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FACILITATING INDUSTRY SELF-MANAGEMENT FOR SPATIALLY MANAGED STOCKS: A SCALLOP CASE STUDY

Julian J Harrington, Malcolm Haddon and Jayson M Semmens

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Published by the Marine Research Laboratories, Tasmanian Aquaculture and Fisheries Institute, University of Tasmania, Private Bag 49, Hobart, Tasmania 7001. E-mail:Malcolm.Haddon@utas.edu.au

Ph. (03) 6227 7277 Fax (03) 6227 8035

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The Fisheries Research and Development Corporation plans, invests in and manages fisheries research and development throughout Australia. It is a statutory authority within the portfolio of the federal Minister for Agriculture, Fisheries and Forestry, jointly funded by the Australian Government and the fishing industry.

Table of Contents

I. NON TECHNICAL SUMMARY

2005/027	Facilitating Industry self-management for spatially managed stocks: A scallop case study.

PRINCIPAL INVESTIGATOR: Associate Professor Malcolm Haddon

ADDRESS: University of Tasmania
Tasmanian Aquaculture and Fisheries Institute
Private Bag 49
Hobart TAS 7001
Telephone: (03) 6227 7279 Fax: (03) 6227 8035

Objectives:

1. Develop a generalized, credible regime of Industry observations to provide the necessary assessment information required to manage a spatially structured fishery.

2. Develop and trial a workable design for a pre-season permit fishery in the Tasmanian and Commonwealth scallop fisheries to provide the information necessary to characterize the stock status in each spatial region of the entire fishery (Size distribution, condition, and possibly abundance).

3. Develop and trial a workable design for within season volunteer Industry survey observations within the Tasmanian and Commonwealth scallop fishery for within season monitoring, comparison with the pre-season survey, and more detailed characterization of the available resource.

4. Develop mechanisms whereby Industry take (foster) ownership over the details of survey design and the organization and funding of such operations, along with how best to generate management advice that is perceived by Industry as unbiased, acceptable to all, and providing maximum return for product landed.

5. Aid the development of a clear vision for the future of the Bass Strait scallop fishery and how it can use spatial management to its own benefit.

OUTCOMES ACHIEVED TO DATE

The principle outcome of this project has been the adoption and incorporation of the Industry-based survey data collection strategy into the spatial management framework of the Tasmanian scallop fishery. As of 2008, the key management requirements of Industry-based surveys have been incorporated into the Fisheries (scallop) rules and are also included within the key management policy documents for the fishery. The closure of the Commonwealth scallop fishery by the Minister for Fisheries for much of the time period of this project made it difficult to implement the Industry-based survey strategy within this fishery. However, the concept of Industry-based surveys and the greater flexibility that such surveys will require were documented and incorporated into the Harvest strategy for the Bass Strait Central Zone Scallop Fishery, which was completed by the CSIRO in late 2007 with assistance by TAFI scallop researchers. This document also incorporated a change in harvest strategy from a most open, little closed spatial strategy to one almost identical to the Tasmanian spatial management model. It is hoped that a fully flexible survey approach, as utilised in the Tasmanian fishery, will be adopted within the Commonwealth fishery with its re-opening.

Within the Tasmanian scallop fishery, the information collected during Industry-based surveys has been fundamental for the operational decision making process, with all decisions within the fishery now being based on fisher collected data. This has benefited Industry and management in many ways. In particular, the costs of management (i.e. fisher levies) do not have to incorporate the extremely high costs of fishery scale scientific surveys. In turn, Industry, research and management can obtain and have access to fishery scale information for the management decision making process.

All sectors involved with the Tasmanian fishery have aimed to incorporate technologies into the data collection process. Today, electronic measuring boards, GPS devices and depth loggers on the dredge are standard survey equipment. Survey participants are familiar with their operation. Such devices have greatly improved the amount of data that can be collected per survey day (value for money) and improved the accuracy and perceived credibility of Industry collected survey data. Industry has a vision to expand the use of technology in the survey process (see 8. Further Developments)

The Tasmanian commercial scallop fishery has taken an increasing level of responsibility for the organisation and implementation of the Industry-based survey process within the Tasmanian scallop fishery. By the conclusion of this project, the TSFA had taken the role of selecting survey participants and the basic organisation and planning of surveys. This ownership of the Industry-based survey process has moved the Tasmanian scallop fishery closer to a full co-management approach, and seen the TSFA take control and ownership of otherwise traditional management operated harvest mechanisms. Of particular note, the Tasmanian scallop Industry fully own the organisation of the fine scale rolling opening harvest mechanism that operates within the legislative open area. Such strategies have ultimately maximised the quality and quantity of product taken from a known scallop resource, which in turn has maximised economic returns to fishers. The full economic benefits have yet to be completely realised, but it is hoped that further growth within the TSFA will lead to greater co-management of the Tasmanian scallop fishery and a realisation by the TSFA that economic return to fishers does not necessarily rely on high catches / TAC's during each fishing year. It is hoped that such ownership of management processes will be incorporated into the Commonwealth fishery once re-opened.

Non Technical Summary

Just prior to the present work, Haddon *et al.* (2006), in "Juvenile scallop discard rates and bed dynamics: testing the management rules for scallops in Bass Strait" (FRDC 2003/017), concluded that a detailed rotational spatial management approach based on a 'most closed, small area open' strategy has many advantages over alternative spatial management options. There are many potential advantages of only opening relatively small areas of a scallop fishery, including: maximising the chance of a worthwhile annual fishery; allowing the selection of scallops in the best condition; enabling greater control over the exploitation of an easily targeted and easily depleted species; minimising the impacts of demersal fishing activities on scallop habitats and related communities; and maximising the abundance of adult spawning scallops within the fishery, which will maximise the chances of a successful recruitment event. Detailed rotational spatial management based on a "most closed, little open' harvest strategy, however, does have a substantial cost. The main part of that cost being to have sufficient quantity and quality of information about available stocks to make decisions concerning a fishery, sometimes within-season and in near real-time. Within the Tasmanian scallop fishery management model, information is required at both the scale of scallop bed and the entire fishery. Fishery-independent surveys could provide the required information however, such surveys would be prohibitively expensive over the scale of the fishery. While video and acoustic technologies offer some possible advantages, they are currently not feasible options (see Haddon *et al.* 2006). The only viable alternative is to develop a reliable and credible scheme where Industry vessels find ways to survey and provide the necessary information needed to spatially manage the fishery. Preliminary pre-season permit based survey trials in Tasmania, conducted during 2003 and 2004, demonstrated that an Industry motivated, spatial survey design has the potential to be successful in providing fishery information to management organizations. However, those trials also identified many problems that still needed to be addressed.

This current project, FRDC 2005/027, aimed to develop and trial a generalised, credible regime of Industry observations that allow for the collection of the stock information needed to manage the Tasmanian commercial scallop fishery under a detailed rotational closed-area spatial harvest regime. The ultimate aim was to develop mechanisms whereby Industry adopt (foster) ownership over the details of the design, organisation and operation of surveys and to generate management advice from this fisher collected data that is perceived by Industry as unbiased, acceptable to all, and providing maximum return for product landed. In doing so, Industry, management and research would develop a clear vision for the future of the Bass Strait scallop fishery (particularly the Tasmanian and Commonwealth fishing zones) and how it can use spatial management to its own benefit.

By conducting a fine scale analysis of Tasmanian scallop vessel fishing effort using Vessel Monitoring System (VMS) data, it has been determined that the majority of scallop fishing is confined to exceptionally small areas. In fact, during the 2003 Tasmanian fishing season, 50% of VMS inferred fishing effort was found to occur within 0.85% of the total available open area; and 95% of fishing effort within ~12% of the open area. Fishing effort was correlated with habitat structure, with low and moderate fished areas containing high abundances of screw shells and their associated hermit crabs, and heavily fished areas containing predominately commercial scallops. Subsequently, commercial dredge fishing effort is in general, confined to scallop habitat, with scallop beds (areas containing high VMS inferred fishing effort) occurring over the scale of km x km. This distribution of fishing effort and scallop beds suits a detailed closed-area spatial harvest strategy. Open regions can be relatively small and potentially the same scale as a scallop bed (km x km), for no significant decline in total catches. This regime of management, however, will

require detailed stock information to be collected at the scale of scallop bed. To ensure annual continuity of supply and longer term harvest strategy planning, information of other scallop stocks (beds) across the spatial scale of the fishery will be required.

The use of fishing vessels and their crews as a mechanism for obtaining fisheries data (Industry-based surveys) was found to greatly improve the affordability, spatial distribution of exploration and quantity of data collected relative to fishery-independent survey techniques. The data recorded by fishers was accepted as a credible source of information and was effective for the spatial management of the Tasmanian scallop fishery. Some data inaccuracies were observed when manual measuring boards and written techniques were used by fishers. Electronic measuring and storing devices removed these inaccuracies, improved data quality and made sampling and data entry at least four times faster relative to manual methodologies. These findings show that Industry-based survey techniques have many advantages over more traditional survey techniques, and management and research organisations should consider using fishers, fishing vessels and electronic technologies for the collection of the stock information needed to spatially manage a fishery.

An effective strategy of Industry-based surveys is largely dependent on the structure of the management agency responsible for a fishery, and the rules and policies that apply to a particular fishery. Fisheries managers must ensure mechanisms to minimise the possible detrimental consequences of using inaccurate fisheries data in the management decision making process. There must be transparency in the survey process, and the ability for all fishers to participate. The management agency responsible for a fishery must have a flexible and adaptive approach to management and the ability to use survey incentives, in particular Research Quota Unit Allocation (RQUA). Also, mechanisms that separate survey and commercial fishing activities, such as designated survey periods and commercial fishing periods, are the preferred strategy. Management and research should simplify the data collection process and make all survey data accessible to all stakeholders. If management rules and policy cannot fulfil these requirements, then Industry-based surveys may not be an effective mechanism for the collection of the data needed to manage a fishery, and other survey strategies, such as scientific or observer program surveys, should be considered.

Once it has been determined that the management agency responsible for a fishery can operate Industry-based surveys under their management rules and policies, then a system of Industry-based survey protocols, which are simple and rapid in their implementation must be developed. Within the Tasmanian scallop fishery, the organisation, implementation and use of Industry-based surveys in the management process can be summarised in seven protocols:

1) Determination of clear and concise survey aims and data collection requirements by all fishery stakeholders.
2) Determination of the type of survey to conduct. These can be divided into three broad categories: a) Pre-seasons surveys; b) within season surveys; and c) out of season surveys.
3) A transparent and expedient process for selecting survey participants.
4) A flexible mechanism for allowing surveys to be conducted within closed-areas and closed seasons.
5) Development of a specific survey design, equipment requirements, education and training requirements.
6) Conduct the survey under agreed design and strategy.
7) Analysis, presentation and archiving of industry-based survey data.

If the organisation and implementation of these protocols is too complex and / or time consuming, fishers may distance themselves from the Industry-based survey process. Subsequently, Industry-based surveys may not necessarily be the most suitable data collection strategy in some fisheries.

Industry-based surveys provide fishers and other Industry stakeholders with far greater roles and responsibilities in the management decision making process. Within the Tasmanian scallop fishery, this has resulted in Industry fostering greater ownership of the management of their fishery. As a consequence, Industry devised and initiated an Industry run within-season rolling opening self-management harvest strategy, as applied to the White Rock open region during 2006. This Industry harvest strategy was credited with providing a better quality scallop product and for maximising the quantity of scallops taken from within the White Rock open region. There was a high level of Industry satisfaction and support for this TSFA controlled Industry rolling opening harvest strategy. A number of potential advantages are possible under such harvest regimes. These include: reducing the race to fish; reducing the patchiness of fishing, spreading of a known resource of scallops over a greater period of time and possibly over several years, and minimisation of the impacts of fishing on the broader marine environment. The concept of within-season co-management should be further explored to realise the full benefits that Industry initiated rolling openings can offer.

Detailed closed-area spatial management and Industry rolling opening harvest strategies essentially force the entire Tasmanian fishing fleet to target fishing effort within exceptionally small regions of the fishery (~ 3km x 3km blocks) until catch rates are considered uneconomical. The impacts of such fishing on scallops, scallop habitat and the broader marine environment were explored during the 2006 White Rock open region. The effects of limited short-term intensive fishing was characterised by a 40% to 80% decrease in the abundance of the dominate species found within the study area, however, no species were fully removed and the dominant species were observed in the same number of sample tows before and after fishing had occurred. No biologically significant differences in water turbidity and suspended solid readings were observed within impacted or control survey regions. Similarly, the composition of sediments within control and impacted strata showed no observable pattern of change. Assuming that the time for recovery in abundances of the species found within a fished scallop habitat can occur within the time scale of a rotational temporal closure, then rotational closed-area and Industry rolling opening harvest strategies may be used as a mechanism to limit the extent of impacts, in terms of the both area impacted and resulting change in habitat structure.

Within Tasmania, scallop Industry members have demonstrated that they are capable of adopting responsibility for important aspects of the management of the resource which they harvest. Such arrangements benefit all participants, especially during years of high catch rates, when sufficient scallop stocks ensure the full scallop quota may be taken. However, even with a detailed spatial management regime, scallop stocks are naturally variable and relatively poor years can occur when none of the three commercial scallop jurisdictions will do well. Cooperative behaviour under such difficult conditions becomes more difficult to achieve, simply because the risk of financial loss to individuals appears greater. Therefore, even though this system in Tasmania is well established, efforts need to be maintained to ensure that the fundamentals of its operation are reinforced and continue into the future, particularly in times of low catches.

This project, combined with the results of the preceding FRDC scallop project (2003/017), has resulted in a clear vision for the future of Bass Strait scallops. It is hoped that all scallops within the SE of Australia can be managed under a rotational closed-area spatial management regime, which sees the majority of the available fishing grounds closed to fishing, and only relatively small areas of known stocks being opened. The rotation interval will allow the recovery of the target species, scallops, as well as the broader habitat that is impacted. The information needed to make decisions concerning openings and closures will be collected by Industry during Industry-based surveys. Scallop Fishermen's Associations will be responsible for much of the planning and organisation of these surveys, with some direction provided by research and management, making the system a co-management approach. A fully automated electronic system of data collection is visualised, and would incorporate a web-based data sharing and monitoring component. The specific spatial harvest regimes implemented will incorporate strategies that maximise and / or promote the chances of successful recruitment within the fishery. With the inclusion of results from FRDC 2008/022, it is hoped that a greater level of unison in the management and research within the current three scallop jurisdictions (Tasmania, Commonwealth and Victoria) can be achieved by a revision and altering of the current OCS arrangements for the fishery. If successful, this would allow synchronisation of harvesting strategies, and a far greater chance of annual continuity of supply into markets. For example, should there be a good supply of large scallops within the Commonwealth fishery during a given fishing period, the Tasmanian / Victorian fisheries could plan not to fish or to take only a low catch to coincide with this period. It must also be acknowledged that during some years only a low TAC may be possible from all the current fishery jurisdictions combined.

If this vision can be realised, there could be a real probability of a continuous and sustainable supply of scallops from the SE Australian scallop resource.

KEYWORDS: Commercial scallops; *Pecten fumatus*; spatial management; Industry-based surveys

II. ACKNOWLEDGEMENTS

We would like to offer our thanks to all the skippers and crew who participated in Industry based surveys. Your efforts, advice and will to take greater responsibilities for your fishery have formed the basis of this report. We would also like to thank the scallop managers at the Tasmanian Department of Primary Industries and Water (DPIW), in particular Rod Pearn and James Parkinson. Your responsiveness and enthusiasm for the work we conducted was outstanding. Also, thanks to the AFMA managers for joining in discussion and pushing for Industry-based surveys to be integrated into the management regime of the commonwealth fishery – we look forward to further developing this regime with you!

Chapter 1
We wish to thank the skippers and crew of the Dell Richey II for their support during the surveys. Thanks also to C. Gardner, P. Ziegler, A. Hirst and H. Pederson, along with 2 anonymous reviewers, whose comments greatly improved the manuscript.

Chapter 2
We wish to thank the skippers and crew of all participating Industry vessels ("Anita", "Brid Venture", "Brid Voyager", "Christa Leanne", "EJ Fairnie", "Karmin", "Petuna", "Soluna", "Suncoaster II", "Tara Lynn", "Waubs Bay"). We would like to thank Rod Pearn and James Parkinson from the Tasmanian DPIW for their help with organisation of surveys and permits. We would also like to thank those TAFI staff and students who volunteered their time to measure scallops, in particular Sam Foster, Justin Hulls, and Steve Leporati.

Chapter 5
We wish to thank the skipper and crew of the Karmin for their support during the surveys that conducted this work.

III. BACKGROUND

Scallop fisheries in Australia and around the world have been described as “boom and bust” fisheries. Such fisheries have disadvantages for fishers and tend to lead to economic inefficiency (through the potential for flooding a market with product), difficulty in maintaining markets if the “bust” of fishery collapse leads to closure of the fishery, and difficulty in maintaining a skilled workforce (fishers, processors and retailers of the product). Such factors ultimately lead to un-predictability of earnings, and may even result in fishers losing money during times of low market value. In both Tasmanian and Commonwealth waters there has been recent growth in the use of spatial management in an attempt to ensure the long-term sustainability of easily targeted species such as scallops. The use of Vessel Monitoring Systems has proved to be a useful tool in the management of such fisheries, and provides compliance organizations with Global Positioning System information for each vessel participating in the fishery. Industry members can now be confident that lines on the water will work for all players in the fishery. The FRDC funded project 2003/017 looked at some of the management rules for scallops and concluded that the optimum spatial management arrangement is to have the majority of scallop beds closed with only a few open each year.

The combination of spatial management and improved VMS compliance should have great advantages for sustainability of spatially managed fisheries as it will permit the development of rotational fishing regimes, or ‘paddock fishing’. However, making appropriate decisions about which ‘paddock’ to open and which to keep closed requires at least some information regarding stock status across the whole spatial structure imposed on the fishery. In the case of scallops, managers should at least know about the size, condition and, ideally, relative abundance of scallops in all beds available, before deciding which area(s) to open. Without information from the entire potential fishing area, management decisions would entail significant elements of trial and error, which may lead to risky decisions and costly inefficiencies. Although Fishery Independent surveys could service this need for information, the spatial scale of most fisheries, combined with the patchiness of the resource would mean that the cost of such surveys would be prohibitively high. Fishery-dependent surveys could also provide such information, but at minimal cost, especially if a percentage of the Total Allowable Catch is allocated to compensation of fishers conducting such surveys.

Preliminary pre-season permit fishery trials in Tasmania conducted during 2003 and 2004 demonstrated that an Industry motivated, spatial survey design has the potential to be successful in providing fishery information to management organizations. However, these surveys also identified many problems that still needed to be addressed. In particular, the credibility of such surveys needed to be increased through the removal of inefficiencies, optimization of the design, and standardization of the analyses employed. The provision of the information necessary for successful spatial management would enable Industry not only to adopt greater ownership of the management of fisheries resources, but also increase the likelihood of the long-term sustainability of their own resource.

An advantage of Industry-based surveys providing information for the spatial management of wild resources is the potential to increase the value and economic return of fish and fish products. Rotational harvesting, eventually of individual scallop beds, has the potential to eliminate the boom and bust nature of the scallop fishery in Tasmania and Bass Strait, thus providing a long-term continuity of market and earnings from the fishery for fishers, processors, and retailers. Preventing markets from being flooded with product should also maintain prices. Furthermore, an increased knowledge of the available product within the entire range of the fishery should allow the opening of areas that will meet the needs of specific niche markets, especially if Industry members have greater involvement in the management decisions made. As an example, the spatial scale of the Tasmanian fishery may ultimately require beds to be open in both the north and south of the State in one year in order to suit the needs of fishers, processors and retailers. Such factors can only be addressed once initial knowledge of the entire available resource is made, regular updates of the status of the resource are obtained, and Industry becomes more involved in the management decisions that are made.

Greater involvement of Industry members is essential to successfully implement the fishery-dependent surveys that will provide the advice necessary to organizations using spatial management. This project (FRDC 2005/027) provided training and other opportunities to influence the future of the fishery by cementing Industry input to management. Involvement in both the collection of data to make management decisions and involvement in decision making itself will generate leaders within the fishery and greater vocational competence of people within and supporting the fishery.

For Industry-based surveys to be effective, fishers will need to modify their perception of the Industry into being a cooperative effort among efficient operators focusing their efforts on identified beds. This contrasts with the present rush to be first and pointless attempts at keeping bed locations secret. This is a large change required and Industry will require time and examples of successful seasons to bring about the required changes.

IV. NEED

In 2005, both the Tasmanian and Commonwealth scallop fisheries were recovering from severe depletion. In an attempt to ensure future sustainability of the fishery, a form of spatial management has been implemented in both jurisdictions, however, specific management protocols are still evolving. This proposal follows naturally from some of the results of FRDC 2003/017, which investigated some of the management rules used in SE Australian scallops (Haddon *et al.* 2006). One conclusion from 2003/017 was that the optimal management regime for widely dispersed scallop beds is to close most of the fishable area and to only open a limited number of beds each year in a rotational fashion. One essential requirement for such management is the need for detailed information about the size and abundance of scallop beds across the entire fishery. Fishery-independent surveys would be far too expensive in a cost-recovery management regime - in Commonwealth waters relatively small surveys have cost at least $45,000 to $50,000 a year and that would not cover the area now available. Therefore, the only economically viable means of providing this information is to devise some means of encouraging Industry members to collect the necessary information both prior-to and during fishing seasons. Ad hoc trials were attempted in Tasmanian waters in 2003 and 2004, which led to the identification of many operational problems with such surveys. Once these practical problems have been overcome, credibility and authority also needed to be added to such fishery-dependent surveys.

The vision of this project is of an on-going Commonwealth and Tasmanian scallop fishery managed at a small spatial scale using information provided by Industry itself in the absence of formal independent observers. Such a vision relies on Industry becoming a vital component of the management, and thus requires the development of protocols to ensure the growth in participation and expertise for Industry-run sampling. This vision has still to be developed in detail but reflects the needs and wishes of Industry for better economic returns to fishers, while ensuring the long-term sustainability of the fishery.

If the general principles of such Industry initiatives are developed in the scallop fishery, then other spatially managed fisheries should be able to develop similar regimes, leading not only to better management but greater Industry involvement in management.

V. OBJECTIVES

1. Develop a generalized, credible regime of Industry observations to provide the necessary assessment information required to manage a spatially structured fishery.

2. Develop and trial a workable design for a pre-season permit fishery in the Tasmanian and Commonwealth scallop fisheries to provide the information necessary to characterize the stock status in each spatial region of the entire fishery (Size distribution, condition, and possibly abundance).

3. Develop and trial a workable design for within season volunteer Industry survey observations within the Tasmanian and Commonwealth scallop fishery for within season monitoring, comparison with the pre-season survey, and more detailed characterization of the available resource.

4. Develop mechanisms whereby Industry take (foster) ownership over the details of survey design and the organization and funding of such operations, along with how best to generate management advice that is perceived by Industry as unbiased, acceptable to all, and providing maximum return for product landed.

5. Aid the development of a clear vision for the future of the Bass Strait scallop fishery and how it can use spatial management to its own benefit.

VI. STRUCTURE OF THE REPORT

This report is structured into 6 chapters, with each chapter being written as a ‘stand alone’ document.

Chapter 1 discusses the distribution of commercial fishing effort within the Tasmanian scallop fishery. The results show that the majority of fishing effort within an open fishing block occurs within an exceptionally small area. This is discussed with reference to survey design, closed-area spatial management and assessing the impacts of fishing on the benthos.

Chapter 2 highlights the benefits of Industry-based surveys as a data collection methodology compared to more traditional fishery-independent survey designs. Issues based around the quantity and quality of data collected are discussed.

Chapter 3 discusses specific management considerations that must be taken into account before Industry-based surveys can be implemented as a data collection mechanism. A system of seven protocols used to organise and implement Industry-based surveys within the Tasmanian fishery are discussed.

Chapter 4 highlights the Industry initiated rolling opening harvest regime first implemented during the 2006 scallop season. This harvest regime was in part a direct evolution from Industry-based survey responsibilities.

Chapter 5 looks at the impacts of intensive short term fishing effort that occurs under rotational closed-area and rolling opening harvest regimes on the benthos and boarder marine environment and discusses the minimal rotational cycles required in the Tasmanian fishery.

Chapter 6 Briefly describes the surveys conducted within the Tasmanian scallop fishery from 2005 to 2008. All reports produced during this period are reproduced within the appendices.

1. SPATIAL DISTRIBUTION OF COMMERCIAL DREDGE FISHING EFFORT: APPLICATION TO SURVEY DESIGN AND THE SPATIAL MANAGEMENT OF A PATCHILY DISTRIBUTED BENTHIC BIVALVE SPECIES.

*Marine and Freshwater Research, 2007, **58**, 756-764.*

1.1 Introduction

Without information on fish stocks and habitat, there can be no credible management planning (Haggan 2001). Traditionally, fisheries data has been collected and grouped at the relatively coarse spatial scale of fishery assessment blocks, such as the 30 nautical mile x 30 nautical mile ICES rectangles based on the EC-logbook forms (Rijnsdorp *et al.* 1998), or the 5 nautical mile x 5 nautical mile blocks used by Veale *et al.* (2000) in their study of commercial scallop fisheries in the North Irish Sea. In more recent years the spatial structure of benthic stocks has been incorporated into the conceptual framework for the analysis and management of benthic fisheries (Orensanz *et al.* 2006). This has bought with it the need to identify appropriate spatial scales for the observation, analysis and management of exploited stocks (Orensanz *et al.* 2006).

Scallop species worldwide tend to have an aggregated distribution within their geographical range (Brand 2006). Within a particular species' geographical range, there are a limited number of regions, termed fishing grounds, capable of supporting commercial fishing operations (see Brand 2006). Within a fishing ground there are usually a number of distinct regions, typically of an area of several km^2, where scallop abundance is higher than elsewhere (scallop beds) (see Brand 2006). It is the task of fishery management organisations to determine what proportion of a fishing ground should be opened to commercial harvesting during a given season. The main factors determining this decision are the spatial distribution of the target species, the expected annual catch (Total Allowable Catch) and the specific harvest strategies and policies implemented by the management organisation responsible for the fishery.

The patchy spatial distribution of scallop species has seen the recent integration of closed-area, spatial management regimes into fisheries management throughout the world (i.e. the Georges Bank region (see Murawski *et al.* 2000) and New Zealand Challenger Program (see Marsden and Bull 2006)). The benefits of such management systems for benthic species, including scallops, have been shown to be: 1) increased density, mean age and size of the exploited species; 2) enhanced local reproductive potential and therefore the likelihood of larval export to the surrounding fishing grounds; 3) increased protection to juveniles to fishing, and increased survival and growth rates; 4) protects other benthic communities and habitats (Gell and Roberts 2003, Halpern 2003, Beukers-Stewart *et al.* 2004).

With the reopening of the Tasmanian commercial scallop, *Pecten fumatus*, fishery in 2003, after a three year closure due to stock collapse, the Tasmanian fisheries management organisation the Department of Primary Industry and Water (DPIW) implemented a detailed closed-area, spatial management harvest regime. A simplistic explanation of this new management approach was that most of the fishery was to remain closed to commercial fishing operations and only relatively small (10's x 10's km) areas of known scallop stocks would be opened for commercial dredge harvesting. Although the fishing Industry was generally supportive of this changed management strategy, there was some concern that opening such small regions would greatly restrict fishing operations and catches. Management and research were not aided by the lack of quantitative information of the fine scale distribution of fishing effort within the Tasmanian scallop fishery, as catch records were recorded at a relatively course scale (10.5km x 14km statistical blocks).

The main tool for observing compliance of the new spatial management regulations implemented within the Tasmanian fishery was a satellite Vessel Monitoring System (VMS), with it being a license requirement for all participating vessels to be fitted with a VMS. Although the primary role of VMS is to monitor Industry compliance with fishery management regulations, the high-resolution position data can also be used to identify the spatial extent of fishing effort, and the level of fishing intensity at spatial scales substantially smaller than those used to assess the fishery (i.e. 500 x 500 m blocks compared with 10.5 x 14 km fishery assessment blocks).

In this chapter we compare the spatial distribution of fishing effort during the 2003 Tasmanian commercial scallop fishery east of Eddystone Point using both fishery logbook data and fine scale VMS data. Patterns in the distribution of fishing effort were also explored at different spatial scales. The dredged benthic communities collected from regions exposed to different levels of fishing intensity, defined at small spatial scales (500m x 500m grid cells), were also compared during an opportunistic dredge survey to determine whether any observed differences were more likely to be explained by pre-existing habitat differences or the effects and intensity of fishing.

1.2 Materials and methods

1.2.1 Study site

The Tasmanian commercial scallop, *Pecten fumatus*, fishery is the major scallop fishery in southeast Australia, and comprises all waters around the Tasmanian coastline to a maximum of 200 nautical miles offshore on the east coast. In 2003, the abundance and size structure of known *P. fumatus* stocks met management decision rules allowing the opening of an approximate 887 square kilometre area near Eddystone Point (approximately 148.41733E, -40.91133S) (Figure 1.1). The region was opened to fishing on the 29th July 2003 and closed to fishing operations on 30th November 2003. Under the newly implemented detailed spatial management strategy, the remainder of the Tasmanian fishery was closed to all commercial dredge fishing operations.

1.2.2 Distribution of fishing effort within the open region

'Fisher Catch Return' records for all vessels participating in the 2003 Tasmanian commercial scallop fishery were obtained from the Tasmanian Department of Primary Industry and Water (DPIW). This data is recorded by each fishing vessel for each fishing day at a spatial scale of 10.5 km x 14 km statistical fishing locality block (see Figure 1.2). The proportion of the total number of fishing hours spent within each locality block was used as an indication of the distribution of fishing effort.

All VMS position data for all vessels fishing within the open region east of Eddystone Point during the open fishing period were obtained through a special agreement between the Tasmanian Aquaculture and Fisheries Institute, University of Tasmania and the Department of Primary Industries and Water (DPIW). All raw VMS data were spatially plotted using the software package ArcView GIS 3.2a for Windows. Data was not standardised to take into account differences in poll-rate (time between two consecutive signals for individual vessels) as initial analysis identified no significant variations in the general spatial distribution and proportion of VMS 'polls' when using all poll rates combined. Areas containing high abundances of VMS polls were assumed to correlate to areas of high fishing activity / scallop abundance. To determine patterns in fishing activity, kernel home ranges (Worton 1989) at the 25%, 50%, 75% and 95% utilisation distributions were calculated from the raw VMS data using the Animal Movement Extension (Hooge, 2001) in ArcView 3.1.

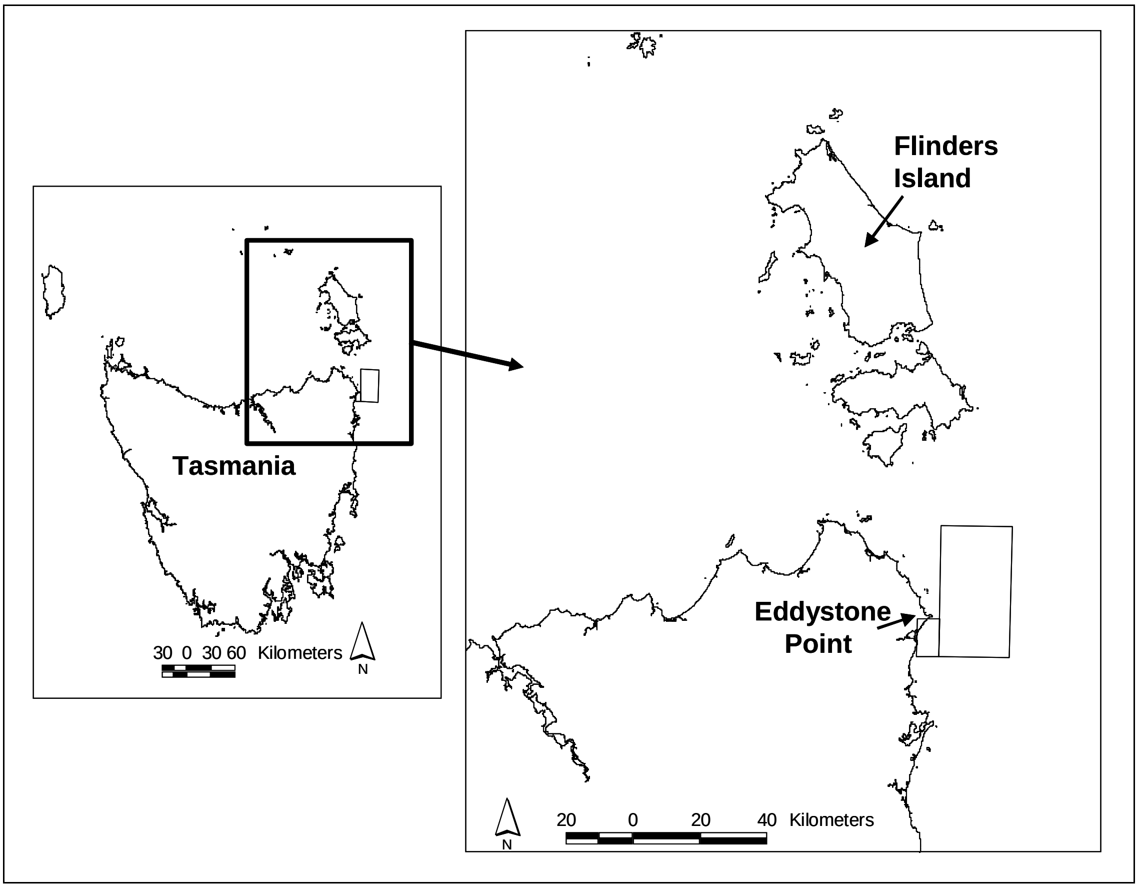


Figure 1.1: Location of the 2003 Tasmanian commercial scallop season to the east of Eddystone Point on the east coast of Tasmania, Australia. The box on the map titled Eddystone Point identifies the boundaries of the region open to commercial harvest.

1.2.3 Measuring the patchiness of fishing effort at different spatial scales

The spatial distribution of fishing effort can be characterised by the degree of patchiness (Pielou 1977). To determine patterns in the spatial distribution of VMS polls at different spatial scales, the coefficient of dispersion (s^2/m) was used as a measure of patchiness (denoted as C) (see Rijnsdorp *et al.* 1998). C-values larger than 1 indicate an increasingly patchy distribution, whereas C values <1 reflect increasingly uniform distributions. The question addressed in this section was at what scale did VMS inferred fishing effort become more randomly distributed within the fished region. C values were calculated at different spatial scales within three 10 km x 10 km windows (see Figure 1.3). These windows were placed around the three most fished scallop beds, which correspond to the region south of Eddystone Point (fishing locality block with 23.8% effort in Figure 1.3) and two windows within the fishing locality block east of Eddystone Point (with 61.5% fishing effort – see Figure 1.3). These windows were then subdivided into grid sizes of 5km x 5km, 1km x

1km, 500m x 500m and 250m x 250m subunits and the C value calculated using the average and variance VMS polls within these subunits for each 10km x 10km window separately.

1.2.4 Assessing the benthic communities found in regions impacted by different levels of fishing intensity

To define fishing intensity within the Eddystone Point region a grid consisting of 500m x 500m cells was overlayed onto the raw VMS data. A count of the total number of individual VMS 'polls' falling within each individual cell was calculated and results used to define different levels of fishing intensity, relative to the maximum number of polls found in any one cell (Figure 1.4). Confidentiality and security issues prevent the publication of the actual number of 'polls' within each defined intensity area, however, if the upper bound of the low fished area is used as an index of 1, then lower fished areas contained between 0.4 – 1 relative VMS 'polls', moderate areas 1 – 4 relative VMS 'polls', and heavy intensity areas 4 – 6 relative VMS 'polls'. Grid cells with <0.4 relative poll rates had a low level of confidence that they were fished.

In November 2003, an opportunistic fishery-independent dredge survey was conducted within the Eddystone Point open region. Although this region was technically still open to fishing, minimal fishing activity (as determined by VMS) was being recorded at this time. During the survey, five replicate dredge samples were collected from low, moderate and heavily fished regions as previously defined (see Figure 1.4). Grid cells falling within the upper bounds of each fishing intensity category were selected for sampling and all scientific dredge samples were conducted within an individually defined fishing intensity cell (to the best ability of the skipper of the survey vessel) region so that each sample could be accurately assigned to a single fishing intensity category (see Figure 1.4).

Benthic dredge samples were collected on a commercial scallop fishing vessel "Dell Richey II" using a standard 'toothed-dredge', with a width of 4.26 m and mesh dimensions of 46 x 70 mm. A 23 x 35 mm mesh liner was fitted to the dredge to allow for the retention of small (juvenile) scallops and other small benthic taxa. All tows were of five minutes duration and covered between 400 and 450 m, in depths ranging from 53 to 64 m. Upon completion of each sample tow, the dredge contents were sorted and identified to the lowest testable taxon. Where numbers of individual taxa were low, all individuals were counted. Where numbers were large, a total count was estimated by counting all individuals within a randomly selected sub-sample, and then scaling up to 100%. Estimates of total catch, *P. fumatus* shell (dead scallop) and other shell (dead) content were also made for each sample tow. Due to variation in the tow distance of each sample tow, all abundance estimates were standardised to the relative number caught per 1000 m^2 dredge tow.

One-way ANOVA tests were performed to investigate differences in total species, total individuals, total catch, *P. fumatus* shell (dead scallop), other shell content (dead) and abundances of the target species, commercial scallops, *P. fumatus*. Where required, data were $\log_{10}$ transformed to avoid violating the assumption of homogeneity of variances. A '*post hoc*' Tukey's honestly significant difference (HSD) test was used to explore significant terms in the models where required. Significant differences between dredge benthic assemblages were determined using analysis of similarities (ANOSIM) and the main species contributing to any observed changes was explored using the SIMPER procedure (see Clarke and Warwick 2001). Data was fourth root transformed and based on a Bray-Curtis Similarity matrix.

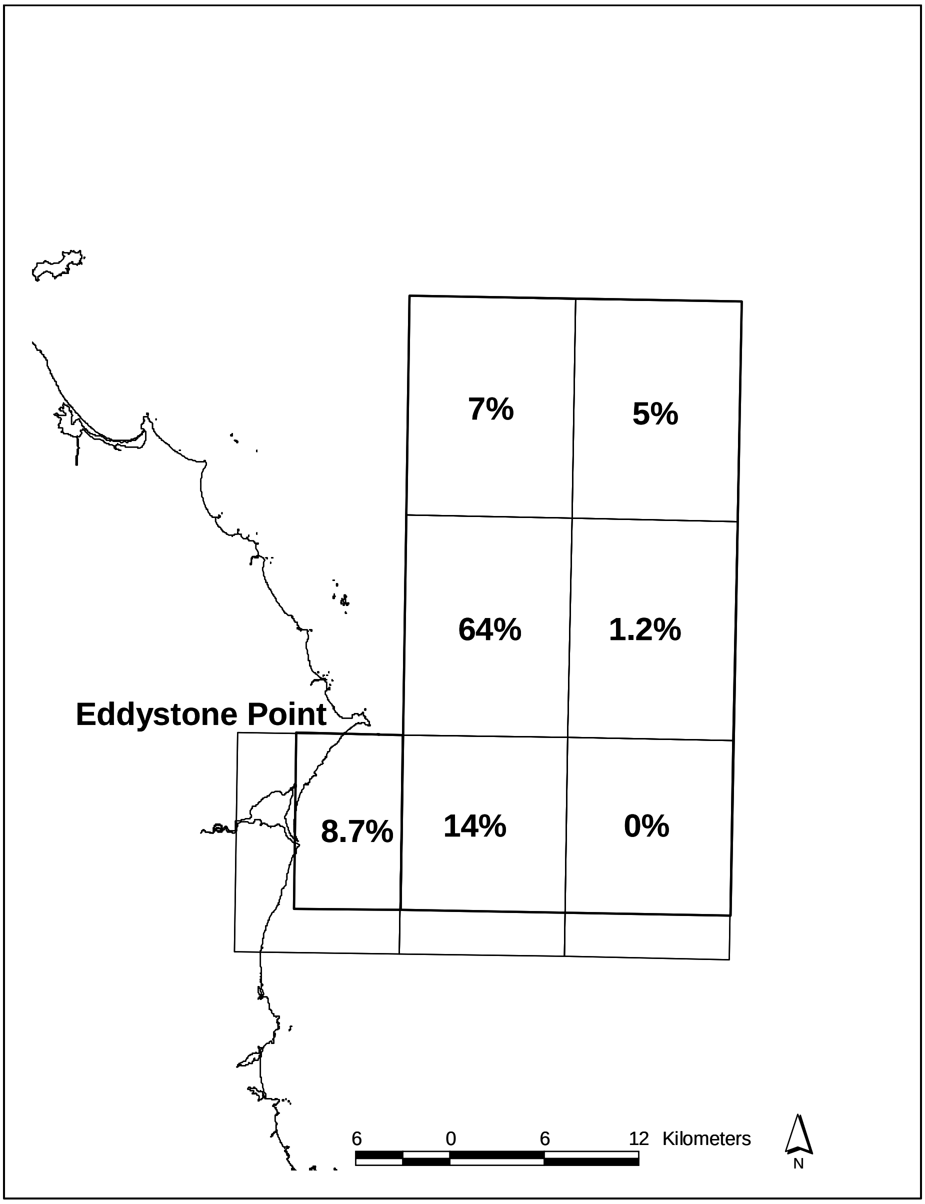


Figure 1.2: Distribution of fishing effort (% of total hours fished) within each locality block for the 2003 Tasmanian scallop season east of Eddystone Point as recorded in fisher catch return data.

Ideally, pre-fishing benthic dredge sample data would be compared to post-fishing data to determine whether any observed differences in the benthic communities examined post-fishing could be explained by pre-existing habitat differences rather than the effects and intensity of fishing. Although a pre-fishing Industry survey was conducted prior to commercial fishing, data collected during this survey did not sufficiently overlap areas that were fished at the highest intensities. In the absence of suitable pre-fishing data, we used depth as a proxy in an attempt to resolve whether the observed differences in benthic communities were more likely the consequence of pre-existing habitats or the effects of fishing. If observed differences were related to pre-existing habitat types, it would be expected that the distribution of abundance of the key species would fall within particular depth ranges. Subsequently, a permutational, one way Analysis of Covariance (PERMANOVA - see Anderson 2001, McArdle and Anderson 2001) was conducted on the key species responsible for the observed differences in the benthic communities collected from areas of different fishing intensity (screwshells and commercial scallops). In the analysis, the three fishing intensity categories were used as the factor of interest, the abundance of scallops (target species) and screwshells (live screwshells and hermit crab inhabited combined) were the variables, and depth the covariate. The data was fourth root transformed and the analysis was based on Bray-Curtis dissimilarities. Pairwise comparisons of significant differences were conducted within the PERMANOVA program (see Anderson 2001, McArdle and Anderson 2001). Trends in the abundances of the key species with depth were examined using scatter plots.

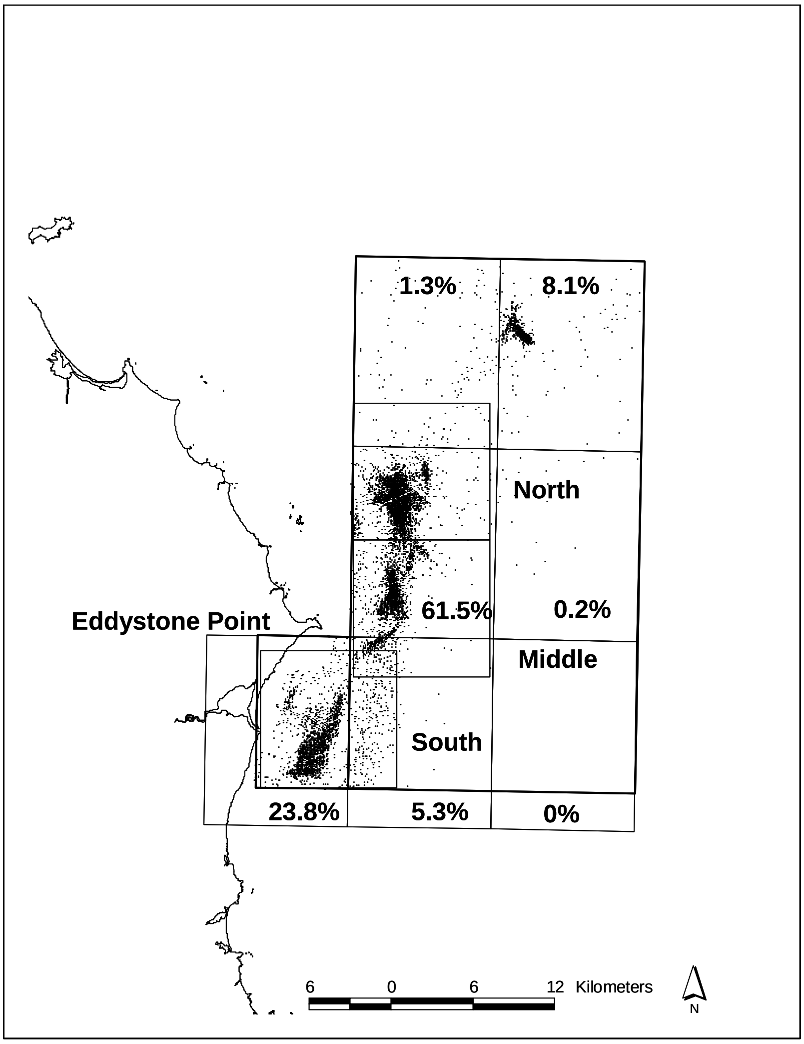


Figure 1.3: Distribution of fishing effort within the open region near Eddystone Point as inferred by Vessel Monitoring System data. Percentages of VMS hits within each fishing locality block are given. The hatched boxes labelled 'north', 'middle' and 'south' identify the groupings of scallop beds used in the patchiness of fishing effort analysis (see Table 1.1).

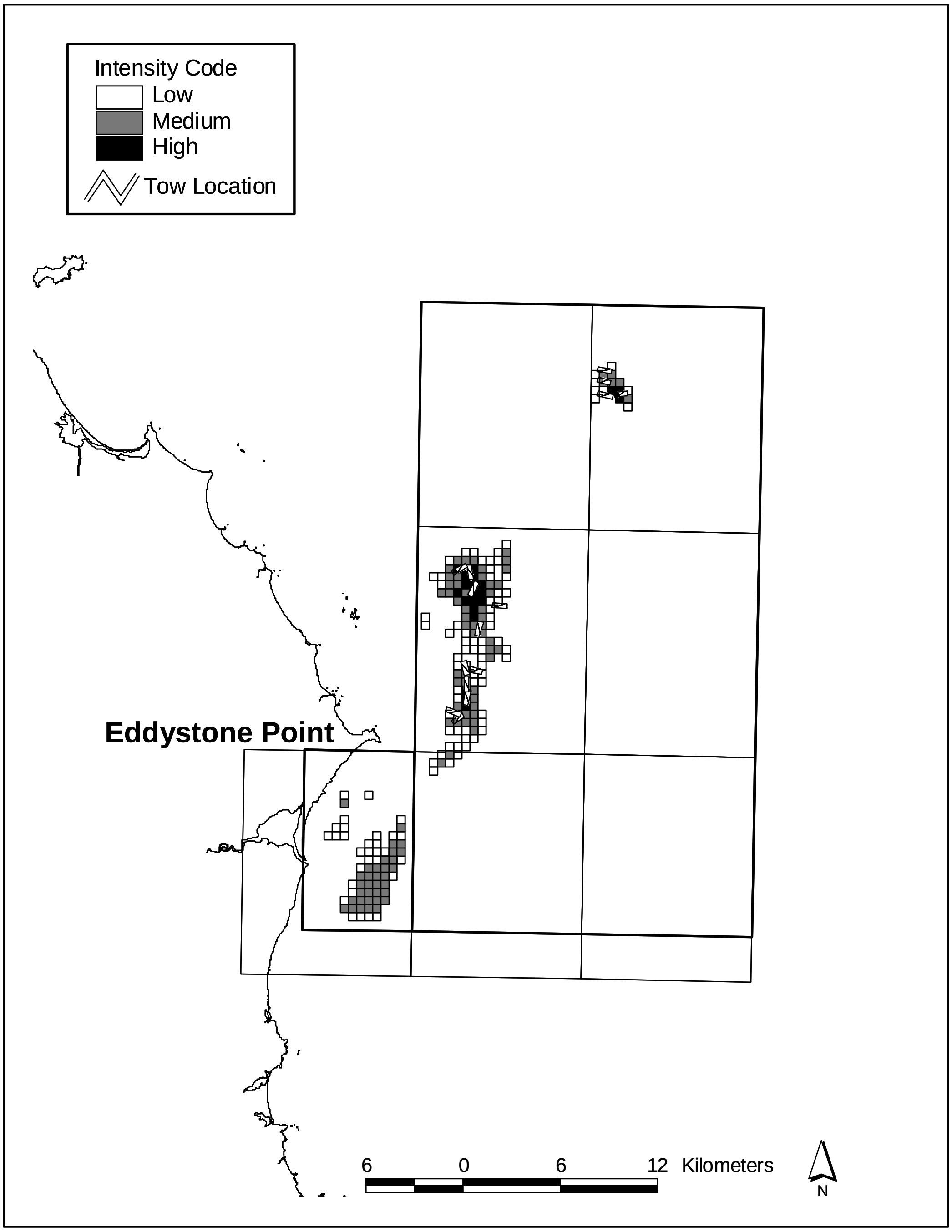


Figure 1.4: Spatial distribution of different levels of VMS inferred fishing intensity as defined within 500m x 500 m grid cells within the Eddystone Point scallop bed. The location of individual sample tows within each fishing intensity category are illustrated.

1.3 Results

1.3.1 Non-technical results summary

- During the 2003 Tasmanian commercial scallop fishing season, dredge fishing effort was observed to occur within a very small region of the total area available to fishing. This is evidenced by the clustering of the majority of fisher catch return data into one fishing locality block (Figure 1.2); the tight grouping of Vessel Monitoring Position (VMS) data into several small, discrete patches (Figures 1.3

and 1.4); and the very small area that 50% of VMS inferred fishing effort was determined to have occurred within (the two lightest colors in Figure 1.5).

- In fact, approximately half of the observed VMS fishing was found to occur within approximately 0.85% of the total available open area (i.e. the two lightest colors in Figure 1.5).
- The community of animals found within areas that were fished at high intensities (i.e. the black squares in Figure 1.4) were different to those found within moderate (grey squares in Figure 1.4) and low (white squares in figure 1.4) fished areas.
- Heavy fished areas contained no screwshells or their associated hermit crabs, while moderate and low fished areas contained relatively high abundances of this species (Table 1.3).
- The distribution of these animals could in part be explained by water depth (Table 1.4), with scallops occurring within water depths > 57 meters (high values to the right of Figure 1.6A), and high abundances of screwshells and their associated hermit crabs occurring within water depths < 55 m (high values to the left of Figure 1.6B)
- If fishing effort is representative of scallop abundance, then areas containing very high abundances of scallops (most heavily fished areas) cover areas in the vicinity of 1 x 1 km and 0.5 x 0.5 km x 5km's (signified by the lower C values in Table 1.1 and the small areas of heavy VMS inferred fishing effort in Figures 1.3, 1.4 and 1.5).

1.3.2 Distribution and extent of fishing effort within the open region

From July 29th to November 30th 2003 approximately 3,000 tonnes shell weight of scallops were recorded as being caught from within the 886.7 square kilometre open area of the Tasmanian scallop fishery to the east of Eddystone Point. Fisher catch return data, recorded at the spatial scale of fishing locality block (approximately 10.5km x 14km scale) showed that 779.7 square kilometres, or 88% of the total open area, was fished (i.e. only one locality block had no fishing effort recorded from within it) (Figure 1.2). There were, however, large variations in the relative amounts of fishing effort within each locality block, with 64% of effort occurring within the heaviest fished locality block and no effort recorded in one locality block (Figure 1.2).

A plot of the raw VMS data showed that fishing effort was clustered into four distinct areas of fishing activity (Figure 1.3). This distribution, in general, concurred with the fisher catch return data for some locality blocks, but not in others (Compare Figures 1.2 and 1.3). Grouping the raw VMS data into kernel home ranges showed that 50% of VMS inferred fishing effort occurred within approximately 7.55 square km, or 0.85%, of the available open area; and 95% of fishing effort within 105.08 square km (11.85%) of the open area (Figure 1.5). The majority of licensed scallop vessels were recorded within all areas identified as being fished

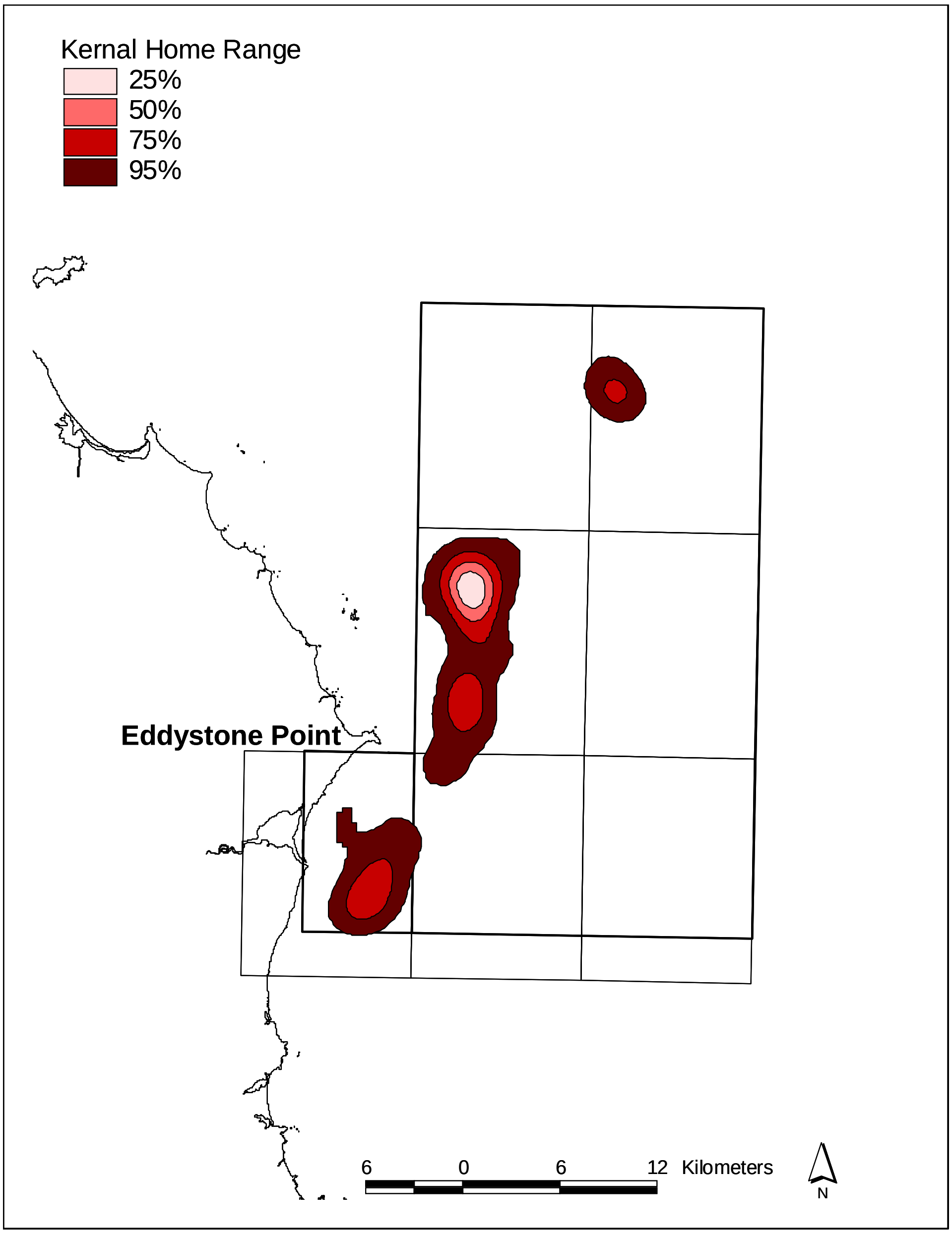


Figure 1.5: Fixed-kernel home ranges at the 25%, 50%, 75% and 95% utilisation distributions for all scallop vessels fishing during the 2003 commercial scallop fishery near Eddystone Point.

1.3.3 Measuring the patchiness of fishing effort at different spatial scales

There were obvious differences in the distribution of VMS hits within the three 10km x 10km windows used in this section of the study, with one window containing 46% of total VMS polls, and the remaining windows 25% and 29% of the total VMS polls (Table 1.1). Fishing effort was also found to be patchy at all measured spatial scales; however, there was a general decrease in patchiness with decreased spatial scale (Table 1.1). Large decreases in the patchiness of fishing effort distribution occurred between the 5km x 5km and 1km x 1km scales and 1km x 1km and 500m x 500m scales (Table 1.1).

Table 1.1: Patchiness of VMS inferred fishing effort at different spatial scales in 2003. The patchiness was calculated within different grid cell subunit sizes of 5km x 5km, 1km x 1km, 0.5km x 0.5km and 0.25km x 0.25km cells. C denotes the mean coefficient of patchiness, calculated over all grid cells falling within each scallop bed zone (south, middle and north – see Figure 2.3). % of total VMS polls indicates the proportion of VMS polls falling within each 10km x 10km scallop bed.

Spatial scale		5 x 5	1 x 1	0.5 x 0.5	0.25 x 0.25
Number windows		4	100	400	1600
Scallop bed	% of total VMS polls	C	C	C	C
South	29	730	109	32	10
Middle	25	935	110	41	13
North	46	3265	264	76	22

1.3.4 Assessing the benthic communities found in regions impacted by different levels of fishing intensity

Comparison of the catch data from each fishing intensity area identified some significant differences in the total species caught (Table 1.2), with pair-wise comparisons identifying higher abundances of total species within moderate fished areas compared to heavily fished areas. No other significant differences were identified for total catch, dead shell catches or scallop catches (Table 1.2). Significant differences in the benthic communities collected within each fishing intensity area were also identified (ANOSIM: Global R = 0.424, p = 0.006). Pairwise comparisons identified these differences to be between heavily fished and moderately fished samples (p = 0.03) and heavily fished and low fished samples (p = 0.008). The main species contributing to approximately 30% of the observed differences were very high abundances of hermit crabs associated with empty New Zealand Screw shells, *Paguristes tuberculatus*, and New Zealand Screw shells, *Maoricolpus roseus* in moderate and low fished areas, but their complete absence within heavily fished areas (Table 1.3).

Table 1.2: Results of the 1-way ANOVA examining differences in total species caught, total individuals, total catch, *P. fumatus* dead (dead scallops)and *P. fumatus* (live scallops), found within each fishing intensity area, averaged per 1000m^2 sample dredge tow. The asterisk denotes the only significant *P* value. All degrees of freedom = 2. Variables that were $\log_{10}$ transformed are identified with a $^{\#}$.

Variable	F	*P*
Total species	4.0	0.047*
Total Individuals$^{\#}$	2.79	0.101
Total catch$^{\#}$	1.613	0.240
P. fumatus dead (dead scallops)$^{\#}$	2.901	0.094
P. fumatus (live scallops)	1.154	0.348

Results of the PERMANCOVA showed that depth was an important explanatory variable in the distribution of abundance of scallops and screwshells (Table 1.4); however, depth alone did not account for all observed differences with fishing intensity (Table 1.4). Scatter plots of scallop / screwshell abundance against depth showed that high abundances of screwshells / hermit crabs were generally found in depths < 56m, and high scallop abundances occurred within depths > 56m (Figures 1.6a and b). Heavy fishing intensity areas fell within a relatively narrow depth range of 57 – 60m, while moderate and low fished sample locations occurred across the entire depth range of the area surveyed (53 - 64 m).

Table 1.3: SIMPER output for Tasmanian benthic community data indicating average abundance (Av. Abund.) per sample, ratio (average similarity / standard deviation similarity) and cumulative % similarity of the three species which most clearly distinguish (between groups) the main significantly different fishing intensity groups of the Tasmanian fishery study site.

Species Name	Heavy Av. Abund.	Moderate Av. Abund.	Ratio	Cumulative % Similarity
Screwshell Hermit Crabs	0.00	2238.85	1.78	24.59
Maoricolpus roseus	0.00	139.93	1.78	36.88
Chlamys asperrimus	60.84	6.55	1.63	43.44
	Heavy Av. Abund.	Low Av. Abund.	Ratio	Cumulative % Similarity
Screwshell Hermit Crabs	0.00	896.46	3.55	23.07
Maoricolpus roseus	0.00	56.03	3.55	34.60
Chlamys asperrimus	60.84	1.55	1.39	42.77

Table 1.4: Results of the PERMANCOVA analysis using fishing intensity as the factor, abundances of screwshells and commercial scallops as the variables, and depth as the covariate.

Source	df	ss	F	P (perm)
Covariable – depth	1	2411.3	20.59	0.001
Fishing Intensity	2	5093.5	21.74	0.002
Residual	11	1288.3		

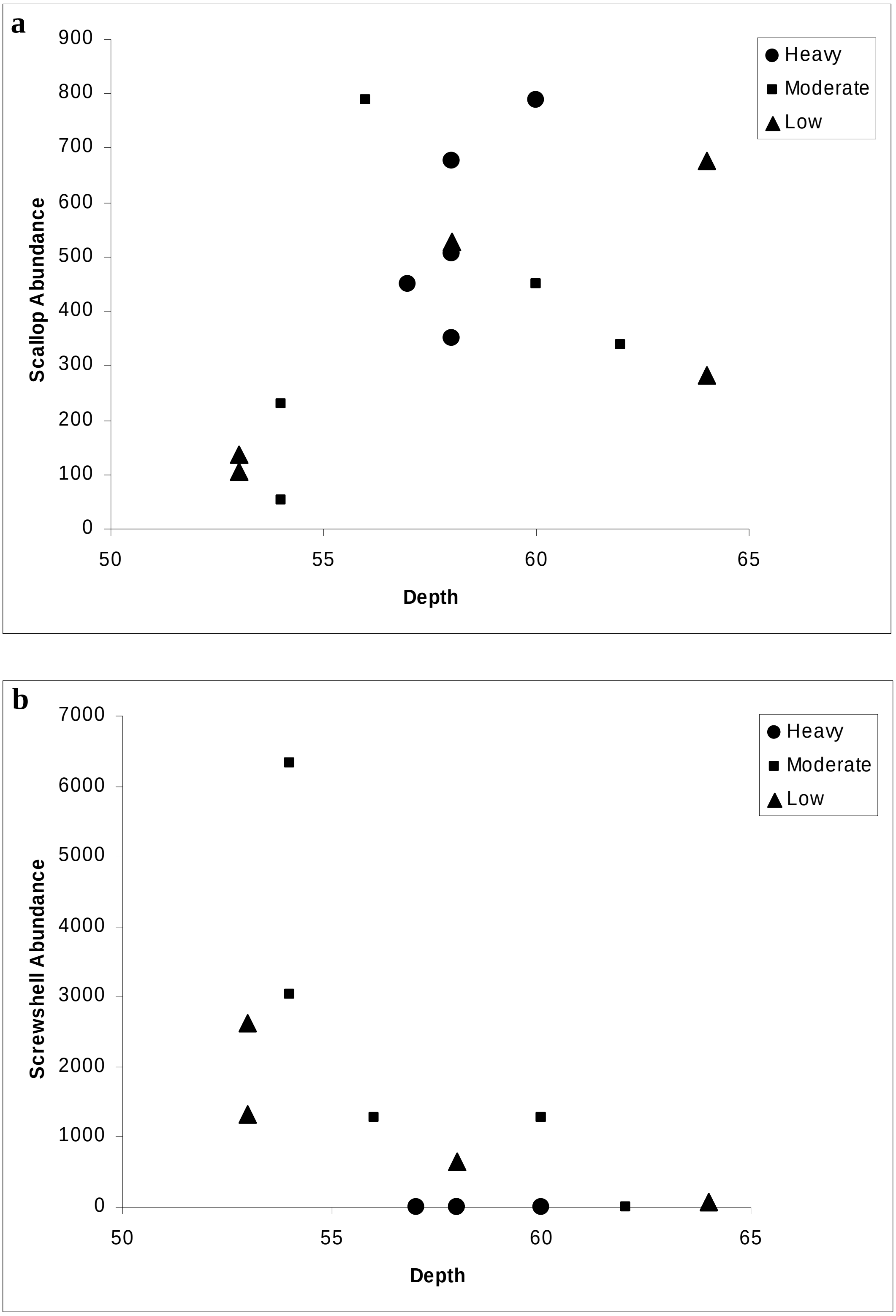


Figure 1.6: Scatterplots showing the abundances of a) commercial scallops and b) Screwshells (including hermit crabs) with sample location depth for each fishing intensity category (Heavy, Moderate and Low).

1.4 Discussion

The distribution of VMS inferred fishing effort of vessels participating in the 2003 Tasmanian scallop fishery to the east of Eddystone Point, Tasmania, showed that the majority of fishing activity occurred within four small regions within the total available fishing ground. If fishing effort is assumed to correlate to regions where higher scallop catches per unit time occurred, which in turn would correlate to higher abundances of scallops on the benthos, then scallop beds to the east of Eddystone Point consist of centralised areas of high scallop abundance (scallop beds), occurring over the spatial scale of km's x km's; which are surrounded by areas of low scallop abundance or no scallops / other habitats. During the 2003 Tasmanian scallop fishery, a significant proportion of the annual TAC (approximately 70%) was caught from the four regions of higher fishing effort, with approximately $^{1}/_{3}$ of the annual TAC (1, 500 tonnes shell weight) estimated to have been caught from a 3.6km x 2.6 km area, or 0.85% of the total available / open area. The degree of patchiness of VMS inferred fishing effort data was also observed to decrease with decreasing spatial scale cells, with the highest observed declines occurring within the 1km x 1km and 500m x 500m measured spatial scales, suggesting that fishing became more random at the scale of scallop beds (km x km scale). Such fine-scale patterns of fishing effort would not have been observed had only fishery statistical data been used (i.e. this data suggested 88% of the total available area was fished).

The relatively fine scale spatial distribution of scallop fishing effort / scallop beds has important implications for closed-area fisheries management strategies. With respect to fisheries for scallops, several approaches of closed-area management have been both suggested, and applied worldwide. Smith and Rago (2004) suggested that, with respect to maximising fertilised egg production, there is greater value in locking up high density scallop beds and fishing low density scallop areas; seabed closures within the Georges Banks and Mid-Atlantic sea scallop fishery, aimed at protecting groundfish stocks, were found to significantly increase the abundance of scallops, with successful but limited commercial harvests occurring within the closed-areas (Stokesbury 2002); while the spatial management strategy in the Australian Commonwealth commercial scallop, *Pecten fumatus*, fishery is to close a relatively small abundance (approximately 400 tonnes shell weight) of known scallop stocks as a broodstock, and open the rest of the available grounds to fishing (see Haddon *et al.* 2006), however, this fishery has been categorised as overfished and closed until at least 2009.

The relatively low TAC (4230.2 tonnes shell weight) and spatial distribution of fishing effort / scallop beds observed within the Tasmanian scallop fishery during the 2003 commercial season supports a closed-area spatial management approach where most of the fishery is closed to fishing operations, and only small areas of known stocks are opened to commercial harvest. Such a strategy would also benefit the current requirements for ecological assessment of fisheries, as under such a strategy the majority of the available fishing grounds are protected from the impacts of dredge fishing. Results presented in this study suggest that the spatial scale of open areas could be as small as individual scallop beds (km's x km's), with no significant drop in overall catches. However, to open a scallop bed to commercial harvest, the abundance of scallops within a given region needs to be a commercial quantity (i.e. relatively high abundances) and meet a set of decision rules based around a legal minimum size (90 mm at widest diameter) and the proportion of undersize scallops within a region (must not be > 20% undersize). To ensure annual continuity of supply, this decision making process will also rely on information of other scallop stocks (beds) across the spatial scale of the fishery to enable harvest strategy planning.

Although the spatial management approach adopted within the Tasmanian scallop fishery has allowed a level of sustainability (i.e. annual continuity of scallop supply), with successful harvests from 2003 to 2006, and good prospects for 2007 – 2008, there has been minimal recruitment observed within the fishery since 2003. Factors which may promote large scale recruitment events, such as leaving areas of high scallop abundance within regions of the fishery as a source of recruits (see Smith and Rago 2004) need to be explored. Another unknown is what impact intensive fishing (i.e. putting the entire fleet within very small regions – scallop beds) has on soft sediment habitats dominated by scallops, and how such impact may affect the subsequent recovery of fished scallop bed habitat.

The fine-scale distribution of VMS inferred fishing effort within the Tasmanian scallop fishery has important implications for predicting the area of a fishing ground that is impacted by dredge fishing activity. Significantly different proportions of the area open to fishing were determined to be impacted depending on whether fisher catch return data (88% of total area fished) or fine scale VMS data (11% of total area fished) is used. Similarly, Rijnsdorp *et al.* (1998) suggested that, when using the 30 x 30 mile ICES rectangles used to assess fisheries within the southern North Sea beam trawl fishery, the most heavily fished regions (rectangles) were, on average, trawled five to seven times per year. However, this result may be biased because fishing effort may not be homogenously distributed within each heavily fished block. In fact, Rijnsdorp *et al.* (1998) looked at the fine scale distribution of trawl frequency within this fishery to estimate that, within the most heavily fished ICES statistical rectangles of the North Sea, 5% of the surface area was trawled less than once in 5 years and 29% less than once in a year. The surface of the sea bed that was trawled between 1 and 2 times in a year was estimated at 30%; while 9% of the sea bed was trawled more than 5 times in a year.

Results of the opportunistic scallop dredge survey conducted within the fished region east of Eddystone Point showed that 500m x 500m grids defined as being fished at low and moderate intensities were dominated by very high abundances of live and dead New Zealand screw shells and their associated hermit crabs, predominately *Paguristes tuberculatus*; and contained significantly different benthic communities than those found within 500m x 500m grids defined as being fished at heavy intensities, which contained no screw shells and their associated hermit crabs. This result could imply that fishing has removed non-target species (screw shells and their associated hermit crabs) from the heavily fished areas, and as such, fishing disturbance and the level of this disturbance has impacted the benthos. It is generally accepted that trawl and dredge fishing can have a high impact on benthic communities, both in the short-term (e.g. Guerra-Garcia 2003, Dolmer *et al.* 2001, Ball *et al.* 2000, Bergman *et al.* 2000, Currie and Parry 1999) and the long-term (e.g. Ball *et al.* 2000, Beukema *et al.* 1999, Bradshaw *et al.* 2001, Frid *et al.* 2000). However, given the apparent separation of high abundance scallop and screwshell habitats with depth, the grouping of VMS inferred fishing intensity data into 500m x 500m blocks appears more likely to have defined fishing behaviour over habitat types that existed prior to fishing rather than identifying the effects of fishing. The scallop bed examined in this study appears to have predominately settled in a narrow depth range (approximately 57 – 60 m – heavy fished), with surrounding regions (shallower and deeper water 53 – 64m – medium / low fished) containing higher abundances of other species.

1.5 Conclusions

In conclusion, the results of this study showed that research looking at the distribution of habitats, fishing effort and changes in habitats resulting from fishing must use spatial scales of sampling relevant to the distribution of habitats present within the study area in order to avoid misinterpretation of results and incorrect conclusions, especially with respect to fisheries management planning. Furthermore, determining the relationships between the level of fishing intensity, possible impact on the benthos, and recovery of the benthos after fishing is essential under a detailed spatial management regime in order to promote sustainable fishing and to ensure that long term, and possibly irreversible damage to scallop habitat does not occur.

2. THE USE OF INDUSTRY-BASED SURVEYS AS THE PRINCIPLE DATA COLLECTION MECHANISM WHEN SPATIALLY MANAGING A DREDGE FISHERY FOR SCALLOPS

2.1 Introduction

In recent years there has been a worldwide expansion in the use of closed-area spatial strategies to manage sessile sedentary species that exhibit patchiness in both their distribution and abundance (see Myers *et al.* 2000; Holland 2003, Beukers-Stewart *et al.* 2004; Orensanz *et al.* 2006). Such management regimes require information about available stocks at spatial and temporal scales appropriate to the management used (see Orensanz *et al.* 2006). Data collection, however, will be affected by a number of factors, including the resources available to management (generally related to the value of the fishery), the specific legislation and policies applicable to a fishery, and the biology and ecology of the target species. For large scale, high value fisheries, such as the off-shore United States sea scallop, *Placopecten magellanicus* (Gmelin, 1791), fishery, management and research organisations have sufficient funding to undertake intensive spatially stratified abundance surveys conducted at the scale of fishery (see Stokesbury 2002; Stokesbury *et al.*2004). Such surveys provide the detailed high quality data needed to make defensible decisions concerning openings and closures within a fishery. In contrast, smaller scale, lower valued benthic fisheries may not be able to obtain sufficient funds to allow scientific surveys to be conducted at the scale of the fishery. Therefore, the collection of the information needed for the successful implementation and operation of spatial management within such fisheries will ultimately rely on the development of alternative low cost data collection strategies that can provide credible stock information at a quality and scale appropriate to the management used.

One solution to the problem of data collection in relatively low value fisheries is to use fishers and fishing vessels to conduct surveys, largely independent of management and research (Industry-based surveys). Traditionally, surveys conducted on fishing vessels have required formal observers to be on board the surveying vessel as a means of co-ordinating the survey, ensuring that survey procedures and processes are adhered to, identifying any by-catch caught, and to ensure that credible data are obtained. These requirements ultimately add to the costs of operation and limit the spatial and temporal scales of data collection. But fishers are often willing and capable of collecting useful fisheries information independent of observers, and they may provide a platform for the collection of substantial quantities of data that are of suitable quality for managing a fishery. Despite this, there are limited examples in the literature of Industry-based surveys being the principle fisheries data collection method. The best example would be the collection of acoustic data for the management of many pelagic fish species throughout the world (see ICES 2007). However, acoustic data can be automatically generated and stored, meaning there is little concern for the quality of information obtained. Conversely, examples of fishers being solely responsible for the recording of biological and abundance data from sample trawls or dredges under survey conditions are rare. This is because management and research agencies have in the past been unwilling to trade-off data accuracy and precision with improved spatial and temporal scales of data collection. However, the increasing application of spatial harvest strategies with their sometimes high data needs (see Harrington *et al.* 2007) combined with the ever increasing costs of operating scientific surveys will ultimately force fisheries managers to consider such trade-offs.

This chapter compares and contrasts the benefits and weaknesses of fishery-independent scientific surveys and surveys conducted solely by fishing vessels and their crew, under minimal direction and observation from management and research (Industry-based surveys). In particular, comparison of the spatial range of survey and the quality and quantity of data obtained will be made. Furthermore, the ability to improve data quality and quantity through the use of electronic measuring and recording devices will be evaluated. Finally, the essential governance requirements allowing Industry-based surveys to be the primary data provider for the spatial management of the Tasmanian commercial scallop (*Pecten fumatus,* Reeve, 1852) fishery will be discussed.

2.2 Materials and Methods

2.2.1 The Tasmanian Scallop Fishery

The Tasmanian commercial scallop (*Pecten fumatus,* Reeve, 1852) fishery is relatively small scale, with a Total Allowable Catch (TAC) of 4,253 tonnes shell weight, at a value of approximately $7AUS million in 2006. The area of the fishery extends between 3 and 20 nautical miles into Bass Strait (the body of water between Tasmania and mainland Australia – refer to Figure 2.1) and 200 nautical miles out from the remainder of the State's coast. Fishers generally operate within 3 nautical miles of the east coast in water depths between 20 and 70 meters. This represents approximately 400 km of coastline for which fisheries data must be obtained.

Vessels use a steel box dredge and all operate using similar fishing techniques and strategies. Commercial operations typically consist of 5 to 20 minute tows, and catch rates of approximately 5000 kilograms shell weight per fishing day are needed to maintain an economical level of harvest. Regulations require that product be landed whole and processed on land, and scallops are sold with their roe still attached. The fishery is seasonal, with commercial operations traditionally occurring between June and November each year. The closed season primarily aims to protect newly settled scallop spat from the impacts of fishing but also ensures the scallops are in good condition when harvested, as *P. fumatus* spawns in winter/spring and loses condition post spawning. Compliance with spatial and temporal management restrictions is achieved through a satellite vessel monitoring system, which all licensed scallop vessels are required to have fitted and operational. The funds needed to manage and research the fishery are obtained through levies placed on the quota holdings of scallop license holders. Given the relatively low value of the fishery, the management and research organisations responsible for the fishery operate on a relatively small budget.

Since 2003, the Tasmanian commercial scallop fishery has been managed under a closed-area spatial harvest strategy. Under this management strategy the majority of the available fishing grounds are closed to fishing. Generally, only relatively small (in the order of 10's km x 10's km) discrete areas known to contain at least one scallop bed that fulfil a number of management criteria are opened to commercial harvest during the fishing season. To open a region of the fishery, the size of a scallop bed and catch rates (abundance) of scallops within the bed must be considered commercial in quantity. Although no specific parameters are placed on the bed size and abundance levels required, the bed must be kilometres by kilometres in size and catch rates must be at least 30kg per five minute survey tow. Industry members play an important role in determining if a region or scallop bed is of commercial value or not. The scallop population surveyed within a scallop bed must contain greater than 80% legal size scallops (90mm legal minimum size). The legal minimum length and 80% rule is designed to ensure that scallops have the opportunity to achieve at least two successful major spawning events before they can be commercially harvested (i.e. a scallop of 90mm diameter is at least 3+ years old and has achieved at least two major spawning events – see McLoughlin 1994; Haddon *et al.* 2006). Industry also consider scallop condition as important for determining when to open an area, as markets require scallops to be less than 80 individuals per kg and for roe condition to be at least partially developed. Any delays to fishing due to poor condition are generally left to an informal Industry code of practice, which operates independently of the government management organisation responsible for the fishery.

