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Spatial distribution patterns of NAFO demersal fish stocks based on data from the Canadian multi-species surveys of Divisions 2HJ3KLNO

by

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Abstract

Fisheries and Oceans Canada's Newfoundland Region conducts spring and autumn multi-species surveys of the Northwest Atlantic Ocean. These surveys provide vital information for the assessment of marine resources, including the necessary data to estimate/model fish abundance and biomass. Because these surveys cover vast areas they also provide the necessary information to monitor the spatial distribution of species/stocks and the capacity to monitor temporal changes in the spatial extent of species. The Canadian surveys provide data necessary for the assessment of domestic stocks as well as those under the jurisdiction of the Northwest Atlantic Fisheries Organization (NAFO). Here we examine the spatial pattern of catches in the Canadian surveys in order to summarize the distribution of NAFO stocks, including American plaice in Divs. 3LNO, Atlantic cod in Divs. 3NO, yellowtail flounder in Divs. 3LNO, witch flounder in Divs. 3NO, redfish in Div. 3O, redfish in Divs. 3LN, Greenland halibut in SA2+Divs. 3KLMNO, roughhead grenadier in SA2+3, witch flounder in Divs. 2J3KL, white hake in Divs. 3NOPs, and thorny skate in Divs. 3LNOPs.

Introduction

Fisheries and Oceans Canada's Newfoundland Region conducts spring and autumn multi-species surveys of the Northwest Atlantic Ocean. These surveys provide vital information for the assessment of marine resources, including the necessary data to estimate/model fish abundance and biomass. Because these surveys cover vast areas they also provide the necessary information to monitor the spatial distribution of species/stocks and the capacity to monitor temporal changes in the spatial extent of species. The Canadian surveys provide data necessary for the assessment of domestic stocks as well as those under the jurisdiction of the Northwest Atlantic Fisheries Organization (NAFO). Here we examine the spatial pattern of catches in the Canadian surveys in order to summarize the distribution of NAFO stocks, including American plaice in Divs. 3LNO, Atlantic cod in Divs. 3NO, yellowtail flounder in Divs. 3LNO, witch flounder in Divs. 3NO, redfish in Div. 3O, redfish in Divs. 3LN, Greenland halibut in SA2+Divs. 3KLMNO, roughhead grenadier in SA2+3, witch flounder in Divs. 2J3KL, white hake in Divs. 3NOPs, and thorny skate in Divs. 3LNOPs.

Methods

The Canadian spring and autumn surveys employ a stratified random design, with the survey area divided up into a number of strata based on depth. The surveys from 1983 to 1995 employed an Engel 145 high-rise bottom trawl. In 1996, research surveys began using the Campelen 1800 shrimp trawl. The Engel trawl catches for 1983-95 were converted to Campelen 1800 shrimp trawl-equivalent catches using a length-based

conversion formulation derived from comparative fishing experiments (Warren 1996; Warren et al. 1997; Stansbury 1996, 1997).

The distribution plots presented here are bubble plots with symbol sizes proportional to the weight of the survey catch (standardized to 0.8 nm) at each location. The scaling is continuous. The plots depict all survey sets and therefore may not necessarily reflect the trends depicted in assessments that employ index strata.

Results & Discussion

The distribution of American plaice in Canadian Spring and autumn surveys are depicted in Figs. 1 and 2, respectively. The plots demonstrate that plaice are distributed over the entire Grand Bank in spring. Since 2005 the highest spring catches of plaice have been taken on the tail of the Grand Bank in the NAFO Regulatory Area. The autumn surveys show results similar to the spring, with plaice distributed over the entire Grand Bank but with the highest catches taken in the NRA.

The Canadian Spring surveys demonstrate that prior to 2003 Atlantic cod in NAFO Divisions 3NO were distributed primarily in Div. 3O (Fig. 3). Larger catches of cod appeared in the spring survey in 2009 (in both 3N and 3O). Over 2012-2015, the largest catches of cod have been taken on the tail of the Grand Bank in the NRA. Over 2009-2013 the largest catches of cod in the autumn survey were also taken in the NRA (Fig. 4). The survey of Divs. 3NO was not completed in 2014. In 2015, there were no larger survey catches like those reported in recent years.

Yellowtail flounder in NAFO Divisions 3LNO in both the Spring (Fig. 5) and autumn (Fig. 6) surveys are distributed over the shallower portion of the Grand Bank, primarily in Divs. 3N and 3O but also in the southern portion of 3L. There are no clear annual or seasonal differences in the distribution of yellowtail flounder. There are significant holes in spring survey coverage in 2006 and 2015 within the typical geographic range of this species. Divs. 3N and 3O were not surveyed in 2014.

Catches of witch flounder in NAFO Divisions 3NO in the spring surveys (Fig. 7) are distributed primarily along the slopes of the Grand Bank and, until the last couple of years, were generally higher in Div. 3O. In 2013, a couple of large survey catches were observed in the western portion of Div. 3O near the border of Subdivision 3Ps. The distribution of witch flounder in the autumn surveys is substantially extended up over the Grand Bank (Fig. 8) and not restricted to the slope as it generally is in the spring. Divs. 3N and 3O were not surveyed in 2014.

Redfish in NAFO Division 3O are distributed almost exclusively on the slope of the bank in both the spring (Fig. 9) and autumn (Fig. 10) surveys. The distribution of redfish can be very patchy with areas that are densely aggregated. Such patterns have resulted in large survey catches (>5000 kg per 15 minute tow) in some years.

Redfish are also distributed along the slope in Divisions 3LN in both spring (Fig. 11) and autumn (Fig. 12). Both surveys demonstrate an increase in survey catch size in recent years and, in particular, increasing southern concentrations of redfish in Div. 3N. The spring survey did not cover the slope of Div. 3N in 2006 and did not cover the nose of the Grand Bank in 2015. The autumn survey did not cover Divs. 3NO in 2014.

Greenland halibut in SA2+Divs. 3KLMNO are managed as a single stock. The Canadian spring survey covers only Divs. 3LNO. Greenland halibut are generally not abundant in these areas and are restricted to the slope around the edge of the Grand Bank (Fig. 13). The spring survey did not cover the slope of Div. 3N in 2006 and did not cover the nose of the Grand Bank in 2015. The Canadian autumn surveys demonstrate that Greenland halibut are distributed primarily north of the Grand Bank in NAFO Divs. 2HJ3K. The autumn survey has not covered Div. 2G since 1999, and while Div. 2H has been surveyed in recent years it was not covered in 2000, 2002-2003, 2005 and 2007-2009. The autumn survey did not cover Divs. 3NO in 2014.

Like Greenland halibut, roughhead grenadier are distributed along the deep slopes of the banks. The Canadian Spring survey covers only the Divs. 3LNO portion of the stock (Fig. 15) and had coverage issues in

2006 and 2015. The Autumn survey covers a larger spatial area and clearly demonstrates the spatial extent of this species, extending from the slope of Div. 3O, around the Grand Bank and up to Div. 2H (Fig. 16).

