CCAMLR

2013 Report on bottom fisheries and vulnerable marine ecosystems

CONTENTS

Throughout this report the CCAMLR fishing season is represented by the year in which that season ended, e.g. 2012 represents the 2011/12 CCAMLR fishing season (from 1 December 2011 to 30 November 2012).

2013 REPORT ON BOTTOM FISHERIES AND VULNERABLE MARINE ECOSYSTEMS

INTRODUCTION

1. In 2006, the Commission and the 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 (Conservation Measure (CM) 21-05). In that same year, the United Nations General Assembly (UNGA) agreed the Sustainable Fisheries Resolution (Resolution 61/105), which calls on States and regional fisheries management organisations (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.

Rationale for the report

3. The report summarises the status of knowledge on bottom fisheries and the types of interactions of fisheries with VMEs in CCAMLR. It provides current assessments of the impacts of bottom fishing on VMEs, and details the types of management strategies in operation or being considered. It also provides management advice, including proposed revisions of conservation measures and priorities for future work.

Glossary

4. A glossary of terms and a diagram illustrating the conceptual relationships between the terms have 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.

DETAILS OF BOTTOM FISHERIES

Types and primary locations of bottom fisheries

5. Total cumulative bottom fishing effort for all subareas/divisions in the area of application of CM 22-06 is summarised in Table 1. Note that the table includes all bottom fishing records from the C2 (for longlines) and C1 (for trawls) CCAMLR databases from 1985 to 2012. Earlier historical effort is not included, and the C1 database may be incomplete with respect to some recent research trawls. Note also that the total effort used imputed values for missing data so that all effort contributed to the footprint calculations.

6. Details of the actual spatial distributions of fishing effort and the areal extent of fishing footprints are considered further under 'Impact assessments' below.

Current conservation measures

7. 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 (2012) – Bottom fishing in the Convention Area, including two annexes
>
> CM 22-07 (2013) – Interim measure for bottom fishing activities subject to CM 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.
>
> CM 22-09 (2012) – Protection of registered vulnerable marine ecosystems in subareas, divisions, small-scale research units or management areas open to bottom fishing.

8. In addition to the conservation measures listed above, 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

Action in response to potential interaction with a VME

9. The process by which encounters with VMEs during bottom fishing are reported, and the subsequent management actions taken following these reports, as required in CM 22-07, are summarised below:

(i) during bottom fishing Members' vessels are required to clearly mark fishing lines into line segments (a 1 000 hook section of line or a 1 200 m section of line, whichever is the shorter) and record the number of 'VME indicator units' on segments. A VME indicator unit is either one litre, or one kilogram, of the VME indicator organisms that are listed in the *CCAMLR VME Taxa Classification Guide*.

(ii) If 10 or more VME indicator units are recovered in one line segment, vessels are required to complete hauling any lines intersecting with the Risk Area without delay and not to set any further lines intersecting with the Risk Area. The Secretariat will notify all fishing vessels in the relevant fishery and their Flag States that the Risk Area is closed.

(iii) within a single rectangle (referred to as a VME fine scale rectangle).When five VME indicator notifications with between five and nine VME indicator units have been reported from within a single fine-scale rectangle (an area of 0.5° latitude × 1° longitude), the Secretariat will notify all fishing vessels in the relevant fishery of the coordinates of the fine-scale rectangle and indicate that VMEs may occur within that area.

Register of VMEs

Registered VMEs and their status

10. Forty-six 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 (22 VMEs), 48.2 (13 VMEs) and 88.1 (9 VMEs) and Division 58.4.1 (2 VMEs). The VMEs were observed using in situ photography and benthic sampling.

11. All notified VMEs are currently afforded protection through specific area closures in Subarea 88.1 and Division 58.4.1 (CM 22-09), and general closures to bottom fishing activities in Subareas 48.1 and 48.2 (CM 32-02).

Measures to conserve registered VMEs

12. At present, registered VMEs are protected through spatial closures of varying sizes for specific 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 155 VME indicator notifications have been submitted in accordance with CM 22-07: 29 notifications in 2009; 24 in 2010; 59 in 2011, 38 in 2012 and 5 in 2013. These notifications were made by vessels operating in the exploratory longline fisheries in

Subareas 48.6 (2 notifications), 88.1 (104 notifications) and 88.2 (48 notifications), and the exploratory crab fishery in Subarea 48.2 (1 notification; this fishery is currently closed).

14. Sixty-four VME indicator notifications reported ≥10 VME indicator units from a single line segment. These notifications resulted in the declaration of 48 VME Risk Areas in Subarea 88.1 and 16 Risk Areas in Subarea 88.2 (Attachment C). In addition, six VME fine-scale rectangles were identified in Subarea 88.1 and two VME fine-scale rectangles were identified in Subarea 88.2.

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 (SC-CAMLR-XXIX, 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. Members and fishers are 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 identify 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 (SC-CAMLR-XXIX, 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 33; see also SC-CAMLR-XXIX, Annex 6, paragraphs 3.27 to 3.35).

ASSESSMENTS OF IMPACTS ON VME

Methods

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 and 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 for each gear type.

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 and 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 SC-CAMLR-XXIX, Annex 4, paragraph 4.19, as follows:

$$\text{Footprint index} = A_0 + f_1 A_1 + f_2 A_2, + \ldots$$

$$\text{Impact index} = A_0 F_0 + f_1 A_1 F_1 + f_2 A_2 F_2 + \ldots$$

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 SC-CAMLR-XXIX, 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 39 to 42 for a worked example). This code can be used to translate gear footprint estimates into a footprint index and impact index estimate for each gear type as required in the annual preliminary assessment pro forma of Annex 22-06/A.

27. Step 6 summarises fishing effort distributions in a spatially explicit manner, in units compatible with those used in steps 1 to 5. The standard unit for reporting effort density for longlines is km of line per km^2 of seabed area (SC-CAMLR-XXIX, 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 (SC-CAMLR-XXIX, 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 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+%), 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. 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-09/08, 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.

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

39. Cumulative fine-scale impact assessments were updated, 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 (SC-CAMLR-XXIX, Annex 4, paragraph 4.16) and WG-EMM (SC-CAMLR-XXIX, Annex 6, paragraph 3.20). Input parameters for the autoline longline fishing method were adapted 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 2 and illustrated in Figure 2.

40. 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 Table 2.

41. 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. 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.

42. 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

43. 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.

44. 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 software was further updated (as plotImpact WG-FSA-11/51 Rev. 1) to include integration with the IApdf library to directly incorporate the footprint and impact index calculation for each gear type. 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 (SC-CAMLR-XXIX, 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

45. In the absence of detailed method assessments for all bottom fishing methods, a longline impact assessment was undertaken in which the Spanish longline, trotline and mixed longline 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 (0.05° latitude × 0.167° longitude) 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).

46. 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%.

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

48. 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 coarser 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.

49. The 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 0.45° latitude × 1.68° longitude, 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 seven-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 types 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.

50. Figure 6(i) shows the locations of Risk Areas in the Ross Sea in relation to the distribution of % impact and the two proposed registered VMEs in 2011. The Risk Areas occur in two main clusters which are not associated with the areas of the highest impact.

51. Figure 9 shows (a) the cumulative longline effort in kilometres and (b) the cumulative trawl effort in kilometres as a proportion of the fishable area in each subarea/division affected by CM 22-06 since effort began to increase in the mid-1990s. The longline patterns cluster into three groups: (i) Subareas 88.1 and 88.2 and Division 58.4.3a; (ii) Division 58.4.4, Subarea 48.6, Divisions 58.4.1, 58.4.3b and 58.4.2; and (iii) Subareas 48.1, 48.2, 48.5 and 88.3. The longline effort, relative to fishable area, is growing fastest in Subarea 88.2, especially in recent years. The trawl effort occurred mainly in the late 1980s in Subareas 48.1 and 48.2 and Division 58.4.2, though records prior to 1980 are not included.

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 10).

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 triggered by 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-10/09) (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 (SC-CAMLR-XXIX, Annex 8, paragraph 9.32). WG-EMM has considered additional potential scenarios to be evaluated (SC-CAMLR-XXIX, 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 (SC-CAMLR-XXIX, 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. Although the quality of preliminary assessments required in CM 22-06 is improving, detailed descriptions of how different gear types interact with the seafloor are needed to estimate footprint and impact indices.

62. As the process to estimate footprint and impact becomes more complex, the preliminary assessments require the use of statistical programs and competency in generating the statistical parameters needed. Not all Members may have the experience necessary to complete these tasks. The Scientific Committee may consider a mechanism which may assist in training or developing capability for Members to meet their obligations in providing preliminary assessments of the effects of fishing on VMEs.

Other advice

63. The current work plan for WG-FSA from the Scientific Committee regarding the effects of bottom fishing (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 (SC-CAMLR-XXIX, 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 SC-CAMLR-XXIX, Annex 8, 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 (SC-CAMLR-XXIX, 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 of 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 (SC-CAMLR-XXIX, Annex 8, paragraphs 9.13 and 9.14). Submissions are needed on Spanish longlines, trotlines, trawl and pot methods (SC-CAMLR-XXIX, Annex 8, 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 (SC-CAMLR-XXIX, Annex 8, 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 (SC-CAMLR-XXIX, 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 (SC-CAMLR-XXIX, Annex 8, 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 (SC-CAMLR-XXIX, Annex 8, 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 (SC-CAMLR-XXIX, Annex 8, 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

64. 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 including research fishing, 1985–2012) in all subareas/divisions affected by CM 22-06. Unspecified longline gear is included in ‘All longline gear’.

Subarea/ division	Mean fished depth (m)	Fished area (fine-scale pixels) (km^2)	Fishable area (600–1 800 m) (km^2)	Cumulative fishing effort (1985–2012)					
				Autoline (km)	Spanish line (km)	Trotline (km)	All longline (km)	Trawl (km)	Pots (km)
48.1	267	16 605	77 851	0	96	0	96	3 020	0
48.2	351	13 824	74 081	0	24	0	24	10 289	47
48.5	628	1 969	73 345	0	0	0	0	67	
48.6	1 357	36 726	84 216	1 840	7 817	6 605	16 262	8	0
58.4.1	1 463	42 726	210 314	226	23 740	4 917	28 884	0	0
58.4.2	1 287	32 415	115 258	1 326	7 104	1 533	9 962	3 048	0
58.4.3a	1 299	20 525	18 605	740	7 062	983	8 786	17	0
58.4.3b	1 485	54 305	130 678	2 647	9 995	1 512	14 824	3	0
58.4.4a	478			1 193	450	0	1 964		
58.4.4b	1 076	17 033	22 743	234	929	0	3 855	0	0
88.1	1 150	144 659	247 229	70 701	54 479	4894	130 693	0	90
88.2	1 384	22 642	31 285	16 078	5 226	1920	23 484	0	1
88.3	1 211	1 960	99 066	0	104	0	590	0	0
Total		405 390	1 184 671	94 986	117 026	22 364	239 423	16 453	138

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

Note that the standard footprint area and lateral movement area, and their ranges, are in units of line. The IApdf and plotImpact software inputs are in m^2/m of line. Translating between the two units is a factor of 1 000 ($km^2/km * 10^3 = m^2/m$).

	Shape	Mean	Std	Range
All longline gears				
Standard footprint area A_0 (m^2/m line)	lognormal	0.82	0.50	0.10–3.0
Standard fragility F_0 (0–1)	normal	0.780	0.15	0.48–1.0
Lateral movement area A_1 (m^2/m line)	lognormal	10.4	0.35	0.50–25.0
Lateral movement fragility F_1 (0–1)	normal	0.699	0.15	0.40–1.0
Lateral movement frequency f_1 (0–1)	normal	0.5	0.15	0.05–0.95

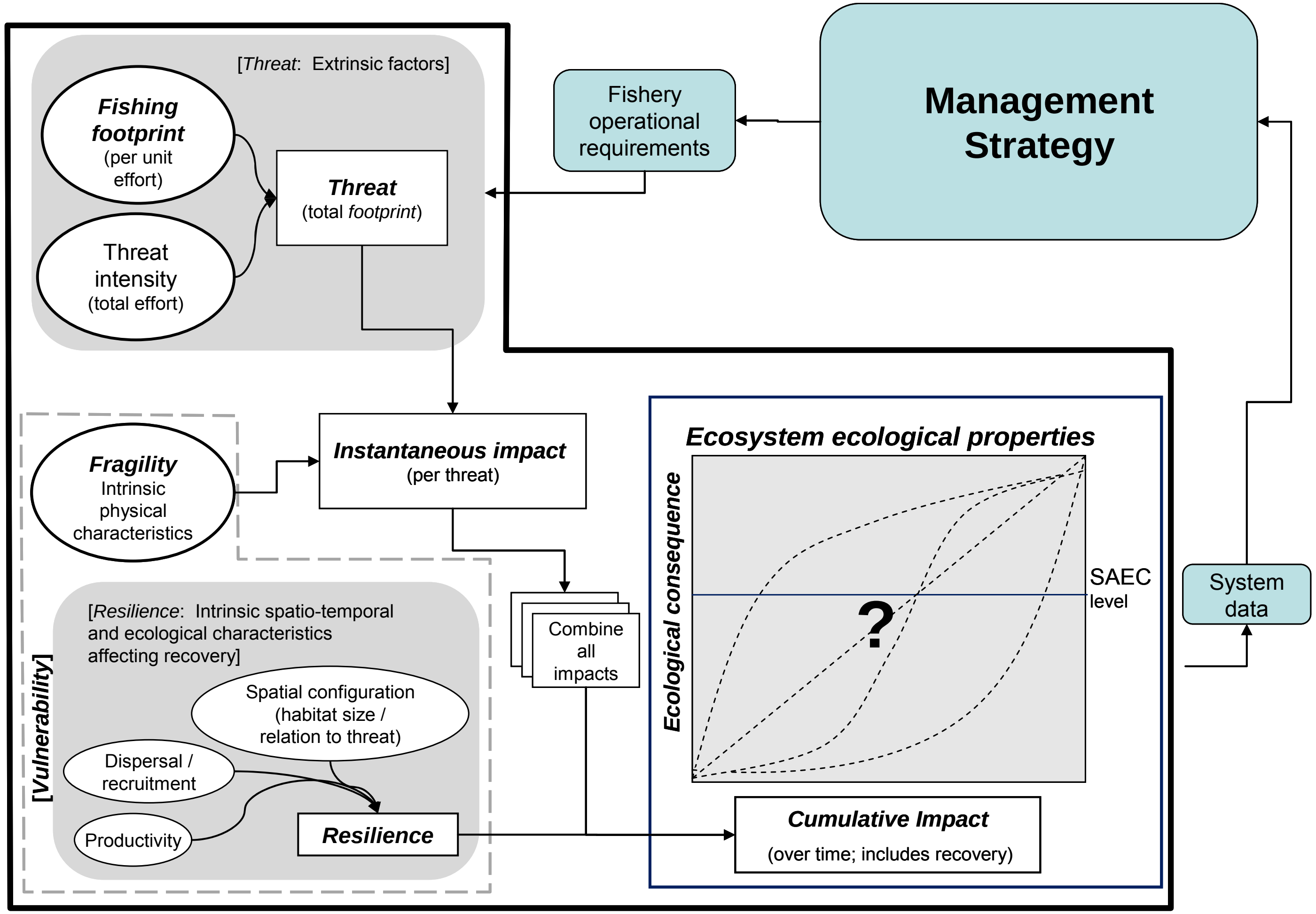


Figure 1: Conceptual diagram of the relationships among the terms used in the VME glossary. The thick black box indicates aspects of ecosystem dynamics and the relationship of the fishery to the ecosystem. Data are derived either from the fishery or as fishery-independent activities. These data are used 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.

