

CHAPTER SEVEN

SCARING DEVICE TRIAL

7.1 Introduction

In both freshwater and marine aquaculture, conflicts with birds can cause tens to hundreds of thousands of dollars of economic loss to aquaculture industries (EIFAC, 1988). Losses are incurred through:

- Stock losses through direct predation, mortality from predation inflicted wounds or escapees from bird damaged nets (EIFAC, 1988; Price & Nickum, 1995).
- Reduced marketability of fish through damage to skin/scales/flesh (Price & Nickum, 1995).
- Interference with artificial feeding. The birds either directly compete for fish feed or their presence stresses the fish, both resulting in reduced growth from reduced feed consumption (EIFAC, 1988; Price & Nickum, 1995).
- Increased risk of spread of disease or continuation of disease outbreaks. Birds can transmit disease and parasites from pond to pond and farm to farm. Stressed fish are also more susceptible to disease (EIFAC, 1988; Price & Nickum, 1995).

Due to the costs associated with bird predation, much research has been undertaken by scientists and aquaculturists on various methods to discourage birds from interacting with farm operations. For example, USDA's (US Department of Agriculture) animal damage control unit (ADC) spent around US\$8 million from 1985 to 1995 conducting research on exclusion and scaring devices for aquaculture facilities (Price & Nickum, 1995). Commonly used methods include various types of

visual deterrents such as balloons, streamers, flags and scarecrows; frightening devices such as firecrackers, propane cannons and shooting; and exclusion devices such as netting ponds, fencing and grids of monofil/nylon wire (Glahn *et al.*, 1999). However, as different species of birds have different modes of predating (such as wading, diving, swooping or surface feeding: Howell & Munford, 1991) there is no one universal or simple solution.

Many of the bird species known to cause problems are protected by law (eg cormorants, herons, sea eagles), so directly killing them by shooting is not a viable or well considered option. In addition, shooting has been shown to be largely ineffective because culled birds are likely to be replaced by immigration and dispersed birds may return once the persecution has relaxed (Van Vessem *et al.*, 1985; Howell & Munford, 1991; Furness, 1996). Continuous human presence has been shown to be effective in reducing the number of birds on some land-based farms in the US and Europe (Howell & Munford, 1991), as the majority of these bird species (herons, cormorants etc.) are shy and avoid people (Howell & Munford, 1991; Carss, 1993). However this method does not deter species such as gulls which are brazen scavengers (Huon Aquaculture, pers. comm.; Soldatini *et al.*, 2007).

Traditional deterrents involve acoustic (guns, sirens, whistles, metallic noises) or visual (flashing lights, scarecrows) alarms. Propane cannons are commonly used on fish ponds in the USA, but they quickly become ineffective (Huner, 1997). The use of bio-acoustics, which is the broadcasting of bird distress and predatory bird calls has been trialled for several species of birds at various sites such as refuse dumps and landfill sites (Howard, 2001; Soldatini *et al.*, 2007), oil platforms (Anonymous,

1996) and aquaculture farms sites in the USA (Andelt & Hopper, 1996) and Australia (Huon Aquaculture, pers. comm.). While this method has been reported to be successful for one landfill site (Howard, 2001) and an oil platform (Anonymous, 1996) it has been reported to be unsuccessful for other sites. Gulls quickly habituated to this type of acoustic deterrent at a refuse depot in Venice (Soldatini *et al.*, 2007), at Rainbow Trout ponds in the US (Andelt & Hopper, 1996) and at Atlantic Salmon farms in Tasmania, Australia (Huon Aquaculture, pers. comm.), and predation rates of trout fingerlings and salmon feed was not reduced.

Habituation to acoustic deterrents appears to be very rapid, and in some cases the predator reaction may go beyond habituation to association and attraction (Howell & Munford, 1991). For example, birds become accustomed to the loud noise of propane cannons (Hall & Price, 2003) and can use the noise to locate feeding sites (Huner, 1997). Draulans (1987) suggested that in most cases acoustic and visual scarers have at best a short term effect (no longer than a month) although this could be prolonged by varying the location of devices around the site and ensuring they are activated as soon as predators arrive, rather than at preset time intervals (Howell & Munford, 1991). However, the effectiveness of audible devices varies with species so more than one stimulus may need to be used. A successful example of this has been reported in Canada to deter seabirds from oil spills (Ronconi *et al.*, 2004). The system is a radar-activated on-demand deterrence systems which detects a flock of birds before they reach a particular site and subsequently sets off several types of deterrents to keep the birds in the air (Ronconi *et al.*, 2004).

Complete exclusion methods (such as netting an entire pond) are the most effective

means of stopping predation by all species (Price & Nickum, 1995; Glahn *et al.*, 1999). Glahn *et al.*, (1999) reported exclusion nets to completely eliminate predation on land-based ponds and Avery *et al.*, (1999) showed netting could increase the production of tropical fish in inland ponds by 50% compared to non-netted ponds. They have also been shown to be effective on Atlantic and Pacific Salmon farms in Europe, the United States and Canada (Howell & Munford, 1991; Price & Nickum, 1995) and more locally on Atlantic Salmon farms in Tasmania (Huon Aquaculture, pers. comm.). However, the nets are costly and can interfere with the usual work activities around ponds such as feeding and harvesting and are not feasible for large ponds and some seacages (Glahn *et al.*, 1999). If nets are used, their successful operation depends on the correct combination of mesh size, tension and positioning and it is crucial that they are properly maintained to ensure damage and deterioration is quickly repaired (Howell & Munford, 1991). If improperly set up, they can be quite ineffective as herons have been shown to sit on top of the nets of sea cage farms and weigh them down to access fish (Price & Nickum, 1995). Netting can also lead to substantial bird mortality through entanglement and drowning unless they adhere to specific guidelines such as using thick, dark material and no monofilament line; a mesh size of 5-7cm; good maintenance; keeping the top of pond netting not taut but not drooping in the water (Furness, 1996; Nemptzov & Olsvig-Whittaker, 2003).

Strategically placed nylon lines have been shown to effectively deter gulls from factory roofs and landfill sites (Belant & Ickes, 1996; Temby, 2003). Similarly, stringing nylon lines in a grid pattern across ponds or raceways has been shown to be relatively effective on some land-based farms (Glahn *et al.*, 1999), but not others as

deterrence can be species specific (Howell & Munford, 1991). It may also only reduce the number of birds that predate at a particular time and do not exclude them entirely (Howell & Munford, 1991). In addition, when used on seacages, they can snap or sag due to the need to maintain pontoon flexibility in rough seas, rendering them ineffective (Huon Aquaculture, pers. comm.).