Witch flounder in NAFO Divs. 2J3KL are distributed on the edge of the banks, within the deep channels crossing the banks and even within some of Newfoundland's deeper bays (Fig. 17). The annual plots for the autumn surveys demonstrate increasing survey catches of witch flounder throughout Div. 3K in particular.

White hake demonstrate a continuous distribution along the slopes of the banks in 3N, 3O and 3Ps and are considered a single stock (Fig. 18, Fig. 19). However, NAFO manages only the portion of the stock in Divs. 3N and 3O while Canada manages the portion of the stock in 3Ps.

Likewise thorny skate in Divs. 3LNOPs (Fig. 21, Fig. 22) are thought to comprise a single population but the portion of the stock in Divs. 3L, 3N and 3O is managed while Canada manages the portion of the stock in 3Ps.

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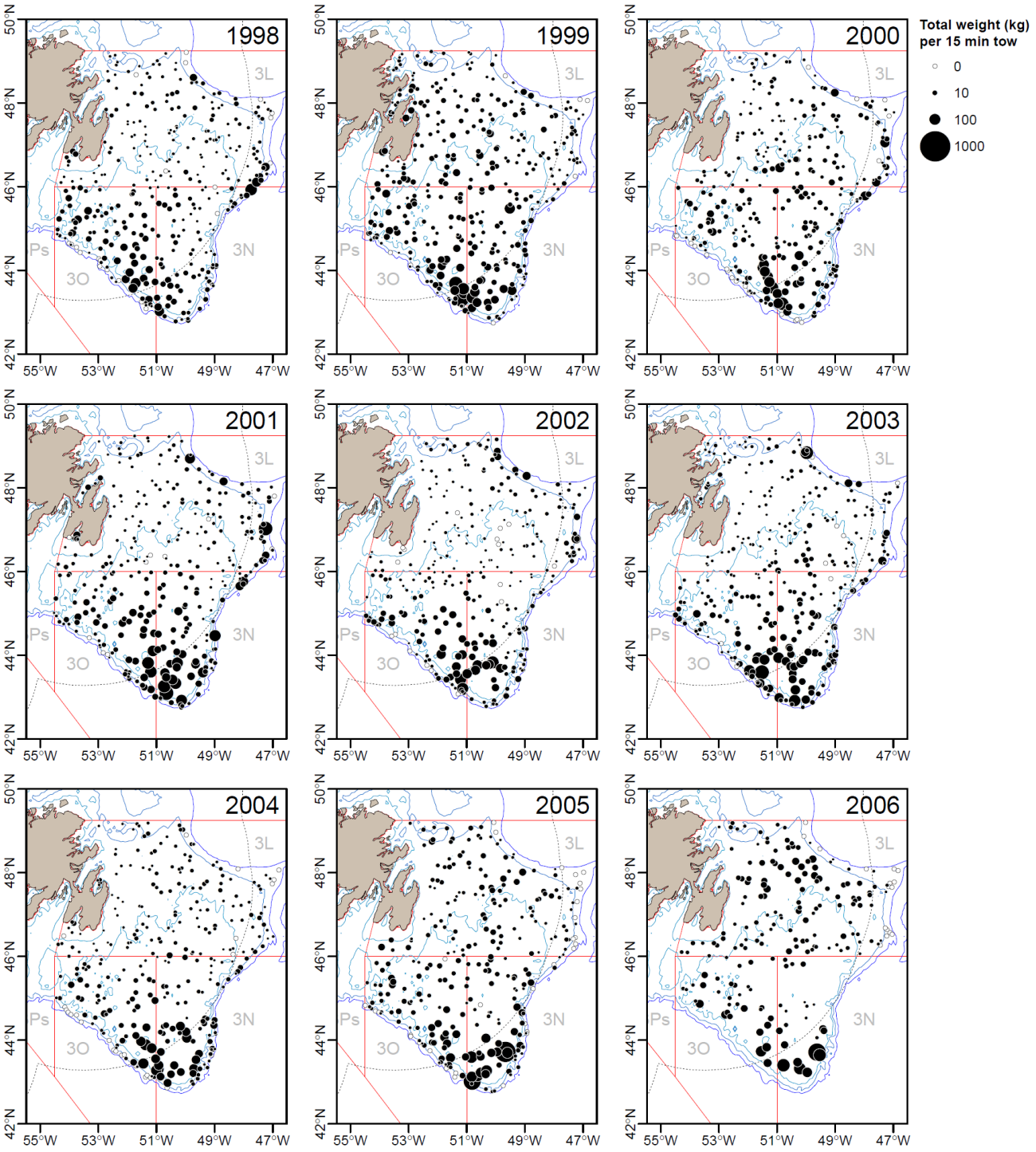
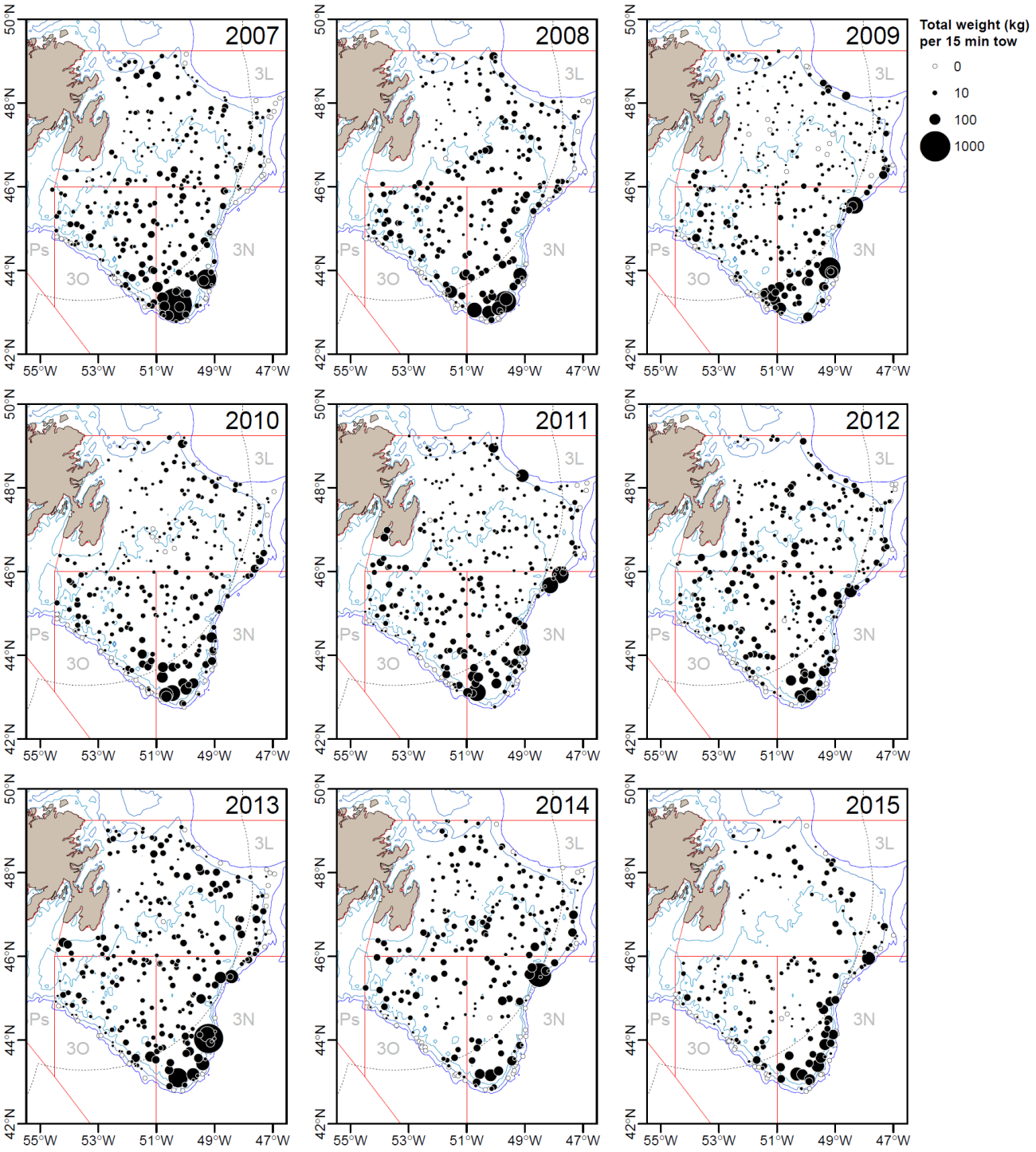


