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Electronic onboard monitoring pilot project for the Eastern Tuna and Billfish Fishery

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Project No. 2009/048

Australian Government
Fisheries Research and Development Corporation

Australian Government
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1 NON TECHNICAL SUMMARY

2009/048	**Electronic onboard monitoring pilot project for the Eastern Tuna and Billfish Fishery**

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Objectives:

1. To deploy electronic monitoring systems on ten commercial fishing vessels in the ETBF and maintain their continuous operation for a period of up to one year.
2. To evaluate the efficacy of electronic monitoring for a number of fishery monitoring issues.
3. To develop an audit-based approach to electronic monitoring data analysis for evaluating fisher logbook data quality.
4. To undertake a cost and benefit analysis of monitoring options and programs required to meet the fisheries data needs.
5. To develop and evaluate the feasibility of establishing a third party service delivery structure for an ongoing electronic monitoring program in the ETBF.

OUTCOMES ACHIEVED TO DATE

Implementing cost effective management arrangements and services is critical for an economically sustainable fishing industry. This report describes the trial of electronic monitoring systems in the Eastern Tuna and Billfish Fishery (ETBF).

The electronic monitoring systems functioned reliably on ETBF vessels during the trial and data collected was of sufficient quality and level of detail to meet many of AFMA's current onboard monitoring requirements. The report outlines how sensor and image data provides an independent record that can be used to implement a sampling regime to randomly check the accuracy of the daily fishing logbook record.

The results of the electronic monitoring trial show that significant savings over onboard observers are possible. Based on these findings, the further development and implementation of an electronic monitoring program will assist the ETBF in a number of areas including:

- More cost-effective and strategic fishery monitoring and assessment processes,
- More efficient and cost-effective management arrangements such as streamlined quota monitoring and reconciliation practices,
- Greater industry ownership of resource management and stewardship, including simplified regulations, and
- Risk based and targeted compliance operations by AFMA, underpinned by audit processes.

At-sea observers are currently used in the Eastern Tuna and Billfish Fishery (ETBF) to collect a range of data including catch, effort, interactions with protected species and the effectiveness of mitigation measures. There is a high cost associated with this monitoring and this is recovered from the fishing industry. As the costs of commercial fishing businesses increase there is a need to assess alternative monitoring options to reduce costs whilst maintaining high quality data for decision making.

Electronic monitoring technology was trialled on ten ETBF vessels between October 2009 and August 2010 and collected data on almost all fishing activity undertaken during this period. Some issues were identified during the trial; however these were associated with installation or servicing and could be corrected in an ongoing program.

Electronic monitoring provided a comprehensive and continuous set of temporal and spatial data on gear setting and hauling activities that compared well to observer data. The agreement between electronic monitoring and observer records was also very close for retained catch; however there were significant differences between the data sources when released catch was compared. The higher level of agreement between observers and electronic monitoring retained catch was due to catch coming aboard in clear view of the cameras. Further improvements can be achieved by working with the crew to develop and adopt a standardised approach to handling catch, thereby improving the ability to observe and detect catch and events from the image data. Electronic monitoring was also able to detect all protected species interactions that were reported in logbook records during the trial.

An ongoing electronic monitoring program with audit and scoring methodologies that compare fishers' logbook data with electronic monitoring data can provide a measure of the reliability of fishing logbook records. When coupled with appropriate checks and feedback loops this program can then be used to modify behaviours, improve logbook reporting, and demonstrate the integrity of the data.

Voluntary and compulsory electronic monitoring programs were examined in terms of costs and benefits. The most easily quantifiable benefit expected from electronic monitoring is cost savings through reduced 'at-sea' observer coverage.

A cost benefit analysis was used to compare the current observer program with two electronic monitoring scenarios. The first was a voluntary program based on a fleet of 40 boats and an 80% uptake of electronic monitoring. Under this scenario it is likely there would be an overall nominal cost decrease of about $150,237 each year and a potential saving of approximately $1.1 million in correct dollar terms over a 10 year period. The other scenario was a compulsory program, which would result in an overall cost decrease of about $71,892 each year and a potential saving of $451,247 over a 10 year period. Changes to parameter values in each model show that the net benefits of an electronic monitoring program are sensitive to effort (fleet size, sets) and level of onboard monitoring coverage specified, electronic monitoring analysis and audit level and observer rates. The marginal cost of increasing onboard monitoring coverage by 1% is also much cheaper with electronic monitoring systems than physical observers. Electronic monitoring program savings would be greater if observer sampling rates needed to be increased in the future.

Additional benefits associated with electronic monitoring may also be possible if other management practises changed. For example restrictive management measures such as hook limits and temporal closures could be removed in favour of more outcome focused methods.

KEYWORDS: Eastern Tuna and Billfish Fishery, electronic monitoring, cameras.

2 ACKNOWLEDGEMENTS

This research project, *Electronic onboard monitoring pilot project for the Eastern Tuna and Billfish Fishery*, was assisted by funding from the Australian Government through the Department of Agriculture, Fisheries and Forestry.

This research was a collaborative study between the Australian Fisheries Management Authority (AFMA), Archipelago Marine Research Ltd. (AMR) and industry members from the Eastern Tuna and Billfish Fishery. The authors appreciate the interest, support and collaborations from industry owners, skippers and crews that participated in the project. Thanks especially to Steve Hall, AFMA observer coordinator for his support and assistance addressing system service matters and data analysis during the field trial period.

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3 BACKGROUND

3.1 PROJECT CONTEXT

On a worldwide basis, the demand for accurate, timely and relevant catch monitoring from commercial fisheries continues to increase. In Australia, fishing operations are known to interact directly with protected species such as seabirds and turtles. Interactions can include incidental capture or direct contact with fishing operations that may result in harm or death. Monitoring protected species interactions during fishing operations is one of the main drivers for implementing 'at-sea' independent observer programs. These programs can incur significant costs direct to the fishing industry. In recent years, increased operating and management costs have highlighted the need to investigate more cost effective ways of 'at-sea' monitoring to achieve the necessary confidence that fishing operations are not having adverse impacts.

3.2 THE EASTERN TUNA AND BILLFISH FISHERY

The Eastern Tuna and Billfish Fishery (ETBF) is a multi-species, multi-method fishery accessed by commercial fishers, recreational game fishers and charter fishing operations. The Australian Fisheries Management Authority (AFMA) manages the commercial sector through a system of input and output controls, including limited entry, zoning, spatial closures, bycatch provisions, gear restrictions and total allowable catch arrangements. The ETBF extends to the Australian Fishing Zone (AFZ) from Cape York to the South Australian-Victorian border and includes waters around Tasmania (Figure 1) and the high seas area of the Western and Central Pacific Fisheries Commission (WCPFC).

The fishery is managed under the *Fisheries Management Act 1991* and the *Eastern Tuna and Billfish Management Plan 2005* and operates in accordance with the decisions of the WCPFC. The majority of targeted effort is at Yellowfin Tuna, Bigeye Tuna, Albacore Tuna and Broadbill Swordfish. A small component of the fishery also takes Striped Marlin on a seasonal basis. Ray's Bream, Dolphin Fish and Oil Fishes are also an important component of the non-targeted catch. Operators fishing in the ETBF also take Southern Bluefin Tuna (SBT) along the New South Wales (NSW) coast during certain times. All catch of SBT that is not released in an alive and vigorous state has to be covered by quota under the *Southern Bluefin Tuna Management Plan 1995*.

The *Eastern Tuna & Billfish Fishery Management Plan 2010* is a key document for managing the ETBF. In March 2011, AFMA implemented a system of individual transferable quotas (output controls) for the 5 key target species; Yellowfin Tuna, Bigeye Tuna, Albacore Tuna, Broadbill Swordfish and Striped Marlin. Other existing management arrangements in the ETBF include:

- Restricted access zones and increased observer requirements on the NSW coast during certain times of the year (around May-November) to control interactions with SBT
- Reporting obligations including logbooks, carriage of observers and independently verified catch disposal records (CDRs)
- Bycatch reduction measures including use of specified tori lines, weighted lines, thawed baits, ban of the use of wire trace and trip limits on sharks.

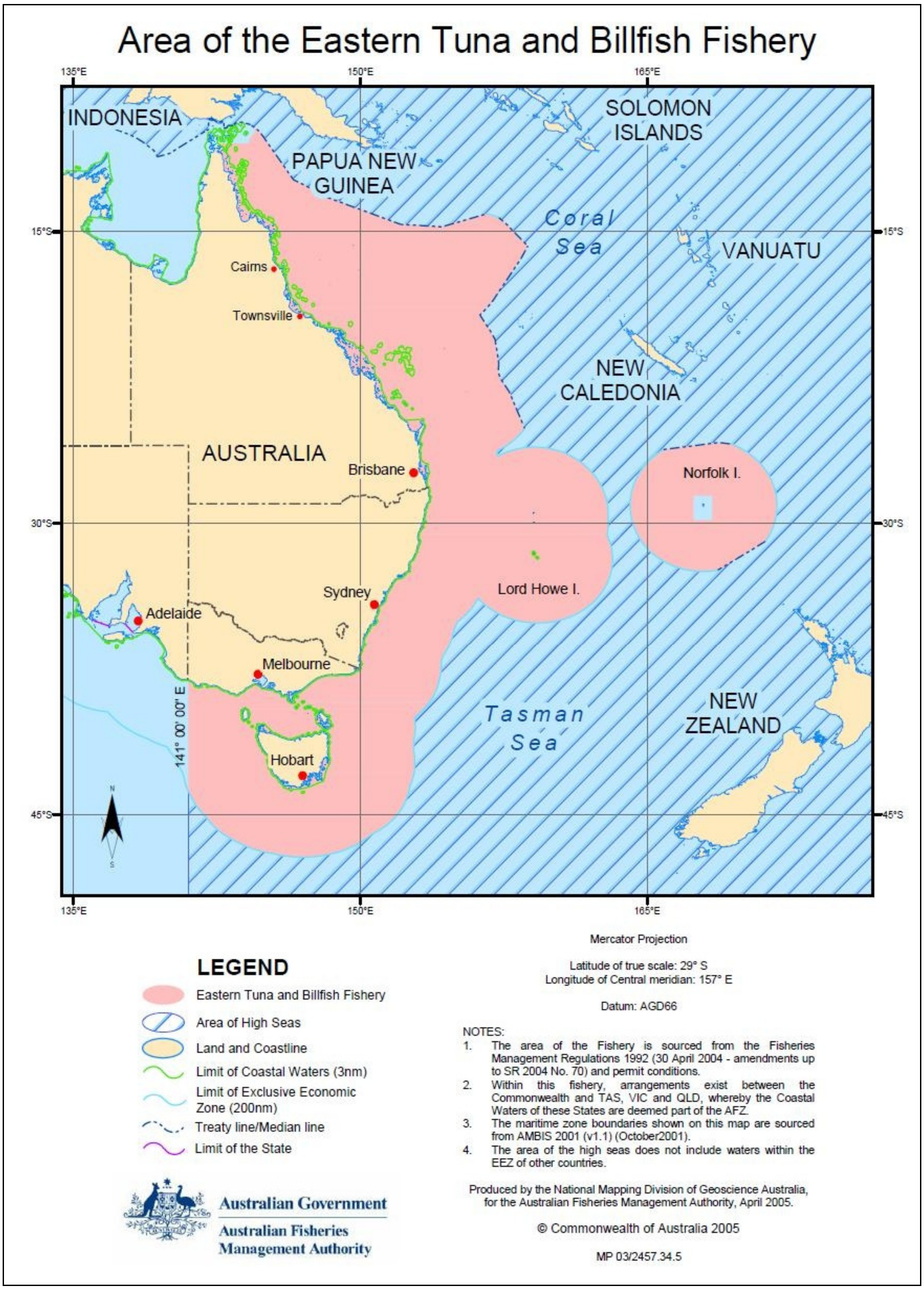

Figure 1: Area and spatial extent of the ETBF.

3.3 MONITORING IN THE EASTERN TUNA AND BILLFISH FISHERY

3.3.1 Drivers of data collection programs

Sound and responsive fisheries management requires data collection programs that are designed and implemented to meet specific monitoring objectives and data needs for decision making processes. Like all Commonwealth fisheries, data collected in the ETBF are used to assess the status of fish stocks, monitor compliance performance and impacts of fishing on the environment. This data is used to help design and implement management arrangements and responses to high risk issues.

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) sets the foundation for assessing the impacts of fishing on the environment and implements the legislative framework to respond to environmental issues in a structured manner. For example, the EPBC Act requires that a strategic assessment of the fishery must be conducted to ensure that the fishery operates within the principles of ecologically sustainable development. These data are required on fishery interactions with species listed under the EPBC Act and bycatch in the fishery. This information is largely collected through the catch and effort logbooks and the 'at-sea' observer program.

An assessment process under the EPBC Act resulted in oceanic longline fishing being listed as a key threatening process for seabirds requiring the development of a Threat Abatement Plan (TAP). Seabirds are attracted to fishing vessels by discarded offal and baits and on occasion ingest baited hooks during the setting or, less commonly, hauling of the longline. The impact of this additional mortality upon marine bird species is uncertain but many are long lived and late maturing with populations that are listed as vulnerable or have unknown status. As such, any additional mortality as a result of longline fishing operations has the potential to lead to further declines in seabird populations. As a requirement of the TAP, an 'at-sea' observer program has been implemented to monitor and report interactions with seabirds.

The current iteration of the TAP (2006) requires the ETBF to significantly reduce the bycatch of seabirds in oceanic longline operations and maintain a bycatch rate of less than 0.05 birds per 1000 hooks in all fishing areas (by 5 degree latitudinal bands) and all seasons (1 September – 30 April; 1 May – 31 August). In the ETBF, AFMA has implemented fishing permit conditions aimed at reducing seabird mortality which are consistent with the objectives and prescriptions of the TAP. Currently, a number of Commonwealth and ETBF specific policies and plans with principles related to fishery data collection processes are in place, these include:

- Commonwealth Fisheries Harvest Strategy
- Commonwealth Bycatch Policy
- Seabird Threat Abatement Plan (TAP) 2006
- Marine Turtle Recovery Plan
- National Plan of Action for Sharks
- ETBF Management Plan (2005)
- ETBF Strategic Assessment Requirements
- Australian Tuna and Billfish Longline Fisheries Bycatch and Discarding Workplan.

3.3.2 Data Collection Program

To collect all data needs in the ETBF, several methods and practices of data collection are employed by AFMA. Programs have been implemented and modified in line with developments in the fishery, changes to management arrangements and needs for environmental assessments. An overview of the major data collection methods are summarised below.

Logbooks
Longline sector operators who are using either or both pelagic longline and minor line methods are required to complete the 'Australian Pelagic Longline Daily Fishing Log' on a set-by-set basis. This records a range of catch and effort information in the fishery.

Catch Disposal Records
On 1 January 2006 AFMA introduced the 'Commonwealth Pelagic Fisheries Catch Disposal Record'. Operators are required to complete catch disposal records (CDRs) when unloading catch to licensed fish receivers. The operator must accurately weigh all fish and complete the first part of the CDR before the receiver takes possession of the fish.

Observers
In December 2006, AFMA increased the observer coverage in the ETBF to 8.5% of all fishing effort in response to the Ministerial Direction issued in December 2005, under section 91 of the *Fisheries Administration Act 1991*. This increase in observer coverage also reflected AFMA's commitments in the policy document *Future Operating Environment for Commonwealth Fisheries* and recommendations made by the Minister for the Environment and Heritage relating to the strategic assessment of the fishery, which was conducted in 2005. In addition to this, AFMA implemented an increased level of observer coverage (of up to 100%) for vessels operating in the identified SBT zones of the fishery.

SBT Zones
In April 2005, AFMA announced arrangements for managing SBT stocks off the East coast of Australia to address the risk of SBT being taken without quota. These arrangements are implemented annually and draw on industry information, sea surface and sub-sea surface temperature data and SBT satellite tagging data to assess the areas which SBT are likely to be located. Through the results of this model, AFMA determines the location SBT "core" and "buffer" zones for a specified time.

In order to operate in these areas, operators must hold a minimum of 500kg of SBT quota and meet the required level of observer coverage, which is based on the SBT quota holdings and charged by the number of sets completed plus a trip fee for each trip. The zones are generally in place from May-October each year and are updated fortnightly during the period.

3.3.3 Compliance risks and monitoring

In the fisheries compliance context, risk equates to the failure of fishing operators to comply with fisheries management arrangements and/or fishing permit/concession conditions. AFMA compliance conducts a risk assessment each financial year of all risks to compliance across the major Commonwealth fisheries to effectively direct resources.

AFMA's compliance program targets high risk activities and operators and implements several monitoring programs including, but not limited to, vessel inspections, sea patrols including aerial surveillance and Integrated Computer Vessel Monitoring System (VMS). The VMS technology is used to monitor pelagic longline operations and the movement of boats in and out of ports. VMS units allow AFMA to contact the skippers of vessels where reports are overdue. Compliance officers ensure that each vessel's VMS is working in accordance with conditions imposed on the fishing permit.

3.4 PREVIOUS ONBOARD ELECTRONIC MONITORING PROJECTS

Over the past decade, Archipelago Marine Research Ltd. (AMR) has pioneered the development of onboard video based electronic monitoring technology. Electronic monitoring systems have been fully integrated as a fishery monitoring tool on the west coast of Canada and the USA. There is a significant level of acceptance by fishers and fishing management agencies in those countries. Additionally, a number of pilot studies have been carried out to test the efficacy of this technology. McElderry (2008) provides a listing of over 25 studies (including four in Australia) spanning diverse geographies, fisheries, fishing vessels and gears, and fishery monitoring issues.

Electronic monitoring technology is increasingly being recognised as part of the fishery monitoring 'toolbox', providing monitoring on vessels where the technology is cost effective and/or logistically feasible as a replacement for observers. Another clear benefit of electronic monitoring is its use to enhance monitoring on vessels carrying observers, where the observer physically cannot monitor different parts of a large ship simultaneously. Lastly, data collected from electronic monitoring offers the unique property whereby image data can be viewed multiple times and used as an audit tool to score the accuracy of fishing vessel logbook data.

Stanley *et al*. (2008) outlined the benefit of image data providing an unbiased sample obtained at the moment of catch that cannot be corrupted. Randomly selected, this independent catch data validated against fisher logbook and dockside monitoring data has been shown to produce accurate catch estimates which, in turn, provide confidence to managers that the harvests are not exceeding catch quotas. Stanley *et al.* 2011) also state that an audit-based approach (versus a census-based approach) to video monitoring is also more robust against equipment failure, can provide greater transparency in how the data is used and increase stakeholders' trust in the program.

Previous pilot studies have shown that electronic monitoring is a useful tool for monitoring protected species interactions. McElderry *et al*. (2007) and McElderry *et al*. (2008) demonstrated that electronic monitoring systems could effectively monitor retrieval operations and encounters with protected and endangered species in New Zealand set net and inshore trawl fisheries respectively. Ames *et al*. (2005) showed that an electronic monitoring program would be able to detect a high proportion of incidentally caught seabirds. More recently, McElderry *et al*. (2010) revealed similar detection rates of protected species by electronic monitoring data analysts and 'at-sea' observers in the Hawaiian pelagic longline fishery.

In 2005, a series of 'proof of concept' studies over a number of Australian Commonwealth fisheries, including the Antarctic longline, Southern Shark gillnet, midwater trawl and Northern Prawn Fishery, identified that electronic monitoring technology addresses many of AFMA's monitoring needs. These studies showed that electronic monitoring systems can be installed and configured for a range of monitoring functions onboard Australian vessels (see McElderry *et al*. 2005a, McElderry *et al*. 2005b) including interactions with protected species.

4 NEED

Like the majority of the world's fisheries, the ‘at-sea’ observer program in the ETBF was implemented to record and verify catch information. Specifically, the program was designed to help understand protected species interactions during the setting and retrieval of the longline gear. As the operating costs of commercial fishing businesses increase, including the cost of management and associated monitoring programs, there is a strong need to assess alternative ‘at sea’ monitoring options. Recent advancements in electronic monitoring technologies have further instigated the fishing industry to investigate whether electronic monitoring can provide a cost effective alternative to the current ‘at-sea’ observer program.

Ames *et al*. (2005) stated that using electronic monitoring systems to monitor all setting and hauling activities of vessels in the Pacific halibut hook-and-line fishery off Alaska is estimated at about one-third the cost of an equivalent observer program. A 2007 AFMA commissioned cost benefit study and business case showed reduced costs if electronic monitoring technologies were adopted in preference to observers in several Commonwealth fisheries (see Gislason 2007). However, there remained considerable uncertainty regarding the extent to which observer coverage can be replaced in the ETBF and the costs involved integrating an electronic monitoring program into AFMA management practices.

This pilot project was designed to collect sufficient information to enable an in-depth cost benefit analysis of integrating an electronic monitoring program in the ETBF. Data processing and storage requirements are also defined as well as understanding the utilities of electronic monitoring technologies for ‘at-sea’ monitoring that provides economic and operational incentives for AFMA Concession or Permit Holders.

5 OBJECTIVES

The project had five major objectives as outlined below:

1. To deploy electronic monitoring systems on ten commercial fishing vessels in the ETBF and maintain their continuous operation for a period of up to one year.

2. To evaluate the efficacy of electronic monitoring for a number of fishery monitoring issues (determining time and location of fishing, catch of retained and discarded species, interactions with protected species and compliance with certain management arrangements such as bycatch mitigation measures).

3. To develop an audit-based approach to electronic monitoring data analysis for evaluating fisher logbook data quality.

4. To undertake a cost and benefit analysis of monitoring options and programs required to meet the fisheries data needs.

5. To develop and evaluate the feasibility of establishing a third party service delivery structure with AMR for an ongoing electronic monitoring program in the ETBF.

6 MATERIALS AND METHODS

6.1 PROJECT PLANNING AND VESSEL SELECTION

AFMA project staff and AMR representatives commenced planning for the project in April 2008 defining project tasks, roles, coordination, timelines, field servicing and vessel requirements. A 10 vessel trial was agreed to commence in October 2009 and operate for a 10 month period concluding in August 2010. In February 2009 AFMA called for expressions of interest to participate in the 10 month electronic monitoring trial from ETBF operators.

Industry members interested in the project attended a one day informational meeting in August 2009 and discussed the project design including the electronic monitoring system and its components, installation, servicing and data processing. A contract for services was agreed between AFMA and AMR with an October 2009 field trial start. The contract covered the leasing of electronic monitoring equipment, installation assistance and training, data analysis and reporting, satellite communications, and the use of data analysis and interpretation software.

Vessels were selected in the trial based on their intended fishing plan for the 10 month trial period and the location of their home port. With limited resources for the field servicing of vessels, those vessels based out of Mooloolaba and Ulladulla were given preference to allow for the best co-ordination for system maintenance and hard drive exchange. Variations in vessel design and type were also selected to help assess system installation and operational issues (see Figure 2). A list of participating vessels is provided in Table 1.

Figure 2: Variations in trial vessel designs include (a) forward wheelhouse fibreglass *FV Ocean Explorer* and (b) aft wheelhouse steel *FV Jordan Kate*.

Before commencement of the trial, a *Code of Conduct* was prepared to help participants understand the responsibilities and obligations during the trial such as assistance and cooperation during system installation and resolving operation problems. It also outlined the provisions of catch and effort information to AMR for data analysis and catch comparisons. Operators participating in the trial agreed to the code through signing a *Memorandum of Understanding* (MoU). The *Code of Conduct* also included an agreed compliance strategy outlining a staged approach of compliance responses and actions for the pilot.

Table 1: List if project vessels and specifications.

Vessel	Home Port	Month system commissioned	Hull material	Wheelhouse	Length (m)	Breadth (m)	Tonnage
Samurai	Mooloolaba	October	Fibreglass	Forward	19.8	6.1	28
Beluga	Mooloolaba	October	Steel	Forward	22.5	6.2	120
Blue Mistress	Mooloolaba	October	Aluminium	Forward	19.8	6.5	45
Ocean Explorer	Mooloolaba	October	Fibreglass	Forward	22.5	6.1	60
Ocean Myst	Mooloolaba	October	Fibreglass	Forward	22.5	6.1	60
Esbjorn*	Mooloolaba	April	Steel	Aft	23.7	6.9	160
Bianca B	Ulladulla	October	Fibreglass	Forward	22	6.2	40
Santo Rocco	Sydney	November	Steel	Forward	28	7.4	266
Jordan Kate	Ulladulla	October	Steel	Aft	20.1	6.5	65
Kaybeanna	Ulladulla	November	Steel	Aft	19.9	6.5	65

*Vessel agreed to participate during the mid point of the trial.

6.2 ELECTRONIC MONITORING SYSTEM

The electronic monitoring system used for this project was custom manufactured by AMR. A schematic diagram of the system is provided in Figure 3. The system consisted of four closed circuit television cameras, a GPS receiver, a hydraulic pressure sensor, a rotation (mainline drum) sensor, and control control centre. Both the rotation sensor and the pressure sensor were used as indicators of fishing equipment activity and to trigger video recording. Using two independent sensors provided a safeguard in the event that one of the sensors failed.

All systems were fitted with satellite transceiver modems for real time reporting of system status. The system Health Statement is an hourly message sent via satellite communication while electronic monitoring systems are powered. This one line message is a synopsis of the previous hour's sensor data including vessel location, activity and system health status. System Health Statements were used throughout the project to monitor the system's hard drive status remotely, to troubleshoot technical problems and prioritise service events.

Sensors and cameras were connected to a control centre located in the wheelhouse. The control centre consisted of a computer that monitored sensor status and activated image recording when the fishing gear was operational. The system was also programmed to record imagery for periods of 30 minutes following the completion of a haul or set. Sensor and image data were recorded onto 500GB hard drives which were estimated to last up to three months of normal longline fishing operations. The system specifications are described in Appendix 3.

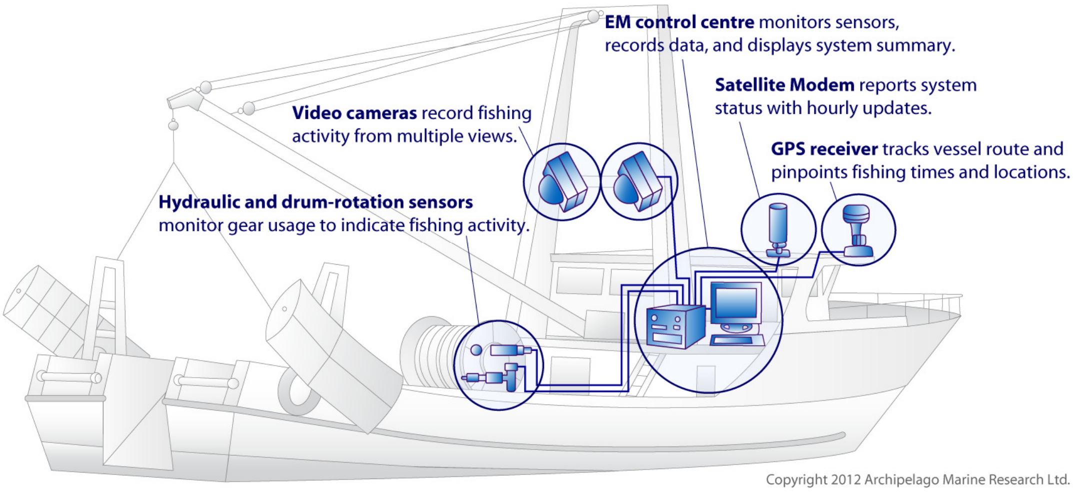

Figure 3: Schematic of a standard electronic monitoring system used in the trial.

6.3 SYSTEM INSTALLATIONS AND SERVICING

During the first week of October 2009, a senior representative from AMR, two representatives from Lat 37 Ltd. (subcontracted during the project) and AFMA project staff commenced installation of systems on project vessels. Before the installation commenced on each vessel the project team scoped and agreed on system component placement, cable runs, fishing operations and onboard practices (e.g. areas where catch is processed) with the vessels skipper and personnel.

The use of system components was the same for all vessels. The electronic monitoring system's GPS receiver and satellite modem were either mounted in the vessel rigging or on top of the wheelhouse. The hydraulic pressure transducer was installed in hydraulic system positive line of the mainline drum and the rotation sensor was mounted on the vessels mainline drum (Figures 4 & 5).

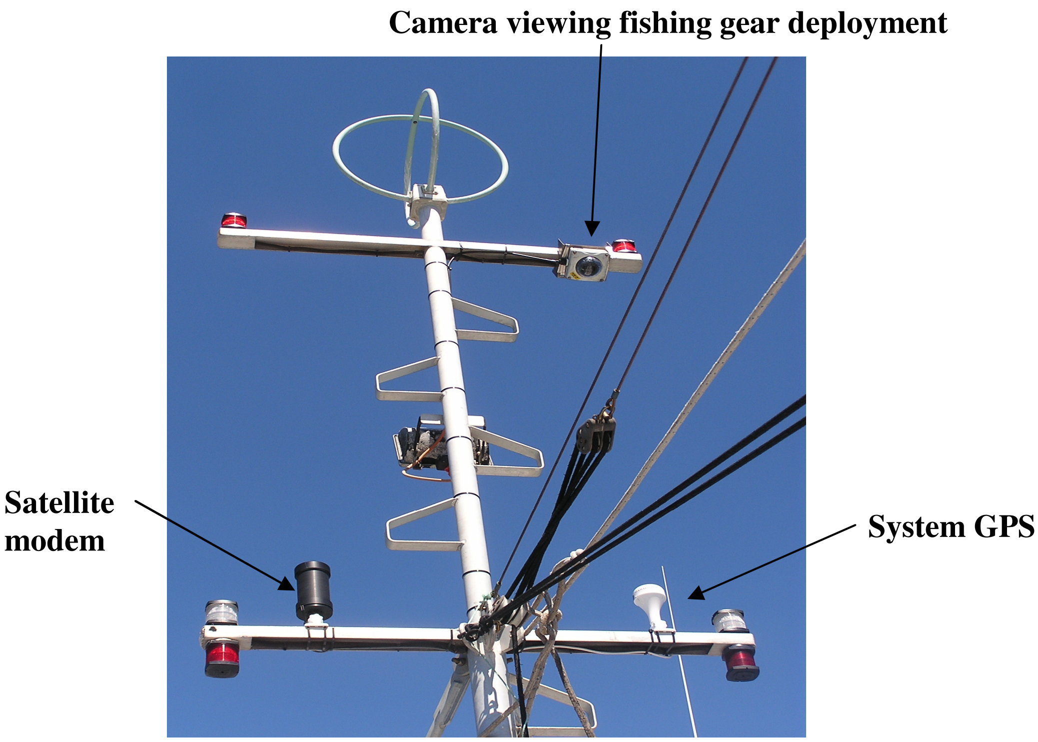

Figure 4: System's GPS receiver and satellite modem mounted in the vessel rigging of the *FV Ocean Explorer*. Camera directed after to capture fishing gear deployment.