Newer, more novel methods that have been trialled include a solar powered, robotic boat that travels up and down the length of a pond (the ‘scarebot’) (Hall & Price, 2003). It can sense motion and uses a water cannon to drive away birds. It has been shown to reduce bird abundance on aquaculture ponds by between 64-71% and can also measure water quality parameters. While it can reduce the labour required to scare birds, the ‘scarebot’ is costly and there are concerns about maintaining power, self sufficiency and safety and maintenance (Hall & Price, 2003). It is also a good example of a device that works well on land-based ponds, but would be likely to be damaged very quickly in the more severe weather conditions encountered on marine farms.

Another novel method is the addition of a non-lethal repellent to fish pellets to prevent bird predation (Harpaz & Clark, 2006). The grape juice flavour enhancer, methyl anthranilate, is highly unpalatable to birds, while mammals are indifferent to it. It has been used successfully as a bird repellent additive in livestock feed (Mason *et al.*, 1985; Glahn *et al.*, 1989) and to deter birds from crops and water bodies (Clark *et al.*, 1991; Dolbeer *et al.*, 1992; Clark & Shah, 1993; Avery, 2002). It was also effective when placed around the circumference of aquaculture ponds in Israel (Harpaz & Clarke, 2006), however, a similar method was found to be ineffective at

catfish farms in the USA (Dorr *et al.*, 1998). Harpaz & Clark (2006) added it to fish feed in a laboratory study, which showed the fish retained the chemical for a short length of time, while having little effect on fish growth and behaviour (GRAS classification) but it is unknown whether it would effectively reduce their predation by birds.

Thus, although many methods have been used to effectively reduce fish predation and scavenging of feed by birds, many were developed for land-based farms, with few options for seacages.

In Port Lincoln, seabirds, in particular the Silver Gull, but also Crested Terns, Pacific Gulls and Short-tailed Shearwaters, scavenge the baitfish fed to the SBT held in pontoons offshore. The majority of feed is scavenged during shovel feeding which is not only visually attractive to the birds, but also makes the food readily available as is strewn across the water surface and slowly sinks. Feed loss to seabirds for the shovel method was 5.3% in 2003, however, no feed was lost when tuna were fed using the frozen block method (Harrison, 2003). The frozen block feeding method (See Chapter 2.2.1.2) is equivalent to netting an entire pond or seacage, where the success of the approach is determined by feed cage mesh size, design and maintenance. Although it effectively reduces feed loss to birds, it is believed this method does not encourage the tuna to feed properly at the start of the season when they are first placed into the pontoons, whereas shovel feeding does stimulate the tuna to feed and consequently many companies still use the shovel method, despite the losses. The shovel method also brings the tuna to the surface, so that the skipper can watch them feed, and monitor feeding rate and satiety, which they see as an

advantage over frozen block feeding, where they have little feedback on the feeding of the tuna. Thus a deterrence method should be used to reduce feed loss to scavenging birds whilst shovel feeding.

The tuna industry uses a few methods to deter seabirds from scavenging feed. These include the 'float on a rope', which is one of the scaring devices used in this trial. They also have also used methods such as throwing coiled rope out, shouting at the birds, striking feed bins with a shovel, cracking a whip and hanging chains from the crane over the feed area. Although exclusion netting over the entire pontoon would probably be effective, as it has been shown to be successful on Atlantic Salmon farms in Tasmania with similar sea conditions (Huon Aquaculture, pers. comm.), it is unlikely to be used on the tuna farms as it is perceived to be too costly to erect and would constrain routine activities (feeding, cage maintenance and harvest) on the farms (tuna farm managers, pers. comm.) and therefore exclusion netting was not considered as an option in this trial. Stringing nylon lines across the cages was also excluded because they would constrain feeding, be likely to break as the pontoon changes shape with the sea conditions and in addition, would pose a potential safety risk as workers on the outer ring of the pontoon could be injured by breaking line.

A range of scaring methods were trialled including an audible scaring device, and three types of devices that were both visual and physical deterrents, but worked in different ways. The air horn was used to test whether a loud noise would scare the birds away. The float on the rope, while already used by some companies, was used to test whether a visual throwing mechanism as well as a potential collision risk would deter birds. Squirting the birds with a water cannon has been shown to be

successful on longliners (Environment Australia, 1998) and by the ‘scarebot’ (Hall & Price, 2003) and thus we used the deck hose to test this method of deterrence.

Waving objects around is frequently used as a means to deter seabirds on feed boats and we tested the long handled gaff as an example of this method.

The devices chosen were objects that are commonly found on all feed boats, and therefore had no cost. They were also easy to use and therefore, if effective would be more likely to be implemented.

Aims

The primary aim of this chapter was to investigate the efficacy of four simple seabird scaring devices in reducing feed loss and seabird abundance at SBT farms compared to a control (no scarer used).

The aims of this trial were to answer the following questions.

- Do results from the preliminary trial suggest that a scaring device trial should be undertaken?
- Do scaring devices reduce the amount of tuna feed consumed by seabirds?
- Do scaring devices reduce seabird abundance inside tuna pontoons?
- Do scaring devices reduce seabird abundance outside tuna pontoons?
- To compare the effectiveness of each scaring device for the above questions.

Hypotheses

H0: The use of scaring devices during shovel feeding will have no effect on the amount of feed scavenged by seabirds.

HA: The use of a scaring device whilst shovel feeding will change the amount of feed scavenged by seabirds.

H0: The use of scaring devices during shovel feeding will have no effect on seabird

abundance both inside and outside the pontoon.

HA: The use of a scaring device whilst shovel feeding will have an effect on seabird abundance both inside and outside the pontoon.

H0: The type of deterrent (visual, physical, audible) will have no impact on the amount of feed scavenged by seabirds.

HA: The type of deterrent (visual, physical, audible) will have an impact on the amount of feed scavenged by seabirds.

7.2 Methods

7.2.1 Study Area

Two trials were undertaken on the Tuna Research Farms in 2005 and 2006 to test the efficacy of several scaring devices in reducing feed loss to scavenging seabirds. The devices were trialled during shovel feeding of several different species of baitfish used by the commercial tuna farming sector. All baitfish used were of a size that was attractive to Silver Gulls and other seabirds present.

