

Biomass Estimates for Sea Cucumbers (*Parastichopus californicus*, *Cucumaria miniata*, *C. pallida*) as Determined Through Surveys Conducted June 2013 to May 2014

N.M.T. Duprey and L.M. Stanton

Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station]
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7
Canada

2018

**Canadian Manuscript Report of
Fisheries and Aquatic Sciences 3112**



Canadian Manuscript Report of Fisheries and Aquatic Sciences

Manuscript reports contain scientific and technical information that contributes to existing knowledge but which deals with national or regional problems. Distribution is restricted to institutions or individuals located in particular regions of Canada. However, no restriction is placed on subject matter, and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Manuscript reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1-900 in this series were issued as Manuscript Reports (Biological Series) of the Biological Board of Canada, and subsequent to 1937 when the name of the Board was changed by Act of Parliament, as Manuscript Reports (Biological Series) of the Fisheries Research Board of Canada. Numbers 1426 - 1550 were issued as Department of Fisheries and the Environment, Fisheries and Marine Service Manuscript Reports. The current series name was changed with report number 1551.

Manuscript reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport manuscrit canadien des sciences halieutiques et aquatiques

Les rapports manuscrits contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais qui traitent de problèmes nationaux ou régionaux. La distribution en est limitée aux organismes et aux personnes de régions particulières du Canada. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les sciences halieutiques et aquatiques.

Les rapports manuscrits peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports manuscrits sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annuel des publications scientifiques et techniques du Ministère.

Les numéros 1 à 900 de cette série ont été publiés à titre de manuscrits (série biologique) de l'Office de biologie du Canada, et après le changement de la désignation de cet organisme par décret du Parlement, en 1937, ont été classés comme manuscrits (série biologique) de l'Office des recherches sur les pêcheries du Canada. Les numéros 901 à 1425 ont été publiés à titre de rapports manuscrits de l'Office des recherches sur les pêcheries du Canada. Les numéros 1426 à 1550 sont parus à titre de rapports manuscrits du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 1551.

Les rapports manuscrits sont produits à l'échelon régional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Manuscript Report of
Fisheries and Aquatic Sciences
3112

BIOMASS ESTIMATES FOR SEA CUCUMBERS (*Parastichopus californicus*,
Cucumaria miniata, *C. pallida*) AS DETERMINED THROUGH SURVEYS
CONDUCTED JUNE 2013 TO MAY 2014

by

N.M.T. Duprey and L.M. Stanton

Fisheries and Oceans
Canada Science Branch,
Pacific Region Pacific
Biological Station Nanaimo,
British Columbia V9T 6N7

© Her Majesty the Queen in Right of Canada, 2018

Cat. No. Fs 97-4/3112E ISBN 978-0-660-07056-8 ISSN 0706-6473

Cat. No. Fs 97-4/3112E-PDF ISBN 978-0-660-07057-5 ISSN 1488-5387

Correct citation for this publication:

Duprey, N.M.T., and Stanton, L.M. 2018. Biomass estimates for sea cucumber (*Parastichopus californicus*, *Cucumaria miniata*, *C. pallida*) as determined through surveys conducted June 2013 to May 2014. Can. Manuscr. Rep. Fish. Aquat. Sci. 3112: x + 72 p.

TABLE OF CONTENTS

ABSTRACT	x
INTRODUCTION	1
METHODS	2
OPEN SURVEY METHODS	2
<i>Surveying</i>	2
<i>Biosampling</i>	3
SURVEY AREA DESCRIPTIONS	3
<i>Laredo Channel</i>	3
<i>Queens Sound</i>	4
<i>Sidney – Sooke</i>	4
DATA ANALYSIS	5
<i>Density estimations</i>	5
<i>Mean weight estimations</i>	6
<i>Shoreline length estimations</i>	6
<i>Biomass estimations</i>	6
RESULTS	6
<i>PFMA 6–11 and 6–14 (Laredo Channel)</i>	7
<i>PFMA 6–12 (Laredo Channel)</i>	8
<i>PFMA 6–15 (Laredo Channel)</i>	9
<i>PFMA 6–16 (Laredo Channel)</i>	10
<i>PFMA 7–18 (Queens Sound)</i>	11
<i>PFMA 7–19 (Queens Sound)</i>	12
<i>PFMA 7–25 (Queens Sound)</i>	13
<i>PFMA 19–3 (Sidney – Sooke)</i>	14
<i>PFMA 19–4 (Sidney – Sooke)</i>	15
<i>PFMA 19–5 (Sidney – Sooke)</i>	16
<i>PFMA 20–5 (Sidney – Sooke)</i>	17
DISCUSSION	19
<i>Laredo Channel</i>	19
<i>Queens Sound</i>	19
<i>Sidney – Sooke</i>	19
LITERATURE CITED	20

LIST OF TABLES

Table 1. Total number and ID of transects surveyed, and number of <i>Parastichopus californicus</i> biosamples collected in Open surveys conducted June 2013 – May 2014, by Pacific Fishery Management (PFM) Subarea.....	22
Table 2. Mean linear <i>Parastichopus californicus</i> density estimates by PFM Subarea, with lower (LCB) and upper (UCB) confidence bounds (sea cucumbers per metre of shoreline: c/m-sh) from Open surveys completed June 2013 – May 2014	23
Table 3. Estimated mean weight of <i>Parastichopus californicus</i> from samples collected during June 2013 – May 2014.....	25

Table 4. Biomass estimates from Open surveys conducted June 2013 – May 2014	26
Table 5. Linear density (sea cucumbers per meter shoreline; c/m-sh) for <i>Parastichopus californicus</i> , <i>Cucumaria miniata</i> and <i>C. pallida</i> , by transect, in the Laredo Channel survey	28
Table 6. Linear density (sea cucumbers per meter shoreline; c/m-sh) for <i>Parastichopus californicus</i> , <i>Cucumaria miniata</i> and <i>C. pallida</i> , by transect, in the Queens Sound survey	32
Table 7. Linear density (sea cucumbers per meter shoreline; c/m-sh) for <i>Parastichopus californicus</i> , <i>Cucumaria miniata</i> and <i>C. pallida</i> , by transect, in the Sidney – Sooke survey	38

LIST OF FIGURES

Figure 1. Sea cucumber surveys (highlighted in red) conducted June 2013 to May 2014. Open surveys were conducted in Laredo Channel, Queens Sound and Sidney - Sooke	40
Figure 2. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of <i>Parastichopus californicus</i> in PFMA 6-11 & 6-14, surveyed as part of the Laredo Channel survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the bootstrapped lower 90% confidence bound calculated for the subarea); green = productive locations (densities between the bootstrapped lower 90% confidence bound and the regional baseline density); blue = very productive locations (densities above the regional baseline density)	41
Figure 3. Relative abundance estimates of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 6-11 & 6-14. The number of animals observed while swimming the transect was noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals	42
Figure 4a. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of <i>Parastichopus californicus</i> in PFMA 6-12 (western portion), surveyed as part of the Laredo Channel survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the bootstrapped lower 90% confidence bound calculated for the subarea); green = productive locations (densities between the bootstrapped lower 90% confidence bound and the regional baseline density); blue = very productive locations (densities above the regional baseline density)	43

Figure 4b. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 6-12 (eastern portion), surveyed as part of the Laredo Channel survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black=zero; red=low density (< 2.5 c/m-sh); yellow=medium density (between 2.5 c/m-sh and the bootstrapped lower 90% confidence bound calculated for the subarea); green=productive locations (densities between the bootstrapped lower 90% confidence bound and the regional baseline density); blue=very productive locations (densities above the regional baseline density)44

Figure 5a. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 6-12 (western portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals..... 45

Figure 5b. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in part of PFMA 6-12 (eastern portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.....46

Figure 6. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 6-15, surveyed as part of the Laredo Channel survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and regional baseline density); green = productive locations (densities above the North Coast regional baseline density)..... 47

Figure 7. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in part of PFMA 6-15. The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals..... 48

Figure 8a. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 6-16 (northwest portion), surveyed as part of the Laredo Channel survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and 6.00 c/m-sh); green = productive locations (between the regional baseline density and the maximum observed in the Subarea)..... 49

Figure 8b. Linear density (sea cucumbers per metre of shoreline; c/m), of *Parastichopus californicus* in PFMA 6-16 (southeast portion), surveyed as part of the Laredo Channel survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 and 6.00 c/m-sh); green = productive locations (between regional baseline density and the maximum observed density in the Subarea).....50

Figure 9a. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in part of PFMA 6-16 (northwest portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals..... 51

Figure 9b. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in part of PFMA 6-16 (southeast portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals52

Figure 10a. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 7-18 (northwest portion), surveyed as part of the Queens Sound survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the regional baseline density); green = productive locations (between the regional baseline density and the maximum observed in the Subarea)..... 53

Figure 10b. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 7-18 (southeast portion), surveyed as part of the Queens Sound survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the regional baseline density); green = productive locations (between the regional baseline density and the maximum observed in the Subarea)54

Figure 11a. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 7-18 (northwest portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals..... 55

Figure 11b. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 7-18 (southeast portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals..... 56

Figure 12. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 7-19, surveyed as part of the Queens Sound survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.50 c/m-sh and the regional baseline density)57

Figure 13. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 7-19. The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals..... 58

Figure 14a. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 7-25 (western portion), surveyed as part of the Queens Sound survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the bootstrapped lower 90% confidence bound calculated for the Subarea); green = productive locations (between the bootstrapped lower 90% confidence bound and the regional baseline density); blue = very productive locations (densities above the regional baseline density). 59

Figure 14b. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 7-25 (eastern portion), surveyed as part of the Queens Sound survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the bootstrapped lower 90% confidence bound calculated for the Subarea); green = productive locations (between the bootstrapped lower 90% confidence bound and the regional baseline density); blue = very productive locations (densities above the regional baseline density). 60

Figure 15a. Abundances of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 7-25 (western portion). The total number of animals observed while swimming the transect is noted and given an abundance scale of A, M, F, or 0. A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals..... 61

Figure 15b. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 7-25 (eastern portion), The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals..... 62

Figure 16. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* PFMA 19-3, surveyed as part of the Sidney-Sooke survey in 2014. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the regional baseline density); green = productive locations (densities above the regional baseline density)..... 63

Figure 17. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 19-3. The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals..... 64

Figure 18. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 19-4, surveyed as part of the Sidney-Sooke survey in 2014. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the regional baseline density); green = productive locations (densities above the regional baseline density)..... 65

Figure 19. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 19-4. The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals..... 66

Figure 20. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 19-5, surveyed as part of the Sidney-Sooke survey in 2014. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 and the regional baseline density); green = productive locations (densities above the regional baseline density and 12.75 c/m-sh). 67

Figure 21. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 19-5. The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals..... 68

Figure 22a. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 20-5 (northwest portion), surveyed as part of the Sidney-Sooke survey in 2014. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 and the regional baseline density); green = productive locations (densities above the regional baseline density)..... 69

Figure 22b. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 20-5 (southeast portion), surveyed as part of the Sidney-Sooke survey in 2014. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 and the regional baseline density); green = productive locations (densities above the regional baseline density)..... 70

Figure 23a. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in a portion of PFMA 20-5 (northwest portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals. 71

Figure 23b. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in a portion of PFMA 20-5 (southeast portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals. 72

ABSTRACT

Duprey, N.M.T., and Stanton, L.M. 2018. Biomass estimates for sea cucumbers (*Parastichopus californicus*, *Cucumaria miniata*, and *C. pallida*) as determined through surveys conducted June 2013 to May 2014. Can. Manuscr. Rep. Fish. Aquat. Sci. 3112: x + 72 p.

Stock assessment surveys of the Giant Red Sea Cucumber, *Parastichopus californicus*, population in British Columbia have been ongoing since 1998. Between June 2013 and May 2014, three surveys were conducted to provide managers with population density and biomass estimates. The relative abundances of Geoduck (*Panopea generosa*), Red Sea Urchin (*Strongylocentrotus franciscanus*), and Green Sea Urchin (*Strongylocentrotus droebachiensis*) were also determined and are presented here. The Sidney – Sooke survey results showed low sea cucumber densities with all subareas having densities below 2.50 c/m-sh. The Laredo Channel and Queens Sound surveys had higher sea cucumber densities, however all subareas were below the regional baseline density.

RÉSUMÉ

Duprey, N.M.T., et Stanton, L.M. 2018. Estimations de la biomasse pour le concombre de mer (*Parastichopus californicus*, *Cucumaria miniata*, *C. pallida*) déterminées au moyen de relevés effectués de juin 2013 à mai 2014. Rapp. manus. can. sci. halieut. aquat. 3112 : x + 72 p.

Des évaluations des stocks de la population d'holothurie rouge géante du *Pacifique* (*Parastichopus californicus*) de la Colombie-Britannique sont en cours depuis 1998. Entre juin 2013 et mai 2014, trois relevés ont été effectués afin d'indiquer aux gestionnaires des pêches la densité de la population et les estimations de la biomasse. L'abondance relative de la panope (*Panopea generosa*), de l'oursin rouge (*Strongylocentrotus franciscanus*), et de l'oursin vert (*Strongylocentrotus droebachiensis*) a également été déterminée; cette information est présentée ci-après. Les résultats des relevés dans la rivière Sooke et le chenal Sidney ont permis d'établir que les densités d'holothuries étaient faibles, se situant sous 2,5 h/m-l dans tous les sous-secteurs. Les relevés effectués dans le chenal Laredo et la passe Queens ont relevé des densités plus élevées; toutefois, tous les sous-secteurs se situent en deçà de la densité régionale de référence.

INTRODUCTION

The fishery for Giant Red Sea Cucumber, *Parastichopus californicus* (Stimpson, 1857), in British Columbia (BC) had an annual value of approximately 7.4 million Canadian dollars in 2011 (K. Ridgway, Pacific Sea Cucumber Harvesters Association, pers. comm.). Landings were first recorded in Canada in 1971, and the fishery underwent several management changes through the 1980s and 1990s. Since 1995, the fishery has undergone a rigorous period of data collection, analysis and information review. The objective was to develop a biologically-based stock assessment program and risk-averse fishery management. The first stock assessment and quota options paper was completed in 1995, utilizing a surplus production model (Phillips and Boutillier 1998). In the course of conducting this assessment, gaps in knowledge of the species' biology were identified and shortcomings of the fishery-dependent data became clear. Phillips and Boutillier (1998) identified the need for a change in approach for the BC sea cucumber fishery and laid the groundwork for a more comprehensive, Phase 0 (see Perry *et al.* 1999 for description of phases), review in 1996 (Boutillier *et al.* 1998). The Phase 0 review paper concluded that the fishery was not providing the information necessary for stock assessments and evaluation of the impacts of the commercial fishery on sea cucumber populations. Accordingly, it was recommended that the fishery henceforth be conducted in a manner that would provide the necessary data. Prior to Phase 1 virtually the entire BC coast was open to commercial harvesting. Phase 1 of the sea cucumber fishery began in 1997 (Hand and Rogers 1999), wherein the area remaining open to commercial harvest was restricted to a static 25% of the coast, another 50% of the coast was closed to harvest, and the remaining 25% of the coast was set aside for experimental fishery research. As only a small fraction of the area set aside for experimental fishery research was used, this essentially left almost 75% of the coast was closed. A fishery-independent survey program was initiated in areas open to commercial harvest in BC. Methods to conduct surveys were developed for these open areas, now termed 'Open' surveys, and are also used for surveying other areas of the coast that are closed to commercial harvesting. These Open surveys are used to determine the density and biomass of sea cucumbers in a given area.

After 10 years of conducting fisheries-dependent and -independent research in the Phase 1 regime, the data collected from Open surveys, experimental fisheries and biological sampling were analyzed and the results and recommendations were presented to, and accepted by, the Pacific Invertebrate Subcommittee of the Canadian Science Advisory Secretariat (CSAS) in 2007 (Hand *et al.* 2009). The recommendation to allow re-opening of the commercial fishery beyond the geographically-restricted area of 25% of the shoreline, using BC-based exploitation rates, was endorsed. It was also recommended and approved that any re-opened areas should be surveyed prior to commercial harvesting (Hand *et al.* 2009; Duprey *et al.* 2011). The sea cucumber fishery then entered Phase 2, 'fishing for commerce' (Perry *et al.* 1999).

Prior to re-opening areas in BC to commercial harvesting, surveys were conducted to estimate the density and biomass of sea cucumbers within them. A total of 154 new Pacific Fishery Management (PFM) subareas have been surveyed from July 2007 through

May 2014, and survey results have provided site-specific estimates of sea cucumber density and biomass (Duprey 2011, 2012, 2014; Duprey and Stanton 2015). The Integrated Fishery Management Plan (DFO 2014) lists all PFM subareas currently open for commercial harvest of sea cucumber.

This manuscript report presents the results of three surveys using the Open survey design conducted between June 2013 and May 2014. The Laredo Channel survey, located in the North Coast region, and Queens Sound survey, located in the Central Coast region, were open to commercial fishing at the time of surveying and were part of the original 25% of the BC coastline that remained open in 1997 (Figure 1). The Sidney – Sooke survey, located in the East Coast of Vancouver Island region, was not open to commercial fishing at the time of the survey, but was being considered for re-opening in the upcoming harvest seasons (Figure 1).

This report summarizes the survey protocols, describes the survey methodology and presents the results of data analysis for density, mean weight and biomass of the *P. californicus* populations, density estimates for the *Cucumaria miniata* and *C. pallida* sea cucumber populations and relative abundance estimates of Geoducks (*Panopea generosa*), Red Sea Urchins (*Strongylocentrotus franciscanus*) and Green Sea Urchins (*S. droebachiensis*).

METHODS

The Open survey design is the standard survey method used in BC to assess the *P. californicus* population (Duprey et al. 2011). They are used to assess density and biomass in areas currently open to commercial harvesting or to assess areas not currently open to commercial harvesting, yet there is a desire to re-open the area in upcoming years.

OPEN SURVEY METHODS

Surveying

While each Open survey was prepared separately, the methods used to prepare and conduct each survey were the same. Firstly, the entire shoreline of the each PFM subarea was measured using ArcGIS 9.3 (Table 1). The basemap used to measure the shoreline was the *cucland.shp* dataset, projected in BC Albers. Using the ArcGIS 9.3 measurements, transect locations were determined by placing transects systematically every 2 km along the shoreline using Xtools (see Table 1 for total number of surveyed transects by PFM subarea). One transect was allocated for every 2 km of shoreline located in each PFM subarea for the Laredo Channel and the Queens Sound Open surveys. A higher density of transects were allocated in the Sidney – Sooke Open survey with one transect placed for every 1 km of shoreline.

Each transect line was marked by placing a leadline perpendicular to shore, from zero gauge depth to 15.2 m gauge depth. The leadline was marked with zap-straps and coloured electrical tape at 5 m intervals called quadrats. A buoy was anchored to the deep end of the line at approximately 15.2 m (50 ft). Each transect was surveyed by two

SCUBA divers, who descended the buoy line to the zap-strap nearest 15.2 m depth and began the survey along the leadline from this depth. Each diver had a 2 m pole with an attached datasheet. One diver was designated as the left diver and the other, the right; each diver swam with the pole perpendicular to the leadline and was responsible for counting and recording the number of sea cucumbers within each quadrat, defined as the area within 2 m of the survey leadline from one zap-strap to the next on their side of the transect line. The left diver was responsible for counting the sea cucumbers straddling the transect line. For each quadrat, the following were recorded: the number of adult and the number juvenile (sea cucumbers less than 15 cm, the size of the pencil used by divers) *P. californicus*; up to three dominant substrate types; and, no more than two dominant algae types. Sea cucumbers were counted if more than half of the animal was within the quadrat. The depth of each quadrat was also recorded. One diver recorded the number of *C. miniata* and *C. pallida* observed on their side of the transect. Because the white tentacles of *C. pallida* can be confused with those of *Eupentacta* spp., some *Eupentacta* may be included in the *C. pallida* numbers presented in this report. As only one diver was recording the *Cucumaria* spp., the swath covered was limited to their pole length of 2 m as compared to the 4 m wide swath covered for *P. californicus*, where both divers count animals. Relative abundance estimates of Geoducks, Green Sea Urchins and Red Sea Urchins were also recorded on the dive regardless of how far they were seen from the transect line; each transect was designated as having either None, Few (1–10), Many (11–100) or Abundant (100+) animals.

Biosampling

The average weight and weight-frequency distribution of the populations were determined from biosamples, which were small collections of *P. californicus* that were individually weighed. Biosamples were collected from predetermined transects that were randomly selected; one transect was randomly selected from every 10 transects in a subarea or for every 10 transects within a group of subareas being analyzed together. After these selected transects were surveyed, the divers handpicked the first 25 sea cucumbers observed from the transect line and surrounding area up to a maximum depth of 15.2 m. Juveniles are not collected during biosampling and are therefore not included in the biomass calculations. The animals were brought on-board the boat, where they were longitudinally split, left to drain and, at the end of the day, individually weighed.

SURVEY AREA DESCRIPTIONS

The three Open surveys were conducted June 2013 through May 2014 and stretched from Laredo Channel in the north to Sidney – Sooke on southern Vancouver Island (Figure 1).

Laredo Channel

Laredo Channel is located within Pacific Fisheries Management Area (PFMA) 6, in the North Coast region (Figure 1). This area was part of the 25% of the BC coastline that remained open to harvesting in 1997 and has been open for commercial harvesting ever since. The survey included five previously unsurveyed PFM Subareas, 6–11, 6–12, 6–14, 6–15, 6–16 (Figures 2-9) and was conducted from August 29 – September 4 and September 9 and 10, 2013 onboard a commercial fishing vessel. The survey was

conducted in partnership with the Pacific Sea Cucumber Harvesters Association (PSCHA); a contract biologist was present for the 9 days of surveying.

PFM Subarea 6–11 at the entrance to Laredo Channel encompasses a small area and includes a segment on the northeast of Rennison Island, starting from Oswald Point, and a segment on the northeast of Aristazabal Island, from Ulric Point to Baker Point. PFM Subarea 6–12 is located within Campana Sound just north of Laredo Channel and includes Chapple Inlet, Emily Carr Inlet, Surf Inlet and Racey Inlet along the western side of Princess Royal Island to Johnstone Point. PFM Subarea 6–14 includes Evinrude Inlet, Commando Inlet, and Helmcken Inlet along the western side of Princes Royal Island and a portion of the eastern side of Aristazabal Island from Baker Point to McPhee Point. PFM Subarea 6–15 continues south into Laredo Channel and includes Kent Inlet and Phillip Narrows. PFM Subarea 6–16 captures the southern portion of Laredo Inlet leading into Laredo Sound, following the shoreline of Princess Royal Island, and includes the areas between Dallian Point to Hartnell Point and Wingate Point to Wilby Point. This subarea also includes the western portions of Swindle and Price Islands and continues along the eastern shoreline of Aristazabal Island until Lombard Point. The total shoreline length of all five PFM Subareas was measured as 346.3 km using ArcGIS 9.3.

Queens Sound

The Queens Sound Open survey was located in PFMA 7, which is located in the Central Coast region (Figure 1). This area was part of the 25% of the BC coastline that remained open to harvesting in 1997; it has been open for commercial harvesting since then. The survey included three previously unsurveyed PFM subareas, 7–18, 7–19 and 7–25 (Figures 10–15) and was conducted from June 20 to July 1, August 28, and September 7–8, 2013 onboard a commercial fishing vessel. The survey was conducted in partnership with the PSCHA; a contract biologist was present for the 14 days of surveying.

PFM Subarea 7–18 covers a large area within Queens Sound. Many Islands are part of this subarea, including the southwestern portion of Campbell Island, the southern part of Stryker Island and Piddington Island, as well as, the McMullen Group, Admiral Group and the Tribal Group of Islands. PFM Subarea 7–19, within Thompson Bay, contains the south side of Princess Alice Island, the Houghton Islands and the western side of Potts Island. PFM Subarea 7–25 encompasses a number of Island Groups including the Sidmonds Group, McNaughton Group, Prince Group and Goose Group of Islands and also includes a western portion of Hunter Island. The total shoreline length of the PFM subareas was measured as 544.3 km using ArcGIS 9.3.

Sidney – Sooke

The Sidney – Sooke Open survey was located in PFMA 19 and PFMA 20 within the East Coast of Vancouver Island region (Figure 1). This area had been closed to sea cucumber harvesting since 1998 and was surveyed for potential re-opening. The survey included four PFM subareas, 19–3 to 19–5 and 20–5 (Figures 16–23), and was conducted from March 16–19, March 21–24, and March 26–27 2014 onboard a commercial fishing vessel. The survey was conducted in partnership with the PSCHA; a contract biologist was present for the 10 days of surveying.

PFM Subarea 19–3 comprises the waters of Juan de Fuca Strait on the southwest coast of Vancouver Island from Harling Point to William Head Lighthouse and includes the southern shores of Victoria heading west past Colwood and Metchosin, but excluding Esquimalt Harbour. The southern boundary line of this subarea follows the international boundary between Canada and the United States. PFM Subarea 19–4 in Haro Strait encompasses Cadboro Bay, Oak Bay and Gonzales (Foul) Bay along the southern tip of Vancouver Island. This area includes Baynes Channel, Plumper Passage, Mayor Channel as well as a number of small islands such as Discovery Island, the Chatham Islands and the Trial Islands. PFM Subarea 19–5 covers a large area within Haro Strait, however only part of this PFM subarea, south of a line from Cowichan Head on Vancouver Island to Wymond Point on Sidney Island, was surveyed. The surveyed area included the D’arcy Island group, Cordova Bay, and the shoreline south to Cadboro Point. PFM Subarea 20–5 in Juan de Fuca Strait encompasses Pedder Bay, Cape Calver, Race Passage, Beecher Bay, Sooke Bay and Orveas Bay on the western portion of the tip of southern Vancouver Island in and around Sooke, from Race Rock Lights to Sheringham Point and excludes Sooke Inlet and Sooke Basin. The total shoreline length of the PFM subareas that were planned for surveying was measured as 161.3 km using ArcGIS 9.3.

DATA ANALYSIS

To estimate the total biomass of sea cucumbers in a given area, three pieces of information are required: the linear density (number of sea cucumbers per metre of shoreline, c/m-sh), the average animal weight, and the length of shoreline. Biomass is estimated, at the Pacific Fisheries Management Area Subarea level, as the product of these three parameters; estimates for each of these are thus required for each subarea that is open to commercial harvest.

Density estimations

Linear estimates of density are used because sea cucumber populations do not exist in discrete beds but, rather, are ubiquitous over most of the shallow seabed (Duprey et al. 2011, Boutillier et al. 1998). As well, no spatial estimates of the nearshore sea floor are available due to the lack of accurate bathymetric data. The linear density of *P. californicus*, *C. miniata* and *C. pallida* was calculated for each transect by dividing the total number of sea cucumbers observed by the width of the transect (4 m for *P. californicus* and 2 m for *C. miniata* and *C. pallida*). On a PFM subarea basis, the transect data were analyzed using the CukeAnalysis Program (version 2008 11 19), which calculated the mean linear density (c/m-sh) and confidence bounds using the bootstrapping technique (see Hand et al. [2009] for more details). Transect data were re-sampled with 1000 iterations using a random seed of 756. Some PFM subareas were small and therefore had sample sizes too low to obtain good results from bootstrapping (a sample size of at least 10 transects is preferred). “Analysis areas” were developed to avoid this complication, whereby PFM subareas in the same survey were pooled with other PFM subareas that had similar bathymetry and geographical shape, and analyzed as one (see Table 1 for a list of analysis areas). The mean *P. californicus*, *C. miniata* and *C.*

pallida density, and 75%, 90%, 95%, 99% confidence bounds from the bootstrap were calculated for each subarea or analysis area.

Mean weight estimations

Biosamples were used to estimate mean animal weight within each PFM subarea. Each sea cucumber collected in a biosample was weighed individually. The individual weights within a biosample (approximately 25 sea cucumbers) were averaged to produce a mean biosample weight from the sampled transect. The PFM subarea's mean weight was the mean of all the biosample averages collected from transects within that subarea (Duprey et al. 2011). If no biosamples were collected within a PFM subarea, then the lowest mean weight estimate of all subareas in the same survey was used (Duprey et al. 2011).

Shoreline Length estimations

The shoreline length used in biomass calculations was measured using the GIS software Compugrid and is currently housed in the DFO Fisheries Management database. In this report, the shoreline categorized as “exposed” (ShorelineExposed) is the cumulative shoreline in a subarea that has been designated “exposed” in the BC Shorezone Classification dataset (Hand et al. 2009; Duprey et al. 2011) and the shoreline categorized as “protected” (ShorelineProtected) is the cumulative shoreline in a subarea that has been designated “semi-exposed” to “very protected” (Duprey et al. 2011). The shoreline categorized as “very exposed”, in the BC Shorezone Classification dataset, is not included in this report as “very exposed” shoreline is attributed a sea cucumber density of 0.00 c/m-sh (Hand et al. 2009; Duprey et al. 2011).

