Ministry for Primary Industries
Manatū Ahu Matua

LITERATURE REVIEW OF ECOLOGICAL EFFECTS OF AQUACULTURE

Seabird Interactions

CAWTHRON INSTITUTE

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AUGUST 2013

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6.1 Feed-added species (salmon, kingfish, hapuku)

6.1.1 Overview of seabird issues

In New Zealand, the generally perceived negative effects of both feed-added aquaculture and filter feeder aquaculture have centred on entanglement (resulting in birds drowning) and habitat exclusion and displacement from feeding grounds by physical structures, disturbance and changes to the food web. Potential negative effects may also include disturbance of breeding colonies and birds' feeding, blockage of the digestive tract following ingestion of foreign objects, injury or death following collision with farm structures and the spread of pathogens or pest species. In contrast, a potential beneficial effect includes the provision of roost sites closer to foraging areas, thus saving energy in flying to and from more traditional roosting sites and so enabling more efficient foraging. Likewise, the attraction and aggregation of small fish around marine farm structures may provide enhanced feeding opportunities for piscivorous seabirds.

A factor not considered in this summary is that of the effect of seabirds on feed-added, filter feeder and lower trophic level aquaculture through the addition of nutrients via bird faeces. Some birds, especially gulls and shags, may roost on aquaculture structures in considerable numbers and, during their time there, may add large amounts of nutrients to the surrounding water which, in turn, may affect the growth of seaweeds, such as those encrusting upon farm structures.

The location of the farm within the range of seabirds and the conservation status (which is a measure of the risk of extinction) of those seabird species are the main factors that may lead to issues of sustainability and conservation concern. Of particular concern are the location of farms in relation to breeding and feeding sites and the operational procedures of regular farm activities. Siting of farms close to breeding and feeding sites may lead to disturbance of the seabirds, the consequences of which will depend upon the conservation status of the species affected. For example, siting of a farm close to a breeding colony of the nationally endangered king shag could lead to total breeding failure for as long as the farm remains at that site; this would have a significant detrimental effect on the king shag population, and so increase the likelihood of its extinction. Operational procedures can affect the likelihood of seabirds becoming entangled or injured – again, the consequences of this would depend upon the conservation status of the seabird species affected.

Siting of a farm close to a seabird breeding colony is very likely to have an immediate adverse effect that will continue as long as the duration of the farm. In contrast, given the current relatively small size of the aquaculture industry in New Zealand, the overlap of farming activities with the feeding areas of seabirds is unlikely to present significant issues. However, this situation may change as the area occupied by marine farms increases. Entanglement and injury due to collision with farm structures may lead to the death of individual seabirds, the significance of which, again, depends upon the conservation status of the species involved.

At present, potential risks are identified on a case-by-case basis. The most obvious is the choice of site for a farm to avoid disturbance to sensitive breeding colonies of seabirds. The aim of all aquaculture operations is to maximise financial return, so each farm needs to optimise growth of its fish whilst minimising costs. Farms must be managed sustainably so that impacts on the environment are minimised. For example, feed-added aquaculture requires that the finfish are contained in such a manner that the farmed fish do not escape and predators (such as shags and terns) are excluded. This is achieved by adopting measures such as enclosing predator nets above and below cages, keeping nets taut and using mesh sizes less than 6cm. Such management practices also minimise the risk of entanglement. Likewise, food falling through the cages is not only a loss to the farm but can also smother the benthos beneath. Consequently, good farm management aims to maximise food intake by finfish whilst minimising losses to the environment and so both benefit. Minimising the potential for rubbish to get into the sea and ensuring that minimal lighting occurs at night are easily managed on a farm-by-farm basis.

There are significant knowledge gaps concerning almost all seabird species in New Zealand. While overall distribution of most species is well documented, detailed information on the time-specific distribution, abundance and critical habitats is lacking. Associated with the identification of critical habitats is the need to determine key prey species of seabirds in order to identify whether these are affected by farms. Most marine aquaculture farms are sited in sheltered, inshore waters, so future research should focus on the seabird species inhabiting these areas. In addition, there should be ongoing research into the operation, design and maintenance of farm structures that minimise disturbance and entanglement risks. If seabird interactions are identified as a concern, then monitoring of the presence and activities of seabirds around marine aquaculture structures, along with observations of the time of day and duration of such activities should be undertaken. Such information can then lead to species-specific management strategies.

6.1.2: Descriptions of main effects and their significance

Table 6.1: Entanglement caused by feed-added species farms.

