Agreement on the Conservation of Albatrosses and Petrels

Sixth Meeting of the Seabird Bycatch Working Group

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SeaBird Saver: an innovative laser technology to reduce seabird bycatch in commercial fisheries

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SUMMARY

Mustad Autoline and SaveWave have developed the SeaBird Saver, a seabird bycatch prevention technology based on innovative laser technology that functions to exclude seabirds from the dangerous areas around fishing vessels. The laser can be coupled with acoustic stimuli creating a dual deterrent. This document summaries results at-sea trials of the SeaBrid Saver, with and without the acoustic deterrent, aboard the Icelandic autoline vessel Tjaldur targeting Atlantic cod (Gadus morhua) in coastal Icelandic fishing grounds around the Snæfellsnes Peninsula. The assemblage of seabirds included northern fulmars, kittiwakes and various larid species.

Over three sets each of 40,000 hooks each, results show that the laser pushed seabirds away from the stern of the ship. Birds quickly reoccupied that area from which they were displaced by the laser when the device was turned off. Although some birds were not displaced, none actively interacted with the line. Available evidence shows that these birds do not habituate to the laser stimulus. These results suggest that the laser beam (and the associated “dot”) of the SeaBird Saver is a successful seabird deterrent that is highly effective during dawn, dusk, cloudy, rainy or foggy conditions. Our experience suggests that marine birds respond to the unnatural and unpredictable threat introduced by the physical presence of the laser dot and beam. Although the laser is designed to be directed at the area adjacent to bird aggregations, and not the bird’s eyes, questions have emerged regarding the potential damage the class 4 laser might pose to the retina of seabirds. We appeal to ACAP to collaborate on at-sea trials to determine the potential of the SeaBird Saver as a best practice seabird bycatch mitigation option for commercial fisheries

RECOMMENDATIONS

1. SeaBird Saver as best practice mitigation

We seek the collaboration and support of the ACAP community to facilitate evaluation of the effectiveness of the SeaBird Saver in reducing interactions of albatross and petrel species with commercial fishing gear.

2. Sea Trials in International Fisheries

We seek ACAP guidance on how to demonstrate that the SeaBird Saver technology is safe for seabirds.

Dispositivo SeaBird Saver: Tecnología de láser innovadora para disminuir la captura secundaria de aves marinas en pesquerías comerciales

Las empresas Mustad Autoline y SaveWave han creado SeaBird Saver, un dispositivo de prevención de captura secundaria de aves marinas basado en tecnología de láser innovadora que espanta a las aves marinas de las áreas peligrosas de las inmediaciones de los buques pesqueros. El láser puede combinarse con una señal sonora que crea una doble disuasión. El presente documento sintetiza los resultados de las pruebas del dispositivo SeaBird Saver efectuadas en el mar con y sin la señal sonora de disuasión, a bordo del buque palangrero Tjaldur de Islandia destinado a la pesca del bacalao del Atlántico (*Gadus morhua*) en los caladeros costeros de Islandia, en la península de Snæfellsnes. La congregación de aves presentes incluyó fulmares boreales, gaviotas y varias especies de láridos.

En el transcurso de tres calados con 40.000 anzuelos cada uno, los resultados demostraron que el láser espantó a las aves marinas de la popa del barco. Cuando se apagó el dispositivo, las aves rápidamente volvieron a ocupar la zona de donde el láser las había espantado. Si bien no se ahuyentó a todas las aves, ninguna tuvo interacción directa con las líneas. Las pruebas disponibles demuestran que estas aves no se habitúan a la señal del láser. Dichos resultados sugieren que el haz del láser (y el "punto" generado) del dispositivo SeaBird Saver es un método eficaz de disuasión de aves marinas, con una alta efectividad al amanecer y al anochecer y durante condiciones climáticas nubladas, lluviosas o de bruma. Nuestra experiencia sugiere que las aves marinas responden a la amenaza artificial e impredecible introducida por la presencia física de un punto y haz de láser. Si bien el láser está diseñado para apuntar al área adyacente al sitio de congregación de aves y no a los ojos de las aves, se plantean dudas sobre el daño que un láser de clase 4 podría ocasionar en la retina de los ojos de estas aves. Solicitamos la colaboración del ACAP durante las pruebas en el mar para determinar el potencial del dispositivo SeaBird Saver como una buena práctica de mitigación de captura secundaria de aves marinas en pesquerías comerciales.

RECOMENDACIONES

1. Que se adopte el dispositivo SeaBird Saver como buena práctica de mitigación.

Solicitamos la colaboración y respaldo de la comunidad del ACAP para facilitar la evaluación de la efectividad de este dispositivo a la hora de reducir las interacciones de las especies de albatros y petreles con los artes de pesca comercial.

2. Que se efectúen pruebas en el mar con pesquerías internacionales.

Solicitamos la orientación del ACAP sobre cómo demostrar que la tecnología del SeaBird Saver es segura para las aves marinas.

SeaBirdSaver : une technologie laser innovante pour réduire les captures accidentelles d'oiseaux marins dans la pêche commerciale

MustadAutoline et SaveWave ont développé le SeaBirdSaver, une technologie de prévention de capture accidentelle des oiseaux marins basée sur une technologie laser innovante qui éloigne les oiseaux marins des zones dangereuses autour des bateaux de pêche. Le laser peut être couplé à des stimuli acoustiques pour créer un double effet dissuasif. Le présent document résume les résultats obtenus lors des essais en mer du SeaBirdSaver, avec et sans dissuasion acoustique, à bord du bateau islandais d'AutolineTjaldur, qui cible la morue (aussi appelée cabillaud - Gadusmorhua) dans les zones de pêche côtières islandaises autour de la péninsule de Snæfellsnes. Les oiseaux marins se composaient de fulmars boréaux, de mouettes et de diverses espèces de Laridés.

