Eye in the sky

Value of SeaGuardian for fisheries management

NZIER report to Hawk Eye Ltd

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Key points

New Zealand is a maritime nation with the third largest exclusive economic zone (EEZ) and one of the world's largest search and rescue areas. Drones provide an opportunity to deliver a more effective maritime surveillance capability at a much lower cost than existing platforms.

The MQ9B SeaGuardian, the unarmed maritime variant of the UK, Australia, Belgium SkyGuardian, is a new capability that can undertake multiple non-military tasks including search and rescue, disaster management, support to the Pacific as well as potential military applications.

NZIER focused initially on scoping the economic returns from enhanced surveillance of Antarctic Toothfish fisheries in the Ross Sea. This is just one potential fishery surveillance application for the SeaGuardian.

In summary, we found the SeaGuardian provides:

- *Bang per buck* – MQ9Bs were significantly more cost-effective than existing platforms such as P3 Orions or fixed-wing alternatives
- *Enhanced capability* – the ability to stay on station for long periods without being easily detected provides a degree of deterrence beyond existing platforms
- *Pays its way* – the economic returns from enhanced surveillance and reducing the need to operate more expensive platforms would both cover the operating costs and meet the overhead and capital costs of the SeaGuardian.

These initial findings show the exciting potential that an enhanced maritime surveillance capability provides New Zealand. Development of the full business case will require reviewing other non-military applications, assessing the best ownership structure (company or government-owned) and governance arrangements (focused on club funding and tasking). However, the potential size of the prize suggests this is not an opportunity to miss.

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1 Introduction

NZIER was asked to undertake a scoping study on the costs and benefits of a new maritime surveillance capability based on the MQ9B SeaGuardian. We used Toothfish in the Ross Sea as a test case to compare the costs and benefits of the SeaGuardian used for fisheries surveillance.

The SeaGuardian has the capability to undertake a range of military and non-military tasks. Development of the full business case will require reviewing a wider range of non-military applications and assessing the best ownership structure (company or government-owned) and governance arrangements applying to funding and tasking. Assessing these wider issues was out of scope for this phase.

The first phase of the project focused on scoping the potential economic returns from enhanced surveillance of Antarctic Toothfish fisheries in the Ross Sea. As a first pass, we accessed readily available public and commercial information. While refinements would be possible in the future, we are confident that the data provides for a robust first pass at comparing costs and benefits.

The rest of this paper is structured in four parts:

- The next section provides background on the Antarctic Toothfish fishery.
- Part 3 discusses the options for drone surveillance.
- Part 4 compares the cost-effectiveness of different capabilities.
- Part 5 presents the overall cost of benefits of the enhanced maritime surveillance capability based on the SeaGuardian.
- Part 6 provides the results in detail.
- Part 7 discusses the next steps.

2 Monitoring and enforcement of marine fisheries

Global seafood is sourced roughly equally between the harvest of wild fish stocks by the fishing industry and the harvest of cultivated stock by the aquaculture industry. Global wild fish harvests have plateaued since the 1990s at around 84 million tonnes per year, as many fisheries have been depleted or fishing activity is restricted in the quest to return harvests to sustainable levels where removals match the regeneration of the wild stocks. Conversely, aquaculture has grown over the same period from relatively small beginnings to now match the total annual production of wild fish harvests.

New Zealand’s fishing industry mirrors the global picture, with annual catches having stabilised after the mid-1980s introduction of the Quota Management System. This provides for the setting of a Total Allowable Catch (TAC) based on fishery assessments, within which, after due allowance is made for recreational and customary catches, a Total Allowable Commercial Catch (TACC) is set, which can be caught by fishers holding Annual Catch Entitlements (ACE) derived from Individual Transferable Quotas (ITQs) for proportional shares of TACC. Commercial aquaculture in New Zealand has grown from small beginnings in the 1970s but is still a long way from matching the volume of seafood production by the fishing industry.

Illegal, unreported and unregulated (IUU) fishing has been estimated to account for 10% to 30% more fish being harvested than is being accounted for by legal fishing around the world. Such illegal activity compromises the sustainability of fish harvesting operations, both because fish caught illegally reduce the availability of fish and increase the costs of catching by authorised fishers, but also because the estimates of available stock on which catch limits are based depend on accurate information on reported catches.

If a significant proportion of fish is being removed illegally without reporting, estimates of fish stock will be distorted. Assuming little IUU could lead to an over-generous grant of TACC, which depletes the stock below a sustainable level; or alternatively, if stock assessments inaccurately assume unreported catch is larger than it is, it could lead to unduly constrained TACC, imposing an opportunity cost on authorised fishers who forgo catches that could be sustainably harvested.

Fishery management over extended sea areas therefore depends on effective monitoring of activity and enforcement of regulations about timing, method and intensity of fishing activity with respect to different areas and fish stocks. Monitoring capability is particularly important with respect to remote areas, which are open to footloose foreign vessels that cannot be relied on to call into ports to verify their catching activity.