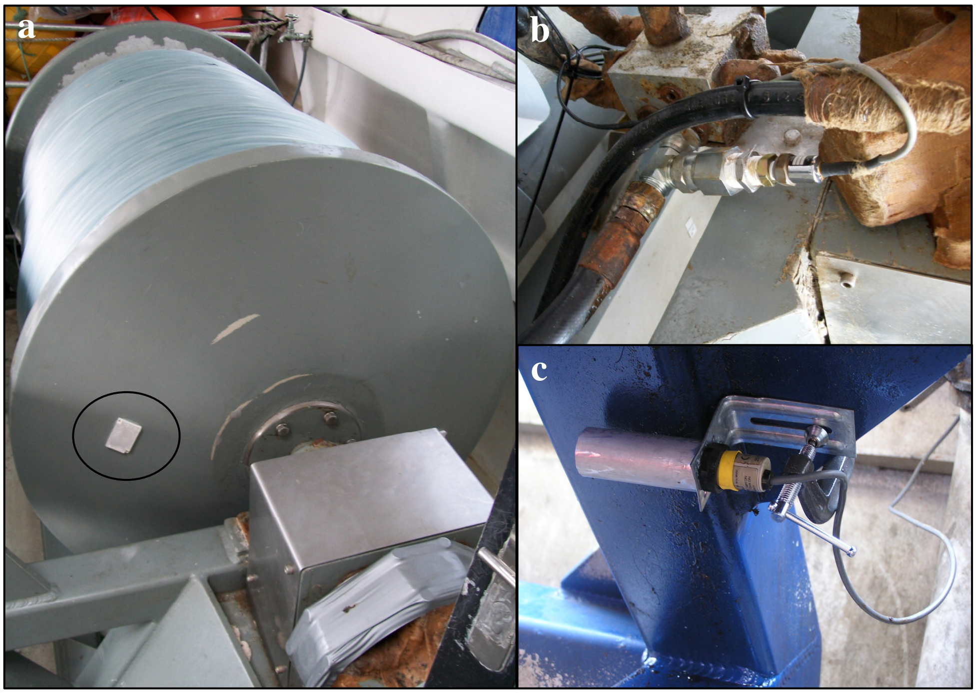

Figure 5: System sensors installed to record operational activities of the mainline drum; (a) standard mainline drum showing the rotation sensor reflector (circled), (b) hydraulic pressure transducer installed on the high pressure side of the mainline drum controller and (c) the rotation sensor.

Cameras were mounted in areas that required minimum fabrication while obtaining unobstructed views of fishing gear deployment and catch handling and processing. On each vessel, every effort was made to mount cameras in the best possible location. However, as a consequence of the variations in vessel designs and the temporary nature of the project, camera placements were opportunistic and a more optimal placement for viewing the fishing operations may be possible in a permanent set up.

The vessel lighting boom was used to install cameras to obtain out-board views of retrieving fishing gear and catch handling. In the event that the vessel did not have a lighting boom, a boom was fabricated and installed to place cameras to obtain the required views (Figure 6). Recommendations to improve camera views and placements were addressed during the project. In general, cameras were installed to observe the following areas:

1. Camera directed aft to view fishing gear deployment (i.e. use of tori-lines / seabird mitigation measures), see Figure 7,
2. Camera on boom to view retrieving fishing gear, handling snoods / clips, see Figure 6,
3. Second camera on boom to view sea door to monitor catch handling, see Figure 6, and
4. Camera directed to view deck area where retrained catch is processed, see Figure 8.

Examples of the four standard camera views captured from each camera are provided in Figure 10.

Figure 6: Cameras placed to enable an outboard view of fishing gear retrieval and catch handling on vessels existing boom (a) *FV Bianca B*, (b) *FV Jordan Kate*, and fabricated and installed boom (c) *FV Beluga* and (d) *FV Ocean Explorer*.

Figure 7: Cameras placed to capture views of fishing gear deployment on project vessels (a) *FV Jordan Kate*, (b) *FV Blue Mistress*, and (c) *FV Samurai*.

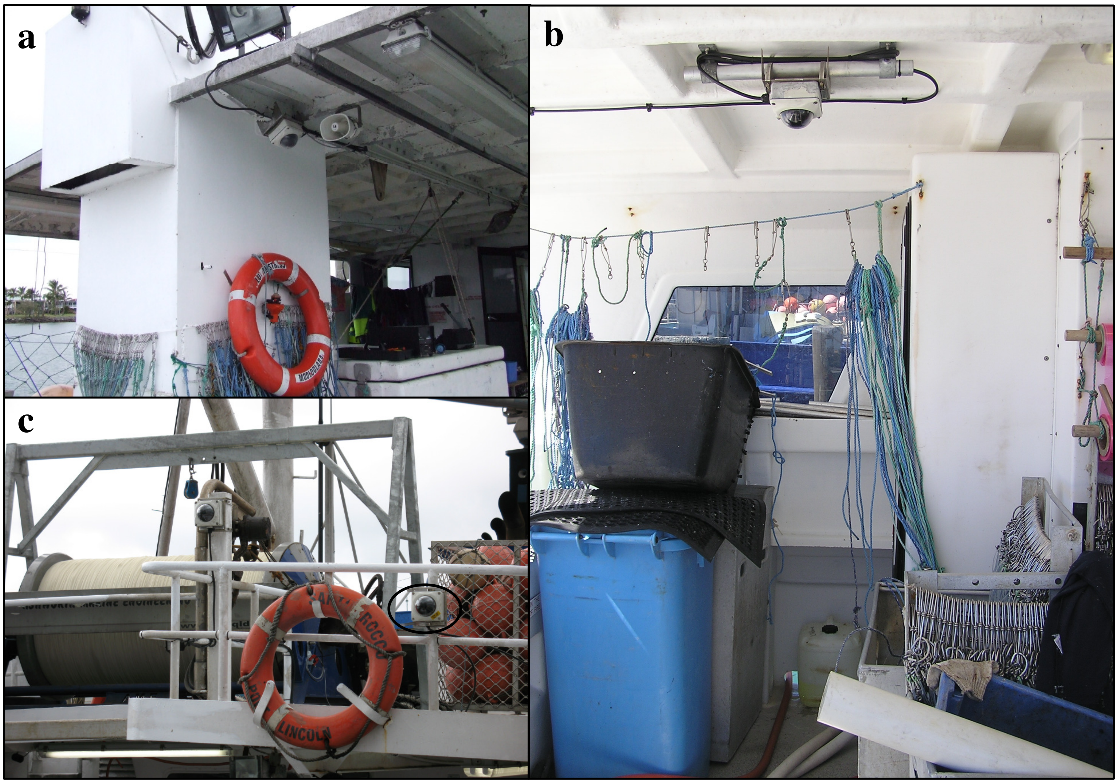

Figure 8: Cameras placed to capture views of catch processing on project vessels (a) *FV Blue Mistress*, (b) *FV Ocean Explorer*, and (c) *FV Santo Rocco*.

Control centres and monitors were located inside the wheel house of each vessel (see Figure 9), and sensor and camera cable runs were drawn to the wheelhouse through ports already in place for hydraulic and electrical lines. Upon completion of the system installation, the system was powered to test all sensors and cameras. The skipper was also briefed on basic system operation, maintenance and the user interface.

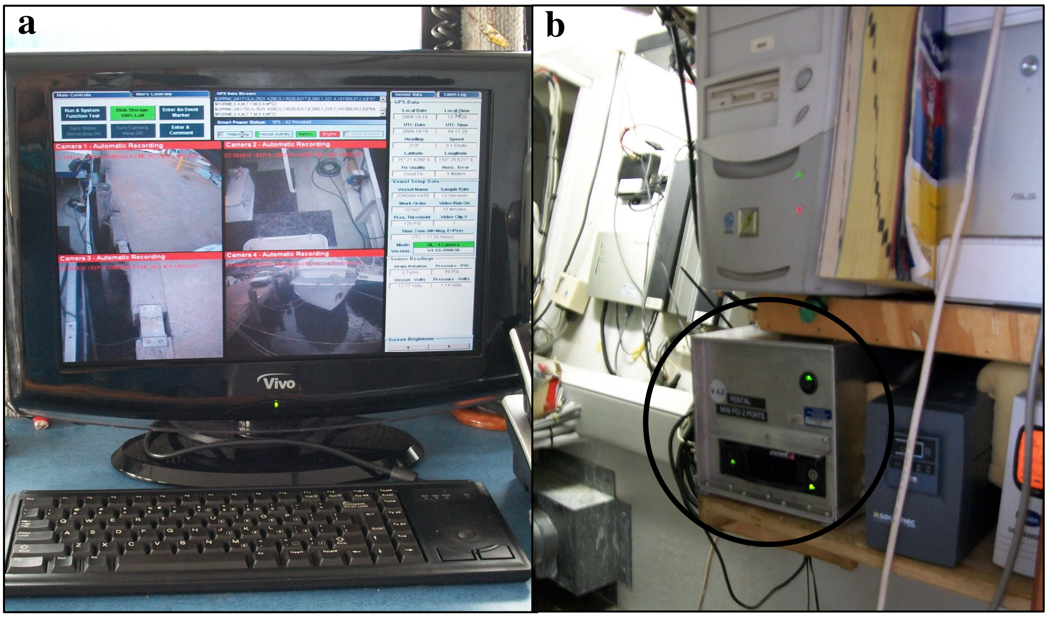

Figure 9: System monitor (a) and circled control centre (b) installed on project vessels.

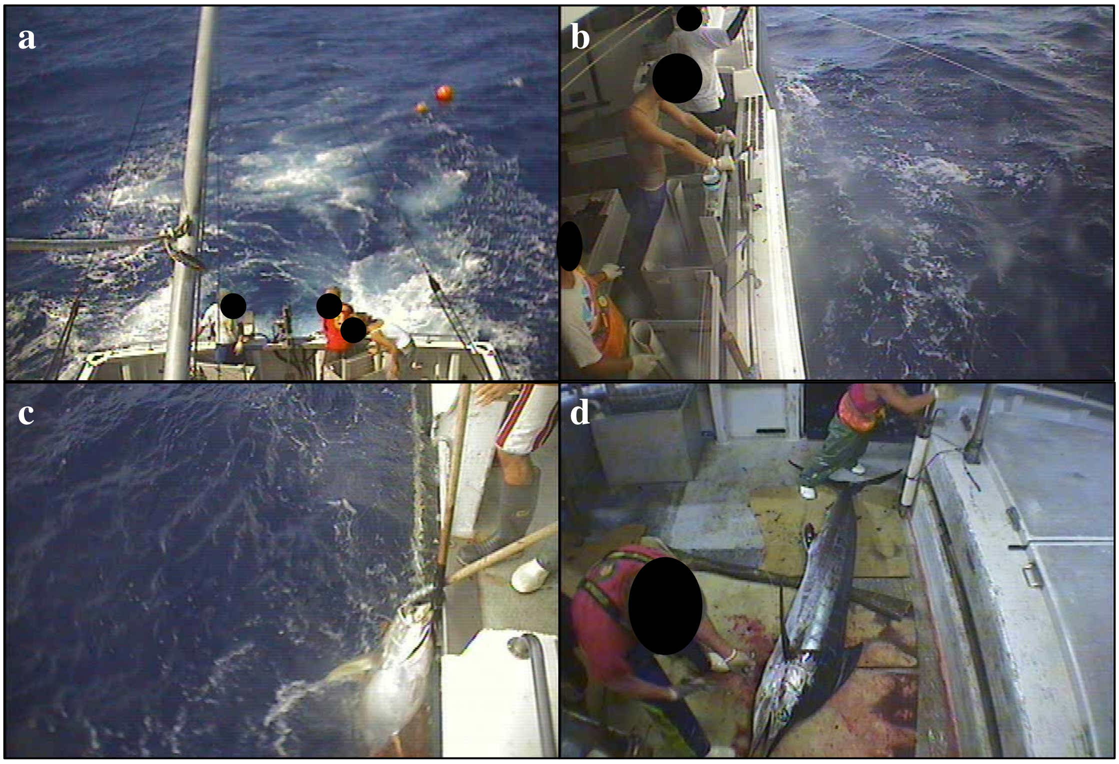

Figure 10: The 4 standard camera views onboard the *FV Ocean Explorer* shows (a) setting operation, (b) hauling operation, (c) bringing catch onboard, and (d) processing catch.

6.4 ELECTRONIC MONITORING DATA PROCESSING AND PLANNING

During the design phase of the project a review of the current 'at-sea' observer data collection practices was undertaken to determine how camera views can be installed to capture and compare the same data. Data interpretation protocols were also designed and communicated to the data analysts before any of the data processing began. The protocols were based on data collection and management priorities as well as previous experiences with electronic monitoring projects.

Vessel logbook and observer data were supplied to AMR during the trial to enable comparisons between the data sources. Following the completion of the data analysis and catch comparisons, assessments of possible logbook audit and scoring methodologies for an ongoing program were undertaken. This included understanding the existing data overlaps and alignments, and comparing how scoring methods have been developed and applied in established electronic monitoring programs.

6.5 ELECTRONIC MONITORING DATA COLLECTION AND INTERPRETATION

During the project, the systems Health Statements were regularly monitored to assess the status and available space on each system's hard drive in order to manage hard drive exchange. System hard drive exchanges were either undertaken through opportunistic meetings with project vessels by field staff or coordinated meetings with the vessel. Sensor data files were uploaded to AMR's internet file transfer protocol (FTP) site for analysis as well as copied with the corresponding image data on consolidated hard drives. Data from several vessels were copied onto a single high capacity hard drive and delivered to AMR staff in Victoria, British Columbia (BC) and were processed by staff designated for this project.

6.5.1 Electronic Monitoring Data Inventory and Fishing Activity Interpretation

The first step in data processing began with an overall inventory of the data set and an assessment of its quality. Through this process a determination was made of missing data and whether the system and sensors performed properly. As the sensor data are recorded on a 10-second frequency, time breaks in the data record are easily identified as time intervals of greater than 10 seconds between adjacent records. As well, the system logs all instances of power interruption or system reboot. Time breaks were recorded in terms of the total time missing. Gaps in the video data were also identified (i.e. a fishing event was identified but no video was recorded).

Using AMR's custom-designed electronic monitoring data analysis software *EM Interpret*, all of the electronic monitoring data collected were processed to asses the completeness of each data set and determine information of fishing activity.

Assessing the completeness of a data set included an evaluation of each of the system's sensors and cameras. The signals from the GPS, electronic pressure transducer and rotation sensor were evaluated for completeness throughout each trip while the signal from each camera was evaluated for each haul. The ratings used were defined as follows:

- Complete - The sensor or camera provided data as expected

- Incomplete - The sensor or camera experienced intermittent failures where it did not report a signal when expected
- No data - The sensor or camera did not operate during the trip or set.

The fishing activity information determined from sensor data included details of the fishing trip such as trip start and end, and the location and time for all fishing events. This fishing activity information was then used by the image data viewer / analyst who could then directly access fishing events of interest.

6.5.2 Image Data Sampling Protocols

Image data from a sample of fishing events were reviewed for catch interpretation, seabird abundance and mitigation device deployment, and some compliance performance.

The raw image data from a fishing trip were sampled for audit-based analysis against the logbook data and comparisons with the observer data. The sample was then prioritised in the following way:

- Ignore data sets with poor or unusable data,
- Analyse all fishing events for trips where there is observer data for validation purposes,
- Prioritise those sets where protected species or SBT were known to occur, and
- Attempt to evenly spread the remainder of the analysis effort across all vessels to gain 10% coverage.

6.5.3 Catch Interpretation

Video Analyser, another AMR custom-designed software package, was used for recording catch and catch utilisation. During catch analysis, all species that were observed were identified to the highest taxonomical level possible and utilisation of each catch item was recorded as either retained, drop-off, released, or released with predation damage. The image quality for each haul analysed was assessed as a combined average of all cameras for the entire haul. The ratings used for assessing imagery data quality were defined as follows:

- High - The imagery was very clear and the viewer / data analyst had a good view of fishing activities. Focus was sharp, light levels were high and activity was easily seen.
- Medium - The view was acceptable, but there may have been difficulty assessing certain activities (e.g., discards). Focus slightly blurred or dark imagery but image analysis still possible.
- Low - The imagery was difficult to work with because some camera views were not available, blurry imagery, or poor lighting.
- Unusable - Imagery was poorly resolved or obstructed such that interpretations could not be reliably made.

6.5.4 Seabird Abundance and Mitigation Device Interpretation

Fishing events / sets with ‘at-sea’ observer data as well as a random 10% from non-observed trips were selected for analysis to determine tori-line deployment and seabird presence during gear shooting and catch composition and utilisation during hauls. Tori-line deployment and seabird interaction analysis was facilitated using *EM Interpret* software.

Viewing of imagery to determine tori-line deployment and seabird abundance was undertaken for two five-minute intervals per set. The first interval started five minutes from the start of the set and the second interval started ten minutes before the end of the set. For each interval the number of tori-lines deployed was recoded as unknown, zero, one, two, or three. The viewer also recorded the abundance and activity of seabirds visible around fishing gear. The categories used for seabird abundance were: none, few (1-5), some (6-25), and many (>25). The categories used for seabird activity were: not interacting, floating, diving, and floating and diving.

6.5.5 Compliance performance

A three step plan for responding to issues of non compliance detected during the project was also established. This was a phased approach to progress from learning, to education following the receipt of analysis outcomes and feedback reports to participants. An assessment of the uses of electronic monitoring for compliance monitoring was undertaken by AFMA compliance officers. Compliance issues monitored and assessed during the project included:

- Handling and reporting of protected species interactions,
- Use of seabird mitigation measures,
- Dropping of clips during hauling, and
- Catch handling and processing.

6.6 COST BENEFIT ANALYSIS

The set-up of an electronic monitoring program requires considerable implementation and ongoing costs. Therefore, a key component of the project was a cost and benefit analysis (CBA) to determine if the benefits of implementing electronic monitoring outweigh the costs. In this instance a CBA was undertaken to compare the costs and benefits of various options to a base case (the status quo). Costs of the various options include implementation costs and ongoing costs. Benefits include reduced costs or improved management outcomes (e.g. better pursuit of objectives). In many CBAs there will be costs and benefits that are not easily quantified. Therefore, where necessary descriptions of costs and assumptions have been included to help explain how a program component cost and / or estimate has been calculated.

All quantifiable costs and benefits of each option were converted to a net present value (NPV) over a 10 year planning horizon. This involves discounting the value of future costs and benefits by a set percentage per year. This is done because a dollar today is worth more than a dollar in the future (due to inflation and other monetary pressures) and it allows easier comparison of the net benefits of options. Information obtained during the pilot was used to provide cost estimates for the key activities and capital purchase for an electronic monitoring program.

A service delivery model was developed which included an assessment of service provider options as well as estimated implementation and ongoing program costs associated with each activity (e.g. installation, maintenance, data analysis). The 2010 ETBF observer program costs and fishery budget was used to formulate the base-case cost of an electronic monitoring program.

Voluntary and compulsory options were considered and compared to the base case (status quo). In addition a sensitivity analysis was conducted to assess to impact of changes to estimated costs and other assumptions (e.g. levels of fishing effort and data analysis). For both options it was assumed that a level of physical observer coverage is required. Therefore an 80% saving in the observer program was assumed following the implementation of an electronic monitoring program.
During the project an assessment of data analysis service providers was also undertaken. This involved data analysts with different backgrounds and levels of experience in fisheries research analysing selected imagery and recording catch information from the trial. Their results were compared with the results recorded from an experienced AFMA observer. The outcomes of this trial were used in the CBA analysis. The outcomes of this assessment are provided in Appendix 4.

7 RESULTS AND DISCUSSION

7.1 DATA ANALYSIS SUMMARY

7.1.1 Data Inventory

An inventory of electronic monitoring data collected during the pilot study is presented in Table 2. The data collection period involved ten vessels, each contributing between 51 and 127 sets, for a combined total of 1,128 days at sea and 792 sets. A total of 7,229 hours of imagery data for sets and hauls were recorded. Imagery data for sets represented close to half of that from hauls.

Initially, 146 sets were selected for imagery viewing, however, after image quality assessments were completed (Table 3), video imagery on 125 sets was determined to be of a quality level that was usable. A discussion of system performance, issues impacting image quality and recommendations for an ongoing program are provided in section 7.3. Imagery from several sets selected for viewing was not available for analysis due to incomplete or no imagery data available, or because image quality was deemed unusable. Examples of image quality ratings are shown in Figure 11.

Table 2: Summary of all trips completed by vessel and imagery collected.

Vessel Name	Trips	Sets	Sea days	Collection Period		Set Imagery Data Collected	Haul Imagery Data Collected
				Start	Finish	(hrs)	(hrs)
Beluga	8	73	110	29-Oct-09	2-Aug-10	283.1	491.2
Bianca B	29	68	99	15-Oct-09	18-Aug-10	190.6	352.2
Blue Mistress	18	127	183	6-Oct-09	12-Aug-10	424.2	865.1
Esbjorn	9	51	88	5-May-10	24-Aug-10	172.8	192.1
Jordan Kate	38	94	108	17-Oct-09	26-Jul-10	278.3	384.4
Kaybeanna	23	58	80	5-Apr-10	1-Aug-10	198.3	259.5
Ocean Explorer	12	86	138	10-Oct-09	7-Jul-10	274	559
Ocean Myst	9	66	108	20-Oct-09	17-Apr-10	195.4	492
Samurai	16	84	97	23-Oct-09	6-Jun-10	207.2	468.8
Santo Rocco	23	85	118	7-Nov-09	13-Jul-10	319.8	620.5
Totals	**185**	**792**	**1128**			**2544**	**4685**

Table 3: Number of sets that were assessed to be within each of the imagery quality categories for the 146 sets selected for review.

Vessel Name	High	Med	Low	Unusable	No Video	Total
Beluga	1	4	3	2	1	11
Bianca B	3	4	2	0	0	9
Blue Mistress	3	9	6	0	0	18
Esbjorn	0	2	6	2	0	10
Jordan Kate	0	14	2	1	0	17
Kaybeanna	0	2	0	0	5	7
Ocean Explorer	2	14	2	0	3	21
Ocean Myst	7	9	0	0	0	16
Samurai	0	11	10	2	0	23
Santo Rocco	0	7	2	2	3	14
Totals	**16**	**76**	**33**	**9**	**12**	**146**

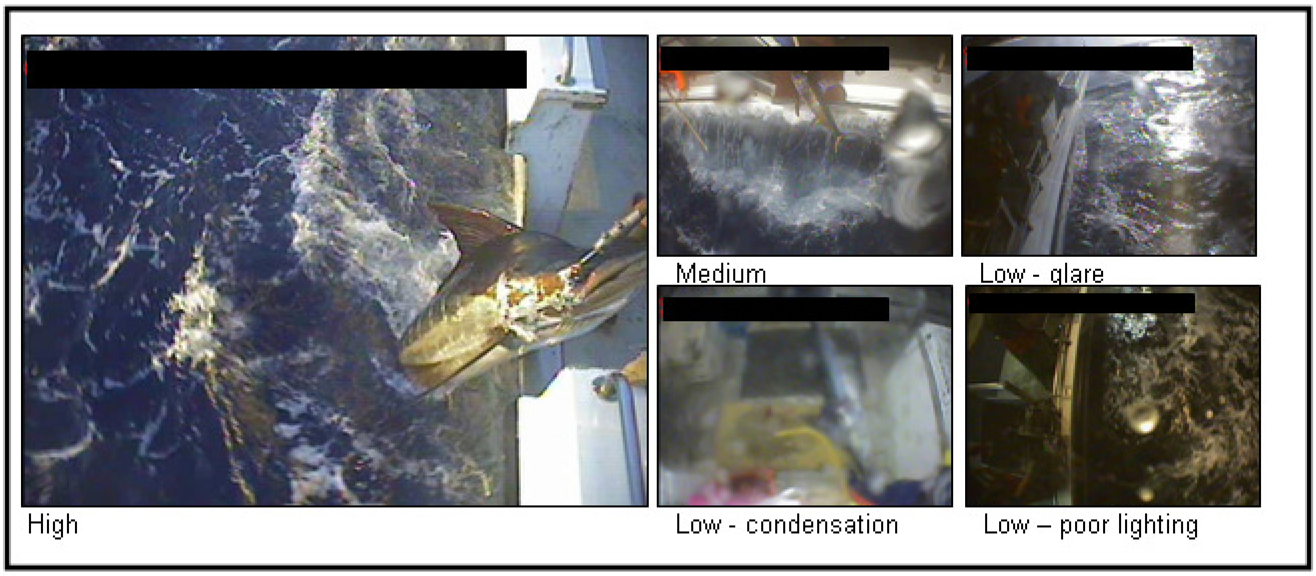

Figure 11: Examples of the levels of imagery quality categories including High, Medium, and Low.

Of the 125 sets that were viewed by an AMR imagery analyst, 62 had data from 'at-sea' observers to compare with (Table 4). All vessels, except for the *FV Beluga*, had an observer on at least one trip, which allowed for comparison between electronic monitoring data and observer collected data. Imagery data were not available for all at-sea observed fishing events.

Table 4: Summary of all trips processed by vessel logbooks (Flogs), and observers (Obs).

Vessel Name	Trips	Total Sets	Data Source		Sets Viewed	
			FLog	Obs	Total	With Obs
Beluga	8	73	73	0	8	0
Bianca B	29	68	68	4	9	4
Blue Mistress	18	127	127	5	18	5
Esbjorn	9	51	51	4	8	2
Jordan Kate	38	94	94	8	16	8
Kaybeanna	23	58	58	6	2	1
Ocean Explorer	12	87	87	10	18	10
Ocean Myst	9	66	66	15	16	15
Samurai	15	77	77	20	21	12
Santo Rocco	18	66	66	8	9	5
Totals	**179**	**767**	**767**	**80**	**125**	**62**

7.1.2 Time and Location Summaries

The following summaries (Table 5a, b and Table 6a, b) compare the start and end information for both set and haul events. Set and haul information was compared for 792 events between electronic monitoring and fishing log, and 62 events between electronic monitoring and observer data. One of the main factors contributing to the differences between fishing log and electronic monitoring positions was the level of accuracy at which the spatial coordinates were recorded. Electronic monitoring data for latitude and longitude were recorded to at least four decimal places, while fishing log coordinates were usually recorded to two decimal places.

Table 5a. Comparison between electronic monitoring (EM) and fishing log spatial data.

Distance Between Points	Beluga	Bianca B	Blue Mistress	Esbjorn	Jordan Kate	Kaybeanna	Ocean Explorer	Ocean Myst	Samurai	Santo Rocco	**Category Totals**	**% of Totals**
Set Start												
< 500 m	5	6	13		17	5	7	8	15	2	**78**	**9.8%**
500 m - 1000 m	14	25	35		32	13	16	20	19	18	**192**	**24.2%**
1000 m - 2000 m	41	29	54		34	30	36	24	31	36	**315**	**39.8%**
>2000 m	13	8	23		11	9	24	14	19	26	**147**	**18.6%**
No EM Data				51		1	1				**53**	**6.7%**
No Flog Data			2				2			3	**7**	**0.9%**
Total Events	**73**	**68**	**127**	**51**	**94**	**58**	**86**	**66**	**84**	**85**	**792**	
Set End												
< 500 m	3	4	10		16	5	4	8	10	6	**66**	**8.3%**
500 m - 1000 m	11	29	20		22	9	18	19	18	10	**156**	**19.7%**
1000 m - 2000 m	49	24	67		47	27	41	25	37	48	**365**	**46.1%**
>2000 m	9	11	28		8	16	20	14	18	18	**142**	**17.9%**
No EM Data	1			51	1	1	1		1		**56**	**7.1%**
No Flog Data			2				2			3	**7**	**0.9%**
Total Events	**73**	**68**	**127**	**51**	**94**	**58**	**86**	**66**	**84**	**85**	**792**	
Haul Start												
< 500 m	1	5	9		11	1	4	15	1	6	**53**	**6.7%**
500 m - 1000 m	9	14	19		15	11	12	19	16	14	**129**	**16.3%**
1000 m - 2000 m	38	31	63		42	29	35	25	50	38	**351**	**44.3%**
>2000 m	25	18	34		26	17	33	7	17	23	**200**	**25.3%**
No EM Data				51						1	**52**	**6.6%**
No Flog Data			2				2			3	**7**	**0.9%**
Total Events	**73**	**68**	**127**	**51**	**94**	**58**	**86**	**66**	**84**	**85**	**792**	
Haul End												
< 500 m	9	6	7		6	2	3	13	4	3	**53**	**6.7%**
500 m - 1000 m	9	21	17		17	9	21	22	14	12	**142**	**17.9%**
1000 m - 2000 m	36	16	57		48	31	38	27	44	38	**335**	**42.3%**
>2000 m	18	25	44		23	16	22	3	22	28	**201**	**25.4%**
No EM Data	1			51				1		1	**54**	**6.8%**
No Flog Data			2				2			3	**7**	**0.9%**
Total Events	**73**	**68**	**127**	**51**	**94**	**58**	**86**	**66**	**84**	**85**	**792**	

Table 5b. Comparison between electronic monitoring (EM) and fishing log temporal data.