Fig. 1. Distribution plots: 3LNO American Plaice (*Hippoglossoides platessoides*). The symbols demonstrate survey set locations for the Canadian spring multi-species surveys and the total standardized weight of American Plaice caught at each location. Symbol area is proportional to catch weight.



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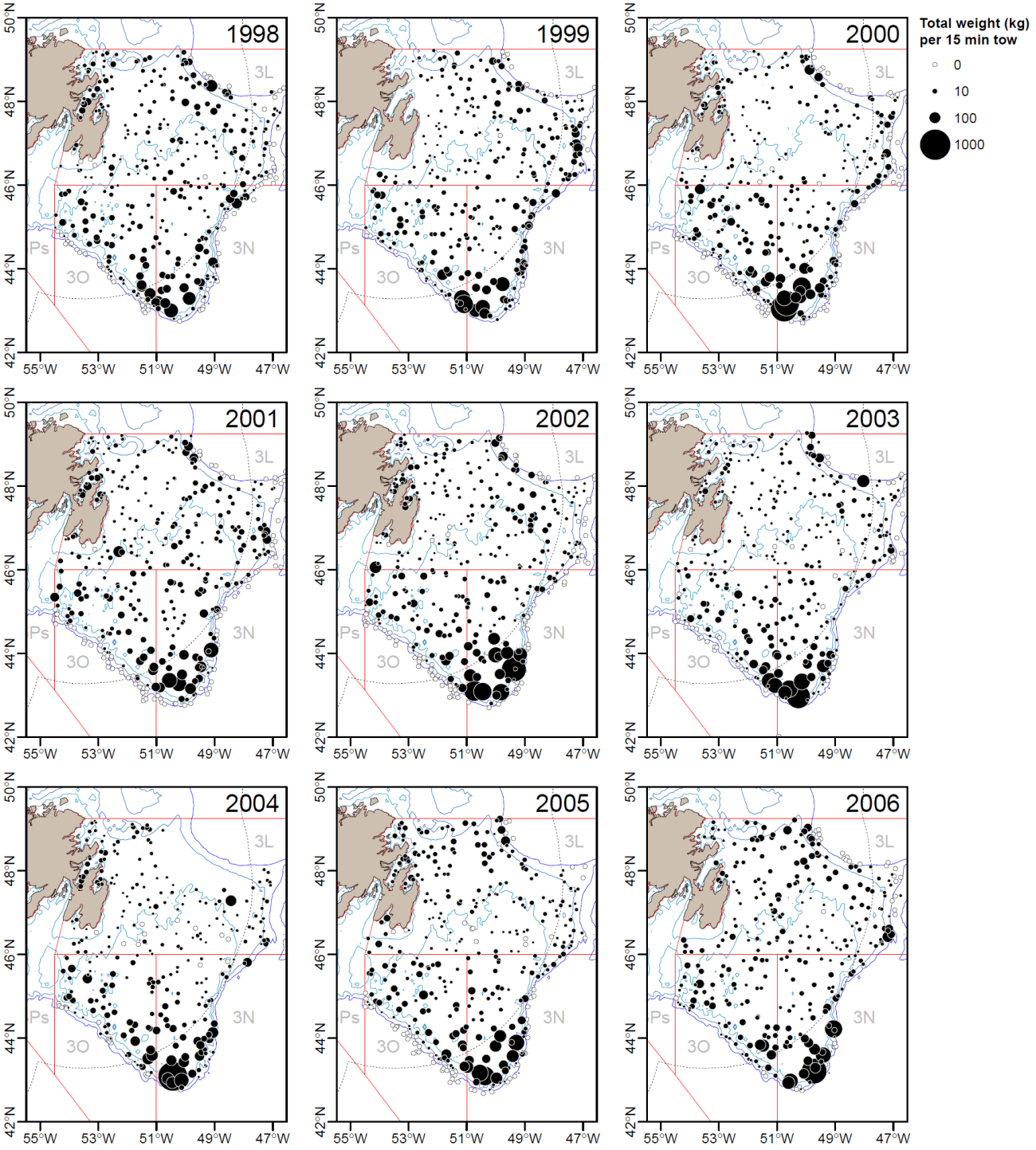
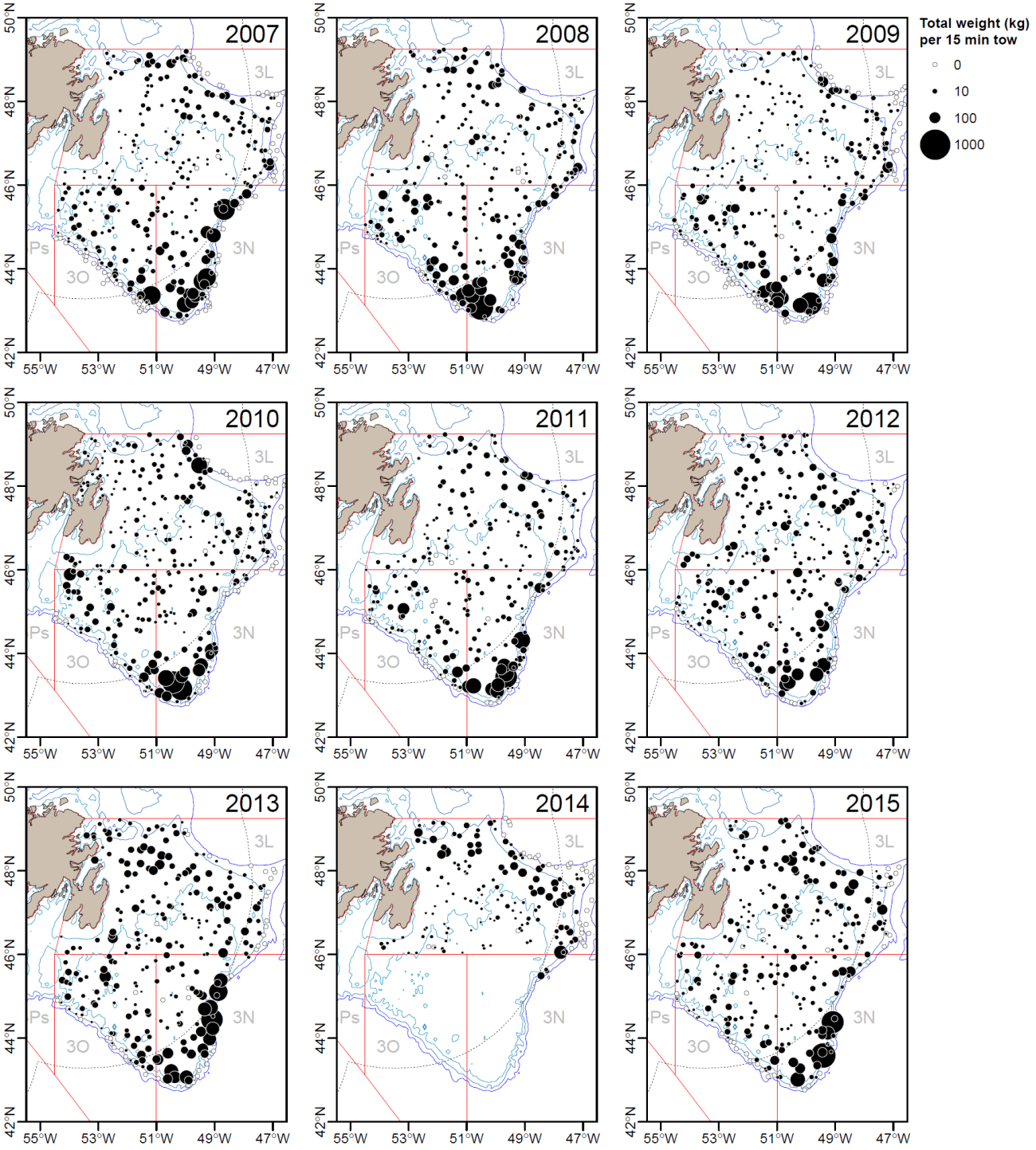