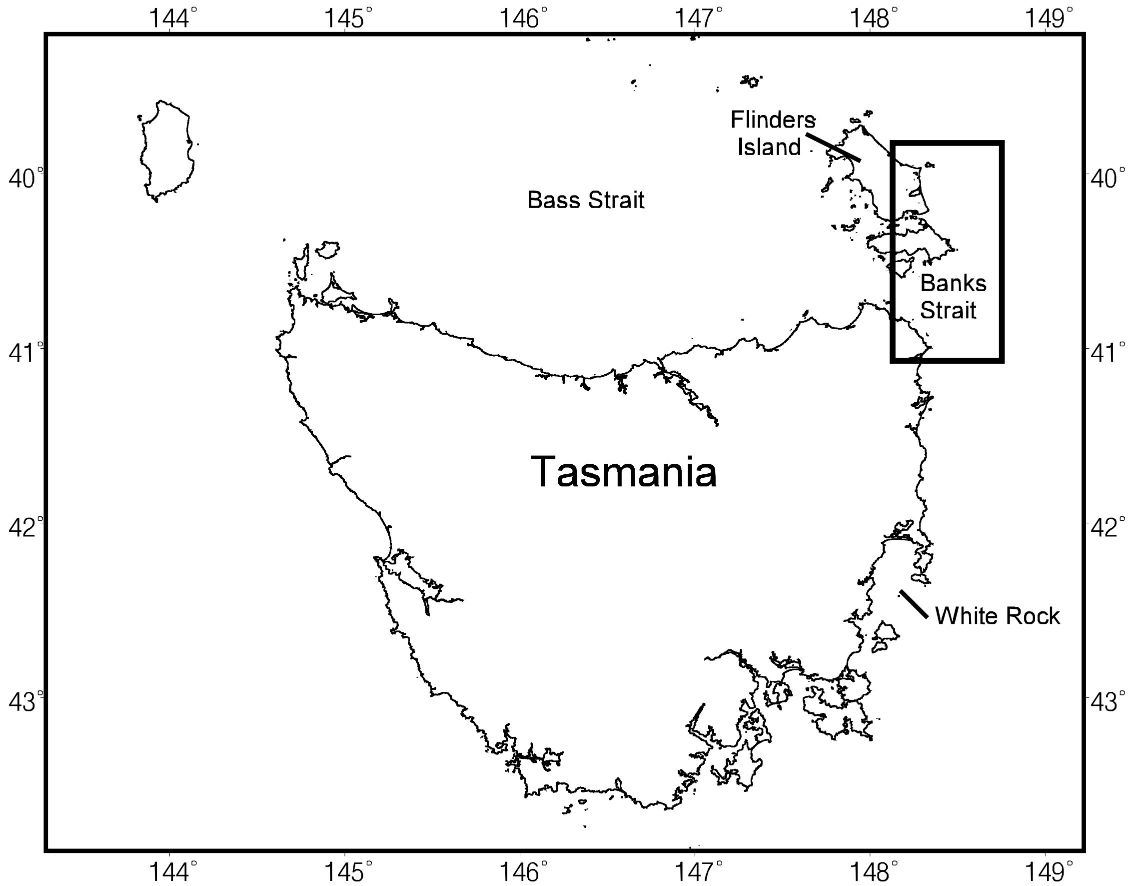


Figure 2.1: Location of the 2005 fishery-independent and Industry-based surveys conducted within Banks Strait and east of Flinders Island (boxed). The location of White Rock, where scallop population data was obtained (length frequency analysis) is also identified).

Although management and researchers acknowledge the need for a formal stock assessment, the costs associated with completing this task at the scale of the fishery and a lack of information on key fishery parameters, such as gear efficiency and scallop catchability, makes precise biomass estimates and fisheries assessments inherently difficult. Instead, a level of insurance against over-fishing of adult spawning stock, and minimisation of the impacts of fishing on both new scallop recruits and suitable scallop habitat is accomplished through the closure of the majority of the fishing grounds during the open season and seasonal closures of the entire fishery. Regardless, in order for a region of the fishery to be opened, the current spatial harvest strategy and management decision rule process requires information about the resources available and the abundance and size structure of surveyed scallops within this resource at a minimum scale of scallop bed (generally km's x km's for *P. fumatus* - see Harrington *et al.* 2007 and Chapter 1 of this report). At the same time, the formation and implementation of longer term contingency plans and harvest strategies requires information at the scale of the fishery. Given the adaptive nature of management of the Tasmanian scallop fishery, information is sometimes needed in near real time. This information must not only be collected in a cost effective manner but the information obtained must be considered credible (i.e. of suitable quality) so that management and research organisations can justify its use in the management of the fishery.

2.2.2 Fishery-independent versus Industry-based surveys

From 2000 to 2003, fishery-independent scallop surveys provided much of the fisheries data needed to make decisions concerning the Tasmanian scallop fishery. In March 2005, a similar strategy of fishery-independent scallop survey was conducted as part of a large scale scallop research project. However, funding was only available for approximately two days of survey time, which in turn limited the spatial scale of exploration to a region known as Banks Strait and East Flinders Island (see Figure 2.1). The survey was conducted on board the chartered fishing vessel, the 'Dell Richey II' with the same equipment and fishing techniques used during normal commercial operations. The only exception was the fitting of a mesh liner to create the mesh dimensions 23 by 35 mm to allow the retention of small scallops. The survey was co-ordinated and conducted by two scallop researchers, using the vessels crew as support.

Since 2003, Industry-based surveys have been trialled and developed as the main data collection mechanism within the Tasmanian scallop fishery. Throughout the 2005 commercial scallop season, Industry-based surveys were conducted within all closed regions of the fishery. During July 2005 an Industry-based survey was conducted within the same region of the Tasmanian fishery that was surveyed during the March fishery-independent survey. Ten scallop vessels and their crew agreed to survey. The skipper of the scallop vessel "Karmin" was designated the role of co-ordinating the vessels, and he was ultimately responsible for ensuring that participating vessels adhered to the survey plan.

The aim of both the fishery-independent and Industry-based surveys was to determine the relative abundance and population size structure of scallops within several known beds of scallops east of Flinders Island (see Figure 2.1) and to explore nearby data-poor regions of the fishery. During the fishery-independent scallop survey, the abundance of scallops per sample tow was estimated by counting all scallops caught within an individual sample tow, or when numbers were large, a total count was estimated by counting all scallops within a randomly selected sub-sample, and then scaling to 100%. During the Industry-based survey, scallop abundance was estimated by the vessel skipper based on his experience with catching and estimating scallops during normal fishing operations. Scallop abundances were standardised to the number of individual scallops caught per five minute sample tow. The population size structure was determined by measuring approximately 100 randomly selected scallops during the scientific and 50 scallops during the Industry-based surveys (or all scallops caught if numbers were less than this). Scallops were measured to the nearest mm using a manual scallop measuring board.

The spatial distribution and quantity of data obtained during each survey was visually compared as abundance plots mapped in Arcview 3.1 for Windows. Spearman’s Rank Correlation coefficient was used to compare the spatial distribution of scallop abundance estimated during the two surveys. A grid containing 2km x 2km subunits was overlayed on the entire survey area and the average number of scallops per 5 minute sample tow was calculated for subunits containing data from both surveys. The abundance estimates within each subunit were then ranked for each dataset separately, and the correlation analysis was conducted on this dataset.

Certain minimum criteria were developed for inclusion of data collected during the Industry-based survey. To determine the number of scallops caught per standardised five minute sample dredge tow, a minimum dataset of start latitude and longitude; shot duration; and an estimate of the total catch (either total scallops or kg of scallops caught) needed to be recorded. To determine the population structure for a sample, scallops needed to be measured.

2.2.3 Manual versus electronic measuring, data logging and download

During October 2005, two scallop vessels conducted a survey within a region of the Tasmanian scallop fishery near Ille des Phoques (White Rock) on the east coast of Tasmania (refer to Figure 2.1). The crew of one vessel collected scallop population structure data using an electronic measuring and storing device; while the other vessel collected scallop measurement data using a manual measuring board and hand written data sheets. Both vessels worked in close proximity within the same bed of scallops, such that the same scallop population structure would be expected from data collected on both vessels. To compare the quality of data collected by fishers using electronic and manual measuring devices the length frequency of scallops caught on each vessel was plotted as histograms (1mm size classes). Because catches were sub-sampled for size frequency, the ratio of the sub-sample to total catch was used to scale the numbers in each 1mm size class. An estimate of the proportion of undersized scallops (< 90mm) was compared between the two data collection methods.

To compare the time saving benefits of using electronic measuring and downloading devices compared with manual measuring boards and datasheets, five members of staff at the TAFI Marine Research Laboratories were timed as they each measured 75 scallops using both sampling techniques. Times were recorded for the measuring and recording of data and the entry and download of the data separately.

2.3 Results

2.3.1 Non-technical results summary

- Compared to fishery-independent scientific surveys, industry-based surveys were cheaper, could be conducted more frequently, covered more area and collected more data (Table 2.1 and Figure 2.2).
- When fishers used manual measuring boards to measure scallops there was a bias to round measurements into groupings of 5 (i.e. peaks at 95, 100, 105, 110 in Figure 2.3 B).
- When fishers used electronic measuring boards to measure scallops, this bias was not observed (Figure 2.3 A).
- The same number of scallops could be measured and the data downloaded approximately 3.5 times faster using electronic measuring boards compared to manual measuring and data entry techniques (Figure 2.4).

2.3.2 Fishery-independent versus Industry-based surveys

A total of 81 sample dredge tows were conducted by one vessel over approximately 26 hours survey time during the fishery-independent survey, compared with 333 sample tows conducted by 10 Industry vessels over an eight hour period during the Industry-based survey (Table 2.1 and see Figure 2.2A & B). When standardised as the dredge distance per vessel per 24 hour sample period, Industry-based surveys were able to achieve close to double (1.86 times – 34,651km : 64,734km – Table 2.1) the survey distance. Industry-based survey participants showed they were able to adhere to the pre-agreed survey plan, partly through the efforts of the survey co-ordinator who provided directions over marine radio (see Figure 2.2B). This ultimately led to good survey coverage (Figure 2.2) and the collection of more detailed and extensive information (compare Figure 2.2A & B). The results of the Spearman rank correlation analysis identified a significant correlation between Industry-based and scientific scallop abundance estimates ($R = 0.796$, $P<0.001$).

The data collected during the fishery-independent survey was of better quality, with all scallop abundance and scallop measurement data being usable. Nevertheless, 90% of the Industry-based survey scallop abundance and 78% of the scallop measurement data was classified as usable (see Table 2.1). Failure to record scallop abundances or incorrect latitude and longitude co-ordinates accounted for the unusable scallop abundance data, while inconsistencies between the two datasets (tow location and abundance and scallop measurements) accounted for the unusable scallop measurement data. It must be noted, however, that the permits allowing the survey vessels to operate within closed regions of the fishery had only specified that scallop length data be collected every 4th sample tow (or 25% of tows conducted). The unusable scallop measurement data at a shot scale could still be aggregated into broader regional scallop population structure data analyses.

The costs associated with the organisation, operation and data analysis / report production was substantially lower for Industry-based surveys compared to fishery-independent surveys (Table 2.1), with the main costs associated with fishery-independent surveys being vessel charter/operating costs. Industry-based surveys, however, did rely on the retention of scallops caught within closed regions of the fishery and / or the allocation of scallop research quota.

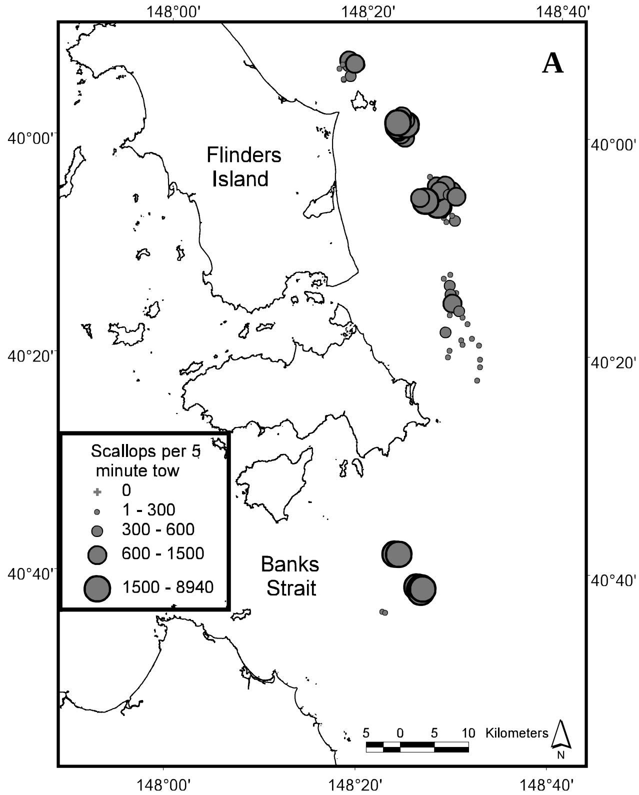
2.3.3 Manual versus electronic measuring, data logging and download

Large numbers of scallops were measured using both the manual and electronic measuring boards (34,745 and 37,355 respectively). The length frequency data collected using the electronic measuring board provided a relatively smooth representation of the size distribution of the catch representing 9.74% as undersized (Fig. 2.3A). Assuming that scallops were randomly selected from the vessel sorting tray after each sample tow, no real differences between the representation of the length frequency of the catch made using the electronic measuring board would be expected whether a scallop scientist or fisher conducted the measurements. On the other hand, with fishers using the manual measuring board the representation of the length frequency of the catch was markedly irregular. The estimate of undersized scallops was only 6.29%, which may have been an expression of an upward or downward bias during measuring. With the manual measuring board there was clearly a propensity to round measurements to the nearest 5 mm mark as exemplified by the larger than expected proportions of scallops recorded at 95, 100, 105, 110, and 115 mm shell diameter (Fig. 2.3B). This tendency to round to the 5 mm marks was not evident with the electronic measuring board (Fig. 2.3A).

Trained researchers were able to measure 75 individual scallops approximately 3.5 times faster using the electronic measuring and data logging device compared with the manual measuring board and datasheet methodology (Figure 2.4). Data entry was 6.4 times faster when downloaded from the electronic device compared to when manually entered from data sheets (Figure 2.4). It should be noted that this time saving would be greater when larger sample sizes are involved, as the time to download electronic measuring boards would remain the same, but it would take longer to manually enter data. The use of electronic measuring boards also decreased the risk of data errors, as there were fewer levels of data transfer required (i.e. one download vs. reading the measure, writing the measure down on datasheets, reading the measure off data sheets and then entering the number into a computer file). Subsequently, the credibility of the data generated is more defensible. No occasions of data loss occurred with the electronic measuring boards.

Table 2.1: Comparison of the quantity and quality of data obtained and costs associated with fishery-independent and Industry-based survey strategies.

	Fishery Independent	Industry-Based Survey
No. Vessels	1	10
Sample Tows Conducted	81	333
Survey Duration (hours)	26.5	8
Total Survey Time (cumulative hours)	26.5	75.5
Total Distance Dredged	38,260	215,780
Approximate Cost	$23,763	$3,000
Scallop Retained / Research TAC	No	Yes
Sample Tows per 24hours	73	999
Sample Tows / vessel / 24 hours	73	100
Distance Sampled / 24 hours	34,651	647,340
Distance Sampled / vessel / 24hours	34,651	64,734
% data usable - abundance data	100	90
% data usable - population structure data	100	78



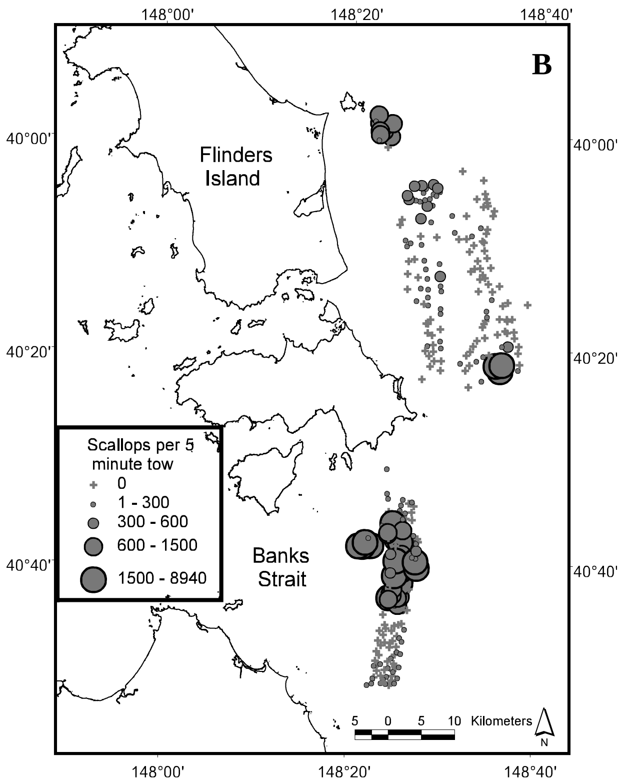


Figure 2.2: Abundances of scallops caught per standardised five minute sample tow during the March 2005 fishery-independent (A) and July 2005 Industry-based survey (B).

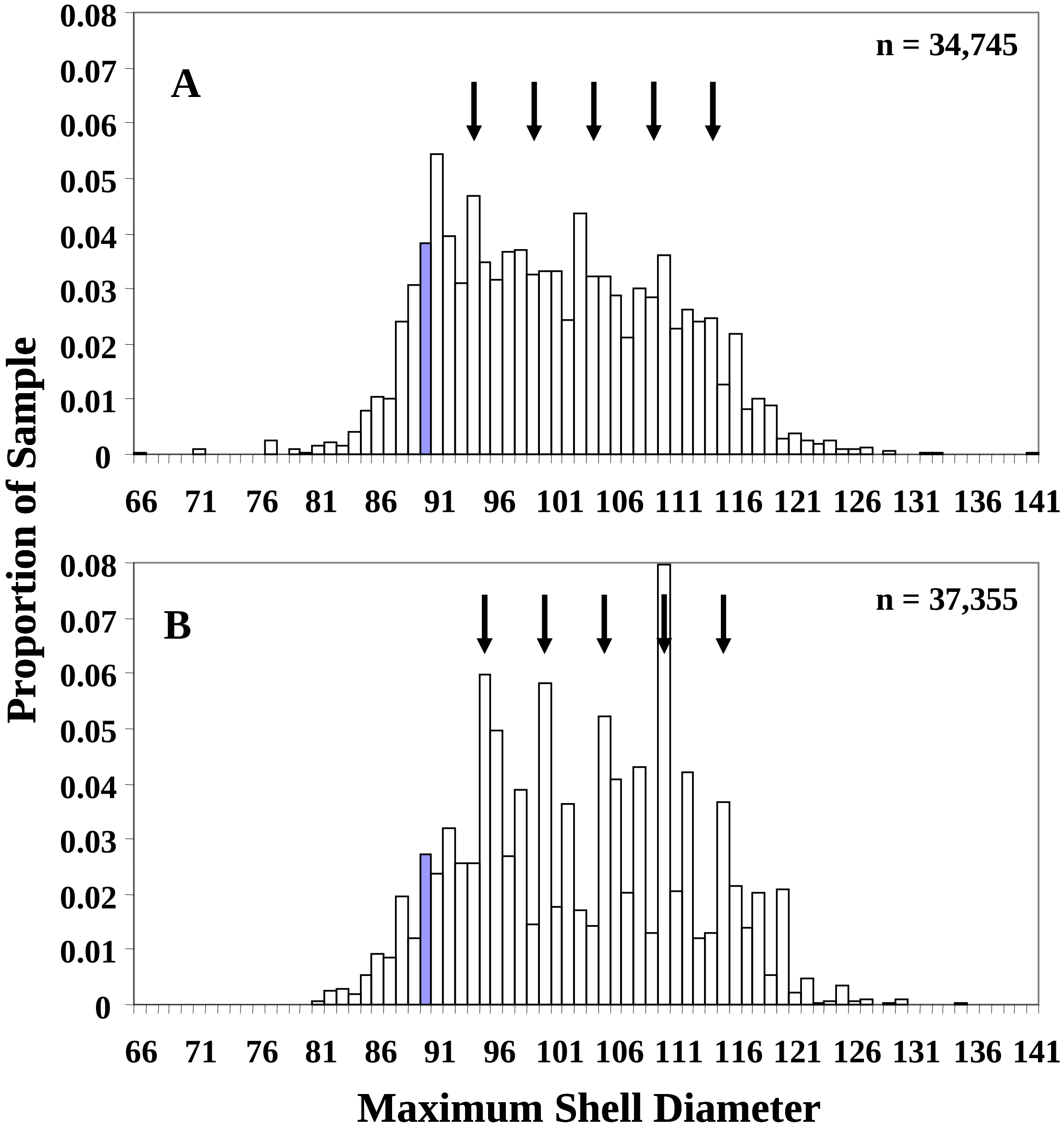


Figure 2.3: The relative frequency of different size classes of scallops (1 mm increments) caught within the White Rock region. A) Represents data collected by a vessel's crew using an electronic measuring and recording device; B) represents data collected by a vessel's crew using a manual scallop measuring board and written data sheets. The filled bar at 90 mm represents the legal minimum length and the five small arrows identify the bars representing the 95, 100, 105, 110, and 115 mm diameter shells in both diagrams.

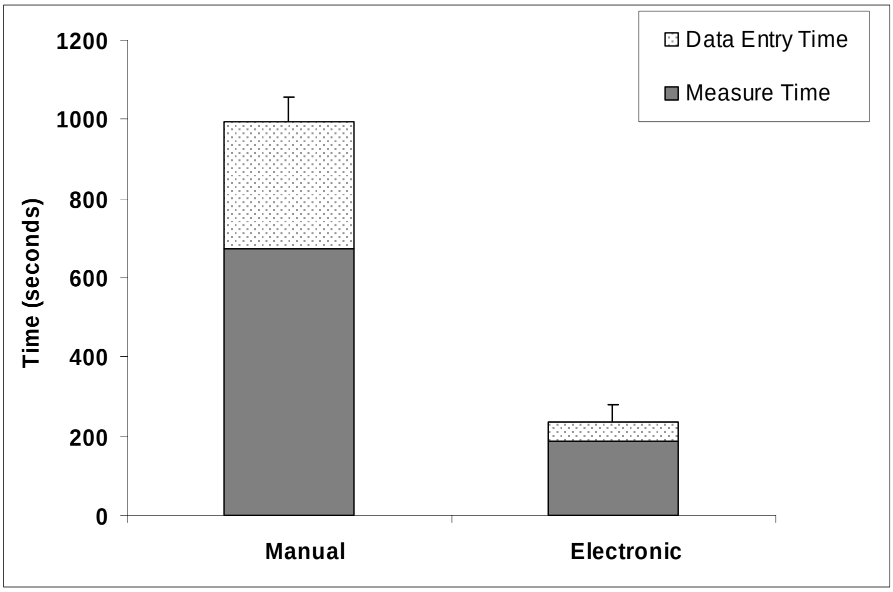


Figure 2.4: The average time taken to measure and enter / download data for 75 scallop samples using manual measuring boards and data sheets, and electronic measuring and downloading devices. Error bars represent the standard error for the times accumulated (i.e. measuring and entering times).

2.4 Discussion

There were many advantages in using fishing vessels and their crew as the primary mechanism for collecting scallop stock location, abundance and population size-structure data within the Tasmanian commercial scallop fishery. Relative to traditional scientific fishery-independent surveys, Industry-based surveys greatly improved the affordability, spatial distribution of exploration, regularity of survey and quantity of data collected. Such advantages were in part due to fishers having better knowledge of where and how to fish, and most importantly, there were far more vessels available to conduct the surveys. Despite these benefits, defensible fisheries management decision making processes require a level of confidence that the data collected is credible (Haggan 2001; Walters 2001). When data is collected by trained scientists during fishery-independent surveys, there are no perceived concerns regarding data quality. However, as evidenced by the lack of examples in the literature, it would appear that fisheries managers and researchers worldwide are sceptical about using Industry-based survey data collected solely by fishers as a substitute for scientifically collected data.

When fishing vessels are used during surveys, management and research organisations have traditionally required an observer or co-ordinator on board the surveying vessel as a means of improving the quality and credibility of the data collected. An observer is not necessarily required where data is automatically collected and stored, as has happened with the collection of acoustic data concerning pelagic fish stocks (see ICES 2007), because the automation eliminates management concerns of data quality and credibility. Fisheries managers and researchers may also accept Industry collected fisheries data if it is used to complement scientifically collected information (see Mackinson and Jeroen, 2006). As an example, Industry-based surveys provide the data needed to make within season decisions for the South Australian Spencer Gulf prawn fishery, with fishers themselves interpreting the data collected and directing the fishing fleet into appropriate locations. However, scientific fishery-independent surveys conducted pre-season determine which regions of the fishery are opened to fishing (S. Miller pers. comm.).

The results of this study showed that scallop fishers were capable of collecting scallop relative abundance data that was representative of the available stocks (i.e. similar to data collected by scientists) during Industry-based surveys. Furthermore, fishers were capable of collecting and recording information about where scallops were not located. Several other studies have shown that untrained volunteers are capable of collecting reliable animal abundance and distribution data as competently as more experienced scientists (Evans *et al.* 2000). For example, Foster-Smith and Evans (2003) showed that untrained volunteers could collect reliable information about the distribution and abundance of common littoral organisms on shores of the Isle of Cumbrae, Scotland. To improve the quality of data collected, fishers must be clear about survey aims and data collection requirements. This will require training of survey procedures, and in some instances, supervision by a technical person on board the survey vessel during its first Industry-based survey to ensure adequate training (see ICES 2007).

During this study, the collection of scallop measurement data with manual measuring and recording techniques during Industry-based surveys was found to have inaccuracies, with rounding up or down to multiples of 5. Such inaccuracies may prove problematic within the Tasmanian commercial scallop fishery as management decision rules require no greater than 20% undersize scallops for a bed to be opened to harvesting. More realistic and representative length frequency plots were obtained when electronic measuring and data storage boards were used. Furthermore, sampling and downloading times were approximately four times faster for electronic compared to manual and written methods. Tamelen (2004) also highlighted the many benefits of using electronic measuring and recording devices for the collection of scientific data, showing that electronic methods were three times faster than written methods. Subsequently, larger numbers of samples could be measured during the same period of time; fewer people were needed to sample (i.e. no data scribe required); and most importantly, there was an increase in data accuracy, as there were fewer steps of data transfer compared to manual and written methods (Tamelen 2004). The continued development of electronic surveying devices will be essential to ensure adequate survey coverage (in both time and space) in the future.

Several aspects of the Tasmanian scallop Industry and management structure were essential for the successful implementation of Industry-based surveys as the data collection method within the fishery. Firstly, the data collecting objectives were limited to information about scallop stocks, which meant that fishers were capable of collecting the required information. If survey aims become too complex, and detailed information is required by management and research about such matters as biomass estimates and the bycatch species caught, then trained observers and scientific surveys may be required (see ICES, 2007, Foster-Smith and Evans, 2003). The closed-area spatial management strategy implemented within the fishery acted as insurance against accepting less precise, but credible fisher collected data, because the impact of any decisions made would be restricted to a relatively small area. The small number of operators within the fishery (between 20 – 25 vessels) was easy to co-ordinate, and allowed all fishers the opportunity to participate. The sessile habit of the target species, *P. fumatus,* allowed the confirmation or monitoring of a scallop bed before decisions were made; while VMS technology provided further information of survey location and time. Tasmanian scallop fishery legislation allowed a simplistic mechanism for surveying within closed regions of the fishery and payment of research quota in-lieu of payment. However, this research payment may not be of value during years of low or no scallop availability, and alternative strategies for ensuring survey work is conducted must be developed. The management and research organisations responsible for the fishery accepted the need for flexibility within the survey process and the need to make decisions in near-real time (adaptive management). Without the capacity for such rapid decision making, Industry would have distanced themselves from the responsibility of data collection. Finally, but most importantly, scallop fishermen accepted the survey strategy, and took it upon themselves to advance the strategy as a data collection method.

The incorporation of fishers in the data collection process was found to have several other management benefits, which are usually associated with fisheries co-management strategies. For example, the fishing sector appears to have an improved perception of fairness, credibility, legitimacy and ownership towards management rules and regulations, and there is overall better relations between fishers, managers and researchers (see Pitcher *et al.* 2001). Given that fisher collected data is being used to make decisions about the fishery, there is an enhanced obligation for fishers to abide by the rules and regulations they helped create. In fact, during the course of this study fisher's first hand knowledge of available scallop stocks led to Industry initiated cooperative management strategies, which would have historically been opposed, and possibly violated, if driven by management using scientifically collected data (see Smith *et al.* 1999; Jentoft, 2000).

2.5 Conclusions

In conclusion, the results of this study have shown the potential for Industry-based surveys to be a cost effective mechanism for obtaining credible fisheries data that can be used to spatially manage a benthic scallop fishery in near-real time. Given fishers acceptance of this data collection strategy, it is hoped that the Tasmanian scallop Industry will continue to take greater responsibility in the organisation and implementation of Industry-based surveys, simplify the collection of data by incorporating technologies, such as GPS loggers and depth recorders on dredges, into survey strategies and take greater ownership of the fishery. If Industry accepts such empowerment, an Industry code of practice may eliminate the need for much of the legislative involvement in the fishery, and make the overall operation of the fishery more simplistic.

3. THE USE OF INDUSTRY-BASED SURVEYS AS A DATA COLLECTION MECHANISM: MANAGEMENT CONSIDERATIONS AND SURVEY PROTOCOLS

This chapter was written in conjunction with Rod Pearn, Principle Fisheries Manager, Tasmanian Department of Primary Industries and Water.

3.1 Introduction

In recent years there has been a growing emphasis on spatially explicit approaches to fisheries management. The management of scallops is no exception, with an increasing number of fisheries worldwide incorporating closed-area spatial management strategies into their harvesting regimes. As examples, regions of the Georges Bank sea scallop (*Placopecten magellanicus)* fishery have been closed to scallop fishing since 1994, with limited short-term harvests occurring within some closed regions since 1999 (see Murawski *et al.*, 2000; Myers *et al.*, 2000; Stokesbury, 2002; Hart, 2003; Stokesbury *et al.*, 2004); and the New Zealand scallop (*Pecten novaeselandiae*) resource found within the Golden Bay and Tasman Bay regions have been harvested under a rotational closed-area and reseeding harvest strategy since 1989 (see Marsden and Bull, 2006).

The incorporation of spatial structure into fisheries management brings with it the need to identify the appropriate spatial scales for the observation and analysis of exploited stocks (Orensanz *et al.* 2006). With respect to closed-area management strategies, there is a need for up-to-date information from both open and closed regions of a fishery. The task of collecting appropriate stock information may not be difficult for large scale, high value resources. For example, managers and scientists responsible for the off-shore United States sea scallop (*Placopecten magellanicus*) fishery have sufficient funding to undertake intensive spatially stratified scientific abundance surveys, which are conducted at the scale of fishery (see Stokesbury 2002; Stokesbury and Harris 2006). Such surveys provide the detailed high quality data needed to make defensible decisions concerning openings and closures within this fishery. In contrast, small, low valued benthic fisheries may not be able to obtain sufficient funds to allow scientific surveys to be conducted at appropriate spatial and temporal scales. The ability to fulfil management decision rules allowing openings and closures within such fisheries will ultimately rely on the development and implementation of low cost survey strategies that provide credible stock information at a quality and scale appropriate to the management system used.

The use of fishers and fishing vessels, independent of observers (Industry-based surveys) is a potential low cost survey mechanism for obtaining appropriate quantities of fisheries data. Regardless, there are few examples in the literature of Industry-based surveys as the principle data collection mechanism for the spatial management of a fishery. This is because managers have historically relied on scientifically collected data. Subsequently, managers and scientists tend to question the accuracy and precision of Industry-based survey data collection techniques, with particular concern revolving around between-vessel variation in characteristics such as instrumentation, gear efficiency and gear selectivity (see ICES 2007).

A system of unsupervised Industry-based surveys is the principle mechanism for the collection of the fisheries data needed to manage the Tasmanian commercial scallop

(*Pecten fumatus*) fishery under a closer-area spatial management regime. Following training and guidance provided by researchers, fishers are responsible for conducting, sampling and recording catch information from dredge surveys. This information is accepted as a credible source of data by management and scientists, and all management decisions are based on fisher collected data (see Chapter 2). This strategy of surveys has also been shown to improve the affordability, spatial distribution of exploration and quantity of data collection; relative to fishery-independent survey techniques (see Chapter 2).

This chapter describes the essential factors that scallop managers and scientists must consider for the successful implementation of Industry-based surveys as a fisheries data collection mechanism. All essential governance and research requirements will be discussed, with examples being specific to the rules and regulations of the Tasmanian fishery. The first section of the chapter will discuss the management and operation of the Tasmanian scallop fishery. Next, general management and research considerations will be highlighted given the legislative regulations of the Tasmanian scallop fishery. Finally, a detailed description of protocols that allow the organisation, implementation and presentation of results of an Industry-based survey within the Tasmania fishery will be described.

3.2 The Tasmanian scallop fishery

The Tasmanian commercial scallop (*Pecten fumatus,* Reeve, 1852) fishery is relatively small scale, with annual catches since 2003 being around 4,000 tonnes shell weight; at a value of approximately $7AUS million in 2006. The area of the fishery extends between 3 and 20 nautical miles into Bass Strait (the body of water between Tasmania and mainland Australia – refer to Figure 2.1 in previous chapter) and 200 nautical miles out from the remainder of the State’s coast. Fishing operations generally occur within 3 nautical miles of the east coast of Tasmania, in water depths between 20 and 70 meters. This area represents a minimum 400 km of coastline for which fisheries data must be obtained.

Vessels use a steel box dredge and all operate using similar fishing techniques and strategies. Commercial tows are typically 5 to 20 minutes duration, and catch rates of between 3,000 and 5,000 kilograms shell weight per fishing day are needed to maintain an economical level of harvest. Regulations require that product be landed whole and processed on land, and scallops are sold with their roe attached. The fishery is seasonal, with commercial operations traditionally occurring between June and November each year, with a closure outside of this period. The closed season primarily aims to protect newly settled scallop spat from the impacts of fishing but also ensures that scallops are in good condition when harvested, as *P. fumatus* spawns in winter/spring and loses condition post spawning. Compliance with spatial and temporal management restrictions is achieved through a satellite vessel monitoring system (VMS), which all licensed scallop vessels are required to have fitted and operational. The funds needed to manage and provide research for the fishery are obtained through levies placed on the quota holdings of scallop license holders. Given the relatively low value of the fishery, the management and research organisations responsible for the fishery operate on a relatively small budget.

Since 2003, the Tasmanian commercial scallop fishery has been managed under a rotational closed-area spatial harvest strategy. Under this management system the majority of the available fishing grounds are closed to fishing and in general, only relatively small (in the order of 10’s km x 10’s km) discrete areas known to contain at least one scallop bed that fulfils a number of management criteria are opened to commercial harvest during the fishing season. To open a region of the fishery, the size of a scallop bed and catch rates (abundance) of scallops within the bed must be considered commercial in quantity. Although no specific parameters are placed on the bed size and abundance levels required, the bed must in general be kilometres by kilometres in size and catch rates must be around 30kg per five minute survey tow. Industry members play an important role in determining if a region or scallop bed is of commercial value or not. The scallop population surveyed within a scallop bed must meet the minimum size criteria, where greater than 80% of scallops are at least legal size (90mm legal minimum size), before the area may be considered as a candidate open area. In addition, during fishing, discard criteria apply, and require a vessel to move away from an area if more than 20% of scallops in a tow are undersize (20% discard rate rule). This criteria provides scallops the opportunity to achieve a minimum of two successful major spawning events before they can be commercially harvested (i.e. a scallop of 90mm diameter is at least 3+ years old and has achieved at least two major spawning events – see McLoughlin 1994; Haddon *et al.* 2006) (two major spawnings criteria). Industry also considers scallop condition as important for determining when to open an area. Any delays to fishing due to poor scallop condition are generally left to an informal Industry code of practice, which operates independently of the government management organisation responsible for the fishery.

Although management and research acknowledge the need for a formal stock assessment to make decisions concerning the Tasmanian scallop fishery, the costs associated with completing this task and a lack of information on key fishery parameters, such as gear efficiency and scallop catchability, makes precise biomass estimates and fisheries assessments inherently difficult. Instead, a level of insurance against over-fishing of adult spawning stock, and minimisation of the impacts of fishing on both new scallop recruits and suitable scallop habitat is accomplished through the closure of the majority of the fishing grounds during the open season and seasonal closures of the entire fishery. Additional and permanent protection is also provided by the prohibition of using scallop harvesters in waters shallower than 20 metres, as well as in many bays and inlets. Regardless, in order for a region of the fishery to be opened, the current spatial harvest strategy and management decision rule process requires information about the resources available and the abundance and size structure of surveyed scallops within this resource at a minimum scale of scallop bed (generally km's x km's for *P. fumatus* - see Harrington *et al.* 2007). At the same time, the formation and implementation of longer term contingency plans and harvest strategies requires information at the scale of the fishery. Given the adaptive nature of management of the Tasmanian scallop fishery, information is sometimes needed in near real-time. This information must not only be collected in a cost effective manner but the information obtained must be considered credible (i.e. of suitable quality) so that management and research organisations can justify its use in the management of the fishery.

3.3 General management considerations for Industry-based surveys

Industry-based surveys were first trialled in the Tasmanian scallop fishery during 2003, and since that time a system of Industry-based surveys has been developed as the principle data collection method for the fishery. Today, fishers, under minimal direction from research, are responsible for the collection of the stock information needed to manage the fishery (see Chapter 2). The following sections (3.3.1 – 3.3.6) discuss the key management considerations, which must be acknowledged before Industry-based surveys can be implemented as a primary mechanism for the collection of fisheries stock information.

3.3.1 Minimising the possible detrimental consequences of using inaccurate fisheries data

If not correctly managed, the inclusion of fishers in the data collection process could result in the collection of inaccurate data through poor interpretation and recording of survey catches by relatively untrained fishers or as a mechanism for fishers to ensure perceived favourable management outcomes. In some instances, the use of incorrect fisheries data in the management decision making process may see unsuitable regions of a fishery being opened to commercial operations. This in turn may have a harmful impact on the future availability of a resource and may even lead to over-fishing and stock collapse. Although management initiatives will never fully alleviate the possible collection and use of incorrect Industry-based survey data, the harvest strategy implemented can spatially limit any negative management outcomes.

A number of mechanism aim to provide accurate and precise fisher collected data within the Tasmanian Industry-based survey process. In particular, education and training and the use of electronic measuring and recording technologies are integrated into the survey process. Furthermore, the closed-area spatial management strategy used within the Tasmanian scallop fishery ensures that the majority of the available fishing grounds are protected from commercial operations during a fishing season. Subsequently, if incorrect Industry-based survey data is used to open an unsuitable region of the fishery, impacts should be restricted to a relatively small region (i.e. a 10’s km’s x 10’s km’s region). Also, additional Industry-based surveys can be undertaken to map appropriate open areas and voluntary Industry code of practise closures can be applied, or if necessary, the legislated open / closed-area can be changed. In Tasmania, this latter process is rapid and takes about 1 week.

3.3.2 Transparency and participation in the Industry-based survey process

Transparency and participation are essential components of modern fisheries management regimes. Transparency is generally accomplished through all stakeholders having access to the principles, procedures, options, trade-offs and outcomes of the management process. Participation is achieved through all stakeholders having greater involvement and responsibility in the management decision making process (i.e. co-management fishery advisory committees). Similarly, Industry-based surveys should be transparent and all stakeholders should be afforded the opportunity to participate in the organisation and operational process.

Since 2008, the process and procedures that govern Industry-based surveys within Tasmania have been written into the Tasmanian scallop fishery rules and harvest policy. These documents are publicly accessible. All Industry members are encouraged to apply to conduct Industry-based surveys, and generally the only limiting criteria are if there has been poor performance during previous surveys. The number of survey participants may also be limited as a consequence of survey requirements or resource availability.

A collaborative and participative approach is taken in the planning and undertaking of Industry-based surveys. Initial survey planning and design occurs under the advice of the Tasmanian Scallop Fishery Advisory Committee (FAC). This committee has fisher, processor, conservation, scientific, compliance and management participation. An important part of the Committee is recommending what incentives and restrictions should apply for a particular survey. More detailed organisational and operational aspects of Industry-based surveys are completed by an ‘Industry-based survey sub-committee’, which has fisher, scientific and management participation. Direct consultation between scallop researchers / management and survey participants finalise survey planning. Also, pre-season stock availability summary reports and regular Industry-based survey updates are produced and distributed to all interested stakeholders (examples of these reports and updates are given in the appendices).

3.3.3 A flexible and adaptive approach to management

A number of factors can delay and alter an Industry-based survey plan; including the need for fishers to conduct commercial fishing operations, adverse weather conditions, vessel maintenance and social engagements. Industry-based surveys also provide fishers first hand knowledge of the availability and status of a scallop resource. This knowledge could lead to fishers requesting immediate changes to already implemented harvest plans. The smooth and co-operative operation of Industry-based surveys therefore relies on an adaptive approach to management and a flexible but simple set of management rules and policies. If the process of organising and operating Industry-based surveys is too complex, and management are not willing or take too long to act on survey results, fishers will distance themselves from the responsibility of data collection.

A workable and simple procedure for Industry-based surveys is continuing to evolve within the Tasmanian fishery, with new and better survey strategies being incorporated into the survey process. Also, there is a level of flexibility in the interpretation of the decision making rules and policy that allow a region of the fishery to be opened to commercial harvest. The managers responsible for the fishery are adaptive in their management approach and prepared to apply new survey and harvest strategies as required. This flexibility and willingness to be adaptive is best illustrated using an example.

A fishery-independent survey conducted in March 2005 identified a significant decline in scallop abundance within a known bed of scallops. Fishers held an obvious concern for both this and another nearby scallop bed. During a scallop FAC meeting held on the 15th June 2005, Industry requested the region be surveyed as a matter of urgency, to fully ascertain the extent of the natural die-off. An Industry-based survey was subsequently organised and conducted on the 11th and 12th July 2005. It should be noted that Industry-based surveys have been approved within 2 hours of request by fishers.

Results of the July 2005 Industry-based survey confirmed that scallop abundances had declined significantly within both known scallop beds. Regardless, scallops were still in commercial quantities and meat and roe condition would fulfil market requirements. Having first hand knowledge of these results, fishers asked that the region be opened to commercial operations before the natural mortality event affected all scallops. But the population structure of sampled scallops did not fulfil the 20% discard rate decision rule, as greater than 20% of measured scallops were smaller than the legal minimum size of 90 mm. The scallop bed, however, was known to be 5+ years old (established age by proxy as it had been surveyed previously) and subsequently met the complementary two major spawnings decision rule (i.e. scallops of 90mm diameter are in general 3+ years old and have had two major spawnings). The high densities of scallops within the beds appeared to have resulted in slow growth rates.

Management could subsequently justify opening the region to fishing, as the primary minimum biological criteria of 3+ age scallops could be established. Flexible management measures allowed a temporary legal minimum size of 80mm to be set for area and the total allowable catch to be increased for the 2005 season. To implement these changes, and open the region to fishing took 22 days from the date of the survey, and resulted in increased scallop yield from the area.

3.3.4 Use of survey incentives

The Tasmanian scallop rules, and harvest policy allow the use of several incentives to survey. These can be categorised into three broad incentives:

1. Retention of scallops from closed-areas or closed seasons during survey;
2. Research Quota Unit Allocation (RQUA); and
3. Monetary Incentives.

These incentives can be offered both individually or in combination, with the general aim of increasing the likelihood of individuals participating in any particular Industry-based survey. Any incentive or combination of incentives should ultimately aim at spreading the costs of Industry-based surveys amongst all Industry members and / or provide a financial return to participants so they can at very least partially recover their operating costs. The mix of incentive types needed to conduct surveys is recommended by the Tasmanian scallop FAC after considering the current fishery drivers and circumstances. Generally catch allocations and / or RQUA are used. Industry-based survey participants can be granted permission to retain scallops during surveys conducted during the closed season and from closed-areas of the fishery, with the amount caught to come from a fishers own quota holdings.

The Tasmanian scallop fishery rules also allow the allocation of scallop RQUA in lieu of payment for approved Industry-based scallop surveys. The scallop rules limit the Secretary of the government organisation responsible for the fishery to approving no more than 100 tonnes RQUA per year without approval by the Minister. In some instances, RQUA may be taken during a survey. The normal practice however, is to allocate the RQU to a fisher's quota holdings, which are to be taken during normal fishing operations from open regions of the fishery. RQUA may also be transferred to the following fishing season when surveys are conducted late in a fishing season.

Alternative survey incentives may be required during fishing seasons when scallop catches are predicted to be poor and scallop research quota will be of little value to a fisher (i.e. they will not even catch their own quota holdings let alone research allocations). The ability to catch RQUA pre-season (i.e. during surveys) can provide a financial benefit for survey participants, as markets may be prepared to pay more for the limited resource. Monetary incentives are particularly important during such periods. For example, the escalating cost of operating fishing vessels, in particular the high price of diesel fuel and possible poor stock or market environments may require more direct financial incentives. Within the Tasmanian fishery, all scallop quota unit holders pay a unit fee to a scallop trust account, which can be used for research and to conduct surveys.

3.3.5 Separation of survey and commercial fishing activities

When Industry-based survey participants are given the authority to conduct commercial fishing operations during a survey, some fishers may prioritise catching scallops over collecting data. This will limit the stock information obtained and may even jeopardise the status of available stocks within closed-areas of a fishery. If Industry-based survey and commercial fishing activities are separated, the collection of data will become the primary objective during a survey. If there is a need to grant permission to commercially fish during a survey period, spatial restrictions on where scallops can be caught can minimise fishing impacts to a small region of the closed-area.

Within the Tasmanian scallop fishery, survey participants are generally required to conduct survey activities prior to catching any scallops that are offered as an incentive. This is generally achieved through research quota units being allocated to a fisher's quota holding, which is to be caught from open regions of the fishery. If survey participants are allowed to commercially fish within closed regions during a survey, an agreed number of survey days or tows must be completed before commercial activities can be conducted. Furthermore, managers or scallop researchers, in consultation with fishers, will generally identify one or more relatively small areas where such operations can occur.

3.3.6 Simplification of the data collection process and accessibility of survey data

Fishermen cannot be expected to collect detailed and complex survey information, as they are not scientifically trained. Furthermore, the primary interest of Industry-based survey participants is to determine the stock status of the target species. As such, the types of data collected during Industry-based surveys should be minimised, and relate directly to within season and future season decision making and planning. If more detailed and complex data is required by researchers or management (i.e. biomass estimation/bycatch / ecosystem information) then alternative survey strategies, such as observers or scientific surveys, should be employed. Electronic measuring and storing devices, such as measuring boards and GPS loggers, have been shown to allow greater amounts of data to be collected per unit time, require fewer people to sample (i.e. no data scribe required) and most importantly, improve data accuracy, as there are fewer steps of data transfer, compared to manual and written methods (see Chapter 2; Tamelen 2004). Such devices should be integrated into the Industry-based survey protocol to simplify the data collection process.

Within the Tasmanian scallop fishery, the data collection requirements of Industry-based surveys are restricted to sample tow location (latitude and longitudes), the abundance of scallops caught per sample tow (kilograms or individual scallops) and population structure data (size measurements of a random selection of scallops). Scallop abundances are generally interpreted as being "no scallops', "low abundances – not commercial", moderate abundances – possibly commercial" and "high abundances – good commercial prospect".

The physical requirements of survey data collection has been simplified through the adoption of technological solutions. Scallops are measured with, and the resulting data stored on, electronic measuring boards, GPS technology marks the vessel location and depth loggers record when a dredge was operating during a survey. Cross-referencing the date and time for the GPS and depth data allows identification of sample tow location. The eventual aim in the Tasmanian fishery is to have a paperless system of data collection, which in turn will assist the entry and analysis of data.

Industry-based surveys have the potential for obtaining relatively large amounts of data. Researchers must therefore develop mechanisms allowing for the entry, collation and analysis of data, as well as the construction of survey reports. Also, a mechanism for archiving data for future reference is required. A number of computer programs and data-bases are available and it will ultimately be up to individual fisheries to determine what works for them. It is also vital that the results of Industry-based surveys are accessible to all Industry stakeholders. Reports should be produced at regular intervals throughout a fishing season, and distributed to all stakeholders. Furthermore, survey data should be presented during appropriate forums, such as FAC's and Industry meetings. The use of the World Wide Web a potential repository and means of easy communication is an obvious option that could be further explored.

3.4 Protocol for organising and implementing Industry-based surveys

Once it has been established that the rules and policies of a fishery can accommodate the collection of fisheries data through Industry-based surveys, there must be a simple and streamlined process for organising and implementing surveys. This process has been split into six protocols within the Tasmanian scallop fishery (see Table 3.1 for summary).

Table 3.1. Summary of the seven Industry-based survey protocols used to organise surveys within the Tasmanian commercial scallop fishery.

Protocol
1. Determine survey aims and data collection requirements
2. Agree on the type of survey to conduct
3. Selection of survey participants
4. Allocation of survey authorisations / permits
5. Specific survey design, education and training
6. Undertake survey
7. data analysis, presentation and archiving

3.4.1 Identification of survey aims and data collection requirements

The first and most important step of any survey, Industry-based or scientific, is to identify the survey aims. A clear and concise definition of where a survey is to be conducted and what it is striving to achieve will simplify all other Industry-based survey protocols. Survey aims are more readily accepted if Industry, management and research survey needs are discussed with all stakeholders involved with a fishery and survey.

The data collection requirements for Industry-based surveys must incorporate the minimum information needed to fulfill management decision rules and allow decision making processes to occur. If the data to be collected is too complex and detailed (i.e. bycatch information) then alternative survey strategies, such as observer or scientific surveys, should be used. If survey incentives are used, there may need to be an agreement between fishers and managers of how much information must be collected (i.e. how many sample tows or survey days to conduct) before an incentive is paid. However, when a fishery becomes more familiar with and responsible for the data collection process, such agreements may not be required.

3.4.2 What type of survey to conduct

A number of different Industry-based survey strategies are available, with three broad categories being used in the Tasmanian scallop fishery.

- *Pre-season surveys* – are conducted in the weeks preceding the opening of a scallop season. Such surveys generally confirm the availability and monitor the condition of known scallop resources to enable a season opening date to be set. Pre-season surveys may also be used to explore data poor regions of the fishery, with the aim of locating scallops that can be harvested during that season or in future seasons. Survey incentives may be provided.
- *Within-season surveys* – are conducted during the period of the open fishing season. Within-season surveys can monitor known scallop stocks or explore for new scallop resource and signs of recruitment. Survey incentives may be provided.

- *Out-of-season surveys* – are conducted during the closed season. Out-of-season surveys primarily aim to explore inaccessible regions of the fishery, when vessels are participating in other fisheries. In general, no survey incentives are offered, and vessels are not able to retain any catch.

For each of these temporal survey categories, Industry-based surveys may be classified as opportunistic or targeted.

- *Opportunistic surveys* – are generally conducted by scallop vessels during transit from their home port to fishing grounds. They tend to provide small amounts of information however, this data may be used to determine the location of targeted surveys. Survey incentives are usually not provided.
- *Targeted surveys* – are conducted to fulfill specific survey aims. Survey incentives are usually offered to conduct targeted survey.

A further classification of surveys incorporates monitoring surveys and exploratory survey strategies.

- *Monitoring surveys* – may utilize one or two vessels to monitor the availability and condition of scallops within a known scallop resource.
- *Exploratory surveys* – are generally used to search within data poor regions of a fishery for unknown scallop resource and / or for signs of recruitment. To maximize survey area, as many vessels as possible (i.e. > 2) are utilized. The number of vessels may be restricted by the available survey incentives.

3.4.3 Selection of survey participants

All active members of a fishery must be provided the opportunity to participate in Industry-based surveys. Fishing representatives should also be incorporated into the participant selection process to ensure a level of transparency. The specific survey selection process used must not result in survey delays or create excessive organization and paperwork for Industry, management and/or research, as both will tend to distance fishers from participating.

If management has a need for a formal set of survey selection criteria, they should weight priority to the selection of fishers and vessels with a proven record of providing high quality data. Nevertheless, criteria should not restrict participation of new fishers, as they may provide suitable data. In some instances, an applicant's vessel may not fulfill minimum survey requirements (i.e. may not have appropriate essential equipment such as power supply and vessel instrumentation – see ICES 2007), and they must be eliminated from the selection process.

Within the Tasmanian scallop fishery, an Expression of Interest (EOI) system is generally used to identify fishers interested in conducting Industry-based surveys. An EOI package is sent to all scallop license holders before the start of a fishing season, with applicants nominating both the areas they prefer to survey and the RQUA per survey day they require to survey. The details are incorporated in an Industry-based survey register and only fishers on this register are eligible to conduct Industry-based surveys. The Tasmanian scallop FAC or Industry-based survey subcommittee can select survey participants from this register according to the requirements of the survey.

An alternative granting type approach has recently been trialed. Under these strategies, a grant type agreement (with milestones) has been entered between management and the Tasmanian Scallop Fishermen's Association (TSFA). This agreement hands the selection of survey participants and much of the survey organization to the TSFA. If the survey data is obtained in the required format then the management agency provides the TSFA the grant. This process streamlines administration processes, increases co-management and transfers more responsibility to Industry. Such development becomes more possible after Industry has had some experience with and has built up trust with regards to the aims and usefulness of such surveys. Building their experience and abilities seems to lead naturally to a wish to increase their ownership and control of the processes involved in Industry-based surveys.

3.4.4 Allocation of survey authorizations

Conducting Industry-based surveys under a closed-area spatial management strategy requires a legal mechanism to allow vessels to deploy fishing gear within closed-areas of a fishery. The system used to achieve this must be relatively quick and simple to attract participants, but at the same time rigid, to deter vessels from conducting unauthorized activities. This may ultimately require the implementation of deterrents (penalties) for violating agreed Industry-based survey activities.

Under the rules governing the Tasmanian scallop fishery, the DPIW can issue survey authorizations to conduct survey and fishing activities within closed regions and during closed seasons, in compliance with the scallop rules, and policy documents. These authorisations specify the dates that the survey may be conducted and location of the survey, amount of scallops that can be retained, if any, and the data collection requirements. All participants must also accommodate an observer if required. Survey authorisations can be issued very quickly (sometimes within 1 hour).

3.4.5 Survey design, equipment, education and training

Industry-based surveys are not the appropriate mechanism for conducting highly detailed, fine scale surveys. If the information needed by management and research requires specific survey designs and sampling locations then alternative survey strategies, such as observers or scientific surveys, should be used.

Prior to an Industry-based survey, fishers, managers and researchers should agree on broad Industry-based survey strategies. In particular, survey participants must determine whether they are working together as a group, or will individually survey specific regions of interest. An effective survey design used within the Tasmanian scallop fishery is for a number of vessels to work in unison. Spatial coverage can be maximised if these vessels run along a survey transect abreast, spaced approximately 500 meters to 1 kilometre apart. The specific sample tow locations and amount of time devoted to different survey regions should in general be left to the discretion of the participating fishers, as they are best placed to determine where greater amounts of information may be required.

Prior to a survey being conducted, survey equipment and datasheets should be made available to participants. Fishers with little or no experience in conducting Industry-based surveys will generally require a level of training and education of survey and data collection techniques and use of electronic survey equipment. This induction may be done by phone, however, port visits or even having a researcher present during a first-time Industry-based survey may be required. An important component of providing survey equipment is to determine how it will be retrieved post-survey.

3.4.6 Conduct the survey

Complete the survey work under the agreed pre-planning constraints. Survey data must also be returned to the research agency as soon as possible to allow rapid analysis, presentation and use in the decision making process.

3.4.7 Survey data analysis, presentation and archiving

After a survey is conducted, data needs to be transferred to a central location and analyzed. To simplify these tasks, all data should be collected and stored using the same format during all surveys. Specific analysis and report production will be specific to individual fishery requirements. However, results should be distributed to fishery stakeholders at regular intervals throughout a season, as both written reports and verbal presentations.

3.5 Discussion

This chapter has identified a number of factors that must be considered by management, research and Industry before Industry-based surveys can become the principle data collection mechanism of a fishery. With respect to management, the agency responsible for a fishery must be flexible and adaptive in their management approach, and have the capacity to provide survey incentives such as RQUA. The rules and policy that govern some fisheries may be inflexible, and the bureaucratic requirements needed to conduct Industry-based survey within closed-areas or seasons (e.g. permits) time consuming and restrictive. For example, prior to 2008, the ability to conduct Industry-based surveys within the Australian Commonwealth Central Bass Strait Zone commercial scallop fishery required the construction of complex permits, which were temporally and spatially restrictive. Furthermore, some permit conditions were written in an ambiguous manner. The construction of such permits often took weeks to complete and there was generally a requirement for a scientific observer to be present on at least one survey vessel. That system of Industry-based surveys often created a level of concern from fishers over the meaning and interpretation of permit conditions; placed too many restrictions on survey participants; and generally created extensive time delays before a survey could be conducted. Such factors are not conducive for promoting co-operative survey strategies and fisher support for Industry-based surveys within this fishery has been low.

Although an effective system of Industry-based surveys can be created on paper, the success of this data collection mechanism will ultimately rely on management and research accepting fisher collected data as a credible source of information, and using this data in the management decision making process. A number of mechanisms for improving data credibility are available, in particular education and training, and the use of electronic measuring and storing devices. Not only can electronic measuring and recording devices increase data accuracy (Tamelen 2004), but such techniques are three to four (see Tamelen 2004 and Chapter 2) times faster than manual methodologies, meaning that a larger numbers of samples could be measured during the same period of time and fewer people were needed to sample (i.e. no data scribe required) (Tamelen 2004).

Mechanisms that improve the ability to obtain credible data from Industry-based surveys will not eliminate the possible collection of inaccurate stock information. The use of inaccurate stock information in the management decision making process has the potential to lead to overfishing and even stock collapse. These management outcomes are generally counteracted through stock assessments, which generally incorporate an estimate of the available biomass. The completion of biomass estimates and stock assessments for scallop fisheries requires detailed spatially stratified scientific surveys and information about key fishery parameters, such as gear efficiency and scallop catchability. Such information is extremely costly to obtain, making them an unrealistic approach in small scale fisheries such as the Tasmanian scallop fishery. For Industry-based surveys to be effective in the management decision making process, other management strategies must insure against poor decision making, overfishing and stock collapse. Within the Tasmanian scallop fishery, a level of insurance against inaccurate information leading to poor management decision making is accomplished through the closure of the majority of the fishing grounds during the open season and seasonal closures of the entire fishery. This management strategy therefore restricts any negative fishing impacts resulting from inaccurate fisher collected data to a relatively small region of the fishery (generally in the range of 10’s km x 10’s km - see Harrington *et al.* 2007).

The inclusion of Industry in the data collection process promotes a co-operative approach to management. Within the Tasmanian scallop fishery, the ability for fishers to collect stock information during Industry-based surveys has led to the TSFA being granted ever increasing roles and responsibilities in the Industry-based survey process. During the 2008 season, the TSFA were provided the role of selecting the four vessels needed to conduct the pre-season survey. Industry was also responsible for organising where vessels should survey, and when surveying would occur. These surveys were very successful, and highlight the ability for fishing associations to take the lead role in once historical management issues.

The future Industry-based survey vision within the Tasmanian scallop fishery is for the TSFA to be fully responsible for organising and conducting all Industry-based surveys, under a broad directive from research and management. The TSFA would be responsible for collecting pre-season and within-season information from all regions of a fishery. The collection of data would be fully electronic, to minimise the time and effort required for collection and analysis and to improve data accuracy. Furthermore, Industry envisages a near-real time web-based data sharing database, which would allow all stakeholders access to survey abundance and size distribution data and video / photo information collected during all Industry-based surveys. Ultimately, it is believed that the Tasmanian scallop fishery could be co-managed, with Industry taking full responsibility for the operational aspects traditionally undertaken by management. This topic will be further explored in the Chapter 4.

4. THE INDUSTRY ROLLING OPENING HARVEST STRATEGY: A MOVE TOWARDS INDUSTRY WITHIN-SEASON SELF-MANAGEMENT

4.1 Introduction

Over the last decade there has been a shift in the governance and management of fisheries to a broader approach that recognizes the participation of fishers, local stewardship, and shared decision-making. Through this process, fishers are empowered to become active members of the management team, balancing rights and responsibilities, and working in partnership with government. This approach to management has been termed co-management (Jentoft 2005, Yandle, 2003). Within the Tasmanian commercial scallop fishery, there are several measures that ensure a level of co-management. All fishery stakeholders have representation and a voice on the scallop Fishery Advisory Committee (FAC) that makes decisions concerning the fishery.

The incorporation of Industry-based surveys as the data collection mechanism for the management decision making process has ultimately empowered Industry with far greater roles and responsibilities. Industry have realised the importance of their role, and have fostered ownership of the Industry-based survey strategy.

Recently, the role of Industry in the management process has been extended to incorporate the operation of within season fishing arrangements. During the 2006 scallop season the Tasmanian Scallop Fishermen's Association (TSFA) took full responsibility for an Industry initiative that aimed to maximise the quantity and quality of scallops harvested from the area opened by the management agency. This chapter describes the events of the 2006 scallop season, and details the Industry driven and operated rolling opening harvest strategy that was implemented. Industry's attitude to the arrangement, determined through a questionnaire process, will also be presented.

4.2 The White Rock open area

An Industry-based survey conducted during October 2005 discovered a substantial area of predominately legal size scallops within a region of the Tasmanian scallop fishery located between Freycinet Peninsula and Maria Island (see Figures 4.1 and 4.2). This scallop bed was referred to as the White Rock scallop bed by fishers. A component of this scallop bed fell within the East Coast Waters Shark Refuge Area (SRA), which under government policy could not be dredged. On the 29th March 2006, the Tasmanian scallop FAC recommended that the component of White Rock scallop bed not falling within the SRA be opened to commercial harvesting from the 13th June 2006 (see Figure 4.3). A requirement of this recommendation was that a pre-season survey be conducted to confirm the availability and condition of scallops for harvesting.

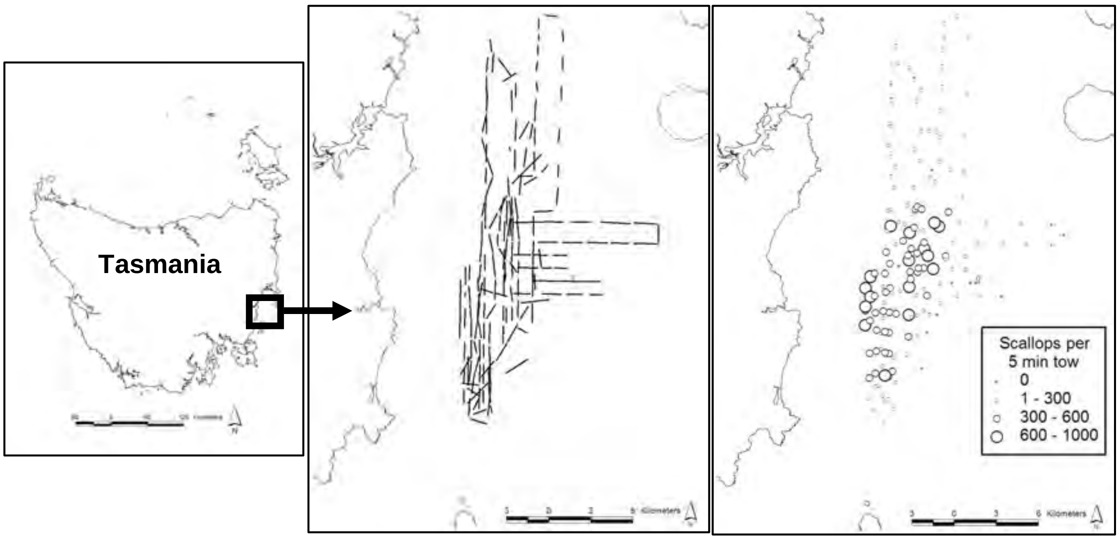


Figure 4.1: The location of sample tows (left) and abundance of scallops caught (right) for sample tows conducted during the White Rock Industry survey. All scallop abundances are standardised as scallops per five minute sample tow.

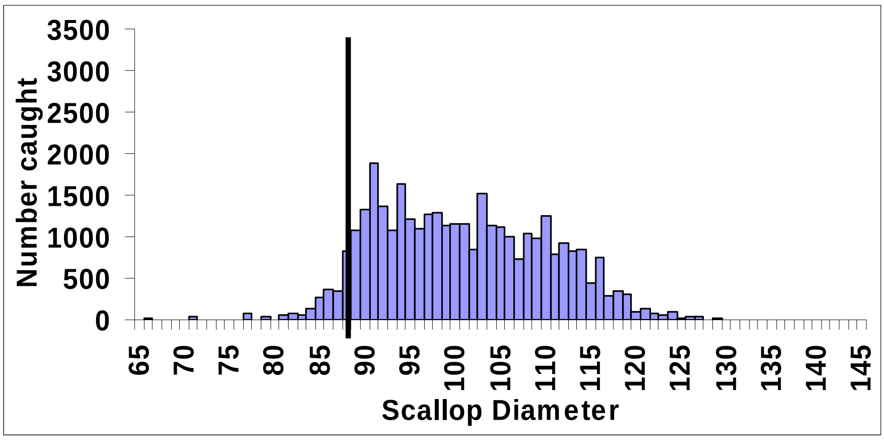


Figure 4.2: The relative frequencies of different sizes of scallops (1 mm increments) caught within the White Rock scallop bed. The line indicates the Legal Minimum Size (90mm).

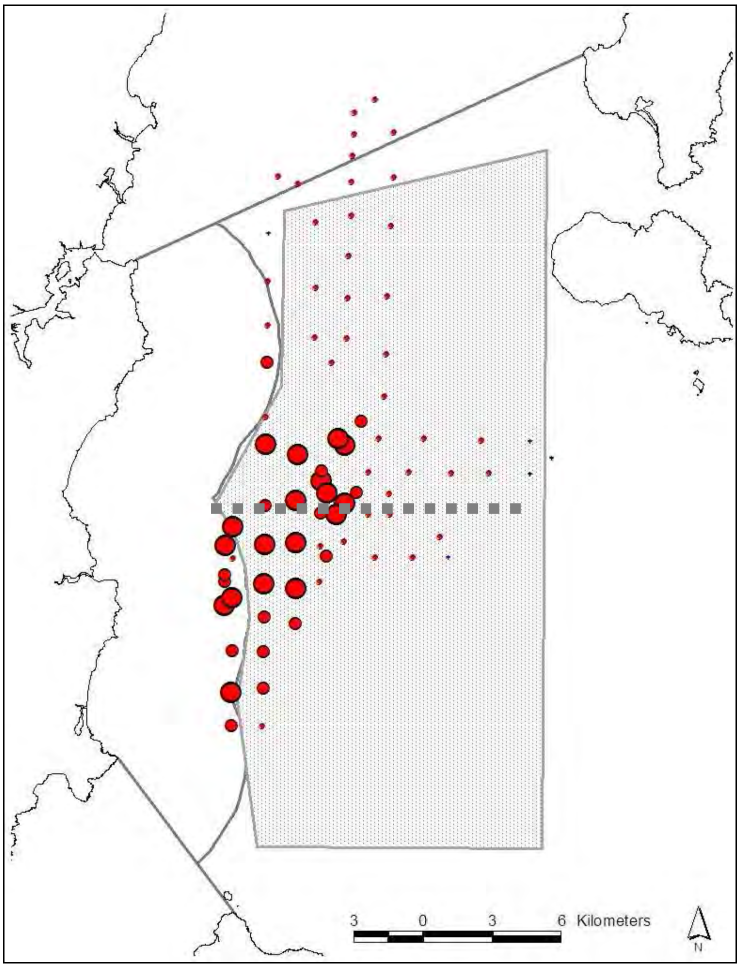


Figure 4.3: 2006 Tasmanian commercial scallop open region within the vicinity of White Rock (Hatched region). Circles represent the scallop abundance data collected during the October 2005 Industry survey. The regions to the north, south and west show the boundaries of the Shark Refuge Areas.

During the March 2006 FAC meeting, the manager responsible for the Tasmanian scallop fishery proposed a strategy of legislative rolling openings within the White Rock scallop bed. Such a strategy would see the open region divided into a number of subunits. At the opening of the season, only one subunit would be opened to fishing. After an agreed period of fishing, another subunit would be opened. It was anticipated that a rolling opening strategy would:

- create a slow start to the season, which would be essential if the opening date was too early and scallops were not in optimum condition;
- reduce the rush to fish;
- give those who are participating in other fisheries a chance to enter the scallop fishery during the opening of a new subunit, with reasonable catch rates;
- reduce the patchiness of fishing, as the scallop bed covered a large area;
- reduce the chances of damage to scallops within the entire scallop bed, thus reducing the risk of “anoxic scallops” (a term commonly used by fishers meaning the scallops are ‘smelly’ and in poor condition).

Industry representatives on the scallop FAC acknowledged these potential benefits however, they held grave concerns about placing legislative rolling opening boundaries within the White Rock open region. Their overall conclusion was that legislative boundaries were not practical for scallop fishers. In particular, they felt that the penalties for minor incursions of legislatives boundaries (i.e. moving into areas where they can fish later in the season) were far too severe. As a compromise, they agreed to the White Rock scallop bed being split into two regions at a latitude equivalent to the location of Ille des Phoques (White Rock) (see Figure 4.3). An Industry code of practice would see the voluntary closure of the northern portion of this boundary for the first month of the fishing season.

A pre-season scallop survey was conducted within the White Rock scallop bed on the 27th May 2006 (also see Chapter 5). The results of this survey confirmed that the White Rock region still contained commercial abundances of scallops. The condition of scallops, however, was poor (i.e. scallop meat was small and roes were watery). These results led to a delay in the legislative opening of the 2006 scallop season, with the rescheduled legislative opening date set for the 26th June. A second pre-season survey, conducted on the 19th June, confirmed that scallop condition had improved (bigger meats and roes started to develop) and that the re-scheduled opening would stand. It was noted during the survey, however, that scallops found in low abundance areas were in substantially better condition compared to those in higher scallop abundance areas.

4.3 An Industry within-season self-management initiative

4.3.1 The governance and leadership arrangements of the TSFA

The Tasmanian Scallop Fishermen's Association (TSFA) is recognised as a fishing body under the Tasmanian Living Marine Resources Act (1995). The association structure consists of a president, vice-president, secretary / treasurer, all of whom are voted in by TSFA members on an annual basis. Membership of the TSFA is open to any person holding a scallop fishing license, scallop quota or a processing license, however, membership is non-compulsory. Funding for the TSFA is through membership fees and a levy placed on the scallop license activation fee, which all operators must pay.

As described in the sections below, the operation of within-season Industry-rolling openings is an industry initiative, and it is therefore industry's choice as to how such a system should operate. They have chosen a relatively informal process, which is based on informal decision rules that determine when and where rolling openings should occur. The system works because the decision making processes are based around maximising profits for the fishery as a whole, and as such, the majority of fishers are willing to follow the decisions made.

It is the consensus of key representatives of the TSFA that a formal documented list of rules and regulations would possibly inhibit the success of the strategy, as in many instances decision must be made very rapidly. Until industry identify a real need for change, the informal approach to industry-rolling openings will remain.

4.3.2 The Industry rolling opening concept

During the May pre-season scallop survey, fishers gauged the full extent of the White Rock scallop bed. Under traditional scallop harvesting strategies, scallop vessels would have the freedom to fish within the entire scallop bed after the first month of the season (i.e. taking into account the Industry code of practice agreement). Such fishing arrangements have, in the past, created a race to fish. Scallop vessels would initially move quickly through the entire scallop bed in an attempt to maximise catch rates. Under a closed-area spatial management strategy, Industry would then request a new region be opened for harvesting and in the interim, would continue to fish in the most abundant regions of the already fished scallop bed. These regions, however, would contain damaged and dead scallops, which fishers suggested would lead to ‘anoxic’ scallop bed conditions. Many scallop Industry members considered such traditional harvest regimes to be inefficient, claiming that more scallops would be damaged and killed compared to those being caught.

Representatives from the TSFA, with the inclusion and support of TAFI scallop researchers, discussed options that would maximise the quantity and quality of scallops taken from the White Rock scallop bed. Despite rejection of a legislative rolling opening strategy during the FAC meeting held in March 2006, Industry considered that a rolling opening harvest regime could be used to fish down the scallop bed to uneconomical catch-rates in a systematic manner. Key TSFA representatives, in consultation with a TAFI scallop researcher, subsequently devised a within-season, Industry rolling opening harvest regime to accomplish this preferred outcome.

4.3.3 Procedures, rules and penalties of the Industry rolling opening strategy

The White Rock scallop bed was sub-divided into eight Industry rolling opening fishing zones, termed zones A – H (see Figure 4.4). The basis of the Industry strategy was for one fishing zone to be opened at the start of the fishing season. This zone was to be fished to uneconomical catch-rates before a new fishing zone could be considered for opening. When a new zone was opened, all previously fished zones would remain open. It was decided that fishing zones could open in any order. An Industry ‘committee at sea’ would be responsible for determining when a region was at uneconomical catch-rates, as well as where and when a new rolling opening zone would be. Communication of decisions was to be by marine radio, mobile phone and word of mouth.

Although no formal parameters for defining uneconomical catch-rates were constructed, catches less than 2 tonnes per fishing night was the point of reference used (K. Krause pers comm.). This relatively low figure took into account the large size of scallops, good scallop condition and close proximity of the open region to the unloading port of Triabunna (~ 17 km). Initially, a 24 hour period was deemed a sufficient time between announcing the opening of a new fishing zone and the zone being opened. However, to extend the amount of fishing effort within each fishing zone and to allow non-active scallop vessels the opportunity to be present for the opening of each new zone, a minimum 3 day time delay from determining that a fishing zone had reached uneconomical catch-rates to the opening of a new zone was implemented. Fishing zone openings were, in general, scheduled for 10 00am on Saturday mornings, as this would allow vessels to unload to processors on Monday mornings.

The violation of these industry rolling opening strategy rules and procedures by a small number of fishers instigated a system of penalties that were operated by industry. A minor violation for a short incursion in an industry closed zone would result in a fisher having a delayed start by being banned from fishing for 6 hours when a new zone was opened . This penalty was termed a yellow card violation. A serious violation of deliberate fishing in a closed area would lead to a fisher being banned for 24 hours after the opening of a new zone (red card). No red cards were given during the 2006 season.

4.3.4 Fisher’s commitment to the Industry rolling opening strategy

The successful implementation and operation of the Industry rolling opening strategy would require all scallop fishers to agree and adhere to the rules, operations and direction given by the TSFA and TSFA committee at sea. To achieve this, the TSFA created a commitment form, which they hoped all scallop license holders / vessel skippers would sign. This commitment form contained two statements:

1. I hereby agree to a voluntary closure until the scallops are of sufficient quality for sale and will only start fishing at 10am on the agreed opening date as determined by the TSFA and advised to me in writing.
2. In the best interests of maximising scallop quality and quantity I agree to a rolling opening and with zone closures as determined by the TSFA and as advised to me in writing or by marine radio.

All scallop fishers and supervisors of the 26 active vessels that operated during the 2006 season ultimately accepted these conditions, and agreed to adhere to the Industry rolling opening harvest strategy.