Time Difference Between Points	Beluga	Bianca B	Blue Mistress	Esbjorn	Jordan Kate	Kaybeanna	Ocean Explorer	Ocean Myst	Samurai	Santo Rocco	Category Totals	% of Totals
Set Start												
< 15 min	68	55	106	44	63	52	74	57	79	47	**645**	**81.4%**
15 min < x < 60 min	3	13	8	1	22	2	6	5	3	16	**79**	**10.0%**
> 60 min	2	0	11	0	9	3	4	4	2	19	**54**	**6.8%**
No EM Data	0	0	0	6	0	1	0	0	0	0	**7**	**0.9%**
No Flog Data	0	0	2	0	0	0	2	0	0	3	**7**	**0.9%**
Total Events	**73**	**68**	**127**	**51**	**94**	**58**	**86**	**66**	**84**	**85**	**792**	
Set End												
< 15 min	70	44	112	45	61	48	77	52	77	47	**633**	**79.9%**
15 min < x < 60 min	1	23	2	0	20	6	1	8	3	23	**87**	**11.0%**
> 60 min	2	1	11	0	13	3	6	6	4	12	**58**	**7.3%**
No EM Data	0	0	0	6	0	1	0	0	0	0	**7**	**0.9%**
No Flog Data	0	0	2	0	0	0	2	0	0	3	**7**	**0.9%**
Total Events	**73**	**68**	**127**	**51**	**94**	**58**	**86**	**66**	**84**	**85**	**792**	
Haul Start												
< 15 min	60	35	101	44	56	37	49	51	72	38	**543**	**68.6%**
15 min < x < 60 min	9	26	12	0	10	3	30	10	11	17	**128**	**16.2%**
> 60 min	3	7	12	1	28	18	5	5	1	25	**105**	**13.3%**
No EM Data	1	0	0	6	0	0	0	0	0	2	**9**	**1.1%**
No Flog Data	0	0	2	0	0	0	2	0	0	3	**7**	**0.9%**
Total Events	**73**	**68**	**127**	**51**	**94**	**58**	**86**	**66**	**84**	**85**	**792**	
Haul End												
< 15 min	59	25	99	44	55	35	70	55	77	36	**555**	**70.1%**
15 min < x < 60 min	7	36	8	1	28	3	8	5	4	22	**122**	**15.4%**
> 60 min	6	7	17	0	11	20	5	6	2	19	**93**	**11.7%**
No EM Data	1	0	1	6	0	0	0	0	1	5	**14**	**1.8%**
No Flog Data	0	0	2	0	0	0	3	0	0	3	**8**	**1.0%**
Total Events	**73**	**68**	**127**	**51**	**94**	**58**	**86**	**66**	**84**	**85**	**792**	

Table 6a. Comparisons between electronic monitoring (EM) and observer spatial data.

Distance Between Points	Bianca B	Blue Mistress	Esbjorn	Jordan Kate	Kaybeanna	Ocean Explorer	Ocean Myst	Samurai	Santo Rocco	**Category Totals**	**% of Totals**
Set Start											
< 500 m	4	5	4	7	2	9	12	15	8	**66**	**82.5%**
500 m - 1000 m	0	0	0	0	0	0	0	3	0	**3**	**3.8%**
1000 m - 2000 m	0	0	0	1	1	0	2	0	0	**4**	**5.0%**
>2000 m	0	0	0	0	3	1	1	2	0	**7**	**8.8%**
Total Events	**4**	**5**	**4**	**8**	**6**	**10**	**15**	**20**	**8**	**80**	
Set End											
< 500 m	4	5	4	8	5	6	13	15	5	**65**	**81.3%**
500 m - 1000 m	0	0	0	0	1	0	0	2	0	**3**	**3.8%**
1000 m - 2000 m	0	0	0	0	0	3	1	0	1	**5**	**6.3%**
>2000 m	0	0	0	0	0	1	1	3	2	**7**	**8.8%**
Total Events	**4**	**5**	**4**	**8**	**6**	**10**	**15**	**20**	**8**	**80**	
Haul Start											
< 500 m	4	4	4	6	2	8	13	12	5	**58**	**72.5%**
500 m - 1000 m	0	0	0	1	1	0	2	0	0	**4**	**5.0%**
1000 m - 2000 m	0	0	0	0	0	1	0	1	3	**5**	**6.3%**
>2000 m	0	1	0	1	3	1	0	7	0	**13**	**16.3%**
Total Events	**4**	**5**	**4**	**8**	**6**	**10**	**15**	**20**	**8**	**80**	
Haul End											
< 500 m	4	3	4	7	1	6	13	12	8	**58**	**72.5%**
500 m - 1000 m	0	0	0	0	2	1	1	2	0	**6**	**7.5%**
1000 m - 2000 m	0	0	0	1	0	1	1	0	0	**3**	**3.8%**
>2000 m	0	2	0	0	3	2	0	6	0	**13**	**16.3%**
Total Events	**4**	**5**	**4**	**8**	**6**	**10**	**15**	**20**	**8**	**80**	

Note: OBS missing haul start location data for 1 haul on the Ocean Myst.

Table 6b. Comparison between electronic monitoring (EM) and observer temporal data.

Time Difference Between Points	Bianca B	Blue Mistress	Esbjorn	Jordan Kate	Kaybeanna	Ocean Explorer	Ocean Myst	Samurai	Santo Rocco	Category Totals	% of Totals
Set Start											
< 15 min	4	5	4	6	5	9	14	18	8	**73**	**91.3%**
15 min < x < 60 min	0	0	0	2	0	0	1	2	0	**5**	**6.3%**
> 60 min	0	0	0	0	1	1	0	0	0	**2**	**2.5%**
Total Events	**4**	**5**	**4**	**8**	**6**	**10**	**15**	**20**	**8**	**80**	
Set End											
< 15 min	4	5	4	8	6	10	15	18	7	**77**	**96.3%**
15 min < x < 60 min	0	0	0	0	0	0	0	1	1	**2**	**2.5%**
> 60 min	0	0	0	0	0	0	0	1	0	**1**	**1.3%**
Total Events	**4**	**5**	**4**	**8**	**6**	**10**	**15**	**20**	**8**	**80**	
Haul Start											
< 15 min	4	5	3	8	3	9	15	13	8	**68**	**85.0%**
15 min < x < 60 min	0	0	1	0	0	1	0	1	0	**3**	**3.8%**
> 60 min	0	0	0	0	3	0	0	6	0	**9**	**11.3%**
Total Events	**4**	**5**	**4**	**8**	**6**	**10**	**15**	**20**	**8**	**80**	
Haul End											
< 15 min	4	4	2	8	3	9	14	12	8	**64**	**80.0%**
15 min < x < 60 min	0	1	1	0	0	1	0	1	0	**4**	**5.0%**
> 60 min	0	0	1	0	3	0	1	7	0	**12**	**15.0%**
Total Events	**4**	**5**	**4**	**8**	**6**	**10**	**15**	**20**	**8**	**80**	

7.1.3 Catch Composition and Comparison Summaries

Catch data from electronic monitoring were taken from all viewed hauls and compared with fishing logbook and observer data. These comparisons were used to assess the quality of data from the three sources and to provide insight into the causes of missed catch from any of the sources. As previously noted, not all hauls that were viewed had ‘at-sea’ observers; however all had fishing logbook data.

It should be noted that electronic monitoring viewers recorded catch items as retained if they did not see them being released. Comparisons between catch and the species group level from electronic monitoring data and fishing logbook data (Table 7) and between electronic monitoring data and observer data (Table 8) are provided below. A summary of all the documented catch and utilisation (retained, released, etc.) from the electronic monitoring data is provided in Table 9.

Table 7: Comparison of retained and released catch between electronic monitoring (EM) image analysis and fishing log (Flog).

Species Group	EM Retained	FLog Retained	Difference Retained	EM Released	FLog Released	Difference Released
Tunas	2270	2311	-1.8%	472	358	24.2%
Billfishes	618	566	8.4%	54	51	5.6%
Lancetfishes	3	50		664	875	-31.8%
Sharks	55	49	10.9%	114	190	-66.7%
Seabirds	1*	0		2	3	
Turtles	1	0		4	7	
Other	1051	1069	-1.7%	228	144	36.8%
Totals	3999	4045	-1.2%	1538	1628	-5.9%

*Retained for necropsy as per condition of the TAP.

Table 8: Comparison of retained and released catch between electronic monitoring (EM) image analysis and observer data (OBS).

Species Group	EM Retained	OBS Retained	Difference Retained	EM Released	OBS Released	Difference Released
Tunas	1311	1329	-1.4%	151	236	-56.3%
Billfishes	330	323	2.1%	20	31	
Lancetfishes	1	2		507	1721	-239.4%
Other	395	412	-4.3%	106	226	-113.2%
Seabirds	1*	2*		1	1	
Sharks	32	36	-12.5%	58	152	-162.1%
Turtles	0	0		1	2	
Totals	2070	2104	-1.6%	844	2369	-180.7%

*Retained for necropsy as per condition of the TAP.

Table 9: Catch by species from image analysis for all hauling events viewed.

Species	Retained	Drop Off	Released - Alive / Moving	Released - Dead	Released	Released - Predation Damaged	Total Pieces
Albacore	681	1			138	8	828
Albatross	1		2				3
Bigeye Tuna	21				1		22
Black Oilfish (Escolar)	77				2		79
Blue Whaler Shark	28	23			33		84
Broadbill Swordfish	510	2			20	10	542
Bronze Whaler Shark	1						1
Crocodile Shark	2				1		3
Dealfish	0	1			1		2
Dolphinfish	475	1				10	486
Great Barracuda	0				7		7
Hammerhead Sharks	2				1	1	4
Lancetfishes	3				664		667
Mackerels	14						14
Mako Sharks	3						3
Marlins,Sailfishes,Etc.	60	2			12	3	77
Oarfish	1	1			2		4
White Tipped Shark	3				1		4
Opah	31						31
Puffer Fish	0				2		2
Pacific Bluefin Tuna	70				2		72
Pelagic Ray	1				10		11
Pomfrets, Breams, Fanfish	208				2	3	213
Ray's Bream	1						1
Rudderfish	1						1
Sea Turtles	1		2	2			5
Sharks (Mixed)	6	25		1	22		54
Shortbill Spearfish	43				3	2	48
Shortfin Mako Shark	7	2			2		11
Silky Shark	0				1		1
Skipjack Tuna	5				2		7
Slender Tuna	5						5
Snake Mackerel	1						1
Snake Mackerels, Escolars	215	5			45	2	267
Southern Bluefin Tuna	12						12
Stingray	0				1		1
Striped Marlin	5						5
Sunfish	0	4			9		13
Tiger Shark	3						3
Tuna (Mixed)	617	65			164	38	884
Unknown	26	63			37	19	145
Wahoo	14				1		15
Yellowfin Tuna	845				46	7	898
Yellowtail Kingfish	1						1
Total Pieces	**4000**	**195**	**4**	**3**	**1232**	**103**	**5537**

7.1.4 Hook-by-Hook Catch Comparison

To validate the accuracy of image analysis results, hook-by-hook comparisons between electronic monitoring and observer catch data were undertaken. A total of 3,794 catch items compared between electronic monitoring and observer data (Table 10), showed that 70.2% resulted in catch items being aligned, 4.8% that were detected by electronic monitoring viewers but not the observer (OBS-/EM+) and 25% that were recorded by the observer but not by the electronic monitoring viewer (OBS+/EM-).

Out of the 3,794 catch records that matched between electronic monitoring and observer data, 70.7% were identified as the same species, 21.8% were identified within the same family, and 1.5% were identified within the same order (Table 10). Of the aligned data, 6% were not identified within the same species, family or order (i.e. identification mismatch).

Electronic monitoring and observer data showed a high level of agreement for utilisation (e.g. retained or released) of catch. Of all the catch records that aligned between electronic monitoring and observer methods, 89.7% of the records had the same utilisation recorded in both data sources (Table 11).

By examining the utilisation of catch that was recorded by observers, but not by electronic monitoring viewers (n = 948), we can better understand some of the causes of the mismatch. Most (75.7%) of the catch that was not in electronic monitoring data but was in observer data was recorded as *released*, whereas, only 24.3% was recorded as *retained* (Table 12). It is possible that the catch that was absent in the electronic monitoring data was released prior to coming into view of the electronic monitoring system cameras. A second factor which may have contributed to the number of catch events that were absent from the electronic monitoring data was the species group; nearly half (48.3%) of the fish that where absent from the electronic monitoring data were Lancetfish, which is predominately a bycatch species and predominately released through jerking the hook to save hauling time and avoid handling the catch onboard (Table 13).

Table 10: Alignment of electronic monitoring (EM) and observer data by hook. Differences between the EM and observer data are differentiated into those that were in EM data, but not the observer data (OBS-/EM+) and those that were in the observer data, but not in the EM data (OBS+/EM-).

Match Level	Record Count	% of Total	Match %
OBS-/EM+	183	4.8%	
OBS+/EM-	948	25.0%	
Species Match	1884	49.7%	70.7%
Family Match	581	15.3%	21.8%
Order+ Match	39	1.0%	1.5%
No Match	159	4.2%	6.0%
Total	**3794**		

Table 11: Comparison of utilisation (retained, released) between catch that was documented in both the electronic monitoring and the observer data.

Match Level	Record Count	% of Total	Match %
Utilisation Match	2388	89.7%	89.7%
Utilisation No Match	275	10.3%	10.3%
Total	**2663**		

Table 12: Summary of catch utilisation for pieces that were documented in the observer data, but were absent in electronic monitoring data (total pieces = 948).

Disposition	Count	Percent
Cut Free	88	9.3%
Discarded	154	16.2%
Escaped - bitten off	24	2.5%
Jerked Free	452	47.7
Retained	230	24.3%
Total	**948**	

Table 13: Piece counts by group for data that were present in the observer data, but not in the electronic monitoring data (total pieces = 948).

By Group	Count	Percent
Tunas	171	18.0%
Sharks	91	9.6%
Billfish	24	2.5%
Lancetfish	458	48.3%
Other	204	21.5%
Total	**948**	

7.1.5 Releasing target species

A number of target species were observed to be released during the trial (see Table 9). Species are released for a number of reasons such as being to small and not marketable. Figure 12 shows an image sequence showing the release of a small Yellowfin Tuna.

Figure 12: Image sequence showing the release of a small yellowfin tuna onboard the FV Beluga.

7.1.6 Protected Species Interactions

Imagery obtained during the project showed a number of captured and released protected species. The protected species observed on the imagery data are included in the summary of all the catch and utilisation recorded by electronic monitoring (Table 7 and 9). All protected species interactions were recorded in logbook and observer records. The usefulness of cameras to detect and identify protected species is shown to be subject to the viewing areas and where captured species are handled. In general, cameras have shown to be a useful tool for detecting and monitoring handling and release of protected species (see Figure 13).

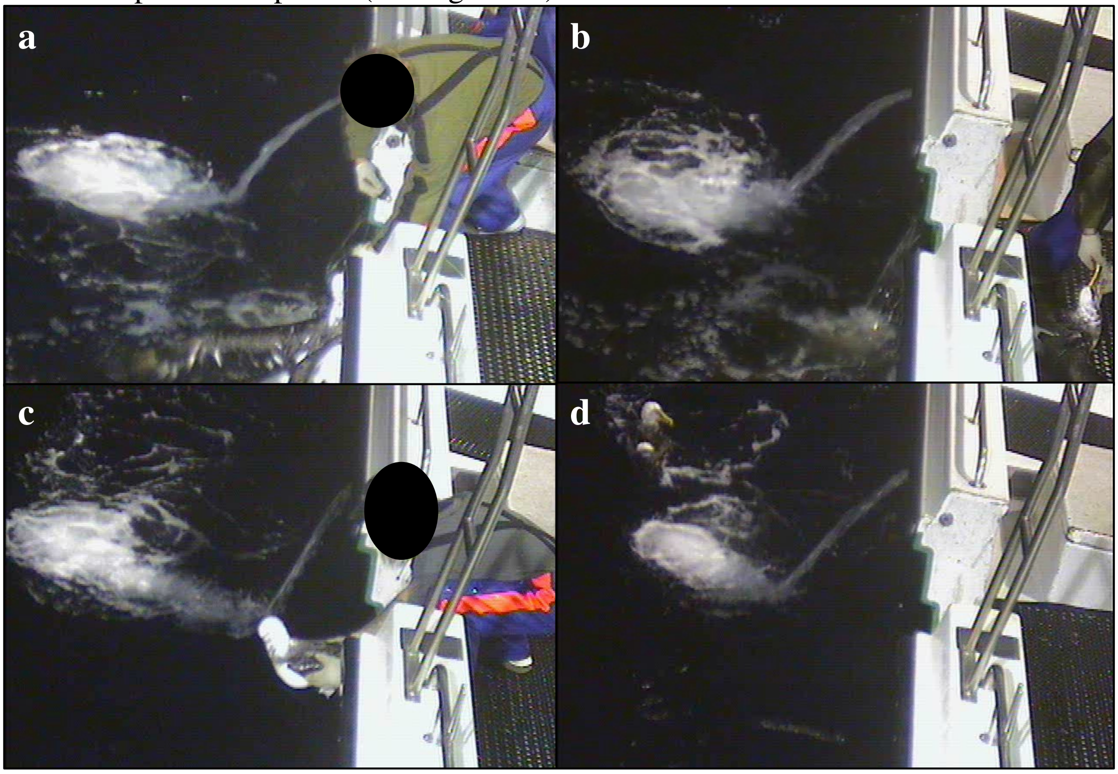

Figure 13: Image sequence showing the capture and release of a seabird (Albatross species) onboard the *FV Bianca B*, (a & b) shows bringing the seabird onboard and removing the hook, (c & d) shows the seabird being released.

7.1.7 Seabird Mitigation

A total of 240 assessments (approximately 2 viewing periods assessed per set) were completed to determine tori-line use and seabird presence during setting (Table 14). Many of the viewed sets were labeled as either “0” tori-lines deployed or “unknown”. If the number of tori-lines was unknown, the data processors were required to provide comments; 26 of the 48 comments were related to the setting occurring at night, 8 were related to poor lighting of the work area impacting visibility, and 7 were related to camera angle.

In general, the aft camera view of the vessels’ setting operation was shown to be reliable for monitoring the use of tori-lines (see Figure 14). This is similar to the findings in Ames *et al*. (2005), assessment of the applications of electronic monitoring to monitor compliance of seabird avoidance devices. However, it was not possible to determine whether tori line deployment met AFMA’s regulations, and further guidelines are needed to ensure electronic monitoring image data can be used to assess whether tori lines have been correctly deployed in accordance with those requirements.

Table 14: Summary of all assessments done to determine tori-line deployment and seabird presence.

	# of Tori Lines Deployed					Seabirds Present				
Vessel	**0**	**1**	**2**	**3**	**Unknown**	**None**	**Few**	**Some**	**Unknown**	**Total**
Beluga	7	6	1		2	14		1	1	16
Bianca B	1	7			8	14			2	16
Blue Mistress	10	10			12	31			1	32
Esbjorn	4	10	1	2	3	17			3	20
Jordan Kate	6	16	3		7	28	3	1		32
Ocean Explorer	5	22			6	32	1			33
Kaybeanna			1	1		1			1	2
Ocean Myst	26				4	30				30
Samurai	15	16	2		4	28	3		6	37
Santo Rocco	20				2	17	2	1	2	22
Total	**94**	**87**	**8**	**3**	**48**	**212**	**9**	**3**	**16**	**240**

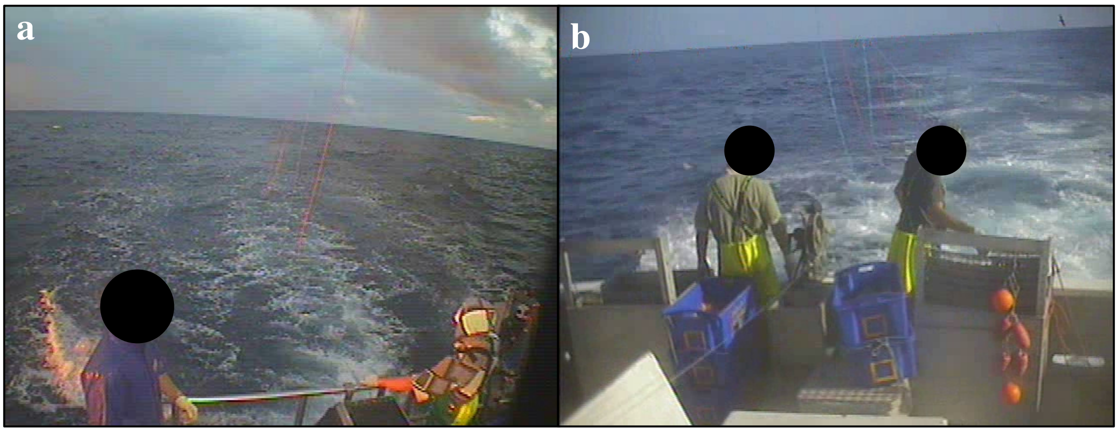

Figure 14: Aft view of the tori-line during setting onboard (a) *FV Kaybeanna* and (b) *FV Bianca B*.

7.1.8 Summary

To assess the applications and utility of electronic monitoring systems to replace observers for 'at-sea' monitoring the project was designed to answer the following questions:

a) Can electronic monitoring image data provide images of sufficient resolution and clarity to allow an imagery viewer to identify interactions with various protected species (e.g. seabirds)?

b) Can electronic monitoring image data provide images of sufficient resolution and clarity to allow an imagery viewer to accurately record the number of target and non-target species?

c) Are results from video monitoring similar to those obtained from on-board observers?

In this study, data collected by 'at-sea' observers was used as a benchmark to measure the accuracy of electronic monitoring analysis results. The field trial from this study provided a sample of 62 fishing events from which to base a comparison between electronic monitoring data analysis outcomes and observer catch data. This approach assumes that the observer data set is 100%. It is understood that errors can exist in observer data from misidentification at-sea and transcription errors at the point of data

entry. Observer error was not accounted for in this study as observer data were the baseline in this trial.
Before addressing the catch monitoring aspects is it instructive to compare fishing effort information (start and end times and positions for both setting and hauling) recorded by electronic monitoring and observers. The comprehensive and continuous sensor data set (GPS, rotation and hydraulic pressure sensors every 10 seconds) is a key strength of electronic monitoring systems. Electronic monitoring data interpretation provided very good temporal and spatial information on gear setting and hauling activities, aligning very closely with observer data: over 90% of set start times were within 15 minutes and over 80% were within 500m. These results suggest that sensor data could reliably be used to monitor the temporal and spatial elements of fishing effort and be used to audit the accuracy of corresponding logbook records. The data collected is more granular than VMS data but is not reviewable until the hard drive is retrieved when the boat returns to port. However, the satellite Health Statement data sent at one hour intervals provides sufficient information to identify vessel activity in a general area.

There was good agreement between electronic monitoring image analysis results and observer catch estimates with a 70.7% match at species level (Table 10). In terms of retained catch, observer and electronic monitoring total piece counts were very close, differing by 1.6% over all observed sets and 1.2% over all logbook sets. In contrast, the difference between the released catch were significant (180.7% difference). The higher level of agreement between observers and electronic monitoring retained catch is due to catch coming aboard in clear view of the cameras. The difference in the released catch can be explained by the significant numbers of Lancetfish that are discarded / jerked free occurring outside the field of camera view. Changing camera views, frame capture rates and improved species of interest handling protocols by crew (i.e. in alignment with existing safe work practices) is expected to improve species recognition capability. Clear protocols for catch handling will need to ensure that the viewer is able to detect the fate for each catch item. This, alongside with feedback to the operators on catch handling, will be needed to improve data collection for discards.

Archipelago Marine Research's image reviewers were not particularly familiar with the species occurring in the ETBF and so distinguished fewer catch categories and used more general species groupings than observer records and AFMA observer image analysis results (see Appendix 4, Table 33). Misidentifications also occurred with species in the same group (i.e. Tunas). The electronic monitoring species identification capability is likely the result of a number of factors. As mentioned earlier, electronic monitoring image reviewing occurred in Canada and misidentifications are partly due to data analysts and reviewers lacking experience with ETBF species catch compositions and how that might change over the fishery. The results were also due to the difficulty for electronic monitoring image reviewers to resolve key identification features of catch in the imagery. Camera placements lacking fine scale resolution and image quality also impacted species identification of catch. Training curriculums for identifying species on video have been successfully developed for other fisheries (e.g. BC hook and line fishery), and something similar would need to be applied in an ETBF electronic monitoring program.

There were nine interactions with protected species recorded by electronic monitoring image reviewers during this study (5 turtles and 3 seabirds).These interactions were

all incidentally captured species during fishing and animals were either released alive, dead or retained for necropsy. Bringing the captured seabirds and turtles in clear view of the camera and showing the crew handling the species and removing the hook made these events recognisable in the electronic monitoring imagery. However, compared to the observers catch data, one seabird and one turtle were not reported from the electronic monitoring image.
Seabird interactions reported by electronic monitoring image reviewers were noted to be easily detected (see Figure 12) and it is unclear why one of these was missed. After failing to account for the interaction the first time, a second review was undertaken and even purposely looking for it, the reviewer was unable to detect the interaction. Three seabird interactions occurred on the same observer trip raising the possibility that the two events could be one. The missed interaction/s could have also taken place outside the camera view well aft of the tuna door.

In this study, hook removal and disentangling for the majority of interactions took place in the camera view, making it possible to determine hooking location and life status. The level of activity during this procedure and upon release also provided some indication of release condition. However, in comparison to observers, there are obvious limitations assessing the extent of injury and survivability of captured protected species from electronic monitoring imagery.

To help detect interactions and assess life status, clear onboard handling practices need to be defined (i.e. handled in clear view of the camera). Additionally, if the animal is brought onboard to enhance survival (e.g. for hook removal), it must be released at a designated point in view of the camera. The crew would be required to adopt new handling practices for onboard cameras to be a feasible replacement for the monitoring of protected species interactions. It is acknowledged that any new catch handling practices must be developed in alignment with the existing handling practices for protected species and comply with the safe working practices exhibited by the crew.

7.2 LOGBOOK AUDIT METHODOLOGY AND FRAMEWORK

7.2.1 Background

The objective of an audit-based assessment of the data collected by monitoring programs for the collection of fisheries data is to allow industry to take ownership and responsibility for the quality of data and imagery collected. The audit mechanism enables self-reported data in fishing logbooks to be validated by comparing randomly selected portions of electronic monitoring interpreted data. Electronic monitoring technology allows for 100% data collection at-sea with the option of reviewing a subset of data collected to validate fisher-provided data, with the back-up option of doing a full review to obtain a complete reconstruction of catch and other activities at-sea.

An audit program is an assessment and feedback loop for improved fisher data with inputs to management decisions. Archipelago Marine Research has developed and implemented this type of audit methodology in the British Columbia (BC), Canada hook-and-line fishery. This has proved very successful in improving data quality of fishing logbooks. An output of this project was the creation of an Audit Framework that can serve as a starting point for developing an ETBF audit program. We begin to explore each of these aspects with respect to the ETBF and the results of this electronic monitoring pilot study.

7.2.2 Public Perception and Industry Involvement

The success of an electronic monitoring audit-based monitoring program is dependent on industry buy-in from an early stage and the process and end result need to be transparent so that all stakeholders will trust the resulting data. The first step in any monitoring program must be communication with, and involvement of, industry members. The collection of data for monitoring use depends on fishers completing forms, running equipment, adjusting certain catch handling behaviour, and reporting data. The importance of industry involvement is further discussed in relation to information feedback loops in section 7.2.6 Electronic Monitoring Program Structure for ETBF.

7.2.3 Monitoring Objectives

The design of an audit program must be based on the data that the fishery needs for effective management. Based on the current status of monitoring requirements in the ETBF the general objectives proposed for an ongoing electronic monitoring audit program would be to:

- account for catch (both retained and released including protected species) in the fishery,
- account for fishing effort, and
- monitor compliance to fishing restrictions and regulations.

These objectives would need to be further refined based on risk and government and industry priorities in order to offer direction for the overall monitoring program design and audit, for example identifying if all catch needs to be tested versus only certain species.

7.2.4 Data Sources

At the core of any audit program is the baseline data against which comparisons are made. In BC’s ground fish audit-based monitoring program the data sources used are fishing logbooks, electronic monitoring, and Dockside Monitoring. The proposed ETBF model uses electronic monitoring data as the baseline to compare the fishing logbook data against but there would be benefits from using dockside data or CDRs to further validate fishing log data for retained catch, for example in terms of identification for similar species.

In order to compare the data and effectively audit the logbooks, there must be a data overlap between sources. Throughout the 2009-2010 ETBF electronic monitoring pilot study there was very good data alignment between electronic monitoring and fishing logs. Comparable relevant data from both data sources includes:

- total catch by species (retained and discarded),
- protected species interactions, and
- fishing location and effort.

The current observer program in the ETBF collects similar data for about 8.5% of the effort in the fishery. If there is an interest in maintaining some observer coverage on the fishery, the observer program data could be used as validation of electronic monitoring data on an on-going basis. This comparison would allow for the continued improvement of the electronic monitoring data collection set-up and processing methods.

Developing a hardcoded link between fishing log and electronic monitoring data would greatly improve efficiency and data reporting timeliness. During the 2009-2010 pilot study there was no hard coded link between fishing logbook page and the electronic monitoring sensor and image data. The simplest way to establish a hardcoded link would be at the ‘data set’ (also referred to as ‘work order’) level where fishermen are required to write down the electronic monitoring work order number in their fishing log, for example.

7.2.5 Evaluation

The evaluation approach needs to be based on the monitoring objectives and take into account the data sources. There are two cost drivers to consider when determining how to evaluate fisher provided data in an audit-based approach: how much should be tested to pass scientific scrutiny and enable stakeholder confidence, and how to determine if the data has integrity and reliability.