Lors des trois essais de pêche comportant chacun 40 000 hameçons, les résultats montrent que le laser a repoussé les oiseaux marins loin de la poupe du navire. Lorsque le laser a été éteint, les oiseaux ont rapidement regagné les zones dont ils avaient été chassés. Bien que certains oiseaux ne se soient pas déplacés, aucun n'a interagi avec la ligne. Les données disponibles montrent que ces oiseaux ne s'habituent pas à la stimulation laser. Ces résultats suggèrent que le faisceau laser (et le « point » associé) du SeaBirdSaver est un moyen de dissuasion performant pour les oiseaux marins, et qui est très efficace à l'aube, au crépuscule, par temps nuageux, pluvieux ou brumeux. Notre expérience suggère que les oiseaux marins réagissent à la menace non naturelle et imprévisible introduite par la présence physique du point et du faisceau du laser. Bien que le laser soit conçu pour être dirigé vers la zone adjacente aux attroupements d'oiseaux, et non pas vers les yeux des oiseaux, des questions ont été soulevées concernant les dommages potentiels que le laser de classe 4 pourrait causer à leur rétine. Nous lançons un appel à l'ACAP pour collaborer sur des essais en mer afin de déterminer le potentiel du SeaBirdSaver comme une bonne pratique pour les options d'atténuation de capture accidentelle des oiseaux marins dans le cas de la pêche commerciale.

RECOMMANDATIONS

1. SeaBirdSaver en tant que bonne pratique d'atténuation

Nous recherchons la collaboration et le soutien de la communauté de l'ACAP pour faciliter l'évaluation de l'efficacité du SeaBirdSaver à réduire les interactions des espèces d'albatros et de pétrels avec les engins de pêche commerciale.

2. Essais en mer dans les pêches internationales

Nous recherchons les conseils de l'ACAP sur la façon de démontrer que la technologie SeaBirdSaver est sans danger pour les oiseaux marins.

SeaBird Saver offshore trial report, West Iceland

Project name: SeaBird Saver

E.E. Schrijver, Marine biologist at SaveWave

Contents

1. Introduction

1.1 Problem outline

Despite efforts to reduce seabird mortality, thousands of albatrosses and other seabirds die every year as a result of by-catch fatalities in fisheries. During the setting of long lines, big flocks of opportunistic seabirds gather near the stern of fishing vessels to await the baited hooks. Stealing the bait of the sinking hook provides the bird with a meal and renders the hook useless for fishing, causing great financial losses in the long lining industry. Some birds are hooked during this process and are dragged underwater, resulting in a horrible death by drowning. All albatrosses and many other species of birds are affected by long lining practices, causing negative publicity for the fisheries. Local law and legislation could dictate that if a certain amout of protected birds are caught during one season, this can cause a forced shutdown of fisheries effort for that season for that particular region.

1.2 Seabird fatalities in Iceland

No hard numbers are available on bird predation or bird fatalities as a result of by-catch in Iceland. All we know is gathered through talking to the crew and captain of the “Tjaldur”: the ship used for this trial. Bird by-catch numbers in these waters vary from trip to trip and throughout the season. Two factors are the main contributors to an increase in bird by-catch. 1): the amount of daylight at the time of the hooks being set. More light brings more species of birds and makes the animals more likely to aim better and longer at the baited hooks. 2): The seasonal nutritional requirements of the local species. During the arriving and nesting period (march-July), food requirements are higher due arriving migrants on their way to nest on Icelandic shores. This causes an overall bird increase and birds come in hungry after an exhausting migration. During the breeding season food requirements rise even more due to hatching and growing chicks, making birds more desperate to collect food. Unfortunately, but not surprisingly, this increase in food requirements coincides with the increasing daylight hours in Iceland. Numbers of hooked birds on the trial vessel number from 4-6 to up to one hundred birds caught for every 40.000 hooks. Large amounts of birds can be hooked due to a chain reaction: If one hooked bird is struggling at the surface, the sinking rate of the line decreases, creating more time for other birds to grab the remaining hooks.

1.3 SeaBird Saver

The SeaBird Saver system is a bird deterrent designed by SaveWave based on the combined strength of a visual and acoustic stimulus to “overpower” the birds’ senses and actively deter them from an area of choice. The acoustic stimulus is generated through a high energy sound system, concentrating bird deterring sounds to the area of choice. The visual stimulus is generated through a powerful patented wide laser beam. This beam is most visible in cloudy or other low light conditions. The systems can be operated independently or can be combined to increase efficacy. The physical presence of the laser beam and the association of this presence with the sound output, causes a greater deterrence effect.

1.4 Earlier trials

During earlier trials on the Dutch coastal North sea last summer, both the sound as the laser system showed effectiveness in deterring foraging seabirds from a fishing vessels. During high light (sunny) conditions, the sound system proved more successful than the laser system. The most effective signals for gull deterrence consisted of species' specific distress calls. The birds reacted very strongly to these vocal signals. The laser is more effective during low light conditions. The visibility and affectivity of laser can be increased by smoke, fog, or precipitation. A very high rate of effectiveness was achieved by the green beam laser in low light conditions with a long recovery time. Both the sound and laser systems of the SeaBird Saver have been tested successfully and the next step towards offshore field tests commenced.