Fig. 2. Distribution plots: 3LNO American Plaice (*Hippoglossoides platessoides*). The symbols demonstrate survey set locations for the Canadian autumn multi-species surveys and the total standardized weight of American Plaice caught at each location. Symbol area is proportional to catch weight.



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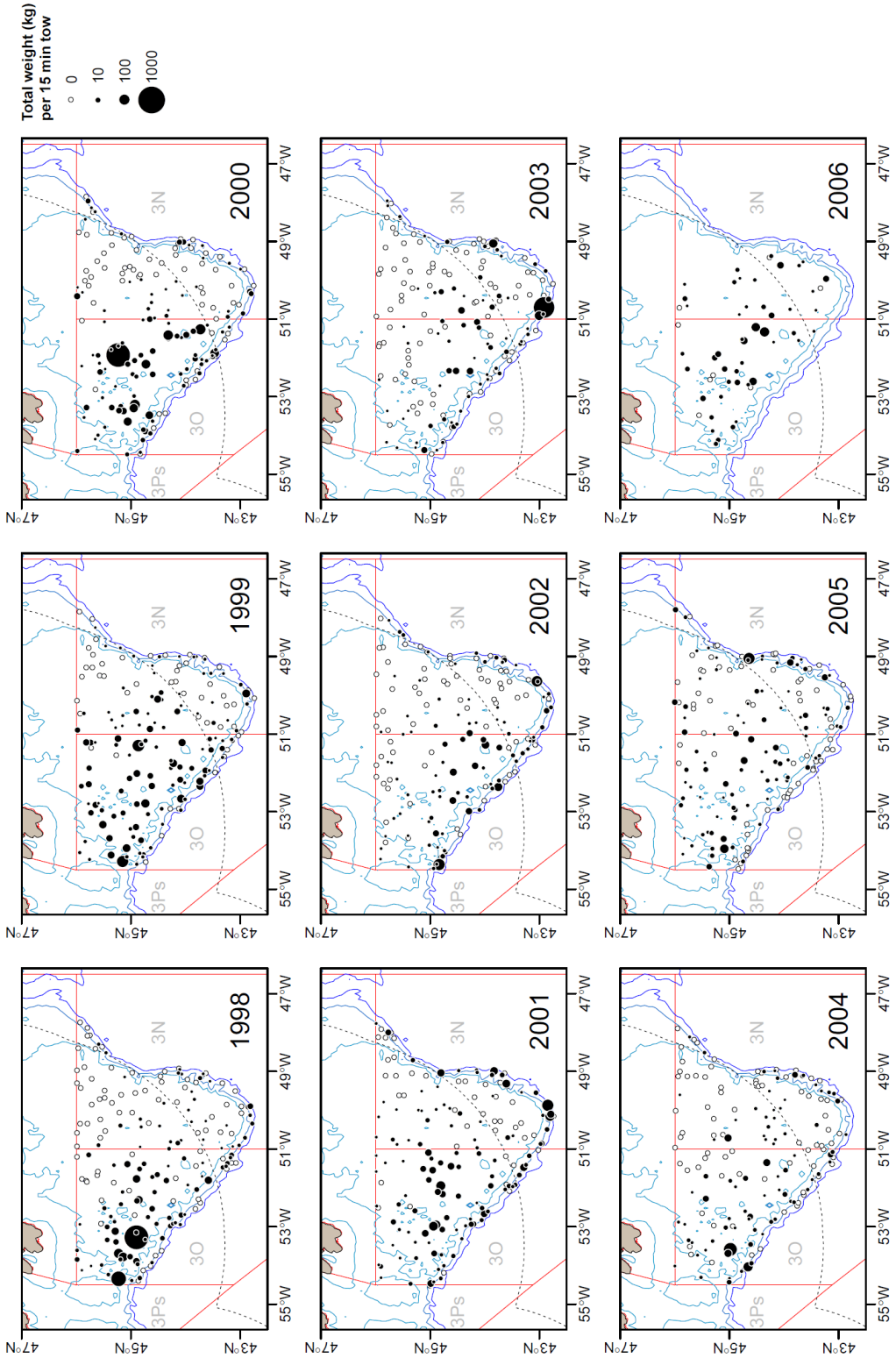


Fig. 3. Distribution plots: 3NO Atlantic Cod (*Gadus morhua*). The symbols demonstrate survey set locations for the Canadian spring multi-species surveys and the total standardized weight of Atlantic Cod caught at each location. Symbol area is proportional to catch weight.