Biomass estimations

The biomass of *P. californicus* in a PFM subarea was estimated at various confidence bounds (CB) using the following formula:

$$\text{Biomass}_{\text{CB}} = [(\text{Shoreline}_{\text{Protected}} * \text{Density}_{\text{CB}}) * \text{Wt}_{\text{mean}}] + [(\text{Shoreline}_{\text{Exposed}} * 2.5) * \text{Wt}_{\text{mean}}]$$

where $\text{Density}_{\text{CB}}$ is the density from the bootstrap output, Wt_{mean} is the mean individual sea cucumber weight attributed to the subarea from biosampling, and the factor of 2.5 represents the linear density estimate used for exposed shoreline in BC (see Duprey et al. 2011 for further explanation). If the $\text{Density}_{\text{CB}}$ value is lower than 2.50 sea cucumbers per metre of shoreline (c/m-sh), then $(\text{Shoreline}_{\text{Exposed}} * 2.5)$ is replaced with the $(\text{Shoreline}_{\text{Exposed}} * \text{Density}_{\text{CB}})$. See Duprey et al. (2011) for a detailed description of methods used to calculate biomass estimates.

RESULTS

The following sections describe the results and analyses of mean linear *Parastichopus californicus* densities, estimated mean weight of biosamples and biomass estimations for each PFM Subarea (Tables 2-4). Linear density estimates of *P. californicus*, *C. miniata*, and *C. pallida* for all transects within the three Open surveys conducted are listed in Tables 5 to 7. A figure was developed for each PFM Subarea,

indicating the position of surveyed transects and providing scaled symbols for density ranges of *P. californicus*. The density ranges represented by the bubble size and colour in the figures differ by Analysis Areas, and were chosen for their relevance to stock assessment benchmarks as follows. There are as many as five categories of density ranges in each figure. Absence of sea cucumbers (0.00 c/m-sh) and up to 2.49 c/m-sh are used in every figure. Zero was chosen as a category to aid in determining areas where no sea cucumbers were seen. The next category range of 0.01 to 2.49 c/m-sh was chosen because a 90% lower confidence bound (LCB) of 2.50 c/m-sh, for an Analysis Area, is the commercial fishery threshold recommended in Duprey et al. (2011). The remaining three category ranges differ depending on the survey location and the results of the analysis. The third density range is between 2.50 c/m-sh and either the regional baseline density or the 90% LCB of the bootstrapped transect densities, whichever is lower. Historically baseline densities were attributed to unsurveyed areas open to commercial harvesting until they could be surveyed and attributed their own density estimate. The baseline densities are region specific as follows: North Coast = 6.0 c/m-sh; Central Coast = 6.0 c/m-sh; East Coast Vancouver Island = 4.1 c/m-sh; and West Coast Vancouver Island = 1.9 c/m-sh (Duprey et al. 2011). The fourth density range is from the regional baseline density to the 90% LCB, or vice versa depending on which is lower. If the maximum estimated density is low, the upper end of the fourth range is the maximum observed density in the Analysis Area. The final range in the figures is from the 90% LCB (or regional baseline density) to the maximum density observed in the Analysis Area. If the maximum observed density is less than the baseline density then this category is not present.

Laredo Channel Density Surveys – PFMA 6

PFMA 6–11 and 6–14 (Laredo Channel)

Parastichopus californicus

The transects within PFM Subareas 6–11 and 6–14 were analyzed together as one analysis area and were combined for the bootstrap analysis; 6 and 29 transects were surveyed in each area, respectively. Overall, both subareas had a variety of both high and low *P. californicus* densities throughout the subareas, many of the higher densities were observed along the southeast side of Subarea 6–14 (Figure 2). A total of 29 of the 35 transects surveyed had a density of less than 6.0 c/m-sh (the regional baseline density for the North Coast; Table 5). The highest density observed was 17.75 c/m-sh and the lowest density observed was 0.25 c/m-sh.

No Shoreline segments were removed due to logistical obstacles or other closures within PFM Subarea 6–11. The DFO Fisheries Management database has a total length for PFM Subarea 6–11 of 11,206 m, all of which is classified as “protected” by the BC Shorezone classification system. The DFO Fisheries Management database has a total length for PFM Subarea 6–14 of 60,413 m, all of which is classified as “protected” by the BC Shorezone classification system. Three of the plotted transects were not surveyed due to inaccessibility (transects 93, 94 and 95); as a result, 6,000 m of shoreline were removed from the total shoreline length to represent this area. Therefore, the total shoreline length used for biomass calculations was 54,413 m of protected shoreline.

The mean sea cucumber density for the analysis area was estimated to be 3.6 c/m-sh with a 90% LCB of 2.8 c/m-sh (Table 2). PFM Subarea 6–11 had an average weight calculated for one biosample (transect 111; Table 3); the average weight for this transect was 264 g (Table 3). PFM Subarea 6–14 had an average weight calculated for each of the three biosamples (transects 77, 92 and 102; Table 3); the average of these three transects was 204 g (Table 3). The 90% LCB of the mean biomass estimate was 8,283 kg for PFM Subarea 6–11 and was 31,081 kg for PFM Subarea 6–14 (Table 4).

Cucumaria miniata and *C. pallida*

C. miniata and *C. pallida* data were recorded on all 35 transects surveyed in PFM Subareas 6–11 and 6–14. No *C. miniata* or *C. pallida* were observed on any of the surveyed transects (Table 5). Therefore, the mean density for both species was estimated to be 0.0 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the corrected shoreline length of PFM Subareas 6–11 and 6–14 and the 90% LCB of the bootstrapped density, the estimated population of *C. miniata* and *C. pallida* was 0 sea cucumbers for both PFM Subareas.

Geoduck, Green Sea Urchin and Red Sea Urchin abundance

Relative abundances were estimated for Geoducks, Green Sea Urchins and Red Urchins on all 35 transects surveyed in PFM Subareas 6–11 and 6–14.

‘Abundant’ Geoduck were observed on 7 (20%) transects, ‘Many’ were observed on 2 (5%) transects, ‘Few’ Geoduck were seen on 3 (9%) transects, and none were observed on the remaining 23 (66%) transects (Figure 3).

‘Many’ Green Sea Urchins were observed on 1 (3%) transect, ‘Few’ were observed on 10 (28%) transects, and none were observed on the remaining 24 (69%) transects (Figure 3). ‘Abundant’ Red Sea Urchins were observed on 17 (48%) transects, ‘Many’ were observed on 7 (20%) transects, ‘Few’ were observed on 3 (9%) transects, and none on the remaining 8 (23%) transects (Figure 3).

PFMA 6–12 (Laredo Channel)

Parastichopus californicus

PFM Subarea 6–12 had the highest densities of *P. californicus* of all the Laredo Channel PFM Subareas. There were high densities of *P. californicus* scattered throughout most of the Subarea with slightly lower densities observed approaching the heads of Chapple Inlet, Surf Inlet and Racey Inlet (Figures 4a, b). A total of 46 of the 58 transects surveyed had a density of 6.00 c/m-sh (the regional baseline density for the North Coast) or less (Table 5). The highest density observed was 19.75 c/m-sh and the lowest density observed was 0.00 c/m-sh.

The DFO Fisheries Management database had a total shoreline length for Subarea 6–12 of 106,882 m, all of which was classified as “protected” by the BC Shorezone classification system. Five transects (160, 161, 162, 167, and 170) were not surveyed due to non-navigable waters. Therefore, 10,000 m of shoreline was removed from the total

shoreline length to represent this non-navigable area. The total shoreline length used for biomass calculations was 96,882 m of protected shoreline.

The mean *P. californicus* density was estimated to be 3.9 c/m-sh and the 90% LCB of the bootstrap was 3.2 c/m-sh (Table 2). An average weight was calculated for each of the five biosamples (transects 123, 126, 136, 144 and 172; Table 3); the average of these five values was 274 g (Table 3). Using the corrected shoreline length, average weight and the 90% LCB of the bootstrapped density the biomass estimate for PFMA 6–12 was 84,946 kg (Table 4).

Cucumaria miniata and *C. pallida*

C. miniata and *C. pallida* data were recorded on all of the 58 transects surveyed in PFM Subarea 6–12. No *C. miniata* or *C. pallida* were observed on any of the surveyed transects (Table 5). Therefore, the mean density for both species was estimated to be 0.0 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the corrected shoreline length of PFM Subarea 6–12 and the 90% LCB of the bootstrapped density, the estimated population of *C. miniata* and *C. pallida* was 0 sea cucumbers.

Geoduck, Green Sea Urchin and Red Sea Urchin abundance

Relative abundances were estimated for Geoducks, Green Sea Urchins and Red Sea Urchins on all 58 transects surveyed in PFM Subarea 6–12.

‘Abundant’ Geoduck were observed on 11 (19%) transects, ‘Many’ were observed on 7 (12%) transects, ‘Few’ were observed on 1 (2%) transect, while none were observed on the remaining 39 (67%) transects (Figures 5a, b).

Relative abundance data for sea urchins were collected on all 58 transects surveyed in Subarea 6–12. ‘Many’ Green Sea Urchins were observed on 2 (3%) transects, ‘Few’ were observed on 10 (17%) transects, and none on the remaining 46 (79%) transects (Figures 5a, b). ‘Abundant’ Red Sea Urchins were observed on 4 (7%) transects, ‘Many’ were observed on 8 (14%) transects, ‘Few’ were observed on 17 (29%) transects, and none were observed on 29 (50%) transects (Figures 5a, b).

PFMA 6–15 (Laredo Channel)

Parastichopus californicus

PFM Subarea 6–15, had low *P. californicus* densities throughout the Subarea (Figure 6). A total of 16 of the 17 transects surveyed had a density of less than 6.0 c/m-sh (the baseline density for the North Coast; Table 5). The highest density observed was 6.75 c/m-sh and the lowest was 0.00 c/m-sh.

No shoreline segments were removed due to logistical obstacles or other closures. The DFO Fisheries Management database had a total length for PFM Subarea 6–15 of 39,866 m, all of which was classified as “protected” by the BC Shorezone classification system.

The mean sea cucumber density was estimated to be 2.3 c/m-sh and the 90% LCB of the bootstrap was 1.5 c/m-sh (Table 2). An average weight was calculated from each of the

two biosamples (transects 63 and 70; Table 3); the average of these two values was 316 g (Table 3). The 90% LCB of the mean biomass estimate was 18,896 kg (Table 4).

Cucumaria miniata and *C. pallida*

C. miniata and *C. pallida* numbers were recorded on all 17 transects surveyed in the subarea. Sixteen of the 17 transects surveyed had no *C. miniata* observed and the highest density observed was 2.5 c/m-sh (Table 5). The mean density was estimated to be 0.1 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the entire shoreline length of PFM Subarea 6–15 and the 90% LCB of the density, the estimated population of *C. miniata* was 0 sea cucumbers.

No *C. pallida* were observed during the 17 transects surveyed (Table 5). The mean density was therefore 0.0 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the entire shoreline length of PFM Subarea 6–15 and the 90% LCB of the density, the estimated population of *C. pallida* was 0 sea cucumbers.

Geoduck, Green Sea Urchin and Red Sea Urchin abundance

Relative abundances were estimated for Geoducks, Green Sea Urchins and Red Sea Urchins on all 17 transects surveyed in PFM Subarea 6–15.

‘Many’ Geoduck were observed on 2 (12%) transects, ‘Few’ on 1 (6%) transect, and none were observed on the remaining 14 (82%) transects (Figure 7).

‘Many’ Green Sea Urchins were observed on 3 (18%) transects, ‘Few’ were observed on 7 (41%) transects, and none were observed on 7 (41%) transects in the subarea (Figure 7). ‘Abundant’ Red Sea Urchins were observed on 9 (53%) transects, ‘Many’ were observed on 4 (23%) transects, ‘Few’ were observed on 1 (6%) transect and none were observed on 3 (18%) transects.

PFMA 6–16 (Laredo Channel)

Parastichopus californicus

PFM Subarea 6–16 exhibited a mixture of low and high densities of *P. californicus* throughout the Subarea with most of the higher densities observed in the southeastern portion of the survey area (Figures 8a, b). A total of 44 of the 54 transects had a density of 6.0 c/m-sh (the regional baseline density for the North Coast) or less (Table 5). The highest density observed was 18.75 c/m-sh and the lowest was 0.00 c/m-sh.

The DFO Fisheries Management database has a total length for PFM Subarea 6–16 of 110,225 m, of which 18,243 m is classified as “exposed” and 91,982 m classified as “protected” by the BC Shorezone classification system. Three of the plotted transects were not surveyed due to non-navigable waters (transects 28, 36 and 44); as a result 6,000 m of the shoreline were removed from the total shoreline length to represent this area. Therefore, the total shoreline length used for biomass calculations was 18,243 m exposed and 85,982 m protected.

The mean sea cucumber density was estimated to be 3.3 c/m-sh with a 90% LCB of 2.5 c/m-sh (Table 2). An average weight was calculated from each of the five biosamples (transects 9, 19, 22, 34 and 47; Table 3); the average of these five values was 279 g (Table 3). The 90% LCB of the mean biomass estimate was 72,697 kg (Table 4).

Cucumaria miniata and *C. pallida*

C. miniata and *C. pallida* data were recorded on all 54 transects surveyed in PFM Subarea 6–16. No *C. miniata* or *C. pallida* were recorded on any of the surveyed transects (Table 5). Therefore, the mean density for both species was estimated to be 0.0 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the corrected shoreline length of PFM Subarea 6–16 and the 90% LCB of the bootstrapped density, the estimated population of *C. miniata* and *C. pallida* was 0 sea cucumbers.

Geoduck, Green Sea Urchin and Red Sea Urchin abundance

Relative abundances were estimated for Geoducks, Green Sea Urchins and Red Sea Urchins for 53 of the 54 transects surveyed in PFM Subarea 6–16.

‘Abundant’ Geoduck were observed on 5 (9%) transects, ‘Many’ were observed on 5 (9%) transects, and none were observed on 43 (81%) transects (Figure 9a, b).

‘Abundant’ Green Sea Urchins were observed on 4 (7%) transects, ‘Many’ were observed on 4 (7%) transects, ‘Few’ were observed on 18 (34%) transects, and 27 (51%) transects had none observed. ‘Abundant’ Red Sea Urchins were observed on 31 (58%) transects, ‘Many’ were observed on 2 (4%) transects, ‘Few’ were observed on 2 (4%) transects, and 18 (34%) transects had none observed (Figure 9a, b).

Queens Sound Density Surveys – PFMA 7

PFMA 7–18 (Queens Sound)

Parastichopus californicus

PFM Subarea 7–18 had a variety of high and low *P. californicus* densities with the highest densities observed on the eastern side of the survey area near Piddington and Campbell Island (Figure 10a, b). A total of 73 of the 94 transects surveyed had a density of less than 6.0 c/m-sh (the regional baseline density for the Central Coast; Table 6). The highest density observed was 23.75 c/m-sh and the lowest was 0.00 c/m-sh.

The DFO Fisheries Management database has a total length for Subarea 7–18 of 197,450 m; 5,417 m of which is classified as “exposed” and 192,033 m of which is classified as “protected” by the BC Shorezone classification system. Eight of the plotted transects were not surveyed (transects 155, 157, 160, 165, 170, 176, 177 and 249); as a result 16,000 m of shoreline were removed from the total shoreline length to represent this area. Therefore, the total shoreline length used for biomass calculations was 5,417 m exposed and 176,033 m of protected shoreline.

The mean sea cucumber density was estimated to be 3.1 c/m-sh with a 90% LCB of 2.4 c/m-sh (Table 2). An average weight was calculated from each of the six biosamples

(transects 190, 202, 210, 215, 229 and 236; Table 3); the average of these six values was 325 g (Table 3). The 90% LCB of the mean biomass estimate was 141,531 kg (Table 4).

Cucumaria miniata and *C. pallida*

C. miniata and *C. pallida* numbers were recorded on 93 of the 94 transects surveyed in the Subarea. Ninety of the 93 transects surveyed had no *C. miniata* observed, the highest density observed was 0.5 c/m-sh (Table 6). The mean density was estimated to be 0.0 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the corrected shoreline length to account for omitted transects, 179,450 m, and the 90% LCB of the density, the estimated population of *C. miniata* was 0 sea cucumbers.

Ninety of the 93 transects surveyed had no *C. pallida* observed (Table 6). The mean density was estimated to be 0.1 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the corrected shoreline length of 179,450 m and the 90% LCB of the density, the estimated population of *C. pallida* was 0 sea cucumbers.

Geoduck, Green Sea Urchin and Red Sea Urchin abundance

Relative abundances were estimated for Geoducks, Green Sea Urchins and Red Sea Urchins for all 94 transects surveyed in PFM Subarea 7–18.

‘Abundant’ Geoduck were seen on 19 (20%) transects, ‘Many’ were seen on 12 (13%) transects, ‘Few’ were seen on 12 (13%) transects, and none were observed on 51 (54%) transects (Figure 11a, b).

‘Abundant’ Green Sea Urchins were seen on 3 (3%) transects, ‘Many’ were seen on 4 (4%) transects, ‘Few’ were seen on 40 (43%) transects, and none were observed on 47 (50%) transects (Figure 11a, b). ‘Many’ Red Sea Urchins were seen on 9 (10%) transects, ‘Few’ were seen on 41 (43%) transects, and none were observed on 44 (47%) transects (Figure 11a, b).

PFMA 7–19 (Queens Sound)

Parastichopus californicus

PFM Subarea 7–19, within Thompson Bay, had extremely low *P. californicus* densities throughout the Subarea (Figure 12). A total of 17 of the 19 transects surveyed had a density of 0.00 c/m-sh and all of the 19 transects surveyed had a density of less than 6.0 c/m-sh (the baseline density for the Central Coast; Table 6). The highest density observed was 0.25 c/m-sh and the lowest was 0.00 c/m-sh.

In PFM Subarea 7–19, no shoreline segments were removed due to logistical obstacles or other closures. The DFO Fisheries Management database has a total length for PFM Subarea 7–19 of 32,978 m of which 2,976 m was classified as “exposed” and 30,002 m classified as “protected” by the BC Shorezone classification system.

The mean sea cucumber density for the Analysis Area was estimated to be 0.0 c/m-sh with a 90% LCB of 0.0 c/m-sh (Table 2). No biosamples were collected in Subarea 7–19; therefore the lowest PFM Subarea mean weight from the Queens Sound survey, 325

g, was used for the biomass calculations (Duprey *et al.* 2011). The 90% LCB of the mean biomass estimate was 0 kg for PFM Subarea 7–19 (Table 4).

Cucumaria miniata and *C. pallida*

C. miniata and *C. pallida* numbers were recorded on all 19 transects surveyed in the Subarea. All transects surveyed had no *C. miniata* and no *C. pallida* observed (Table 6). The mean density was therefore 0.0 c/m-sh and the 90% LCB of the bootstrap was 0.0 c/m-sh. Using the entire shoreline lengths of Subarea 7–19 and the 90% LCB of the density, the estimated population was 0 sea cucumbers for both *C. miniata* and *C. pallida*.

Geoduck, Green Sea Urchin and Red Sea Urchin abundance

Relative abundances were estimated for Geoducks, Green Sea Urchins and Red Sea Urchins for all of the 19 transects surveyed in PFM Subarea 7–19.

‘Abundant’ Geoduck were noted on 1 (5%) transect, ‘Many’ on 1 (5%) transect, and none on the remaining 17 (90%) transects (Figure 13).

No Green Sea Urchins were observed in the PFM Subarea (Figure 13). ‘Few’ Red Sea Urchins were seen on 2 (11%) transects, ‘Many’ on 2 (11%) transects and the remaining 15 (78%) transects had no Red Sea Urchin observed (Figure 13).

PFMA 7–25 (Queens Sound)

Parastichopus californicus

PFM Subarea 7–25 had a mixture of high and low densities, with higher densities of *P. californicus* observed in the western section of the Subarea near the McNaughton Group of Islands and Hunter Island, moderate to low densities surrounding the Simonds Group and Prince Group of Islands and extremely low densities in the western portion of the Subarea near the Goose Group of Islands (Figure 14a, b). A total of 98 of the 140 transects had a density of 6.0 c/m-sh (the regional baseline density for the Central Coast) or less (Table 6). The highest density observed was 31.00 c/m-sh and 43 transects had 0.00 c/m-sh.

The DFO Fisheries Management database has a total length for Subarea 7–25 of 279,082 m; 7,014 m of which is classified as “exposed” and 272,068 m of which is classified as “protected” by the BC Shorezone classification system. Twelve transects were not surveyed due to inaccessible or non-navigable waters (transects 48, 49, 50, 51, 52, 82, 83, 137, 138, 139, 140 and 144). A total of 24,000 m of shoreline was removed from the total shoreline length to represent these areas. Therefore, the total shoreline length used for biomass calculations was 7,014 m exposed and 248,068 m of protected shoreline.

The mean sea cucumber density was estimated to be 4.5 c/m-sh with a 90% LCB of 3.8 c/m-sh (Table 2). PFM Subarea 7–25 had an average weight calculated for each of the 11 biosamples (transects 5, 20, 24, 39, 55, 68, 79, 85, 94, 108 and 117; Table 3); the average of these 11 values was 327 g (Table 3). The 90% LCB of the mean biomass estimate was 313,983 kg for PFM Subarea 7–25 (Table 4).

Cucumaria miniata and *C. pallida*

C. miniata and *C. pallida* data were recorded on 129 of the 140 transects surveyed in PFM Subareas 7–25. A total of 111 of the 129 transects surveyed had no *C. miniata* observed and the highest density observed was 52.5 c/m-sh (Table 6). The mean density was estimated to be 0.7 c/m-sh with a 90% LCB of 0.3 c/m-sh. Using the corrected shoreline length of 233,082 for PFM Subarea 7–25 and the 90% LCB of the density, the estimated population of *C. miniata* was 69,925 sea cucumbers.

A total of 106 of the 129 transects surveyed had no *C. pallida* observed and the highest density observed was 52.5.0 c/m-sh (Table 6). The mean density was estimated to be 1.3 c/m-sh with a 90% LCB of 0.7 c/m-sh. Using the corrected shoreline length for PFM Subarea 7–25 and the 90% LCB of the density, the estimated population of *C. pallida* was 163,158 sea cucumbers.

Geoduck, Green Sea Urchin and Red Sea Urchin abundance

Relative abundances were estimated for Geoducks, Green Sea Urchins and Red Sea Urchins for the 140 transects surveyed in PFM Subarea 7–25.

‘Abundant’ Geoduck were observed on 32 (23%) transects, ‘Many’ were observed on 3 (2%) transects, ‘Few’ were observed on 10 (7%) transects, and none were observed on the remaining 95 (68%) transects (Figure 15a, b).

‘Abundant’ Green Sea Urchins were observed on 5 (3%) transects, ‘Many’ were observed on 8 (6%) transects, ‘Few’ were observed on 39 (28%) transects, and none on the remaining 88 (63%) transects (Figure 15a, b). ‘Abundant’ Red Sea Urchins were observed on 9 (6%) transects, ‘Many’ were observed on 24 (17%) transects, ‘Few’ were observed on 47 (34%) transects, and none on the remaining 60 (43%) transects (Figure 15a, b).

Sidney – Sooke Density Surveys – PFMA 19 and 20

PFMA 19–3 (Sidney – Sooke)

Parastichopus californicus

PFM Subarea 19–3 had mostly low densities transects of *P. californicus* with a few high density transects scattered throughout the subarea (Figure 16). A total of 9 of the 13 transects surveyed had a density of 0.5 c/m-sh or less (Table 7). The highest density observed was 40.5 c/m-sh and the lowest was 0.00 c/m-sh.

The DFO Fisheries Management database has a total length for Subarea 19–3 of 35,196 m; 456 m of which is classified as “exposed” and 34,740 m of which is classified as “protected” by the BC Shorezone classification system. Nineteen of the plotted transects were not surveyed (28, 30, 32, 34, 36, 37, 38, 39, 40, 42, 44, 46, 48, 49, 51, 53, 55, 57, and 59); as a result 19,000 m of shoreline were removed from the total shoreline length to represent this area (in Sidney – Sooke each transect represents 1 km of shoreline). Therefore, the total shoreline length used for biomass calculations was 456 m exposed and 15,740 m of protected shoreline.

The mean sea cucumber density was estimated to be 4.8 c/m-sh with a 90% LCB of 1.4 c/m-sh (Table 2). An average weight was calculated from each of the three biosamples (transects 33, 50 and 72; Table 3); the average of these three values was 246 g (Table 3). The 90% LCB of the mean biomass estimate was 5,578 kg (Table 4).

Cucumaria miniata and *C. pallida*

C. miniata and *C. pallida* data were recorded on all 13 transects surveyed in the Subarea. Eleven of the 13 transects surveyed had no *C. miniata* observed and the highest density observed was 21.5 c/m-sh (Table 7). The mean density was estimated to be 1.8 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the total shoreline length of Subarea 19–3 and the 90% LCB of the density, the estimated population of *C. miniata* was 0 sea cucumbers.

No *C. pallida* were observed on the 13 transects surveyed (Table 7). The mean density was therefore 0.0 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the total shoreline length of Subarea 19–3 and the 90% LCB of the density, the estimated population of *C. pallida* was 0 sea cucumbers.

Geoduck, Green Sea Urchin and Red Sea Urchin abundance

Relative abundances were estimated for Geoducks, Green Sea Urchins and Red Sea Urchins for all of the 13 transects surveyed in PFM Subarea 19–3.

‘Many’ Geoduck were observed on 2 (15%) transects, ‘Few’ were observed on 2 (15%) transects, none were observed on the remaining 9 (69%) transects (Figure 17).

‘Many’ Green Sea Urchins were observed on 2 (15%) transects, and none on the remaining 11 (55%) transects (Figure 17). ‘Many’ Red Sea Urchins were observed on 2 (15%) transects, ‘Few’ were observed on 1 (8%) transect, and none on the remaining 10 (77%) transects (Figure 17).

PFMA 19–4 (Sidney – Sooke)

Parastichopus californicus

PFM Subarea 19–4 had low *P. californicus* densities overall, however, there were a few higher density transects near Plumber Passage (Figure 18). Twenty-three of the 28 transects surveyed had a density of less than 4.1 c/m-sh (the regional baseline density for the East Coast of Vancouver Island; Table 7). The highest density observed was 19.50 c/m-sh and the lowest 0.00 c/m-sh.

The DFO Fisheries Management database has a total length for Subarea 19–4 of 48,754 m, all of which is classified as “protected” by the BC Shorezone classification system. Seventeen of the plotted transects were not surveyed (transects 117, 118, 119, 122, 123, 124, 125, 126, 127, 128, 129, 130, 135, 142, 147, 148, and 155); as a result 17,000 m of shoreline were removed from the total shoreline length to represent this area (in Sidney – Sooke each transect represents 1 km of shoreline). Therefore, the total shoreline length used for biomass calculations was 31,754 m of protected shoreline.

The mean sea cucumber density was estimated to be 2.3 c/m-sh with a 90% LCB of 1.3 c/m-sh (Table 2). An average weight was calculated for Subarea 19–4 from one biosample (transect 158; Table 3); the average was 279 g (Table 3). The 90% LCB of the mean biomass estimate for PFM Subarea 19–4 was 11,517 kg (Table 4).

Cucumaria miniata and *C. pallida*

C. miniata and *C. pallida* data were recorded on 20 of the 28 transects surveyed in the PFM Subarea. A total of 18 of the 20 transects surveyed had no *C. miniata* observed and the highest density observed was 3.5 c/m-sh (Table 7). The mean density was estimated to be 0.2 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the corrected shoreline lengths for the PFM Subarea and the 90% LCB of the density, the estimated population of *C. miniata* was 0 sea cucumbers.

No *C. pallida* were observed on the 20 transects surveyed (Table 7). Therefore, the mean density was 0.0 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the total shoreline length for the PFM Subarea and the 90% LCB of the density, the estimated population of *C. pallida* was 0 sea cucumbers.

Geoduck, Green Sea Urchin and Red Sea Urchin abundance

Relative abundances were estimated for Geoducks and Red Sea Urchins on all 28 transects surveyed in the PFM Subarea 19–4, whereas relative abundance of Green Sea Urchins were only estimated on 27 of the 28 transects surveyed in Subarea 19–4.

Geoducks were not observed on any transects in the PFM Subarea (Figure 19).

‘Abundant’ Green Sea Urchin were observed on 2 (7%) transects, ‘Many’ were observed on 5 (19%) transects, ‘Few’ were observed on 3 (11%) transects, and none were observed on the remaining 17 (63%) transects (Figure 19). ‘Abundant’ Red Sea Urchin were observed on 5 (18%) transects, ‘Many’ were observed on 4 (14%) transects, ‘Few’ were observed on 3 (11%) transects, and 16 (57%) transects had none observed (Figure 19).

PFMA 19–5 (Sidney – Sooke)

Parastichopus californicus

PFM Subarea 19–5 had extremely low *P. californicus* densities within Cordova Bay, however due to a very high density on one transect, the Subarea had the highest densities of all the Sidney – Sooke Surveys with the highest densities observed surrounding D’Arcy Island (Figure 20). A total of 12 of the 15 transects surveyed had a density of less than 4.1 c/m-sh (the regional baseline density for the East Coast of Vancouver Island; Table 7). The highest density observed was 55.25 c/m-sh and the lowest 0.00 c/m-sh.

The DFO Fisheries Management database has a total length for Subarea 19–5 of 114,442 m; 239 m of which is classified as “exposed” and 114,203 m of which is classified as “protected” by the BC Shorezone classification system. A large portion of the PFMA Subarea 19–5 was not included in this survey (as mentioned in the area description

above), the total area removed from the PFM Subarea was 86,532 m. Also twelve transects were not surveyed in the remainder of the Subarea (transects 1, 9, 10, 11, 12, 14, 16, 18, 20, 22, 24, and 27); as a result 12,000 m of shoreline was removed to represent these unsurveyed areas (in Sidney – Sooke each transect represents 1 km of shoreline). The total shoreline length used for biomass calculations after the removal of unsurveyed shoreline lengths was 239 m classified as exposed and 15,671 m classified as protected shoreline.