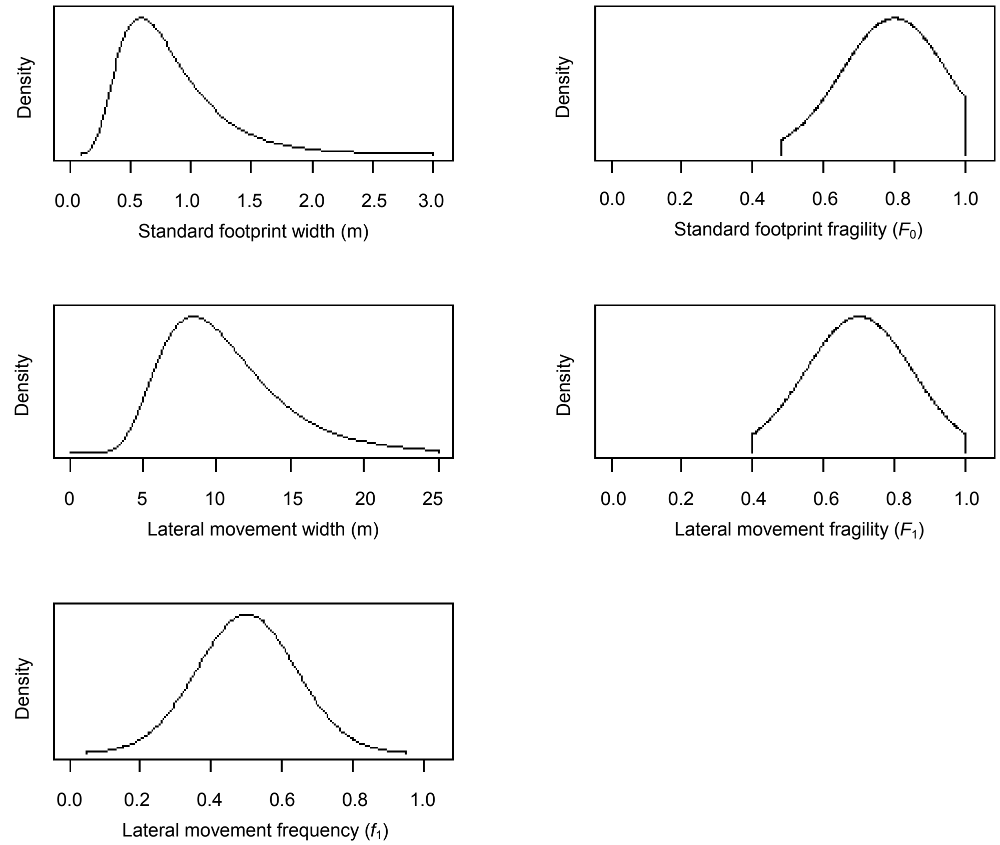


Figure 2: Default prior distributions for model inputs used in the estimation of footprint index and mortality index. Footprint width distributions are shown in metres for ease of interpretation; these can be translated into the footprint area input terms A_0 and A_1 (in km^2) by multiplying by 10^{-3}.

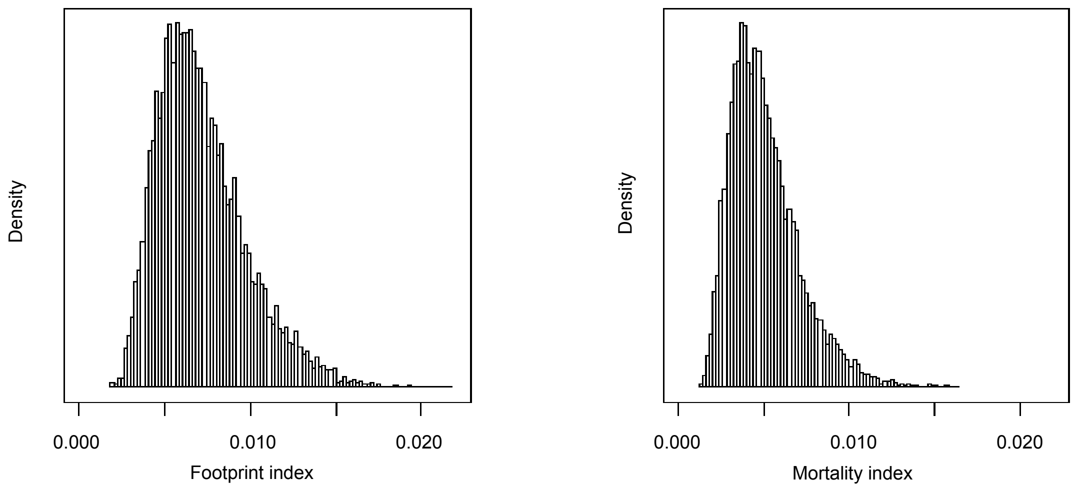


Figure 3: Posterior distributions of the footprint index and mortality index (note that CM 22-06 refers to this as the impact index) values predicted from the impact simulation using the R-Library IApdf using input assumptions as in Figure 2. Corresponding impact estimates within each subarea are summarised in Figure 4. The mean footprint index is 0.005993 and the mean mortality index is 0.004239.

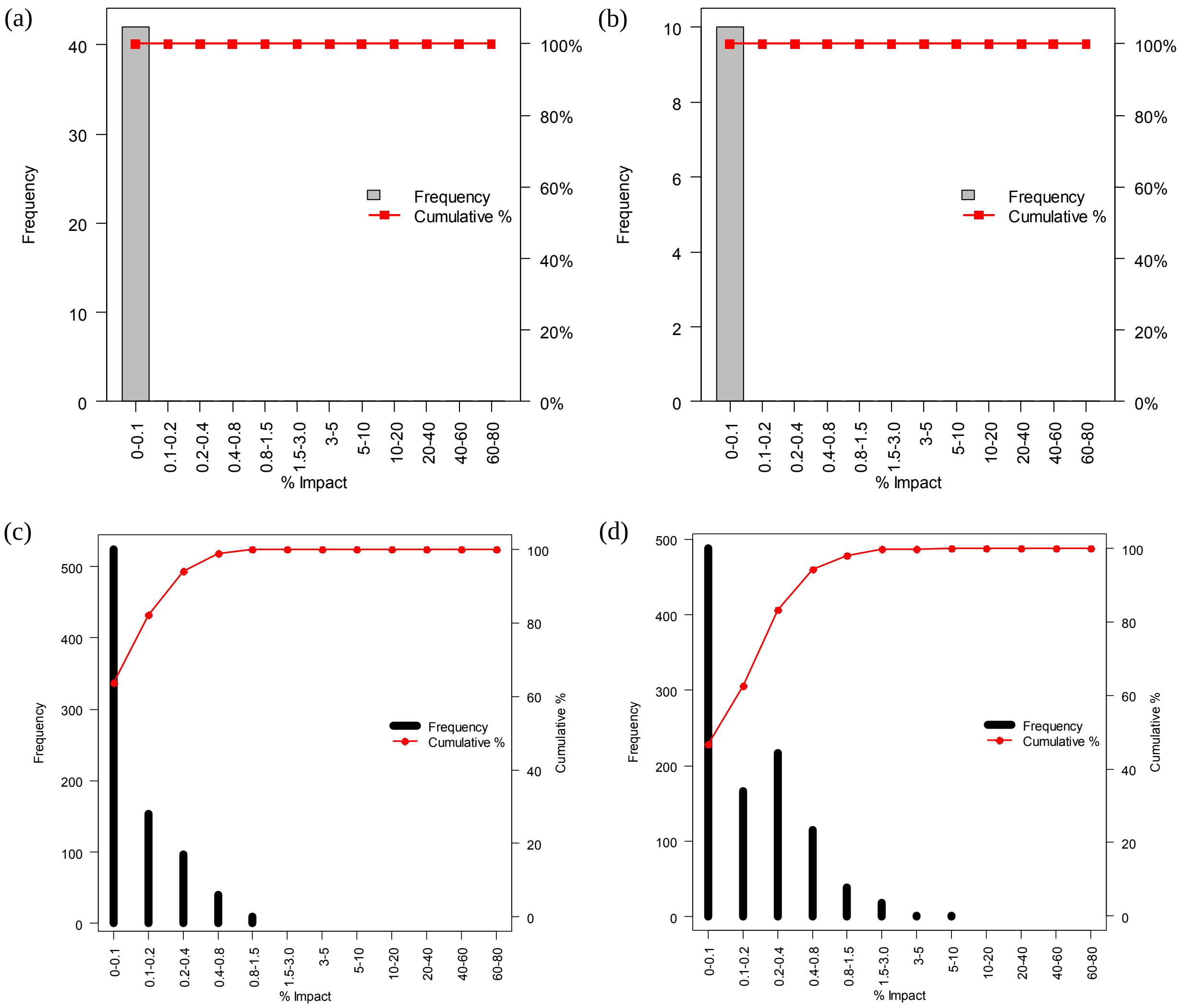


Figure 4(a–d): Cumulative impacts estimated for total longline fishing effort (1985–2012) in subareas/divisions affected by CM 22-06: (a) Subarea 48.1, (b) Subarea 48.2, (c) Subarea 48.6, and (d) Division 58.4.1. Histograms depict frequency distributions of small-scale pixels (0.05° latitude × 0.167° 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.

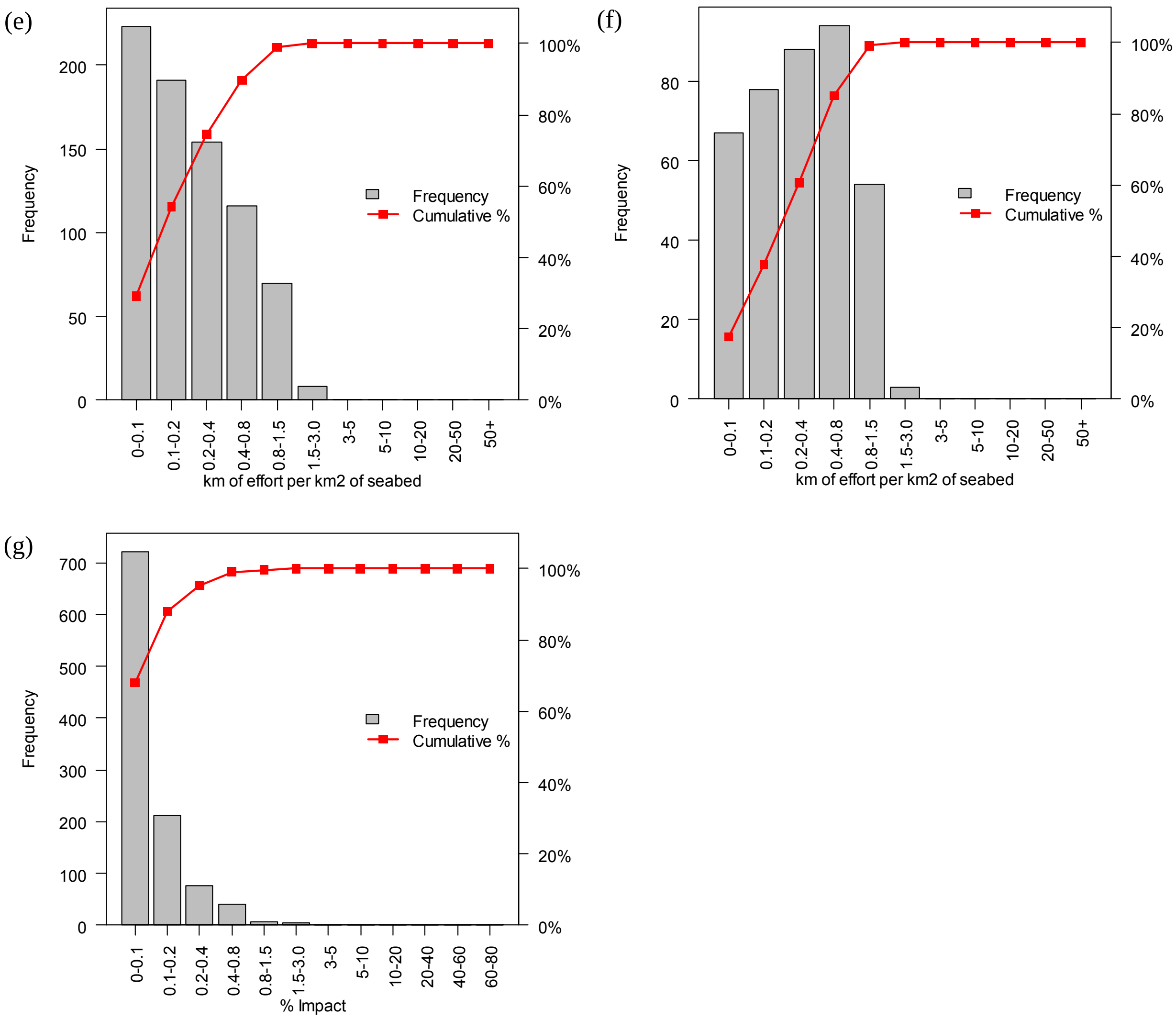


Figure 4(e–g): Cumulative impacts estimated for total longline fishing effort (1985–2012) in subareas/divisions affected by CM 22-06: (e) Division 58.4.2, (f) Division 58.4.3a, and (g) Division 58.4.3b. The histograms depict frequency distributions of small-scale pixels (0.05° latitude × 0.167° longitude) 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.

