APPENDIX E

REPORT ON BOTTOM FISHERIES AND VULNERABLE MARINE ECOSYSTEMS

CONTENTS

REPORT ON BOTTOM FISHERIES AND VULNERABLE MARINE ECOSYSTEMS

INTRODUCTION

In 2006, the Commission and Scientific Committee began to discuss methods to eliminate destructive fishing practices on benthic ecosystems, adopting a measure to control bottom trawling in high-seas areas (CM 21-05). In that same year, the United Nations General Assembly (UNGA) agreed the Sustainable Fisheries Resolution (61/105), which calls on States and RFMOs or other arrangements to take immediate action to ensure fish stocks are managed sustainably and to protect vulnerable marine ecosystems (VMEs), including seamounts, hydrothermal vents and cold-water corals, from destructive fishing practices. More specifically, UNGA Resolution 61/105 calls on States and RFMOs and other arrangements to regulate and manage all bottom fisheries in high-seas areas so as to prevent significant adverse impacts on VMEs by no later than 31 December 2008 (UNGA Resolution 61/105, OP80–OP91).

2. Since then, the Scientific Committee has provided advice on methods to implement this resolution. The issue has been considered primarily in WG-FSA but with increasing attention of WG-SAM on methods and WG-EMM on the biology and ecology of VMEs. In 2009, a Workshop on VMEs (WS-VME) was held (SC-CAMLR-XXVIII, Annex 10). This report aims to summarise the current scientific advice pertinent to this issue.

Glossary

3. A glossary of terms and a diagram illustrating the conceptual relationships between the terms has been developed by WG-EMM and WG-FSA, to clarify the meaning of terms used in discussions on bottom fisheries and VMEs. The glossary can be found in Attachment A; the diagram is shown as Figure 1.

Benthos classification guide

4. In 2007, the Scientific Committee endorsed the conclusions of WG-FSA that specific guidance would need to be developed to adequately monitor fisheries by-catch for evidence of encounters with vulnerable habitats and to potentially trigger management actions (SC-CAMLR-XXVI, paragraphs 4.164 and 4.165). The CCAMLR VME taxa classification guide, adopted for use by fishing vessels, is publicly available on the CCAMLR website (www.ccamlr.org/pu/e/sc/obs/vme-guide.pdf). A field guide to benthic invertebrates for the region of Heard Island and McDonald Islands is available at the Australian Antarctic Division website (www.heardisland.aq/research/fish-and-invertebrates).

Rationale for the report

5. The report summarises the status of knowledge on bottom fisheries and the types of interactions of fisheries with VMEs. Also, it provides current assessments of bottom fishing impacts on VMEs, and could include approaches to review and evaluate different assessment methods. Lastly, it details the types of management strategies in operation or being considered, and provides management advice, including proposed revisions of conservation measures and priorities for future work.

DETAILS OF BOTTOM FISHERIES

Types and primary locations of bottom fisheries

6. Total cumulative bottom fishing effort for all subareas/divisions in the area relevant to CM 22-06 is summarised in Table 2. Note the table includes all bottom fishing records from the C2 (for longlines) and C1 (for trawls) CCAMLR databases from 1985 to 2010. Earlier historical effort is not included, and the C1 database may be incomplete with respect to some recent research trawls.

7. Actual spatial distributions of fishing effort and the areal extent of fishing footprints will be considered further under 'Impact assessments' below.

Current conservation measures

8. The current conservation measures in force pertaining to VMEs are:

CM 22-05 (2008) – Restrictions on the use of bottom trawling gear in high-seas areas of the Convention Area

CM 22-06 (2009) – Bottom fishing in the Convention Area, including two annexes

CM 22-07 (2009) – Interim measure for bottom fishing activities subject to Conservation Measure 22-06 encountering potential vulnerable marine ecosystems in the Convention Area

CM 22-08 (2009) – Prohibition on fishing for *Dissostichus* spp. in depths shallower than 550 m in exploratory fisheries.

9. In addition, specific measures are present in the general new (CM 21-01) and exploratory (CM 21-02) fisheries measures to provide, within notifications, information on the known and anticipated impacts of bottom trawl gear on VMEs, including benthos and benthic communities. Also, a Member shall not authorise, under CM 10-02, vessels flying their flag to participate in the proposed bottom fishing activities if the procedures outlined in CM 22-06, paragraph 7, have not been fully complied with.

DETAILS OF VULNERABLE MARINE ECOSYSTEMS

Register of VMEs

VMEs present on the register and their status

10. Thirty-two encounters with VMEs have been notified in accordance with CM 22-06 (Attachment B). The encounters were notified during the course of research in Subareas 48.1 and 48.2 and Division 58.4.1. The VMEs were observed using *in situ* photography and benthic sampling.

11. The notifications of evidence of VMEs occurred in areas which are currently closed to most bottom fishing activities. Directed fishing for finfish is prohibited in Subareas 48.1 and 48.2 (e.g. CMs 32-02 and 32-03), and the experimental fishing blocks in Subarea 48.2 where the notified VMEs are located (Blocks A, C and E), are closed to the exploratory fishery for crab (CM 52-02). In Division 58.4.1, the SSMU where the notified VMEs are located (SSRU H) is closed to the exploratory fishery for *Dissostichus* spp. (CM 41-11).

Measures to conserve registered VMEs

12. At present, registered VMEs are protected through spatial closures of varying sizes for some areas (Attachment B). There are no general measures in place to give specific protection to all registered VMEs.

Risk Areas

Registered Risk Areas

13. A total of 53 VME indicator notifications have been submitted in accordance with CM 22-07. These notifications originated from the exploratory pot fishery for crab in Subarea 48.2, and the exploratory longline fisheries for *Dissostichus* spp. in Subareas 48.6, 88.1 and 88.2. Of these notifications, 29 were made in 2008/09 and 24 have been made so far in 2009/10.

14. Fifteen VME-indicator notifications reported ≥10 VME indicator units from a single line segment. These notifications were made in Subareas 88.1 and 88.2, and resulted in the declaration of 15 Risk Areas (Attachment C).

Process for reviewing status of Risk Areas

15. WG-EMM advised that a review process should include reference to all available information indicative of the nature, abundance and ecological importance of VME taxa in the area (Annex 6, paragraph 3.40), including:

(i) ecological characteristics of the VME taxa encountered at the Risk Area, along with the likely characteristics of the benthic community, including consideration of the organisms present and their life histories, rarity and ecological structure and function, and how the Risk Area relates to the distributions of those taxa in the wider area;

(ii) benthos by-catch data in the vicinity of the Risk Area;

(iii) the reliability of longline by-catch for the taxa in question as indicators of a VME;

(iv) the environmental, bathymetric or topographic context of the Risk Area location (e.g. submarine canyon, seamount etc.) with reference to known habitat associations;

(v) diversity and abundance of taxa in the local area, to incorporate the potential ecological importance of multi-species assemblages;

(vi) the actual and/or likely level of threat to the habitat or location, and associated footprint and impact estimates;

(vii) the overall management framework in place to avoid significant adverse impacts on VMEs.

16. It also recommended that Members and fishers be encouraged to collect new information wherever possible to inform the continued assessment of vulnerable habitats. Establishing the link between catch rates and organism density on the seafloor for each vulnerable taxon will be important to document the actual distribution and abundance of these habitats and identifying areas with no vulnerable habitats. Deployment of drop cameras as described in WG-EMM-10/24 in and near existing Risk Areas, or by systematically mapping habitats using cameras deployed from fishing vessel platforms, could provide valuable data to characterise the distribution of vulnerable habitats (Annex 6, paragraph 3.41).

Current status of Risk Areas

17. No progress has been made in reviewing the status of current Risk Areas.

Potential overlap between fishery activities and VMEs

18. Although there has been no explicit analysis of the potential overlap between fishery activities and VMEs, progress has been made on using fishery by-catch data to test for evidence of spatial correlation between VME taxa and target species within the fished area, and for identifying some types of habitats (see paragraph 32; see also Annex 6, paragraphs 3.27 to 3.35).

ASSESSMENTS OF VME IMPACTS

Methodologies

Impact assessment framework

19. The impact assessment framework used by CCAMLR to estimate current bottom fishing impacts on VMEs is described initially in Sharp et al. (2009), and had been updated (WG-FSA-10/31) following developments in the Scientific Committee and its working groups. It is designed as a flexible framework within which to estimate total impact across all bottom fishing methods, to inform comparison between impacts occurring in different areas from different fisheries, and/or arising from different fishing methods.

20. The impact assessment involves the following steps. The means by which terms representing impact assessment inputs are combined to yield quantitative estimates of subsequent terms is consistent with Figure 1:

Step 1 Description of the fishing gear

Step 2 Description of fishing activity, and estimated *Fishing footprint* per unit effort for a typical fishing gear deployment event

Step 3 Description of non-standard gear deployment scenarios, and estimation of associated frequencies and fishing footprints per unit effort

Step 4 Characterisation of *Fragility* for VME taxa within each spatial footprint identified in Steps 2 and 3

Step 5 Calculation of *Footprint index* and *Impact index* for the fishing method

Step 6 Spatial summary of historical fishing effort

Step 7 Calculation of spatially resolved cumulative footprint and impact.

21. In steps 1–2, the material properties and physical layout of the gear, and the means by which the gear is deployed, are described as comprehensively as possible (e.g. Fenaughty and Bennett, 2005; WG-FSA-08/60) to inform estimation of the spatial footprints within which the gear may contact benthic organisms. Different footprints may be assigned separately to different components of the gear identified in step 1. For example, the autoline longline assessment described in Sharp et al. (2009) defined the footprint of the anchors and grapnels separate from the footprint of the mainline with hooks. Similarly, an assessment of the impacts of bottom trawling may be expected to define separate footprints for the different portions of the trawl gear (e.g. trawl doors, sweeps, ground gear and net). Together these footprints would comprise the 'standard set' footprint.

22. Step 3 provides for unintended or infrequent behaviours of the gear. For example, bottom longlines have been observed to sometimes move laterally across the ocean floor during hauling, and accidents or mishaps may result in other types of movement with distinct associated impacts. Fishing footprints are assigned for each of these non-standard deployment scenarios, along with their estimated frequency of occurrence, to capture impacts additional to the impact of the standard set.

23. Step 4 characterises the fragility of taxa within each of the footprints defined in steps 2–3. Fragility is expressed as the proportion (0–1) of each VME taxon within the footprint that impacted in a particular interaction with the fishing gear. Fragility will be different for different VME taxa; when the impact assessment framework is applied generically without reference to particular taxa, generally only the highest fragility estimates are used. Note that because impact estimates are expressed as a proportion rather than as absolute numbers, they are independent of the abundance (or even presence) of VME taxa within the footprint; the application of the impact assessment framework, therefore, does not rely on accurate knowledge of the distribution of benthic organisms.

24. Step 5 calculates the per unit effort indices of footprint and impact in accordance with Annex 4 (paragraph 4.19), as follows:

$$\textit{Footprint index} = A_0 + f_1A_1 + f_2A_2,+ \ldots$$

$$\textit{Impact index} = A_0F_0 + f_1 A_1F_1 + f_2 A_2F_2 + \ldots$$

where: A_0 = area of the standard footprint (km^2 of seabed area per km of line)
F_0 = fragility within the standard impact footprint (range 0–1)
f_1 = frequency (0–1) of non-standard scenario 1
A_1 = area of the footprint associated with scenario 1
F_1 = fragility within the scenario 1 footprint;
...

25. Units are in km^2 of seabed area per km of line. Note that setting fragility = 1 for all scenario footprints (i.e. 100% mortality within all footprints) implies an *Impact index* identical to the *Footprint index*.

26. Consistent with Annex 4, paragraph 4.12, prior distributions rather than point estimates of the input parameters are used to represent uncertainty and to generate confidence intervals around the calculated output distributions for *Footprint index* and *Impact index*. Code is available from the Secretariat to facilitate the calculation of these two indices using frequency distributions (the R-library 'IApdf' is described in WG-SAM-10/20 – see paragraphs 41 to 44 for a worked example).

27. Step 6 summarises fishing effort distributions in a spatially explicit manner, in units compatible with those used in steps 1–5. The standard unit for reporting effort density for longlines is km of line per km^2 of seabed area (Annex 4, paragraph 4.19).

28. In step 7, spatially explicit effort-density distributions are multiplied by the relevant *Footprint index* and/or *Impact index,* yielding estimates of proportional footprint and proportional impact for each area.

29. The impact assessment can be applied at any spatial scale for which spatially resolved fishing effort data is available. A key structural assumption of the impact assessment methodology is that there is no systematic relationship between the spatial distributions of fishing effort and of VME taxa within spatial scales at which effort and corresponding impacts are summarised (i.e. 'within the pixel'). At large spatial scales (i.e. 100s of km to 1 000s of km) this assumption is almost certainly false; spatial distributions of fish, of fishing and of benthic invertebrate abundance, may be influenced by a similar suite of environmental

variables (e.g. depth, benthic topography, water temperature) and are thus likely to be correlated (positively or negatively). Where there is a positive relationship, the assessment framework will underestimate impacts on VMEs; where the relationship is negative, it will overestimate impacts. Ideally, the assessment will be undertaken at a scale where there is no systematic relationship within a pixel between the deployment of the gear and the location of VMEs. However, at the smallest scales there can be no systematic relationship.

30. In 2010, WG-SAM (Annex 4, paragraphs 4.17 and 4.18) concluded that, because effort distributions become sufficiently disordered at scales smaller than 10 km pixels, there is likely to be no systematic association between fishing effort and VME taxa at this scale within the Ross Sea fishery. It recommended that impact assessments be carried out at the scale of 0.05° latitude × 0.167° longitude pixels. Where the assessment method is applied at larger scales, impact estimates arising from the method will accurately represent average impact levels within the pixel, but where VMEs are correlated with fishing effort at smaller scales, these averages may be misleading.

31. Note that the assessment framework makes the simplifying assumption that multiple footprints in the same area are non-overlapping, i.e. maximising the size of the footprint. Where cumulative proportional footprints are consistently low, this is likely to be a reasonable approximation of reality, but as cumulative footprint becomes a substantial proportion of the area, then this assumption may overestimate both footprint and impact. For heavily impacted areas, or for fishing methods with significantly larger footprints (e.g. bottom trawling), it may be necessary to address the effects of overlapping footprints.

Estimating habitat locations based on by-catch

32. Fishing gears are not designed to capture or retain non-target species, and are often specifically designed to avoid capture of non-target species. However, by-catch data can be used to infer the location of VME indicator taxa, although the absence of by-catch does not necessarily mean the absence of a VME. The degree to which catchability can be estimated, and the corresponding sampling density needed to infer absence with acceptable uncertainty, will be taxon-dependent and is best made through comparisons with independent sampling methods such as underwater video.

33. The probability of incidental capture is dependent on the specific configuration of the gear, the physical or behavioural characteristics of the species, and the mechanism of interaction between the two. The actual catchability observed at the surface will be a function of the occurrence of the species where fishing occurs, the probability of a unit of fishing gear interacting with the species, the probability that the specimen is initially retained (versus displaced, injured or killed), and the probability that the specimen is landed by the vessel and recorded. By-catch of VME taxa can be used for two purposes: determination of presence of a VME taxon in a location, or to estimate the relative abundance of a taxon at the location.

34. If incidental catchability is extremely low or excessively variable (haphazard), then no inference about VME taxon presence can be made when by-catch is zero, and conclusions are restricted to observations of presence-only when by-catch occurs. However, if catchability is moderate or high, and sampling density is sufficiently high, then both presence and absence can be inferred. The degree to which catchability can be estimated has been assessed in part

by WG-FSA-10/30, but the corresponding sampling density needed to infer absence with acceptable uncertainty will be taxon-specific and dependent on the density on the seafloor, and is best made through comparisons with independent sampling methods such as underwater video.

35. If the by-catch level can be shown to vary with taxon density in an area, then an actual index of abundance may be developed and positive catches in excess of some threshold can be used to indicate areas of relatively high abundance, and could provide evidence of a VME.

36. WG-FSA-10/30 provided further analysis since WG-EMM-10 of spatial patterns of benthic invertebrate habitats from fishery by-catch in the Ross Sea region. Some taxa are relatively common as by-catch (e.g. Porifera, anemones, stylasterid hydrocorals) and the detectability of habitats containing these taxa with autoline longline gear is moderate to high (e.g. 70+%). The detectability of each taxon and any discernible relationship with density should be examined to the fullest extent possible in areas with sufficiently high fishing effort and also for non-autoline gear configurations, and ultimately should be confirmed with independent sampling to link actual densities on the seafloor with amounts of by-catch observed using different fishing methods. Analysis of by-catch rates for several VME taxa from longline sets made with different gear configurations in the same fishing area would also be useful to assess the relative catchabilities of VME taxa using different gear types and to identify discrepancies in reporting patterns.

37. An important factor to consider when evaluating VME indicator taxa by-catch is the accuracy of observer classification. The accuracy of observer classification of VME taxa has been examined in three studies (TASO-09/8, WG-FSA-09/23 and TASO-10/10). These studies have shown that observers can reliably distinguish non-VME taxa from VME taxa, especially with some training. However, some individual groups can be confused (e.g. Scleractinia and Stylasteridae), and analyses that separate these groups should be interpreted with caution. Member States asking observers to identify individual invertebrate taxa or VME indicator taxa should provide information on training details and an assessment of observer accuracy so that data quality can be appropriately assessed.

38. Some VMEs may consist of rare or unique communities. Even with high detectability, the utility of using by-catch information is not likely to provide information about the extent of distributions of these taxa. Establishing alternative means of detecting these communities is desirable.

Assessment results

Review of Members' assessments 2010

39. Nine Members submitted notifications to participate in new and exploratory fisheries under CM 21-02 and submitted preliminary benthic impact assessments as required under CM 22-06. An additional notification from France was submitted but withdrawn and not considered further. Review of the benthic impact assessments followed the report card format endorsed by the Scientific Committee (SC-CAMLR-XXVIII, paragraph 4.244 and Annex 5, paragraphs 10.4 to 10.8 and Table 17).

40. Preliminary impact assessments submitted in 2010 were much more complete compared to those submitted in 2009, and most provided detailed information and diagrams of gear configuration, proposed effort and anticipated impacts allowing a more meaningful review and estimation of cumulative proposed fishing footprint (Table 2).

Cumulative impact assessment combined for all bottom fisheries in areas covered by CM 22-06

41. Cumulative fine-scale impact assessments were attempted, combined for all bottom fishing methods, within all subareas and divisions included in CM 22-06 following the framework above as recommended by WG-SAM (Annex 4, paragraph 4.16) and WG-EMM (Annex 6, paragraph 3.20). Input parameters for the autoline longline fishing method were adopted from WG-FSA-10/31 characterising two different types of bottom contact by autoline longlines, i.e. the 'standard footprint' within which the line is pulled in a longitudinal direction, and a 'lateral movement footprint' within which the longline may move sideways in contact with benthic organisms during the hauling process (WG-EMM-10/33). The presumed relationship between lateral longline movement frequency f_1 and depth in WG-FSA-10/31 was not used; $f_1 = 0.5$ was applied to all sets independent of depth. The input parameters for the impact assessment on autolines are given in Table 3 and illustrated in Figure 2.

