical habitats and species. For this reason, farming operations will not be permitted to adversely affect critical habitat or species in the proposed standards. This especially applies to shellfish operations that employ dredging as a means to harvest crops that are ready for market. Although we have not excluded bottom culture from potential certification, dredging will not be allowed if there is a significant risk to critical habitat or endangered species.

We acknowledge that harvest methods, such as dredging (either with a "dry" dredge or with hydraulic jets that loosen the soil) or even raking with hand rakes, will disturb the benthos and will cause some degree of mortality to non-target organisms, such as worms and crabs. However, when a grower uses a dredge on his lease, he or she typically knows exactly where to go and will typically harvest planted shellfish in an efficient and systematic fashion.

Most shellfish farming takes place in shallow coastal waters with sandy or silty bottom. The species that live in these waters are well-adapted to periodic disturbances from storms and wave action. (DeAlteris et al. 1999) Species in these environments tend to be opportunists that rapidly re-colonize disturbed bottom and are tolerant of high loads of suspended sediment (Coen, 1995). Studies have shown that these environments will recover from dredge harvesting in a few weeks or months. Perhaps most significantly, shellfish farmers replant seed (and often replace shell) following harvest and allow that seed to grow undisturbed for many months (and, in some cases, up to three years), replacing and improving the firm substrate that provides important habitat for many species. It has been observed that cultured bottom is typically far more diverse and productive than nearby areas devoid of shellfish cultivation or areas that are regularly dredged by wild harvest fishermen. (DeAlteris et al. 2004)

The final measure to ensure that farming operations are not adversely affecting the ecological integrity of the area in which they are located is to make certain that farmers have the appropriate level of environmental awareness. This can be done by requiring farmers to have documentation of environmental training/education or to be in compliance with a set of environmental codes of practices and/or management plans.

CRITERIA

2.1 Benthic effects
2.2 Pelagic effects
2.3 Environmental awareness
2.4 Critical habitat and species interactions

INDICATORS

2.1.1 Organic enrichment as indicated by a tiered assessment approach linked to standards for total ‘free’ sulfide and bottom video/imaging for sub-tidal sediments
2.2.1 Filtration capacity of cultured bivalves relative to the residence and primary production times of the body of water where the farm is located

2.3.1 Producer knowledge/management plans
2.4.1 Adverse effects on critical habitat and species (e.g. threatened or endangered species)

STANDARDS

2.1.1 Tiered assessment approach for bivalve culture (See **Table 1** below):

Tier 1 – Risk assessment stage – Bottom video/imaging, sulfide analysis

a. bottom video reveals non-depositional (sand, cobble) bottom → acceptable monitor every 5 years
b. sulfide levels ≤ 1500 μM →acceptable monitor every 5 years

Tier 2 – Depositional bottom with sulfide levels ≥ 1500 μM

a. sulfide levels ≤ 3000 μM → acceptable, but more monitoring is required (every year)
b. Sulfide levels ≥ 3000 μM → not acceptable – management response necessary before farm is eligible for certification

Table 1

Method	**Classification**	**Decision**	**Condition**
Seabed video/ imaging and surficial sediment sulfide (S) concentration at farm sampling sites vs. reference sites	Non-depositional, coarse sediment (sand, cobble) or S ≤1500 μM)	Acceptable	Monitor every 5 years.
	Depositional, fine sediment and A) S >1500 and ≤ 3000 μM	Acceptable	Monitor every year.
	B) S > 3000 μM	Unacceptable	Management response (e.g. site fallowing) necessary before farm is eligible for certification

Assessment exemptions and additional conditions for organic enrichment:

1) Bivalve aquaculture will not be considered acceptable within depositional areas that provide a particularly significant or essential biological or ecological function within the broader ecosystem. Examples include areas containing biogenic structures (i.e. tubeworm mounds, bryozoan mounds, bivalve beds and reefs, or sponge gardens that form a structure for other epifauna). Some biological structures are dominated by filter feeders that are not particularly adapted to sedimentation or organic enrichment.
2) Bivalve aquaculture will not be considered acceptable if it causes adverse benthic impacts within specific areas occupied by critical habitat/endangered species, or containing physical and biological features essential to the conservation of the species, and that may require special management considerations or protection (i.e. critical habitat essential for endangered species survival).
3) There are cases where the natural benthic environment is heavily enriched with organic matter prior to the initiation of any shellfish aquaculture activities. Farming activity is permitted in an area where natural sulfide levels exceed 3000 μM, but that annual S

concentrations should not significantly exceed levels measured at reference sites located outside the farm.

2.2.1 Tiered assessment approach for filtration capacity for cultured bivalves vs. residence and primary production times. (See **Appendix** for calculations)

Tier 1 – The clearance ratio indicator (CT/RT) is a simple calculation that has been used in many studies to compare the volume of water filtered by bivalves with the tidal exchange as a means of replacing that filtered water.

a. > 1 = green → acceptable

b. ≤ 1 = yellow → go to tier 2

Tier 2 – Grazing ratio indicator (CT/PPT)

a. > 3 = green → acceptable

b. ≤ 3 = red → not acceptable – A bay wide management plan is necessary to reduce regional stocking levels

2.3.1 Documentation of training, or codes of practices, or environmental management plans, etc. (The Aquaculture Stewardship Council, which will manage the Dialogue standards, will provide a basic level of environmental awareness and best management practices.)

