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SPRING, SUMMER AND FALL DISTRIBUTION OF COMMON DEMERSAL FISHES ON THE SCOTIAN SHELF BETWEEN 1978 AND 1985

by

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Commonly occurring demersal fish species on the Scotian Shelf were recorded in a series of research vessel trawl surveys during spring, summer and fall seasons between the years of 1978 and 1985. Mapping the spatial distribution of these species on the Scotian Shelf during different seasons allows for the visual assessment of spatial overlap or differences among seasons. Seasonal maps were created for 32 fish species for the 1978 to 1985 time period to provide managers and stakeholders with a more thorough understanding of seasonal shifts in the distribution of these species on the Scotian Shelf. This information should inform oceans and coastal management and planning, including marine protected area network development.

RÉSUMÉ

Les espèces de poisson de fond couramment présentes sur le plateau néo-écossais ont été consignées dans une série de relevés au chalut par navire scientifique au cours des saisons de printemps, d'été et d'automne entre 1978 et 1985. La cartographie de la répartition spatiale de ces espèces sur le plateau néo-écossais au cours des différentes saisons permet l'évaluation visuelle du chevauchement spatial ou des différences entre les saisons. Des cartes saisonnières ont été créées pour 32 espèces de poissons pour la période de 1978 à 1985; elles permettent aux gestionnaires et aux intervenants de mieux comprendre les changements saisonniers dans la répartition de ces espèces sur le plateau néo-écossais. Ces renseignements devraient orienter la planification et la gestion côtière et des océans, y compris l'établissement d'un réseau d'aires marines protégées.

INTRODUCTION

Canada's *Oceans Act* (1997) serves as the legislative framework for an integrated, ecosystem approach to coastal and oceans management in Canada, where maintaining marine biological diversity and productivity is of fundamental importance. As the responsible authority under the Act, Fisheries and Oceans Canada (DFO) is implementing this approach through a range of programs and activities. To implement an ecosystem approach to management that maintains marine biodiversity and productivity, it is important to understand the spatial and temporal distribution of these ecosystem characteristics.

Fish represent an important component of the biodiversity of the Scotian Shelf. The purpose of this report is to describe and compare the spatial distribution of key demersal and other fish species on the Scotian Shelf, using research vessel trawl survey data from the spring, summer and fall between 1978 and 1985. There were no comparable winter survey data collected within this time period. The report was prepared for the Oceans and Coastal Management Division and can inform marine protected area (MPA) network development and other integrated ecosystem management and planning activities. It is meant to complement the existing *Atlas of important habitat for key fish species of the Scotian Shelf, Canada* (Horsman and Shackell 2009), which displays the summer distribution of ecologically significant and depleted fish species. The seasonal species distribution layers presented in this report are stored as ArcGIS raster files, which will allow for the analysis and interpretation of the associated seasonal variables in order to identify possible key factors that influence species distribution. No invertebrate species, other than short-fin squid (*Illex illecebrosus)* were included in this report as they were not consistently recorded between 1978 and 1985.

METHODOLOGY

KEY SPECIES

The species list used in this report is identical to that used in the *Atlas of important habitat for key fish species of the Scotian Shelf, Canada* (Horsman and Shackell 2009) and is comprised mostly of ecologically significant species and depleted species. More specifically, the species considered fall within one or more of the following four categories: 1) forage species; 2) influential predator species; 3) depleted species; 4) additional dominant species observed in trawl survey (Horsman and Shackell 2009) (Table 1). See DFO (2006, 2007) for more information on ecologically significant and depleted species and how they are considered in integrated oceans management. It is important to note that the depleted category did not exist when the data were collected (1978-1985) and is used in order to be consistent with Horsman and Shackell (2009). The species included in this report have been organized in alphabetical order for ease of use.

Table 1. List of species (in order of appearance) that have been included in this report, including scientific name and species category.

Species name (common)	Scientific name	Characteristic type as of 2009
American Plaice	*Hippoglossoides platessoides*	Influential Predator
Atlantic Argentine	*Argentina silus*	Dominant Trawl Survey Species
Atlantic Cod	*Gadus morhus*	Influential Predator, Depleted Species
Atlantic Halibut	*Hippoglossus hippoglossus*	Influential Predator
Atlantic Wolffish	*Anarhichas lupus*	Depleted Species
Capelin	*Mallotus villosus*	Forage Species
Cusk	*Brosme brosme*	Depleted Species
Haddock	*Melanogrammus aeglefinus*	Influential Predator
Herring	*Clupea harengus*	Forage Species
Longfin Hake	*Phycis chesteri*	Dominant Trawl Survey Species
Longhorn Sculpin	*Myoxocephalus octodecemspinosus*	Influential Predator
Mackerel	*Scomber scrombus*	Forage Species
Monkfish	*Lophius americanus*	Dominant Trawl Survey Species
Moustache Sculpin	*Triglops murrayi*	Dominant Trawl Survey Species
Northern Wolffish	*Anarhichas denticulatus*	Depleted Species
Ocean Pout	*Zoarces americanus*	Dominant Trawl Survey Species
Pollock	*Pollachius virens*	Influential Predator
Redfish	*Sebastes sp.*	Influential Predator
Red Hake	*Urophycis chuss*	Influential predator
Sandlance	*Ammodytes dubius*	Forage Species
Sea Raven	*Hemitripterus americanus*	Dominant Trawl Survey Species
Shortfin Squid	*Illex illecebrosus*	Forage Species
Silver Hake	*Merluccius bilinearis*	Influential Predator
Smooth Skate	*Malacoraja senta*	Influential Predator
Spiny Dogfish	*Squalus acanthias*	Influential Predator
Spotted Wolffish	*Anarhichas minor*	Depleted Species
Thorny Skate	*Amblyraja radiata*	Dominant Trawl Survey Species
White Hake	*Urophycis tenuis*	Influential Predator
Winter Flounder	*Pseudopleuronectes americanus*	Dominant Trawl Survey Species
Winter Skate	*Leucoraja ocellata*	Influential Predator, Depleted Species
Witch Flounder	*Glytocephalus cynoglossus*	Forage Species
Yellowtail Flounder	*Limanda ferruginea*	Dominant Trawl Survey Species

RESEARCH VESSEL SURVEY

DFO has conducted an annual summer research vessel (RV) survey of the Scotian Shelf typically during the month of July since 1970. The survey uses a random stratified sampling design within forty eight unique strata that are defined by geographic location and a uniform water depth. The gear used in the RV survey is a Western IIa bottom trawl with a 19 mm codend liner. The trawl is towed at a constant speed of 3.5 knots for 30 minutes and covers approximately 0.0404 km^2 of area (Horsman and Shackell 2009). From the fall of 1978 through to the spring of 1985, DFO also conducted spring and fall surveys using the same stratified random sampling design. Three different survey vessels were used during this time period. For the summer survey, the *AT Cameron* was used with a Yankee 36 trawl from 1970 to 1981, the *Lady Hammond* with a Western IIA trawl was used in 1982 and 1983, and the *Alfred Needler* with a Western IIA trawl was used from 1984 to present. The fall survey was conducted by the *Lady Hammond* from 1978 to 1982 and then changed to the *Alfred Needler* until 1984. The spring survey started in 1979 and was conducted by the *Lady Hammond* until 1983, followed by the *Alfred Needler* until 1985. The spring RV surveys took place in February, March or April while the fall surveys were conducted during September, October or November.

It is important to acknowledge that the catchability of certain species would have varied with the different survey vessels and gear types used from 1978 to 1985. No reliable conversion factors can be applied to standardize for these discrepancies in catchability (H. Stone, DFO, pers. comm.). As a result, there is some variability in the data used to generate the seasonal distribution maps. This issue should not have a drastic effect on the general distribution patterns presented in this report. It should also be noted that the spring survey included sampling on Georges Bank, while the summer and fall series did not (D. Clark, DFO, pers. comm.). There were also certain years where the spring survey coverage was limited by ice cover on the eastern Scotian Shelf. The Bay of Fundy was also not always well sampled in the spring survey. These differences in spatial coverage of the surveys could have a slight skewing effect on the spring distribution maps for certain species.

The distribution maps presented in this report were created using seasonal RV survey data collected between 1978 and 1985. These years represent a period of recovery for many domestic stocks as Canada had just claimed its 200 nautical mile limit (Exclusive Economic Zone) and the domestic fishery was not fully developed (Horsman and Shackell 2009).

INTERPOLATION METHODS

The analysis presented in this report examines, for each species, the weight (or biomass) sampled per tow in the RV survey. These data have been treated with a logarithm of 10 in order to reduce the range of values. Using ArcGIS 10.0, the inverse distance weighting (IDW) tool was used to interpolate the data, including null values. To maintain consistency between the results of this analysis and those in Horsman and Shackell (2009), the same parameters were used. Within the IDW tool, a fixed search radius of 0.15 degrees was used (which would be equivalent to approximately 15 kilometres on the Scotian Shelf), with an output cell size of 0.026177 degrees. The North American Datum 1983 spatial reference was used consistently throughout the analysis.

RESULTS

TRENDS IN RESULTS

Three maps are presented for each species, one each for the spring, summer and fall RV surveys between 1978 and 1985. The three seasonal maps are presented at the same scale (1:11,000,000), are within the same geographic location, use the same cell size, and have been produced with the same methods (as previously outlined) at identical spatial references.

Similar to Horsman and Shackell (2009), areas where sampling occurred on each of the RV trawl surveys but did not yield a species observation are displayed in dark blue. In addition, areas with no colour were not sampled during the seasonal RV trawl survey between 1978 and 1985. Areas which bear an orange or red colour are distinguishable as areas with a high biomass (>60 percentile) for that particular species.

SPECIES MAPS

The results of the 1978-1985 seasonal habitat comparison for key fish species on the Scotian Shelf are presented below (Figures 1 to 32), in alphabetical order. Thirty-two fish species have been included in this analysis.

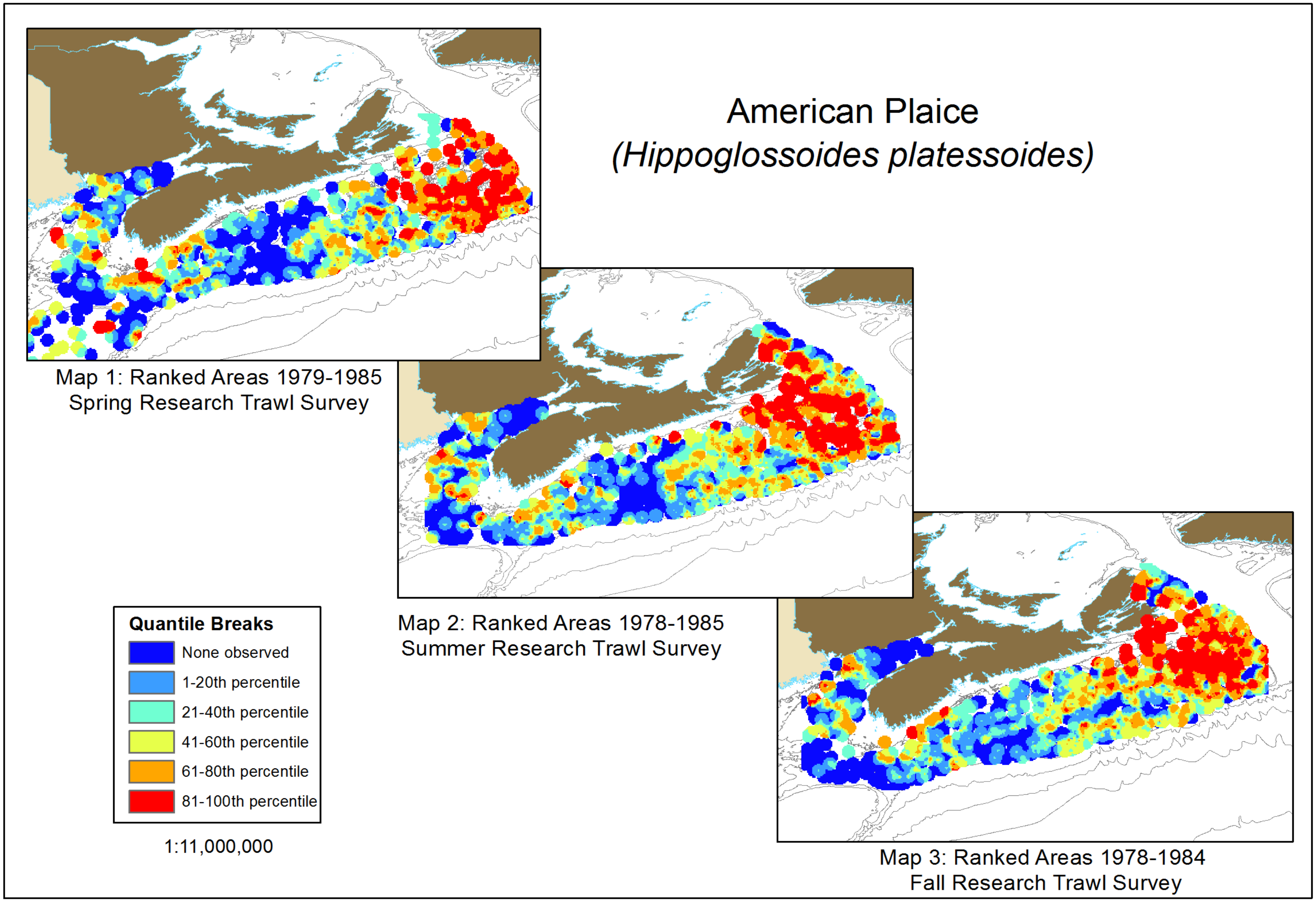

Figure 1. Maps showing distribution of American Plaice from spring, summer and fall research trawl surveys (1978-1985).

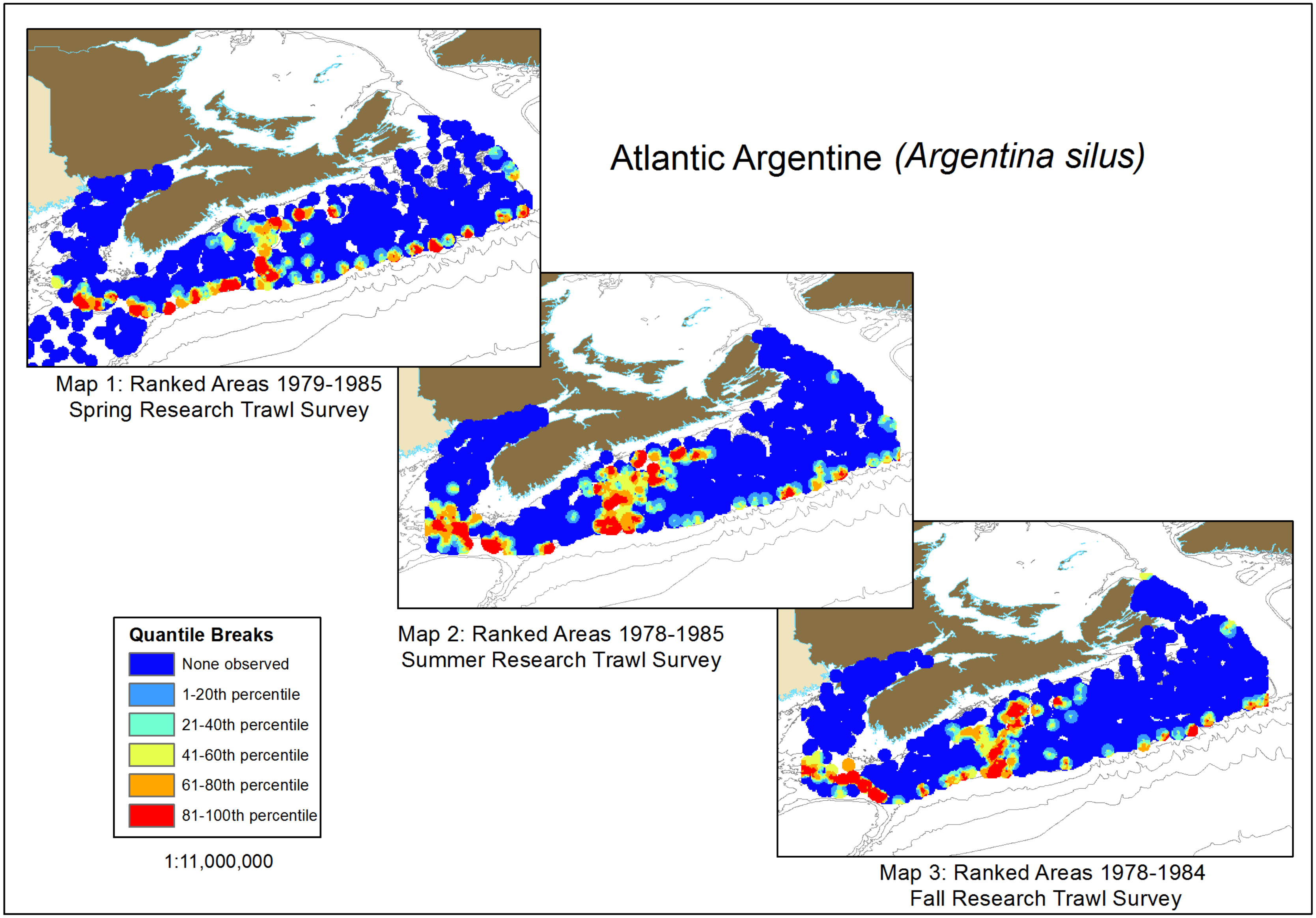

Figure 2. Maps showing distribution of Atlantic Argentine from spring, summer and fall research trawl surveys (1978-1985).