Description of effect(s)	Diving birds become entangled in the underwater nets used to contain the farmed fish and so drown. In addition, birds become entangled in above-water nets used to exclude potential predators (such as seabirds and marine mammals) of the farmed fish, resulting in injury to wings and/or legs, which may lead to the birds becoming incapable of flying and/or feeding, and so leading to death. There are no New Zealand reports of seabird deaths as a result of entanglement.
Spatial scale	*Local* to *regional* – scale dependent upon the size of population.
Duration	*Short* to *long term* – minor injury to individual to death of critically endangered animal that can have long-term consequences for vulnerable populations.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges, critical breeding and foraging habitats and/or migration routes. Adopting measures such as enclosing predator nets at the bottom, keeping nets taut, using mesh sizes of less than 6 cm, and keeping nets well maintained (e.g., repairing holes).
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species. Potential significance of entanglement on the various species. Ongoing research into the types of design, maintenance features and operational procedures that minimise entanglement risk.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary
One of the main perceived negative effects of both feed-added and filter feeder aquaculture has centred on entanglement (resulting in birds drowning). However, there are no reports of seabird deaths as a result of entanglement in aquaculture facilities in New Zealand (Butler 2003; Lloyd 2003). Drowning of birds (mostly cormorants) after entering sea cages has occurred overseas (Iwama et al. 1997), but the deployment of top nets over sea cages to exclude birds appears to be an effective management procedure in New Zealand.

Table 6.2: Habitat exclusion caused by feed-added species aquaculture.

Description of effect(s)	The habitat available for surface feeding seabirds, such as gulls, terns and shearwaters, becomes reduced because of the physical presence of farm structures.
Spatial scale	*Local* scale – Including and within 50 metres of the farm.
Duration	*Short* to *long term* – Exclusion may be temporary for migrating species or until resident species habituate to the structures and/or activities, or avoidance may be for the farms' duration and so be permanent.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges, critical breeding and foraging habitats and/or migration routes.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

The potential effects of habitat exclusion are considered to be insignificant given the small area occupied by feed-added aquaculture in New Zealand in relation to the large total area of suitable habitat available for foraging seabirds. Forrest et al. (2007) noted that if any adverse effects of habitat exclusion occurred, then their significance will depend on the spatial scale of the aquaculture facility in relation to the distribution and abundance of prey species. Effective management can be achieved by careful site selection that avoids key foraging areas of seabird species with restricted habitat requirements.

Table 6.3: Smothering of benthos beneath farm feed-added species farm.

Description of effect(s)	The habitat available for benthic feeding seabirds, such as shags and penguins, becomes reduced because of the smothering of the benthos by food residues and faeces from farmed fish.
Spatial scale	*Local scale* – Immediately underneath and within 200 metres of the farm.
Duration	*Long term* – For the duration of the farm.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges. Site selection in areas where marine currents and/or tidal flows disperse waste material from the farm, and so reduce the area over which the impact occurs. Adaptive on-farm management.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species. Food and feeding behaviour of key seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

The potential effects of smothering of the seabed by food residue and faeces, leading to changes in the fauna available to seabirds as prey are considered to be insignificant given the small area occupied by feed-added aquaculture in New Zealand in relation to the large total area of suitable habitats available for foraging seabirds. Forrest et al. (2007) noted that if any adverse effects of the smothering of the benthos occurred, then their significance will depend on the spatial scale of the aquaculture facility in relation to the distribution and abundance of prey species. Effective management can be achieved by careful site selection that avoids key foraging areas of seabird species with more restricted habitat requirements.

Table 6.4: Changed abundance of prey caused by feed-added aquaculture.

Description of effect(s)	Small fish are attracted to the farm to feed on food residue and to shelter under the farm structures. These aggregations may become potential prey of birds such as terns, shags and penguins. In addition, nutrients from the farm entering the water column may cause localised algal blooms that affect the food chain or the ability or birds to obtain their usual prey.
Spatial scale	*Local* scale – Within 100 metres of the farm.
Duration	*Long term* – For the duration of the farm.
Management options	Minimise the amount of food residue from the farm both becoming available to small wild fish and enriching the water in the vicinity of the farms, and so causing algal growth. Site farms in areas with strong marine currents that disperse additional nutrients.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species. Food and feeding behaviour of key seabird species. Effects of enhanced feeding opportunities on key seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Increases in the abundance and diversity of some small fish species around aquaculture facilities have been documented (e.g., Grange 2002), probably attracted by shelter under the farm structures and to feed on food falling through sea cages. Consequently, piscivorous seabirds, such as shags, terns and penguins, may be attracted to, and benefit from, these enhanced feeding opportunities.

Table 6.5: Provision of roosts by feed-added aquaculture.