2.4.1 Evidence of the avoidance, remediation, and/or mitigation of harm in the establishment or on-going use of the farm to critical habitat and endangered species.

Principle 3: Avoid adverse effects on the health and genetic diversity of wild populations
Relevant issues: biosecurity, genetics

A leading cause of biodiversity loss in many aquatic ecosystems is the introduction of exotic species. When species are introduced into an area, they may cause increased predation and competition, disease, habitat destruction, genetic stock alterations, and even extinction. Approximately 68 percent of fish species lost in North America over the last century were caused by an invasion of exotic species (Miller et. al, 1989). Bivalve aquaculture may pose risks to wild populations through introduced cultivated species and exotic pests and pathogens. Most growing areas already have stringent requirements regarding the introduction of exotic animals and plants into the environment. However, to make certain that shellfish growers are taking all precautions necessary to ensure against unwanted introductions, farms associated with the introduction of an exotic species, pest or pathogen within two years prior to being audited will not be eligible for certification.

The Pacific oyster, *C. gigas,* has been introduced from its native home in Japan, to many regions around the world, ranging from North America to Australia, New Zealand and Europe. It has become a commercially important species in many of these places, and is the number one shellfish resource in Washington state. In most instances *C. gigas* was introduced to these areas between 50 to 100 years ago. It has proven to be very successful at colonization and, in some instances, has out-competed local bivalve species. For this reason, the Bivalve Aquaculture Dialogue standards only allow the farming of the Pacific oyster if it is already locally established and/or managed. No new introductions of *C. gigas* will be permitted after the publish date of the standards.

An environmental standard for aquaculture operations that source wild seed to stock farms necessitates an assessment of the sustainability of that wild stock. This is not an issue if the farming operations are harvesting beach cast spat or local larvae and growing them to market size on their farm, since larval survival rates are exponentially higher on farms than off and because wild recruitment is limited by post-set survival far more than larval abundance. However, if growers are transporting seed or spat collected from other biogeographic regions (areas of animal and plant distribution having similar or shared characteristics throughout) or harvesting seed from the seabed, an assessment is necessary to determine whether the manner in which the wild seed is collected for grow-out adversely affects ecosystem health. Potential solutions to this problem involve relying on other credible certification bodies (e.g. the Marine Stewardship Council) to ensure sustainably sourced wild seed.

Selectively breeding seed in hatcheries comes with its own set of potential risks to wild populations. It is possible that hatchery production of seed could negatively impact wild populations of the cultivated species by altering their genetic composition over time in ways that compromise their long-term viability. The extent of the potential genetic impact of bivalve aquaculture operations depends on three factors: (1) the degree to which the cultured stock is genetically different from wild stocks, (2) the proximity of farms to wild populations, and (3) the number of animals in cultivation compared to the effective population size of the naturally occurring wild stock. In most cases, genetic drift will be minimal. However, there may be some instances where the existing levels and patterns of genetic variation in wild populations are the product of local adaptation to specific environmental conditions, and if these locally-adapted populations harbor sufficient genetic variation to respond to future challenges, genetic pollution from hatchery reared animals could reduce fitness, eliminate valuable genetic variation, or even completely replace adapted wild genotypes with non-adapted alien ones. On the other hand, in some areas, selectively bred hatchery seed may be more able to withstand disease and other modern environmental pressures than their struggling wild counterparts. Many shellfish restoration efforts employ the use of selectively bred hatchery seed in order to reestablish wild populations in areas devastated by disease and overfishing. Nonetheless, if significant scientific evidence of genetic risk to wild populations exists, selectively or cross bred hatchery seed will not be allowed.

The farming of transgenic animals creates additional issues regarding genetic pollution and impacts on farm stocks and wild populations. For this reason transgenic animals will not be allowed under the standard.

CRITERIA

3.1 Introduced pests and pathogens
3.2 Sustainable wild seed procurement
3.3 Introduced non-native cultivated species
3.4 Native species cultivation
3.5 Transgenic animals

INDICATORS

3.1.1 Responsibly sourced seed (biosecurity)
3.1.2 Responsible transfer and management of farming equipment
3.2.1 Adverse impacts on ecosystem from seed procurement
3.3.1 Farming of non-native species
3.4.1 Genotype of cultivated animals
3.5.1 Framing transgenic animals

STANDARDS

3.1.1.1 Documentation of compliance with protocol for preventing disease and pest introductions with seed

3.1.1.2 No legally documented disease and pest introduction attributable to farming operation within the last two years
3.1.2 Documentation of compliance with protocol for preventing disease and pest introduction with farm equipment
3.2.1 Demonstration of sustainably sourced wild seed (e.g. a tiered approach, Marine Stewardship Council certification of wild seed stocks)
3.3.1 No farming of species that are not locally established and/or managed
3.4.1 No farming of selectively or cross bred animals where there is significant scientific evidence they pose a genetic threat to natural wild populations.
3.5.1 No farming of transgenic animals (introduced genes from other organisms)