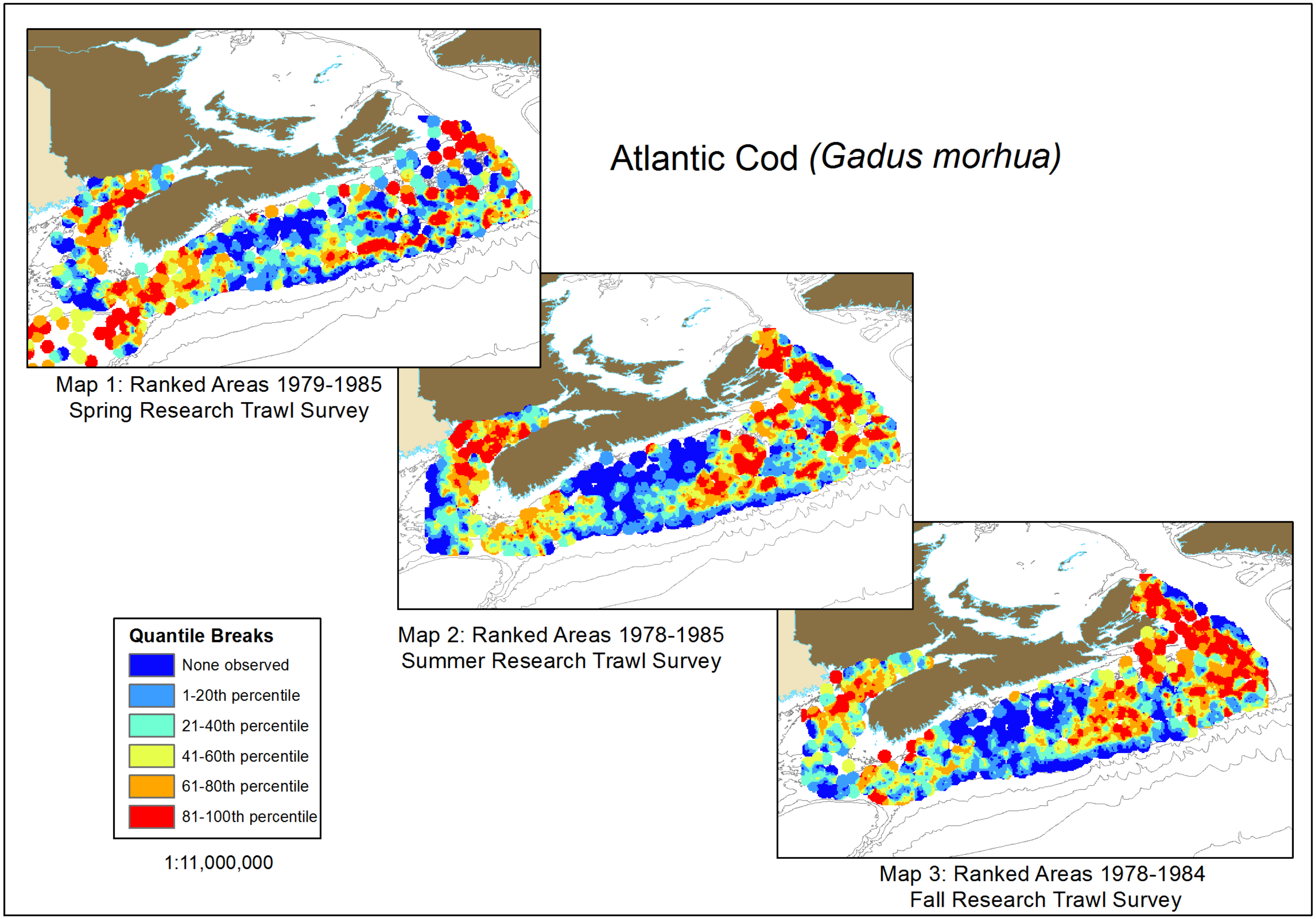

Figure 3. Maps showing distribution of Atlantic Cod from spring, summer and fall research trawl surveys (1978-1985).

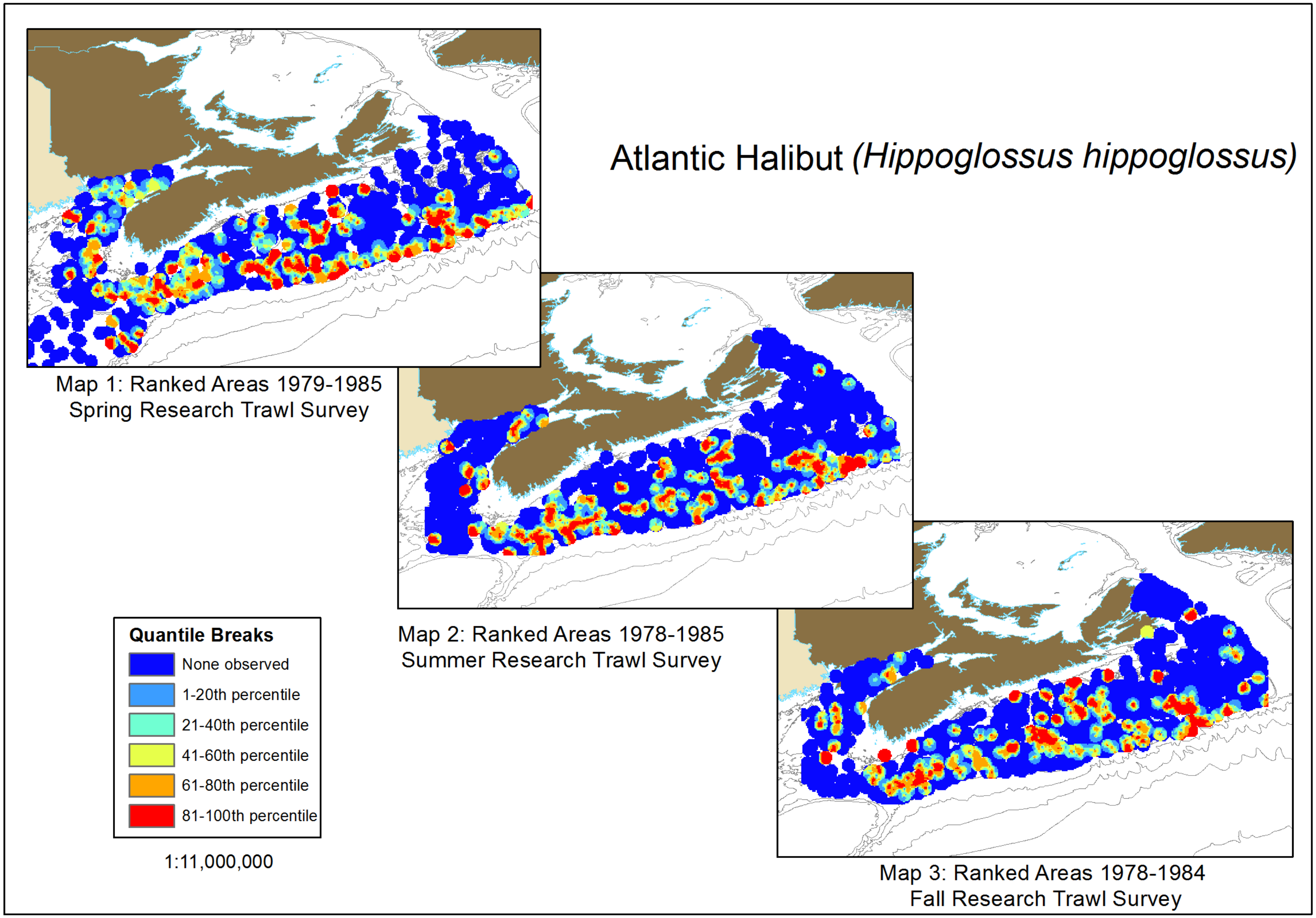

Figure 4. Maps showing distribution of Atlantic Halibut from spring, summer and fall research trawl surveys (1978-1985).

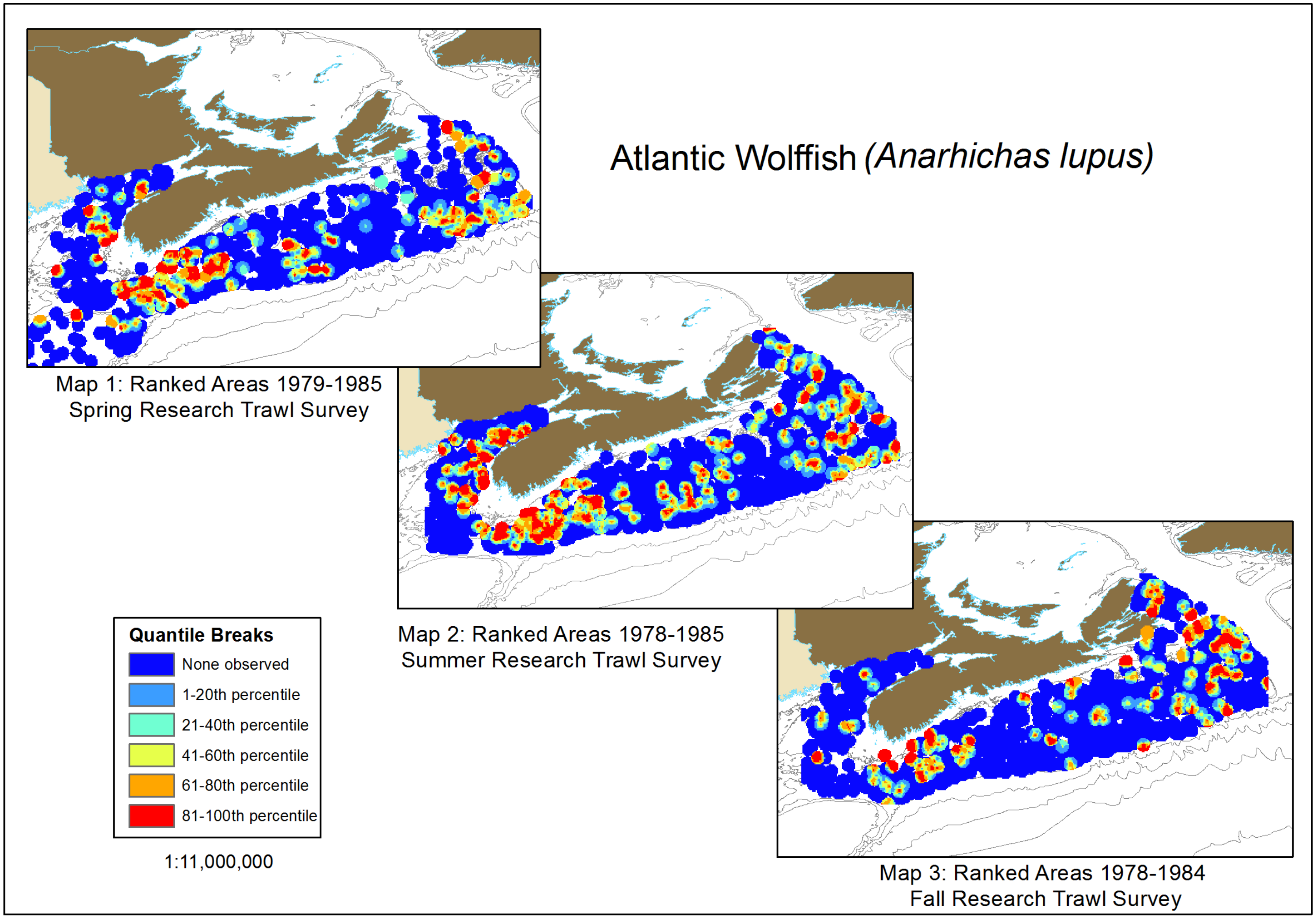

Figure 5. Maps showing distribution of Atlantic Wolffish from spring, summer and fall research trawl surveys (1978-1985).

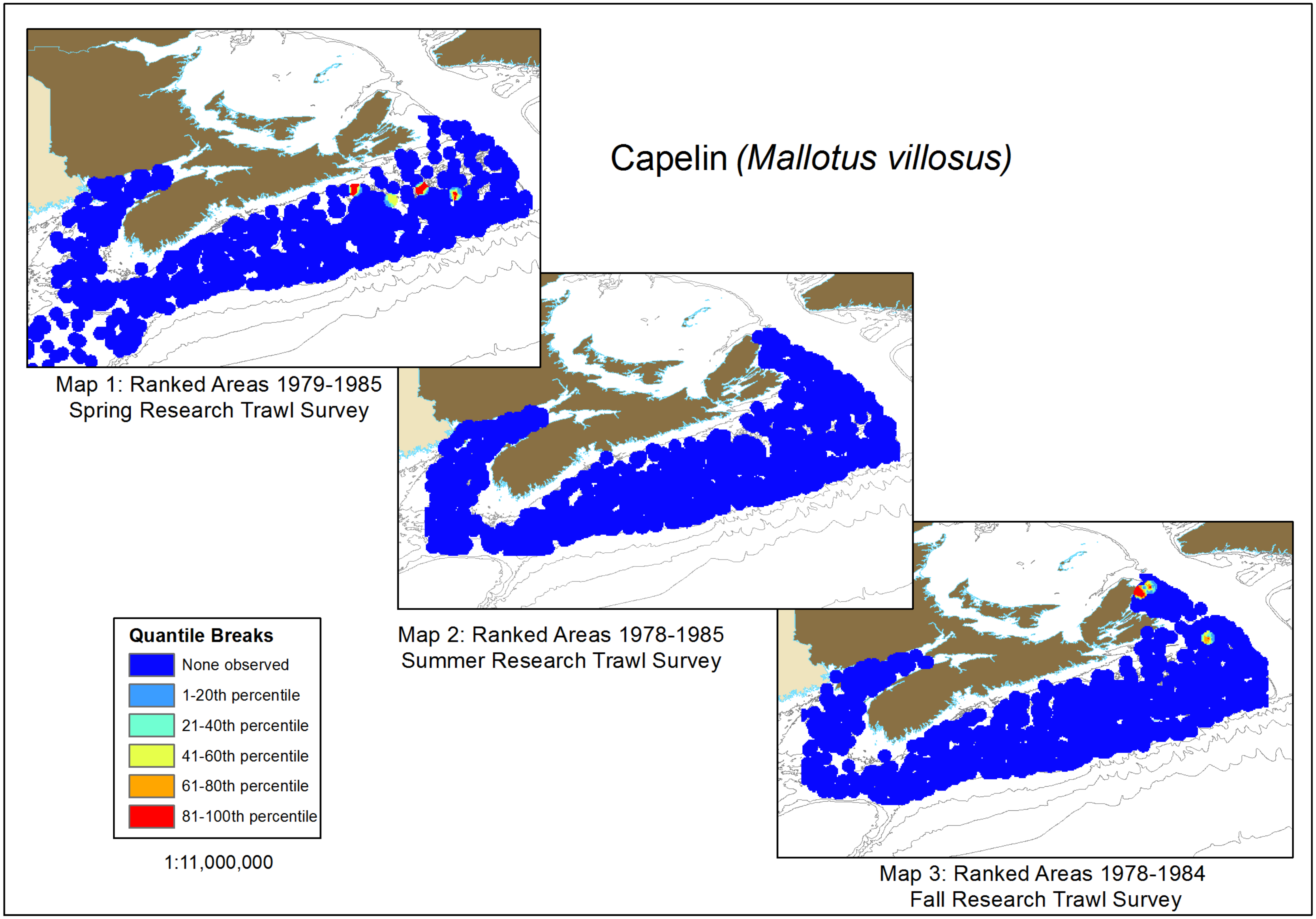

Figure 6. Maps showing distribution of Capelin from spring, summer and fall research trawl surveys (1978-1985).