Description of effect(s)	Floating structures may provide roosting sites for seabirds close to their foraging areas but away from terrestrial predators.
Spatial scale	*Local* scale – On floating farm structures.
Duration	*Long term* – For the duration of the farm.
Management options	Ensure that nets are kept taut so that roosting birds do not become entangled. Use of nets with mesh size less than 6cm to reduce likelihood of entanglement.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most population of seabird species. Effects of nutrient input from faeces of roosting seabirds on phytoplankton and macro-algal growth in the vicinity of aquaculture farm.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Both feed-added and filter feeder aquaculture facilities provide new roosting sites (usually on buoys supporting sea cages or ropes supporting predator exclusion netting). This may benefit some seabird species (Lalas 2001), with shags, gulls and terns most likely to benefit from additional roosting sites close to enhanced feeding opportunities. Use of such new roosting sites may reduce the energy expenditure of the birds because they do not have to fly to and from their natural land-based roosting sites, which may be some distance from their foraging area.

Table 6.6: Disturbance cause by feed-added aquaculture.

Description of effect(s)	The presence of the farm and associated activities, plus the additional boat traffic, disturbs breeding and feeding seabirds.
Spatial scale	*Local* scale – Within 100 metres of the farm.
Duration	*Long term* – For the duration of the farm.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges, critical breeding and foraging habitats.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Increased human activity associated with feed-added and filter feeder aquaculture facilities can have significant detrimental effects on the feeding and breeding of seabirds. For example, small boat traffic, or noise associated with aquaculture facilities, may disturb birds that are feeding or breeding in the vicinity. The easiest means of avoiding significant effects on colonial nesting species, such as shags, gulls and terns, is careful site selection.

Little is known about the distances over which foraging and feeding seabirds may become disturbed. However, it is likely to be species specific. In New Zealand, literature about disturbance distances for king shags in the Marlborough Sounds is ambiguous. For example, Davidson et al. (1995) proposed buffer zones of 300m around roosting sites and 1000 metres around breeding colonies, but Taylor (2000) recommended that small boats do not approach breeding colonies closer than 100m. More recently, Lalas (2001) noted that king shags resting ashore or on emergent objects only flew off when approached to within 30 metres.

Table 6.7: Ingestion of and entanglement associated with foreign objects from feed-added aquaculture.

Description of effect(s)	Impairment of the digestive tract of seabirds through the ingestion of rubbish, flotsam and jetsam originating from farms; entanglement resulting in death.
Spatial scale	*Local* to *bay wide* – A wide area downwind and down current of the aquaculture facility.
Duration	*Long term* – For the duration of the farm.
Management options	Can be controlled through management practices to minimise potential for rubbish from farms to end up in the sea.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Ingestion of marine litter, particularly plastics, is common among seabirds and can cause death by dehydration, blockage of the digestive tract, or toxins released in the intestines. In addition, large numbers of seabirds have been reported to have died as a result of becoming entangled in plastic debris (Derraik 2002). Among seabirds, the ingestion of plastics is directly related to foraging behaviour and diet (Ryan 1987). For example, species that feed on surface or near-surface dwelling invertebrates are more likely to confuse pieces of plastic with their prey than are piscivores, therefore, the former have a higher incidence of ingested plastics (Azzarello & Van-Vleet 1987); although piscivores have been recorded to consume plastic bags and food-handling gloves (P.M. Sagar pers. obs.), both of which may have been mistaken for fish. Also, it should be noted that the harm caused by the ingestion of plastics may not be restricted to the individual seabird that consumed them because adults that regurgitate food to their chicks could pass them onto their offspring (Fry et al. 1987).

Entanglement in plastic debris, especially in discarded fishing gear (nets), is also a very serious threat to seabirds. For example, entanglement accounted for 13 percent to 29 percent of the observed mortality of gannets (*Sula bassana*) in the German Bight (Schrey & Vauk 1987). However, marine litter arising from marine aquaculture operations can be minimised by management practices.

Table 6.8: Attraction to lights from feed-added aquaculture facilities.

Description of effect(s)	Attraction of flying seabirds to lights, resulting in injury or death following collision with farm structures.
Spatial scale	*Local* – Within 100 metres of the farm.
Duration	*Long term* – For the duration of the farm.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges, critical breeding and foraging habitats and/or migration routes. Minimising the use of lights and using only downward-pointing shaded light sources.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Seabirds flying at night may become attracted to artificial lighting and have been recorded colliding with fishing vessels and lighthouses (Montevecchi 2006). The attraction of seabirds to artificial lighting appears to be more pronounced when mist or light rain prevails (P.M. Sagar pers. obs.). The results of such collisions include death as a result of injury. Feeding of some seabirds, particularly species of petrels, shearwaters and shags, is related to the phase of the moon. For example, shags have been recorded foraging at night, with their absences from breeding colonies (presumably on feeding trips) coinciding with a half or full moon, although the greatest majority of feeding occurs during the day (Saptoznikow & Quintana 2002; White et al. 2008). Mitigation measures include site selection to avoid being on the flight path between foraging areas and breeding colonies, minimising the use of lights and using downward shades.