Aerial surveillance complements other monitoring capabilities by covering large areas of sea relatively quickly, identifying vessels in areas and those acting suspiciously (such as operating with their Automatic Identification System (AIS) tracking devices switched off). Aerial surveillance can observe activity unobtrusively from afar and move in closer to check for signs of regulatory violation, such as fishing methods used or discharges that may indicate onboard activities such as processing of freshly caught fish. Aerial surveillance can also call in assistance from surface vessels if needed for closer inspection, so it adds to other monitoring capabilities rather than replaces them.

2.1 Background to Antarctic Toothfish fishery

New Zealand monitors fisheries in the Ross Sea sector of the Southern Ocean under the auspices of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR). A principal target of that management is the prevention of illegal fishing for Antarctic Toothfish, which is found within and solely managed under the CCAMLR (unlike Patagonian Toothfish further north, which is found within New Zealand's EEZ and has been admitted into the QMS).

Fishing for Antarctic Toothfish is permitted only in summer months when areas called *polynas* open in the sea ice allowing access to the continental shelf. The fishing method is restricted to longlining which is less damaging to the surrounding environment than some other methods. Vessels from New Zealand, Australia, Japan, Korea, Russia, South Africa, Uruguay and the UK fish these waters from the season opening in December, penetrating south through opening *polynas* during January and retreating before February's re-icing.

There is a TACC for Antarctic Toothfish, which is set according to stock estimates, but there are no individual quotas, so fishers have the incentive to catch as many fish as soon as possible before recorded catches indicate the TACC limit is reached. In 2006 the TACC was set at 3,000 tonnes, equivalent to 100,000 fish with a wholesale value of NZ$50 million.[1]

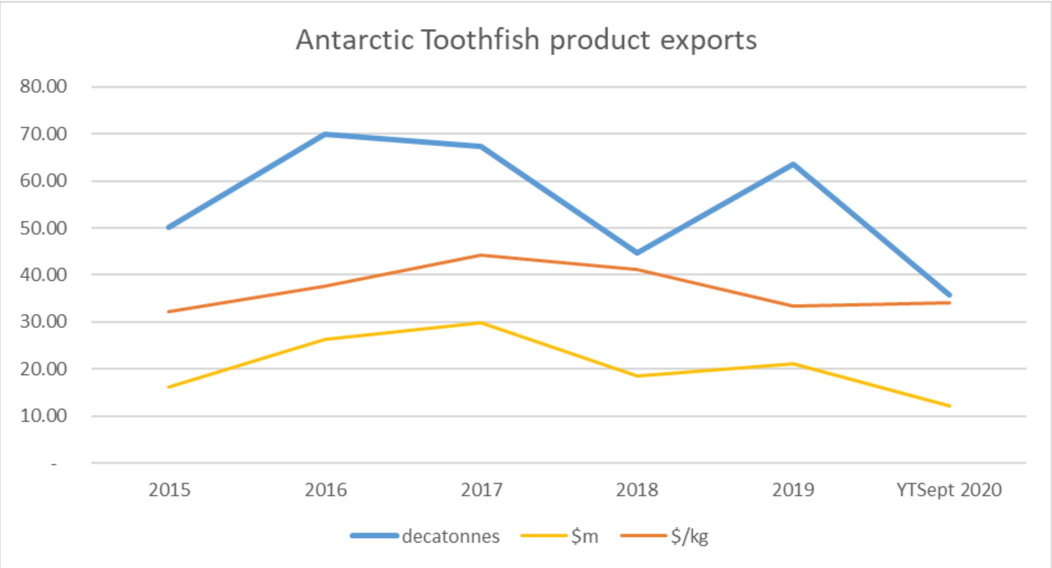
In 2020 the TACC was set at 4,017 tonnes, split between 3,120 in Area 88.1 and 897 tonnes in Area 88.2. There were 23 vessels authorised to fish for Antarctic Toothfish, including 3 from New Zealand, one each from Australia, Chile, Spain, UK and Uruguay and 3 or more each from Korea, Russia, Ukraine and UK.

Over the five years, 2015-2019, New Zealand exports of Antarctic Toothfish products per year have ranged from 448 to 699 tonnes, averaging around 550 tonnes.[2] New Zealand's greenweight catch averaged 641 tonnes per year over that period, ranging from 458 to 782 tonnes. The value of these exports to New Zealand ranged from $12.2 million in 2020 (year ending June) and $29.1 million (2017), with a mean of $21 million. There is little additional value from sales onto the domestic New Zealand market sales of waste products for use in fishmeal and similar products: Toothfish heads and guts have high fish oil content, and there is little demand for them.

By way of comparison, in 2018, New Zealand exported 267,901 tonnes of seafood products, worth $1.8 billion. The Antarctic Toothfish supports a very small proportion of that total, with net price per kilogram having New Zealand dollar values ranging between the low thirties and the mid-forties, making it a moderately high value fish.

Figure 1 shows the volume and value of New Zealand's Antarctic Toothfish exports over the past 5 years. Over this period, there has been some variation in volume caught and export revenue earned, but unit prices have remained relatively stable.