Principle 4: Manage disease and pests in an environmentally responsible manner
Relevant issues: disease and pest management, ecosystem integrity

Some of the most challenging issues faced by shellfish farmers involve the control and management of diseases, predators, pests and fouling organisms. Most shellfish species are susceptible to a number of parasitic, bacterial and viral diseases (Bower & McGladdery 1997). Low levels of sub-lethal infection are almost routine, and mass mortalities are common. Shellfish are primitive organisms with rudimentary immune systems and, once they leave the hatchery, there is no economical way to deliver drugs or antibiotics to significant numbers of animals. Perhaps the best hope of controlling the spread of disease is through the use of management practices that call for the pathological inspection of animals to ensure that infected animals are not moved into areas that do not currently have endemic infections. Long-term selective breeding programs that mimic nature by amplifying the genetic tendencies for disease resistance are also showing promise in limiting the impacts of diseases that are already endemic.

Fouling control represents perhaps the greatest challenge for many shellfish farmers. The firm substrate offered by shell, ropes and the various containers that growers use to protect their crop from predators provides an ideal habitat for numerous fouling organisms that may include seaweeds, other shellfish, barnacles and many species of tunicates and bryozoans. Fouling organisms block the flow of food-rich water, often competing for food, and frequently decreasing the quality, appearance and value of the end product. Fouling organisms can quickly colonize clean gear, more than doubling the weight of culture gear in a few weeks. Some growers estimate that as much as 30 percent of their operating costs are related to fouling control (Adams et al. 2009). Control measures include avoidance (temporal or spatially keeping the crop away from the larval stages of the fouling organisms) mechanical removal (scraping, brushing or power washing) and killing the fouling organisms (air drying or dipping in various caustic solutions such as brine, acetic acid or lime). Most of these solutions are components already found in seawater (salt or CaCo3) and as long as they are handled and disposed of properly (allowing for appropriate dilution) there should be little impact to non-target organisms.

Pests and predators also pose a significant threat for shellfish farmers. Shellfish at high densities (especially juveniles) are a tempting treat for armies of crabs, starfish, fish, rays, predatory snails and diving birds. It is not uncommon for unprotected plantings to suffer near 100 percent mortalities in just a few weeks. Growers have developed a wide array of predator exclusion devices to protect their crops, ranging from mesh bags to rolls of netting similar to those used to protect fruit trees from birds. For birds, which are protected from lethal control measures by law, growers must rely on exclusion barriers or repellants such as lasers and noise, similar to land farmers. For more primitive predators, such as starfish, conchs and crabs, growers typically use a combination of barriers and trapping. New England oyster farmers have relied on dragging starfish “mops” (large weighted cotton ropes that entangle starfish which are then dipped in vats of boiling water) since the late 1800s. They also historically used applications of quicklime (CaO_2) to control starfish and oyster drills (*Urosalpinx cinerea*). Many jurisdictions continue to mandate lethal control of starfish wherever they are encountered.

Setting a strict, non-subjective, standard to ensure that these control measures are done in an environmentally responsible manner is challenging. Since any action will have some measurable impact, the challenge then is to ensure that any impacts are localized, temporary, and reversible and that actions do not cause significant harm to critical species or habitats. Since this is a science-based standard, the guiding principle must be that the preponderance of peer-reviewed scientific literature indicates that the practice in question does not cause significant negative impacts.

CRITERIA
4.1 Disease and pest management practices

INDICATORS
4.1.1 Pesticide use
4.1.2 Chemical use
4.1.3 Predator management techniques
4.1.4 Explosives

STANDARDS
4.1.1 No mutagenic, carcinogenic, teratogenic, or eco-toxic[1] pesticides applied on farm or farmed animals
4.1.2 No residual harmful chemicals[2] applied on farm or farmed animals
4.1.3 Only non-lethal management (e.g. exclusion, deterrents, removal) of critical species that are pests or predators
4.1.4 No use of explosives

Principle 5: Use resources efficiently
Relevant issue: farm maintenance

Climate change represents the biggest environmental challenge facing current and future generations. Because of this, energy consumption used in food production has become a source of major public concern. Although shellfish farming has one of the lowest carbon footprints of all intensive/semi-intensive food production systems, the Bivalve Aquaculture Dialogue recognizes the importance of efficient and sustainable energy use. Therefore, the standards state that on-farm energy consumption should be monitored on a continual basis and that growers should develop means to improve efficiency and reduce consumption of energy sources, particularly those that are limited or carbon-based.

Shellfish growers should also be responsible about disposing of waste and protecting against harmful chemical and hydrocarbon spills. Farming operations should have sufficient prevention

[1] Natural or synthetic chemicals/pesticides that demonstrably disrupt the natural biochemistry, physiology, behavior and interactions of the living organisms that comprise an ecosystem

[2] Toxic agents that remain active for a relatively long period of time, or depending on the actual chemical used, indefinitely

and response plans in place and farm employees should have the proper training necessary to properly dispose of waste, and prevent and manage chemical and hydrocarbon spills.