Preliminary Trial

The preliminary trial took place during the commercial tuna season, on four days between April and June 2005 on the four Tuna Research pontoons maintained by DI Fishing. This trial was undertaken to ascertain whether using a scaring device would successfully reduce feed loss to scavenging seabirds and whether a larger scale trial was warranted.

The pontoons used were smaller in diameter (32m) than commercial pontoons (50m) and generally, the food was distributed into the pontoons once a day, which meant

there were four feeding events per day. Three methods were trialled using two scaring devices (float on a rope and the long handled gaff separately, and also the float and gaff together) plus a control in which there was no scarer.

Full Scale Trial

The second trial took place outside of the tuna season, on 13 days during December 2005 and January 2006 on a single Tuna Research pontoon serviced by DI Fishing. This pontoon was being used in the tuna Long Term Holding Project and was a 32m diameter cage. Four devices were tested during this period (float on a rope, long handled gaff, deck hose and air horn), plus a control (no scarer).

7.2.2 Scaring Devices Used

Float on a rope

As the name suggests, this device is a 22cm diameter float or buoy, tied to a 9mm rope and thrown out over the feeding area every few minutes. Although it is not believed to be relevant, two different coloured floats were used (red and yellow) because two different boats were used to feed the fish on different days. These were treated as the same device. The device is primarily a visual scaring device, but its physical presence is likely to have an effect as well (as it has the potential to collide with birds). The free end of the rope was attached to the side rail on the boat and the float was then thrown out by a deckhand about half way across the cage, pulled back in and launched again (Figures 7.1, 7.2 & 7.3).



Figure 7.1: Throwing the float on a rope.



Figure 7.2: The float on a rope (red float).



Figure 7.3: The float on a rope (yellow float).

Long Handled Gaff

The long handled gaff is used to pick objects out of the water, for example plastic or cardboard used to wrap baitfish. It is a three to four metre long wooden pole with a large stainless steel hook on the end. The gaff was waved back and forth near the area where the feed was distributed. It is believed to have a visual scaring function and a slight physical presence as it was waved over part of the feed area (Figures 7.4 & 7.5).



Figure 7.4: Waving the long handled gaff.



Figure 7.5: The long handled gaff.

Air Horn

The air horn is a hand-held sounding and safety device kept on all boats. It was used as a loud, acoustic scaring device in this trial and was sounded for 2-3 seconds every few shovel loads (Figure 7.6).



Figure 7.6: The air horn.

Deck Hose

All feed boats have a deck hose on board for cleaning purposes and the provision of seawater for thawing frozen baitfish for shovelling or for feed siphoning. The deck hose was believed to function as both a visual and physical deterrent because it was sprayed over the feed area and the birds could both see the water and would be hit by the jet if attempting to feed. The deck hose was either hand-held or tied to the side of the boat and pointed out towards the pontoon (Figure 7.7). It was angled so that it sprayed water (flow rate ~25 litres/min) over the area where feed was distributed. The carry and drift of the spray was greatly affected by the wind speed and direction (Figure 7.8).



Figure 7.7: The deck hose.



Figure 7.8: The wind affecting the carry and drift of the water from the deck hose.

Control (no scarer)

Feed loss rates to birds using no scaring device were also obtained during this trial as it was unlikely that rates would be comparable to that of commercial farms due to the seasonal and stocking density factors explained below.

Allocation of Scaring Device

Preliminary Trial

As four pontoons were used during the preliminary trial, scaring devices were allocated randomly and used for the entire feeding event (the time taken to distribute food to the tuna). The exception was collecting data for the feeding with no device (control). Feed loss to birds was high using no scaring device and as these tuna were being used for another experiment, this treatment was only undertaken twice and was used at the start of a feeding event. The decision to only have two control feeding events was made by the skipper of the vessel after consultation with the researcher. It was unreasonable to insist that the nutrition of the tuna and the results of the other study be potentially compromised by the experiment.

The float on a rope was observed over 8 feeding events (19 April x 4, 19 May x 2, 23 June x 2), the long handled gaff over 4 feeding events (19 May x 2, 23 June x 2), the long handled gaff and float combined over 2 feeding events (17 June x 2) and the control at the start of 2 feeding events (17 June x 2).

Full Scale Trial

As only one pontoon, which was fed twice a day, was used during the full scale trial, it was not possible to use a scaring device for an entire feeding event as not enough data would have been obtained. Instead, two scaring devices were used per feeding event, for half a feeding event each over 13 days (Table 7.1). Scaring devices were randomly allocated, as was the control (no device), over 18 feeding events.

Therefore, if both the morning and afternoon feed were observed, it was possible to test a maximum of four scaring devices a day. Each scaring device and control were allocated a similar number of first half feeding events as second half feeding events.

This meant that any effect of time and previous scaring device was equal for all devices. Overall, 8 trials were undertaken for each scaring device over a period of 50 days, with a break over Christmas from 22/12/05 to 16/1/06.

Table 7.1: Full scale scaring device trial test dates.

	Number of times tested	Dates observed
Control	9	7, 9, 19(x2) December 16, 18, 23(x2), 24 January
Float on a rope	8	7, 8, 13, 21(x2) December 18, 24, 25 January
Long-handled gaff	8	8, 19(x2), 20(x2) December 16, 18, 24 January
Deck hose	8	7, 8, 20(x2) December 16, 18, 23, 25 January
Air horn	8	9, 19, 21(x2) December 17(x2), 24, 25 January

7.2.3 Observations

Amount of Feed Consumed by Seabirds

The method used to estimate the amount of feed scavenged by seabirds during the trial was the same method described for shovel feeding in Chapter 2.2.2.1.

Seabird Abundance

Seabird numbers were estimated using a direct counting method or an estimation method as described previously in Chapter 2.2.3 and 2.3.

They were recorded for two positions around the pontoon.

1. Inside and above the pontoon.
2. Outside the pontoon.

Seabird abundance was recorded twice during every trial of a scaring device and the average was taken to determine abundance.

Feeding Rate

In both trials, the cages used had a much lower stocking density of tuna than occurs on commercial farms. The feed was therefore fed out at a much slower rate and floated for a reasonably long time, which meant that there was more feed available to birds than would occur on a commercial farm.