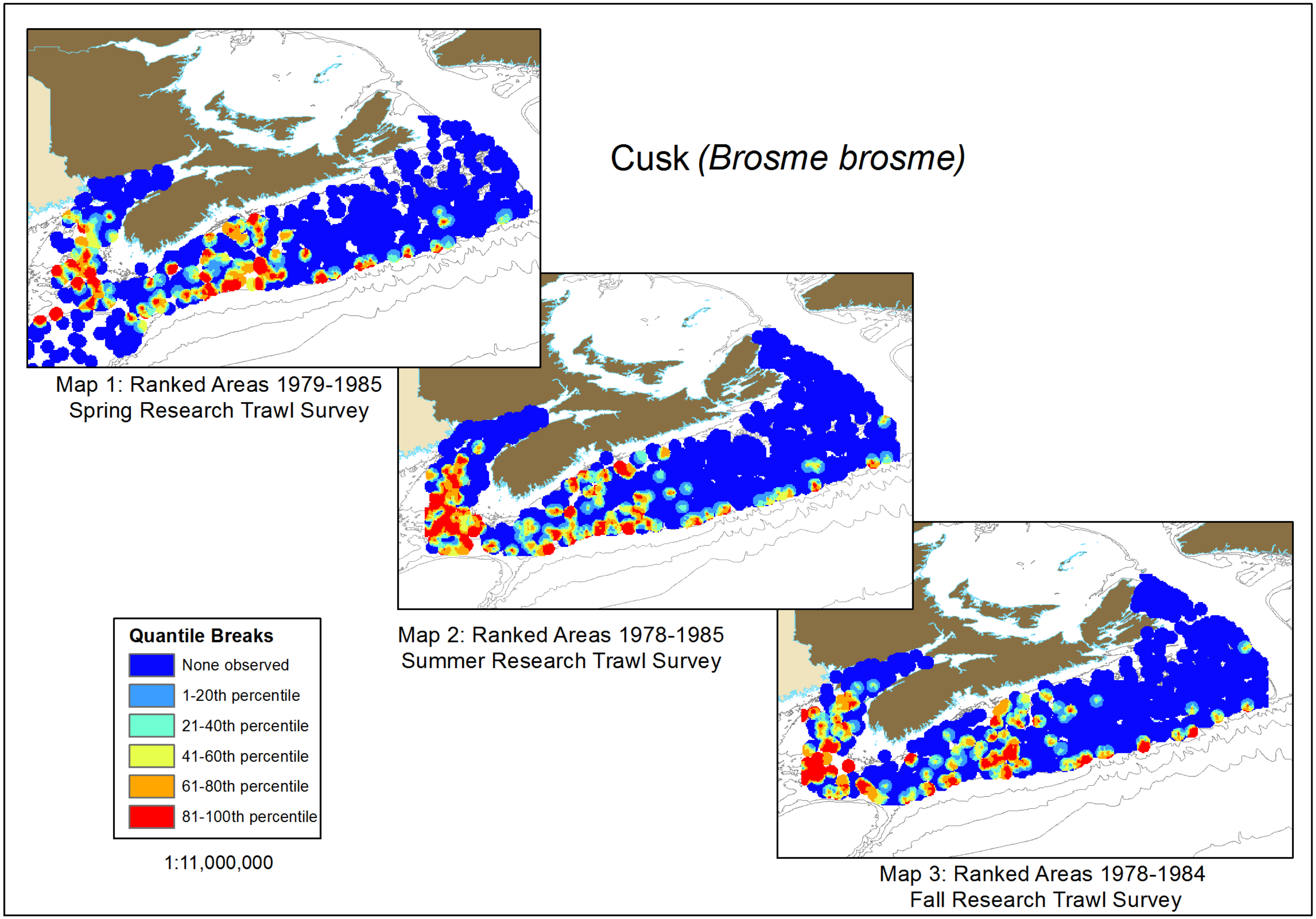

Figure 7. Maps showing distribution of Cusk from spring, summer and fall research trawl surveys (1978-1985).

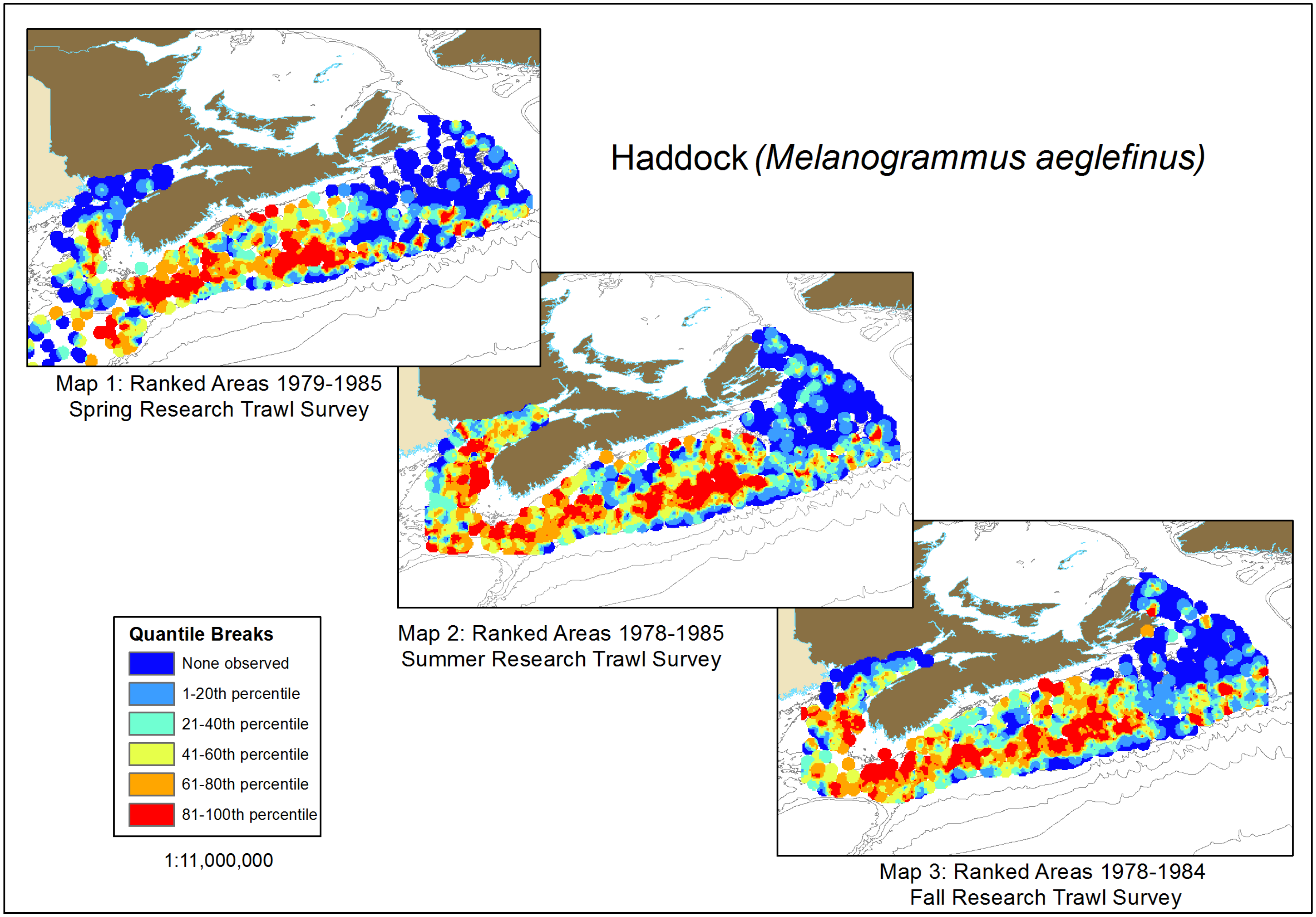

Figure 8. Maps showing distribution of Haddock from spring, summer and fall research trawl surveys (1978-1985).

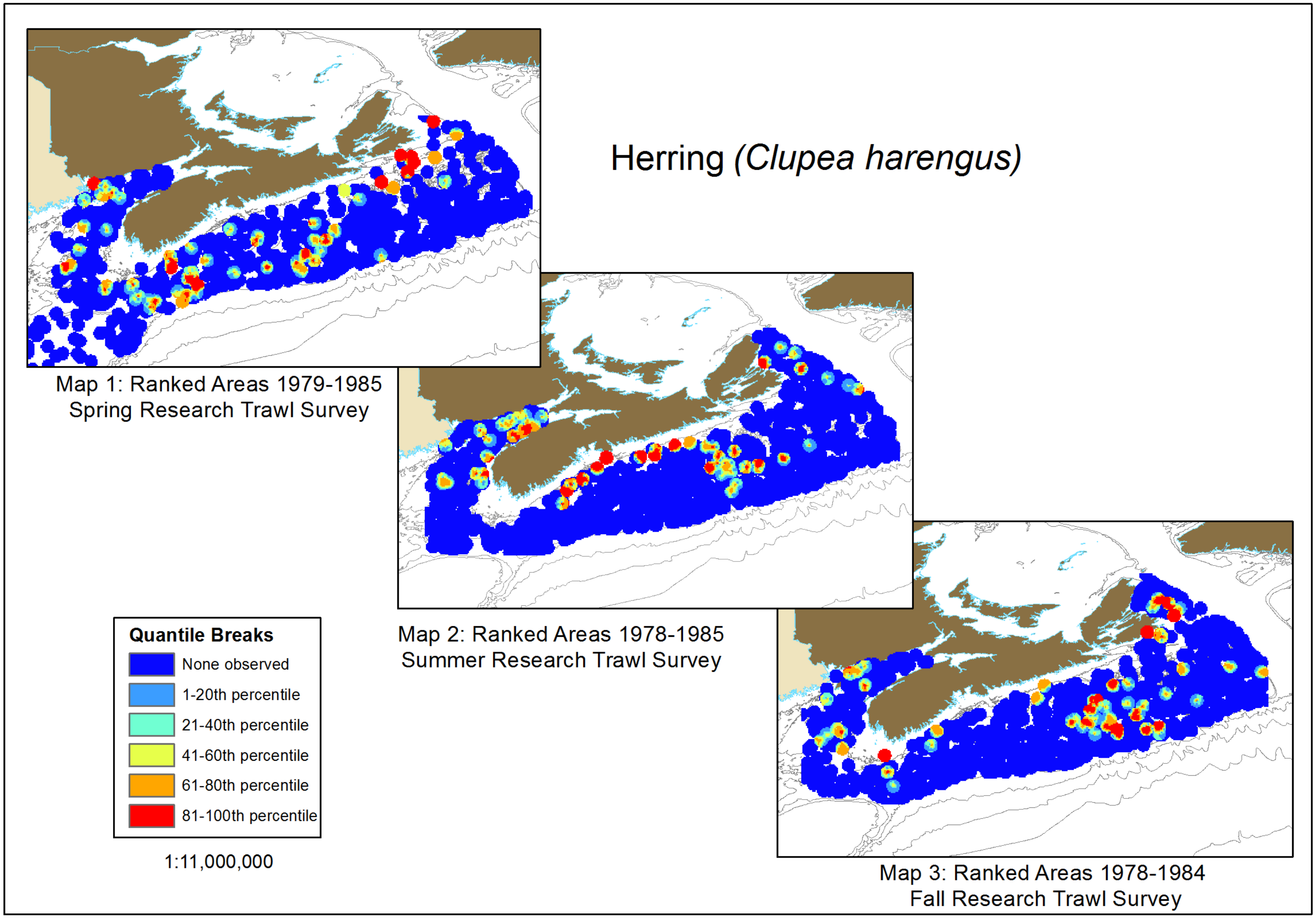

Figure 9. Maps showing distribution of Herring from spring, summer and fall research trawl surveys (1978-1985).

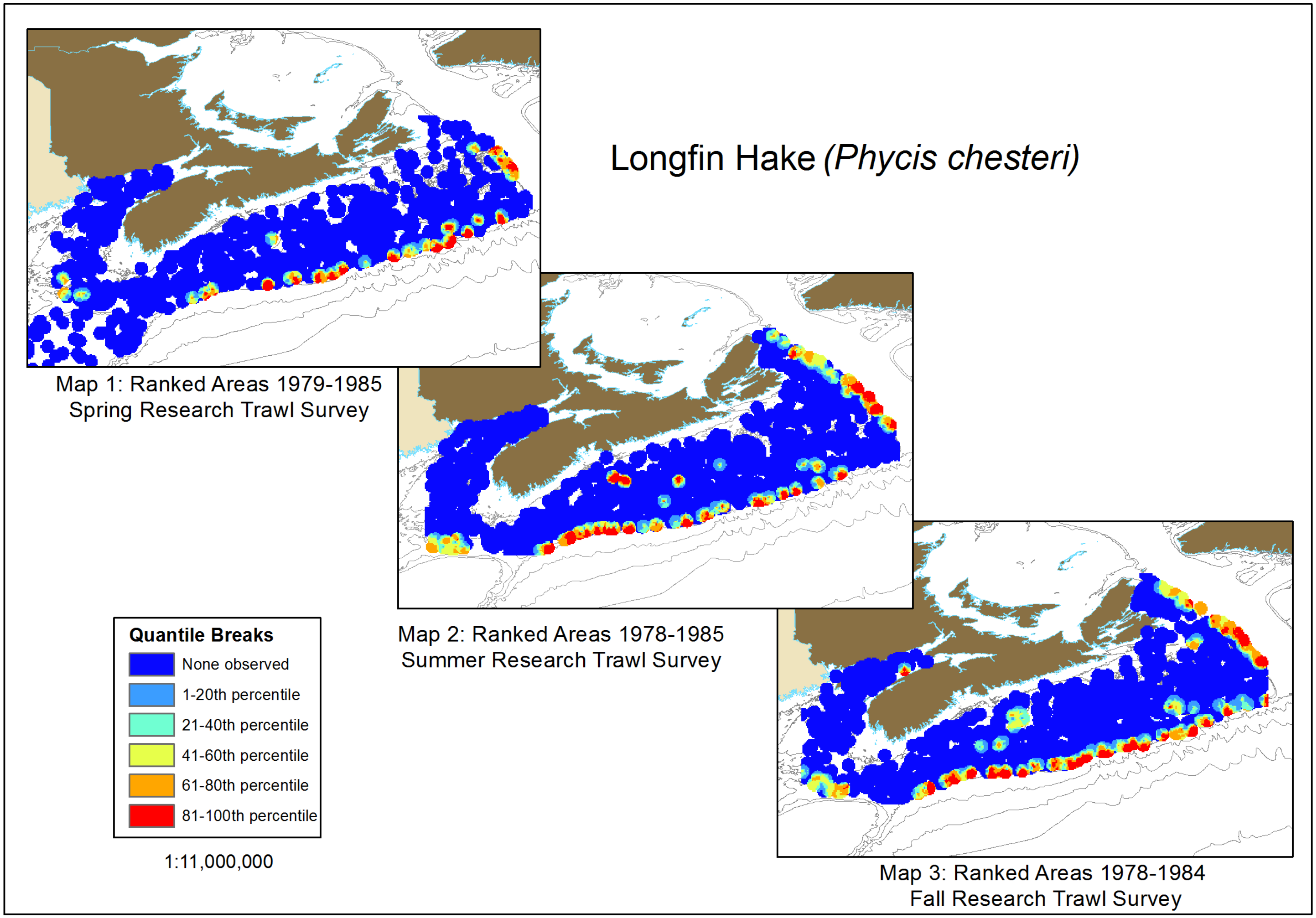

Figure 10. Maps showing distribution of Longfin Hake from spring, summer and fall research trawl surveys (1978-1985).

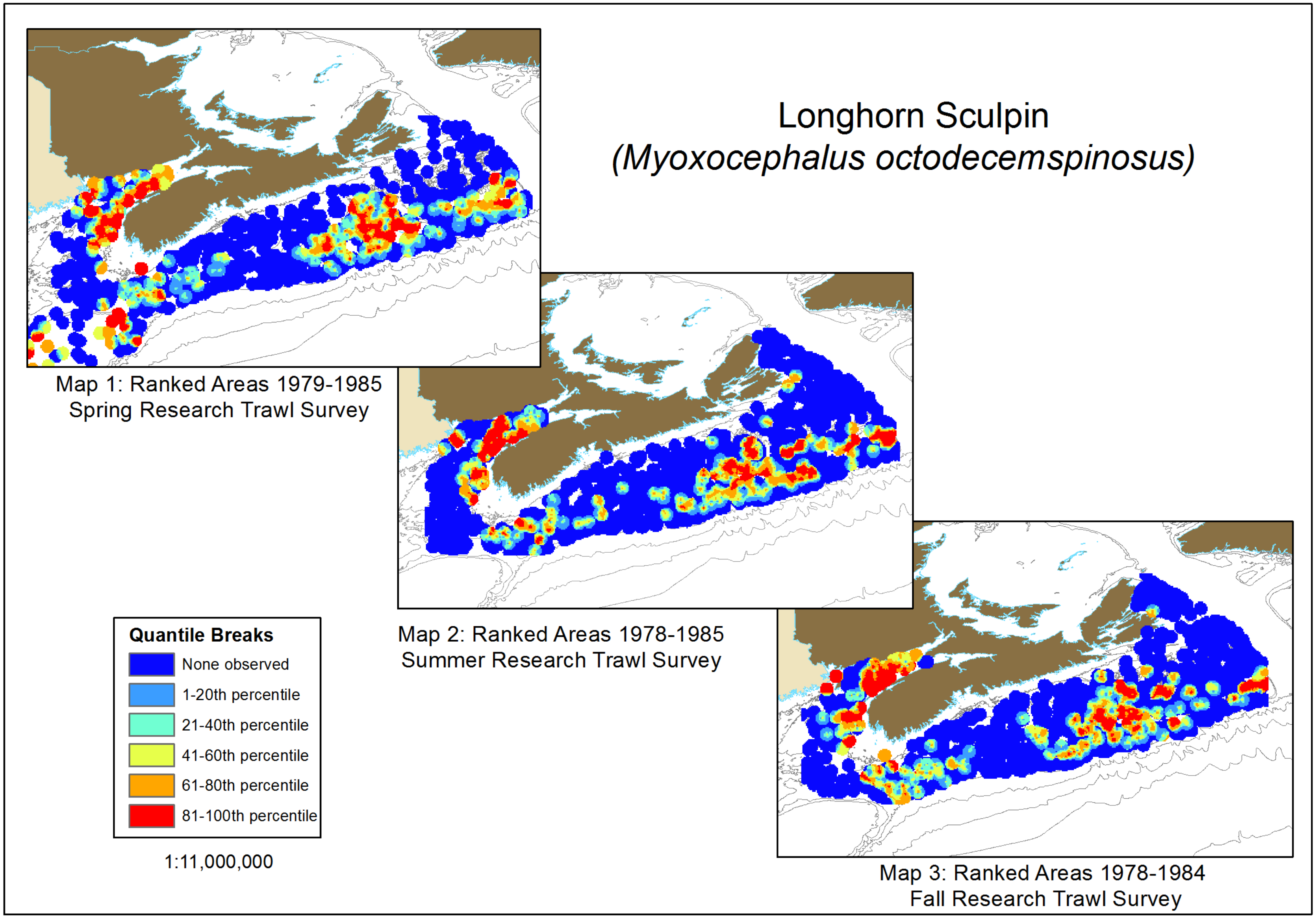

Figure 11. Maps showing distribution of Longhorn Sculpin from spring, summer and fall research trawl surveys (1978-1985).