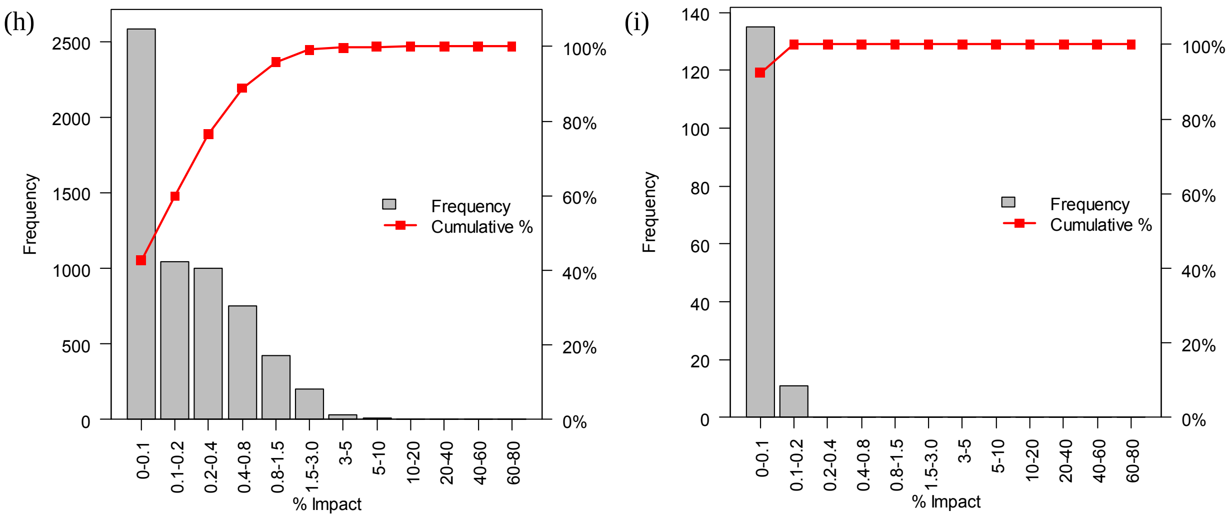


Figure 4(h–i): Cumulative impacts estimated for total longline fishing effort (1985–2012) in subareas/divisions affected by CM 22-06: (h) Subareas 88.1 and 88.2, and (i) Subarea 88.3. The histograms depict frequency distributions of small-scale pixels (0.05° latitude × 0.167° longitude) experiencing 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.

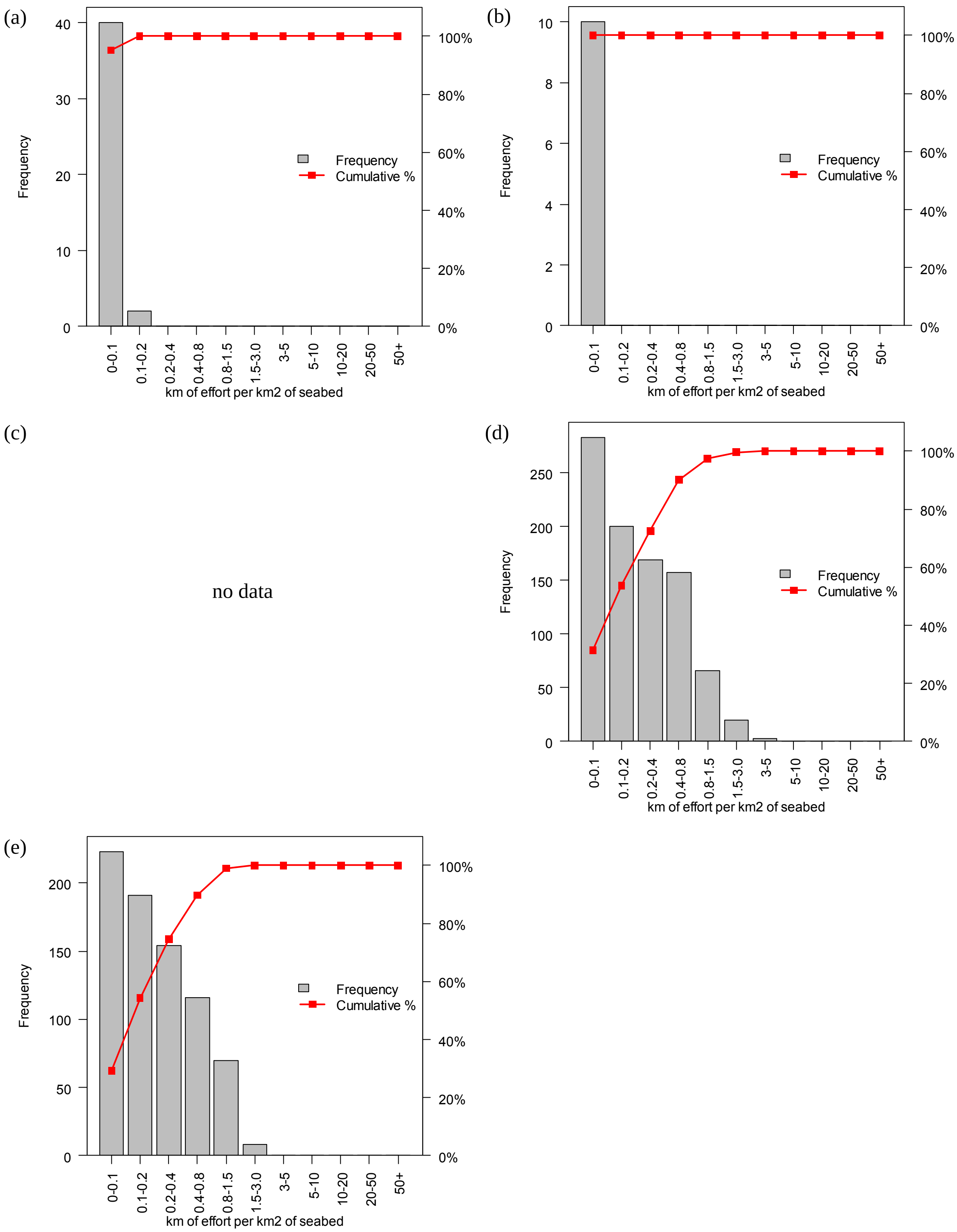


Figure 5(a–e): Cumulative effort density of trawl fishing effort (1985–2010) in subareas/divisions affected by CM 22-06: (a) Subarea 48.1, (b) Subarea 48.2, (c) Subarea 48.5, (d) Subarea 48.6, and (e) Division 58.4.2. The histograms depict frequency distributions of small-scale pixels (0.05° latitude × 0.167° longitude) with different historical concentrations of trawl effort. Only pixels with non-zero values for trawl effort are shown.

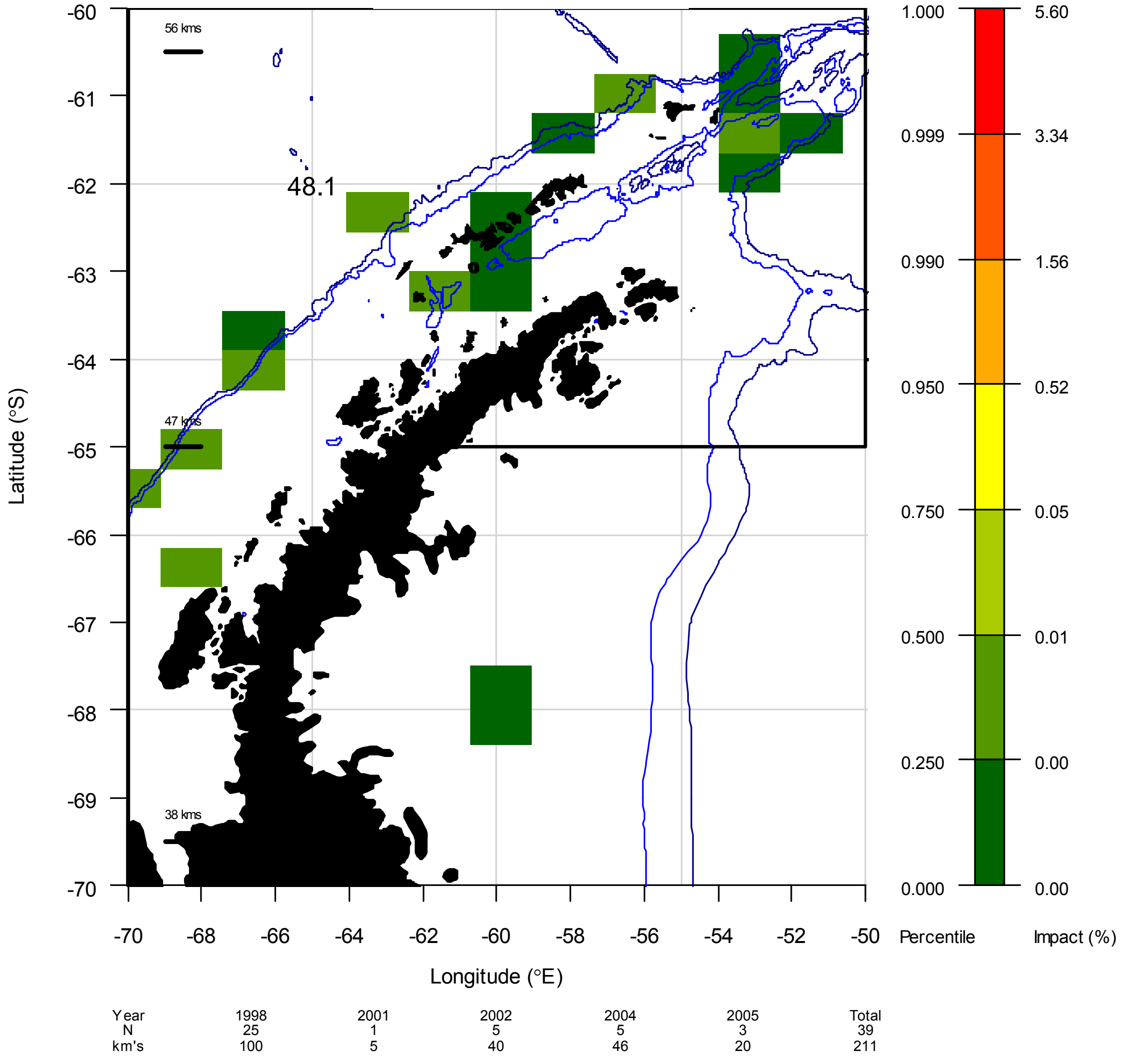


Figure 6(a): Map showing estimated percent impact due to longline bottom fishing (all longline types) for Subarea 48.1. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown. Blue dots indicate registered VMEs notified under CM 22-06.

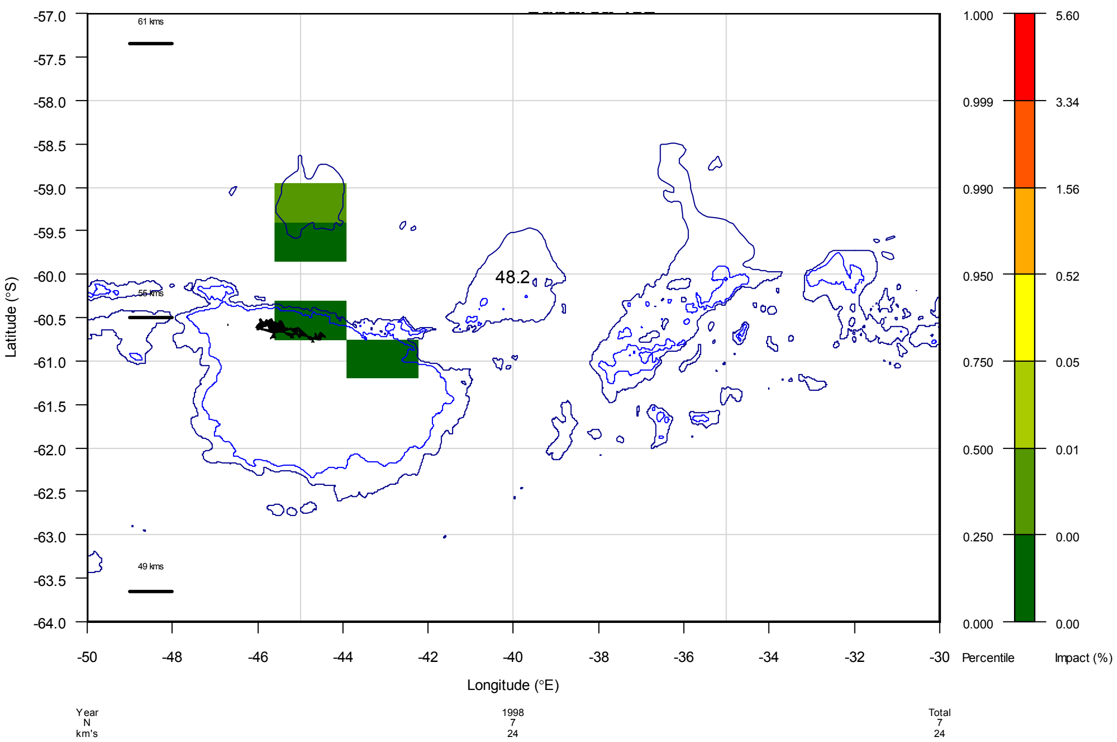
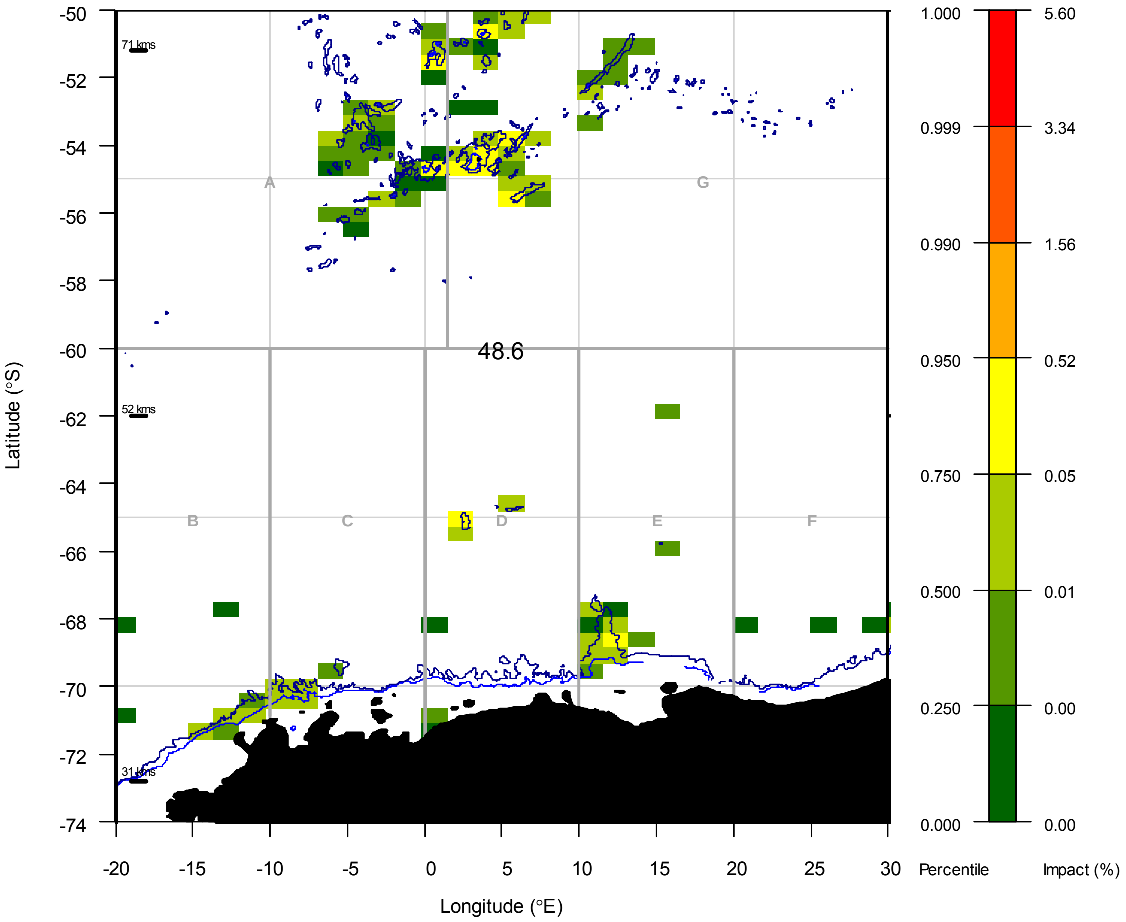