7.2.4 Data Analysis

The preliminary trial data were analysed using Kruskal Wallis Tests to analyse for differences in: percent feed lost to seabirds; seabird abundance inside and above the cage; and seabird abundance outside the cage, between the three scaring device methods and a control. This test was used as the sample sizes were too small to meet the assumptions for a One Way ANOVA.

A One Way ANOVA was used to analyse for differences in percent feed loss during tuna feeding using the five methods (four scaring devices plus a control) for the full scale trial. The Brown Forsythe test was used as a robust test of equality of means as the assumption of homogeneity of variance was violated. Post hoc analyses were performed using the Tukey HSD method to assess pair wise comparisons.

An arcsin transformation was applied to the percentage feed loss data, but this was found not to be necessary, as the results for the un-transformed and transformed data were very similar.

A One Way ANOVA was used to analyse for differences in seabird abundance inside and above the pontoon during tuna feeding using the five methods (four scaring devices plus a control). Post hoc analyses were performed using the Tukey HSD

method to assess pair wise comparisons.

7.3 Results

7.3.1 Preliminary Trial

7.3.1.1 Feed Loss Comparisons

Feed loss to seabirds during control feeding (no scaring) was 10-20 fold higher than feed loss when a scaring device was used (Table 7.2); however, the small samples meant the difference was not significant (Kruskall Wallis: $\chi^2_3 = 6.522$, $p = 0.089$).

The percentage data indicate that the float on the rope method appeared to reduce the amount of feed scavenged by birds most effectively, closely followed by using both the float and gaff together, and then the long handled gaff alone (Table 7.2; Figure 7.9). Although the feed loss during the control was higher than at commercial farms, the data indicate that scaring devices reduce the amount of feed scavenged by birds and thus indicates a larger scale trial was worthwhile.

Table 7.2: A comparison of percent (%) feed loss to seabirds during the preliminary scaring device trial.

Feed Loss	No Device (Control)	Float on a Rope	Long Handled Gaff	Float and Gaff
Mean	21.72	0.71	2.11	1.41
Median	21.72	0.39	1.86	1.41
Range	10.42-33.02	0-2.08	0.08-4.65	0.22-2.60
Standard Deviation	15.98	0.89	2.30	1.68
N	2	8	4	2

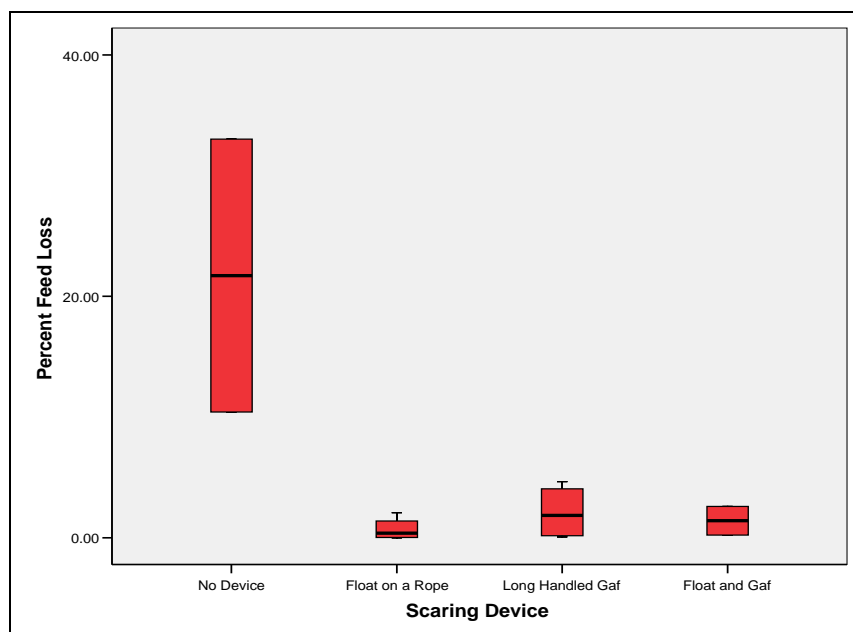


Figure 7.9: A comparison of percent (%) feed loss to seabirds during the preliminary scaring device trial.

7.3.1.2 Seabird Abundance

Inside and Above the Pontoon

There were more seabirds inside and above the pontoon during control shovel (no scarer) compared to when a scaring device was used, though this was not significant (Kruskall Wallis: $\chi^2_3 = 6.795$, $p = 0.079$). This was again most likely to be due to the small sample size (Table 7.3; Figure 7.10).

Table 7.3: A comparison of seabird abundance inside and above the pontoon during the preliminary scaring device trial.

	No Device (Control)	Float on a Rope	Long Handled Gaff	Float and Gaff
Mean	173	25	41	28
Median	173	24	40	28
Range	150-195	4-55	15-69	25-30
Standard Deviation	31.82	15.26	22.72	3.54
N	2	8	4	2

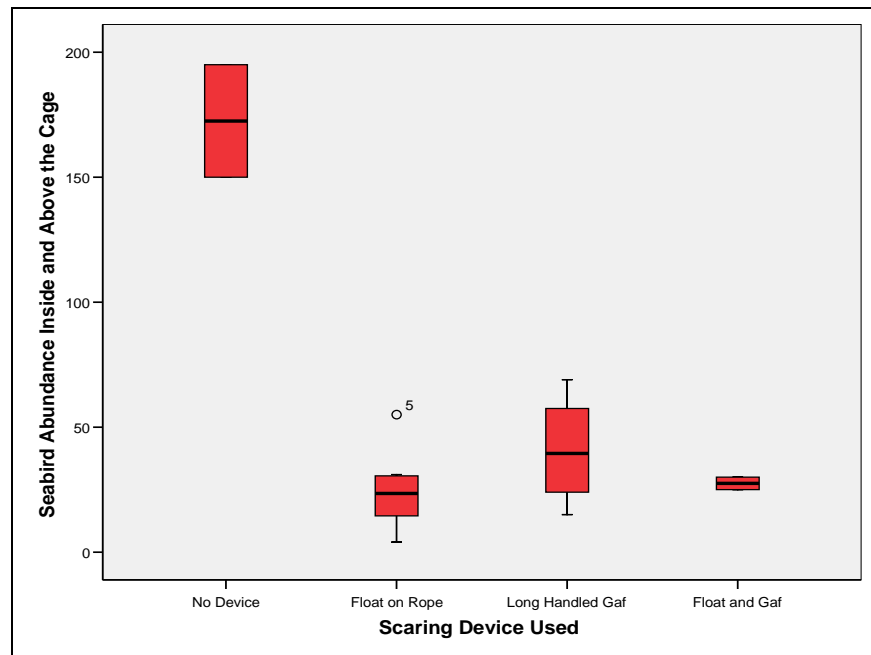


Figure 7.10: A comparison of seabird abundance inside and above the pontoon during the preliminary scaring device trial.