42. The corresponding output distributions of *Footprint index* and *Mortality index* for the autoline longline method, generated using the R-library `IApdf`, are shown in Figure 2 and described as follows:

Footprint index: mean = 6.67×10^{-3}; median = 5.26×10^{-3}; 95% quantile = 12.1×10^{-3}
Impact index: mean = 5.07×10^{-3}; median = 4.70×10^{-3}; 95% quantile = 9.04×10^{-3}.

43. The assumptions and corresponding input parameters giving rise to these estimates of *Footprint index* and *Impact index* for the autoline longline method have been the subject of considerable discussion arising from previous iterations of the impact assessment framework but similar assessments for other bottom fishing methods – i.e. Spanish longlines, trotlines, pots and bottom trawls – have not been completed. Members are requested to complete method assessments for these fishing methods in the intersessional period. Method assessments for the Spanish longline and trotline methods will likely require estimates of the same five input parameters used in the autoline assessment above (i.e. characterising both the standard set without lateral movement and also the potential for lateral movement during hauling) and potentially parameters characterising other non-standard scenarios particular to these methods. An impact assessment for trawl gears is also needed to estimate historical impacts where trawling occurred in the areas included in CM 22-06.

44. Parameter values to characterise footprint and impact indices for pots and trawls have not yet been developed, and an impact assessment was not completed for these methods. Instead, spatial effort patterns for pots and trawls are displayed separately as effort-density distributions without corresponding estimates of impact. When method assessments for these gear types are available, actual footprint and impact estimates can be derived.

Fishing effort distributions

45. Effort totals for each fishing method by subarea/division are shown in Table 1. Also shown is the total area of the fishing effort distribution, and the estimated fishable area (600–1 800 m depth) in each subarea or division. Note, however, that the proportion of fishable area that has been fished at some level may not correspond to actual proportional impacts on VMEs because the distribution of VMEs with respect to the fished area is unknown. Note also that the fishing effort distribution summarised in a pixellated map is distinct from the fishing footprint which refers to the actual total area of the seafloor (within the fished area) contacted by fishing gear.

46. Spatially explicit effort distributions for all bottom fishing gear types were extracted from the CCAMLR C1 and C2 databases using the R routines developed by Mr J. McKinlay (Australia) and updated since being reported in WG-SAM-10/22 (available from the Secretariat). The trawl database includes effort from 1985 to 2010, and is known to be incomplete with respect to some recent research trawls. Updating the trawl database is a priority. Effort for each longline or trawl was distributed evenly along the length of the line/trawl at intervals of 1 km, and total effort was then summarised at a scale of 0.05° latitude × 0.177° longitude pixels, and converted to an actual effort density (km of line or trawl per km^2 of seabed area) by dividing by the area of the pixel. This spatial scale generates pixel sizes of approximately 5 km × 5 km at moderate latitudes, comparable to, or smaller than, the length of most longline deployments. WG-SAM-10 (Annex 4, paragraph 4.17) endorsed the application of the impact assessment framework at this scale for the Ross Sea fishery as a means of ensuring that there could be no systematic spatial association between the distributions of longlines and VME taxa at scales smaller than the summarised pixel.

Impact estimates

47. In the absence of detailed method assessments for all bottom fishing methods, a longline impact assessment was undertaken in which the Spanish longline and trotline methods were assigned the same *Footprint index* and *Impact index* values as the autoline longline method. The validity of assuming identical impacts for all longlines remains to be established. Spatially explicit estimates of longline footprint and impact were generated by multiplying the fine-scale effort density maps by the mean impact index in Figure 3 (i.e. 5.07×10^{-3}) * 100%. The resulting fine-scale impact estimates are not presented here in map form but are available from the Secretariat under the Rules for Access and Use of CCAMLR Data. Instead, these maps are summarised as histograms depicting the frequency distribution of pixels experiencing impact at different levels (see Figure 4) (SC-CAMLR-XXIX/BG/13).

48. The histograms in Figure 4 show that estimated impacts from longlines are generally low, and that within the fished areas of each subarea or division, fishing effort is distributed unevenly, with most fished pixels experiencing very low impacts (<0.4%) and with higher impacts concentrated in a few pixels; 41 of 10 155 fished pixels in all of the subareas included within CM 22-06 are estimated to have experienced greater than 3% longline impact mean estimate for the most fragile VME taxa (applying the mean estimate of impact index). The single-highest fine-scale pixel-specific longline impact mean estimate is 10.07%.

49. Effort density histograms for trawls are shown in Figure 5. Multiplying the effort densities on the x-axis by an appropriate impact index (Annex 4, paragraph 4.19) for trawls would yield an impact estimate distribution comparable to those in Figure 4.

50. Consistent with the procedures for publishing maps of fishing activity in the public domain, the fine-scale impact and effort density maps corresponding to Figures 4 and 5 were recreated at a larger spatial scale. These maps are shown as Figures 6 to 8. Note that because effort densities are now averaged across larger areas, maximum impact and maximum effort densities within each pixel are correspondingly lower.

51. The effort distribution maps in Figures 6 to 8 display coastline and islands (shaded light blue), the 1 000 m (blue) and 2 000 m (dark blue) isobaths, statistical division boundaries (black) and SSMU boundaries (grey). Displays are divided into cells that are 1.68° longitude × 0.45° latitude, equating to an area of approximately 2 500 km^2 at 74.5° latitude. A scale bar along the left axis indicates the distance in kilometres of 1° of longitude at the highest, lowest and middle latitude of the map. Mean estimated percent impact (for all longlines) (applying the mean estimate of impact index) or effort density (for trawls and pots) is shown for each cell on the map using a 7-point colour-ramp (green to red) determined from the quartiles and 95th, 99th and 99.9th percentile points of the impact/effort density distribution across the entire Convention Area. No maps were produced if accumulated effort in an area for all gear type since 1985 was less than 50 km. Beneath each map is a summary of fishing events (N) and total effort (km) by year for all three gear types.

STRATEGIES TO AVOID SIGNIFICANT ADVERSE IMPACTS ON VMEs

Current management system

52. The current framework for considering strategies to conserve VMEs is indicated in SC-CAMLR-XXVIII, Annex 5, paragraph 10.37 (Figure 9).

53. This figure was derived from existing practices and procedures and can be used as the framework for indicating what research and data collection activities might be required at different stages of the process of managing bottom fishing. It also clearly shows what is needed to develop scientific advice (SC-CAMLR-XXVI, Annex 5, paragraphs 14.21 to 14.39).

54. The current management strategy consists of the following components:

(i) a ban on bottom trawling in the high-seas areas of the Convention Area;

(ii) restriction of exploratory fishing for toothfish to areas deeper than 550 m;

(iii) closure of Risk Areas around by-catch of VME indicator taxa when greater than a threshold level;

(iv) notification of areas with evidence of VMEs to be included on a VME register.

55. This procedure has been reviewed by WS-VME and WG-EMM but no further recommendations on revising the conservation measures have been given.

Consideration of alternative avoidance and mitigation methods

56. There has been no other consideration of alternative avoidance and mitigation methods.

Evaluation of different strategies

57. Two programs, both written in R, are available for evaluating management strategies to avoid significant adverse impacts on VMEs by simulating key processes of VMEs and bottom fishing effort, and to evaluate the effects of various management strategies on the conservation status of VMEs:

(i) Patch v2.0 (WG-SAM-10/9) (manual and routines are available from the Secretariat);

(ii) spatially structured Schaefer production model (WG-SAM-10/19, WG-FSA-10/29) (an R library is available from the Secretariat).

58. The spatially structured Schaefer production model described in WG-FSA-10/29 has demonstrated, with simple case studies, that it operates consistent with expectations under extreme scenarios (main report, paragraph 9.32). WG-EMM has considered additional potential scenarios to be evaluated (Annex 6, paragraphs 3.52 to 3.56). Several factors require consideration when performing these evaluations, including temporal scales, spatial scales and whether the framework is considering individual species or ecosystem effects. Plausible scenarios for representing the ecosystem in operating models may include consideration of life-history characteristics, ecological theory, patch dynamics of sessile organisms and interaction between the fishery and habitat. Currently it is likely to be easier to evaluate individual taxa in the first instance as opposed to system-based approaches.

59. Simulations could be used to identify and characterise the types of data that may need to be collected in order to monitor and further develop options for management strategies, including, for example, mapping of habitats to inform the designation of open and closed fishing areas over particular types of VMEs, and the measurement of the effects of bottom fisheries on VMEs.

60. WG-EMM (Annex 6, paragraph 3.55) identified eight different factors that could be considered in developing case studies, and identified the ranges of those factors that would be a priority:

Factor	Range
Succession	None, literature range (consistent with factors in patch dynamics and spatial distribution)
Productivity	Low (r = 0.01) to high (r = 0.20)
Dispersal	None, literature range
Target species and VME taxa correlation	Negative, None, Positive, Separate spatial scales (fish at larger scale than VMEs) – in all cases distinguish between causal versus incidental correlation
Gear impact (footprint*fragility)	Impact assessment range
Spatial distribution of habitats	Random, restricted (several scales)
Management action Current/new approaches	None, current, in-season versus annual step closures; representative closed areas
Fleet dynamics	Uniform random, incorporating target correlation (ideal free), historical

MANAGEMENT ADVICE

Conservation measures

61. The Working Group agreed that the impact estimation requirements in CM 22-06 could be improved and recommended that the draft annex be adopted for use next year (see paragraphs above and Appendix D).

Other advice

62. The Working Group noted the progress on the different elements of the work plan of the Scientific Committee on bottom fisheries (SC-CAMLR-XXVIII, paragraph 4.251):

(i) Definition of Risk Areas –

No further progress.

(ii) Review of existing Risk Areas, including the development of a review process –

WG-EMM has summarised data to consider in reviewing Risk Areas (Annex 6, paragraph 3.40).

(iii) Development of a glossary of terms, including quantitative definitions as appropriate, to improve understanding and communication on these issues (SC-CAMLR-XXVIII, Annex 5, paragraphs 10.36 and 10.40) –

A glossary and accompanying diagram is included in Attachment A and Figure 1 and further discussed in the main report, paragraphs 9.2 to 9.11.

(iv) Further consideration of criteria to assist the Scientific Committee in defining areas as VMEs under CM 22-06 (SC-CAMLR-XXVIII, Annex 10, paragraph 6.14) –

WG-EMM has summarised characteristics that might be considered as evidence of VMEs (Annex 6, paragraph 3.48).

(v) Evaluation of the proportions of fishable areas that would comprise different benthic habitats and whether the frequency of observations of benthos in by-catch is consistent with the proportional coverage of these different habitats –

Some progress has been made on identifying habitat types using by-catch data (paragraph 36).

(vi) Development of alternate trigger levels for a range of VME taxa, including distinction between 'heavy' and 'light' taxa, along with options to enable taxon-specific weights to be collected (SC-CAMLR-XXVIII, Annex 5, paragraph 10.44) –

No further progress.

(vii) Consideration of whether the presence of high densities of rare taxonomic groups or unique community assemblages specific to the Southern Ocean will warrant additional attention, and perhaps an increased level of precaution (SC-CAMLR-XXVIII, Annex 4, paragraph 5.9) –

Some consideration has been given to this issue but no substantive progress has been made on methods on identifying locations of rare or unique assemblages (paragraphs 32 to 38).

(viii) Further consideration of fishing footprint and its possible impacts on VMEs, taking account of the differences in the interactions of different gears with the bottom (SC-CAMLR-XXVIII, Annex 5, paragraphs 10.20 to 10.22) –

An impact assessment procedure has been used to assess impacts of longline fishing (main report, paragraphs 9.13 and 9.14). Submissions are needed on Spanish longlines, trotlines, trawl and pot methods (main report, paragraphs 9.19 and 9.20).

(ix) Refinement of methods for creating cumulative fishery-scale footprint maps (SC-CAMLR-XXVIII, Annex 5, paragraphs 10.14 to 10.16), including resolving technical issues for their production, in order to update the calculations annually (SC-CAMLR-XXVIII, Annex 5, paragraphs 10.16 and 10.17) –

Software is now available in the Secretariat (main report, paragraph 9.12).

(x) Development of plausible scenarios of the types and dynamics of VMEs and the spatial and temporal interactions of the fishery with VMEs (SC-CAMLR-XXVIII, Annex 5, paragraph 10.45) –

Consideration of plausible scenarios by WG-EMM (Annex 6, paragraphs 3.52 to 3.55). The Working Group recommended that a focus topic be held on this issue at WG-FSA in 2012 when experts in benthic ecology could be invited to attend.

(xi) Evaluation of management strategies within the conservation measures, along with other possible strategies for avoiding significant adverse impacts on VMEs –

Progress has been made on developing simulation tools to evaluate management strategies (main report, paragraphs 9.32 and 9.33; Annex 4, paragraphs 4.7 to 4.11).

(xii) Further development of risk assessment frameworks (SC-CAMLR-XXVIII, Annex 4, paragraph 5.11; Annex 6, paragraphs 4.9 and 4.16; Annex 10, paragraphs 4.1 to 4.5) and simulation approaches, such as 'Patch' (SC-CAMLR-XXVIII, Annex 4, paragraphs 5.11 to 5.14; Annex 5, paragraphs 10.46 to 10.48; Annex 6, paragraphs 4.10 to 4.15, 4.17 to 4.19; Annex 10, paragraphs 4.6 to 4.10) –

This report presents the impact assessment framework currently being used to assess cumulative impacts, as well as describing the simulation methods that have been developed.

(xiii) Further assessment of benthic taxa against the seven criteria for assisting in evaluating their vulnerability (SC-CAMLR-XXVIII, Annex 10, paragraphs 3.1 to 3.10 and Table 1) –

No further progress has been made.

(xiv) Consideration of different methods for identifying locations of VMEs (SC-CAMLR-XXVIII, Annex 10, paragraphs 5.1 to 5.37 and 6.10 to 6.13) –

Methods to use by-catch data for locating habitat types have been developed (main report, paragraph 9.28).

(xv) Consideration of how the footprint estimates for different gears might be used to assess whether proposed bottom fishing activities would contribute to having significant adverse impacts on VMEs (SC-CAMLR-XXVIII, Annex 5, paragraph 10.13) –

Work is yet to be undertaken to use the impact assessment methods on assessing the impacts of proposed bottom fishing activities in the future. The simulation methods might be used in this regard.

(xvi) Further development of the Secretariat's capability to manage, store, process and summarise data resulting from CMs 22-06 and 22-07 is necessary (SC-CAMLR-XXVIII, Annex 5, paragraph 10.39), including the development of a work plan and budget, prioritising the capability to provide real-time data, and to provide data for use by the Scientific Committee and its working groups –

The Working Group endorsed the proposal of the Secretariat to further develop this capability (main report, paragraphs 9.29 and 9.30).

(xvii) Further develop the procedural framework for managing bottom fisheries –

No further progress has been made on this. The current framework is contained in Figure 9 (SC-CAMLR-XXVIII, Annex 5, paragraph 10.37 and Figure 13).

FUTURE WORK

63. Progress on the items above that are not yet completed is recommended.

REFERENCES

Fenaughty, J. and J. Bennett. 2005. Longlining operations on New Zealand autoline vessels fishing for toothfish in CCAMLR waters. Document *WG-FSA-05/54.* CCAMLR, Hobart, Australia.

Sharp, B.R., S.J. Parker and N. Smith. 2009. An impact assessment framework for bottom fishing methods in the CAMLR Convention Area. *CCAMLR Science*, 16: 195–210.

Table 1: Summary of historical bottom fishing effort (C1 and C2 database, 1985–2010) in all subareas/divisions affected by CM 22-06.

Subarea/ division	Mean fished depth (m)	Fished area (fine-scale pixels) (km²)	Fishable area (600–1 800 m) (km²)	Cumulative fishing effort (1985–2010)						
				Autoline (km)	Spanish line (km)	Trotline (km)	Unspecified longline (km)	All longline (km)	Trawl (km)	Pots (km)
48.1	344	16 605	77 851	0	97	0	0	97	2 900	0
48.2	296	13 824	74 081	0	24	0	0	24	10 310	47
48.5	936	1 969	73 345	30	18	0	0	48	67	
48.6	1 445	36 726	84 216	1 853	7 262	1 593	0	10 708	8	0
58.4.1	1 533	42 726	210 314	226	22 308	1 769	0	24 303	0	0
58.4.2	1 202	32 415	115 258	1 334	7 106	185	0	8 626	3 053	0
58.4.3a	1 334	20 525	18 605	238	7 062	902	0	8 202	17	0
58.4.3b	1 506	54 305	130 678	2 647	9 995	1 512	280	14 434	2	0
58.4.4	763	17 033	22 743	1 427	694	0	1 330	3 452	0	0
88.1	1 041	144 659	247 229	60 389	45 186	695	242	106 513	0	90
88.2	1 229	22 642	31 285	11 337	4 067	0	3	15 406	0	1
88.3	1 055	1 960	99 066	18	111	0	0	129	0	0
Total		405 390	1 184 671	79 499	103 930	6 656	1 855	191 941	16 358	138

Table 2: Report card review of Members' preliminary assessments of the effects of bottom fishing on VMEs under CM 22-06. Individual assessments were not ranked relative to each other, but reviewed relative to compliance, completeness and level of detail provided.

Member/gear	**Argentina**	**Japan**	**Korea, Republic of**	**New Zealand**	**Russia**	**South Africa**	**Spain**	**UK**	**Uruguay**	**Total**
1.1 Scope										
Number of vessels	1	1	7	4	4	1	1	2	1	22
Number of subareas/divisions	2	6	5	4	2	3	4	2	2	30
Notifications (vessel*fishery)	2	6	25	12	7	3	4	4	2	65
Assessment submitted	+	+	+	+	+	+	+	+	+	
1.2 Proposed fishing activity										
1.2.1 Detailed description of gear	L	M	H	H	H	H	H	H	M	
1.2.2 Scale of proposed activity (number of sets)	90	400	840	550	875	NA	125	250	64	
1.2.3 Spatial distribution of activity	+	+	+	+	+	+	+	+	+	
1.3 Mitigation measures to be used	+	+	+	+	+	+	+	+	+	
Effectiveness	+	+	+	+	+	+	+	+	+	
2.1 Assessment of known/ anticipated impacts on VMEs										
2.1.1 Estimated spatial effort footprint *Please provide details of % area covered by fishing effort.*	+	+	+	+	+	+	+	+	+	
2.1.2 Summary of potential VMEs present within areas of activity	+	+	+	+	+	+	+	+	+	
2.1.3 Probability of impacts	+	+	+	+	+	+	+	+	+	
2.1.4 Magnitude/severity of the interaction of the proposed fishing gear with VMEs	+	+	+	+	+	+	+	+	+	
2.1.5 Physical and biological/ecological consequences of impact	+	+	+	+	+	+	+	+	+	
2.2 Estimated cumulative footprint	+	+	+	+	+	+	+	+	+	
2.3 Research activities related to provision of new information on VMEs										
2.3.1 Previous research	+	+	+	+	+	+	+	+	+	
2.3.2 In-season research	+	+	+	+	+	+	+	+	+	
2.3.3 Follow-on research	+	+	+	+	+	+	+	+	+	
Cumulative assessment quality	H	H	H	H	H	H	H	H	H	

Table 3: Descriptive statistics for input distributions used by the impact simulation as shown in Figure 2.