The mean sea cucumber density was estimated to be 4.9 c/m-sh with a 90% LCB of 1.0 c/m-sh (Table 2). No biosamples were collected in Subarea 19–5; therefore the lowest PFM Subarea mean weight from the Sidney – Sooke survey, 243 g, was used for biomass calculations (Duprey *et al.* 2011). The 90% LCB of the mean biomass estimate was 3,866 kg for PFM Subarea 19–5 (Table 4).

Cucumaria miniata and *C. pallida*

C. miniata and *C. pallida* data were recorded on 14 of the 15 transects surveyed in the PFM Subarea. Nine of the 14 transects surveyed had no *C. miniata* observed and the highest density observed was 19.0 c/m-sh (Table 7). The mean density was estimated to be 2.6 c/m-sh with a 90% LCB of 1.0 c/m-sh. Using the corrected shoreline length of the PFM Subarea, 14,910 m, and the 90% LCB of the density, the estimated population of *C. miniata* was 14,910 sea cucumbers.

Eleven of the 14 transects surveyed had no *C. pallida* observed and the highest density observed was 0.5 c/m-sh (Table 7). The mean density was estimated to be 0.1 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the corrected shoreline length of the Subarea and the 90% LCB of the density, the estimated population of *C. pallida* was 0 sea cucumbers.

Geoduck, Green Sea Urchin and Red Sea Urchin abundance

Relative abundances were estimated for Geoducks, Green Sea Urchins and Red Sea Urchins for all 15 transects surveyed in the PFM Subarea 19–5.

‘Many’ Geoduck were observed on 1 (7%) transect, ‘Few’ were observed on 4 (27%) transects, and none were observed on the remaining 10 (67%) transects (Figure 21).

‘Abundant’ Green Sea Urchins were observed on 1 (6%) transect, ‘Many’ on 1 (6%) transect, ‘Few’ were observed on 1 (6%) transect, and none were observed on the remaining 12 (80%) transects (Figure 21). ‘Abundant’ Red Sea Urchins were observed on 1 (6%) transect, ‘Many’ on 1 (6%) transect, ‘Few’ were observed on 1 (6%) transect, and zero on the remaining 12 (80%) transects (Figure 21).

PFMA 20–5 (Sidney – Sooke)

Parastichopus californicus

PFM Subarea 20–5 had low *P. californicus* densities on the western side and eastern side of the survey area with the highest densities observed in Becher Bay and near Beechey Head (Figure 22a, b). A total of 25 of the 34 transects surveyed had a density less than 4.1 c/m-sh (the regional baseline density for the East Coast of Vancouver Island;

Table 7). The highest density observed was 15.00 c/m-sh and the lowest density observed was 0.00 c/m-sh.

The DFO Fisheries Management database has a total length for Subarea 20–5 of 53,575 m; 4,961 m of which is classified as “exposed” and 48,614 m of which is classified as “protected” by the BC Shorezone classification system. Twenty-three of the plotted transects were not surveyed (transects 62, 64, 66, 69, 76, 78, 80, 87, 88, 90, 91, 92, 100, 102, 105, 106, 107, 108, 110, 112, 113, 115, and 116); as a result 23,000 m of shoreline was removed to represent these unsurveyed areas (in Sidney – Sooke each transect represents 1 km of shoreline). Therefore, the total shoreline length used for biomass calculations was 4,961 m exposed and 25,614 m of protected shoreline.

The mean sea cucumber density was estimated to be 2.9 c/m-sh with a 90% LCB of 1.9 c/m-sh (Table 2). An average weight was calculated for the two biosamples collected (transects 82 and 97; Table 3); the average was 243 g (Table 3). The 90% LCB of the mean biomass estimate was 14,116 kg for Subarea 20–5 (Table 4).

Cucumaria miniata and *C. pallida*

C. miniata and *C. pallida* data were recorded on 33 of the 34 transects surveyed in the PFM Subarea. Twenty-nine of the 33 transects surveyed had no *C. miniata* observed and the highest density observed was 3.5 c/m-sh (Table 7). The mean density was estimated to be 0.3 c/m-sh with a 90% LCB of 0.1 c/m-sh. Using the corrected shoreline length of Subarea 20–5 and the 90% LCB of the density, the estimated population of *C. miniata* was 2,958 sea cucumbers.

No *C. pallida* were observed on the 33 transects surveyed (Table 7). The mean density was therefore 0.0 c/m-sh with a 90% LCB of 0.0 c/m-sh. Using the corrected shoreline length of Subarea 20–5 and the 90% LCB of the density, the estimated population of *C. pallida* was 0 sea cucumbers.

Geoduck, Green Sea Urchin and Red Sea Urchin abundance

Relative abundances were estimated for Geoducks on all 34 transects surveyed in PFM Subarea 20–5. Relative abundances were estimated for Green Sea Urchins and Red Sea Urchins on 33 of the 34 transects surveyed in Subarea 20–5.

‘Many’ Geoduck were observed on 6 (18%) transects, ‘Few’ were observed on 1 (3%) transect, and the remaining 27 (79%) transects had no Geoduck observed (Figure 23a, b).

‘Abundant’ Green Sea Urchins were observed on 3 (9%) transects, ‘Many’ were observed on 5 (15%) transects, ‘Few’ were observed on 1 (3%) transect, and on 24 (73%) transects no Green Sea Urchin were observed (Figure 23a, b). ‘Abundant’ Red Sea Urchins were observed on 3 (9%) transects, ‘Many’ were observed on 4 (12%) transects, ‘Few’ were observed on 2 (6%) transects, and none were observed on the remaining 24 (73%) transects (Figure 23a, b).

DISCUSSION

Results of the surveys presented in this report are discussed in relation to policy recommendations in the sea cucumber assessment framework (Duprey et al. 2011). The recommendations that are specific to biomass estimation include a minimum density threshold for opening to commercial harvest of 2.5 c/m-sh, and use of the 90% LCB of the estimated mean density and the mean weight estimates for biomass estimation (Duprey et al. 2011).

Laredo Channel

The estimated densities of *P. californicus* in the Laredo Channel survey were low, however four out of the five surveyed PFM Subareas had bootstrapped 90% LCBs equal to or higher than 2.50 c/m-sh. PFM Subarea 6–15 had a bootstrapped 90% LCB of the estimated density of less than 2.50 c/m-sh. The other four PFM Subareas, 6–11, 6–12, 6–14, and 6–16 had 90% LCBs of the bootstrapped estimated densities that were only approximately half or less than the regional baseline used for the North Coast region, 6.0 c/m-sh (Duprey et al. 2011). This area has remained open to commercial harvesting of *P. californicus* since 1997 as part of the 25% of the BC coast open during Phase 1 of the fishery. As this was the first time the area had been surveyed, it is not possible to determine how the population has changed since 1997.

Queens Sound

The estimated densities of *P. californicus* in the Queens Sound survey were also low and all but one PFM Subarea had 90% LCBs of the bootstrapped estimated density lower than 2.50 c/m-sh. The only PFM Subarea in the Queens Sound survey that had 90% LCBs that exceeded 2.50 c/m-sh was PFM Subarea 7–25 and this area was still below the regional baseline used for the Central Coast region, 6.0 c/m-sh (Duprey et al. 2011). The Queen Sound area is part of the coastline that has remained open to commercial harvesting of *P. californicus* since 1997, part of the 25% of the BC coast open during Phase 1 of the fishery. As this was the first time the area had been surveyed, it is not possible to determine how the population has changed since 1997.

Sidney – Sooke

The results for the Sidney – Sooke survey indicated low densities, overall. None of the four PFM Subareas had 90% LCB bootstrapped estimated densities above 2.50 c/m-sh. However, it should be noted that some subareas, namely PFM Subarea 19–3 and 19–5 exhibited higher mean linear densities of 4.8 and 4.9 c/m-sh, respectively. This was due to a few extremely high density transects in concentrated areas within the subarea, leading to higher observed means, but not into higher 90% LCBs of the bootstrapped values. In addition, a large portion of the PFM Subarea 19–5 was not included in the survey and was consequently removed from the biomass calculations.

ACKNOWLEDGEMENTS

Many vessels and crew contributed to collecting the data presented in this report and their efforts and dedication is much appreciated. Thank you to the many divers and skippers who were active in collecting data on the 3 surveys; Lawrence Anderson, Mike Atkins, Steve Gagnon, Joel Harding, Ken Ridgway Jr., Sigi Scheer, and Jeff Sparks. Surveys were conducted through a close partnership with the Pacific Sea Cucumber Harvesting Association and much of this work would not have been possible without their continued financial and logistical support. This manuscript was improved by the reviews and comments by Brenda Waddell.

LITERATURE CITED

- Boutillier, J.A., Campbell, A., Harbo, R., and Neifer, S. 1998. Scientific advice for management of the sea cucumber (*Parastichopus californicus*) fishery in British Columbia. In Invertebrate Working Papers reviewed by the Pacific Stock Assessment Review Committee (PSARC) in 1996. Edited by G.E. Gillespie and L.C. Walters. Can. Tech. Rep. Fish. Aquat. Sci. 2221. pp. 309-340.
(<http://www.dfo-mpo.gc.ca/Library/230784.pdf>) (last accessed 13 September, 2016).
- DFO. 2014. Pacific Region. Integrated Fishery Management Plan. Sea Cucumber By Dive. October 1, 2014 to September 30, 2015.
(<http://www.dfo-mpo.gc.ca/Library/356289.pdf>) (last accessed 13 September, 2016).
- Duprey, N.M.T. 2011. Sea Cucumber biomass estimations from surveys completed June 2009 to May 2010. Can. Manuscr. Rep. Fish. Aquat. Sci. 2954: viii + 97 p.
(<http://www.dfo-mpo.gc.ca/Library/344269.pdf>) (last accessed 13 September, 2016).
- Duprey, N.M.T. 2012. Sea Cucumber biomass estimations from surveys completed June 2010 to May 2011. Can. Manuscr. Rep. Fish. Aquat. Sci. 2960: xi + 150 p.
(<http://www.dfo-mpo.gc.ca/Library/346266.pdf>) (last accessed 13 September, 2016).
- Duprey, N.M.T. 2014. Biomass estimates for sea cucumbers (*Parastichopus californicus*, *Cucumaria miniata*, *C. pallida*) as determined through surveys conducted June 2011 to May 2012. Can. Manuscr. Rep. Fish. Aquat. Sci. 3017: xi + 155 p.
(<http://www.dfo-mpo.gc.ca/Library/355478.pdf>) (last accessed 13 September, 2016)
- Duprey, N.M.T., and Stanton, L.M. 2015. Biomass estimates for sea cucumbers (*Parastichopus californicus*, *Cucumaria miniata*, *C. pallida*) as determined through surveys conducted June 2012 to May 2013. Can. Manuscr. Rep. Fish. Aquat. Sci. 3083: viii + 109p. (<http://www.dfo-mpo.gc.ca/Library/355478.pdf>). (last accessed 13 September, 2016)

- Duprey, N.M.T., Hand, C.M., Lohead, J., and Hajas, W. 2011. Assessment framework for sea cucumber (*Parastichopus californicus*) in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/105. 44 p. (http://www.dfo-mpo.gc.ca/csas-sccs/Publications/ResDocs-DocRech/2010/2010_105-eng.html) (last accessed 13 September, 2016).
- Hand, C.M., Hajas, W., Duprey, N., Lohead, J., Deault, J., and Caldwell, J. 2009. An evaluation of fishery and research data collected during the Phase 1 sea cucumber fishery in British Columbia 1998 to 2007. DFO Can. Sci. Advis. Sec. Res. Doc. 2008/065. 125 p. (http://www.dfo-mpo.gc.ca/csas-sccs/publications/resdocs-docrech/2008/2008_065-eng.htm) (last accessed 13 September, 2016).
- Hand, C.M., and Rogers, J. 1999. Sea Cucumber Phase 1 fishery progress report. DFO Can. Sci. Advis. Sec. Res. Doc. 1999/141. 26 p. (http://www.dfo-mpo.gc.ca/csas-sccs/publications/resdocs-docrech/1999/1999_141-eng.htm) (last accessed 13 September, 2016).
- Perry, R.I., Walters, C.J., and Boutillier, J.A. 1999. A framework for providing scientific advice for the management of new and developing invertebrate fisheries. Reviews in Fish Biology and Fisheries **9**: 125–150.
- Phillips, A.C., and Boutillier, J.A. 1998. Stock assessment and quota options for the sea cucumber fishery. In Invertebrate Working Papers reviewed by the Pacific Stock Assessment Review Committee (PSARC) in 1995. Part 2. Echinoderms. Edited by B.J. Waddell, G.E. Gillespie, and L.C. Walther. Can. Tech. Rep. Fish. Aquat. Sci. 2215. pp. 147-167. (<http://www.dfo-mpo.gc.ca/Library/235572.pdf>) (last accessed 13 September, 2016).

Table 1. Total number and ID of transects surveyed, and number of *Parastichopus californicus* biosamples collected in Open surveys conducted June 2013 – May 2014, by Pacific Fishery Management (PFM) subarea. The total shoreline length is measured from the cucland.shp dataset using ArcGIS 9.3. (Note this is different from the shoreline length used for biomass calculations, which was measured using Compugrid).

Analysis Areas	Survey	PFM Subareas	Shoreline Length (Km)	Number (and ID) of Transects	Biosamples
1	Laredo Channel	6–11	10.8	6 (TR 107–112)	1
	Laredo Channel	6–14	62.7	29 (TR 75–106)	3
2	Laredo Channel	6–12	125.7	58 (TR 113–175)	5
3	Laredo Channel	6–15	34.3	17 (TR 58–74)	2
4	Laredo Channel	6–16	112.8	54 (TR 1–57)	5
5	Queens Sound	7–18	203.9	94 (TR 153–254)	6
6	Queens Sound	7–19	36.7	19 (TR 255–273)	0
7	Queens Sound	7–25	303.7	140 (TR 1–152)	11
8	Sidney – Sooke	19–3	31.9	13 (TR 29–59)	3
9	Sidney – Sooke	19–4	46.5	28 (TR 120–161)	1
10	Sidney – Sooke	19–5	25.9	15 (TR 2–26)	0
11	Sidney – Sooke	20–5	57.0	34 (TR 60–115)	2
Total		12	1051.9	507	39

Table 2. Mean linear *Parastichopus californicus* density estimates by PFM Subarea, with lower (LCB) and upper (UCB) confidence bounds (sea cucumbers per metre of shoreline: c/m-sh) from Open surveys completed June 2013 – May 2014. Each PFM Subarea was analyzed separately except those shown with *, which indicates that the transects were pooled into Analysis Areas.

PFM Subarea	Survey	No. Transects	Mean	Confidence Level	LCB	UCB
6-11&14	Laredo Channel	35	3.6	99	2.5	5.6
				95	2.7	5.1
				90	2.8	4.8
				75	3.0	4.4
6-12	Laredo Channel	58	3.9	99	2.9	5.7
				95	3.1	5.2
				90	3.2	4.9
				75	3.4	4.6
6-15	Laredo Channel	17	2.3	99	1.3	3.7
				95	1.4	3.3
				90	1.5	3.2
				75	1.7	2.9
6-16	Laredo Channel	54	3.3	99	2.2	4.9
				95	2.4	4.7
				90	2.5	4.4
				75	2.7	4.1
7-18	Queen Sounds	94	3.1	99	2.0	4.4
				95	2.3	4.0
				90	2.4	3.8
				75	2.6	3.6
7-19	Queen Sounds	19	0.0	99	0.0	0.1
				95	0.0	0.0
				90	0.0	0.0
				75	0.0	0.0
7-25	Queen Sounds	140	4.5	99	3.4	5.9
				95	3.7	5.6
				90	3.8	5.4
				75	4.0	5.1

Table 2, cont'd.

PFMA Subarea	Survey	No. Transects	Mean	Confidence Level	LCB	UCB
19-3	Sidney – Sooke	13	4.8	99	0.8	14.7
				95	1.2	14.4
				90	1.4	13.6
				75	2.0	10.8
19-4	Sidney – Sooke	28	2.3	99	1.0	5.6
				95	1.2	4.7
				90	1.3	4.2
				75	1.6	3.6
19-5	Sidney – Sooke	15	4.9	99	0.4	18.6
				95	0.8	18.9
				90	1.0	16.3
				75	1.6	12.4
20-5	Sidney – Sooke	34	2.9	99	1.5	5.0
				95	1.7	4.5
				90	1.9	4.3
				75	2.2	3.8

Table 3. Estimated mean weight of individual *Parastichopus californicus* from biosamples collected during June 2013 – May 2014. The “subarea mean” is the mean weight of all the transect averages located within the subarea, and is used for biomass calculations (Duprey et al. 2011).

PFMA Subarea	Survey	Transect no.	Average (g)	SD (g)	Subarea mean (g)
6-11	Laredo Channel	11	263.7	58.08	264
6-12	Laredo Channel	123	425.6	121.79	274
6-12	Laredo Channel	126	173.9	64.23	
6-12	Laredo Channel	136	231.0	104.78	
6-12	Laredo Channel	144	292.2	83.34	
6-12	Laredo Channel	172	247.4	55.52	
6-14	Laredo Channel	77	241.0	51.24	204
6-14	Laredo Channel	92	156.0	73.35	
6-14	Laredo Channel	102	215.0	86.84	
6-15	Laredo Channel	63	383.4	146.59	316
6-15	Laredo Channel	70	249.2	59.53	
6-16	Laredo Channel	9	197.2	41.61	279
6-16	Laredo Channel	19	288.4	79.48	
6-16	Laredo Channel	22	304.2	61.02	
6-16	Laredo Channel	34	212.3	61.46	
6-16	Laredo Channel	47	394.0	139.31	
7-18	Queens Sound	190	283.4	114.49	325
7-18	Queens Sound	202	206.6	92.31	
7-18	Queens Sound	210	366.7	134.06	
7-18	Queens Sound	215	365.4	82.00	
7-18	Queens Sound	229	410.8	124.44	
7-18	Queens Sound	236	320.0	99.33	
7-25	Queens Sound	5	289.8	97.84	327
7-25	Queens Sound	20	375.5	149.15	
7-25	Queens Sound	24	337.8	92.79	
7-25	Queens Sound	39	415.4	91.46	
7-25	Queens Sound	55	336.6	180.00	
7-25	Queens Sound	68	332.0	74.48	
7-25	Queens Sound	79	299.4	91.61	
7-25	Queens Sound	85	255.1	50.76	
7-25	Queens Sound	94	423.3	101.64	
7-25	Queens Sound	108	292.8	83.86	
7-25	Queens Sound	117	235.0	77.35	
19-3	Sidney – Sooke	33	214.1	30.46	246
19-3	Sidney – Sooke	50	273.5	106.03	
19-3	Sidney – Sooke	72	249.0	56.88	
19-4	Sidney – Sooke	158	278.5	77.41	279
20-5	Sidney – Sooke	82	276.9	62.57	243
20-5	Sidney – Sooke	97	208.6	51.39	

Table 4. Biomass estimates from Open surveys conducted June 2013 – May 2014. Biosamples were not collected from all subareas; the lowest Wt_{mean} in the same survey was used as Wt_{mean} for subareas marked with an *(Duprey et al. 2011).

PFMA	Survey	Shoreline Length - exposed	Shoreline Length - protected	Confidence Level	Biomass (kg) LCB	Biomass (kg) UCB
6–11	Laredo Channel	0	11,206	99	7,396	16,567
				95	7,988	15,088
				90	8,283	14,200
				75	8,875	13,017
6–12	Laredo Channel	0	96,882	99	76,982	151,310
				95	82,292	138,037
				90	84,946	130,074
				75	90,255	122,110
6–14	Laredo Channel	0	54,413	99	27,751	62,161
				95	29,971	56,611
				90	31,081	53,281
				75	33,301	48,841
6–15	Laredo Channel	0	39,866	99	16,377	46,611
				95	17,637	41,572
				90	18,896	40,312
				75	21,416	36,533
6–16	Laredo Channel	18,243	85,982	99	63,973	130,270
				95	69,789	125,473
				90	72,697	118,276
				75	77,495	111,079
7–18	Queens Sound	5,419	176,033	99	117,943	256,129
				95	135,634	233,244
				90	141,531	221,802
				75	153,149	210,360
7–19	Queens Sound	2,976	30,002	99	0	1,072
				95	0	0
				90	0	0
				75	0	0
7–25	Queens Sound	7,014	248,068	99	281,536	484,332
				95	305,871	459,996
				90	313,983	443,772
				75	330,207	419,437

Table 4, cont'd.

PFMA	Survey	Shoreline Length - exposed	Shoreline Length - protected	Confidence Level	Biomass (kg) LCB	Biomass (kg) UCB
19-3	Sidney – Sooke	456	15,740	99	3,187	57,199
				95	4,781	56,038
				90	5,578	52,940
				75	7,968	42,098
19-4	Sidney – Sooke	0	31,754	99	8,859	49,612
				95	10,631	41,639
				90	11,517	37,209
				75	14,175	31,894
19-5*	Sidney – Sooke	239	15,671	99	1,546	70,975
				95	3,093	72,117
				90	3,866	62,216
				75	6,186	47,365
20-5	Sidney – Sooke	4,961	25,614	99	11,145	34,135
				95	12,631	31,023
				90	14,116	29,778
				75	16,345	26,666

Table 5. Linear density (sea cucumbers per meter shoreline; c/m-sh) for *Parastichopus californicus*, *Cucumaria miniata* and *C. pallida*, by transect in the Laredo Channel survey.

Survey	PFMA	Subarea	Transect No.	Linear Density (c/m-sh)		
				<i>P. californicus</i>	<i>C. miniata</i>	<i>C. pallida</i>
Laredo Channel	6	16	1	1.25	0.0	0.0
Laredo Channel	6	16	2	1.50	0.0	0.0
Laredo Channel	6	16	3	1.25	0.0	0.0
Laredo Channel	6	16	4	3.25	0.0	0.0
Laredo Channel	6	16	5	1.50	0.0	0.0
Laredo Channel	6	16	6	4.25	0.0	0.0
Laredo Channel	6	16	7	10.50	0.0	0.0
Laredo Channel	6	16	8	0.50	0.0	0.0
Laredo Channel	6	16	9	4.25	0.0	0.0
Laredo Channel	6	16	10	0.00	0.0	0.0
Laredo Channel	6	16	11	0.00	0.0	0.0
Laredo Channel	6	16	12	0.25	0.0	0.0
Laredo Channel	6	16	13	0.00	0.0	0.0
Laredo Channel	6	16	14	2.75	0.0	0.0
Laredo Channel	6	16	15	0.00	0.0	0.0
Laredo Channel	6	16	16	2.25	0.0	0.0
Laredo Channel	6	16	17	2.75	0.0	0.0
Laredo Channel	6	16	18	3.25	0.0	0.0
Laredo Channel	6	16	19	4.00	0.0	0.0
Laredo Channel	6	16	20	1.00	0.0	0.0
Laredo Channel	6	16	21	5.50	0.0	0.0
Laredo Channel	6	16	22	7.00	0.0	0.0
Laredo Channel	6	16	23	0.25	0.0	0.0
Laredo Channel	6	16	24	1.25	0.0	0.0
Laredo Channel	6	16	25	0.00	0.0	0.0
Laredo Channel	6	16	26	3.00	0.0	0.0
Laredo Channel	6	16	27	0.50	0.0	0.0
Laredo Channel	6	16	29	9.50	0.0	0.0
Laredo Channel	6	16	30	15.50	0.0	0.0
Laredo Channel	6	16	31	14.25	0.0	0.0
Laredo Channel	6	16	32	0.25	0.0	0.0
Laredo Channel	6	16	33	0.50	0.0	0.0
Laredo Channel	6	16	34	6.75	0.0	0.0
Laredo Channel	6	16	35	3.00	0.0	0.0
Laredo Channel	6	16	37	9.50	0.0	0.0
Laredo Channel	6	16	38	2.50	0.0	0.0
Laredo Channel	6	16	39	6.50	0.0	0.0
Laredo Channel	6	16	40	0.00	0.0	0.0
Laredo Channel	6	16	41	0.00	0.0	0.0
Laredo Channel	6	16	42	0.00	0.0	0.0
Laredo Channel	6	16	43	0.00	0.0	0.0
Laredo Channel	6	16	45	0.00	0.0	0.0
Laredo Channel	6	16	46	0.00	0.0	0.0
Laredo Channel	6	16	47	3.00	0.0	0.0
Laredo Channel	6	16	48	18.75	0.0	0.0
Laredo Channel	6	16	49	4.50	0.0	0.0
Laredo Channel	6	16	50	5.75	0.0	0.0
Laredo Channel	6	16	51	0.00	0.0	0.0

Table 5, Laredo Channel cont'd.

Survey	PFMA	Subarea	Transect No.	Linear Density (c/m-sh)		
				<i>P. californicus</i>	<i>C. miniata</i>	<i>C. pallida</i>
Laredo Channel	6	16	52	0.00	0.0	0.0
Laredo Channel	6	16	53	0.00	0.0	0.0
Laredo Channel	6	16	54	8.25	0.0	0.0
Laredo Channel	6	16	55	2.25	0.0	0.0
Laredo Channel	6	16	56	5.50	0.0	0.0
Laredo Channel	6	16	57	2.50	0.0	0.0
Laredo Channel	6	15	58	2.00	0.0	0.0
Laredo Channel	6	15	59	3.50	0.0	0.0
Laredo Channel	6	15	60	6.75	0.0	0.0
Laredo Channel	6	15	61	0.00	0.0	0.0
Laredo Channel	6	15	62	0.00	0.0	0.0
Laredo Channel	6	15	63	1.75	0.0	0.0
Laredo Channel	6	15	64	5.75	2.5	0.0
Laredo Channel	6	15	65	2.25	0.0	0.0
Laredo Channel	6	15	66	0.00	0.0	0.0
Laredo Channel	6	15	67	1.75	0.0	0.0
Laredo Channel	6	15	68	1.00	0.0	0.0
Laredo Channel	6	15	69	4.25	0.0	0.0
Laredo Channel	6	15	70	4.00	0.0	0.0
Laredo Channel	6	15	71	3.00	0.0	0.0
Laredo Channel	6	15	72	2.75	0.0	0.0
Laredo Channel	6	15	73	0.00	0.0	0.0
Laredo Channel	6	15	74	0.00	0.0	0.0
Laredo Channel	6	14	75	1.00	0.0	0.0
Laredo Channel	6	14	76	17.75	0.0	0.0
Laredo Channel	6	14	77	2.75	0.0	0.0
Laredo Channel	6	14	78	2.75	0.0	0.0
Laredo Channel	6	14	79	1.50	0.0	0.0
Laredo Channel	6	14	80	0.25	0.0	0.0
Laredo Channel	6	14	81	4.75	0.0	0.0
Laredo Channel	6	14	82	0.75	0.0	0.0
Laredo Channel	6	14	83	0.75	0.0	0.0
Laredo Channel	6	14	84	1.75	0.0	0.0
Laredo Channel	6	14	85	7.25	0.0	0.0
Laredo Channel	6	14	86	0.50	0.0	0.0
Laredo Channel	6	14	87	5.75	0.0	0.0
Laredo Channel	6	14	88	1.75	0.0	0.0
Laredo Channel	6	14	89	4.25	0.0	0.0
Laredo Channel	6	14	90	0.50	0.0	0.0
Laredo Channel	6	14	91	3.00	0.0	0.0
Laredo Channel	6	14	92	2.75	0.0	0.0
Laredo Channel	6	14	96	6.75	0.0	0.0
Laredo Channel	6	14	97	4.00	0.0	0.0
Laredo Channel	6	14	98	0.75	0.0	0.0
Laredo Channel	6	14	99	1.25	0.0	0.0
Laredo Channel	6	14	100	1.25	0.0	0.0
Laredo Channel	6	14	101	1.25	0.0	0.0
Laredo Channel	6	14	102	10.00	0.0	0.0

Table 5, Laredo Channel cont'd.