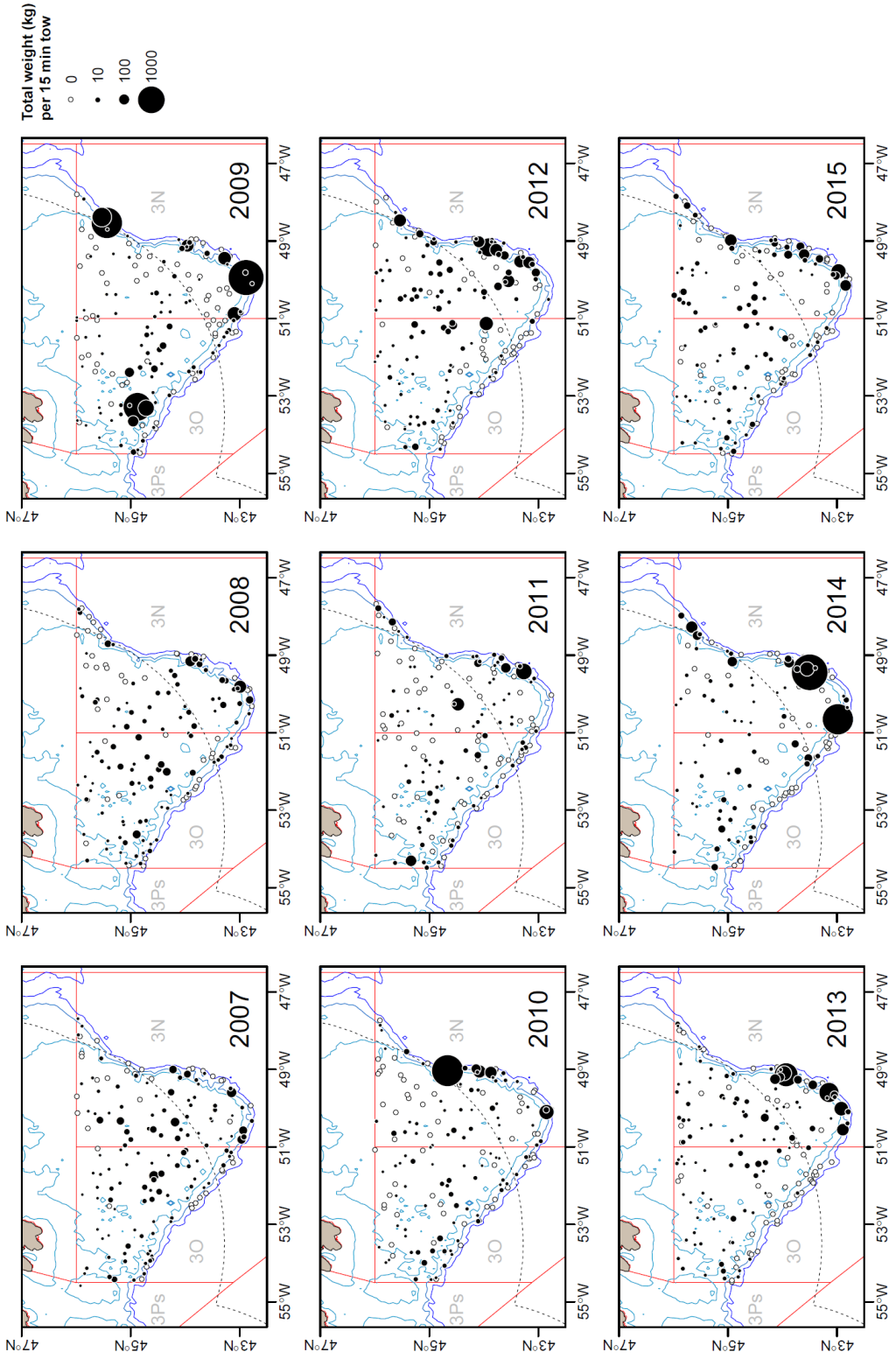


Fig. 3. Continued…

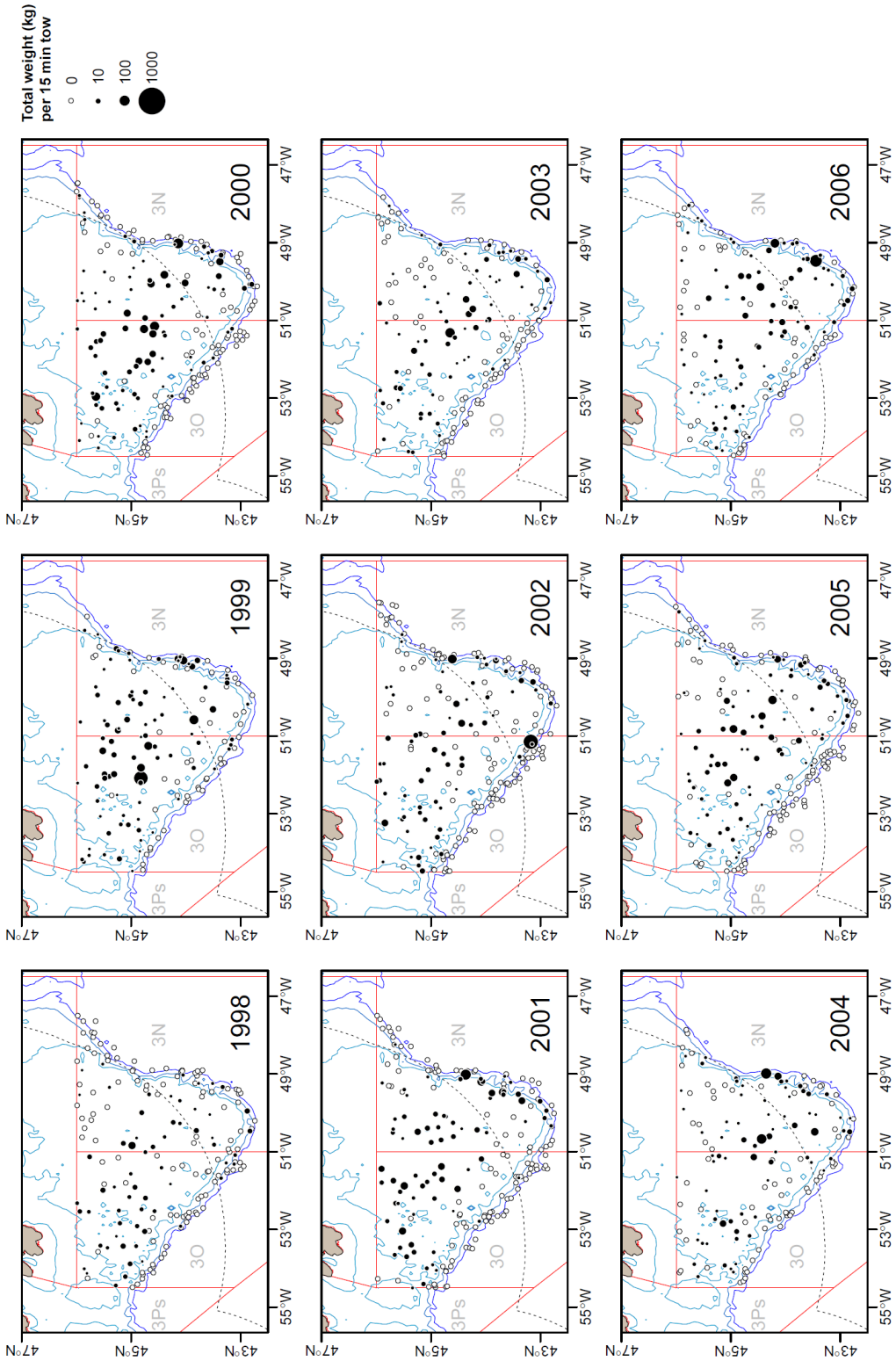
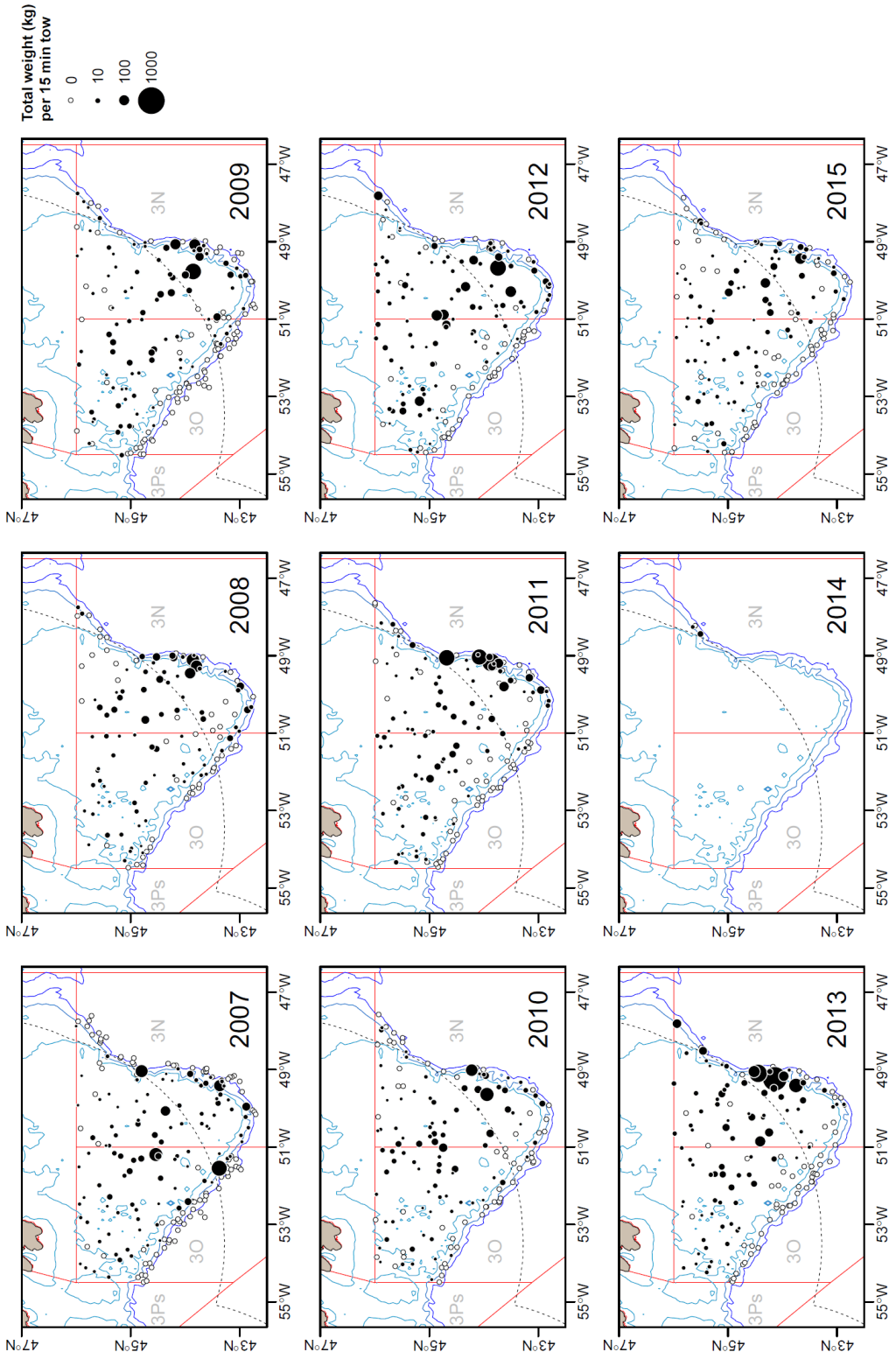


Fig. 4. Distribution plots: 3NO Atlantic Cod (*Gadus morhua*). The symbols demonstrate survey set locations for the Canadian autumn multi-species surveys and the total standardized weight of Atlantic Cod caught at each location. Symbol area is proportional to catch weight.