1.5 Trial characteristics

1.5.1 Ship and operations

The ship selected for this trial was the Icelandic fishing vessel Tjaldur. The Tjaldur is a relatively modern and quite large vessel, modified for and equipped with a state of the art automatic longline system designed by Mustad Autoline AS, carrying 40.000 hooks on 16 lines. In this case, the lines were all connected to form one long line of about 50 kilometres. The targeted fish species was at Atlantic cod (*Gadus morhua*). Setting time varied at around 4 hours at eight knots with a automatic baiting system baiting about 80-95% of all hooks. Herring and Squid were used as bait. After setting, hauling started after 0-5 hrs of soaking, depending on tidal conditions, fish behaviour etc. Hauling time varied at around 6-8 hours at a speed of about two knots. One complete cycle of setting, hauling and moving to another area was generally completed in about 24 hrs.

Figure 1: The longline vessel Tjaldur moored at the coastal town of Rif. The yellow x marks the preferred location of the Seabird Saver in this vessel. The lines are shot out of the back just below this point.

As a standard anti-bird measure, het lines are set during darkness hours, minimizing visual hunters like gannets and *Larus* gull species. A bird deterring buoy was dragged behind the ship at a distance of about 50 metres. An anti bird gas cannon with an shooting interval of 5-15 minutes was also used during setting, to great irritation of the sleeping crew. Overall these measures were not very effective and the spashing of the buoy behind the vessel works in some occations rather as an attractant for the birds than a deterrent due to the disturbance of the water surface. Many seabirds are attracted by this.

1.5.2 Location:

This trial was set up to take place in coastal Icelandic fishing grounds around the Snæfellsnes peninsula, where bird predation in long line fisheries is high. Two fishing areas were selected (illustrated in fig. 2) by A and B. Location A was preferred due to the average size of fish in this area. Because of heavy winds coming in from the Northeast, a secondary, more sheltered location: location B was chosen during two of the five fishing days.

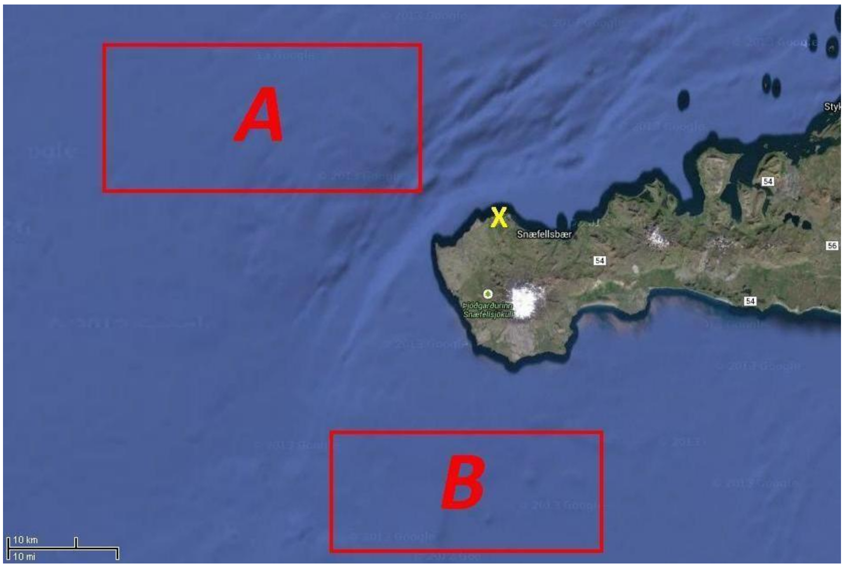


Figure 2: Fishing locations off the Snæfellsnes peninsula. West-Iceland. Primary fishing grounds (A) and secondary fishing grounds in bad North-easterly winds (B). The homeport of Rif is marked by the yellow X.

1.5.3 Bird Species (in order of importance)

Northern Fulmar (*Fulmarus glacialis*)

The Northern Fulmar, or Arctic Fulmar is a highly abundant sea bird found primarily in subarctic regions of the North Atlantic and North Pacific oceans. It is a true seabird, capable of surviving on the ocean without touching land for long times. Related to albatross species, the Northern fulmar is a member of the tube-noses. Named after a tube shaped organ on the top of the bill used for smelling and to secrete excess salt from the body. Due to its great sense of smell, it can detect fishing activity both at day and night. It can plunge, peck or even actively dive for food just beneath the surface.

Kittiwake (*Rissa tridactyla*)

It is a coastal breeding bird around the North Pacific and North Atlantic oceans, found most commonly in North America and Europe. Despite its medium size, it is one of the most offshore gull species in the Northern Hemisphere. Together with the Northern Fulmar, this was the only bird species observed feeding at night during the tests. Like all gull species it is capable of swooping down and peck items of the surface, or plunge down to reach items further down into the water column.

Glaucous gull (*Larus hyperboreus*)

The Glaucous Gull is a large gull which breeds in the Arctic regions of the Northern hemisphere and the Atlantic coasts of Europe. It is migratory, wintering from in the North Atlantic and North Pacific oceans as far south as the British Isles and northernmost states of the USA, like all *Larus* species, it is capable of swooping down and peck items of the surface, or plunge down to reach further down into the water column.