Survey	PFMA	Subarea	Transect No.	Linear Density (c/m-sh)		
				<i>P. californicus</i>	<i>C. miniata</i>	<i>C. pallida</i>
Laredo Channel	6	14	103	7.00	0.0	0.0
Laredo Channel	6	14	104	4.75	0.0	0.0
Laredo Channel	6	14	105	3.25	0.0	0.0
Laredo Channel	6	14	106	1.50	0.0	0.0
Laredo Channel	6	11	107	10.00	0.0	0.0
Laredo Channel	6	11	108	2.75	0.0	0.0
Laredo Channel	6	11	109	4.50	0.0	0.0
Laredo Channel	6	11	110	2.25	0.0	0.0
Laredo Channel	6	11	111	2.75	0.0	0.0
Laredo Channel	6	11	112	2.75	0.0	0.0
Laredo Channel	6	12	113	1.75	0.0	0.0
Laredo Channel	6	12	114	11.50	0.0	0.0
Laredo Channel	6	12	115	1.75	0.0	0.0
Laredo Channel	6	12	116	4.00	0.0	0.0
Laredo Channel	6	12	117	3.50	0.0	0.0
Laredo Channel	6	12	118	2.25	0.0	0.0
Laredo Channel	6	12	119	0.25	0.0	0.0
Laredo Channel	6	12	120	0.25	0.0	0.0
Laredo Channel	6	12	121	4.50	0.0	0.0
Laredo Channel	6	12	122	0.25	0.0	0.0
Laredo Channel	6	12	123	16.00	0.0	0.0
Laredo Channel	6	12	124	2.75	0.0	0.0
Laredo Channel	6	12	125	2.75	0.0	0.0
Laredo Channel	6	12	126	6.50	0.0	0.0
Laredo Channel	6	12	127	3.75	0.0	0.0
Laredo Channel	6	12	128	4.50	0.0	0.0
Laredo Channel	6	12	129	1.50	0.0	0.0
Laredo Channel	6	12	130	0.00	0.0	0.0
Laredo Channel	6	12	131	8.50	0.0	0.0
Laredo Channel	6	12	132	7.75	0.0	0.0
Laredo Channel	6	12	133	4.25	0.0	0.0
Laredo Channel	6	12	134	2.50	0.0	0.0
Laredo Channel	6	12	135	0.00	0.0	0.0
Laredo Channel	6	12	136	2.75	0.0	0.0
Laredo Channel	6	12	137	0.50	0.0	0.0
Laredo Channel	6	12	138	4.00	0.0	0.0
Laredo Channel	6	12	139	5.50	0.0	0.0
Laredo Channel	6	12	140	2.00	0.0	0.0
Laredo Channel	6	12	141	0.25	0.0	0.0
Laredo Channel	6	12	142	3.00	0.0	0.0
Laredo Channel	6	12	143	0.25	0.0	0.0
Laredo Channel	6	12	144	2.25	0.0	0.0
Laredo Channel	6	12	145	0.00	0.0	0.0
Laredo Channel	6	12	146	1.25	0.0	0.0
Laredo Channel	6	12	147	2.00	0.0	0.0
Laredo Channel	6	12	148	0.00	0.0	0.0
Laredo Channel	6	12	149	1.25	0.0	0.0
Laredo Channel	6	12	150	2.75	0.0	0.0

Table 5, Laredo Channel cont'd.

Survey	PFMA	Subarea	Transect No.	Linear Density (c/m-sh)		
				<i>P. californicus</i>	<i>C. miniata</i>	<i>C. pallida</i>
Laredo Channel	6	12	151	8.50	0.0	0.0
Laredo Channel	6	12	152	3.75	0.0	0.0
Laredo Channel	6	12	153	6.25	0.0	0.0
Laredo Channel	6	12	154	5.50	0.0	0.0
Laredo Channel	6	12	155	3.00	0.0	0.0
Laredo Channel	6	12	156	2.75	0.0	0.0
Laredo Channel	6	12	157	1.75	0.0	0.0
Laredo Channel	6	12	158	3.25	0.0	0.0
Laredo Channel	6	12	159	0.00	0.0	0.0
Laredo Channel	6	12	163	0.00	0.0	0.0
Laredo Channel	6	12	164	1.50	0.0	0.0
Laredo Channel	6	12	165	5.75	0.0	0.0
Laredo Channel	6	12	166	4.00	0.0	0.0
Laredo Channel	6	12	168	6.50	0.0	0.0
Laredo Channel	6	12	169	12.25	0.0	0.0
Laredo Channel	6	12	171	6.50	0.0	0.0
Laredo Channel	6	12	172	19.75	0.0	0.0
Laredo Channel	6	12	173	5.50	0.0	0.0
Laredo Channel	6	12	174	8.75	0.0	0.0
Laredo Channel	6	12	175	2.75	0.0	0.0

Table 6. Linear density (sea cucumbers per meter shoreline; c/m-sh) for *Parastichopus californicus*, *Cucumaria miniata* and *C. pallida*, by transect, in the Queens Sound survey.

Survey	PFMA	Subarea	Transect No.	Linear Density (c/m-sh)		
				<i>P. californicus</i>	<i>C. miniata</i>	<i>C. pallida</i>
Queens Sound	7	25	1	8.25	1.0	2.5
Queens Sound	7	25	2	16.00	0.5	0.0
Queens Sound	7	25	3	29.75	0.0	0.0
Queens Sound	7	25	4	12.00	8.5	5.5
Queens Sound	7	25	5	12.25	52.5	52.5
Queens Sound	7	25	6	6.00	1.0	2.5
Queens Sound	7	25	7	1.75	5.5	6.0
Queens Sound	7	25	8	7.50	2.5	3.0
Queens Sound	7	25	9	6.50	0.0	0.0
Queens Sound	7	25	10	1.50	5.5	2.5
Queens Sound	7	25	11	1.75	1.0	0.0
Queens Sound	7	25	12	2.50	2.0	0.5
Queens Sound	7	25	13	31.00	6.5	7.5
Queens Sound	7	25	14	8.50	1.0	0.0
Queens Sound	7	25	15	0.25	0.0	0.0
Queens Sound	7	25	16	2.25	0.0	0.0
Queens Sound	7	25	17	3.00	0.5	0.0
Queens Sound	7	25	18	11.50	1.0	0.5
Queens Sound	7	25	19	9.25	0.0	0.0
Queens Sound	7	25	20	22.75	0.0	0.0
Queens Sound	7	25	21	12.75	0.0	0.0
Queens Sound	7	25	22	7.25	0.0	0.0
Queens Sound	7	25	23	6.50	0.0	0.0
Queens Sound	7	25	24	4.00	0.0	0.0
Queens Sound	7	25	25	9.25	0.0	0.0
Queens Sound	7	25	26	10.25	0.0	0.0
Queens Sound	7	25	27	10.75	0.0	0.0
Queens Sound	7	25	28	1.50	0.0	0.0
Queens Sound	7	25	29	7.00	0.0	0.0
Queens Sound	7	25	30	6.75	0.0	0.0
Queens Sound	7	25	31	5.00	0.0	0.0
Queens Sound	7	25	32	1.50	0.0	0.0
Queens Sound	7	25	33	2.75	0.0	0.0
Queens Sound	7	25	34	2.50	0.0	0.0
Queens Sound	7	25	35	1.75	0.0	0.0
Queens Sound	7	25	36	6.50	0.0	0.0
Queens Sound	7	25	37	10.25	0.0	0.0
Queens Sound	7	25	38	5.50	0.0	0.0
Queens Sound	7	25	39	4.50	0.0	0.0
Queens Sound	7	25	40	10.75	0.0	0.0
Queens Sound	7	25	41	7.50	0.0	0.0
Queens Sound	7	25	42	10.75	0.0	0.0
Queens Sound	7	25	43	8.75	0.0	0.0
Queens Sound	7	25	44	3.50	0.0	0.0
Queens Sound	7	25	45	4.00	0.0	0.0
Queens Sound	7	25	46	4.25	0.0	0.0
Queens Sound	7	25	47	0.75	0.0	0.0
Queens Sound	7	25	53	0.00	0.0	0.0

Table 6, Queens Sound survey cont'd.

Survey	PFMA	Subarea	Transect No.	Linear Density (c/m-sh)		
				<i>P. californicus</i>	<i>C. miniata</i>	<i>C. pallida</i>
Queens Sound	7	25	54	2.00	0.0	0.0
Queens Sound	7	25	55	7.00	0.0	0.0
Queens Sound	7	25	56	5.00	0.0	0.0
Queens Sound	7	25	57	6.00	0.0	0.0
Queens Sound	7	25	58	28.25	0.0	0.0
Queens Sound	7	25	59	16.00	0.0	0.0
Queens Sound	7	25	60	4.50	0.0	0.0
Queens Sound	7	25	61	5.00	0.0	0.0
Queens Sound	7	25	62	7.25	0.0	0.0
Queens Sound	7	25	63	4.00	0.0	0.0
Queens Sound	7	25	64	0.00	0.0	0.0
Queens Sound	7	25	65	0.50	0.0	0.0
Queens Sound	7	25	66	2.50	0.0	0.0
Queens Sound	7	25	67	0.00	0.0	0.0
Queens Sound	7	25	68	11.75	0.0	38.0
Queens Sound	7	25	69	11.00	0.0	2.0
Queens Sound	7	25	70	0.25	0.0	0.0
Queens Sound	7	25	71	1.25	0.0	0.0
Queens Sound	7	25	72	15.25	0.0	0.0
Queens Sound	7	25	73	3.50	--	--
Queens Sound	7	25	74	2.50	0.0	0.0
Queens Sound	7	25	75	0.00	0.0	0.0
Queens Sound	7	25	76	2.50	0.0	0.0
Queens Sound	7	25	77	5.75	0.0	0.0
Queens Sound	7	25	78	3.50	0.0	1.0
Queens Sound	7	25	79	11.50	0.0	0.0
Queens Sound	7	25	80	10.00	0.0	5.0
Queens Sound	7	25	81	4.50	0.0	0.0
Queens Sound	7	25	84	0.50	0.0	0.0
Queens Sound	7	25	85	1.00	0.0	0.0
Queens Sound	7	25	86	10.25	0.0	0.0
Queens Sound	7	25	87	8.50	0.0	0.0
Queens Sound	7	25	88	5.50	0.0	0.0
Queens Sound	7	25	89	0.00	0.0	0.0
Queens Sound	7	25	90	0.00	0.0	0.0
Queens Sound	7	25	91	0.00	0.0	0.0
Queens Sound	7	25	92	0.00	0.0	0.0
Queens Sound	7	25	93	0.00	0.0	0.0
Queens Sound	7	25	94	13.75	0.0	0.0
Queens Sound	7	25	95	13.25	0.0	0.0
Queens Sound	7	25	96	0.00	0.0	0.0
Queens Sound	7	25	97	0.00	0.0	0.0
Queens Sound	7	25	98	4.00	0.0	0.0
Queens Sound	7	25	99	1.00	0.0	0.0
Queens Sound	7	25	100	2.00	0.0	0.0
Queens Sound	7	25	101	0.00	0.0	0.0
Queens Sound	7	25	102	2.25	0.0	0.0
Queens Sound	7	25	103	1.00	0.0	0.0

Table 6, Queens Sound survey cont'd.

Survey	PFMA	Subarea	Transect No.	Linear Density (c/m-sh)		
				<i>P. californicus</i>	<i>C. miniata</i>	<i>C. pallida</i>
Queens Sound	7	25	104	2.00	1.0	1.5
Queens Sound	7	25	105	1.75	0.0	0.5
Queens Sound	7	25	106	1.25	0.0	8.0
Queens Sound	7	25	107	4.00	1.0	4.0
Queens Sound	7	25	108	2.00	0.0	0.0
Queens Sound	7	25	109	0.00	0.5	2.5
Queens Sound	7	25	110	0.00	0.0	0.0
Queens Sound	7	25	111	0.75	0.0	6.0
Queens Sound	7	25	112	1.50	0.0	0.0
Queens Sound	7	25	113	10.00	0.0	0.0
Queens Sound	7	25	114	4.00	0.0	0.0
Queens Sound	7	25	115	2.25	0.0	2.0
Queens Sound	7	25	116	1.25	0.0	3.0
Queens Sound	7	25	117	2.00	0.5	5.0
Queens Sound	7	25	118	0.00	0.0	0.0
Queens Sound	7	25	119	1.50	0.0	0.0
Queens Sound	7	25	120	0.00	0.0	0.0
Queens Sound	7	25	121	0.00	--	--
Queens Sound	7	25	122	0.00	0.0	0.0
Queens Sound	7	25	123	0.00	0.0	0.0
Queens Sound	7	25	124	0.00	0.0	0.0
Queens Sound	7	25	125	0.00	0.0	0.0
Queens Sound	7	25	126	0.00	0.0	0.0
Queens Sound	7	25	127	0.00	0.0	0.0
Queens Sound	7	25	128	0.00	0.0	0.0
Queens Sound	7	25	129	0.00	0.0	0.0
Queens Sound	7	25	130	0.00	0.0	0.0
Queens Sound	7	25	131	0.00	0.0	0.0
Queens Sound	7	25	132	0.00	0.0	0.0
Queens Sound	7	25	133	0.00	0.0	0.0
Queens Sound	7	25	134	0.00	0.0	0.0
Queens Sound	7	25	135	0.00	0.0	0.0
Queens Sound	7	25	136	0.00	0.0	0.0
Queens Sound	7	25	141	0.00	--	--
Queens Sound	7	25	142	0.00	--	--
Queens Sound	7	25	143	0.00	0.0	0.0
Queens Sound	7	25	145	0.00	0.0	0.0
Queens Sound	7	25	146	0.00	--	--
Queens Sound	7	25	147	0.00	--	--
Queens Sound	7	25	148	0.00	--	--
Queens Sound	7	25	149	0.00	--	--
Queens Sound	7	25	150	0.00	--	--
Queens Sound	7	25	151	0.00	--	--
Queens Sound	7	25	152	0.00	--	--
Queens Sound	7	18	153	0.00	0.0	0.0
Queens Sound	7	18	154	0.00	0.0	0.0
Queens Sound	7	18	156	0.00	0.0	0.0
Queens Sound	7	18	158	0.00	0.0	0.0

Table 6, Queens Sound survey cont'd

Survey	PFMA	Subarea	Transect No.	Linear Density (c/m-sh)		
				<i>P. californicus</i>	<i>C. miniata</i>	<i>C. pallida</i>
Queens Sound	7	18	159	0.00	0.0	0.0
Queens Sound	7	18	161	0.00	0.0	0.0
Queens Sound	7	18	162	0.00	0.0	0.0
Queens Sound	7	18	163	0.00	0.0	0.0
Queens Sound	7	18	164	0.00	0.0	0.0
Queens Sound	7	18	166	0.00	0.0	0.0
Queens Sound	7	18	167	0.00	0.0	0.0
Queens Sound	7	18	168	0.00	0.0	0.0
Queens Sound	7	18	169	0.00	0.0	0.0
Queens Sound	7	18	171	0.00	0.0	0.0
Queens Sound	7	18	172	0.00	0.0	0.0
Queens Sound	7	18	173	0.00	0.0	0.0
Queens Sound	7	18	174	0.00	0.0	0.0
Queens Sound	7	18	175	0.00	0.0	0.0
Queens Sound	7	18	178	0.00	0.0	0.0
Queens Sound	7	18	179	0.00	0.0	0.0
Queens Sound	7	18	180	0.00	0.0	0.0
Queens Sound	7	18	181	0.75	0.0	0.0
Queens Sound	7	18	182	4.75	0.0	0.0
Queens Sound	7	18	183	0.25	0.0	0.0
Queens Sound	7	18	184	3.00	0.0	0.0
Queens Sound	7	18	185	0.00	0.0	0.0
Queens Sound	7	18	186	0.00	0.0	0.0
Queens Sound	7	18	187	0.25	0.0	0.0
Queens Sound	7	18	188	0.00	0.0	0.0
Queens Sound	7	18	189	0.00	0.0	0.0
Queens Sound	7	18	190	1.25	0.0	0.0
Queens Sound	7	18	191	0.50	0.0	0.0
Queens Sound	7	18	192	1.75	0.0	0.0
Queens Sound	7	18	193	0.25	0.0	0.0
Queens Sound	7	18	194	6.75	0.0	0.0
Queens Sound	7	18	195	0.00	0.0	0.0
Queens Sound	7	18	196	0.00	0.0	0.0
Queens Sound	7	18	197	0.50	0.0	0.0
Queens Sound	7	18	198	2.75	0.5	0.0
Queens Sound	7	18	199	5.00	0.5	0.0
Queens Sound	7	18	200	5.25	0.0	0.0
Queens Sound	7	18	201	0.25	0.0	0.0
Queens Sound	7	18	202	1.00	0.0	0.0
Queens Sound	7	18	203	0.50	0.0	0.0
Queens Sound	7	18	204	0.25	0.0	0.0
Queens Sound	7	18	205	9.00	--	--
Queens Sound	7	18	206	5.50	0.0	0.0
Queens Sound	7	18	207	10.75	0.0	0.0
Queens Sound	7	18	208	4.00	0.0	0.0
Queens Sound	7	18	209	1.50	0.0	0.0
Queens Sound	7	18	210	10.75	0.0	0.0
Queens Sound	7	18	211	9.50	0.0	0.0

Table 6, Queens Sound survey cont'd

Survey	PFMA	Subarea	Transect No.	Linear Density (c/m-sh)		
				<i>P. californicus</i>	<i>C. miniata</i>	<i>C. pallida</i>
Queens Sound	7	18	212	23.75	0.0	0.0
Queens Sound	7	18	213	15.50	0.0	0.0
Queens Sound	7	18	214	6.00	0.0	0.0
Queens Sound	7	18	215	7.75	0.0	0.0
Queens Sound	7	18	216	9.75	0.0	0.0
Queens Sound	7	18	217	10.50	0.0	0.0
Queens Sound	7	18	218	10.25	0.0	0.0
Queens Sound	7	18	219	8.00	0.0	0.0
Queens Sound	7	18	220	4.25	0.0	0.0
Queens Sound	7	18	221	8.25	0.0	0.0
Queens Sound	7	18	222	4.75	0.0	0.0
Queens Sound	7	18	223	3.50	0.0	0.0
Queens Sound	7	18	224	6.00	0.0	0.0
Queens Sound	7	18	225	7.75	0.0	0.0
Queens Sound	7	18	226	5.25	0.0	0.0
Queens Sound	7	18	227	2.00	0.0	0.0
Queens Sound	7	18	228	0.00	0.0	0.0
Queens Sound	7	18	229	1.00	0.0	5.5
Queens Sound	7	18	230	12.00	0.0	0.0
Queens Sound	7	18	231	3.50	0.0	1.5
Queens Sound	7	18	232	6.50	0.0	2.5
Queens Sound	7	18	233	6.75	0.0	0.0
Queens Sound	7	18	234	1.50	0.0	0.0
Queens Sound	7	18	235	0.00	0.0	0.0
Queens Sound	7	18	236	3.00	0.0	0.0
Queens Sound	7	18	237	2.00	0.0	0.0
Queens Sound	7	18	238	0.25	0.0	0.0
Queens Sound	7	18	239	3.00	0.0	0.0
Queens Sound	7	18	240	10.50	0.0	0.0
Queens Sound	7	18	241	12.25	0.0	0.0
Queens Sound	7	18	242	3.75	0.0	0.0
Queens Sound	7	18	243	0.25	0.0	0.0
Queens Sound	7	18	244	0.00	0.5	0.0
Queens Sound	7	18	245	1.75	0.0	0.0
Queens Sound	7	18	246	0.50	0.0	0.0
Queens Sound	7	18	247	2.75	0.0	0.0
Queens Sound	7	18	248	0.00	0.0	0.0
Queens Sound	7	18	250	0.00	0.0	0.0
Queens Sound	7	18	251	0.00	0.0	0.0
Queens Sound	7	18	252	0.00	0.0	0.0
Queens Sound	7	18	253	0.00	0.0	0.0
Queens Sound	7	18	254	0.25	0.0	0.0
Queens Sound	7	19	255	0.00	0.0	0.0
Queens Sound	7	19	256	0.00	0.0	0.0
Queens Sound	7	19	257	0.25	0.0	0.0
Queens Sound	7	19	258	0.00	0.0	0.0
Queens Sound	7	19	259	0.00	0.0	0.0
Queens Sound	7	19	260	0.00	0.0	0.0

Table 6, Queens Sound survey cont'd

Survey	PFMA	Subarea	Transect No.	Linear Density (c/m-sh)		
				<i>P. californicus</i>	<i>C. miniata</i>	<i>C. pallida</i>
Queens Sound	7	19	261	0.00	0.0	0.0
Queens Sound	7	19	262	0.00	0.0	0.0
Queens Sound	7	19	263	0.00	0.0	0.0
Queens Sound	7	19	264	0.00	0.0	0.0
Queens Sound	7	19	265	0.00	0.0	0.0
Queens Sound	7	19	266	0.00	0.0	0.0
Queens Sound	7	19	267	0.00	0.0	0.0
Queens Sound	7	19	268	0.25	0.0	0.0
Queens Sound	7	19	269	0.00	0.0	0.0
Queens Sound	7	19	270	0.00	0.0	0.0
Queens Sound	7	19	271	0.00	0.0	0.0
Queens Sound	7	19	272	0.00	0.0	0.0
Queens Sound	7	19	273	0.00	0.0	0.0

Table 7. Linear density (sea cucumbers per meter shoreline; c/m-sh) for *Parastichopus californicus*, *Cucumaria miniata* and *C. pallida*, by transect, in the Sidney - Sooke survey.

Survey	PFMA	Subarea	Transect No.	Linear Density (c/m-sh)		
				<i>P. californicus</i>	<i>C. miniata</i>	<i>C. pallida</i>
Sidney - Sooke	19	5	2	5.00	0.0	0.0
Sidney - Sooke	19	5	3	10.50	19.0	0.5
Sidney - Sooke	19	5	4	0.00	0.0	0.0
Sidney - Sooke	19	5	5	0.50	1.5	0.0
Sidney - Sooke	19	5	6	55.25	8.0	0.5
Sidney - Sooke	19	5	7	0.50	6.0	0.5
Sidney - Sooke	19	5	8	2.00	2.5	0.0
Sidney - Sooke	19	5	13	0.00	0.0	0.0
Sidney - Sooke	19	5	15	0.25	0.0	0.0
Sidney - Sooke	19	5	17	0.00	0.0	0.0
Sidney - Sooke	19	5	19	0.00	0.0	0.0
Sidney - Sooke	19	5	21	0.00	0.0	0.0
Sidney - Sooke	19	5	23	0.00	0.0	0.0
Sidney - Sooke	19	5	25	0.00	0.0	0.0
Sidney - Sooke	19	5	26	0.00	--	--
Sidney - Sooke	19	3	29	4.50	0.0	0.0
Sidney - Sooke	19	3	31	0.50	0.0	0.0
Sidney - Sooke	19	3	33	40.50	21.5	0.0
Sidney - Sooke	19	3	35	9.00	1.5	0.0
Sidney - Sooke	19	3	41	0.00	0.0	0.0
Sidney - Sooke	19	3	43	0.00	0.0	0.0
Sidney - Sooke	19	3	45	0.00	0.0	0.0
Sidney - Sooke	19	3	47	0.00	0.0	0.0
Sidney - Sooke	19	3	50	7.00	0.0	0.0
Sidney - Sooke	19	3	52	0.25	0.0	0.0
Sidney - Sooke	19	3	54	0.25	0.0	0.0
Sidney - Sooke	19	3	56	0.00	0.0	0.0
Sidney - Sooke	19	3	58	0.00	0.0	0.0
Sidney - Sooke	20	5	60	0.00	0.0	0.0
Sidney - Sooke	20	5	61	0.00	0.0	0.0
Sidney - Sooke	20	5	63	0.00	0.0	0.0
Sidney - Sooke	20	5	65	0.00	0.0	0.0
Sidney - Sooke	20	5	67	0.00	0.0	0.0
Sidney - Sooke	20	5	68	4.50	0.0	0.0
Sidney - Sooke	20	5	70	0.00	0.0	0.0
Sidney - Sooke	20	5	71	3.75	0.0	0.0
Sidney - Sooke	20	5	72	7.50	0.0	0.0
Sidney - Sooke	20	5	73	0.00	0.0	0.0
Sidney - Sooke	20	5	74	0.50	0.0	0.0
Sidney - Sooke	20	5	75	6.25	0.0	0.0
Sidney - Sooke	20	5	77	5.00	1.0	0.0
Sidney - Sooke	20	5	79	2.75	3.5	0.0

Table 7, Sidney - Sooke survey cont'd.

Survey	PFMA	Subarea	Transect No.	Linear Density (c/m-sh)		
				<i>P. californicus</i>	<i>C. miniata</i>	<i>C. pallida</i>
Sidney - Sooke	20	5	89	0.00	0.0	0.0
Sidney - Sooke	20	5	93	0.25	0.0	0.0
Sidney - Sooke	20	5	94	0.00	0.0	0.0
Sidney - Sooke	20	5	95	11.75	0.0	0.0
Sidney - Sooke	20	5	96	0.75	0.0	0.0
Sidney - Sooke	20	5	97	6.50	0.0	0.0
Sidney - Sooke	20	5	98	2.75	--	--
Sidney - Sooke	20	5	99	2.25	0.0	0.0
Sidney - Sooke	20	5	101	0.75	0.0	0.0
Sidney - Sooke	20	5	103	0.50	0.0	0.0
Sidney - Sooke	20	5	104	0.50	0.0	0.0
Sidney - Sooke	20	5	109	0.75	0.0	0.0
Sidney - Sooke	20	5	111	0.00	0.0	0.0
Sidney - Sooke	20	5	114	0.00	0.0	0.0
Sidney - Sooke	19	4	120	0.00	0.0	0.0
Sidney - Sooke	19	4	121	0.00	3.5	0.0
Sidney - Sooke	19	4	131	0.25	0.0	0.0
Sidney - Sooke	19	4	132	0.00	0.0	0.0
Sidney - Sooke	19	4	133	0.00	0.0	0.0
Sidney - Sooke	19	4	134	0.25	0.0	0.0
Sidney - Sooke	19	4	136	0.75	0.0	0.0
Sidney - Sooke	19	4	137	3.00	0.0	0.0
Sidney - Sooke	19	4	138	0.25	0.0	0.0
Sidney - Sooke	19	4	139	7.25	0.0	0.0
Sidney - Sooke	19	4	140	0.25	0.0	0.0
Sidney - Sooke	19	4	141	2.50	0.0	0.0
Sidney - Sooke	19	4	143	2.00	0.0	0.0
Sidney - Sooke	19	4	144	0.25	--	--
Sidney - Sooke	19	4	145	3.00	0.0	0.0
Sidney - Sooke	19	4	146	0.00	--	--
Sidney - Sooke	19	4	149	0.00	--	--
Sidney - Sooke	19	4	150	5.75	--	--
Sidney - Sooke	19	4	151	0.00	--	--
Sidney - Sooke	19	4	152	0.25	--	--
Sidney - Sooke	19	4	153	1.50	0.0	0.0
Sidney - Sooke	19	4	154	9.50	0.0	0.0
Sidney - Sooke	19	4	156	0.25	0.0	0.0
Sidney - Sooke	19	4	157	0.75	0.0	0.0
Sidney - Sooke	19	4	158	19.50	1.0	0.0
Sidney - Sooke	19	4	159	0.00	0.0	0.0
Sidney - Sooke	19	4	160	3.25	--	--
Sidney - Sooke	19	4	161	5.25	--	--

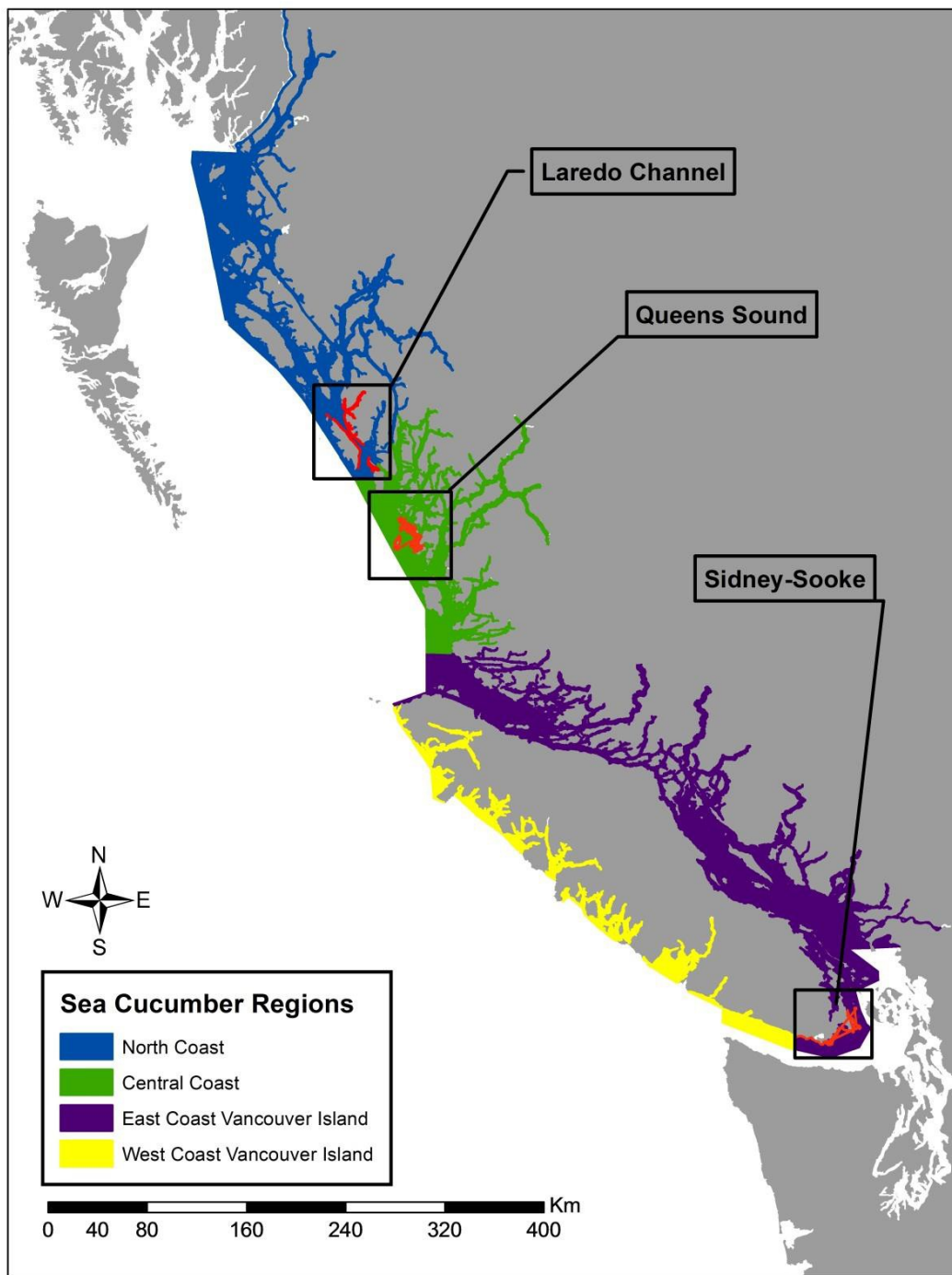


Figure 1. Sea cucumber surveys (highlighted in red) conducted June 2013 to May 2014. Open surveys were conducted in Laredo Channel, Queens Sound and Sidney - Sooke.