	Shape	Mean	Median	Range
Standard footprint area A_0 (km^2)	lognormal	0.82×10^{-3}	0.74×10^{-3}	0.10–3.0
Standard fragility F_0 (0–1)	normal	0.780	0.786	0.48–1.0
Lateral movement area A_1 (km^2)	lognormal	10.4×10^{-3}	9.74×10^{-3}	0.50–25.0
Lateral movement fragility F_1 (0–1)	normal	0.699	0.699	0.40–1.0
Lateral movement frequency f_1 (0–1)	normal	0.5	0.5	0.05–0.95

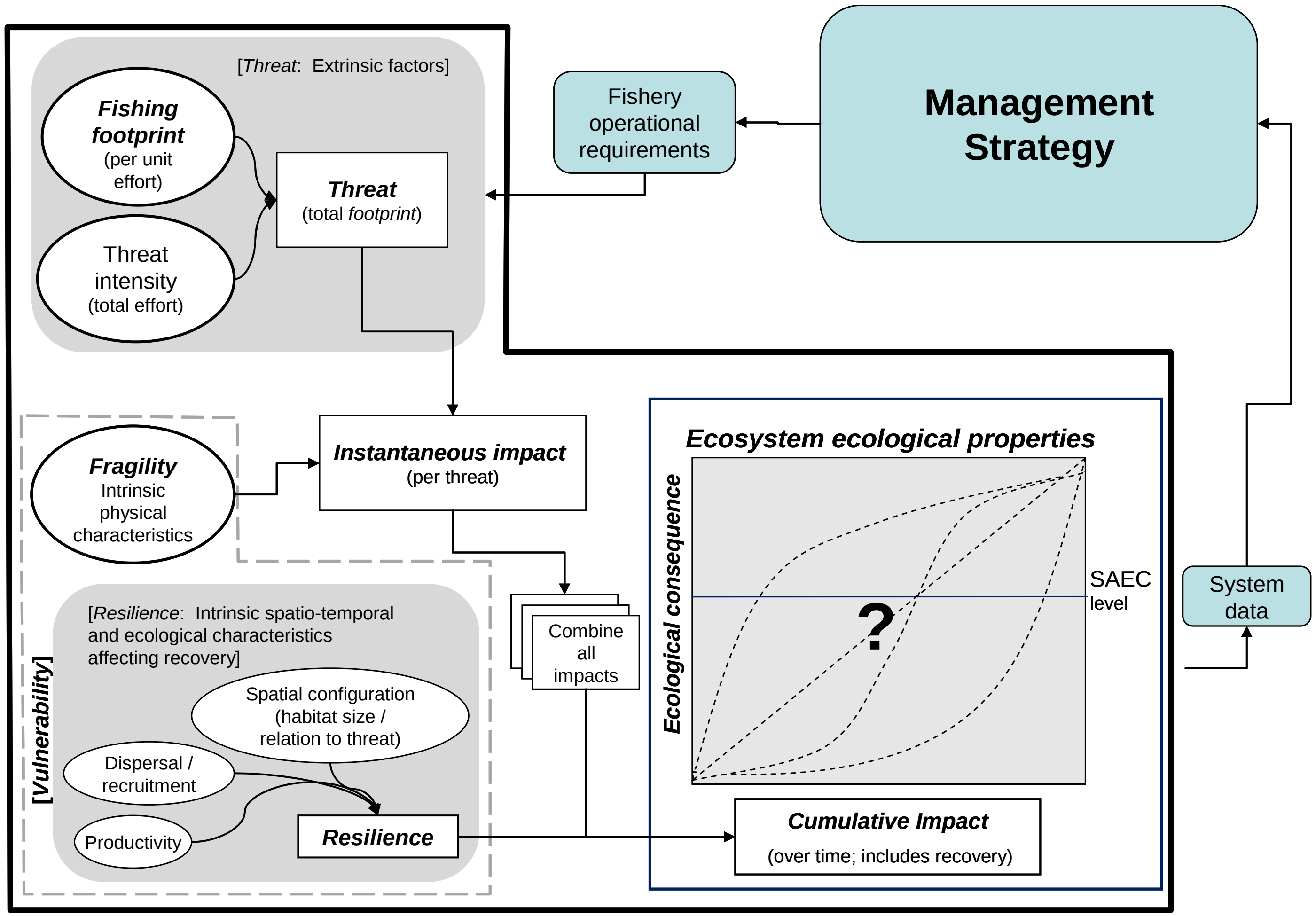

Figure 1: Conceptual diagram of the relationships among the terms used in the VME glossary. The thick black box indicates aspects of ecosystem dynamics and the relationship of the fishery to the ecosystem. Data are derived either from the fishery or as fishery-independent activities. These data are used in the management strategy, which determines the operational requirements of the fishery. A management strategy includes assessment method/s and decision rules or approaches by which the results of the assessment, which can include estimates of risk, can be used to adjust the operations of the fishery as needed.

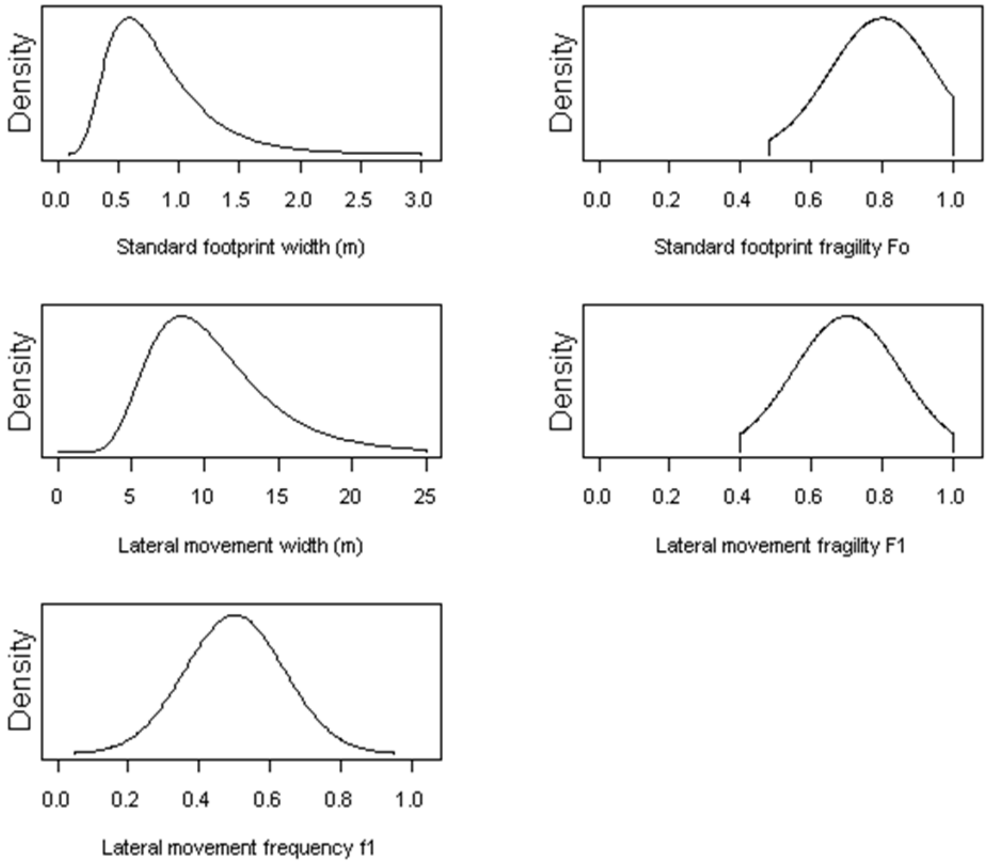

Figure 2: Default prior distributions for model inputs used in the estimation of *Footprint index* and *Mortality index*. Footprint width distributions are shown in metres for ease of interpretation; these can be translated into the footprint area input terms A_0 and A_1 (in km^2) by multiplying by 10^{-3}.

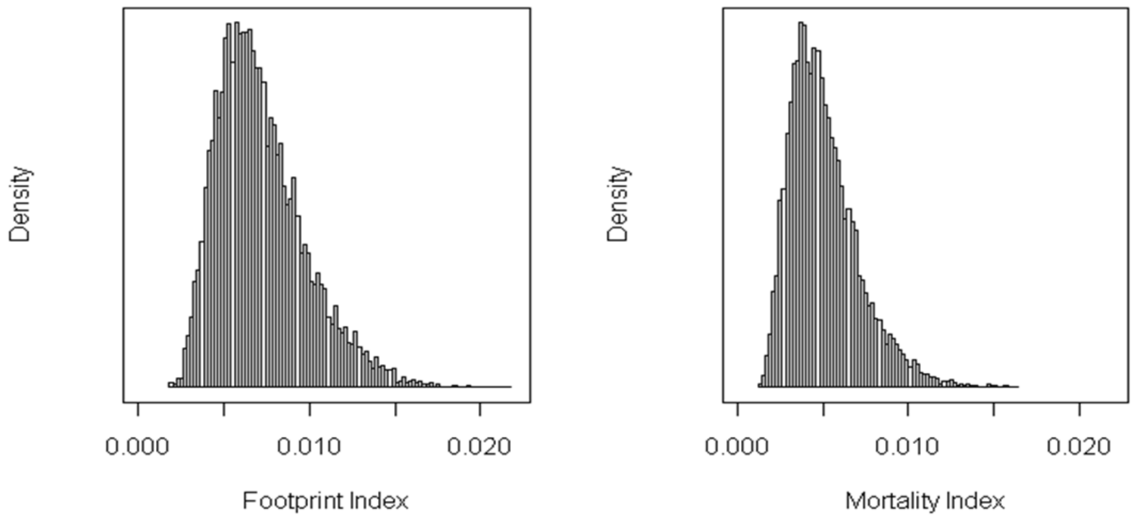

Figure 3: Posterior distributions of the *Footprint index* and *Mortality index* values predicted from the impact simulation using the R-Library IApdf using input assumptions as in Figure 2. Corresponding impact estimates within each subarea are summarised in Figure 4.

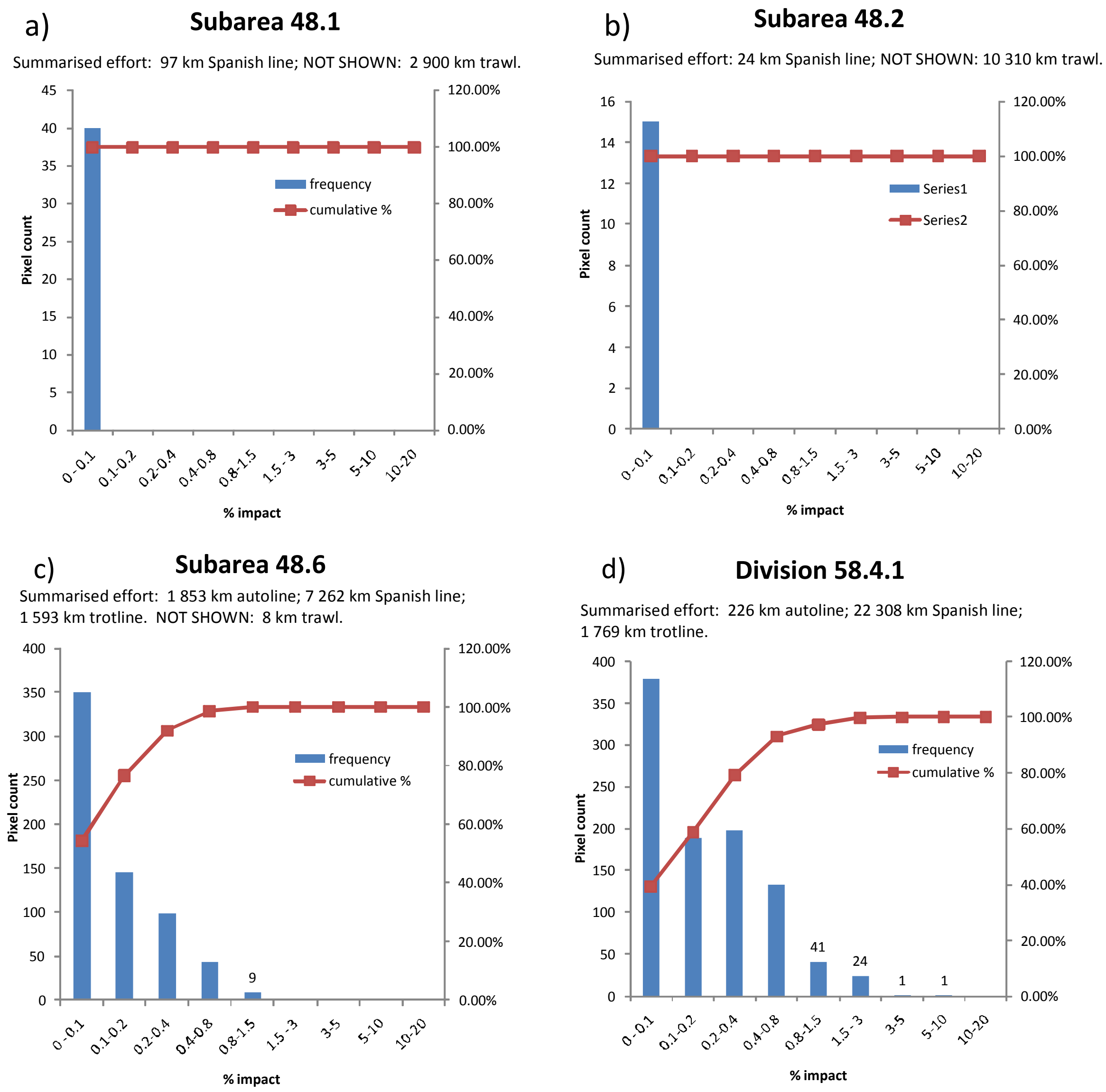

Figure 4(a–d): Cumulative impacts estimated for total longline fishing effort (1985–2010) in subareas/divisions affected by CM 22-06: (a) Subarea 48.1, (b) Subarea 48.2, (c) Subarea 48.6 and (d) Division 58.4.1. Histograms depict frequency distributions of small-scale pixels (0.05° latitude × 0.167° longitude) experiencing different levels of impact, applying the mean impact index value for the most-fragile VME taxa. Only pixels with non-zero values for cumulative longline effort are shown.

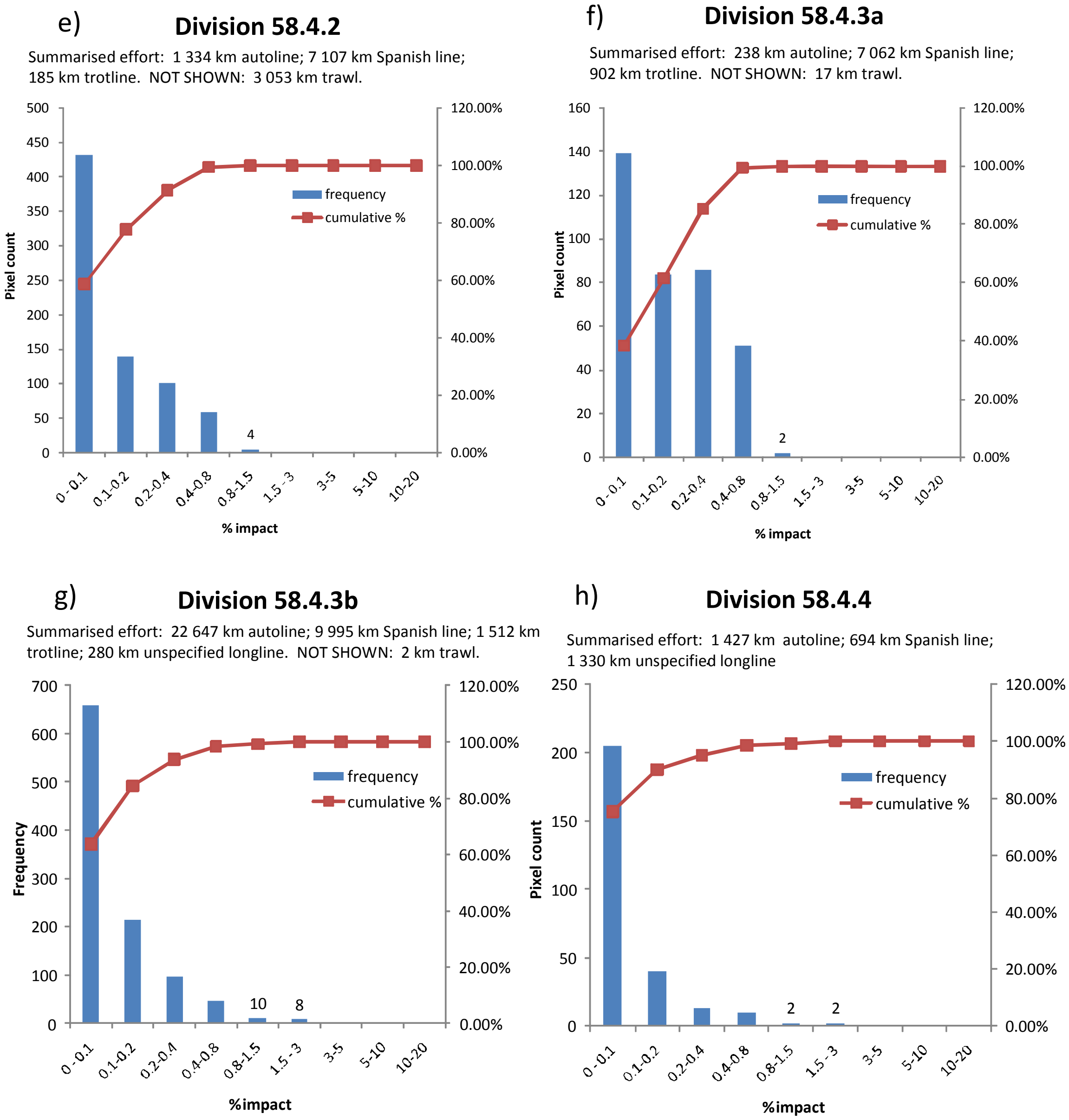

Figure 4(e–h): Cumulative impacts estimated for total longline fishing effort (1985–2010) in subareas/divisions affected by CM 22-06: (e) Division 58.4.2, (f) Division 58.4.3a, (g) Division 58.4.3b and (h) Division 58.4.4. The histograms depict frequency distributions of small-scale pixels (0.05° latitude × 0.167° longitude) experiencing different levels of impact, applying the mean impact index value for the most-fragile VME taxa. Only pixels with non-zero values for cumulative longline effort are shown.