Iceland gull (*Larus glaucoides*)

The Iceland Gull is a medium sized gull which breeds in the Arctic regions of Canada and Greenland, but not Iceland, where it is only seen in the winter. I. It is capable of swooping down and peck items of the surface, or plunge down to reach further down into the water column.

Northern Gannet (*Morus bassanus*)

The Northern Gannet is a true seabird and it is the largest member of the gannet family. Nesting in colonies as large as 60,000 pairs on both sides of the North Atlantic. This bird undertakes seasonal migrations and is a spectacular high-speed diver, able to dive down to depths of about 6 metres, with the ability to swim down even deeper to chase its food.

Great black-backed gull (*Larus marinus*)

The Great Black-backed Gull , also known as the Greater Black-backed Gull or, informally, as the Black-back, is the largest member of the *larus* gull family. It breeds on the European and North American coasts and islands of the North Atlantic. Like all *Larus* species it is capable of swooping down and peck items of the surface, or plunge down to reach further down into the water column.

Looking at certain specifications per species from own observations on board, table 2 was made. This table shows different characteristics per species regarding possible negative associations with the longline industry in Iceland. Birds at medium risk are highlighted in orange. Birds highlighted in red are at high risk of fatal interactions with longline practices.

Table 1: Tale showing the possible danger to each bird species, derived from it's foraging activities near long lining vessels. Birds at medium risk are marked orange. Birds at high risk of injury or death due to longline fisheries are marked red.

Species	Active Diurnal/ nocturnal/ both	Interaction depth Surface/ Medium/ Deep	Dangerous interaction with line during setting	Dangerous interaction with line during hauling
Northern fulmar	Both	Surface to Medium	yes	yes
Kittiwake	Both	Surface	yes	yes
Glaucous gull	Diurnal	Surface	yes	no
Iceland gull	Diurnal	Surface	yes	no
Northern Gannet	Diurnal	Surface to Deep	no	yes
Black-backed gull	Both	Surface	yes	no

2. Activity log

During the trial, an activity log was kept (table 2). This report will focus on prototype installation and workings (marked green).

Table 2: Activity log Orkney, Note that prototype testing is marked green.

Date **(Jan-Feb 2014)**	**Morning and afternoon 06:00-18:00**	**Evening and night 18:00-06:00**
Thu 30th	Flight Amsterdam-Keflavik	Stay overnight in Grindavik
Fri 31th	Drive Grindavik-Rif	Stay overnight in Rif
Sat 1st	Loading proto, boarding ship & installation proto	Leaving for fishing grounds Setting line 1 (no observation due to sea sickness)
Sun 2nd	Hauling line 1 (no observations)	Setting line 2 (control test)
Mon 3rd	Hauling line 2 (fish count)	Setting line 3 (test I)
Tue 4th	Hauling line 3 (fish count)	Setting line 4 (test II)
Wed 5th	Hauling line 4 (fish count)	Setting line 5 (test III)
Thu 6th	Hauling line 5 (fish count)	Return to port, Stay overnight in Grundarfjordir
Fri 7th	One day rest	Travel Grundarfjordir-Reykjavik, Stay overnight in Reykjavik
Sat 8th	Flight Keflavik-Amsterdam	

3. Current prototype

3.1 Prototype lay-out and specifications

The current Seabird Saver prototype has been modified since the last tests on the North Sea, and resembles the finished product in most ways. The prototype consists of two systems:

3.1.1 The laser system:

This system consists of two connected units with one holding the actual laser source. It his been placed in a protective housing, providing a shield from rain and salt spray and containing a small heater to keep the housing free of icing in cold waters. The other unit is the power unit, within a water resistant casing, connecting the source with a power supply on board.

Figure 3: The Installed prototype set-up, with the laser on top and the sound system on the bottom.

3.1.2 The sound system:

This unit is responsible for the acoustic deterrence stimulus, generated through a 135dB speaker, capable of emitting both signals designed by SaveWave through an I-pod. It also has a built in alert tone, which has a slightly higher sound output and can be used as a last resort measure.

3.2 Desired prototype-set up

The desired location for the prototype was high up on the back deck of the vessel. Locations were limited by the following factors:

- Line of sight connection with the approximate line-setting area.
- Power (230V) availability within 20 metres.
- Stable mounting point.
- Minimum damage probability to prototype (out of the way of normal operations).
- Minimum chance of eye exposure to crew.

Taking all these factors into consideration: the prototype was installed on a lower deck, out of the way of normal operations (fig 1).

3.3 recommendations

After talking to the captain, mechanic and crew members, the following recommendations on prototype lay-out were made:

- No Aluminium components, due to their highly corrosive nature.
- A longer connecting line between the laser source and the power supply box, to allow laser activation from the bridge.
  Pro: better operations and safety control. Con: loss of output in longer cable
- Boxing the entire laser source in a sealed container that can be opened during operations and closed afterwards to keep the laser source out of the weather and possible damaging activities on board.

4. Trial set-up and data recording

4.1 Set-up

The trial consisted of five fishing days and five lines set and hauled in total (table 2). Of the five lines, four were used for testing the SeaBird Saver system. The second line was the control count. During line number 3-5, the device was tested. During line 3 and 4 without sound and during line 5 with sound and laser sources. The devices were mounted on the back deck of the fishing vessel (fig 3). Both the lasers and sound system were aimed straight behind the boat opposite to the direction of travel. The green solid beam laser has no deviation and shines straight out the back. The sound System has a deviation of 7,5 degrees from the transect line. Both sources could be turned on or off and moved separately. Whilst the vessel was moving in a constant speed of about eight knots. Data was recorded on the datasheet (Appendix I) based on linear offshore seabird counts.