Figure 6(b): Map showing estimated percent impact due to longline bottom fishing (all longline types) for Subarea 48.2. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown. Blue dots indicate registered VMEs notified under CM 22-06.



Year	1999	2000	2001	2002	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
N	2	2	1	6	40	129	263	238	39	128	316	236	277	1677
km's	15	9	5	50	408	1148	2367	2151	351	1232	3973	2165	2698	16572

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.

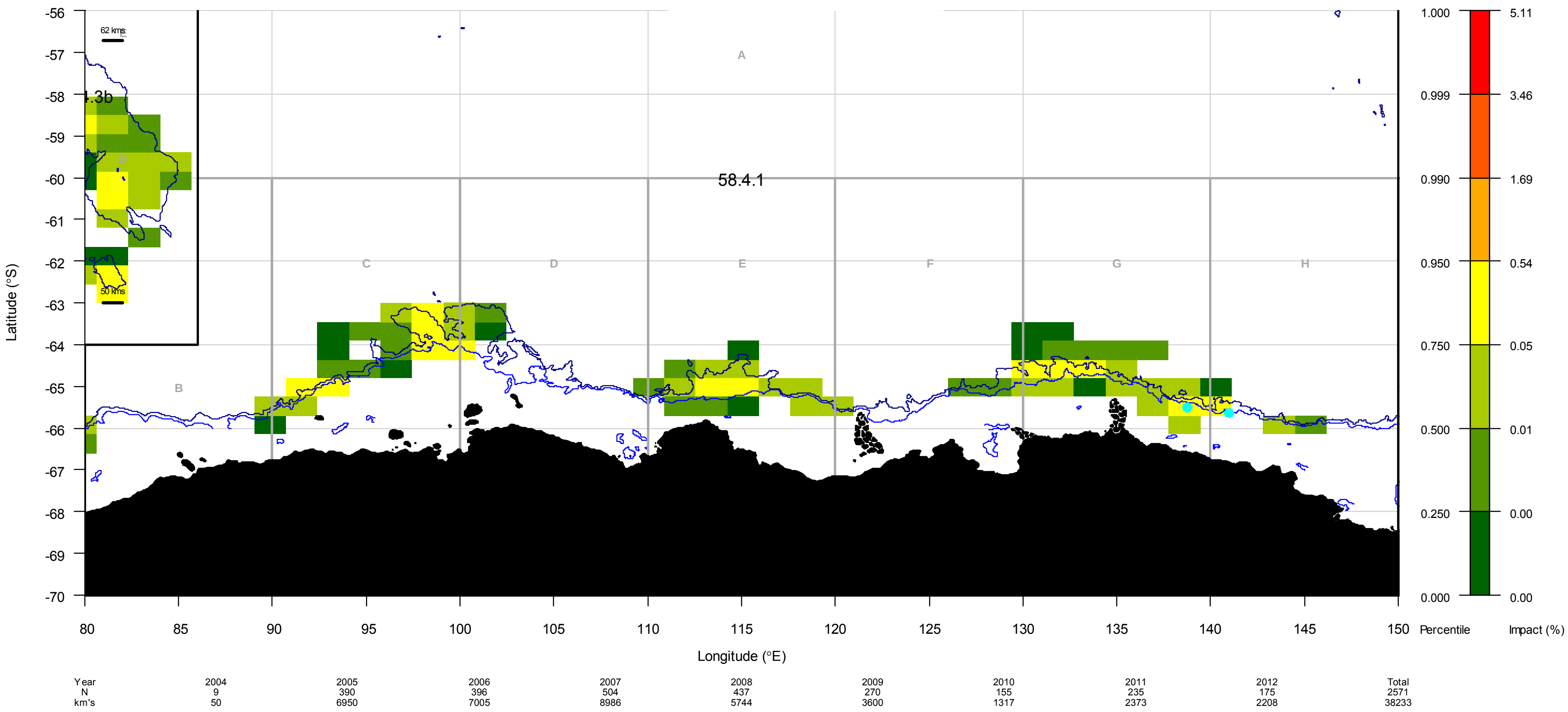
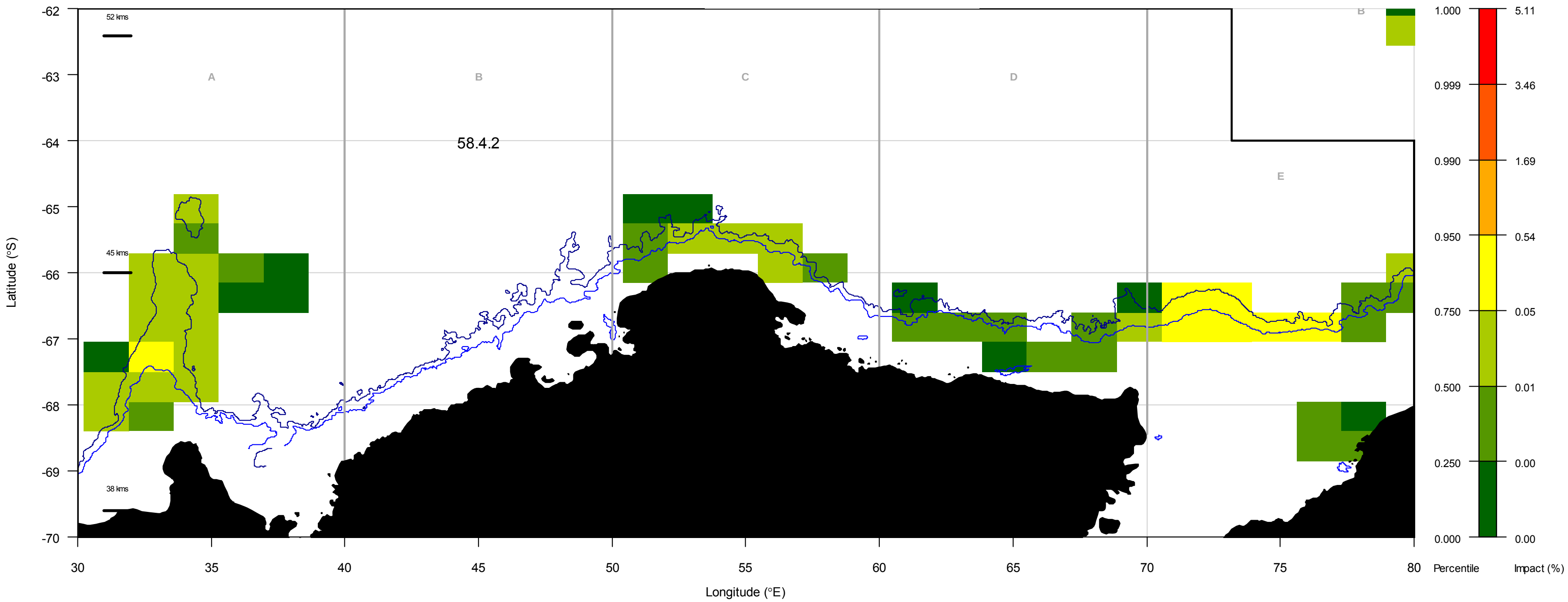


Figure 6(d): Map showing estimated percent impact due to longline bottom fishing (all longline types) for Division 58.4.1. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts across the entire Convention Area. The 1 000 and 2 000 m isobaths are shown. Blue dots indicate registered VMEs notified under CM 22-06.



Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
N	141	46	165	110	114	110	41	57	22	95	901
km's	710	297	2261	1246	1527	1628	433	513	236	1111	9962

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.

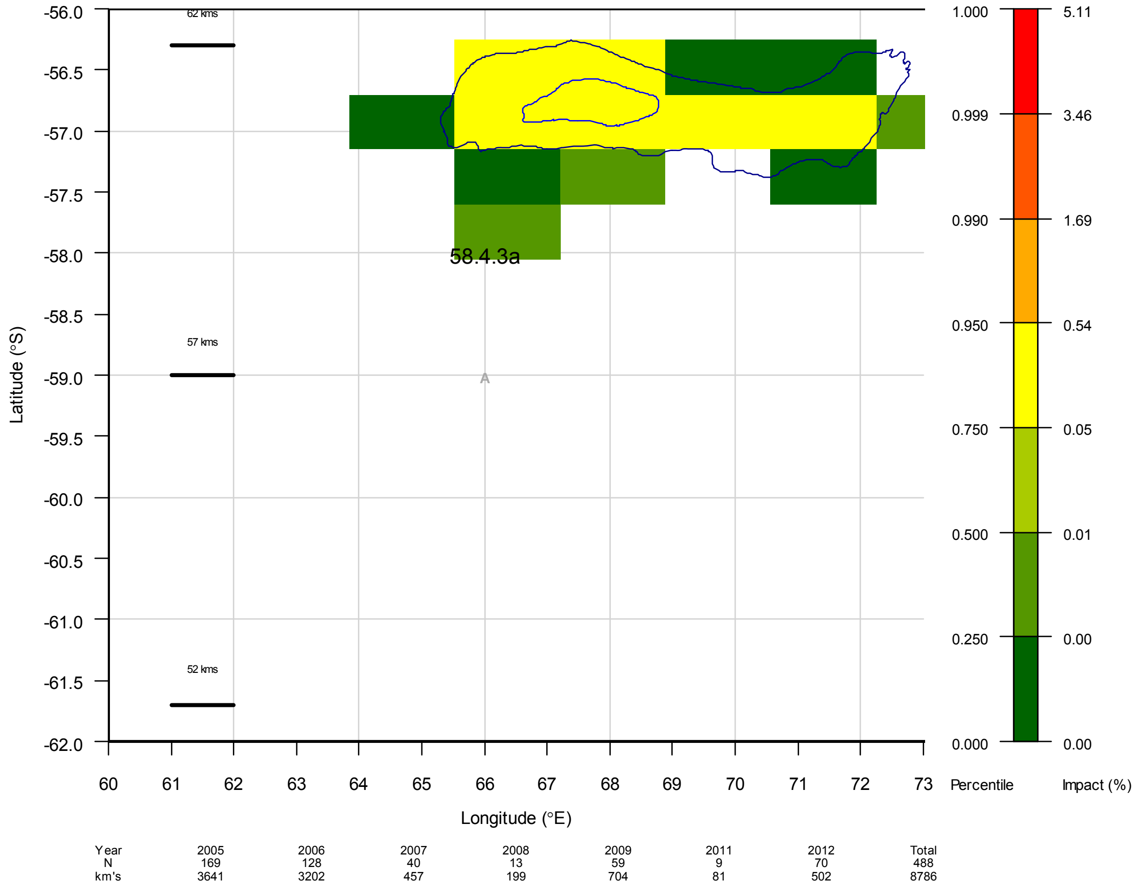
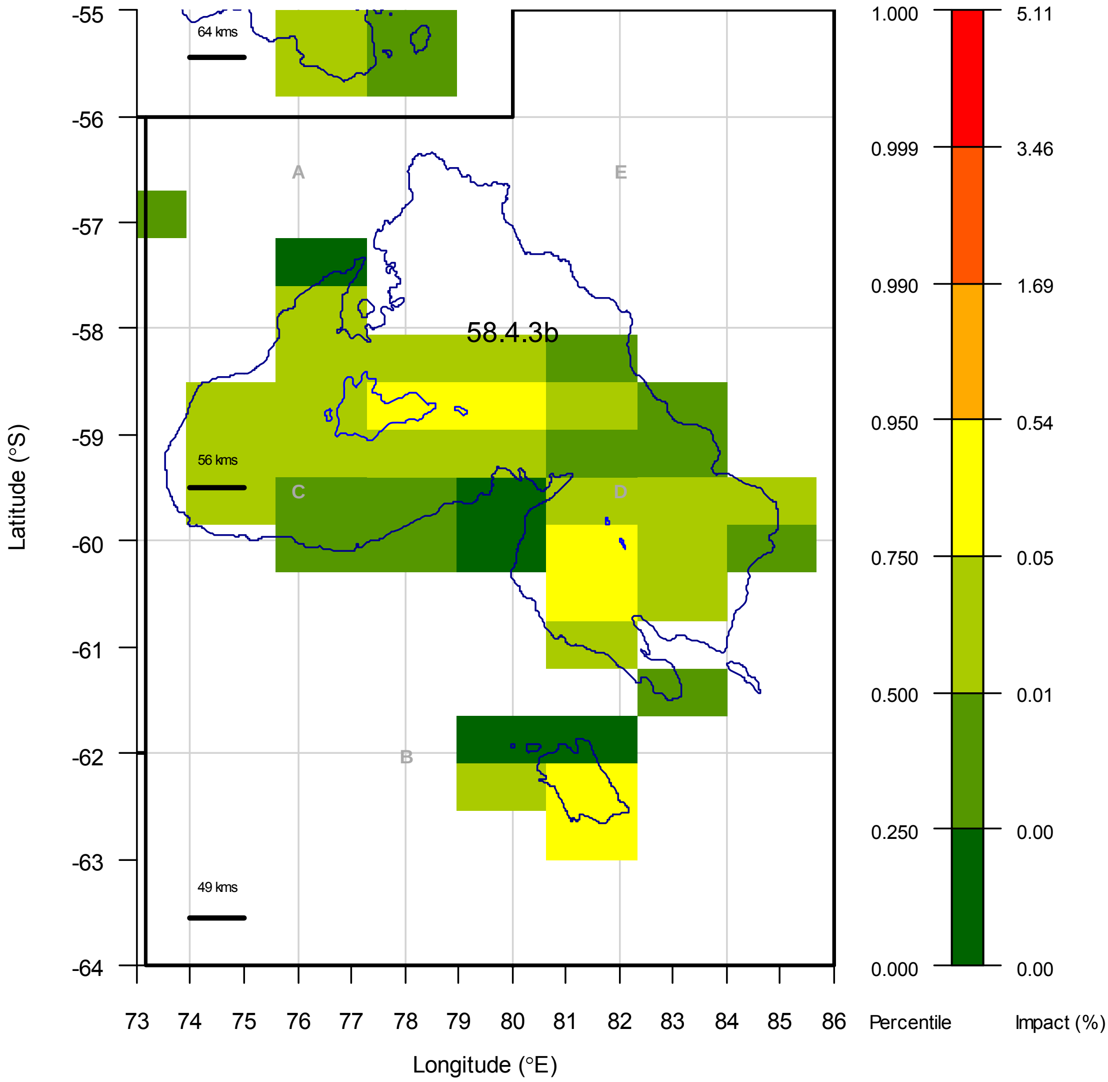