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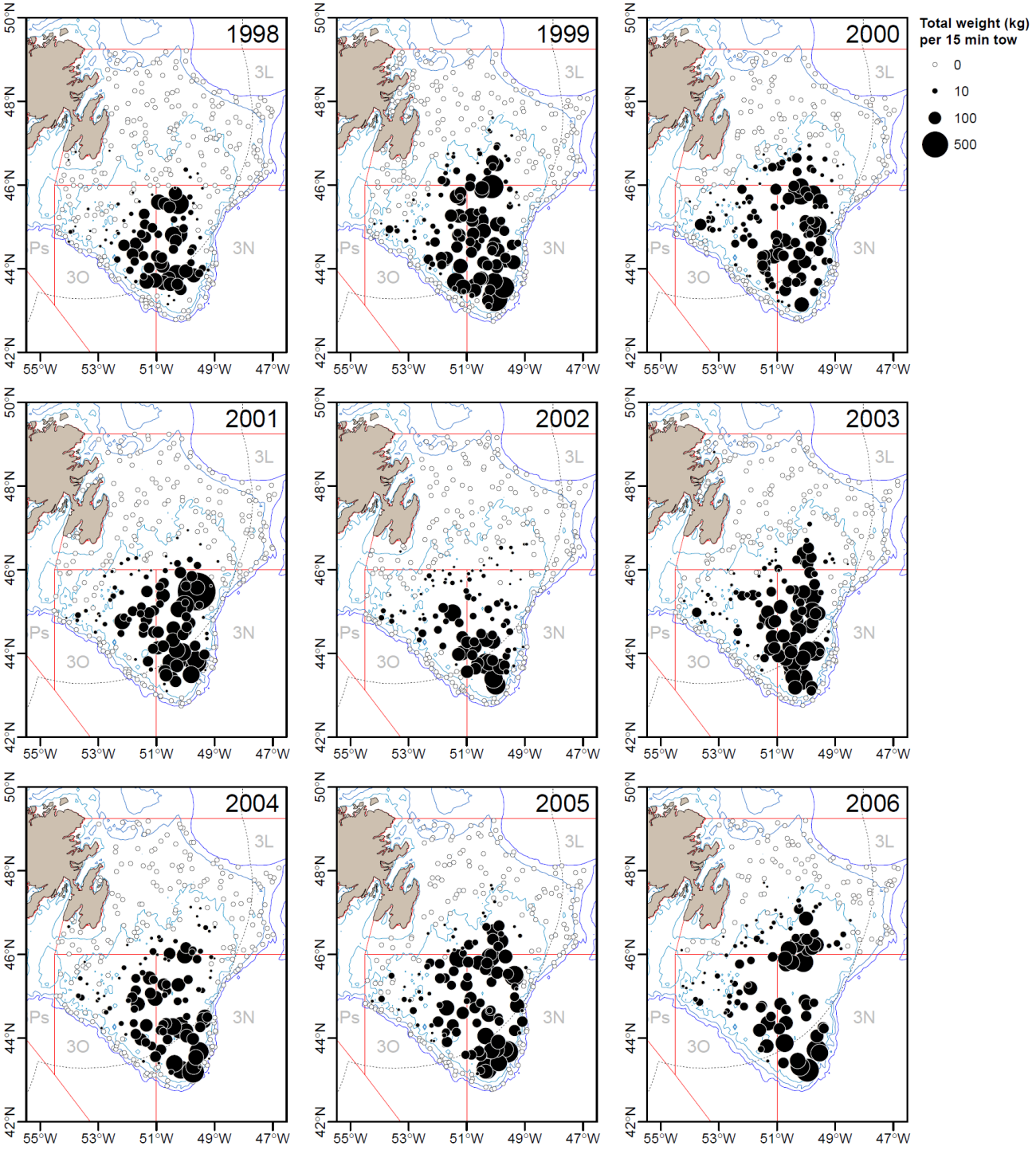
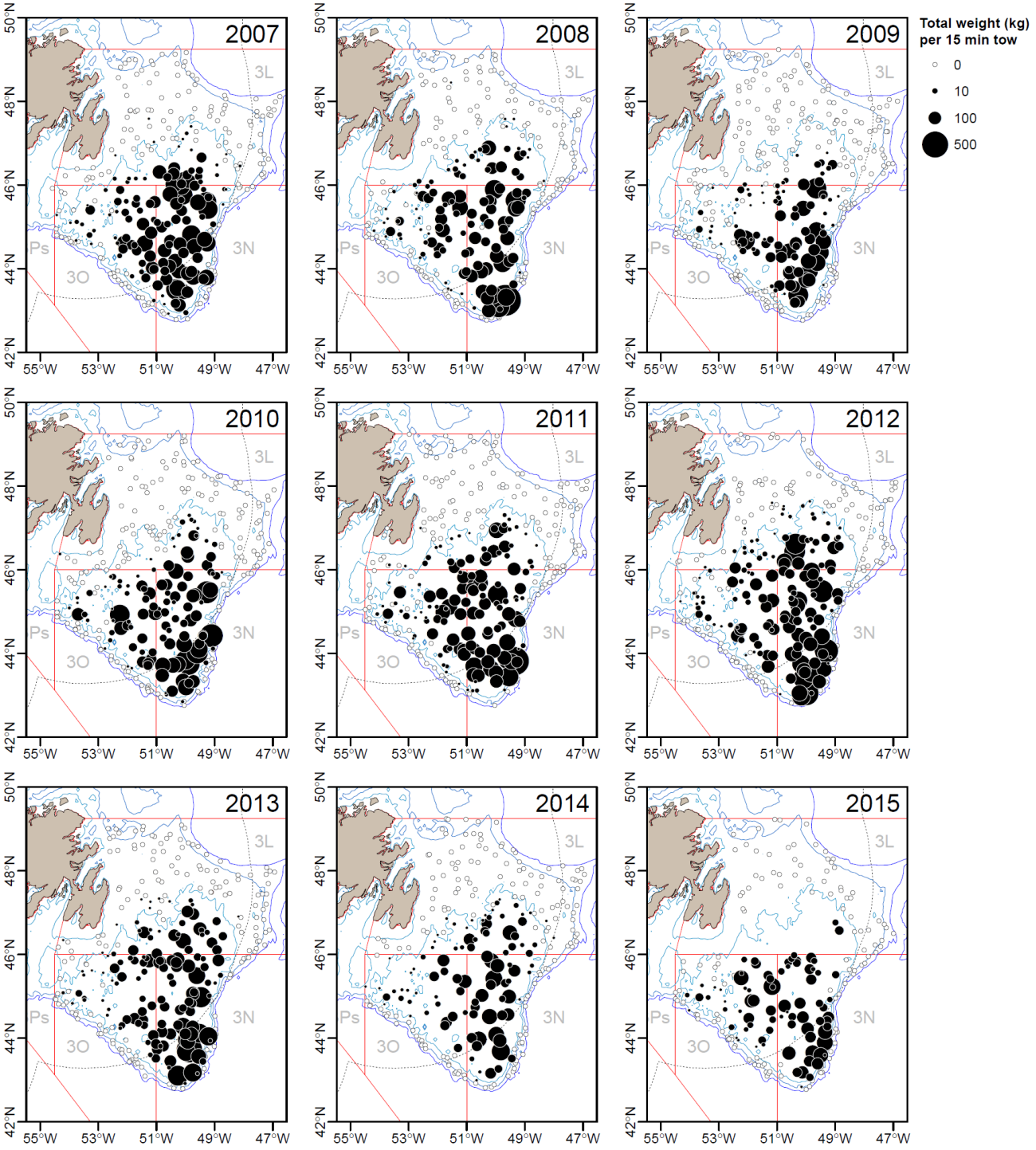


Fig. 5. Distribution plots: 3LNO Yellowtail Flounder (*Limanda ferruginea*). The symbols demonstrate survey set locations for the Canadian spring multi-species surveys and the total standardized weight of Yellowtail Flounder caught at each location. Symbol area is proportional to catch weight.