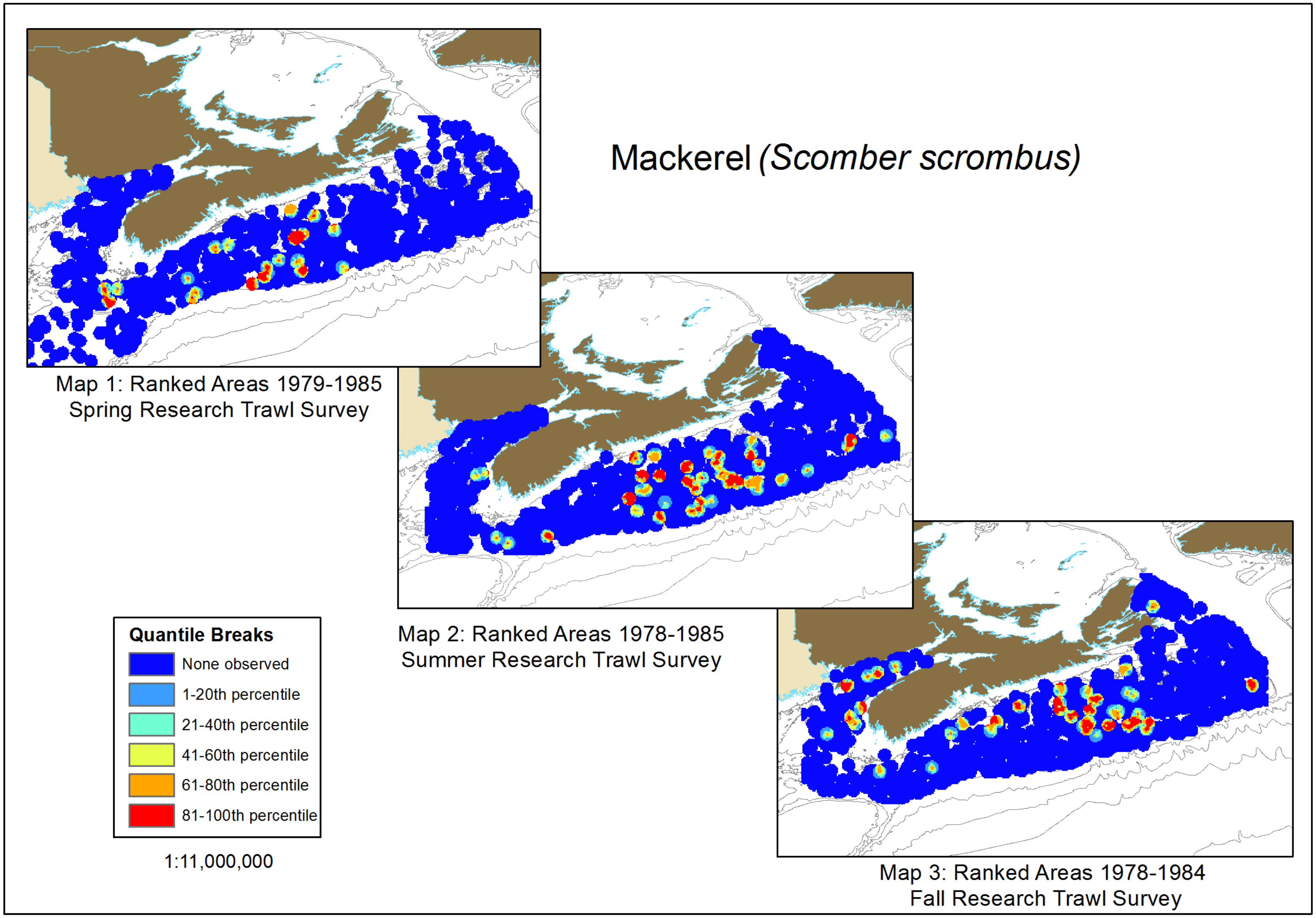

Figure 12. Maps showing distribution of Mackerel from spring, summer and fall research trawl surveys (1978-1985).

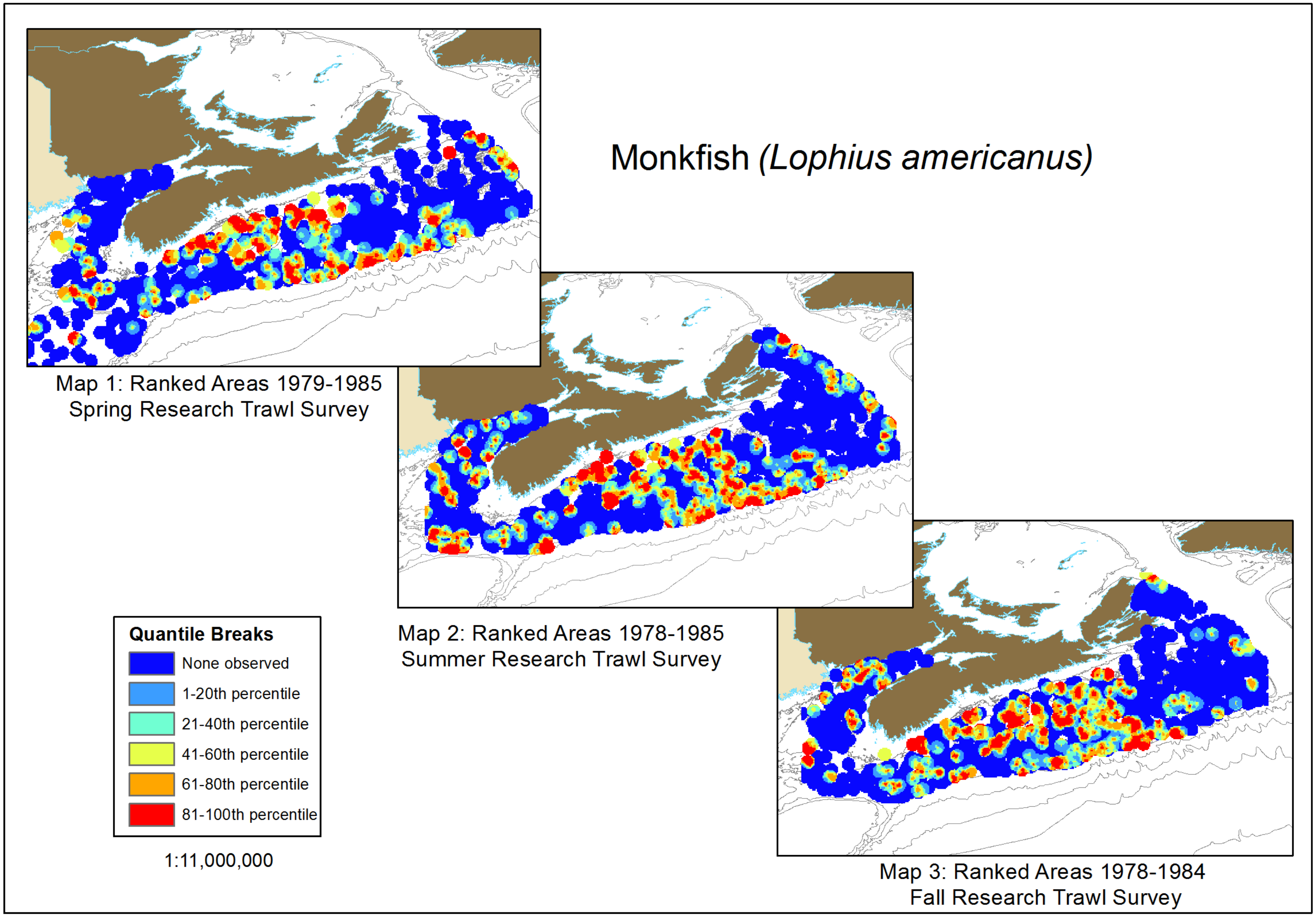

Figure 13. Maps showing distribution of Monkfish from spring, summer and fall research trawl surveys (1978-1985).

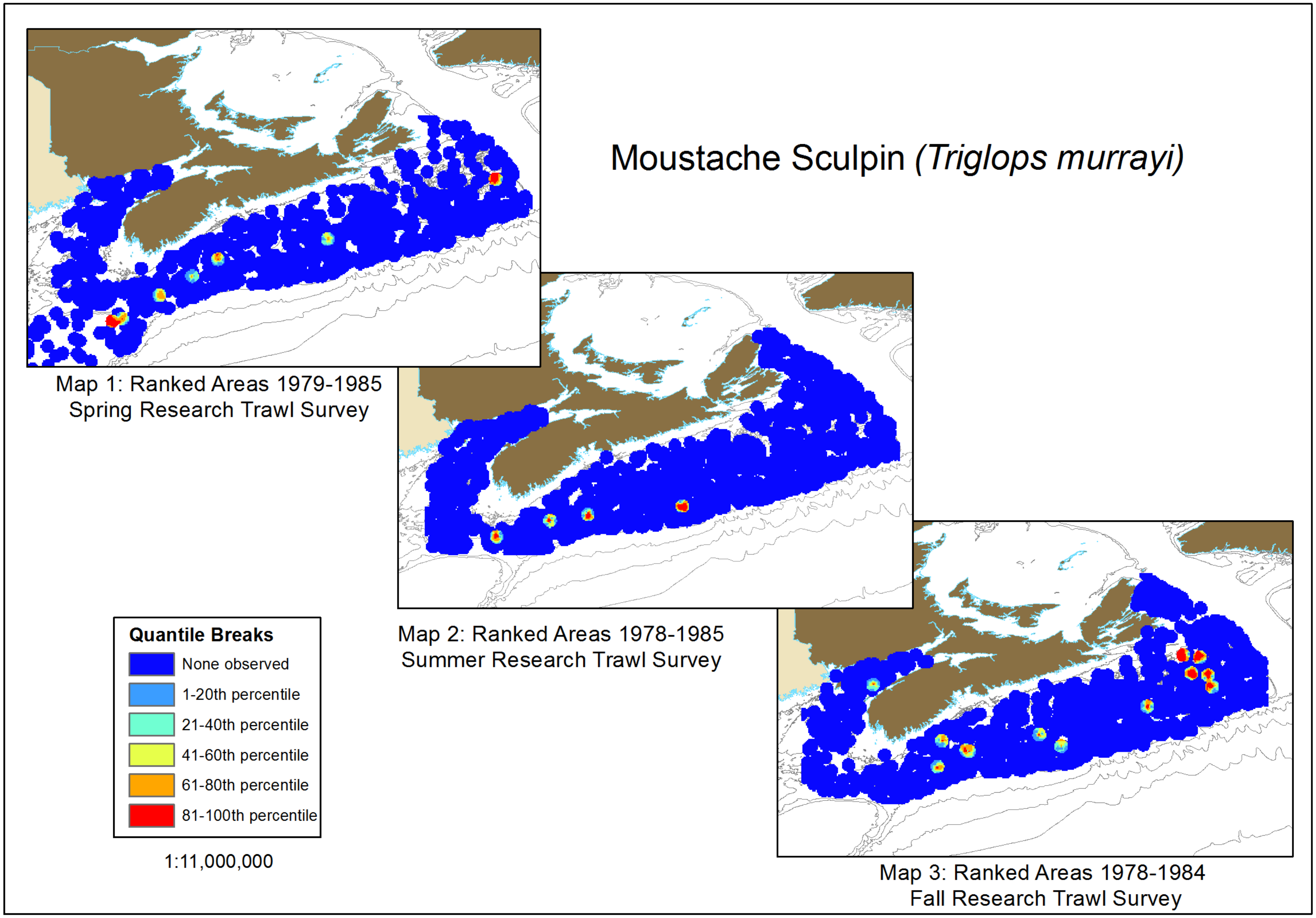

Figure 14. Maps showing distribution of Moustache Sculpin from spring, summer and fall research trawl surveys (1978-1985).

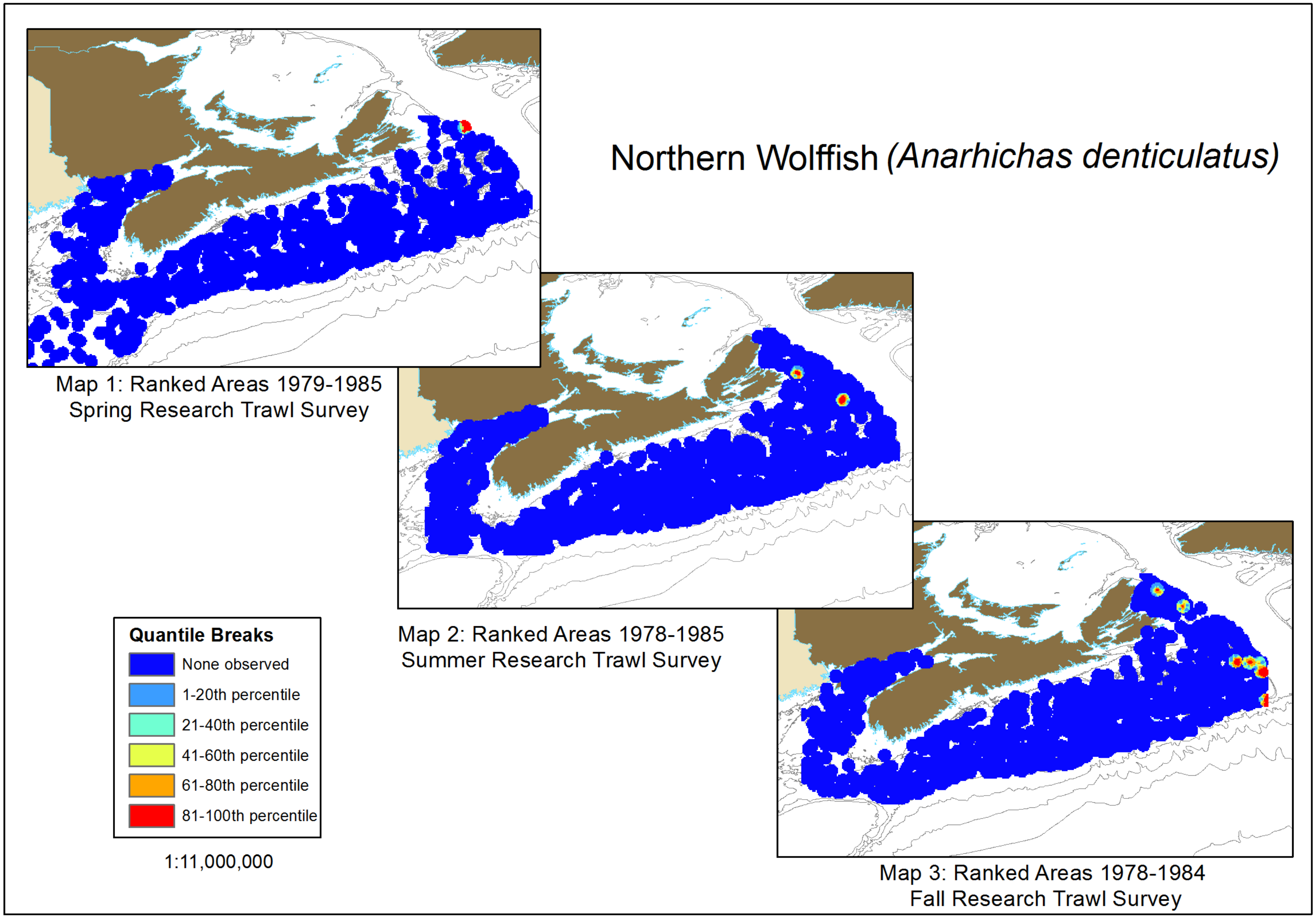

Figure 15. Maps showing distribution of Northern Wolffish from spring, summer and fall research trawl surveys (1978-1985).