Figure 6(f): Map showing estimated percent impact due to longline bottom fishing (all longline types) for Division 58.4.3a. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of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



Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
N	19	160	191	282	192	95	24	56	30	1049
km's	109	3080	3922	4036	1867	1204	216	697	279	15410

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 × 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.

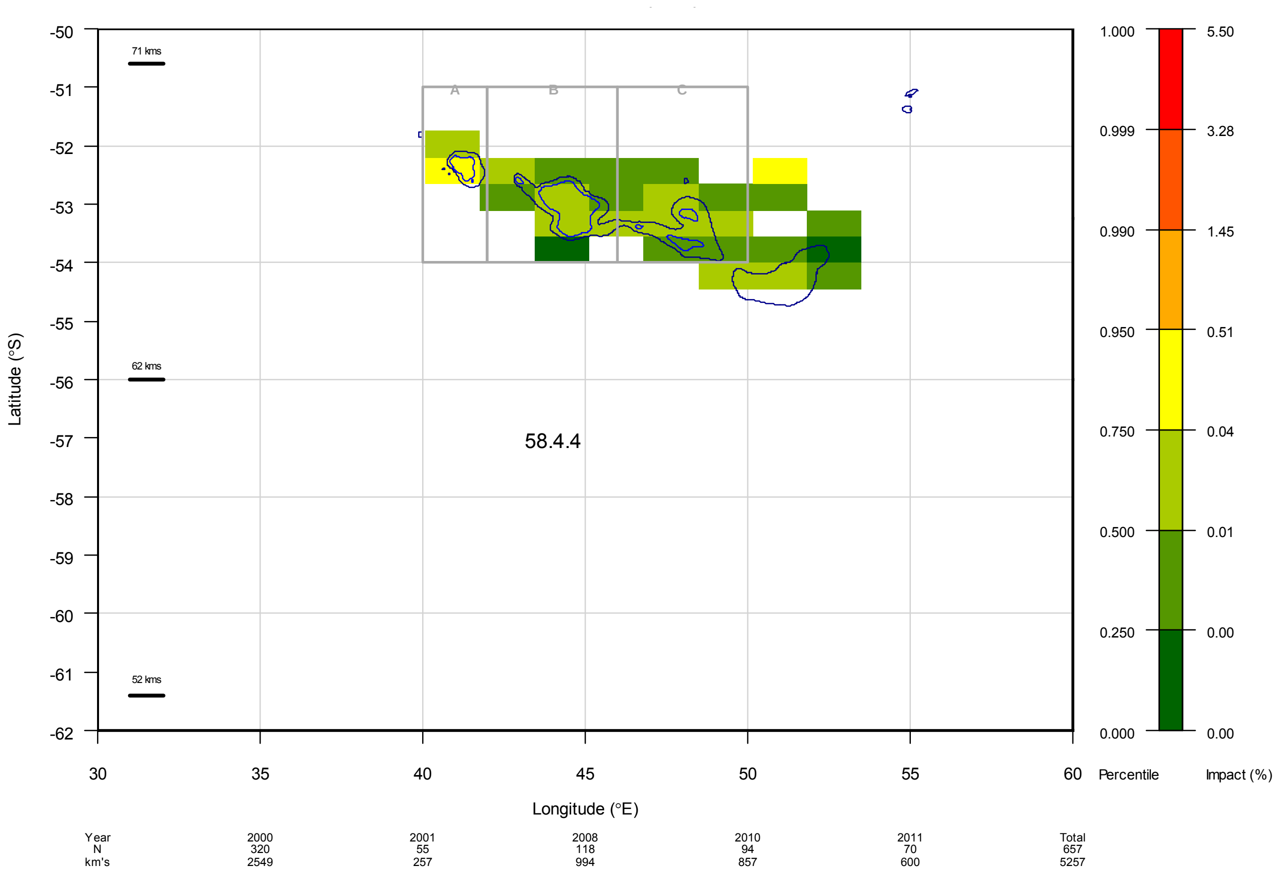
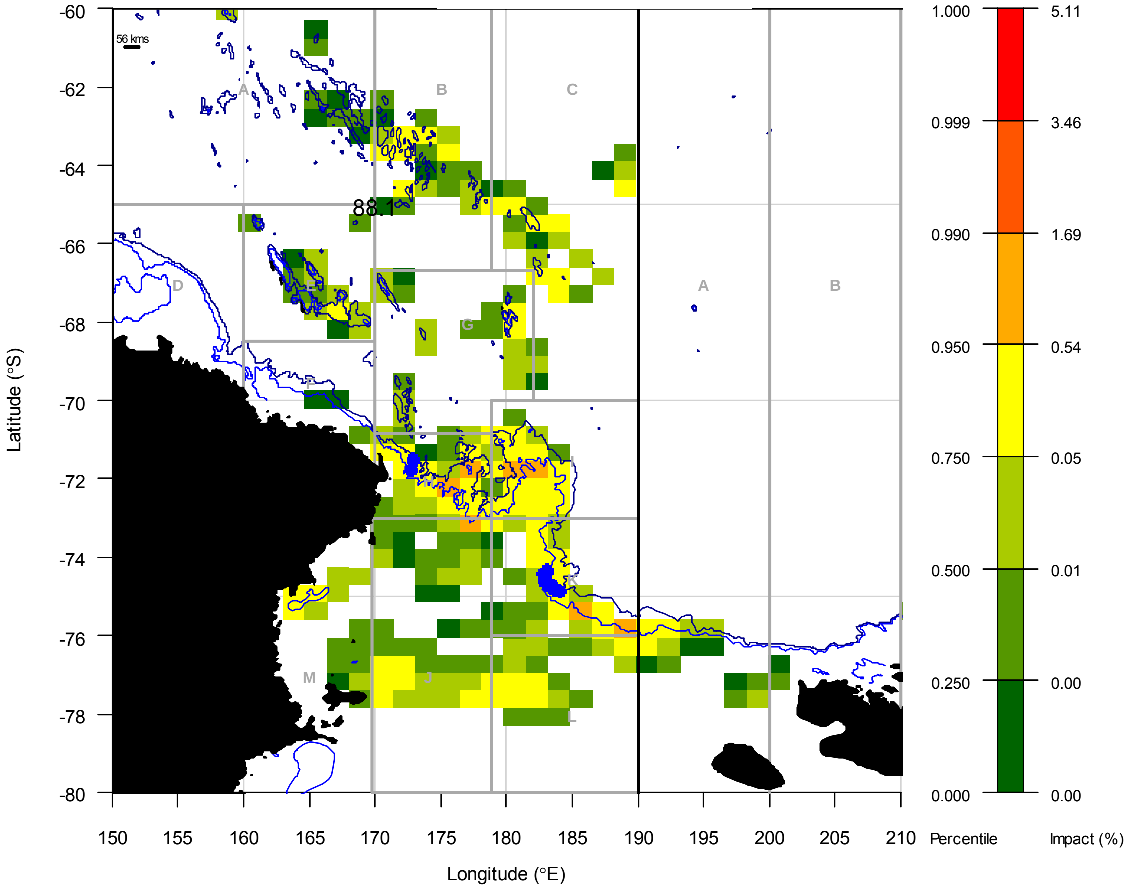
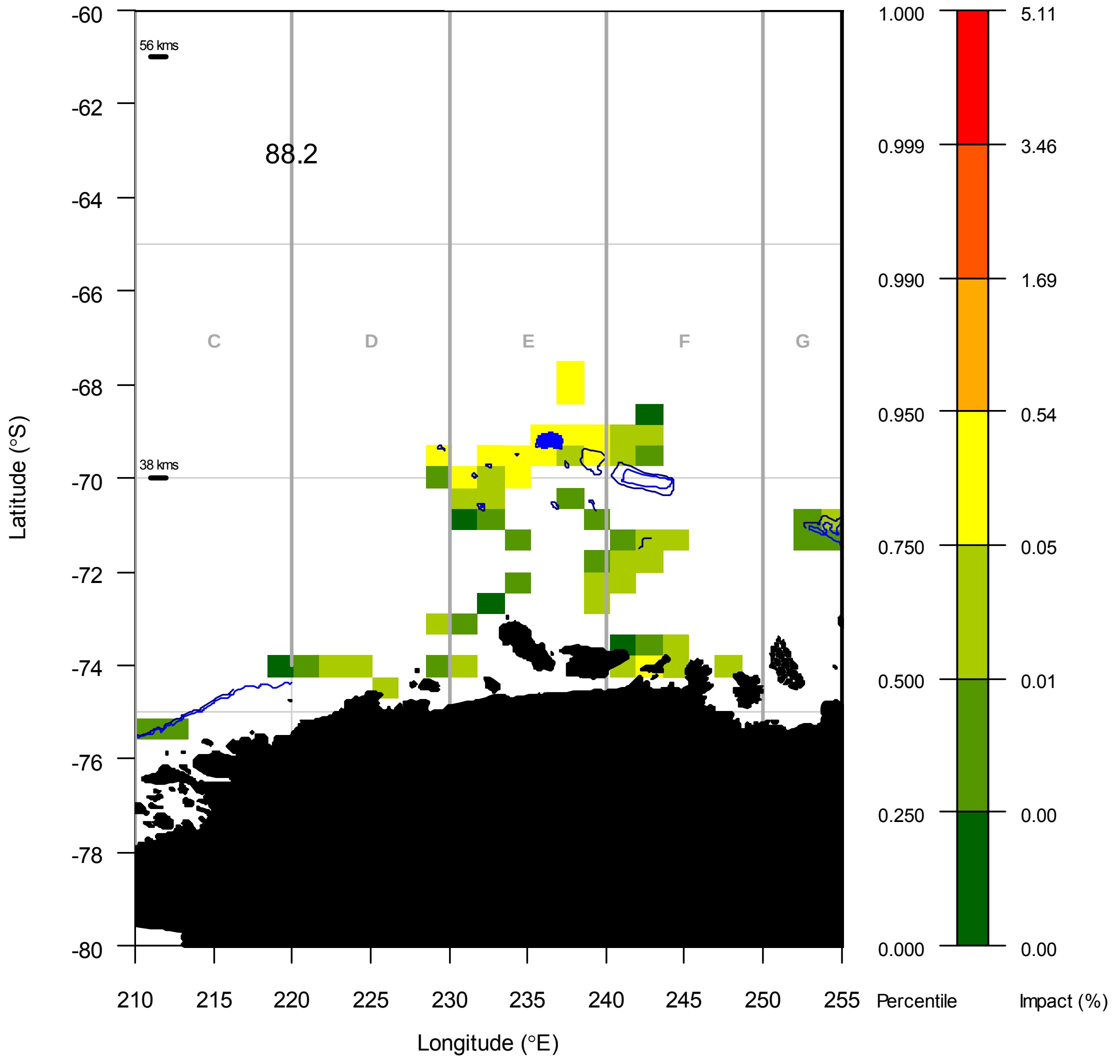


Figure 6(h): Map showing estimated percent impact due to longline bottom fishing (all longline types) for Division 58.4.4. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of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



Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
N	2	82	252	480	683	432	794	2160	1529	1040	1395	1012	966	1071	987	1079	13964
km's	4	330	1769	2660	4576	3370	7009	19512	13657	10233	11783	10127	9080	13683	12238	12435	132466

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. Blue dots indicate Risk Areas generated under CM 22-07. Cyan dots indicate the proposed locations of two registered VMEs (notified under CM 22-06) recommended in 2011.



Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
N	78	168	89	267	279	128	532	201	445	360	2547
km's	422	1147	544	1945	2922	1346	3985	2114	4234	3051	21710

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.