An acceptable level of electronic monitoring data review needs to be established based on assessment of risk and consultation with stakeholders. All sensor data should be interpreted to determine data completeness, electronic monitoring system performance, start and end of fishing trips, sets, and hauls. A certain proportion of fishing events could then be randomly selected to examine deployment of tori-lines and account for catch. The BC ground fish hook-and-line fishery, for example, selects 10% of fishing events per voyage with a minimum of one event (i.e. if the total events are less than 14, one fishing event is reviewed; if the total events are between 15 and 24, two fishing events are reviewed, etc.). In the case of the ETBF a percentage of events could be selected either based on voyage or data collection period if it encompasses multiple voyages, depending of data reporting requirements.

Several tests could be used in the ETBF to establish the quality of the logbook data compared to electronic monitoring data. Table 15 lists a series of possible tests along with a proposed evaluation methodology for implementation in the ETBF. Evaluation methods are defined as scoring accuracy, standards met, and vessel history.

Scoring could be applied by dividing the range of possible test results (e.g. retained piece differences between electronic monitoring and fishing log for a specific species) into categories and assigning a score to each one of them. Table 16 shows the scoring methodology for the BC ground fish hook-and-line fishery as an example. In this case, the possible test results have been further divided depending on the total amount of pieces being tested into percentage and piece differences. Percentages are a powerful way of comparing two numbers when dealing with large total number of pieces but become meaningless when comparing small numbers. An audit for the ETBF may consider creating additional scoring categories as there would be a large amount of tests with less than 30 pieces but a considerable variation within 1 to 29 pieces; this variability is due the low catch densities of retained species in the pelagic ETBF as compared with the relatively high counts in the BC ground fish fishery.

Standards involve binary decisions, i.e. the standard is met or not met. The standard itself can be based on a particular score, an average of scores, or some other comparison of results (e.g. set starts need to be within one hour). Layering standards on top of scores or an average of scores can offer great flexibility in placing emphasis on data quality based on risk. For example, a score of 8 may be acceptable for Dolphinfish but a score of 9 may be required to meet standards on SBT. Standards are designed so that they can be adjusted as the maturity of process and understanding of stakeholders increase, monitoring objectives evolve or risks change.

Vessel history is the last layer in the evaluation methodology and must be based on either scores or standards, and its meaning and use should evolve as vessels gather history and the program matures. It can be used in different ways but the main objective is to highlight individual accountability by taking into account past performance when considering the data quality assessment scores of a current analysis. This approach is very powerful once consequences with agreed responses are applied to the program. When well designed audits programs are in place, operators that consistently perform poorly in their evaluation will have consequences escalated much faster than for operators who have consistently provided good fishing log data but failed to do so on a single trip. In industry funded programs, vessel history can serve as an incentive by affecting the level of scrutiny required when sampling video and hence cost to the operator.

Vessel history can also play a role in providing additional information, especially with rare or low occurring events. Scoring methodologies could leave a loophole for very rare events (e.g. protected species interactions, or rare species). Using the BC scoring as an example, a high score could be achieved even if nothing was recorded in the fishing log simply because the total number of pieces reviewed in electronic monitoring is below three. Summing the number of pieces compared across numerous hauls could provide a more meaningful result.

Catch evaluation in an ETBF electronic monitoring program is likely the most complex aspect of an audit system. This complexity is due to the many different species that may be present in any given haul, and each of them would likely need to be separated by utilisation (retained and released as a minimum). Differing levels of concern among species could be reflected in an audit program as not all species need to be tested (even if catch information is still recorded for all) or at least not tested to the same level of detail.

A nested approach to testing catch would be appropriate, i.e. some species may be tested separately while others may be tested as part of species groupings. For example, the species identified as the primary species of concern for management purposes include Albacore, Yellowfin Tuna, Bigeye Tuna, Southern Bluefin Tuna, Broadbill Swordfish, and Striped Marlin. However, the rest of the Tunas and Billfishes can still be tested by classifying at an ‘all Tunas” and “all Billfishes” group level.

Table 15: Examples for potential tests and evaluations to be performed in an ETBF log audit using electronic monitoring data.

Test	Evaluation Method	Score/Standard Example	Result
Fishery management issues			
Species - by utilisation	Scoring; Standard met or not met; Vessel history.	Score based on piece counts; Standard based on risk	Feedback for first two years, then feedback and consequences.
Species Groups - by utilisation	Scoring; Standard met or not met; Vessel history.	Score based on piece counts; Standard based on risk.	Feedback for first two years, then feedback and consequences.
Protected species interactions	Standard met or not met; Vessel history.	Match	Feedback for first two years, then feedback and consequences.
Total hook count	Standard met or not met	Within 10%	Feedback
Total float count	Standard met or not met	Match	Feedback
Fishing time	Standard met or not met	Within one hour	Feedback
Fishing location	Standard met or not met	Within two Km	Feedback
Fishing management area	Standard met or not met	Match	Feedback for first two years, then feedback and consequences.
Mainline length	Standard met or not met	Within 10%	Feedback
Enforcement issues			
EM data captured	Scoring; Standard met or not met; Vessel history.	Score based on amount of data lost and risk	Feedback for first two years, then feedback and consequences.
Tori Line Deployment	Standard met	Match	Reported when standard not met.
Dropping clips during hauling	Standard met	No clips dropped	Reported when standard not met.
Fishing in closed areas	Standard met	No fishing in closed areas	Reported when observed
Shark Finning	Standard met	No shark finning	Reported when observed

Table 16: Scoring scale used in the British Columbia hook-and-line audit-based catch monitoring program.

Score	Difference when Pieces < 30[*1]	Difference when Pieces ≥ 30[*1]
10	0 Pieces	0 - 2%
9	1 – 3 Pieces	2 - 10%
8	4 – 6 Pieces	10 - 20%
7	7 – 9 Pieces	20 - 30%
5	10 – 12 Pieces	30 - 40%
3	13 – 15 Pieces	40 - 50%
0	Over 15 Pieces	> 50%

[*1] Where the number of pieces is determined by electronic monitoring.

7.2.6 Electronic Monitoring Program Structure for ETBF

The structure of the program is outlined in a suggested conceptual model (Figure 15). The process would begin with a skipper completing a fishing trip, recording catch in the fishing logbook and using electronic monitoring equipment to collect data. Both the electronic monitoring and fishing logbook data sets are processed, audited and scored for each trip. The first step would be to create electronic monitoring data trip report/s from the vessel's electronic monitoring system hard drive summarising the trip/s data and comparing this to fishing logbook quality. AFMA would then decide which actions need to be taken. For example, audit scores not meeting a predetermined threshold will be passed for further analysis, which could include 100% viewing of the electronic monitoring imagery or referral to Compliance.

Audit results would be provided to concession holders. Actions taken for poor audit scores will be in accordance with a "response matrix" to be developed. A stakeholder workshop is required during the program implementation phase to identify all the tools available to deal with discrepancies based on audit results and to encourage improvements in data quality. If necessary, information would also be provided to the service technician/s to make adjustments to the electronic monitoring equipment.

The feedback loop provided in this process gives feedback on a regular basis to concession holders, skippers and fishery managers. The outcome sought is continuous improvement in data quality, accuracy and timeliness. The proposed audit framework is a starting point for developing a program that allows for full catch documentation and continued improvement to monitoring methods.

Based on previous electronic monitoring program experiences, the feedback loop is integral in ensuring the success of the program, which demonstrates that fisher logbooks can become a reliable source of data. The audit-based monitoring program should be implemented in stages, where the emphasis in the first one or two years is providing feedback to industry, polishing the process and analysing the information gathered to understand where most of the data quality issues or risks are. For the first year there may only be scores and the standards may act more like guidelines for each vessel to understand where they sit within the preliminary expectations. Not until the program is generally understood by industry and participants know where they sit in relation to the standards and within overall fleet performance would it be advisable to begin considering consequences for poor data quality. The goal of an audit-based program is to obtain good quality data from industry by setting challenging but realistic expectations of logbook completeness and accuracy.

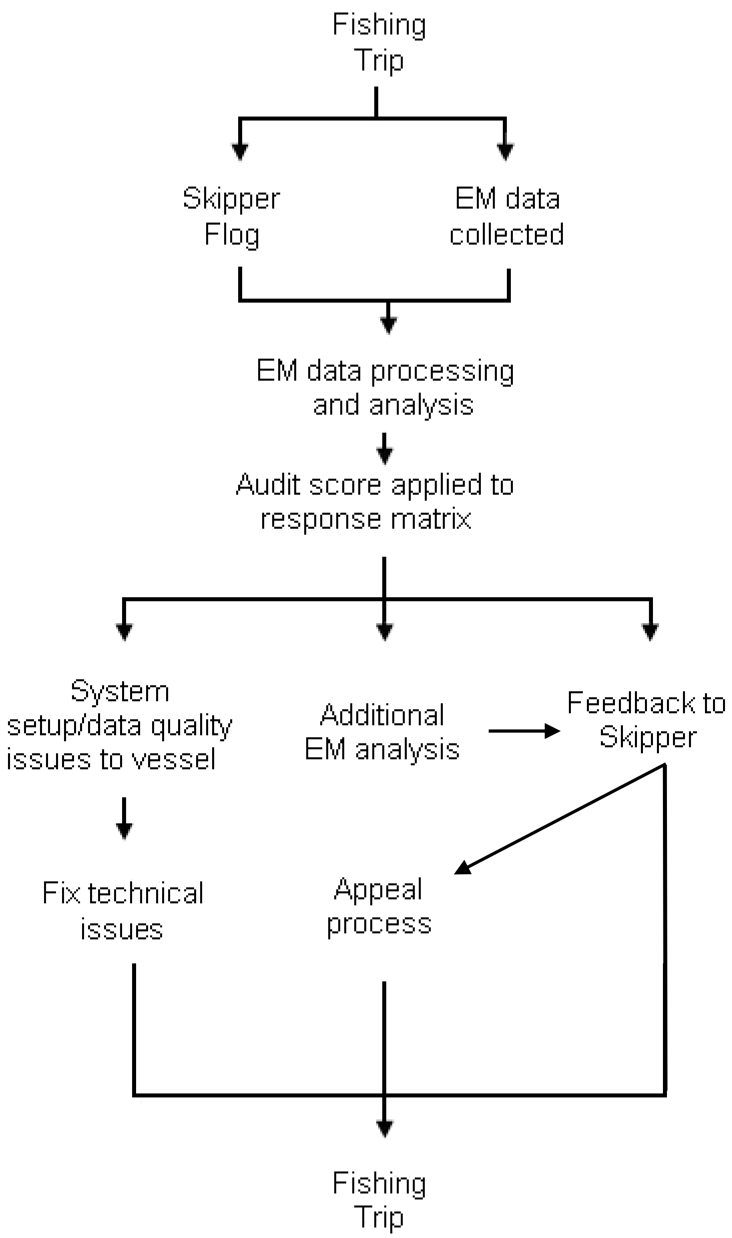

Figure 15: High level conceptual model of the program structure and flow of information within an audit program.

7.3 ASSESSMENT OF SYSTEM PERFORMANCE

7.3.1 System reliability during trial

Methods to assess data completeness were applied to determine system reliability and performance. Imagery and sensor data completeness were evaluated based on the total expected hours of data compared with the number of hours actually collected. The expected hours for sensor data were estimated based on start and end times of fishing trips. Nine of the ten vessels had very high levels of sensor data completeness with most trips having over 99% and an overall average of 96.9%, indicating that the data set was nearly complete for the entire study period (Table 17). However, the *FV Esbjorn* had the lowest data collection success with virtually no data collected for two entire trips because it experienced an incomplete install mid way through the trial (no satellite modem and subsequent Health Statement available). As a result system malfunctions were not detected or addressed in a timely manner.

Imagery data completeness for sets was 89.8% while completeness for hauls was 81.4%. The *FV Esbjorn* had considerably lower data collection success for hauls than the rest (44.2%). Although some of the missed imagery data during sets and hauls was caused by data gaps, most of it was caused by recording not being triggered. Table 18 provides a summary of time gaps in electronic monitoring data. These triggering issues were in turn caused by sensors not being installed or being removed, sensor malfunctions and inappropriate trigger thresholds. All of which could be rectified in an ongoing program.

Table 17: Summary of all trips completed by vessel and percentage of successful data capture.

Vessel Name	Trips	Sets	Sensor Data Completeness	Set Imagery Data Completeness	Haul Imagery Data Completeness
Beluga	8	73	99.3%	98.0%	80.6%
Bianca B	29	68	99.9%	92.4%	93.1%
Blue Mistress	18	127	100.0%	88.5%	82.8%
Esbjorn	9	51	85.2%	84.3%	44.2%
Jordan Kate	38	94	99.9%	95.1%	86.4%
Kaybeanna	23	58	93.5%	93.7%	76.6%
Ocean Explorer	12	86	92.0%	84.0%	77.2%
Ocean Myst	9	66	93.5%	99.4%	90.7%
Samurai	16	84	99.6%	69.7%	80.3%
Santo Rocco	23	85	99.2%	97.3%	94.8%
Totals	**185**	**792**	**96.9%**	**89.8%**	**81.4%**

In this trial the systems were powered by the boats 240 volt power system and in some instances there was an inline uninterruptible power supply (UPS). Several factors contributed to the loss of electronic monitoring data during fishing events over the course of the trial. This included loss of power or the switching off of power to the control centre, service issues or operating system problems with the control centre.

The *FVs Beluga* and *Bianca B* both experienced operating systems issues that resulted in the loss of 34 and 8 fishing events over the course of the trial. The *FV Beluga* had a particularly problematic control centre that required a C: drive replacement and reimaging. The issue was resolved with a control centre replacement in April. The issue with the control centre on *FV Bianca B* was resolved with a systems reimage in early April. The *FV Kaybeanna* also had a problematic control centre that was required to be reimaged a number of times before becoming operational in April.

There were occasions/trips where the control centres were unplugged and/or simply turned off resulting in data loss. These included 10 fishing events on the *FV Beluga*, 9 on the *FV Blue Mistress*, 6 on *FV Esbjorn*, 10 on *FV Jordan Kate* where a plug got knocked out, 10 on the *FV Ocean Explorer* and in the case of the *FV Santo Rocco* a crew member unplugged the system to recharge a mobile phone which resulted in the loss of a haul but not the set.

From time to time there were short power losses to the electronic monitoring systems associated with power switching or the necessity to turn off generators for oil and or filter changes. These were expected over the term of the trial and the systems would restart due to the internal watchdog system. These small power losses are not reflected in this examination but do occur in some of the time availability analysis undertaken by AMR.

In summary there was a 4.81% loss of events due to operating systems software issues identified with the *FVs Beluga* and *Bianca B* and a 5.15% loss of events due to systems being turned off or unplugged. In the first case this was a service scheduling and access to the vessel issue, the second of power to the control centre relates to simple checks and awareness on the part of the crew. All the participants did have monitors with the systems and as such all the instances where the power was off should have been obvious to the skippers or crew.

Table 18: Summary of missing fishing events by vessel.

Vessel Name	Electronic monitoring Overall Fishing Events	Fishing Log Fishing Events	Difference	Time Gap in electronic monitoring data
Beluga	73	117	-44	44
Bianca B	68	76	-8	8
Blue Mistress	127	136	-9	9
Esbjorn	51	57	-6	6
Jordan Kate	94	104	-10	10
Kaybeanna	58	58	0	0
Ocean Explorer	86	96	-10	10
Ocean Myst	66	66	0	0
Samurai	84	84	0	0
Santo Rocco	85	85	0	0
Totals	**792**	**879**	**-87**	**87**

7.3.2 Sensor reliability

There were issues with individual sensors on some trips. The failure of either the rotation or pressure sensor did not necessarily compromise the functional collection of imagery and or data for fishing operations. However the failure of both would result in data and imagery loss.

Sensor performance at the trip level is summarized in Table 19. Complete GPS data were obtained for 92.4% of the trips monitored, while 82.7% and 87.6% of the trips had complete hydraulic and drum sensor data respectively. At this point it was not possible to separate trips with sensor malfunctions from those on which sensors were not installed or were removed part way through a trip.

Table 19: Summary of performance by system components.

Sensor Performance	Rotation Sensor	Pressure transducer	GPS
Complete	162	153	162
Partial Malfunction	14	12	4
Total Malfunction	9	20	10
Total Trips	**185**	**185**	**185**
Percent Complete	**87.6%**	**82.7%**	**92.4%**

7.3.3 System issues by vessel

System performance issues were identified during the trial either through monitoring the system Health Statements, undertaking service events, hard drive exchange and function tests or being notified directly by operators. Table 20 provides a summary of system issues by vessel and outlines how issues were addressed.

Table 20: Summary of system issues addressed during the project by vessel.

Vessel	System issue	Issues addressed
Beluga	Operating system corrupted, GPS failure during installation and a pressure sensor cable join issue.	Replaced C drive in control centre. Replaced GPS and remaking the join at the sensor cable on two occasions.
Bianca B	An incorrect fitting was used causing hydraulic fluid to leak between the fitting and the sensor.	Pressure sensor was not reinstalled during the trial and the system operated solely on the rotation sensor.
Blue Mistress	The control centre and monitor had to be repositioned after the first installation. Rotation sensor reflector became misaligned. Power supply issues due to generator rectifier problems and a sensor cable join failure.	The repositioning of the control centre required the extension and reconnection of eight cables. The boats power problems were addressed by the owners and the sensor issue remedied at the time of a hard drive exchange.
Esbjorn	GPS and satellite modem not installed. Rotation sensor reflector detached during haul and issue not detected until servicing occurred.	Initial system install never fully completed and there was no opportunity to finalise the install due to the vessel being a late participant in the trial.
Jordan Kate	Power interruptions, some issues with pressure memory retention and for one part of a trip the GPS was not functioning.	The resistor in the control centre was re-seated to overcome the memory retention issue. The power interruptions included a plug top “falling out” that was unnoticed and the voltage output of the transformer appeared to decline toward the end of the trial. The GPS was OK after the terminals were replaced.
Kaybeanna	Problems with the operating system software. A hydraulic pressure memory retention issue. The satellite modem cable cut during line setting. The loss of a camera in bad weather event.	System was operational from April 2010. Pressure memory rectified by reseating the inline resistor. The satellite modem cable was never repaired as the cut was at the cable gland and would require a workshop fix rather than a field fix. Failed camera not replaced due to limited technical support.
Ocean Explorer	Rotation sensor and hydraulic sensor issues. Some power supply issues related to the gen-set regulator.	Service technician repaired the sensor wiring and installed a UPS in an attempt to improve power to the control centre.

Ocean Myst	Power supply issues. Rotation sensor cable cut.	Service technician repaired cable.
Samurai	Drum rotation reflector became lost. A rotation sensor knocked out of alignment. Some GPS and control centre issues reported that were linked to the use of HF radio on high power output.	Rotation sensor reflector problem and alignment rectified when in port by service technician. Skipper used radio on low power without the issue reappearing.
Santo Rocco	Hydraulic sensor on the setting side and which resulted in no hauling signal. Disconnected power supply. A 1000 hour time offset mistakenly configured to the system confused the data analysis process.	Hydraulic sensor re-fitted mid point of the trial, first half of trial the system was trigged by the rotation sensor. The time offset was corrected at the next service event and analysts were able to allow for 1000 hour offset

An ongoing program for electronic monitoring requires a level of engineering support from the suppliers and installers of electronic monitoring equipment to overcome minor issues such as those described above. The level of technical support available during the project meant service levels were not as high as intended for an ongoing program. AFMA will need to work with suppliers, maintainers and operators of equipment to ensure a robust implementation and support framework.

7.3.4 Summary of issues by system component

I. Pressure sensor issues

Leaking Transducer thread

The transducers sourced from Canada have a ¼” NPT (National Pipe Thread) screw thread fitting. The standard in common use in Australia is ¼” BSP (British Standard Pipe). Characteristics of NPT (also known as ANSI/ASME B1.20.1 Pipe Threads):

- tapered thread 1^{o} 47'
- truncation of roots and crests are flat
- 60^{o} thread angle
- pitch is measured in threads per inch
- ¼” NPT has 18 threads per inch.

Characteristics of BSP taper threads:

- tapered thread 1^{o} 47'
- truncation of roots and crests are rounded
- 55^{o} thread angle
- pitch is measured in threads per inch
- taper is 3/4" per foot or 1 in 16 on the diameter
- ¼” BSP has 19 threads per inch.

The three issues here are the differences in thread pitch, thread angle and the form of roots and crests. Five of the leaks or issues reported at the pressure transducer were due to the incompatible nature of the male NPT transducer and the female BSP socket to which they were fitted.

Transducer fitted to the wrong side of the line drum

In four instances the pressure sensors were fitted to the wrong side of the line drum for an effective hauling pressure signal. This necessitated the moving of the pressure sensor to the alternate side of the drums’ hydraulic motor. In addition there were hydraulic fluid leak issues with some of the tee fittings that were inserted into systems to accommodate the pressure transducer.

False signal issues
Several vessels in the trial used a single hydraulic power pack to power a number of pieces of equipment. The operating pressure of a gypsy or anchor winch caused an event that triggered video even though the mainline drum was not turning. This was often associated with baiting operations. Lifting the pressure threshold often remedied this situation as the line drum was most often the highest operational pressure item of equipment.

Pressure "memory retention" issue
This particular issue was in fact a control centre issue most usually related to the resistor in the sensor input at the interface (I/O) card. It was noted to occur in three instances. There were occasions where the system might be turned off for a few hours or days and the fault would rectify itself and on other occasions the fault was rectified by reseating the inline resistor.

Cable and cable splice issues
The Belcon cable used did not have a shielded neutral wire and on some occasions a small nick in the outer sheath allowed saltwater to "wick" along the unsheathed wire resulting in problematic connections and possibly false readings. On two occasions a slight hydraulic leak compromised the integrity of the electrical tape and amalgamating tape used at cabling joins close to the pressure transducer.

Protection
By its design the pressure sensor needs the best mechanical protection where the cable enters the body of the sensor and where that part of the sensor cable that is exposed on the work deck or other traffic areas. Where possible an engine room mounting of the pressure sensor would be the best long term installation option. This did not occur during the trial because it involved structural changes and limited expertise was available plus this exercise was considered too costly for the trial.

The project team recommends the use of 4 wire heavy wall piezo (Geotech) cable due to its heavier outer case and individual protection for each wire. The Geotech cable is robust as it is designed for sensor use in the mining and underground hydrology sectors.

II. Rotation Sensor issues
There were several instances in the trial where the rocking of the drum was sufficient to register a signal and activate the camera. One possible option to consider is an in port geo fence so that drum line maintenance in port would not activate the camera recording system. Geo fences were unavailable to use during the trial.
Cable and cable splice issues
There was not the same level of cabling related issues with the rotation sensor as there was with the pressure sensor. However it also would still be susceptible to damage in working areas. In one instance it is understood that a dissatisfied crew member severed the sensor cable.

Protection

By its design the photo reflective sensor needs the best mechanical protection where the cable enters the body of the sensor and that part of the sensor cable that is exposed on the work deck or other traffic areas. As previously stated the 4 wire heavy wall piezo Geotech cable would be preferable due to its heavier outer case and individual protection for each wire.

Mounting Bracket
Galvanised steel bracket were used during the trial, while they might be satisfactory for temporary installations and for trial purposes, they are less than ideal for long term installations in the on boat environment. More robust brackets with additional mechanical protection for the counter body and hood would be highly desirable. For example, in one instance with the *FV Samurai* the bracket was bent and caused a misalignment between reflector and rotation sensor leading to a lack of rotation counts and recording trigger.

Alternatives
The proximity sensor would be a possible alternative to the photo reflective rotation counter. The signal is the same as the photo reflective rotation counter and could well be an effective alternative if there are ongoing issues with reflector maintenance and or life of the photo reflective sensor. In Australia the Omron proximity sensor is used by Line Master for monitoring and counting line shooter rotations.

III. GPS issues
The install on the *FV Esbjorn* was the only time a significant GPS issue was noted (the operating system had no data feed from the connected GPS) and at this stage we are still unsure as to the cause of the issue. When a second GPS was wired to the control centre the GPS function worked as per specification.

Temporary loss of GPS
There were several instances on other boats in the trial where there appeared to be a GPS “lockup”. The issue was never isolated and addressed however it assumed that the lockup was within the GPS engine and a restart/reboot cleared the issue or problem. There was the suggestion in the case of the *FV Samurai* that some radio frequency noise might have impacted on the control centre and or GPS.

Archipelago Marine Research technicians have confirmed that they have noted GPS lockup/losses on occasions in Canada with those losses in some cases attributed to HF radio and in some cases possibly radar interference. There were no instances of cable damage in the course of the trial.

IV. Camera related issues
In terms of functionality, only one camera was observed to fail during the trial due to moisture damage. This indicates a high success rate in terms of cameras being able to function reliably on ETBF vessels for extended periods. The project did however identify a number of camera related issues impacting image quality and usability, these include:

- Camera location and deployment during fishing operations
- Initial setup and focus
- Orientation
- Humidity and moisture build up
- Glare

- Lighting
- Maintenance.

7.3.5 Camera issues and variations between vessels

The aft facing camera was installed to monitor the setting operation including the use of seabird mitigation measures (tori-lines) and seabird abundance and behaviours. Figure 16 shows the variations in the camera views on different vessels captured during the trial. Camera position and view was found to be optimal when the camera was mounted lower at about 3 meters above sea level with a wide angle view and the horizon at a third to half way from the bottom of the image. In some instances there were high mounted cameras that could not capture a sense of the bird activity aft of the boat (see Figure 16a, *FV Jordan Kate*).

The camera looking at the processing of fish generally had an optimum view when mounted under the shelter deck looking at the process with a view of the tuna door beyond the processing area. The *FVs Kaybeanna*, *Jordan Kate* and *Esbjorn* were wheelhouse aft boats where the camera view of the processing was from above the wheelhouse. The routing of cabling to the shelter deck area would have been very difficult in each instance. In an optimum operating installation there would need to be a conduit to run the coaxial cable from the wheelhouse to the underside of the shelter deck.

There were two outboard cameras the first of which was looking at fishing operations and branch line handling from the line control station back to the tuna door, and then a second camera with a closer view in and around the tuna door. These cameras were mounted on outboard lighting arms or their own deployable booms. For the best possible views the cameras should be as far outboard as practicable. It is worth noting that if these booms and arms are not deployed there will be no useful monitoring imagery obtained.

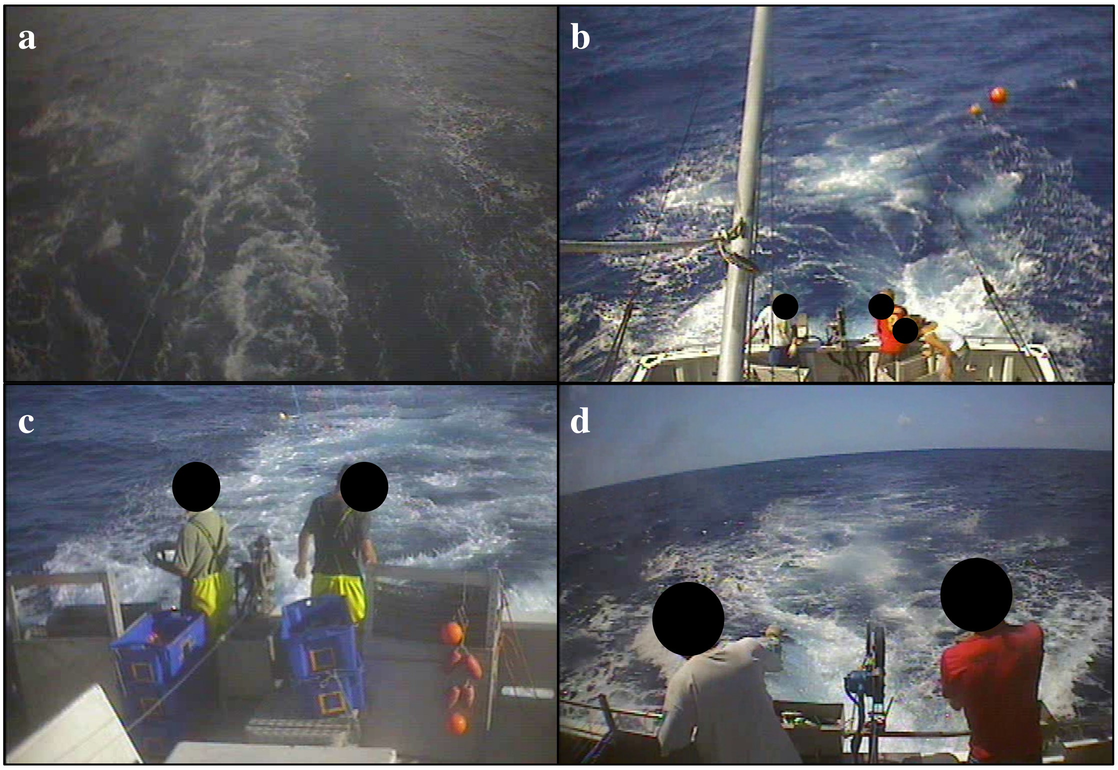

Figure 16: Variations in aft facing camera views between trial vessels include (a) *Jordan Kate*, (b) *Blue Mistress,* (c) *Bianca B* and (d) *Samurai*.

Initial set up and focus

The Honeywell cameras have a fixed focus lens and so the initial focus and lockdown on installation is critical to image quality. Some of the cameras used in the trial had previous service and in some instances there were external scuff marks and scratches on the camera domes that affected image quality. In an ongoing program, standards of image quality will need to be established and complied with for effective 'at-sea' monitoring using cameras. The use of financial incentives can be used to help ensure high standards of image quality are maintained. For example, poor imagery may result in additional analysis time / costs, subsequently these costs can be recovered through a 'fee-for-service' arrangement by hard drive, by vessel.