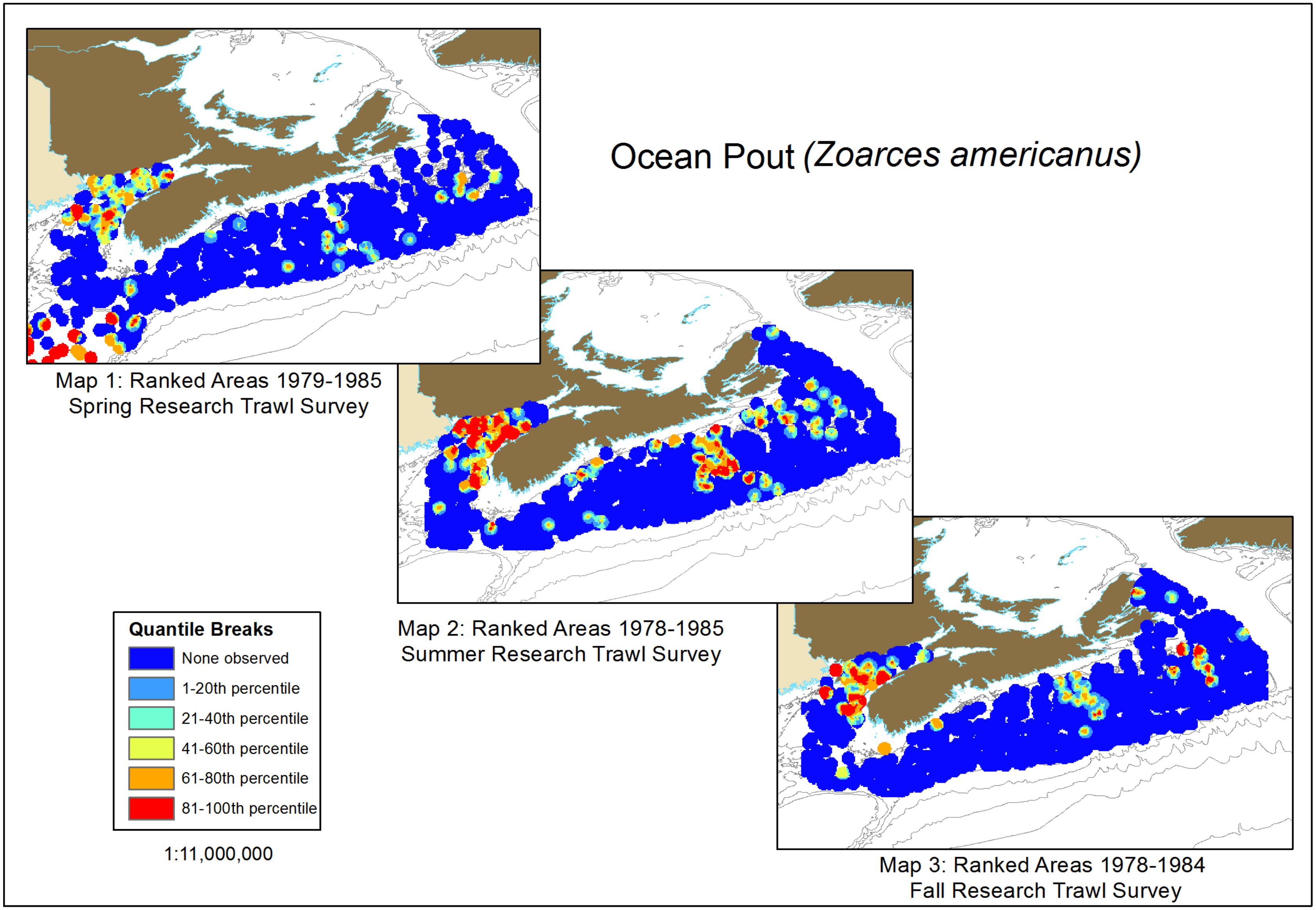

Figure 16. Maps showing distribution of Ocean Pout from spring, summer and fall research trawl surveys (1978-1985).

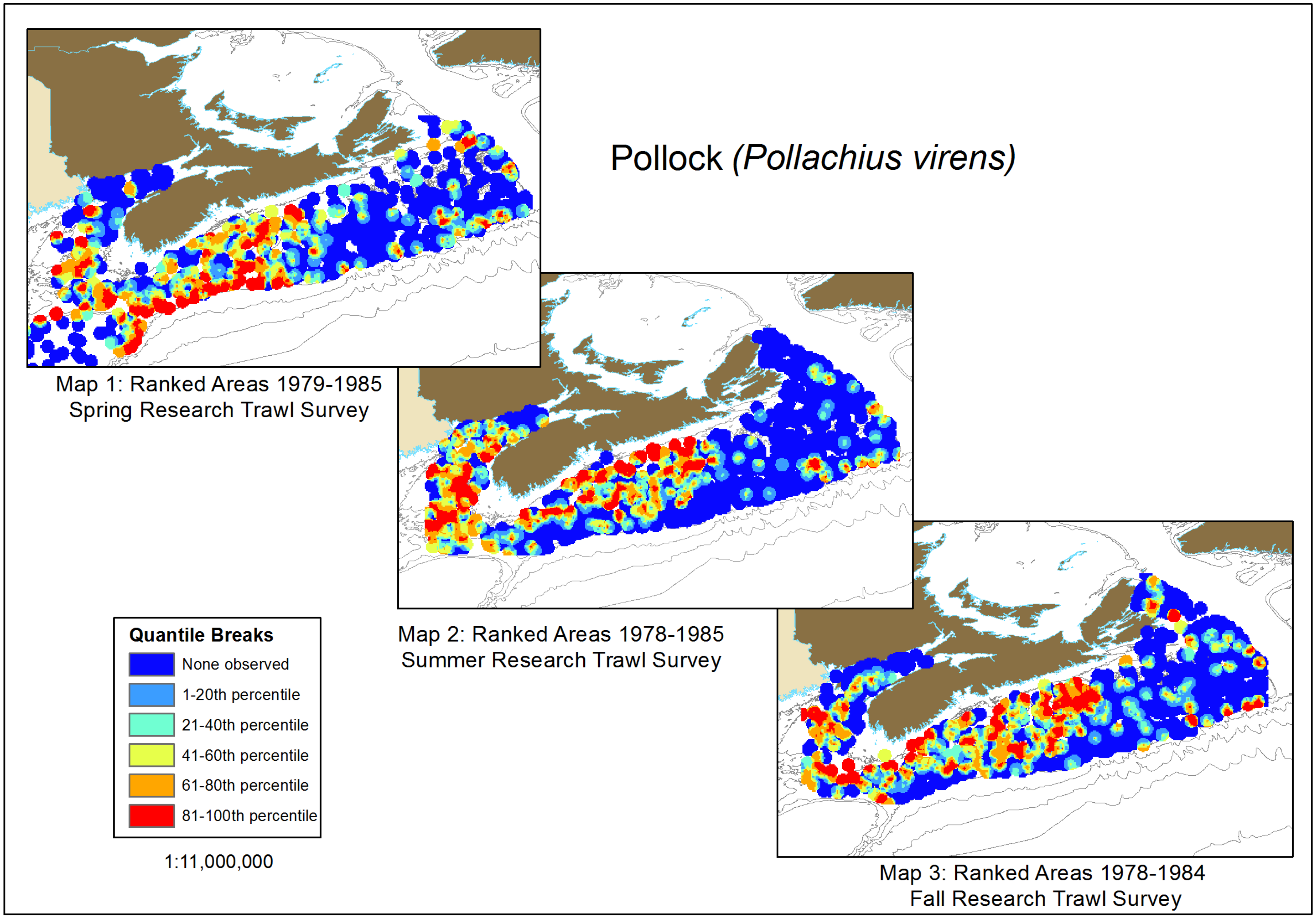

Figure 17. Maps showing distribution of Pollock from spring, summer and fall research trawl surveys (1978-1985).

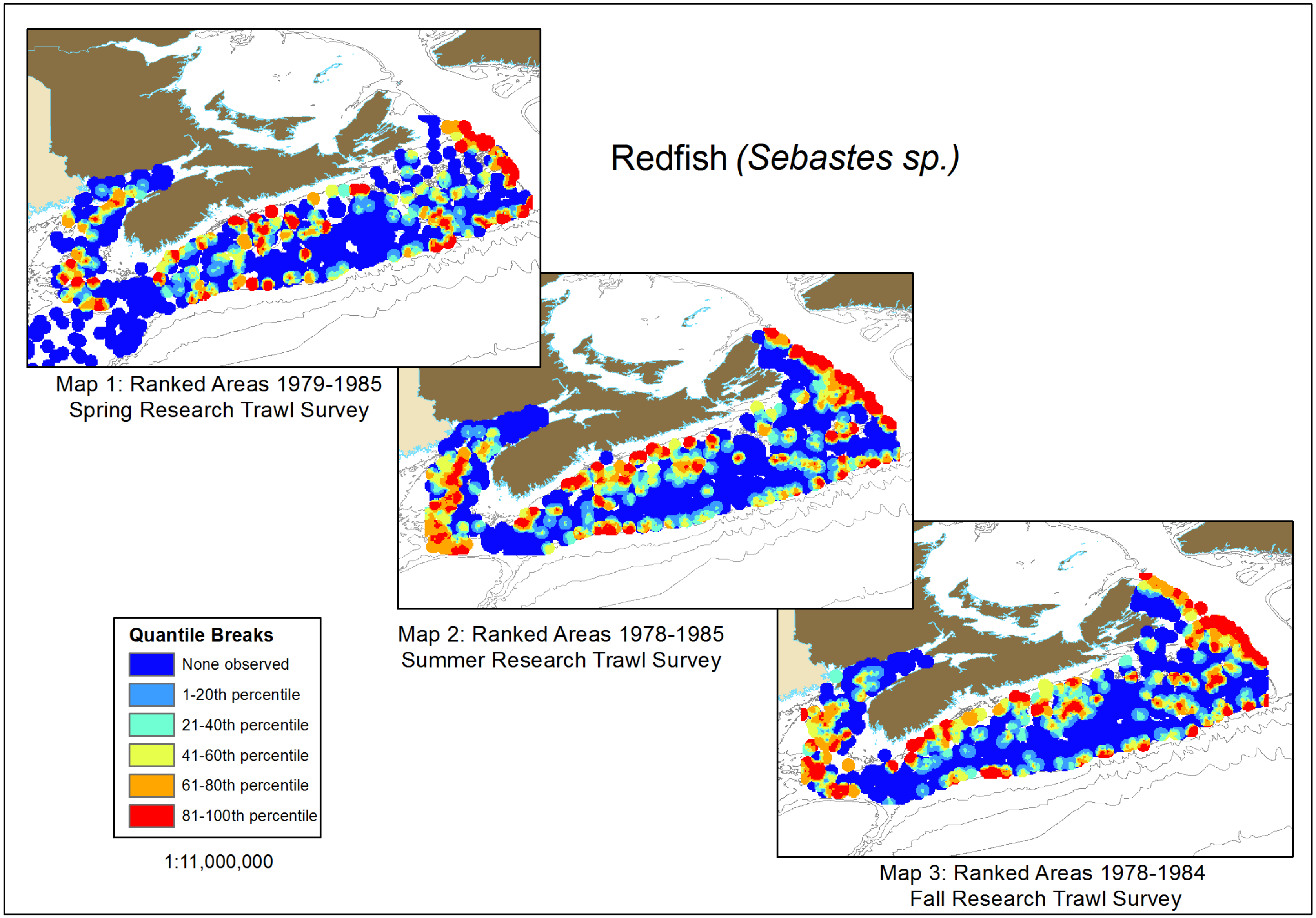

Figure 18. Maps showing distribution of Redfish from spring, summer and fall research trawl surveys (1978-1985).

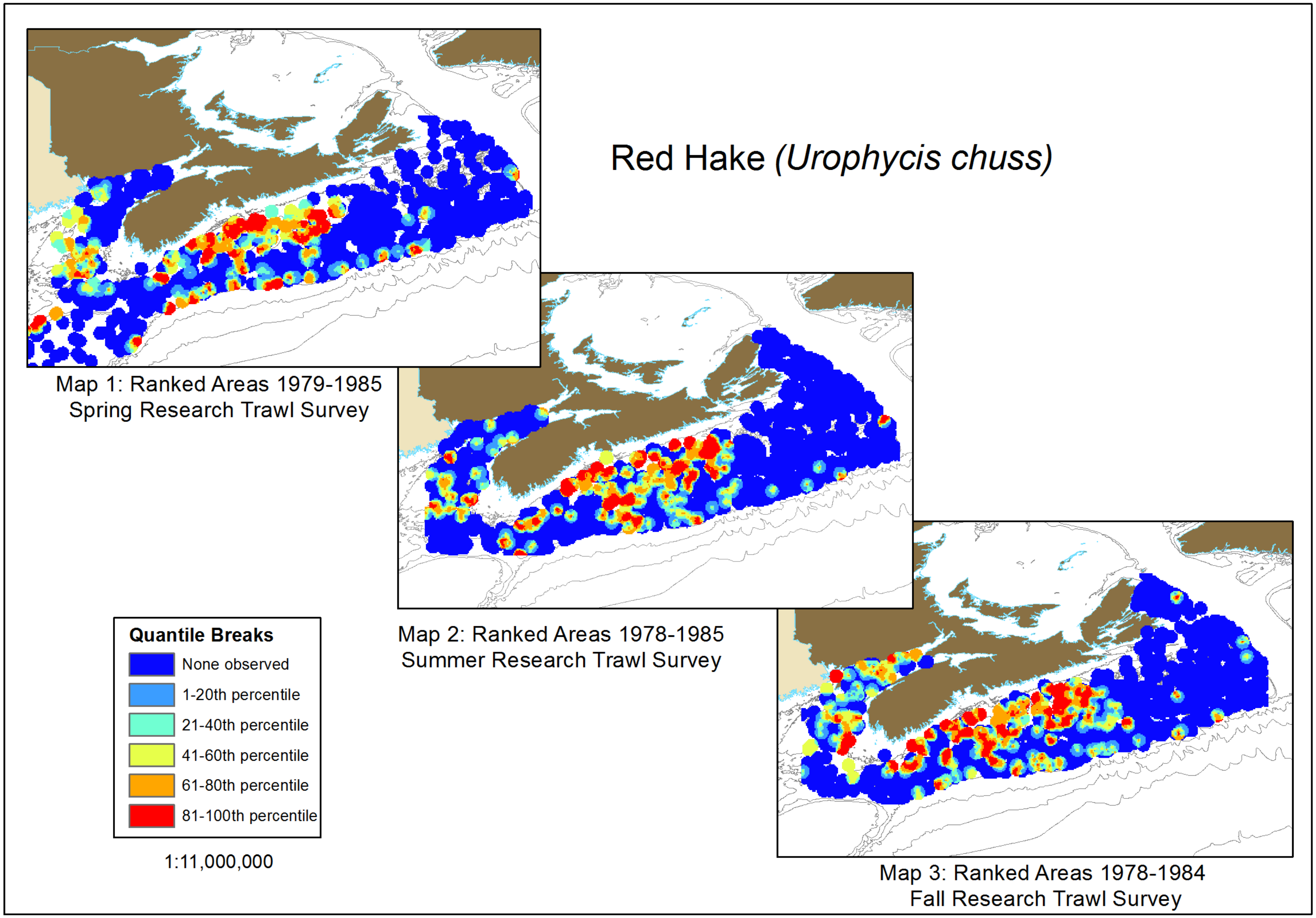

Figure 19. Maps showing distribution of Red Hake from spring, summer and fall research trawl surveys (1978-1985).