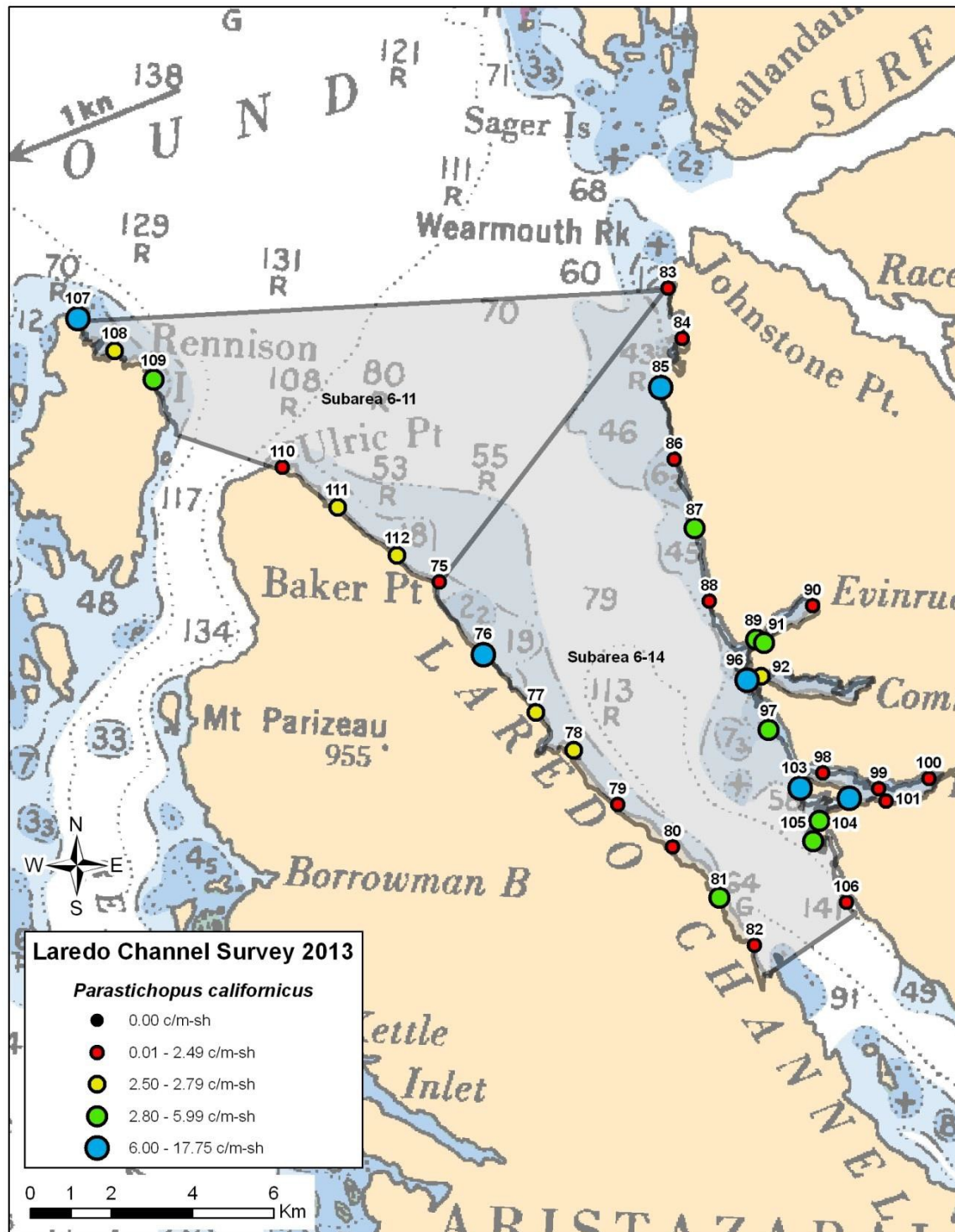


Figure 2. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 6-11 & 6-14, surveyed as part of the Laredo Channel survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the bootstrapped lower 90% confidence bound calculated for the subarea); green = productive locations (densities between the bootstrapped lower 90% confidence bound and the regional baseline density); blue = very productive locations (densities above the regional baseline density).

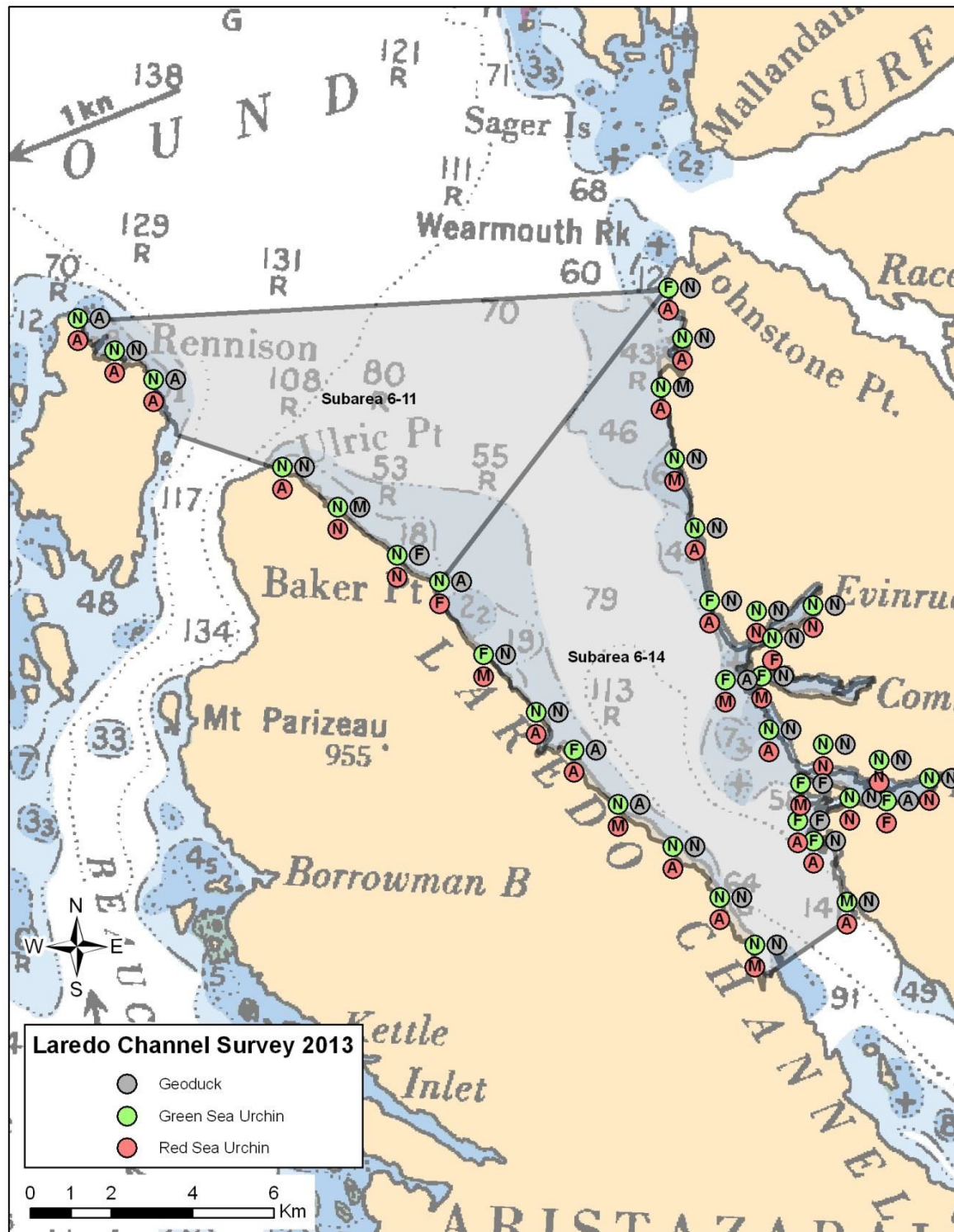


Figure 3. Relative abundance estimates of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 6-11 & 6-14. The number of animals observed while swimming the transect was noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

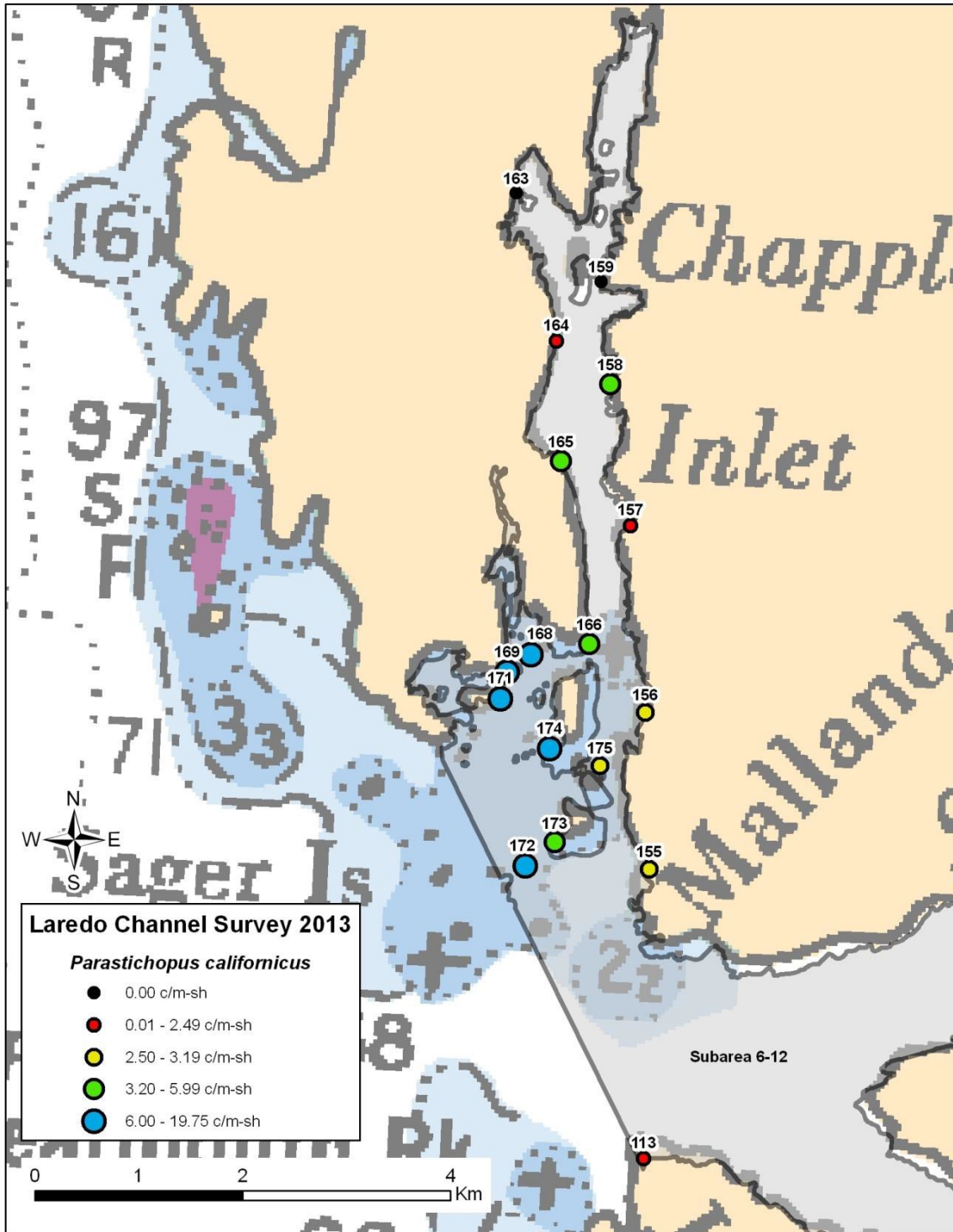


Figure 4a. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 6-12 (western portion), surveyed as part of the Laredo Channel survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the bootstrapped lower 90% confidence bound calculated for the subarea); green = productive locations (densities between the bootstrapped lower 90% confidence bound and the regional baseline density); blue = very productive locations (densities above the regional baseline density).

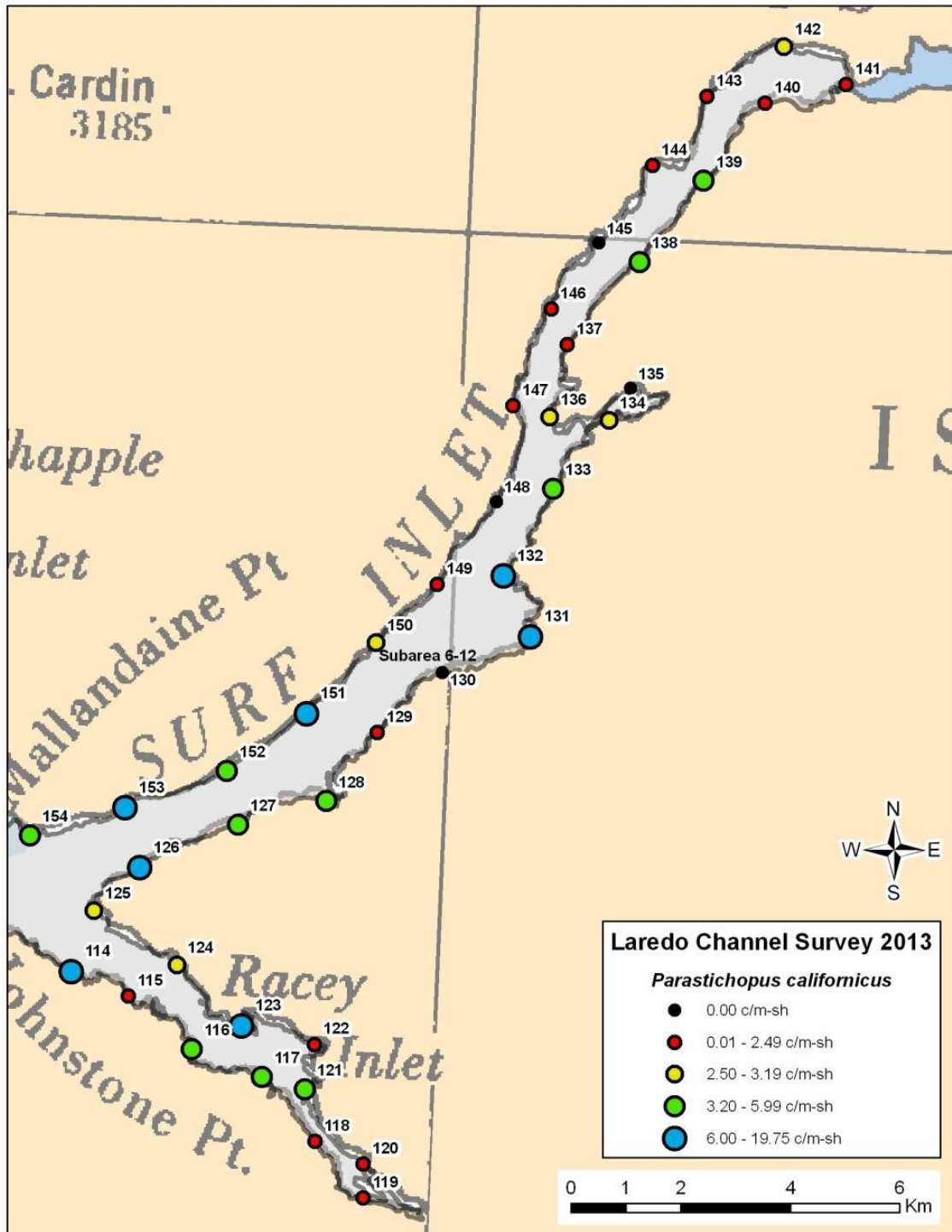


Figure 4b. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 6-12 (eastern portion), surveyed as part of the Laredo Channel survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the bootstrapped lower 90% confidence bound calculated for the subarea); green = productive locations (densities between the bootstrapped lower 90% confidence bound and the regional baseline density); blue = very productive locations (densities above the regional baseline density)

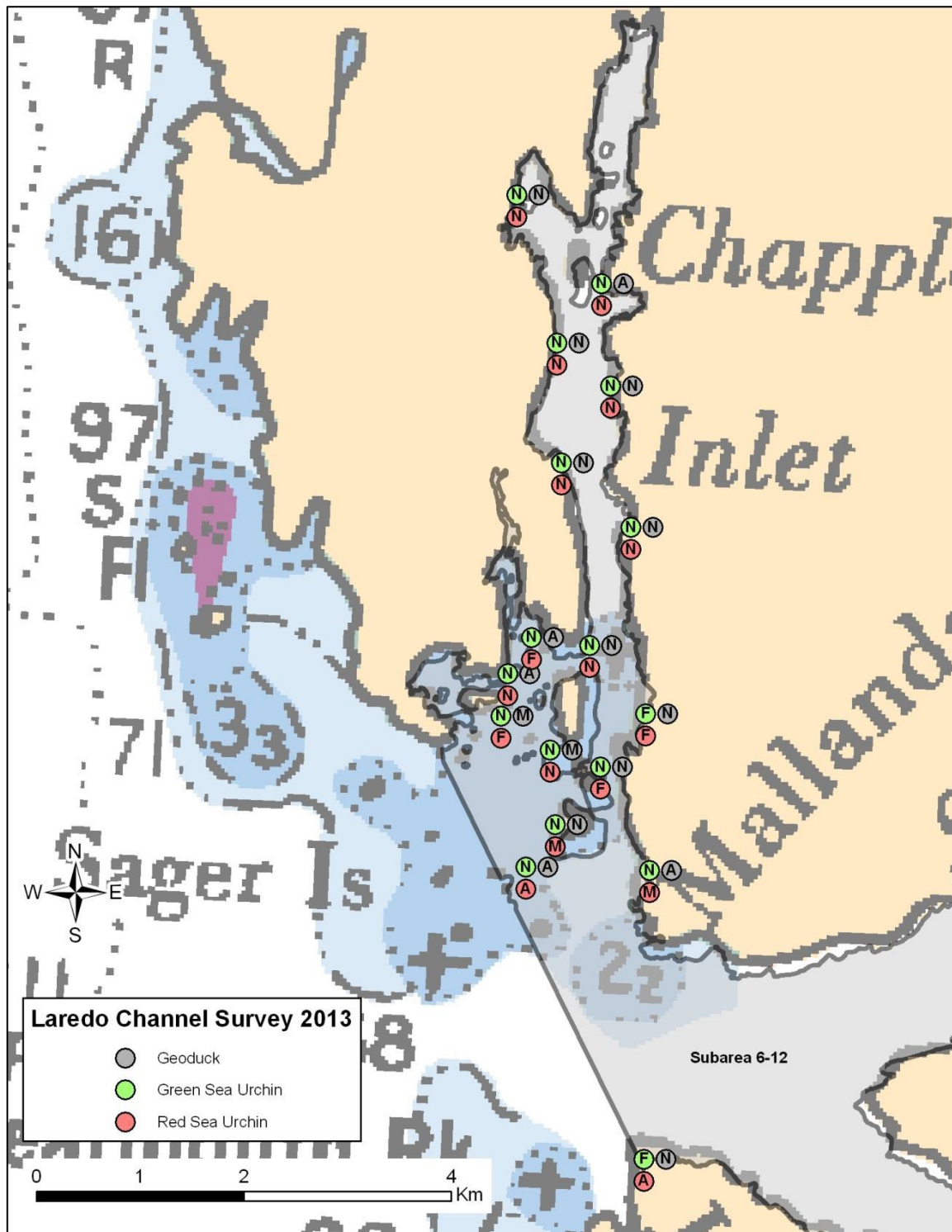


Figure 5a. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 6-12 (western portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

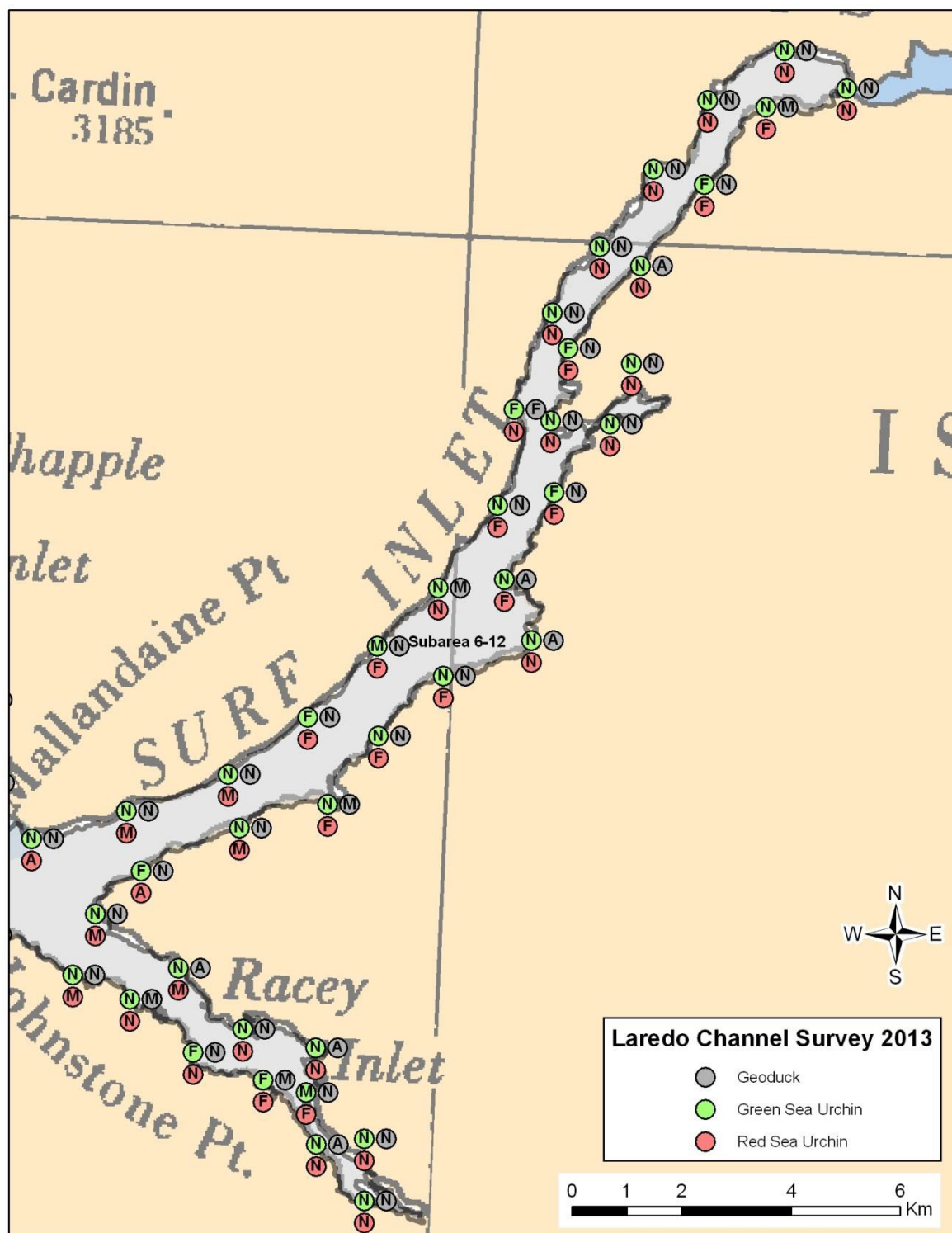


Figure 5b. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in part of PFMA 6-12 (eastern portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

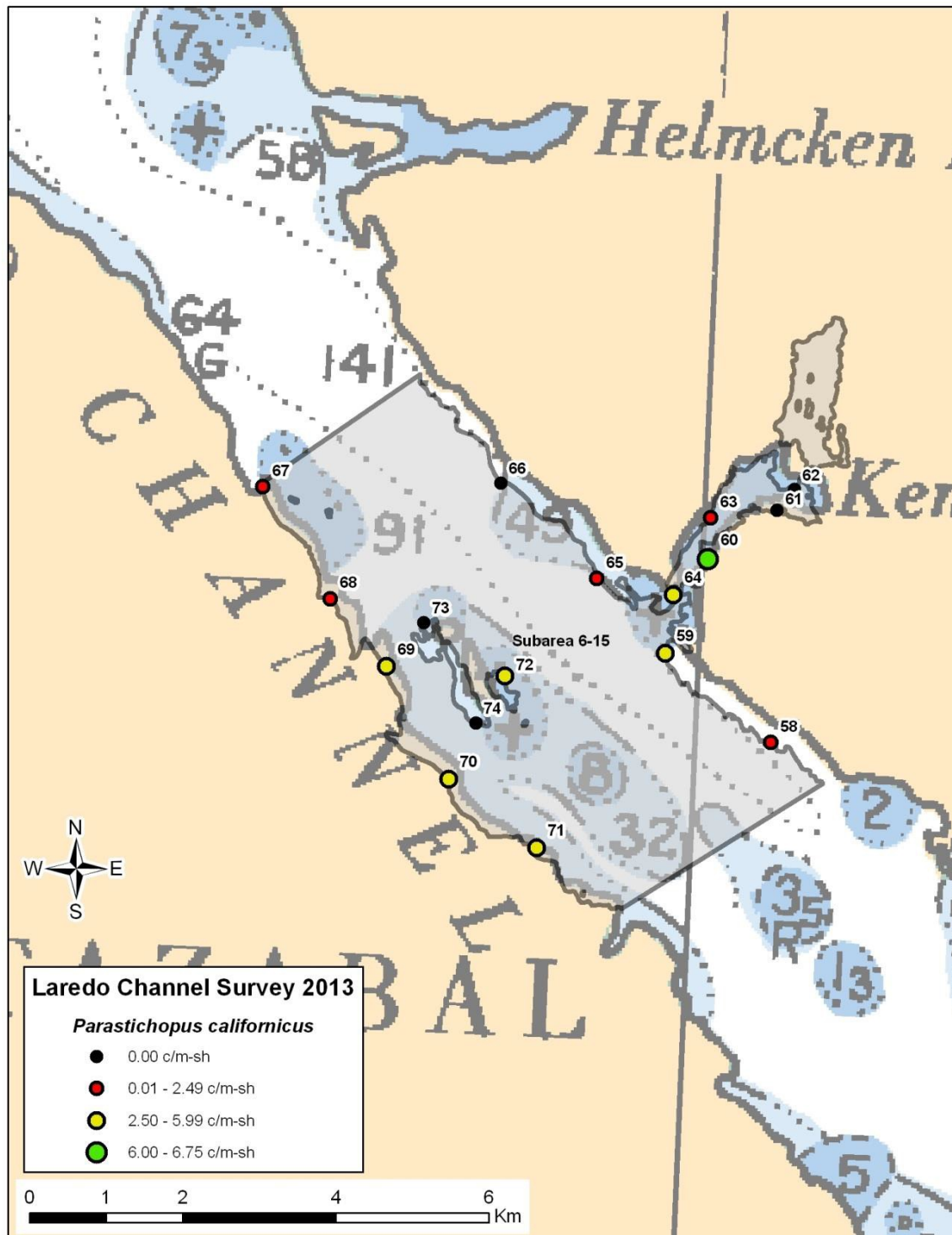


Figure 6. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 6-15, surveyed as part of the Laredo Channel survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and regional baseline density); green = productive locations (densities above the North Coast regional baseline density).