Figure 1 Volume and value of New Zealand's Antarctic Toothfish exports



Source: Seafood New Zealand

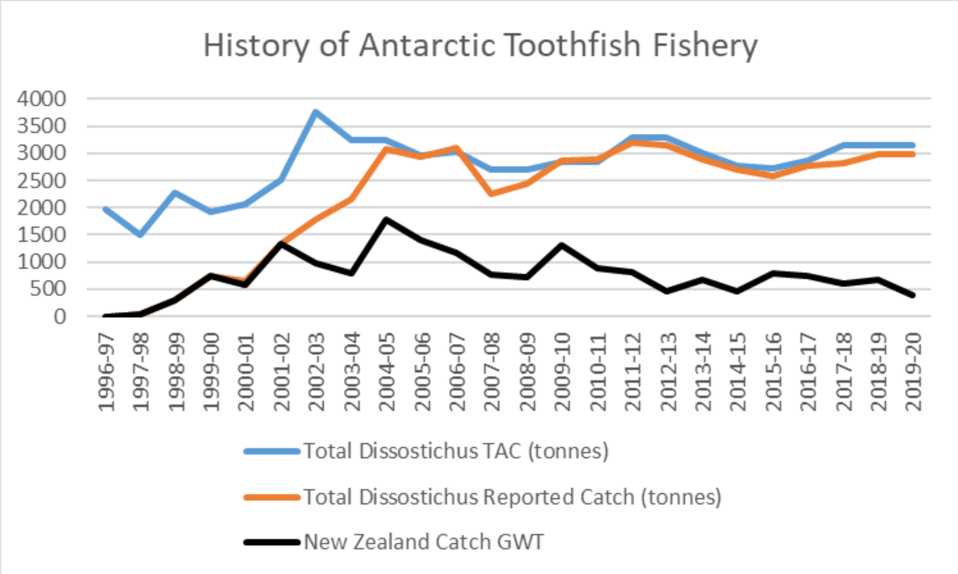
Over the longer term, however, New Zealand has faced a declining share of the TACC from the Ross Sea, as more countries and more vessels have been authorised to fish there. New

1 Dennis Gordon & Warren Judd; The Ross Sea Toothfish Fishery; New Zealand Geographic Magazine, Issue 079, May-June 2006.

2 https://www.seafoodnewzealand.org.nz/publications/export-information/export-statistics/?tx_ttnews%5Btt_news%5D=1712&cHash=6fa842587b374ab37cd124fa0d2edb04

Zealand pioneered the Ross Sea Toothfish fishery and accounted for all tonnage caught in the 1990s, but has since accounted for a declining share of the catch, as shown in Figure 2. In 2020 New Zealand had three long lining vessels in the fishery, and their catches accounted for just 13% of the total catch.

Figure 2 Long term volume of New Zealand's Antarctic Toothfish catches



Source: Seafood New Zealand

In 2006 the RNZAF tested the feasibility of operating a P3-K Orion off the airbase at McMurdo Sound to extend its ability to patrol the Ross Sea for longer periods than is possible operating out of New Zealand. At the time, IUU activity was not a major problem in New Zealand's sector of the Southern Ocean, but as the number of vessels has increased, so too has the probability of some vessels acting in non-compliant ways in the fishery. Because of the remoteness of the Ross Sea and the expense of getting there, the risk of non-compliant behaviour is greatest amongst the fleet of authorised vessels, who may seek to catch fish before the season starts or in areas closed off from fishing. Because the number of boats has been increasing, the seasons have been getting shorter as the allowable catch is extracted earlier, so there is an advantage in boats filling their holds early.

There is a risk that IUU vessels may move further south from the Patagonian Toothfish grounds further north (where they appear to have diminished), requiring enhanced surveillance capability in the Ross Sea. Future replacements of the P3 Orions by P-8A Poseidon aircraft – the military variant of the Boeing B737-800, due to be brought into service in 2024, are heavier jet aircraft, which will be faster in transit but less suited to long periods on slow cruising and unobtrusive surveillance of vessels operating in the area.

2.1.1 Current monitoring of Antarctic Toothfish fishery

The Antarctic Toothfish season runs from 1 December each year for three months. To date, New Zealand has sent a frigate or similar vessel to patrol the area on the seaward side of the ice sheet and run 2 or 3 patrols per year with a P3-Orion, varying year by year with availability.

Deterrence is the main objective of this presence in the Southern Ocean. While several countries have vessels authorised to fish in those waters and may be tempted to enter the area early to gain an advantage in early catches, the consequences of being detected in illegal operations are to have a vessel identified as an IUU vessel, placed on a list of such vessels and banned from further operation in the fishery for a period. All countries' fishing boats may send photographic evidence of another ship engaged in illegal activity to the CCAMLR, and that body will determine the penalty on the miscreant vessel. Exclusion from the fishery may cost a vessel several million a year in lost revenue, so all vessels have an incentive not to be observed doing anything illegal.

As photographic evidence of boats handling fishing gear is usually sufficient for identification of IUU activity, a ship presence may not be necessary. The range of the P3 Orion allows only a couple of hours on station in the Ross Sea area, and it is unable to reach the sub-area 88.2 at all unless stopping for refuelling at McMurdo Station in Antarctica. The NZDF has considered stationing P3s on the ice but has not done so, as this would require a full ground crew and two flight crew stationed down there to provide the capacity for instantaneous response.

2.2 Benefits and costs of fishery monitoring and enforcement

Surveillance is one part of fishery monitoring and enforcement, which requires other capabilities for registering authorised vessels and accurately recording their catches. Surveillance provides a means of checking that only authorised vessels are operating in a restricted area and that all vessels are complying with the requirements for operating in that area.