4.2 Data recording

4.2.1 Seabird counting method.

The observed area was divided in three bands due to the by-catch risk potential for birds in these areas (Fig. 4). Band III: Minimal, Band II: medium and band I: immediate. Note that due to the sinking of the baited line, at a distance of about 100 metres of the possibility of a bird reaching the line has reduced to minimal.

From the start of the trial (During the setting of the lines), a scan was made every five minutes by the observer. During these scans, the amount of seabirds interacting with the stern and the line was counted in three distance bands to monitor bird presence & abundance: Band I (0-10m), band II (10-50m) and ban three (50-100m).

During this five minute snapshot, birds flying above, sitting on, or interacting with the different bands were counted. Counted species and observed behaviours were recorded, as were weather conditions and sightability of birds. Counting continued throughout setting of the lines, with laser activation of the SeaBird Saver generally after one hour of line setting and deactivation after the setting was completed. Counting continued after setting to observe the recovery time of birds interacting with the stern of the vessel.

Recorded data was entered and analysed using statistical programmes to prove the workings of the Bird Saver. This was accomplished by proving a significant reduction of foraging birds behind fishing ships when the Bird Saver is operational.

4.2.2 Fish counts

During the hauling of the lines, a fish count was made. Caught fish, baited hooks and caught birds were counted for two sets of 1000 hooks during every haul. No empirical evidence was detected for the amount of fish caught during the SeaBird Saver trials and the control test. Mainly due to the change of fishing locations and the varying catch rate throughout the line. No caught birds were observed during these counts. Therefore, the results of these counts were rendered insignificant to this report and left out.