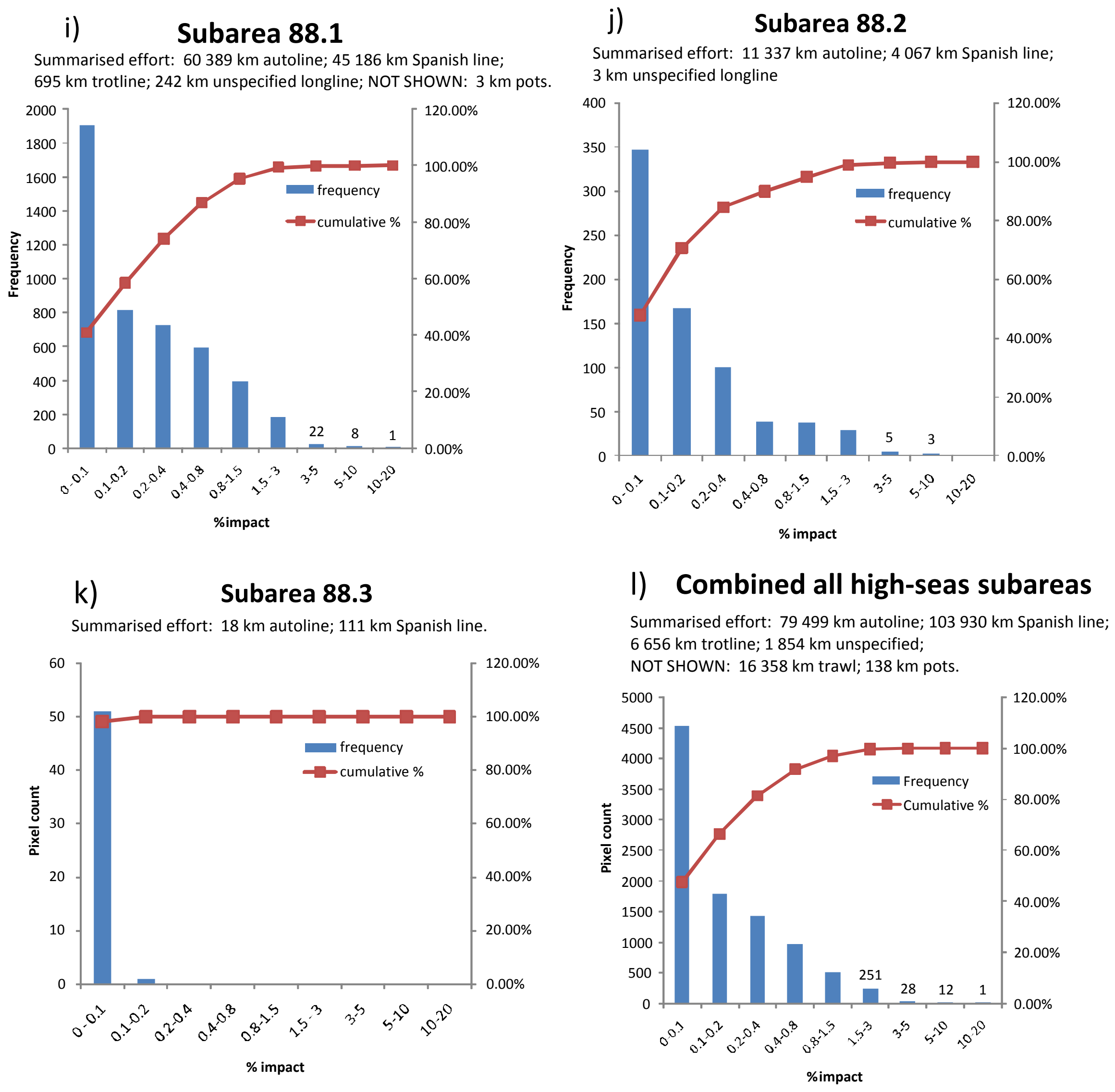

Figure 4(i–l): Cumulative impacts estimated for total longline fishing effort (1985–2010) in subareas/divisions affected by CM 22-06: (i) Subarea 88.1, (j) Subarea 88.2, (k) Subarea 88.3 and (l) combined for all high-seas subareas. The histograms depict frequency distributions of small-scale pixels (0.05° latitude × 0.167° longitude) experiencing different levels of impact, applying the mean impact index value for the most-fragile VME taxa. Only pixels with non-zero values for cumulative longline effort are shown.

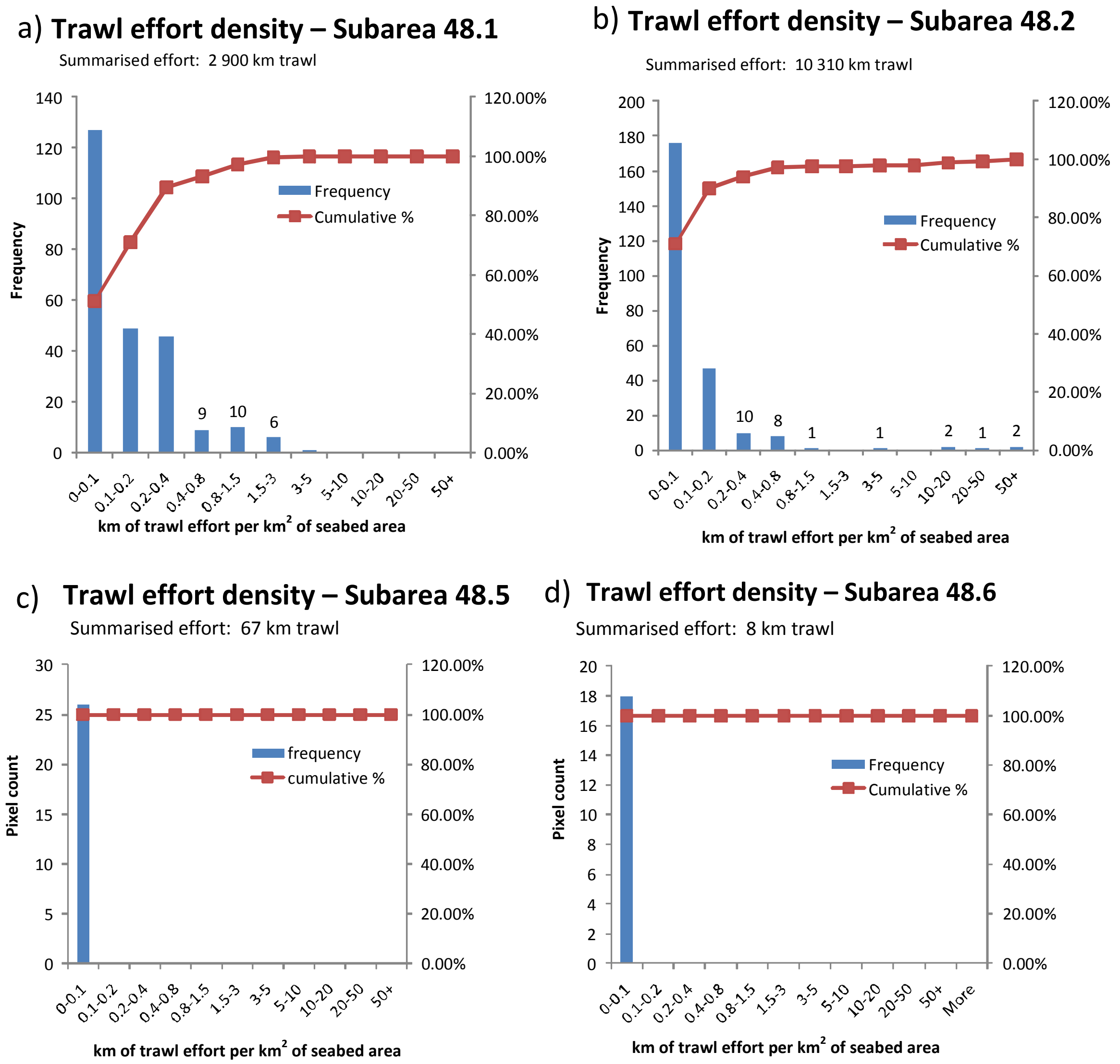

Figure 5(a–d): Cumulative effort density of trawl fishing effort (1985–2010) in subareas/divisions affected by CM 22-06: (a) Subarea 48.1, (b) Subarea 48.2, (c) Subarea 48.5 and (d) Subarea 48.6. The histograms depict frequency distributions of small-scale pixels (0.05° latitude × 0.167° longitude) with different historical concentrations of trawl effort. Only pixels with non-zero values for trawl effort are shown.

e) **Trawl effort density – Division 58.4.2**

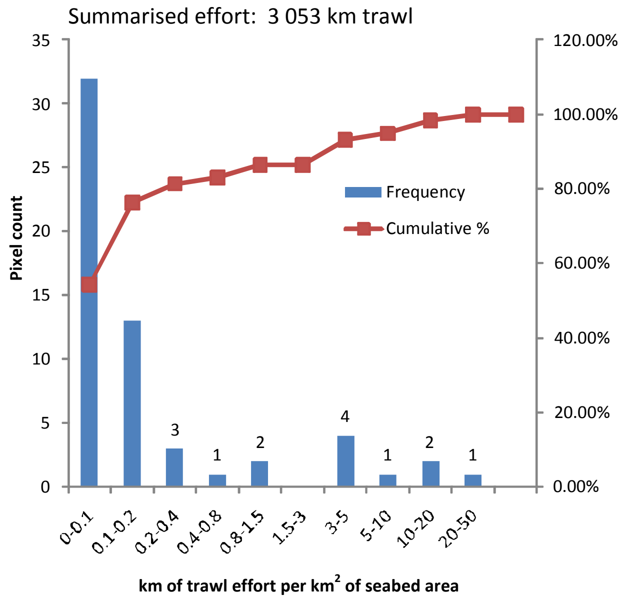

Figure 5(e): Cumulative effort density of trawl fishing effort (1985–2010) in subareas/divisions affected by CM 22-06: (e) Division 58.4.2. The histograms depict frequency distributions of small-scale pixels (0.05° latitude × 0.167° longitude) with different historical concentrations of trawl effort. Only pixels with non-zero values for trawl effort are shown.

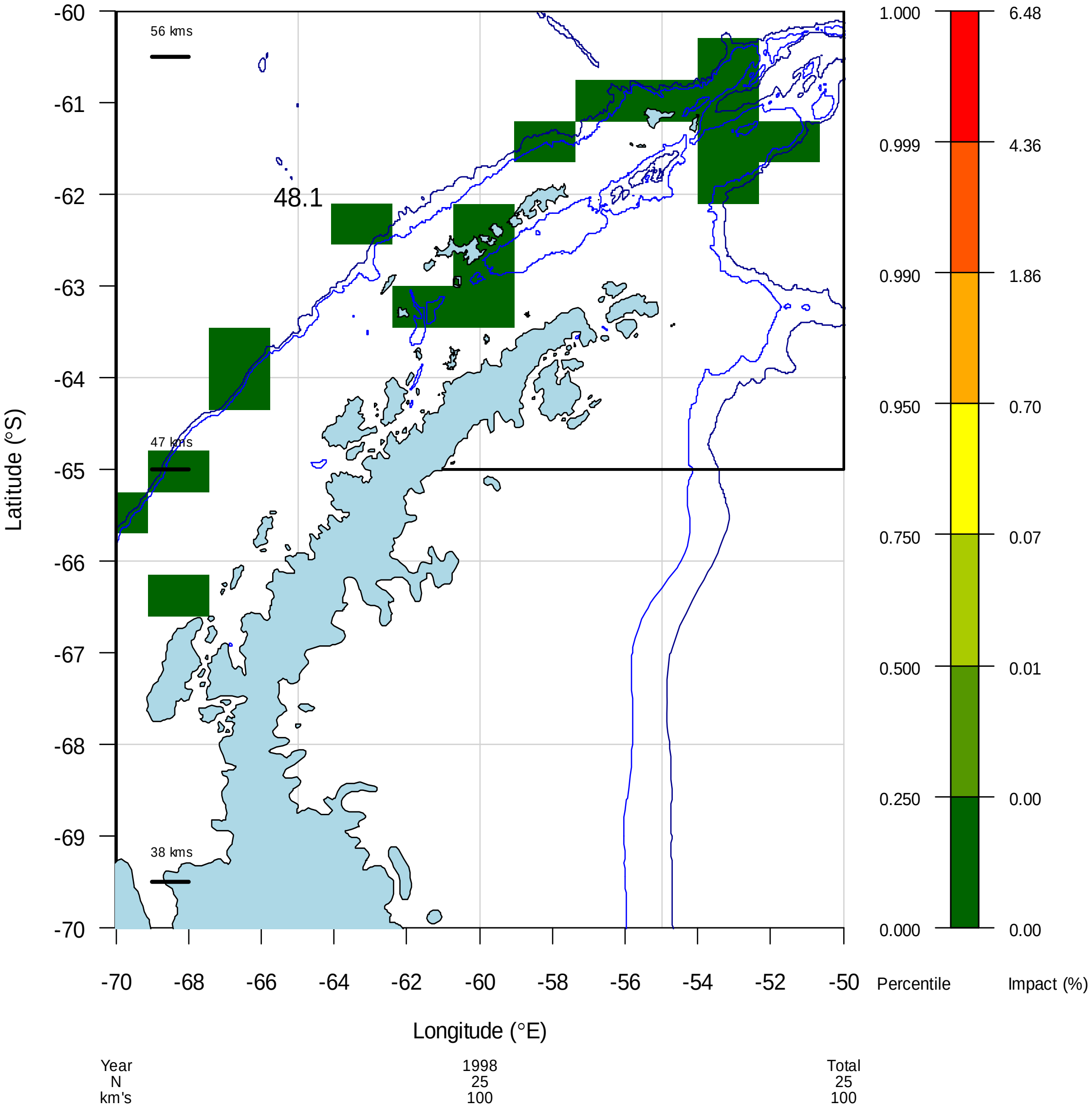

Figure 6(a)*: Map showing estimated percent impact due to longline bottom fishing (all longline types) for Subarea 48.1. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

* This figure is available in colour on the CCAMLR website (www.ccamlr.org).