Preventing IUU fishing affects three types of benefits:

- Direct benefit of avoiding the loss of payments due on licence fees, royalties, fines and other charges faced by authorised vessels – an averted opportunity cost for the New Zealand government
- Indirect benefit of mainly productivity gains from reducing negative impacts such as:
  - Depletion of fishable biomass
  - Avoidance of taxes and levies due, and creation of opportunities for transfer pricing by unauthorised transhipments of fish at sea
  - Compromising coastal zone management and marine environmental protection
  - Reduction of authorised fleet efficiency and profitability due to biomass reduction
  - Reduction of production-related employment both at sea and onshore
  - Additional management and control measures due to stock decline
  - Reduction in the legitimacy of management measures perceived to be based on inaccurate information (unknown IUU catch distorts assessments of stock and TACC)
  - Additional costs of catching and handling illegal fish and subversion of traceability.
- Illegal fishers gain short term benefit of their non-compliant operations, which they will pursue if the expected value of illegal activity exceeds the expected impact of being caught; but this private benefit for a minority offsets the direct and indirect

societal impacts listed above, so illegal fisher benefit needs to be reduced to realise the benefits of averting payment losses and reduction of negative impacts.

Raising the likelihood of being caught and the consequences of those caught are principal measures that states can take to deter IUU.

The impact of IUU is not confined to monetary measures of illicit profit. IUU operations are less likely to take effective measures to prevent by-catch of non-target species (including mammals and birds) and also less likely to adhere to labour laws around health and safety and appropriate wage levels.

In summary, therefore, improved capability for surveillance, monitoring and enforcement against IUU:

- Is beneficial in improving production by reducing loss of fish biomass out of authorised market processes, and with it loss of value for New Zealand from production and processing and export of Toothfish, and associated returns to NZ labour and capital
- Is beneficial in reducing loss of fishery-related revenues to government
- Is beneficial in improving non-market outcomes, to the extent that the improved range and scope of surveillance should detect and deter by-catch, high-grading and other infringements of good environmental practice in fishing operations
- Is beneficial in enabling some cost reduction in patrolling the Ross Sea, with reduced vehicle operating cost and faster response times, and fewer labour hours tied up in surveillance: some costs of running planes as an alternative or operating ships in the regions should be reduced compared to continuation of the current operation
- There will be costs in acquiring and operating the SeaGuardian vehicle(s) and setting up a control base on the mainland and connections to other locations at sea and on Antarctica.

At a minimum, the cost-effectiveness of the SeaGuardian and continuation of current arrangements could be compared on the assumption that both deliver the same outcome. We can then consider the effect of functional differences between the two operations (e.g. SeaGuardian may be able to hover in situ for longer and be more effective in identifying non-compliant activity, leading to a higher rate of violation detection and enforcement, leading to higher gain in output value).

3 Options for drone surveillance of Antarctic Toothfish fishery

This analysis compares the additional costs required to set up and operate the SeaGuardian system to cover the Ross Sea against the cost of the current operation of surveillance of the Ross Sea for the three months (or longer) that the Toothfish population is at risk of IUU. The cost of fishery regulation is assumed to fall on the New Zealand government in the first instance due to its international obligations in managing the area: benefits accrue to the fishing industry and the wider community to the extent that there are environmental and safety improvements provided by additional surveillance coverage of the Ross Sea. Fishery benefits may be captured by New Zealand fishers, but given the nature of the fishery, other nations' fishers may also benefit.

- Data has been drawn from the current presentation materials, or other sources
- We start with a cost-effectiveness comparison of SeaGuardian and the current system of aerial surveillance in performing the same function (annual cost of patrolling the Ross Sea for Toothfish surveillance) – focusing on aerial operations on the assumption that ship presence to follow up detected violations will probably be the same in each case
- We then develop some scenarios for estimating the benefits in quantitative terms and applying dollar values where feasible (e.g. for production gains, but environmental gains just noted) – projected over 5-10 years, allowing for activity changes
- This is to be summarised in a two-page statement on what the risks are in the Ross Sea Toothfish fishery and what the difference SeaGuardian could make in detecting and reducing them.

3.1 Options for drone operation in the Toothfish fishery

The basic premise for examination is that surveillance monitoring of the Ross Sea Antarctic Toothfish fishery can be more effectively achieved with remote operation of aerial drones than under the current arrangement of infrequent flights by manned Orion aircraft and occasional visits by a naval vessel.

The principal option considered is the government purchasing the services of two Company Owned, Company Operated (COCO) aircraft for a set number of flight hours each year. The drones are MQ-9B aircraft capable of running missions of up to 35 hours in the air (Light Maritime configuration) or 26 hours with Heavy Maritime configuration.

3.1.1 Two Company Owned, Company Operated drones #1

The first option would procure the services of 2 drone aircraft and up to 5,840 flight hours a year, for an annual cost of $63.3 million a year in the first year. This option would also necessitate the purchase of a Data Fusion system for managing and analysing data collected, with a start-up cost of $14.7 million in the first year and a recurring annual suppler of $10.2 million in the subsequent year.