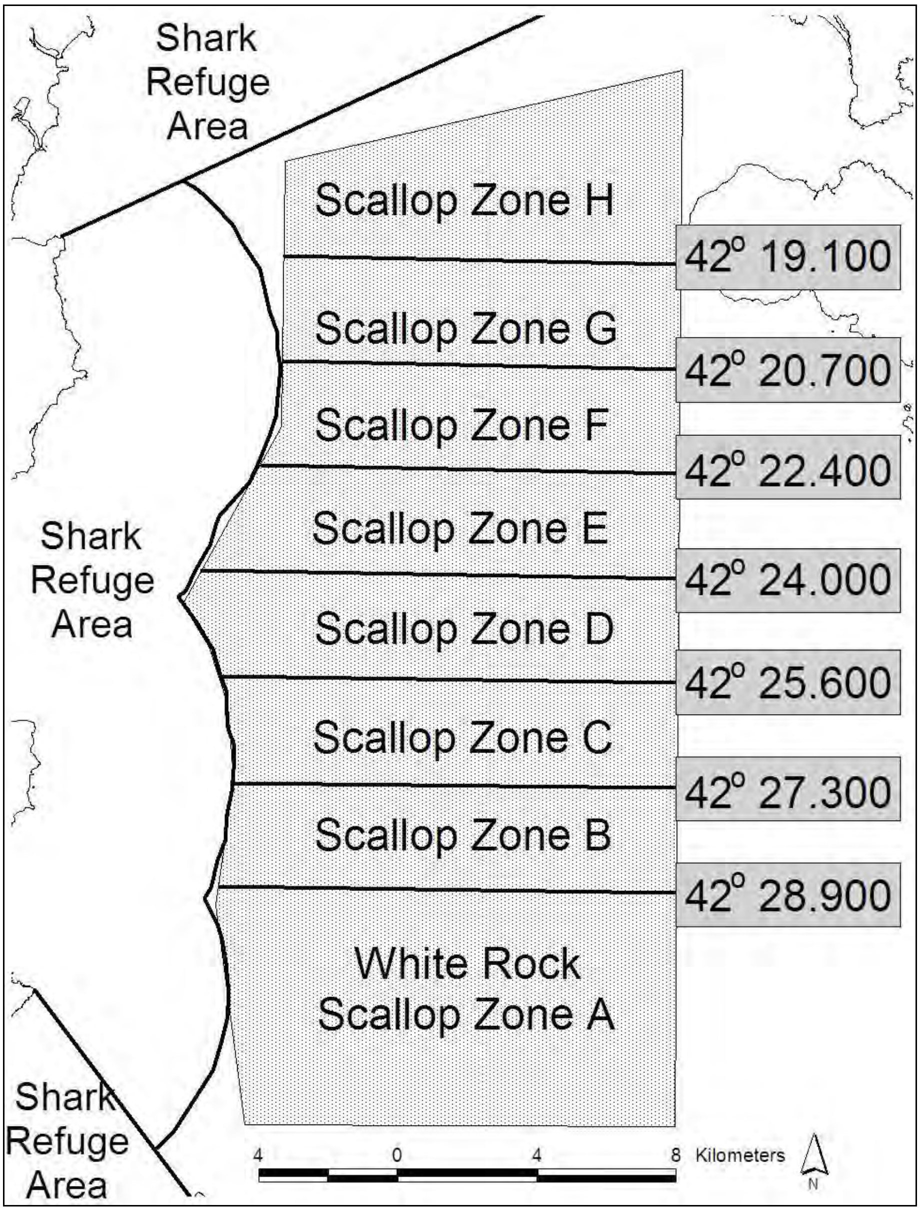


Figure 4.4: Location of the eight Industry rolling opening scallop zones.

4.4 The 2006 White Rock season: Sequence of rolling openings

4.4.1 Fishing Zone A

White Rock scallop fishing zone A was opened to fishing at 10 00am on the 26th June 2006. This region provided a slow start to the season, as it contained low abundances of scallops that covered a relatively small area. Catch-rates quickly declined after fishing commenced and fishers soon requested a new rolling opening zone be made available for harvesting. The TSFA 'committee at sea' made the decision to move to another fishing zone on the 29th June.

4.4.2 Fishing Zones H and G

At the start of the season it was observed that areas containing lower abundances of scallops were in better condition compared to scallops in high abundance areas. Subsequently, the TSFA decided to open what was believed to be a low abundance scallop zone after zone A had been harvested. Subsequently, scallop zone H was opened at 10 00 am on the 1st July 2006. Sixteen vessels were present for the opening.

An extensive search within zone H failed to identify commercial quantities of scallops. The TSFA 'committee at sea' therefore decided to open zone G, active immediately. However, an extensive survey of this region by the sixteen vessels also failed to find commercial abundances of scallops. It must be noted that Industry-based survey information had already shown that the area covered by fishing zones H and G contained low abundances of scallops. So, although the lack of scallops within these zones was disappointing, it was not totally unexpected. The TSFA 'committee at sea' decided to open scallop zone B, effective immediately.

4.4.3 Fishing Zone B

Scallop zone B was opened to fishing at 18 00 on the 1st July 2006. Catch-rates were reported as reasonable and scallop condition was improving. Within a short time of opening, some fishers voiced concern over the operation of the rolling opening strategy. In particular, they were upset with low catch-rates, especially when they knew that a more abundant scallop resource was available within the next rolling opening region. A small group of fishers did move into an unopened region for a short period of time in an attempt to dismantle the rolling opening fishing strategy. In response, an Industry meeting was held in St. Helens on the 7th July. At this meeting, all fishers agreed to continue with the Industry rolling opening harvest strategy. It was also agreed that scallop zone F should open as of 10 00 on the 11th July 2006.

4.4.4 Fishing Zone F

Scallop zone F was opened at 10 00am on the 11th July. Catches were reported as slow, but scallop condition was very good. On the 12th July, the TSFA 'committee at sea' declared that scallop zone C would be opened to fishing from 10 00 on the 15th July.

4.4.5 Fishing Zone C

Scallop zone C was opened to fishing at 10 00 on the 15th July. Catch-rates and scallop condition were very good. The TSFA made the decision to move to the next fishing zone on the 26th July.

4.4.6 Fishing Zone D

Scallop zone D was opened at 10 00 on the 29th July. Catch-rates and scallop condition were excellent. The TSFA 'committee at sea' made the decision to move to the next fishing zone on the 9th August.

4.4.7 Fishing Zone E

Scallop zone E was opened to fishing at 10 00 on the 12th August. Although catches were poorer than expected, catch-rates were still good and scallop condition excellent.

4.4.8 Access to the Shark Refuge Area (SRA)

A significant portion of the White Rock scallop bed overlapped the East Coast Waters Shark Refuge Area (SRA) (see Figure 4.4). Government policy prohibited scallop dredging within this component of the scallop bed. In early June 2006, the TSFA lobbied for permission to allow the current scallop fishery to extend its operations into the eastern side of the SRA. The key argument put forward was that the scallop Industry would remove debris (scallop spat collectors and ropes) that was left behind after a failed aquaculture project in the 1980's. Furthermore, Industry offered to remove the introduced marine pest, the northern Pacific seastar, which was known to occur in large abundances within a portion of the SRA.

The TSFA's bid for access to the SRA required negotiation with the Tasmanian Minister for Fisheries and a wide range of fishing and conservation stakeholders with an interest in the White Rock region (primarily the Tasmanian Recreational FAC, the Tasmanian Association for Recreation Fishing (TARFISH), the Commonwealth Shark RAG, the Tasmanian Scallop FAC, scientists at TAFI, shark experts at CSIRO and conservationists). By early September 2006, the TSFA had gained full approval for a once-only harvest of scallops in the eastern portion of the SRA (Figure 4.5). A strict condition of this agreement was that scallop vessels would retain all marine debris on board the vessels for proper disposal on land. Commercial fishing within the SRA occurred between the 9th September and 6th October. A rolling opening strategy similar to that implemented within the White Rock open area was employed.

4.5 2006 scallop season statistics

The vast majority of the 2006 Total Allowable Catch – 88.85% (TAC = 4253.2 tonnes shell weight) was taken during three months fishing in the White Rock region. The landed catch and % of the TAC taken for each month that the White Rock scallop bed was harvested (including the SRA portion) is shown in Table 5.1.

Table 4.1: Landed catch by month for times that overlapped the White Rock fishing season during 2006. ** Open for 5 days only (from 26 June) Source: DPIW internal data

Month	Landed Catch (tonnes)	% of TAC taken
June**	178.9	4.21
July	1156.0	27.18
August	1122.4	26.39
September	1321.5	31.07
Total	**3778.8**	**88.85**

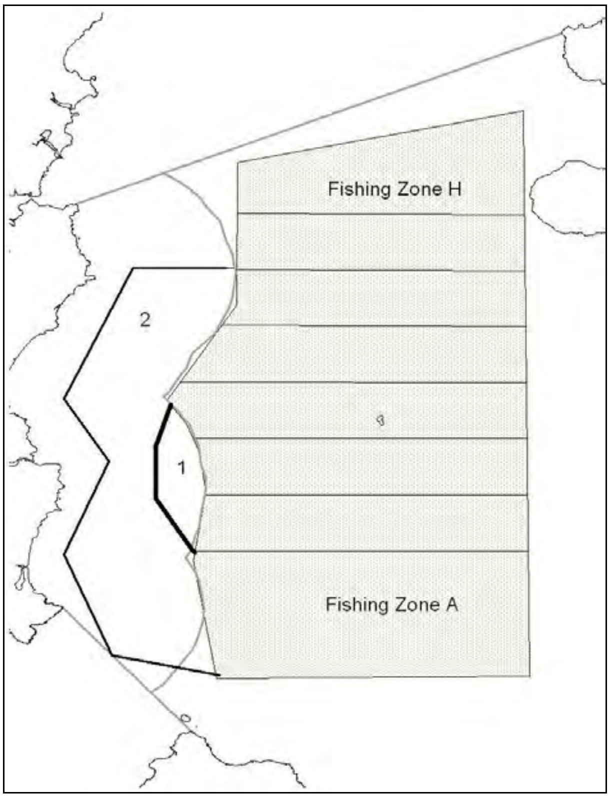


Figure 4.5: Location of the two regions within the east coast waters SRA that were opened to a limited on-off fishing event during 2006. Note: Note: further negotiations with the Minister for Fisheries by the TSFA during 2006 led to the region designated within the symbol 2 (larger opening) becoming a permanent region available to the scallop fishery.

4.6 Fishers' attitude to the White Rock Industry rolling opening strategy

During July and August 2006, TAFI researchers conducted a survey of Industry members using a questionnaire, which aimed at determining scallop fishers attitudes towards the 2006 Industry rolling opening harvest strategy. Questions were developed in consultation with the TSFA and DPIW. It was proposed that all fishers participating within the 2006 season would be interviewed. Unfortunately, the Industry issue of gaining access to the Shark Refuge Area created a level of dissatisfaction for some operators towards management and research sectors of the fishery. It was believed that such discontent could bias responses provided during the interview process. Subsequently, the questionnaire process was discontinued once access to the SRA became a prominent issue. As a consequence 8 fishers completed the questionnaire. Regardless, this represented more than a third of the 26 active vessels participating in the 2006 season (taking into account that several operators manage more than one vessel). Furthermore, the interests of the interviewees covered large and small vessels, large quota holders and those who may lease quota and Tasmanian and Victorian based vessels. The following sections provide a summary of the responses provided.

4.6.1 Question 1:

Are you happy with the TSFA taking greater responsibility (as trialled in the 2006 open season) for within-season management (i.e. code of practice) of the Tasmanian scallop fishery? What benefits have you identified with this year's within-season self-management? Are there problems for you with this year's within-season self management?

All interviewees were happy with the TSFA taking greater responsibility for within-season self management strategies, however, one respondent was clear in stating that they supported the principle of Industry rolling openings only. All interviewees said that the rolling opening harvest strategy had improved scallop quality, and in particular, no 'smelly fish' had been reported as being caught. All interviewees also acknowledged that more fish had been harvested from the White Rock region than would normally have been as a direct consequence of the rolling opening strategy, which in turn meant that the region had lasted for a longer period of time relative to what would occur under traditional harvest strategies. Two fishers made specific comments that, relative to DPIW controlled rolling openings, the Industry management model allowed for more rapid response times and quicker openings when the circumstances required such responses. One fisher suggested that the system relied on the signing of an Industry code of practise (commitment form).

The question highlighted a number of problems with the rolling opening system. Several fishers commented that a more formal decision making process was required, as there were too many examples where some vessel operators were not fully aware of what decisions had been made and / or retracted. Two comments referred to the need for radio contact of any decisions via both UHF and VHF radio, as some vessels only have one type of radio. A further issue that was raised was that the rules of the rolling opening strategy should not change unless there is wide-spread consultation. One interviewee said that during the pre-season, the agreed period from deciding a move was necessary to the opening of the new area was to be 24 hours. For several reasons, this time period did change several times during the season. Difficulties in planning fishing trips and transport of catch to Victoria without knowledge of when and where new openings would occur were noted.

One respondent had the perception that many rolling opening decisions appeared to have been made to benefit individuals or small groups within the fishery. The example provided was that when certain vessels were not ready to fish, low scallop abundance areas were opened. This fisher also thought that the fishing zones would open consecutively (i.e. A then B then C etc). Finally, one interviewee believed that the main benefits of Industry self-management had not been realised during 2006. The key problem identified was the stop – start nature of fishing within the White Rock area. This person, however, believed this was purely an outcome of the decision making process that was in operation within the White Rock region.

4.6.2 Question 2:

Do you think that Management (DPIW) need to be involved (i.e. regulation or legislation) with the rolling opening / season opening process? (i.e. once a public notice of the open area and date has been made?)

The unanimous consensus from all fishers was that the DPIW did not need to be involved with within-season management (i.e. rolling opening / season opening processes). One interviewee's response specified no, as long as the TSFA meet and make decisions about within season self-management.

Two interviewees acknowledged the need for some involvement by the DPIW, with specific reference being made to the organisation of pre-season surveys and with respect to the policing of and violation of Industry within-season management rules. Several fishers commented that voluntary closures have been easier, and Industry as a whole has followed Industry lines on the water far better than legislative lines. One response commented that scallop researchers from TAFI should remain involved throughout a fishing season.

4.6.3 Question 3:

Do you agree that scallop quality should be the key factor when deciding when / where to start fishing (both season and area)? For example, did you agree with the 2 week delayed opening of the 2006 season because of poor scallop quality? Should this be legislative or by Code of Practice?

All interviewees agreed with the 2 week delayed opening of the 2006 season to allow scallop quality to improve. It was also unanimous that an Industry code of practice should determine when Industry starts fishing (i.e. gazette a date that an opening can occur after).

What scallop condition do you think is needed to open a region to fishing? (e.g. Export quality)

There was also an overall agreement that export quality (i.e. < 80 scallops per kg and roe at least 20% developed) is the ideal scallop condition for harvesting. Three comments suggested that local and export markets have the same requirement for export quality scallops. A further three comments, however, said that export quality may not always be possible, and that local markets can handle a poorer quality scallop. One respondent suggested that anything over 100 scallops per kg should not be harvested.

Are you happy with the TSFA deciding this opening condition on quality independent of DPIW?

Six respondents agreed that the TSFA should be the mechanism for deciding the condition of scallops suitable for opening a region to fishing. Two interviewees suggested that this decision should not be made in isolation, and that all stakeholders, especially scallop processors, should be involved in the decision making process.

How much time is required from decision being made and opening occurring?

Four respondents suggested one week as a sufficient period of time to get scallop gear on their vessels and travel to the open area (even from Victoria). Two respondents suggested a two week period for the opening of the season and two respondents suggested that three days would be sufficient as all operators had known that the season was going to open during a general period of time.

4.6.4 Question 4:

Do you agree that measures that maximise the quantity of scallops caught within an open area should be implemented (i.e. rolling openings)?

All 8 respondents agreed that measures that maximising the quantity of scallops taken from open regions should be implemented. One commented better rules for Industry rolling openings needed to be set down explicitly.

Are you happy with the TSFA deciding within- season rolling opening strategies independent of DPIW?

All comments supported the TSFA deciding within-season rolling opening strategies independent of DPIW. One comment specified that the DPIW should say where to fish and Industry can work out how to fish. Another fisher specified the need for a transparent Industry process.

Are you happy with the system of rolling openings (8 zones) implemented within the White Rock area?

In general, all participants agreed with the 8 zone system used within the White Rock area. Two respondents commented that the system would have worked better if all fishing zones contained good abundances of scallops. One fisher commented that most problems within the White Rock zoning system revolved around the Industry decision making process to move to new zones. Three fishers made comments about scallops ‘working up’ and the need for different zoning systems and rules in different regions of the fishery.

Are you happy with the TSFA committee at sea decision making process for moving to a new fishing area (zone)? (Alternatives = catch rates, meeting of all participants etc, etc)

Six interviewees were happy with the TSFA ‘committee at sea’ decision making process for moving to new fishing zones. Of these six responses:

- One comment suggested that the process was at times too slow
- One comment said that some decisions did not benefit the fishery as a whole
- One commented that licence holders who do not fish should not have a say in the decision making process, which should be left to active fishers.
- Two commented that some written guidelines / documentation of the decision making process would be helpful.

One interviewee said that the ‘committee at sea’ should have stuck with the 24 hour notice rule as this is what all fishers agreed to and signed onto during the preseason. This fisher also commented that the system required better documentation.

One interviewee answered no, saying a more stringent decision making process that was based on maximising economic returns in yield was required.

4.6.5 Question 5:

Given the current open area location, proximity to Triabunna and condition of scallops being caught at what catch rate would you stop fishing?
(Catch Per hour / Catch Per 24 hour)

Responses to this question varied between 2 – 6 tonne per day. Four fishers suggested a range of 2 – 3 tonne per night (i.e. during darkness as these were night fishers), while three fishers suggested 4 – 5 tonne per night. One fisher commented that they needed to catch a full load of fish (i.e. 5 – 6 tonnes per day) in two days in order to fill a truck to send to Victoria.

Would this change if condition of scallop changed? (Improved / Declined)

All fishers commented that a decline in scallop condition would mean they would stop fishing and either move to a new open area or wait for condition to improve. An improvement in condition appeared to have no bearing though was always welcome.

Would catch rate requirements change if the open area was elsewhere? (Eddystone Pt / Flinders Island)?

In general, if a fishing ground is relatively close to an unloading port, they can afford to catch less during the one trip (i.e. catches from Eddystone would be similar to White Rock). This will change, however, when longer travel distances to fishing grounds are required (i.e. Flinders Island). Seven respondents suggested that they would need to catch a full load of scallops (i.e. 10 – 15 tonne) over three days if they were working further from port. This equates to approximately 3.5 – 5 tonnes per day fishing. One fisher commented they needed a full load in 2 days.

4.7 The 2007 Banks Strait rolling opening experience

During 2007, a substantial region within Banks Strait was opened to commercial harvesting (Figure 4.6). This open area incorporated a bed of scallops, which was known to contain some extremely dense aggregations. The justification for such a large opening was that commercial fishing only occurs in the areas which have undergone a survey and meet the biological criteria and that the TSFA only gradually “open/release” “Industry fishing zones” as needed. This would require Industry-based survey data to be obtained from regions of the open area where there was no current information available. The Banks Strait region of the fishery was opened to commercial fishing operations on the 9th July 2007 (note that the season opened on the 15th June within a region off Eddystone point).

The TSFA implemented a series of rolling openings within the Banks Strait open area. These boundaries were in general based around lines of latitude within the open fishing block, however, in some instances longitudinal boundaries were also imposed. Although the operation of rolling openings within the Banks Strait region were reported as being effective, the landing of scallops during the 2007 season did not live up to expectations. This was the consequence of:

- Poor scallop condition
- Excessive growth (oysters / barnacles) on scallop shell
- No export markets

- Low beach price for product
- More remote location of the open area
- Adverse weather conditions within the open region

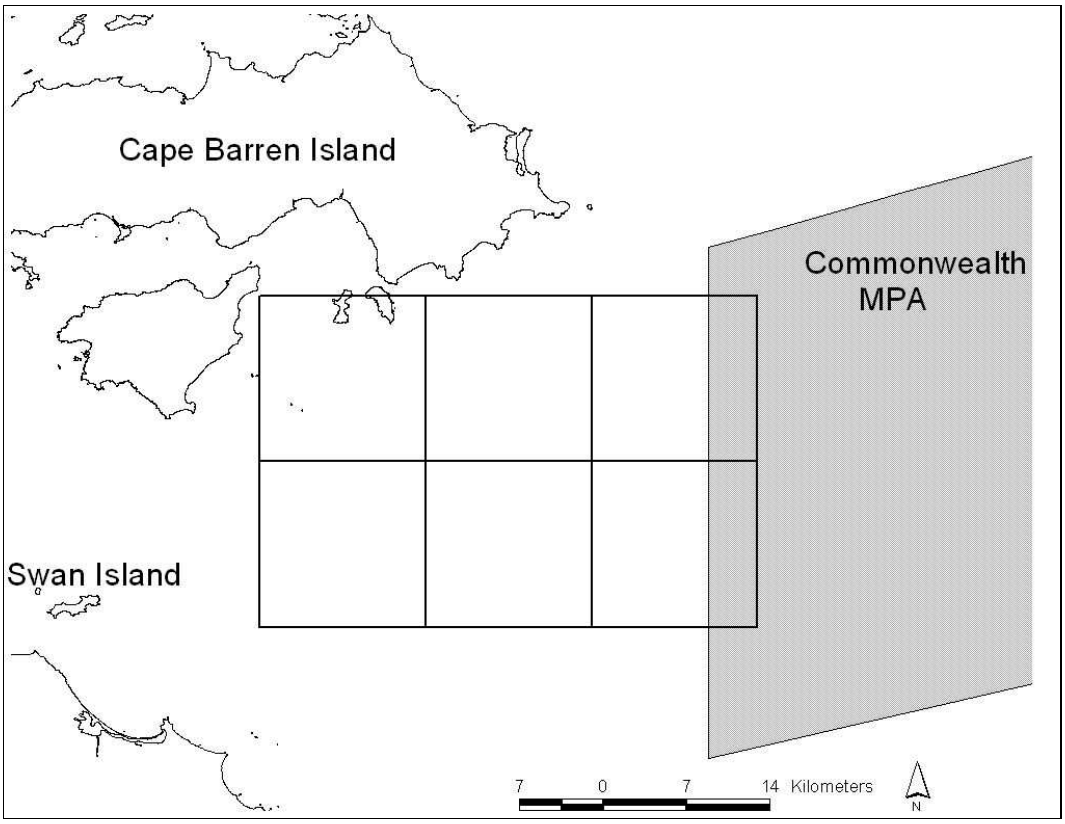


Figure 4.6: Location of the 2007 open region within Banks Strait. The region of the recently implemented Commonwealth Marine Protected Area is identified to the right.

4.8 Discussion

There was a high level of support for and satisfaction with a rolling opening harvest strategy when governed by the TSFA as an Industry code of practice. The Industry rolling opening harvest strategy implemented within the White Rock region was credited with providing a better quality scallop product and for maximising the quantity of scallops taken from within the open region. Industry implemented rolling opening boundaries and restrictions were adhered to far better than previously implemented government imposed legislative boundaries. Furthermore, there was no need for government monitoring of these boundaries (i.e. VMS operators and police). Also the Industry rolling opening harvest strategy greatly reduced the time needed by management to complete the operational details of the scallop season, as each rolling opening boundary change did not need to be gazetted as public notices. These latter factors will ultimately decrease the operational costs associated with management.

An Industry rolling opening harvest strategy can be used to reduce the race to fish by creating a slow start to a fishing season. This can be achieved by limiting the area available to fishing and / or restricting the fishable region to low scallop abundance regions. The rolling opening strategy also gives vessel operators the option of staying in other fisheries for a longer period of time, while still guaranteeing that when they enter the scallop fishery, the opening of a new subunit should guarantee good catch rates. Such strategies are essential if the legislative opening for the season is too early and scallops are not in optimum condition, as a flood of poor quality scallops into the market place will greatly reduce the beach price / returns to fishers. The rolling opening harvest strategy also reduces the patchiness of fishing by confining the fishing fleet to a relative small region of a scallop bed. This in turn will minimise the chance of damage to scallops within the entire scallop bed and the potential risk of creating an anoxic environment.

With respect to promoting a level of sustainability and insuring annual continuity of supply of scallops into the market place, an Industry rolling opening harvest strategy can operate as an effective mechanism for spreading a known resource of scallops over a greater number of fishing seasons. This can be achieved through limiting the area open to fishing during a given year and encouraging fishers to continue fishing within a rolling opening subunit at relatively low catchrates (i.e. maximise catches from an open region). This strategy compares to historical harvest regimes, where the vast majority (if not all) of the available fishing grounds are opened to fishing. Under such regimes, fishing vessels tended to move rapidly through regions that contain dense aggregations of scallops to maximise catch rates and returns. After this initial fishing period, fishing vessels will then move back to areas that had contained the densest scallops, which by this stage would more than likely be in poor health and often described as an anoxic environment containing dead and dying “smelly” damaged fish.

A further potential advantage of an Industry rolling opening harvest strategy is the possibility of a partial harvest of a large individual scallop bed. Such a management scenario would allow the remainder of the bed to be fished during the following or future fishing seasons. Such strategies may be a vital mechanism for assuring annual continuity of supply during years with low harvesting potential. To illustrate this concept, the White Rock scallop bed may be capable of producing up to 5,000 tonnes shell weight of scallops (i.e. produced approximately 4,000 tonnes shell weight in 2006 with limited fishing opportunity within the SRA component of the bed - see Table 4.1). If this bed was the only known significant region of scallops within the Tasmanian fishery, then several harvesting options would be available. Firstly, Industry could accept one season at a full TAC (i.e. 4,353 tonnes), which would then be followed by a minimum one year fishery closure. Conversely, they could instigate a rolling opening strategy that split the bed over two fishing seasons (i.e. an annual TAC of approximately 2,500 tonnes), or possibly even three seasons (i.e. 1,700 tonnes TAC). There are several other benefits associated with spreading a known adult stock over several fishing seasons. In particular, the strategy will maintain a dense aggregation of adult spawning biomass in the water for a longer period of time, which in turn will maximise the chances of a successful spawning event occurring within the fishery. Also, recent literature has suggested that dense aggregations of adult spawning stock is more advantageous for promoting recruitment compared with leaving areas of less dense adult scallops (see Smith and Rago 2004). There is a risk that the longer the scallops stay in the water the more they will die through natural causes. However, in Tasmania scallop beds commonly last at least 5 – 7 years, so as long as Industry monitoring follows the history of known scallop beds this split bed strategy may provide for a more continuous market supply than taking a full bed at each opening.

A rolling opening harvest strategy will also minimise the impacts of commercial fishing operations to small regions of scallop habitat. Such a fishing strategy will have significant benefits for the broader marine environment, as other non-scallop habitat will not be impacted. Furthermore, if the fished scallop habitat is capable of recovering within the scheduled closed period under a rotational harvest strategy, then the overall impacts of scallop fishing will be minimal. This topic is further explored in Chapter 5.

4.9 Conclusions

The Tasmanian scallop Industry has demonstrated that it is capable of managing within-season management strategies aimed at maximising the quality and quantity of scallops caught from a given area of scallops. Improvements are possible but can be developed by Industry in response to their own concerns. The full potential and benefits of Industry rolling openings, however, are yet to be realized. Such strategies also have the potential for increasing the chance of an annual continuity of supply. It is possible that given limited supply in some years, demand may see better profits during seasons with low catches (i.e. processors may be prepared to pay more money for a limited scallop supply).

5. IMPACT OF INTENSIVE SHORT-TERM COMMERCIAL SCALLOP (PECTEN FUMATUS) DREDGE FISHING ON THE ASSOCIATED EPIBENTHIC COMMUNITY.

5.1 Introduction

It is now well established that fishing activities that involve mobile gear that interacts with the benthos can have a physical impact upon the seabed and the biota that lives there (for reviews see Jones 1992, Dayton et al,. 1995, Jennings and Kaiser 1998, Kaiser *et al.* 2002). Direct changes can result from the crushing of individuals or removal as bycatch, while the partial excavation and damage of benthic organisms can attract mobile predators / scavengers (Kaiser and Spencer 1996, Dayton *et al.* 1995, Thrush *et al.* 1998). Further changes may occur because of habitat modification (Auster *et al.* 1996), changes in sedimentation (Churchill 1989) or benthic algal production and nutrient cycling (Mayer *et al.* 1991). Scallop dredges, which are capable of penetrating the substratum, are recognised as being potentially one of the most damaging types of benthic fishing gear (Thrush *et al.*, 1995, Currie and Parry, 1996, Collie *et al.*, 1997, Hall-Spencer and Moore 2000).

In recent years, fisheries management strategies have increasingly focused on techniques that may alleviate both the effects of fishing on the target species and the impact on the seabed (Collie *et al.* 1997, Kaiser *et al.* 2000, Murawski *et al.* 2000). For many marine species, this can be achieved by means of rotational closed-area spatial harvesting. The potential advantages of rotational closed-area management derive from: 1) increased protection from fishing and consequent increased abundance and mean size of exploited species; (2) enhanced local reproductive potential and therefore increased likelihood of larval export to the surrounding fishing grounds; and (3) protection of associated benthic communities and habitats (e.g. Ward *et al.* 2001; Gell and Roberts 2003; Halpern 2003; Beukers-Stewart *et al.* 2004). An effective strategy of rotational closed-area management will ultimately depend on the spatial distribution of a species, its reproductive biology and the rules and regulations that govern a specific fishery.

The relatively sedentary habit and patchy spatial distribution of most scallop species make them ideal candidates for closed-area spatial management systems and it is hardly surprising that scallop fisheries worldwide are increasingly being managed with such strategies. As examples, regions of the Georges Bank sea scallop, *Placopecten magellanicus,* fishery were closed to fishing during 1994, with limited, short-term harvests occurring within some closed regions since 1998 (see Murawski *et al.*, 2000; Myers *et al.*, 2000; Stokesbury, 2002; Hart, 2003; Stokesbury *et al.*, 2004); and since 2003, the management of the Australian Commonwealth Central Bass Strait commercial scallop (*Pecten fumatus*) fishery has required the closure of a minimum biomass of adult brood-stock (see Haddon *et al.* 2006).

In more recent years it has been suggested that a rotational network of closures may be beneficial for both target scallop species and the broader benthic habitat (see Myers *et al.* 2000, Hart 2003, Smith and Rago 2004). An example of rotational closed-area harvesting comes from the New Zealand scallop (*Pecten novaeselandiae*) resource found within the Golden Bay and Tasman Bay regions. These areas have been managed under a closed-area rotational fishing and reseeding strategy since 1989 (see Marsden and Bull, 2006). The implementation of rotational closed-area spatial harvest strategies will restrict where fishing vessels can operate, which in turn will alter fleet dynamics. Any shift in fishing patterns will change the intensity of fishing within an open region and the resulting impacts on the target species and benthic habitat. The successful implementation of rotational closed-area harvest strategies will therefore rely on what level of impact is caused by fishing and the impacted habitat or species in question having recovery times that fall within the time scale of any temporal closures (Kaiser *et al.* 2002).

The Tasmanian commercial scallop (*Pecten fumatus*) fishery has been managed under a rotational closed-area spatial management regime since 2003. A simplistic explanation of the strategy is that only relatively small regions of known scallop resource (generally < 30km x 30km blocks) are opened to commercial fishing operations, and all remaining regions of the fishery stay closed (see Haddon *et al.* 2006; Harrington *et al.* 2007). Once a region of the fishery has been harvested, it should remain closed for at least three years (the minimum time needed for scallops settle after fishing and reach legal minimum size requirements). The Tasmanian scallop fishing community have added an extra layer of spatial complexity to this harvest model, in the form of an Industry rolling opening harvest regime. Under this fisher driven strategy, scallop vessels are restricted to fishing within a subunit (3km x 3km subunits in 2006) of the already small legislative open region. An Industry code of practice ensures that fishers remain within opened subunits until catch-rates are considered uneconomical, which is determined by Industry representatives. Only after this decision is made will a new sub-unit be made available to fishing.

Prior to 2003, Tasmanian scallop vessels had access to the entire range of the fishery during the open fishing season, and the fishery could be impacted on an annual basis, with the exception of years when there was a fishery closure. During the 2006 commercial scallop season, the legislative rotational closed-area and Industry rolling opening harvest strategies re-defined traditional fishing patterns. Vessels were now restricted to operating within a 3km by 3km area until catch-rates were considered uneconomical. Although scallop fishers suggested that the system of fishing experienced during 2006 led to areas being fished at intensities far higher than traditionally experienced, impacts were short-term, and the entire legislative open region would be closed to fishing after the 2006 season to allow recovery of at least the scallop stocks. However, it was unknown if the intensity of fishing and resulting impact to the benthos would be detrimental to the recovery of both the target species and the benthic habitat. Furthermore, it was unknown if intensive dredging within a portion of a scallop bed (Industry rolling opening subunit) would negatively impact adjacent protected regions (subunits). The success of rotational closed-area and rolling opening harvest strategies, and the possibility of harvesting an individual scallop bed over two fishing seasons (i.e. fish half the bed in one season and the remainder the following season) relied on determining the consequences of this strategy of fishing on scallop habitat.

This study aimed to 1) determine the impact of intensive but short-term dredge fishing within commercial scallop (*Pecten fumatus*) habitat; and 2) determine the impact of intensive but short-term dredge fishing on the sediment composition and water quality found within commercial scallop habitat. Results will be discussed in light of rotational closed-area and Industry rolling opening harvest strategies.

5.2 Methods and Materials

5.2.1 Study site

The study was conducted within an 18 km by 6 km bed of scallops located between the Tasmanian mainland and the island Ille des Phoques (referred to as the ‘White Rock scallop bed' by fishers) (~ 148.12^{o}E, 42.33^{o}S and 148.06^{o} E, 42.51^{o}S – see Figure 5.1). Prior to 2006, the White Rock scallop bed had not been harvested for at least 22 years, and it was assumed that the benthic communities found within the region were representative of a relatively stable scallop habitat. The study incorporated three sample locations, which will be referred to as Stratum C, Stratum D and Stratum SRA. These sample sites were adjacent portions of the White Rock scallop bed (see Figure 5.1). Strata C and D overlayed parts of the 361 square kilometre White Rock legislative open region and corresponded with two of the eight Industry rolling opening subunits located within this legislative open region (see Figure 5.1). The third stratum, Stratum SRA, fell within the confines of a Shark Refuge Area (SRA), which under Tasmanian government policy was to be protected from dredge fishing. All study strata were known to contain relatively homogenous sandy habitat, which was dominated by commercial scallops (i.e. a scallop bed covered all strata). The water depth within all strata was relatively consistent, falling between 43.5 and 45.5 metres, and all regions were believed to be similarly affected by tides and swells.

5.2.2 Impact of commercial dredging on scallop habitat

This component of the study has been split into two parts, which will be referred to as experiment I and experiment II. In experiment I, a before-after-control-impact (BACI) study design was used to determine any changes to scallop habitat resulting from intensive, short-term commercial intensity scallop dredging. A baseline survey (survey 1) was conducted prior to fishing activities within all strata (C, D and the SRA) between the 30th May and 19th June 2006. Between the 26th June 2006 and early August 2006, strata C and D were commercially fished by 25 scallop vessels of approximate 20 – 25 metres length. All vessels used a single steel box dredge to conduct commercial tows of 5 – 20 minutes duration. A second survey (survey 2) was conducted on the 21st August 2006, after strata C and D had been impacted by fishing but stratum SRA remained unfished, and as such could be used as a control.

Within experiment I, the control stratum SRA was assumed to contain similar habitat to the impacted strata. Subsequently, if the control SRA stratum was to be commercially fished, changes to the benthic habitat similar to those observed in strata C and D of experiment I would be expected. From 2nd September 2006 until mid October 2006 the control stratum SRA was unexpectedly opened to commercial fishing operations under a special agreement between the Tasmanian government and Tasmanian scallop Industry. Experiment II was subsequently conducted to measure the impact of this commercial dredging on the scallop habitat found within stratum SRA. Before fishing, baseline survey data was collected during survey 2 (see previous experiment). A third survey was conducted on the 22nd October 2006, after the SRA had been impacted by the Tasmanian scallop fleet.

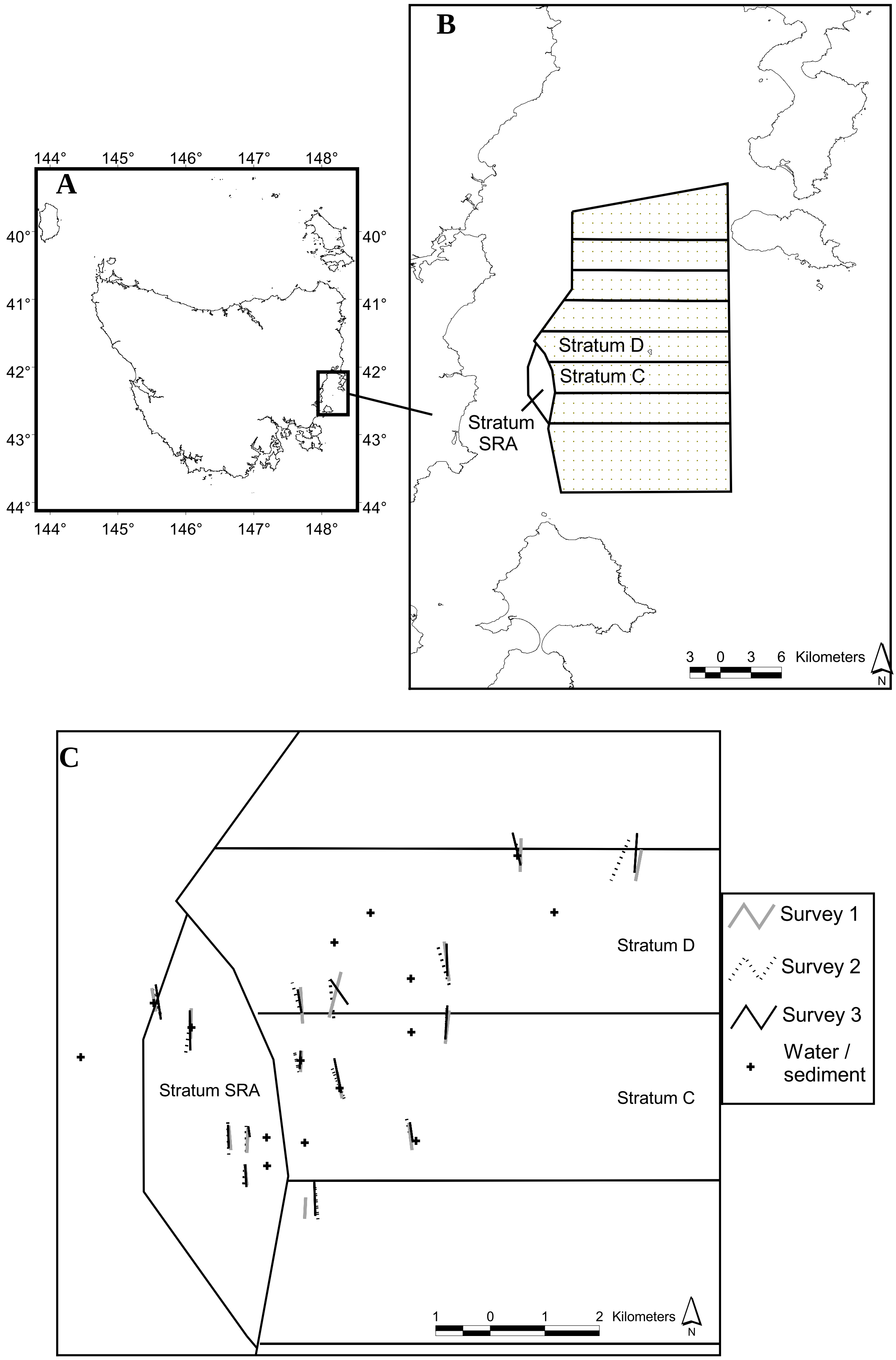


Figure 5.1: Map of the study area showing its location within Tasmania (A); the location of the 2006 open region and location of the three study strata relative to this open area (B); and locations of each sample tow conducted during the three dredge surveys and two water / sediment surveys (C).

All surveys were conducted on board the scallop fishing vessel 'Karmin' using a typical commercial box dredge with a width of 4.2m and mesh dimensions of 46 x 70mm. Five sample locations were randomly selected within each survey strata and each sample location was monitored during all three surveys (see Figure 5.1). Sample tows were approximately 5 minutes in duration and covered between 300 and 700 meters in length. All sample tows were conducted on relatively calm days and in a north – south / south – north direction. Upon completion of each sample tow, the dredge contents were sorted and all macrofauna identified to the lowest identifiable taxon. Where the abundance of the dredge contents was low all individual taxa were counted. Where abundances of the catch were high a total count was estimated by counting all individuals within a randomly selected sub-sample (generally half the catch) and then scaling counts to 100%. To account for variations in the exact tow distance of each sample tow, all abundance estimates were standardised to the relative number caught per 500 m sample tow length.

For data collected in both experiments I and II, significant differences between the dredged benthic assemblages caught during the different surveys were determined using analysis of similarities (ANOSIM) and multidimensional scaling (MDS) techniques (see Clarke and Warwick 2001). The main species contributing to any observed changes were identified using the SIMPER procedure (see Clarke and Warwick 2001). Data was fourth root transformed and used to generate a Bray-Curtis Similarity Matrix. To further explore changes in benthic community structure between surveys, the frequency of occurrence of each dominate species found in the scallop bed (i.e. how many sample tows a species was found in) was plotted against its mean abundance per 500 meter sample tow. This analysis was conducted separately for the impacted sites and control site in experiment I. Mean abundances were natural log transformed to better visualise patterns of observed change.

To generalise observations of the species found within the White Rock scallop bed before and after fishing, data from both experiments I and II were grouped as follows. Before fishing, baseline data was represented by benthic data collected within strata C and D during survey 1 and benthic data collected within the 'control' SRA stratum during survey 2. After fishing, impacted data was represented by benthic data collected within strata C and D during survey 2 and benthic data collected within the SRA stratum during the survey 3. The average abundance per 500 m sample tow and the frequency of occurrence (i.e. number of times they were caught across all samples) were calculated for each species before and after fishing.

5.2.3 Water and sediment surveys

A BACI study design was used to determine the impact of intensive but short-term commercial dredge fishing on water quality and sediment structure. Before fishing, samples were collected within strata C, D and the SRA on the 18th May 2006. A second set of samples were collected on the 15th August 2006, after strata C and D had been impacted by commercial dredge fishing, but stratum SRA remained unfished (i.e. control site). Five sample locations were randomly selected within each survey strata (see Figure 1).

Water samples were collected from three depths at each sample location: 3 – 5m (surface water), 20 – 25 m (mid-water column) and within 3 meters of the substrate (bottom water). Samples were collected using a five litre Niskon bottle and depths were estimated using the vessel depth sounder. Turbidity readings were taken upon collection of each sample using a Hach 2100P Turbidimeter. The remaining sample portion was stored in sealed plastic containers, refrigerated in complete darkness and processed within 48 hours of collection. Total suspended solid content was determined by filtering a measured portion of each sample over a pre-weighed filter paper. The filter paper was then dried and re-weighed, and total suspended solids determined as the difference in weight of the two filter paper measures. Separate two-way ANOVAs were conducted for each survey strata to test for any significant changes in turbidity and suspended solid readings, with survey and depth being the fixed factors.

Sediment samples were collected using a standard Van Veen grab sampler from the same sample locations as the water samples. Upon collection, a representative portion of the sample was transferred to a sealed storage container and kept refrigerated in darkness until processed. A portion of each sample was dried and weighed. It was then wet sieved through a graded series of sieves (4mm, 2mm, 1mm, 500μm, 250μm, 125μm and 63μm), as per standard laboratory techniques. The sediment retained on each sieve was dried and reweighed, and totals determined as portions of the total weight. The portion < 63μm was determined by calculation of the difference between the initial sample weight and the combined weight of the retained fractions. To observe any changes in the sediment structure of samples collected before and after fishing, cumulative phi curves of the before and after data were constructed for each sample location.

5.3 Results

5.3.1 Non-technical results summary

- Eight species were found to dominate the White Rock scallop bed: Commercial Scallops; New Zealand Screwshells and their associated hermit crabs; oysters; doughboy scallops; mussels; hermit crabs; 11-arm seastars; and sea urchins (identified in Table 5.1)
- Short-term intensive dredge fishing was found to change the White Rock scallop community structure (Table 5.2). This is evidenced by the fact that the before and after fishing samples occur within different areas of the MDS plots shown in Figures 5.2 and 5.5.
- The change in community structure before and after fishing was the result of a 40 – 80% decrease in the abundances of the key species found within the scallop bed. This is illustrated by the lower values after fishing in Table 5.1; evidenced by lower abundances of species after fishing occurred in the after fishing column in Table 5.1, and separation of the after fishing samples from the pre-fishing samples Table 5.2; Figures 5.2, 5.3).
- These changes were characterised by a 40 – 80% decrease in the abundances of the key species found within the scallop bed (Table 5.3 and lower values after fishing in Table 5.3 and Figures 5.3 and 5.5).
- These species, however, were found in the same number of sample tows both before and after fishing had occurred (Table 5.1; Figures 5.3, 5.5).
- No species were completely removed as a consequence of intensive dredge fishing.
- Although water quality samples suggested poorer quality after fishing (higher values in Figure 5.6), these changes were not considered to be biologically significant, with water quality remaining very good after fishing; Figure 5.6)
- The particle structure of sediments showed no pattern of change as a consequence of intensive dredge fishing. This was evidenced by the before and after curves illustrated in figure 5.7 generally being the same regardless of sample time.

5.3.2 Impacts of commercial dredge fishing on benthic communities

5.3.2.1 General Observations from the White Rock bed

A total of 32 species were identified during the three surveys conducted within the White Rock scallops bed, with molluscs accounting for approximately 38% of these species (Table 5.1). Twenty-three species were identified before fishing, and 29 species after fishing had occurred. The same eight species were found to dominate the benthic community structure, in terms of abundance and frequency of occurrence, both before and after fishing (see Table 5.1). Commercial scallops were found in high abundances within all sample tows prior to fishing. Screwshells, which were predominately empty and occupied by hermit crabs, were found in exceptionally high abundances within some sample tows but were absent in others. Doughboy scallops, mussels, oysters, common urchins, 11-arm seastars and hermit crabs were regularly found, but in relatively low abundances (Table 5.1). All other species were recorded in low abundances and in fewer than half the sample tows conducted (Table 5.1).

The abundances of the eight key species found in the White Rock scallop bed decreased after fishing had occurred (also see experiment I and II results), however, they were still encountered as frequently after fishing (see Table 5.1). Three species observed before fishing were not encountered after fishing (see Table 5.1). These species were uncommon within the survey region and found in less than two sample tows. Nine species were only encountered after fishing had occurred; with fishes accounting for five of these species (see Table 5.1).

Table 5.1: List of species, average abundances per sample tow ± standard error (SE) and the number of sample tows each species was found (frequency) for the sample dredge tows grouped into before and after fishing samples (see methods). Blanks indicate no individuals as being caught and the asterisk in the scientific name field identify the 8 species which dominated the scallop bed.

Common Name	Scientific Name	Before Fishing Average ± SE	After Fishing Average ± SE	Before fishing frequency	After fishing frequency
Molluscs					
Commercial Scallop	**Pecten fumatus*	750 ± 123	228 ± 61	15	15
New Zealand Screwshell	**Maoricolpus roseus*	2774 ± 1093	428 ± 258	7	3
Mud Oyster	**Ostrea angasi*	196 ± 55	52 ± 13.78	12	15
Doughboy Scallop	**Chlamys asperrimus*	61 ± 14.17	18.82 ± 6.55	13	14
Mussel	**Mytilus edulis*	31.16 ± 9.66	7.33 ± 3.31	11	9
New Holland Spindle Shell	*Fusinus novaehollandiae*	3.26 ± 1.31	1.57 ± 0.52	5	7
Triton Shell	*Charonia lampas*	2.88 ± 1.5	1.07 ± 0.46	4	5
Razor clam	*Atrina tasmanica*	0.76 ± 0.68		2	0
Cowrie Shell	*Cypraea hesitata*	0.69 ± 0.69		1	0
Pale Octopus	*Octopus pallidus*	0.55 ± 0.55	0.84 ± 0.31	1	6
Tulip Shell	*Pleuroploca australasia*	0.26 ± 0.26	0.14 ± 0.1	1	2
Whelk	*Penion maxima*		0.82 ± 0.82	0	1
Crustaceans					
Hermit Crab	**Stigopagurus strigimanus*	24.73 ± 13.43	6.54 ± 2.42	9	12
Spider Crab	*Leptomithrax gaimardii*	0.91 ± 0.63	0.18 ± 0.13	2	2
Hairy Shore Crab	*Pilumnus tomentosus*		0.11 ± 0.11	0	1
Hermit Crab	Unidentified sp.		0.09 ± 0.09	0	1
Echinoderms					
11-Arm Seastar	**Coscinasterias muricata*	17.99 ± 6.1	6.93 ± 2.2	9	9
Common Urchin	**Heliocidaris erythrogramma*	13.97 ± 5.22	4.43 ± 1.19	10	11
	Bollinaster pectinatus	4.65 ± 1.83	0.61 ± 0.37	6	3
	Nectria ocellata	4.37 ± 1.99	1.61 ± 0.68	5	7
Pencil Urchin	Unidentified sp.	4.37 ± 1.76	1.71 ± 1.13	5	3

Table 1: Cont'd

Common Name	Scientific Name	Before Fishing Average ± SE	Before Fishing Average ± SE	Before fishing frequency	After fishing frequency
Fishes					
Crested Flounder	*Lophonectes gallus*	0.28 ± 0.28	0.57 ± 0.35	1	3
Lachet	*Lepidotrigla vanessa*	0.11 ± 0.11	0.27 ± 0.19	1	2
Common Guarnard	*Neosebastes scorpaenoides*		0.6 ± 0.36	0	3
Tiger Flathead	*Neoplatycephalus richardsoni*		0.33 ± 0.33	0	1
Common Stinkfish	*Foetorepus calauropomus*		0.16 ± 0.16	0	1
Spotted Flounder	*Ammotretis lituratus*		0. 1 ± 0.1	0	1
Shaws Cowfish	*Aracana aurita*		0.04 ± 0.04	0	1
Rays					
Tasmanian Numbfish	*Narcine tasmaniensis*	0.09 ± 0.09		1	0
Banded Stingaree	*Urolophus cruciatus*	0.06 ± 0.06	0.09 ± 0.09	1	1
Other Species					
Pumpkin Sponge	Unidentified sp.	0.05 ± 0.05	1.83 ± 1.02	1	4
Sea Cucumber	Unidentified sp.		0.1 ± 0.1	0	1

5.3.2.2 Experiment I

There was a significant difference in the benthic communities collected during the two surveys conducted during experiment I (ANOSIM: Global r = 0.305; P = 0.001). Pair-wise comparisons identified these differences to be between survey 1 (before fishing) and survey 2 (after fishing) data from stratum C (Table 5.2); survey 1 data from stratum SRA and the survey 2 data (after fishing) from both strata C and D; and survey 2 data from Stratum SRA and survey 2 data (after fishing) from both strata C and D (Table 5.2). There was no significant difference in the benthic communities collected within the non-impacted control stratum SRA during the two surveys (Table 5.2).

Table 5.2: Results of the ANOSIM pair-wise comparisons for the benthic community data collected during experiment I. The asterisks denote significant P values.

		R Statistic	*P* value
Within Survey Comparisons			
Survey 1			
Survey 1 Control	Survey 1 C	0.296	0.056
Survey 1 Control	Survey 1 D	-0.004	0.421
Survey 1 C	Survey 1 D	-0.036	0.579
Survey 2			
Survey 2 Control	Survey 2 C	0.588	0.008*
Survey 2 Control	Survey 2 D	0.52	0.008*
Survey 2 C	Survey 2 D	0.3	0.024*
Between Survey Comparisons			
Survey 1 Control	Survey 2 Control	-0.166	0.754
Survey 1 Control	Survey 2 C	0.712	0.008*
Survey 1 Control	Survey 2 D	0.664	0.008*
Survey 1 C	Survey 2 Control	0.276	0.063
Survey 1 C	Survey 2 C	0.304	0.008*
Survey 1 C	Survey 2 D	0.684	0.008*
Survey 1 D	Survey 2 Control	-0.008	0.429
Survey 1 D	Survey 2 C	0.228	0.063
Survey 1 D	Survey 2 D	0.276	0.063

The two-dimensional MDS visual comparison of the benthic assemblages collected within each sample during the two surveys, identified a general separation of the non-impacted survey samples (i.e. survey 1 / before fishing data from strata C and D and survey 1 and 2 data from the control stratum SRA) (left of MDS area) and the impacted survey samples (i.e. survey 2 / after fishing data from strata C and D) (right of MDS area) (Figure 5.2). An individual sample collected within Stratum D during survey 1 (before fishing) was found to occupy the same space as the after fishing benthic samples (Figure 5.2), and may account for the non-significant result within the ANOSIM statistical comparison previously described.

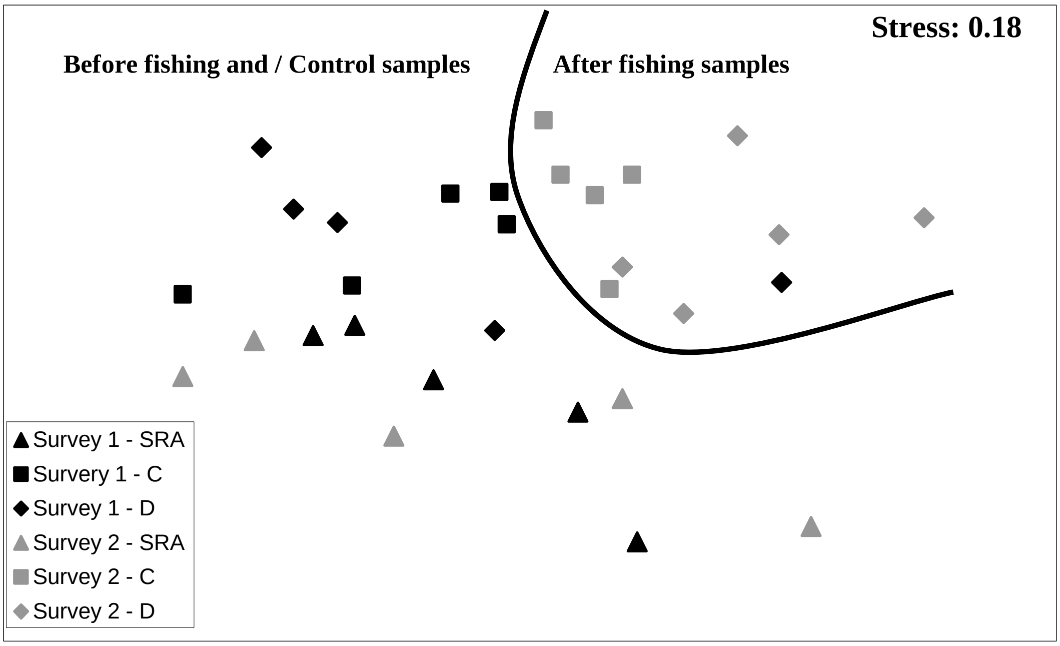


Figure 5.2: MDS plot of the fourth root, Bray-Curtis similarity transformed benthic community data collected during experiment I. Each survey and strata are identified as different symbols.

The statistical analysis and MDS identified differences in the benthic community structure data collected during survey 1 (before fishing) and survey 2 (after fishing) within strata C and D. These differences could be explained by a decrease in the abundances of eight species: commercial scallops, screwshells (hermit crabs), doughboy scallops, 11-arm seastars, mussels, hermit crabs (not associated with screwshells), urchins and oysters (SIMPER analysis – Table 5.3 and Figure 5.3a). Abundances of these species were 72%, 100%, 78%, 84%, 79%, 79%, 77% and 77% lower after fishing had occurred, respectively (see Figure 5.3a). These species, however, were still observed in the same number of sample tows after fishing (Figure 5.3a). No clear pattern of change was observed for the survey 1 and survey 2 data collected within the control (non-impacted) stratum SRA (Figure 5.3b).

Table 5.3: SIMPER output for benthic community data collected as part of experiment I indicating average abundance per 500m sample (mean abund.), ratio (average similarity/standard deviation similarity) and cumulative percentage similarity of the species responsible for approximately 50% of the observed significant differences within the between survey ANOSIM pair-wise tests.

Species	**Survey 1 stratum SRA mean abund.**	**Survey 2 stratum C Mean abund.**	**ratio**	**Cumulative % similarity**
Screwshell (hermit crabs)	1060.7	0	0.8	11.99
11-arm seastar	38.34	0.32	2.43	23.78
Commercial scallop	1205.3	182.5	4.26	35.56
Oyster	27.86	109.61	1.05	46.2
Mussel	39.95	4.47	7.66	58.86
	Survey 1 stratum SRA mean abund.	**Survey 2 stratum D mean abund.**	**ratio**	**Cumulative % similarity**
Commercial scallop	1205.3	119.6	2.74	14.59
Screwshell (hermit crabs)	1060.7	0	0.79	26.46
11-arm seastar	38.34	3.91	1.26	34.66
Doughboy scallop	54.4	1.64	2.29	42.77
Mussel	39.95	1.77	1.38	50.27
	Survey 1 stratum C mean abund.	**Survey 2 stratum C mean abund.**	**ratio**	**Cumulative % similarity**
Screwshell (hermit crab)	3187.66	0	0.8	17.91
Hermit crab	56.38	8.45	1.33	27.21
Commercial scallop	653.59	182.51	2.03	35.64
Oyster	415.61	109.61	2.06	44.01
Doughboy scallop	97.53	24.35	1.56	50.69
	Survey 1 stratum C mean abund.	**Survey 2 stratum D mean abund.**	**ratio**	**Cumulative % similarity**
Screwshell (hermit crab)	3187.66	0	0.8	14.52
Oyster	415.61	23.11	2.76	26.95
Doughboy scallop	97.53	1.64	2.11	37.82
Commercial scallop	653.59	119.57	1.88	45.12
Mussel	16.85	1.77	1.44	54.41
	Survey 1 stratum D mean abund.	**Survey 2 stratum D mean abund.**	**ratio**	**Cumulative % similarity**
Screwshell (hermit crab)	2008.39	0	1.05	21.15
Commercial scallop	436.51	119.57	1.6	28.99
Mussel	17.63	1.77	1.4	36.83
11-arm seastar	18.91	3.91	1.18	43.66
Oyster	156.18	23.11	1.49	50.12

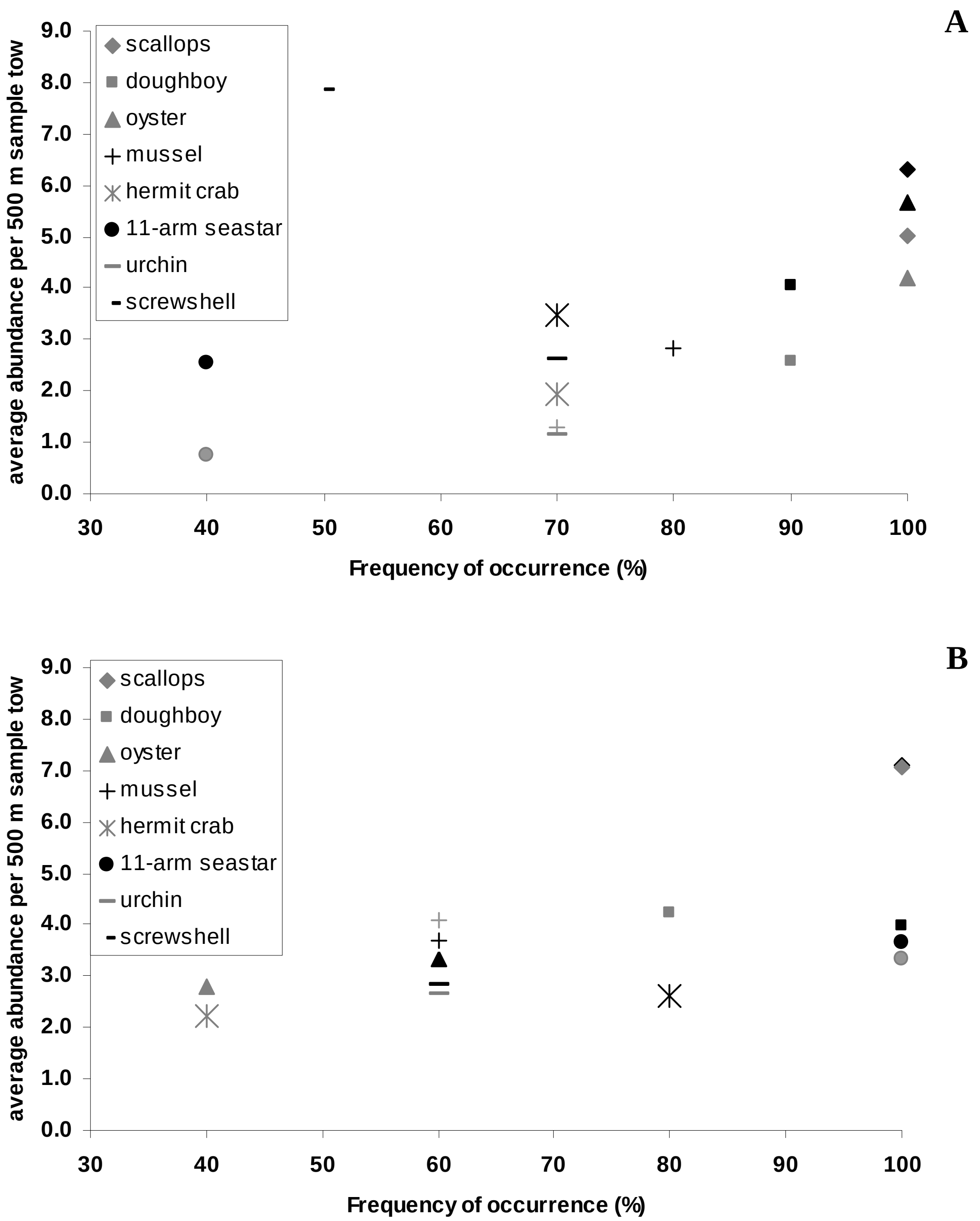


Figure 5.3: The average abundance of species caught per 500 m sample tow against the frequency of occurrence (number of sample tows found in) for each of the key species found within the impacted (A) and control location (B) during experiment I. Black represents before fishing abundances and the grey the after fishing abundances. Note – abundances for screwshells caught within the impacted sites during the second survey are not represented as no individuals were caught. For an indication of standard errors for each species refer to Table 5.2.

5.3.2.3 Experiment II

No significant difference in the benthic communities collected during survey 2 (before fishing) and survey 3 (after fishing) was observed in experiment II (ANOSIM: Global r = 0.084; $P = 0.198$). The two-dimensional MDS visual comparison, however, did suggest a separation of the datasets collected within the two surveys, with survey 2 (before fishing) data falling to the top of the MDS area and survey 3 (after fishing) data to the bottom of the MDS area (Figure 5.4).

The separation of the data observed in the MDS was the consequence of a decrease in the abundances of commercial scallops, screwshells (hermit crabs), doughboy scallops, 11-arm seastars, mussels, hermit crabs and urchins after fishing had occurred. The abundances of these species were 67%, 59%, 55%, 42%, 75%, 38% and 51% lower after fishing, respectively (see Figure 5.5). The abundance of oysters was found to increase after fishing (see Figure 5.5). Also, screwshells, doughboy scallops, hermit crabs, urchins and oysters were present in a greater number of sample tows during survey 3 (after fishing) (Figure 5.5).

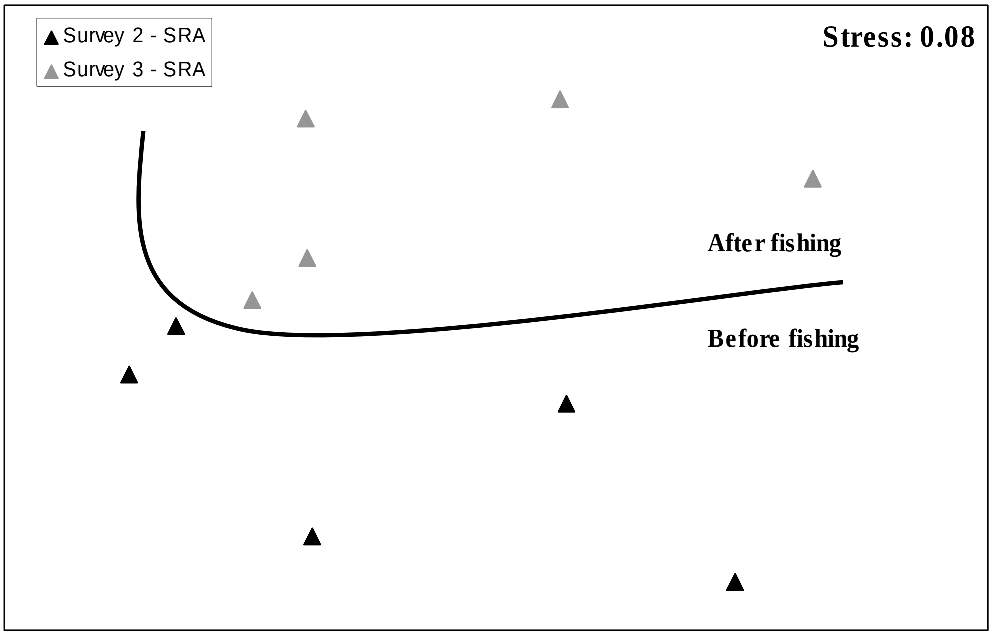


Figure 5.4: MDS plot of the fourth root, Bray-Curtis similarity transformed benthic community data collected as part of experiment II.

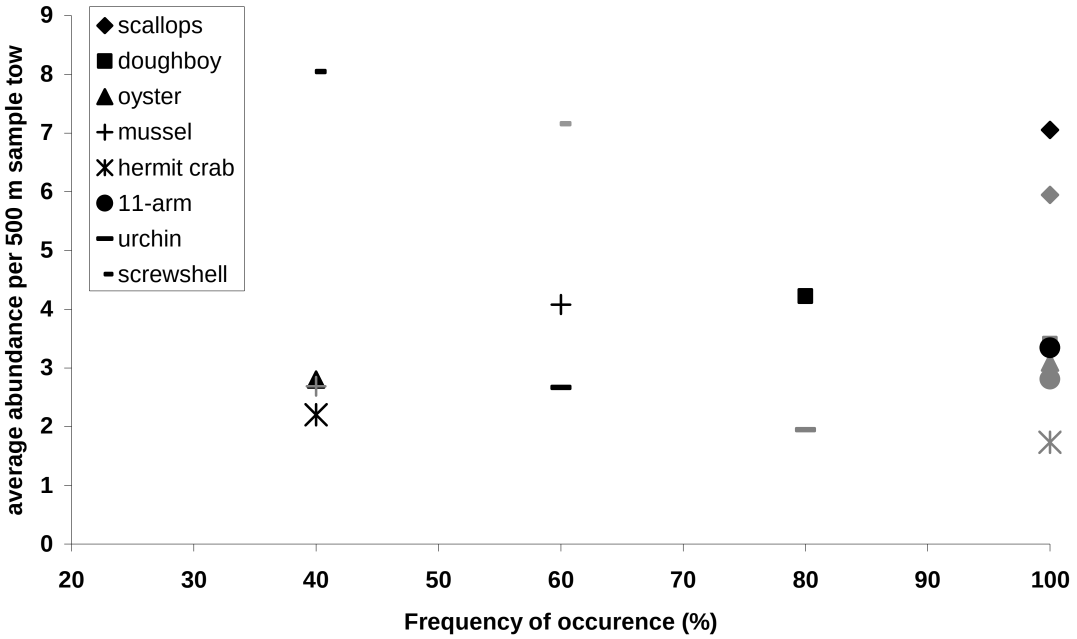


Figure 5.5: The average abundance of species caught per 500 m sample tow against the frequency of occurrence (number of sample tows found in) for each of the key species found within the SRA stratum during experiment II. Black represents before fishing abundances and the grey the after fishing abundances. For an indication of standard errors for each species refer to Table 2.

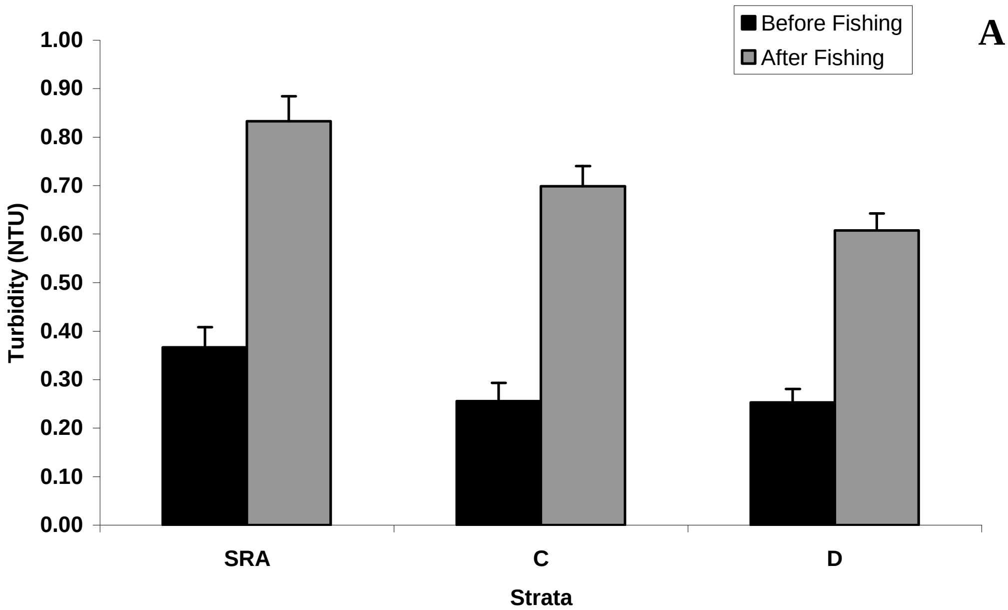
5.3.3 Impact of commercial fishing on water quality and sediment structure

There were no significant interactions between survey time and sample depth for turbidity and suspended solid readings within all surveyed strata. Depth was a significant term in the model for the turbidity readings within the control, SRA stratum only (F = 3.687; P = 0.04), with bottom samples having higher readings compared to the middle samples. Significant differences in turbidity and suspended solid readings were identified between the two surveys within all strata, the only exception being suspended solid readings within stratum D (Table 5.4). There was a general trend for higher turbidity and suspended solid readings during the second survey within both the impacted strata C and D and control, non-impacted stratum SRA (Figure 5.6).

There were no observable patterns in the differences in the cumulative sediment compositions for samples collected during the two surveys for both the impacted strata C and D or the control, non-impacted stratum SRA, with most before and after fishing data overlaying each other (Figure 5.7).

Table 5.4: Two-way ANOVA analysis results comparing turbidity and suspended solid readings before and after fishing had occurred. The asterisks denote significant *P* values.

Survey strata	F	*P*
Turbidity		
SRA	58.26	<0.001*
C	57.81	<0.001*
D	58.54	<0.001*
Suspended solids		
SRA	19.66	<0.001*
C	4.78	0.039*
D	1.74	0.201



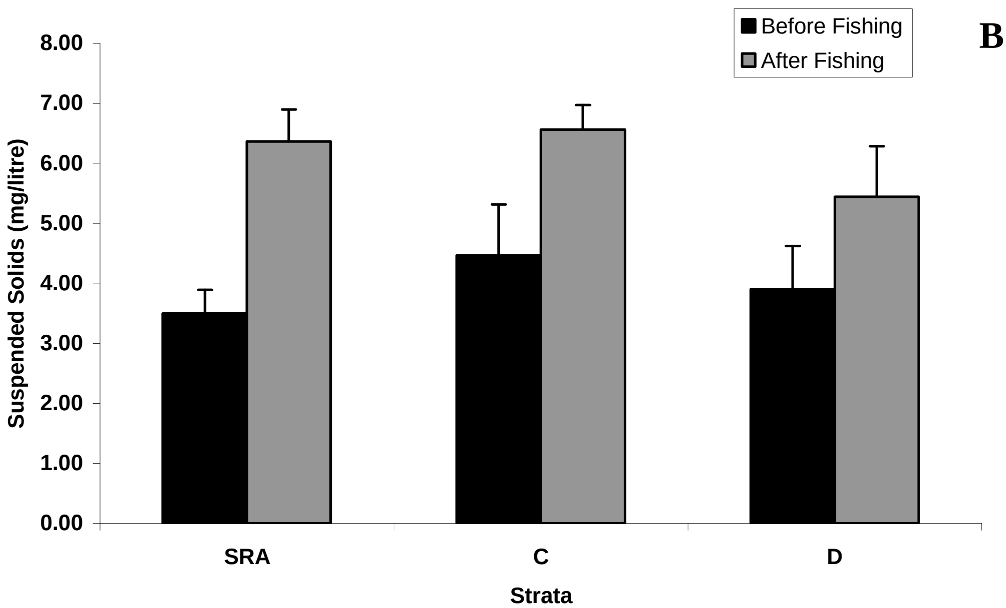


Figure 5.6: Average turbidity (A) and suspended solid (B) measurements ± SE for samples collected within each of the three survey strata before and after fishing

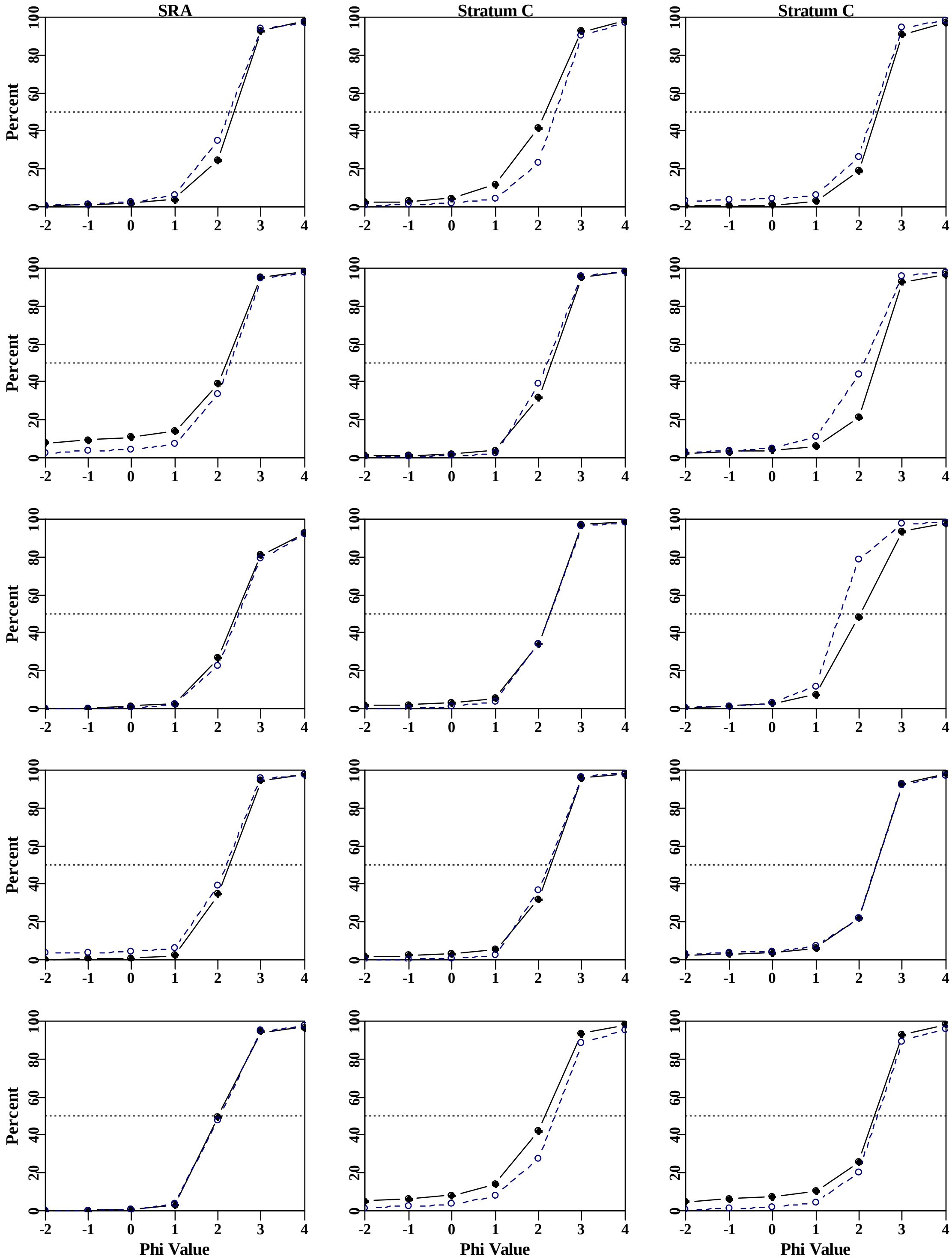


Figure 5.7: Phi curves for the SRA control, stratum C, and stratum D sediment sample locations. Black solid line with filled points represents before fishing samples. Dashed lines and empty points represents corresponding samples after fishing had occurred. The horizontal dotted lines represent the 50% mark.

5.4 Discussion

Intensive, short-term fishing associated with rotational closed-area and Industry rolling opening harvest strategies was found to alter the structure of scallop community. These changes were characterised by a 40% to 80% decrease in the abundance of the dominate species found within the study area. These dominate species were in general observed in the same number of sample tows before and after fishing had occurred. No species were completely removed as a consequence of intensive short-term dredging. A number of mobile species (predominately fish) were observed only after fishing, however, these species most likely moved into the survey region to scavenge on discarded and damaged animals (see Ramsay *et al.* 1998).

Water turbidity and suspended solid readings increased significantly within both the impacted (strata C and D) and the control (stratum SRA) strata during the second sampling period (i.e. after intensive short-term fishing in strata C and D). Readings collected during both surveys, however, represented good water quality for marine systems (i.e. all NTU readings < 0.80 and all suspended solid measures < 0.0065 grams per litre). As such, the magnitude of change observed during the second survey was not considered to be biologically significant. The composition of sediments within all strata showed no observable pattern of change with intensive, short-term dredging.