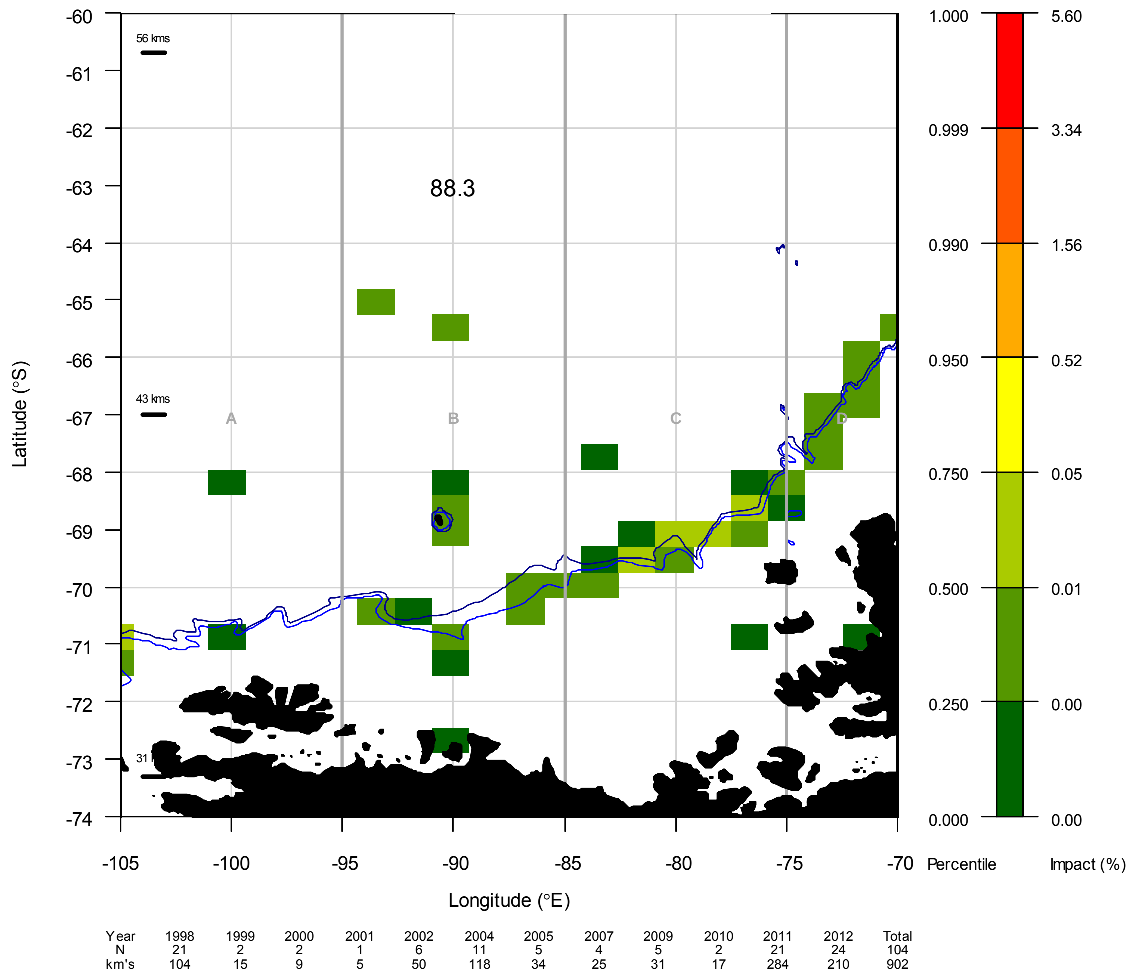
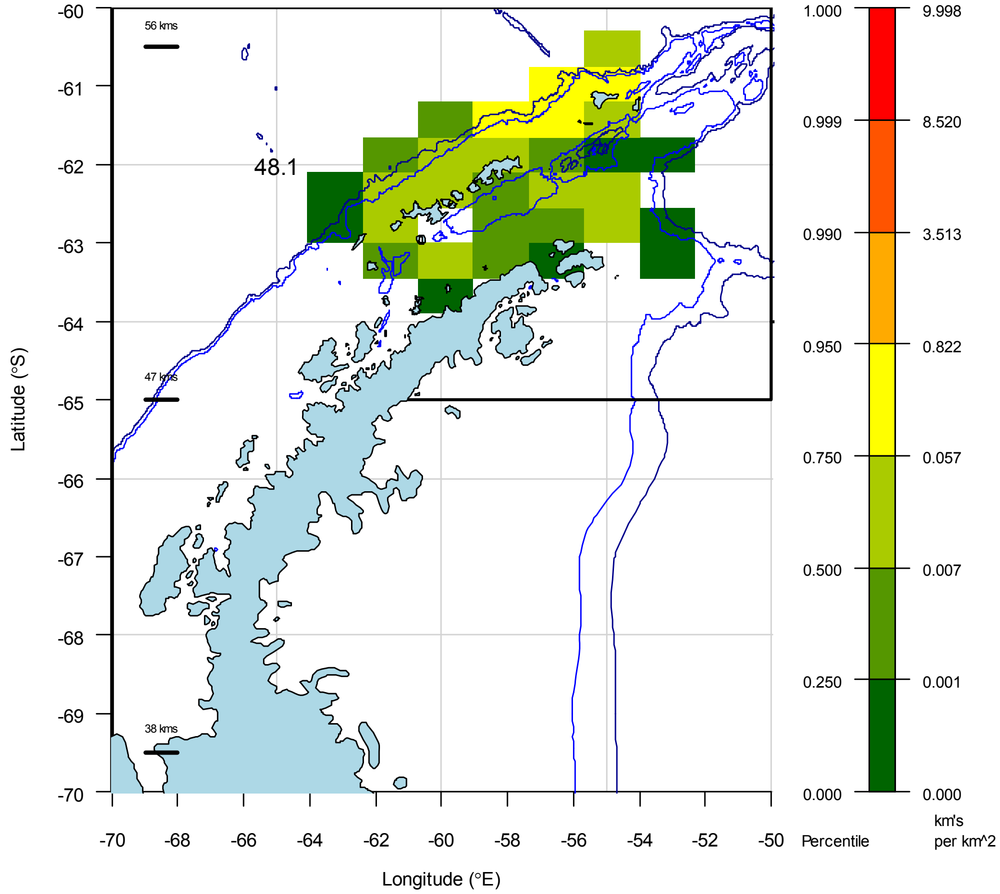


Figure 6(k): Map showing estimated percent impact due to longline bottom fishing (all longline types) for Subarea 88.3. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp indicating impact values is determined from the quartiles and 95th, 99th and 99.9th percentiles of the distribution of impacts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



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	927	171	156	61	208	171	222	163	124	273	12	2804

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.

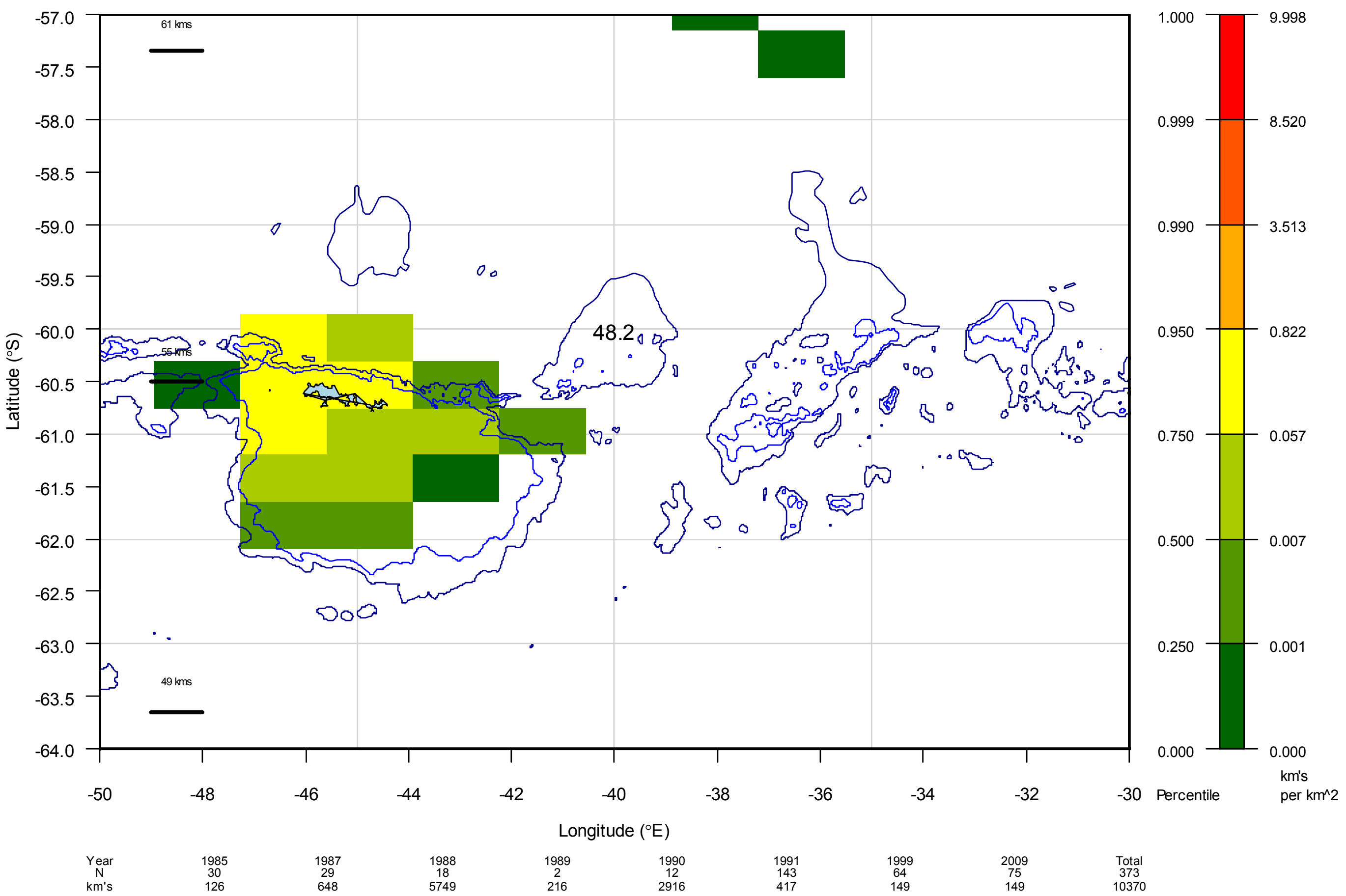


Figure 7(b): Map showing bottom trawl effort density for Subarea 48.2. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp is determined from the quartiles and 95th, 99th and 99.9th percentile points of the distribution of trawl effort density across the entire Convention Area. The 1 000 and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

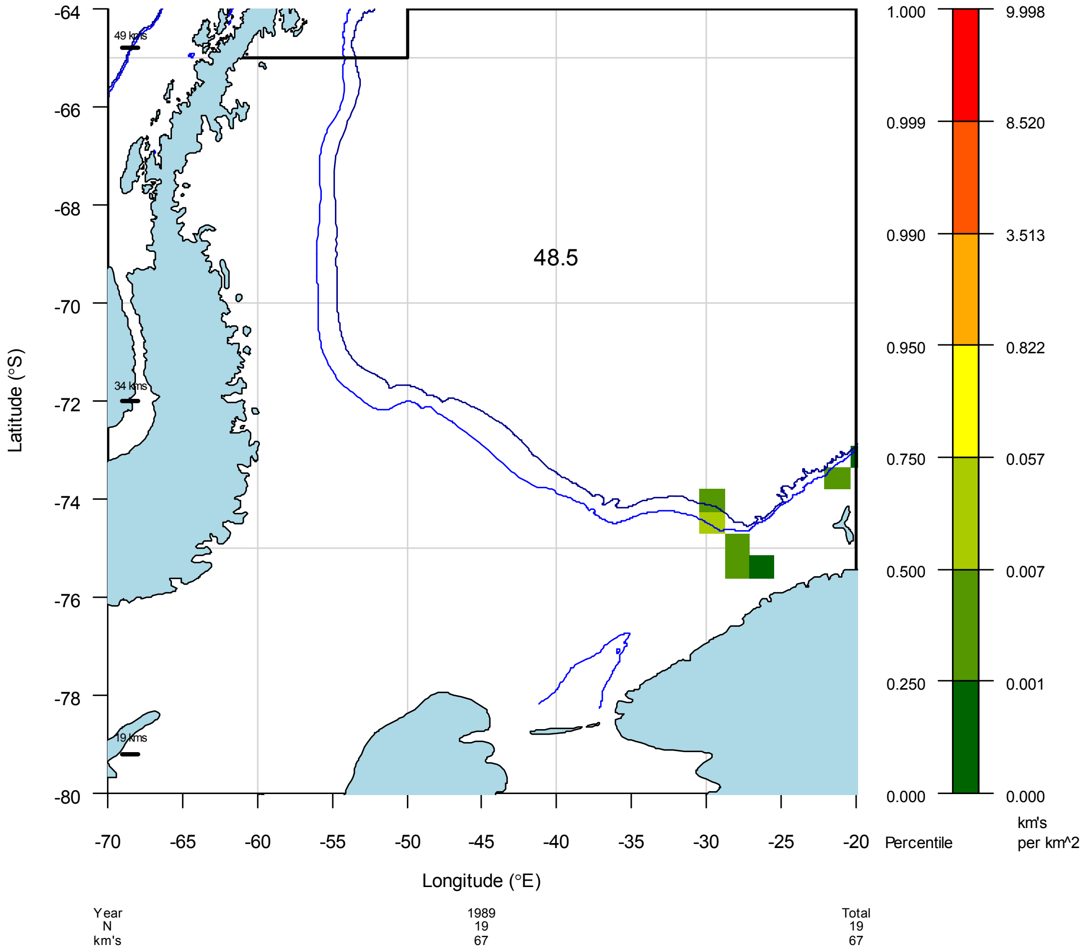


Figure 7(c): Map showing bottom trawl effort density for Subarea 48.5. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp is determined from the quartiles and 95th, 99th and 99.9th percentile points of the distribution of trawl effort density across the entire Convention Area. The 1 000 and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