3.1.2 Two Company Owned, Company Operated drones #2

The second option would procure the services of 2 drone aircraft and up to 2,000 flight hours a year, for an annual cost of $51.1 million a year in the first year. This option would also necessitate the purchase of a Data Fusion system for managing and analysing data collected, with a start-up cost of $14.7 million in the first year and a recurring annual suppler of $10.2 million in the subsequent year.

3.1.3 One Company Owned, Company operated drone # 3

The final review of this paper highlighted the option of New Zealand leasing one MQ9 SeaGuardian and one Ground Control Station (GCS) for 3000 flying hours initially for one year. These options could be extended by increasing the numbers of MQ9 and flying hours in subsequent years. The cost of this one year COCO would be approximately $US34 million (NZ$49 million) for the year plus additional one-off costs of US$4 million (NZ$5.7 million). This option has been included for completeness here but not analysed as part of this scoping study.

3.1.4 Non-drone alternative

These options would enable cost savings from backing out non-drone alternative surveillance currently in use. The alternative surveillance currently available is:

- Remote surveillance of AIS tracking systems on ships, which may give suggestive evidence of non-compliant activity (such as when ships switch off their AIS system and avoid remote detection), but cannot give conclusive evidence of wrong-doing. This system has very low cost and would probably be retained in any future surveillance programme, so there would be no benefit from backing out this activity
- Observations by other fishing vessels in the Ross Sea, for instance, recovery of fishing gear from areas of the sea in which fishing activity is prohibited. This is also a low-cost surveillance method, but it is limited to areas in which other ships are operating, and it depends on the cooperation of other nation's vessels to report things that they find
- Aerial surveillance by crewed aircraft, which to date means 2-3 flights each season by P-3K2 Orion aircraft and crew. These aircraft have an operating cost variously put at between $12,500 and $20,000 per hour in RNZAF service and $US27,000 per hour in United States Navy service. In short, the derived operating cost for any of these platforms is totally dependent on what cost elements are included and on the number of flying hours achieved. A P-3K2 would require 12-hour missions and transit times of over 5 hours each way for a couple of hours on station in the Ross Sea. As aircrew generally change shifts at eight or nine-hour intervals, this may require double crewing some of the critical flying and navigation functions on the aircraft. Trials have been made of refuelling aircraft off the McMurdo Base airstrip, but this has not been relied on because of the logistical costs of supplying and maintaining fuel and crew based in Antarctica. Backing out these flights provide various benefits as they:
  - Incur costs in running the aircraft and supplying crew for the flights
  - Have limited surveillance time over the Ross Sea and hence have limited effect on detecting or deterring non-compliance
  - Pose a risk to the safety of flight crews exposed to long periods flying over a remote and hostile surface environment in which it would be difficult to mount an effective rescue operation
- A SeaGuardian, on the other hand, could operate from McMurdo Base Airfield with a minimal crew (two or three) and minimal infrastructure providing almost 24-hour coverage of the surveillance area.
- Naval vessels are periodically sent to project a presence in the Ross Sea, more for information gathering and deterrence than actual inspections. We expect a month's tour of duty of a naval vessel to cost several million dollars and use a figure of $4 million for the benefit of withdrawing one tour of such a vessel each year.[3]

3.2 Other benefits

Apart from the cost savings, a principal benefit of improved surveillance, deterrence and detection of fishing activity is the opportunity for New Zealand vessels to catch more

[3] From previous work we understand the cost of running a frigate in New Zealand to be around $20 million a year, so $4 million for a deployment of around a month may be an over-estimate.

Toothfish before the allowable catch is reached, and the fishery is closed. Removing miscreant vessels from the fishery lengthens the season and increase the probability of remaining compliant boats, including those from New Zealand, to catch a larger share of the allowable catch.

There is no reliable evidence on how much a reduced presence of boats enables New Zealand boats to increase their catch. However, with a greenweight catch averaging around 650 tonnes and giving rise to exports of around 600 tonnes, this provides a benchmark against which to assess the likelihood of an increase in tonnage. We also provide a back calculation of how much additional catch would be required to cover any loss in the analysis.

Apart from improving the monitoring of the fishery, drone operation also enables improved monitoring of environmental regulations such as avoidance of by-catch. There is no firm evidence for quantifying this effect, but note that such improvements should positively reduce other measures to avoid or remedy environmental damage.

4 Cost-effectiveness of alternative forms of aerial surveillance

To compare the cost-effectiveness of different forms of aerial surveillance, we assume a common scenario of different ways of delivering aerial surveillance to the Ross Sea. We compare the two MQ-9B drone options of COCO#1 and COCO#2, and a crewed flight in the P-3K2 Orion, assuming low costs of $12,500 per flight hour and high costs of $20,000 per flight hour. For the two COCO options, we divide the annual operating cost by the maximum flight hours to obtain average costs per flight hour of $10,839 for COCO#1 and $25,550 for COCO#2.

We assume the flight from Invercargill airport to the Ross Sea covers 1800 nautical miles and calculate the hours required for each aircraft to get there. The results are summarised in Table 1. This shows the drone to have a longer feasible time in the air, so although it takes longer to reach its target area, it also has longer on station while above the Ross Sea than the crewed options. This gives the drone additional capability for doing sweeps across the area, covering a broader area of sea and potentially staying longer over suspect vessels to verify what they are doing.