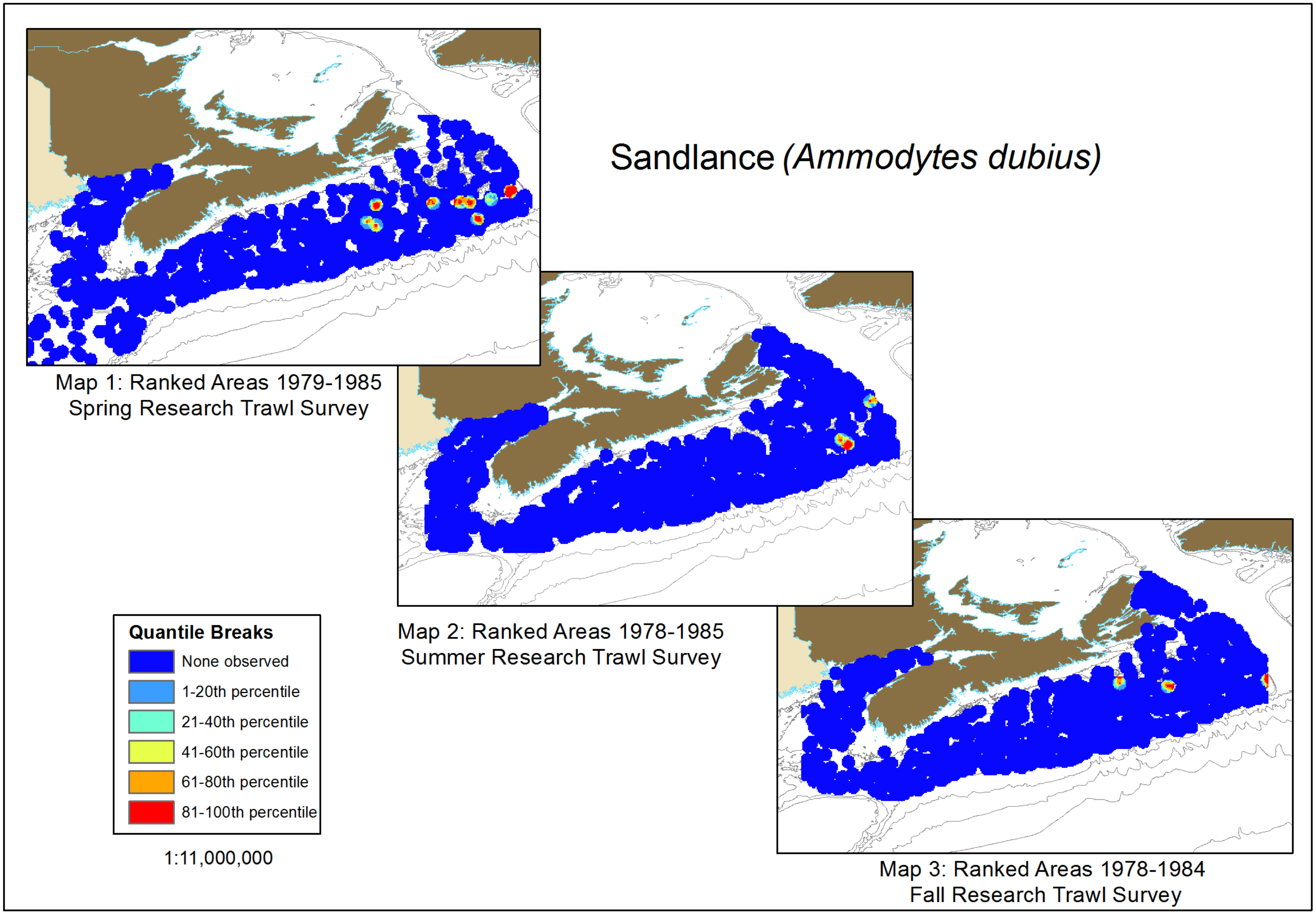

Figure 20. Maps showing distribution of Sandlance from spring, summer and fall research trawl surveys (1978-1985).

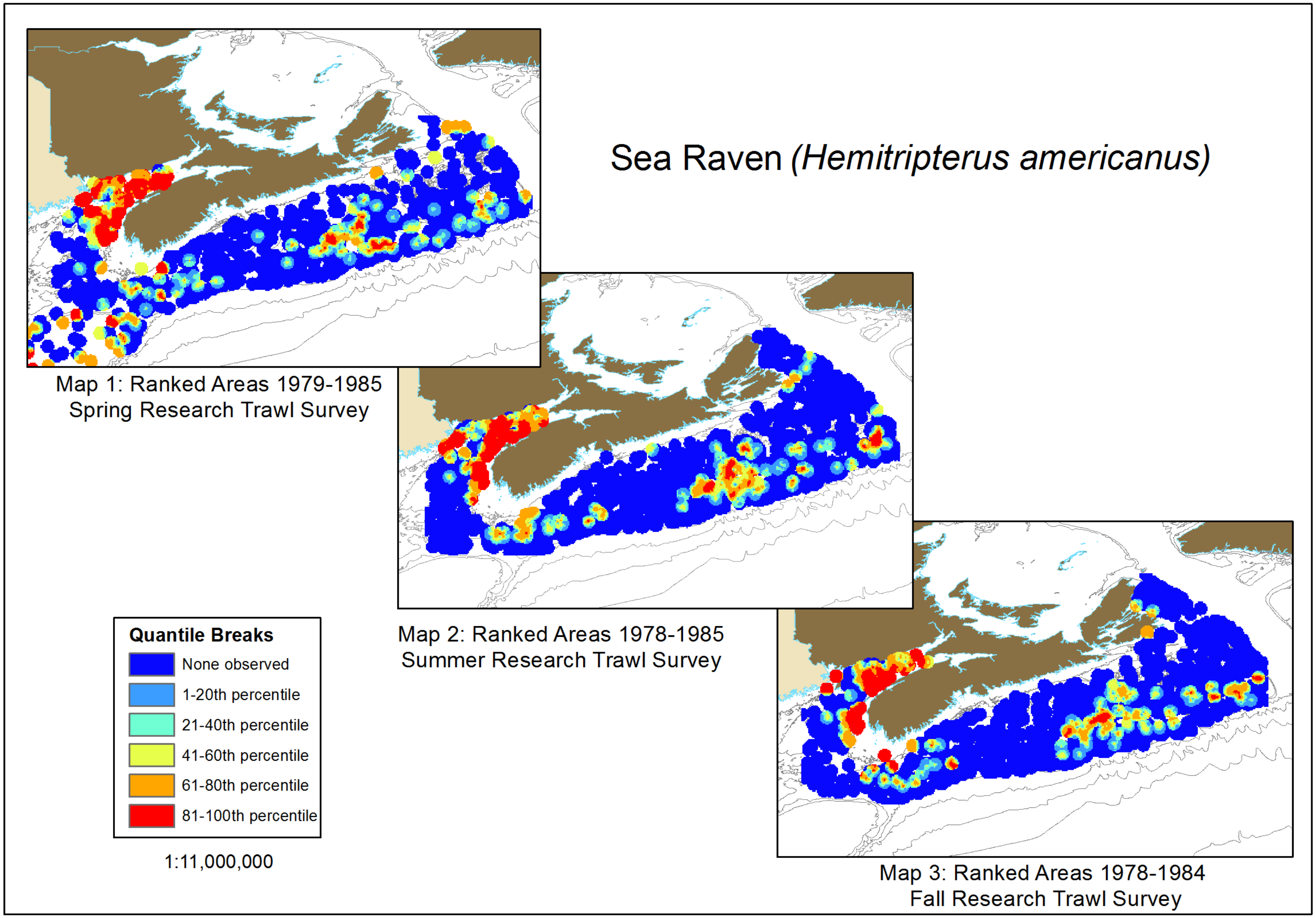

Figure 21. Maps showing distribution of Sea Raven from spring, summer and fall research trawl surveys (1978-1985).

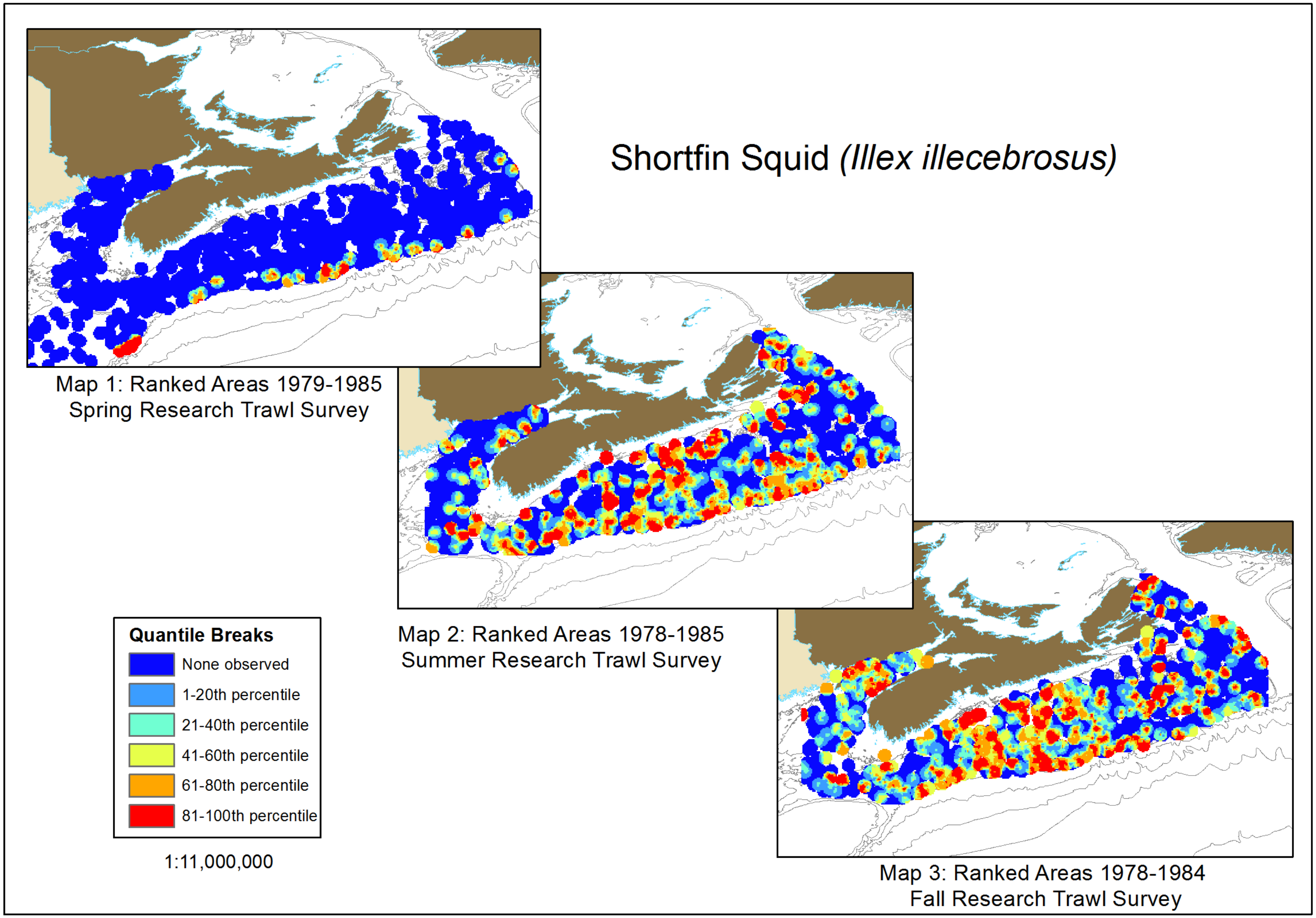

Figure 22. Maps showing distribution of Shortfin Squid from spring, summer and fall research trawl surveys (1978-1985).

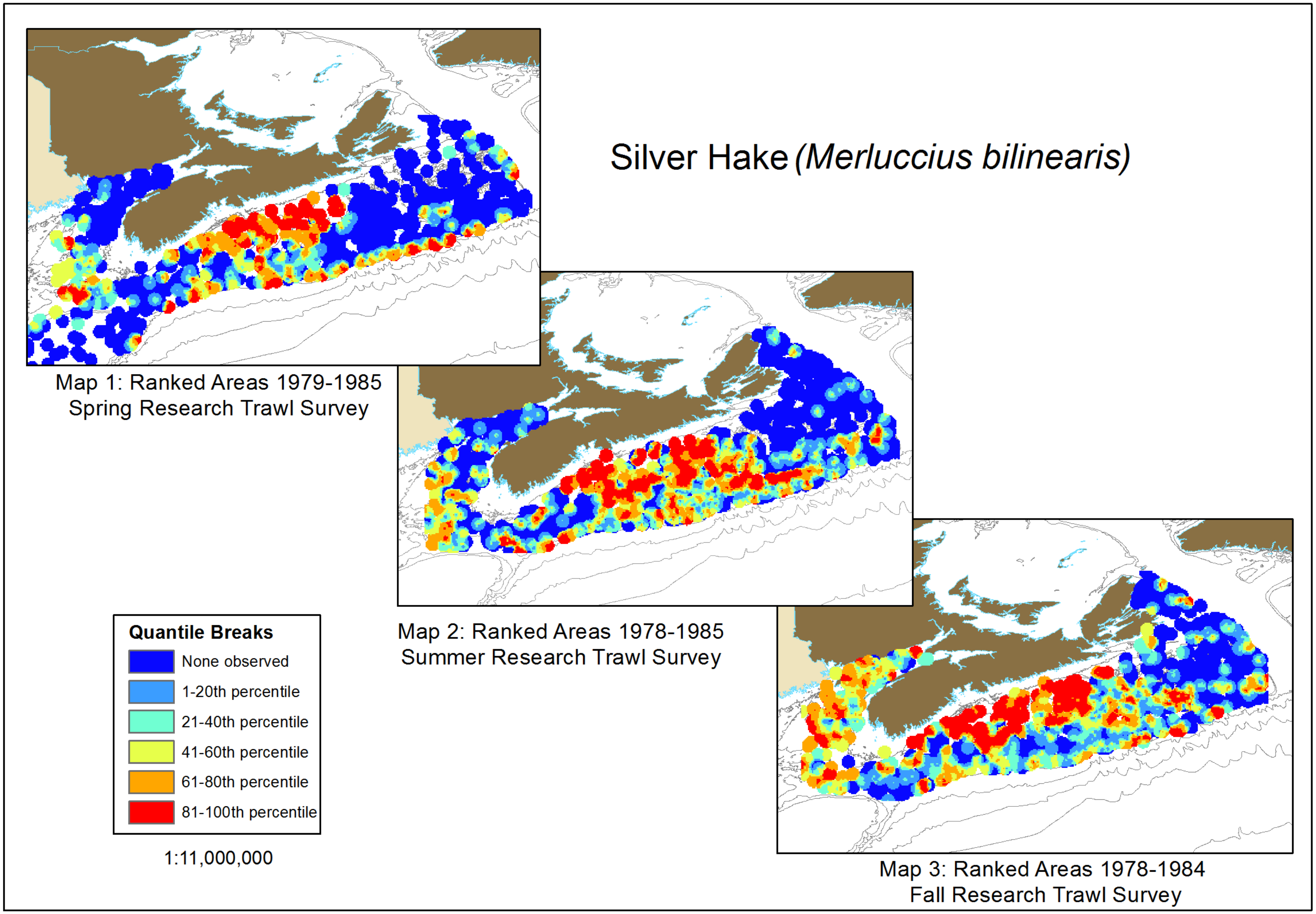

Figure 23. Maps showing distribution of Silver Hake from spring, summer and fall research trawl surveys (1978-1985).

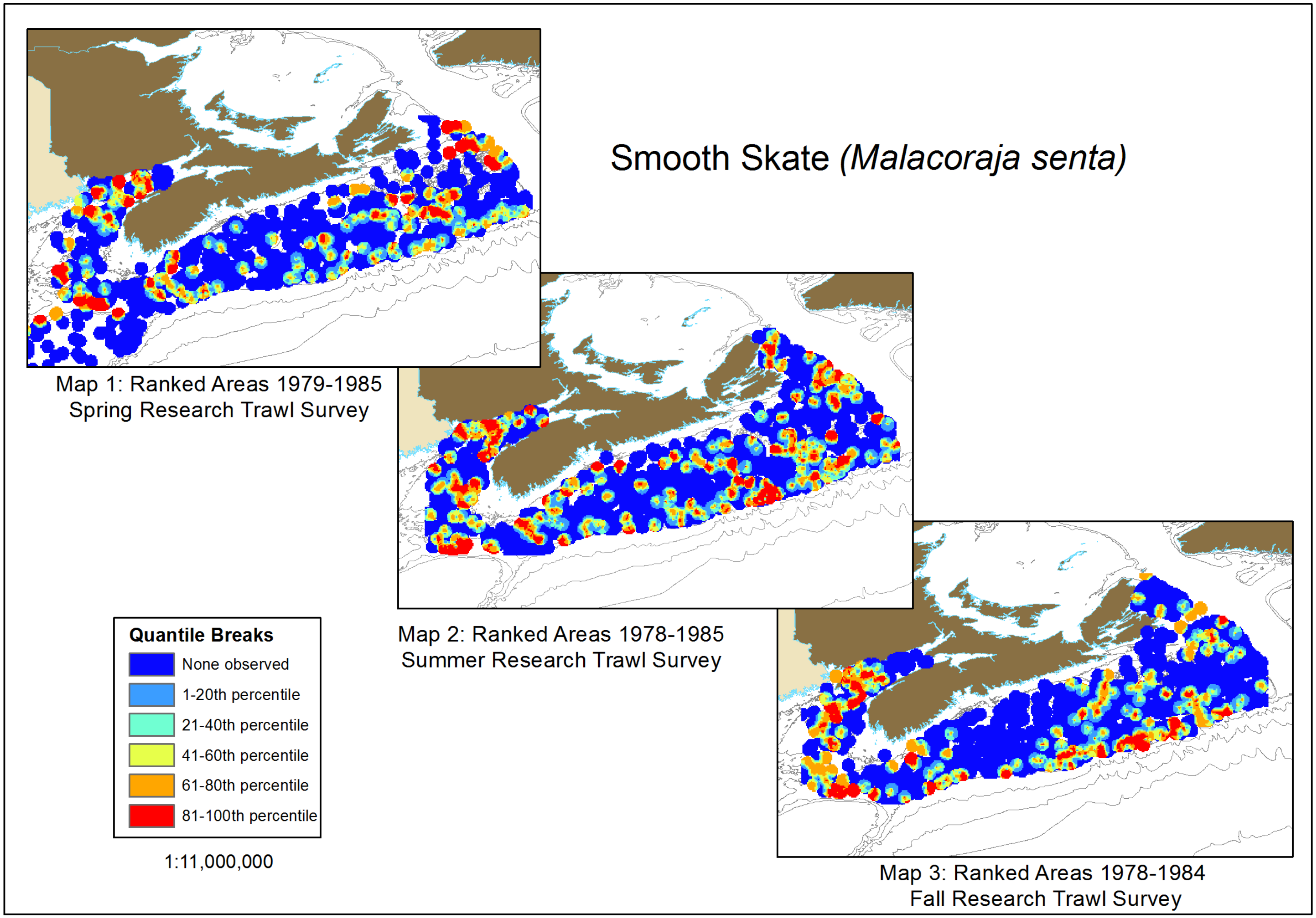

Figure 24. Maps showing distribution of Smooth Skate from spring, summer and fall research trawl surveys (1978-1985).