CRITERIA
5.1 Waste management
5.2 Energy efficiency
5.3 Pollution control

INDICATORS
5.1.1 Operational equipment and plastics are reduced, reused, recycled or properly disposed of
5.1.2 Biological waste is properly disposed of (e.g. shell, dead animal)
5.1.3 Chemical and hydrocarbon waste is properly disposed of
5.2.1. Energy use monitoring
5.2.2 Equipment operation and maintenance (e.g. hull cleanliness, fluid leaks)
5.3.1 Mitigation of chemical and hydrocarbon pollution

STANDARDS
5.1.1 Evidence of waste reduction (e.g. reuse and recycling) programs
5.1.2 Evidence of appropriate storage and/or disposal of biological waste
5.1.3 Evidence of appropriate storage and/or disposal of chemical and hydrocarbon wastes
5.2.1.1 Records of energy consumption (e.g. volume and type)
5.2.1.2 Evidence of an energy use assessment (e.g. energy audit, in-house estimates)
5.2.2 Maintenance records are up to date and available
5.3.1 Spill prevention and response plan for chemicals/hydrocarbons originating from farming operations

Principle 6: Be a good neighbor and conscientious coastal citizen
Relevant issues: multi-user cooperation, farm maintenance

While it is recognized that farming bivalve shellfish is one of the most sustainable forms of food production, shellfish aquaculture often occurs in close proximity to communities that may be affected by farming activities. Conflict resulting from a lack of agreement over how coastal resources should be used can severely impact the social sustainability of a shellfish farming operation. Regular proactive communication and consultation can build trusting relationships with local communities and prevent or minimize conflicts. Some stakeholders may not want shellfish farming to exist near their communities, but by fostering an open dialogue and a constant relationship of engagement, shellfish farmers can strive to earn the trust of local communities and gain the social license to operate. While it is hard to incorporate this type of proactive approach into a set of standards, the Bivalve Aquaculture Dialogue feels that it is very important for shellfish farmers to establish good relationships with the communities in which they operate, not only for their own benefit, but for the benefit of the industry as a whole.

CRITERIA (if applicable to area)
6.1 Aesthetic impact
6.2 Farm marking
6.3 Escaped equipment, gear, etc.
6.4 Complaints
6.5 Community and indigenous outreach/communication
6.6 Recognizing cultural differences, needs and rights

INDICATORS
6.1.1 Orderly and uniform farm sites
6.2.1 Gear is properly marked and does not unduly impede navigation
6.3.1 Escaped gear is recovered
6.4.1 Response to publicly documented complaints (operational complaints)
6.5.1 Evidence of effort/time spent engaging the community and indigenous groups
6.6.1 Access for indigenous groups to traditional harvesting areas and practices and/or resources

STANDARDS
6.1.1 Uniform visible float color except where otherwise specified by law
6.1.2 Uniform positioning and orientation of visible farm structures except where specified by law
6.2.1 Evidence of compliance with all applicable navigational rules and regulations
6.3.1 Documented cleanup of receiving shoreline in response to gear loss and/or complaints based on local conditions
6.3.2 Substantial gear is identifiable to farm (e.g. floats, cages, bags, predator nets, racks)
6.3.3 Provision of equipment for gear recovery (e.g. scoop nets, grapple hook)
6.4.1 Complaint response protocol including at a minimum a registry of complaints and responses
6.5.1 Documentation of outreach (e.g. meeting records, newsletters, consultation with communities and indigenous peoples of the area, or membership in association with documented outreach program)
6.6.1 Documentation and evidence of acknowledgment of indigenous groups' rights (e.g. a memorandum of understanding)

Principle 7: Develop and operate farms in a socially and culturally responsible manner

Bivalve aquaculture should be undertaken in a socially responsible manner that ensures the operations benefit farm workers and local communities. The labor rights of individuals working on shellfish farms are important and farm working conditions should ensure that employees are treated and paid fairly. Appropriate farm conditions include no child labor, no forced labor and no discrimination. Complaint procedures and protection for whistle blowers are critical to achieving and maintaining fair and equitable working conditions. Socially responsible shellfish farming should ensure worker health and welfare through safe and hygienic working conditions with relevant training available for workers and managers. Please refer to the **Appendix** for guidance and definitions for the following social standards.

CRITERIA
7.1 Child labor
7.2 Forced, bonded, or compulsory labor
7.3 Discrimination
7.4 Health and safety
7.5 Fair and decent wages
7.6.1 Freedom of association and collective bargaining
7.7.1 Non-abusive disciplinary practices
7.8.1 Working hours and overtime

INDICATORS
7.1.1 Incidences of child labor

7.2.1 Incidences of forced, bonded, or compulsory labor
7.3.1 Incidences of discrimination
7.4.1 Occurrences of health and safety related accidents and violations
7.4.2 Workers trained in health and safety practices
7.4.3 Company responsibility for job related accidents and injuries
7.5.1 Payment of fair and decent wages
7.6.1 Worker access to trade associations and collective bargaining
7.7.1 Presence of abusive disciplinary practices
7.8.1 Violations of working hours and overtime