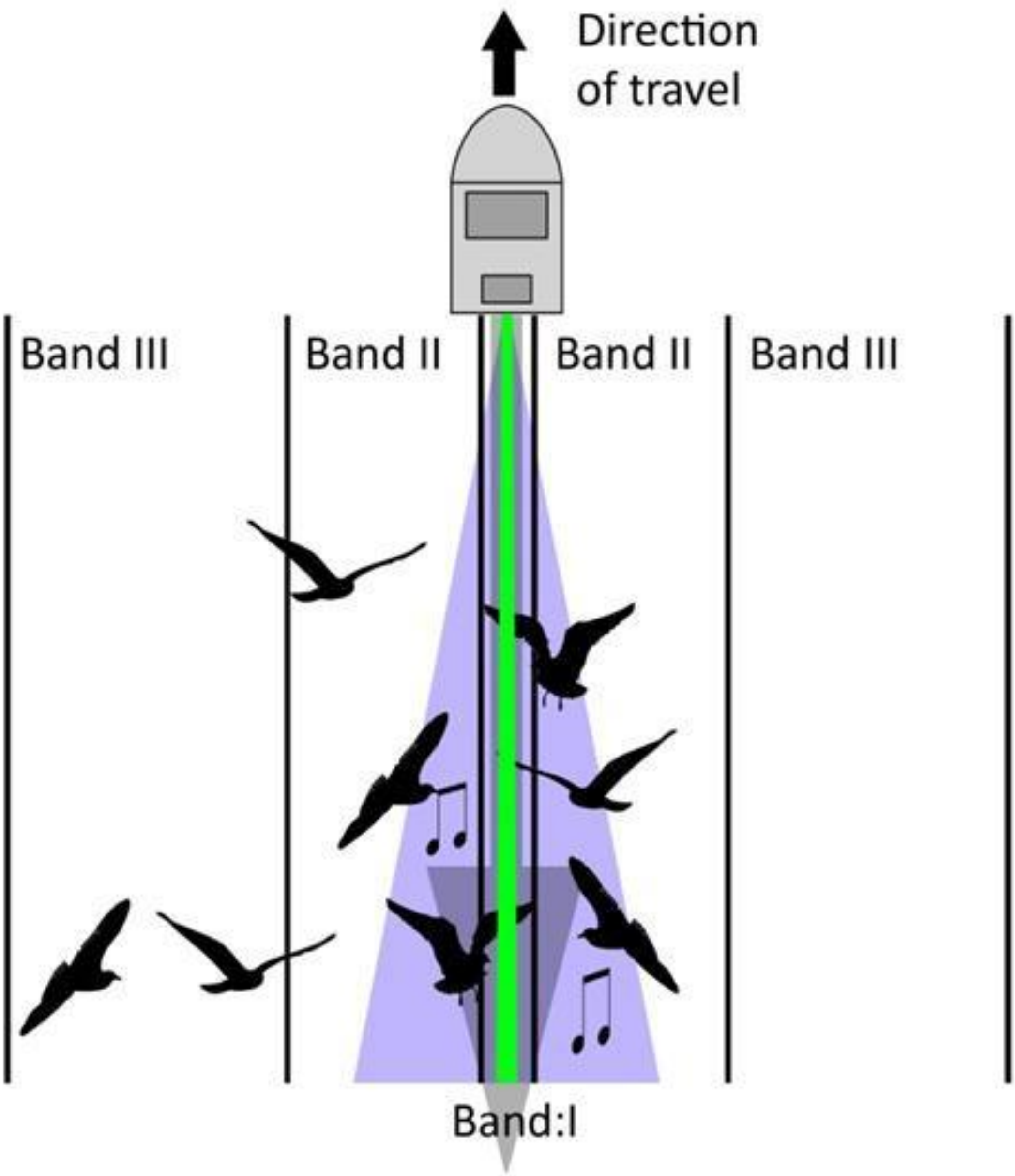


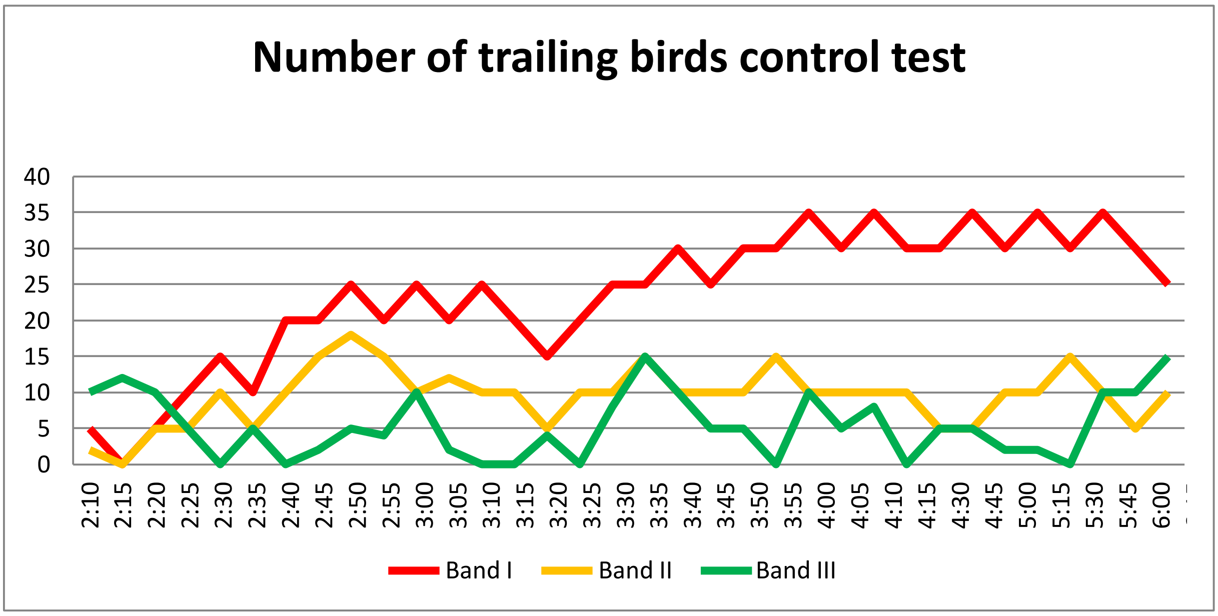
Figure 4: Set up of the SeaBird Saver trial. Birds were counted ever five minutes in different bands. In this case: Band I: 0, BandII:6 and Band III: 2.

5. Results

The data was analysed using Microsoft Excel. The behavioural response of the birds was illustrated in various graphs concerning bird amounts and distance from the line. During test I and II the sound device was tested. During test III, both laser and sound systems were tested. The graphs below illustrate the reaction of the foraging gulls behind the boat to the separate systems and sounds. Note that all tests were conducted during setting which occurred in darkness, reducing visibility to about 50-100 meters behind the vessel, resulting in smaller numbers of birds observed than present in reality.

5.1 Control test.

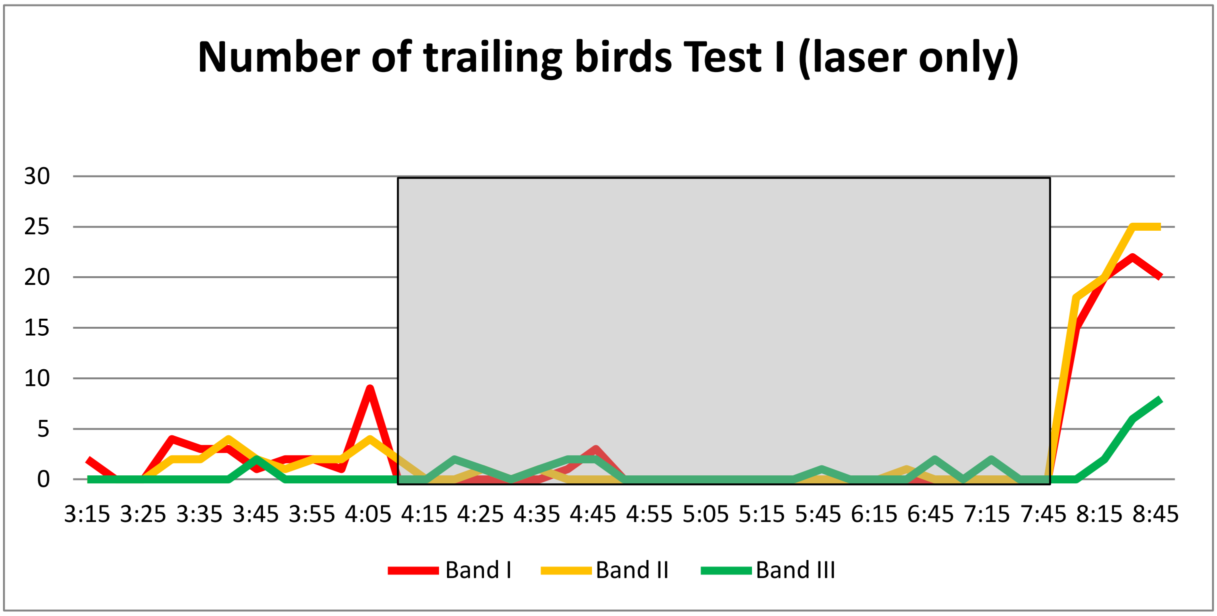
During the start of setting line II, some birds were alredy present behind the ship. During setting, the amount of birds steadily grew. More birds were present further behind the ship, but were not countable due to the dark conditions. Birds were interacting with the line, pecking at the surface and swooping down to grab bait and detached bait parts. Interacting species: northern fulmar.