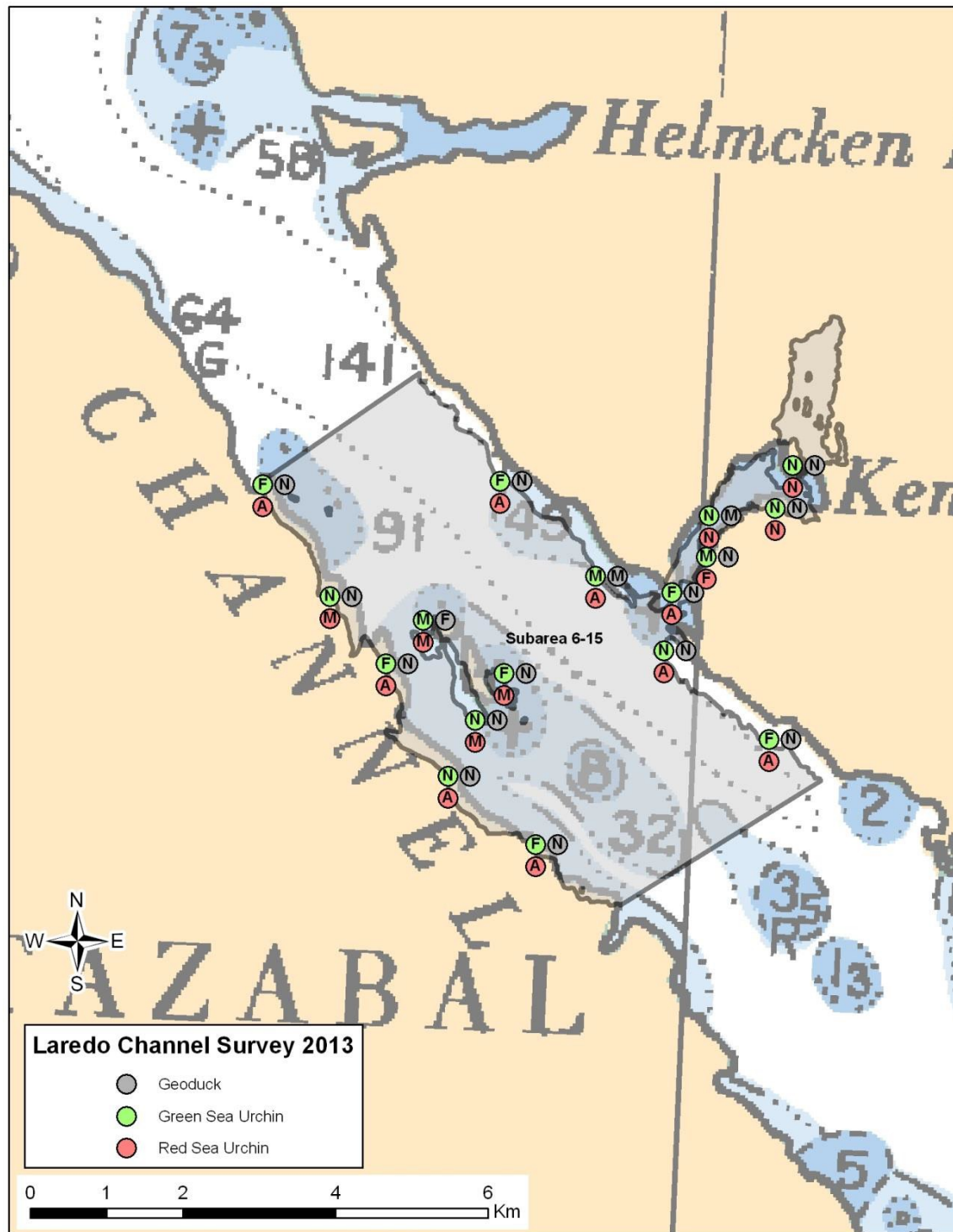


Figure 7. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in part of PFMA 6-15. The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

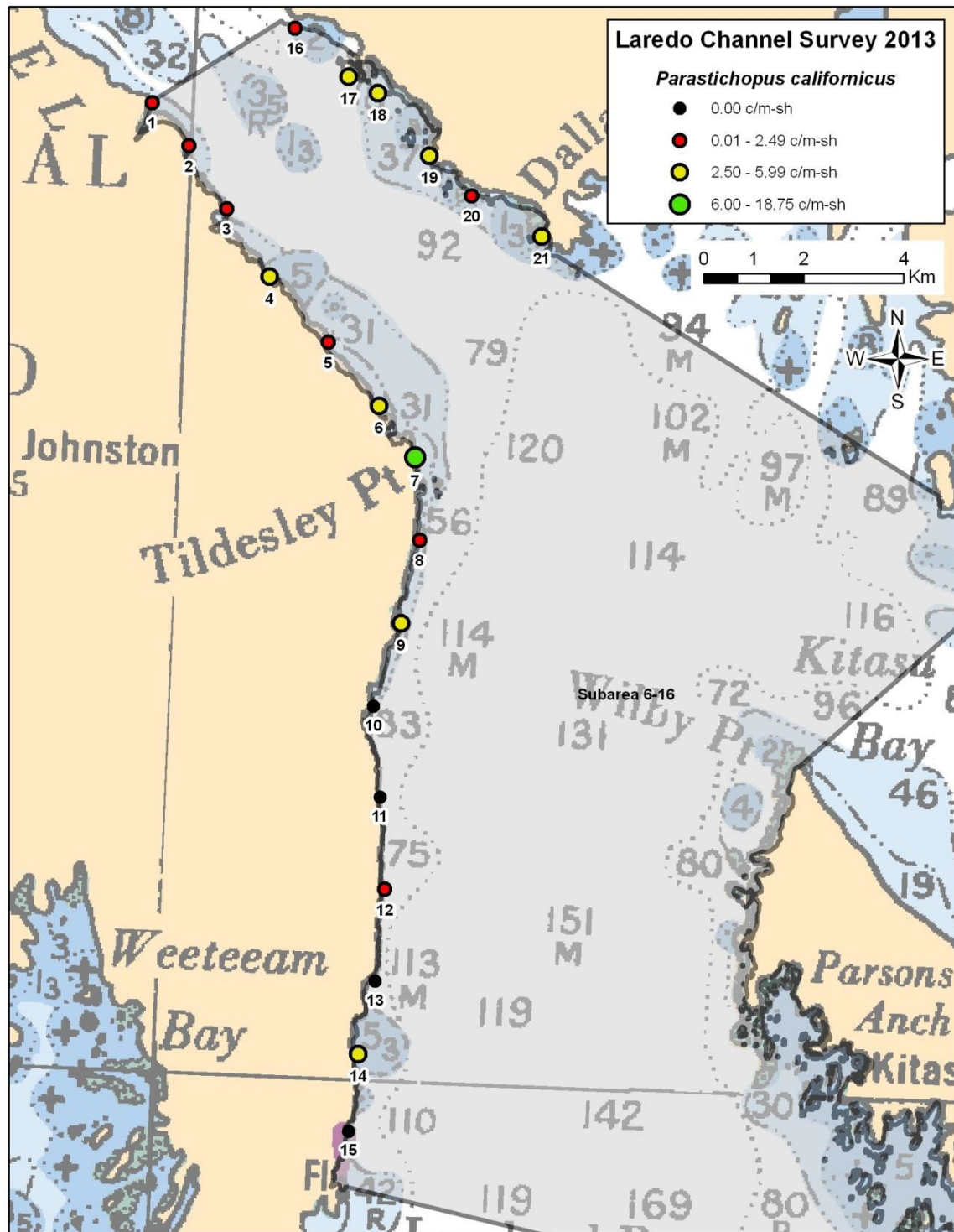


Figure 8a. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 6-16 (northwest portion), surveyed as part of the Laredo Channel survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and 6.00 c/m-sh); green = productive locations (between the regional baseline density and the maximum observed in the Subarea).

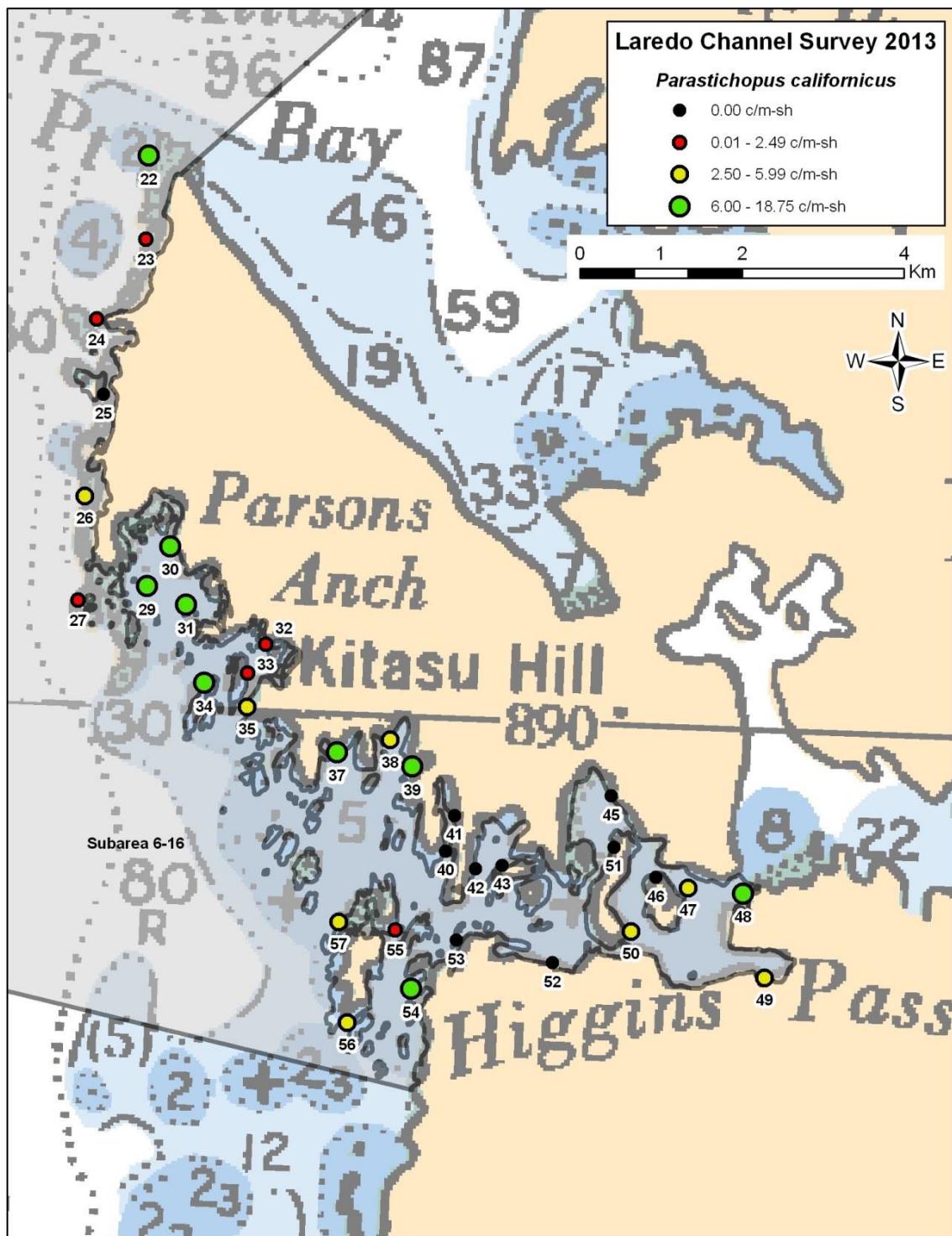
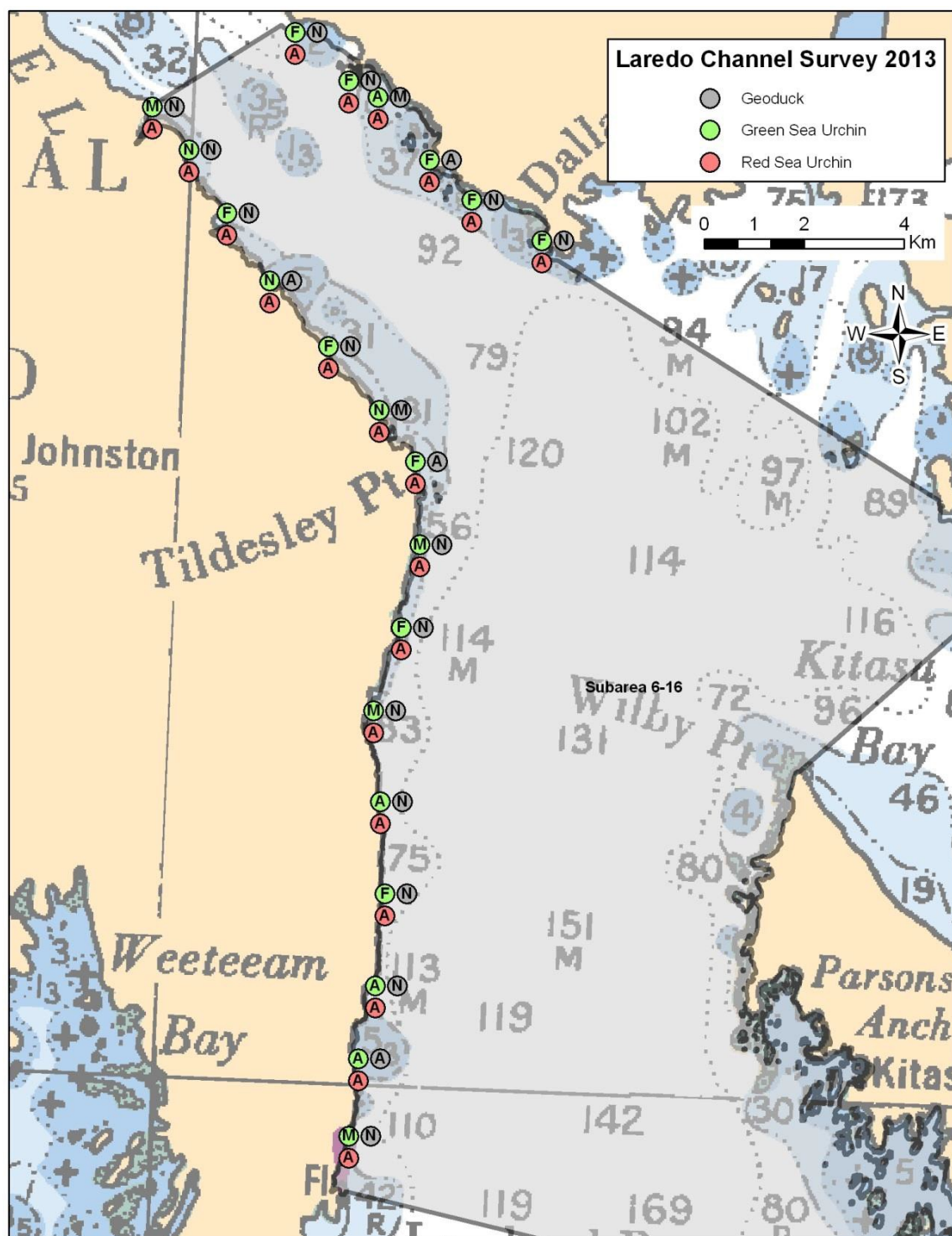


Figure 8b. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 6-16 (southeast portion), surveyed as part of the Laredo Channel survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 and 6.00 c/m-sh); green = productive locations (between regional baseline density and the maximum observed density in the Subarea).



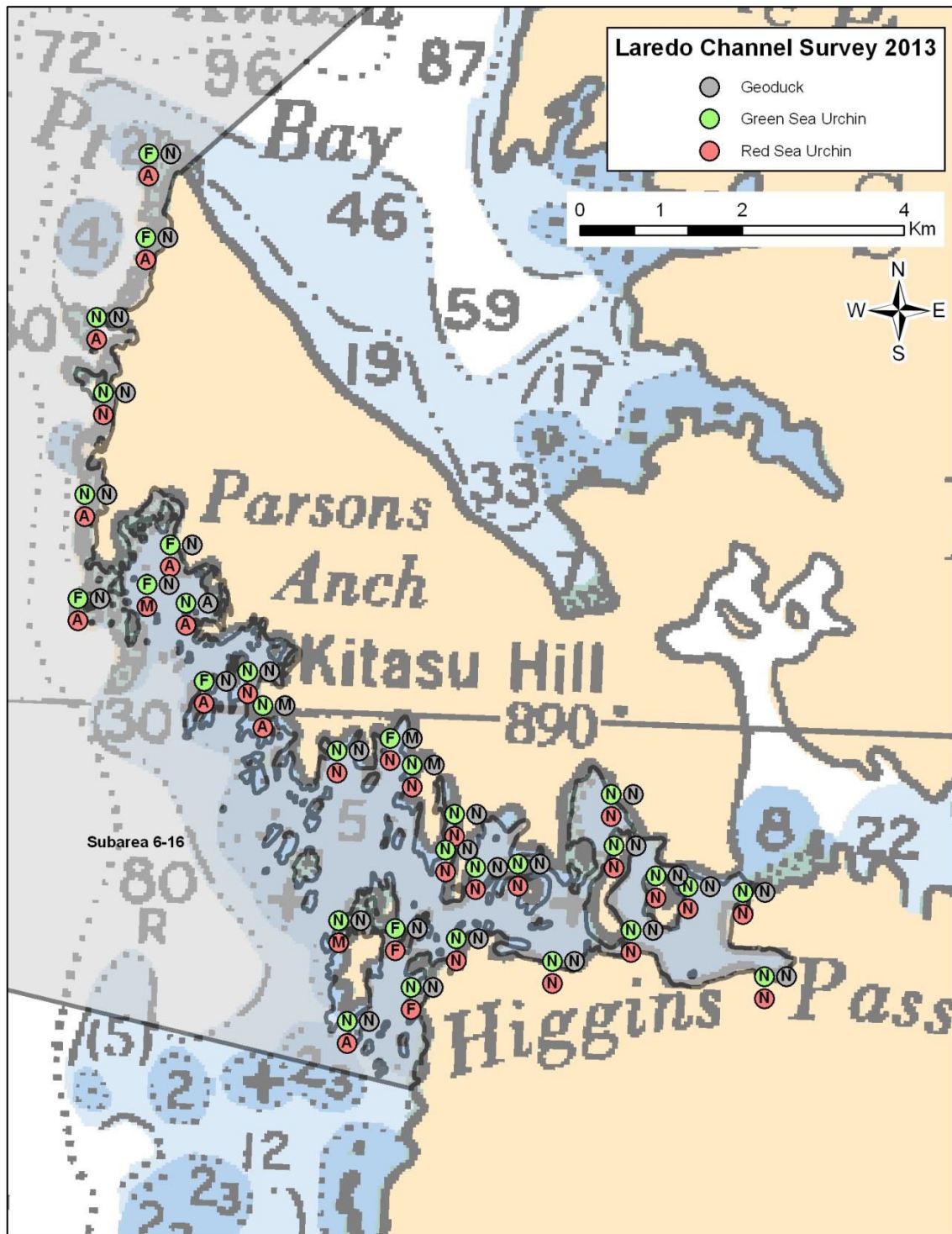


Figure 9b. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in part of PFMA 6-16 (southeast portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

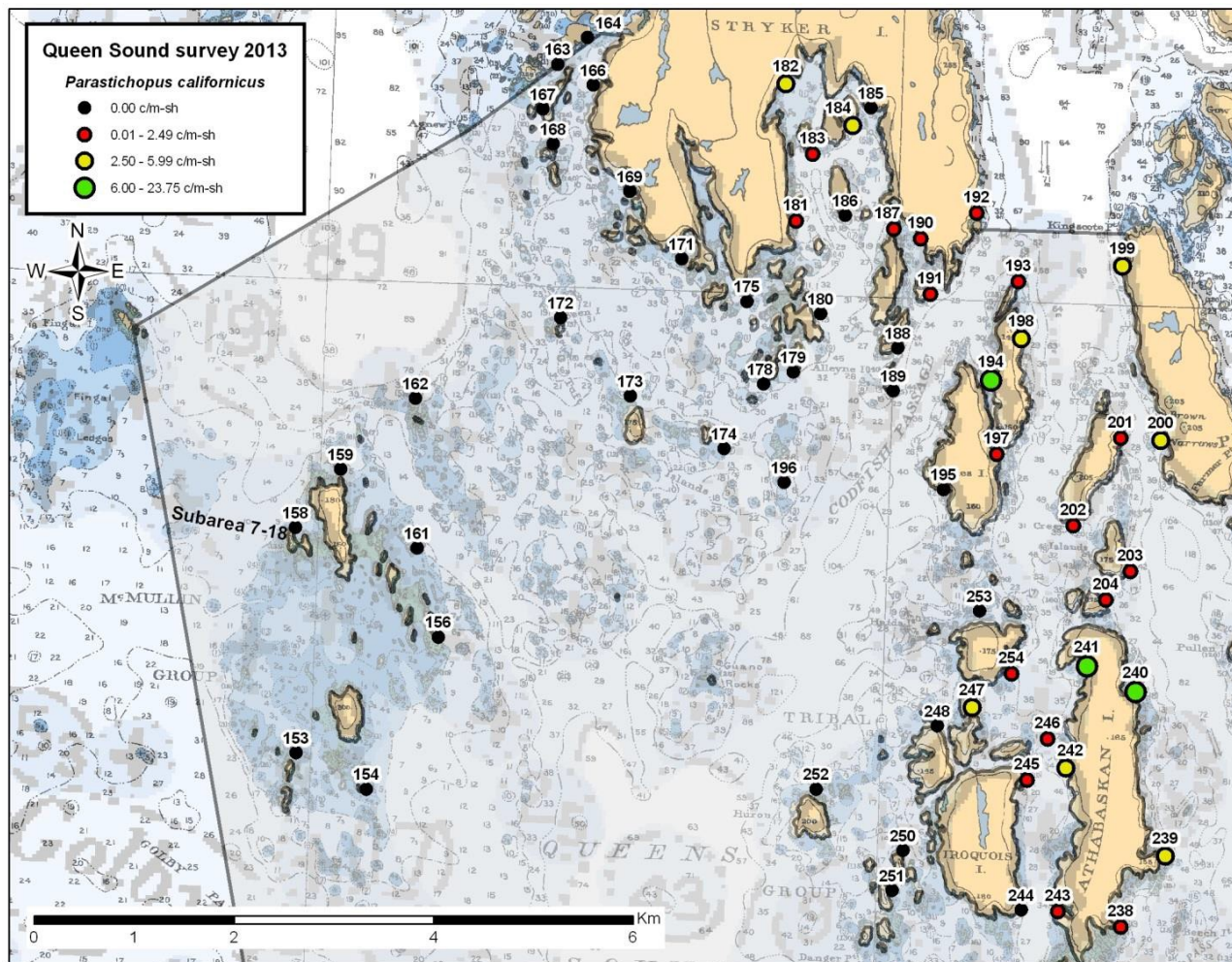


Figure 10a. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 7-18 (northwest portion), surveyed as part of the Queens Sound survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the regional baseline density); green = productive locations (between the regional baseline density and the maximum observed in the Subarea).

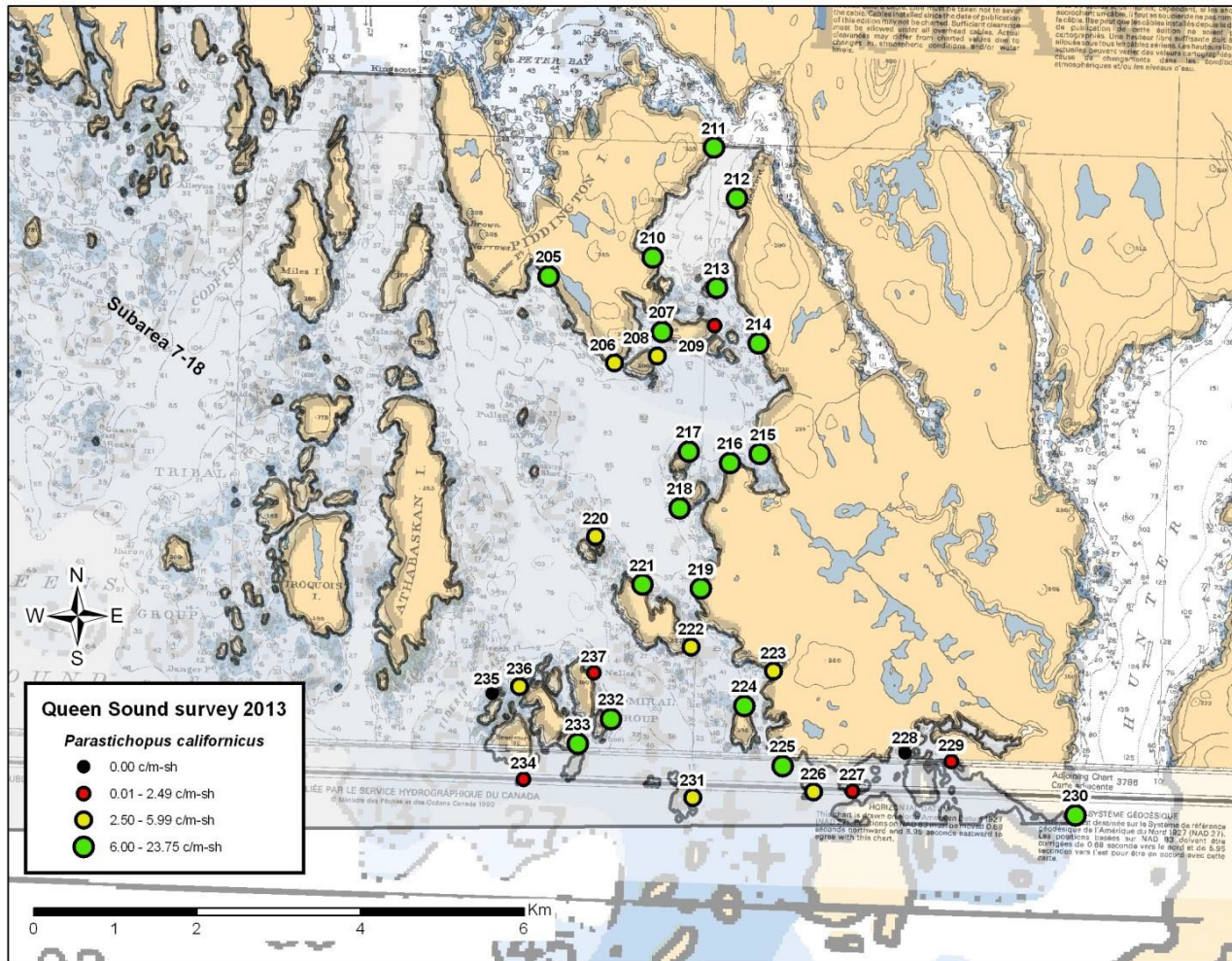


Figure 10b. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 7-18 (southeast portion), surveyed as part of the Queens Sound survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the regional baseline density); green = productive locations (between the regional baseline density and the maximum observed in the Subarea).