STANDARDS
7.1.1 No child labor
7.2.1 No forced, compulsory or bonded labor
7.3.1 No discrimination
7.4.1 All health and safety related accidents and violations are recorded and corrective action is taken
7.4.2 Occupational health and safety training is available for all employees, including accident reporting and response
7.4.3 Unless otherwise covered, company is responsible for 100% of employee costs in a job-related accident or injury
7.5.1 All employees are paid fair and decent wages
7.6.1 Employees have 100% access to freedom of association and collective bargaining
7.7.1 No abusive disciplinary practices occur on the farm
7.8.1 No violations of working hours or overtime occur on the farm

Appendix

Principle 2: Avoid, remedy or mitigate significant adverse effects on habitats, biodiversity, and ecological processes

<u>Total 'free' sulfide measurement</u>

By comparing the level of total 'free' sulfides in the sediment beneath a farm to a nearby control site, the degree of organic enrichment can be assessed. Sediment organic enrichment classifications have been identified based on the known effects of changes in sediment sulphide on the biodiversity of macrofauna (Cranford et al., 2006 and Hargrave et al., 2008b). The associated sulphide threshold values enable managers to distinguish between normal ranges of "background" concentrations from those indicative of benthic habitat degradation.

Relationships between biological variables are consistent with changes in sulphide levels as sediments are transformed from oxic to anoxic status. Impacts to benthic fauna biodiversity resulting from increased S concentrations can be significant and occur at low S levels. The transition from oxic to hypoxic conditions has been identified as occurring at 1500 μM S. This threshold represents a transition from "moderate" to "reduced" macrobenthic sulphide concentration and changes in the benthic macrofauna community structure have been described by Hargrave et al. (2008b). A nomogram was used to show that various benthic enrichment classification schemes based on changes in different inter-related chemical and infauna biodiversity (defined by Pearson and Rosenberg, 1975) at which the mean number of taxa are reduced by approximately 50 to 60% relative to typical oxic conditions (Hargrave et al. 2008b). Anoxic sediments were characterized by S concentrations >6000 μM S. A transition within the hypoxic class of sediments at 3000 μM has been identified where less S-tolerant taxa disappear but more tolerant opportunistic species have not increased in abundance. S levels above 3000 μM represent a condition that exerts "severe hypoxic stress" on benthic community structure (defined by Diaz and Rosenberg, 1995) and characterize a "polluted" sediment condition (defined by Pearson and Rosenberg, 1975) that poses a high risk to benthic habitat.

Phytoplankton depletion explanation and calculations

If water renewal is faster than water clearance (CT>RT) it is expected that carrying capacity will not be exceeded. If CT<RT cultured bivalves may be able to control the ecosystem and an additional assessment is required linking clearance time to primary production (PPT). The rationale for the Tier 2 calculation is that phytoplankton production in a bay can support sustainable aquaculture, up to a point, even when the bay is poorly flushed. Primary production time should be shorter than clearance time; otherwise the algae which shellfish feed on will quickly be depleted. In theory the standard could be CT/PPT>1 but in practice CT/PPT should be >3. This is based on empirical data from a series of estuaries and is a logical assumption due to the algal buffer stock required in order to realize a certain level of primary production, not to mention the occurrence of other unknown filter-feeder stocks in proximity to the shellfish farming operations (Smaal & Prins, 1993). It should be understood that this factor of 3 is a practical figure rather than an ecological fixed standard. When CT/PPT ≤ 3, farms are no longer eligible for certification. If this is the case, bay wide management plans that address the potential cumulative pelagic effects of multiple farms and reduce regional stocking levels are necessary in order to ensure that the ecological carrying capacity is not being exceeded.

Calculations:

CT = clearance time is the number of days required for the dominant bivalve stock(s) (wild and cultured) to clear the volume of the bay or regional water body (sites with no clear boundaries). The calculation is based on published clearance rate data for the bivalve group (mussels, scallops, clams, oysters);

$$CT\ (\text{days}) = V_t / (N \times C),$$

where N is number of bivalves, V_t is the total volume of the water body at high tide (liters) and C is average clearance rate (l/individual/d) at harvest size. A table of average C values will be provided.

A protocol for defining bay and other water body boundaries will be developed based on considerations of the depths of the culture grow-out structures, water mixing and light penetration and coastal morphology criteria and in the case of open-water sites a depletion footprint considered to be ecologically important (e.g. Gibbs, 2007).

RT = retention time is the number of days for tides to flush a volume of water equal to the volume of the bay or water body,

$$RT = -1 \times P / \ln (V_l / V_t)$$

Where, tidal periodicity (P) is the length of the tidal cycle (e.g. ~0.5 days for semidiuranl tides) and V_l is the bay volume at low tide. Note that for deep stratified culture areas (e.g. open ocean, fjord), this calculation should be limited to the surface mixed layer. In areas where water exchange is not dominated by tidal flushing (e.g. controlled primarily by river flow or wind forcing), an appropriate volume exchange should be calculated.