Outside the Pontoon

Seabird abundance outside the pontoon was similar for feeding events using each scaring device and for the control (Table 7.4; Figure 7.11), and the differences were not significant (Kruskall Wallis: $\chi^2_3 = 6.795$, $p = 0.635$).

Table 7.4: A comparison of seabird abundance outside the pontoon during the preliminary scaring device trial.

	No Device (Control)	Float on a Rope	Long Handled Gaff	Float and Gaf
Mean	272	236	335	320
Median	272	142	301	320
Range	252-292	104-554	127-613	280-360
Standard Deviation	28.28	166.92	227.25	56.57
N	2	8	4	2

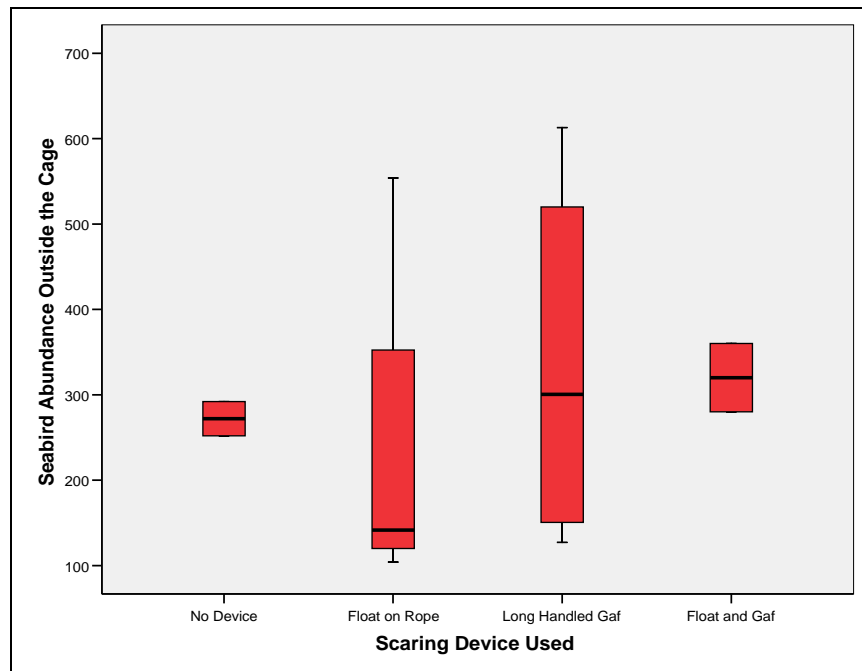


Figure 7.11: A comparison of seabird abundance outside the pontoon during the preliminary scaring device trial.

7.3.2 Full Scale Trial

7.3.2.1 Feed Loss Comparisons

Control feed loss to seabirds was lower in the full scale trial (mean=13.27%) than for the preliminary trial (mean=21.27%), however, it was still much higher than that of commercial farms. Feed loss to seabirds was significantly reduced during shovel feeding by using a scaring device compared to control feeding (One Way ANOVA: (Brown-Forsythe) $F_{4, 24} = 7.44$, $p < 0.001$). The float on the rope was the most effective device and significantly reduced feed loss to seabirds by 87.6% (mean feed loss 1.47%) (Table 7.5; Figure 7.12) compared to control feeding (mean feed loss 13.27%) (Tukey HSD: $p < 0.0001$). The long handled gaff also significantly reduced feed loss to seabirds by 78.2% when compared to the control ($p < 0.002$). However, although the deck hose and the air horn did reduce the amount of feed scavenged by seabirds during shovel feeding (Table 7.5; Figure 7.12), the differences were not significant ($p = 0.608$ and $p = 0.092$ respectively). The float on the rope also

significantly reduced the amount of feed scavenged by seabirds when compared to the deck hose ($p=0.027$). However, although the float on the rope was the most effective scaring device, it was not statistically different from the long handled gaff ($p=0.982$) and the air horn ($p=0.288$). There was also no significant difference between the deck hose and the gaff ($p=0.095$), the deck hose and the air horn ($p=0.982$) and the gaff and the air horn ($p=0.598$).

Figure 7.13 shows feed loss for each device trial by trial. There is no clear pattern of habituation by the birds to any scaring method over the time-period tested. However, the results for trial 5 seem lower for the control, deck hose and air horn than other trials, probably because these trials took place after the Christmas break on 16 or 17/1/06, with the trial before this undertaken on 21/12/06.

Table 7.5: A comparison of the effectiveness of four different scaring devices in reducing the percent of feed scavenged by seabirds.

% Feed Loss	No Device (Control)	Deck Hose	Long Handled Gaff	Float on a Rope	Air Horn
Mean	13.27	9.62	2.89	1.47	6.68
Range	1.38-24.25	2.34-20.33	0.86-6.96	0.76-3.01	0.61-17.49
Std Deviation	6.89	6.33	1.98	0.82	6.40
N	9	8	8	8	8

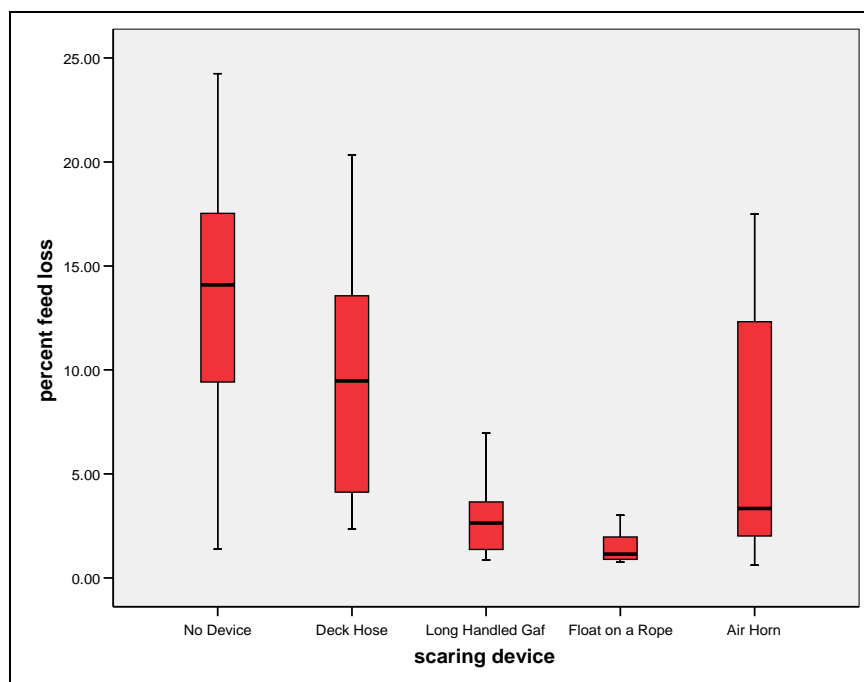


Figure 7.12: A comparison of percent feed loss to seabirds using four different scaring devices and no device.