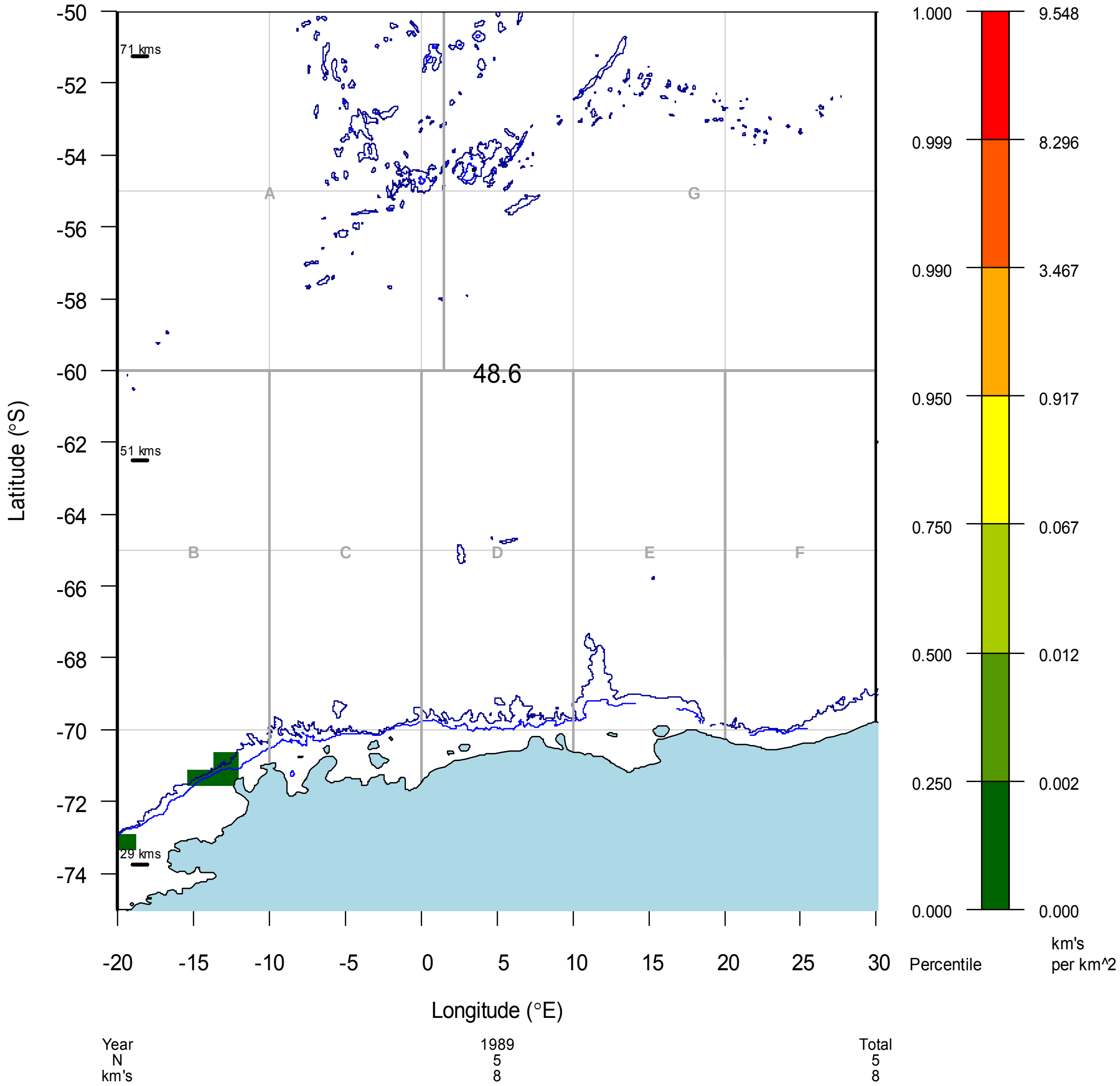


Figure 7(d): Map showing bottom trawl effort density for Subarea 48.6. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp is determined from the quartiles and 95th, 99th and 99.9th percentile points of the distribution of trawl effort density across the entire Convention Area. The 1 000 and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

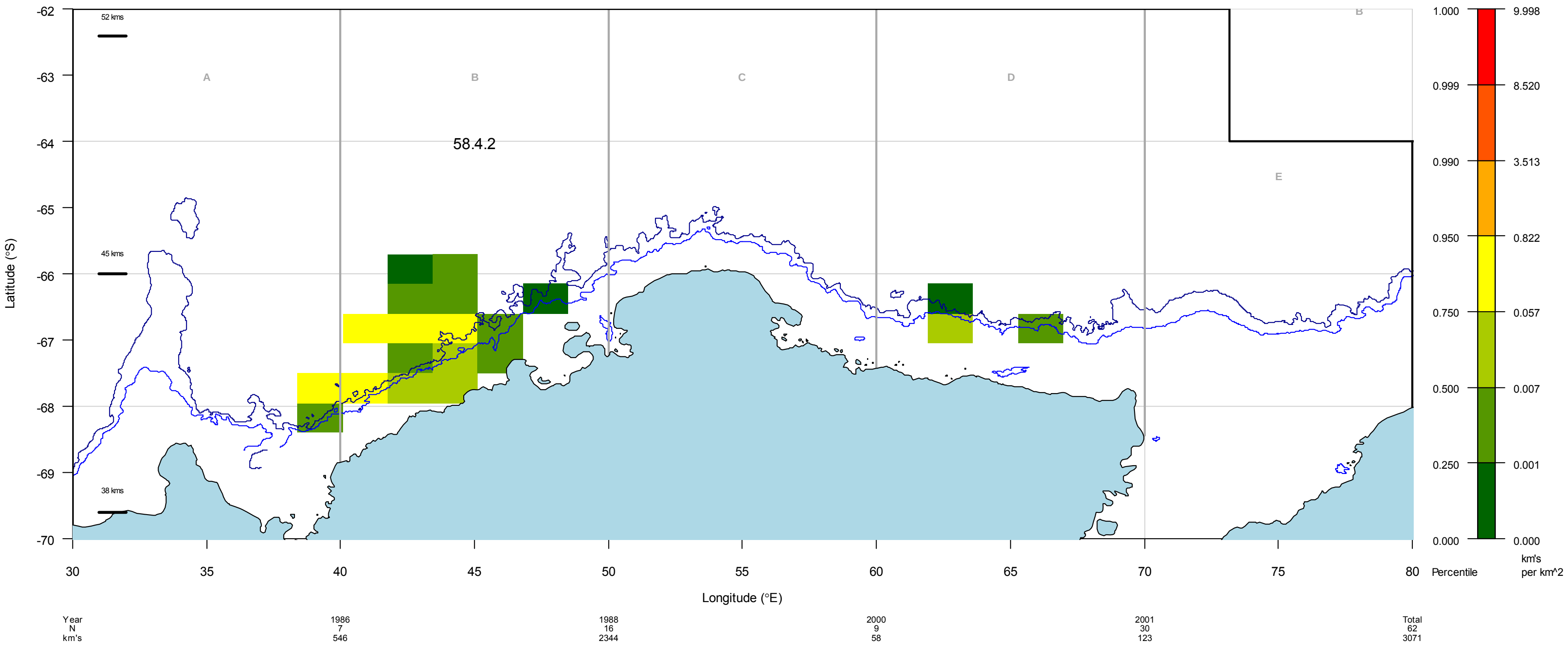


Figure 7(e): Map showing bottom trawl effort density for Division 58.4.2. Cells are 0.45° latitude × 1.68° longitude. The colour-ramp is determined from the quartiles and 95th, 99th and 99.9th percentile points of the distribution of trawl effort density across the entire Convention Area. The 1 000 and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

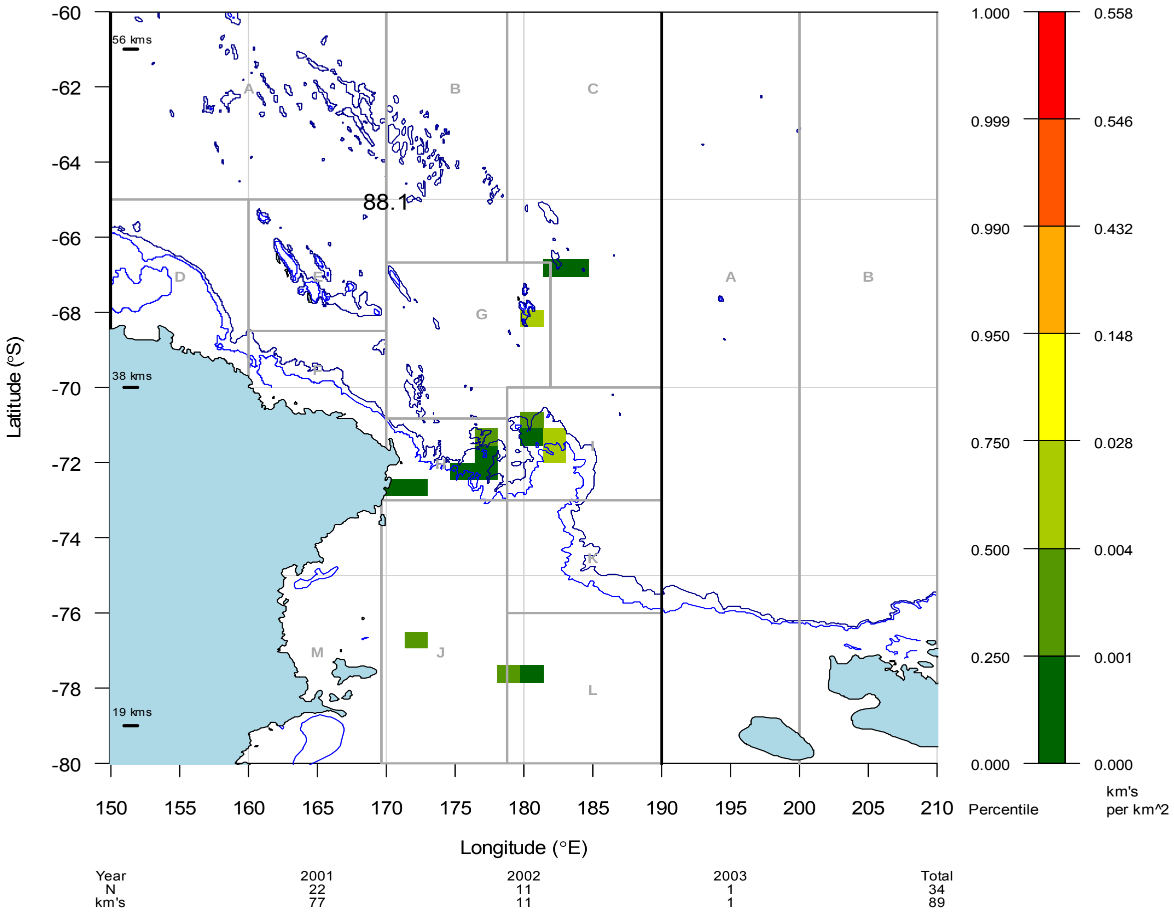
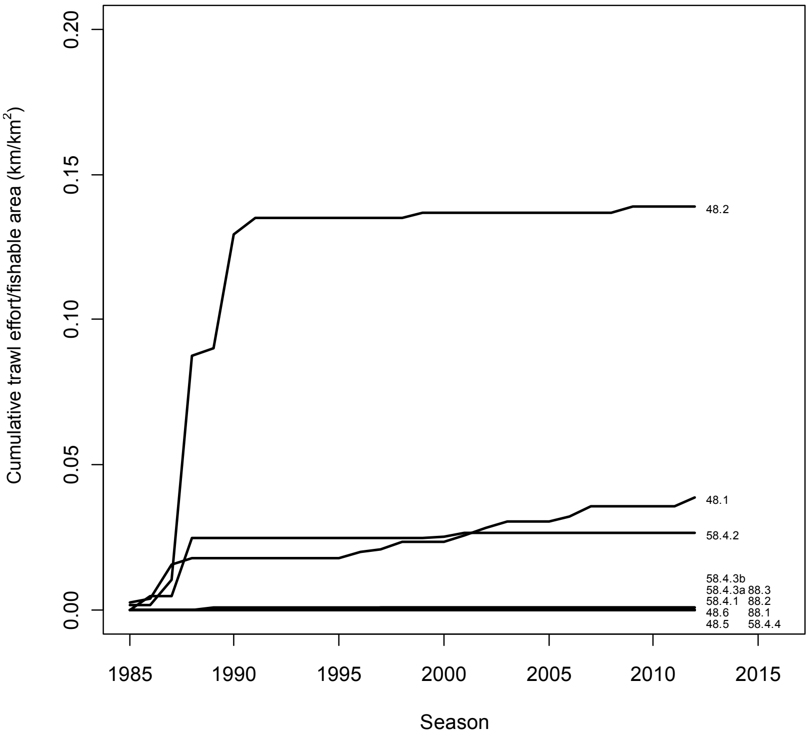


Figure 8: Map showing bottom trawl effort density for Subareas 88.1 (all) and 88.2 (SSRUs A and B only). Cells are 0.45° latitude × 1.68° longitude. The colour-ramp is determined from the quartiles and 95th, 99th and 99.9th percentile points of the distribution of effort density across the entire Convention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

(a)



(b)

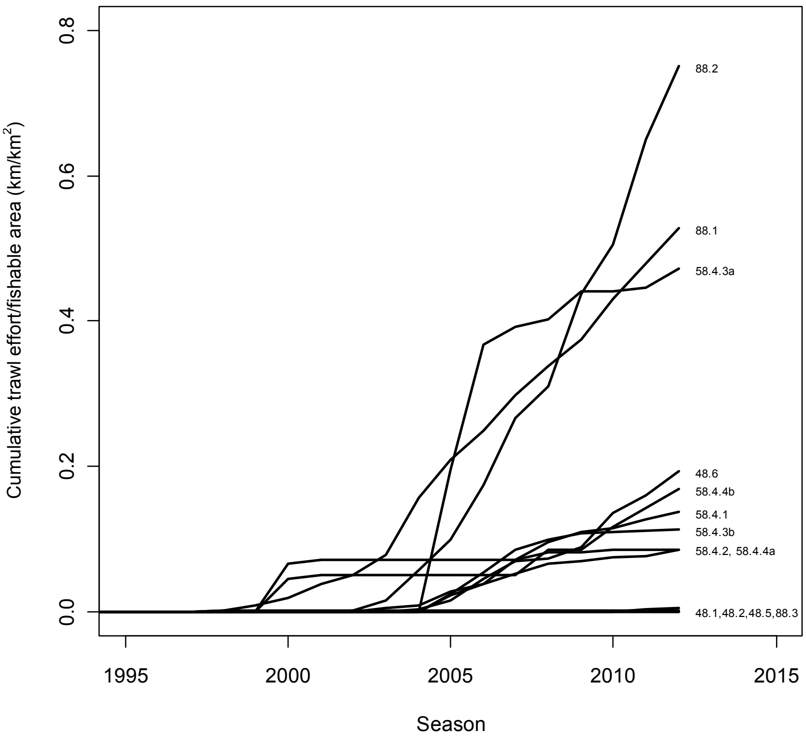


Figure 9: Cumulative effort as a proportion of fishable area in subareas/divisions affected by CM 22-06 for (a) trawls and (b) longline fisheries.