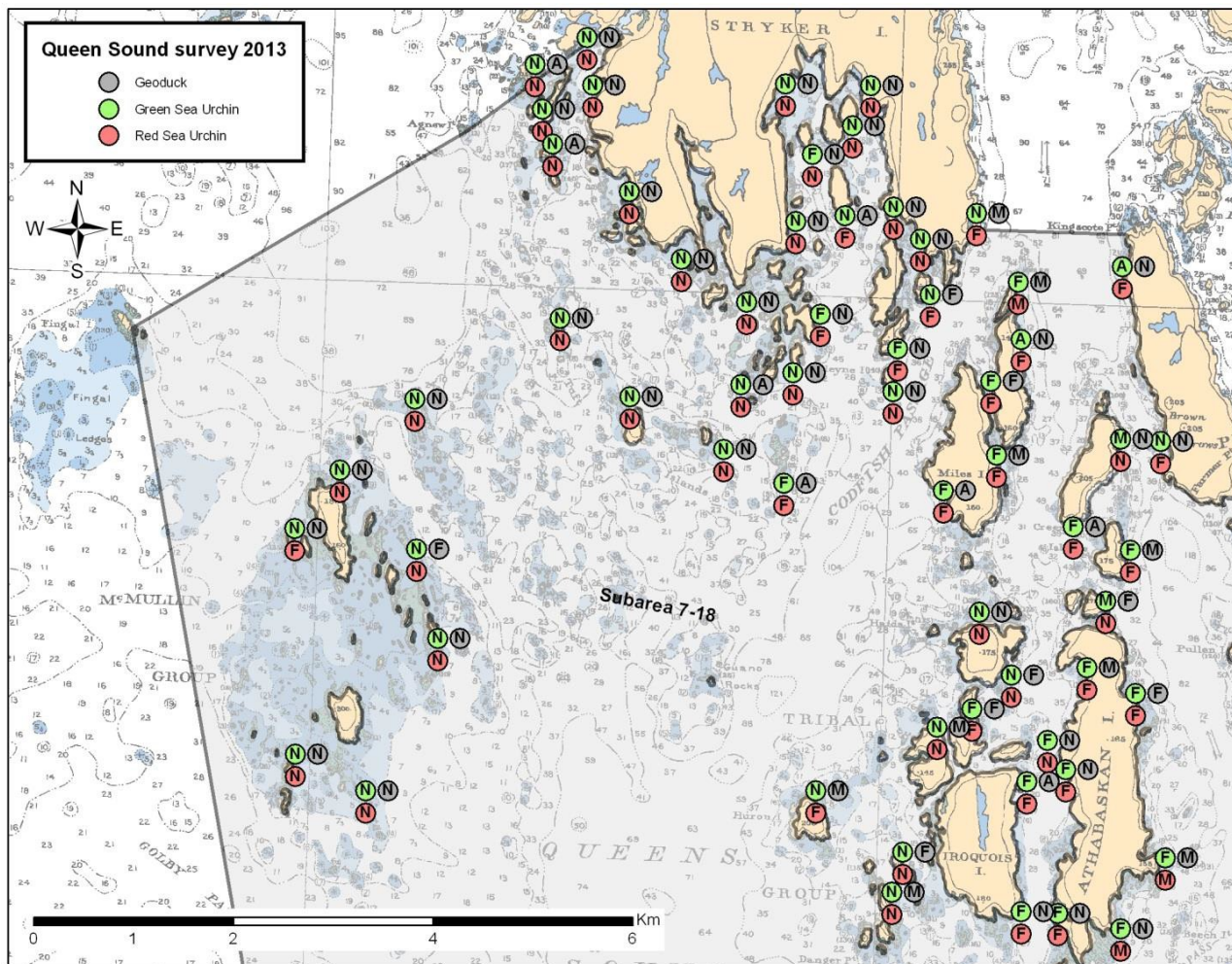


Figure 11a. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 7-18 (northwest portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

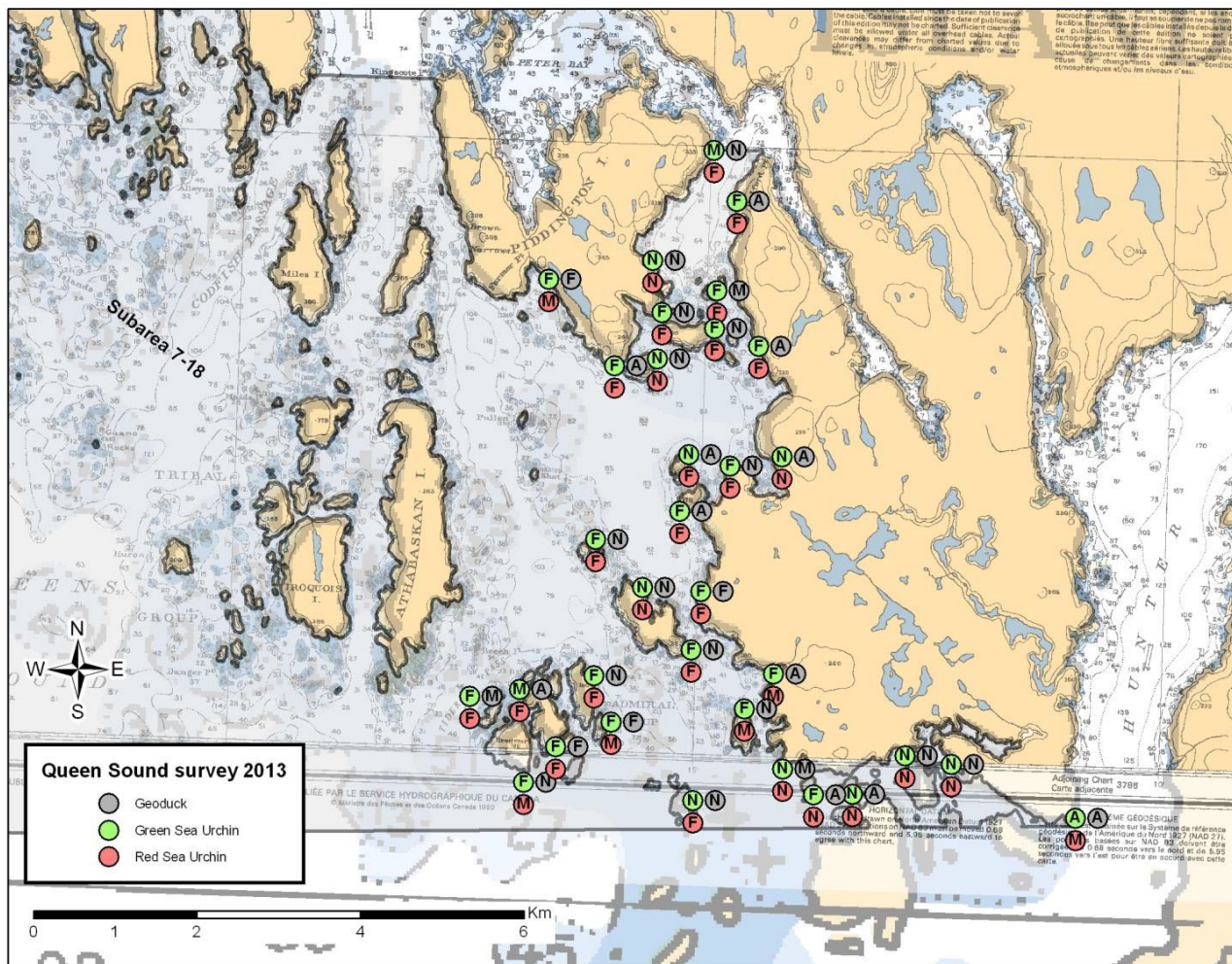


Figure 11b. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 7-18 (southeast portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

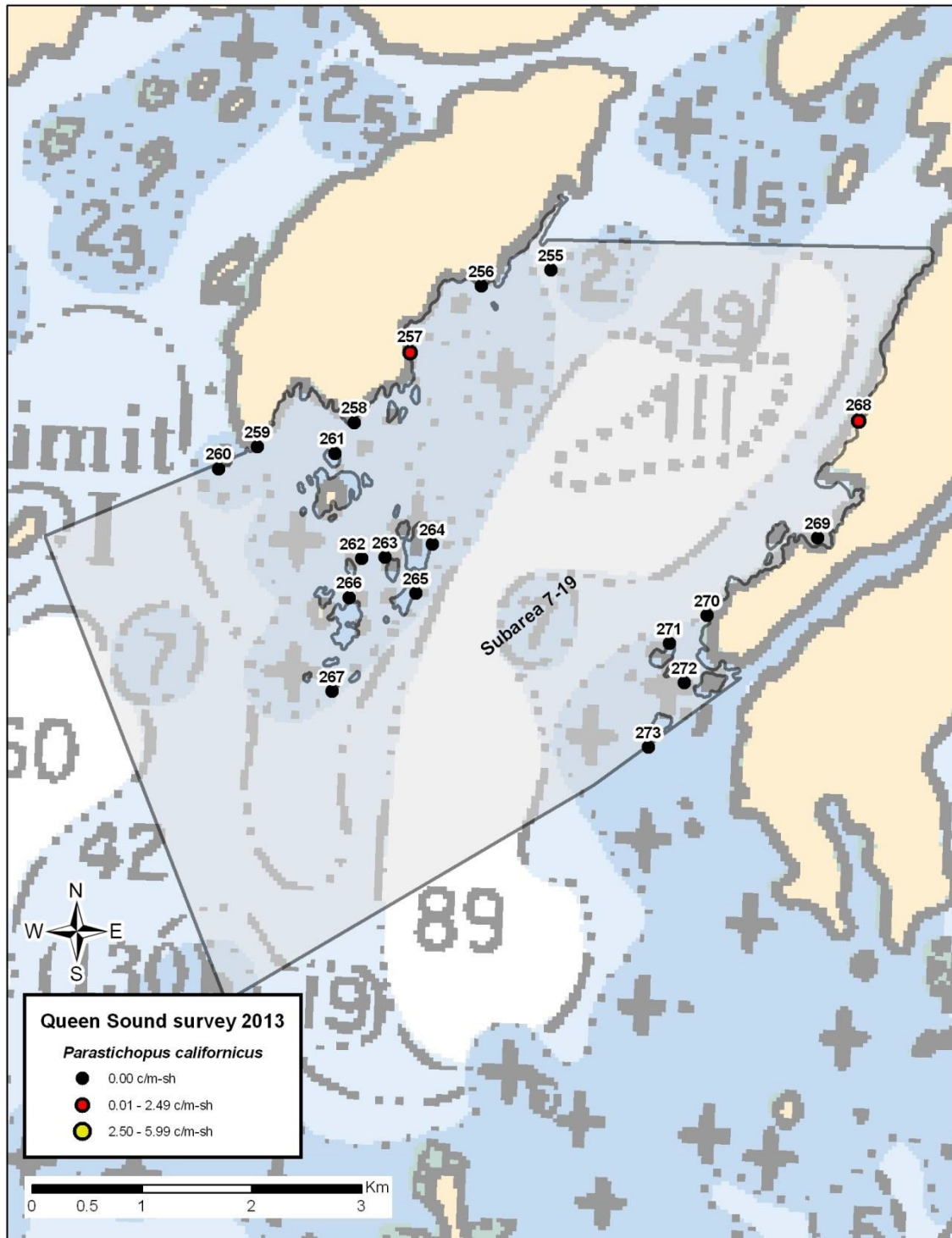


Figure 12. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 7-19, surveyed as part of the Queens Sound survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.50 c/m-sh and the regional baseline density).

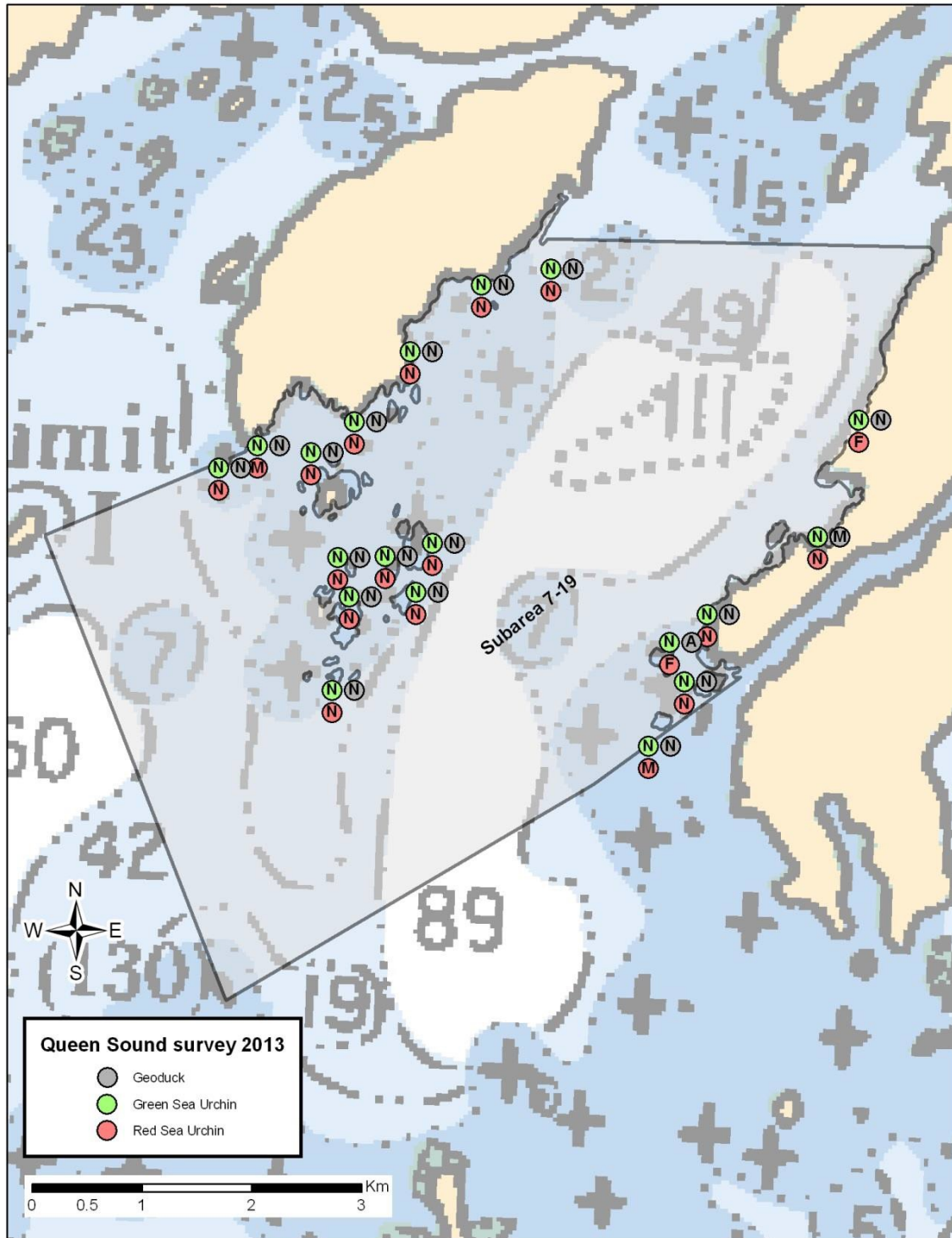


Figure 13. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 7-19. The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

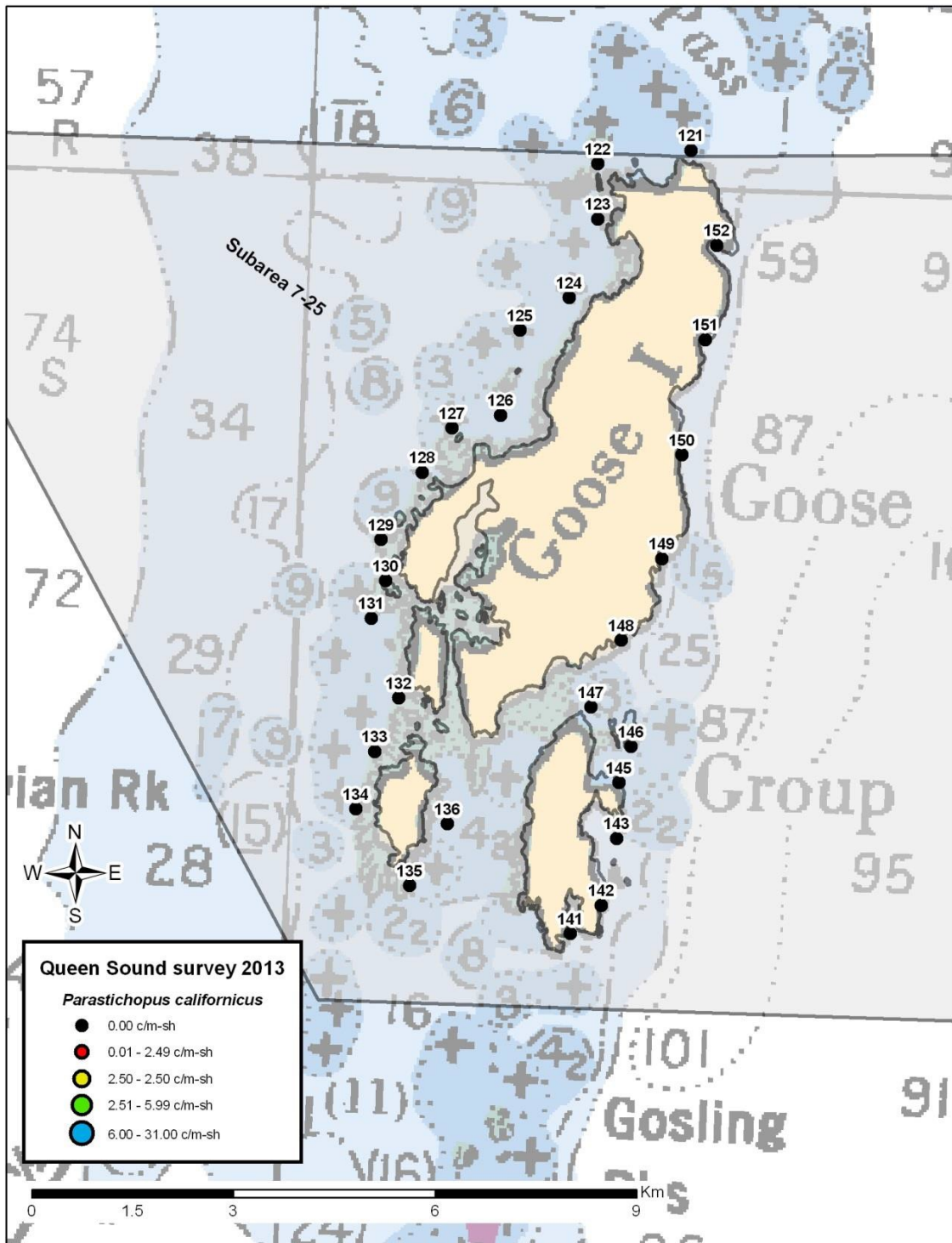


Figure 14a. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 7-25 (western portion), surveyed as part of the Queens Sound survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the bootstrapped lower 90% confidence bound calculated for the Subarea); green = productive locations (between the bootstrapped lower 90% confidence bound and the regional baseline density); blue = very productive locations (densities above the regional baseline density).

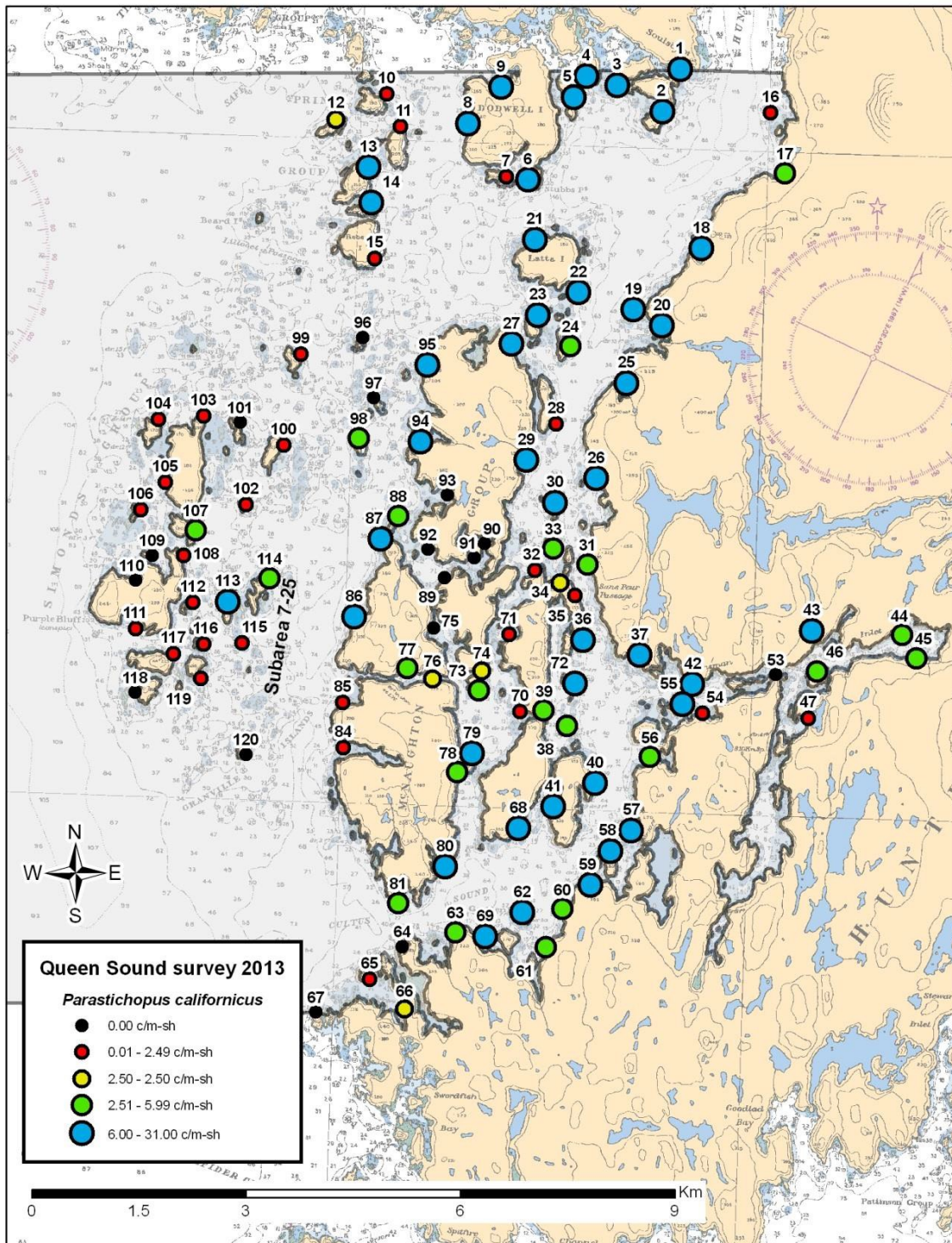


Figure 14b. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 7-25 (eastern portion), surveyed as part of the Queens Sound survey in 2013. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the bootstrapped lower 90% confidence bound calculated for the Subarea); green = productive locations (between the bootstrapped lower 90% confidence bound and the regional baseline density); blue = very productive locations (densities above the regional baseline density).

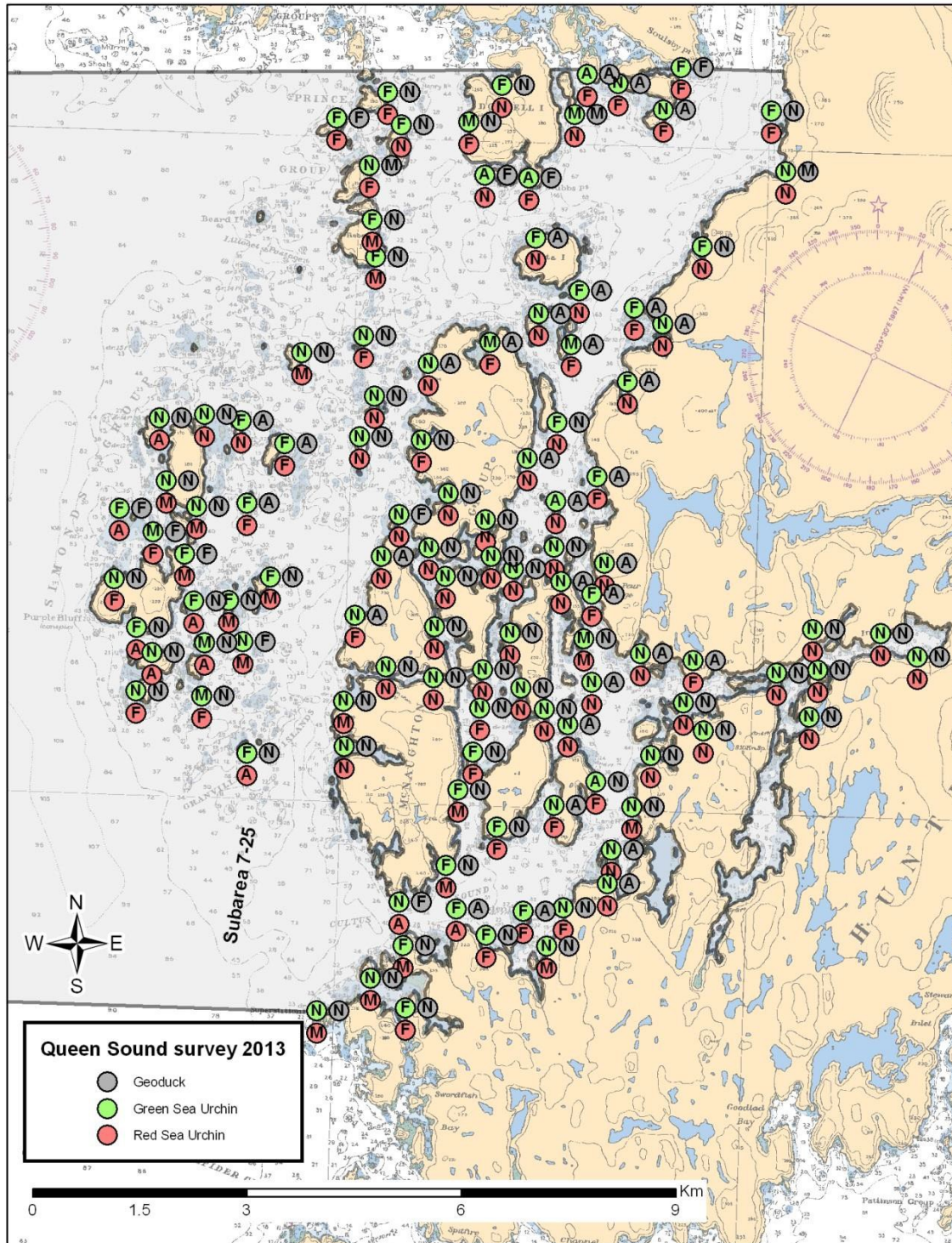


Figure 15b. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 7-25 (eastern portion), The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

Figure 16. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* PFMA 19-3, surveyed as part of the Sidney-Sooke survey in 2014. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the regional baseline density); green = productive locations (densities above the regional baseline density).

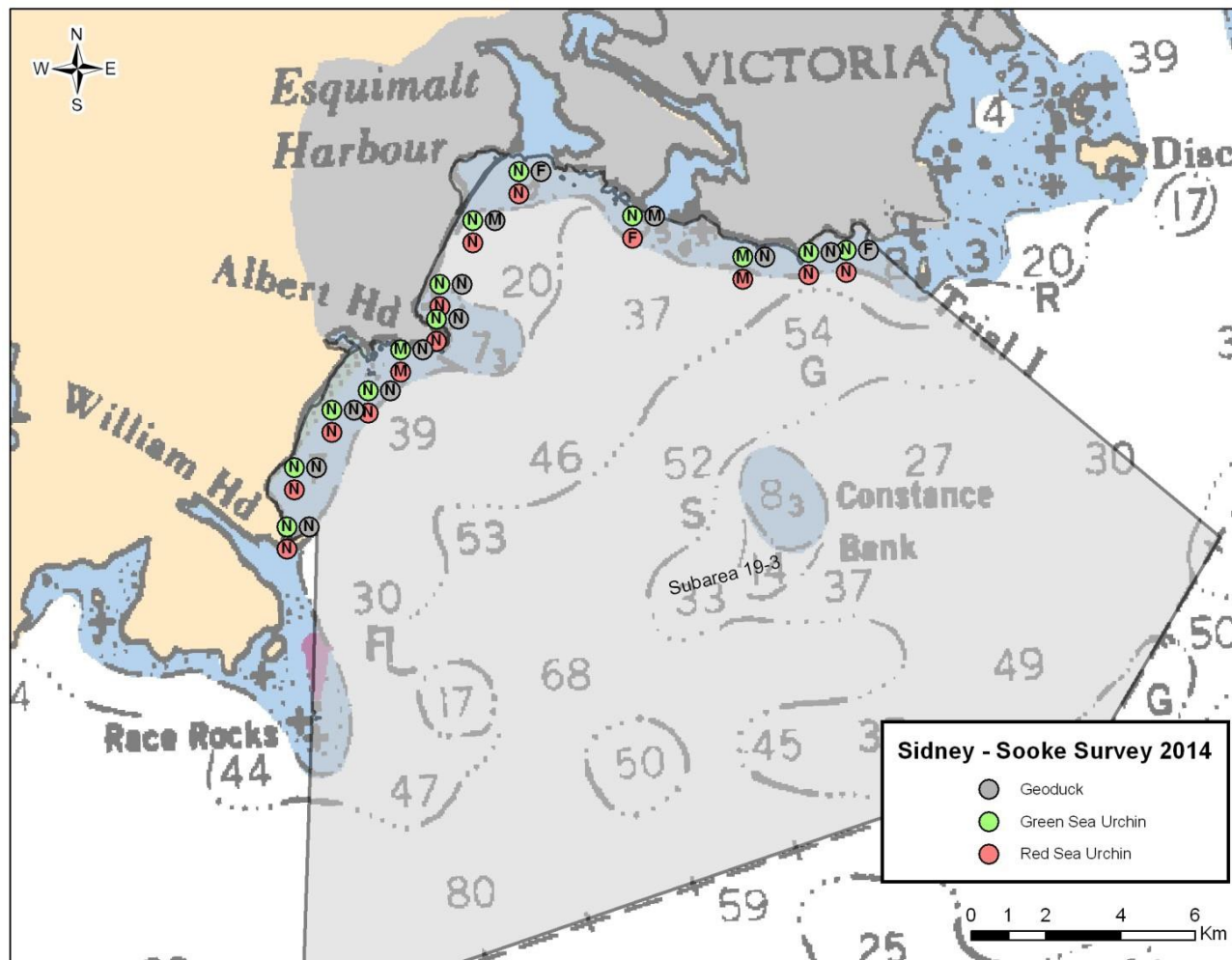


Figure 17. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 19-3. The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

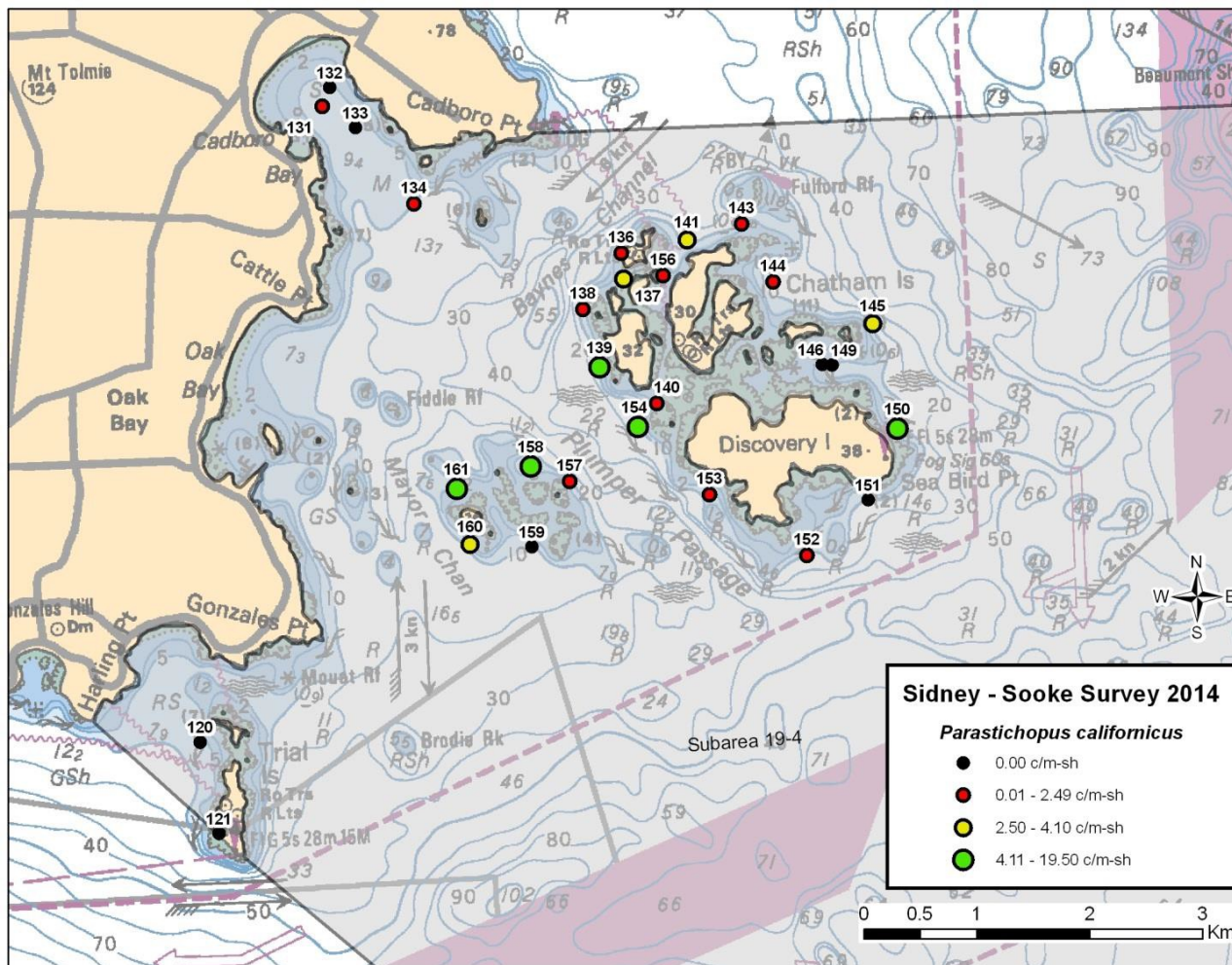


Figure 18. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 19-4, surveyed as part of the Sidney-Sooke survey in 2014. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 c/m-sh and the regional baseline density); green = productive locations (densities above the regional baseline density).