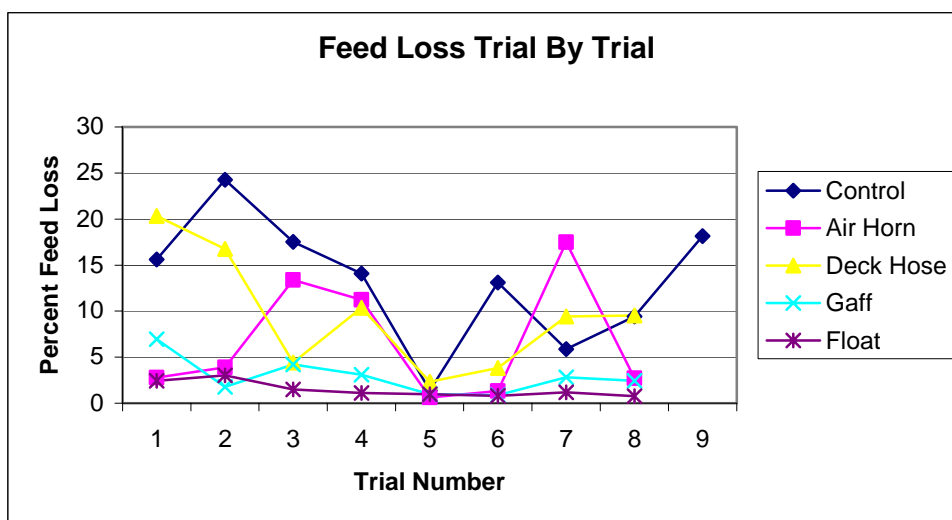


Figure 7.13: A comparison of feed loss for each scaring device, trial by trial (from 7/12/2005-25/1/2006).

7.3.2.2 Seabird Abundance

Inside and Above the Pontoon

There was a significant difference in seabird abundance inside and above the cage between the four different scaring devices and the control (Table 7.6; Figure 7.14)

(One Way ANOVA: $F_{4,36} = 3.117$, $p = 0.027$). However, post hoc comparisons found

this difference to be between the deck hose (mean = 72 birds) and the float on a rope only (mean = 36 birds) (Tukey HSD: $p=0.05$).

Table 7.6: Seabird abundance inside and above the pontoon during feeding events using different scaring devices.

% Feed Loss	No Device (Control)	Deck Hose	Long Handled Gaff	Float on a Rope	Air Horn
Mean	66	72	44	36	45
Range	23-153	50-119	23-85	16-83	25-79
Std Deviation	36.39	21.91	20.99	21.33	17.98
N	9	8	8	8	8

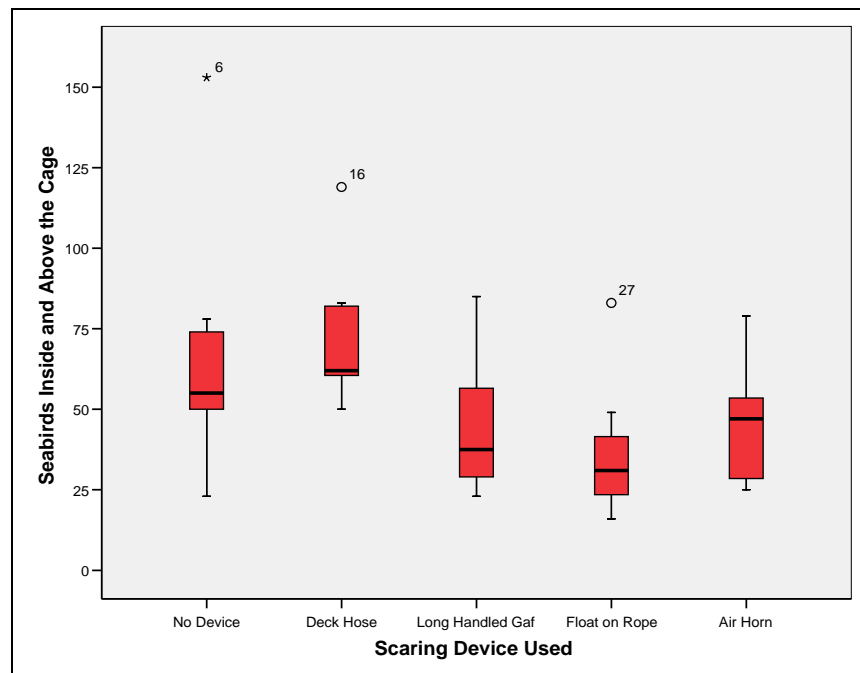


Figure 7.14: Seabird abundance inside and above the pontoon during feeding events using different scaring devices (Case ID no. is next to outliers).

Outside the Pontoon

Seabird abundance outside the pontoon during shovel feeding was highest when using the deck hose and lowest when using the air horn (Table 7.7; Figure 7.15), however abundance was relatively similar and subsequent analysis showed there was

no significant difference between the devices (One Way ANOVA: $F_{4,36} = 1.029$, $p = 0.405$).

Table 7.7: Seabird abundance outside the pontoon during feeding events using different scaring devices.