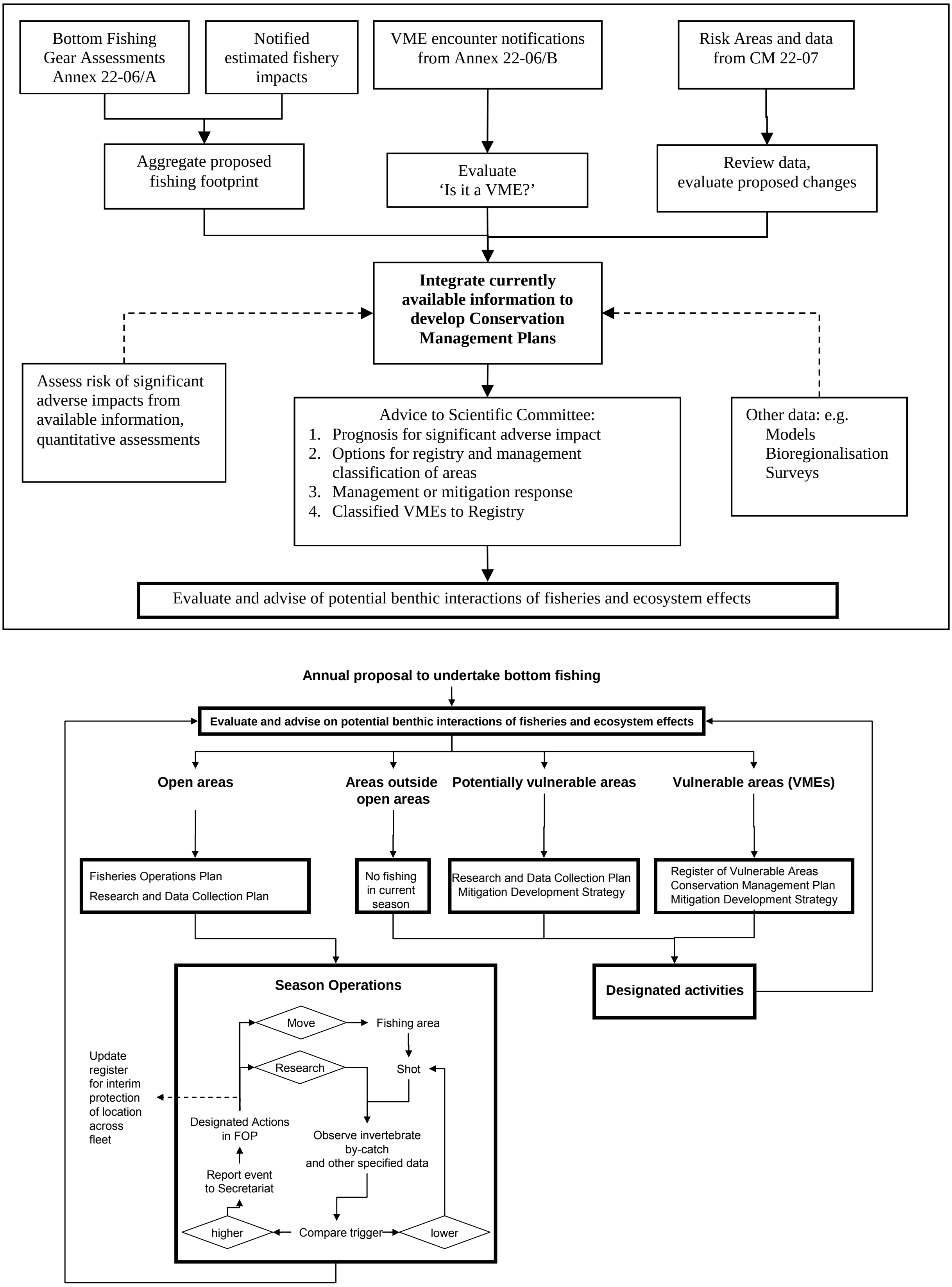


Figure 10: Proposed framework for managing flow and review of information resulting from implementation of Conservation Measures 22-06 and 22-07 (top panel) leading to the evaluation and advice on potential benthic interactions of fisheries and ecosystem effects (from SC-CAMLR-XXVI, Figure 1, bottom panel).

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 1, 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.

Attachment B

VME REGISTER

Notifications of VME encounters made under CM 22-06.

Subarea/ division	Encounter date	Start position (dd mm.00)		End position (dd mm.00)		Seafloor depth (m)	Protection
		Latitude	Longitude	Latitude	Longitude		
48.1	08-Mar-09	63°15.45'S	59°03.60'W	63°14.25'S	59°05.63'W	296–405	CM 32-02
	05-Mar-09	62°37.17'S	56°37.20'W	62°36.55'S	56°35.09'W	226–228	
	05-Mar-09	62°36.84'S	55°27.13'W	62°36.35'S	55°24.35'W	141–157	
	05-Mar-09	63°00.95'S	52°22.80'W	63°00.94'S	52°25.76'W	633–642	
	03-Mar-06	62°46.45'S	56°51.95'W	62°45.35'S	56°51.53'W	176–180	
	22-Feb-06	63°03.00'S	58°45.82'W	63°03.00'S	58°48.07'W	210–226	
	02-Mar-06	61°49.30'S	53°59.97'W	61°48.35'S	54°00.02'W	290–293	
	08-Mar-06	62°43.99'S	54°58.38'W	62°43.99'S	54°57.32'W	160–161	
	05-Mar-06	62°43.83'S	55°31.81'W	62°43.87'S	55°33.66'W	136–142	
	03-Mar-06	62°47.57'S	56°42.14'W	62°46.99'S	56°43.83'W	150–178	
	20-Feb-06	63°14.58'S	59°46.79'W	63°13.56'S	59°46.86'W	221–249	
	21-Feb-06	63°04.98'S	58°35.55'W	63°04.98'S	58°37.84'W	126–135	
	22-Feb-06	63°00.02'S	58°03.91'W	63°00.02'S	58°06.10'W	225	
	19-Feb-06	63°27.40'S	60°02.69'W	63°27.68'S	60°04.77'W	103–121	
	20-Feb-06	63°13.28'S	59°53.12'W	63°12.27'S	59°52.68'W	330–345	
	15-Mar-06	62°49.66'S	57°27.38'W	62°48.87'S	57°26.33'W	132–137	
	19-Feb-06	63°25.38'S	59°41.73'W	63°25.36'S	59°44.02'W	92–100	
	14-Mar-03	61°14.34'S	54°48.66'W	61°15.03' S	54°35.50'W	-	
	14-Mar-03	61°03.61'S	54°34.00'W	61°04.01' S	54°35.15'W	-	
	16-Mar-03	60°55.02'S	55°43.21'W	60°52.95' S	55°41.85'W	-	
	20-Mar-03	61°27.08'S	55°51.49'W	61°24.31' S	55°53.44'W	-	
	18-Mar-12	61°20.00'S	55°27.17'W	61°20.50' S	55°33.63'W	-	
48.2	01-Mar-09	60°26.44'S	46°31.35'W	60°25.49'S	46°31.34'W	150–252	CM 32-02
	02-Mar-09	60°46.02'S	46°18.56'W	60°46.24'S	46°15.85'W	158–230	
	02-Mar-09	60°42.61'S	46°38.58'W	60°41.44'S	46°37.81'W	127–153	
	02-Mar-09	60°42.82'S	46°00.03'W	60°42.62'S	46°02.02'W	96–102	
	26-Feb-09	60°55.25'S	46°15.59'W	60°55.24'S	46°17.64'W	225–226	
	12-Feb-09	60°36.08'S	44°45.87'W	60°35.35'S	44°45.44'W	105–137	
	09-Feb-09	60°25.78'S	46°25.11'W	60°25.77'S	46°27.21'W	140–153	
	13-Feb-09	60°36.52'S	44°20.56'W	60°35.90'S	44°18.77'W	190–233	
	25-Feb-09	60°37.98'S	46°31.43'W	60°37.98'S	46°33.10'W	128–130	
	17-Feb-09	60°49.27'S	44°29.46'W	60°50.30'S	44°29.84'W	169–174	
	10-Feb-09	60°26.25'S	46°17.77'W	60°25.75'S	46°19.54'W	138–152	
	11-Feb-09	60°29.37'S	45°08.10'W	60°28.41'S	45°07.28'W	350	
	14-Feb-09	60°52.22'S	43°11.78'W	60°53.00'S	43°13.49'W	336	
58.4.1	06-Jan-08	65°49.67'S	142°59.74'E	65°46.27'S	142°59.11'E	523–837	CM 22-09
	17-Jan-08	65°42.38'S	140°35.61'E	65°36.84'S	140°20.19'E	436–844	
88.1	13-Mar-08	66°56.04'S	170°51.66'E	66°56.04' S	170°51.66'E	578–578	CM 22-09
	13-Mar-08	67°10.14'S	171°10.26'E	67°10.14' S	171°10.26'E	602–788	
	*	74°42.14'S	164°03.31'E	74°42.14' S	164°03.31'E	-	
	*	74°41.61'S	164°05.47'E	74°41.61' S	164°05.47'E	-	
	*	74°41.79'S	164°07.07'E	74°41.79' S	164°07.07'E	-	
	*	74°41.97'S	164°07.30'E	74°41.97' S	164°07.30'E	-	
	*	74°46.23'S	163°57.47'E	74°46.23' S	163°57.47'E	-	
	*	74°46.24'S	163°56.03'E	74°46.24' S	163°56.03'E	-	
	*	74°46.50'S	163°57.37'E	74°46.50' S	163°57.37'E	-	

* reported July 2012

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 date	Risk Area			VME indicator units notified
		Latitude (DD MM.mm)	Longitude (DDD MM.mm)	Seafloor depth (m)	
88.1	07-Jan-09	75°08.52'S	176°07.14'W	1057–1298	69
	07-Jan-09	75°08.70'S	176°04.98'W	1057–1298	60
	07-Jan-09	75°12.10'S	175°55.10'W	1053–1209	25
	15-Jan-09	71°34.90'S	172°11.40'E	1307–1350	11
	15-Jan-09	71°40.60'S	172°15.40'E	1296–1296	13
	10-Jan-10	75°10.20'S	176°01.70'W	676–1216	18
	10-Jan-10	75°10.60'S	176°03.40'W	676–1216	19
	10-Jan-10	75°11.10'S	176°05.10'W	676–1216	38
	10-Jan-10	75°11.20'S	176°07.60'W	676–1216	32
	10-Jan-10	75°11.20'S	176°08.90'W	676–1216	29
	15-Jan-10	71°54.63'S	172°09.31'E	1170–1194	12
	16-Dec-10	75°14.90'S	175°42.70'W	919–1087	12
	26-Dec-10	75°03.24'S	176°29.77'W	1054–1241	11
	26-Dec-10	75°04.39'S	176°27.53'W	1054–1241	35
	26-Dec-10	75°04.66'S	176°27.04'W	1054–1241	21
	26-Dec-10	75°05.81'S	176°24.72'W	760–1038	23
	26-Dec-10	75°07.01'S	176°22.39'W	760–1038	12
	27-Dec-10	75°02.50'S	176°43.40'W	707–913	19
	27-Dec-10	75°03.12'S	176°42.43'W	707–913	23
	27-Dec-10	75°03.70'S	176°34.90'W	771–1039	13
	27-Dec-10	75°04.28'S	176°40.55'W	707–913	20
	27-Dec-10	75°04.29'S	176°34.04'W	771–1039	17
	27-Dec-10	75°04.80'S	176°39.69'W	707–913	20
	27-Dec-10	75°04.88'S	176°33.09'W	771–1039	21
	27-Dec-10	75°05.50'S	176°32.14'W	771–1039	16
	27-Dec-10	75°06.18'S	176°31.14'W	771–1039	19
	28-Dec-10	74°55.20'S	176°52.33'W	869–1162	21
	28-Dec-10	74°55.79'S	176°52.84'W	869–1162	14
	28-Dec-10	74°56.42'S	176°53.43'W	869–1162	11
	28-Dec-10	74°57.02'S	176°53.91'W	869–1162	29
	28-Dec-10	74°57.63'S	176°54.31'W	869–1162	22
	30-Dec-10	74°45.48'S	177°04.21'W	642–920	13
	30-Dec-10	74°48.43'S	176°56.33'W	971–1130	12
	30-Dec-10	74°54.17'S	177°00.46'W	823–970	34
	30-Dec-10	74°58.58'S	177°00.26'W	823–970	15
	01-Jan-11	74°38.84'S	176°46.92'W	1147–1227	14
	01-Jan-11	74°39.50'S	176°46.46'W	1147–1227	12
	01-Jan-11	74°41.38'S	176°47.13'W	1147–1227	11
	01-Jan-11	74°42.17'S	176°48.20'W	1197–1201	14
	01-Jan-11	74°43.33'S	176°49.55'W	1197–1201	14
	01-Jan-11	74°43.93'S	176°50.51'W	1197–1201	11
	01-Jan-11	74°44.46'S	176°51.24'W	1197–1201	13
	30-Dec-11	71°57.36'S	173°22.39'E	1342–1571	14

(continued)

VME Risk Areas (continued)

Subarea/ division	Notification date	Risk Area			VME indicator units notified
		Latitude (DD MM.mm)	Longitude (DDD MM.mm)	Seafloor depth (m)	
88.1	04-Jan-12	74°35.74'S	176°28.43'W	1245–1354	18
	04-Jan-12	74°35.86'S	176°17.65'W	1260–1548	14
	22-Jan-12	75°45.12'S	173°06.56'W	791–853	11
	22-Jan-12	75°45.38'S	173°04.16'W	791–853	12
	04-Dec-12	65°23.01'S	178°15.50' W	1498-1602	42
88.2	19-Jan-09	69°07.98'S	123°41.34'W	1272–1374	10
	19-Jan-09	69°08.04'S	123°43.86'W	1332–1543	10
	22-Jan-10	69°04.90'S	123°19.30'W	1371–1487	15
	11-Feb-10	69°08.20'S	122°59.50'W	1487–1602	13
	01-Feb-12	69°05.81'S	123°14.10'W	1422–1539	61
	01-Feb-12	69°06.15'S	123°12.15'W	1422–1539	10
	01-Feb-12	69°07.87'S	123°05.10'W	1614–1681	100
	11-Feb-12	69°08.52'S	122°55.36'W	1634–1663	25
	12-Feb-12	69°03.69'S	123°27.47'W	1327–1443	12
	12-Feb-12	69°06.47'S	123°19.23'W	1189–1397	10
	12-Feb-12	69°07.02'S	123°16.18'W	1189–1397	15
	12-Feb-12	69°08.75'S	123°15.72'W	1483–1521	15
	12-Feb-12	69°08.97'S	123°17.32'W	1483–1521	11
	21-Feb-12	69°07.70'S	123°11.84'W	1801–1810	10
	21-Feb-12	69°08.22'S	123°12.57'W	1801–1810	12
	23-Feb-12	69°06.71'S	123°06.25'W	1509–1905	12