6.2 Filter feeders (green-lipped mussels and Pacific oysters)

6.2.1 Overview of seabird issues

In New Zealand, the generally perceived negative effects of both feed-added aquaculture and filter feeder aquaculture have centred on entanglement (resulting in birds drowning) and habitat exclusion and displacement from feeding grounds. Additional detrimental effects may include disturbance of breeding colonies and birds' feeding, blockage of the digestive tract following ingestion of foreign objects, injury or death following collision with farm structures and the spread of pathogens or pest species. In contrast, a potential beneficial effect includes the provision of roost sites closer to foraging areas, thus saving energy in flying to and from more traditional roosting sites and so enabling more efficient foraging. Likewise, the attraction of aggregations of small fish around marine farm structures may provide enhanced feeding opportunities for piscivorous seabirds.

A factor not considered in this summary is that of the effect of seabirds on feed-added, filter feeder and lower trophic level aquaculture through the addition of nutrients via bird faeces. Some birds, especially gulls and shags, may roost on aquaculture structures in considerable numbers and, during their time there, may add large amounts of nutrients to the surrounding water which, in turn, may affect the growth of seaweeds, such as those encrusting upon farm structures.

The location of the farm within the range of seabirds and the conservation status (which is a measure of the risk of extinction) of those seabird species are the main factors that may lead to issues of sustainability and conservation concern. Of particular concern are the location of farms in relation to breeding and feeding sites and the operational procedures of regular farm activities. Siting of farms close to breeding and feeding sites may lead to disturbance of the seabirds, the consequences of which will depend upon the conservation status of the species affected. For example, siting of a farm close to a breeding colony of the nationally endangered king shag could lead to total breeding failure for as long as the farm remains at that site, this would have a significant detrimental effect on the king shag population and so increase the likelihood of its extinction. Operational procedures can affect the likelihood of seabirds becoming entangled or injured – again, the consequences of this would depend upon the conservation status of the seabird species affected.

Any adverse effects of marine aquaculture on seabirds depend upon the conservation status of the species affected and the duration of the effect. Siting of a farm close to a seabird breeding colony is very likely to have an immediate adverse effect that will continue as long as the duration of the farm. In contrast, given the current relatively small size of the aquaculture industry in New Zealand, the overlap of farming activities with the feeding areas of seabirds is unlikely to present significant issues. However, this situation may change as the area occupied by marine farms increases. Entanglement and injury due to collision with farm structures may lead to the death of individual seabirds, the significance of which, again, depends upon the conservation status of the species involved.

At present, potential risks are identified on a case-by-case basis. The most obvious is the choice of site for a farm to avoid disturbance to sensitive breeding colonies of seabirds. The aim of all aquaculture operations is to maximise financial return, so each farm needs to optimise growth of its fish whilst minimising costs. Farms must be managed sustainably so that impacts on the environment are minimised, for example, reducing the potential for rubbish to get into the sea and ensuring that minimal lighting occurs at night are easily managed on a farm-by-farm basis.

There are significant knowledge gaps concerning almost all seabird species in New Zealand. While overall distribution of most species is well documented, detailed information on the time-specific distribution, abundance and critical habitats is lacking. Associated with the identification of critical habitats is the need to determine key prey species of seabirds in order to identify whether these are affected by farms. Most marine aquaculture farms are sited in sheltered, inshore waters, so future research should focus on the seabird species inhabiting these areas. In addition, there should be ongoing research into the operation, design and maintenance of farm structures that minimise disturbance and entanglement risks. Finally, there should be monitoring of the presence and activities of seabirds around marine aquaculture structures, along with observations of the time of day and duration of such activities. Such information can then lead into species-specific management strategies.

6.2.2 Descriptions of main effects and their significance

Table 6.9: Entanglement caused by filter-feeder species farms.

Description of effect(s)	Diving birds become entangled in underwater ropes, and so drown. There are no New Zealand reports of seabird deaths as a result of entanglement.
Spatial scale	*Local* to *regional-scale* – Depending upon the size of population.
Duration	*Short* to *long term* – Minor injury to individual to death of critically endangered animal that can have long-term consequences for vulnerable populations.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges, critical breeding and foraging habitats and/or migration routes.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species. Potential significance of entanglement on the various species. Ongoing research into the types of design, maintenance features and operational procedures that minimise entanglement risk.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary
The generally perceived negative effects of both feed-added and filter feeder aquaculture have centred on entanglement (resulting in birds drowning), habitat exclusion and displacement from feeding grounds. However, there are no reports of seabird deaths as a result of entanglement in aquaculture facilities in New Zealand (Butler 2003; Lloyd 2003).

Table 6.10: Habitat exclusion due to filter-feeder species farms.