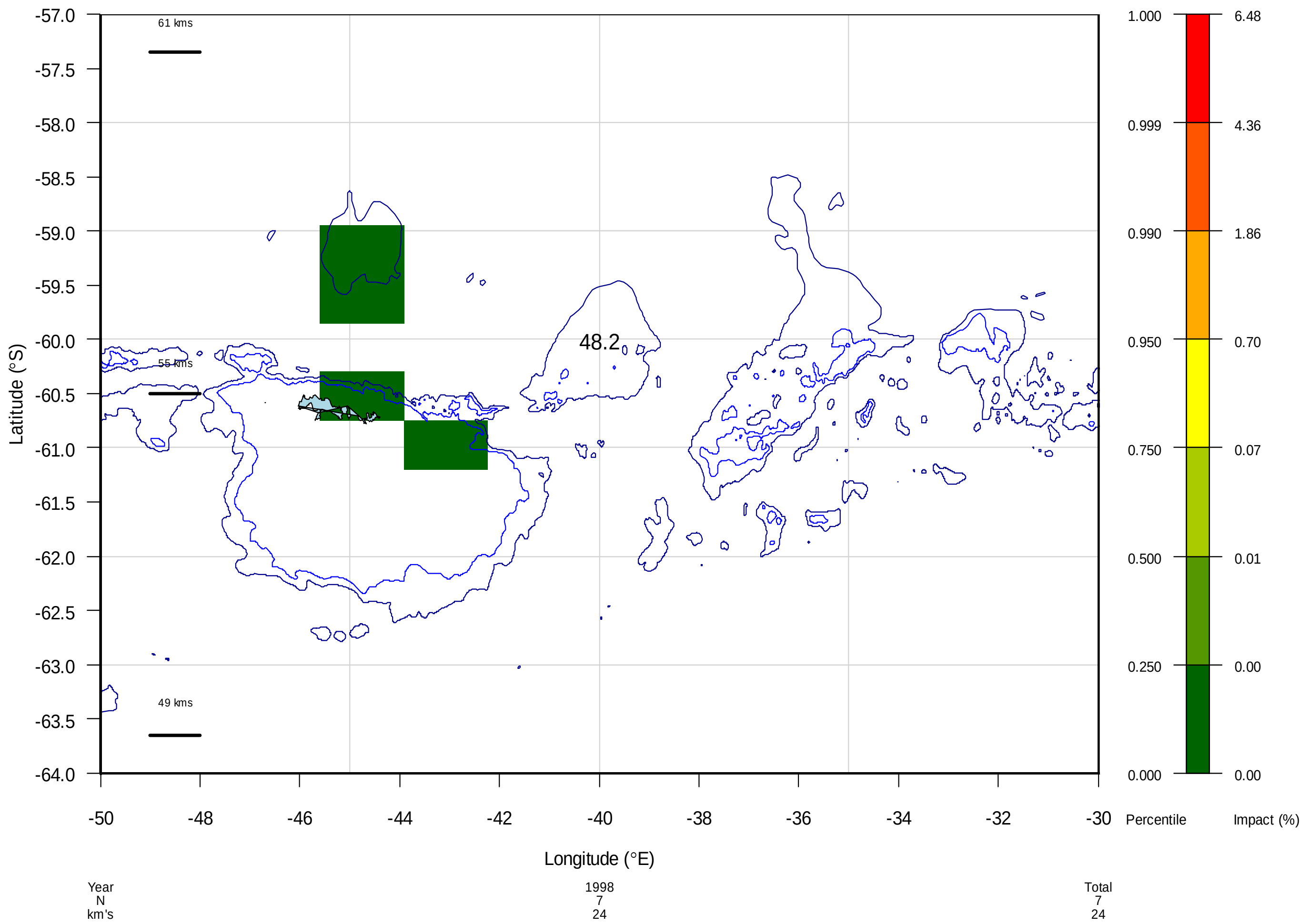

Figure 6(b)*: Map showing estimated percent impact due to longline bottom fishing (all longline types) for Subarea 48.2. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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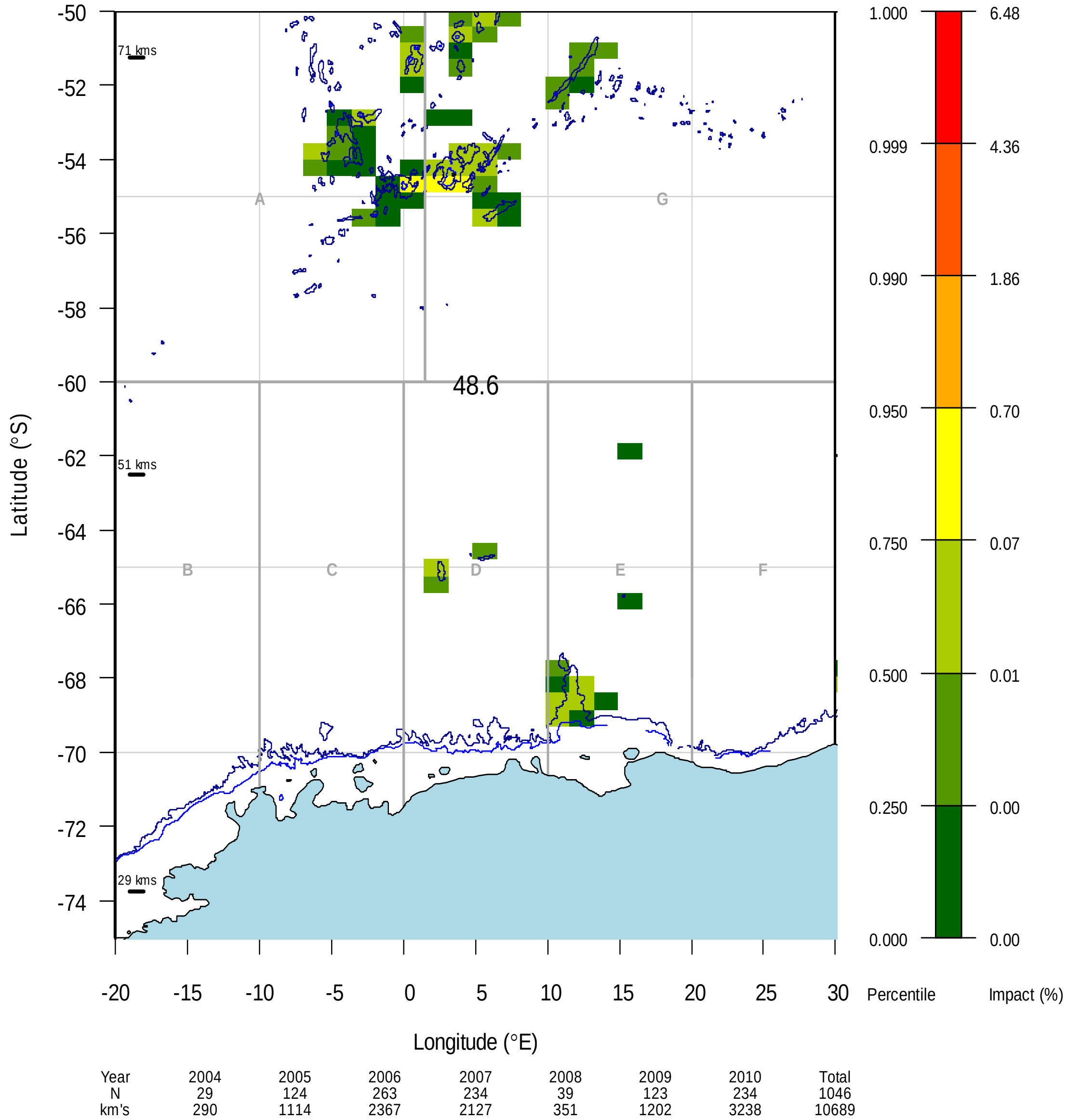

Figure 6(c)*: Map showing estimated percent impact due to longline bottom fishing (all longline types) for Subarea 48.6. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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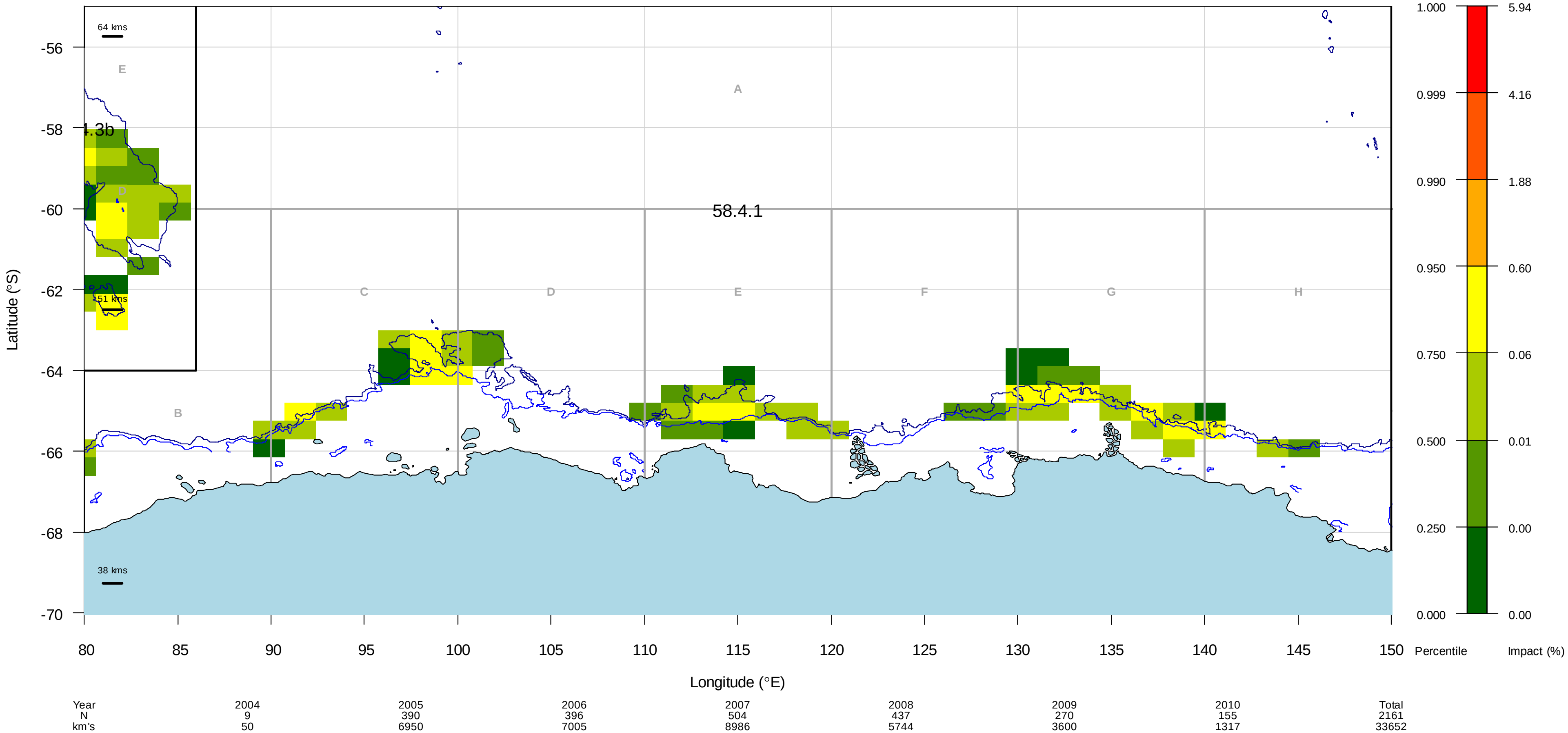

Figure 6(d)*: Map showing estimated percent impact due to longline bottom fishing (all longline types) for Division 58.4.1. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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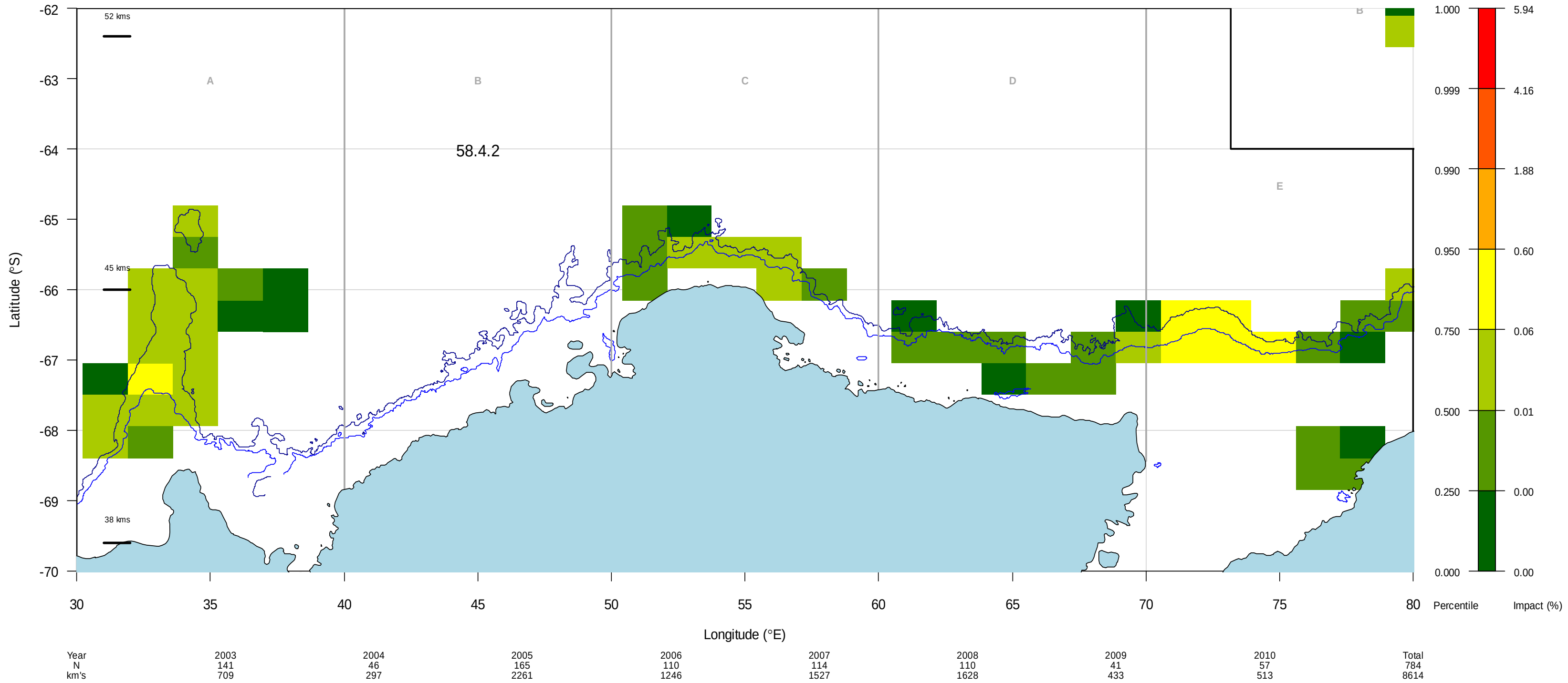

Figure 6(e)*: Map showing estimated percent impact due to longline bottom fishing (all longline types) for Division 58.4.2. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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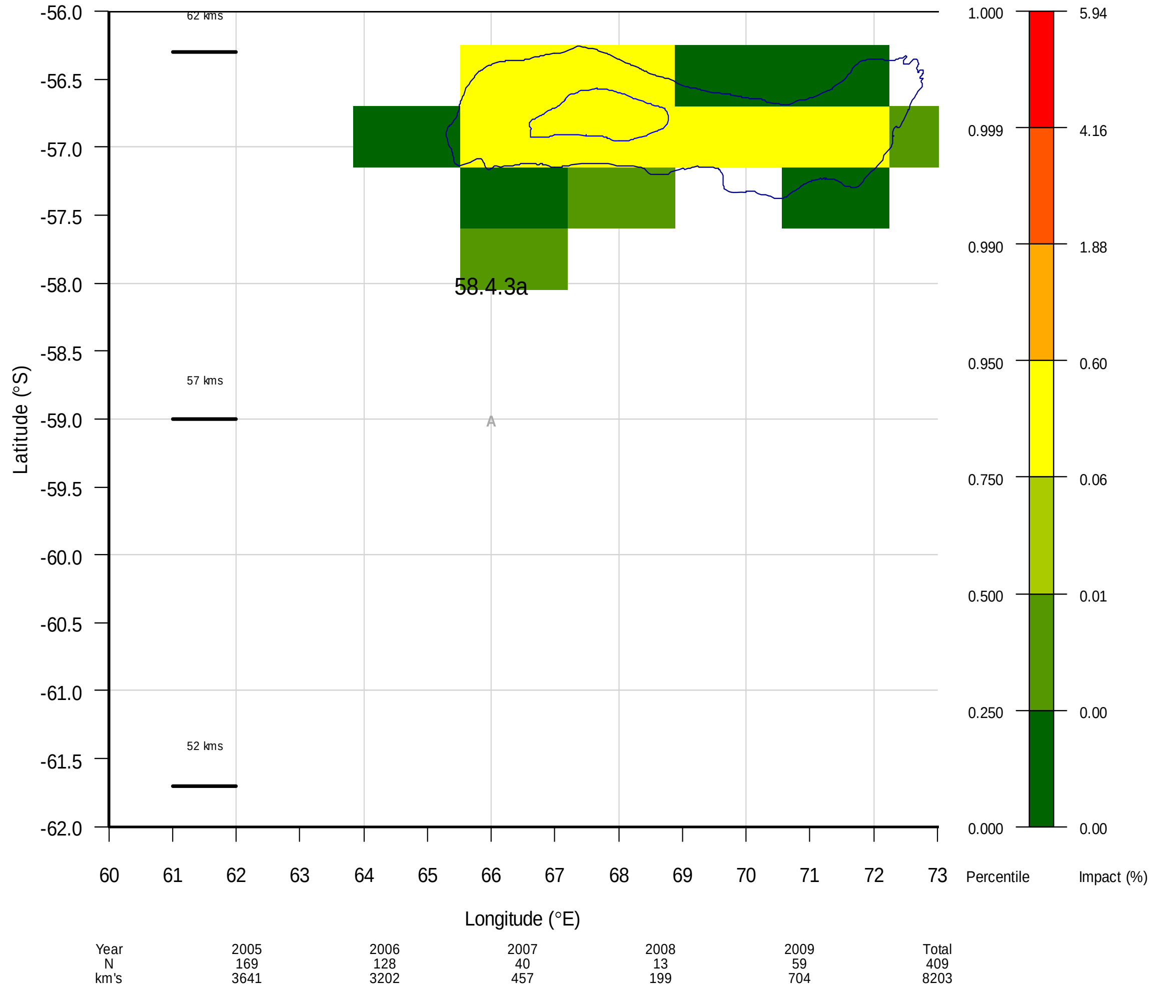

Figure 6(f)*: Map showing estimated percent impact due to longline bottom fishing (all longline types) for Division 58.4.3a. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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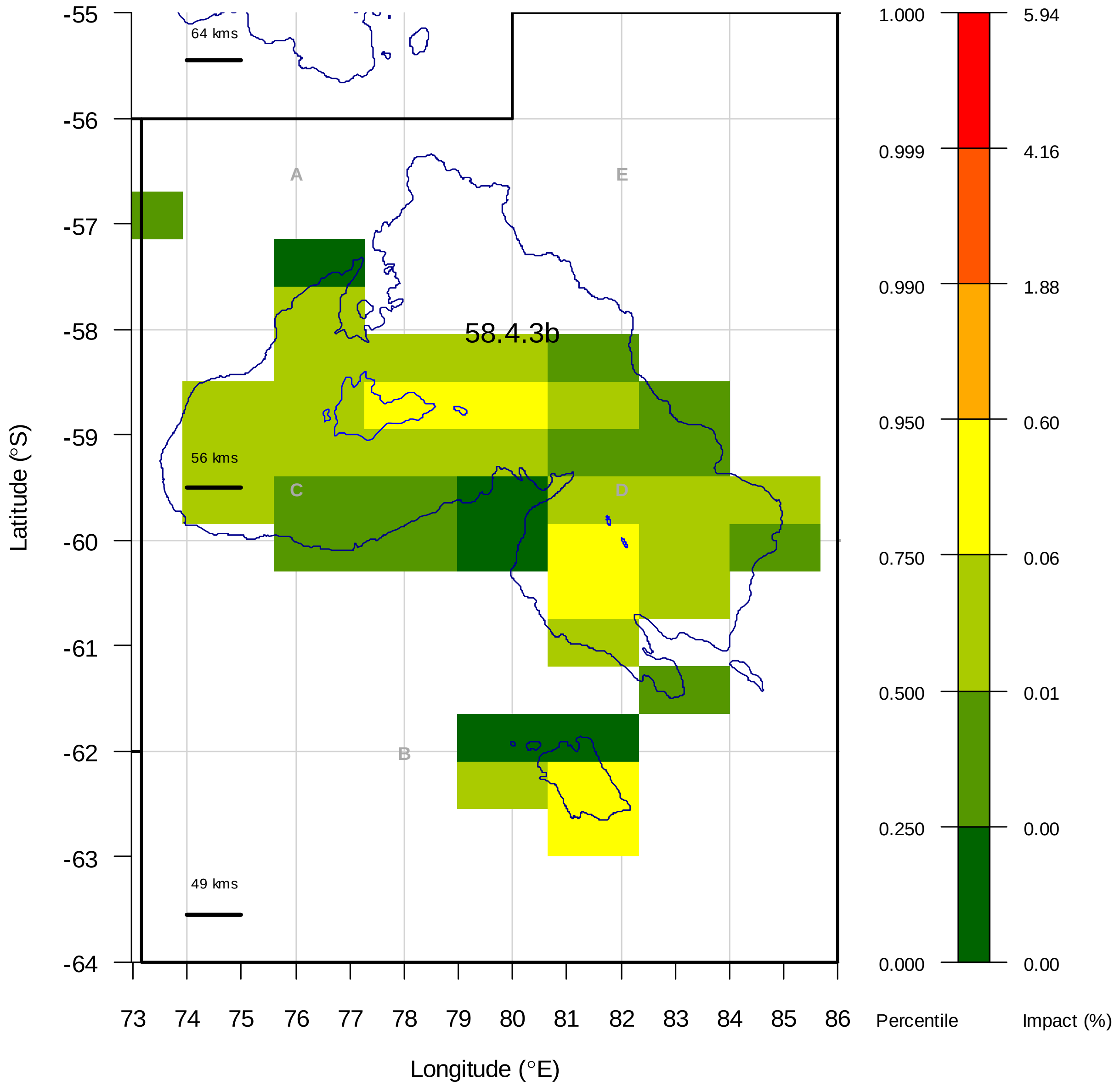

Year	2004	2005	2006	2007	2008	2009	2010	Total
N	19	160	191	282	192	95	24	963
km's	109	3080	3922	4036	1867	1204	216	14434