PPT = primary production time is the number of days required for the replacement of the standing stock of phytoplankton in the bay (i.e. time-scale of phytoplankton population growth). PPT is the ratio of yearly averages of phytoplankton biomass (B) to phytoplankton primary production (*PPP*) within the system. B can be estimated from chlorophyll *a* measurements, published data or satellite predictions assuming a carbon to chlorophyll ratio of 50. *PPP* can be obtained from published results or model predictions. Some examples of available data resources include:

http://marine.rutgers.edu/opp/
http://www.science.oregonstate.edu/ocean.productivity/index.php

Principle 4: Manage disease and pests in an environmentally responsible manner

Temporary Assessment Exemption

The Bivalve Aquaculture Dialogue's GSC agreed on a temporary explicit exemption for the use of carbaryl by shellfish growers in the Northwest United States. Two coastal estuaries in this region produce approximately 25 percent of United States oysters. Since the late 1950s these bays have been plagued by increased populations of burrowing shrimp that undermine the oyster beds causing the oysters to sink, suffocate and die. The shrimp have been controlled since 1963 with low tide aerial applications of the pesticide carbaryl. The application has been thoroughly studied finding no long term adverse impacts. The use of the pesticide is regulated by the United States Department of Agriculture under the Federal Insecticide Fungicide and Rodenticide Act and the Washington Department of Ecology under the Clean Water Act. Shellfish growers in this region are obligated to implement Integrated Pest Management (IPM) under a Memorandum of Agreement with various agencies and fund a full-time IPM coordinator. For a number of years, a coordinated research program has been attempting, albeit unsuccessfully, to identify non-chemical alternative controls that provide a comparable light touch on the estuary. In light of the level of research around the carbaryl application and the growers' commitment to IPM and finding non-chemical alternatives, the Bivalve Aquaculture Dialogue GSC agreed the farms in the United States' Pacific Northwest could be granted an explicit exemption from standard 4.1.1 for a period not to extend past September 2012. The explicit exemption is only available to companies who grow shellfish in Willapa Bay or Grays Harbor in the United States. To qualify for the explicit exemption companies must have an integrated pest management plan and agree to phase out the use of carbaryl or any other mutagenic, carcinogenic, teratogenic, or eco-toxic pesticide by September 2012.

Principle 7: Develop and operate farms in a socially and culturally responsible manner

Guidance and definitions:

The standards related to labor issues and work conditions on the farm were developed based on ILO core principles and with input from Social Accountability International (SAI). Certification to SA 8000 or equivalent ISEAL compliant labor certification system indicates compliance with these standards. The following guidance can be used to inform the social component of the Bivalve Aquaculture Dialogue standards.

Criteria: Child Labor

Guidance:

- No Child Labor- minimum age of permanent workers is 15 years old unless local law mandates a higher legal limit, in which case the legal minimum is followed. (Employer is accountable for correct documentation of appropriate age)
- Child workers under the age of 15 perform only light work (see definition below) as long as it does not exceed 2 hours per day on a school day or holiday and the total number of hours spent on light work and on school should not exceed 7 hours/ day.
- For employees aged 15-18 (Young Workers), work should not conflict with schooling (combination of daily transportation, school time and work time should not exceed 10 hours). Hazardous work is not performed by those below age 18 (see definition below, including heavy lifting disproportionate to their size, operating heavy machinery, working night shift, exposure to any toxic chemicals)

Definitions:

" Light Work": (ILO convention 138, article 7.1) Light work is work that is 1) not likely to be harmful to a child's health or development and 2) not likely to prejudice their attendance at school, participation in vocational orientation or training programs, or diminish their capacity to benefit from instruction received

Criteria: Forced, Bonded, Compulsory Labor

Guidance:

- Employer should never be permitted to withhold original identity documents
- Contracts should be clearly stated and understood by employees and never lead to employee being indebted (such as employees paying for training programs)
- Employees should be free to leave the workplace and manage their own time

Definitions:

Forced Labor: All work or service that is extracted from any person under the menace of any penalty for which said person has not offered him or herself voluntarily or for which such work or service is demanded as a repayment of debt. "Penalty" can imply monetary sanctions, physical punishment such as loss of rights and privileges or restriction of movement (or withholding of identity documents)

Bonded Labor: when a person is forced by the employer or creditor to work to repay a financial debt to the crediting agency

(Note: extra care should be given to migrants and contractor/ subcontractor situations)

Criteria: Discrimination

Guidance:

- Company shall not engage in or support discrimination in hiring, remuneration, access to training, promotion, termination or retirement based on caste, national origin, religion, disability, gender, sexual orientation, union membership, political affiliation, age, or any other condition that may give rise to discrimination

- Company shall not interfere with employee rights to exercise or observe tenets or practices, or to meet needs related to race, caste, national origin, religion, disability, gender, sexual orientation, union membership or political affiliation, or any other condition that may give rise to discrimination
- Respect the principle of equal pay for equal work

Definitions:

Discrimination: any distinction, exclusion, or preferences, which has the effect of nullifying or impairing equality of opportunity or treatment. Not all distinction, exclusion, or preference constitutes discrimination. For instance, a merit or performance based pay increase or bonus is not by itself discriminatory. Positive discrimination in favor of people from certain underrepresented groups may be legal in some countries.