Orientation

Those cameras that faced directly downward or only slightly off the vertical often had a small "lens of water" accumulate on the dome and movement of the boat, the "lens" of water" reduced image quality on many occasions. Thirty degrees off the vertical would be a recommended minimum to reduce the instances of the "water lens". Camera orientation considerations will need to be made without compromising the required viewing area (e.g. processing catch). Facing vertically down there is often a water lens external to the dome that distorts the image (Figure 17).

Humidity and moisture build up

During installation the cameras had desiccant gel packs inserted inside the camera housings and this was generally successful over the course of the trial. However, there were several cases of moisture ingress into the camera housing that affected image quality (Figure 18). A regular function test regime should identify the development of these problems and issues. In most cases the camera housing should be resealed with a silicon pack and gel to deal with moisture problems. In a worst case scenario the camera's power board and lens will need to be replaced. It is expected that gel packs will need to be replaced once a year at minimal cost.

Camera fixing brackets

In some instances the stainless steel tensioning brackets holding the cameras in place had very nearly failed and a better long term answer would be to weld the camera mounting bracket in place where that position is determined to be the best for the particular boat and fishery. In those instances where cameras are located under the shelter deck a direct surface mount would be preferable.

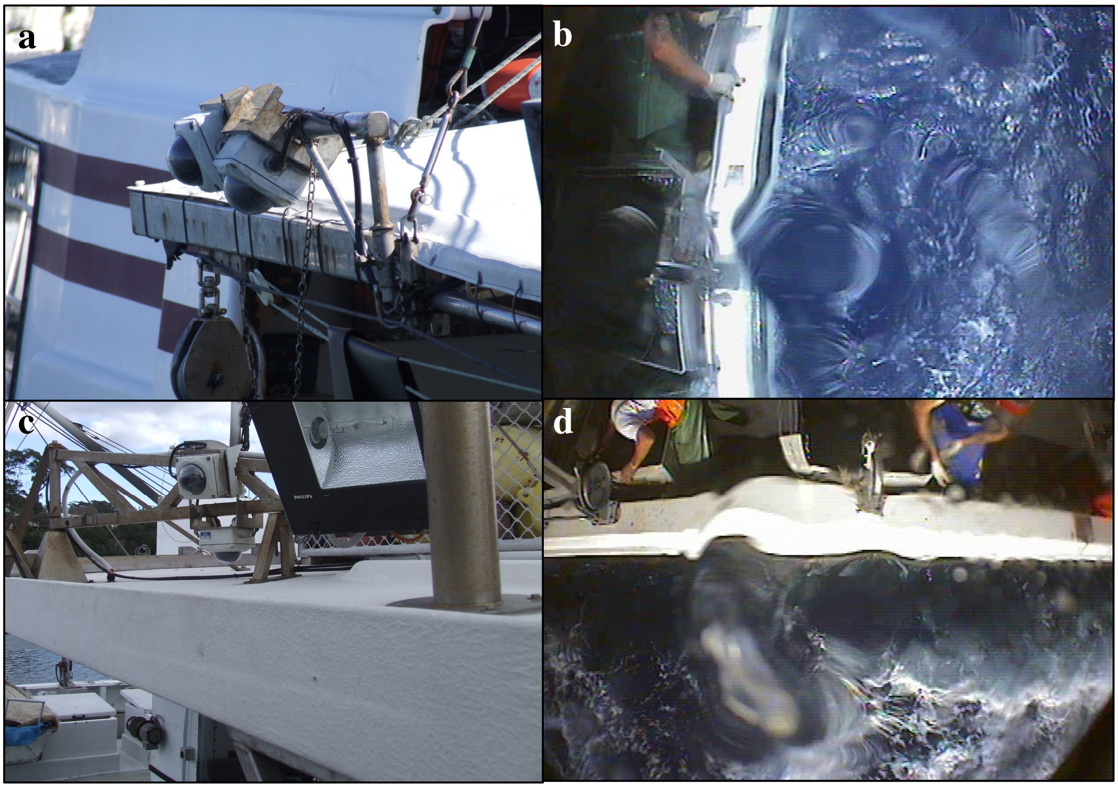

Figure 17: Corresponding camera position and view showing issues with camera orientation and image quality on the *FVs Samurai* (a, b) and *Bianca B* (c, d)

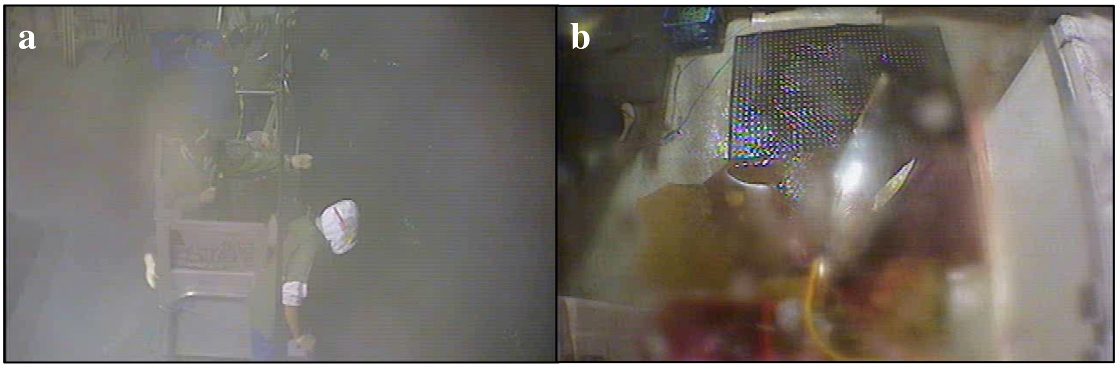

Figure 18: Problems with humidity and moisture impacting image quality onboard the (a) *FVs Esbjorn* and (b) *Blue Mistress.*

Glare

Glare problems were observed on outboard camera views during hauling (Figure 19a). Glare on the water will often occur with low sun angles and in some case specific lighting incident angles. Glare due to low sun angles are largely unavoidable at particular times of day however, the extent of glare can be reduced with wider angle views and the use of sun shades within the camera housing. In those instances where the glare is due to onboard lighting, the only possible solution is a change in the camera location if it is possible.

Lighting

Most night fishing operations require significant outboard illumination of the area where branch lines are retrieved and fish are handled at the tuna door. Generally over the course of the trial the lighting was sufficient to achieve at least medium quality imagery however there were some instances where the light was limited significantly compromising image quality.

Maintenance
External salt build up on the camera domes compromised imagery in some cases and this build up would have been noted with regular skipper initiated function tests and remedial cleaning could have been undertaken. During the trial salt build up was identified on outboard forward facing cameras (Figure 19b).

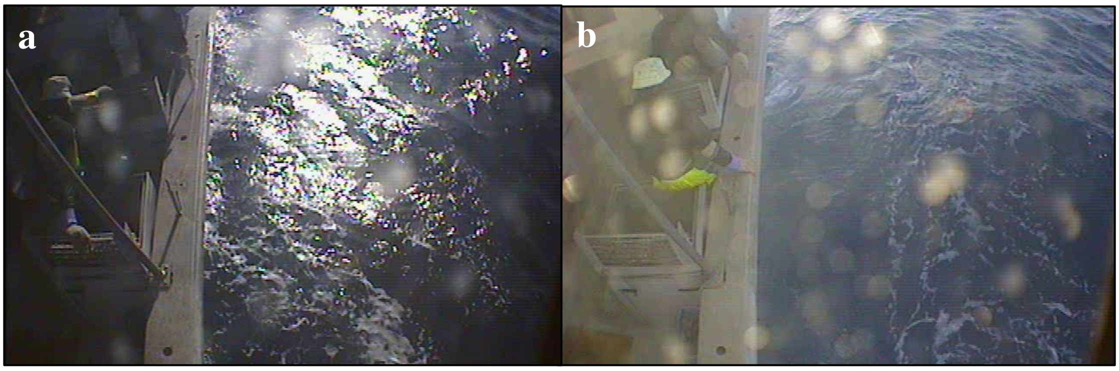

Figure 19: Camera directed forward showing problem with glare (a) and salt build up (b) on the *FV Blue Mistress.*

Coaxial Cable Mechanical Protection
There was no coaxial cable damaged over the course of the trial where much of the cabling was simply attached to existing railings etc. A more preferable long term solution would involve running the coaxial (video) cable and sensor cable through dedicated conduits to afford the best possible mechanical protection and minimise onboard OH&S hazards.

7.3.6 Monitoring and uses of the System Health Statement

The Health Statement is a system status monitoring tool that is not a regular feature of electronic monitoring systems in Canada due to the fact they have high (per trip) data retrieval and analysis rates. In the ETBF trial, the Health Statement was a key component in the monitoring of the hard drive status and the scheduling of data retrievals from the trial participants.

During the course of the trial the Health Statement was used to check vessel location and the equipment status. Figure 20 shows an example of the Health Statement viewing software. The four windows shown include, (a) the data file and hourly statements, (b) the vessel track, (c) the location of the vessel at the selected point in the data file overlayed on satellite imagery and (d) a graphical plot of the selected values and settings. The satellite imagery overlay shows the vessel is located in Mooloolaba and remained there for several days. An alternative view of the Health Statement, Figure 21 shows the statistics file; these statistics are a listing of the power outages from the system. These outages are displayed on the graphical plot and the vessel track windows as PF points.

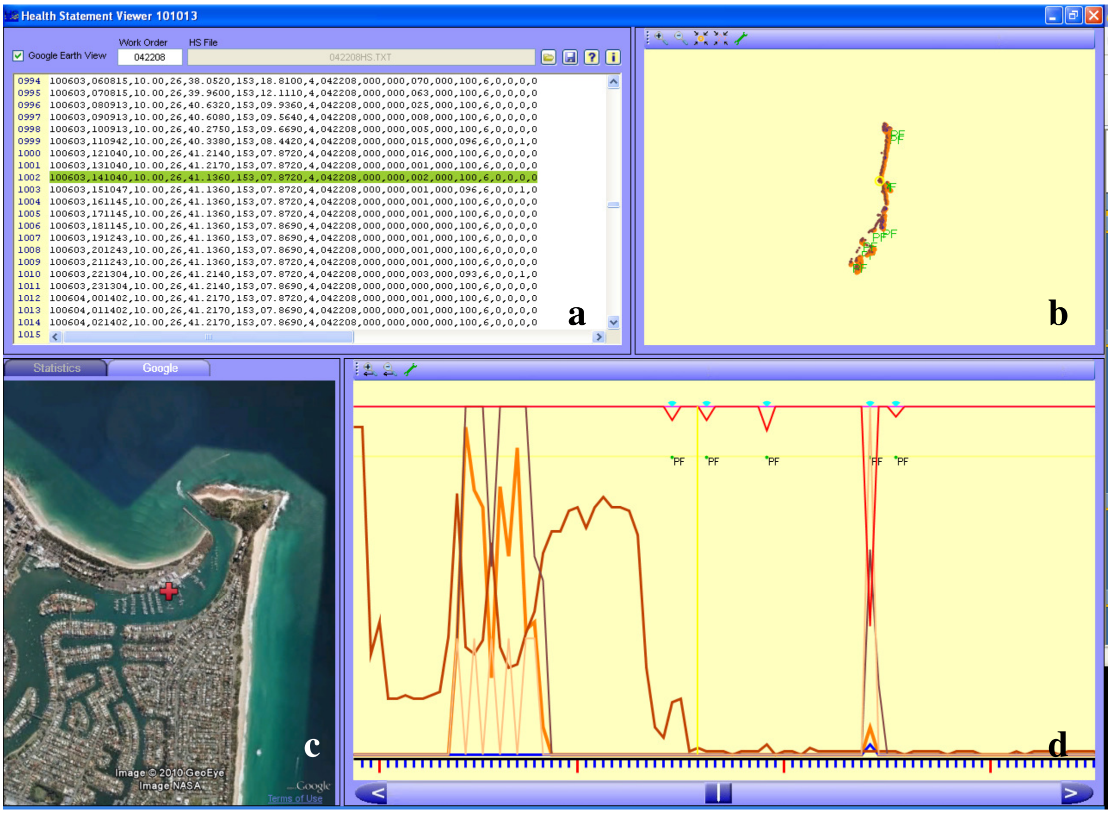

Figure 20: Screen capture of the Health Statement Viewer showing satellite imagery overlay.

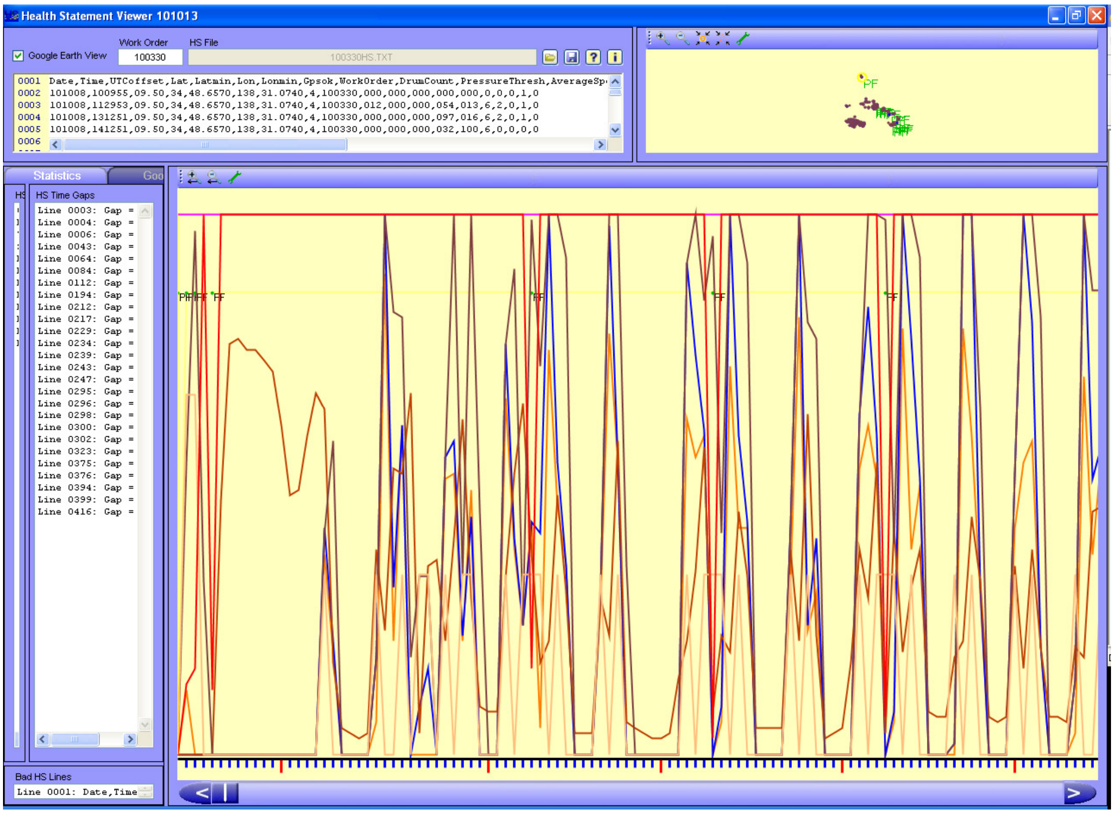

Figure 21: Screen capture of the Health Statement Viewer showing system power outage (Time Gaps).

Monitoring systems status using the Health Statement Viewer proved to be a valuable tool given the limited technical resources available to the project and the remoteness and area covered by the fishing fleet in the ETBF. It proved a useful tool for monitoring vessel activities and identifying possible issues with the system and components (e.g. sensors). Data from the hourly statements was graphed over time to determine fishing events and activities. Figure 22 shows an example screen capture of the Heath Statement values and settings.

This tool also enabled project technicians to prioritise service events (e.g. hard drive exchange) and identify issues requiring further attention. For example, Figure 23 shows three fishing operations with only the last one having any values (plotted in dark blue) from the hydraulic pressure transducer. This would indicate one of two possible issues with the sensor, either a setting threshold that is too high and would benefit from being reduced by 50 PSI or, alternatively, an intermittent problem with a spade connection at the terminal strip or at the wire splice. Further experiences with Health Statement data and documenting interpretations of these data would assist the reductions in response time to problems and guide necessary actions.

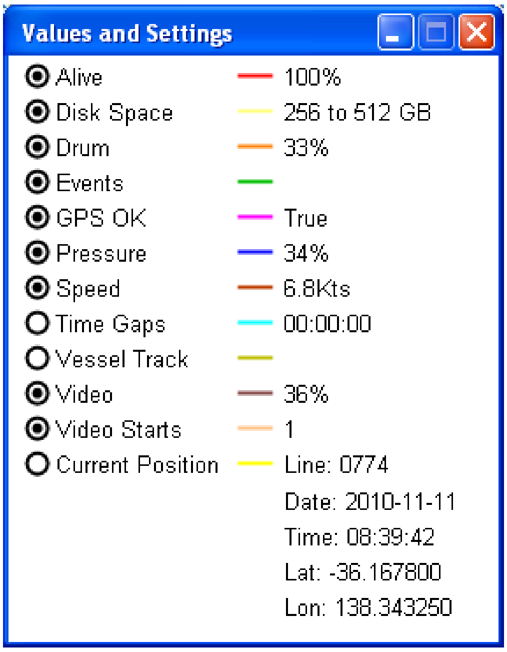

Figure 22: Example of values and settings from Health Statement Viewer.

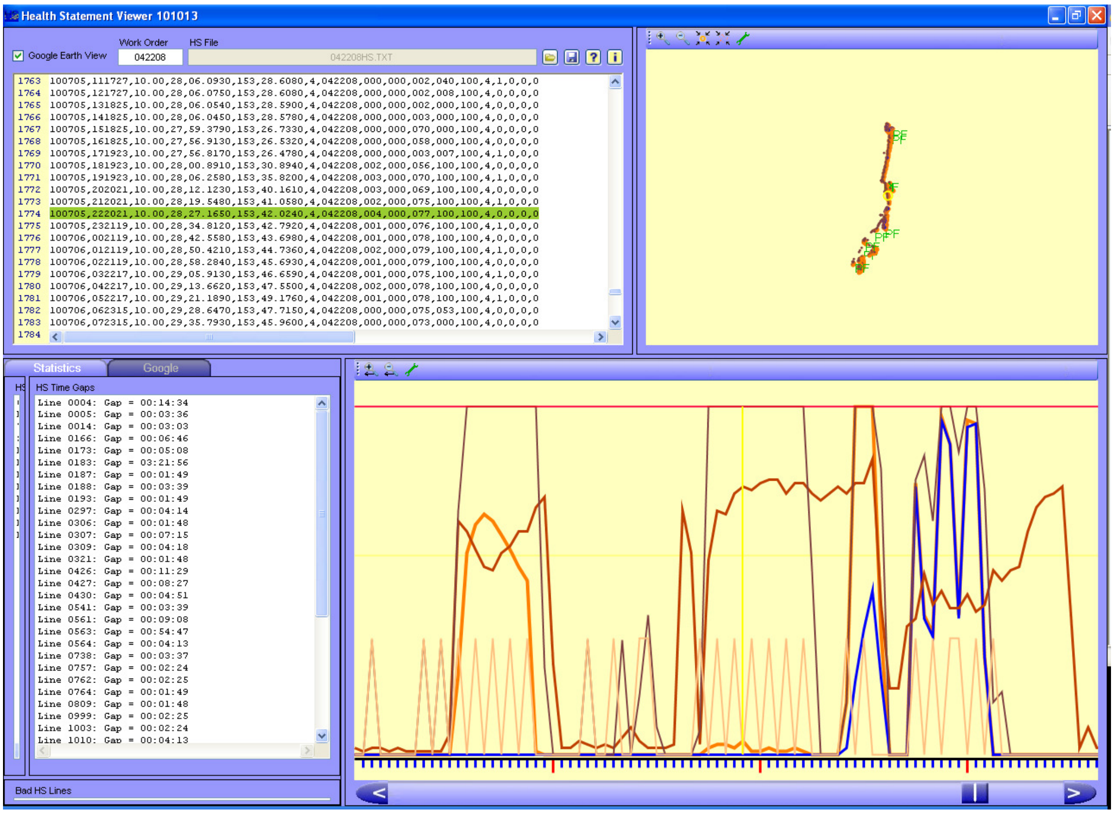

Figure 23: Screen capture from Health Statement Viewer showing inconsistent pressure sensor data graphed.

In an operational electronic monitoring program the Health Statement could be used by;

- AFMA to monitor the operational status of systems and compliance with function testing requirements and protocols. It may also be used as a proxy for VMS
- Field service providers to schedule servicing
- The fishing operators for the remote management of fishing operations.

7.3.7 Summary and Recommendations

Overall electronic monitoring systems were able to operate reliably and consistently on ETBF vessels. The most common issues were related to the hydraulic sensors, followed by drum sensors largely due to these sensors placed in exposed areas on the work deck. Recommendations to mitigate system related issues experienced in the trial and enhance electronic monitoring system reliability and installation life are provided in Appendix 6 (Table 38). The data collection failure problems seen in this project are from four main sources:

1. Hardware related - There were a few instances of operating system failure that required replacement of the internal operating system hard drive. This problem is rare and seemingly related to power fluctuations (frequent on/off events). Another problem was with a constant high pressure signal, one due to wire short and others due to a resistors' inline connection on an IO board.
2. Installation related – There were several problems with incorrect equipment installation including incorrect wiring of components and hydraulic sensor mounted to low pressure side of system (should be high pressure side). The vessel is responsible for hydraulic system access. Tests are performed upon first install but the problem may not be identified until after the first fishing

trip where we have a chance to see hydraulic pressure profiles across vessel activity.

3. Service related – There were many issues not identified and corrected during servicing. These simple problems compound over multiple trips creating larger data deficiencies. Examples include not repairing broken wires, failure to realign and clean rotation sensors, removing a control centre but not having a replacement.
4. Vessel related – There were a number of issues and actions by vessel personnel that led to incomplete data including: vandalism (one instance), turning the power off, damaged wires, removing a hydraulic sensor (leaking fitting), sensor knocked out of alignment.

Northern Hemisphere integrated electronic monitoring programs are designed to have a high data retrieval and service technician inspection frequency, most usually about twice a month. During this trial the project team attempted to stretch this service frequency out to every two or three months due to the movements of the participating vessels and staff resourcing limitations. These factors combined did not allow a high level of servicing as implemented overseas. There were some instances where the systems performed very well at this service frequency; however, there were, in some cases, issues or concerns that should have been obvious to operators that were not understood or brought to the attention of the project management team who might then have made a service call a priority. In addition, because there was a long period before any analysis was undertaken there was no timely feedback from the analysis process that highlighted concerns with systems settings or sensors.

Many of the components are in the exposed working deck environment and need regular attention. Most of the problems experienced in this project lie with the peripheral components, how they are connected to the control centre, and how they are serviced during the project. In an ongoing program, vessel personnel will need to learn more about the operation of the equipment to detect and report equipment failures. The priority toward resolving issues needs to be at the forefront of concession holders' and skippers' minds such that problems are resolved in a timely fashion and fishing vessels are not at sea with inoperable electronic monitoring systems. Program integration will require a cost effective engineering support framework from the manufacturers, installers and service technicians including clear protocols and management responses when dealing with system problems whilst at-sea.

In an ongoing program, AFMA will need assurance at the start of each trip that the electronic monitoring system is fully functional and that the imagery will be fully suitable for monitoring needs. This can be achieved with the use of regular Heath Statement monitoring and the requirement to have the owners and skippers to undertake a system function test before a trip start and routinely over the course of the trip. A system function test is a short test (about 3 minutes) that verifies that sensors, GPS, and camera views are adequate. The in-port function test should be conducted well before scheduled sailing such that service technicians can address any issues that are noted during the test.

It is understood that a fully operational program, as detailed elsewhere, would address technical failures and the audit program would ensure operators are well aware of system performance over time and the costs for not ensuring reliability of systems and the quality of imagery captured. AFMA does not plan to run a team of service technicians. AFMA will work with industry and others to implement a robust engineering support framework.

7.4 COSTS AND BENEFITS OF ELECTRONIC MONITORING IN THE ETBF

7.4.1 Service delivery model

An effective electronic monitoring program requires strong links between key activities and elements to enable efficient capture, storage and use of the data. The service delivery model specifies how the program will be delivered. In the Northern Hemisphere, the development and integration of electronic monitoring programs has supported a fully-stand alone service delivery model or ‘Canadian model’ based on a single third party contractor offering full service monitoring programs. The operation of an electronic monitoring system under the Canadian model would mean AFMA will be involved in electronic monitoring as a receiver and user of the data, and that a third party service provider will be involved in the technical advice, installation of systems and analysis of electronic monitoring footage.

In regard to electronic monitoring programs, alternatives to the ‘Canadian model’ were limited due to the very little electronic monitoring expertise, infrastructure and experience that exist within Australia. This being the case, the costs associated with an AFMA conceptualised co-ordinated program model are considered with a focus on electronic monitoring capacity development and collaborations with stakeholders for effective service delivery.

Figure 24 outlines a high-level process map of key operational activities, data movement and management framework for the considered service delivery of an electronic monitoring program.

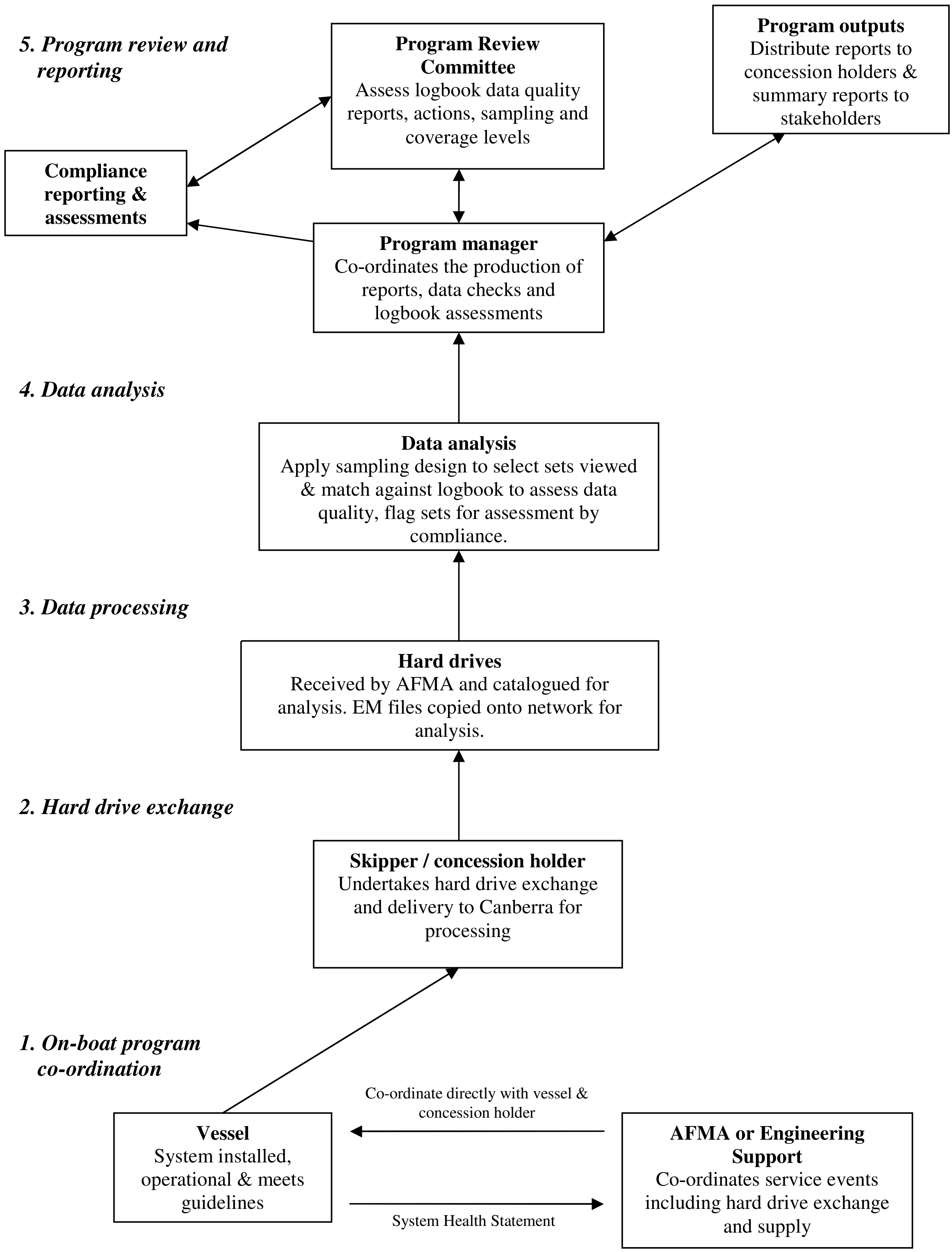

Figure 24: High level process map of an AFMA co-ordinated electronic monitoring program.

7.4.2 Program options

The implementation of electronic monitoring in Commonwealth fisheries involves considerable costs. Consequently, the potential benefits must be weighed against the costs to determine if electronic monitoring is appropriate. Not all costs and benefits are easily quantifiable. Items that are not quantifiable are assessed in a qualitative way as best as practicable.

In order to compare options a base case is established. This analysis will assume the base case as the status quo with 8.5% observer coverage and no further investigation of electronic monitoring. Given that there are alternative ways electronic monitoring could be implemented, it is necessary to outline various options in order to compare the costs and benefits relative to the base case. The options considered are:

1. Status quo – no electronic monitoring program
2. Implement electronic monitoring with the following characteristics
    a. Voluntary adoption (non-program participants will incur onboard observer program costs)
    b. Industry responsible for:
        i. Installation of equipment
        ii. Hard drive exchange
        iii. Maintenance of equipment
    c. AFMA responsible for:
        i. Reviewing footage (casual staff) and other data
        ii. Managing process (analysing data, comparison to log data, database management, reporting, certification, distribution of hard drives, use of data etc.)
3. Same as option 2, but compulsory adoption and program participation

The base case represents current management arrangements. However, it is possible that community expectations regarding discarding practices may increase the minimum acceptable level of monitoring in the future. To compare the options, net present values (NPV) are calculated over a 10 year planning horizon at an annual real discount rate of 5%. All costs and cost savings contained in this report include AFMA on-costs and overheads.