The short-term effects of benthic dredging and trawling are well documented, and generalised as changes in the local abundance of infaunal and epifaunal species, and the temporary modification of habitat structure (for reviews see Jones 1992; Dayton *et al.* 1995, Jennings and Kaiser 1998). As an example, Currie and Parry (1999) reported a 20-30% decrease of infauna and the flattening of volcano-like mounds and depressions during their study looking at the impact of scallop dredging on different soft substrates within Port Phillip Bay, Australia. Furthermore, Collie *et al.* (2000) conducted a meta-analysis of 39 published fishing impact studies to show that the immediate (short-term) effects of fishing were characterised by an average 46% decrease in the total number of individuals within disturbed regions. Other short-term effects of benthic dredging include changes to sediment grain size distribution or characteristics, suspended load and the magnitude of sediment transport processes (Reimann and Hoffmann 1991, Pilskaln *et al.* 1998). Stokesbury and Harris (2006) found significant differences in sediment composition of samples collected before and after short-term fishing within closed regions of the Georges Bank sea scallop (*Placopecten magellanicus*) fishery. However, changes were also observed within control, non-impacted regions, and the authors concluded that limited short-term fishing alters the epibenthic community and sediment composition less that the natural dynamic environmental conditions of Georges Bank (Stokesbury and Harris 2006). The overall degree of change in habitat structure and sediment characteristic will be dependent on a number of factors, including sediment type, intensity and frequency of disturbance regime and the occurrence of natural disturbance events (Collie *et al.* 2000, Kaiser *et al.,* 2002).

The repeated long-term (i.e. year after year impacts) effects of fishing on benthic habitat are generally more severe, and characterised by a shift in benthic community structure from communities dominated by species with relatively large adult body size towards dominance by high abundances of small-bodied organisms (Jennings *et al.*, 2001; Kaiser *et al.,* 2000; Kaiser and Spencer, 1996; Watling and Norse, 1998, Veale *et al.* 2000). Furthermore, continuation of fishing within a disturbed region will create a permanently altered community structure dominated by relatively short-lived species that are adapted to regular disturbance events.

Given that the White Rock scallop bed had not been fished for a minimum 22 years prior to the 2006 scallop season, it would be reasonable to assume that the benthic habitat and species composition found within this habitat was representative of an undisturbed scallop community for this region. This undisturbed scallop habitat was dominated by commercial scallops, and other relatively fast growing and short-lived molluscs and crustaceans. Such habitat remained relatively stable within the control, non-impacted stratum SRA during the two surveys conducted during experiment I, despite intensive fishing occurring within very close proximity (~ 500 meters) of some sample tows. Within the impacted sites, all species found before fishing were observed at the same frequency after fishing had occurred, but in lower abundances. Subsequently, the observed changes to benthic community structure was most likely the consequence of short-term fishing disturbance, and not related to any repeated long-term fishing impacts or natural disturbance events.

Future closed-area rotational harvest regimes may also consider the partial opening of a scallop bed during a fishing season. Such a harvest strategy may have many benefits, and ultimately help eliminate the boom and bust nature of scallop fisheries. The strategy will allow a known resource of scallops to be spread over a greater period of time. This may be particularly relevant if the Total Allowable Catch (TAC) for a season can be taken from a portion of a scallop bed. The strategy may also allow the conservation of high abundance areas of adult spawning scallops within regions of a fishery, which may ultimately promote recruitment events at the scale of a fishery (see Smith and Rago 2004).

Rotational closed-area harvest regimes allow time for recovery or restoration of fished benthic habitat, and the ultimate success of such strategies (including Industry rolling openings) will rely on impacted habitat having recovery times that fall within the time scale of any temporal closures (Kaiser *et al.* 2002). It has been suggested that benthic communities adapted to living in sandy substrata are likely to be less affected by the physical impact of fishing gear relative to other types of seabed (i.e. gravely, sandshell seabeds or mud) (Watling and Norse 1998, Hall 1998, Kaiser *et al.* 2002). Subsequently, sandy habitats that are subject to regular natural disturbance events may be capable of rapid recovery from short-term fishing events. Collie *et al.*, (2000) suggested that benthic communities associated with sandy sediments area able to recover within 100 days of disturbance. However, sandy sediment habitats often contain one or two longer-lived and therefore vulnerable species (Kaiser *et al.* 2002). For example, the majority of the benthos within the intertidal zone of the Wadeen Sea recovered from dredging within 6 months, with the exception of the large bivalve *Mya arenaria*, which remained depleted for at least 2 years after being impacted (Beukema 1995).

A rotational closed-area harvest strategy that requires scallops within an open area to be fished to uneconomical abundances and the subsequent closure of this open region (i.e. Tasmanian fishery example) will have a minimum recovery time equivalent to that needed for settlement and growth to harvestable size of the target species. Hart (2003) looked at yield- and biomass-per-recruit analysis for rotational fisheries to show that an ideal rotation of 6 years should be applied to the Atlantic sea scallop (*Placopecten magellanicus*). During the course of the present study, a major scallop recruitment event was observed within the fished region approximately 2 months after fishing stopped within the White Rock region (unpub. data). Assuming they survive, these scallops will take at least 3 years to reach the legal minimum size of 90mm (see McLoughlin 1994; Haddon *et al.* 2006). Subsequently, the minimum rotation time within the Tasmanian fishery would be three years. However, given that markets prefer scallops > 100 mm shell diameter, a longer rotation may be required (i.e. 4 – 6 years). Future research will determine whether the scallop habitat found within the White Rock region can recover to pre-fishing community structure within the minimum rotational period of three years.

5.5 Conclusions

In conclusion, the epibenthic community and habitat within the White Rock scallop bed did not appear to be irreversibly effected by the intensity of limited short-term fishing experienced during 2006. In fact, scallops were observed to recruit back into the system within a very short period of time (~ 2 months). Subsequently, rotational closed-area and Industry rolling opening harvest strategies, which promote intensive but short term fishing, may minimise the impacts of fishing on the marine benthic environment. Such strategies, however, must ensure that only scallop habitat is opened to commercial fishing operations and that the time period of rotation is suitable for the recovery of impacted benthic habitat.

6. INDUSTRY-BASED SURVEY REPORTS: 2005 TO 2008

6.1 Introduction

During the course of this project (FRDC 2005/027), TAFI have produced and distributed a number of reports that depict the results of Industry-based surveys in a format suited to the Tasmanian Industry and management requirements. These reports provide information about the location of survey sample tows, the abundance of scallops caught during these sample tows and a representation of the length frequency distribution of scallops from different survey regions. Subsequently, the information provided in survey reports has proven crucial for the management of the Tasmanian scallop fishery, with almost all important management decisions being based on fisher collected information.

The ultimate aim of this chapter is to provide the format under which Industry-based survey data has been presented to Industry and management and to highlight the key management outcomes that have occurred as a consequence of the information and advice provided within survey reports. During the period covered by these surveys and reports the survey formats and protocols evolved and the management of the Tasmanian scallop fishery became dependent upon the information that these surveys provide.

6.2 2005 Industry-based survey summary report (see Appendix 11.3)

6.2.1 Overview

This report described the results of surveys conducted during the 2005 commercial scallop season. Survey strategies ranged from one or two vessels exploring within data poor regions of the fishery (i.e. Northwest Tasmania) to a highly organised and structured survey that incorporated 10 Industry vessels working in unison (Banks Strait / East Flinders).

6.2.2 Key management outcomes

The information collected during surveys conducted during 2005 (see appendix 11.3) had several major consequences for the management and operation of the Tasmanian scallop fishery.

1. Industry survey information collected near Eddystone Point (Eddystone Point to Scamander section of report) resulted in the opening of a region near fishing locality block 4H3P at the start of the 2005 fishing season.
2. Industry survey information collected near the Gardens (Eddystone Point to Scamander section of report) led to the opening of this region during the 2005 season.
3. Information collected within Marion Bay led to the opening of this region to commercial operations during 2005.
4. The high abundances of predominately undersize scallops located within Banks Strait resulted in this region being designated a Class 1 Closed-area. Such closures prohibit any access or transit by active scallop vessels. This information also provided the basis for suggested changes to the South-East Commonwealth Marine Protected Areas, proposed in 2006. Without this information, a large and valuable part of the Tasmanian scallop fishery would have been closed forever.

5. Evidence of a natural scallop die-off event of two known scallop beds to the south east of Babel Island (East Flinders section of report) led to several major management decisions:
    - The region near Babel Island was opened to commercial fishing operations, as these scallops fulfilled the 2 major spawnings management rule criteria, despite the population structure of scallops violating the 20% discard (<20% of scallops may be < 90mm shell diameter) rate management rule.
    - The legal minimum size for scallops within this open region was reduced from 90 mm shell diameter to 80 mm shell diameter.
    - The total allowable catch for the 2005 season was increased with the extra catch only to be taken from the Babel Island region.

6.3 Industry Survey data – June to December 2005 (Appendix 11.4)

6.3.1 Overview

This report had considerable overlap with the information presented in the previous section (Appendix 11.3), with the only new information presented being for the White Rock region.

6.3.2 Key management outcomes

1. The results of the survey conducted within the White Rock area of the fishery led to the opening of this region of the fishery to commercial fishing during the 2006 scallop season.

6.4 August 2006 survey update (Appendix 11.5)

6.4.1 Overview

This report presented the results of Industry-based surveys conducted within the Eddystone Point and Banks Strait regions of the fishery. A further scientific survey was conducted within the White Rock region, but is not shown in the report.

6.4.2 Key management outcomes

1. The information from the White Rock survey work (not shown in report) led to a delay in the opening of the 2006 season and aided the Industry rolling opening strategy within this open area (see Chapter 5).

6.5 August / September 2006 survey results (Appendix 11.6)

6.5.1 Overview

This report presented the results of a survey conducted during August and September 2006. The survey was conducted between Eddystone Point and Friendly Beaches. The ultimate aim of the survey was to identify regions that could be opened for commercial fishing for the latter part of the 2006 season.

6.5.2 Key management outcomes

1. Opening of the Long Point region to commercial harvesting

6.6 2006 Industry survey summary (Appendix 11.7)

6.6.1 Overview

This report provided an overview of all Industry-based survey data collected during 2006, and summarised the information presented in sections 7.4 and 7.5 of this chapter.

6.7 June 2007 survey update (Appendix 11.8)

6.7.1 Overview

This report provided information from Industry-based surveys conducted within the two key candidate regions for the 2007 season. The information was ultimately provided to allow the scallop FAC to make more informed decisions about the 2007 season.

6.7.2 Key management outcomes

1. Opening of a fishing block in the vicinity of Eddystone Point.
2. Opening of the Banks Strait region to commercial fishing operations.

6.8 2007 Industry-based survey summary (Appendix 11.9)

6.8.1 Overview

This report provided an overview of all Industry-based surveys conducted throughout the 2007 season. The general conclusion from these surveys was that prospects for future harvests (2008 / 2009) were minimal.

6.9 TAFI background paper to FAC (Appendix 11.10)

6.9.1 Overview

This paper discussed issues concerning a proposed extension of the 2007 scallop season from the 21st December, to the end of February 2008. Also discussed were strategies for conducting Industry-based surveys during future years, including the possibility of out of season surveys.

6.10 Pre-season report 2008 (Appendix 11.11)

6.10.1 Overview

This report provided the most up-to-date knowledge of available stocks within the Tasmanian fishery prior to the 2008 season. The general conclusion of the report was that further pre-season surveys were essential for any 2008 season planning.

6.10.2 Key management outcomes

1. Results led to the formulation of a pre-season Industry-based survey plan that aimed at obtaining suitable information for making decisions concerning fishery openings during 2008.

6.11 Pre-season survey report 2008 (Appendix 11.12)

6.11.1 Overview

This report provided the results of the pre-season surveys conducted during May and June 2008.

6.11.2 Key management outcomes

1. Results led to two regions being designated as suitable regions for opening, with the aim of providing a small season (i.e. provide continuity of supply).
2. There was extensive discussion amongst the FAC members about the specific operation of the 2008 season. This issue was yet to be resolved at the time of writing.

7. BENEFITS AND PLANNED OUTCOMES

The principle outcome of this project has been the adoption and incorporation of the Industry-based survey data collection strategy into the spatial management framework of the Tasmanian scallop fishery. As of 2008, the key management requirements of Industry-based surveys have been incorporated into the Fisheries (scallop) rules and are also including within the key management policy documents for the fishery. The closure of the Commonwealth scallop fishery by the Minister for Fisheries for much of the time period of this project made it difficult to implement the Industry-based survey strategy within this fishery. However, the concept of Industry-based surveys and the greater flexibility that such surveys will require were documented and incorporated into the Harvest strategy for the Bass Strait Central Zone Scallop Fishery, which was completed by the CSIRO in late 2007 with assistance by TAFI scallop researchers. This document also incorporated a change in harvest strategy from a most open, little closed spatial strategy to one almost identical to the Tasmanian spatial management model. It is hoped that a fully flexible survey approach, as utilised in the Tasmanian fishery, will be adopted within the Commonwealth fishery with its re-opening.

Within the Tasmanian scallop fishery, the information collected during Industry-based surveys has been fundamental for the operational decision making process, with all decisions within the fishery now being based on fisher collected data. This has benefited Industry and management in many ways. In particular, the costs of management (i.e. fisher levies) do not have to incorporate the extremely high costs of fishery scale scientific surveys. In turn, Industry, research and management can obtain and have access to fishery scale information for the management decision making process.

All sectors involved with the Tasmanian fishery have aimed to incorporate technologies into the data collection process. Today, electronic measuring boards, GPS devices and depth loggers on the dredge are standard survey equipment. Survey participants are familiar with their operation. Such devices have greatly improved the amount of data that can be collected per survey day (value for money) and improved the accuracy and perceived credibility of Industry collected survey data. Industry has a vision to expand the use of technology in the survey process (see 8. Further Developments)

The Tasmanian commercial scallop fishery has taken an increasing level of responsibility for the organisation and implementation of the Industry-based survey process within the Tasmanian scallop fishery. By the conclusion of this project, the TSFA had taken the role of selecting survey participants and the basic organisation and planning of surveys. This ownership of the Industry-based survey process has moved the Tasmanian scallop fishery closer to a full co-management approach, and seen the TSFA take control and ownership of otherwise traditional management operated harvest mechanisms. Of particular note, the Tasmanian scallop Industry fully own the organisation of the fine scale rolling opening harvest mechanism that operates within the legislative open area. Such strategies have ultimately maximised the quality and quantity of product taken from a known scallop resource, which in turn has maximised economic returns to fishers. The full economic benefits have yet to be completely realised, but it is hoped that further growth within the TSFA will lead to greater co-management of the Tasmanian scallop fishery and a realisation by the TSFA that economic return to fishers does not necessarily rely on high catches / TAC’s during each fishing year. It is hoped that such ownership of management processes will be incorporated into the Commonwealth fisher once re-opened.

8. FURTHER DEVELOPMENT

It is hoped that the survey strategies devised as part of this project and the improved Industry participation in the management process that has stemmed from such survey strategies will lead to the development of a co-management harvest strategy for the Tasmanian scallop fishery. A continuation of the maturity shown by the Tasmanian scallop Industry, and their ability to build on their within-season rolling opening harvesting strategy will hopefully convince all stakeholders of the TSFA's ability to take on such responsibility. An evolution of the Industry-based survey process will be to continue to incorporate electronic data collection mechanisms into the survey process. There is a vision for a fully electronic data collection and sharing system, which will incorporate electronic measuring devices / GPS technology and the up-linking of survey data in near real-time over a secure web-based, user friendly database. Access to such information will aid the Industry rolling opening strategy, especially if the system is capable of identifying where individual vessels are located. Once achieved within the Tasmanian fishery, the next task would be to integrate the Industry-based survey procedure within the Commonwealth fishery.

From a research perspective, the next step is to better understand the population structure of scallops within the SE fisheries (all scallop jurisdictions) and determine some of the large scale (across current jurisdictions) and fine scale (within fishing regions or even beds – i.e. potential for self-seeding) recruitment processes. The ability to promote recruitment of scallops is the final link in providing a continuous and sustainable management regime for scallops. Also, the determination of scallop population structure provides the best possible approach to resolving the OCS arrangements, which have been a topic of discussion for at least the last decade. These research objectives have been incorporated within the FRDC project "Establishing fine-scale Industry based spatial management and harvest strategies for the commercial scallop fishery in south east Australia (FRDC 2008/022), which started on the 1st July 2008.

9. CONCLUSIONS

This project has developed a generalised, credible regime of Industry observations that form the basis of the information required to manage a spatially structured fishery. A formal and operational system of Industry-based surveys has been constructed, which allows the simple yet workable organisation of Industry-based pre-season and within-season surveys. The information collected during such surveys has been fully incorporated into the management decision making process of the Tasmanian scallop fishery. The overall Industry-based survey structure and system has been included within the Tasmanian scallop fishery rules and policies that govern the Tasmanian scallop fishery. The information collected during surveys is presented at management decision making forums (FAC's) for discussion, and ultimately allows all management planning and within season operational decision making to occur. Similarly, the Industry-based survey strategy has been incorporated within the recently completed harvest strategy for the Bass Strait Central Zone Scallop Fishery. The management agency for this fishery, the Australian Fisheries Management Authority, also plan to fully incorporate the Tasmanian Industry-based survey model into the within-season management protocols for their fishery.

Any effective strategy of Industry-based surveys must be operable under the rules and policy that governs a fishery. The Industry-based survey process must be transparent and participatory. The managers responsible for a fishery must have the ability to be flexible and adaptive in their management approach and the ability to use Research Quota Unit Allocations or other similar incentives to conduct surveys. Without such management, fishers may not be supportive of the Industry-based survey process and / or will distance themselves from the data collection requirements. Finally, technologies that simplify the collection of survey data and improve data accuracy and credibility must be incorporated into the Industry-based survey design wherever possible.

Within the Tasmanian scallop fishery, a system of seven protocols is used to organise and implement Industry-based surveys. This system is as follows:

1. Determination of clear and concise survey aims and data collection requirements by all fishery stakeholders.
2) Determination of the type of survey to conduct. These can be divided into three broad categories: a) Pre-seasons surveys; b) within season surveys; and c) out of season surveys.
3) A transparent and expedient process for selecting survey participants.
4) A flexible mechanism for allowing surveys to be conducted within closed-areas and closed seasons.
5) Development of a specific survey design, equipment requirements, education and training requirements.
6) Conduct the survey under agreed design and strategy.
7) Analysis, presentation and archiving of industry-based survey data.

Industry-based surveys have ultimately improved Industry's participation in the management decision making process. This has created a greater sense of ownership by Industry towards the Tasmanian scallop fishery, which in turn has resulted in the Tasmanian Scallop Fishermen's Association (TSFA) taking ownership of much of the Industry-based survey design and organisational requirements. Furthermore, the TSFA have implemented harvest strategies that have attempted to maximise the quality and quantity of scallops harvested from within an open area. The Industry-based rolling opening strategy first implemented during the 2006 season in White Rock was found to greatly improve the quality of scallops harvested, and has been credited with maximising the number of scallops harvested from the open region. Industry support for such a strategy was high, and future developments of the strategy will further maximise the quality and quantity of scallop harvested from within the Tasmanian fishery.

The impacts of intensive short term dredge fishing effort on scallops, scallop habitat and the broader marine environment are relatively unknown. The impacts of fishing associated with detailed rotational closed-area spatial management and Industry within-season rolling opening regimes within the White Rock scallop bed were characterised by a 40% to 80% decrease in the abundance of the dominate species found within the study area, however, no species were fully removed and the dominant species were observed in the same number of sample tows before and after fishing had occurred. No biologically significant differences in water turbidity and suspended solid readings were observed. The composition of sediments within control and impacted strata showed no observable pattern of change. Ongoing work will determine whether the time for recovery or restoration of the fished benthic habitat falls within the time scale of any temporal closures. If found to be the case, then rotational closed-area and Industry rolling opening harvest strategies, which promote intensive but short term fishing, may minimise the impacts of fishing on the marine benthic environment.

This project, combined with the results of the preceding FRDC scallop project (2003/017), has resulted in a clear vision for the future of Bass Strait scallops. It is hoped that all scallops within the SE of Australia can be managed under a rotational closed-area spatial management regime, which sees the majority of the available fishing grounds closed to fishing, and only relatively small areas of known stocks being opened. The rotation interval will allow the recovery of the target species, scallops, and the broader habitat that is impacted. The information needed to make decisions concerning openings and closures will be collected by Industry during Industry-based surveys. Scallop Fishermen's Associations will be responsible for much of the planning and organisation of these surveys, with some direction provided by research and management, making the system a co-management approach. A fully automated electronic system of data collection is visualised, and would incorporate a web-based data sharing and monitoring component. The specific spatial harvest regimes implemented will incorporate strategies that maximise and / or promote the chances of successful recruitment within the fishery. With the inclusion of results from FRDC 2008/022, it is hoped that a greater level of unison in the management and research within the current three scallop jurisdictions (Tasmania, Commonwealth and Victoria) can be achieved by a revision and if necessary altering of the current OCS arrangements for the fishery. If successful, this would allow synchronisation of harvesting strategies, and a far greater chance of annual continuity of supply into markets. For example, should there be a good supply of large scallops within the Commonwealth fishery during a given fishing period, the Tasmanian / Victorian fisheries could plan not to fish or to take only a low catch to coincide with this period. It must also be acknowledge that during some years only a low TAC may be possible from all the current fishery jurisdictions combined.

If this vision can be realised, there could be a real possibility of a continuous and sustainable supply of scallops from the SE Australian scallop resource. Within Tasmania the scallop Industry members have demonstrated that they are capable of adopting responsibility for important aspects of the management of the resource which they harvest. Such arrangements benefit all participants, especially during years of high catch rates and sufficient scallop stocks to ensure the full scallop quota may be taken. However, even with a detailed spatial management regime, scallop stocks are naturally variable and relatively poor years can occur when none of the three commercial scallop jurisdictions will do well. Cooperative behaviour under such difficult conditions becomes more difficult to achieve, simply because the risk of financial loss to individuals appears greater.. Therefore, even though this system in Tasmania is well established, efforts need to be maintained to ensure that the fundamentals of its operation are reinforced and continue into the future.

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11. APPENDICES

Appendix 11.1: Intellectual Property

There are no intellectual property issues relating to this project.

Appendix 11.2: List of Staff

Mr. Julian Harrington – Junior Research Fellow
Assoc. Prof. Malcolm Haddon – Principal Investigator
Dr. Jayson Semmens – Co-investigator

Appendix 11.3: June – Sept. 2005 Industry-based survey data report

Dear Fisher / Processor,

The scallop research team at TAFI thought we would take this opportunity to not only provide you with the data from the most recent Industry surveys, but also thank you for your involvement and contributions to the surveys conducted over the last 6 months. Firstly, however, we would like to apologise for the delay in providing this information. As some of you may be aware, Julian has recently been in hospital, and has consequently spent the last 4 weeks recovering. However, he has now returned to the office and will be continuing with the scallop work!

The Industry-based surveys conducted this season have been very successful in providing information about the scallop resource around the coast of Tasmania. This type of data is pivotal in the decision making process of the Tasmanian scallop fishery, and will hopefully guide the fishery to a long-term sustainable harvest.

Find below information relating to the Industry-based surveys conducted this season. It needs to be emphasised that the circles on the maps represent abundances of scallops, or the number of scallops caught per 5 minute tow. In other words, each circle represents an approximate catch rate for a 400 metre by 4 metre (dredge width) sample tow. In no way do these abundance circles represent the area that scallops were found over. Furthermore, length frequency plots provide information for those scallops that were measured only, i.e. length frequencies have not been weighted with respect to total catches.

This information has been distributed to all persons who have participated in Industry based surveys, and FAC members. Feel free to distribute to any other interested parties.

Furthermore, feel free to contact Malcolm Haddon (62 277 279), Jayson Semmens (62 277 275) or Julian Harrington (62 277 201) regarding the information presented within this document.

Happy fishing to you all

Scallop Research Team

TAFI - MRL

Northwest Tasmania

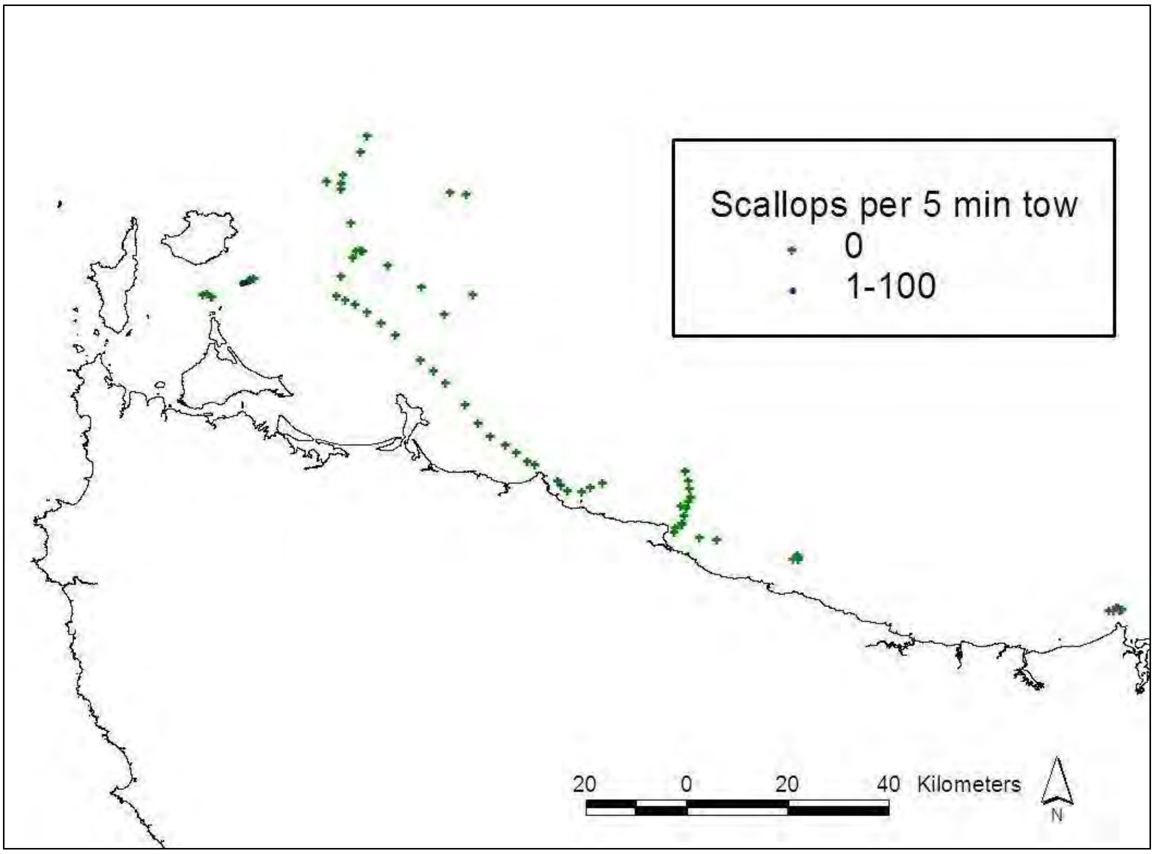


Figure 1: Location of sample shots and abundance of scallops caught in the Northwest of Tasmania, 2005.

Survey Results:
Virtually no scallops were caught within the surveyed region to the northwest of Tasmania. In fact, only two sample tows conducted to the south east of Three Hummock Island had very low abundances (<100 scallops per 5 minute tow) of scallops recorded in the catch.

Future Harvesting Potential:
Given the results of the resent survey, there is no short-term fishery potential within this region.

Northeast Tasmania / West Flinders

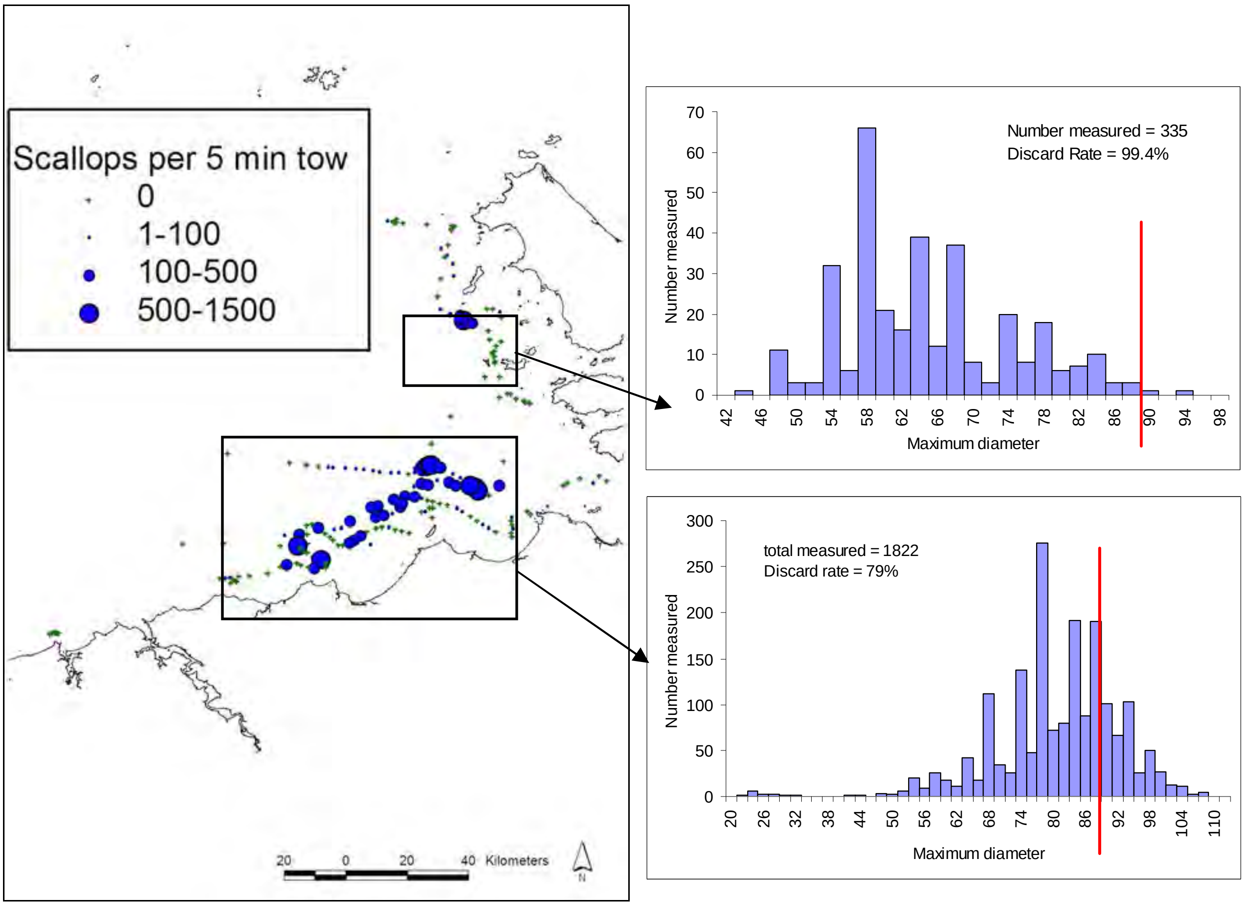


Figure 2: Location of sample shots and abundance of scallops caught in the Northeast of Tasmania / West of Flinders Island, 2005; and length - frequency analysis of scallops caught around Ringarooma and Anderson Bays (bottom plot) and west of Flinders Island (top plot). The vertical line on the length frequency plots indicates the legal size limit for commercial scallops.

Survey Results:

An extensive area within the Ringarooma / Anderson Bay region was found to contain scallops, with some individual sample tows containing greater than 500 scallops per five minutes dredging (Figure 2, lower box on the map). However, this region would best be described as a 'scattering' of scallops, with areas containing high abundances of scallops being within close proximity to areas containing no / very low abundances of scallops (Figure 2). There was a high discard rate (79%) for those scallops that were caught and measured within this region (Figure 2, bottom length frequency plot).

Only one small area to the west of Flinders Island (south of Prime Seal Island) was found to contain higher abundances of scallops. The vast majority of scallops measured in this region were well below the legal size limit, with a discard rate of 99.4% (Figure 2). All remaining survey tows within this region contained very low abundances of scallops.

Future Harvesting Potential:
The high discard rate of scallops measured within both areas suggests no harvesting potential within the next 12 to 24 months. However, this is highly dependent on growth rates and condition of scallops within this region. Future monitoring of this area will provide this information.

Banks Strait

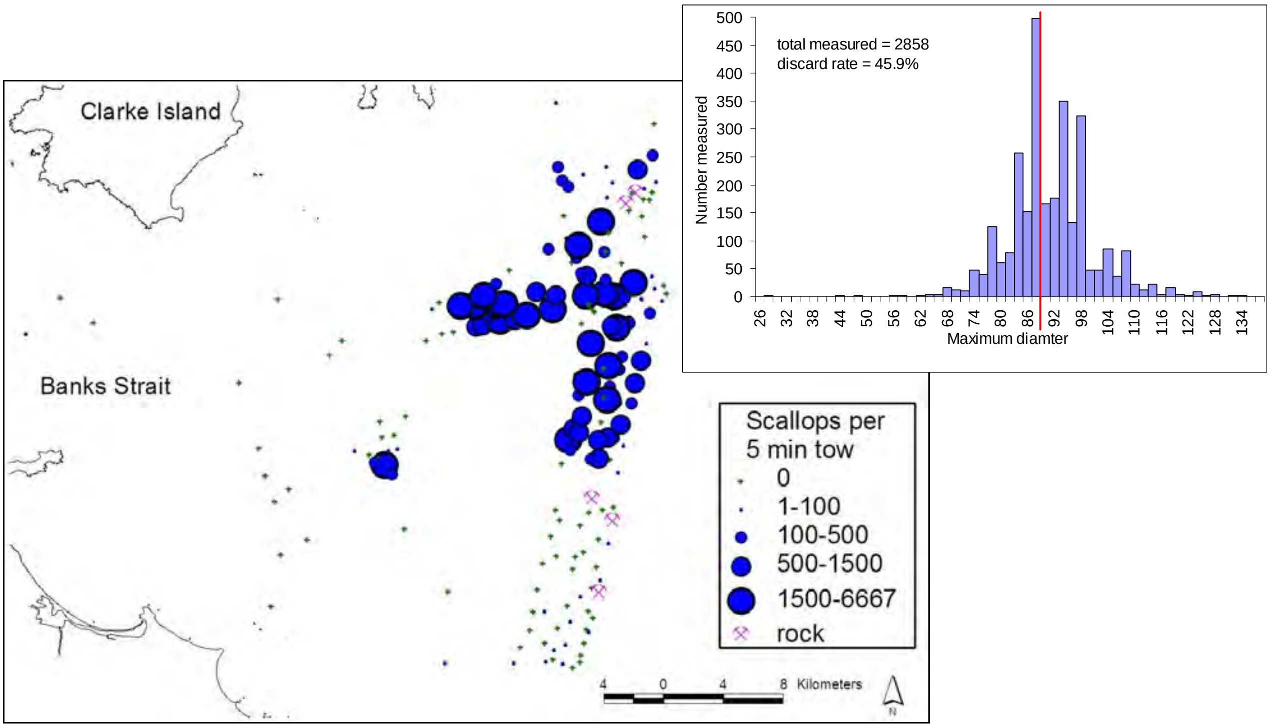


Figure 3: Location of sample shots and abundance of scallops caught in Banks Strait, 2005; and the length-frequency analysis of scallops caught for all data combined within this region. The vertical on the length-frequency plot indicates the legal size limit for commercial scallops.

Survey Results:
Several fishers have spoken about the ‘sand banks’ of the Banks Strait region, and how they would fish for scallops within the troughs of the sand hills. Results of resent work conducted within this region would suggest that the ‘sand banks’ are beginning to refill with scallops after being fished down during the 1980’s. Within some troughs, very high catch-rates of scallops were recorded (approximately 5000 per 1000m^2). However, the scallop catches within this area did vary from tow to tow. For example, sample tows

containing high abundances of predominately undersized scallops have been recorded within close proximity (100's meters) of areas containing high abundances of predominately legal size scallops, which in turn have been recorded within close proximity of sample tows containing very few, or no scallops. The overall results from Banks Strait showed an extensive area of predominately undersize scallops (discard rate = 45.9%) (Figure 3).

Future Harvesting Potential:
Fishers have suggested that the scallops found within this region require a further 12 to 24 months growth before the majority of scallops reach a suitable harvesting size.

East Flinders

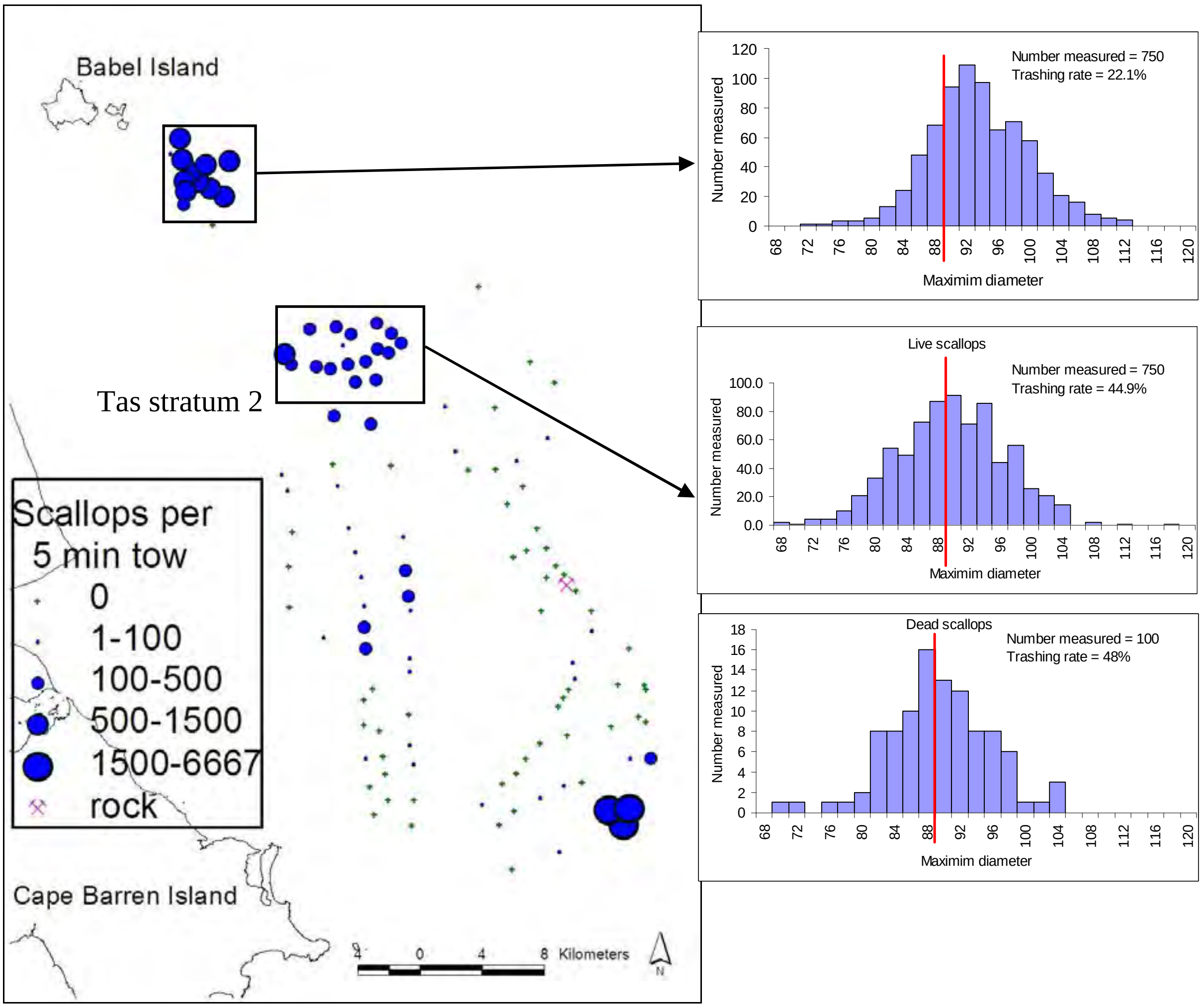


Figure 4: Location of sample shots and abundance of scallops caught to the east of Flinders Island, 2005; and the length-frequency analysis of live scallops caught in tas stratum 3 (top plot) and Tas stratum 2 (middle plot). The bottom length-frequency plot indicates the size structure of recently dead scallops shells (predominately clappers) caught within Tasmania stratum 2. The vertical line on all length-frequency plots indicates the legal size limit for commercial scallops.

Survey Results:

The surveyed region to the east of Cape Barren Island (also referred to as the Pot Boil) was found to contain virtually no scallops, the only exception being a small, very dense area of scallops within deeper water well east of Cape Barren Island.

An extensive search within the known scallop bed 'tas stratum 2' indicated a major die-back of scallops. Although the onset of this die-back was apparent within the outer, eastern fringes of the bed during a survey conducted in March (three months prior to this survey), the proportion of live to newly dead shell has not only increased dramatically, but also spread throughout the entire bed. A comparison of the length frequency plots of live scallops (Figure 4, middle plot) and recently dead shell (clappers) (Figure 4, bottom plot) indicates that all cohorts within the bed area dying, not just the larger, older scallops. The size structure of live scallops showed that Tas Stratum 2 was predominately undersize at the time of survey, with a discard rate of approximately 44.9% (Figure 4).

Although the scallop bed ‘tas stratum 3’, southeast of Babel Island, was also found to contain newly dead scallop shell, the proportion of live to dead scallops was substantially lower compared to that found in ‘tas stratum 2’. Consequently, high abundances of live scallops (>1500 per 5 minute tow) were found over a large area (Figure 4). Length frequency data indicated that most scallops were greater than 90mm in diameter, with approximately 22% being below the legal size limit (discard rate). The vast majority of scallops within this region were out of condition, and had small, watery roes.

Future Harvesting Potential:
Given the availability of large scallops elsewhere within the Tasmanian fishery, 20% discard rate policy, 90mm legal size limit of scallops, and current market requirements, the scallop beds located to the east of Flinders Island (Tas stratum 2 and Tas stratum 3) were unsuitable for harvest prior to the 2005 season. Advice from fishers during the survey period suggested that if scallops within the Babel bed were to improve roe condition, they should reach 70 to 80 per kg, and therefore market requirements. Given the die-back observed within both beds, it was advised that the scallops to the east of Flinders Island should be made available to commercial fishing during 2005, regardless of current observed discard rates.

At the time of writing this report, observations within the Babel bed indicated that scallops had dramatically improved condition, and that catch-rates of export quality scallops were very high.

Eddystone Point to Scamander

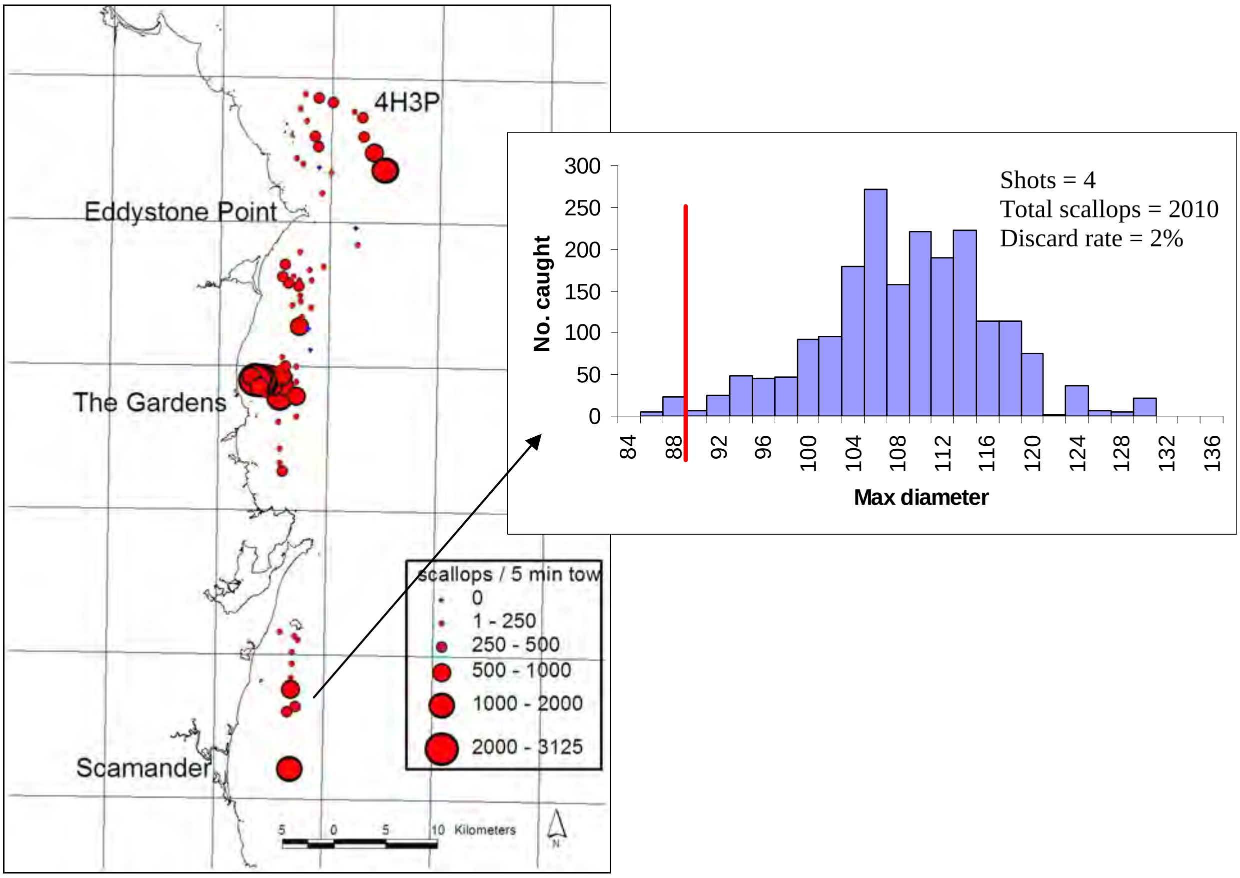


Figure 5: Location of sample shots and abundance of scallops caught from Georges Rocks to Scamander, 2005. The length frequency plot indicates the size structure of scallops from the St. Helens Island region. The vertical line on this plot indicates the legal size limit for commercial scallops.

Survey Results:

Survey data collected from The Gardens / Georges Rocks region are now redundant given the commercial fishing operations within these regions during the 2005 season.

Although a pre-season survey of the Eddystone Point scallop bed (fishing locality block 4H3P) identified good abundances of predominately legal sized scallops (approximately 4% trashing rate), commercial fishing operations within this region identified high numbers of undersize scallops (predominately in the 60 – 70 mm range, however small numbers of 20-30mm scallops were also recorded). The bed was subsequently closed to fishing. Further sampling of this bed is required to determine the extent of any recruitment, and viability of this bed for opening during the 2006 open season.

Generally low abundances of legal sized scallops (discard rate 2%) were caught south of St. Helens Point / Scamander regions (Figure 5), however, some sample tows did have high catch rates (1000-2000 per 5 minute tow).

Future Harvesting Potential:
Unless high abundances of residual scallops remain in the Gardens / Binalong scallop bed, this area will require time for future recruitment and subsequent recovery.

Several fishers have suggested that the abundances of scallops within the St. Helens Island region were too low to support a commercial fishery.

Further survey work is required within the Eddystone Point scallop bed to determine the size structure of scallops present, and extent of undersize scallops within the bed.

Nth Long Pt to Sth Bicheno

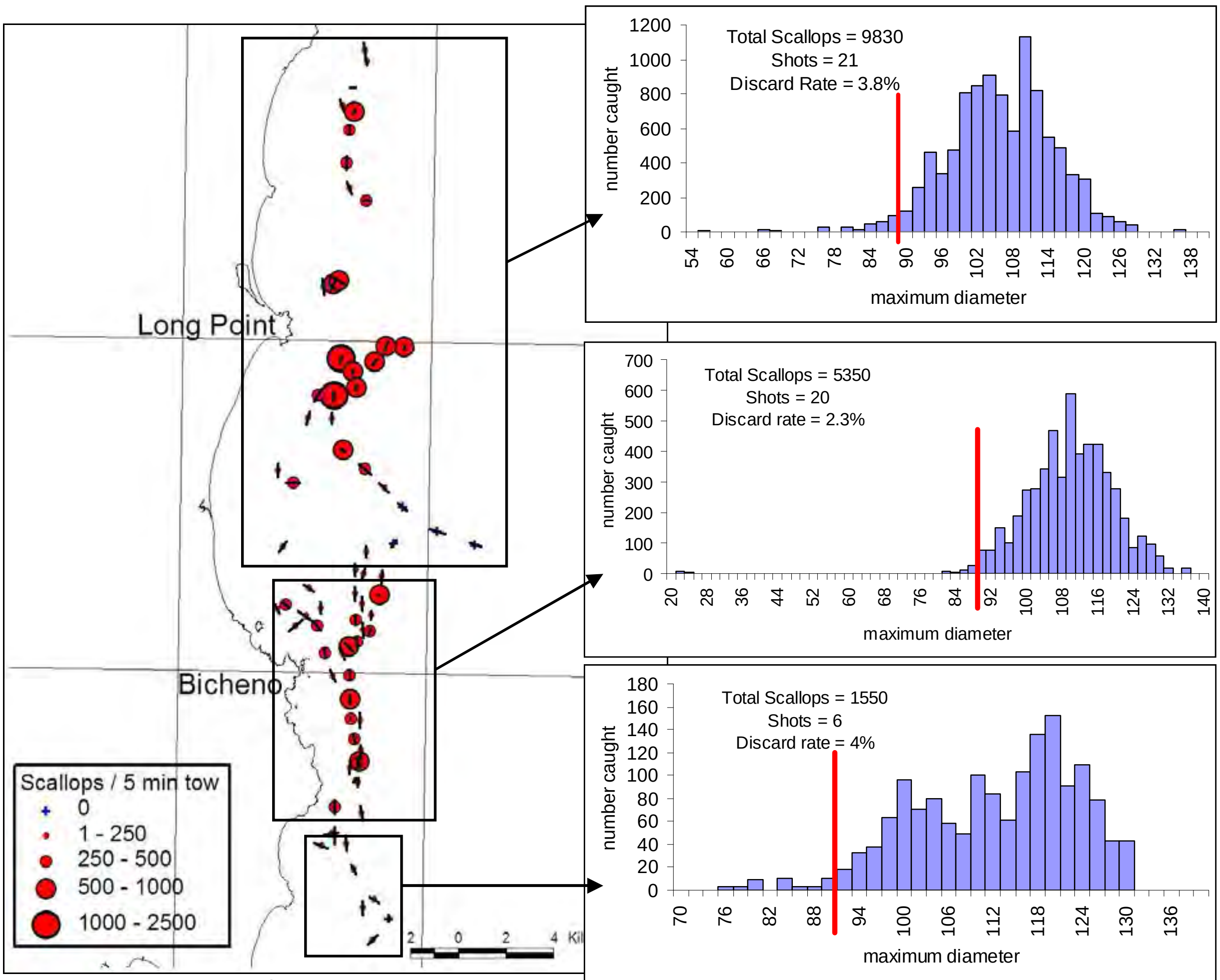


Figure 6: Location of sample shots and abundance of scallops caught Nth of Long Point to sth of Bicheno, 2005. The length frequency plots indicate the size structure of scallops from each corresponding area on the map. The vertical lines on these plots indicate the legal size limit for commercial scallops.

Survey Results:
Reasonably extensive areas containing 250 – 1000 scallops per 5 minute tow were found within the Long Point / Bicheno region (Figure 6). These scallops have survived the 2004 commercial season, and were predominately legal size, with discard rates below 5% (Figure 6).

Future Harvesting Potential:
This region was open to commercial fishing at the time of writing this report.

Marion Bay

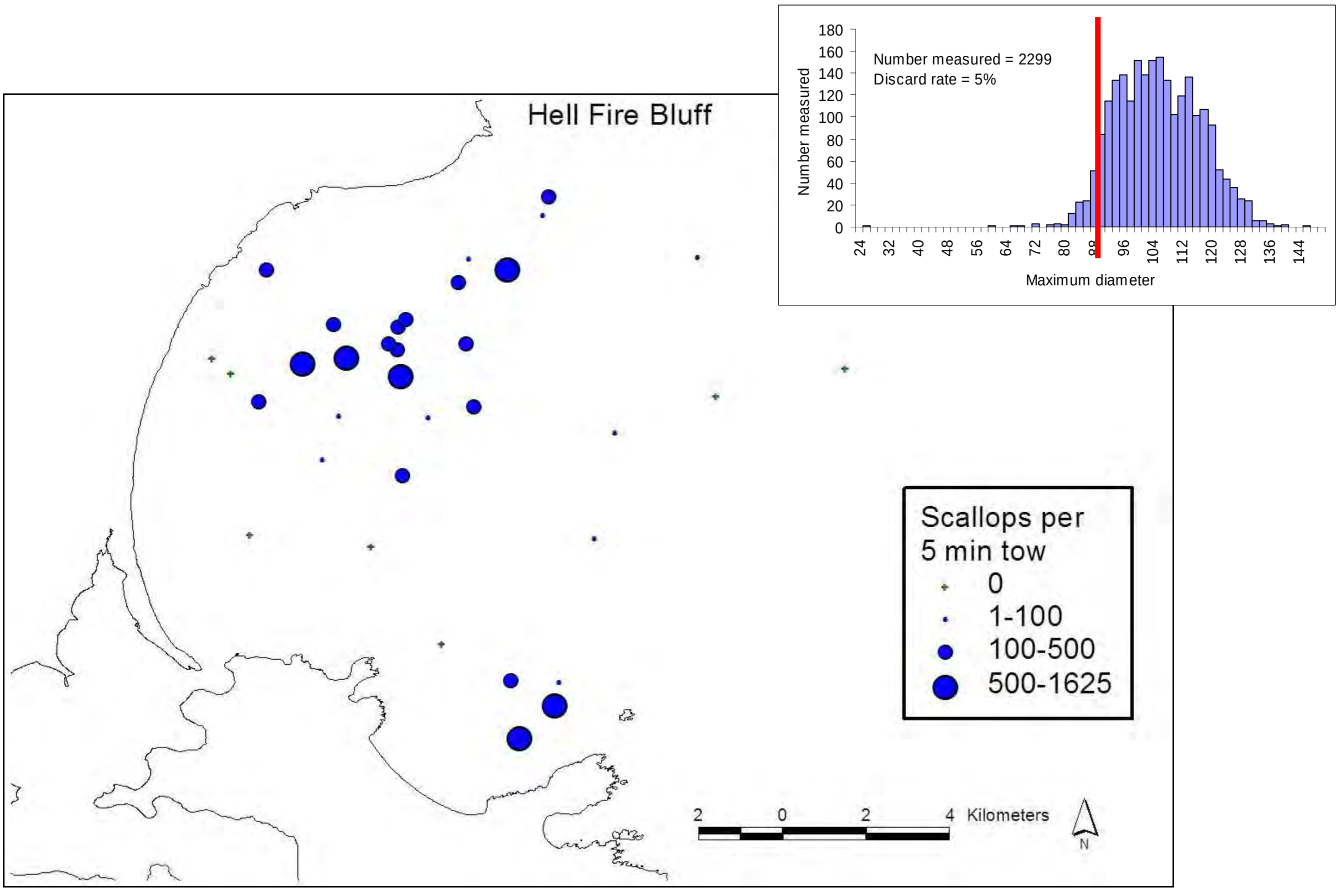


Figure 7: Location of sample shots and abundance of scallops in Marion and North Bays, 2005; and the length-frequency plot for all data combined. The vertical line on the plot indicate the legal size limit for commercial scallops.

Survey Results:
Small areas within the Marion Bay / North Bay regions were found to contain abundances of scallops above 500 per 5 minute tow (Figure 7). All remaining survey areas contained very low abundances, or no scallops. Relative to the size and abundance of scallops found within areas such as the Gardens and Eddystone Point, the overall numbers of scallops within Marion Bay were not considered to be very high.

Future Harvesting Potential:
At the time of writing this report, Marion Bay was open to commercial fishing.

Appendix 11.4: 2005 Industry-based survey data summary report

Current knowledge of the Tasmanian Scallop Resource

Industry Survey Data
June 2005 to December 2005

Julian Harrington, Malcolm Haddon, Jayson Semmens
University of Tasmania

Tasmanian Aquaculture & Fisheries Institute
University of Tasmania

Australian Government
Fisheries Research and Development Corporation
Australian Fisheries Management Authority

Introduction

This report presents all Industry survey data collected from June 2005 to December 2005. The Industry surveys conducted during this time have been jointly organised and implemented by TAFI and Tasmanian DPIWE, as part of the FRDC funded project 'Facilitating Industry Self-Management for Spatially Managed Stocks: A Scallop Case Study' (FRDC 2005/027). The data collected during these surveys have not only increased knowledge of the scallop stocks available within Tasmanian waters, but have also allowed several important management decisions to be implemented.

Figure 1 provides an overview of all sample tows conducted within Tasmanian waters since June 2005. It should be obvious that the use of Industry to survey within Tasmanian waters has greatly increased our knowledge of scallops stocks, at minimal costs to fishers, management and research. The following sections of this report will provide greater detail of the sample tows conducted, amount of scallops caught, and length frequency distribution (size structure) of scallops caught within different survey regions around the coast of Tasmania. Unlike previous reports, the amount of scallops caught will be presented as the total amount in kg's of scallops caught for each sample tow identified (where data is provided). It must be noted that this does not take into account the time of the sample tow (length of tow), however plots of the length of each tow are provided.

Finally, the authors of this report would like to thank the skippers and crew of all vessels that have participated in Industry surveys from June to December 2005 (in alphabetical order): Anita, Brid Venture, Brid Voyager, Christa Leanne, EJ Fairnie, Karmin, Petuna, Soluna, Suncoaster II, Tara Lyn and Waubs Bay. This report is compiled from the Industry sample tows that you conducted (Figure 1).

Overview

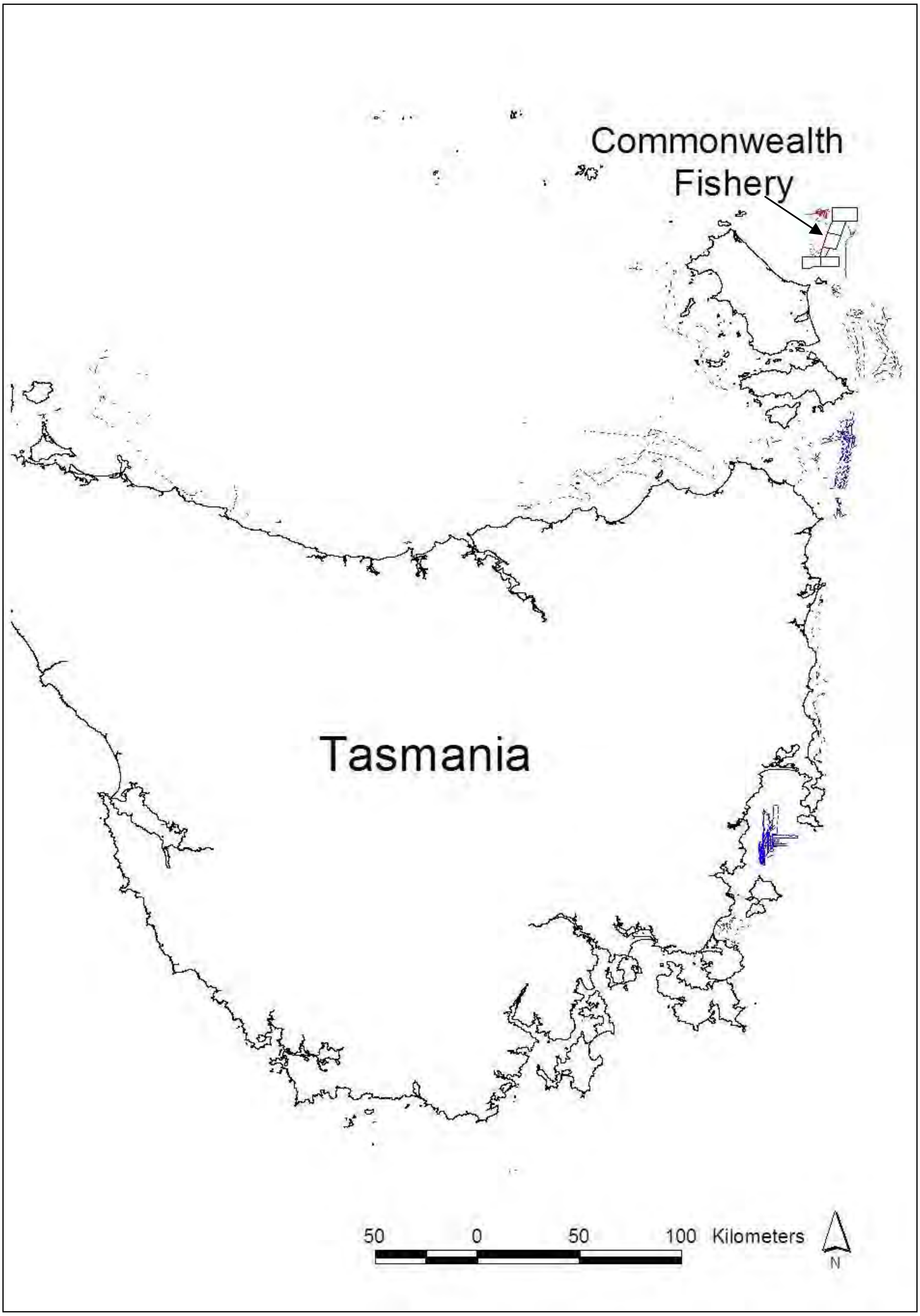


Figure 1: Industry survey tows, which have been conducted within Tasmanian waters from June 2005 to December 2005. Industry tows conducted within Commonwealth waters during this time are also illustrated to the north east of Flinders Island (near the strata identified).

North West Coast

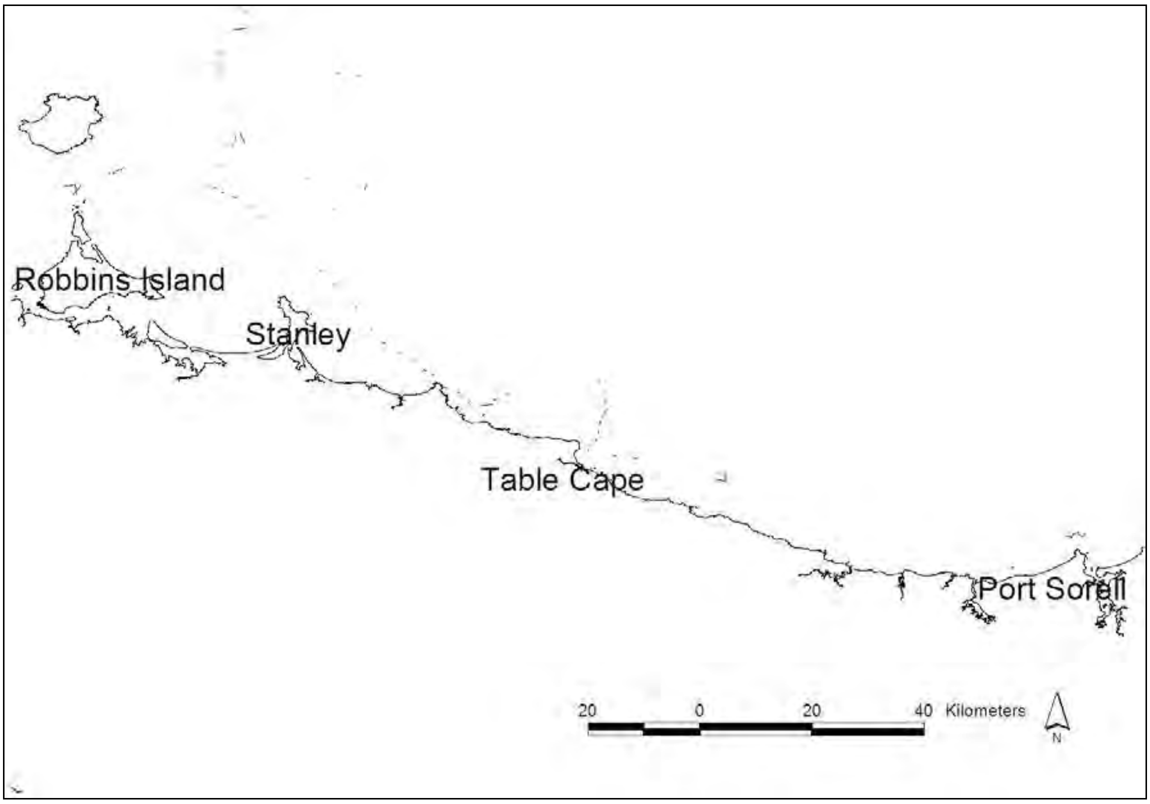


Figure 2a: The location of the Industry survey tows conducted along the North West coast during June and July 2005.

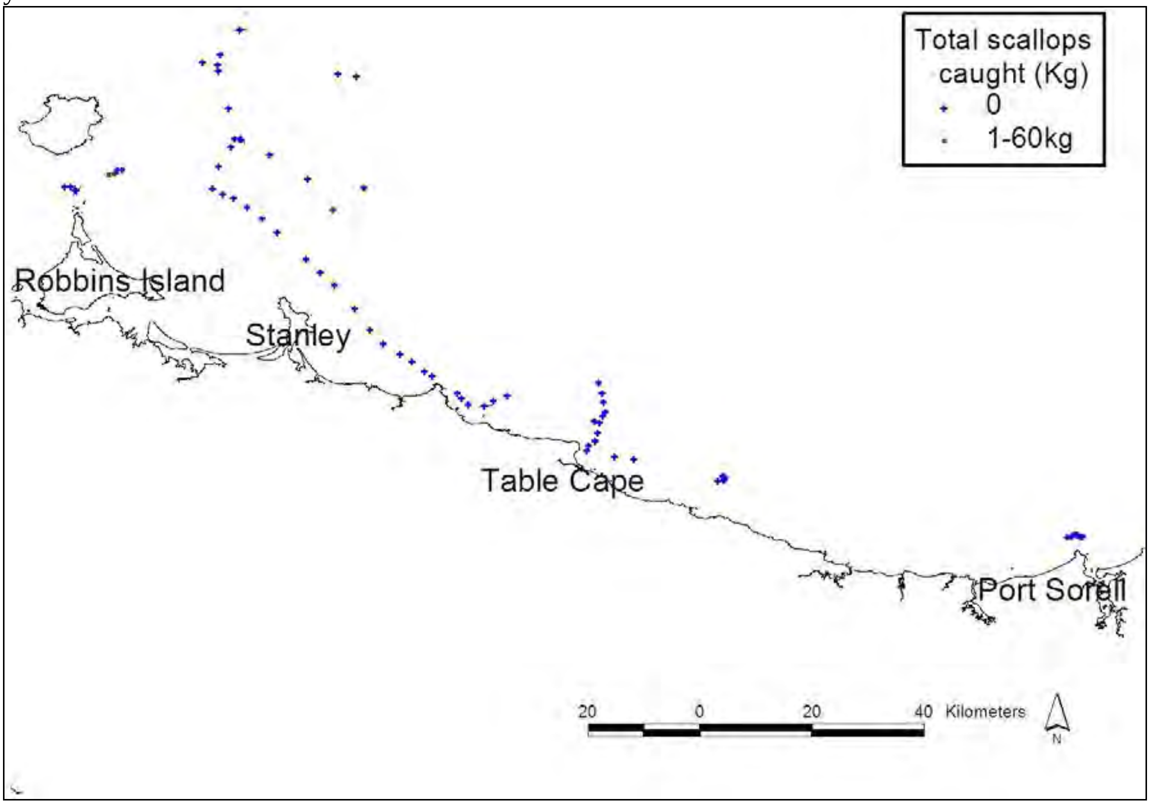


Figure 2b: The amount of scallops caught, as total kg's of scallops, for each Industry survey tow identified in Figure 2a. In conclusion, no commercial scallop stocks were identified along the North West coast.

West Flinders / Northeast Coast

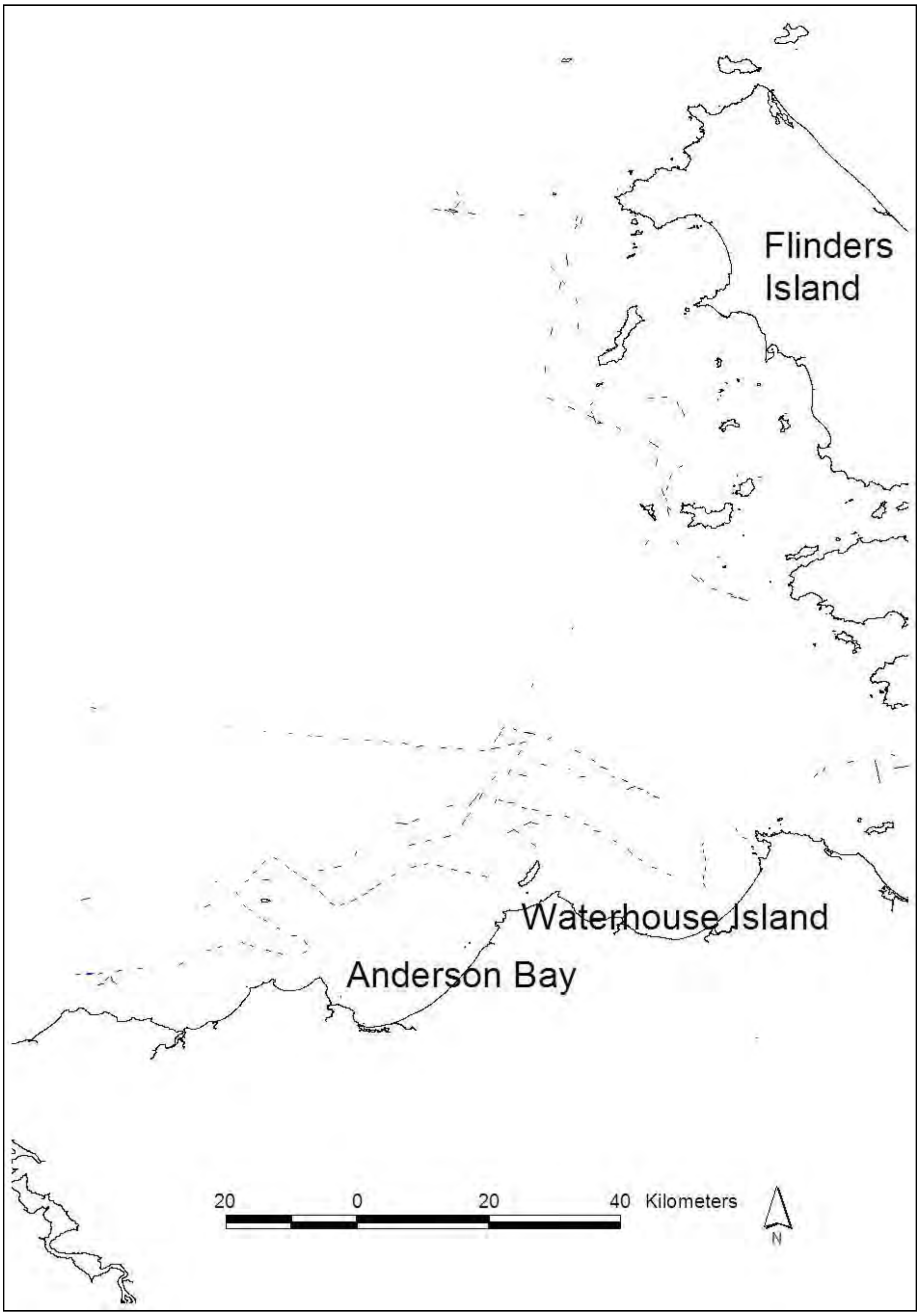


Figure 3a: The location of the Industry survey tows conducted West of Flinders Island and along the Northeast coast during June and July 2005. Majority of tows were 5 minutes duration.

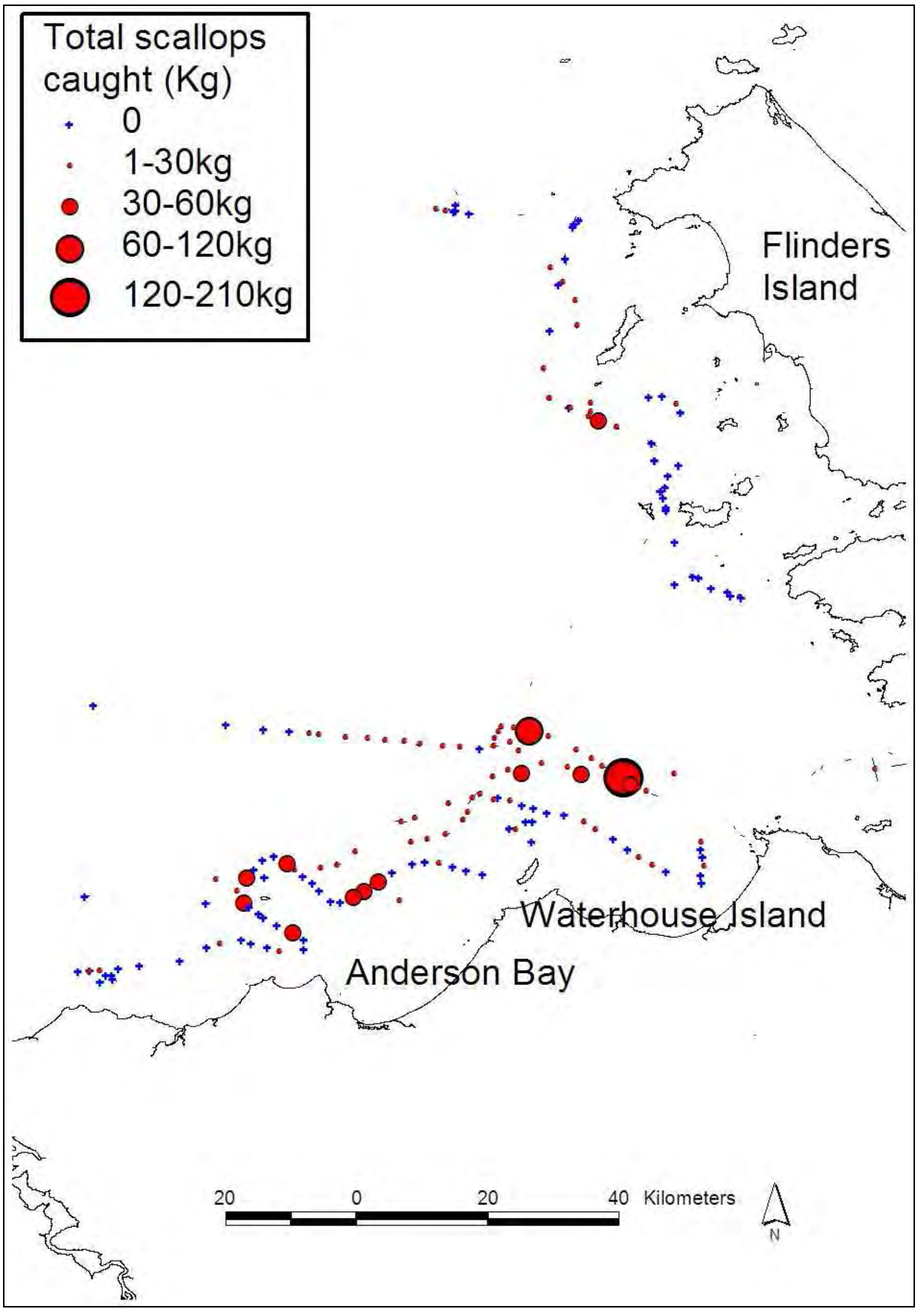


Figure 3b: The amount of scallops caught, as total kg's of scallops, for each Industry survey tow identified in Figure 3a. Note: some sample tows had no total catch recorded, so therefore do not give a catch estimate. Scallops to the west of Flinders Island were predominately undersize (99% < 90mm), with most being in the 60 – 70 mm range. See Figure 4 for size distribution of other scallops (Anderson Bay / Waterhouse Island scallops).

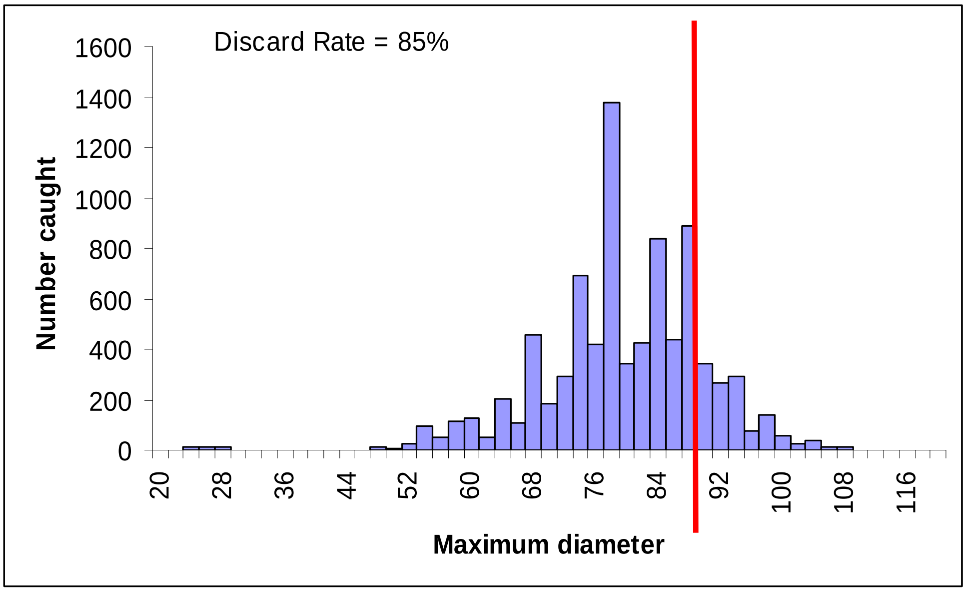


Figure 4: Size distribution (length frequency plot) of scallops caught north of Anderson Bay / Waterhouse Island region. Discard rate = 85%. Numbers are scaled to the entire catch.