Criteria: Health and Safety

Guidance:

- Minimization of hazards/ risks in the working environment including documented procedures and policies to prevent workplace accidents/injuries. Emergency response procedures should exist and be known by employees.
- Documentation of occupational health and safety violations.
- Regular Health and Safety training for employees (once a year and for all new employees) including training on potential hazards, risk minimization
- Access to clean lavatories, potable water, sanitary facilities, and in the case of dormitories, they must be clean, safe, and meet the basic needs of employees
- Insurance, if not otherwise provided, to cover employees who suffer accident or injury in the work environment. Special consideration must be given to migrant or foreign workers who may fall outside of local or national laws and legislation.
- Corrective action plan for accidents that have occurred

Criteria: Fair and Decent Wages

Guidance:

- Companies should ensure that wages paid for a standard working week (no more than 48 hours) always meet at least legal/ industry minimum standards and meet the basic needs of personnel as well as provide some discretionary income
- No deductions for disciplinary actions, wage and benefits are clearly articulated to employees, wages and benefits are rendered in a manner convenient to employees (no travel, no promissory notes, coupons or products/ merchandise to replace cash/ check or electronic methods)
- No labor-only contracting relationships or false apprenticeship schemes (see below)

Definitions:

Labor-only contracting arrangement: practice of hiring workers without establishing a formal employment relationship for the purpose of avoiding payment of regular wages or the provision of legally required benefits, such as health and safety protection.

False Apprenticeship Scheme: practice of hiring workers under apprenticeship terms without stipulating terms of the apprenticeship/ wages under contract. It is a “false” apprenticeship if purpose is to underpay people, avoid legal obligations, or employ children.

Criteria: Freedom of Association and Collective Bargaining

Guidance:

- Employers should respect the right of all personnel to form and join trade unions of their choice and to bargain collectively
- When such situations are restricted under law, employers should facilitate parallel means of independent and free association and bargaining and ensure they are not the subject of discrimination. (When rights are restricted the company needs to make clear to workers that they are willing to engage workers in collective dialogue through representative structure and that they are willing to provide them with the opportunity to do so)

Criteria: Non-Abusive Disciplinary Practices

Guidance:

- Absolutely no engagement in or support of corporeal punishment, mental or physical coercion, or verbal abuse. Fines or wage deductions are also not an acceptable method for disciplining workers.

Criteria: Working hours and overtime

Guidance:

- Company must comply with applicable laws and industry standards related to working hours. “Normal workweek” can be defined by law but shall not on a regular basis (constantly or majority of the time) exceed 48 hours.
- Employees should be provided with at least one day off in every seven day period
- All overtime should be paid at a premium and should not exceed 12 hours per week. Overtime work shall be voluntary except in the case where a company has arranged—through a collective bargaining agreement- for mandatory overtime to meet short-term business demand

Global Steering Committee and Regional Advisory Group members

<u>Global Steering Committee</u>
Bill Dewey: Taylor Shellfish
Peter Cranford: Bedford Institute of Oceanography
Bob Rheault: East Coast Shellfish Growers Association
Mike Mandeno: Aquaculture New Zealand
Ken Grange: National Institute of Water and Atmosphere (New Zealand)
Francene Wineti: Te Ohu Kai Moana
Aad Smaal: Wageningen University
Paddy Walker: The Wadden Sea Society
Tom Pickerell and David Jarrad: Shellfish Association of Great Britain

Antonio Hervas: IFQC
Corey Peet: The David Suzuki Foundation
Sandy Shumway: University of Connecticut
Colin Brannen: WWF

<u>New Zealand Regional Advisors</u>
Mike Mandeno: Aquaculture New Zealand
Ken Grange: National Institute of Water and Atmospheric Research
Alastair Macfarlane: New Zealand Seafood Industry Council
Jim Sinner: Cawthron Institute
Rebecca Bird: World Wildlife Fund New Zealand
Wendy Banta/Dan Lees: Ministry of Fisheries
Francene Wineti: Te Ohu Maori
Helen Mussely: Sealord

<u>Europe Regional Advisors</u>
Jacobo de Novoa: Bureau Veritas
Aad Small: Wageningen UR
Gráinne O'Brien: Bord Iascaigh Mhara
Antonio Hervas: IFQC Ltd.
Ana Manjua: Associadad de Productores en Aquacultura du Algarve (Portugal)
John Holmyard: Offshore Shellfish Limited
Tom Pickerell and David Jarrad: Shellfish Association of Great Britain
Sara Cunha: Sapalsado
Paddy Walker: Waddenvereniging
José Carlos Macías Rivero: Desarrollo Agrario y Pesquero (DAP)