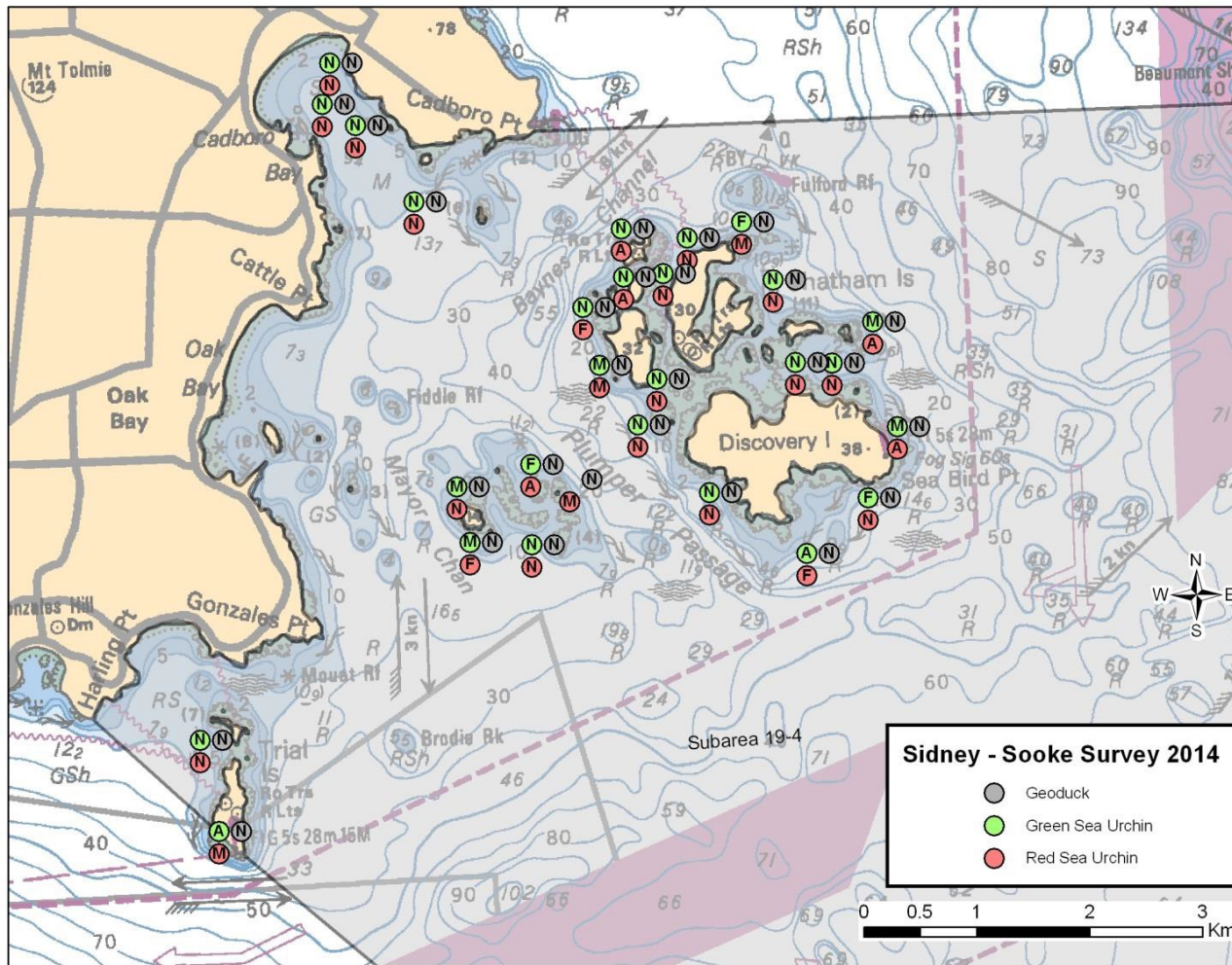


Figure 19. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 19-4. The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

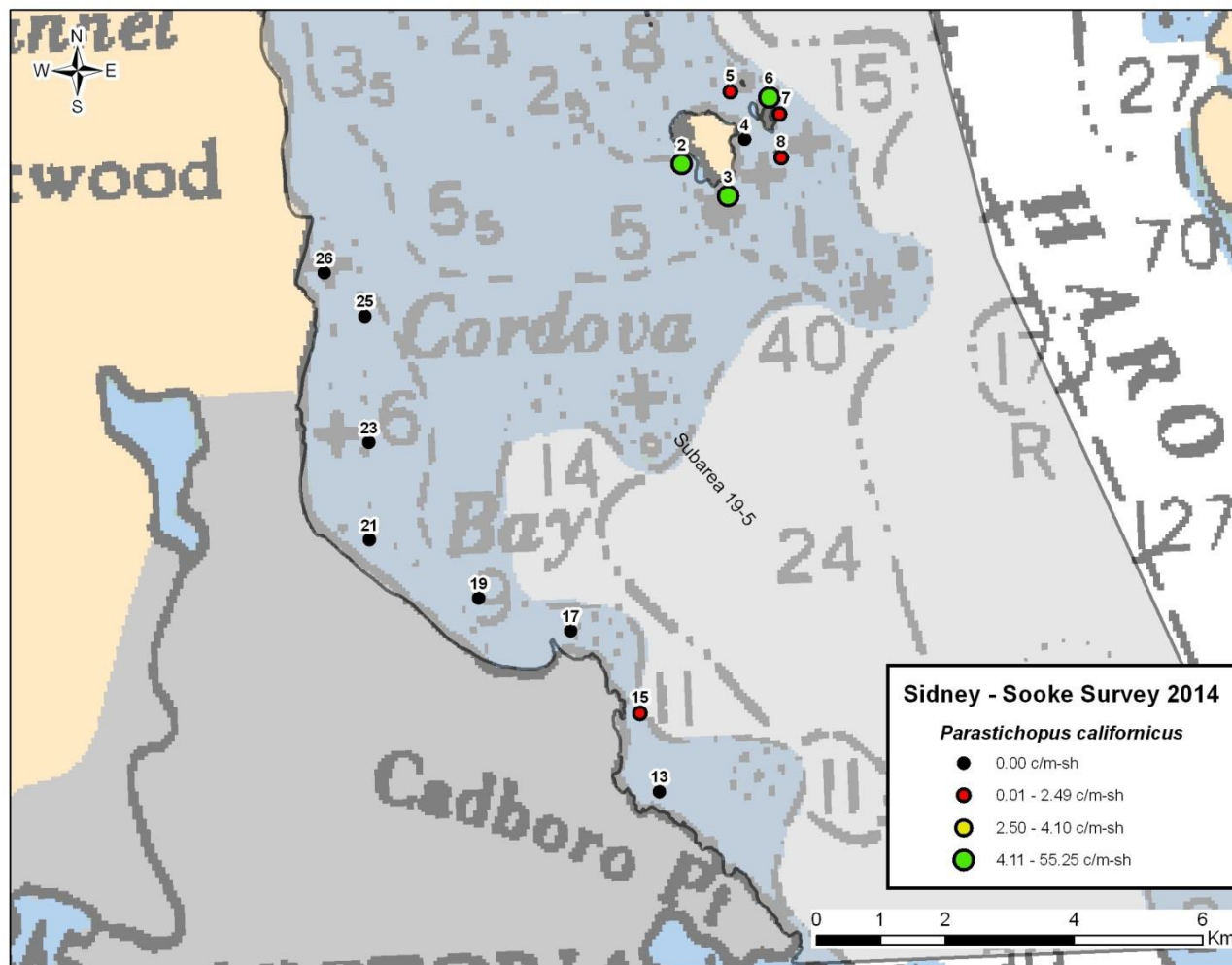


Figure 20. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 19-5, surveyed as part of the Sidney-Sooke survey in 2014. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 and the regional baseline density); green = productive locations (densities above the regional baseline density and 12.75 c/m-sh).

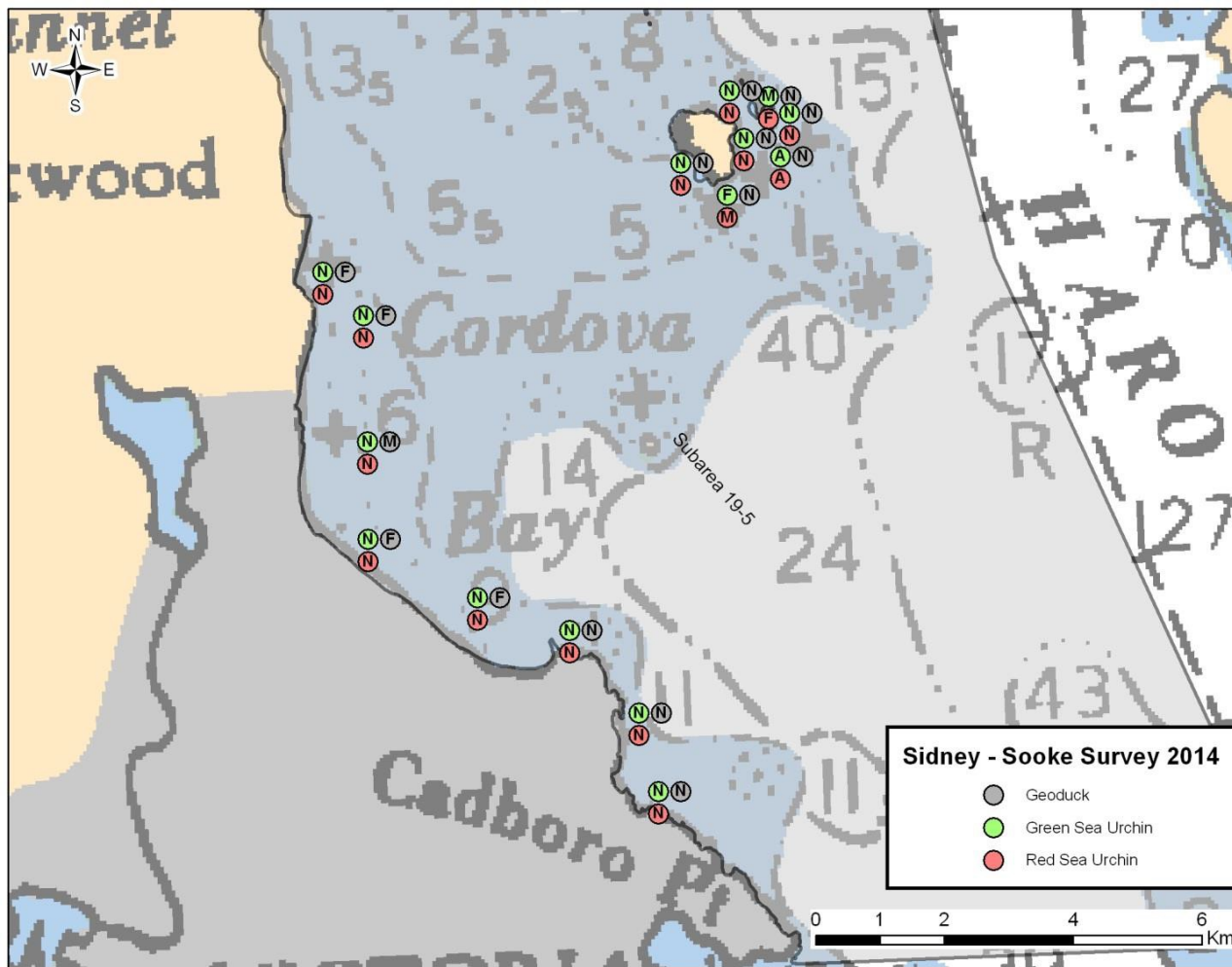


Figure 21. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in PFMA 19-5. The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

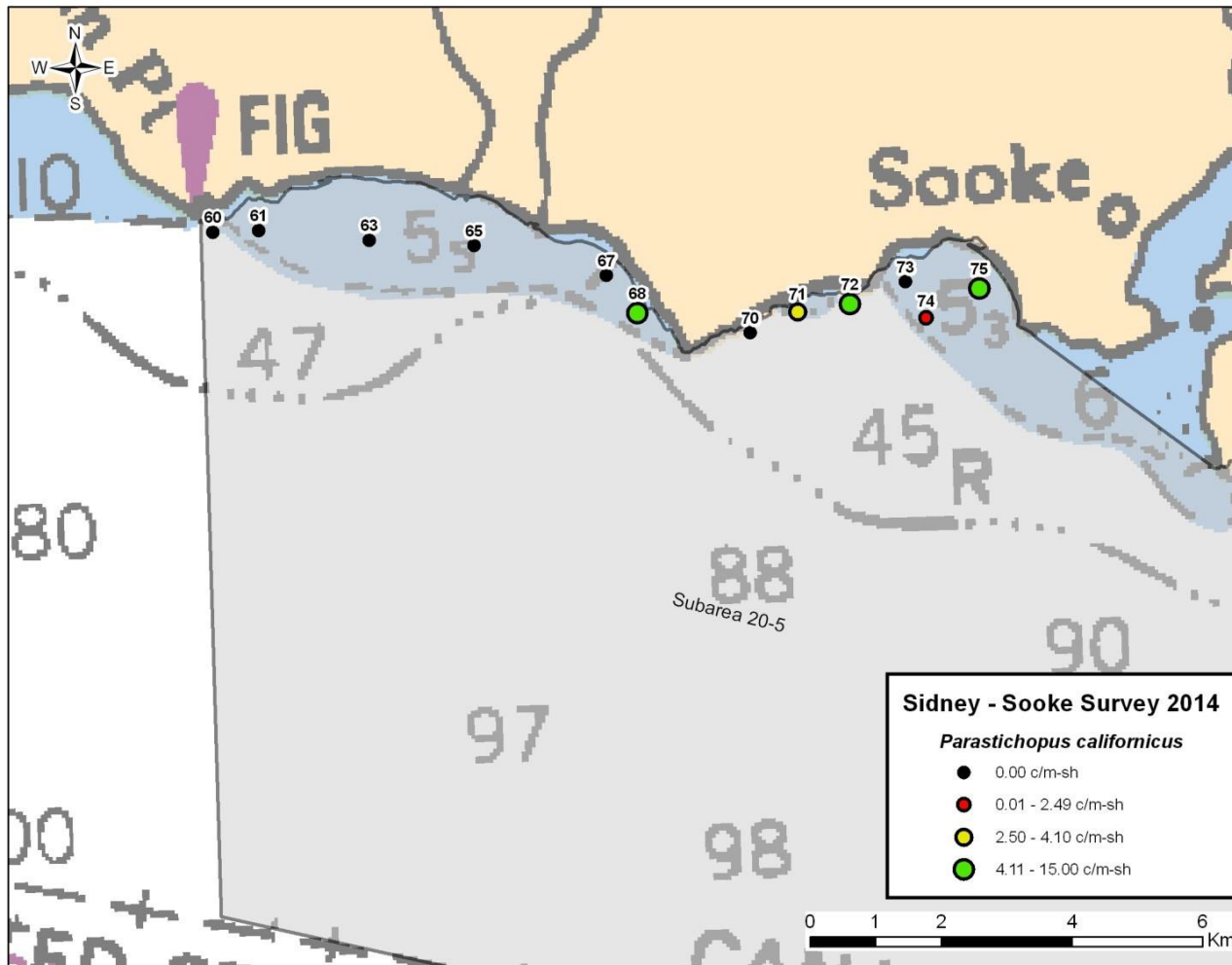


Figure 22a. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 20-5 (northwest portion), surveyed as part of the Sidney-Sooke survey in 2014. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 and the regional baseline density); green = productive locations (densities above the regional baseline density).

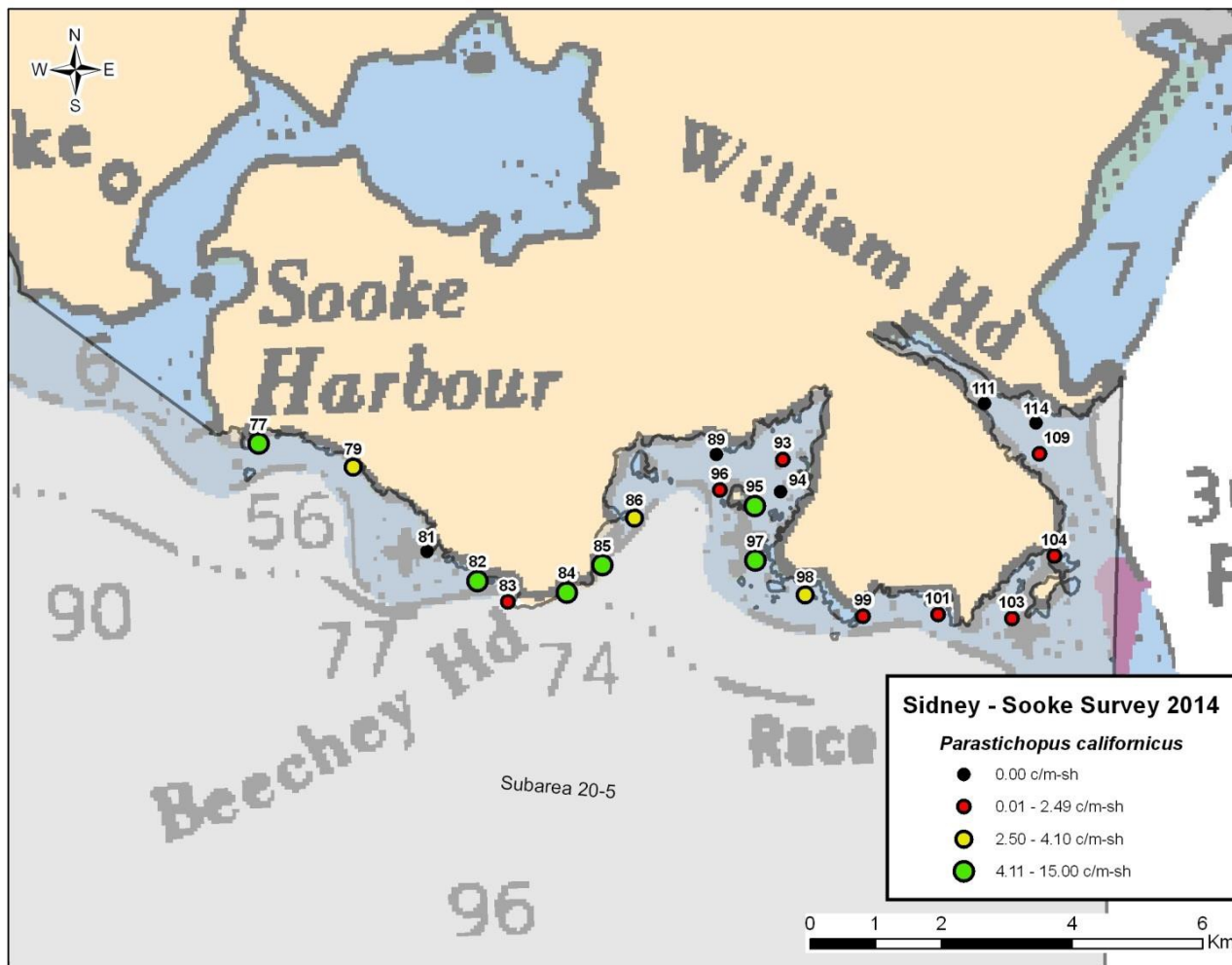


Figure 22b. Linear density (sea cucumbers per metre of shoreline; c/m-sh), of *Parastichopus californicus* in PFMA 20-5 (southeast portion), surveyed as part of the Sidney-Sooke survey in 2014. Each coloured dot indicates the location of a survey transect identified by the transect number above the dot. Black = zero; red = low density (<2.5 c/m-sh); yellow = medium density (between 2.5 and the regional baseline density); green = productive locations (densities above the regional baseline density).

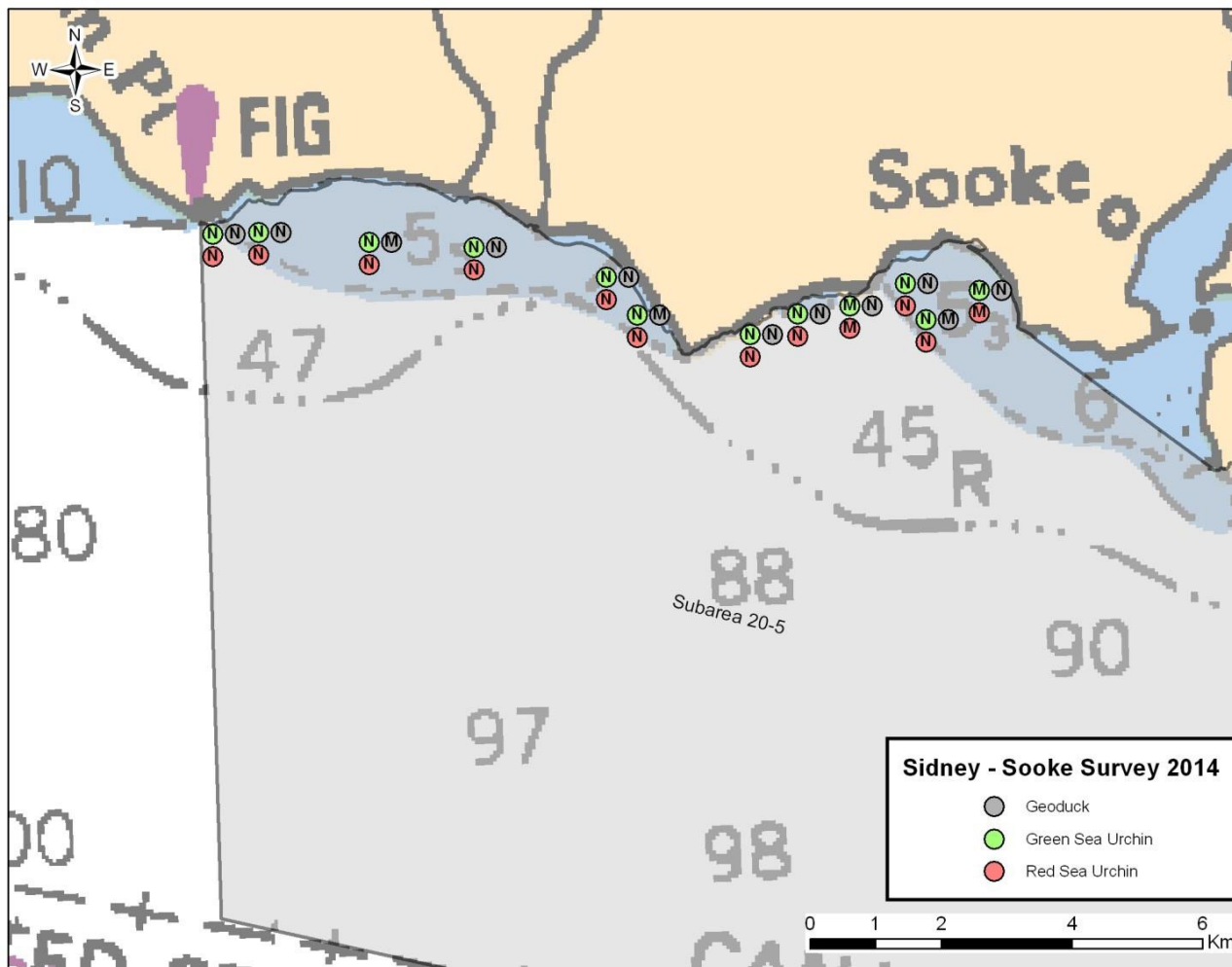


Figure 23a. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in a portion of PFMA 20-5 (northwest portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.

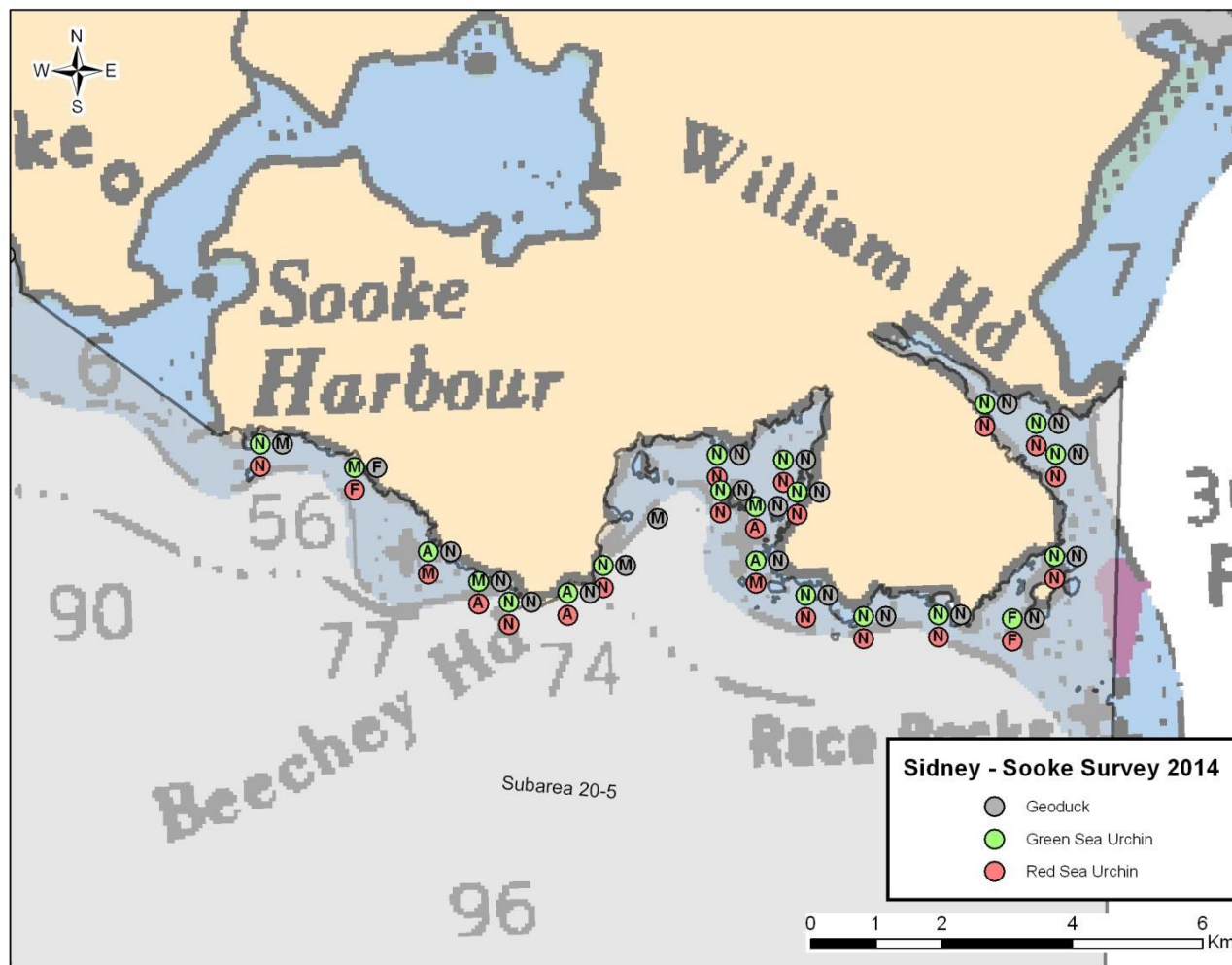


Figure 23b. Relative abundance of Geoducks, Green Sea Urchins and Red Sea Urchins on transects surveyed for sea cucumber in a portion of PFMA 20-5 (southeast portion). The number of animals observed while swimming the transect is noted and given an abundance category: A=Abundant (101+ animals); M=Many (11-100 animals); F=Few (1-10 animals); N=zero animals.