7.4.3 Option 1 – Status quo

This option involves no change from the current system and no further consideration of electronic monitoring. It is used as the base case to compare the costs and benefits of alternative options.

7.4.4 Option 2 – Voluntary electronic monitoring

This option is with voluntary uptake and industry responsible for equipment install, hard drive exchange and maintenance of equipment. AFMA would manage the process including the reviewing of footage, comparison of video data to log data, storing data etc.

In order to cost this option it is necessary to assume the number of boats operating in the fishery and the likely voluntary uptake rate. The costs and benefits below are based on a fleet of 40 boats and an 80% uptake rate (32 participating vessels).

Costs

The following provides cost descriptions and estimates of the program set-up and ongoing elements for the electronic monitoring program options. A summary of cost item is provided in Table 21. The details of each cost item and any assumptions are outlined below.

Table 21: Summary of electronic monitoring (EM) costs - option 1.

Item #	Cost item	Year 1 (set-up cost)	Ongoing annual cost	Responsibility	Who pays
1	EM system purchase	$411,840		Concession holders	Concession holders
2	Installation	$95,573		Concession holders	Concession holders
3	Maintenance of equipment	$41,600	$41,600	Concession holders	Concession holders
4	AMR training	$10,000		Concession holders	Concession holders
5	Hard drive purchase	$20,800	$8,320	AFMA	Recoverable cost
6	Hard drive exchange	$1,997	$1,997	Concession holders	Recoverable Cost
7	Database development	$16,625	$0	AFMA	Overhead
8	Program manager	$166,249	$83,125	AFMA	Recoverable Cost
9	IT data storage hardware	$22,000		AFMA	Recoverable Cost
10	IT data storage software	$1,600	$250	AFMA	Recoverable Cost
11	Resourcing - IT support	$28,099	$12,049	AFMA	Recoverable Cost
12	Analysis of EM data - AFMA data entry	$132,219	$132,219	AFMA	Recoverable Cost
13	Control centre software lease	$15,840	$15,840	Concession holders	Concession holders
14	Analysis software lease	$10,395	$10,395	AFMA	Recoverable Cost
15	Health Statement	$19,008	$19,008	AFMA	Recoverable Cost
16	Ongoing independent audit (5% of analysis)		$6,611	AFMA	Recoverable Cost
Total		$993,845	$331,414		

1. System Purchase Costs

Includes electronic monitoring system cost with the current ETBF configuration (4 cameras, satellite modem), shipping and currency exchange. Equipment life is estimated at five years, (McElderry 2010 per comm.). Therefore when Net Present Values (NPVs) are calculated, this cost is included in the initial year and year 5.

2. Installation of equipment

In this model, local technicians arranged by the concession holder will undertake installation and maintenance of the system. The time for the system installation is dependant on a number of factors including the vessel design and feasibility to undertake adequate cable runs and fit cameras to the defined standard. Time and cost estimates are outlined in Table 22. Based on the average time per install and at a rate of $800 per day (TMQ International estimate July 2010) and 32 vessels total install costs are estimated at $95,573. In this instance, travel time for the technician is not included in costs.

Table 21: Summary of system installs tasks by hours and estimated costs.

Task	Average hours	Worst case
Install video coax cables 4	8	12
Install Satellite modem, GPS, cables run to control centre	3	4
Install pressure, rotation sensor and cable runs	2	3
Mount pressure sensor - Hydraulic technician	1	2
Mount and align rotation sensor	1	2
Install control centre and connect all cables	2	3
Install 4 cameras and adjust to meet specifications	3	5
Install monitor	1	2
Initial setup and trouble shoot	3	6
Boom fabrication and fitting where required	**4**	**5**
Total hours	**28**	**44**
Cost at TMQ rate of $800 per day (7.5 hour days)	**$2,986.67**	**$4,693.33**

Requirements for this cost item include:

- Local marine technicians required for installation and maintenance. A cost effective engineering support framework is required including clear protocols to address system problems in a timely manner and management responses when extensive problems are observed. For example, if an extended period to rectify a system problem is experienced the vessel maybe required to carry an observer (i.e. vessel intends to fish within SBT zones).
- Development of system function and non-function specifications and software requirements (user-friendly hard drive swap), one week AFMA technician staff time and confirm with AMR.
- Vessels demonstrating issues with power supply to support the system will require an additional purchase of a stand alone battery bank at a cost of $2,500 for the system. These costs are not included in Table 22. The requirement of this purchase will be determined by AFMA, in consultation with the concession holder.
- Systems install verification checks will be undertaken following collection of the vessels first hard drive. Checks will be undertaken against an agreed standard of hard drive file content (files types) and camera views.

3. Maintenance of equipment

Maintenance costs are the responsibility of the concession holder and would depend to a large extent on the care and upkeep provided. As a general rule, Archipelago Marine Research suggests using 10% of the equipment purchase price for annual maintenance.

4. Training from Archipelago Marine Research

As local marine technicians will be responsible for installation and maintenance, and AMR will be required to provide specialised training. Training costs are estimated at $10,000 per year although this cost may vary depending on the range of technicians adopting service roles, the turn over of technicians and need for ongoing support. Also complex equipment repairs may still require shipping the control centre to Canada further exacerbating the maintenance of equipment costs.

5. Hard drive purchase
AFMA would purchase the hard drives and we estimate a requirement of 5 hard drives per vessel. It is assumed that due to some hard drive failures and requirements for some original hard drives to be stored for compliance, two extra hard drives will need to be purchased per vessel per year.

6. Hard drive exchange
In the longer term, AFMA expects that this would be an industry responsibility where the concession holder would be responsible for exchange of the hard drive and posting to AFMA. It is assumed that with current fishing efforts the average hard drive exchange will occur every 3 months. Registered postage costs to Canberra, including shipping material are estimated at $1997 per year in total.

7. Database development
Electronic monitoring data modelling, integration with AFMA's databases and database development is estimated to take one month to complete at the executive level one (EL1) level. The majority of the data modelling is complete and there is potential for these remaining costs to be covered in-kind through existing AFMA budgets.

8. Program manager
The program manager will be required to undertake a number of tasks before commencement of the program. One full time equivalent (FTE) program manager (EL1) is budgeted for this role for the first 12 months of the program (includes the 6 month implementation phase). Following this period, 0.5 FTE EL1 is budgeted to manage the program.

9. IT data storage hardware
In order to provide enough capacity to support the electronic monitoring data received by AFMA for analysis, a small disk array is recommended. This proposed device will initially have 20 terabytes (TBs) of disk space with the capacity to expand up to 196TBs. It connects directly into a switch and can be accessed from anywhere on the network. A small server would also be required to support a dedicated network. Set-up costs include the iSCSI disk array - $14,000 and server - $8,000. A 4 year warranty is included in costs, however the hardware would need to be replaced post this (i.e. every 4 years).

10. IT data storage software
Data storage software required includes Windows server 2008, Antivirus; set-up costs $1,600 and ongoing costs $250.

11. AFMA IT support resourcing
In the initial stages of the project, the requirement of IT support anticipated is 0.2 of an APS4 FTE. While, on-going support would be approximately 0.1 of an APS4 FTE. Services to install and configure the server by an external contractor would be required at a cost of $4000 in the first year.

12. Data analysis and reporting
To determine data analysis costs, estimates of annual fishing effort were undertaken. In this case, an average of 15 sets per month by vessel was used to estimate total annual effort (e.g. 5760 sets for 32 vessels). Analysis cost is based on a 10% (logbook

audit) of total sets at an average analysis time of 3.5 hours per set. In reality, adopting a sampling regime at 10% with a minimum of one set per trip may result in higher analysis coverage levels due to variations in trip length and the activities of vessels in the fleet.

A detailed assessment of data analysis for an ongoing program was undertaken with various options considered. The most cost effective option was a contracted provider. The assumptions made were 32 Vessels at 15 sets per month, 5760 sets per year, 10% EM analysis at 3.5 hrs per sets, plus 20% for other reporting duties totalling 2419hrs. This was costed at $132,198.

13. Electronic monitoring control centre software (EM Record™)
This includes annual license fees for control centre software.

14. Electronic monitoring analysis software
This includes annual license fees for data analysis software. It is anticipated that several licenses will be required for an ongoing electronic monitoring program. The analysis workload and subsequently the number of licenses will also be dependent on the analysis turn around requirements and participating vessels.

15. Health Statement communication costs
This includes monthly communication costs for satellite health statement communications.

16. Ongoing program audit
An independent audit program is budgeted at 5% of the analysis costs to check the outcomes and competency of the programs video analysers. This program will demonstrate data quality assurance to industry and stakeholders.

Program implications and assumptions following integration
It is anticipated that AFMA will recover both the electronic monitoring and observer program costs on a fee-for-service basis in a dual monitoring program; operators can either choose to opt into the electronic monitoring program or continue to carry observers to meeting the fishery monitoring requirements. For example, those operators that don't take-up electronic monitoring will incur the costs of the observer program based on 8.5% of their effort to be recovered during the year. This excludes the coverage requirements and observer costs associated with the SBT monitoring program. In comparison, operators that take-up electronic monitoring will incur the electronic monitoring program costs. These costs include a reduced level of observer coverage (e.g. ~2%) to enable the collection of 'at-sea' data not possible by electronic monitoring systems (e.g. biological information).
Previously research projects in the ETBF have utilised the onboard observer program to undertake additional work on top of their observing duties (e.g. tagging programs and fishing gear trials). If an electronic monitoring program is supported, and an observer program is phased down over time, future research projects requiring sea trials may be required to include at-sea observer costs.

7.4.5 Option 2 Benefits

Not all other benefits of adopting this option are quantifiable. Nevertheless it is possible to quantify some major cost savings and describe some of the non-quantifiable benefits. A summary of quantifiable benefits is provided in Table 23.

Table 23: Summary of quantifiable benefits of option 2.

	Annual saving
Observer cost savings (80% of total costs)	$587,520
VMS savings (polling costs for 32 vessels)	$14,285
Total quantifiable benefits	$601,805

Savings in observer costs

The easily quantifiable benefits of electronic monitoring are in the form of potential saved costs from reduced observer coverage. With an 80% take up of electronic monitoring in a 40 boat fleet the observer budget for the fishery would be reduced by 80% — or $587,520 per year. For boats that do not opt for electronic monitoring, observers would still be required. These boats would pay for the observer coverage cost required rather than the cost being funded through the levy base.

If increased observer coverage is required in the future – increasing the electronic monitoring analysis (coverage) is a much cheaper option. For observer coverage, the marginal cost of an additional percentage point of coverage is around $86,400 per year. For video analysis, the marginal cost is around $14,500 per year. Therefore the difference between these two figures – $71,900 – is a *potential* cost saving in the future for every one percentage point increase in required observer coverage.

Compliance savings

An assessment of the applications of electronic monitoring for detecting non-compliance shows that under an electronic monitoring program the majority of risk ratings (e.g. compliant with seabird mitigation measures) will be reduced as electronic monitoring provides a greater capacity for assessing the compliance performance of each vessel (see Appendix 5). However, under a dual model (voluntary program with 80% uptake) of observers and electronic monitoring, the reduction in risk ratings and hence long term cost savings and benefits are likely to be less than in a compulsory electronic monitoring model. AFMA has determined the impacts of electronic monitoring, in a compliance sense, are as follows;

1. Despite these reduced (or eliminated) risks there will be no reduction in the need for, or costs associated with, port based inspections.
2. The need for at sea patrols in the fishery will be reduced. However, the need for, and costs associated with, at sea patrols in other related fisheries would remain and hence there will be no real reduction in costs.
3. There is likely to be an increase in compliance costs in the fishery in the short to medium term as a result of a “spike” in detection rates due to the increased capacity to monitor compliance performance. It is impossible to quantify this likely increase. However, over time efficiency gains are expected for the compliance program in terms of assessing and addressing compliance risks.

Vessel Monitoring System (VMS)

VMS is used to monitor pelagic longline operations and the movement of boats in and out of ports. AFMA monitors the activity of the fleet through VMS to ensure that the vessels and VMS’s are working in accordance with conditions imposed on fishing permits.

The electronic monitoring system Health Statement is an hourly message via satellite communication while electronic monitoring systems are turned on. The one line message is a synopsis of the previous hour reports on vessel location, activity and system health status. The Vessel Monitoring System (VMS) with a computer attached, currently provides for real-time location information with a variable polling rate, two way messaging and in some cases a distress function. These functions are not currently available with an Electronic Monitoring System. As technology develops, the Electronic Monitoring system Health Statement may remove the need for a VMS system as an additional requirement to electronic monitoring, where fitted. As an example, the removal of VMS polling costs on a fleet size of 32 vessels would provide an annual saving of $14,285 in AFMA's costs (which are recovered from the fishing industry).

The current electronic monitoring system Health Statement has restricted functions and utilities in comparison to VMS. For example, Health Statements are currently limited to hourly polls, and not set-up for real time polling, no capacity for shore to ship messages, no emergency beacon and currently not compliant with Western and Central Pacific Fisheries Commission (WCPFC) conditions. In time, further development and needs may increase the systems functionalities in terms of Health Statement polling. The current variations in utilities of VMS and the systems Health Statement are provided in Table 24.

Table 24: Utility and functionality status of Vessel Monitoring System (VMS) and electronic monitoring (EM) systems.

Function / Condition	VMS	EM
Variable polling rate	Yes (remote)	Health Statement currently restricted to hourly polling. This could change in future configurations with subsequent impacts on communication costs.
Real time - on demand Poll	Yes (remote)	No
Shore to ship message Capability	Yes	No
Emergency Beacon	Yes	No
WCPFC Compliant	Yes	No (possibly able to meet requirements in the future)

Reduced Occupational, Health and Safety (OH&S) risks

There are considerable occupational health and safety concerns for at sea observers. Reducing the level of observer coverage has the additional benefit of reducing OH&S risks and exposure in the ETBF.

Behaviour change

The presence of an observer is determined in advance and is known to all onboard. Consequently, fishers are aware that the chance of being observed is either zero or close to 100%. This means fishers may behave differently when no observer is onboard, particularly regarding the reporting of discards and interactions with protected species.

Conversely, electronic monitoring would involve recording 100% of fishing activity. This means all behaviour would be observable but not necessarily observed. If a random sample of video was analysed and audited then fishers could never be certain whether or not any action would be monitored. All fishing activity would have a chance of being observed between zero and 100% (dependent on the proportion of video to be analysed and audited). Behavioural changes are expected to be greatest when the logbook audit methodology and scoring has clear consequences and there is a strong feedback loop to operators.

Although there is a risk that fishers will develop new methods of avoiding detection or tamper with the cameras, penalties should minimise this risk. For example, there should not be a problem with tampering with the onus on the operator to ensure the cameras are working (and there are enforceable penalties associated with a failure to do so). There would be additional costs to concession holders where the audit score indicated concerns over inconsistencies in reporting therefore requiring full analysis of the imagery.

Increased accuracy of scientific information
The accuracy of logbooks should improve dramatically given the above described behaviour change. Logbook and observer data are key inputs to stock assessments. Electronic monitoring could improve the reliability of this information by providing an independent, verifiable record of fishing activity. For example, Stanley *et al.* (2008) examined the accuracy of catch estimates of Yelloweye Rockfish in the third year of an integrated electronic monitoring program in the BC hook-and-line fishery. This program employs an image review process that randomly selects fishing events (10% of the events from each trip). Using a catch estimate derived from the image review, Stanley *et al*. (2008) showed that the overall monitoring produces accurate catch estimates.

Improved scientific information has many flow-on benefits. Fisheries managers rely on the accuracy of stock assessments to set total allowable catch and effort levels — so improved information may lead to better management outcomes. Stakeholders and the wider community can also be more confident that economic returns are being maximised and sustainability goals are being met. Reducing uncertainty through improved data quality may make environmental auditing procedures simpler. This may have positive implications for market access and product certification.

More cost effective rules
With a greater capacity for onboard monitoring, electronic monitoring also has the potential to be able to effectively monitor a far greater range of management options. Tailored management arrangements aligned to an electronic monitoring program have the potential to provide a range of fishing operational benefits to industry. Management arrangements and consequences can apply to individual vessels rather than the entire fleet (e.g. current TAP for Seabirds) which would strengthen environmental stewardship. New rules may require a trial period before acceptance and adoptions by all stakeholders.

7.4.6 Option 2 Net benefits compared to the status quo

In nominal terms, this option is expected to cost an average of $451,568 each year more than the base case with average benefits of $601,805 per year. This results in an overall net benefit (benefits less costs) of approximately $1.5 million over a 10 year period (Table 25). It is important to note that there are significant implementation costs in the first year and it takes several years to break even. In NPV terms (5% discount rate) this equates to a net benefit of approximately $1.1 million (Table 26).

Table 25: Option 2 nominal costs and benefits in 2010-11 for a 10 year period.

Year	Marginal costs	Marginal benefits: Observer savings	VMS savings	Total	Net benefits
0	$993,845	$587,520	$14,285	$601,805	-$392,040
1	$331,414	$587,520	$14,285	$601,805	$270,391
2	$331,414	$587,520	$14,285	$601,805	$270,391
3	$353,414	$587,520	$14,285	$601,805	$248,391
4	$331,414	$587,520	$14,285	$601,805	$270,391
5	$826,528	$587,520	$14,285	$601,805	-$224,723
6	$331,414	$587,520	$14,285	$601,805	$270,391
7	$353,414	$587,520	$14,285	$601,805	$248,391
8	$331,414	$587,520	$14,285	$601,805	$270,391
9	$331,414	$587,520	$14,285	$601,805	$270,391
Total	$4,515,684	$5,875,200	$142,850	$6,018,050	$1,502,366

Table 26: Option 2 net present value assessment of costs and benefits for a 10 year period (discount rate 5%).

Year	Marginal costs	Marginal benefits: Observer savings	VMS savings	Total	Net benefits
0	$993,845	$587,520	$14,285	$601,805	-$392,040
1	$315,632	$559,543	$13,605	$573,148	$257,515
2	$300,602	$532,898	$12,957	$545,855	$245,253
3	$305,292	$507,522	$12,340	$519,862	$214,570
4	$272,655	$483,354	$11,752	$495,106	$222,451
5	$647,606	$460,337	$11,193	$471,530	-$176,076
6	$247,306	$438,416	$10,660	$449,076	$201,770
7	$251,165	$417,539	$10,152	$427,692	$176,527
8	$224,314	$397,657	$9,669	$407,325	$183,011
9	$213,632	$378,721	$9,208	$387,929	$174,297
Total	$3,772,050	$4,763,507	$115,820	$4,879,328	$1,107,278

7.4.7

In addition to the quantifiable benefits and costs, there are all the non-quantifiable benefits previously described including the increased confidence in the accuracy of logbook data and reporting, reduced compliance risks and improved compliance outcomes, reduced OH&S risks for observers and new management arrangements that provide flexibility and benefits to operators.

7.4.8 Option 3 – Compulsory electronic monitoring

This option is with compulsory uptake and industry responsible for equipment install, hard drive exchange and maintenance of equipment. AFMA would manage the process including the reviewing of footage, comparison of video data to log data, storing data etc. Observer coverage levels would be maintained at 2% of effort for monitoring and data collections not possible by electronic monitoring systems.

In order to cost this option it is necessary to assume the number of boats operating in the fishery. Costs and benefits are based on 40 boats in the ETBF fleet. A summary of costs is provided in Table 20, and a description of each cost item is provided below including any assumptions.

Table 27: Summary of electronic monitoring (EM) costs - option 3.

Cost #	Cost item	Year 1 (set-up costs)	Ongoing annual cost	Responsibility	Who pays
1	EM system purchase	$514,800		Concession holders	Concession holders
2	Installation	$119,467		Concession holders	Concession holders
3	Maintenance of equipment	$52,000	$52,000	Concession holders	Concession holders
4	AMR training	$10,000		Concession holders	Concession holders
5	Hard drive purchase	$26,000	$10,400	AFMA	Recoverable cost
6	Hard drive exchange	$2,496	$2,496	Concession holders	Recoverable Cost
7	Database development	$16,625	$0	AFMA	Overhead
8	Program manager	$166,249	$83,125	AFMA	Recoverable Cost
9	IT data storage hardware	$22,000		AFMA	Recoverable Cost
10	IT data storage software	$1,600	$250	AFMA	Recoverable Cost
11	Resourcing - IT support	$28,099	$12,049	AFMA	Recoverable Cost
12	Analysis of EM data AFMA data entry	$165,274	$165,274	AFMA	Recoverable Cost
13	Control centre software lease	$19,800	$19,800	Concession holders	Concession holders
14	Analysis software lease	$10,395	$10,395	AFMA	Recoverable Cost
15	Health Statement	$23,760	$23,760	AFMA	Recoverable Cost
16	Ongoing independent audit (5% of analysis)		$8,264	AFMA	Recoverable Cost
Total		$1,178,564	$387,813		

1. **System Purchase Costs**

Same as option 2 but based on 40 vessels. Costs include shipping, GST and Customs clearance costs as at February 2011.

2. **Installation of equipment**

Considered – Industry responsibility as per option 2.

3. **Maintenance of equipment**

Same as option 2 but based on 40 vessels.

4. **Archipelago Marine Research training – as per option 2.**

5. **Hard drive purchase**

Same as option 2 but based on 40 vessels.

6. **Hard drive exchange - as per option 2.**

7. **Database development - as per option 2.**

8. **Program manager - as per option 2.**

9. IT data storage hardware - as per option 2.

10. IT data storage software - as per option 2.

11. Resourcing - IT support - as per option 2.

12. Data analysis and reporting
Same as option 2 but based on 40 vessels.

13. Electronic monitoring control centre software (EM Record™) – as per option 2.

14. Electronic monitoring analysis software - as per option 2.

15. Health Statement communication costs – as per option 2.

16. Ongoing program audit – as per option 2.

7.4.9 Option 3 Benefits

Not all of the benefits of adopting this option are quantifiable. Nevertheless it is possible to quantify some major cost savings and describe some of the non-quantifiable benefits. A summary of quantifiable benefits is provided in Table 28.

Table 28: Summary of quantifiable benefits of option 3.

	Annual saving
Observer cost savings (80% of total costs)	$587,520
VMS savings (polling costs for 40 vessels)	$17,856
Total quantifiable benefits	$605,376

Savings in observer costs
The easily quantifiable benefits of electronic monitoring are in the form of potential saved costs from reduced observer coverage. With 100% compulsory take up of electronic monitoring in a 40 boat fleet, it is anticipated that a level of observer coverage would still be required to record operational information, catch data and other activities not possible through electronic monitoring systems (e.g. biological information, tagging and gear trials). Complete saving in the current observer budget for the fishery equates to an annual saving of $605,376. As per option 2, an 80% saving (at $601,805) is anticipated following the integration of an electronic monitoring program. A further scale down of the observer program overtime will increase the cost savings from the observer program. An assessment of phasing down the observer program for this option is provided in Table 31.

As per option 2, reduced OH&S issues for observers particularly if the onboard observer program is phased down. While increased behavioural changes in terms of improved reporting by all of industry and more flexible management arrangements are applicable under option 3. Long term compliance cost savings and benefits are expected to be greater under a compulsory electronic monitoring model. Even though a mandatory program will provide a greater understanding and assessment of compliance risks, a compulsory model may raise equity issues in terms of program costs between full and part time operators in the fishery.

7.4.10 Option 3 Net benefits compared to the status quo

In nominal terms this option is expected to cost an average of $533,485 each year more than the base case with average benefits of $605,376 per year. This results in an overall net benefit (benefits less costs) of $718,915 over a 10 year period (Table 29). It is important to note that there are significant implementation costs in the first year and it takes several years to break even. In NPV terms (5% discount rate) this equates to a net benefit of $451,247 (Table 27).

It is also recognised that the non-quantifiable benefits previously described (as per option 2) will be realised in a compulsory program including reduced compliance risks and efficiency gains in the compliance program, reduced OH&S risks for observers and new management arrangements that provide flexibility and benefits to all operators.

Table 29: Option 3 nominal costs and benefits in 2010-11 for a 10 year period.

	Marginal costs	Marginal benefits		Total benefits	Net benefits
Year		Observer savings	VMS savings		
0	$1,178,564	$587,520	$17,856	$605,376	-$573,188
1	$387,813	$587,520	$17,856	$605,376	$217,563
2	$387,813	$587,520	$17,856	$605,376	$217,563
3	$409,813	$587,520	$17,856	$605,376	$195,563
4	$387,813	$587,520	$17,856	$605,376	$217,563
5	$1,009,780	$587,520	$17,856	$605,376	-$404,404
6	$387,813	$587,520	$17,856	$605,376	$217,563
7	$409,813	$587,520	$17,856	$605,376	$195,563
8	$387,813	$587,520	$17,856	$605,376	$217,563
9	$387,813	$587,520	$17,856	$605,376	$217,563
Total	$5,334,845	$5,875,200	$178,560	$6,053,760	$718,915

Table 30: Option 3 net present value assessment of costs and benefits for a 10 year period (discount rate 5%).

	Marginal costs	Marginal benefits		Total benefits	Net benefits
Year		Observer savings	VMS savings		
0	$1,178,564	$587,520	$17,856	$605,376	-$573,188
1	$369,345	$559,543	$17,006	$576,549	$207,203
2	$351,757	$532,898	$16,196	$549,094	$197,336
3	$354,011	$507,522	$15,425	$522,947	$168,935
4	$319,054	$483,354	$14,690	$498,044	$178,990
5	$791,189	$460,337	$13,991	$474,328	-$316,861
6	$289,392	$438,416	$13,324	$451,741	$162,349
7	$291,246	$417,539	$12,690	$430,229	$138,983
8	$262,487	$397,657	$12,086	$409,742	$147,256
9	$249,987	$378,721	$11,510	$390,231	$140,243
Total	$4,457,034	$4,763,507	$144,773	$4,908,281	$451,247

7.4.11 Sensitivity analysis

In this section estimates of costs, benefits and net benefits are estimated under different parameter values for some of the key variables such as fleet size, number of sets, analysis time etc. The purpose of this is to determine for which variables changes to parameter values are important and if preferred options change given changes to parameter values. This analysis shows that the net benefits of an electronic monitoring program are sensitive to effort (fleet size, sets) and level of observer coverage, electronic monitoring analysis and audit level and observer rates (Tables 31 & 32).

Table 31: Option 2 base model parameters and outputs of the sensitivity analysis for a range of electronic monitoring (EM) options.

Cost item	Options	Costs	Benefits	Net benefits
Fleet size	Base case 40	$3,772,050	$4,879,328	$1,107,278
	20	$2,402,081	$2,497,574	$95,493
	30	$3,087,066	$3,688,451	$601,385
	60	$5,142,018	$7,261,081	$2,119,063
Sets per month	Base case 15			
	10	$3,399,050	$3,291,492	-$107,558
	20	$4,145,049	$6,467,163	$2,322,114
Analysis time hrs/set	Base case 3.5			
	2.5	$3,452,336	$4,879,328	$1,426,992
	4.5	$4,091,764	$4,879,328	$787,564
EM analysis and audit level with equivalent observer coverage	Base case 10%			
	8.5%	$3,604,200	$4,879,328	$1,275,128
	15%	$4,331,549	$8,522,010	$4,190,461
	20%	$4,891,048	$11,324,073	$6,433,025
Observer savings %	Base case 80%			
	90%	$3,772,050	$5,474,766	$1,702,716
	100%	$3,772,050	$6,070,204	$2,298,155
Observer rates $/day	Base case $1200			
	1500	$3,772,050	$6,070,204	$2,298,155
	1000	$3,772,050	$4,085,410	$313,360
Phasing out observer program	80% years 1, 2; 90% year 3 & 100% years 4+	3,772,050	5,716,827	1,944,777
Maintenance costs $/yr	Base case $1,300			
	$1,000	$3,694,215	$4,879,328	$1,185,113
	$1,800	$3,901,775	$4,879,328	$977,553
Ongoing Program Co-ordinator EL1	Base case 0.5 FTE			
	0.25 FTE	$3,476,633	$4,879,328	$1,402,695
	1.0 FTE	$4,362,884	$4,879,328	$516,443
VMS removed saving/yr	Base case $14,285			
VMS remains saving/yr	0	$3,772,050	$4,763,507	$991,458
Health Statement	Base case $50/mth			
Health Statement increase	$60/mth	$3,802,872	$4,879,328	$1,076,455
Discount rate	Base case 5%			
	3%	$4,039,380	$5,287,524	$1,248,144
	7%	$3,537,752	$4,522,704	$984,953

Table 32: Option 3 base model parameters and outputs of the sensitivity analysis for a range of options.