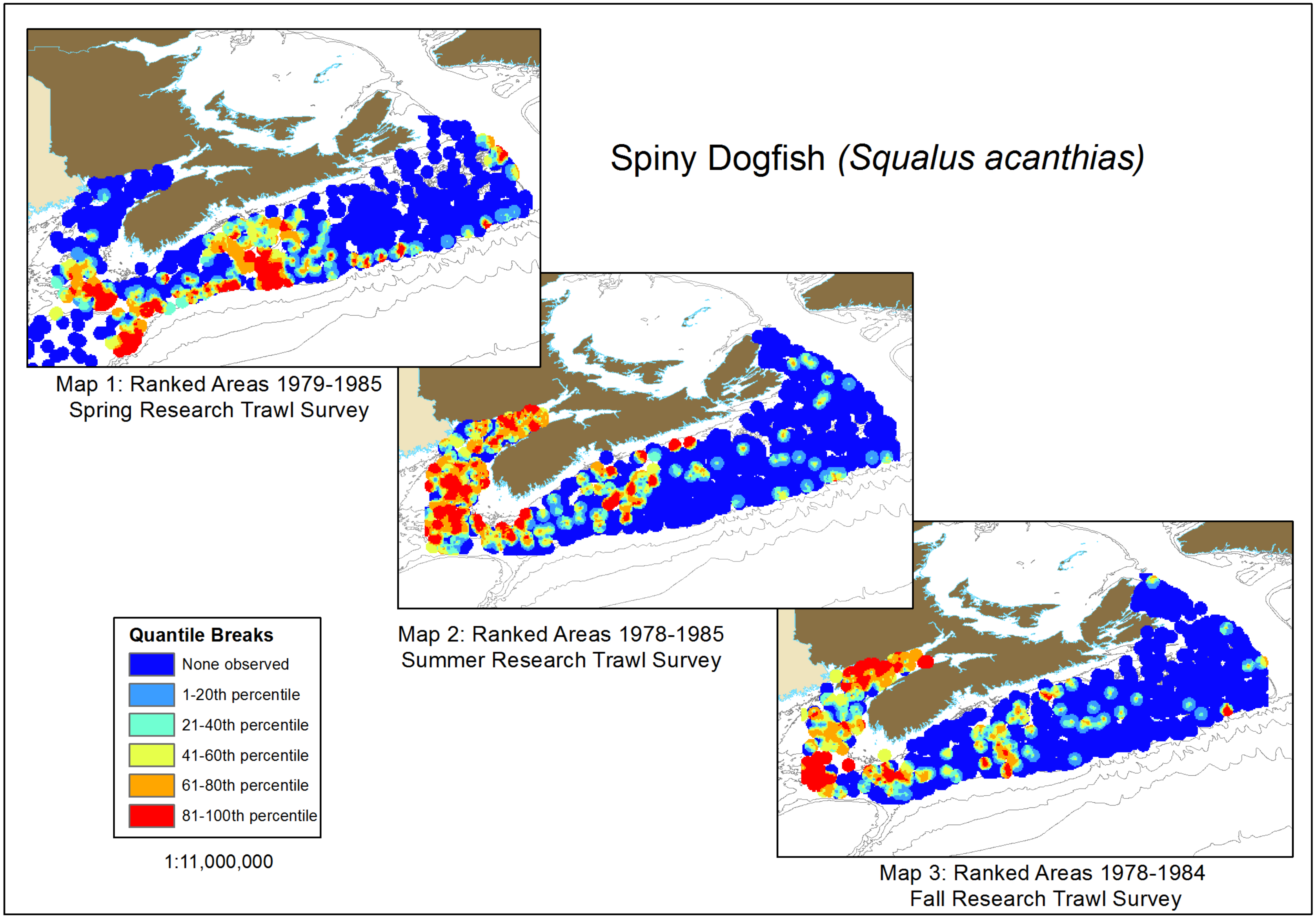

Figure 25. Maps showing distribution of Spiny Dogfish from spring, summer and fall research trawl surveys (1978-1985).

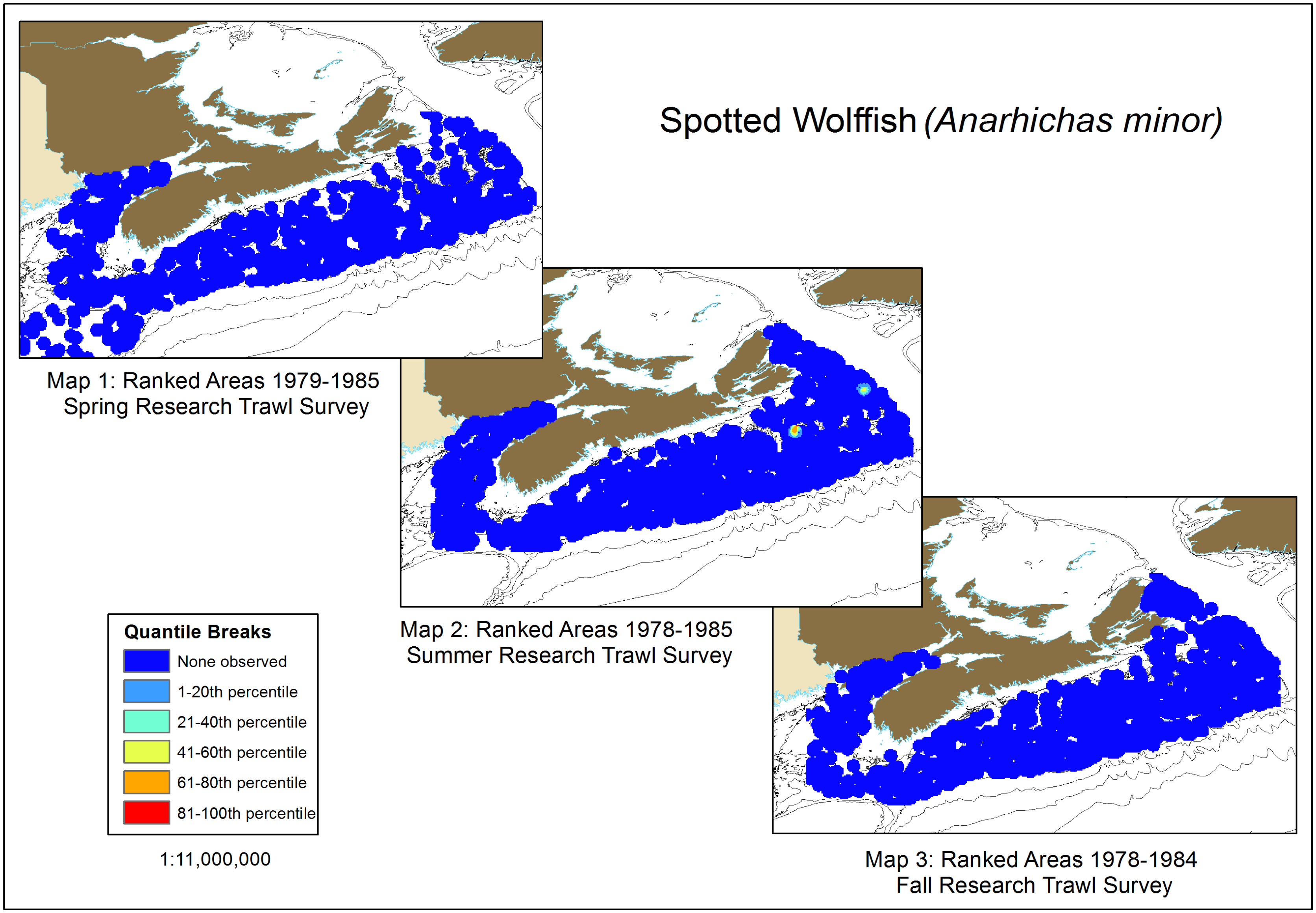

Figure 26. Maps showing distribution of Spotted Wolffish from spring, summer and fall research trawl surveys (1978-1985).

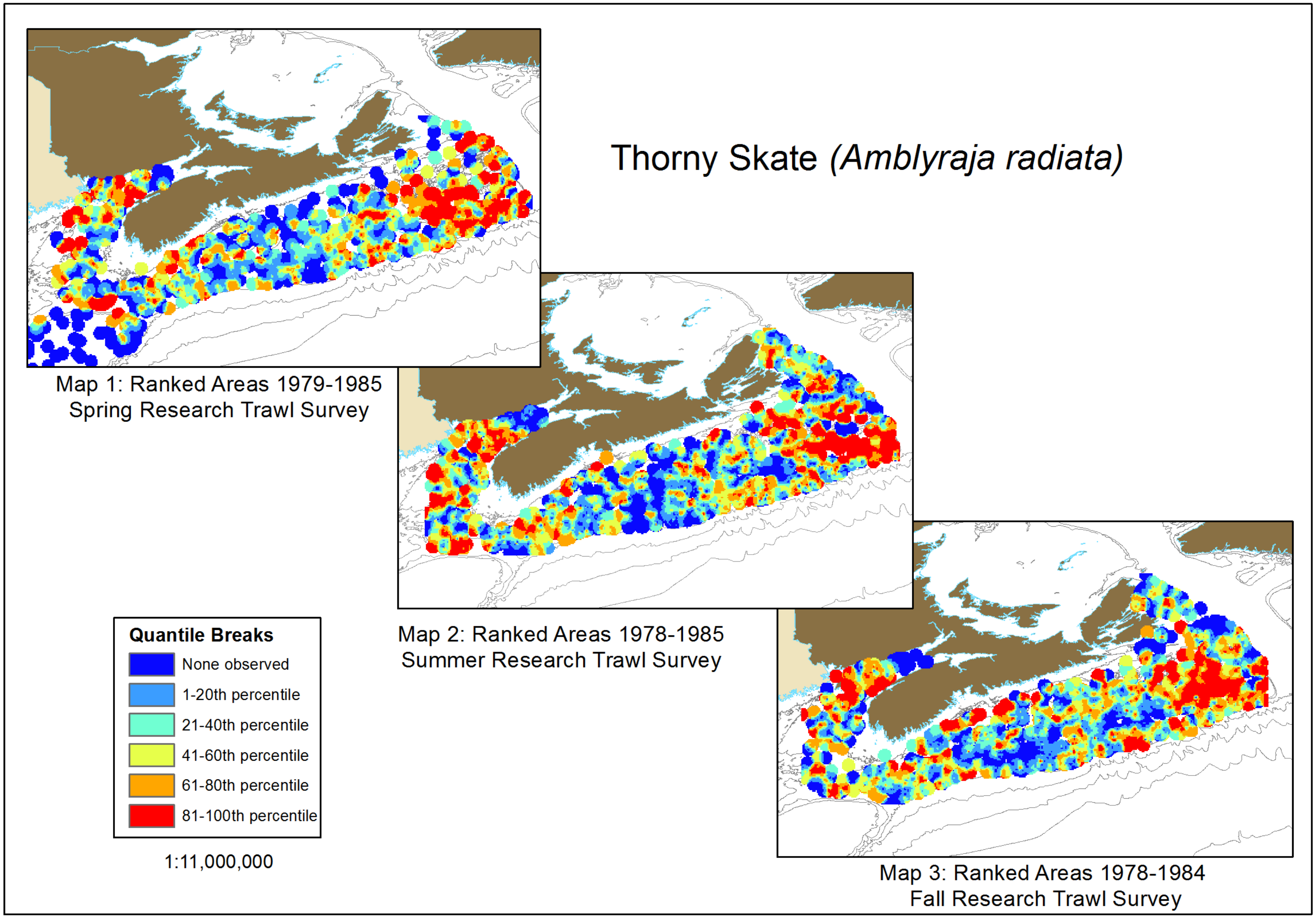

Figure 27. Maps showing distribution of Thorny Skate from spring, summer and fall research trawl surveys (1978-1985).

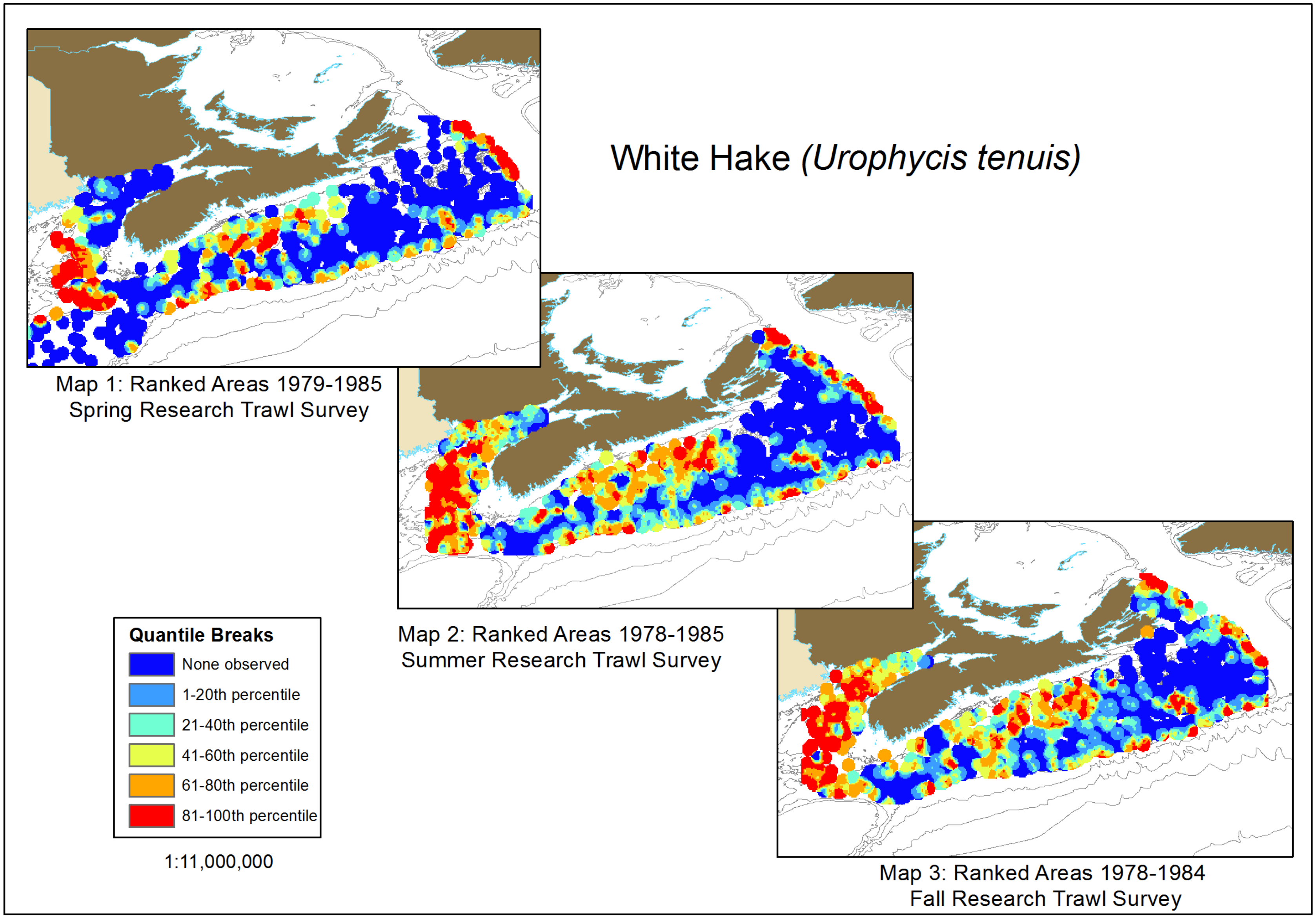

Figure 28. Maps showing distribution of White Hake from spring, summer and fall research trawl surveys (1978-1985).