Table 1 Cost-effectiveness of options for aerial surveillance of the Ross Sea

	COCO#1 MQ9B	COCO#2 MQ9B	P-3K2 Low cost	P-3K2 High cost
Outward transit hrs	11	11	5.0	5.0
Time on Station hrs	13	13	1.0	1.0
Return transit hrs	11	11	5.0	5.0
Sortie hours (Light)	35	35	11	11
Total Sortie Cost	$ 336,010	$ 792,050	$ 137,500	$ 220,000

	COCO#1 MQ9B	COCO#2 MQ9B	P-3K2 Low cost	P-3K2 High cost
Cost/hour on station	**$ 25,847**	**$ 60,926**	**$ 137,500**	**$ 220,000**
3 Sorties a season	$ 1,008,031	$ 2,376,150	$ 412,500	$ 660,000
Hours on station	39	39	3	3
36 hour surveillance	$ 1,344,041	$ 3,168,200	$ 2,475,000	$ 3,960,000

Source: NZIER

The costs per sortie are lower for the crewed aircraft than for the drone, as the charge for the latter covers the long-run marginal cost of the new equipment, whereas the crewed aircraft cost covers only short-run marginal cost. However, in terms of the cost of the aircraft being on station, the longer sortie hours and lack of onboard crew constraint mean the drone options are more cost-effective in delivering hours of surveillance than the crewed aircraft.

The drone options also have a qualitative advantage, in that much more elaborate surveillance can be provided by a 9-hour stint over the ocean than by the shorter stints in the crewed aircraft. With two drones in each of the COCO options, it is possible to deploy each consecutively to provide up to 18 hours of continuous surveillance, a far longer period than can be provided by the crewed aircraft.

Table 1 shows that of the four options, COCO#1 has the lowest cost per hour on station. COCO#2 is 20% cheaper than COCO#1 but enables 66% fewer flight hours, so COCO#2 is more costly per sortie than P-3k2 options. Either P-3K2 option is cheaper than MQ-9B for three sorties but has a shorter time on station. Increasing surveillance time further to 36 hours, COCO#1 is the cheapest option. But, P-3K2 would require flight crews to spend 120 hours in transit for those 36 hours. As flight crews face a recommended duty shift of 9 hours, a 12-hour sortie would need a double flight crew.

COCO#1 is more costly than COCO#2 but also more cost-effective in supplying surveillance. P-3K2 appear less costly in supplying flights, but time on station would be limited.

The P-3KB Orions are due to be replaced in 2023 by P-8A Poseidon aircraft, a variant of the Boeing 737-800 adapted for coastal patrols. These are larger, heavier and faster jet aircraft than the Orions but less suited to unobtrusive observation than the drones, which can operate at slower speeds at low altitudes. Evidence from the Australian Air Force P8A Poseidons suggests their time on station may not be much different from those of the Orion (Table 2), and we assume their costs per hour are unlikely to be lower as well. In the absence of better data, this suggests the P8A is unlikely to challenge the MQ-9B’s advantages in operational and cost-effectiveness terms.

Table 2 Comparison of aircraft options for aerial surveillance of the Ross Sea

		MQ-9B	P-3K2	P8A Poseidon
One way distance to the Ross Sea	nm	1800	1800	1800
Cruise speed	kts	164	360	461
One way transit time	hr	11.0	5.0	3.9
Time on station	hr	13.0	1.0	1.0
Return to base	hr	11.0	5.0	3.9
Endurance at cruise speed	hr	35.0	11.0	8.8

Source: NZIER

5 Cost-benefit analysis of the drone option

A cost-benefit analysis attempts to identify, quantify and attach value to all the costs and benefits that arise due to the drone option being taken up by the government. From a New Zealand national perspective, the costs and benefits that matter are those accruing to New Zealand residents, although there could be benefits for the wider global community as well.

The MQ-9B drone would both replace some current surveillance operations and also extend the surveillance capability. The principal benefit of that would be from either increasing the detection of non-compliant activity in the Ross Sea fishery, that would lead to the positive identification of erring vessels and place them on the CCAMLR's list with temporary removal from the fishery, and the deterrent effect of more regular patrols that should reduce the number of infringements and level the playing field for compliant vessels. Either of those outcomes has the potential to increase the probability of New Zealand vessels catching more fish, of benefit to the fish harvesting operations and also to the processing and marketing operations that handle Toothfish.

The nature of the Antarctic Toothfish fishery means not all the potential benefits identified in section 2.1 above are significant for this analysis:

- Avoiding evasion of payments on licences, royalties, and other charges is not significant, as the only charge on the fishery is a payment to the CCAMLR for fishery conservation: if a notified vessel is barred from the fishery and withdraws, the CCAMLR will lose its contribution, but this will have little effect on New Zealand operations in the area
- Reducing loss of fish biomass available for New Zealand harvest is significant, although the volumes may be rather small unless multiple vessels are detected and barred from the fishery, leaving a substantial uncaught quantity for other boats to share – this should increase the productivity, efficiency and profitability of authorised boats still operating in the fishery
- Cost reduction in patrolling the Ross Sea, or rather improving the patrol effectiveness at a lower cost than is possible with the existing fleet of air and sea vessels, can provide an improvement in value for money for the government

- Several non-market outcomes could also improve with enhanced surveillance capability in the fishery, including a reduction in environmental damage from the fishing operation
- The presence of drones in the region has potential benefits for other activities, such as search and rescue operations, reducing the safety risks for the crew of air and sea vessels in the current regulatory surveillance operation.