Graph 1: Number of trailing birds behind vessel during control test. Vertical axis indicating bird numbers for different bands. Horizontal axis indicating time in UTC. Red indicating Band I, orange indicating Band II and green indicating Band III.

5.2 Test I

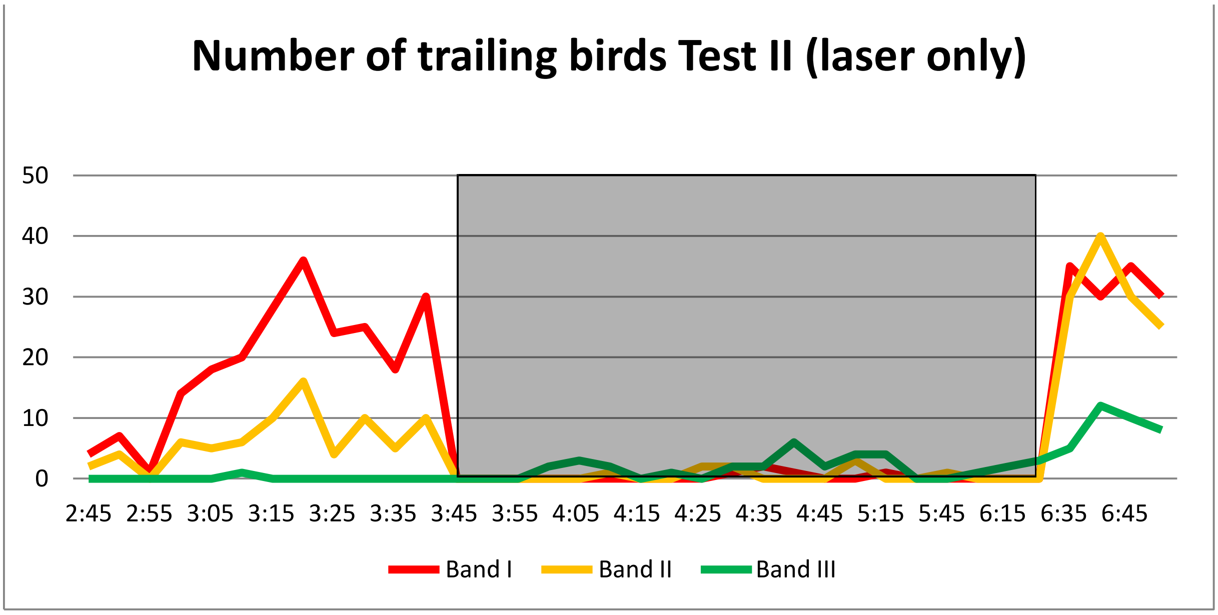
During test I, few birds were present at the beginning of setting. Numbers of foraging birds slowly increased. The majority of birds disappeared out of sight when the laser source was turned on. Some birds were visible during the laser trial, but none actively interacted with the line. When the laser was turned off, many birds appeared in a very short time span to greater numbers than before. Interacting species: northern fulmar, kittiwake and various *larus* gull species. Little birds were counted during laser source exposure. However, many birds recovered within minutes after the test, indicating that they have probrably been present throughout, but far behind the vessel.



Graph 2: Number of trailing birds behind vessel during control test. Vertical axis indicating bird numbers for different bands. Horizontal axis indicating time in UTC. Red indicating Band I, orange indicating Band II and green indicating Band III. Source output is indicated by a shaded area.

5.3 Test II

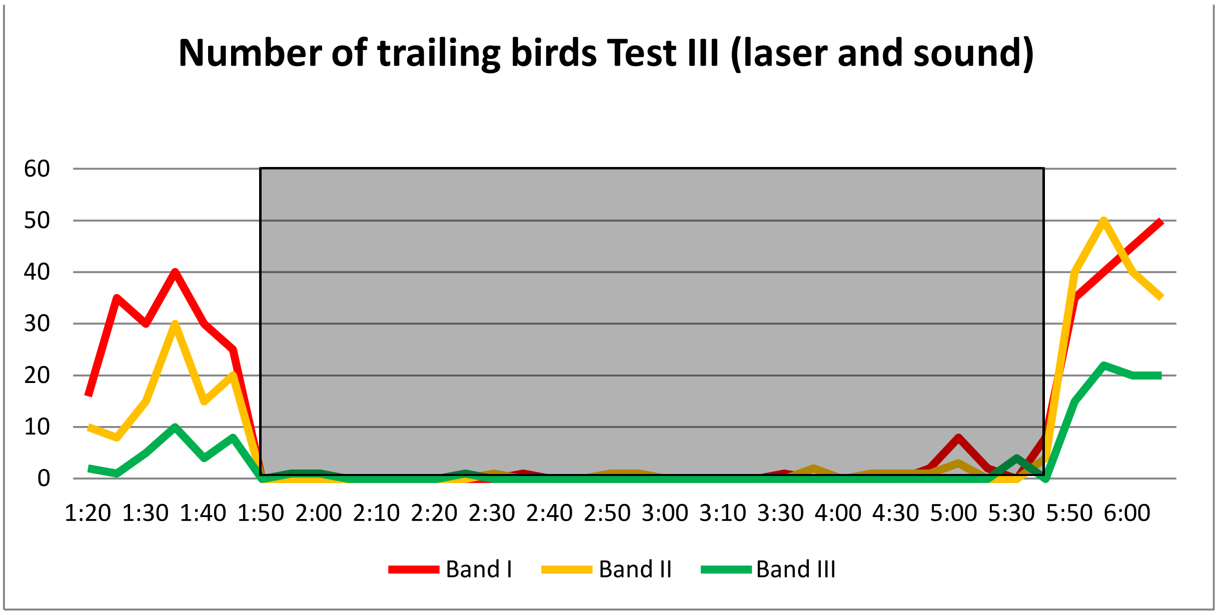
During test II, more birds were visible during the beginning of setting. Numbers of foraging birds steadily increased to about 50 visible animals. The majority of birds disappeared out of sight when the laser source was turned on. Some birds were visible during the laser trial, but none actively interacted with the line. When the laser was turned off, the amount of birds behind the ship recovered in a very short time span to greater numbers than before. Interacting species: northern fulmar, kittiwake and greater black-backed gull.