Description of effect(s)	The habitat available for surface feeding seabirds, such as gulls, terns and shearwaters, becomes reduced because of the physical presence of farm structures.
Spatial scale	*Local* – Including and within 50 metres of the farm.
Duration	*Short* to *long term* – Exclusion may be temporary for migrating species or until resident species habituate to the structures and/or activities, or avoidance may be for the farms' duration and so be permanent.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges, critical breeding and foraging habitats and/or migration routes.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

The potential effects of habitat exclusion are considered to be insignificant given the small area occupied by filter-feeder aquaculture in New Zealand in relation to the large total area of suitable habitat available for foraging seabirds. If any adverse effects of habitat exclusion occurred, then their significance will depend on the spatial scale of the aquaculture facility in relation to the distribution and abundance of prey species, as noted for finfish aquaculture (Forrest et al. 2007). Effective management can be achieved by careful site selection that avoids key foraging areas of seabird species with restricted habitat requirements.

Table 6.11: Smothering of benthos beneath filter-feeder aquaculture farms.

Description of effect(s)	The habitat available for benthic feeding seabirds, such as shags and penguins, becomes reduced because of changed benthic fauna due to the settlement of shell and debris from ropes used to grow filter feeders.
Spatial scale	*Local* – Immediately underneath and within 200 metres of the farm.
Duration	*Long term* – For the duration of the farm.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges. Site selection in areas where marine currents and/or tidal flows disperse waste material from the farm and so reduce the area over which the impact occurs. Adaptive on-farm management.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species. Food and feeding behaviour of key seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

The potential effects of smothering of the seabed by debris from ropes leading to changes in the fauna are considered to be insignificant given the small area occupied by filter feeder aquaculture in New Zealand in relation to the large total area of suitable habitat available for foraging seabirds. If any adverse effects of the smothering of the benthos occurred, then their significance will depend on the spatial scale of the aquaculture facility in relation to the distribution and abundance of prey species, as noted for finfish farming by Forrest et al. (2007). Effective management can be achieved by careful site selection that avoids key foraging areas of seabird species with more restricted habitat requirements.

Table 6.12: Changed abundance of prey due to filter-feeder aquaculture operations.

Description of effect(s)	Small fish are attracted to the farm to feed on organisms growing on ropes and to shelter under the farm structures. These aggregations may become potential prey of birds such as terns, shags and penguins.
Spatial scale	*Local* – Within 100 metres of the farm.
Duration	*Long term* – For the duration of the farm.
Management options	None required.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species. Food and feeding behaviour of key seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Increases in the abundance and diversity of some small fish species around aquaculture facilities have been documented (e.g., Grange 2002), probably attracted by shelter under the farm structures and to feed on organisms inhabiting the ropes and farm structures. Consequently, piscivorous seabirds, such as shags, terns and penguins, may be attracted to, and benefit from, enhanced feeding opportunities.

Table 6.13: Provision of roosts by filter-feeder aquaculture.

Description of effect(s)	Floating structures may provide roosting sites for seabirds close to their foraging areas but away from terrestrial predators.
Spatial scale	*Local* – Floating farm structures.
Duration	*Long term* – For the duration of the farm.
Management options	Ensure nets are kept taut so that roosting birds do not become entangled. Use of nets with mesh size less than 6 centimetres to reduce likelihood of entanglement.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species. Effects of nutrient input from faeces of roosting seabirds on phytoplankton and macro-algal growth in the vicinity of aquaculture farm.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Both feed-added and filter feeder aquaculture facilities provide new roosting sites (usually on buoys supporting sea cages or ropes supporting predator exclusion netting). This may benefit some seabird species (Lalas 2001), with shags, gulls and terns most likely to benefit from additional roosting sites close to enhanced feeding opportunities. Use of such new roosting sites may reduce the energy expenditure of the birds because they do not have to fly to and from their natural land-based roosting sites, which may be some distance from their foraging area.

Table 6.14: Disturbance by filter-feeder aquaculture.

Description of effect(s)	The presence of the farm and associated activities, plus the additional boat traffic, disturbs breeding and feeding seabirds.
Spatial scale	*Local* – Within 100 metres of the farm.
Duration	*Long term* – For the duration of the farm.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges, critical breeding and foraging habitats.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Increased human activity associated with filter feeder aquaculture facilities can have significant detrimental effects on the feeding and breeding of seabirds. For example, small boat traffic, or noise associated with aquaculture facilities, may disturb birds that are feeding or breeding in the vicinity. The easiest means of avoiding significant effects on colonial nesting species, such as shags, gulls and terns, is careful site selection.

Little is known about the distances over which foraging and feeding seabirds may become disturbed. However, it is likely to be species specific. In New Zealand, literature about disturbance distances for king shags in the Marlborough Sounds is ambiguous. For example, Davidson et al. (1995) proposed buffer zones of 300 metres around roosting sites and 1000 metres around breeding colonies, but Taylor (2000) recommended that small boats do not approach breeding colonies closer than 100 metres. More recently, Lalas (2001) noted that king shags resting ashore or on emergent objects only flew off when approached to within 30 metres.