Cost item	Options	Costs	Benefits	Net benefits
Fleet size	Base case 40	$4,457,034	$4,908,281	$451,247
	20	$2,744,573	$2,526,527	-$218,046
	30	$3,600,804	$3,717,404	$116,600
	60	$6,169,494	$7,290,034	$1,120,540
Sets per month	Base case 15			
	10	$3,990,785	$3,320,445	-$670,340
	20	$4,923,283	$6,496,116	$1,572,833
Analysis time hrs/set	Base case 3.5			
	2.5	$4,057,392	$4,908,281	$850,889
	4.5	$4,856,676	$4,908,281	$51,604
EM analysis and audit level with equivalent observer coverage	Base case 10%			
	8.5%	$4,247,222	$4,908,281	$661,059
	15%	$5,156,408	$8,550,963	$3,394,555
	20%	$5,855,782	$11,353,026	$5,497,244
Observer savings %	Base case 80%			
	90%	$4,457,034	$5,503,719	$1,046,685
	100%	$4,457,034	$6,099,158	$1,642,124
Observer rates $/day	Base case $1200			
	1500	$4,457,034	$6,099,158	$1,642,124
	1000	$4,457,034	$4,114,363	-$342,671
Phasing out observer program	80% years 1, 2; 90% year 3 & 100% years 4+	4,457,034	5,745,780	1,288,746
Maintenance costs $/yr	Base case $1,300			
	$1,000	$4,359,740	$4,908,281	$548,541
	$1,800	$4,619,190	$4,908,281	$289,090
Ongoing Program Co-ordinator EL1	Base case 0.5 FTE			
	0.25 FTE	$4,161,617	$4,908,281	$746,664
	1.0 FTE	$5,047,868	$4,908,281	-$139,588
VMS removed saving/yr	Base case $17,856			
VMS remains saving/yr	0	$4,457,034	$4,763,507	$306,473
Health Statement	Base case $50/mth			
Health Statement increase	$60/mth	$4,495,562	$4,908,281	$412,718
Discount rate	Base case 5%			
	3%	$4,772,651	$5,318,899	$546,249
	7%	$4,180,366	$4,549,541	$369,175

7.4.12 Cost benefit impacts of electronic monitoring on ETBF compliance

An assessment of electronic monitoring for monitoring compliance performance against current permit conditions and management arrangements was under taken during the trial (see Appendix 5) and the compliance benefits are summarised in section 5.4.5. Currently the compliance costs are not divided up by fishery and it is therefore very difficult to separate ETBF compliance costs from other Commonwealth fisheries. This is particularly so as compliance programs are, in the main, not fishery specific.

Nonetheless it may be valid to estimate the compliance costs of ETBF on the basis of the proportion (of the fleet) ETBF represents. Currently ETBF vessels constitute approximately 10% of the fleet and, on that basis, it could be argued would constitute 10% of the (2009-10) general deterrence budget of $2.1 million or approximately $210,000. However, it should be noted that estimating ETBF compliance costs on this basis does not take into account 'big ticket' items from other fisheries. For example every year a number of at sea patrols are undertaken in other fisheries at a cost of $300,000 – $400,000 (or approximately 14 -19% of the total budget).

Allocation of Compliance Budgets (all fisheries)
As outlined above compliance funds are not allocated on a fishery by fishery basis. Funds are combined and directed towards prioritised risks across all commonwealth fisheries. The budget for each year is determined on the basis of planned programs (and known patrols). These funds are then split nominally on the basis of 80% of funds to planned programs, 10% to risk based programs and 10% to 'reactive' programs. However, this split is constantly varied over the year with the expectation that as risk programs are developed and implemented the proportion of funding to risk programs would increase at the expense of "planned" programs.

Allocation of Compliance Budgets (ETBF)
If we were to apply the above split to the ETBF then we could assume that of the $210,000 for ETBF compliance costs, $21,000 is allocated to risk based programs. Further given that for 10/11 there are 7 risk based programs this means a nominal allocation of $3,000 per prioritised risk.

The remaining 90% ($189,000) would be allocated nominally to planned and re-active components and would, in the main, not be affected. However, electronic monitoring may result in an increase in offence detections leading to an increase in spending on the re-active component. Currently one of the prioritised risks is, in fact, an ETBF specific risk – being the risk associated with the *Seabird Threat Abatement Plan (TAP) for the Eastern Tuna and Billfish Fishery (ETBF).* It is recognised that this risk would be eliminated (or significantly reduced) as a result of electronic monitoring and would therefore not require treatment thereby possibly giving a nominal saving of $3000.

The remaining 6 risks are likely to remain in the fishery despite the presence of electronic monitoring. Further there are no cost savings with respect to these risks (even if they are reduced as a result of the electronic monitoring) as either:

- There are no ETBF specific programs (and costs) targeting these risks; or
- The programs (such as port inspections) and costs would remain to address other risks and/or compliance needs.

8 EXTENSION

The extension of information to stakeholders occurred throughout the course of the project. The importance of good extension of information particularly during the project planning and commencement of the field trial was critical to the success of the project. All of the research was conducted on industry vessels that willingly nominated to participate in the project. The extension commenced with an information paper and request for expression of interest to all ETBF concession holders. Following the selection of project participants, an industry project steering committee was arranged.

The industry project steering committee served as an appropriate forum to discuss project issues and results with those directly involved in the project. A formal Memorandum of Understanding and Code of Conduct was prepared and signed between AFMA and participants before commencement of the trial. This outlined obligations and established clear understandings relating to a number of data management and system operational matters. It also stated how compliance matters will be addressed during the trial whish was requested by industry members. Furthermore, the interest and awareness generated by the project (during the install phase) resulted in other crews and vessels in the ports discussing the project with the project team, AFMA observers and other crews involved in the project.

Parties associated with the project acknowledge that the direct involvement and participation by industry members assisted the success of the project regardless of the level of electronic monitoring equipment uptake by the fishery. However, the flow of communication from vessel owner passed on to vessel skipper and crew was noted to be an issue in some cases. It is essential for an ongoing program that the vessel's personnel learn as much as possible about the equipment to maintain system operational standards and to monitor, report and address equipment failures in a timely manner.

At the higher level input and support for the project was provided by the ETBF Resource Assessment Group (RAG) and Management Advisory Committee (MAC), both of which have representatives from research, management, environmental groups and the industry. In particular, during the planning stage the RAG reviewed the current roles of onboard observers and the data collected which helped design the image assessment protocols and sampling design for the project.

The adoption of this system by industry and the development and integration of an ongoing program meant that the practicalities and associated cost needed to be realised. The findings from the assessment of the applications of electronic monitoring systems and the cost-benefit analysis were the key considerations during the project. These results were presented to various stakeholder groups including a range of imagery obtained during the project. Overall, the responses to the quality and uses of the imagery were positive. Although Industry members raised a number of privacy concerns regarding the handling, access and storage of image data. These concerns are understood given the nature of commercial fishing operations and AFMA is considering data handling and storage protocols and policies to address concerns.

Other support has been from representatives from environmental groups (both government and non-government) involved in fisheries and marine resource management. These representatives noted that imagery presented shows an insight into longline fishing in the ETBF, the uses of seabird mitigation measures and protected species interactions. The concept and logbook audit design of an ongoing program was supported largely due to the increased abilities to ‘hold operators to account’ for reporting protected species interactions and monitoring the compliance performance of vessels.

9 BENEFITS AND ADOPTION

Responses from industry members and stakeholder groups have been positive in their support for using electronic monitoring technologies for onboard monitoring. This support is a result of the potential benefits associated with these systems in a clearly defined and structured program. The benefits include:

- an equivalent cost effective ‘at-sea’ monitoring alternative to ETBF fishing concession holders with potential long term savings
- a feedback loop to operators detailing the output of logbook audit reports (and consequences / penalties) will prompt onboard behavioural changes such as improved reporting of protected species interactions and uses of mitigation measures
- increased capacity to evaluate the accuracy of fisher logbook records providing confidence to stakeholders
- reducing the level of observer coverage has the additional benefit to AFMA of lowering the OH&S risks
- compliance risks in the fishery will be significantly reduced
- tailored management arrangements aligned to an electronic monitoring program are recognised to provide a range of fishing operational benefits to industry
- a sense amongst concession holders that electronic monitoring offers a more equitable solution of monitoring as some operators feel they have higher level of observer coverage than others.

The benefits and beneficiaries are similar to those in the original application. Industry and AFMA will directly benefit from this project and the further development and adoption of electronic monitoring through reduced management and business costs, improved relationships and greater stewardship of fisheries resources. Sectors of the fishing industry, government and community that will benefit include:

- Pelagic longline fishers
- AFMA – Tropical Tuna MAC and RAG
- Recreational and charter fishers
- DAFF – Sustainable Resource Management Division
- SEWPaC – Department of Sustainability, Environment, Water, Population and Communities
- AAD – Australian Antarctic Division
- NGOs – Humane Society International, World Wide Fund for Nature.

10 FURTHER DEVELOPMENT

To implement electronic monitoring in the ETBF and other Commonwealth fisheries a number of areas will require further developments in the near future, these include:

1. Development of new version of the control centre software by AMR to enable a user-friendly hard drive exchange.

2. Development and release of a new version of electronic monitoring data interpretation / analysis software by AMR.
3. Develop data handling and storage protocols including data use, lifecycle and archiving length and
4. Develop policies specifying data uses and release to address privacy concerns.
5. Training curriculum, requirements and testing of data analysts.
6. Development of the legislative framework including conditional requirement for the program including:
    a. System operational matters and specifications,
    b. Handling and the delivery of hard drives,
    c. Data processing, storage, access and released of information, and
    d. Enforcement regime and policy.
7. Decisions around details of the audit-based monitoring program (such as required reporting timelines, Fishing Log data evaluation, use of electronic monitoring vs. Fishing Log data in case of 'failed' audits, etc.)
8. Penalties described and legislated for data discrepancies between logbook and electronic monitoring data including communication and appeal process.
9. Development of a communication strategy and outreach program to support the information flow relating to the electronic monitoring program structure and operational requirements.
10. A further review of data needs in the ETBF will be required to determine the level of 'at-sea' observer coverage required in conjunction with an electronic monitoring program.
11. The design of a viable framework and risk assessment of installation and field maintenance services to industry including a management and response framework to deal with system problems, and
12. System design and development work to ensure data quality and integrity is maintained in the AFMA Observer Database.

The implementation of an AFMA co-ordinated electronic monitoring program will require a review and re-design of systems and business processes to administer the receipt and assessment of all 'at-sea' data collected (electronic monitoring, logbook, observer and VMS data). The system will be required to align all data collected to meet the information requirements of fishery managers, scientists and compliance officers for the management of the fishery.

As an electronic monitoring program evolves and more Commonwealth fisheries adopt these technologies further uses and access of electronic monitoring data are expected. For example, the development of presentation layers to provide data back to authorised stakeholders, such as concession holder access to electronic monitoring data via online secure portal will help streamline the reporting and program review process.

11 PLANNED OUTCOMES

The planned outcomes detailed in the projects application were:

- Determination of the efficiency of electronic monitoring for a number of fishery monitoring issues

- Development of an audit-based approach to electronic monitoring data analysis for evaluating fisher logbook data quality
- Determination of the costs and benefits of an electronic monitoring program.

This project has demonstrated the worth and usability of electronic monitoring for a number of onboard monitoring functions in the ETBF. Based on this study and electronic monitoring programs in Canadian fisheries, a logbook audit methodology and program structure is proposed. By randomly sampling electronic monitoring data for analysis to compare with fisher logbook data, ongoing feedback and communications to operators will improve the accuracy of fishery data and inputs in decision making processes.

This project has identified potential cost savings by adopting and integrating an electronic monitoring program in place of the current observer program. The Tropical Tuna MAC has acknowledged the benefits identified in this project and supported in the implementation of a voluntary program during 2010. A number of possible changes to rules and permit conditions have been considered by industry members. Support for the implementation of new rules that provide operational benefits to industry will be assisted by the adoption and success of an electronic monitoring program.

Furthermore, as the commercial fishing industry continues to face increased scrutiny into onboard fishing practices and impacts on the environment. Ongoing extensions of the results of this project will help build support for the integration and adoptions of these technologies for fisheries monitoring purposes.

12 CONCLUSION

This study produced valuable insights into the functionality and applications of electronic monitoring systems in the ETBF. On the whole, electronic monitoring systems worked well and it is likely that better performance could be expected from other vessels in the fleet using lessons learnt from this trial. Results have shown electronic monitoring systems can be used for a number of monitoring functions and the benefits of adopting a logbook auditing program are described. Information contained in this report was used by AFMA to agree to implement electronic monitoring in the ETBF on an ongoing basis.

12.1 APPLICATIONS OF ELECTRONIC MONITORING IN THE ETBF

A sample of 62 fishing events was used to base a comparison between electronic monitoring data analysis outcomes and observer catch data. The level of agreement between electronic monitoring image analysis results and observer catch estimates was good with a 70.7% match at species level. Observer and electronic monitoring total piece counts were very close for retained catch, while significant differences were found with the released catch. The higher level of agreement between observers and electronic monitoring retained catch was due to catch coming aboard in clear view of the cameras.

In terms of species identification, AMR's image reviewers distinguished fewer catch categories and used more general species groupings than observer records and AFMA observer image analysis results. Misidentifications also occurred with species in the same group (i.e. Tunas), partly due to data analysts and reviewers lacking experience with ETBF species catch compositions.

Electronic monitoring image reviewers recorded a number of interactions with protected species during this study (5 turtles and 3 seabirds). These interactions were all incidentally captured species during fishing and animals were either released alive, dead or retained for necropsy. Bringing the captured seabirds and turtles in clear view of the camera and showing the crew handling the species and removing the hook made these recognisable events in the electronic monitoring imagery. Working with the crew to develop and apply a standardised approach to handling catch, will help ensure catch and events are detected from the image data.

In this study, hook removal and disentangling for the majority of interactions took place in the camera view, making it possible to determine hooking location and life status. The level of activity during this procedure and upon release also provided an indication of release condition. However, in comparison to onboard observers, there are obvious limitations assessing the extent of injury and survivability of captured protected species from electronic monitoring imagery. To help detect interactions and assess life status clear onboard handling practices need to be defined (handled in clear view of the camera) and complied with by crew for onboard cameras to be a feasible replacement for monitoring protected species interactions.

These outcomes and other assessments during the project have shown electronic monitoring can perform a number of functions including (but not limited to):

- Identify fishing events (e.g. line deployment and retrieval) and the location where those events took place
- Determine the catch compositions and number of fish in longline catch
- Determine catch utilisation either retained or released
- Determine deployment of seabird mitigation measures (tori-lines)
- Detect and identify protected interactions including the life status of captures.

Audit and scoring methodologies are considered to enable fishers' logbook data to be validated by comparing random portions with electronic monitoring interpreted data. The structure of the proposed audit program is a series of steps that include collecting data, evaluating data, and providing feedback. Each stage of the program involves both fishers and managers, so that communication is ongoing.

The process begins with the operator completing a fishing trip, recording catch in the fishing logbook, and using electronic monitoring equipment to collect data. Both the analysed electronic monitoring data and the fishing logbook data sets would then be used for processing, auditing and scoring the trip/s. Based on previous electronic monitoring program experiences, the feedback loop is integral in ensuring success of the program demonstrating that fisher logbooks can become a reliable source of data with appropriate checks and feedback loops.

12.2 SYSTEM INSTALL AND PERFORMANCE

Electronic monitoring systems functioned and operated successfully during the trial. For example, nine of the ten vessels had very high levels of sensor data completeness with most trips having over 99% and an overall average of 96.9%, indicating that the data set was nearly complete for the entire study period. Imagery data completeness for sets was 89.8% while completeness for hauls was 81.4%. The *FV Esbjorn* experienced an incomplete install mid trial and system problems were unable to be detected via the systems Health Statement and serviced in a timely manner. This resulted in considerably lower data collection success compared to other vessels and was the cause for the significant drop in percentages of data completeness.

The majority of system performance issues were defined as being either installation or service related whereby problems reported with incorrect equipment installation and many issues not identified and corrected during servicing. As such, simple problems compound over multiple trips creating larger data deficiencies. Most of the problems seen in this project lie with the peripheral components; a number of recommendations are made to improve performance including image quality and usability.

In an ongoing program, vessel personnel will be required to learn more about the operation of the equipment to detect and report equipment failures. The priority toward resolving issues needs to be elevated such that problems are resolved in a timely fashion and fishing vessels are not at sea with inoperable electronic monitoring systems. The installation program must be set up with adequately trained and resourced technicians using pre defined quality assurance procedures.

12.3 COST BENEFIT ANALYSIS

Voluntary and compulsory electronic monitoring programs were examined in terms of costs and benefits. The most easily quantifiable expected benefit from electronic monitoring is in the form of cost savings through reduced observer coverage.

In comparison with the current observer program a voluntary program based on a fleet of 40 boats and an 80% uptake rate (32 participating vessels) results in an overall cost decrease of about $150,237 each year and a decrease of approximately $1.1 million over a 10 year period (NPV). Whereas a compulsory program results in an overall cost decrease of about $71,892 each year and a decrease of $451,247 over a 10 year period (NPV). Changes to parameter values in each model shows that the net benefits of an electronic monitoring program are sensitive to effort (fleet size, sets) and level of observer coverage, electronic monitoring analysis and audit level and observer rates.

Other benefits from electronic monitoring include improved scientific information and the potential for behaviour change (e.g. improved logbook reporting). There are further benefits available from electronic monitoring if other management practices are changed. For example, fisher behaviour change would be greater if electronic monitoring were also used for compliance purposes. Also, more restrictive management tools could be removed in favour of more outcome focused methods.

As electronic monitoring provides a greater capacity for assessing the compliance performance of each vessel, it is expected that a number of compliance risks in the fishery will be reduced. However, under a dual model (voluntary program with 80% uptake) consisting of both observers and electronic monitoring the reduction in risk ratings and hence long term cost savings, efficiency gains and benefits are likely to be less than a compulsory electronic monitoring model.

12.4 ELECTRONIC MONITORING PROGRAM DEVELOPMENT AND INTEGRATION

At the time this project was undertaken and results became available to industry, the ETBF was experiencing a declining fishing fleet due to difficult financial times. This was largely due to an operating environment of increasing costs and variable catch rates. In addition, the ETBF is reliant on a successful export market and the dynamic nature of exchange rates has obvious impacts on returns. As such, the recent high Australian dollar has limited access and profits from overseas markets.

The financial benefit of electronic monitoring to individual fishers depends heavily on the fishing effort of their boats and the set-up of their fishing operations. Concession holders who have a relatively low fishing effort and a low observer requirement for each year may find it more cost effective to continue to pay a daily rate for observers than to install an electronic monitoring system. The incentive to move to electronic monitoring in a particular fishery is highly dependant on the data needs of that fishery, so while electronic monitoring may provide substantial savings for many operators in a fishery, the relationship between the cost and benefits of electronic monitoring are expected to inhibit its uptake by all operators on a voluntary basis.

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13 APPENDIX 1: INTELLECTUAL PROPERTY

The intellectual property associated with this project includes the software leased from Archipelago Marine Research Ltd. including control centre (EM Record™) and data analysis / interpretation software.

14 APPENDIX 2: STAFF

Name	Organisation	Project Involvement
Matthew Piasente	AFMA	Principle Investigator
Bob Stanley	AFMA	Co-investigator
Trent Timmiss	AFMA	ETBF Manager
Steve Hall	AFMA	AFMA Observer Program and Field technician
Howard McElderry	AMR	Project lead
Morgan Dyas	AMR	Field Manager
Maria Jose Pria	AMR	Data Manager
Jessica Schrader	AMR	Data Analyst
Coral Taylor	AMR	Data Analyst
Adam Batty	AMR	Data Analyst
Karl Flower	AMR	Data Analyst

15 APPENDIX 3: SYSTEM SPECIFICATIONS

Control Centre

Dimensions	8” x 8” x 13” (20 x 20 x 31 cm)
Weight	11 lbs, 5.2 kg
Chassis/Container	Welded Aluminium (splash-proof)
Video Storage	Removable hard disk up to 500 Gigabytes
Recording Time	Configuration dependent, up to 1000 hrs
Recording Channels	4
Video Resolution	VGA (640-480 pixels)
Video Compression	Windows or DivX
Frame Rate (fps)	Up to 30 total
Operating System	Microsoft Windows XP Embedded on Solid State Disk
Operating Software	Autonomous at-sea execution, user configurable recording operations according to sensor input events

Power Specifications

DC Power	12 to 16 VDC
AC Power (adaptor)	90 to 240 VAC
Operating Current	6 Amps
Protection	20 Amp fuse, Battery deep discharge prevention
Protection	Low current (20 mA) Sleep Mode

Available Sensors and Options

GPS, Radio Frequency ID Tag, pressure, rotation, acoustic receiver, contact closure, power supply monitor, and Iridium satellite modem (ship to shore).

Standard Camera

Housing	Powder coated cast aluminium, sealed to IP66
Power	12 VDC
Resolution	480 TV lines, analogue NTSC signal
Lenses	2.9 (fisheye) to 16 mm (telephoto)
Light rating	1 – Lux
Aiming	Fixed aim, internally adjustable for Pan, Tilt, and Rotation.

16 APPENDIX 4: DATA ANALYSIS COSTS AND SERVICE PROVIDERS

Summary

The purpose of this assessment was to compare the costs and quality of analysis between different analyser groups and determine which option is the most cost effective for an ongoing electronic monitoring program in the ETBF.

The results of this review support the assertion that given sufficient training, staff such as casual university students or AFMA data entry staff can provide electronic monitoring data analysis outcomes that are comparable with experienced observers. However, there are some significant qualifiers that must be placed on this claim. Principally there are some species identification issues for smaller SBT and Bigeye Tuna that exist for experienced observers as well as other analysts.

Species identification for other key commercial species is generally very good but for bycatch species there is significant risk that electronic monitoring will underestimate the quantity of some bycatch species. Furthermore, some analysts may not be as good at species identification and the training program will need to have some form of screening process.

In terms of analysis costs, analysts such as university students are not dissimilar to that of AFMA data entry (D&S Datafix) staff and 10% less than observers. On a cost per set basis university student's work out at \$224.99, AFMA data entry staff cost \$229.53 and observers \$258.68.

Training costs for new staff, in particular university students or data entry staff would be higher than observers. However, given the demonstrated learning curve, ongoing data entry employees are likely to be the most cost effective option to provide data analysis and reporting services in the long term.

Methods

Four options for video analysis were selected based on consideration of availability, experience and cost. The options compared were;

- Contracting analysis to Archipelago Marine Research Ltd. (AMR)
- Conducting analysis in-house using AFMA data entry staff (D&S Datafix)
- Conducting analysis in-house using AFMA observers
- Conducting analysis in-house using casual university students.

Each group of analysts were given the same footage from a 21 set sample in the ETBF captured in October/November 2009. Video analysis was conducted using AMR software developed for similar electronic monitoring programs overseas.

For each of the 21 sample sets, a human observer was onboard the vessel and logbook and Catch Disposal Record (CDR) data is available.

Data observed and recorded

Each analyser viewed 21 sets and recorded:

- Piece counts – number of species retained / discarded by species
- Fishing operation details – setting / hauling time position
- Fishing gear details – Seabird mitigation during setting & number of hooks (number of hooks b/n bubbles x no. bubbles)
- Seabird abundance and behaviour – during setting (for comparisons with observer data)
- Threatened, endangered and protected species interactions
- Issues of non compliance.

Comparisons

Due to time differences between the onboard observer recording catch coming off the longlines and catch recorded in real time by the cameras, it was not possible to directly compare each fish identified by the onboard observer to the video analysts. Instead one experienced observer was selected to review all footage from the 21 sets to establish a benchmark to which the results of the other analysts could be compared. The other analysts included 3 university students, 1 member of the data entry team and the AMR data analyst.

Comparison of total number of fish and species identification per set between onboard observer, logbook, CDRs and the experienced observers analysis results to confirm wether using the observer's results as a benchmark, is a valid assumption.

A scoring mechanism was developed to compare the 4 analysts' results (3 students & 1 data entry analyst) to the benchmark (observers' results). This involved distinguishing between correctly identifying the event when a fish was caught on the longline and correctly identifying the species of that fish. A correct identification of both the event and the species was awarded 2 points, incorrect identification of the fish but correct identification of the even was awarded 1 point and failing to identify either the fish or the vent was awarded 0 points. This scoring method was not applied to the results from AMR.

Results for each analyst were tallied and compared by species to detect key identification issues and by set to determine potential learning curves.

The time taken for each analyst was recorded. These times were then used to estimate a cost per set for each type of analyser based on their hourly rate including overheads. These figures were used to identify the most cost effective option.

Results

Comparison of onboard observer to observer analysis of video footage

Onboard observer data on total fish recorded for each species aligns very well with electronic monitoring counts identified by the experienced observer for key commercial species (Table 33) and byproduct species (Table 34). The one exception to this is for Southern Bluefin Tuna (SBT) with the experienced observer recording fewer of these than were reported in the logbooks, CDR and by the onboard observer. Small SBT are particularly challenging to distinguish between Bigeye Tuna and Albacore. From these numbers it is most likely that 2 of the six undercounted SBT were mistaken for Bigeye Tuna and four of the smaller SBT were identified as albacore.

Table 33: Comparison of species ID and catches of key commercial species recorded by Logbooks (Flog), Catch Disposal Records (CDR), onboard observers (Obs) and electronic monitoring analysts; AFMA observer (EM Obs) and AMR.

	Retained					**Released**			
Key commercial species	FLog	CDR	Obs	EM Obs	AMR	FLog	Obs	EM Obs	AMR
Albacore	153	140	152	162	128	4	6	7	1
Bigeye tuna	8	8	8	10	6	0	1	0	0
Skipjack Tuna	4	4	4	0	1	0	0	1	0
Southern Bluefin Tuna	14	n/a	14	8	3	4	4	0	0
Striped Marlin	16	18	19	17	19	1	0	1	1
Swordfish	89	91	92	92	95	3	0	3	1
Yellowfin Tuna	64	66	65	66	65	2	5	0	1
Tuna (Mixed)	0	0	0	0	41				6
Short bill spearfish	0	3	3	3	3	0	0	1	0
Total	348	330	357	358	361	14	16	13	10

Table 34: Comparison of species ID and catches of byproduct species recorded by Logbooks (Flog), Catch Disposal Records (CDR), onboard observers (Obs) and electronic monitoring analysts; AFMA observer (EM Obs) and AMR.

	Retained					**Released***			
Byproduct species	FLog	CDR	Obs	EM Obs	AMR	FLog	Obs	EM Obs	AMR
Shortfin Mako	5	4	5	5	2	1	2	1	2
Escolar/Rudderfish	69	74	80	75	76	1	5	4	0
Mahi Mahi	37	39	54	56	57	0	7	3	1
Wahoo	15	13	13	14	11	0	0	0	0
Moonfish (mixed)/Opah	5	7	7	6	8	1	1	0	0
Ray's Bream/Atlantic pomfret	6	9	8	3	6	1	0	0	0
Gemfish	1	0	2	0	0	0	0	0	0
Oilfish	0	5	2	0	0	0	0	0	0
Total	138	151	171	159	160	4	15	8	3

Generally some of the smaller species such as Rays Bream were more difficult to pick up from the video footage and identifying total numbers for bycatch species (Table 35) was not always consistent with the onboard observer. However, overall most bycatch species were identified but for Blue Shark and Lancetfish, considerable numbers were missed. For many of these it could be because they are cut free from the lines out of the field of view.

Overall the experienced observer analysing video footage did very well with species identifications and provides a logical benchmark to which the other analysts can be compared.

Comparison of AFMA observer analysis of video footage and AMR

Comparing the results between the AFMA observer and AMR viewer show strong matches of total piece counts between key commercial species and byproduct species for the sets viewed. The main reporting difference occurs at the species identification level. AMR analysts reported more species groups compared to the AFMA observer, for example 41 species reported as Tuna (Mixed) (see Tables 35 and 36). The use of more general species groupings by AMR analysts can be largely attributed to the lack of experience with ETBF catch compositions.

Table 35: Comparison of species ID and catches of bycatch species recorded by Logbooks(Flog), Catch Disposal Records (CDR), onboard observers (Obs) and electronic monitoring analysts; AFMA observer (EM Obs) and AMR.

	Retained					**Released***			
Bycatch species	FLog	CDR	Obs	EM Obs	AMR	FLog	Obs	EM Obs	AMR
Lancetfishes	50	0	0	0	0	218	269	77	102
Blue Shark	0	0	0	0	0	29	33	15	0
Ocean Sunfish	0	0	0	0	0	3	8	4	1
Oceanic Whitetip Shark	0	0	0	0	0	2	4	1	0
Silky Shark	0	0	0	0	0	2	2	2	1
Skates and rays	0	0	0	0	0	2	1	1	2
Snake Mackerel	0	0	0	0	0	2	8	1	0
Southern Ribbonfish	0	0	0	0	0	2	0	0	0
Thresher Shark	0	0	0	0	0	1	5	1	0
Dealfish	0	0	0	0	0	0	2	3	1
Great barracuda	0	0	0	0	0	0	2	2	2
Tiger shark	0	0	0	0	0	0	2	0	0
Whaler shark	0	0	0	0	3	0	0	1	8
Sharks (mixed)	0	0	0	0	0	0	0	0	5
Unknown	0	0	0	1	8	0	10	43	5
Total	50	0	0	1	11	261	346	151	127

Comparison of other analysts to experienced observer

Set Comparisons

All the university students (Analysts 1-3) and the one member of the data entry team (Analyst 4) showed a distinct learning curve over the first ten sets with species identification improving with experience (Figure 25). However, there was a slight dip around set 12 after which 3 of the 4 analysts continued to improve identification skills, performing very well over the last five sets and scoring very close to the experienced observer.

Analyst 2 was the exception to this trend and scored quite low for the latter half of the sets. More detailed analysis of this revealed that they were consistently misidentifying Broadbill Swordfish as marlin and in Swordfish rich sets this heavily dragged down the results. In addition to this error they generally scored lower than the other analysts for most sets.