Figure 6(g)*: Map showing estimated percent impact due to longline bottom fishing (all longline types) for Statistical Division 58.4.3b. Cells are 0.45° latitude by 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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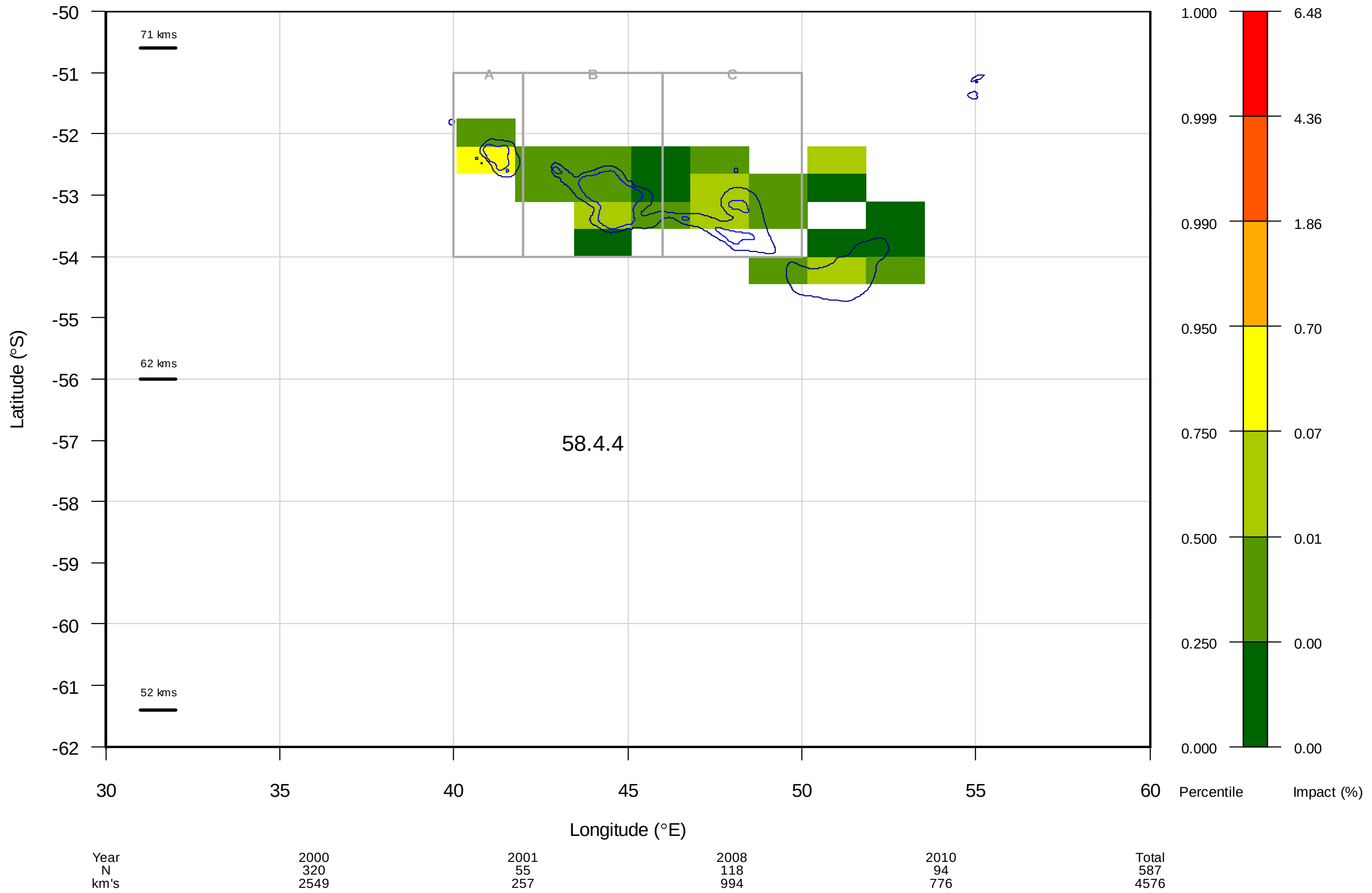

Figure 6(h)*: Map showing estimated percent impact due to longline bottom fishing (all longline types) for Division 58.4.4. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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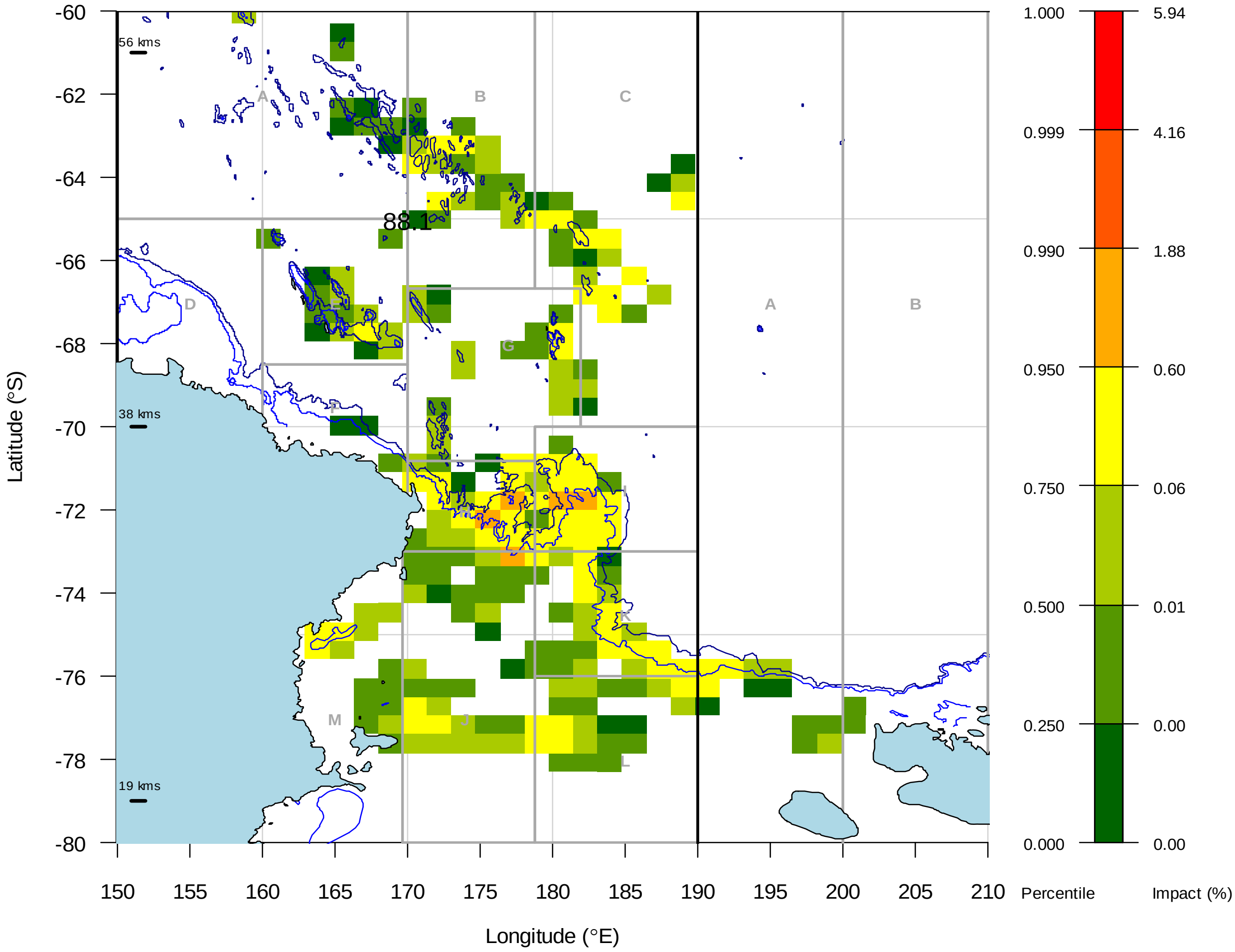

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
N	2	82	252	480	683	432	794	2160	1529	1040	1395	1012	966	1068	11895
km's	4	330	1769	2660	4576	3370	7009	19512	13657	10233	11783	10127	9080	13633	107743

Figure 6(i)*: Map showing estimated percent impact due to longline bottom fishing (all longline types) for Subareas 88.1 (all) and 88.2 (SSRUs A and B only). Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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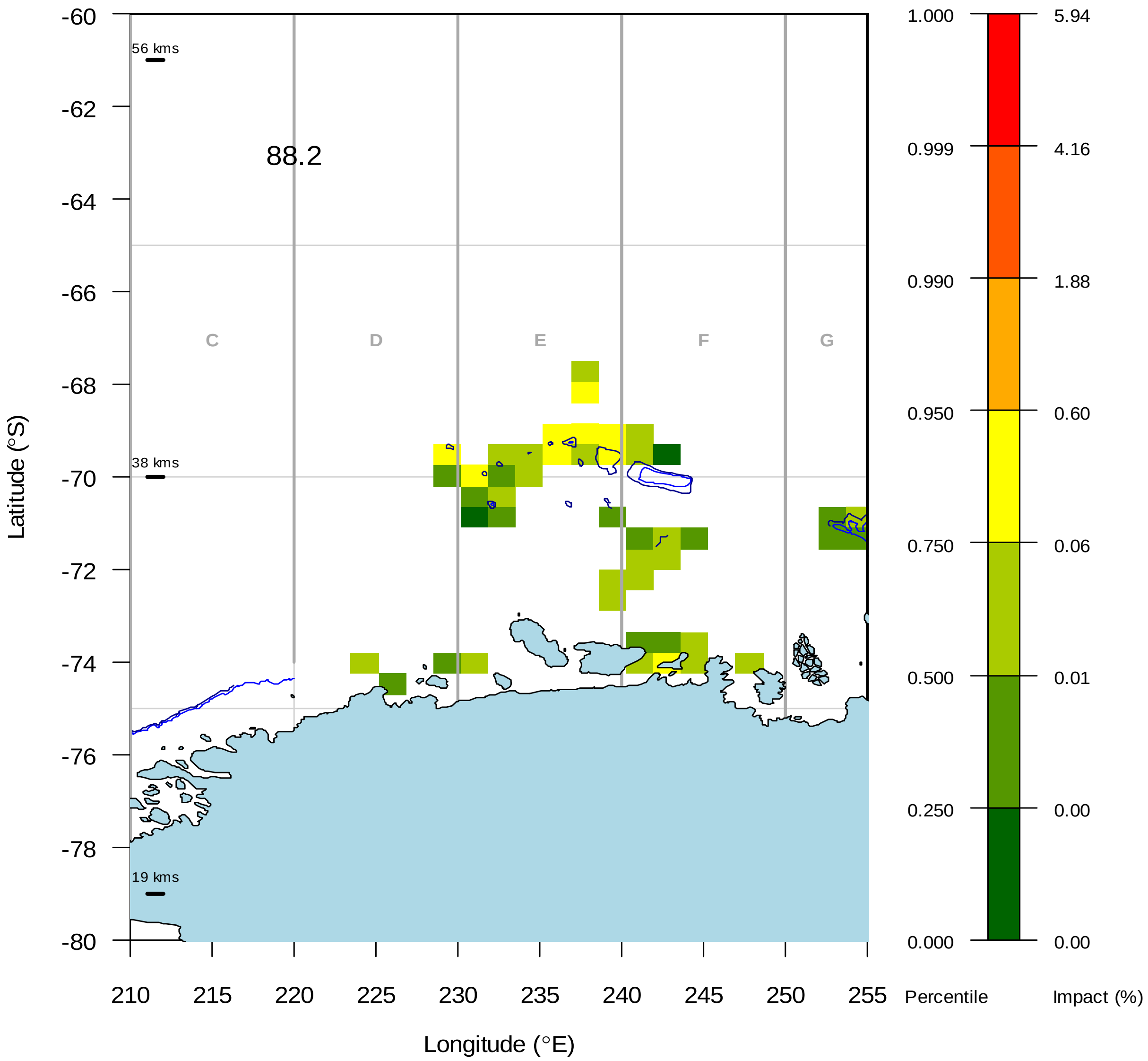

Year	2003	2004	2005	2006	2007	2008	2009	2010	Total
N	78	168	89	267	279	128	532	201	1742
km's	422	1147	544	1945	2922	1346	3985	2114	14425

Figure 6(j)*: Map showing estimated percent impact due to longline bottom fishing (all longline types) for Subarea 88.2 (SSRUs C–G only). Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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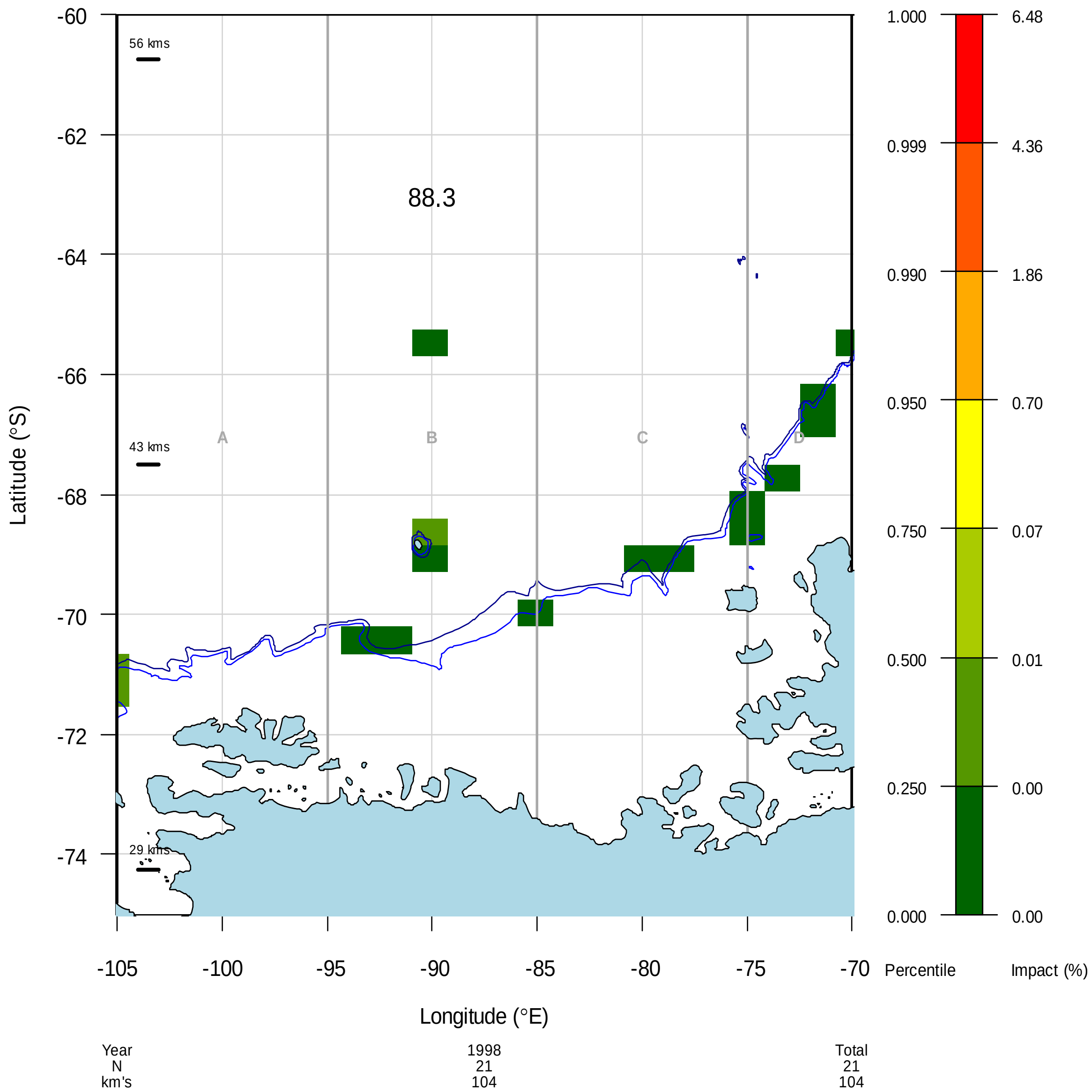

Figure 6(k)*: Map showing estimated percent impact due to longline bottom fishing (all longline types) for Subarea 88.3. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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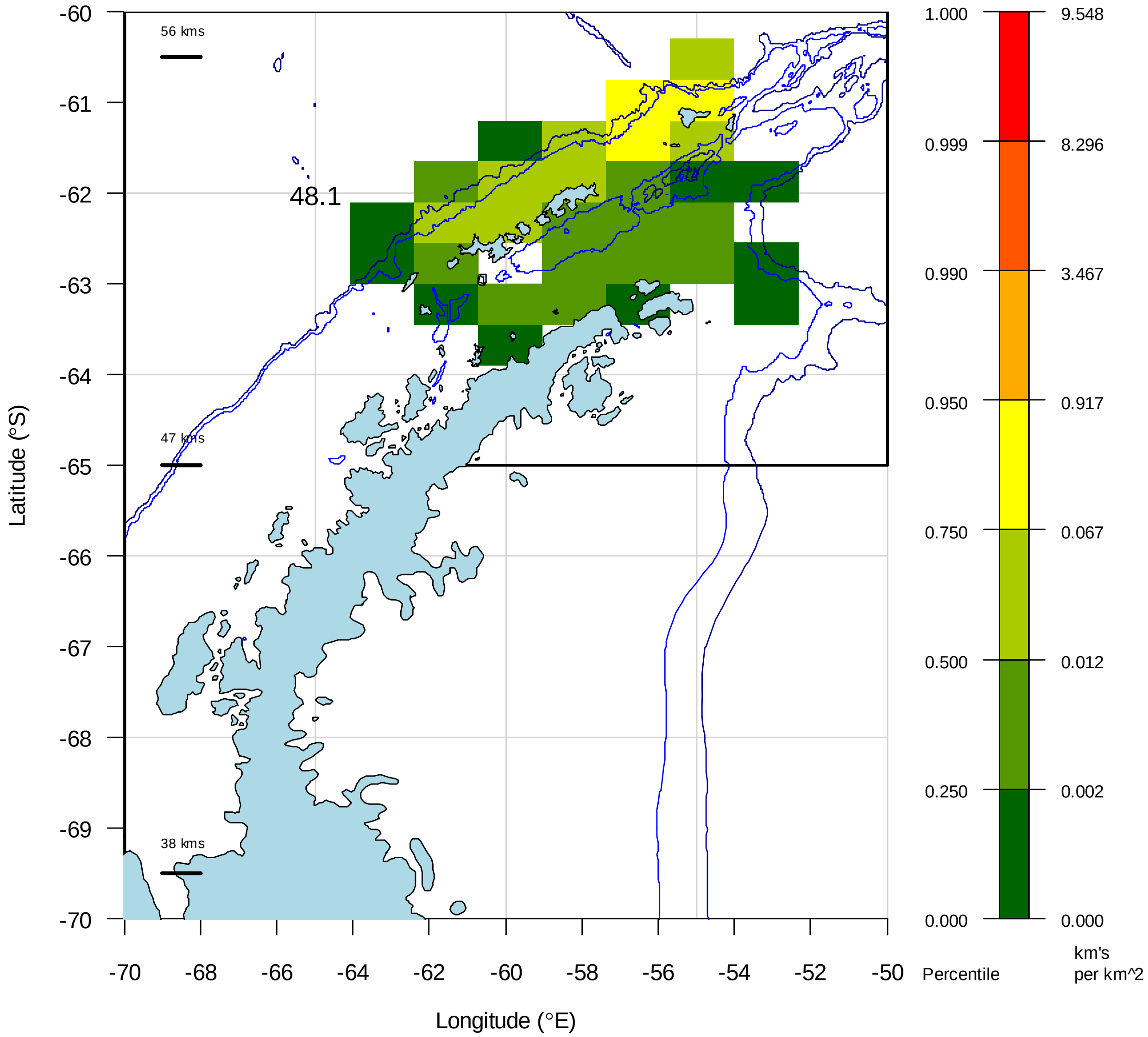