East Flinders (Pot Boil and Babel Beds)

Figure 5a: The location of the Industry survey tows conducted East of Flinders Island (Pot Boil and Babel Beds) during July 2005. Data is for 10 participating vessels. Most sample tows were 5 minutes duration. Some tows were > 10 minutes.

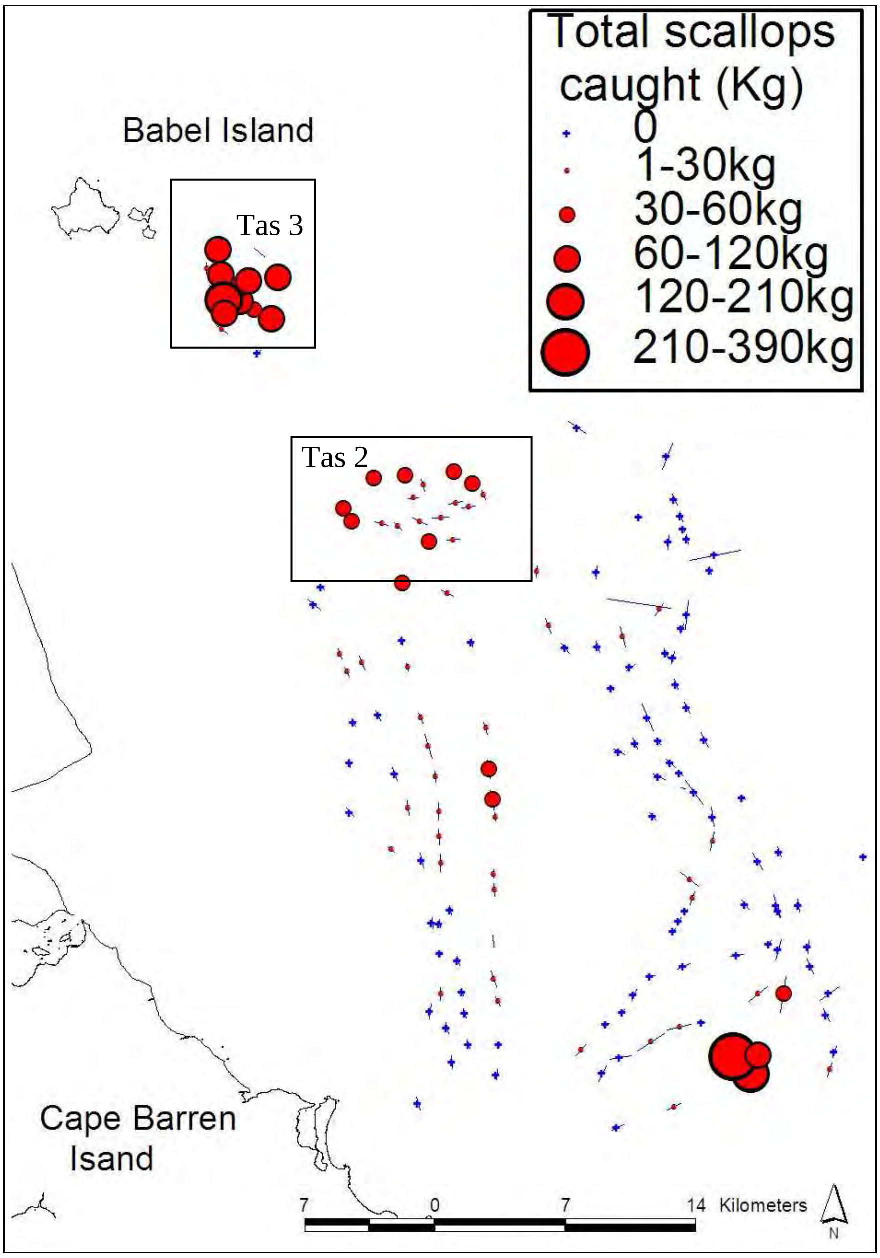


Figure 5b: The amount of scallops caught, as total kg's of scallops, for each Industry survey tow identified in Figure 5a. Note: some sample tows had no total catch recorded, so therefore do not give a catch estimate.

Tas 2 and Tas 3

The data presented in figure 5b resulted in several management decisions.
1) open the area near Tas 2 and Tas 3 to commercial fishing;
2) put in place an exemption order to decrease the Legal Minimum Size from 90 mm to 80 mm (within this region only);
3) increase the TAC, and;
4) extend the scallop season. These management changes were due to the observed die-off of scallops within this region.

Without the data collected by Industry, these management decisions would not have been possible. As a result of commercial fishing operations, these data are no longer applicable to the area, and as such, no length frequency data will be presented for the tas 2 and tas 3 regions. Minimal scallops were caught elsewhere. Further exploration of the one dense area of scallops is required to determine the extent of any bed that may / may not be there.

Banks Strait

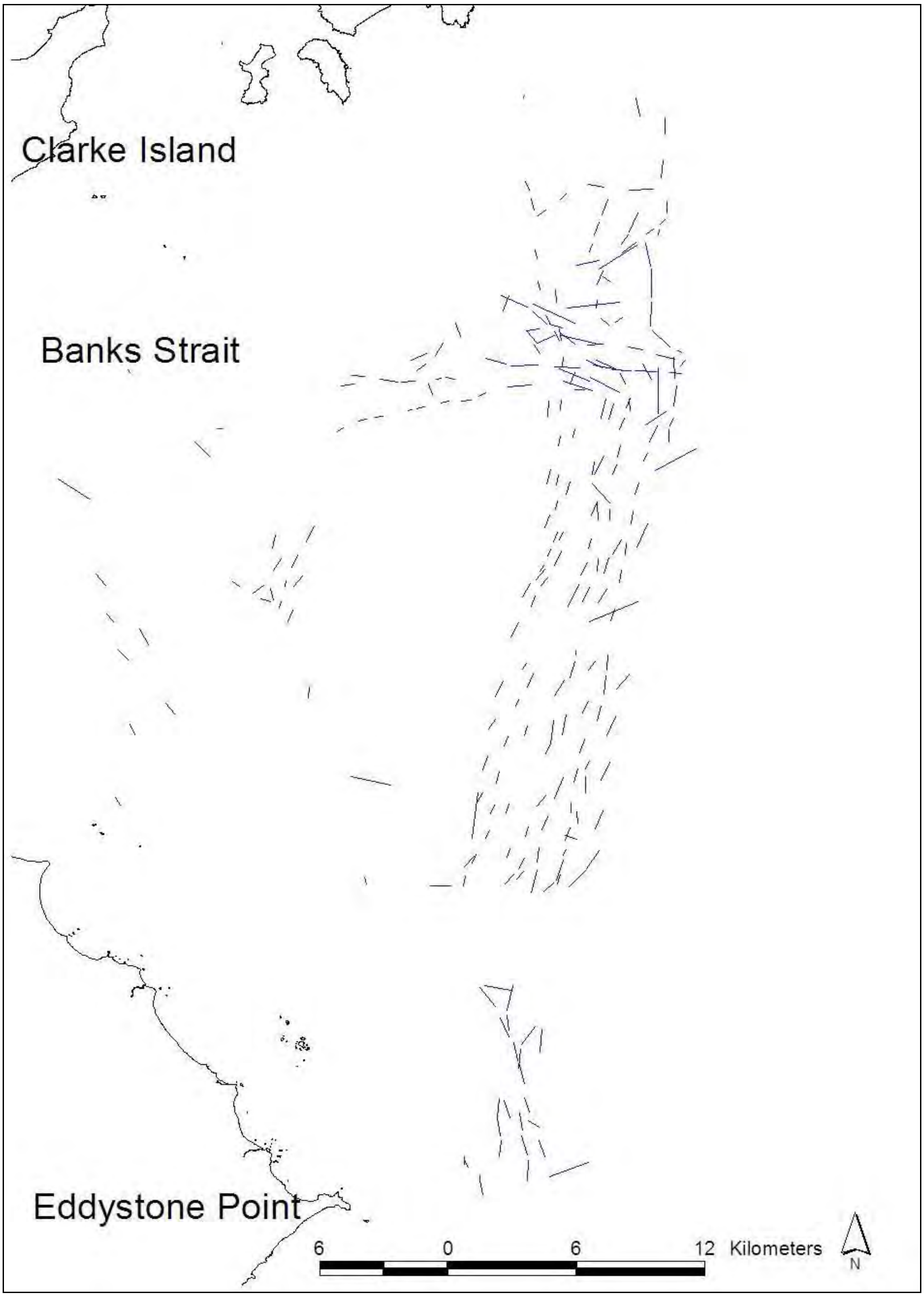


Figure 6a: The location of the Industry survey tows conducted within Banks Strait during June, July and December 2005. Data is for 11 participating vessels over 3 surveys. Most tows were 5 minutes or less in duration. Some tows were > 10 minutes.

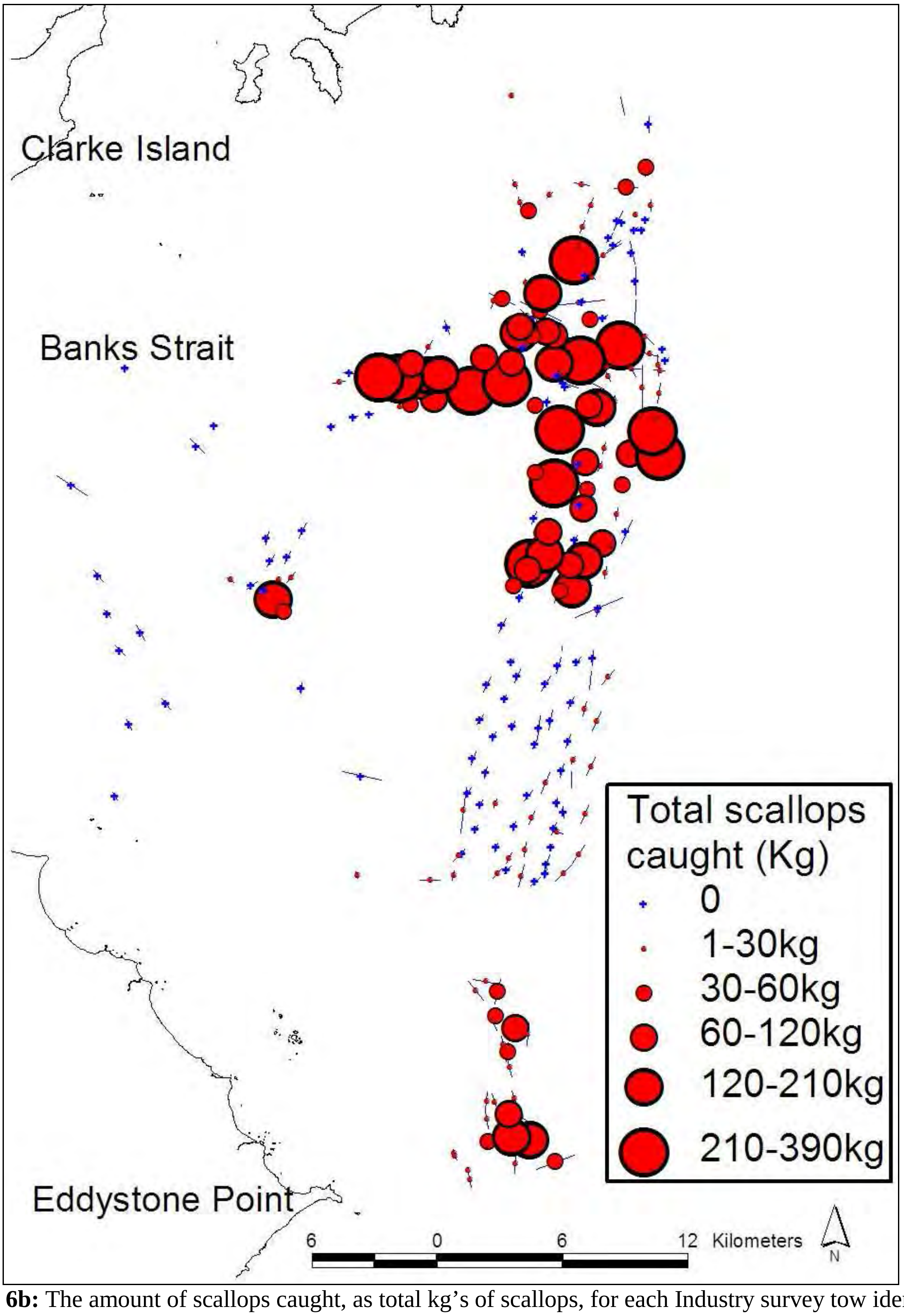


Figure 6b: The amount of scallops caught, as total kg's of scallops, for each Industry survey tow identified in Figure 6a. Note: some sample tows had no total catch recorded, so therefore do not give a catch estimate.

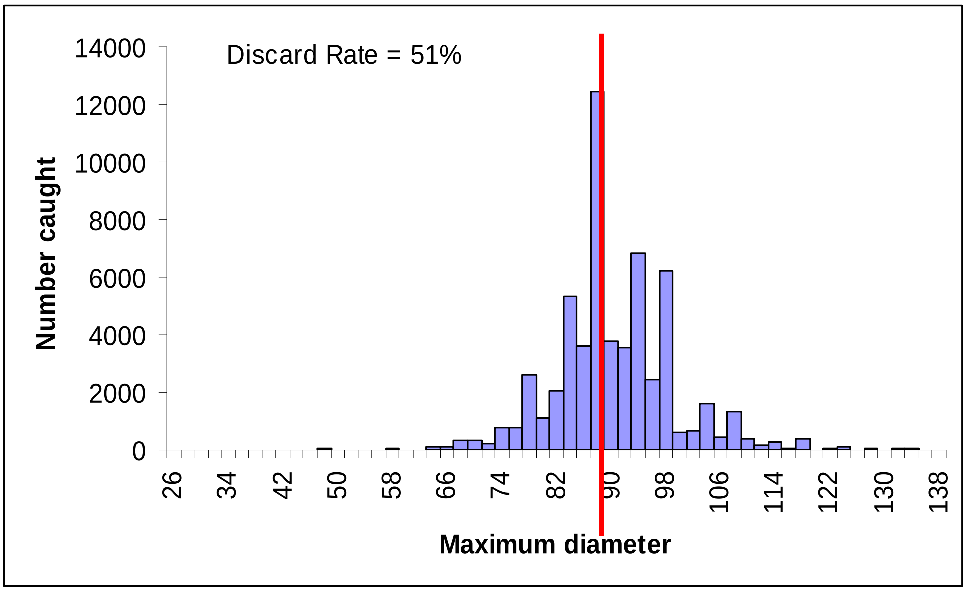


Figure 7a: Banks Strait scallop size distribution (Length frequency plot). Discard rate = 51%. Note that very low numbers of scallops measuring 28mm were caught but are not visible on the plot.

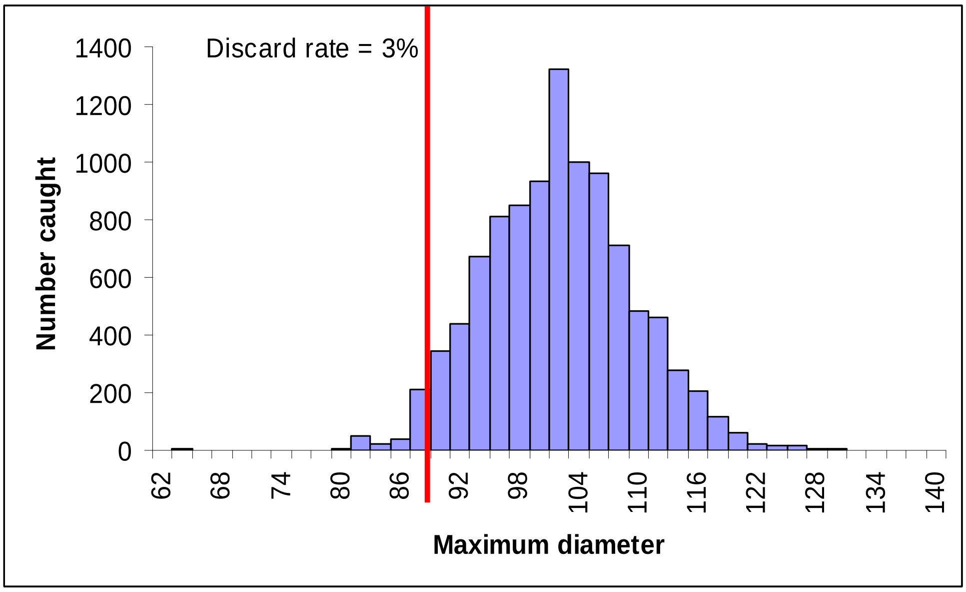


Figure 7b: Eddystone Point scallop size distribution (Length frequency plot). Discard rate = 3%.

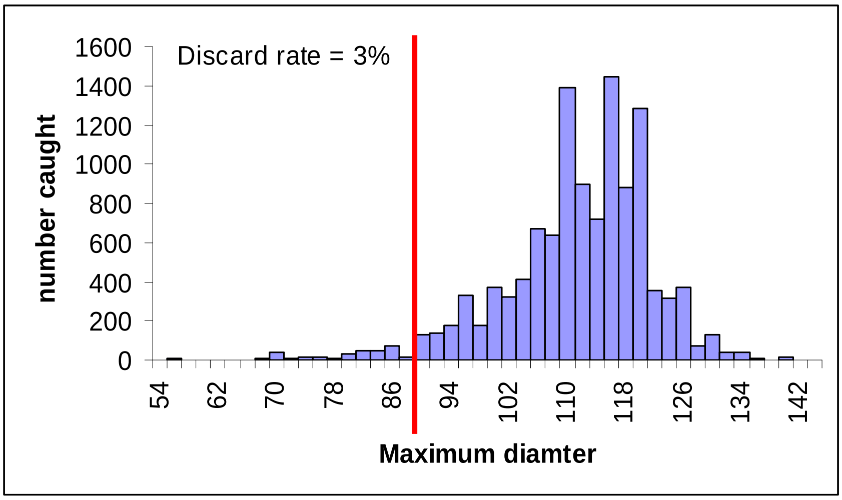


Figure 8: Size distribution for scallops caught from St. Helens Point to Friendly Beaches (see figure 9a and 9b). Discard rate = 3%. NB all but two of the sample tows had very low discard rates. NB The two sample tows with high discard rates (17% and 27%) had very low catches of scallops.

St. Helens Point to Friendly Beaches

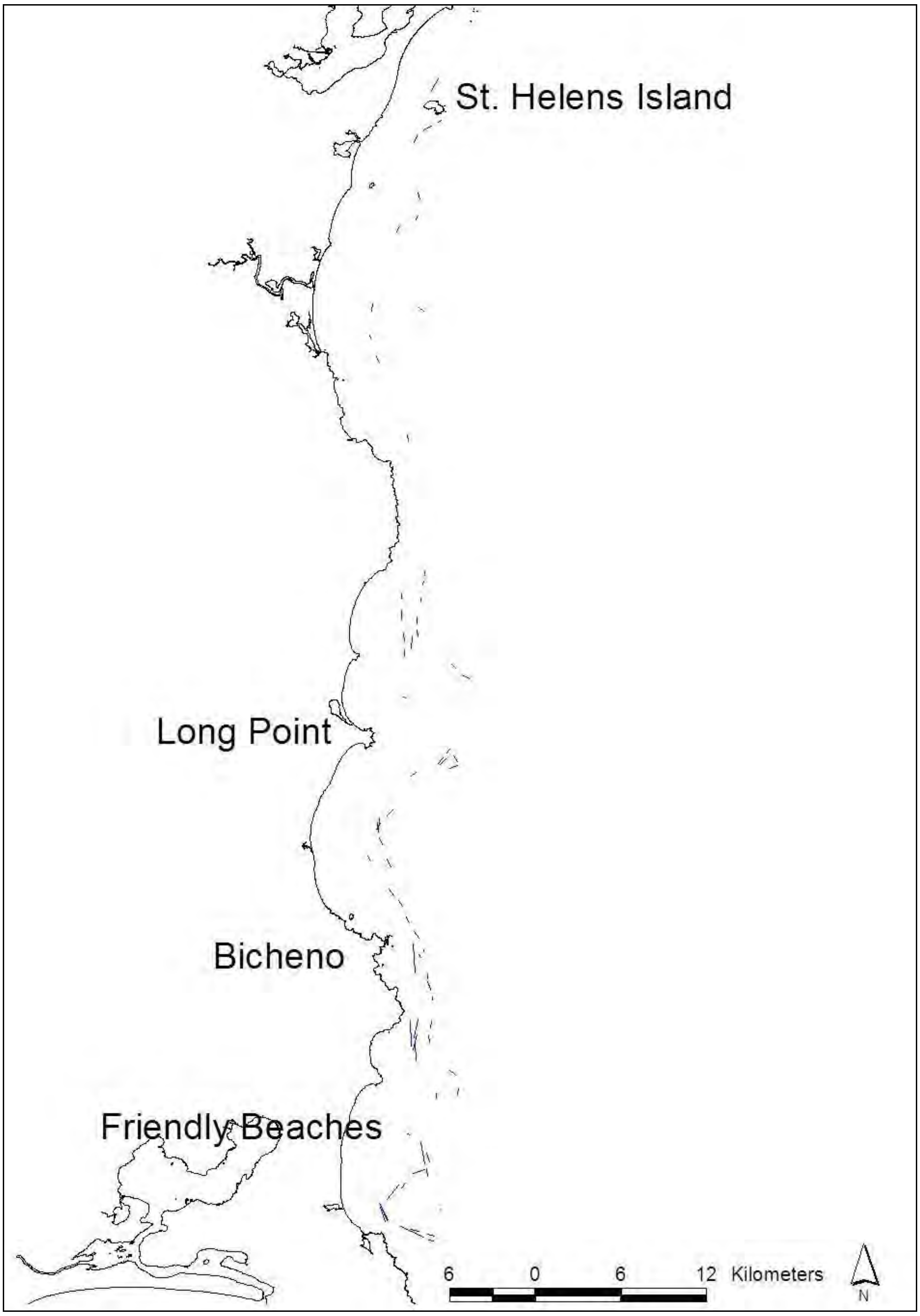


Figure 9a: The location of the Industry survey tows conducted from St. Helens Point to Friendly Beaches during July 2005. Data is for 2 participating vessels. Most tows were 5 minutes duration. Some tows were > 10 minutes.

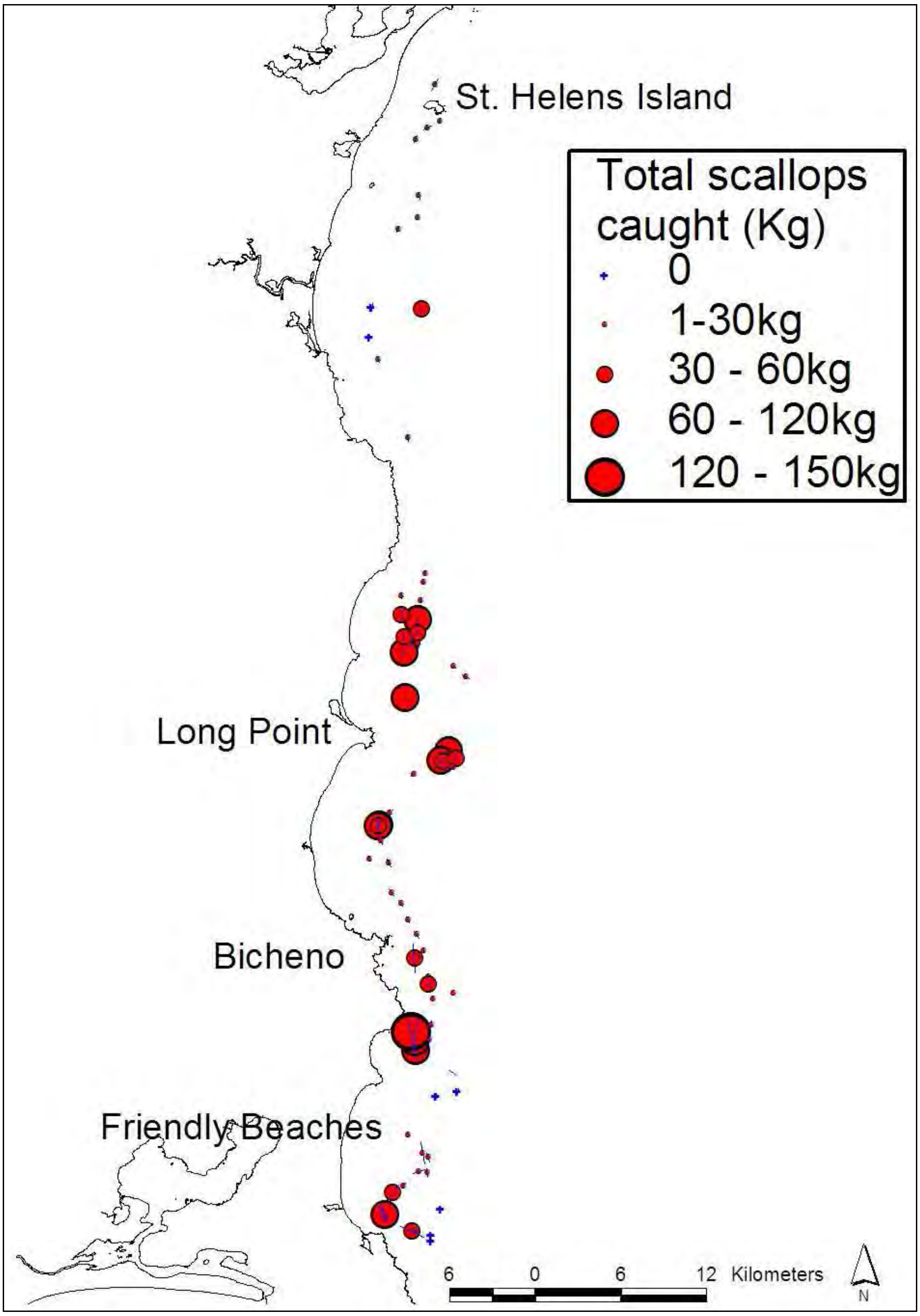


Figure 9b: The amount of scallops caught, as total kg's of scallops, for each Industry survey tow identified in Figure 8a. Note: some sample tows had no total catch recorded, so therefore do not give a catch estimate.

White Rock

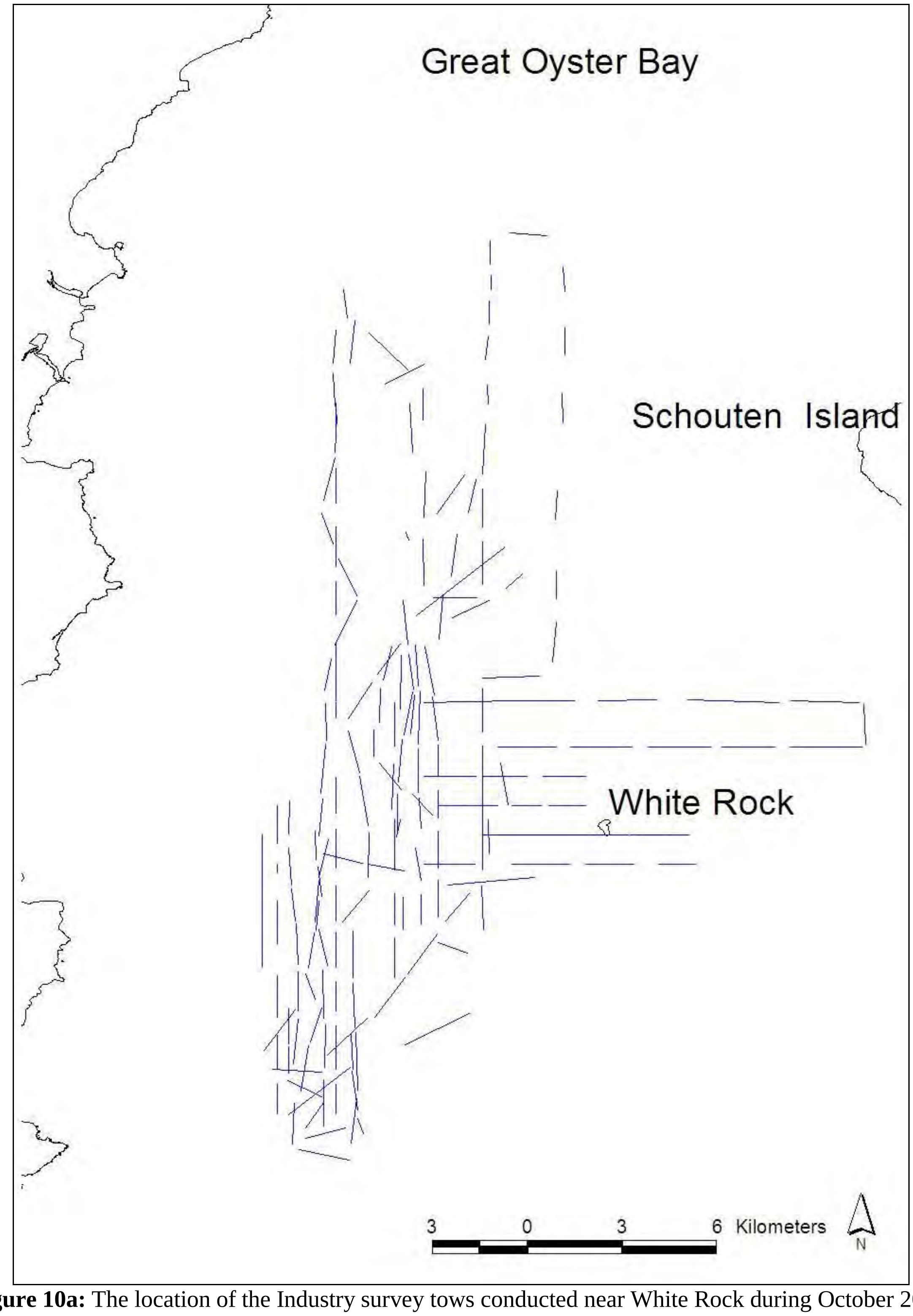


Figure 10a: The location of the Industry survey tows conducted near White Rock during October 2005. Data is for 3 participating vessels. Most tows were 10 – 15 minutes duration.

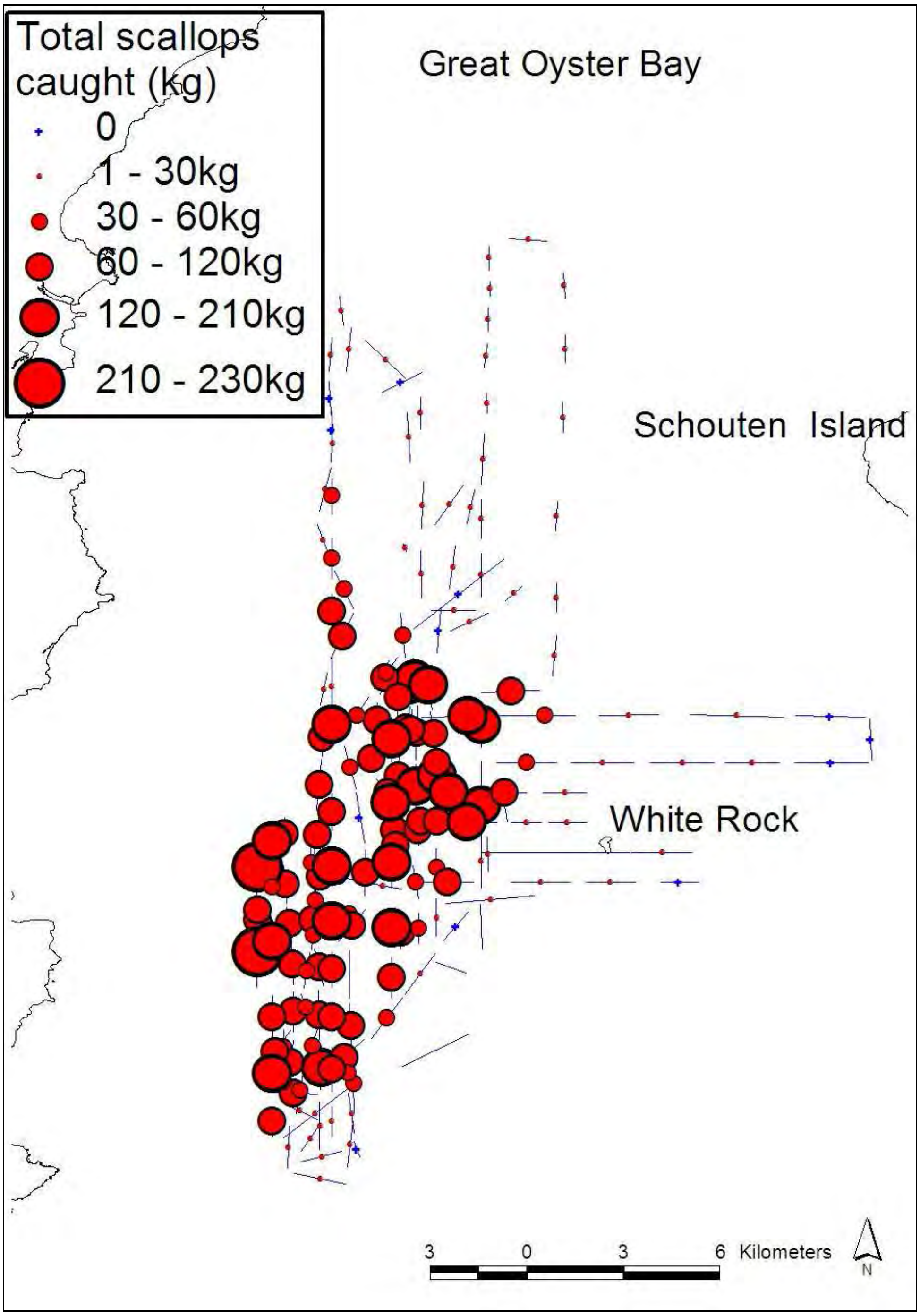


Figure 10b: The amount of scallops caught, as total kg's of scallops, for each Industry survey tow identified in Figure 10a. Note: some sample tows had no total catch recorded, so therefore do not give a catch estimate. Most tows were 10 – 15 minutes duration.

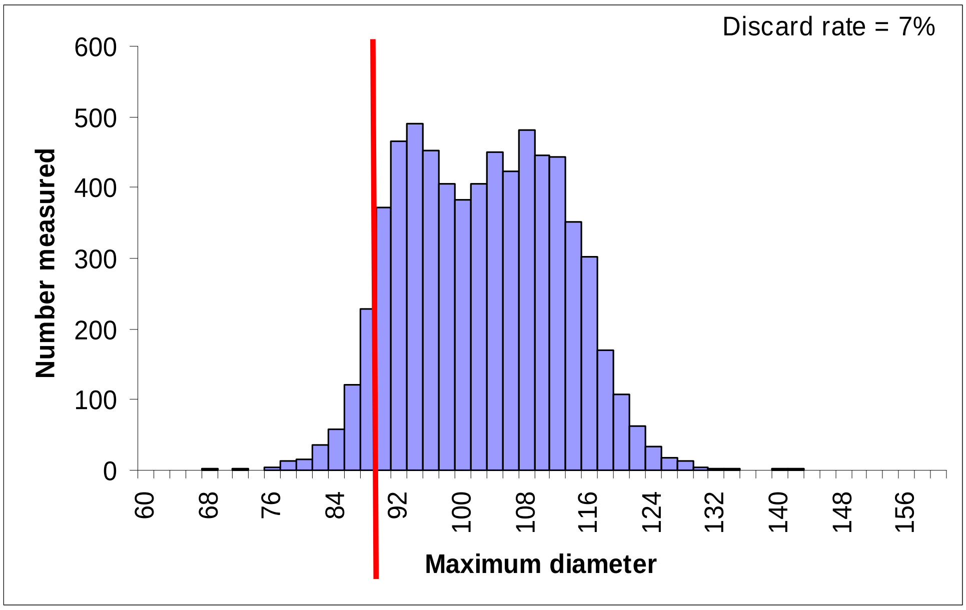


Figure 11: Size distribution for scallops caught and measured near White Rock, as illustrated in Figure 11a. Discard rate = 7%. NB data presented in this plot are for measured scallops only. Data has not been scaled to actual catches.

Marion Bay / North Bay

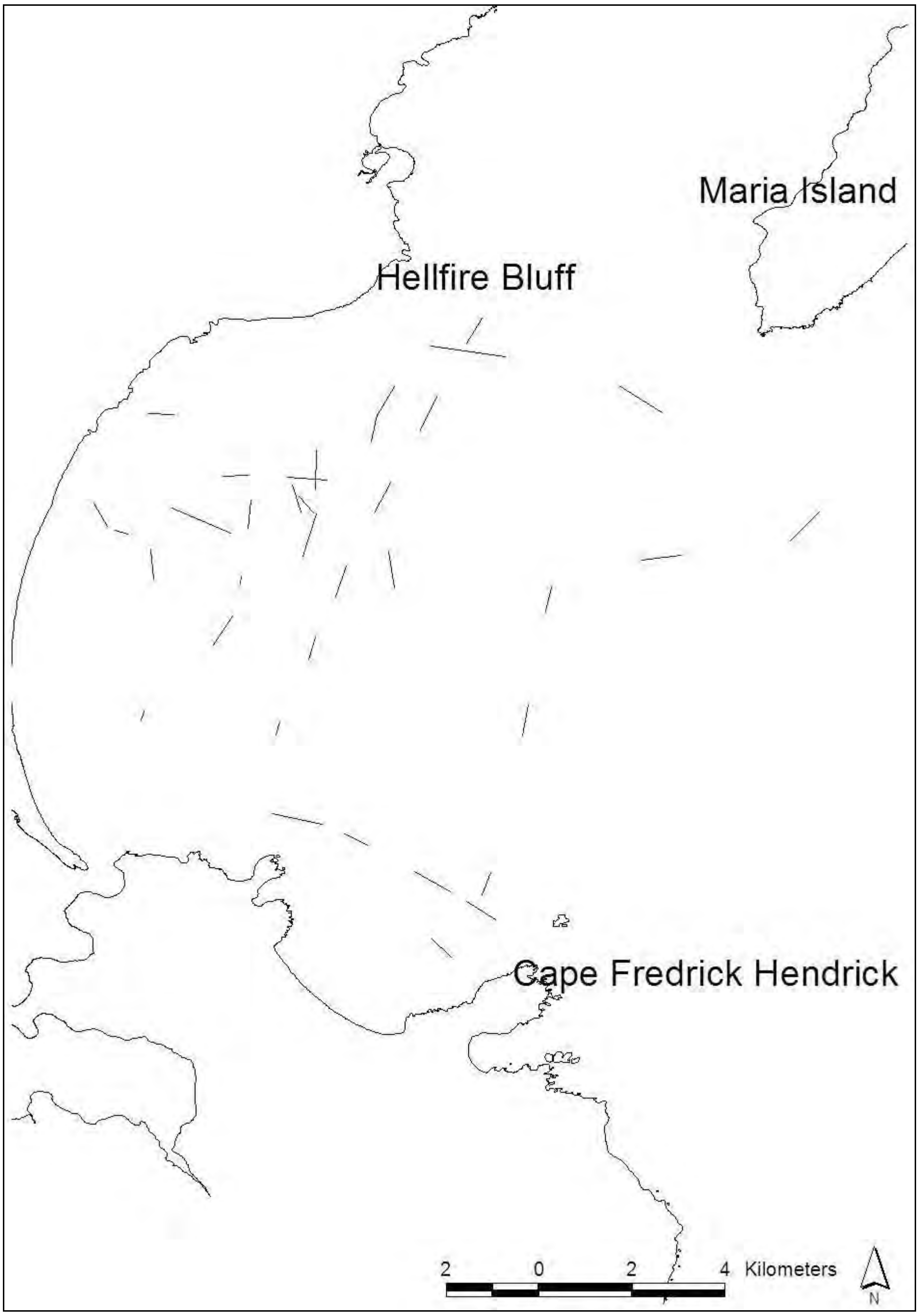


Figure 11a: The location of the Industry survey tows conducted in Marion and North Bays during July 2005. Most tows were 5 minutes duration.

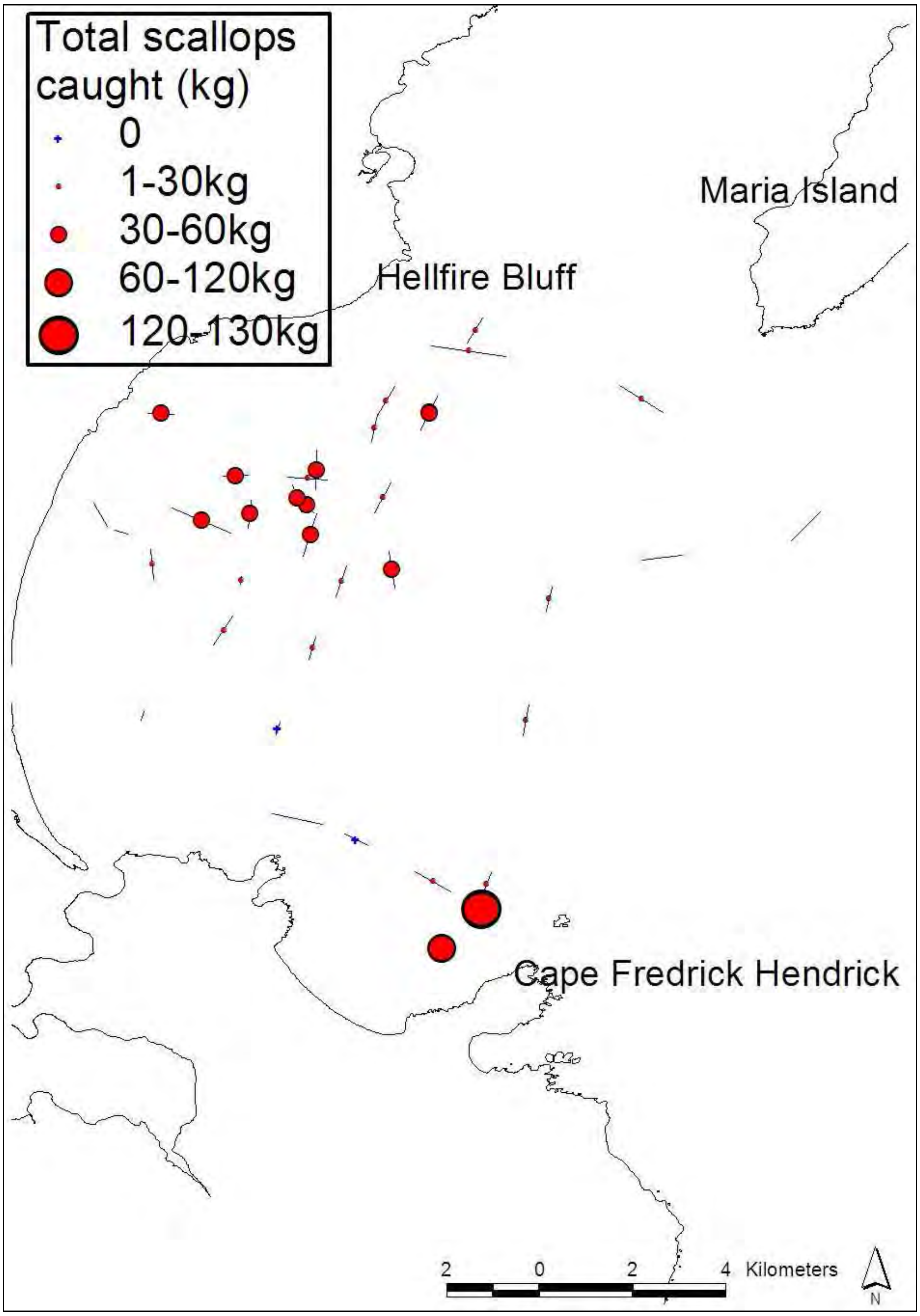


Figure 11b: The amount of scallops caught, as total kg's of scallops, for each Industry survey tow identified in Figure 11a. Note: some sample tows had no total catch recorded, so therefore do not give a catch estimate.

As a result of commercial fishing operations within Marion Bay during the 2005 season, the data presented in figures 11b are no longer applicable to the area, and as such, no length frequency data will be presented.

Appendix 11.5: August 2006 survey update

2006 Industry Survey Data – Update August 2006

Tasmanian Aquaculture & Fisheries Institute
University of Tasmania

Australian Government
Fisheries Research and Development Corporation
Australian Fisheries Management Authority

INTRODUCTION

This report presents Industry data collected during Industry surveys conducted prior to and during the 2006 Tasmanian scallop season. The Industry surveys conducted during this time have been jointly organised by TAFI and the Tasmanian DPIW, as part of the FRDC funded project "Facilitating Industry Self-Management for Spatially Managed Stocks: A Scallop Case Study (FRDC 2005/027). We would like to thank the skippers and crew of participating vessels for their efforts in data collection during surveys. Without the data collected by you, decisions concerning the Tasmanian scallop fishery could not be made.

EDDYSTONE POINT – July 2006

Scallop Abundance

The most recent data from the Eddystone Point region was obtained during a survey conducted by three vessels on the 25th July 2006. Figure 1 illustrates the location of all sample tows conducted during the survey; while Figure 2 identifies the abundance of scallop caught during these tows (standardised as kg of scallops per 5 minute sample tow). The highest abundances of scallops were located within the northeast region of fishing locality block 4H3P, but higher abundances were also recorded throughout the eastern regions of the survey area (Figure 2). Lower catch-rates were recorded from the sample tows that overlapped areas that were fished during the 2003 Tasmanian scallop season (Figure 3). Data from surveys conducted within this region during June 2006 suggest that scallop abundance may have decline within these western areas of the survey region over the last few weeks (see new datapoints in Figure 4), however, tidal cycles, time of day, prevailing swell conditions and different vessels may have contributed to these apparent differences.

Scallop Size

In general, the scallops caught within the Eddystone Point region were of legal size (>90 mm) (Figure 5a). Sample tows from those areas within the dashed circle identified in Figure 4 are from a bed of scallops located within deeper water (80m). This bed of scallops was first monitored in 2003, and are believed to be very slow growing scallops. Scallops within this region are predominately undersize (see Figure 5b). One fisher reported almost no scallops from this region were legal size.

Scallop Condition

Information from the participating fishers and processors was varied. The fisher who conducted the majority of sample tows within the high scallop abundance region (northeast / east) suggested that scallops were in good health, and scallop meat and roe condition was good. However, there was a level of concern for the health of scallops caught from lower abundance survey regions. High abundances of dead scallop (clappers) and scallop in exceptionally poor condition were reported from some regions, but with more healthy scallops in better condition being reported from nearby areas. These reports were confirmed by processors, who reported that catches contained a mixture of good and poor quality scallops. Samples of both good and poor condition scallops have been sent to the Fish Health Unit Laboratories for analysis.

Summary

It appears that some regions of the Eddystone Point bed are in poor health, however, there are extensive areas containing high abundances of good conditioned scallops, which are predominately of legal size (>90 mm) (Figure 5a). Given that Eddystone Point has fished in a more tradition manner in the past (i.e. can work up the bottom) it is hoped that a reasonable amount of good quality scallop can be harvested from both the good, and potentially the poorer regions during 2006.

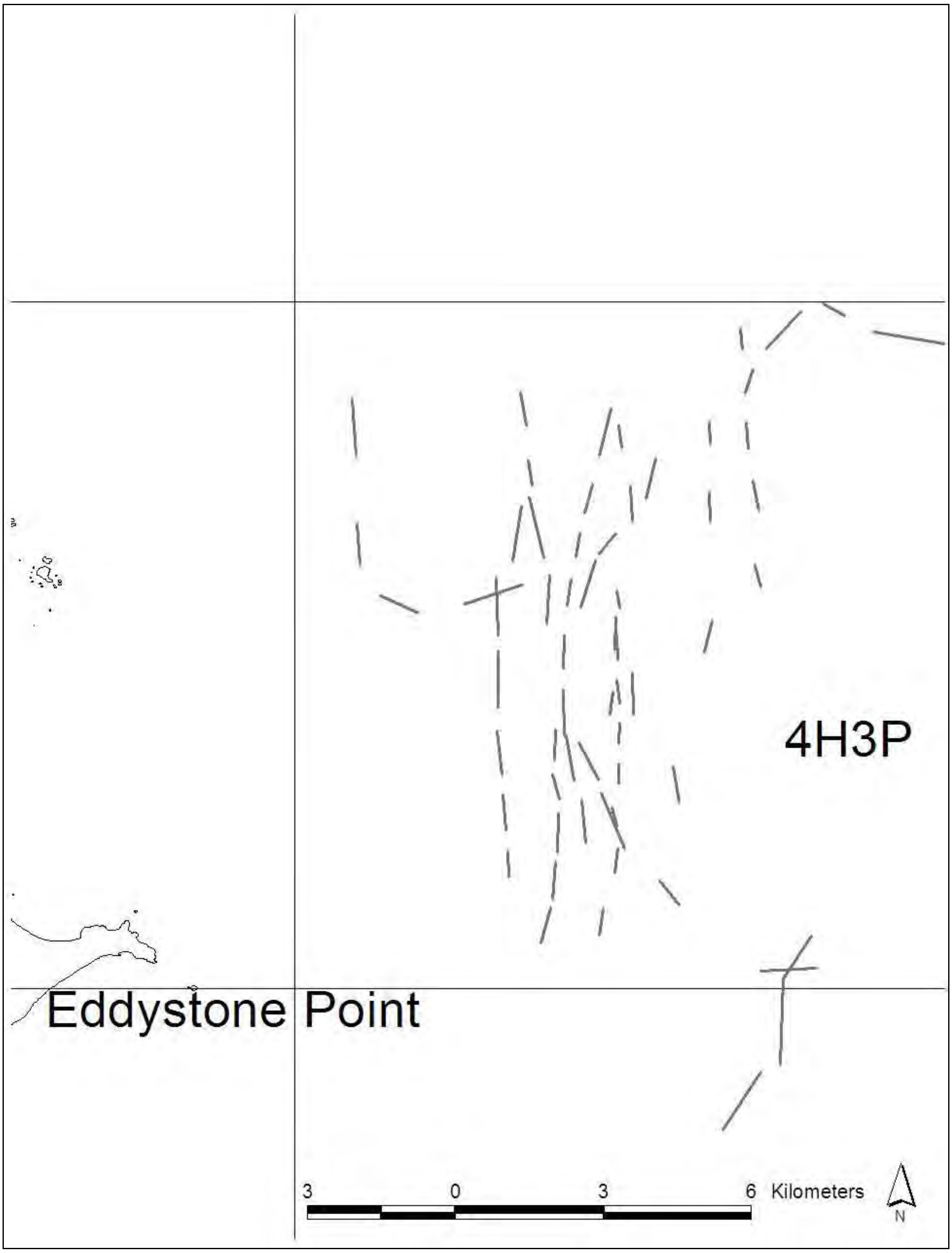


Figure 1: Location of sample tows conducted by three participating vessels on the 25th July 2006.

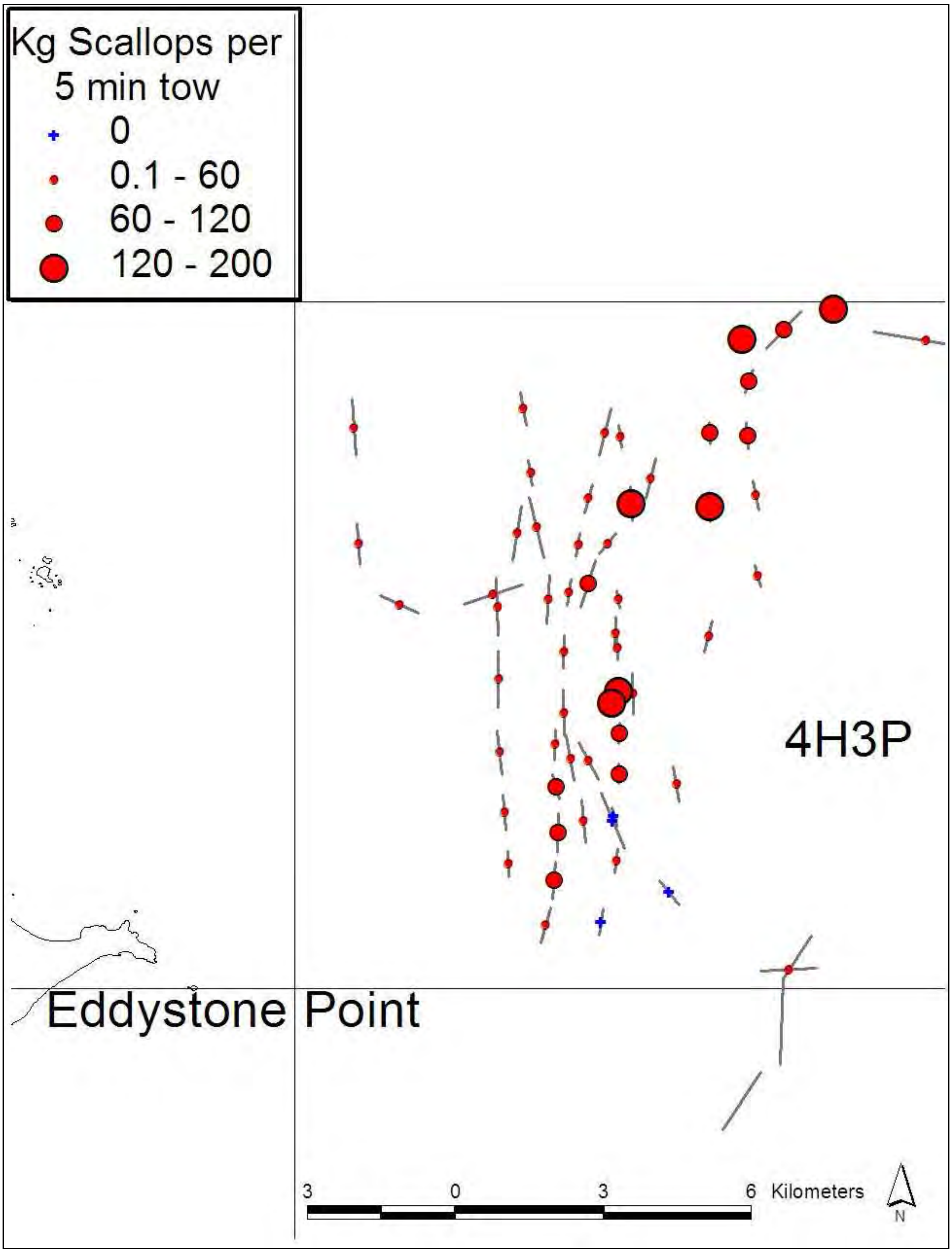


Figure 2: Abundance of scallops caught within each sample tow. Abundances are kg of scallops per 5 min sample tow.

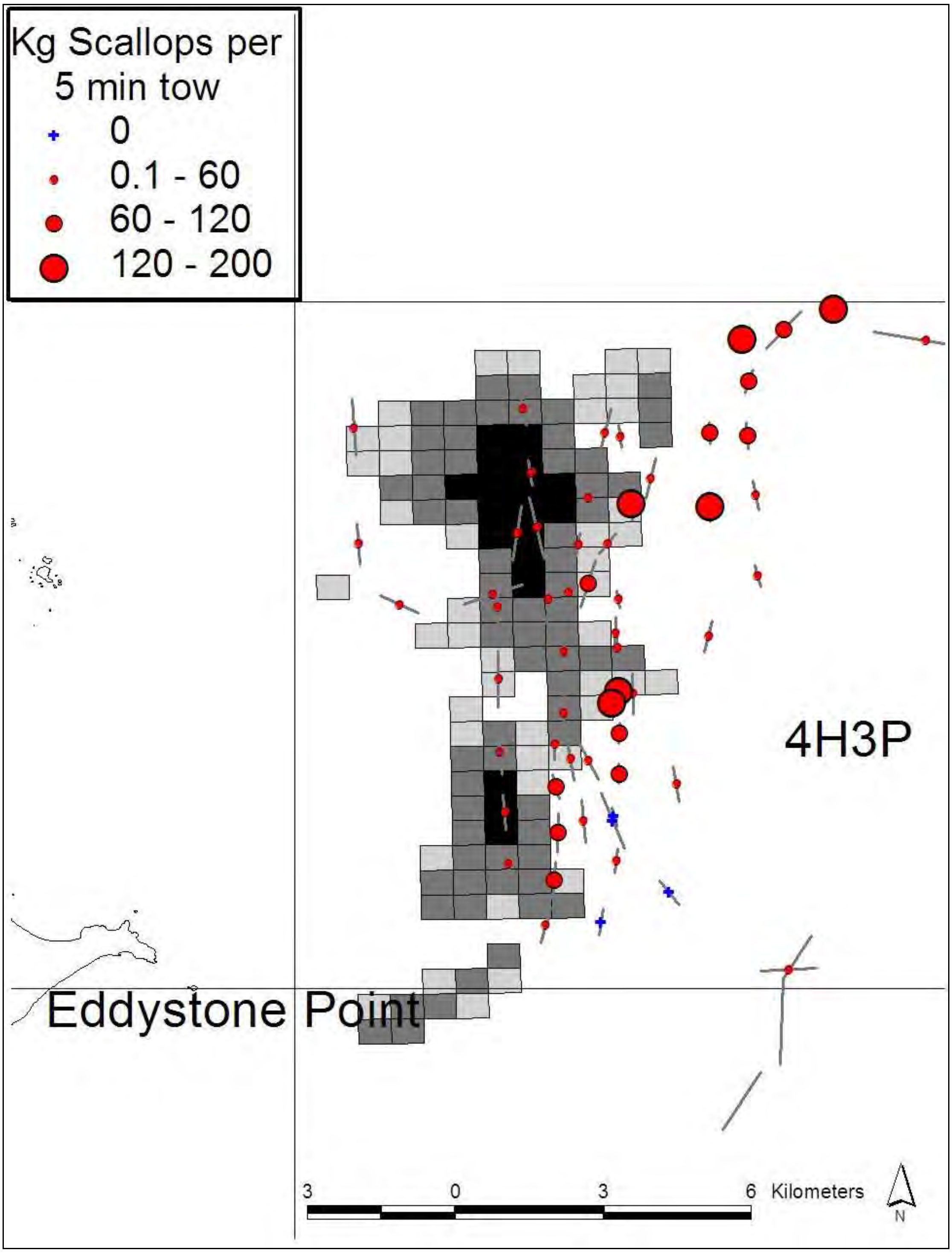


Figure 3: Location of sample tows and abundance of scallops caught per sample tow (kg scallops per 5 min tow) with VMS data for the 2003 Tasmanian scallop fishery overlaid. The darker the square, the greater the fishing effort.

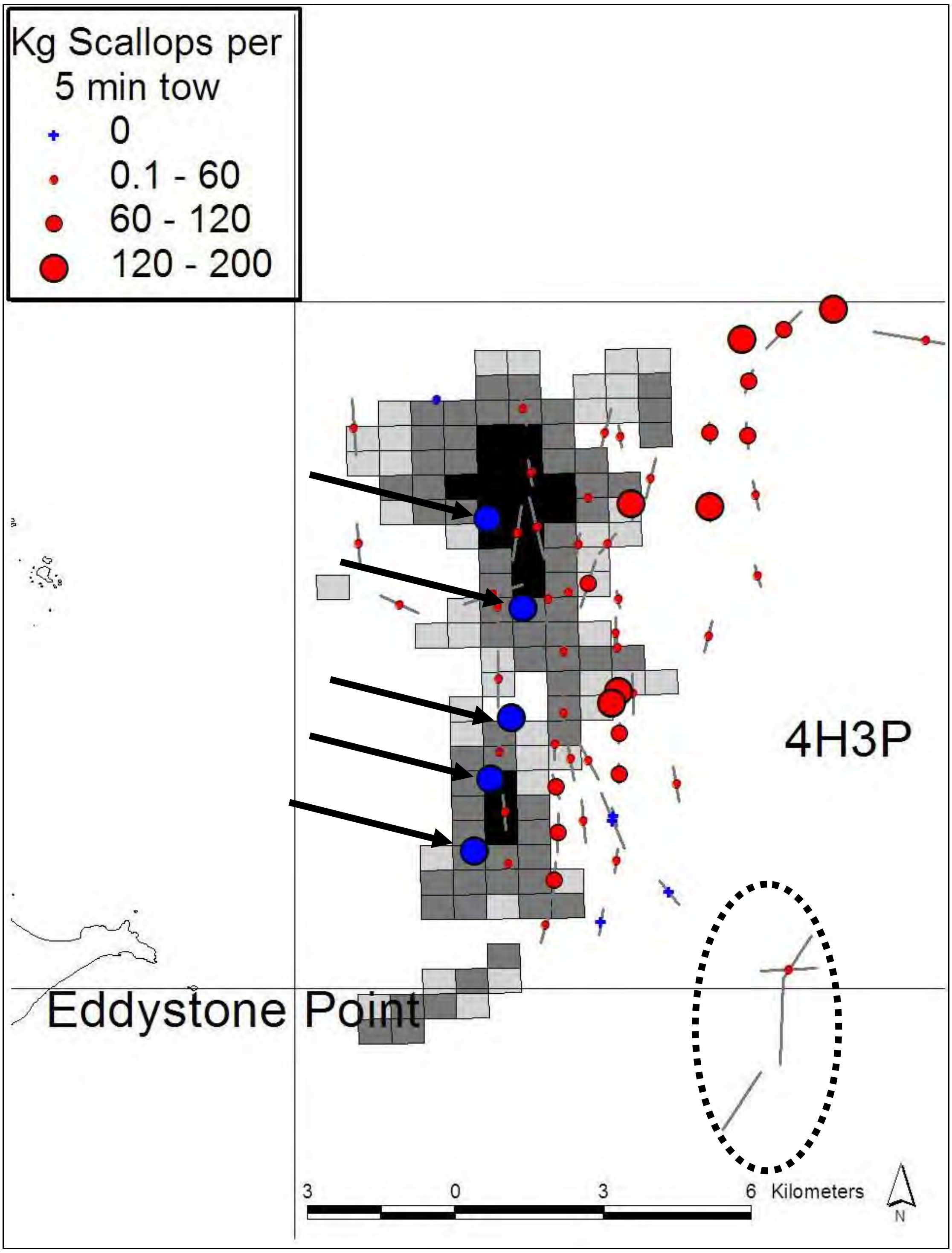


Figure 4: Location of and abundance of scallops for sample tows conducted prior to the 2006 Tasmanian scallop season. Arrows indicate location of new sample tows.

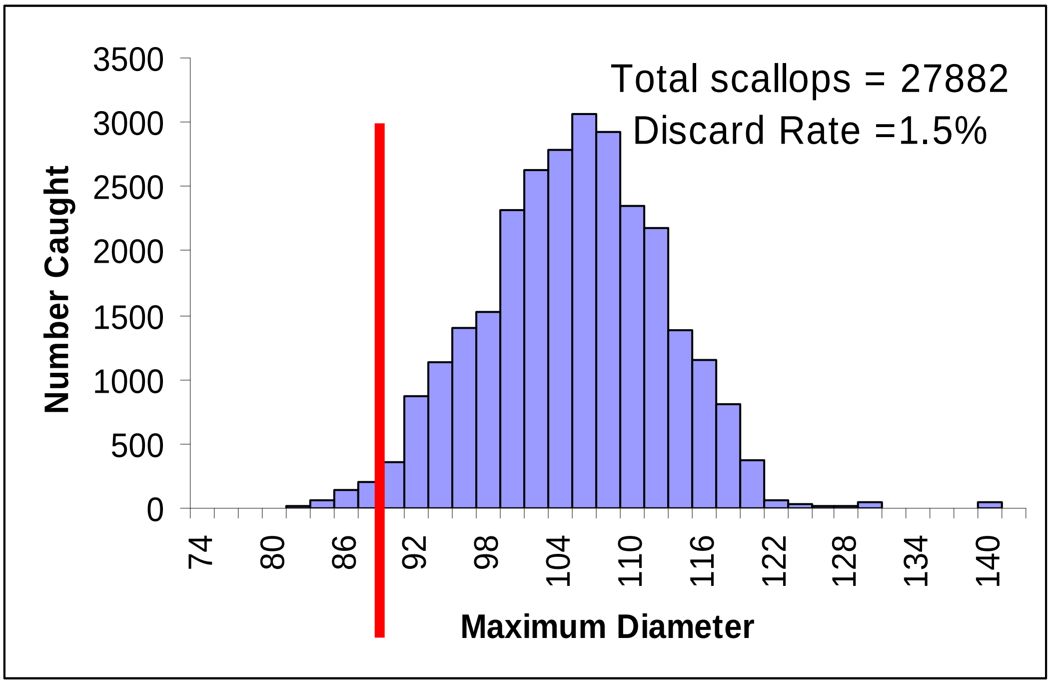


Figure 5a: Size distribution of scallops caught from Eddsystone Point during the July 2006 survey. Scallop sizes were similar throughout the survey region, with the exception of the deeper water area (see 5b).

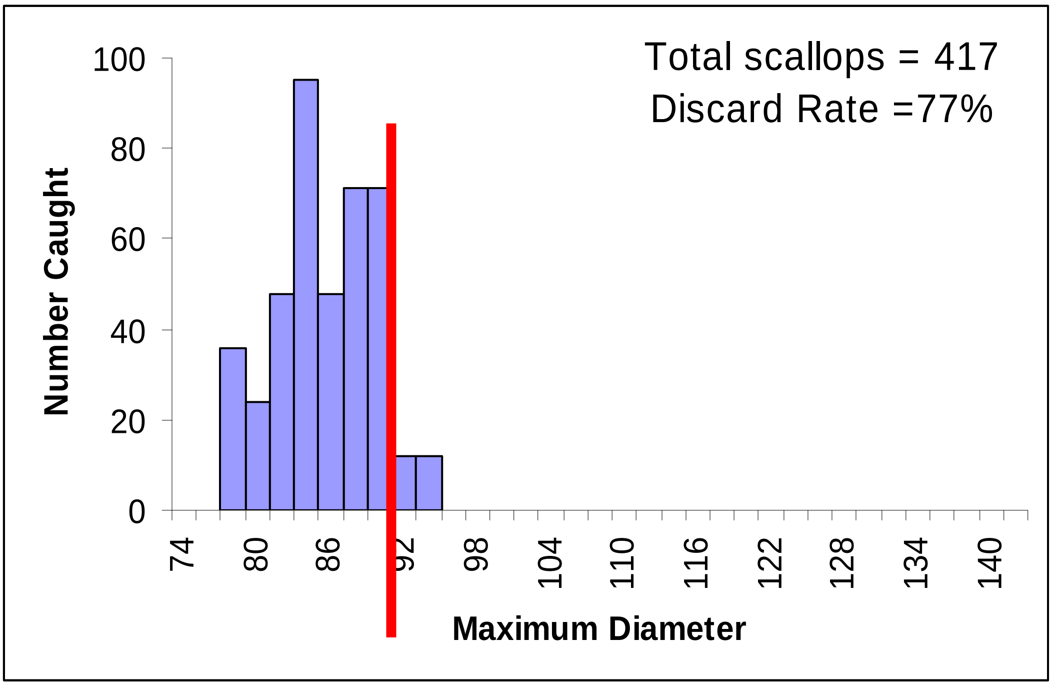


Figure 5b: Size distribution of scallops caught from the deeper water region of Eddystone Point (circled area of Figure 4) during the July 2006 survey. Scallops within this region were predominately undersize.

BANKS STRAIT – July 2006

The observation of poor conditioned scallops from some regions of Eddystone Point resulted in participants of the Eddystone survey requesting approval to check the health of scallops within the known Banks Strait region (Class 1 Closed Zone – Figure 6). The three participating vessels were subsequently granted approval to survey within the Banks Strait Class 1 Closed Zone. Unfortunately, difficulties in communication with participants and adverse weather conditions meant that only one vessel conducted a detailed search within this region.

Scallop Abundance

In general, abundances of scallops located within the Banks Strait region were low, with only three sample tows containing higher scallop abundances (Figure 7). However, sample tows containing low or no scallops were found to correspond to areas identified during the 2005 survey as containing low abundances of scallops or no scallops (Figure 8). It is believed that the sandhills within the Banks Strait region provide a diverse array of depths and habitats for scallops to inhabit, and that two sample tows conducted within reasonably close proximity to each other may contain large differences in scallop abundance. Scallops appeared to have grown since the 2005 survey, with 16% discard rate being observed for the scallops caught during the survey (Figure 9).

Scallop Condition

Two sample tows from a small area within the southern region of the survey area were found to contain high abundances of scallop shell. Scallops within the northern and north western regions were reportedly in good health and condition.

Summary

Although high abundances of scallops were not located within the surveyed regions, the health of the majority of scallops observed was reported as being good. A more detailed survey with a greater number of fishers is proposed for later this season, when the fishery moves to Eddystone Point.

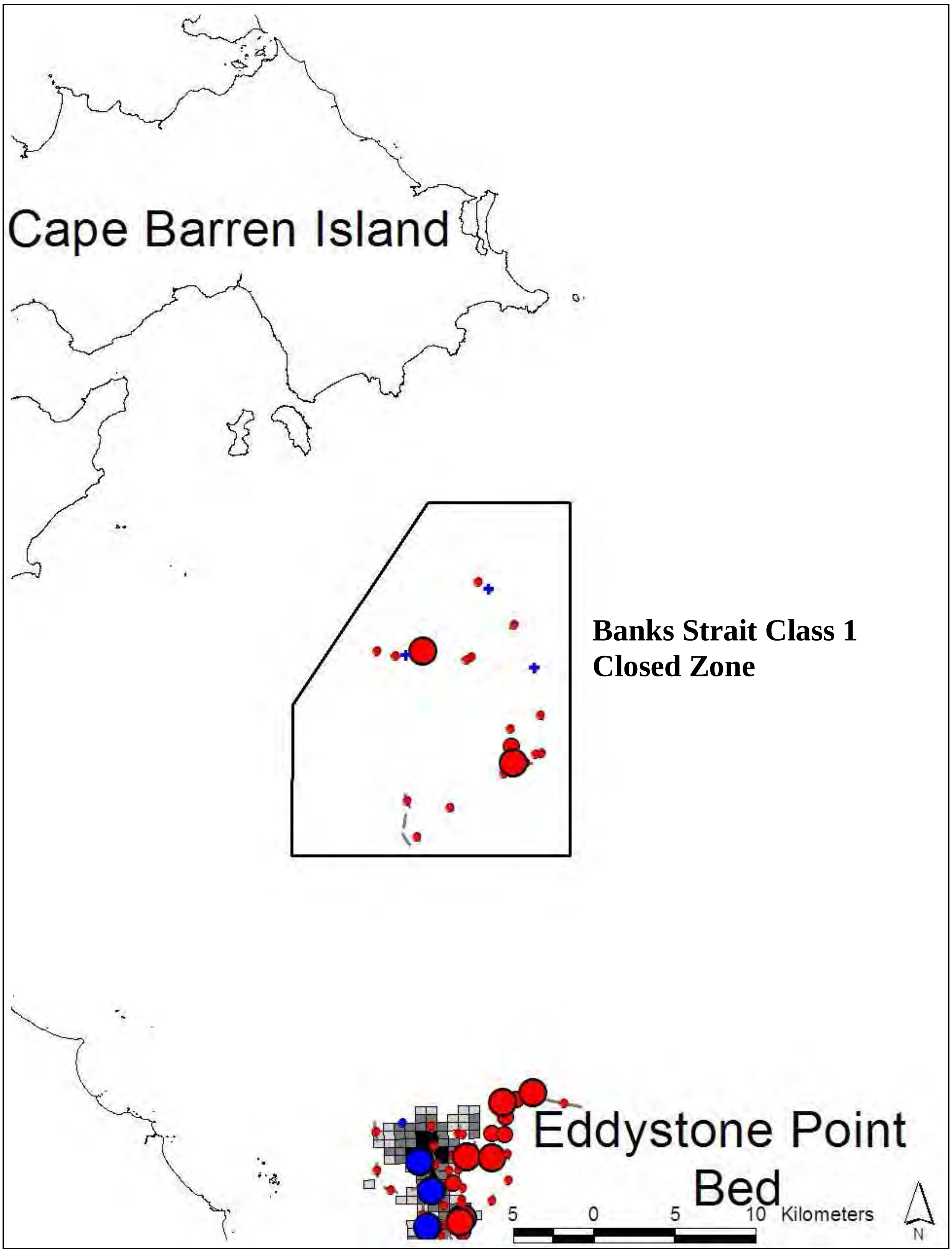


Figure 6: Location of the Banks Strait Class 1 Closed Zone relative to the Eddystone Point survey region.

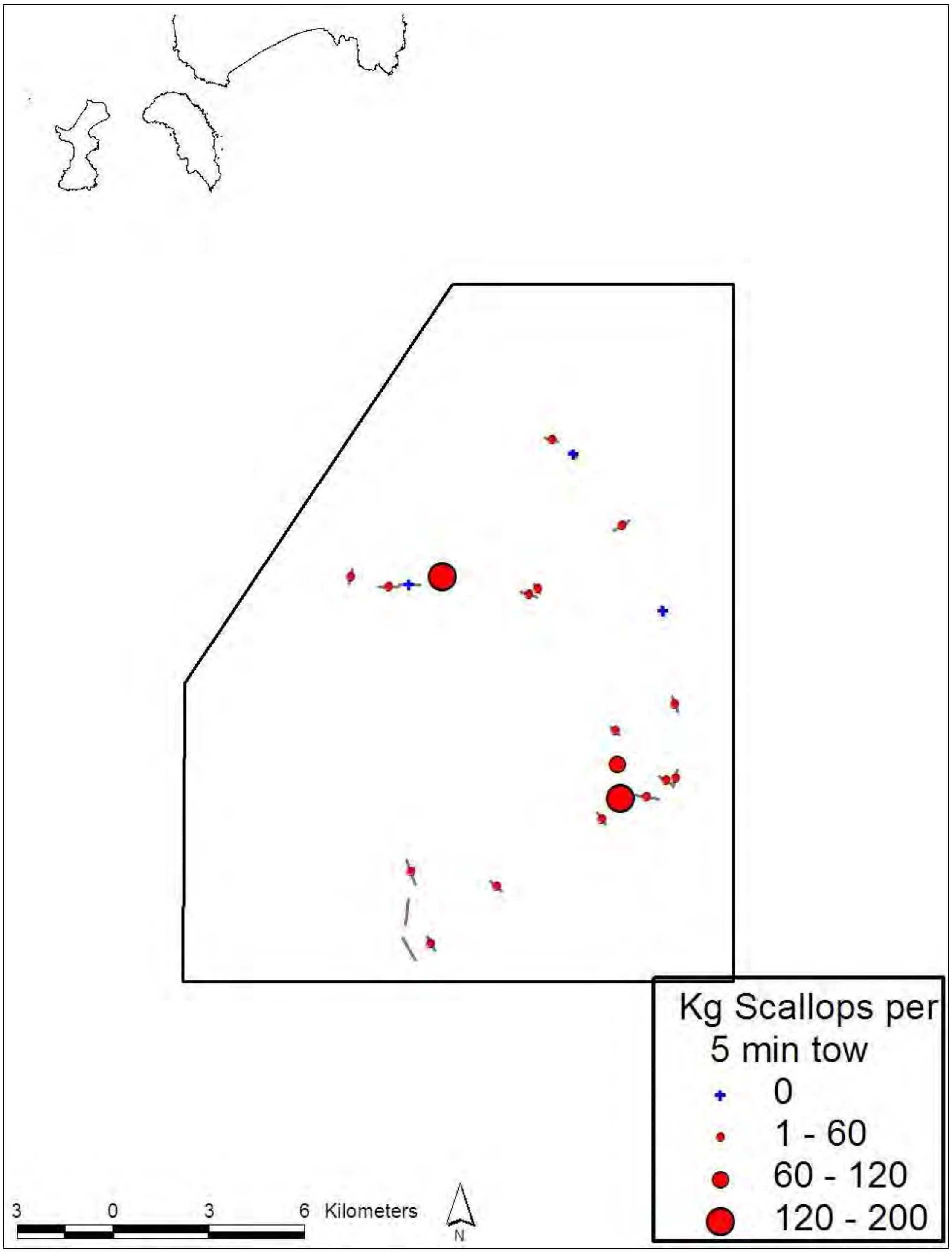


Figure 7: Abundance of scallops caught during survey tows conducted within Banks Strait during July 2006.