% Feed Loss	No Device (Control)	Deck Hose	Long Handled Gaff	Float on a Rope	Air Horn
Mean	165	218	202	202	127
Range	58-310	93-511	58-410	82-351	45-215
Std Deviation	74.73	141.44	110.47	114.08	55.78
N	9	8	8	8	8

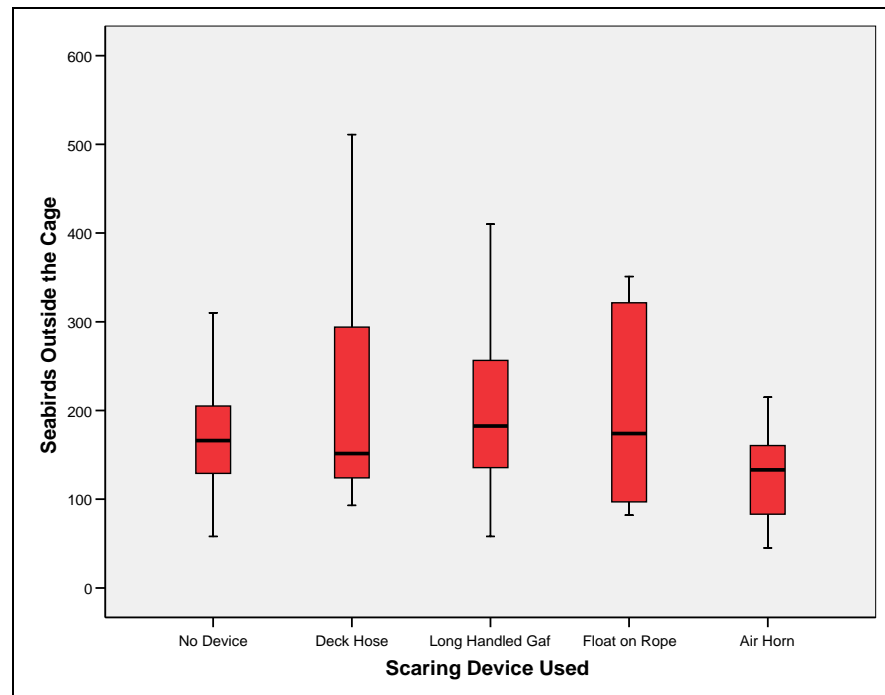


Figure 7.15: Seabird abundance outside the pontoon during feeding events using different scaring devices.

7.4 Discussion

A scaring device trial was undertaken to determine the efficacy of four simple devices in reducing SBT feed loss to seabirds. The most effective scaring devices or deterrents used to reduce aquaculture stock losses to birds include exclusion devices

such as netting entire ponds or seacages, or placing grids of lines or wires above the ponds (Price & Nickum, 1995; Glahn *et al.*, 1999). Other deterrents that alarm birds acoustically (guns, sirens, whistles, metallic noises) or visually (flashing lights, scarecrows) are effective initially, but the birds rapidly habituate, and in some cases the birds associate the stimuli with feeding and may be actually attracted by the scarers (Howell & Munford, 1991). Although used in similar circumstances, these methods are not feasible for the SBT industry being too costly or too time consuming to employ on pontoons. Therefore, the scaring devices chosen in this trial had to be low cost, easy to use and not inconvenient for workers. The float on the rope used in this trial has been used by a few companies for several years and although deemed effective by these companies, its efficacy had not been quantified.

The preliminary trial undertaken during 2005 was carried out to ascertain whether scaring the birds using simple devices was actually feasible and if a larger scale trial was warranted. The results of the preliminary trial showed that feed loss to scavenging seabirds could be reduced by scaring them and similar results were shown for the full scale trial. As already noted, the feed losses in the preliminary and full scale trial are high compared to commercial farms because smaller research pontoons were used, with a low tuna stocking density, which meant feeding was slow. This gave the seabirds greater access to the feed than would occur on commercial farms and therefore the feed loss results were exaggerated. In addition, there was a lack of replication across farms and pontoons. Nevertheless, these results can be used as a guide to the effectiveness of each device on commercial farms.

The scaring device trials show that deploying a scaring device during shovel feeding

reduces the amount of feed scavenged by seabirds. This is important as SBT are not fed a set amount, but are fed to satiation. Therefore if feed loss to birds can be reduced, there is less competition for SBT feed (as there is little competition elsewhere for food, such as from other wild fish species (Ellis, pers. comm.)). This inevitably means less food is required to reach SBT satiation, equating to a real economic benefit to the industry.

The most effective devices trialled were the float on the rope, which reduced feed loss by 87% and the long handled gaff which reduced feed loss by 77%. Both devices did not seem to lose their effectiveness over time, as they were as effective in the full scale trial as they were in the preliminary trial and they remained effective for the duration of both trials. This suggests that the birds did not habituate to these devices over the months they were used. However the deck hose and the air horn had no significant effect on seabird scavenging, though feed loss was reduced slightly by these devices. The deck hose was ineffective even when initially used. Although the water reached out over the feed site, the pressure of the water was not very high and the spray was greatly affected by wind speed and direction and seabirds were not concerned by water squirting them, which is contrary to the findings for land-based ponds (Hall & Price, 2003). If the hose pressure had been higher, it may have been more effective, but water cannons have limited effectiveness on fishing longliners (Environment Australia, 1998; Prado, 2000). The high pressure water can annoy the birds and can drive them away initially (Environment Australia, 1998; Prado, 2000; Hall & Price, 2003), but, if the birds are hungry, they are likely to continue to feed (Slater 1980; Howell & Munford, 1991).

The air horn was reasonably effective for the first two feeding events, with birds flying away each time it was sounded. However, the birds did seem to become accustomed to the noise over several feeding events and it became ineffective very quickly. Added to this, the air horn is very loud and annoying and the crew made it clear that they would not use it at each feeding event (personal communication). These results are similar to those found for other acoustic devices used on aquaculture facilities (Howell & Munford, 1991; Price & Nickum, 1995; Hall & Price, 2003), where they work initially, but the birds soon habituate and the loud noises soon lose their effectiveness, but continue to irritate the workers. In addition, tuna feed boats can be noisy and wind direction can also greatly reduce the noise reaching the birds is, all of which decreases the efficacy of these devices.