Table 6.15: Ingestion of and entanglement associated with foreign objects from filter-feeder aquaculture.

Description of effect(s)	Impairment of the digestive tract of seabirds through the ingestion of rubbish, flotsam and jetsam originating from farms; entanglement resulting in death.
Spatial scale	*Local* to *bay-wide* – A wide area downwind and down current of the aquaculture facility.
Duration	*Long term* – For the duration of the farm.
Management options	Management practices to minimise potential for rubbish from farms to end up in the sea.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most population of seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Ingestion of marine litter, particularly plastics, is common among seabirds and can cause death by dehydration, blockage of the digestive tract, or toxins released in the intestines. In addition, large numbers of seabirds have been reported to have died as a result of becoming entangled in plastic debris (Derraik 2002). Among seabirds, the ingestion of plastics is directly related to foraging behaviour and diet (Ryan 1987). For example, species that feed on surface or near-surface dwelling invertebrates are more likely to confuse pieces of plastic with their prey than are piscivores, therefore, the former have a higher incidence of ingested plastics (Azzarello & Van-Vleet 1987); although piscivores have been recorded to consume plastic bags and food-handling gloves (P.M. Sagar pers. obs.), both of which may have been mistaken for fish. It should also be noted that the harm caused by the ingestion of plastics may not be restricted to the individual seabird that consumed them because adults that regurgitate food to their chicks could pass them onto their offspring (Fry et al. 1987).

Entanglement in plastic debris, especially in discarded fishing gear (nets), is also a very serious threat to seabirds. For example, entanglement accounted for 13 percent to 29 percent of the observed mortality of gannets (*Sula bassana*) in the German Bight (Schrey & Vauk 1987). However, marine litter arising from marine aquaculture operations can be minimised by management practices.

Table 6.16: Attraction to lights of filter-feeder aquaculture operations.

Description of effect(s)	Attraction of flying seabirds to lights, resulting in injury or death following collision with farm structures.
Spatial scale	*Local* – Within 100 metres of the farm.
Duration	*Long term* – for the duration of the farm.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges, critical breeding and foraging habitats and/or migration routes. Minimising the use of lights and using only downward-pointing shaded light sources.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Seabirds flying at night may become attracted to artificial lighting and have been recorded colliding with fishing vessels and lighthouses (Montevecchi 2006). The attraction of seabirds to artificial lighting appears to be more pronounced when mist or light rain prevail (P.M. Sagar pers. obs.). The results of such collisions include death as a result of injury. Feeding of some seabirds, particularly species of petrels, shearwaters and shags, is related to the phase of the moon. For example, shags have been recorded foraging at night, with their absences from breeding colonies (presumably on feeding trips) coinciding with a half or full moon, although the great majority of feeding occurs during the day (Saptoznikow & Quintana 2002; White et al. 2008). Mitigation measures include site selection to avoid being on the flight path between foraging areas and breeding colonies, minimising the use of lights and using downward-pointing and shaded lights.

6.3 Lower trophic level species (*Undaria* and sea cucumbers)

6.3.1 Overview of seabird issues

Lower trophic level aquaculture is taken to include sea horses, seaweeds, sea cucumbers, sea urchins, sponges and paua.

A factor not considered in this summary is that of the effect of seabirds on feed-added, filter feeder and lower trophic level aquaculture through the addition of nutrients via bird faeces. Some birds, especially gulls and shags, may roost on aquaculture structures in considerable numbers and, during their time, there may add large amounts of nutrients to the surrounding water which, in turn, may affect the growth of seaweeds, for example *Undaria.*

The location of the farm within the range of seabirds and the conservation status (which is a measure of the risk of extinction) of those seabird species are the main factors that may lead to issues of sustainability and conservation concern. Of particular concern are the location of farms in relation to breeding and feeding sites and the operational procedures of regular farm activities. Siting of farms close to breeding and feeding sites may lead to disturbance of the seabirds, the consequences of which will depend upon the conservation status of the species affected. For example, siting of a farm close to a breeding colony of the nationally endangered king shag could lead to total breeding failure for as long as the farm remains at that site, this would have a significant detrimental effect on the king shag population and so increase the likelihood of its extinction. Operational procedures can affect the likelihood of seabirds becoming entangled or injured – again, the consequences of this would depend upon the conservation status of the seabird species affected.

Any adverse effects of marine aquaculture on seabirds depend upon the conservation status of the species affected and the duration of the effect. Siting of a farm close to a seabird breeding colony is very likely to have an immediate adverse effect that will continue as long as the duration of the farm. In contrast, given the current relatively small size of the aquaculture industry in New Zealand, the overlap of farming activities with the feeding areas of seabirds is unlikely to present significant issues. However, this situation may change as the area occupied by marine farms increases. Entanglement and injury due to collision with farm structures may lead to the death of individual seabirds, the significance of which, again, depends upon the conservation status of the species involved.