<u>North America Regional Advisors</u>
Mike Beck: The Nature Conservancy
John Kraeuter: Rutgers University
Ian Jefferds: Penn Cove Shellfish, Kona Coast Shellfish
Dennis Hedgecock: University of Southern California
Peter Becker: Little Skookum Shellfish
Robin Downey: Pacific Coast Shellfish Growers Association
David McCallum: British Columbia Shellfish Growers Association
Bettie Arseneault: New Brunswick Professional Shellfish Growers Association
Steve Cross: University of Victoria
Fiona Cubitt: British Columbia Ministry of Agriculture and Lands
Steven Lanteigne: Department of Fisheries and Oceans, Canada, Gulf region
Shelley McKeachie: Association for Responsible Shellfish Farming
Alison McGarry: New Brunswick Department of Agriculture and Aquaculture
Bill Dewey and Marco Pinchot: Taylor Shellfish
Peter Cranford: Bedford Institute of Oceanography
Corey Peet: The David Suzuki Foundation
Sandy Shumway: University of Connecticut

References

Adams, C., Getchis, T., Shumway, S. and Whitlatch, R. 2009. Biofouling in Marine Molluscan Shellfish Aquaculture: A Survey Assessing the Business and Economic Implications of Mitigation. *Biofouling. (IN REVIEW)*

Bower, S.M., McGladdery, S.E. (1997): Synopsis of Infectious Diseases and Parasites of Commercially Exploited Shellfish. http://www.pac.dfo-mpo.gc.ca/science/species-especes/shellfish-coquillages/disease maladies/intro-eng.htm

Coen L.D. 1995 A review of the potential impacts of mechanical harvesting on subtidal and intertidal shellfish resources. Prepared for the South Carolina Department of Natural Resources, Marine Resources Research Institute, 46 pp.

Cranford, P.J., R. Anderson, P. Archambault, T. Balch, S.S. Bates, G. Bugden, M.D. Callier, C. Carver, L. Comeau, B. Hargrave, W.G. Harrison, E. Horne, P.E. Kepkay, W.K.W. Li, A. Mallet, M. Ouellette and P Strain, 2006. Indicators and Thresholds for Use in Assessing Shellfish Aquaculture Impacts on Fish Habitat, CSAS-DFO, Research Doc. 2006/034, 116 p. http://www.dfo-mpo.gc.ca/csas/Csas/DocREC/2006/RES2006_034_e.pdf

Cranford, P.J., B.T. Hargrave and L.I. Doucette. 2009. Benthic organic enrichment from suspended mussel (*Mytilus edulis*) culture in Prince Edward Island, Canada. Aquaculture. 292:189-196.

De Alteris, J., Skrobe, L., and Lipsky, C. 1999. The significance of seabed disturbance by mobile fishing gear relative to natural processes: a case study in Narragansett Bay, Rhode Island. Pages 224-237 in L. Beraka (ed.) Fish habitat: essential fish habitat and rehabilitation. American Fisheries Society, Symposium 22. Bethesda, Maryland.

Dealteris, J.T., B.D. Kilpatrick, R.B. Rheault. 2004. A comparative evaluation of the habitat value of shellfish aquaculture gear, submerged aquatic vegetation, and a non-vegetated seabed. Journal of Shellfish Research, Vol. 23, no. 3, 867-874.

Diaz, R.J. and R. Rosenberg. 1995. Marine benthic hypoxia: A review of its ecological effects and the behavioral responses of benthic macrofauna. Oceanogr. Mar. Biol. Annu. Rev. 33: 245–303.

Gibbs, M.T. 2007. Sustainability performance indicators for suspended bivalve aquaculture activities. Ecological Indicators, 7: 94-107.

Hargrave, B.T., L.I. Doucette, P.J. Cranford, B.A. Law and T.G. Milligan. 2008a. Influence of mussel aquaculture on sediment organic enrichment in a nutrient-rich coastal embayment. Mar Ecol. Prog. Ser. 363: 137-149.

Hargrave, B.T., Holmer, M. and Newcombe, C.P. 2008b. Towards a classification of organic enrichment in marine sediments based on biogeochemical indicators. Mar. Poll. Bull. 56: 810-824.

Inglis, G.J., Hayden, B.J., Ross, A.H., 2000. An Overview of Factors Affecting the Carrying Capacity of Coastal Embayments for Mussel Culture. NIWA, Christchurch. Client Report CHC00/69: vi+31 p.

Joyce, S., and I. Thomson. 1999. Earning a Social License to Operate: Social Acceptability and Resource Development in Latin America. Mining Journal, 11 June, 441.

MacKenzie, C.L. (2007). Causes underlying the historical decline in eastern oyster (*Crassostrea virginica* Gmelin, 1791) landings. J. Shellfish. Res. 26(4)927–938

Miller, R.R. et al. 1989. Extinctions of North American fishes during the past century. Fisheries 14: 22-38. Status of endangered fish.

Pearson, T.H. and Rosenberg, R., 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. Oceangr. Mar. Biol. Ann. Rev. 16, 229-311.

Smaal, A.C. & T.C. Prins, 1993. The uptake of organic matter and the release of inorganic nutrients by bivalve suspension feeder beds. In: Dame, R.F. (ed), Bivalve filter feeders in estuarine and coastal ecosystem processes, NATO ASI Series, Series G, Ecological Sciences, Vol. 33. Springer-Verlag, Berlin, p. 271-298 Dame RF and Prins TC (1998) Bivalve carrying capacity in coastal ecosystems. Aquatic Ecology 31: 409 - 421.