5.1.1 Modelling the costs and benefits

To illustrate the costs and benefits, we prepare a simple model in which the costs of adopting COCO#1 over a 7-year contract period are compared against:

- The avoided costs of other air sorties for fishery surveillance are assumed to be 3 per season at a total cost of NZ$660,000
- The avoided cost of sending a naval ship to the Ross Sea for a month each year, which we assume a cost of $4 million per trip
- The availability of the drone to assist in search and rescue and other safety improvements from reducing risks to air force and naval personnel spending less time in the hazardous environment of the Ross Sea – we assume a value of $0.47 million per year or 10% of the value attached to saving one life in the NZTA's transport appraisals
- The productivity gain in additional fish caught from the enhanced surveillance capability: we have no crystal ball on how large that would be, but run our model backwards to estimate how big that gain would need to be, given current catches and prices, for the drone operation to break even after other costs and benefits have been taken into account.

We also suspect the drone operation would make a positive contribution to New Zealand reducing its emissions of greenhouse gases, in line with the zero carbon aspirations, given the drone is a lighter bodied aircraft with longer flight times relative to the higher emitting take-off and landing stages than the crewed aircraft it would replace. However, we have seen no technical data on how large that benefit might be and leave this as an unquantified benefit in the analysis.

The operation costs under the COCO options include the charge covering annual operating costs for each seven-year contract period, a one-off cost of $14.7m. to install a Data Fusion programme to manage and analyse data and ongoing maintenance and support of Data Fusion at $10.7 million per year. Costs are projected in constant dollar terms, i.e. without accounting for inflation which would add an extra layer of forecast uncertainty to the estimates. In recent years general price inflation has been around 2% per year and would have a limited effect on the analysis outcome.

The share of total drone costs attributable to the Toothfish surveillance is apportioned in proportion to the share of available flight time under the COCO contracts. As drone operating costs can be identified per flight hour, it is necessary to specify the number of flights the drones would make in their surveillance season.

For this purpose, we assume 4 sorties (2 each by 2 drones), which implies a substantial increase in time on station above the fishery to 36 hours per season, compared to about 1-2 hours per flight on 3 flights per season by the current Orion patrols. Increased time on station would offer both an increased presence for deterrence and detection purposes and the opportunity for increased collection of scientific information such as whale sightings and perhaps air composition to provide further value from the flights.

If we assume the COCO contracts use all the flight hours available under them, accounting for flights hours as described in aggregate will cover the full cost of the contracts. There could also be an opportunity cost from deploying drones for Toothfish patrols in the sense that they would not then be available for other potential uses away from the southern end of New Zealand, but that could be managed by planning the deployment of the drones over the year, and also by compressing time spent in Southland to the period when they are most valuable in deterring IUU activity, just before and at the beginning of the Toothfish season.

6 Results

Table 3 shows the results of the COCO#1 option on the initial settings above. It shows costs exceeding benefits when the benefit is confined to backing out alternative surveillance flights by crewed P3 Orions. Backwards analysis indicates break-even requires the value of exports from enhanced catches to increase by 3.4%, about $0.7 million additional exports per year at a current price of NZ$37/kg. This would be equivalent to about 27 additional tonnes of Toothfish caught each season.

Table 3 also shows that if an additional benefit of around $0.42 million is assumed for contributions to search and rescue (SAR) and other uses the drone could provide concurrent with these flights (e.g. scientific information gathering), COCO#1 would have a net benefit of $2.3 million. And if the drone surveillance flights could avoid the cost of sending a naval vessel to the Ross Sea for a month each year, saving a marginal cost of frigate operation of around $4 million for that period, net benefits would increase to nearly $25 million with a benefit-cost ratio of 4.3.

Table 3 Results for COCO#1

Successive insertion of additional benefits. Break-even in the second column from the left (NPV=0, BCR=1)

	COCO#1 6%	COCO#1 6%	COCO#1 6%	COCO#1 6%
Number of sorties	4	4	4	4
Productivity gain to break even	0.0%	3.4%	3.4%	3.4%
Annual value gain $m	0.0	4.8	4.8	4.8
Avoided costs of other air sorties	4.6	4.6	4.6	4.6
Avoided cost of naval presence	0.0	0.0	0.0	28.0
Availability for SAR & other uses	0.0	0.0	2.9	2.9
NPV $m	**-3.8**	**0.0**	**2.3**	**24.7**
BCR	**0.5**	**1.0**	**1.3**	**4.3**
Discount rate	6.0%	6.0%	6.0%	6.0%

Source: NZIER

An increase in 27 tonnes of Toothfish a year caught by New Zealand vessels appears to be a feasible and achievable outcome. Over the past 10 years, New Zealand boats have caught on average 196 tonnes per year, while other countries' boats have caught 171 tonnes on average. On those figures, New Zealand would need to gain 16% of the catch of any vessel barred from the fishery would no longer be extracting from the fishery. That percentage is similar to New Zealand boats' current share of total recorded removals from the fishery, so it appears feasible.