Year	1985	1986	1987	1988	1996	1997	1998	2001	2002	2003	2006	2007	2009	Total
N	47	37	57	25	41	18	75	71	75	69	65	85	3	668
km's	195	121	922	170	156	61	208	171	222	163	124	376	12	2901

Figure 7(a)*: Map showing bottom trawl effort density for Subarea 48.1. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp is determined from the quartiles and 95th, 99th and 99.9th percentile points of the distribution of trawl effort density across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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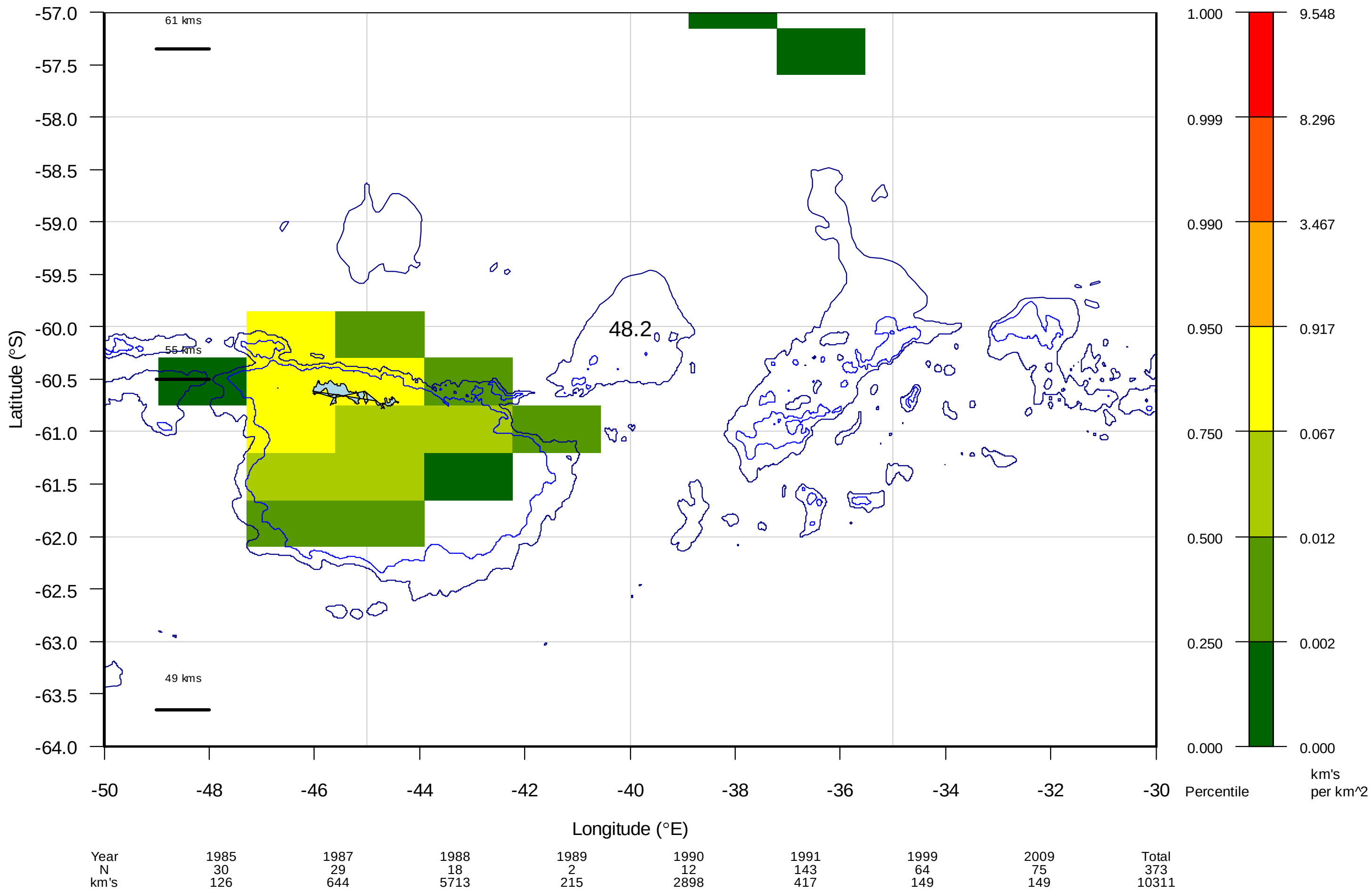

Figure 7(b)*: Map showing bottom trawl effort density for Subarea 48.2. Cells are 1.68° longitude × 0.45° latitude. The colour-ramp is determined from the quartiles and 95th, 99th and 99.9th percentile points of the distribution of trawl effort density across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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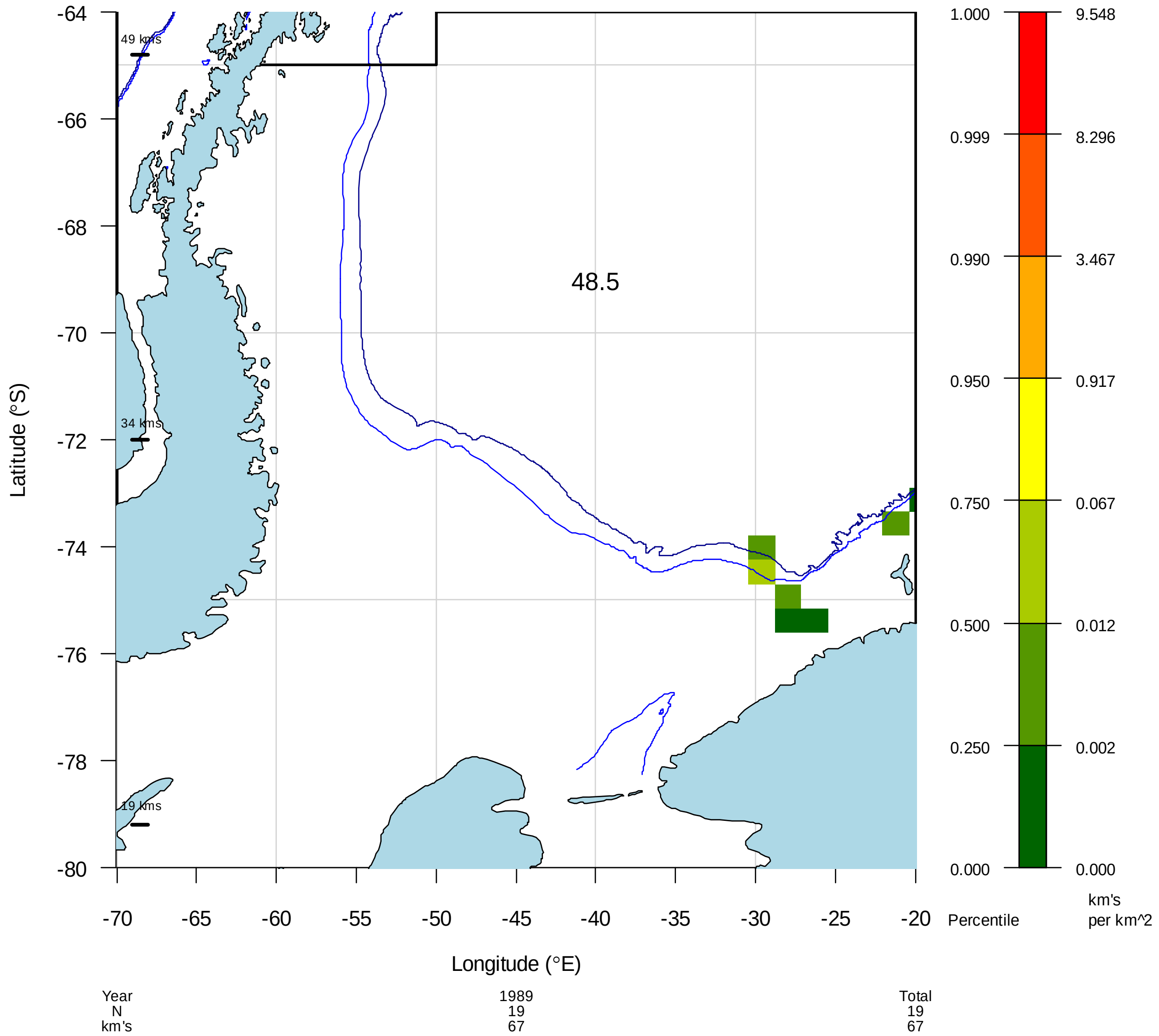

Figure 7(c)*: Map showing bottom trawl effort density for Subarea 48.5. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp is determined from the quartiles and 95th, 99th and 99.9th percentile points of the distribution of trawl effort density across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

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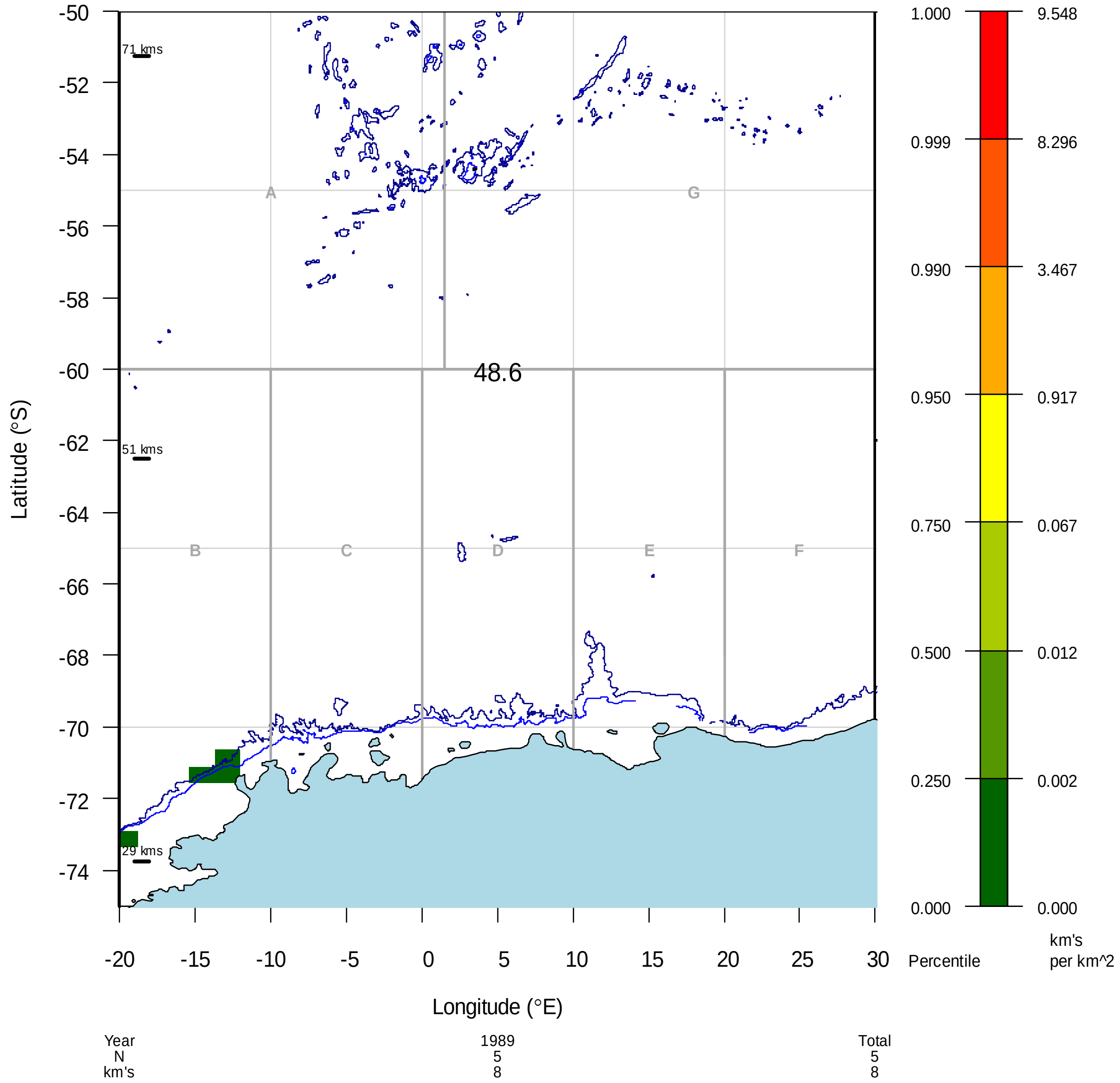

Figure 7(d)*: Map showing bottom trawl effort density for Subarea 48.6. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp is determined from the quartiles and 95th, 99th and 99.9th percentile points of the distribution of trawl effort density across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

* This figure is available in colour on the CCAMLR website (www.ccamlr.org).

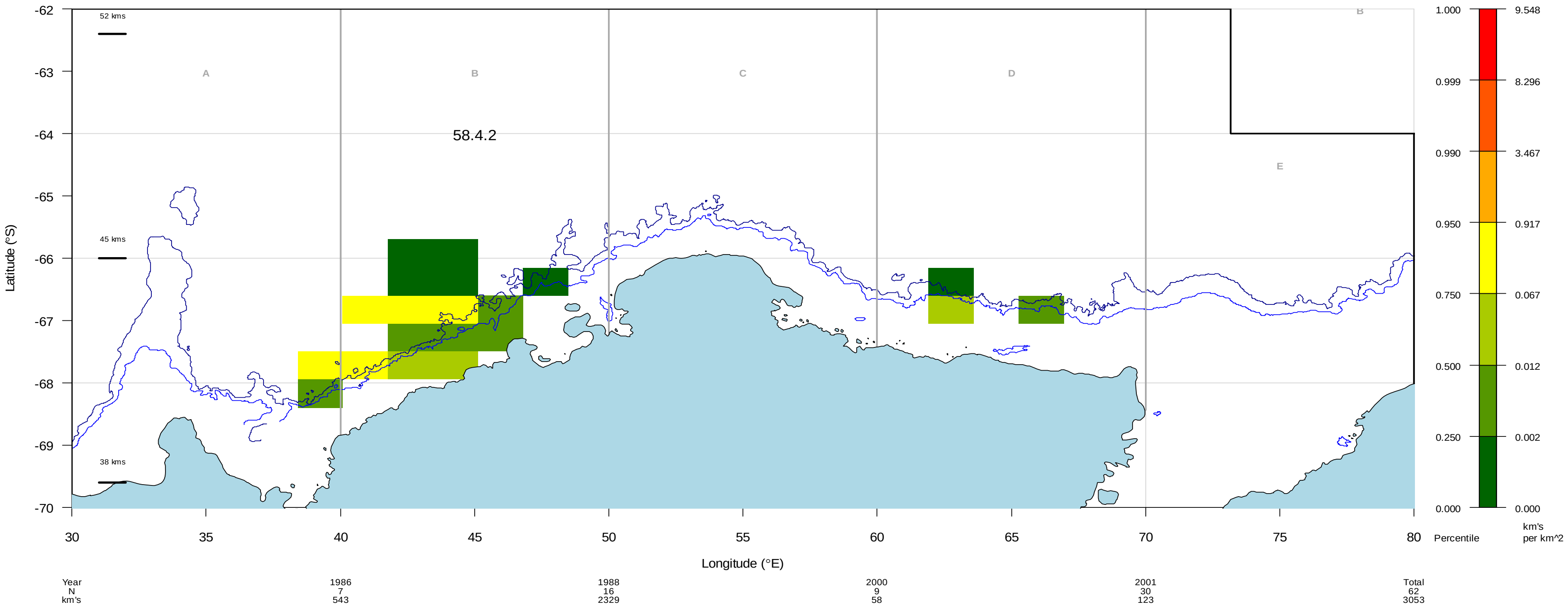

Figure 7(e)*: Map showing bottom trawl effort density for Division 58.4.2. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp is determined from the quartiles and 95th, 99th and 99.9th percentile points of the distribution of trawl effort density across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

* This figure is available in colour on the CCAMLR website (www.ccamlr.org).

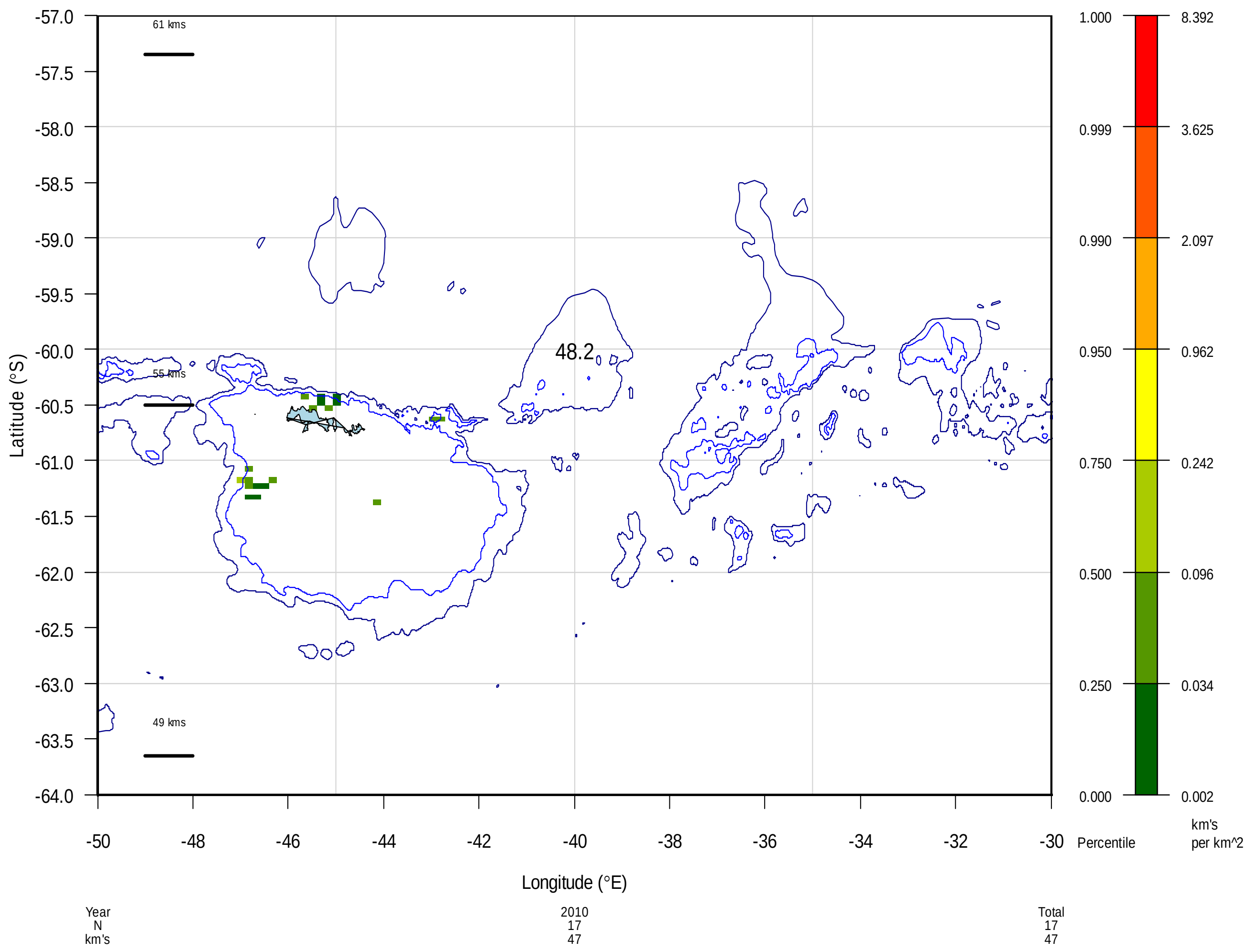

Figure 8(a)*: Map showing bottom trawl effort density for Subarea 48.2. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp is determined from the quartiles and 95th, 99th and 99.9th percentile points of the distribution of pot effort density across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

* This figure is available in colour on the CCAMLR website (www.ccamlr.org).