Graph 3: Number of trailing birds behind vessel during control test. Vertical axis indicating bird numbers for different bands. Horizontal axis indicating time in UTC. Red indicating Band I, orange indicating Band II and green indicating Band III. Source output: laser, sound or both is indicated by a shaded area.

5.4 Test III

During test III, many birds were visible at the beginning of setting. Numbers of foraging birds stayed level at about 50-70 visible animals. The great majority of birds disappeared out of sight when the laser source was turned on. Some birds were visible during the laser trial, but none actively interacted with the line. When the laser was turned off, the amount of birds behind the ship recovered in a very short time span to greater numbers than before. Interacting species: northern fulmar, kittiwake, greater black-backed gull and other *larus* gull species. During this test, the Seabird sound system was also in use with a duty cycle of 8%.



Graph 4: Number of trailing birds behind vessel during control test. Vertical axis indicating bird numbers for different bands. Horizontal axis indicating time in UTC. Red indicating Band I, orange indicating Band II and green indicating Band III. Source output: laser, sound or both is indicated by a shaded area.

6. Conclusion & discussion

The graphs showed above prove the workings of the SeaBird Saver system in the experienced setting conditions. The laser pushes the birds further back from the stern of the ship. The birds were present, but did not interact within dangerous areas around the stern, which is of course the main objective. The fact that biologically, success was achieved with Northern Fulmars, gives good hope that the system should be successful on albatross species as well.

Some observed conclusions cannot be displayed in graphs and are explained below:

Booked results during testing vary only in presence of birds inside the virtual bands I, II and III. No birds interfered with the setting lines in all trials. The small difference in presence in the bands could have been depending on wind direction. The laser seems to create a larger complete bird free zone in head wind. In this situation, birds need to approach ship from behind, facing into the laser.
During side wind, birds can approach the ship from the side in a 90 degree angle from laser, making the beam less visible in this approach. Some birds did come down to inspect the line, but kept on being “pushed” away by it. No attack on the lines was documented.

Sound stimuli has a positive effect, but does not greatly increase overall effectiveness, because the laser itself under the used conditions was already close to 100% effective in keeping birds from interfering with the setting line. Sound exposure with longer long intervals (10-15 min) between pulses proved to more effective than short intervals (1 min) during these trials.

Things to take into consideration when finalizing product:

- Moderate modifications: Longer cable between laser source and power supply to create a more flexible system that can be activated by captain from bridge.
- No aluminium components in final model.
- Horizon block on future models could be an option.
- In case of combined visual and audio models, reduce audio duty cycle from 8% to less.

The captain of the Tjaldur vessel has been using the product for an additional three 5-day trips and the effect remained. He therefore decided to buy the product.

Appendix I

Data sheet

SaveWave®	Specifications	Weather Conditions	Page of pages
	Band 1: (0-10m)	Visibility (1-4):	
Ship name:	Band 2: (10-50m)	Waves (0-7):	
	Band 2: (50-100m)	Swell (1-3):	
Observers:		Wind speed (0-7):	
Year Month Day 20		Wind direction (1-360): **Source: 0=off 1=soft 2=full 3=interval X**	

Time	Speed: Knots	Course 1-360	species	Band I	Band II	Band III	**Source:**	Remarks

ANNEX 1

B1. SeaBird Saver Laser specifications

Optical

Laser Class	4
Color laser beam	Green
Wavelength	532 nm
Service life laser source	10000 hrs (during normal operating conditions)

Electrical

Power	110 V – 230 V
Cable length power supply - laser	2 m

Environmental

Operating temperature	-20 °C to +25 °C
Relative humidity	0 % - 95 %
Storage temperature	- 30 °C to + 45 °C

Mechanical laser box

Weight	4.5 kg
Length	400 mm
Width	150 mm
Height	130 mm

Mechanical power supply box

Weight	6.5 kg
Length	330 mm
Width	230 mm
Height	155 mm

Safety

Interlock system	Yes
LED output emission indicator	Yes
Safety key control	Yes
Beam shutter	Yes
On/Off switch	Yes
Emergency stop button	Yes