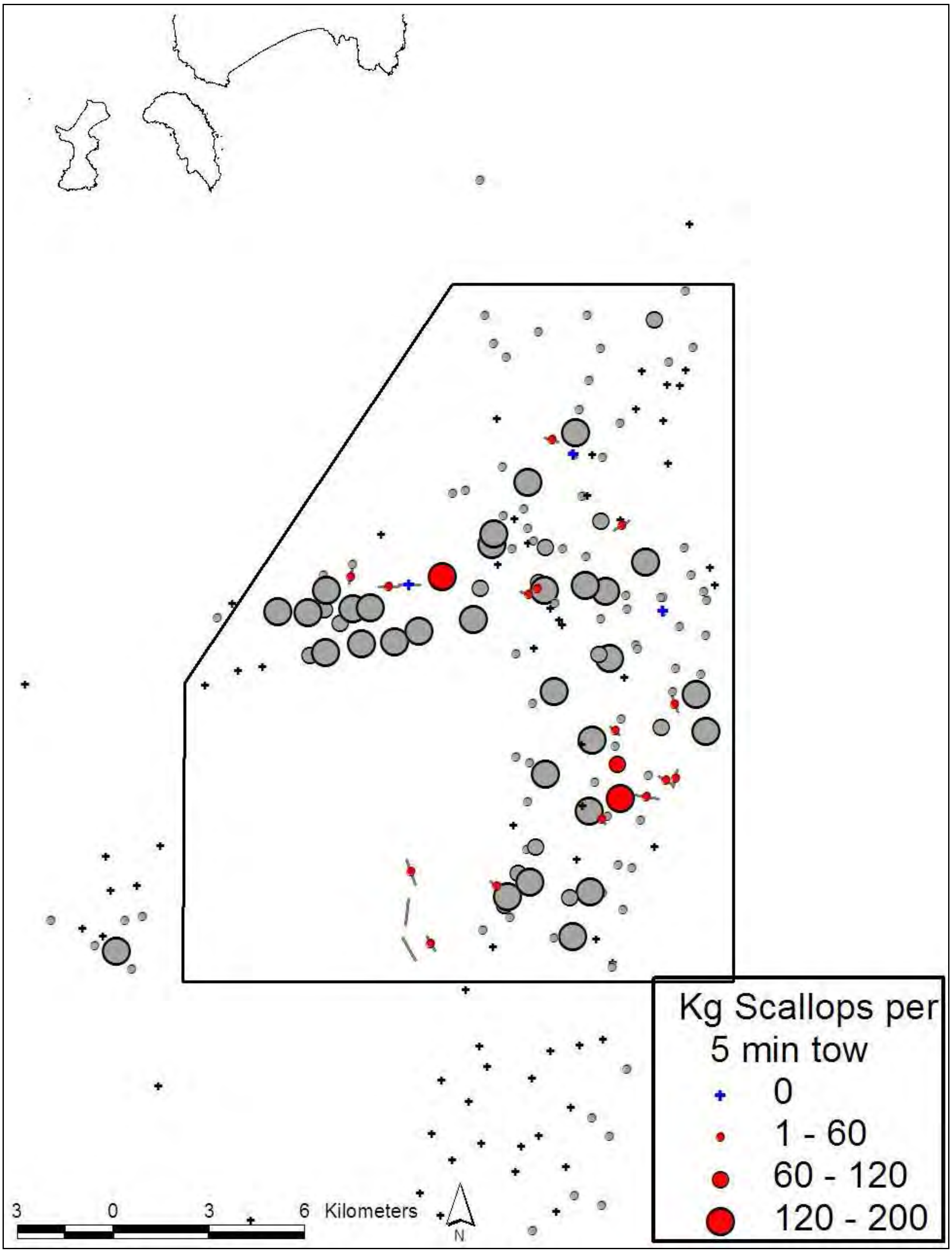


Figure 8: Location of July 2006 sample tows (marked in dark red) relative to the sample tows conducted during the 2005 (marked in light grey) survey for Banks Strait.

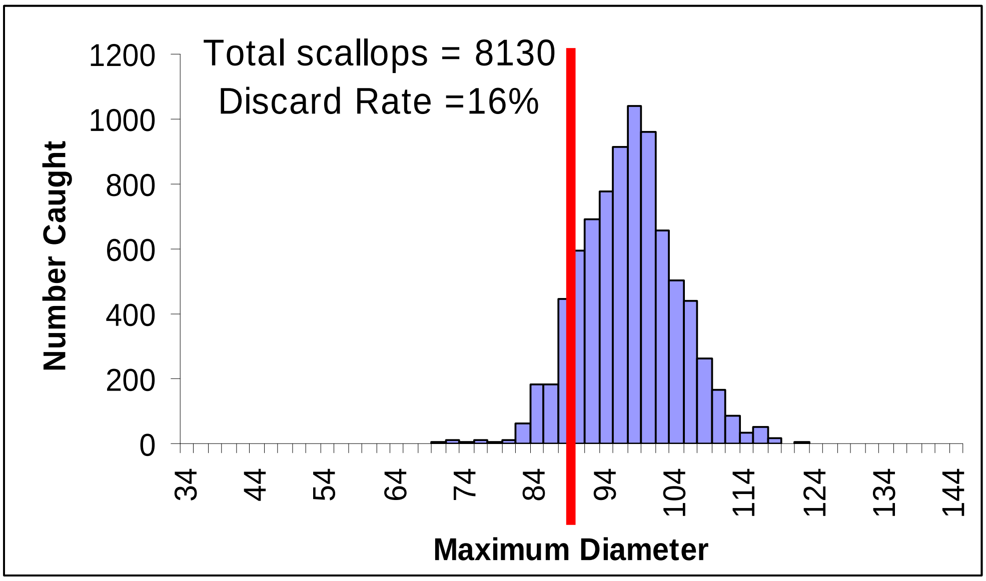


Figure 9: Length frequency of scallops caught within the Banks Strait region.

OTHER SURVEYED AREAS

Several vessels opportunistically surveyed along the North Coast (Northeast coast) during transit to the White Rock open region. Data showed some scallops within this region, however, further more detailed surveys area required.

Two vessels also surveyed south of Marion Bay and within the Storm Bay / Bruny Island region. No scallops were reported from these regions.

Appendix 11.6: August / September 2006 survey results

East Coast Survey
4 vessels
30 August – 1 September

Figure 1 shows the locations of all sample tows conducted during the survey and Figure 2 shows an overview of the abundances of scallops caught during these survey tows.

Although relatively high abundances of scallops were caught within some regions within Eddystone Point (Figure 3), condition was generally reported as being very poor.

Low abundances of scallops were caught within the Ansons Bay / Binalong Bay regions, however, these was some evidence of a recruitment event, with low numbers of very small scallops being caught (Figure 4). Relatively high abundances of undersize scallops were caught within deeper water east of Ansons / Eddystone Point (Figures 3, 4 and 5). The small scallops east of Eddystone Point are known to be older than 3 years old.

Low catches of scallops were recorded of Scamander and Friendly Beaches (Figures 6 and 8). Generally low abundances of scallops were caught off Long Point / Bicheno, although they were on average substantially higher than off Scamander and Friendly Beaches (Figure 7). However, condition and size of these scallops were reported as being excellent. This area may provide commercial catches of scallops if the remaining TAC (after White Rock has been fished) is relatively low.

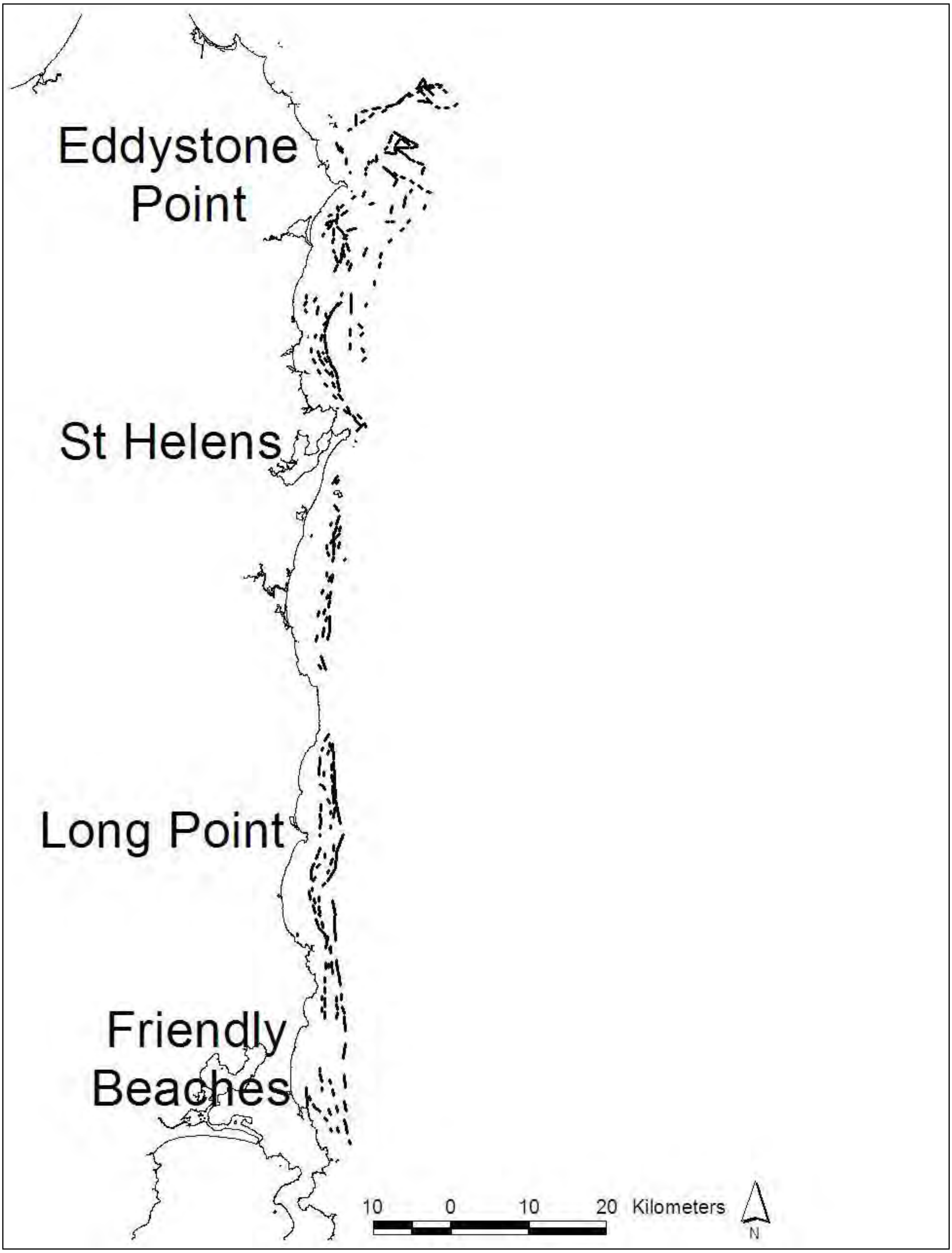


Figure 1: Location of sample tows conducted during the August / September 2006 survey.

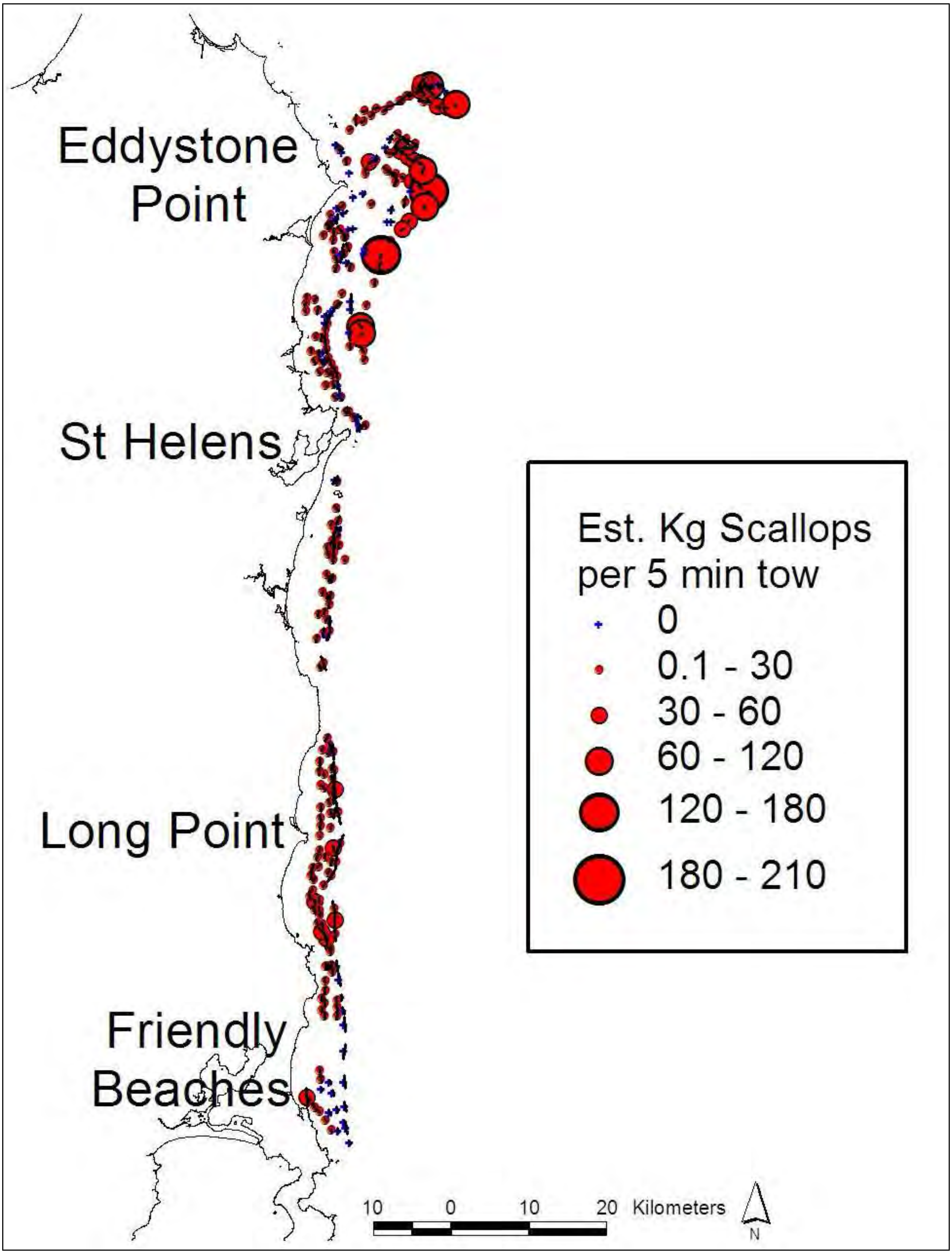


Figure 2: Overview of scallop abundances (as Kg scallop standardised to a 5 minute sample tow) caught during the August / September 2006 east coast survey.

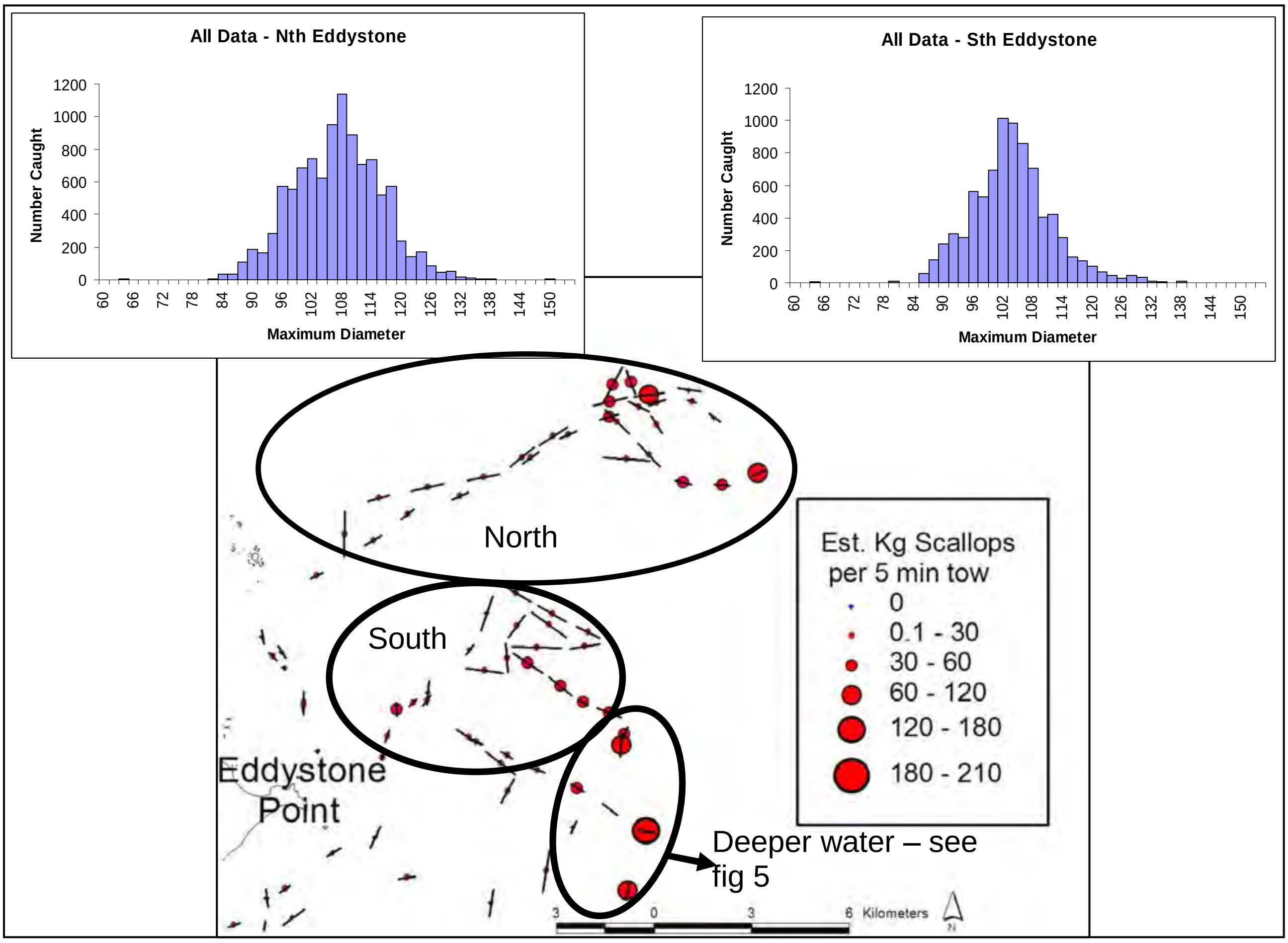


Figure 3: Location of sample tows, scallops caught and size structure of scallops caught within the Eddystone Point region during the August / September survey.

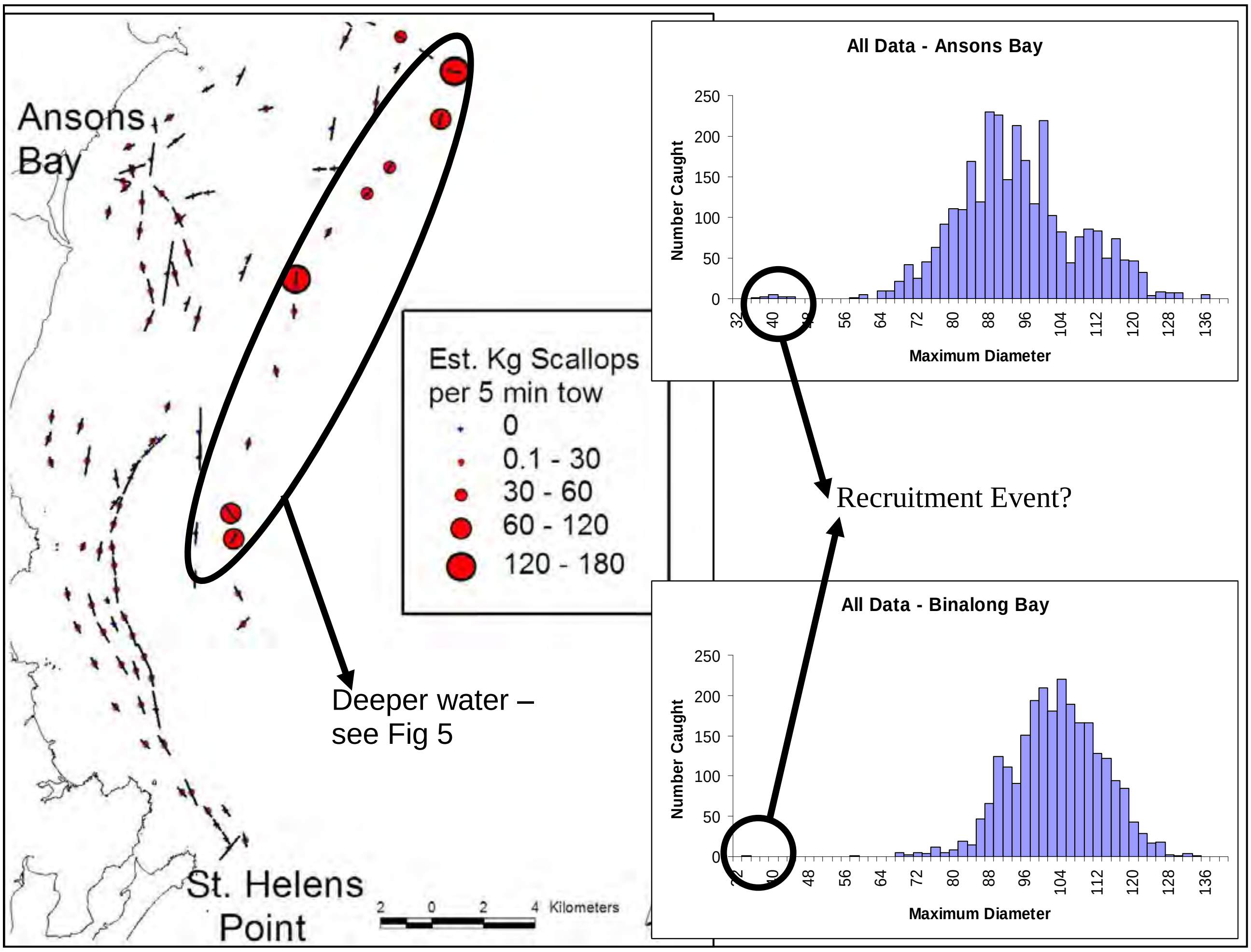


Figure 8: Location of sample tows, scallops caught and size structure of the scallops caught within the Ansons / Binalong Bay regions.

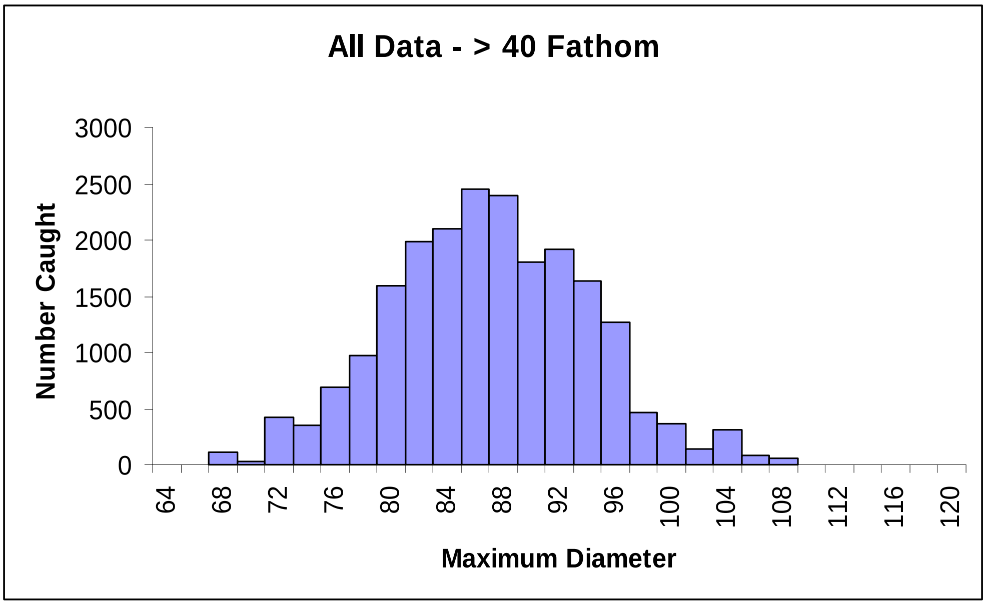


Figure 5: Scallop size structure, derived from scallops measured within the deeper water sample tows east of Eddystone Point / Ansons Bay and extrapolated to the entire scallops caught (see Figures 6 and 7).

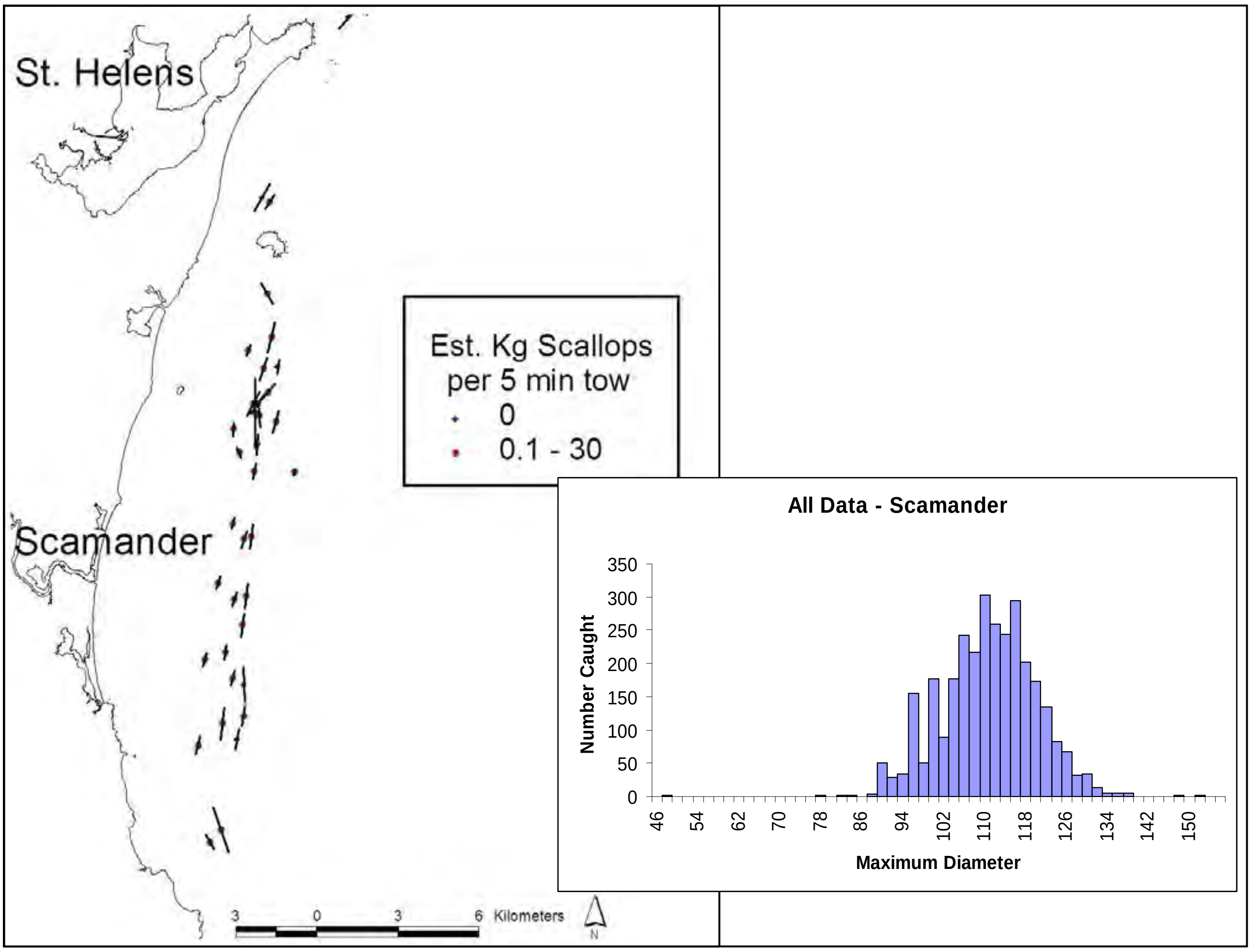


Figure 6: Location of sample tows, scallops caught and size structure of scallops caught within the Scamander region, South of St. Helens Point.

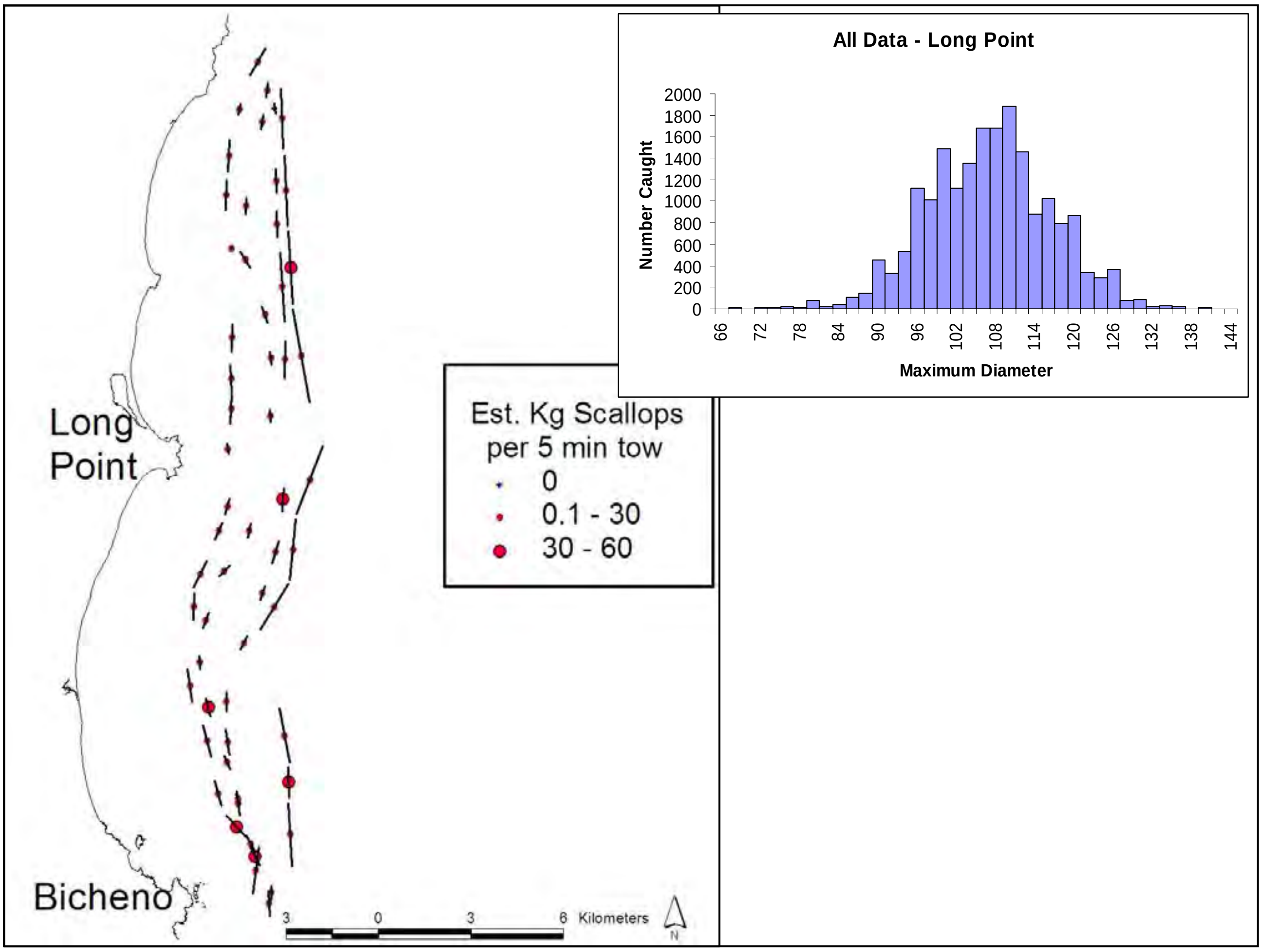


Figure 7: Location of sample tows and scallops caught within the Long Point survey region.

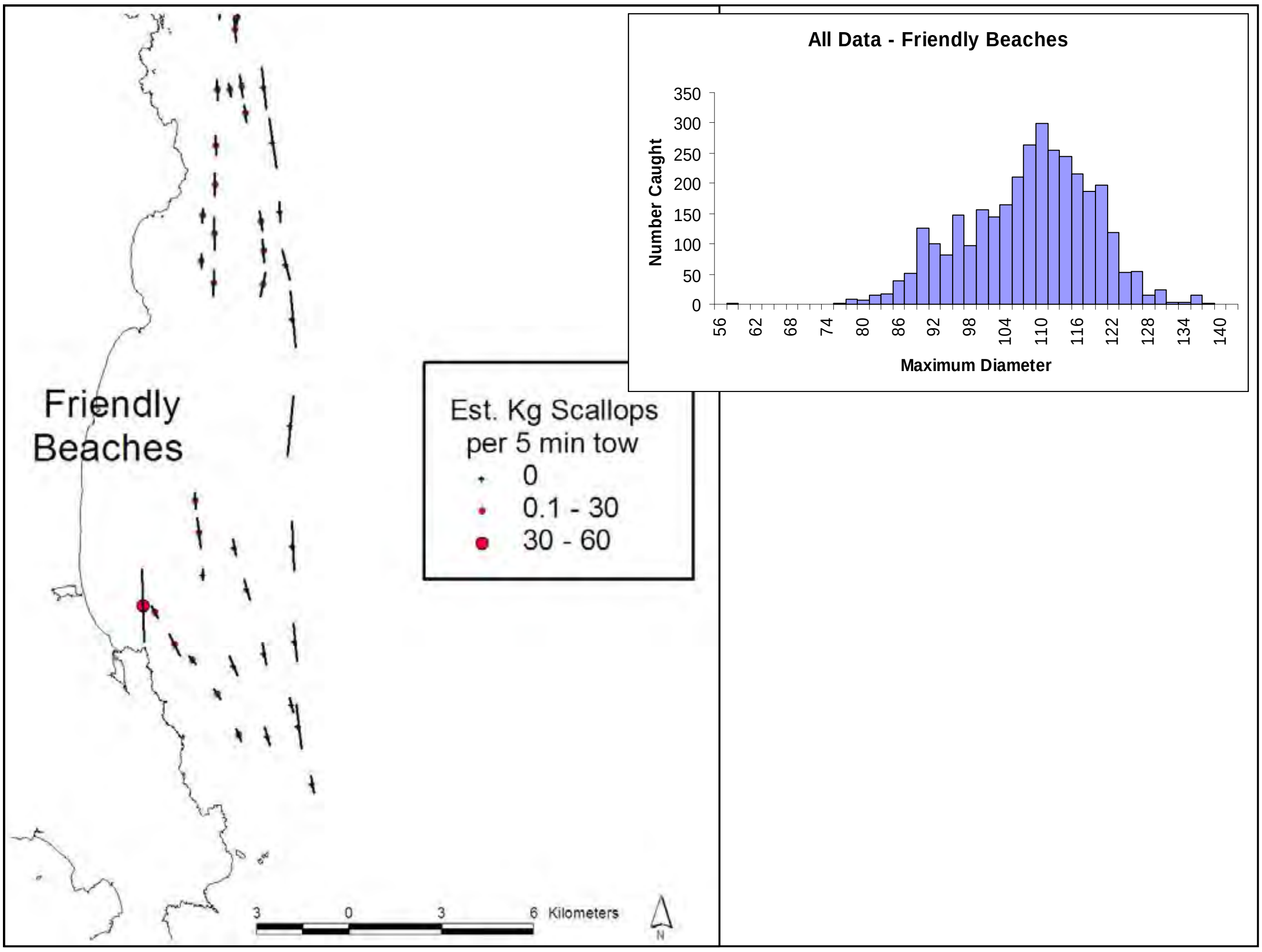


Figure 8: Location and abundance of scallops caught per 5 minute standardised sample tow within the Friendly Beaches region, south of Bicheno.

Appendix 11.7: 2006 Industry survey summary

2006 Industry Survey Summary

FRDC 2005/027

Tasmanian Aquaculture
& Fisheries Institute
University of Tasmania

Australian Government
Fisheries Research and
Development Corporation

Tasmania
DEPARTMENT *of*
PRIMARY INDUSTRIES,
WATER *and* ENVIRONMENT

Julian Harrington
Malcolm Haddon
Jayson Semmens

General Introduction

Throughout the 2006 Tasmanian scallop season a number of Industry surveys have been conducted. The ultimate aim of these surveys was (is) to provide Industry, Management and Research with information of scallop stock status over the spatial range of the Tasmanian scallop fishery. In conjunction with the TAFI run FRDC project: "Facilitating Industry Self-Management for Spatially Managed Stocks: A Scallop Case Study", a number of mechanisms for implementing and conducting Industry survey strategies were trialled and compared throughout 2006. These have included structured 'scientific' surveys aimed at answering specific questions; more structured Industry run surveys; as well as more flexible survey arrangements, that ultimately left participants to determine where the specific locations of survey tows (but within the jurisdiction of issued permits). Surveys have utilised several boats working in unison as well as individual boats. This report provides an overview of the data collected during all Industry surveys conducted during 2006.

2006 Industry Survey Summary

The location of the Industry survey tows conducted on the east coast and around Flinders Island, within Tasmanian waters, during the 2006 Tasmanian scallop season are shown in Figure 1 and 2; and more specific details of each survey conducted are summarised in Table 1.

Table 1: Summary information of all Industry surveys conducted during 2006.

Survey Location	Survey Date	Total survey days	Vessels	Tows Conducted	Research Quota
White Rock (Including 8 tows in SRA)	30 May 2006	2	1	24	Yes
White Rock	19 June 2006	1	1	19	Yes
NE + Eddystone	May / June 2006	NA	3	20	Opportunistic
Maria Island – Storm Bay	25th July	1	1	32	Yes
Sthn Tasmania	26 / 26th July	1	1	35	Yes
Eddystone and Banks Strait	25th / 26th July	5	3	85	Yes
East Flinders	6th August	2	2	74	Yes
White Rock	21st August	1	1	25	Yes
East Coast (Friendly Beaches – Eddystone Pt.	30th August to 1st Sept.	10	4	300	Yes
West Flinders	12th / 13th September	2	1	60	Yes
East Flinders	15th / 16th September	2	1	52	Yes
TOTALS				726	27 DAYS

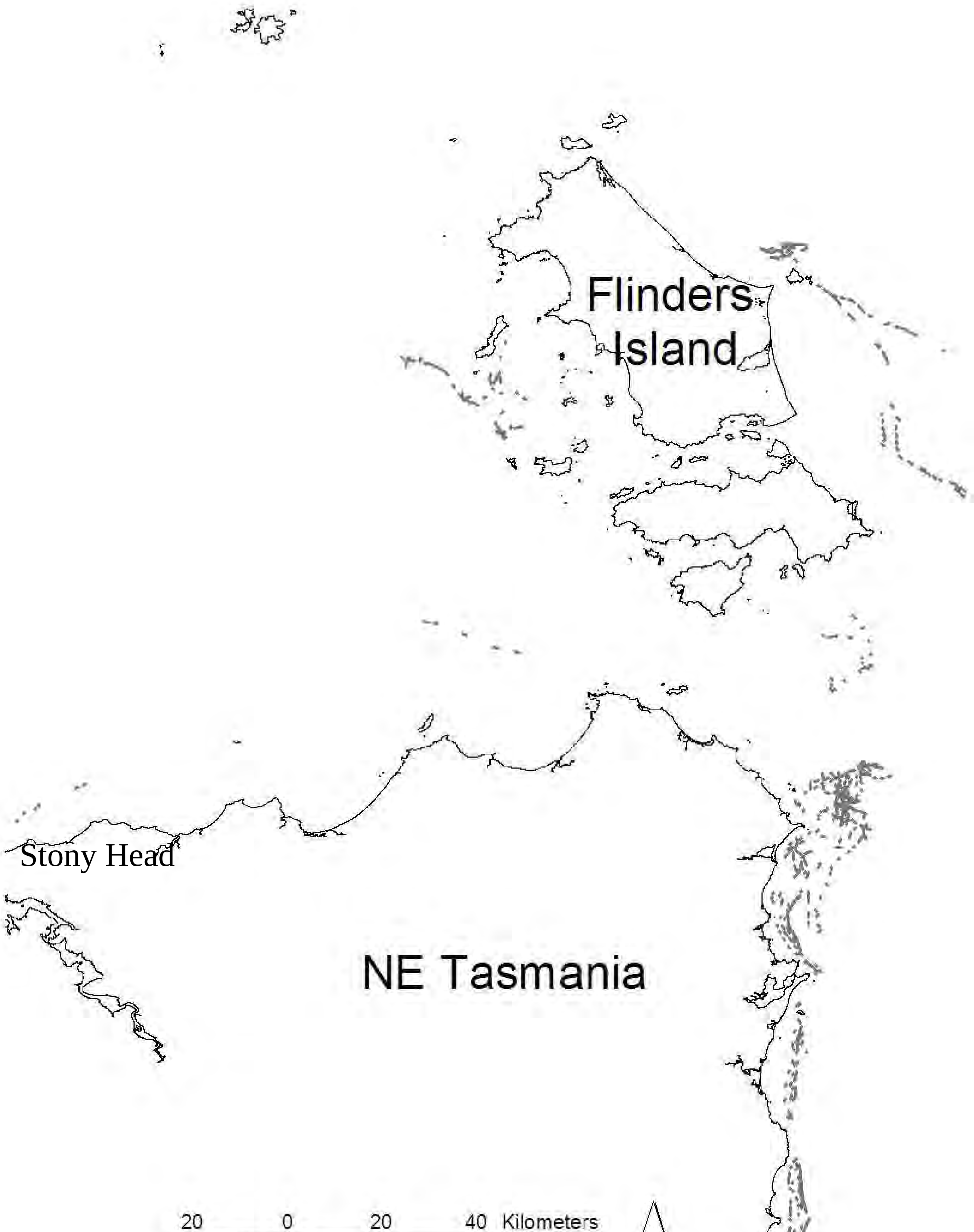


Figure 1: Location of all Industry survey sample tows conducted during 2006 within northern regions of Tasmanian (including around Flinders Island).

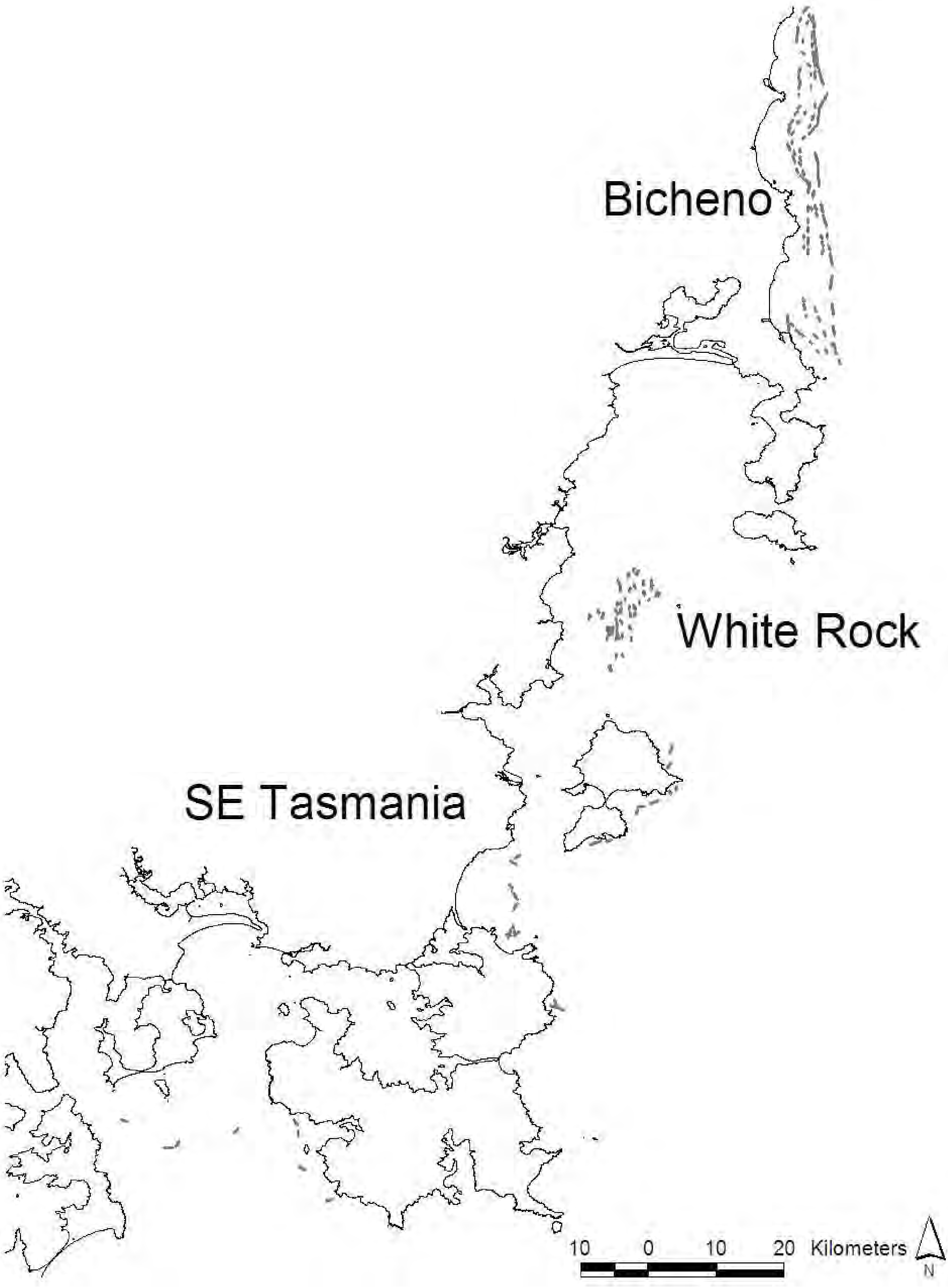


Figure 2: Location of all Industry survey sample tows conducted during 2006 within southern regions of Tasmanian.

2006 Industry Survey Data

The following sections provide a more detailed account of the survey tows and catches from surveys conducted during 2006.

North / Northeast (including Flinders Island)

A number of opportunistic and Research Quota allocation surveys / survey tows were conducted within the northeast region (including around Flinders Island). Although only a limited number of sample tows were conducted along the NE coast (see Figure 1) data suggested a possible bed of undersize scallops may exist within the vicinity of Tenth Island, north of Stony Head (labelled on Figure 1a). A more detailed opportunistic survey within this region may occur late in 2006.

Three vessels conducted Industry survey tows within the vicinity of Flinders Island (see overview in Figure 1). The abundances of scallops caught for samples tows conducted both west and east of Flinders Island were relatively low (Figure 3). Scallops caught to the west of Flinders Island were predominately undersize (Figure 4); while on the east side of Flinders scallops were found to be legal size (Figure 4). In summary, no commercial quantities of legal or undersize scallops were identified in the regions surveyed.

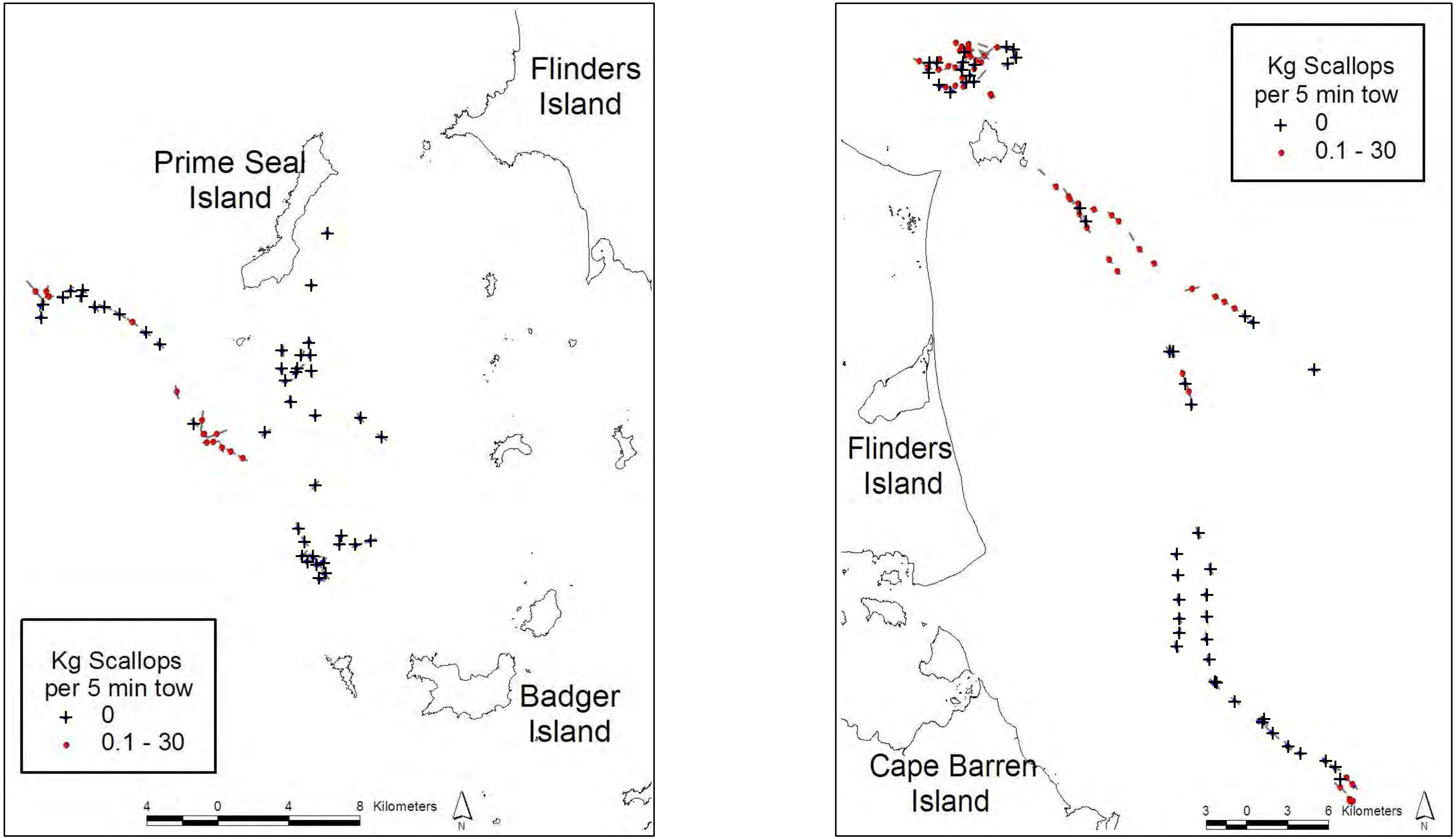


Figure 3: Location of sample tows and abundances of scallops caught within sample tows conducted west (left) and east (right) of Flinders Island during 2006.

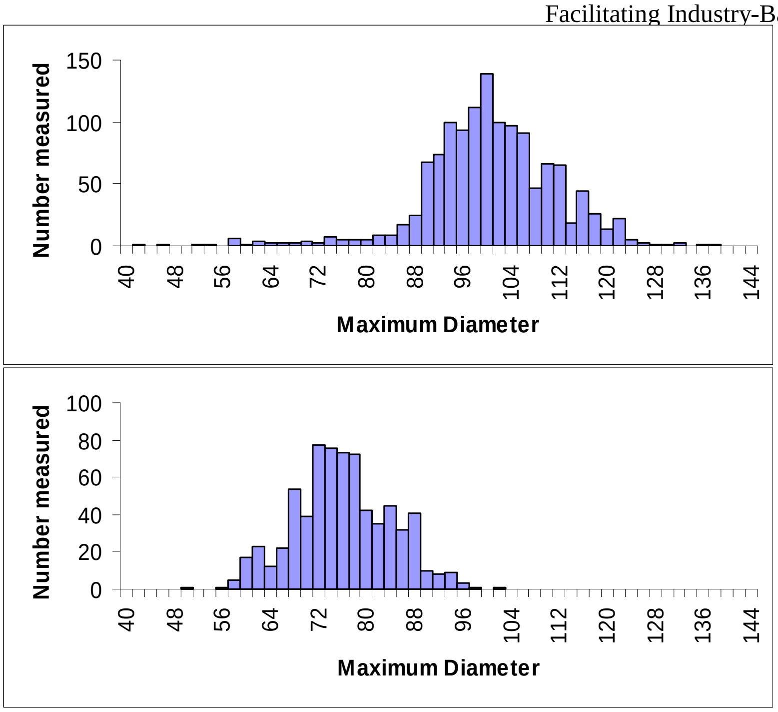


Figure 4: Size structure of scallops caught east (top) and west (bottom) of Flinders Island.

East Coast (including Banks Strait)

A limited number of Industry survey tows were conducted within the Banks Strait Class 1 Closed Zone during late July 2006 (Figure 1). For the majority of sample tows conducted, low catches were recorded; however, these tows did not overlap known regions of high scallop abundance. Several sample tows did contain high abundances of scallops, which were reported as being healthy and in good condition. A large amount of growth (barnacles) was found to occur on the shells of some scallops caught within this region. There is the potential for an opportunistic survey within the Banks Strait region near the end of the 2006 season, in early preparation for the 2007 season.

Surveys conducted during June / July 2006 identified high abundances of scallops within the region that was fished during 2003 (Figure 5); however, scallops were reported as being in exceptionally poor condition during both surveys. Much lower abundances of scallops were identified during the most recent survey conducted in late August / early September 2006 (Figure 6 vs Figure 5). The continued report of poor scallop condition suggests these scallop may have died / be undergoing a major die-off. Relatively high abundances of predominately undersize scallops were found in deep water (40 – 45 Fathom) from east of Eddystone Point to east of the Gardens (Figures 6 to 8). These deeper water scallops east of Eddystone Point have been monitored since 2003, and as such are known to be > 3 years old, but very slow growing.

With the exception of these deeper water scallops, scallop abundance within the Ansons Bay / Gardens / Binalong Bay regions was found to be low (Figure 7). However, some smaller scallops (approximately 40mm) were located within the Ansons Bay region, suggesting a potential recruitment event within this area (data from August / September survey).

Scallop abundances were generally low within the surveyed regions east of Scamander (Figure 9), Long Point / Bicheno (Figure 10) and Friendly Beaches (Figure 11) regions. However, condition of scallops within the Long Point region was reported as excellent.

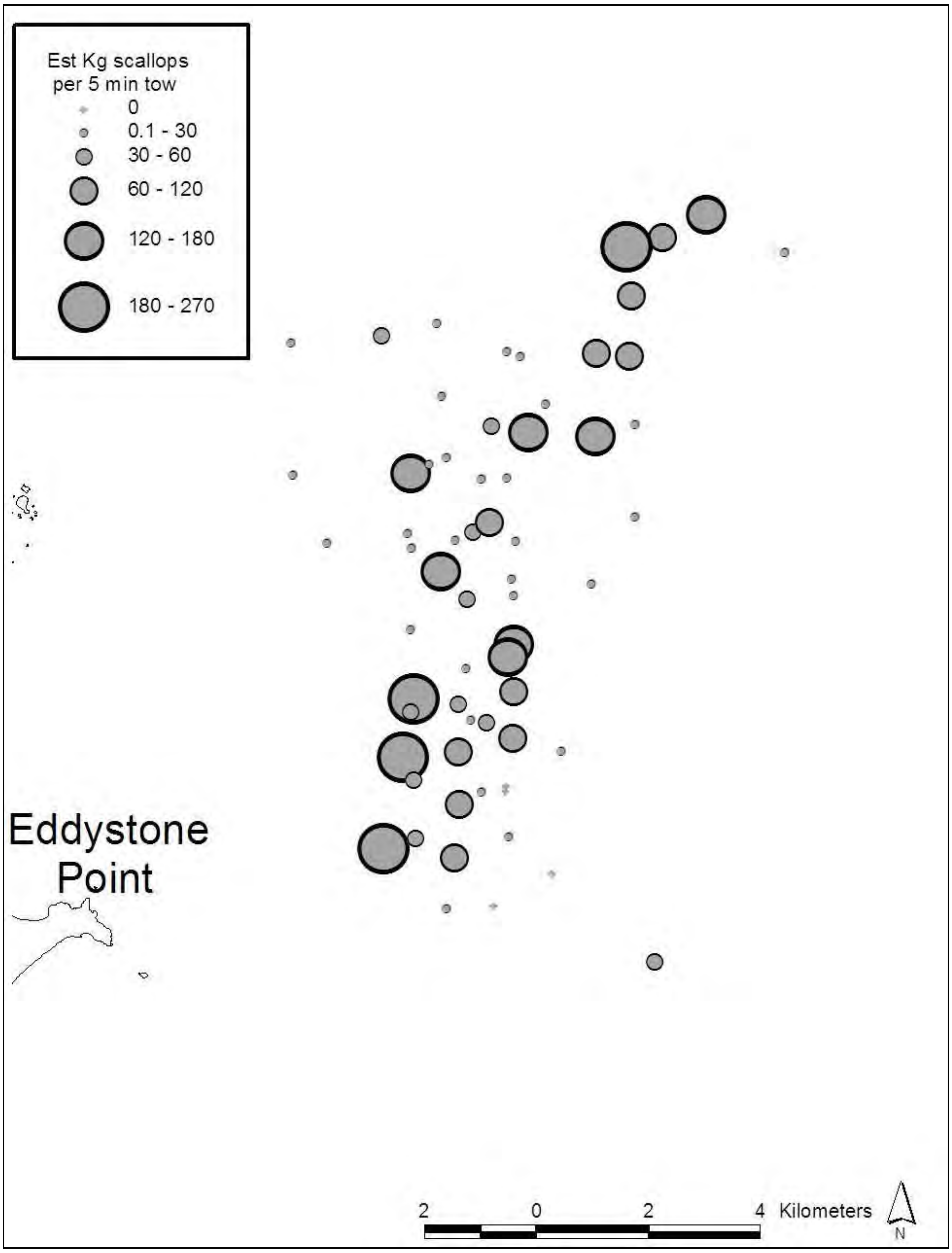


Figure 5: Catch rates of all scallops caught during surveys conducted during June / July 2006 within the Eddystone Point region.

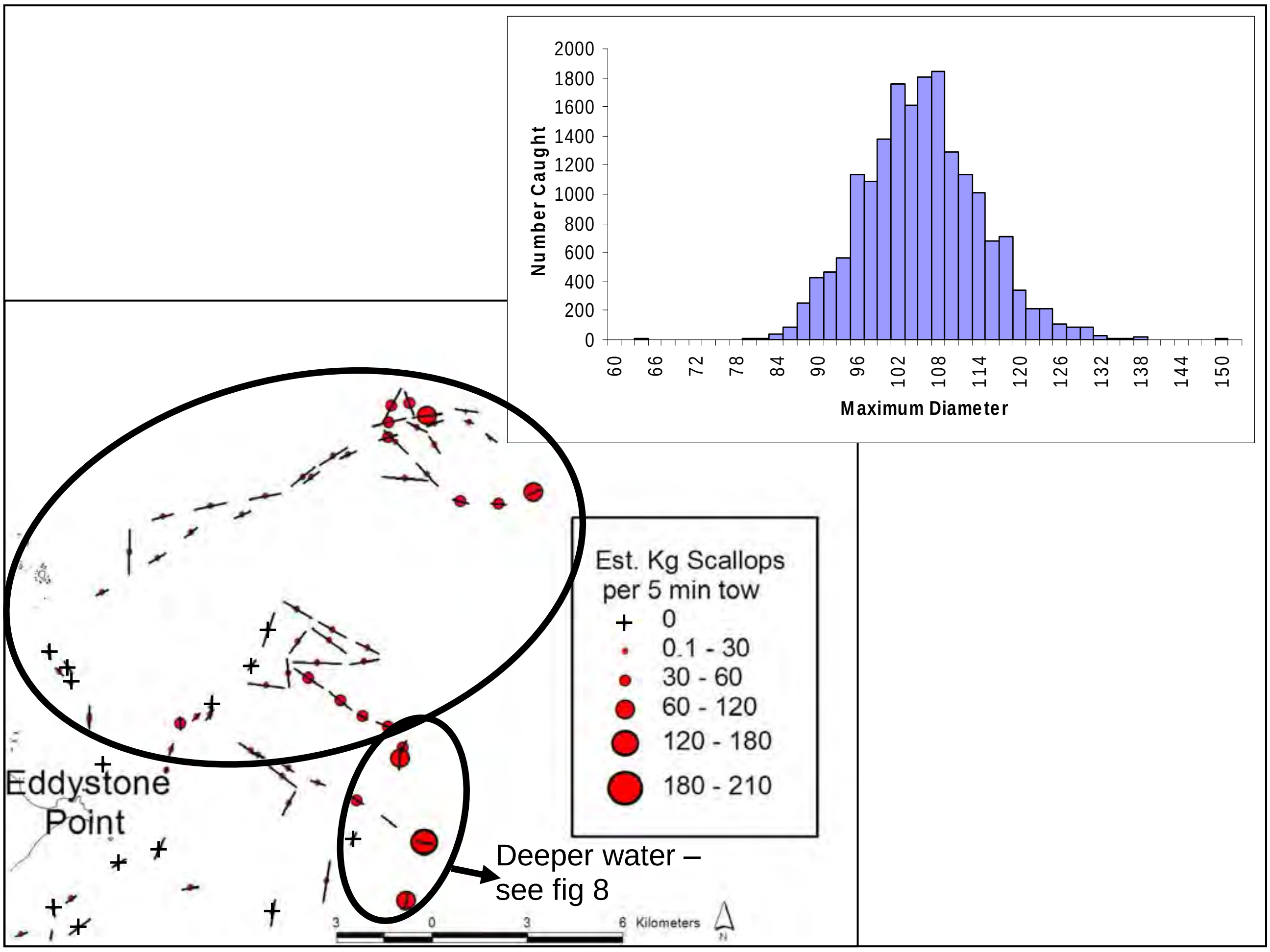


Figure 6: Location of sample tows, scallops caught and size structure of scallops caught within the Eddystone Point region during the August / September survey.

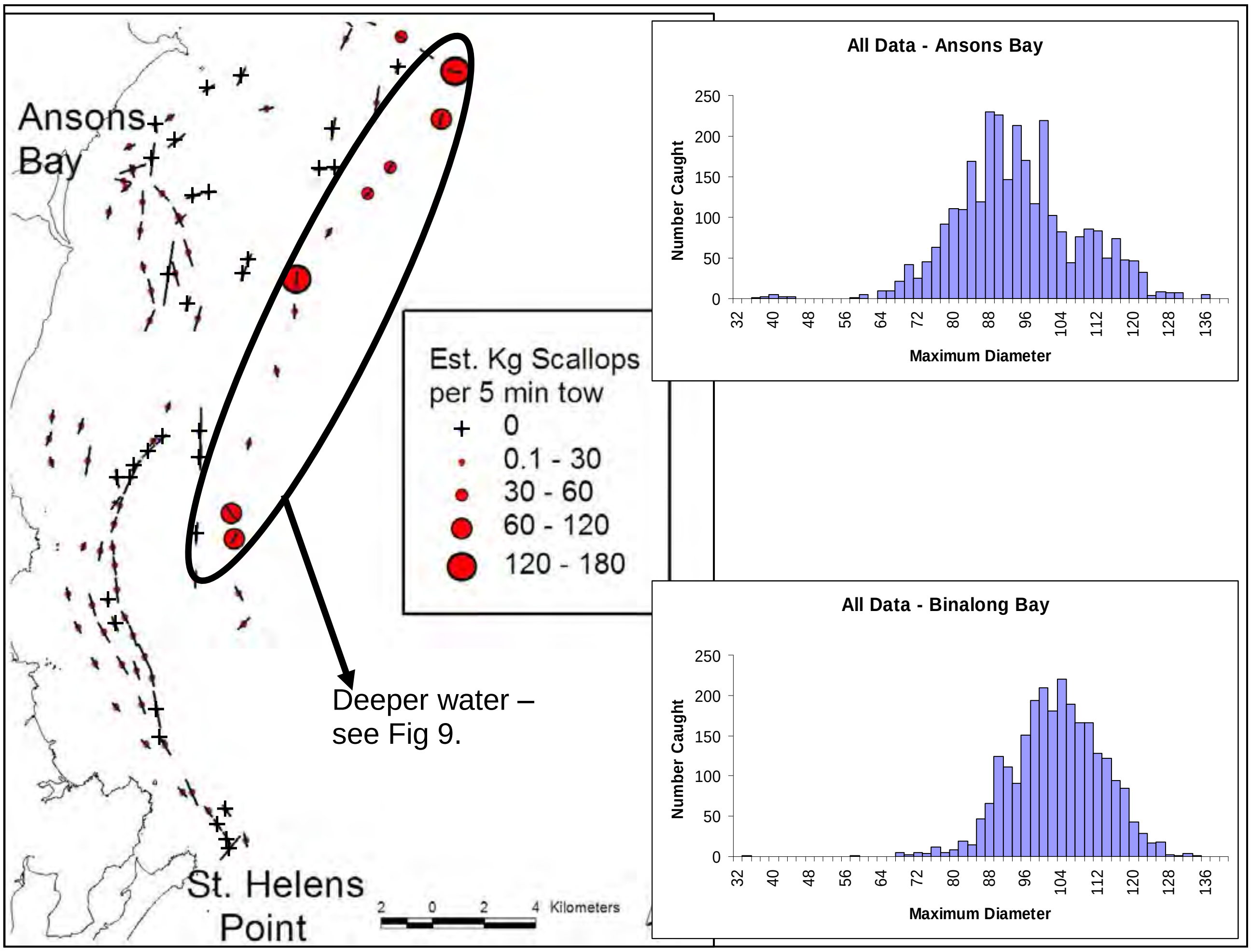


Figure 7: Location of sample tows, scallops caught and size structure of the scallops caught within the Ansons / Binalong Bay regions.

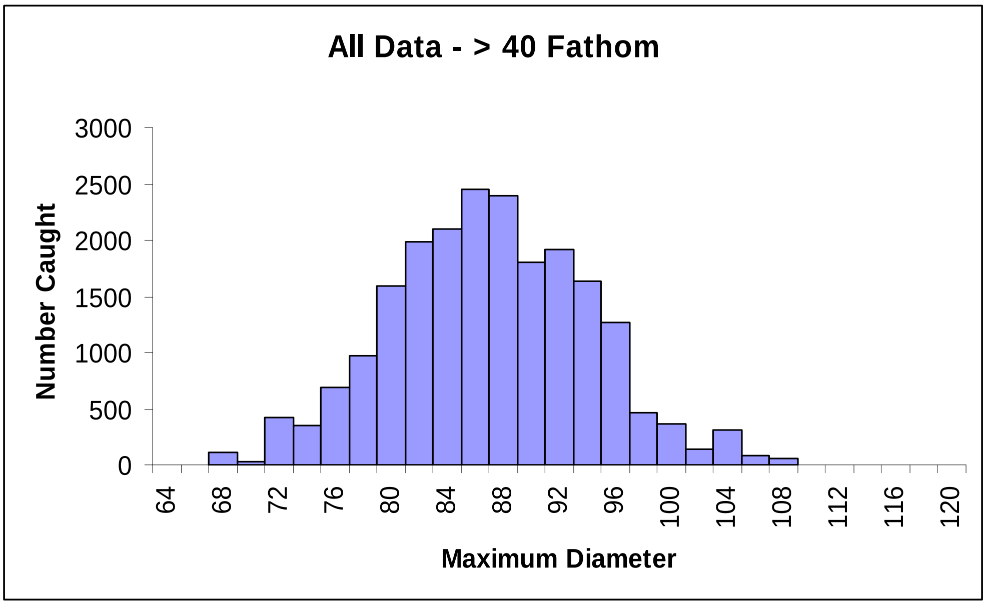


Figure 8: Scallop size structure, derived from scallops measured within the deeper water sample tows east of Eddystone Point / Ansons Bay and extrapolated to the entire scallops caught (see Figures 6 and 7).

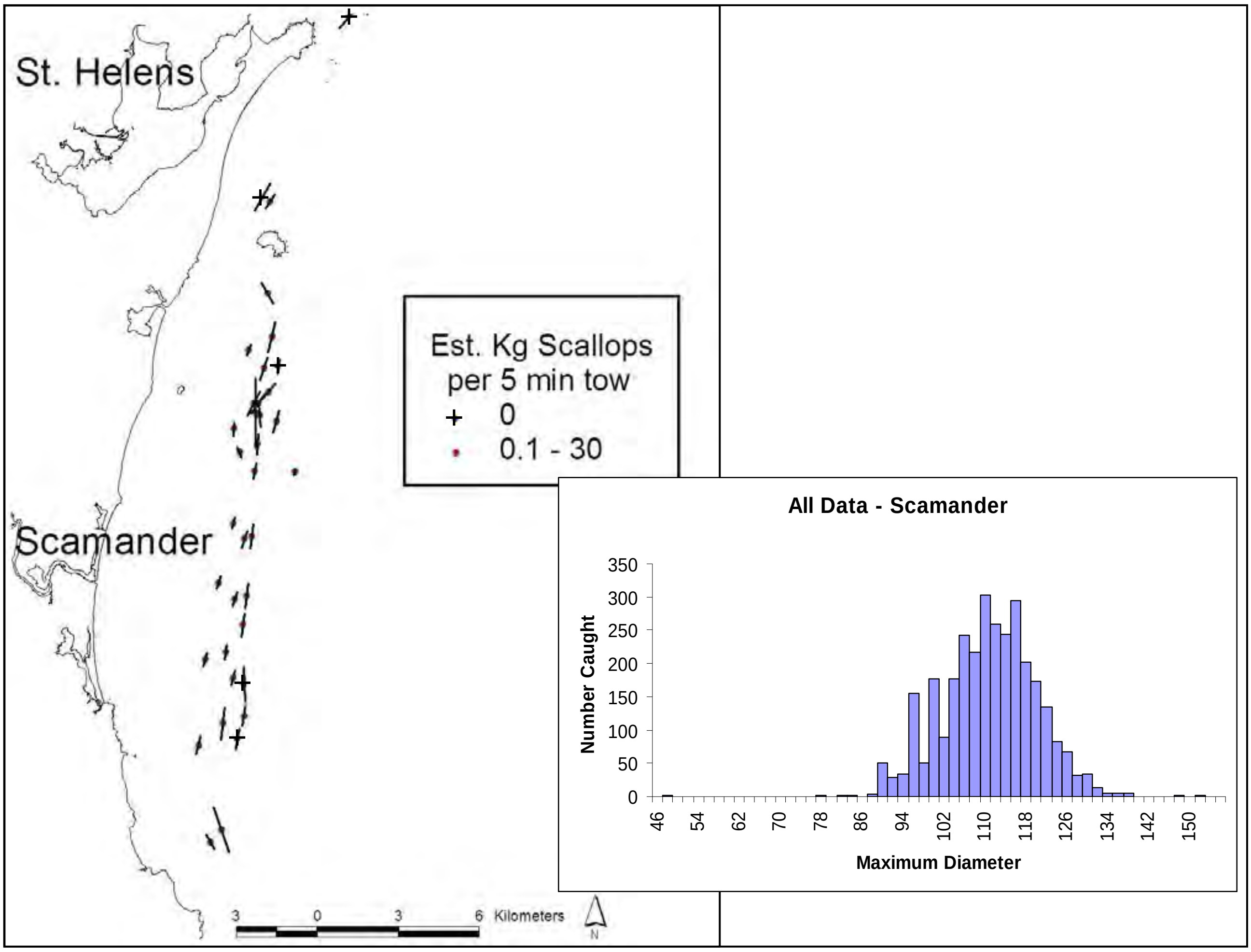


Figure 9: Location of sample tows, scallops caught and size structure of scallops caught within the Scamander region, South of St. Helens Point.

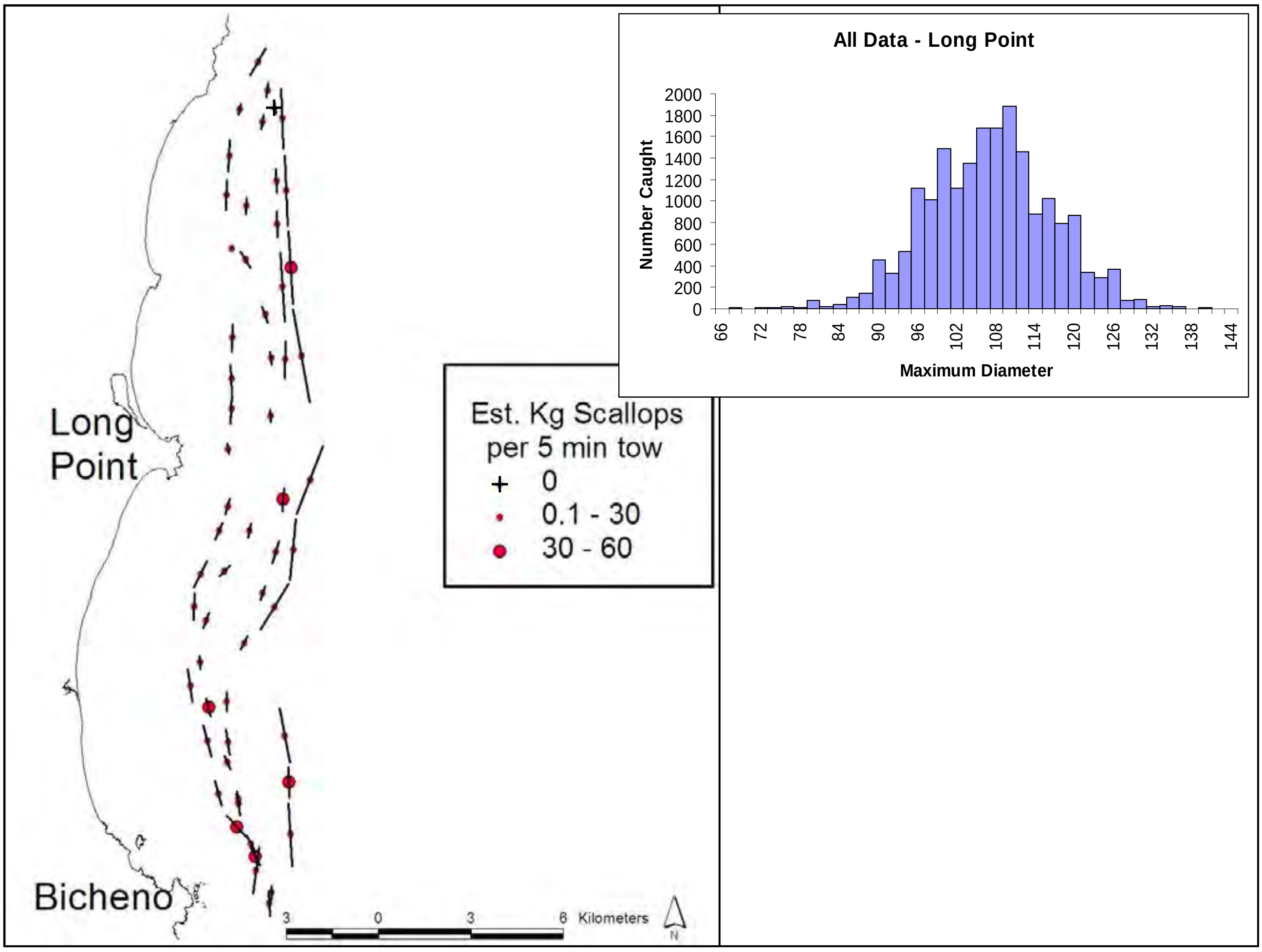


Figure 10: Location of sample tows and scallops caught within the Long Point survey region.

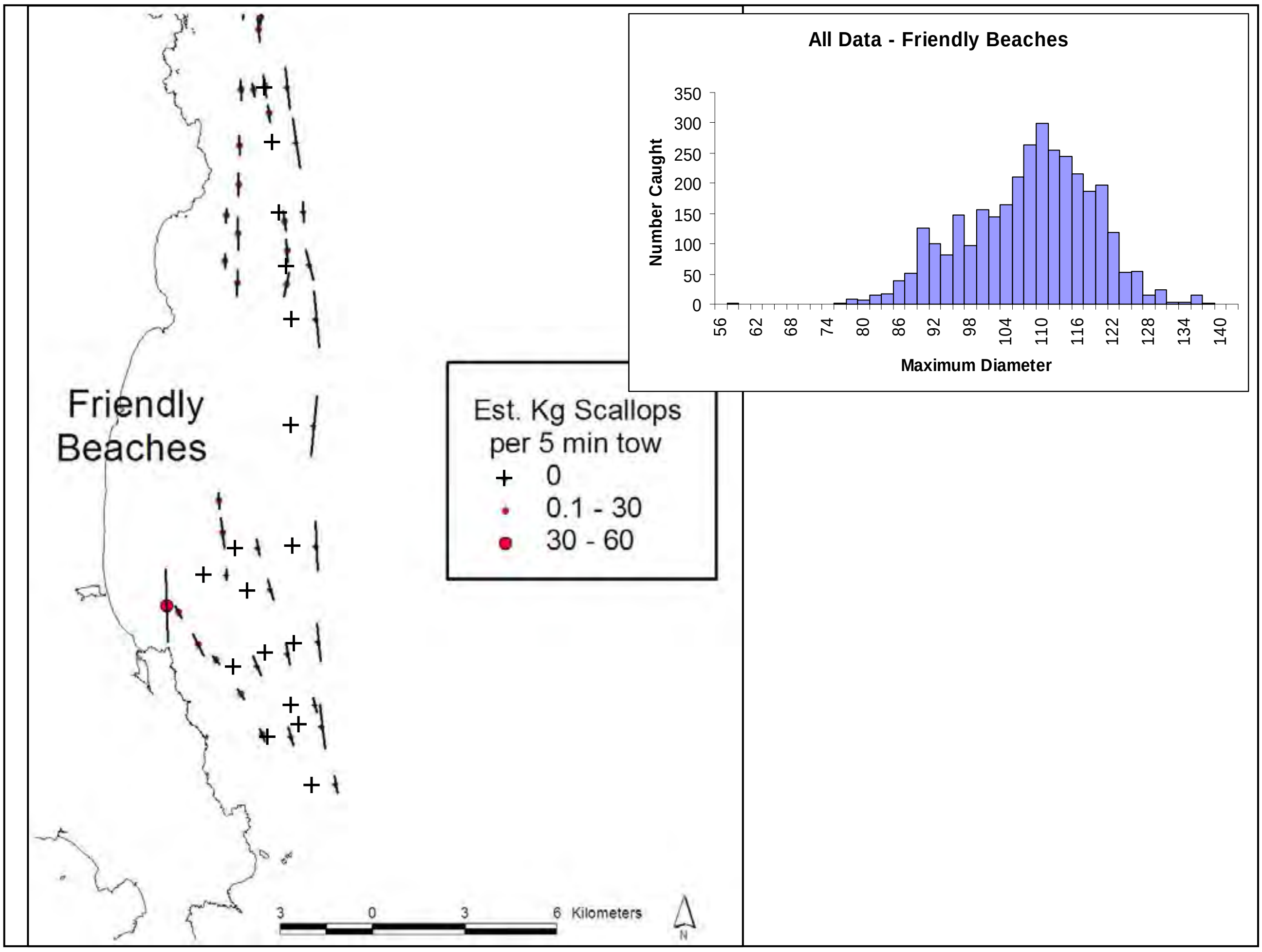


Figure 11: Location and abundance of scallops caught per 5 minute standardised sample tow within the Friendly Beaches region, south of Bicheno.