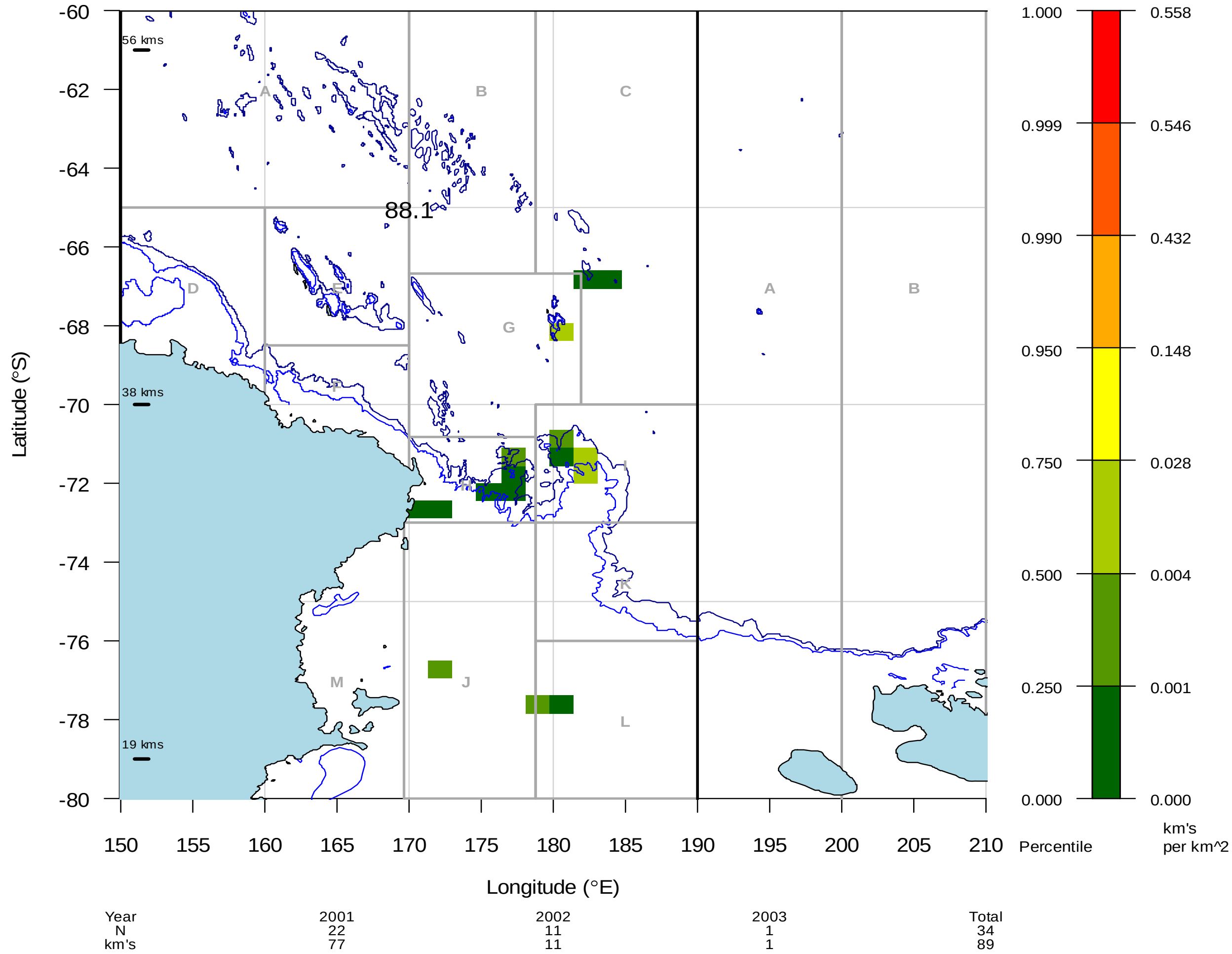

Figure 8(b)*: Map showing bottom trawl effort density for Subareas 88.1 (all) and 88.2 (SSRUs A and B only). Cells are 0.45° latitude × 1.68° longitude. The colour-ramp is determined from the quartiles and 95th, 99th and 99.9th percentile points of the distribution of pot effort density across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown.

* This figure is available in colour on the CCAMLR website (www.ccamlr.org).

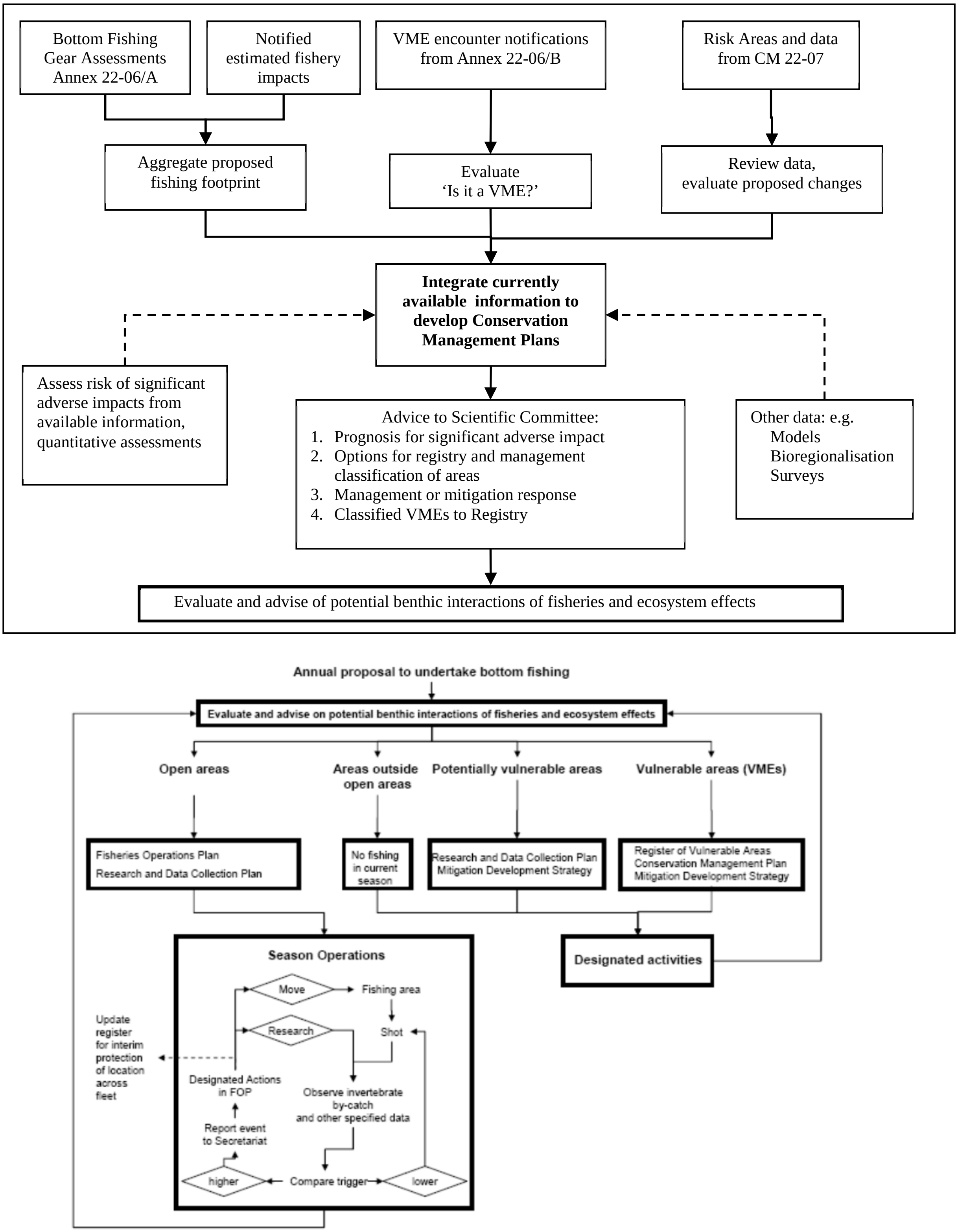

Figure 9: Proposed framework for managing flow and review of information resulting from implementation of Conservation Measures 22-06 and 22-07 (top panel) leading to the evaluation and advice on potential benthic interactions of fisheries and ecosystem effects (from SC-CAMLR-XXVII, Figure 1, bottom panel).

ATTACHMENT A

GLOSSARY OF TERMS, DEFINITIONS AND CONCEPTS

Fragility **–** The susceptibility of a taxon or habitat to impact (physical damage or mortality) arising from a particular interaction with a particular type of threat, e.g. bottom trawls or longlines. Fragility refers to an intrinsic physical property of the organism and the nature of the threat, without reference to the actual presence or intensity of the threat.

Example: Tall, brittle organisms would be more fragile as a result of shearing forces exerted by lateral longline movement than low profile or flexible organisms.

Resilience **–** The ability of a species or habitat to recover from impact over time, incorporating longevity, productivity/growth rate, dispersal and colonisation, rarity, patch size and spatial distribution, and ecological succession.

Vulnerability **–** The susceptibility of a taxon or habitat to impact by a particular type of threat over time, without reference to the actual presence or intensity of the threat. Vulnerability incorporates fragility and resilience.

Example: A species with high fragility but, as a population, also high resilience (i.e. rapid growth, reliable and abundant recruitment) would have lower vulnerability than a species with comparable fragility and slower growth, or with comparable fragility and infrequent or lagged recruitment.

Threat **–** An anthropogenic activity (e.g. bottom fishing) that may exert an impact on vulnerable organisms or habitats. The level of threat reflects factors extrinsic to the organism or habitat (e.g. intensity of fishing effort).

Instantaneous impact **–** Change in status to a particular taxon, habitat or other component of an ecosystem, arising from a threat over a period within which recovery is unlikely to occur. Conceptually, instantaneous impact is the product of fragility and threat.

Cumulative impact **–** The accumulated impact over time, including recovery.

Fishing footprint **–** The area of the seafloor within which fishing gear interacts with benthic organisms. Fishing footprint may be expressed per unit of fishing effort for a particular gear configuration (e.g. for longlines, km^2 seabed contacted per km of longline deployed), or as a cumulative footprint when calculated and summed for all fishing gear deployments in a defined period and area. This areal measure does not incorporate the level of impact within the footprint.

Ecological consequence **–** The magnitude of ecological effects likely to arise from a particular level of cumulative impact. For example, impacts to VMEs may affect benthic-pelagic coupling, the availability of three-dimensional structural habitat for associated species, reproductive output of benthic organisms, succession in the benthic assemblage or the viability of the affected population. Ecological consequence is a function of the level of cumulative impact and the ecological attributes of the benthic ecosystem.

Risk **–** The probability that an activity will have an unacceptable ecological consequence under a particular management strategy and in a specified timeframe, taking account of uncertainty. With specific reference to the management of bottom fishing impacts on VMEs, risk may be calculated as the probability that the ecological consequence associated with an impact will exceed the 'significant adverse ecological consequence' (SAEC) threshold as shown in Figure A1, consistent with the limits of acceptable impact expressed in the CAMLR Convention, Article II. Risk may be expressed with reference to activities to date, or in association with a future management strategy.

VME REGISTER

Notifications of VME encounters made under CM 22-06.

Subarea/ division	Identifier	Encounter date	Start position (dd mm.00)		End position (dd mm.00)		Seafloor depth (m)	Protection
			Latitude	Longitude	Latitude	Longitude		
48.1	12	08-Mar-09	63°15.45'S	59°03.60'W	63°14.25'S	59°05.63'W	296–405	CM 32-02
	13	05-Mar-09	62°37.17'S	56°37.20'W	62°36.55'S	56°35.09'W	226–228	
	14	05-Mar-09	62°36.84'S	55°27.13'W	62°36.35'S	55°24.35'W	141–157	
	15	05-Mar-09	63°00.95'S	52°22.80'W	63°00.94'S	52°25.76'W	633–642	
	16	03-Mar-06	62°46.45'S	56°51.95'W	62°45.35'S	56°51.53'W	176–180	
	17	22-Feb-06	63°03.00'S	58°45.82'W	63°03.00'S	58°48.07'W	210–226	
	18	02-Mar-06	61°49.30'S	53°59.97'W	61°48.35'S	54°00.02'W	290–293	
	19	08-Mar-06	62°43.99'S	54°58.38'W	62°43.99'S	54°57.32'W	160–161	
	20	05-Mar-06	62°43.83'S	55°31.81'W	62°43.87'S	55°33.66'W	136–142	
	21	03-Mar-06	62°47.57'S	56°42.14'W	62°46.99'S	56°43.83'W	150–178	
	22	20-Feb-06	63°14.58'S	59°46.79'W	63°13.56'S	59°46.86'W	221–249	
	23	21-Feb-06	63°04.98'S	58°35.55'W	63°04.98'S	58°37.84'W	126–135	
	24	22-Feb-06	63°00.02'S	58°03.91'W	63°00.02'S	58°06.10'W	225	
	25	19-Feb-06	63°27.40'S	60°02.69'W	63°27.68'S	60°04.77'W	103–121	
	26	20-Feb-06	63°13.28'S	59°53.12'W	63°12.27'S	59°52.68'W	330–345	
	27	15-Mar-06	62°49.66'S	57°27.38'W	62°48.87'S	57°26.33'W	132–137	
	28	19-Feb-06	63°25.38'S	59°41.73'W	63°25.36'S	59°44.02'W	92–100	

(continued)

(continued)

Subarea/ division	Identifier	Encounter date	Start position (dd mm.00)		End position (dd mm.00)		Seafloor depth (m)	Protection
			Latitude	Longitude	Latitude	Longitude		
48.2	1	01-Mar-09	60°26.44'S	46°31.35'W	60°25.49'S	46°31.34'W	150–252	CMs 32-03, 52-02 (blocks A, C, E)
	2	02-Mar-09	60°46.02'S	46°18.56'W	60°46.24'S	46°15.85'W	158–230	
	3	02-Mar-09	60°42.61'S	46°38.58'W	60°41.44'S	46°37.81'W	127–153	
	4	02-Mar-09	60°42.82'S	46°00.03'W	60°42.62'S	46°02.02'W	96–102	
	5	26-Feb-09	60°55.25'S	46°15.59'W	60°55.24'S	46°17.64'W	225–226	
	6	12-Feb-09	60°36.08'S	44°45.87'W	60°35.35'S	44°45.44'W	105–137	
	7	09-Feb-09	60°25.78'S	46°25.11'W	60°25.77'S	46°27.21'W	140–153	
	8	13-Feb-09	60°36.52'S	44°20.56'W	60°35.90'S	44°18.77'W	190–233	
	9	25-Feb-09	60°37.98'S	46°31.43'W	60°37.98'S	46°33.10'W	128–130	
	10	17-Feb-09	60°49.27'S	44°29.46'W	60°50.30'S	44°29.84'W	169–174	
	11	10-Feb-09	60°26.25'S	46°17.77'W	60°25.75'S	46°19.54'W	138–152	
	31	11-Feb-09	60º 29.37'S	45º 08.10'W	60º 28.41'S	45º 07.28'W	350	
	32	14-Feb-09	60º 52.22'S	43º 11.78'W	60º 53.00'S	43º 13.49'W	336	
58.4.1	29	06-Jan-08	65°49.67'S	142°59.74'E	65°46.27'S	142°59.11'E	523–837	CMs 22-08, 41-11 (SSRU H)
	30	17-Jan-08	65°42.38'S	140°35.61'E	65°36.84'S	140°20.19'E	436–844	

REGISTER OF RISK AREAS

VME Risk Areas based on notifications made under CM 22-07. The risk areas are 1 n mile radius closed areas centred on each position.

Subarea/ division	Notification		VME indicator units notified	Risk Area		
	Identifier	Date		Latitude (dd mm.mm)	Longitude (ddd mm.mm)	Seafloor depth (m)
88.1	1	07-Jan-09	69	75°08.52'S	176°07.14'W	1057–1298
	2	07-Jan-09	60	75°08.70'S	176°04.98'W	1057–1298
	3	07-Jan-09	25	75°12.10'S	175°55.10'W	1053–1209
	4	15-Jan-09	11	71°34.90'S	172°11.40'E	1307–1350
	5	15-Jan-09	13	71°40.60'S	172°15.40'E	1296–1296
	6	10-Jan-10	18	75°10.20'S	176°01.70'W	676–1216
	7	10-Jan-10	19	75°10.60'S	176°03.40'W	676–1216
	8	10-Jan-10	38	75°11.10'S	176°05.10'W	676–1216
	9	10-Jan-10	29	75°11.20'S	176°08.90'W	676–1216
	10	10-Jan-10	32	75°11.20'S	176°07.60'W	676–1216
	11	15-Jan-10	12	71°54.63'S	172°09.31'E	1170–1194
88.2	12	19-Jan-09	10	69°07.98'S	123°41.34'W	1272–1374
	13	19-Jan-09	10	69°08.04'S	123°43.86'W	1332–1543
	14	22-Jan-10	15	69°04.90'S	123°19.30'W	1371–1487
	15	11-Feb-10	13	69°08.20'S	122°59.50'W	1487–1602