At present, potential risks are identified on a case-by-case basis. The most obvious is the choice of site for a farm to avoid disturbance to sensitive breeding colonies of seabirds. The aim of all aquaculture operations is to maximise financial return, so each farm needs to optimise growth of its fish whilst minimising costs. To do so, the farm has to be managed sustainably so it minimises the impacts on the environment.

Consequently, farm management maximises food intake by finfish whilst minimising loses to the environment so both benefit. Minimising the potential for rubbish to get into the sea and ensuring that minimal lighting occurs at night are easily managed on a farm-by-farm basis.

There are significant knowledge gaps concerning almost all seabird species in New Zealand. While overall distribution of most species is well documented, detailed information on the time-specific distribution, abundance and critical habitats is lacking. Associated with the identification of critical habitats is the need to determine key prey species of seabirds in order to identify whether these are affected by farms. Most marine aquaculture farms are sited in sheltered, inshore waters and so future research should focus on the seabird species inhabiting these areas.

In addition, there should be ongoing research into the operation, design and maintenance of farm structures that minimise disturbance and entanglement risks. Finally, there should be monitoring of the presence and activities of seabirds around marine aquaculture structures, along with observations of the time of day and duration of such activities. Such information can then lead into species-specific management strategies.

6.3.2 Descriptions of main effects and their significance

Table 6.17: Entanglement in lower trophic-level aquaculture facilities.

Description of effect(s)	Diving birds become entangled in underwater nets and ropes and so drown. There are no New Zealand reports of seabird deaths as a result of entanglement.
Spatial scale	*Local* to *regional* scale – Depending upon the size of seabird population.
Duration	*Short* to *long term* – Minor injury to individual to death of critically endangered animal that can have long-term consequences for vulnerable populations.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges, critical breeding and foraging habitats and/or migration routes. By adopting measures such as enclosing predator nets at the bottom, keeping nets taut, using mesh sizes of less than 6 centimetres, and keeping nets well maintained (e.g., repairing holes).
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species. Potential significance of entanglement on the various species. Ongoing research into the types of design, maintenance features and operational procedures that minimise entanglement risk.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

The generally perceived negative effects of lower trophic level aquaculture have centred on entanglement (resulting in birds drowning), habitat exclusion and displacement from feeding grounds. However, there are no reports of seabird deaths as a result of entanglement in aquaculture facilities in New Zealand (Butler 2003; Lloyd 2003).

Table 6.18: Habitat exclusion caused by lower-trophic level aquaculture.

Description of effect(s)	The habitat available for feeding seabirds, such as shags, gulls, terns and shearwaters, becomes reduced because of the physical presence of farm structures.
Spatial scale	*Local* – Within 50 metres of the farm.
Duration	*Long term* – for the duration of the farm.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges, critical breeding and foraging habitats and/or migration routes.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

The potential effects of habitat exclusion are considered to be insignificant given the small area occupied by lower trophic level aquaculture in New Zealand in relation to the large total area of suitable habitat available for foraging seabirds. Forrest et al. (2007) noted that if any adverse effects of habitat exclusion occurred, then their significance will depend on the spatial scale of the aquaculture facility in relation to the distribution and abundance of prey species. Effective management can be achieved by careful site selection that avoids key foraging areas of seabird species with restricted habitat requirements.

Table 6.19: Changed abundance of prey caused by lower trophic-level aquaculture.

Description of effect(s)	Small fish are attracted to the farm to feed on organisms growing on ropes/nets/cages and to shelter under the farm structures. These aggregations may become potential prey of birds such as terns, shags and penguins.
Spatial scale	*Local* – Within 100 metres of the farm.
Duration	*Long term* – For the duration of the farm.
Management options	None required.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species. Food and feeding behaviour of key seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary
Increases in the abundance and diversity of some small fish species around aquaculture facilities have been documented (e.g., Grange 2002), probably attracted by shelter under the farm structures and to feed on organisms inhabiting the ropes and/or farm structures. Consequently, piscivorous seabirds, such as shags, terns and penguins, may be attracted to, and benefit from, these enhanced feeding opportunities.

Table 6.20: Provision of roosts by lower trophic-level aquaculture.

Description of effect(s)	Floating structures may provide safe roosting sites for seabirds close to their foraging areas and away from terrestrial predators.
Spatial scale	*Local* – Floating farm structures.
Duration	*Long term* – For the duration of the farm.
Management options	Ensure nets are kept taut so that roosting birds do not become entangled. Use of nets with mesh size less than 6 centimetres to reduce likelihood of entanglement.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most population of seabird species. Effects of nutrient input from faeces of roosting seabirds on phytoplankton and macro-algal growth in the vicinity of aquaculture farm.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary
Aquaculture facilities provide new roosting sites (usually on buoys supporting sea cages or ropes supporting predator exclusion netting). This may benefit some seabird species (Lalas 2001), with shags, gulls and terns most likely to benefit from additional roosting sites close to enhanced feeding opportunities. Use of such new roosting sites may reduce energy expenditure of the birds because they do not have to fly to and from their natural land-based roosting sites, which may be some distance from their foraging area.