Table 4 presents similar results for Coco#2. Because that option provides for fewer flight hours, the average flight costs are higher. The option achieves a negative net present value of $-14 million if the only benefit is the avoided costs of other sorties. Break-even of this option would require a larger productivity gain – a 12.5% increase in the value obtained from the fishery, requiring 101 additional tonnes of Toothfish caught each season. This is equivalent to about 60% of the average catch of a non-New Zealand vessel which is banned because of detection of fishery infringements by the enhanced drone presence. Unless the enhanced surveillance greatly increases the number of non-compliant boats detected and banned from the fishery, to achieve this productivity gain, New Zealand boats would have to catch a higher proportion of the forgone harvests of the banned boats than do of total harvest from the fishery.

Table 4 Results for COCO#2

Successive insertion of additional benefits. Break-even in the second column from the left (NPV=0, BCR=1)

	COCO#2 6%	COCO#2 6%	COCO#2 6%	COCO#2 6%
Number of sorties	4	4	4	4
Productivity gain to break even	0.0%	12.5%	12.5%	12.5%
Annual value gain $m	0.0	17.6	17.6	17.6
Avoided costs of other air sorties	4.6	4.6	4.6	4.6
Avoided cost of naval presence	0.0	0.0	0.0	28.0
Availability for SAR & other uses	0.0	0.0	2.9	2.9
NPV $m	**-14.0**	**0.0**	**2.3**	**24.7**
BCR	**0.2**	**1.0**	**1.1**	**2.4**
Discount rate	6.0%	6.0%	6.0%	6.0%

Source: NZIER

Table 5 shows results for the same scenario of sorties run by a Military Owned, Military Operated outfit. This model is a little different from the COCO options in that there is a capital acquisition cost of $181 million to be accounted for. We annualise this over 7 years at a discount rate of 6%. We use a marginal cost per flight hour covering fuel and labour of about $4,680 per hour (derived from US figures converted at the average exchange rate over the past 5 years) to calculate costs per sortie of about $145,000 and $16,114 per hour on station. These are lower costs than the COCO options because capital costs are not covered. Accordingly, we apportion a share of annualised capital cost in proportion to the fisheries share of total flight hours to calculate the overall cost-benefit result.

Table 5 shows the results of this calculation. Without any increase in productivity and just backing out of other surveillance counted as a benefit, this option has a negative net present value of $5.6 million. It would require a productivity gain of 5% to break even, other things held constant. Adding in the benefits of SAR and scientific uses, the net benefit rises to $2.3 million. With the backing out of naval vessel presence, benefit increases to $24.7 million with a benefit-cost ratio of 3.7.

Table 5 Results for Military owned, Military operated option

Successive insertion of additional benefits. Break-even in the second column from the left (NPV=0, BCR=1)

	MOMO 6%	MOMO 6%	MOMO 6%	MOMO 6%
Number of sorties	4	4	4	4
Productivity gain to break even	0.0%	5.0%	5.0%	5.0%
Annual value gain $m	0.0	7.0	7.0	7.0
Avoided costs of other air sorties	4.6	4.6	4.6	4.6
Avoided cost of naval presence	0.0	0.0	0.0	28.0
Availability for SAR & other uses	0.0	0.0	2.9	2.9
NPV $m	**-5.6**	**0.0**	**2.3**	**24.7**
BCR	**0.4**	**1.0**	**1.3**	**3.7**
Discount rate	6.0%	6.0%	6.0%	6.0%

Source: NZIER

These results suggest the naval option falls somewhere between COCO#1 and COCO#2 in terms of net benefits from the same surveillance operation. The productivity gain it requires to break even is more feasible than that of COCO#2, being modelled on 5,280 flight hours like COCO#1.

All these results are based on input data of variable quality. Reading across the tables, the columns on the left have the figures of greatest certainty, and those more open to question entered towards the right. There are also a number of non-quantifiable benefits for environmental monitoring which do not appear in this analysis. Nevertheless, the estimates give an indication that the MQ9 drone options under a variety of management arrangements could be net beneficial and that the options could be refined for further investigation.

7 Next steps

This scoping study was a test case focusing on one potential application of the SeaGuardian drawing on data to hand on Antarctic Toothfish. We conclude that the SeaGuardian:

- is a cost-effective capability
- covers its full costs by reducing the operating cost of existing platforms and enabling a 3% increase in fisheries catch from enhanced surveillance
- generates other unquantified co-benefits such as reduced bi-catch and an enhanced search and rescue capability.

Development of the full business case will require assessing the best ownership structure (company or government owned), governance arrangements (focused on club funding and tasking) and reviewing other non-military applications that can exploit SeaGuardian's sophisticated sensors, extended range and endurance and its capability to carry out many tasks simultaneously. These applications include but are not limited to firefighting, combatting drug, arms and people trafficking, search and rescue, biosecurity response, disaster response, law enforcement, and infrastructure monitoring. However, this first pass shows the exciting potential that an enhanced maritime surveillance capability provides New Zealand.