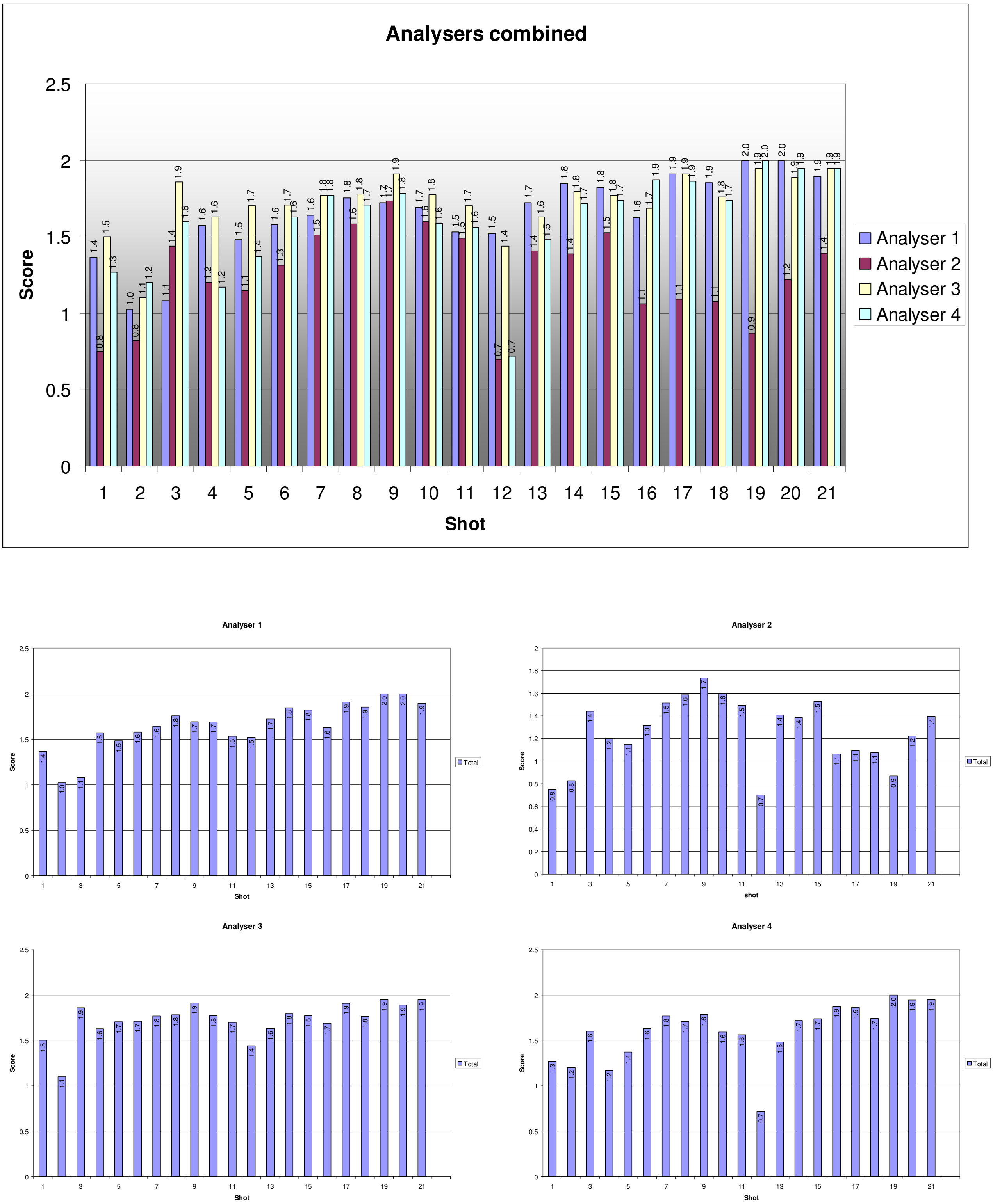

Figure 25: Combined and individual results of analyser scores relative to the experienced observer's analysis of video footage.

Species comparison

Across all species there was considerable variation in species identification scores. Scores for some species seem quite low (Figure 26), however, these scores do not take into account the learning curve and are amplified by low sample size.

For key commercial species the scores were generally very good for Albacore, Broadbill Swordfish, Skipjack Tuna, Striped Marlin and Yellowfin Tuna (Figure 27). Results of Shortbill Spearfish were inconsistent and arranged from a perfect score to quite low. Scores for big eye tuna and SBT were consistently the lowest for key commercial species which is not surprising given the challenge in correctly distinguishing between the two species. Furthermore the experienced observer undercounted the correct number of SBT which could influence the accuracy of these scores.

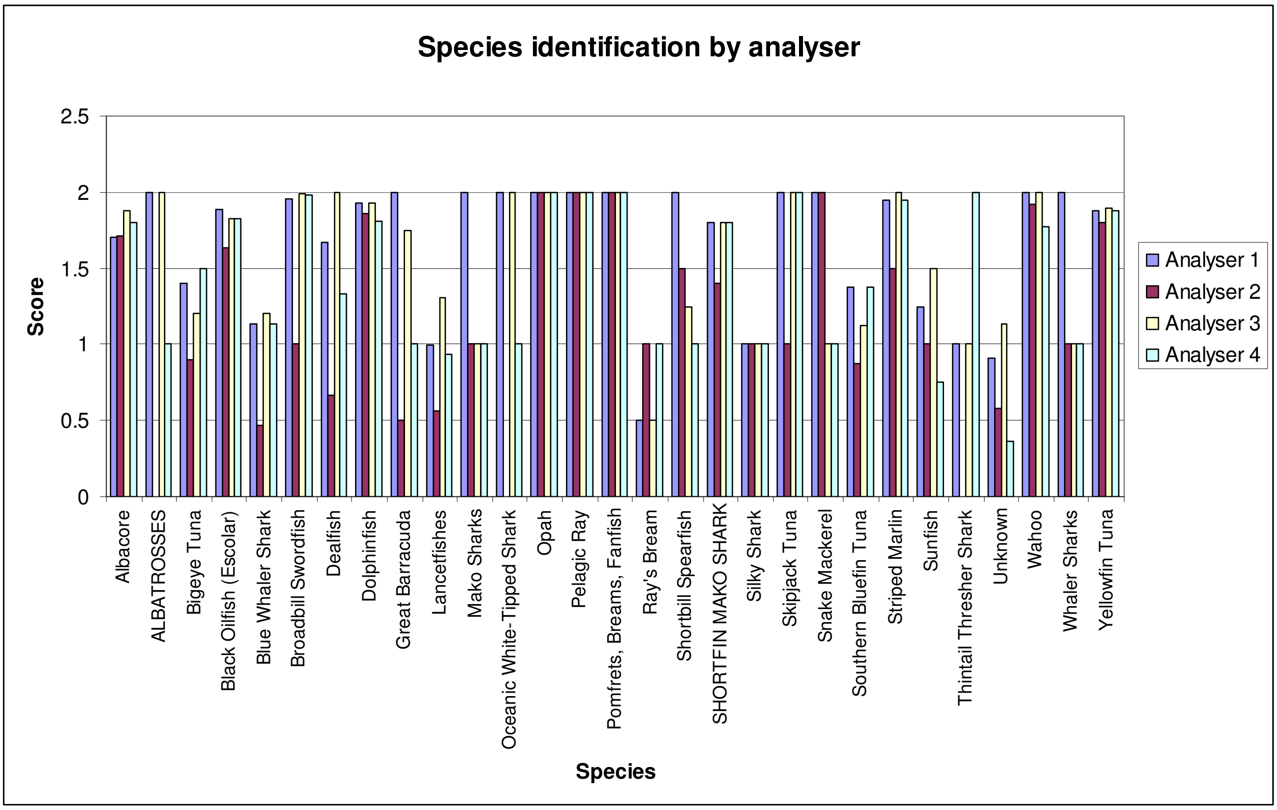

Figure 26: Species identification scores for all species and for each analyser.

Scores for bycatch species were mixed with some achieving consistently good scores and others consistently poor (Figure 28). Generally the species that received good scores and that do not pose identification issues are Escolar, Dealfish, Dolphinfish, Opah, Pelagic Rays, Pomfrets, Shortfin Mako Sharks, Sunfish and Wahoo. The poorest scored species were Thresher Sharks, Rays Bream, Oceanic Whitetip, Lancetfish and Blue Whaler Sharks. For many of these species the experienced observer had issues in detecting and identifying these as well and the major discrepancies are most likely due to difficulties in picking up the event if the fish were cut free.

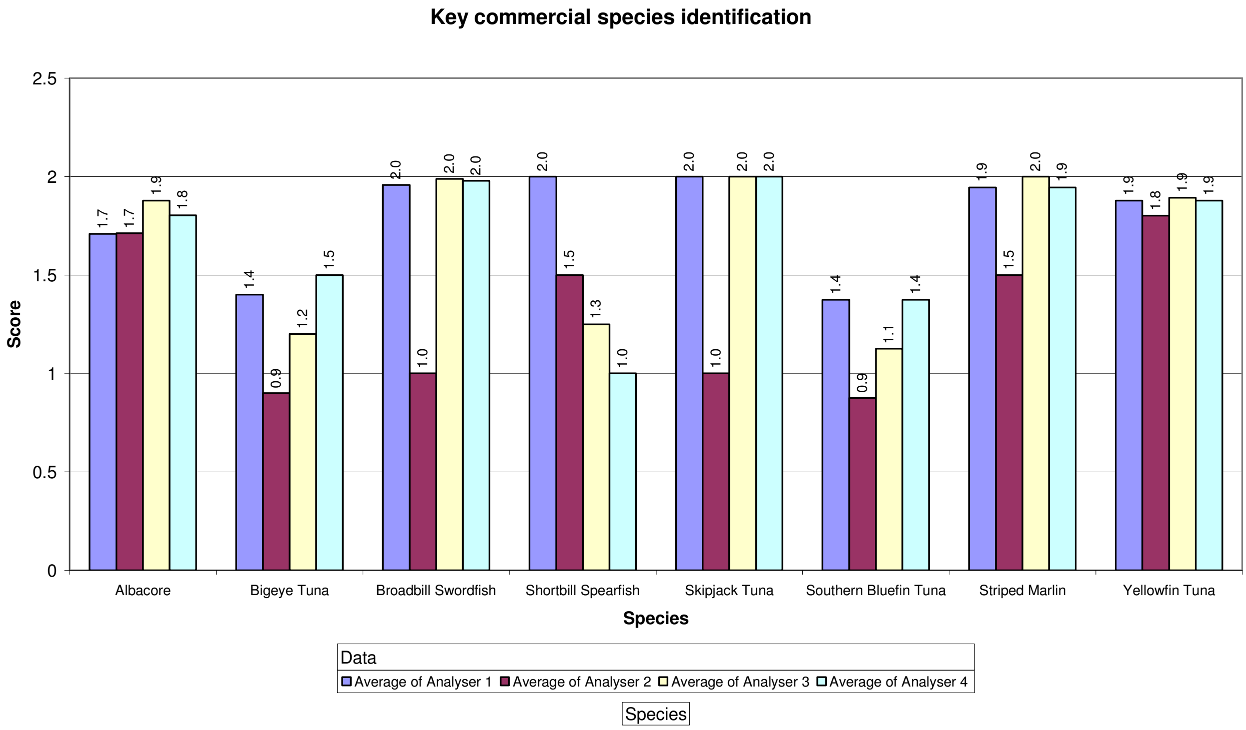

Figure 27: Species identification scores for commercial species by analyst.

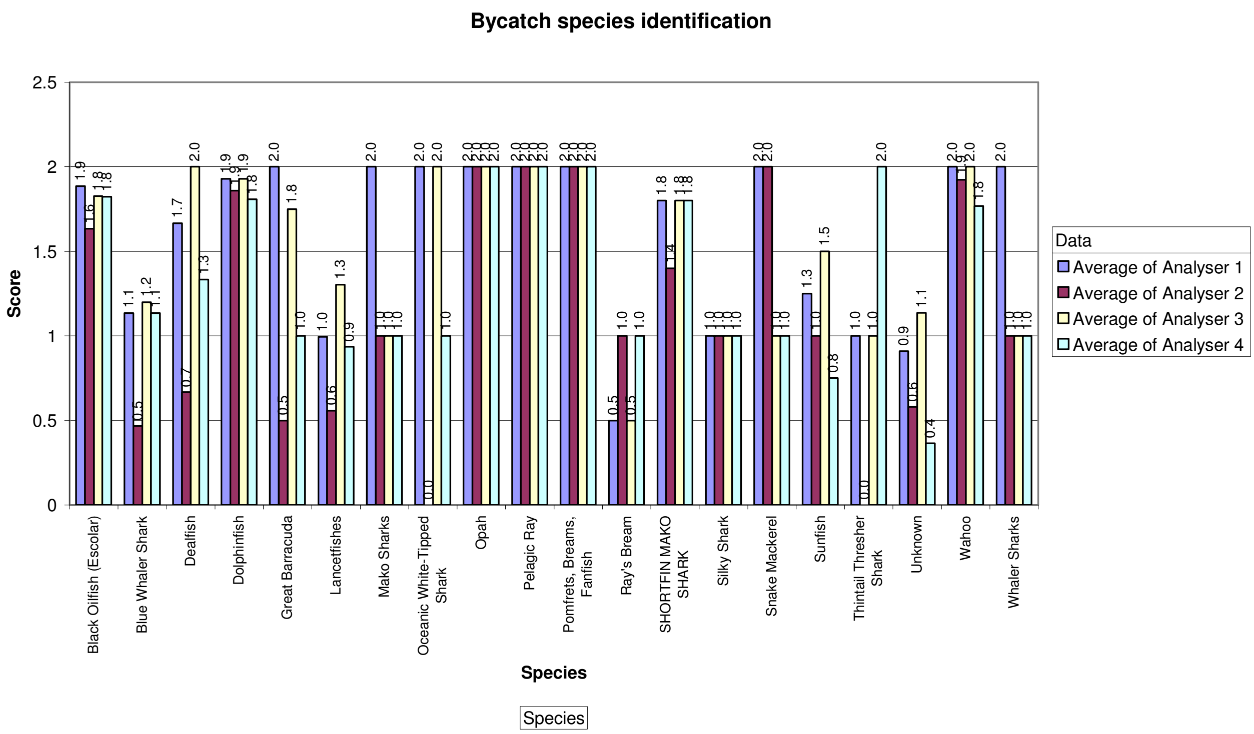

Figure 28: Species identification scores for bycatch species by analyst.

Conclusions and costs

The greatest challenge in analysing video footage is to correctly identify each fish. Initial analysis of the 21 set sampled by an experienced observer matched the onboard observer generally very well but raised a couple of key issues. Firstly identification of smaller SBT from video footage is difficult and of the 14 SBT caught across the 21 sets, the observer identified 8 from the video footage. It is most likely the SBT missed were smaller SBT that were mistaken for Bigeye or Albacore.

The second issue was the ability of the observer to record bycatch species such as Blue Shark and Lancetfish. It is likely these species were undercounted due to fish being cut free from the lines or released without coming onboard out of the field of view.

All analysts were able to record events well and showed a general learning curve for species identification with scores increasing consistently up to set 10. However, scores did not continue to increase for analyser 2 who showed poor scores due to consistently mistaking Broadbill Swordfish for Marlin. Such errors can be corrected in training if analysts are provided feedback throughout the training.

Analysts 1, 3 and 4 showed continued improvement after set 10 and by the final sets were receiving scores close to the observer benchmark. This demonstrates that either both the university students and AFMA date entry staff are capable of achieving identifications close to an experienced observer provided they have a sound training program.

Training

Overall, comparisons between the benchmark set by the experienced observer and analysis by university students and data entry staff demonstrates a strong learning curve over a period of around 20 sets. Through analysing about 20 sets analysts with little or no experience in fish identification are capable of learning the required skills and performing nearly as well as an experienced observer.

A one week training program for all new analysts involving analysis of 20 sets would be sufficient time to perfect the learning curve, provided there is close monitoring and real time feedback provided through out. This would help to avoid consistent identification errors as identified for analyser 2. If this option were adopted there would need to be a formal standard established to identify anyone with consistently poor identification results and preclude them from further work if they cannot reach this standard over the course of the one week training program.

During a training period it would be beneficial to provide analysts with electronic monitoring images of each key species to assist with the identification. Some of the analysts pointed out in their final assessment that it was initially difficult to use just the identification cards provided as they didn't provide any useful guides or examples specific to identification from electronic monitoring footage. The experienced observer who reviewed all the footage also stated that there are a few techniques you can use to assist with identification of fish species form video footage. It would be beneficial to incorporate such information into the training program.

Costs
Training costs for university students and data entry staff are calculated based on a standard 37 hour training week with university students rates based on employment at APS 2.0 and Data fix staff current contracted hourly rate. Overheads are included within the analysis to estimate total real cost and allow direct comparison calculations of onboard observer coast that include overheads (Table 36).

Table 36: Training costs for university students, AFMA data entry and observers.

Analyst	Hours	Hourly rate with overheads	Total including overheads
Uni student - APS 2 mid point	37	$53.57	$1,982.09
AFMA data entry - D&S Datafix	37	$54.65*	$2,022.05
AFMA observer - APS 4 mid point	15	$61.59	$923.85

*Includes oncosts, all AFMA overhead A and half AFMA overheads B and C.

It is unlikely that experienced observers would need a full week of training and 2 days of training to familiarise them with the video software would be adequate. Observer costs provided here are based on a standard APS 4 with overheads. It is likely that university students would be employed as casual staff incurring higher hourly rates. In this case higher rates for casual staff would be balanced by reduced overheads and total costs would not be too dissimilar to an ongoing employee.

Table 37: Cost per set for different analysts based on 3.5 hours per set.

Analyst	Hourly rate with overheads	Rate per set	Rate per set plus 20%
Uni student - APS 2 mid point	$53.57	$187.50	$224.99
AFMA data entry - D&S Datafix	$54.65*	$191.28	$229.53
AFMA observer - APS 4 mid point	$61.59	$215.57	$258.68

*Includes oncosts, all AFMA overhead A and half AFMA overheads B and C.

Overall training costs of observers are significantly less than university students and AFMA data entry staff (~50% less). However, since most observers are based outside of Canberra there would likely be additional costs associated with travel that are not factored here.

Based on the average time of 3.5 hours to analyse one set, the rates between a university student and AFMA data entry are very similar with a $4 difference (Table 37). In extrapolating total costs across multiple sets an additional 20% is added to costs per set to account for other data management and reporting tasks.

Whilst the analysis here utilised university students one could equally employ other casual staff at the same costs to get the job done. It is possible that over time the average analysis time per set could be less than the times provided here. This is because we haven't taken into account the learning curve in the estimates of average time. However, that relies on the assumption that analysis times will increase with more experience at identifying fish. Since the experienced observer who analysed the same sets took longer than the uni students this may not be the case.

Conclusion

The results of this review support the assertion that given sufficient training, casual staff such as university students or AFMA data entry with limited onboard fishing experience can provide electronic monitoring data analysis that is on par with experienced observers. However, there are some significant qualifiers that must be placed on this claim. Principally there are some species identification issues for smaller SBT and Bigeye Tuna that exist for experienced observers as well as other analysts.

Species identification for other key commercial species is generally very good but for bycatch species there is significant risk that electronic monitoring will underestimate the quantity of key bycatch species. Furthermore some analysts may not be as good at species identification and the training program will need to have some form of screening and testing process.

In terms of analysis costs, analysts such as university students are not dissimilar to that of AFMA data entry (D&S Datafix) staff and 10% less than observers. On a cost per set basis university student's work out at $224.99, AFMA data entry staff cost $229.53 and observers $258.68. In an ongoing program, turn-over rates of casual university students are expected to be higher resulting in increased training and recruitment costs compared to ongoing data entry staff or observers. It is also anticipated that efficiency gains and transitional costs are expected to be less and more streamlined combining AFMA data entry with other electronic monitoring program services (e.g. Health Statement monitoring). In this case, AFMA data entry staff contracted to undertake data analysis and reporting services are recommended to be the most cost effective long term option for an ongoing electronic monitoring program.

17 APPENDIX 5: ASSESSMENT OF ELECTRONIC MONITORING FOR COMPLIANCE MONITORING

The following report details the outcomes of an assessment by AFMA compliance officers viewing imagery obtained from the ETBF trial for monitoring compliance performance against current permit conditions and management arrangements. Imagery viewed included:

- *Bianca B - 24/11/09 thru till 29/11/09*
- *Jordan Kate - 17/10/09 thru till 18/10/09*
- *Ocean Myst - 23/10/09 thru till 26/10/09*
- *Samurai - 03/11/09 thru till 5/11/09*
- *Interactions with protected species*

Non-Frozen Baits are attached to the hooks
Dependant on the angle of the camera and where the bait is laid out to thaw, it can generally be observed (towards the start of a set) if the crew have complied with permit conditions. Cameras that have been set up on the forward wheelhouse (West coaster design vessels) appear to generally show bait being laid out to thaw. However, vessels with aft wheelhouses such as the *FV Jordan Kate* had no camera vision of compliance value to asses this permit condition or to adequately review the actions of the crew during setting.

Prior to longlines entering the water he/she deploys a separate tori-line at each point at which hooks enter the water
Dependant on the angle of the camera it was quite easy to observe compliance to the permit conditions. It was difficult to ascertain any real length requirements however it was possible to observe if the streamers are uniformly arranged and if the tori-line afforded protection to that area where baited hooks were cast.

Longlines are weighted with either a minimum of; a) 60 gram swivels at a distance of no more than 3.5metres from the hook; or b) 96 gram swivels at a distance of no more than 4 metres from each hook.
It was difficult to estimate the weight of a swivel based on the camera footage. The distance from the hook can be 'best guesstimated' reasonably accurately from the vision. A possible solution to this is by making it a requirement to colour either the 60 or 90gram swivels/and or tubing (used to join the line to the swivel) making them easily identifiable.

No discharge while hauling (except on small boats). If discharging during hauling, it must be on the opposite side of the boat.
From the observed footage and with the exception of the *FV Jordan Kate* (poor camera angle), all vessels were observed to be discharging during hauling, hence you can observe non-compliance with this permit condition well. Generally provided the camera was over the processing area and supporting cameras (i.e. near the door) you can observe non- compliance to this permit condition very well.

Fishing in Area E - No more than 500 made up hooks in total are carried on the boat or are attached to any snoods, branchlines, lines and/or clips at any time whether they are on the boat or in the water.
This would be an easy task to observe if the cameras were at their optimum angle. However it would generally be easier to count from observations during the hauling

sequence. From a compliance point of view and personal experience, it would be difficult to believe that a commercial longline vessel would only have 500 made up hooks in total on board. Over this 500 hook limit would be easy to observe on hauling from the footage observed. The vessel may only show 500 hooks being set and hauled from the footage however it would be impossible to know if their were more than 500 hooks onboard based on the footage.

Landing requirements for sharks –must be landed with their fins still attached to their carcass
All observed shark captures (landed – not released) were landed with their fins attached to their carcass. From the footage it appears that there are a few 'black spots' away from camera view. There is the opportunity to remove shark fins from a shark and remain out of camera view. Given the extent of crew activity on vessels during the haul, it would need to be a very premeditated event for this to occur, and hence a possible, but unlikely compliance risk.

Limited to 20 sharks per trip, excluding Gummy, School, Saw shark and Elephant fish of which a combined total of 5 may be taken.
None of the footage observed highlighted any vessel nearing the 20 landed shark limit. From the footage observed the cameras provided an excellent observation tool to compliance of this permit condition.

Operators are prohibited to use wire traces
It was possible to observe this in most instances on setting; however it was much easier to ascertain this on hauling the set.

Bycatch limits e.g.: Qld limitations 20 Wahoo 10 Spanish Mackerel, Blue and Black Marlin, Northern Waters Albacore Trip limit 200
Observations from the footage indicate an excellent tool in monitoring compliance behaviour based on bycatch limits. It was very easy to observe the majority of fish landed and to monitor trip / bycatch limits. It should be noted that such limits are trip limits and not set limits, as such there would need to be all of trip analysis undertaken if this requirement is to be fully monitored.

Protected species handling
From the footage observed of protected interactions with a Turtle and Seabird the crews did normally behave in a manner as recommended maximising the survival chances of the released species. It must be noted that there is 'black spot' the aft quarter between tuna door and transom with no camera view or very limited view. Observers have sometimes noted crew 'drop a clip' such that a dead seabird is missed by the observer, this can potentially be missed by the cameras. Suggested best practice to any viewings of footage would be to watch for and note dropped clips on hauling.

Landing requirements for Tuna - must not allow the removal of caudal keel or any dorsal, pectoral or anal fin of any Billfish excluding Broadbill Swordfish
This particular ETBF Permit Condition reads as only broadbill swordfish may have the removal of caudal keel, any dorsal, pectoral or anal fin. From observing the footage it was common practice on some of the vessels to indeed remove certain fins from (in particular) marlin. Provided the camera was covering the processing area it was very easy to observe any compliant or non compliant behaviour regarding this permit condition.

Released SBT must be alive and vigorous state
Camera views limit a clear and visible assessment of the state of fish released as fish that weren't retained were either shaken off the hook or cut free. To make a reasonable assessment, each fish would need to be physically lifted from the water in clear view of the camera. This activity may result in harm further limiting survival chances on release. It is considered that this rule would be extremely difficult to monitor and enforce with cameras.

General comments from Compliance Assessor
From the footage observed it was most impressive, and much more comprehensive than initially anticipated. In most instances you could always clearly observe regular setting and hauling procedures. This enabled easy identification of catch and discarded catch (in most situations). It also highlighted any protected species interactions. From the example footage taken and the expected roll out across the ETBF vessels. It would be reasonable to envisage and account for but not limit to breaches in:

- Misreporting amounts of catch by count
- Misreporting area of capture
- Spatial and temporal closures and Marine Protected Areas
- Dumping, discarding or high grading
- Exceeding bycatch or catch limits
- Retention of prohibited catch
- Gear restrictions
- Gear conflict
- Vessel Licence Conditions.

The biggest concern that has already been identified is the limited number of camera views. Camera angles need to be placed in an optimum position for its intended purpose. Sources of problems of camera footage included:

- Reflection from different angles of the sun
- Water splashed against the camera lens
- Camera angle
- Start/Stop times of the camera itself
- Clear field of view and no new obstructions
- 'Black spots'
- Generally poor bird identification ability at different distances from the boat.

There will need to be some form of regulation in regards to clear and evident tampering with the system (i.e. breach of permit conditions). Other suggested improvements include:

- Optimum camera angles and image quality standards
- Adjust permit conditions to incorporate the use of cameras on board and tampering penalties etc
- Possible colouration of swivels and or tubing used to secure line around the swivel
- Ensure viewers of the footage are adequately trained in order to maintain some form of consistency of data recording.

Skillsets for Evaluating Footage
Footage should be evaluated by someone with a good understanding of the rules and regulations as well as a good idea of the expected fish ID, bird ID and likely protected species interactions. Ideally the candidates chosen to perform this role will need to have the suggested training/familiarisation.

- Fish ID training
- Bird ID training
- Protected species training
- Training on the longlining fishing operations
- Observer 'recorder' Training
- ETBF Permit conditions
- Basic navigation.

Ideally this training could be run 'in house' as AFMA has enough skill and experience to cover this training.

18 APPENDIX 6: RECOMMENDATIONS REGARDING ELECTRONIC MONITORING SYSTEM INSTALLATION AND MAINTENANCE

Table 38: Summary of key electronic monitoring system performance issues and recommendations.

Component	Key issues	Installation recommendations	Maintenance recommendations
Hydraulic Pressure Sensor	Installation and Transducer thread	Installed by a hydraulic specialist. Permanent install recommended in the engine room reduces risks of damage and operational problems being exposed on the working deck. Using a ¼ inch NPT female socket.	Check for visible signs of oil leak at the pressure transducer.
	False signals	Install after the line drum controller and before the hydraulic motor as this reduces the instances in a common hydraulic system where anchor winches and lifting booms might trigger video activity.	Service technician might raise the pressure trigger threshold.
	Control centre 'memory retention'		Regular Function Test by owner or skipper would identify if this occurs.
Rotation sensor	False signals	Where possible lock the drum to restrict movement.	
	Reflector problems	Where the drum design allows install a proximity sensor to reduce issue with the reflector (e.g. alignment) and ongoing maintenance requirements.	Regular Function Test by owner or skipper would highlight any reflector issues.
	Mounting brackets	Use heavy gauge welded mounting bracket with mechanical protection.	
GPS	Functioning 'lock-up'		Regular Function Test by owner or skipper
Control centre	Cooling ventilation and access	Install in the wheelhouse in a position that allows for the ready removal and replacement of the hard drive. The location of the control centre should allow for unimpeded ventilation of the control centre.	Do not restrict airflow near the control centre with books, charts or rags.

Component	Key issues	Installation recommendations	Maintenance recommendations
Cables	Protection	Where possible have cables run through aluminium or steel conduit/pipe to offer the best possible mechanical protection. PVC is an alternative but has limited life due to ultra violet light degradation. Use the 4 wire heavy wall piezo (Geotech) cable due to its heavier outer case and added protection.	Where there are splices and joins in exposed wires at the work deck level they might be examined on a monthly basis for any oil or seawater ingress and nicks or chaffing.
Cameras	Initial set-up & focus	Where possible don't install outboard cameras facing forward as the water spray / salt build up on these cameras is high and ongoing maintenance will be required.	Onboard monitoring and maintenance required by vessel personnel.
	Orientation	Don't install cameras facing cameras directly down; install cameras with a viewing angle at a minimum 30 degrees off the vertical to reduce water accumulation on the dome impacting image quality.	
	Humidity and moisture build up	The use of silica gel packs during camera installs will reduce moisture issues.	Regular system function tests and monitoring by vessel personnel will highlight image quality deterioration.
	Glare	Glare will be inevitable at particular times of the day on outboard view cameras. Install sun shield in housing will help limit the impact of glare.	
	Lighting		Implement and monitor operational standards in terms of lighting requirements for the program.
	Salt build-up		Onboard monitoring and maintenance required by vessel personnel.
	Mounting brackets		When the optimum camera locations are agreed the stainless steel straps might be replaced by permanent welding of the brackets to the supporting structure.

Component	Key issues	Installation recommendations	Maintenance recommendations
Power supply	Problematic power supply	Where necessary use a UPS or run directly from a dedicated battery bank if significant power issues become apparent.	Regular Function Test by owner or skipper would identify if there is a low voltage issue.
Installation	Who arranges?	This should be an industry responsibility. AFMA should set minimal specifications that are outcome focussed. AFMA may have a Q/A role.	
Maintenance arrangements	As above	Again, an industry responsibility. Going to sea with equipment not working would incur penalties.	
AFMA role	To be defined	Current thinking is that AFMA would have a role in ensuring a robust implementation and maintenance framework is in place and an ongoing Q/A role.	