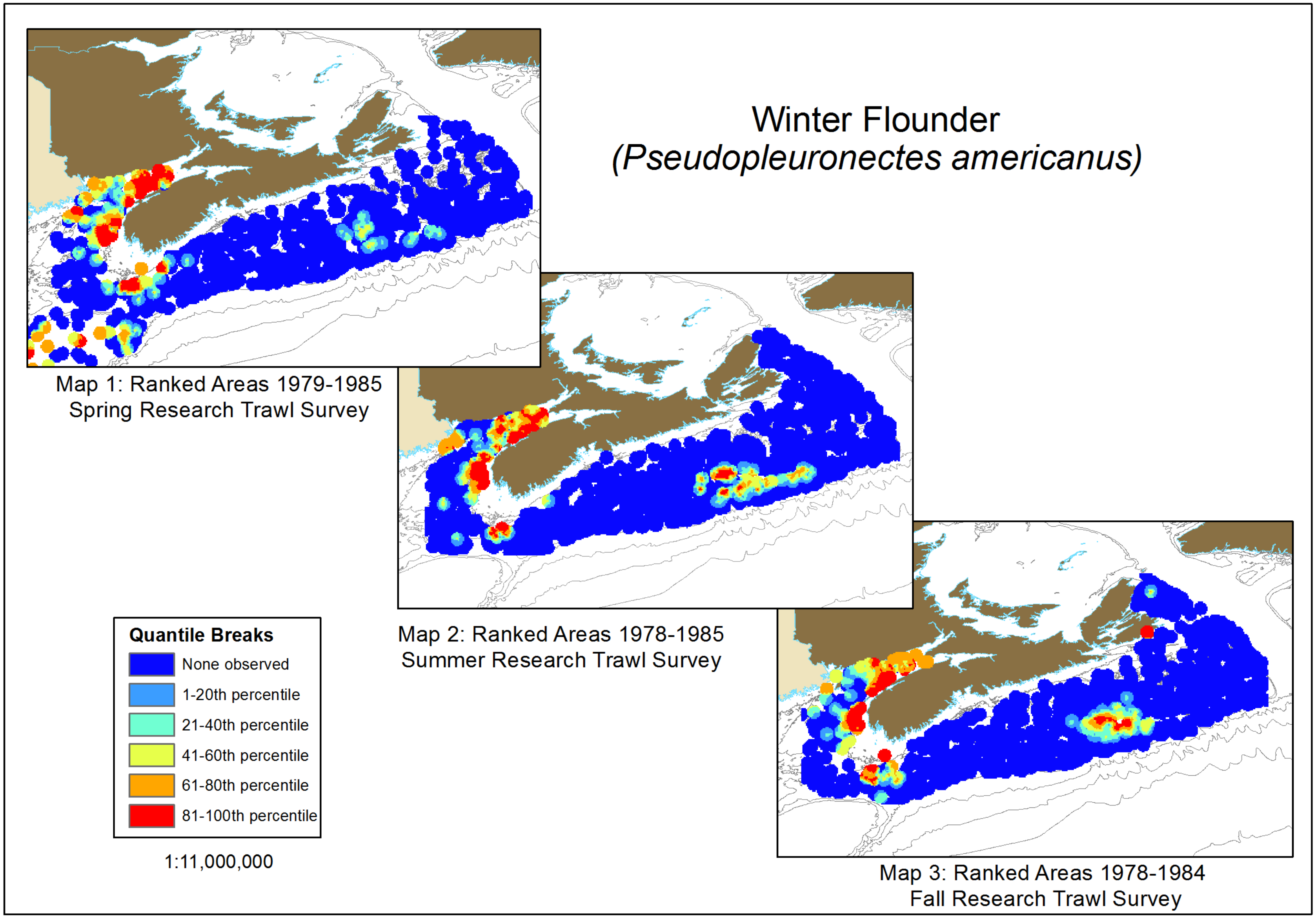

Figure 29. Maps showing distribution of Winter Flounder from spring, summer and fall research trawl surveys (1978-1985).

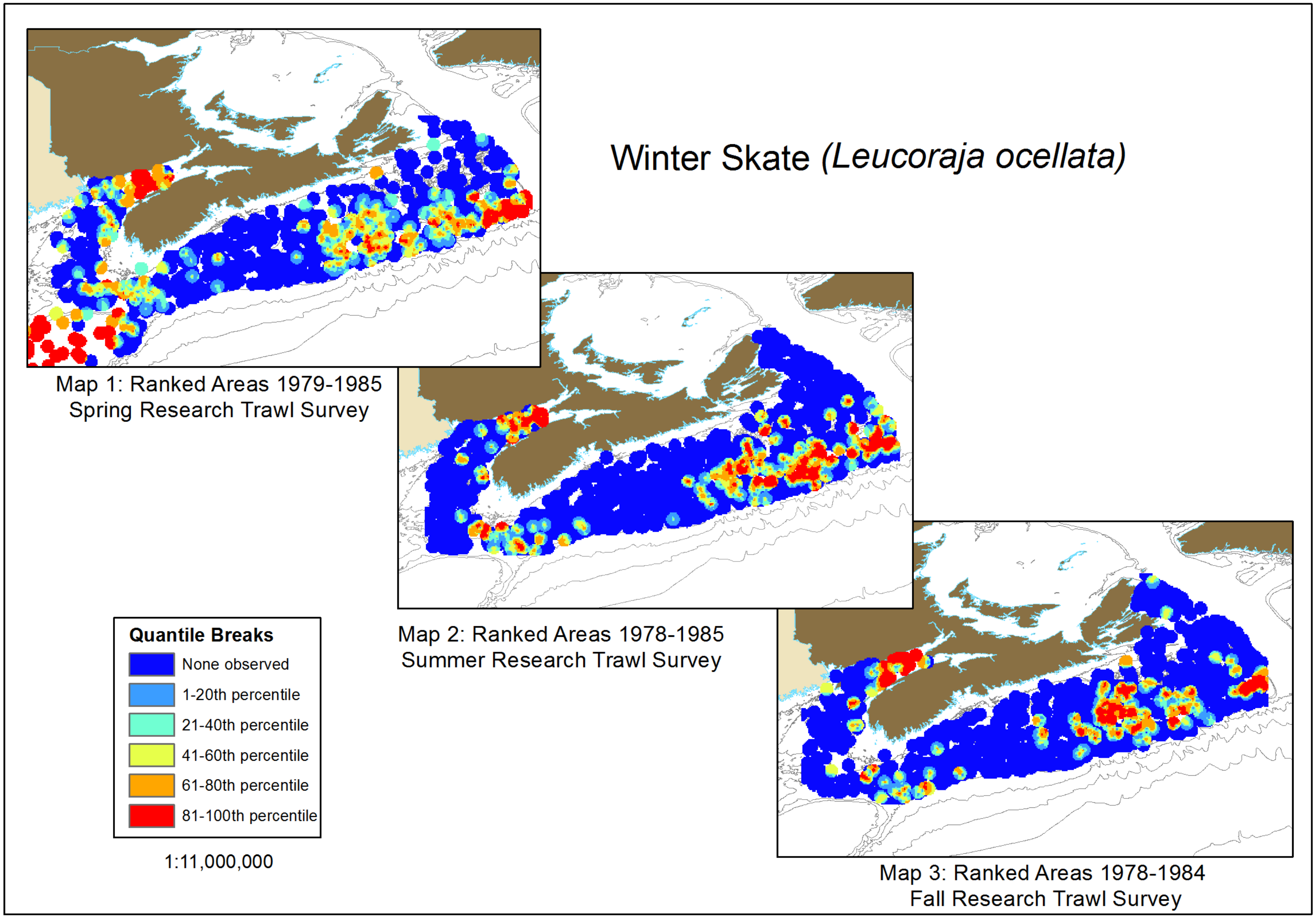

Figure 30. Maps showing distribution of Winter Skate from spring, summer and fall research trawl surveys (1978-1985).

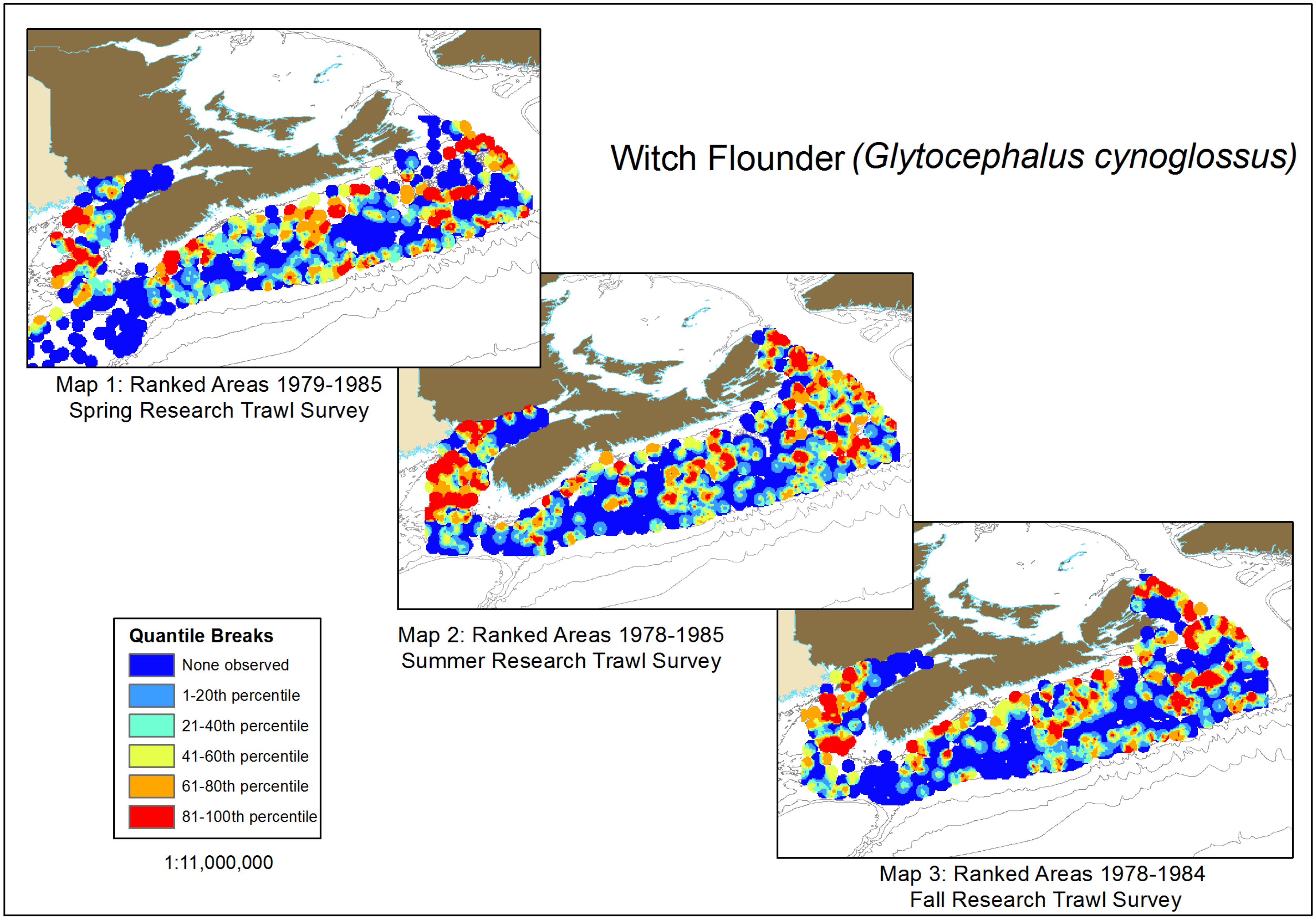

Figure 31. Maps showing distribution of Witch Flounder from spring, summer and fall research trawl surveys (1978-1985).

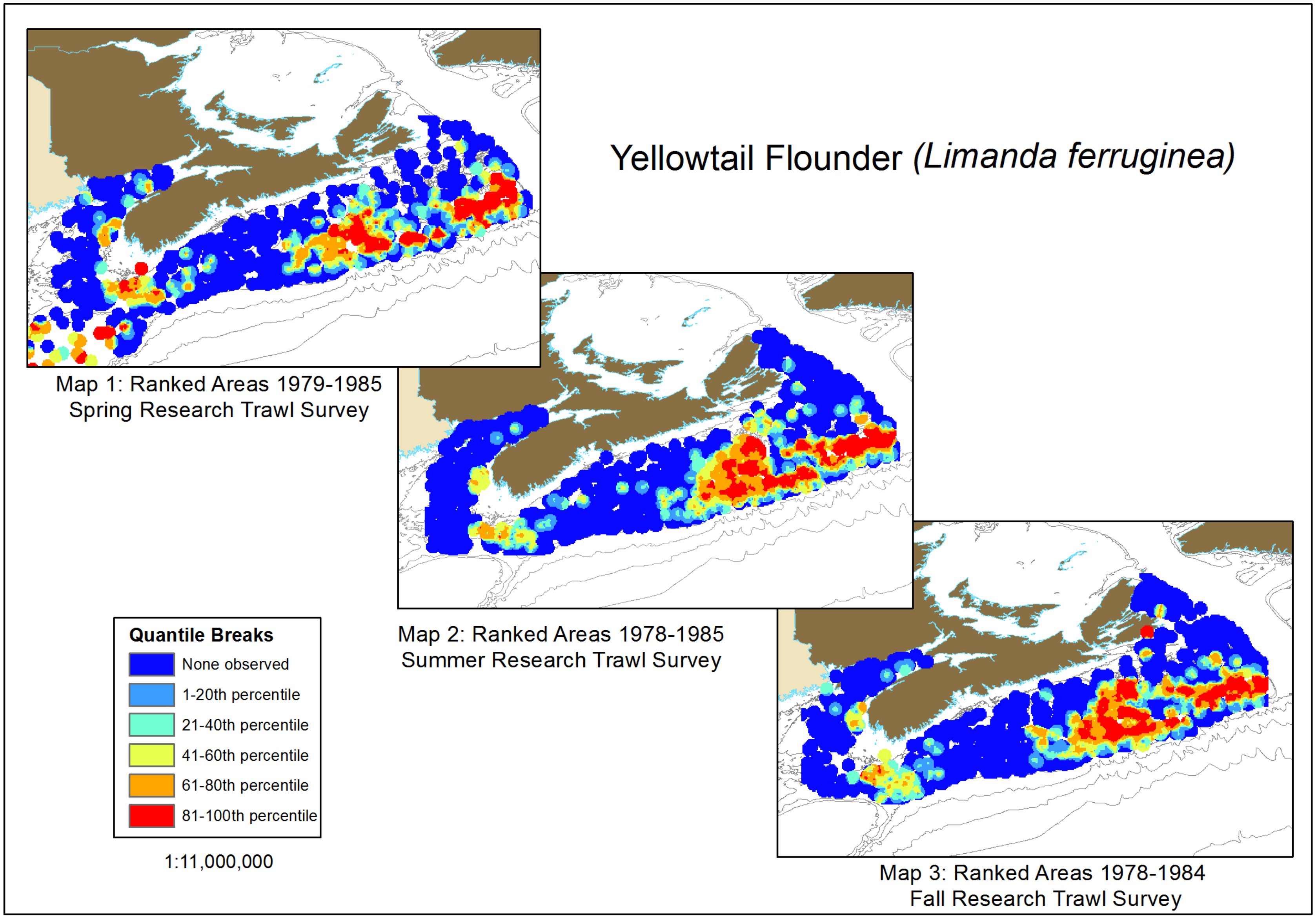

Figure 32. Maps showing distribution of Yellowtail Flounder from spring, summer and fall research trawl surveys (1978-1985).

DISCUSSION

APPLICATION OF THE MAPS

The maps presented in this report were created to complement the *Atlas of important habitat for key fish species of the Scotian Shelf, Canada* (Horseman and Shackell 2009) by providing a snapshot of the spring, summer and fall distributions of 32 demersal fish species between 1978 and 1985. The maps allow for a visual comparison of fish distributions during different times of the year. Developing a general understanding of the seasonal shifts in the distribution of key species will allow managers and planners to take this information into account in various fisheries and oceans management processes. For example, the results of the report could be considered in the design of a network of MPAs in the Scotian Shelf Bioregion.

SUGGESTIONS FOR FUTURE WORK

The RV trawl survey data between 1978 and 1985 represent the most complete and best available seasonal trawl survey data in the Scotian Shelf Bioregion. The overall ecosystem and the abundance and distribution of most demersal fishes have significantly changed since this time period (Frank et al. 2011). Resuming seasonal surveys in the bioregion would allow for a more recent comparison of seasonal species distributions. The inverse distance weighting (IDW) tool that was used to interpolate between data points is a relatively simple approach to creating surfaces from point data. More sophisticated species distribution models that incorporate environmental variables could be explored to develop more detailed predicted distribution maps for key fish species.

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