White Rock

Several surveys were conducted within the White Rock region. Two structured pre-season surveys collected detailed bycatch data from the White Rock open region and Shark Refuge Area (SRA) prior to fishing operations. These surveys also provided information on scallop condition, which led to the two week delay in opening the season, and opening on the 26th June 2006.

A post-commercial fishing survey was conducted in August 2006, after all regions within the White Rock open area had been fished BUT prior to the opening of the SRA. This survey aimed at monitoring the effects of fishing on benthic animals, including scallops, and used the SRA pre-fishing data as a baseline area that was not affected by fishing.

An observer was on board for all surveys, and the limited number of survey sample tows conducted within the SRA were completed under strict permit conditions.

South / South East Tasmania Surveys
Two vessels conducted sample tows within the SE / Southern Tasmanian regions. Low abundances of pre-dominantly legal size scallops were caught east of Maria Island and within Marion Bay (Figure 12). No scallops were located within Storm Bay (Figure 12) or between Recherche and Adventure Bay, with only approximately 20 scallops being caught in two sample tows in the northern regions of Adventure Bay.

No commercial quantities of scallops or indication of a recruitment event were identified within these survey regions.

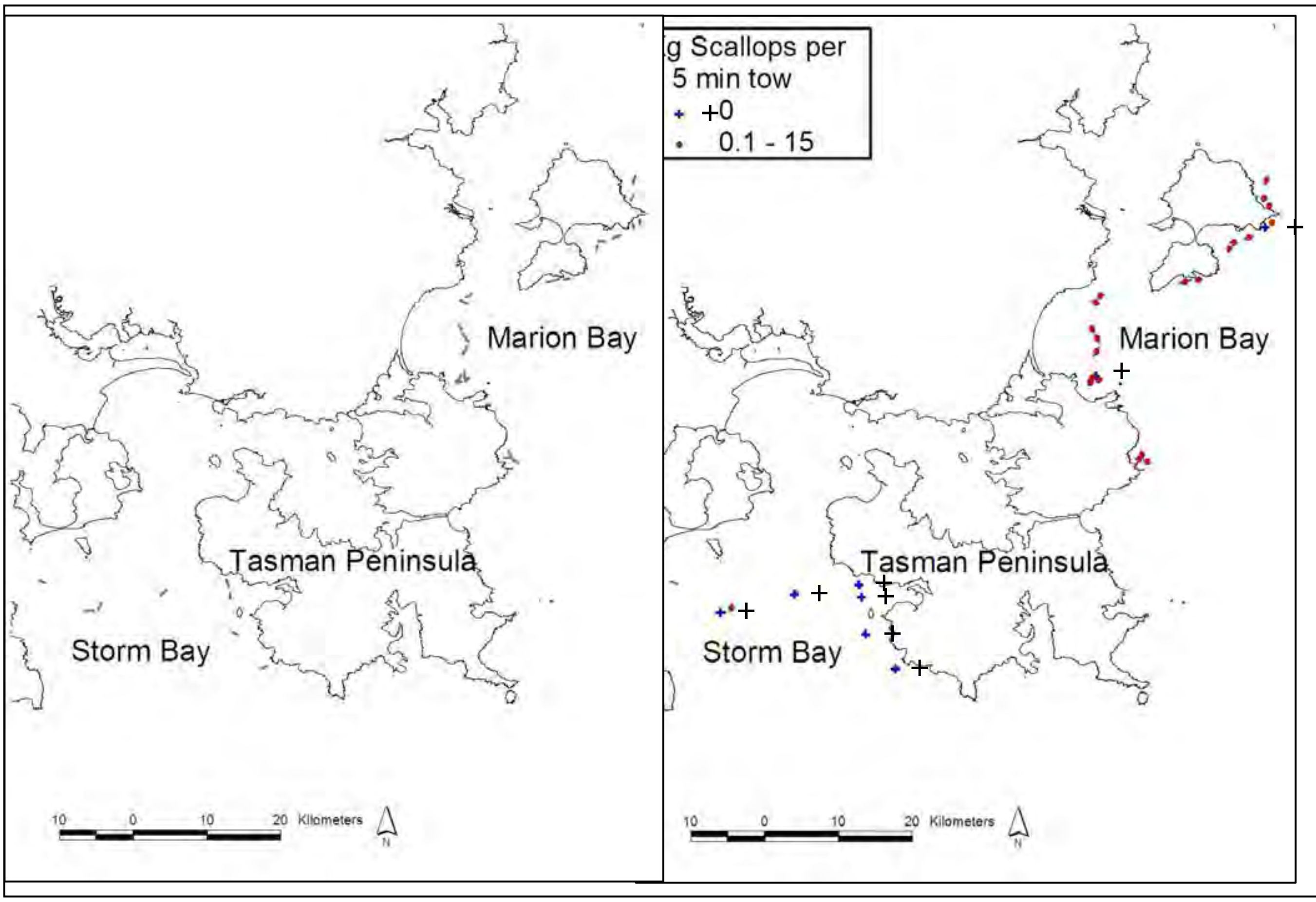


Figure 12: Location of sample tows conducted during the August / September 2006 survey.

Summary

- The Industry surveys conducted during 2006 have covered extensive regions of the Tasmanian fishery.
- Data collected during 2005 and 2006 suggest that Banks Strait is the main prospect for the 2007 season.
- More Industry surveys (data) required within several regions:
    - Banks Strait
    - Waterhouse Island / Ringarooma
    - Tenth Island
- Also need to monitor all regions for any signs of a recruitment event.
- Surveys will continue during 2007. For more information contact:

Julian Harrington
TAFI – MRL
(03) 62 277 201
0429 178592

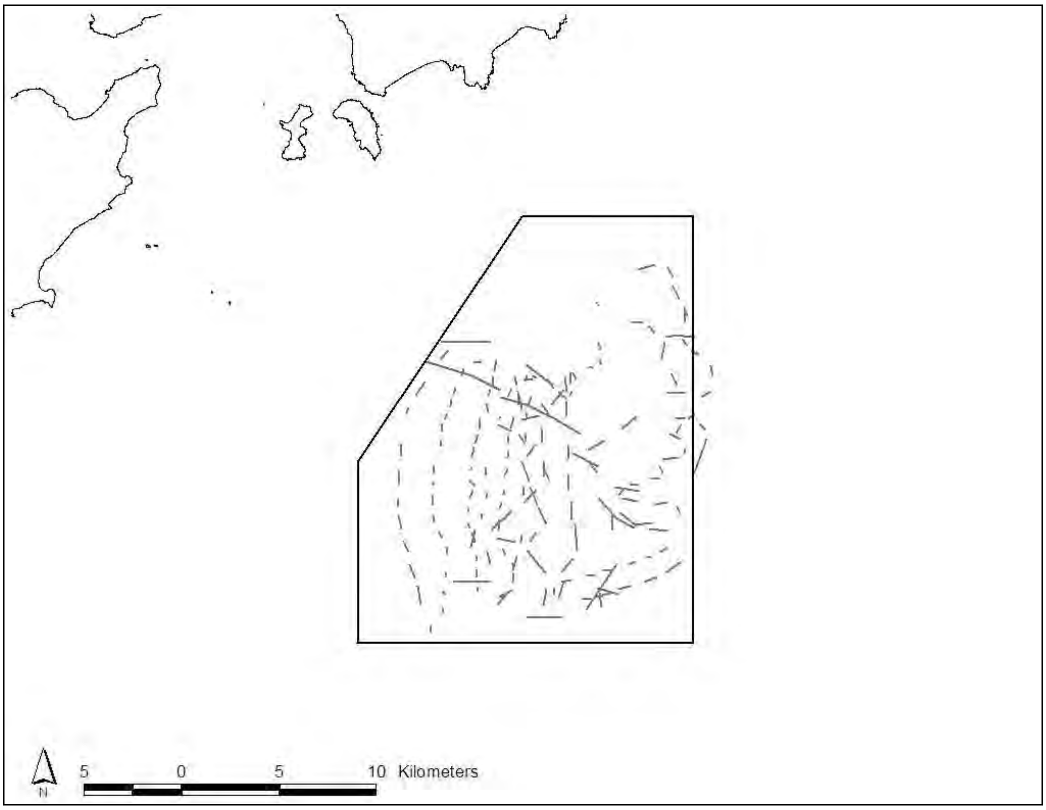
Appendix 11.8: June 2007 survey update

2007 Industry Surveys – Preliminary update

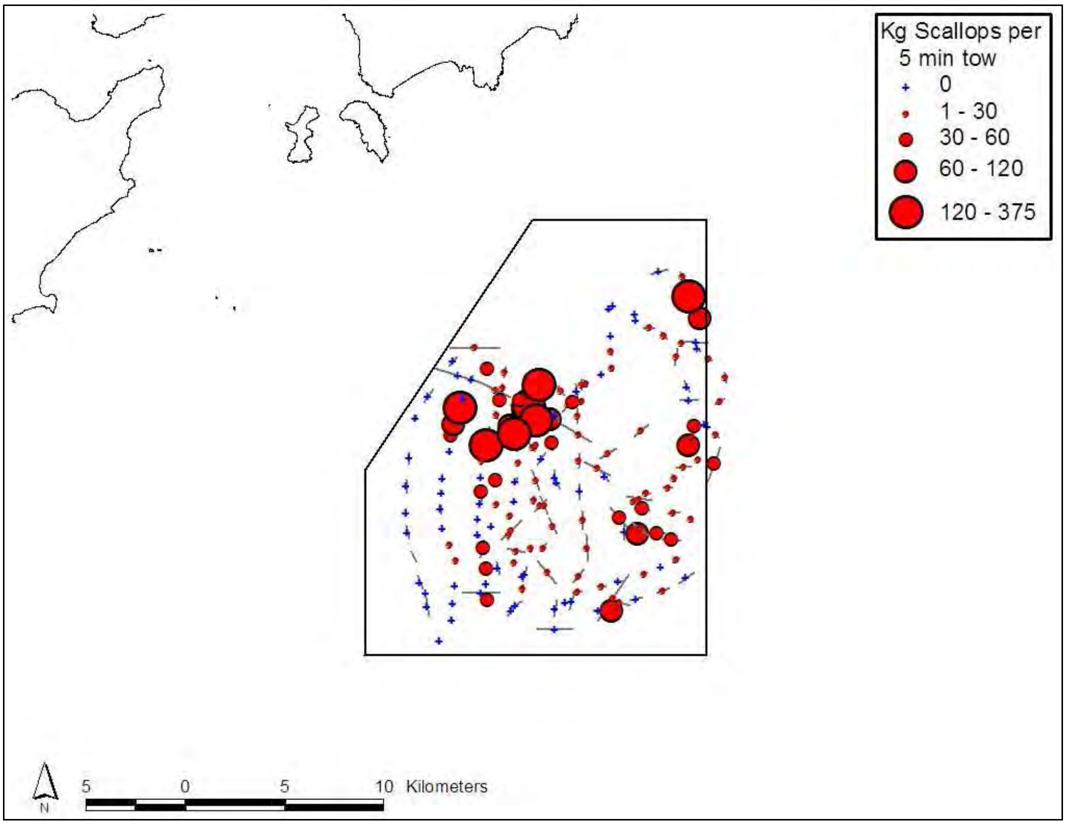
Tasmanian Aquaculture & Fisheries Institute
University of Tasmania

Australian Government
Fisheries Research and Development Corporation
Australian Fisheries Management Authority

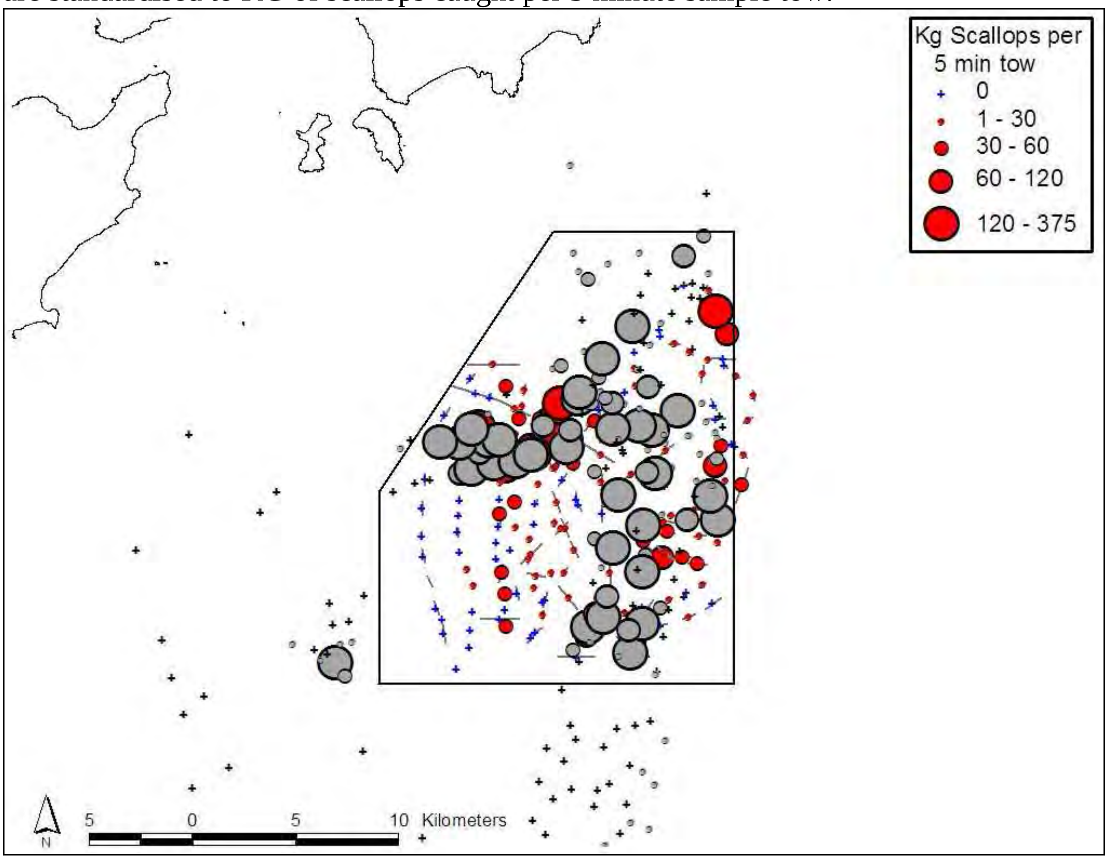
This report provides a brief preliminary update of information obtained during an Industry survey conducted by two vessels within the region of Banks Strait from June 14th – 17th 2007. The main aim of the report is to provide information allowing for more informed decision making during the up-coming Scallop FAC meeting (to be held on the 28th June 2007).



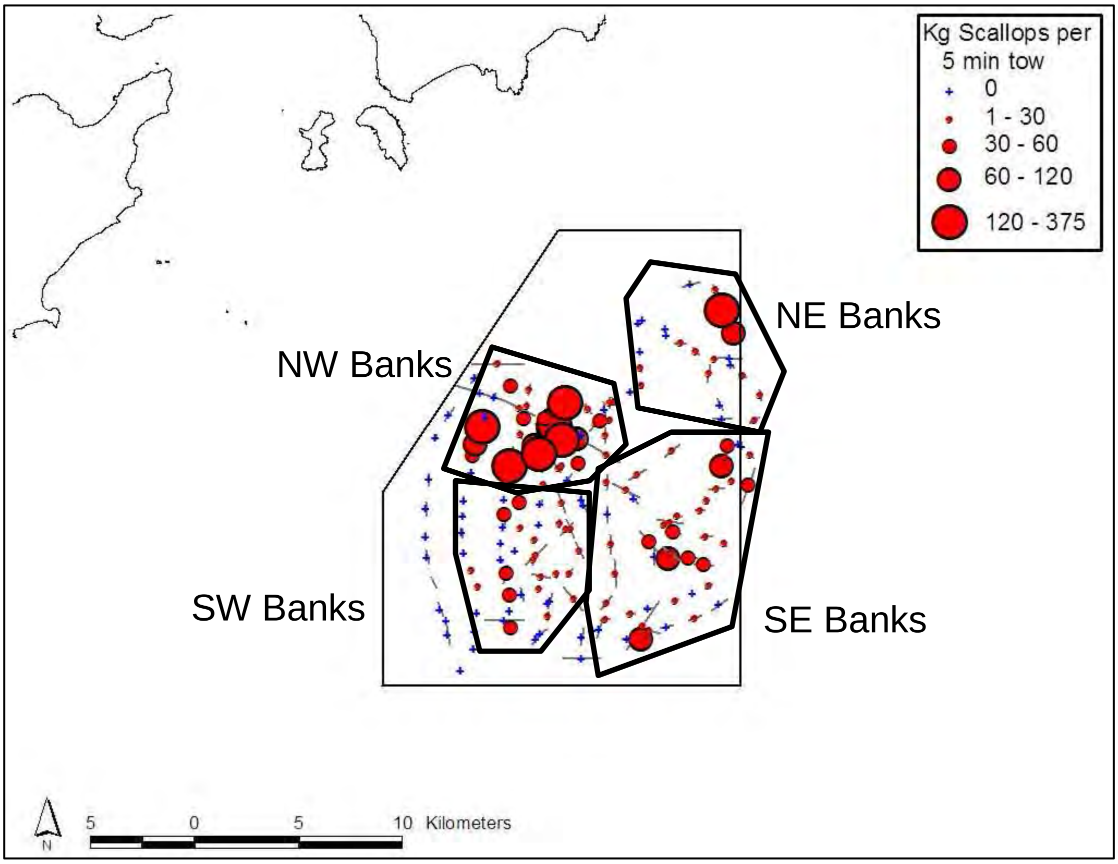
Location of survey tows conducted within the Banks Strait Class 1 Closed Zone from the 14th – 17th June. Sample tows conducted by another Industry vessel on the 8 June 2007 are also shown.



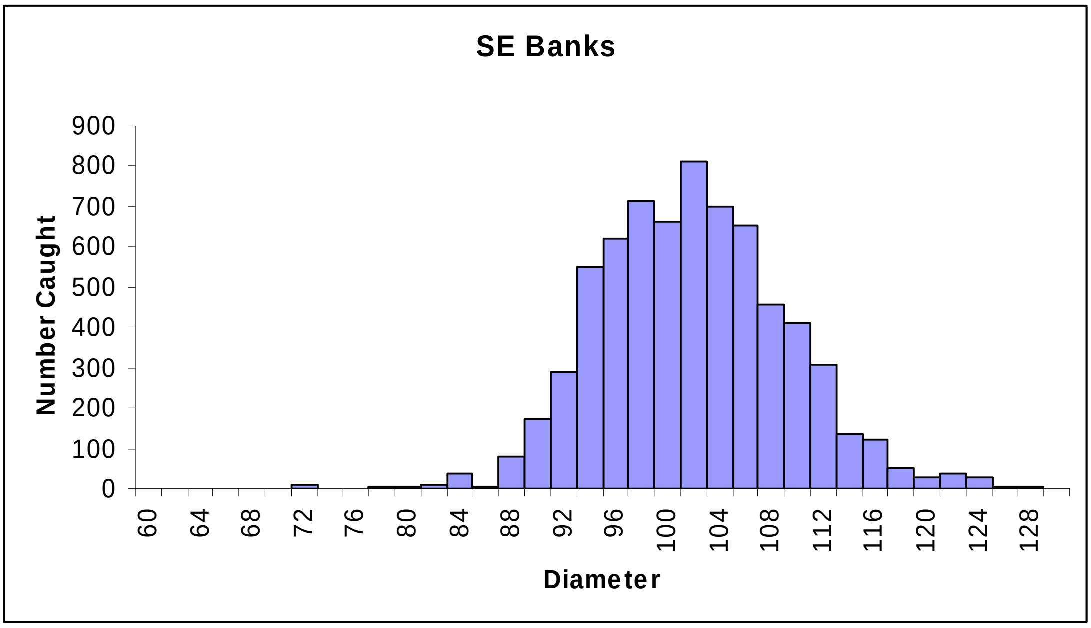
Abundances of scallops caught during the June 2007 Banks Strait surveys. Abundances are standardised to KG of scallops caught per 5 minute sample tow.



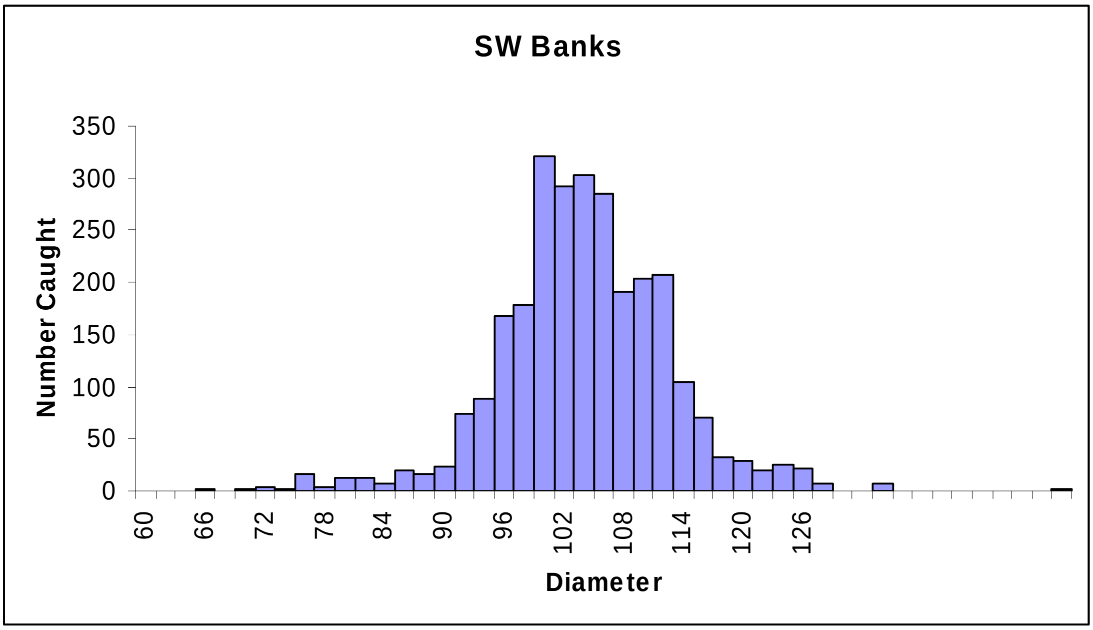
Location of both the June 2007 sample tow abundance data, and the July 2005 Industry survey data collected by 9 Industry vessels. Note: the maximum caught per 5 minute survey tow during the 2005 survey was 600 kg. Large amounts of scallop shell, oyster and screw shells were recorded during both surveys.



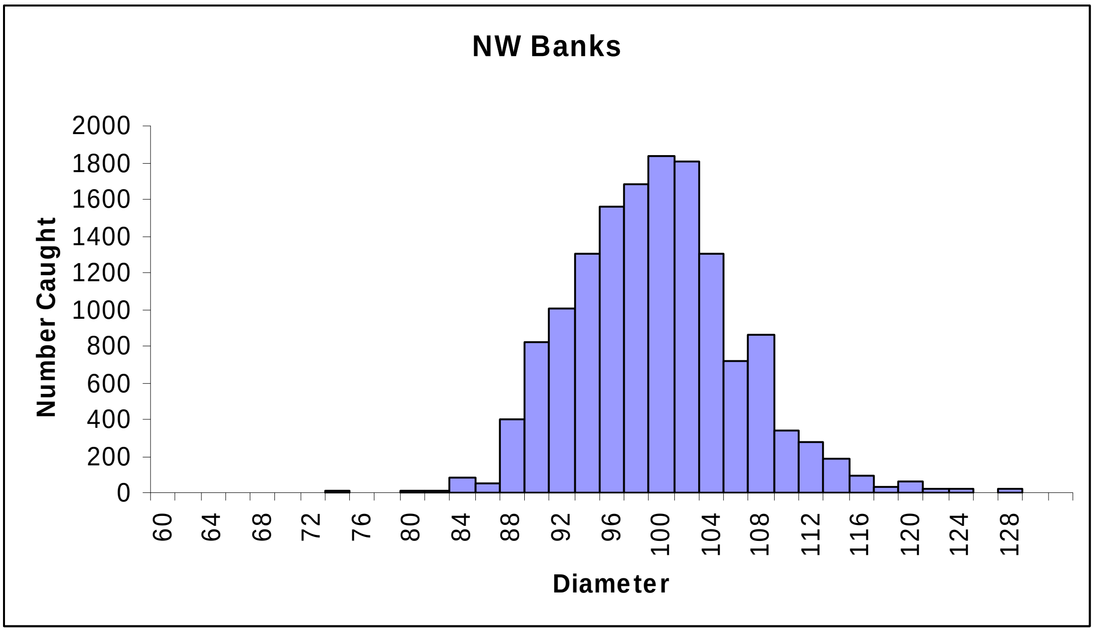
Location of zones used to analyse scallop measurement data. See length frequencies below.



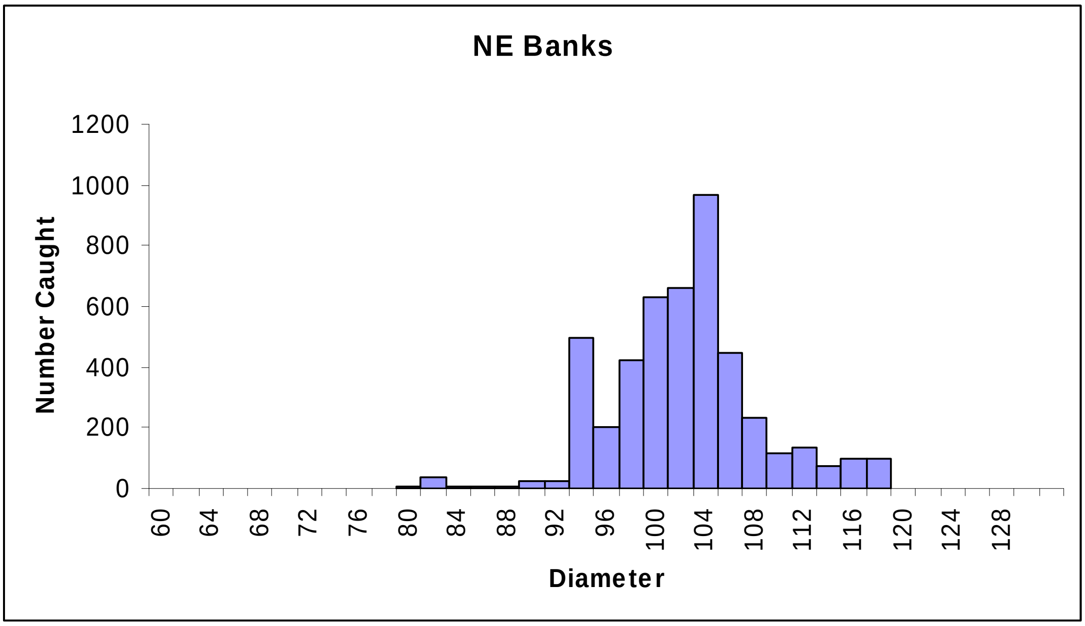
Size structure of scallops caught within the SouthEast region of Banks Strait (for the tows illustrated). Discard rate (i.e. scallops < 90mm diameter) = 3.5%.



Size structure of scallops caught within the Southwest region of Banks Strait (for the tows illustrated). Discard rate = 4%.



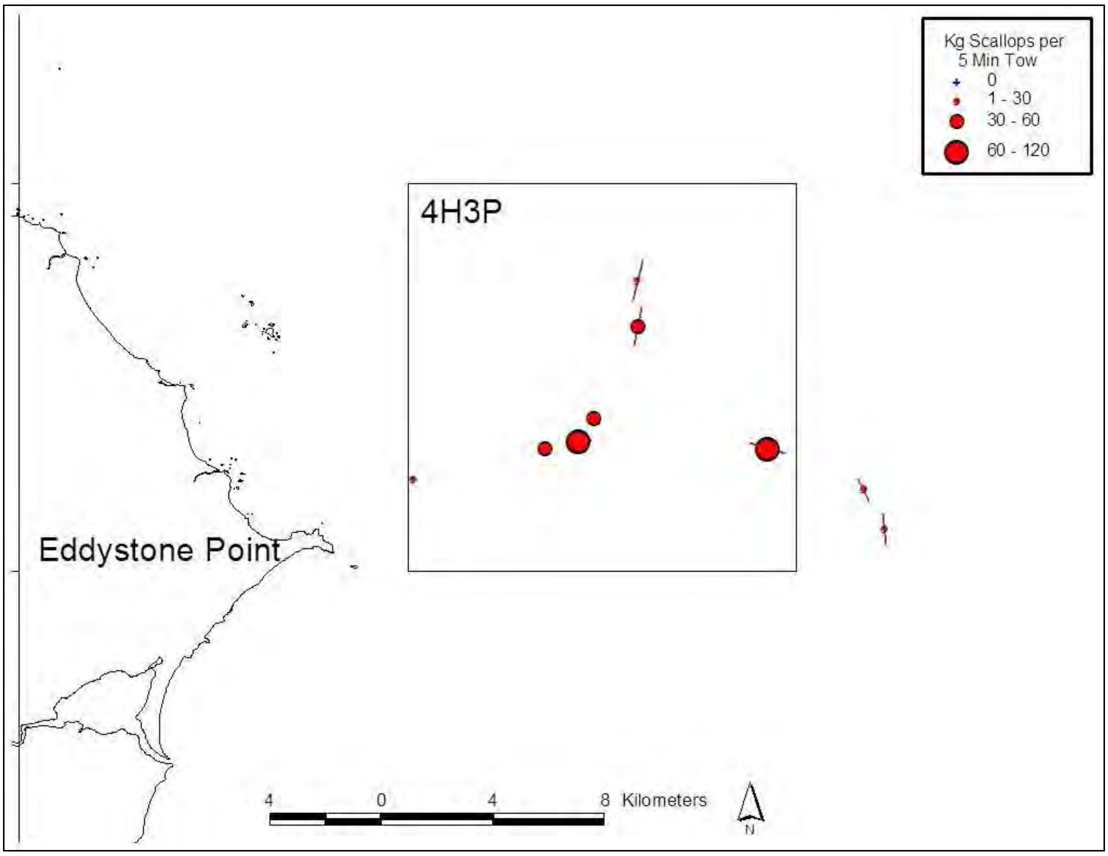
Size structure of scallops caught within the Northwest region of Banks Strait (for the tows illustrated). Vast majority of scallops were > 90mm.



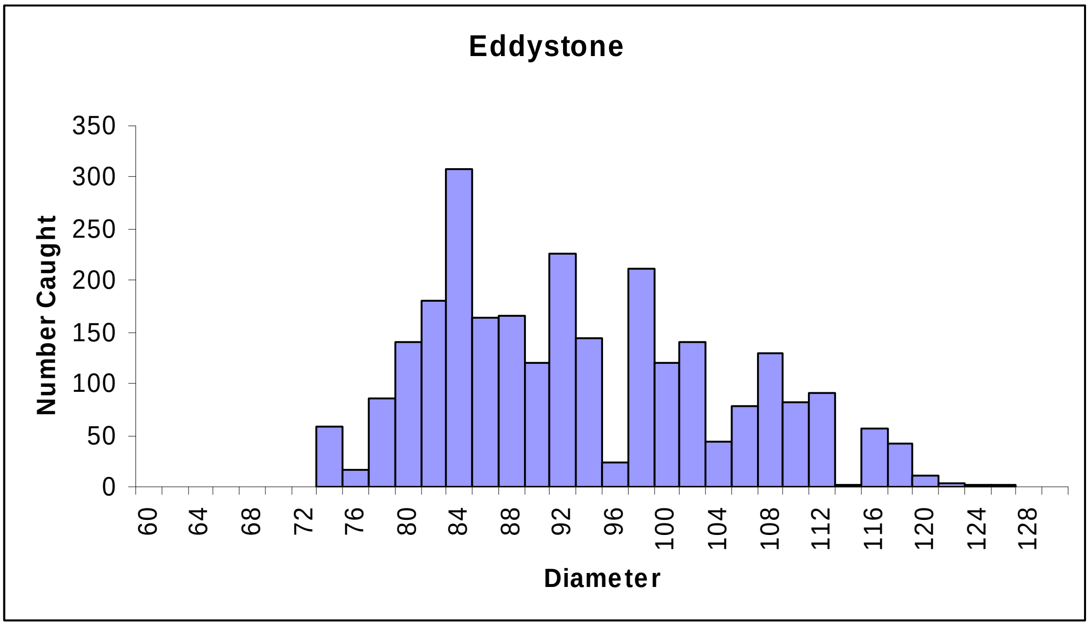
Size structure of scallops caught within the Northeast region of Banks Strait (for the tows illustrated). Discard rate = 2%.

Banks Strait Scallops – Processors perspective:

- Counts – averaged 78 – 80 scallops per kg.
- Ranged from 55 – over 100 per kg depending on where they were caught.
- Meats were, in general, reported as being large and in good condition.
- Roe condition was yet to improve.
- Should allow at least two weeks for better conditioning.



Location and abundance of scallops caught during June 2007 within the Eddystone Point region.



Size structure of scallops caught within the Eddystone Point region. Note the high discard rate (42%). It must be noted, however, that several sample tows were conducted within known small scallops occurring within deep water. These scallops meet the 2 spawnings criteria (i.e. are > 3 years old).

Eddystone Scallops:

- Very small meats and watery roes.
- Was commented that they are in better condition than the similar time last year.
- Need at least 4 weeks to improve condition.
- High discard rate needs to be considered.

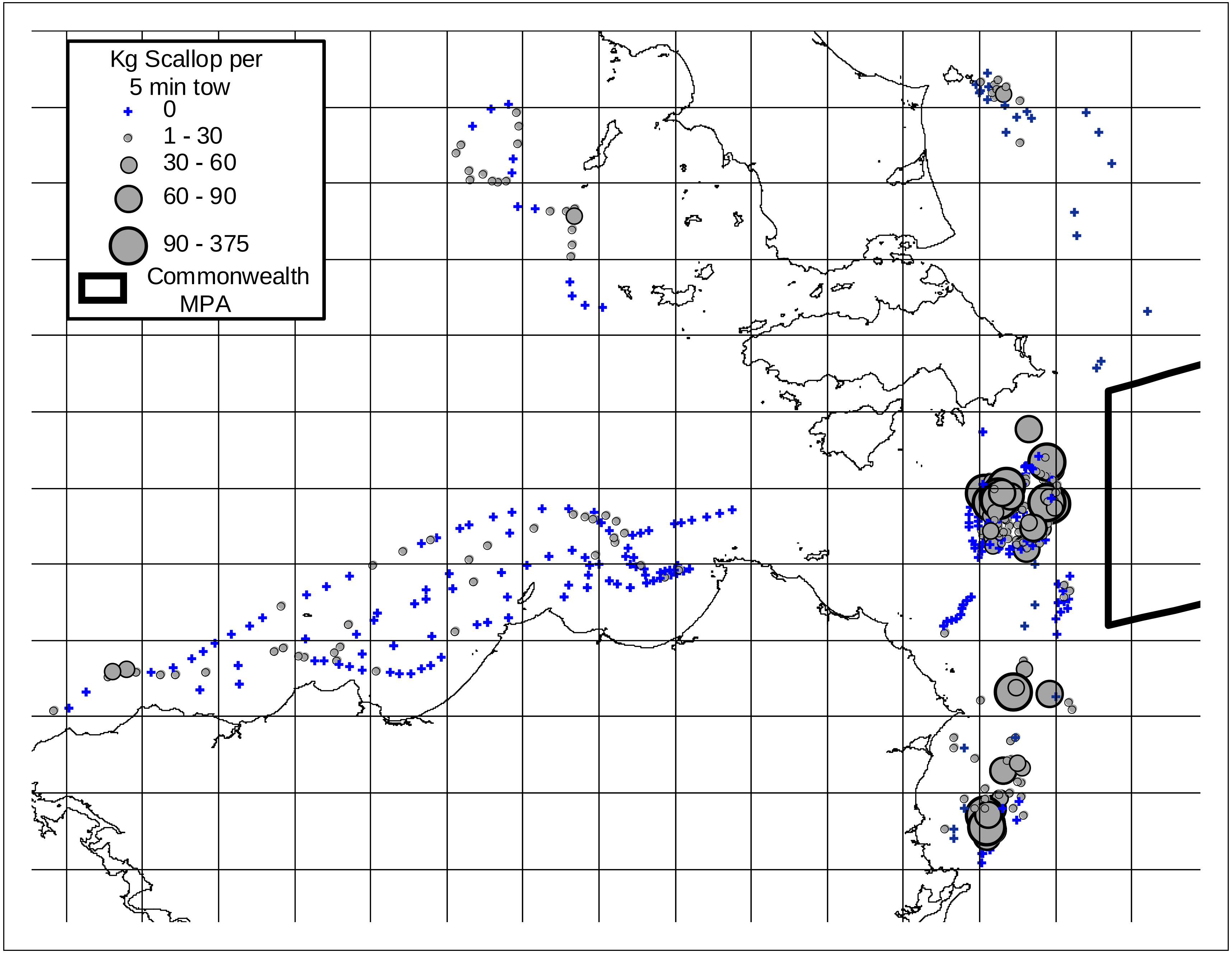
Appendix 11.9: 2007 Industry-based survey summary

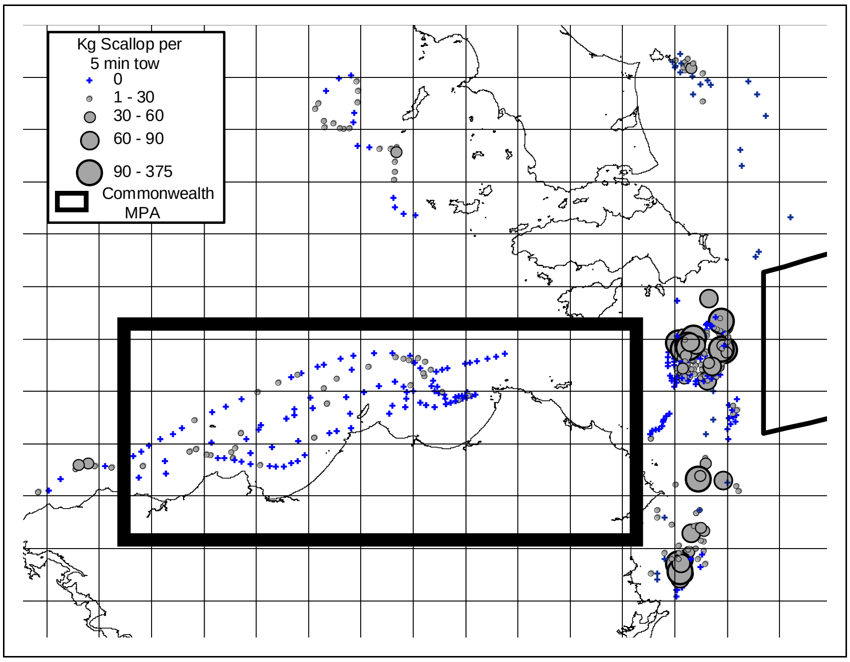
2007 Industry-based survey data summary

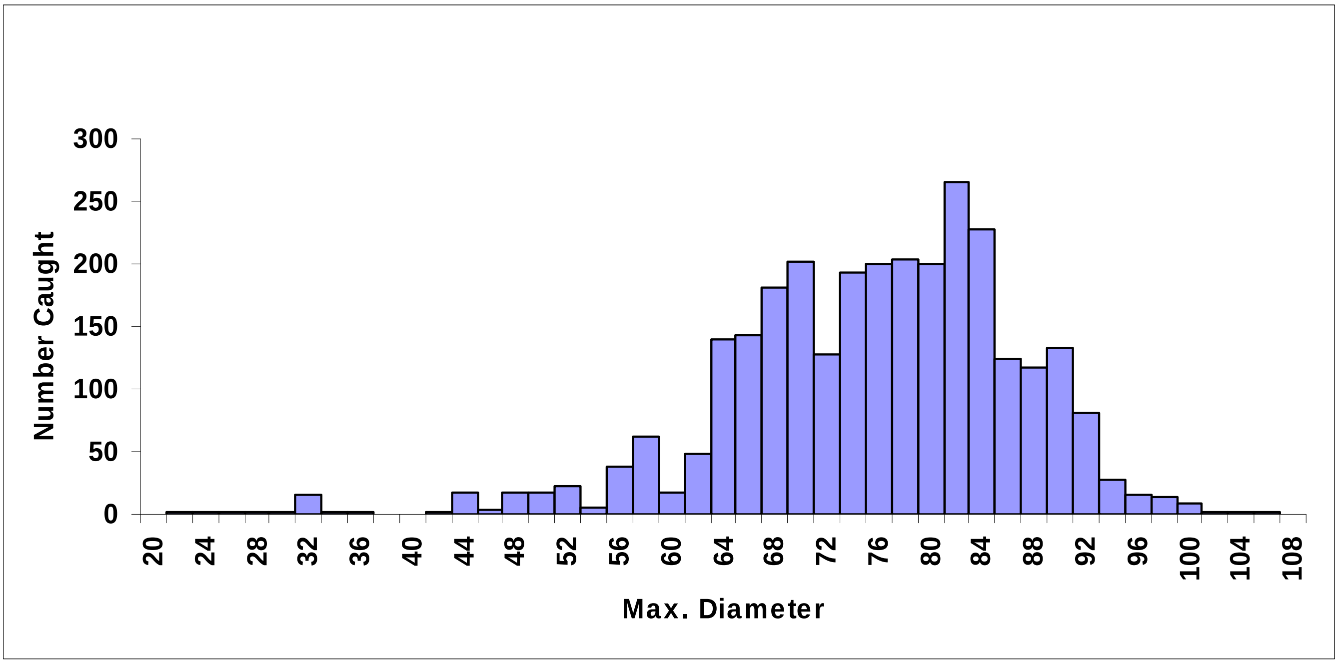
TAFI Scallop Research Team

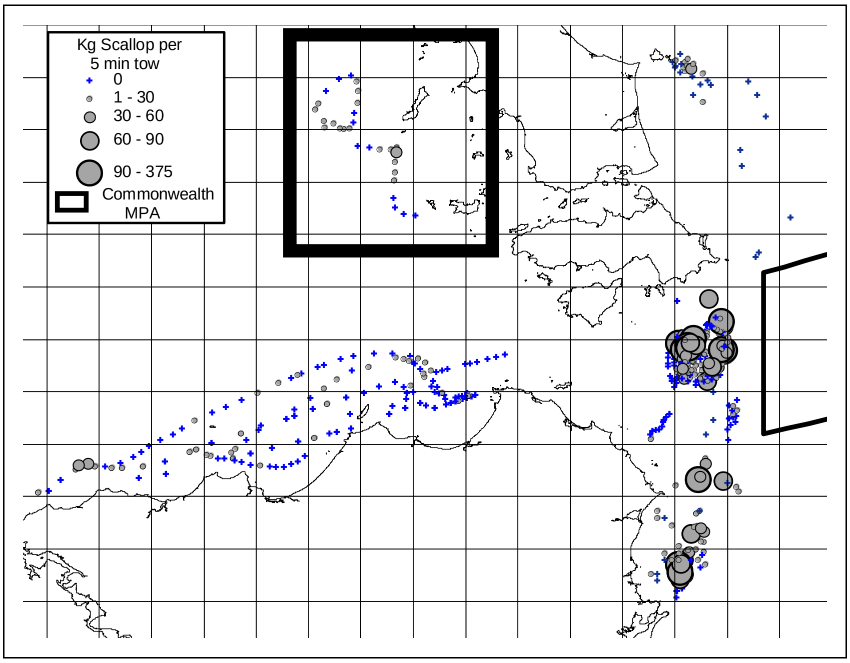
Introduction

This report provides a summary of the Industry-Based survey data collected during 2007. The figure on the following page provides an overview of all data collected. Representative scallop length frequency plots are then provided for broad survey regions. It should be noted that the diagram for the east Flinders Island / Babel Island region represents the number of scallops measured. Reports from this region suggested young scallops in the 40 – 60mm size range over a relatively large area. If more information is required, contact Julian Harrington on 62 277 201 or 0429 178 592.

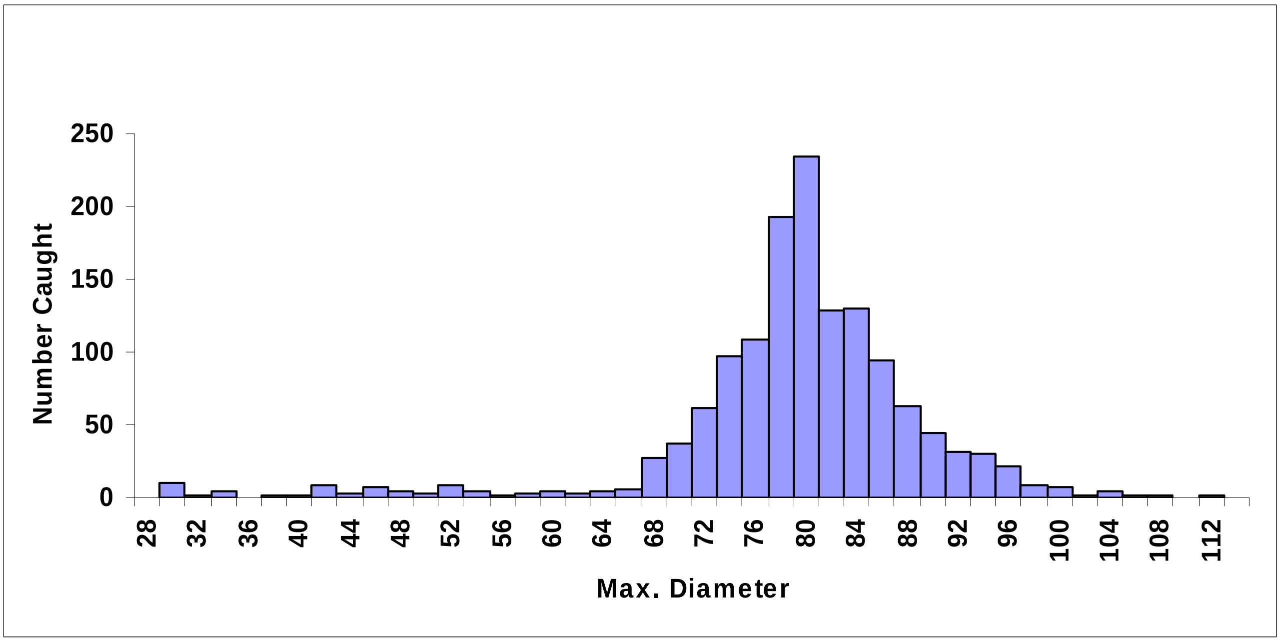

Kg Scallop per
5 min tow
0
1 - 30
30 - 60
60 - 90
90 - 375
Commonwealth
MPA


Kg Scallop per
5 min tow
0
1 - 30
30 - 60
60 - 90
90 - 375
Commonwealth
MPA

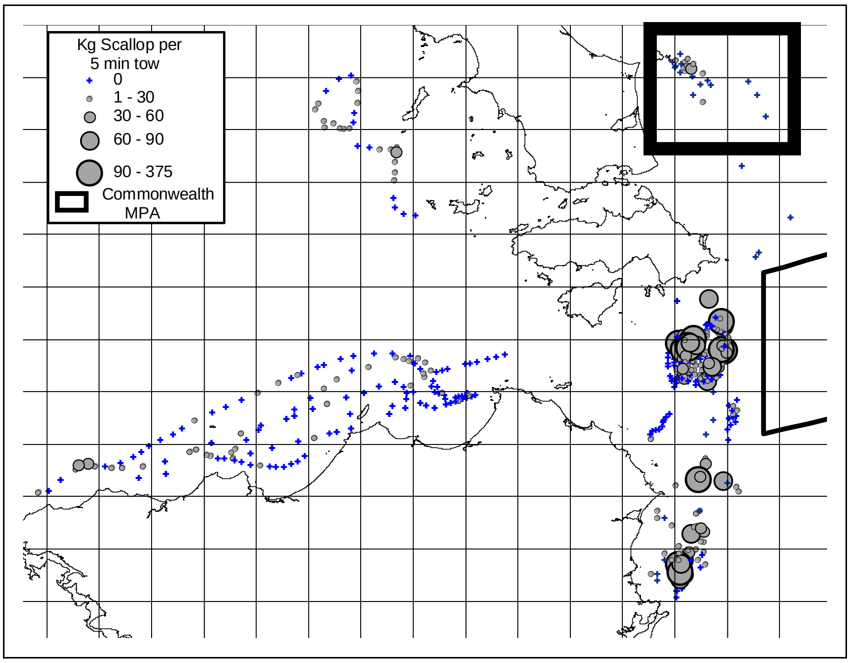

Number Caught
300
250
200
150
100
50
0
20
24
28
32
36
40
44
48
52
56
60
64
68
72
76
80
84
88
92
96
100
104
108
Max. Diameter

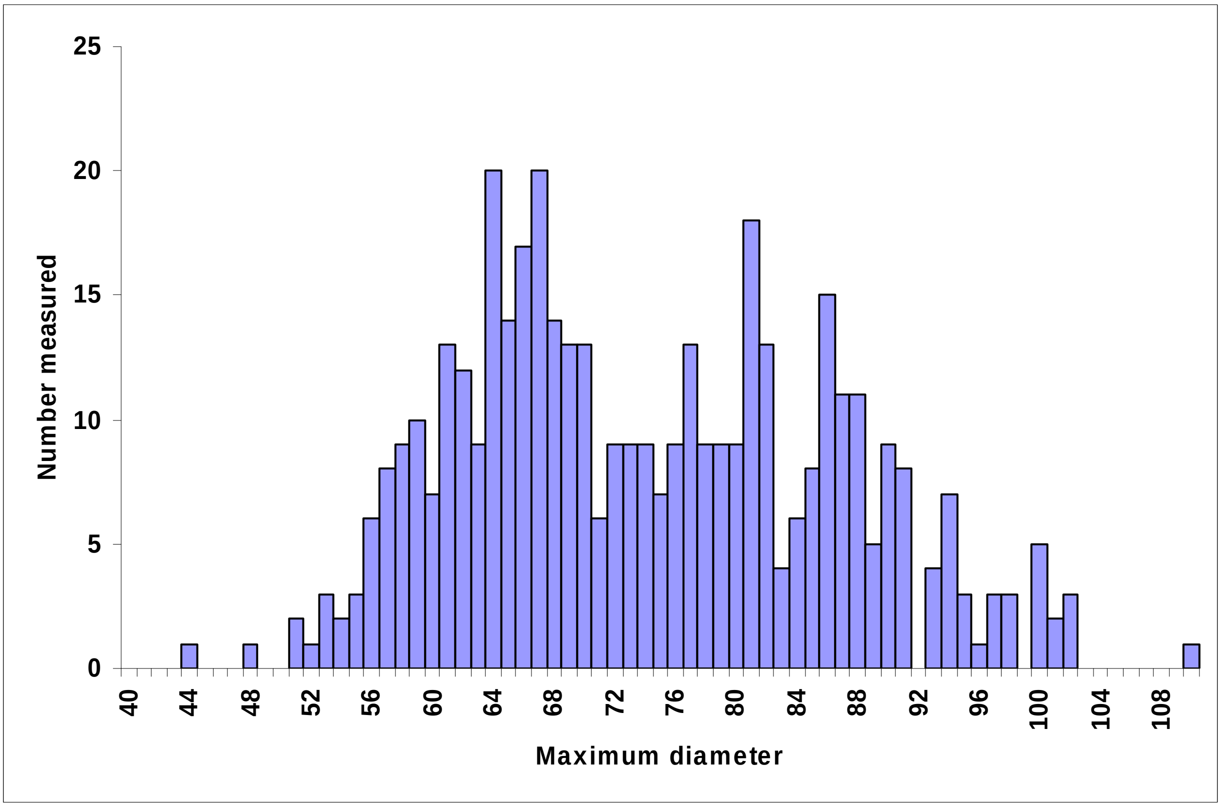


Kg Scallop per
5 min tow
0
1 - 30
30 - 60
60 - 90
90 - 375
Commonwealth
MPA



Number Caught
250
200
150
100
50
0
28
32
36
40
44
48
52
56
60
64
68
72
76
80
84
88
92
96
100
104
108
112
Max. Diameter


Kg Scallop per
5 min tow
0
1 - 30
30 - 60
60 - 90
90 - 375
Commonwealth
MPA


Number measured
Maximum diameter
0
5
10
15
20
25
40
44
48
52
56
60
64
68
72
76
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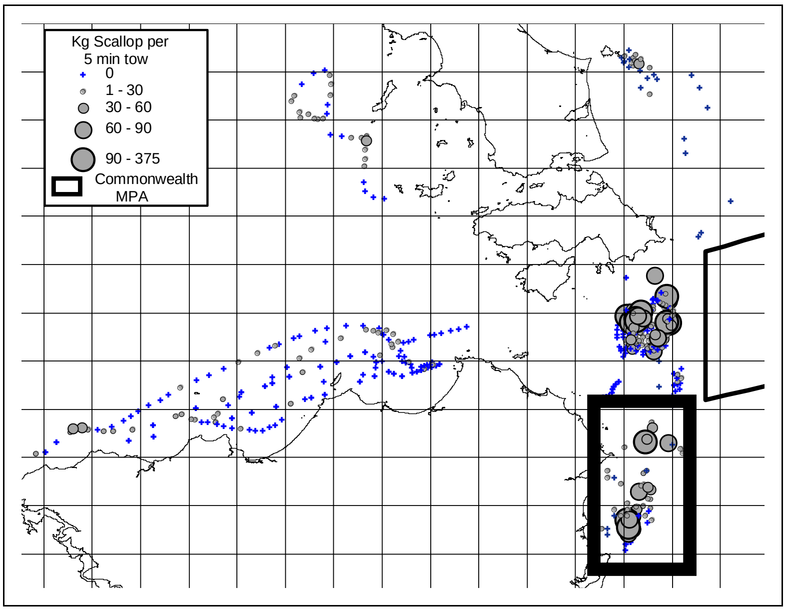
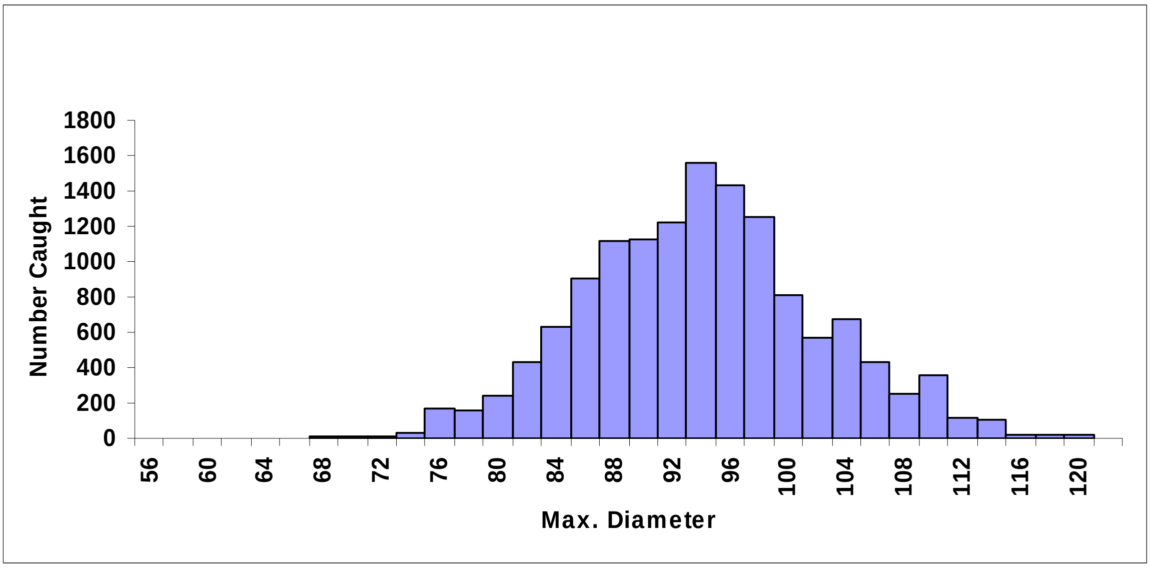
88
92
96
100
104
108


Kg Scallop per
5 min tow
0
1 - 30
30 - 60
60 - 90
90 - 375
Commonwealth
MPA


Number Caught
1800
1600
1400
1200
1000
800
600
400
200
0
56
60
64
68
72
76
80
84
88
92
96
100
104
108
112
116
120
Max. Diameter

Appendix 11.10 – TAFI Background paper to FAC

TAFI Background Paper
November 2nd FAC meeting.

Introduction
This background paper addresses two main issues:

1) the proposal to extend the fishing season to the end of February, and
2) The strategy for conducting Industry-Based Surveys, including out of season dredge surveys.

For each issue a discussion is provided and suggestions are put forward. The DPIW formally requested TAFI advice on these issues.

Scallop Fishing Season Extension

The TSFA have put forward a proposal to extend the scallop fishing season from the 21st December 2007 until the end of February 2008. The ScFAC have given preliminary support for the extension and will formally consider the issue at the meeting on 2 November. While this may have economic benefits it may have unintended biological implications for subsequent recruitment.

Scallop Recruitment and Settlement periods.

The main source of information on the biology behind scallop recruitment / settlement within the wild fishery was obtained during the CSIRO FRDC scallop project conducted during the mid 1980's. The interim final report of this project (noting that no final report was produced) showed:

"On the east coast of Tasmania, the period of peak settlement occurs in September (early spring) with a minor settlement in late spring and early summer . Settlement in collectors was observed between October and December in Port Philip Bay, in spring and summer in eastern Bass Strait, and in early and late spring in Jervis Bay. While Settlement may occur over an extended period, consistent with duration of spawning, there is some evidence to suggest that major settlement peaks result from gametes shed over a more limited period".

The reproductive cycle of commercial scallops relies on adult scallops gaining roe condition and spawning. This is followed by a planktonic larval period (approximately 30 days) during which dispersal can occur. Settlement on the seabed occurs after this planktonic larval period. Individuals and beds of scallops are capable of having more than one spawning event per year (which entails repeatedly developing roe condition). This means there is already considerable overlap of commercial fishing activities within peak settlement periods. If there are only limited scallop beds spawning then it would be essential to protect appropriate habitat for settlement of scallop spat from the detrimental impacts of fishing for at least part of the settlement period. Without successful settlement within the fishery, there will be no future commercial scallop resource available. Furthermore, protection (in time) must also be provided to newly settled recruits, which is merely an extension of the 20% discard rule.

TAFI does not in-principle support the precedent of an unrestricted extension of the Tasmanian scallop season though to February as this would fully overlap the peak settlement period. Protection to newly settled spat, which will ultimately provide the foundation for future harvestable scallop resource must take priority over short term harvesting gain during 2007 and future seasons.

On the other hand, TAFI may support the opening of a small, discrete area of known scallop resource until February. This decision would ultimately depend on the size and location of the proposed open region and the size and condition of scallops contained within the area. It must be noted, however, that any season extension in time and area during the 2007 season will also reduce the already seemingly limited prospects for the 2008 commercial season.

Industry-Based Survey Strategies.

During the 2007 scallop season, TAFI took a more passive support role in the Industry survey process, in order to give Industry the ability to organise and conduct their own surveys within the confines of the fishery regulations. This is an important part of the process of empowering Industry post the current FRDC project, due to finish prior to the 2008 season. Broad and flexible permits issued this year allowed for exploratory survey work within all regions of the Tasmania scallop fishery, noting however, that scallop beds on the east coast that were fished during 2004 / 2005 were seen as a lower priority survey region. A survey working group (consisting of Bob Lister, Rod Pearn and Jayson Semmens) identified priority survey locations, and research quota allocation was provided for vessels surveying these regions. Industry members themselves were essentially left to their own devices to organise and conduct opportunistic / targeted survey work. While taking a back seat, TAFI remained open to providing input to Industry on survey design and activities during the 2007 scallop season. Bearing in mind the difficulties associated with the 2007 season (in particular the delay to the season, poor scallop condition and stock availability, the low beach price of scallops and adverse weather conditions within Banks Strait), minimal survey work has been conducted (see Figure 1)

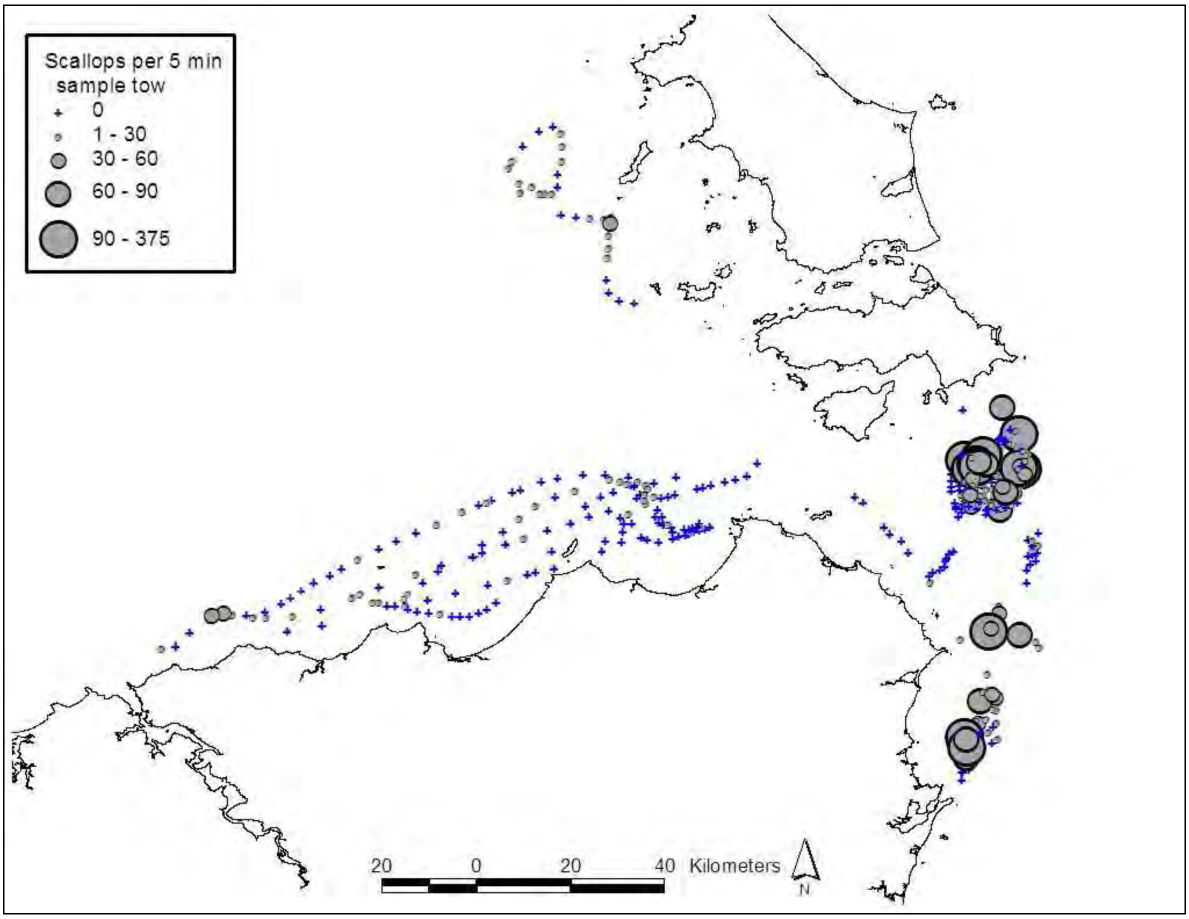


Figure 1: Abundance of scallops caught during all Industry survey sample tows conducted during 2007.

Industry survey strategy

Given the minimal number of Industry-Based survey events during 2007, TAFI suggests that to achieve a sufficient level of surveying each year a clear Industry-Based survey strategy be developed. This should primarily be driven by Industry, with the support of an Industry Survey Committee that could provide some direction and monitoring of activities. The strategy should take into account recent survey results, previous year's fishing activities and known recruitment events within the fishery. Any strategy would ultimately rely on a clear definition of the data collecting and resource monitoring aims for a given fishing season / period. This definition would obviously include Industry and management data requirements, thus enabling legislative and Industry Code of Practice decisions to be made in real time. Note - this data collection process precedes any data management and sharing component – such as the ideas put forward by Industry in the scallop FRDC project. The principles underlaying a strategy would include:

1) If a region of the fishery has been extensively surveyed, there is a lower requirement for future survey work to be conducted.

2) If a region has been fished within the previous 2 – 3 years to uneconomical levels, there is a lower requirement for survey work to be conducted in the region (perhaps occasional searching for signs of recruitment).
3) If recruitment has been observed within a region of the fishery, there is no reason for extensive survey work (only monitoring of growth) until scallops are old / large enough to harvest.

Spatial scale strategy

Spatially, a survey and consequent harvest strategy would be simplified if Tasmania was divided into distinct regions, which would be based on known scallop bed locations (which in turn can be based on VMS inferred fishing activities). Each region could then be easily classified into a survey category (i.e. extensive survey this year, minimal monitoring in 2008, Research Allocation available, only opportunistic survey work, no survey required during 2008). An Industry Code of Practice could then define regions that the TSFA / survey committee consider do / do not need surveying. This would still allow broad simple permits to be issued by the DPIW.

As an example, Figure 2 identifies regions of the Tasmanian scallop fishery. These regions are based on both known beds of scallops that have been fished since 2003, and broader locations of minimal, unknown or no scallop resource.

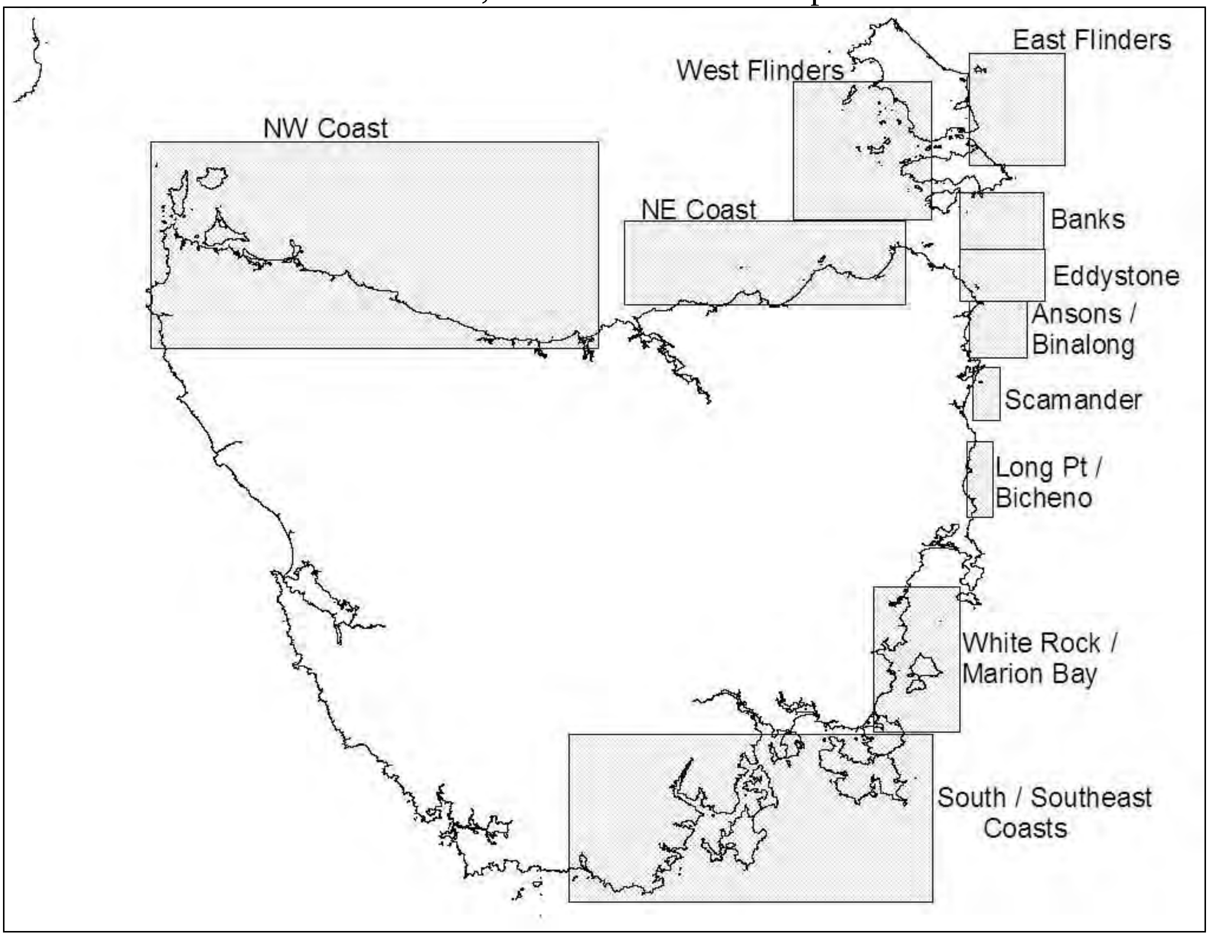


Figure 2: Proposed regions for use in an Industry survey strategy.

Table 1 outlines the information known about each of the regions shown in Figure 1. Such information would provide the foundation to classify each region into a survey priority category.

Table 1.

Zone	**Survey (mm/yy)**	**Survey extent**	**Most recent open / fished**	**Recruitment**	**Survey Priority**
NW Coast	June 2005				
NE Coast	August 2007			Anecdotal	
West Flinders	August 2007				
East Flinders	August 2006		2005		
Banks Strait	June 2007		2007		
Eddystone	2007		2007		
Ansons / Binalong	2007		2004	Inshore 2006	
Scamander	August 2006		2005		
Long Pt / Bicheno	August 2006		2006		
White Rock / Marion	July 2007		2006 2004	2007	
South / Southeast Coasts	2005 / 2006				

Temporal Scale Strategy

Given that detailed spatial management and the Industry Rolling Opening strategy both rely on near real time information for their successful implementation, there needs to be distinct periods set aside for collection of data / information both at the broad (fishery) and fine (scallop bed) scales. Similarly, the Spencer Gulf Prawn Fishery has a designated period at the start of each season for an overall stock assessment, followed by smaller scale Industry surveys for identifying appropriate catchable prawn stocks. In the prawn fishery, decisions are made by Industry in real time, and are based on the information from both survey types. A fishing season cannot open until a pre-season survey is conducted, and fishing in a particular region of the open area cannot occur unless Industry surveys are conducted. The objective of such a surveying strategy is to obtain the necessary stock information to meet management and Industry code of practice requirements, and to ensure continuity and sustainability of the resource.

The Tasmanian scallop fishery may need to consider a similar survey approach to ensure that regions of the fishery are surveyed as required.

TAFI position on out of season Industry survey activities

Detailed spatial management, with most areas closed and few open requires information about the available resource within the fishery for the planning of successful future management. All data obtained should have some use. TAFI suggest that the above mentioned spatial survey priority system be used to identify regions that are appropriate to survey out of season. Such a strategy would not allow some regions to be surveyed out of season (using dredge) in order to provide some protection for newly settled scallop stocks.

Video survey techniques would be the preferred system for surveys out of season. The TSFA have a video camera available, and TAFI could make available another camera in their possession. If new scallop resource is identified using video, then out of season dredge survey activities may be granted within these regions if deemed appropriate.

TAFI suggest that any permits issued should be more spatially directed than within season permits and that no scallop are retained out of season.

Appendix 11.11: Pre-season report 2008

Pre-Season Report
2008 Commercial Scallop Fishery

TAFI Scallop Research Team
FRDC 2005/027
Julian Harrington
Malcolm Haddon and Jayson Semmens

Tasmanian Aquaculture
& Fisheries Institute
University of Tasmania

Australian Government
Fisheries Research and Development Corporation
Australian Fisheries Management Authority

1. Introduction

This report aims to provide information about our knowledge of the commercial scallop resource within Tasmanian waters prior to the 2008 season. The information provided will incorporate both survey data and other anecdotal information that has been obtained throughout 2007.

2. Tasmanian Survey Regions

For ease of organisation and summation, the Tasmanian coastline has been divided into 9 survey regions (Figure 1). These regions have been based around known areas / beds of scallops, and have attempted to use recognisable longitudes and landmarks for separation of the regions. A brief status report for each of these regions will be provided.

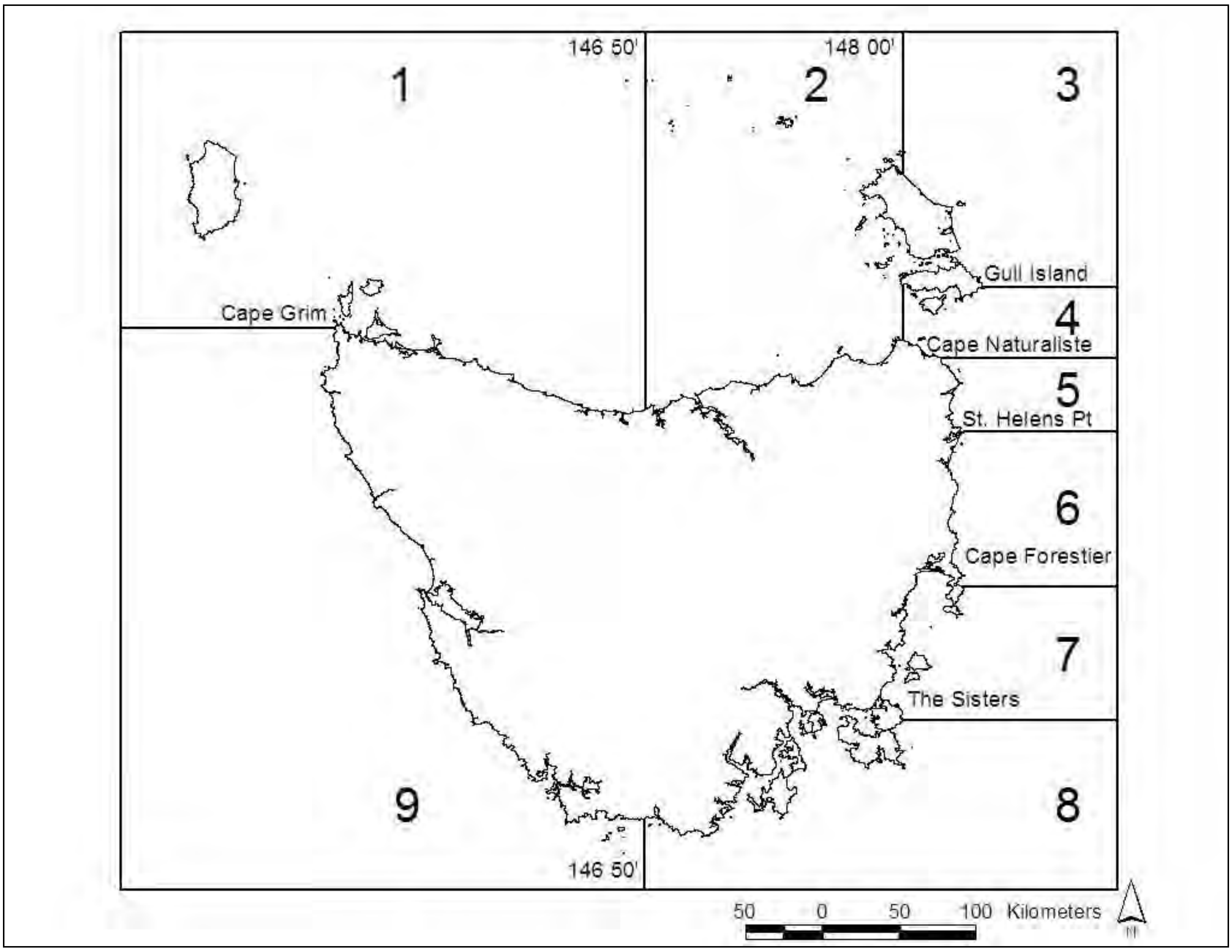


Figure 1: Map identifying the 9 survey regions around the Tasmanian coastline.