The effectiveness of the float and the gaff seems to stem from both their visual and physical threat. The float was thrown out across the feed area where the birds dive to obtain the feed. This device was capable of hitting any birds that did not move, and it did so on a few occasions. However, if the float was not thrown out at regular intervals, the birds soon returned and continued to feed (personal observation). Therefore, for it to be effective, the rate at which it is thrown must be adjusted for seabird abundance. The gaff was also effective as it was moved in the path of scavenging seabirds and there was a potential for seabirds to collide with it which is why it and the float remained so effective. However, as the gaff has not been used over several years, as the float has, birds may habituate to it if they recognise that it provides no adverse associations (unlike the float) as reported for other scaring devices (Draulans, 1987). Whilst the float has been used to decrease shovel feed loss on a few companies' pontoons over several years, it is not used by all companies and

therefore overall feed loss has not dramatically decreased (Chapter 3). However, those companies that did use the float whilst shovel feeding had a much lower feed loss rate (0.34%) than companies that did not use it (2.38%) (Chapter 3). However, it is unknown whether these companies consistently use the float, so feed loss may be higher on average than observed. There is also the potential that birds that once used the companies that do use scarers as a food source may move to surrounding companies' pontoons and continue to scavenge tuna feed.

Seabird abundance inside and above the pontoon was lowest when using the float on the rope and was highest when using the deck hose. Although differences in seabird abundance were found for scaring devices versus control, post hoc comparisons only found a difference in seabird abundance inside and above the pontoon when using the deck hose compared to when using the float on the rope. No such significant differences were found in seabird abundance outside of the pontoon whilst using the different devices, however, it was lowest when using the air horn and highest when using the deck hose. This suggests that although the attractiveness of the farms to the birds was not decreased by using a scaring device and thus they still accumulated in relatively similar numbers, both inside and above the pontoon, the gaff and the float did reduce the amount of feed scavenged. Therefore, the birds still hovered above the pontoon, observing the feed source, but were obviously less inclined to dive and scavenge the food. Thus these devices decrease scavenging and feed loss to birds, but do not decrease seabird abundance at pontoons.

Although seabird abundance was relatively similar inside and above the pontoon between the preliminary trial (during the tuna season) and the full scale trial (in the

off season), it was much smaller outside the pontoon during the full scale trial (off season). Added to this, although not shown, Silver Gull abundance (by far the most abundant species in the tuna season) was much lower during the full scale trial as they were not breeding at this time. This indicates that these devices may need to be tested on commercial farms during the SBT season, to see whether these results are transferable and to demonstrate proof of concept. However, the float on the rope is known to work on commercial farms as companies that used this device whilst shovel feeding had a much lower feed loss to seabirds (0.34%) than companies that did not use it (2.38%) (Chapter 3).

As seabird abundance outside of the pontoon was not lowered by the use of scaring devices during this trial, deterrents need to be deployed to continue to reduce scavenging. It must be pointed out that at the time when the full scale trial was undertaken, no other farms were operational so the birds could not simply move to another lease site, so it remains to be seen if scarers are used long term by a company, seabird abundance may decrease at their lease which may increase the scavenging pressure at a pontoon or site that does not use a deterrent. It is therefore in the best interest of each individual company to use a deterrent at all times when shovel feeding.

It is worth mentioning that the feeding scarers used in this trial will not stop the seabirds rafting in numbers within the lease area, so if disease should become a problem for the tuna and seabirds are possible vectors, other scaring methods may have to be undertaken to deter the birds before they reach the farm site. This may include the use of radar-activated on-demand deterrence systems which work by

detecting flocks of birds before they reach a site and set off several types of deterrents as has successfully deterred seabirds at oil spills in Canada (Ronconi *et al.*, 2004). The nature of these deterrents will need to be researched for tuna farming circumstances.

Although the float on a rope was shown to be very effective in reducing feed loss to seabirds, it does require someone to deploy it. Whilst there was sufficient manpower on all boats to undertake both feeding and scaring (due to crew requirement regulations) and there was no additional cost to the company/industry to use a scaring device (Ellis, pers. comm.), many companies were reluctant to use scarers. Even though several of the tuna farm managers stated that they used scaring devices on their farms, on many occasions when I have spoken to the deckhands about it, they stated they were meant to use them, but only did so when the manager was present or requested it. Similarly, as I have been travelling on a vessel past some farms that reportedly always use scaring devices, I have observed large flocks of seabirds over the pontoons, and no evidence of scaring devices being deployed. To overcome this, an automatic mechanical float on a rope would be an advantage as it would provide effective deterrence without the use of manpower and may be more likely to be used. Although the development of an automatic or mechanical device may increase the chance that it is used, there are a number of requirements that would need to be considered in its design. These include the safety concerns from it being deployed, and its launch rate would have to be variable to avoid habituation. This idea may be a possibility for the future.

Although only very simple devices were tested, the solution to reducing seabird/tuna

farm interactions may lie with other methods which were outside the scope of this project. Exclusion devices such as netting the entire seacage have been shown to be effective on Atlantic and Pacific Salmon farms in Europe, the United States and Canada (Howell & Munford, 1991; Price & Nickum, 1995). This has also been shown to be effective more locally on Atlantic Salmon farms in Tasmania (Huon Aquaculture, pers. comm.) where the pontoons and weather conditions are similar to those in the SBT industry. If netting could be used on tuna farms it would almost completely eliminate the problem with birds and would also be likely to stop seals jumping into the cage and predated the tuna, although entanglement may be an issue. However, feeding would be difficult as the baitfish would have to be shovelled through the net, or the net would have to be taken off during feeding, which would negate its effects and birds may become trapped or entangled. It would also make it difficult to frozen block feed, as the feed cage is pulled to the side of the pontoon, a crane lowers the feed into the feed cage and it is then moved back into the middle using a pulley system. However, if designed correctly this could be overcome, although a feed cage may not be necessary with exclusion netting. The initial cost, keeping the net suspended and maintaining it are also reported to be issues by the SBT industry. All of these factors make it apparently unfeasible for the SBT industry to adopt the practice, however, it is worth pointing out that salmon farmers in Tasmania have overcome the same issues and their methods could be adopted and adapted to see them used on the tuna farms.

Although netting the pontoon is not necessary to reduce the predation of stocked fish by seabirds, it will be if and when the lifecycle of SBT is closed and fingerlings are placed into seacages. If the pontoons are not netted as is done for kingfish, very

valuable fish could be quickly consumed by birds.

In conclusion, of the methods tested, the float on a rope, a device devised by the tuna industry itself, is the most effective in reducing feed loss to birds. It is a very simple device with materials that will be found on any boat and can be used in all weather conditions. Its downfall is it does require someone to deploy it. If tuna farmers are unwilling or unable to use exclusion devices at this point in time, this device will do the most effective job and it is recommended that it should be used by all tuna farming companies during shovel feeding.