Table 6.21: Disturbance caused by lower trophic-level aquaculture.

Description of effect(s)	The presence of the farm and associated activities, plus the additional boat traffic, disturbs breeding and feeding seabirds.
Spatial scale	*Local scale* – Within 100 metres of the farm.
Duration	*Long term* – For the duration of the farm.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with limited species' home ranges, critical breeding and foraging habitats.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Increased human activity associated with aquaculture facilities can have significant detrimental effects on the feeding and breeding of seabirds. For example, small boat traffic, or noise associated with aquaculture facilities, may disturb birds that are feeding or breeding in the vicinity. The easiest means of avoiding significant effects on colonial nesting species, such as shags, gulls and terns, is careful site selection.

Little is known about the distances over which foraging and feeding seabirds may become disturbed. However, it is likely to be species specific. In New Zealand, literature about disturbance distances for king shags in the Marlborough Sounds is ambiguous. For example, Davidson et al. (1995) proposed buffer zones of 300m around roosting sites 1000 metres and around breeding colonies, but Taylor (2000) recommended that small boats do not approach breeding colonies closer than 100 metres. More recently, Lalas (2001) noted that king shags resting ashore or on emergent objects only flew off when approached to within 30 metres.

Table 6.22: Ingestion of and entanglement associated with foreign objects from lower trophic-level aquaculture.

Description of effect(s)	Impairment of the digestive tract of seabirds through the ingestion of rubbish, flotsam and jetsam originating from farms; entanglement resulting in death.
Spatial scale	*Local* – *Bay-wide* downwind and down current of the aquaculture facility.
Duration	*Long term* – for the duration of the farm.
Management options	Management practices to minimise potential for rubbish from farms to end up in the sea.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most population of seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Ingestion of marine litter, particularly plastics, is common among seabirds and can cause death by dehydration, blockage of the digestive tract, or toxins released in the intestines. In addition, large numbers of seabirds have been reported to have died as a result of becoming entangled in plastic debris (Derraik 2002). Among seabirds, the ingestion of plastics is directly related to foraging behaviour and diet (Ryan 1987). For example, species that feed on surface or near-surface dwelling invertebrates are more likely to confuse pieces of plastic with their prey than are piscivores, therefore, the former have a higher incidence of ingested plastics (Azzarello & Van-Vleet 1987); although piscivores have been recorded to consume plastic bags and food-handling gloves (P.M. Sagar pers. obs.), both of which may have been mistaken for fish. It should also be noted that the harm caused by the ingestion of plastics may not be restricted to the individual seabird that consumed them because adults that regurgitate food to their chicks could pass them onto their offspring (Fry et al. 1987).

Entanglement in plastic debris, especially in discarded fishing gear (nets), is also a very serious threat to seabirds. For example, entanglement accounted for 13 percent to 29 percent of the observed mortality of Gannets (*Sula bassana*) in the German Bight (Schrey & Vauk 1987). However, marine litter arising from marine aquaculture operations can be minimised by management practices.

Table 6.23: Attraction to lights from lower trophic level aquaculture.

Description of effect(s)	Attraction of flying seabirds to lights, resulting in injury or death following collision with farm structures.
Spatial scale	*Local* – Within 100 metres of the farm.
Duration	*Long term* – For the duration of the farm.
Management options	Site selection to minimise or avoid the likelihood of spatial overlap with range restricted species' home ranges, critical breeding and foraging habitats and/or migration routes. Minimising the use of lights and using only downward pointing shaded light sources.
Knowledge gaps	Home ranges or location of important feeding and breeding habitats for most populations of seabird species.

* Italicised text in this table is defined in chapter 1 – Introduction.

Summary

Seabirds flying at night may become attracted to artificial lighting and have been recorded colliding with fishing vessels and lighthouses (Montevecchi 2006). The attraction of seabirds to artificial lighting appears to be more pronounced when mist or light rain prevails (P.M. Sagar pers. obs.). The results of such collisions include death as a result of injury. Feeding of some seabirds, particularly species of petrels, shearwaters and shags, is related to the phase of the moon, For example, shags have been recorded foraging at night, with their absences from breeding colonies (presumably on feeding trips) coinciding with a half or full moon, although the greatest majority of feeding occurs during the day (Saptoznikow & Quintana 2002; White et al. 2008). Mitigation measures include site selection to avoid being on the flight path between foraging areas and breeding colonies, minimising the use of lights and using downward shades.

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