3. Current knowledge of the Tasmanian scallop resource

Survey Region 1 – Northwest Tasmania

Known scallop beds (since 2003):	None
Last Fished:	Prior to 2003
Last Surveyed:	2005
Scallop abundance information:	No recent information
Population structure information	None
FAC survey priority:	
FAC survey requirements:	

Survey Region 2 – Northeast / West Flinders

Known scallop beds (since 2003):	None
Last Fished:	Prior to 2003
Last Surveyed:	2007 (see Fig 2)
Scallop abundance information:	Low scallop abundances along NE Coast and West of Flinders Island (Fig 2)
Population structure information	Predominately undersize scallops (Fig 3)
FAC survey priority:	
FAC survey requirements:	

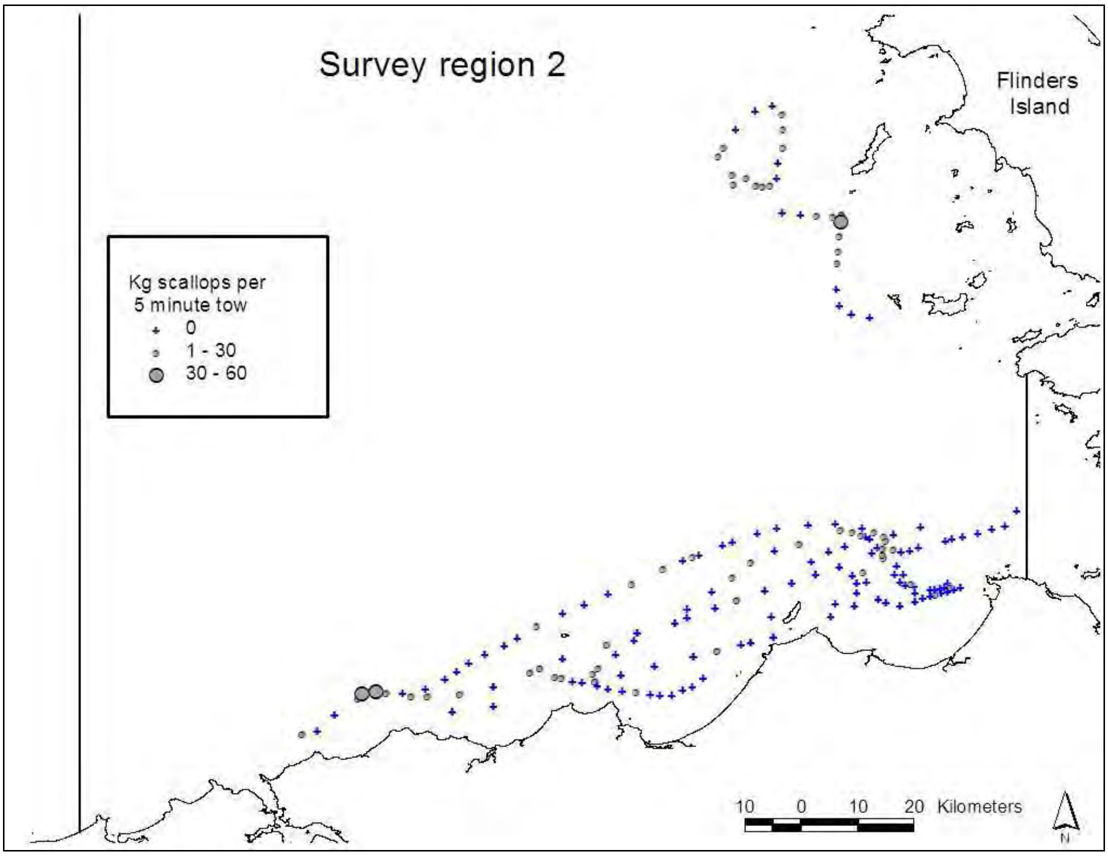


Figure 2: Location and abundance of scallops caught during 2007 surveys conducted within survey region 2.

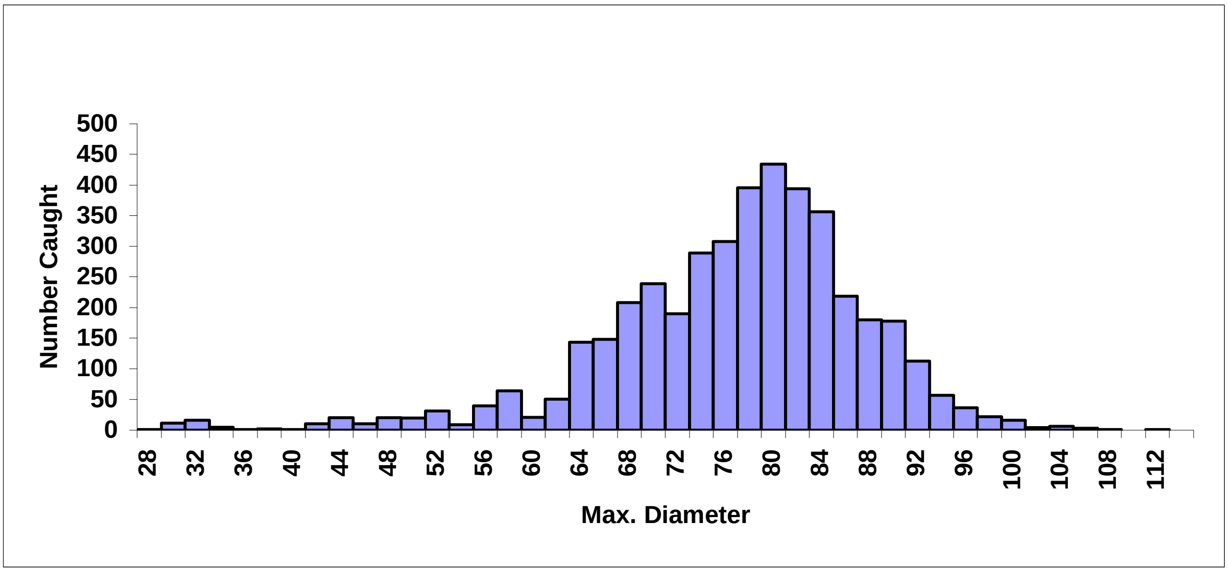


Figure 3: Length Frequency distribution for scallops caught within the NE and West of Flinders Island during surveys conducted during 2007 (refer to Fig 2).

Survey Region 3 – East Flinders

Known scallop beds (since 2003):	Babel Island beds
Last Fished:	2005
Last Surveyed:	2007 (see Fig 4)
Scallop abundance information:	Low scallop abundances (Fig 4)
Population structure information	Evidence of recruitment event during 2007 surveys (Fig 5)
FAC survey priority:	
FAC survey requirements:	

Survey Region 4 – Banks Strait

Known scallop beds (since 2003):	Banks Strait bed
Last Fished:	2007
Last Surveyed:	2007 (see Fig 4)
Scallop abundance information:	Residual scallops of unknown abundance. Some comments suggest may still be regions of commercial value.
Population structure information	Anecdotal information about recruitment within the region late last season.
FAC survey priority:	
FAC survey requirements:	

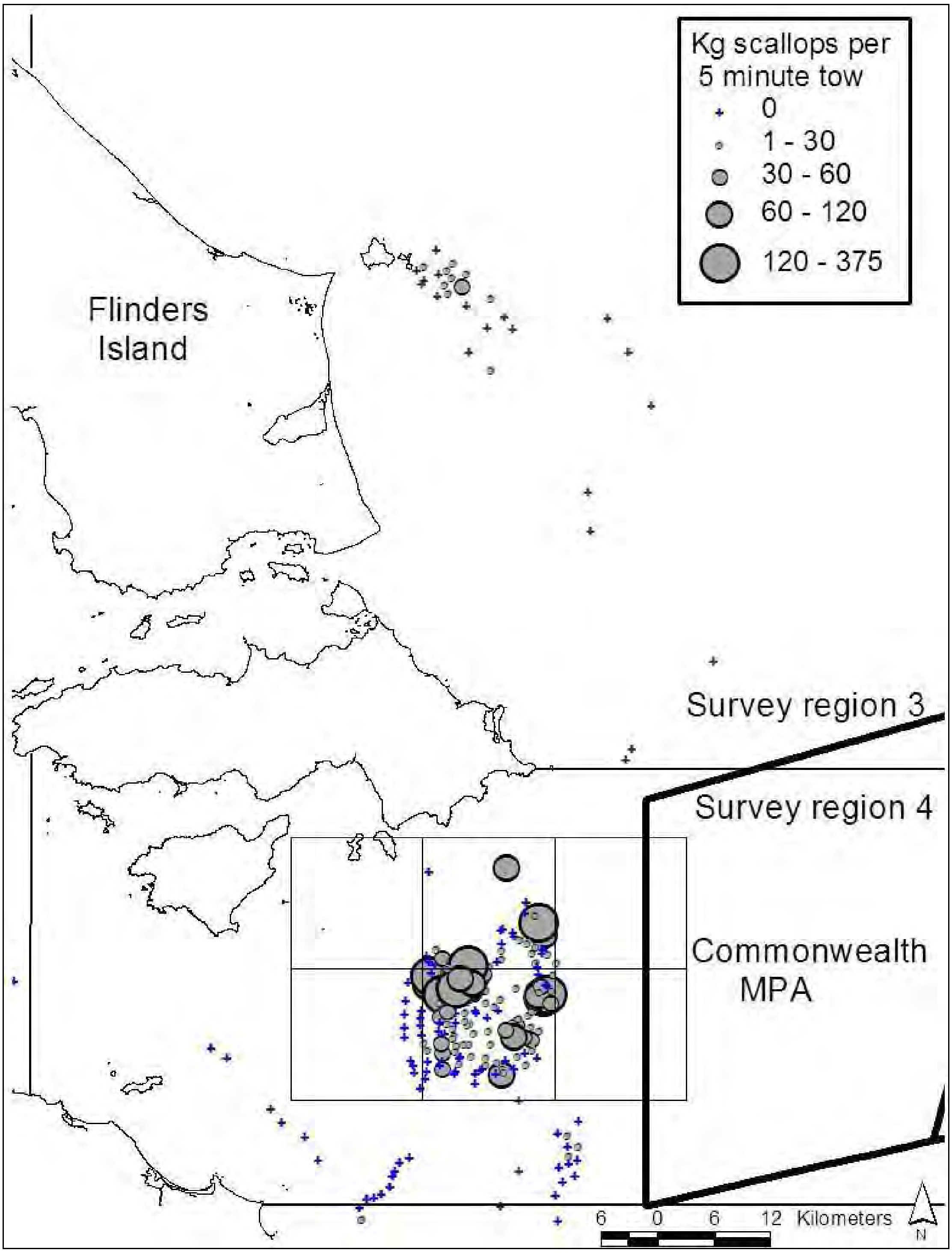


Figure 4: Scallop abundance information collected within survey regions 3 and 4 during 2007. The grid area in region 4 illustrates the 2007 open region, and the dark line to the right the boundary of a Commonwealth MPA. Note that the representation of scallop abundance illustrates what was find prior to being fished during the 2007 commercial season.

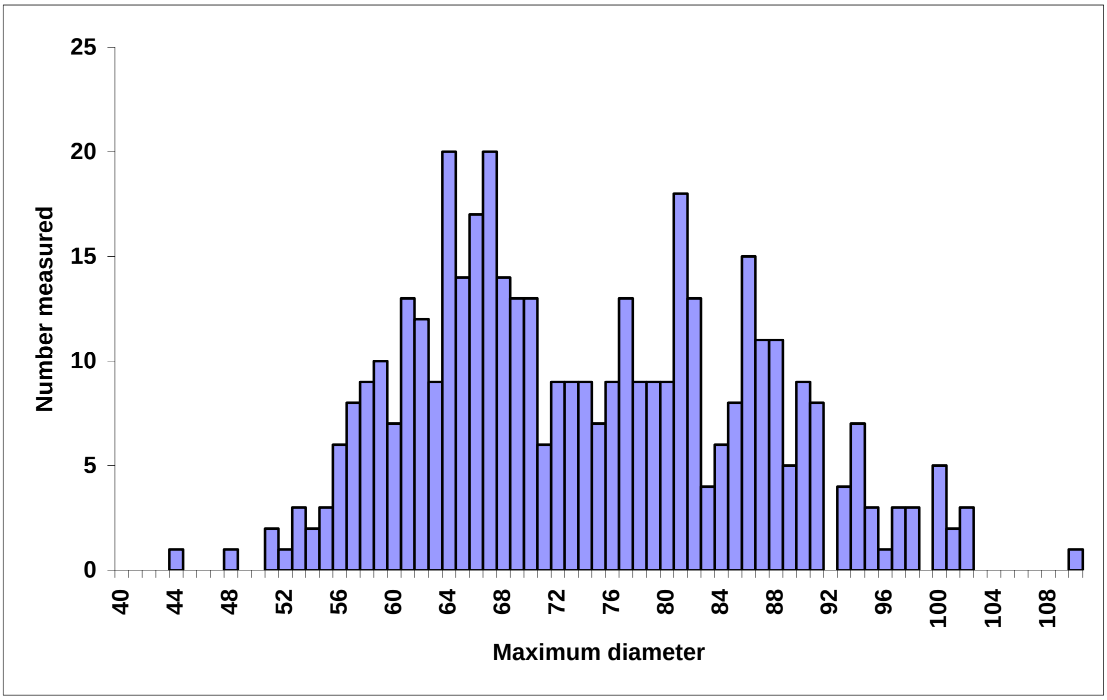


Figure 5: Length frequency distribution for scallops caught near Babel Island in survey region 3 during surveys conducted in 2007.

Survey Region 5 – Eddystone Point

Known scallop beds (since 2003):	a) Eddystone Point Scallop bed b) Ansons Bay scallop bed c) Binalong Bay scallop bed d) Deep water scallops St. Helens Pt to Eddystone Pt
Last Fished:	a) Eddystone Point Scallop bed - 2007 b) Ansons Bay scallop bed – 2003 c) Binalong Bay scallop bed - 2004
Last Surveyed:	2007 (see Fig 6)
Scallop abundance information:	a) Old scallops, poor condition, low abundances b) Low abundances c) No information d) High abundances, small scallops very poor condition (see Figure 6)
Population structure information	Believed to be predominately undersize but monitored for more than 3 years.
FAC survey priority:	
FAC survey requirements:	

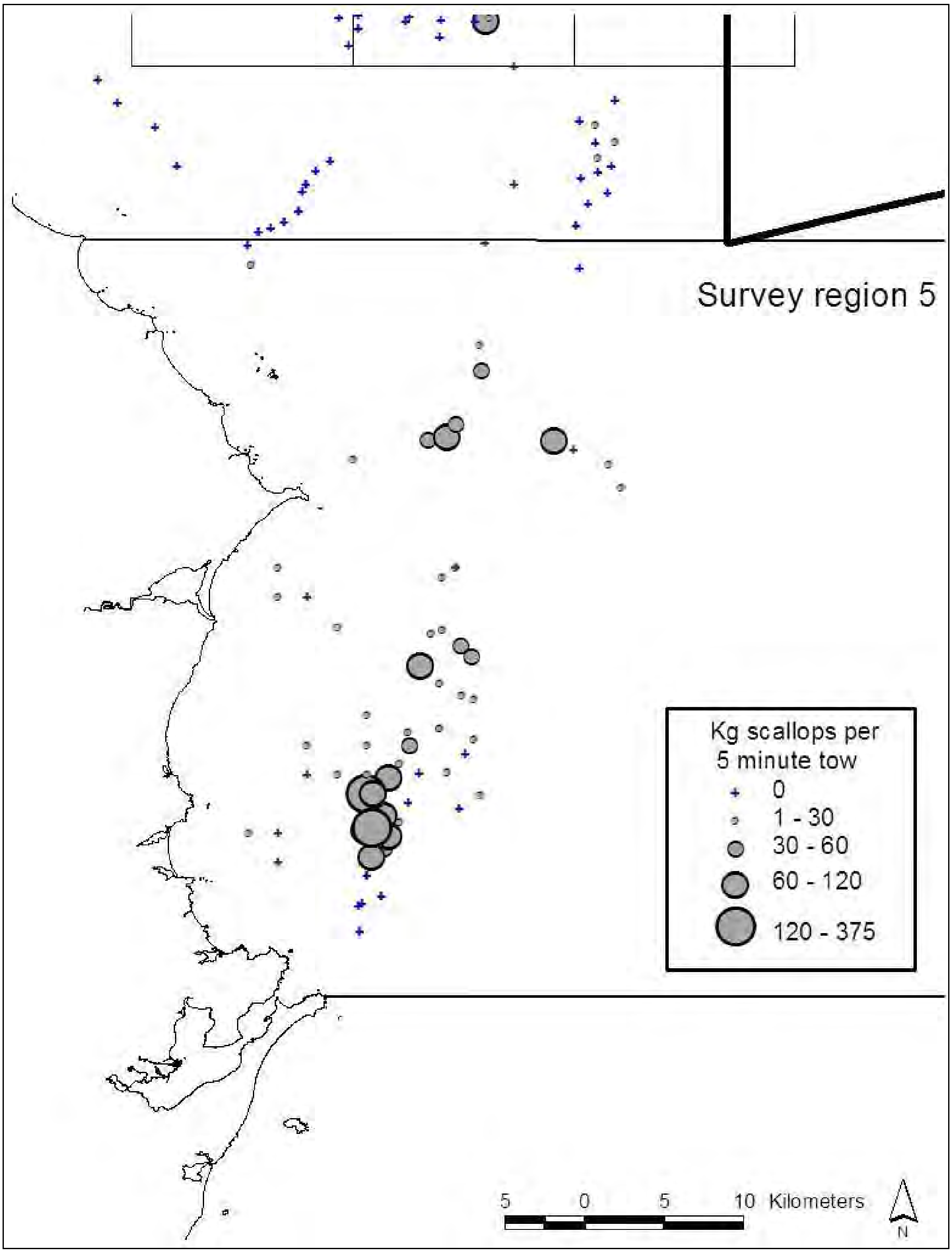


Figure 6: Scallop abundance information collected within survey region 5 during 2007. Most sample tows represent deep water scallop locations.

Survey Region 6 - Bicheno

Known scallop habitat (since 2003):	a) Scamander scallop bed b) Long Point beds (nth and sth) c) Bicheno scallop bed
Last Fished:	a) 2004 b) 2006 c) 2004
Last Surveyed:	2006
Scallop abundance information:	All regions are believed to contain low scallop abundances – not commercial quantities.
Population structure information	Residual scallops from fishery. Unknown if recruitment into this region since 2006.
FAC survey priority:	
FAC survey requirements:	

Survey Region 7 – White Rock

Known scallop habitat (since 2003):	a) White Rock scallop bed b) Marion Bay scallop bed
Last Fished:	a) 2006 b) 2005
Last Surveyed:	2007
Scallop abundance information:	Low residual scallop abundances after fishing. Survey evidence of recruitment in White Rock. Video evidence of recruitment in Marion Bay. Scallops believed to currently be 60 – 70 mm.
Population structure information	Refer to Figure 7.
FAC survey priority:	
FAC survey requirements:	

Survey Regions 8 and 9 – Southeast and Southwest

Known scallop habitat (since 2003):	None
Last Fished:	Prior to 2003
Last Surveyed:	Minimal survey work conducted
Scallop abundance information:	No scallop resource located in region
Population structure information	
FAC survey priority:	
FAC survey requirements:	

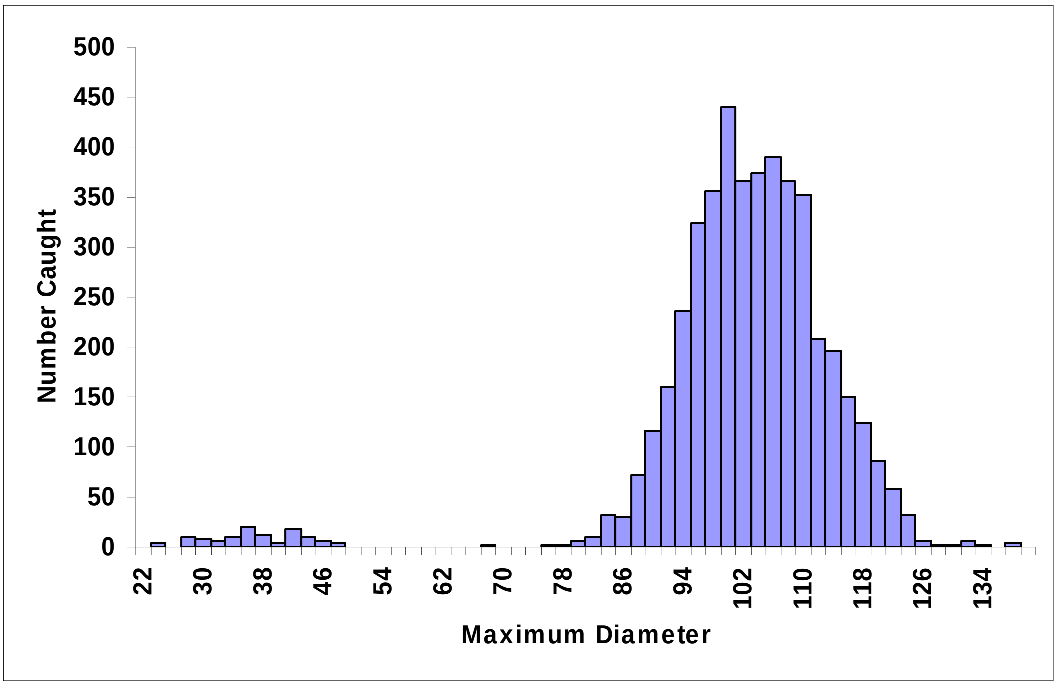


Figure 7: Length frequency distribution for scallops caught within White Rock during 2007.

4. Possible options for the 2008 Season

Based on the current available information about the scallop resource within the Tasmanian fishery, TAFI takes the position that no areas currently meet the minimum management rule criteria allowing an opening in 2008. Subsequently, TAFI recommend that further surveys are needed to identify possible suitable regions for an opening during 2008.

5. Bycatch and impacts of dredge fishing

TAFI have conducted a detailed impact of dredge fishing study within the White Rock scallop bed during 2006 and 2007. This work has been prepared into a draft manuscript for submission to a scientific journal. This draft manuscript is titled "Impact of intensive short-term commercial scallop (*Pecten fumatus*) dredge fishing on the associated epibenthic community" and will be made available to all fishers upon request once finalised.

The next phase of this important work is to monitor the recovery of the White Rock scallop bed. It is essential that the region is surveyed again before mid-July 2008, as results will greatly aid future Ecological Sustainable Development (ESD) approval.

6. TAFI contacts

Julian Harrington – 62 277 201
Jayson Semmens – 62 277 275
Malcolm Haddon – 62 277 279

Appendix 11.12: Pre-season survey data summary

Preliminary 2008 pre-season survey data summary

Industry Survey Data
May and June 2008

Julian Harrington, Jayson Semmens, Malcolm Haddon
TAFI – MRL, University of Tasmania

Tasmanian Aquaculture & Fisheries Institute
University of Tasmania

Australian Government
Fisheries Research and Development Corporation
Australian Fisheries Management Authority

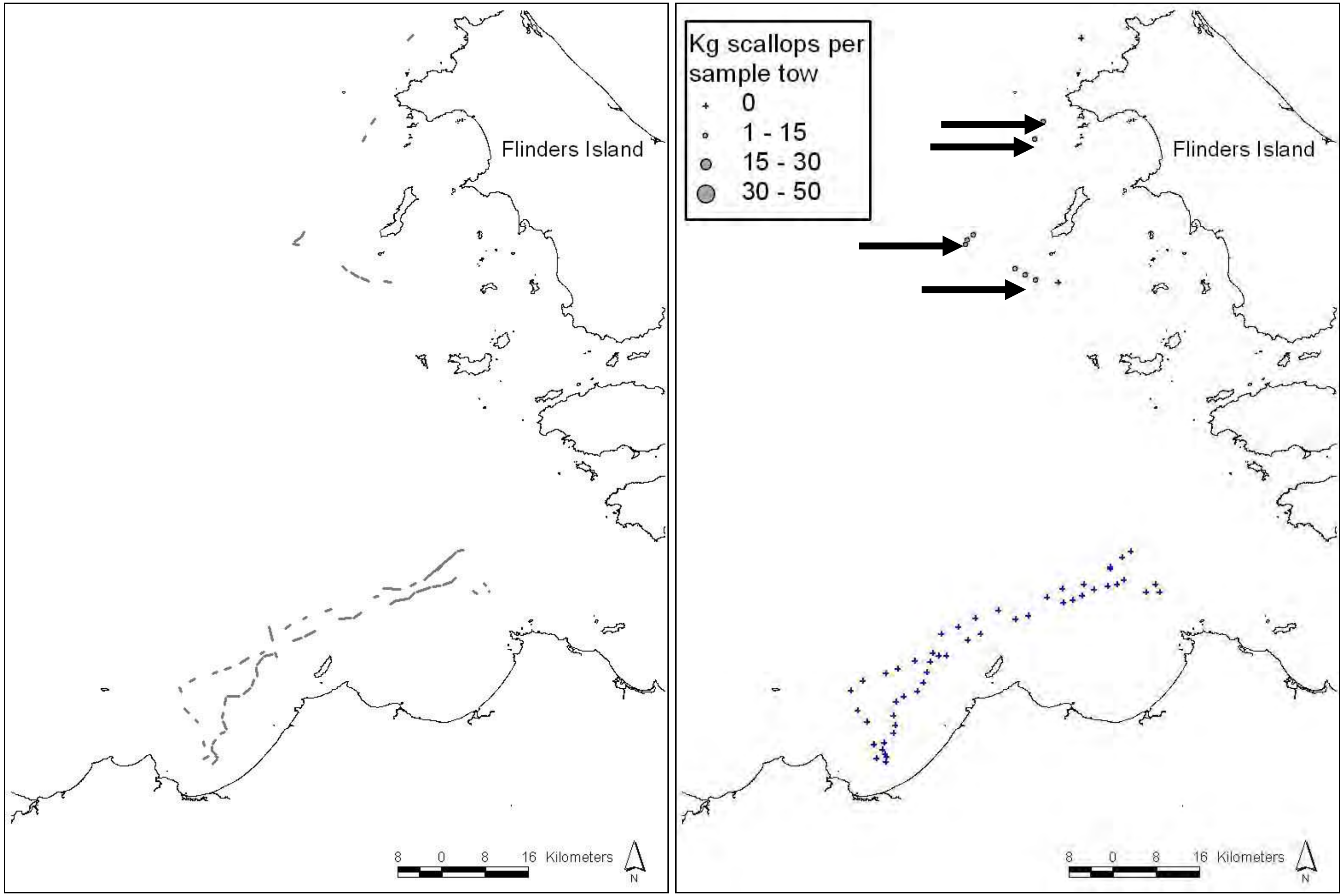


Figure 1: The location of sample tows conducted to the west of Flinders Island and within the Bridport / Cape Portland regions (left). The abundance of scallops caught within each sample tow (kg of scallops) is shown in the figure to the right. Only five scallops were measured in the region between Waterhouse Island and Cape Portland (all between 82 and 89 mm). The arrows indicate the general locations of sample tows located to the West of Flinders Island that contributed to the length frequency diagram in Figure 2.

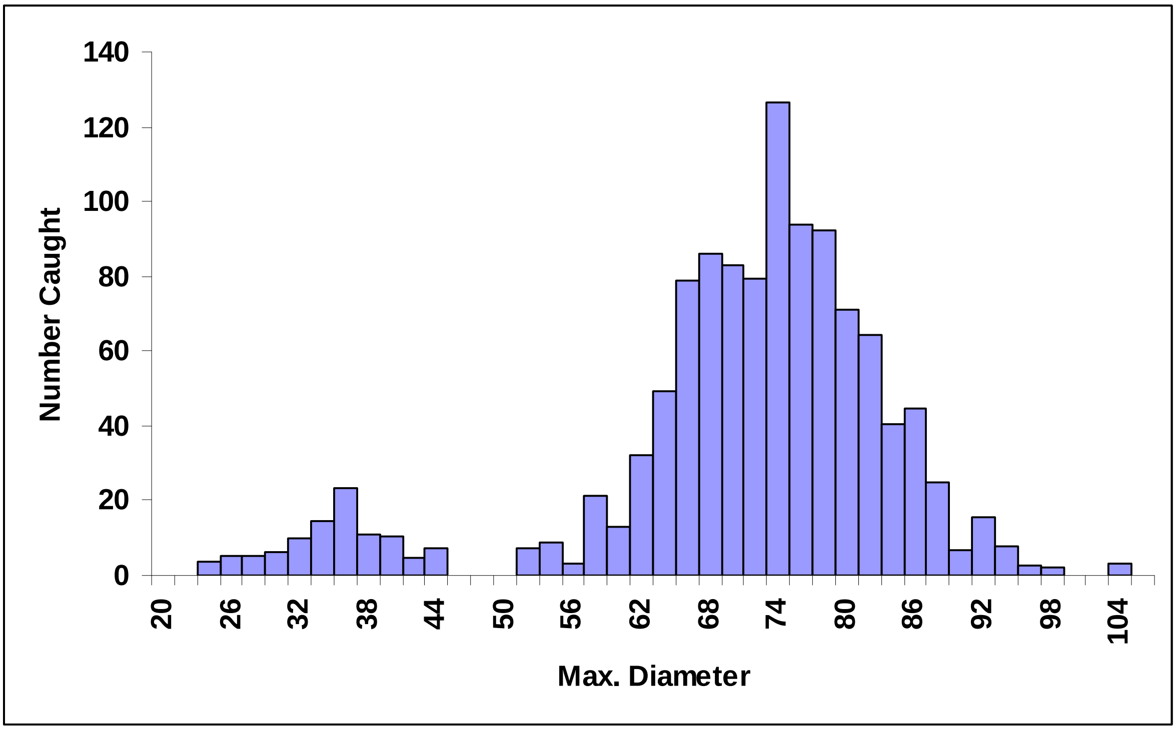


Figure 2: Length frequency histogram for scallops caught to the west of Flinders Island (indicated by arrows in Figure 1). The vast majority of scallops caught within this region were undersize, with a discard rate of approximately 95%.

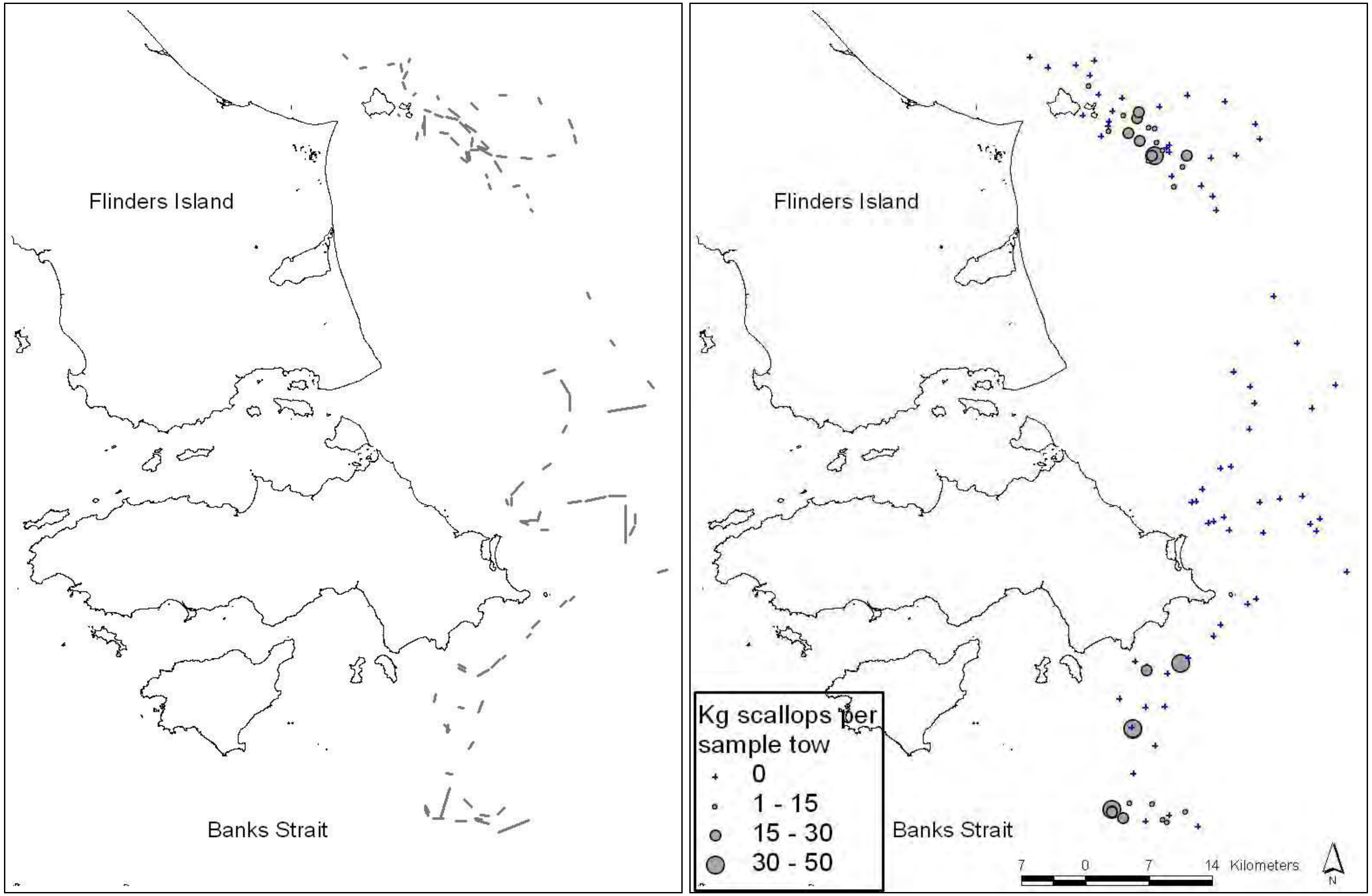


Figure 3: The location of sample tows conducted within Banks Strait, the Potboil and Babel Island regions near Flinders Island (left). The abundance of scallops (kg of scallops) caught within each sample tow is shown in the figure to the right.

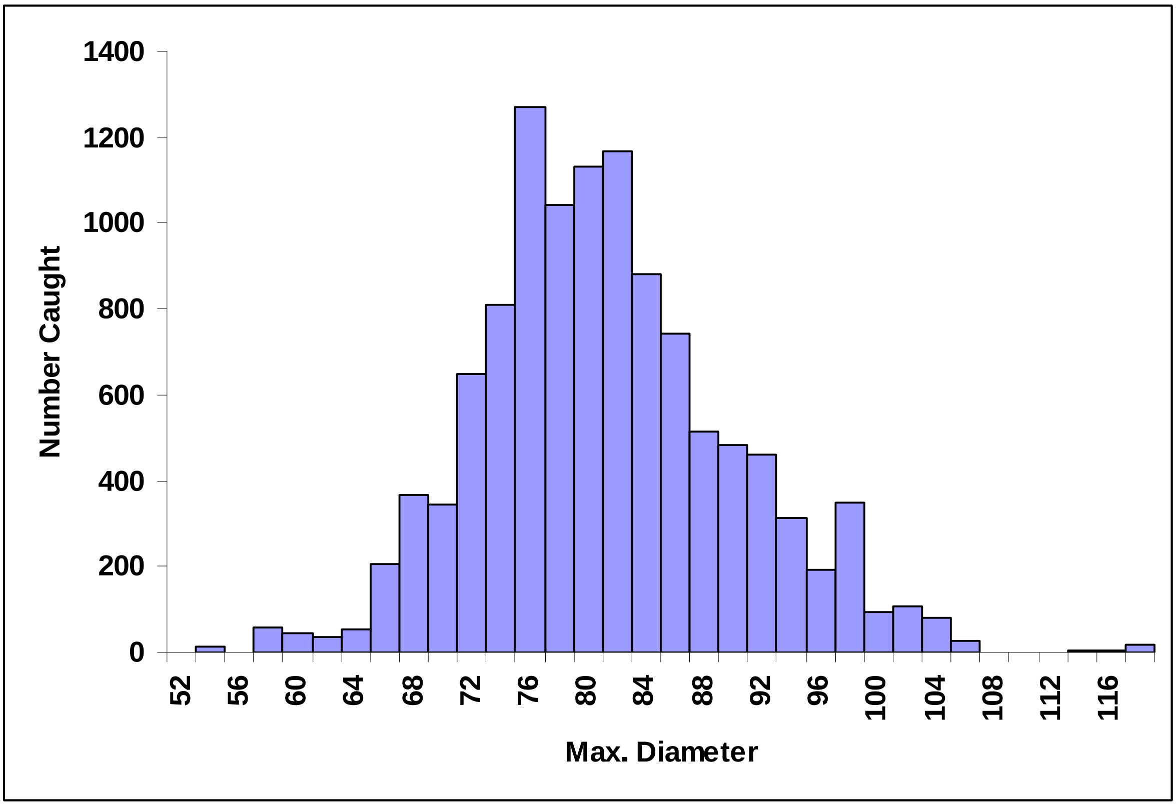


Figure 4: Length frequency histogram for scallops caught near Babel Island. To the east of Flinders Island (see Figure 3). The vast majority of scallops caught within this region were undersize. The discard rate was 81%.

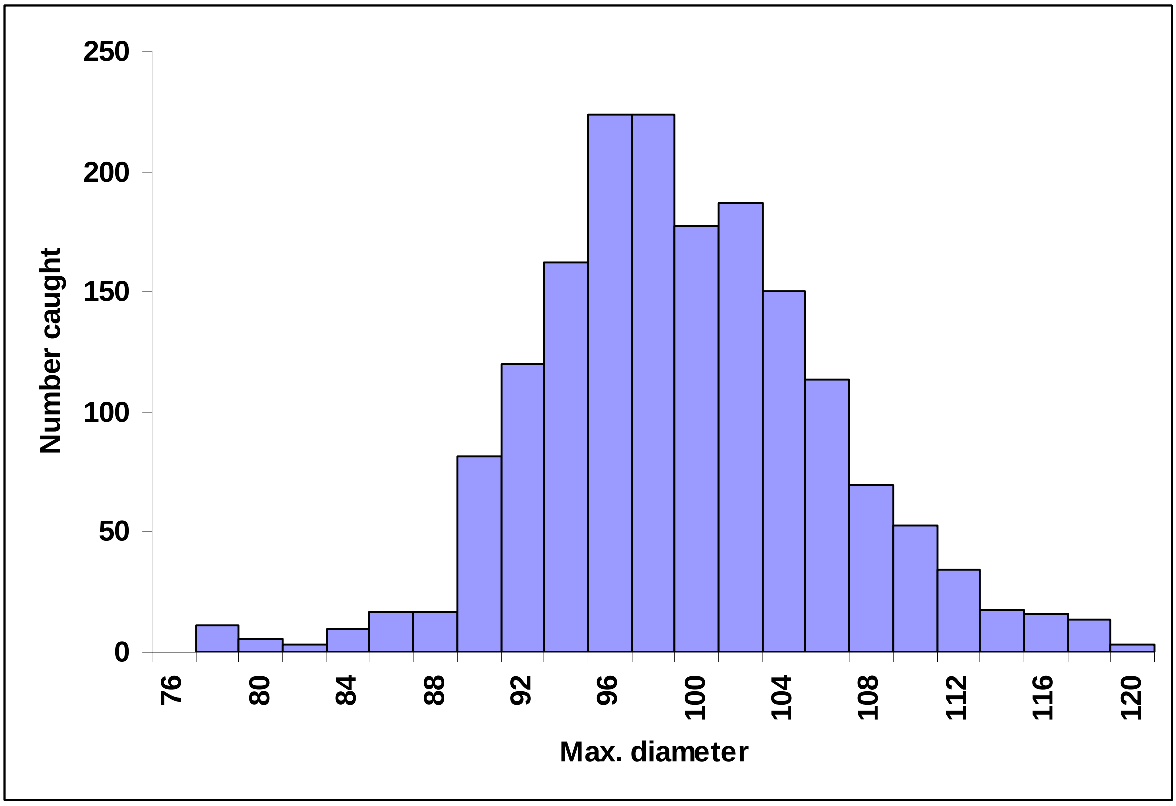


Figure 5: Length frequency histogram for scallops caught within Banks Strait (see Figure 3). The discard rate is 4%. Note the different max. diameter scale bar from figure 4.

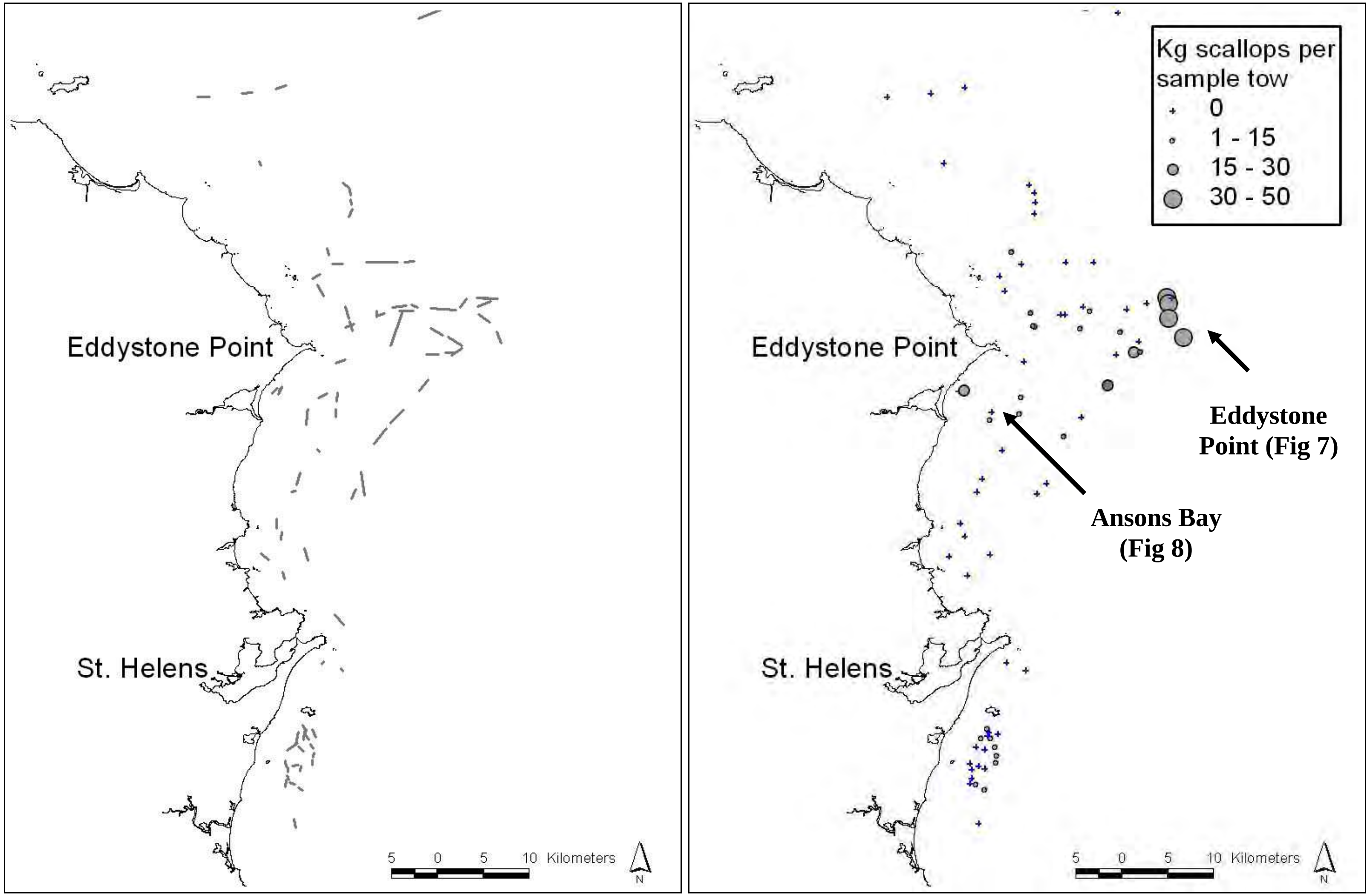


Figure 6: The location of sample tows conducted within Eddystone Point, Ansons and Binalong Bays and near St. Helens Island. (left).The abundance of scallops (as kg of scallops) caught within each sample tow is shown in the figure to the right. Scallops were reported as being in very poor condition (similar to that evidenced during the 2006 and 2008 seasons. These may improve condition later in the season.

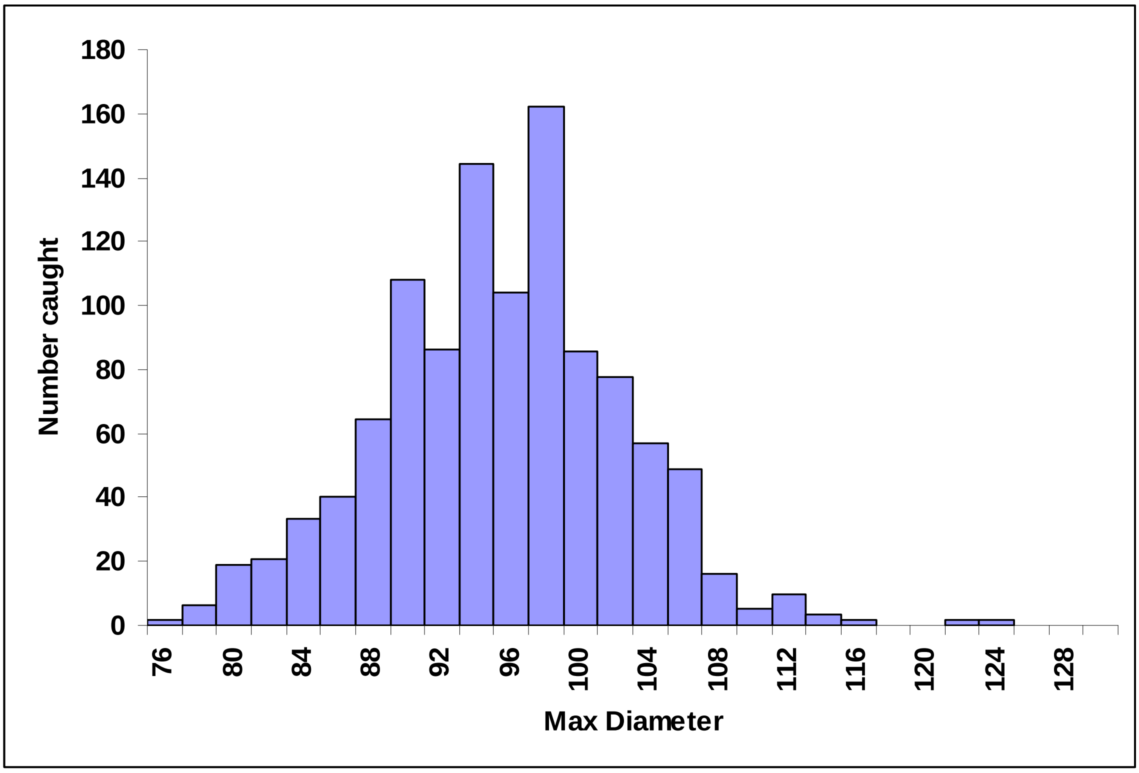


Figure 7: Length frequency histogram for scallops caught within Eddystone Point (see Figure 6). The discard rate is 21%.

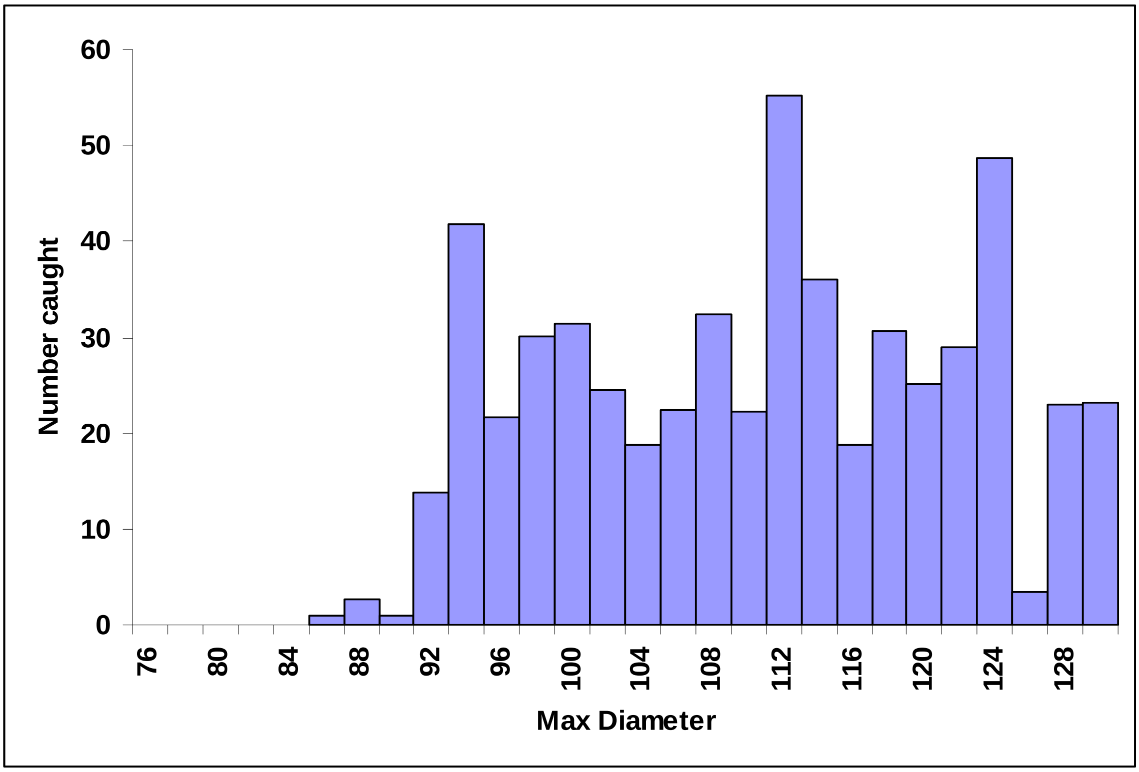


Figure 8: Length frequency histogram for scallops caught near Ansons Bay (see Figure 6). The discard rate is < 2%.

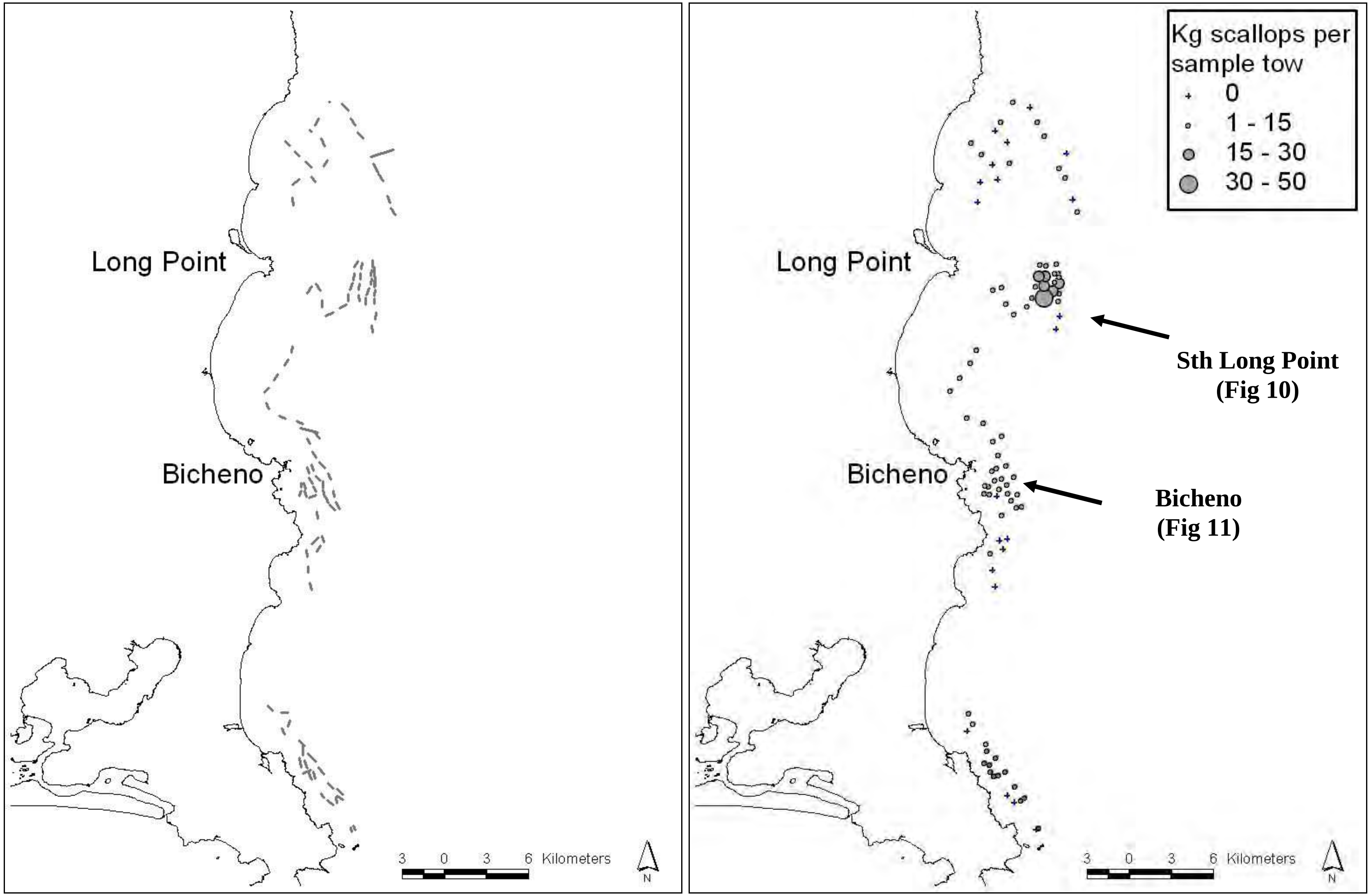


Figure 9: The location of sample tows conducted within the Long Point, Bicheno and Friendly Beaches regions (left). The abundance of scallops (as kg of scallops) caught within each sample tow is shown in the figure to the right. The condition of scallops reported from these regions was good, with large meats and developing roes.

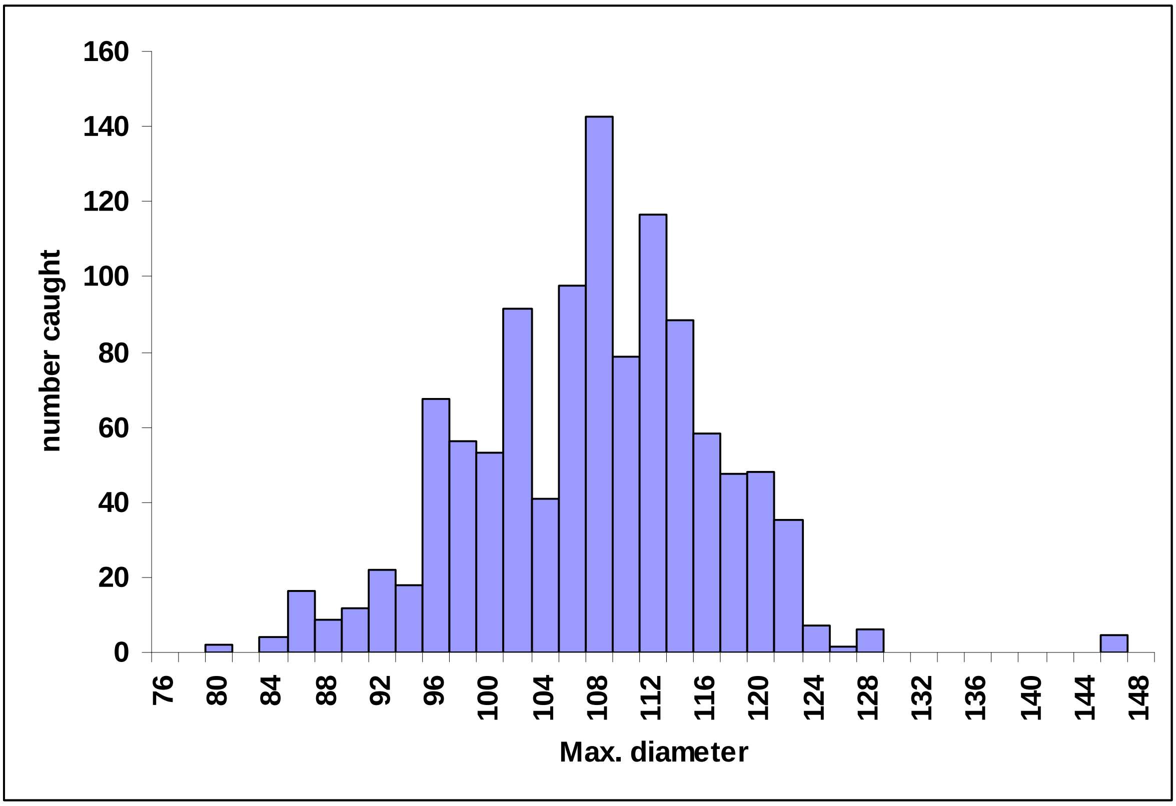


Figure 10: Length frequency histogram for scallops caught in the region to the south of Long Point (see Figure 9). The discard rate is 3%.

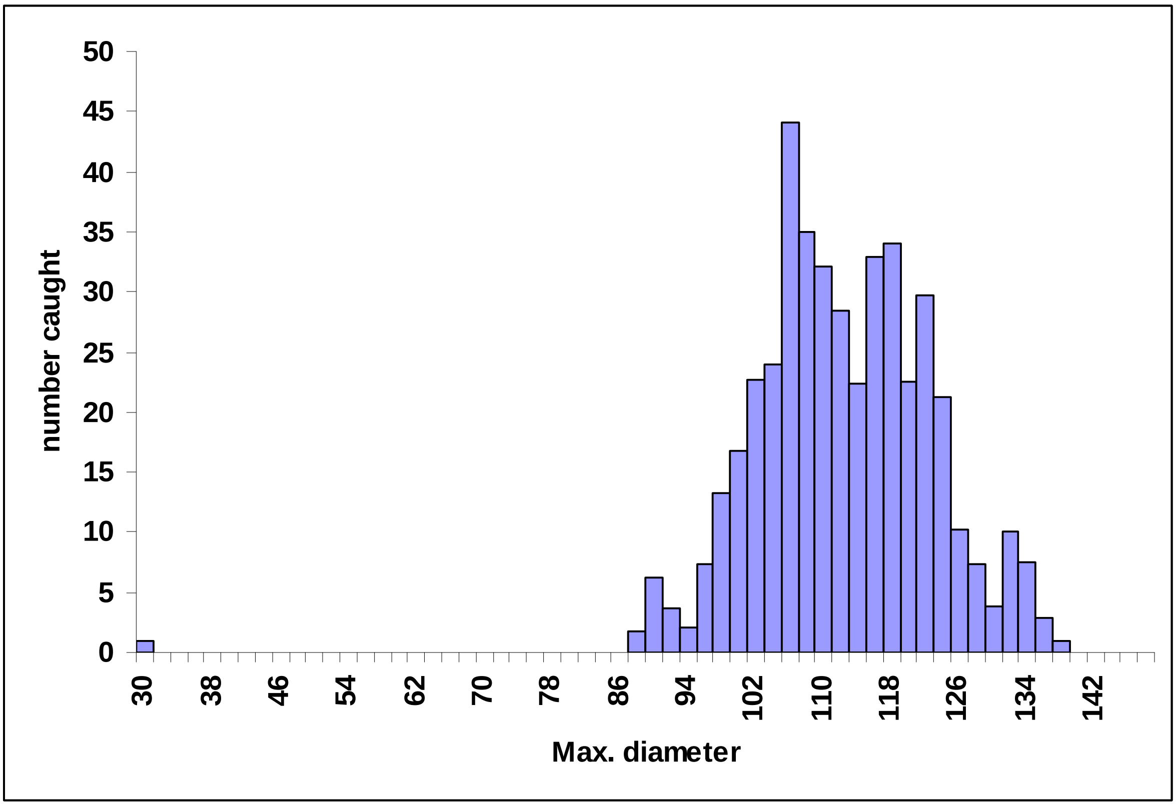


Figure 11: Length frequency histogram for scallops caught in the region near Bicheno (see Figure 9). The discard rate is 1%. Note the different max. diameter scale bar compared to figure 10.

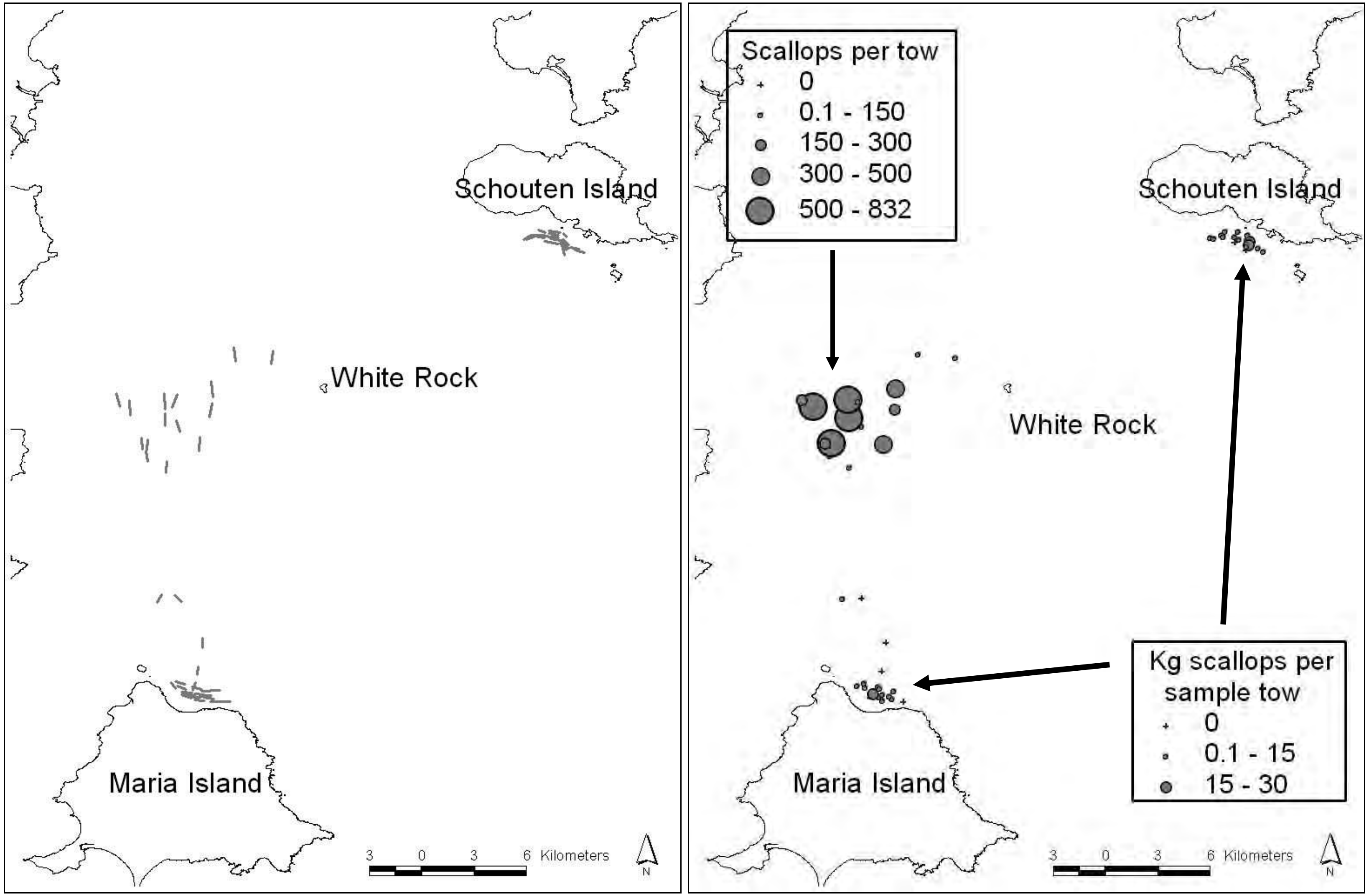


Figure 12: The location of sample tows conducted within White Rock (left). The abundance of scallops (number of scallops) caught within each sample tow is shown in the figure to the right. It must be noted that this some of this work was conducted as part of a longer term study looking at the recovery of scallop habitat after commercial fishing. Bad weather conditions and time restrictions prevented further exploration during this survey.

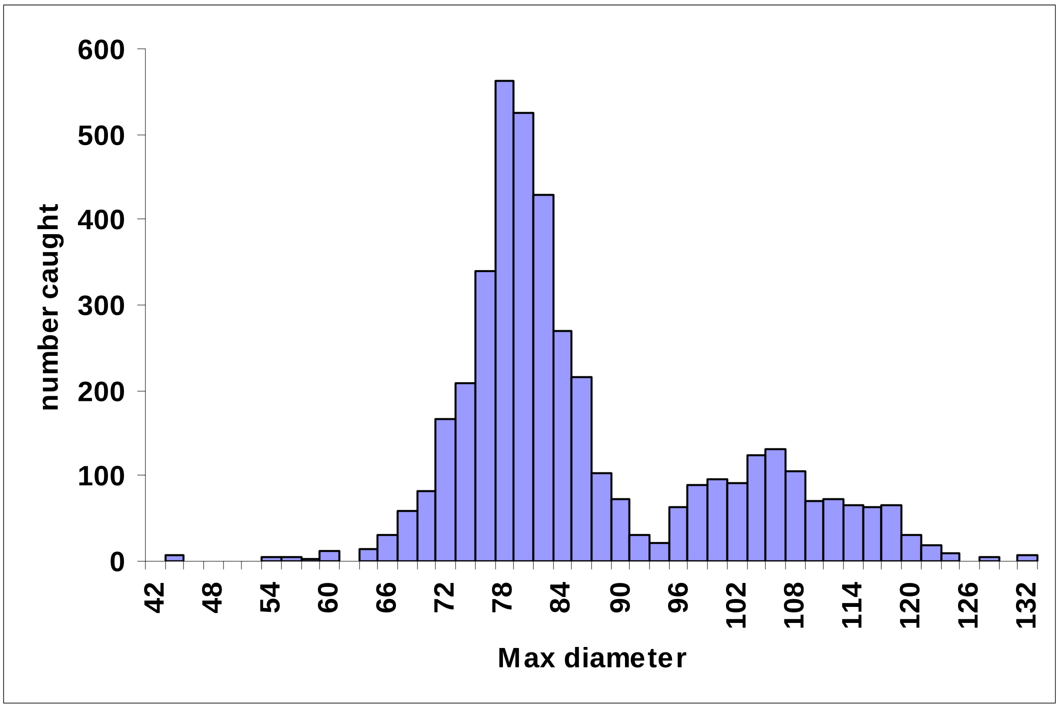


Figure 13: Length frequency histogram for scallops caught in the region near White Rock (see Figure 12). The discard rate is 71%.

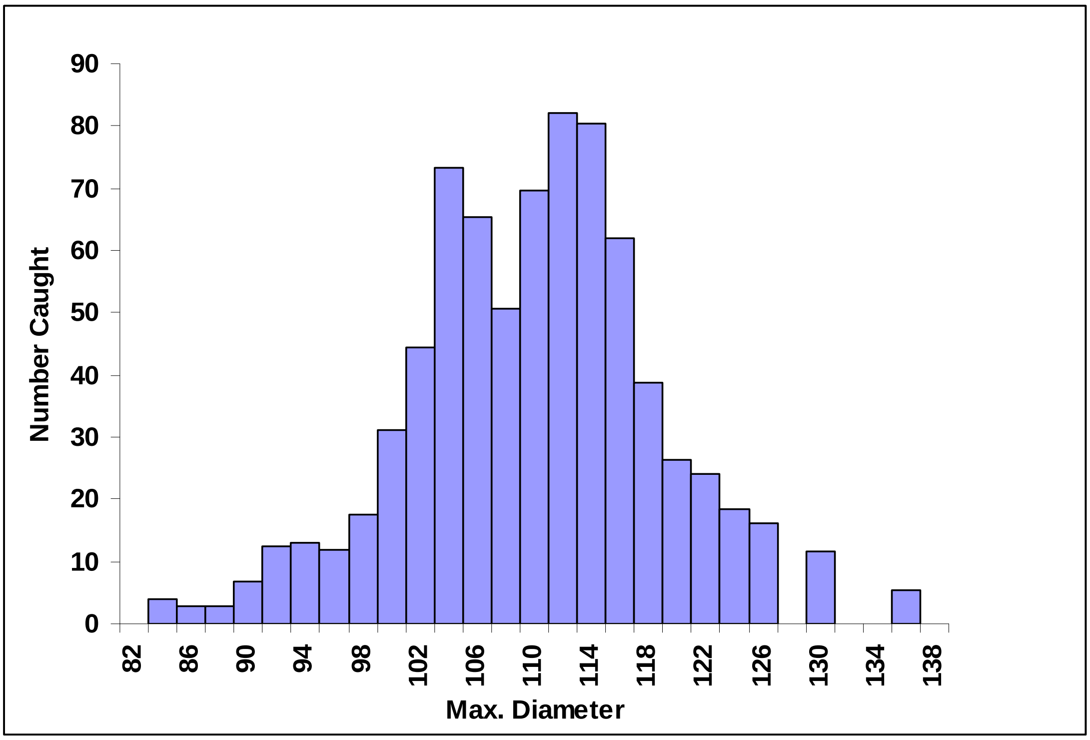


Figure 14: : Length frequency histogram for scallops caught within Fossil Cliffs and South Shouten Island regions (see Figure 12). The discard rate is ~ 1%.

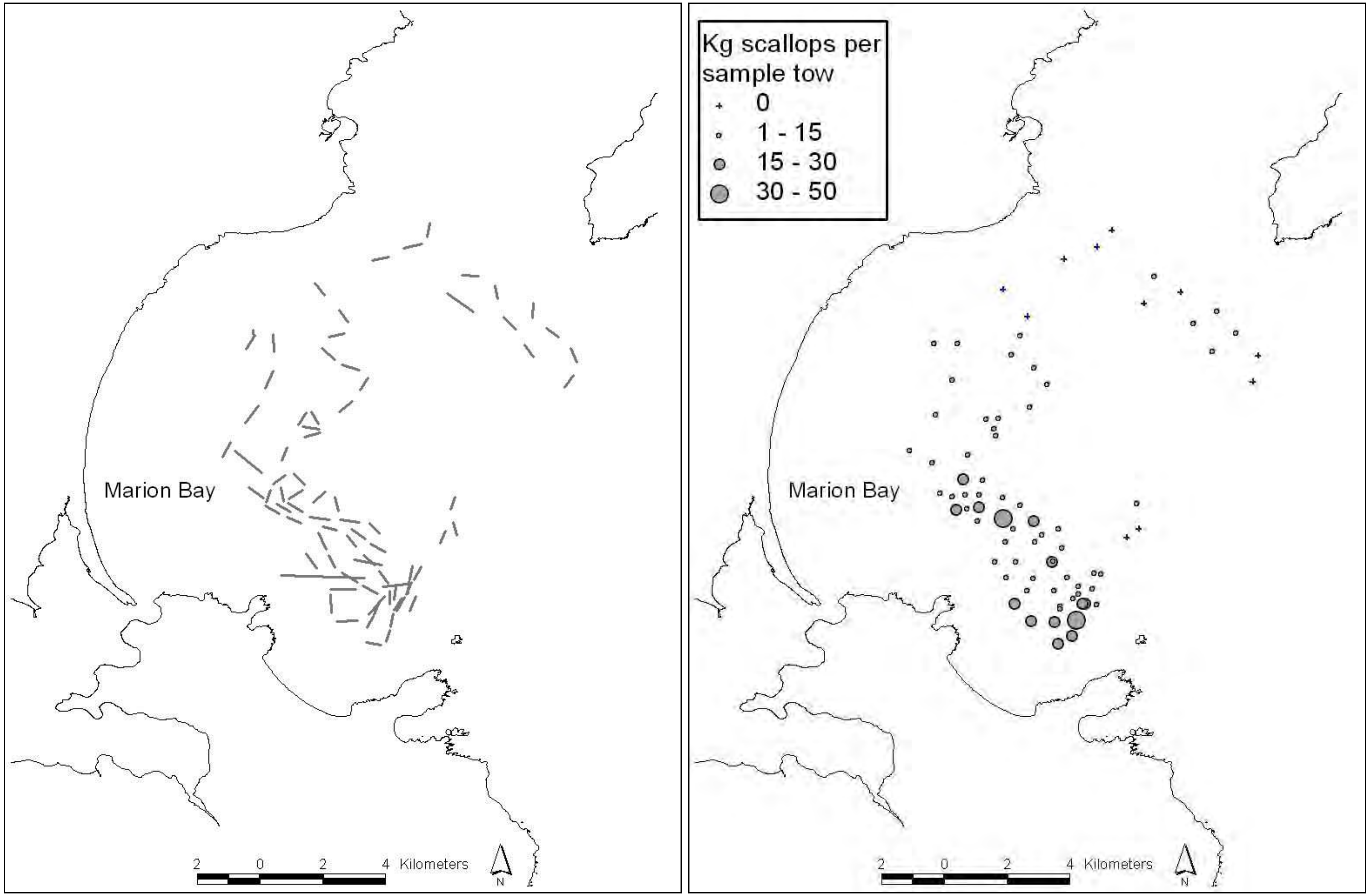


Figure 15: The location of sample tows conducted within Marion Bay (left). The abundance of scallops (as kg of scallops) caught within each sample tow is shown in the figure to the right.

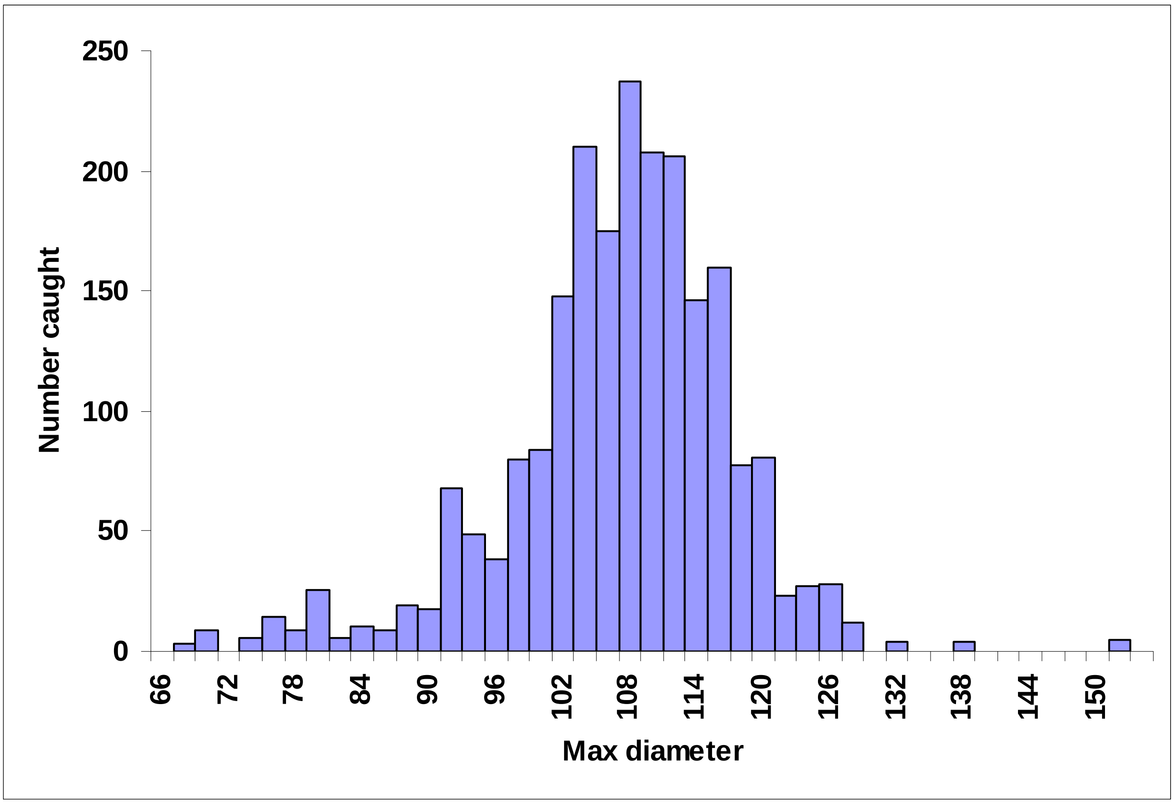


Figure 16: Length frequency histogram for scallops caught in the region near Marion Bay (see Figure 14). The discard rate is 5%.

Overview:

This report provides preliminary data obtained before the 16th July 2008 from surveys conducted during the 2008 pre-season Industry-based surveys. It should be noted that the strategy of providing monetary and research quota that could be caught during the pre-season survey period appears to be an effective strategy during predicted poor seasons. It is hoped that the three vessels that participated in the surveys (Brid Venture, Brid Voyager and the Alexander Vanessa) will recoup the costs of conducting surveys.

Possible commercial options for the 2008 scallop season

Based purely on the discard rate criteria and a reasonable coverage / number of sample tows being conducted within a survey area, several regions could be considered for commercial harvest during the 2008 season.

- Banks Strait (Figures 3, 5)
- Eddystone Point (Figures 6, 7)
- Sth Long Point (Figures 9, 10)
- Bicheno (Figures 9, 11)
- Shouten Island / Fossil Cliffs (Figures 12, 14)
- Marion Bay (Figures 15, 16)

The majority of these regions have been commercially fished during at least one fishing season since 2003, and in general, the scallops found have been left from these commercial operations. Subsequently, scallop abundances are predicted to be relatively low. The remaining regions cover relatively small areas.

Possible commercial options for future scallop seasons

Two regions have shown signs of significant recruitment.

- Babel Island / east Flinders (see Figs. 3, 4).
- White Rock (see Figs 12, 13).

For both areas, further industries surveys are needed to a) better map the extent of the beds and b) determine when they can be harvested.