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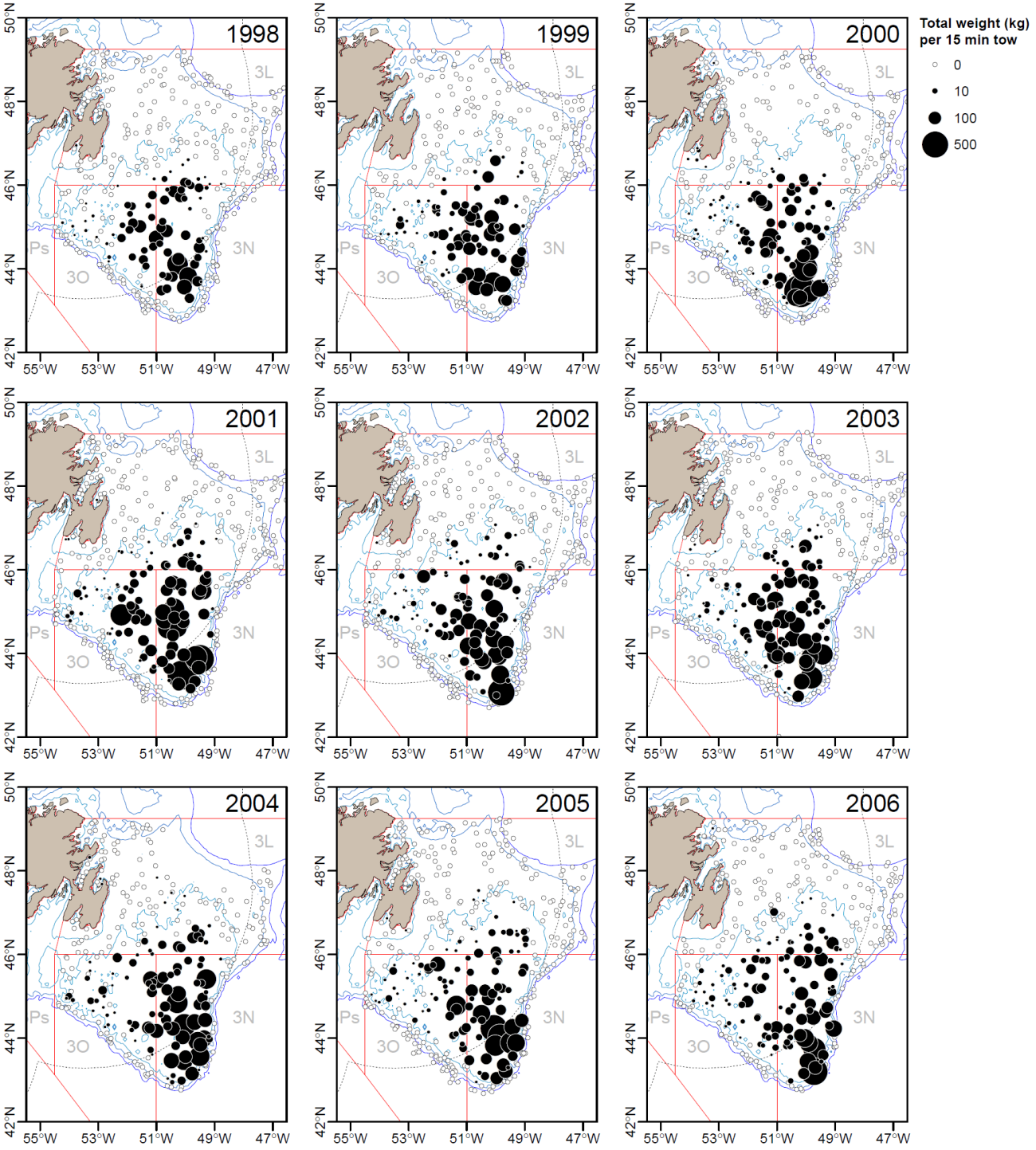
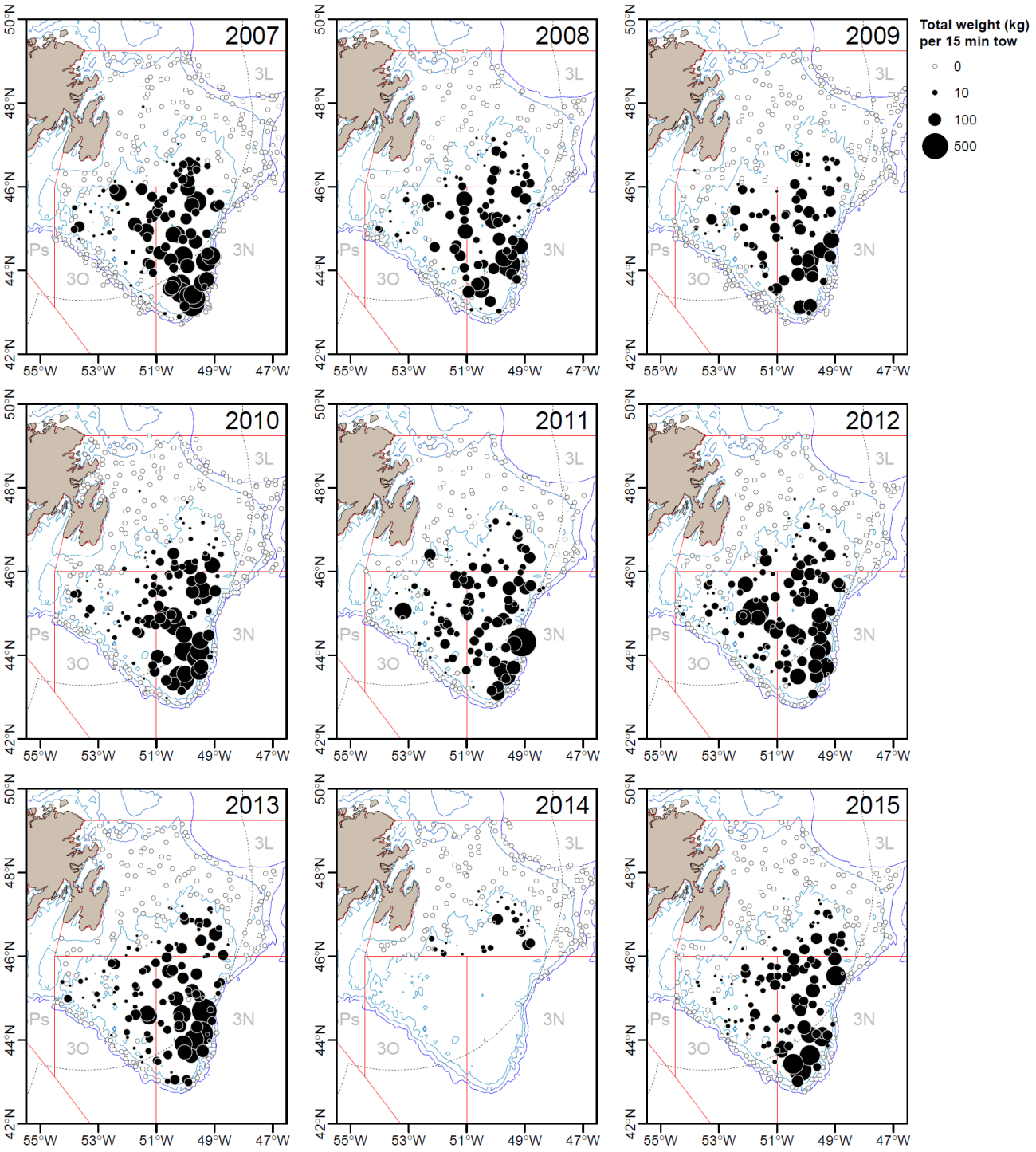


Fig. 6. Distribution plots: 3LNO Yellowtail Flounder (*Limanda ferruginea*). The symbols demonstrate survey set locations for the Canadian autumn multi-species surveys and the total standardized weight of Yellowtail Flounder caught at each location. Symbol area is proportional to catch weight.



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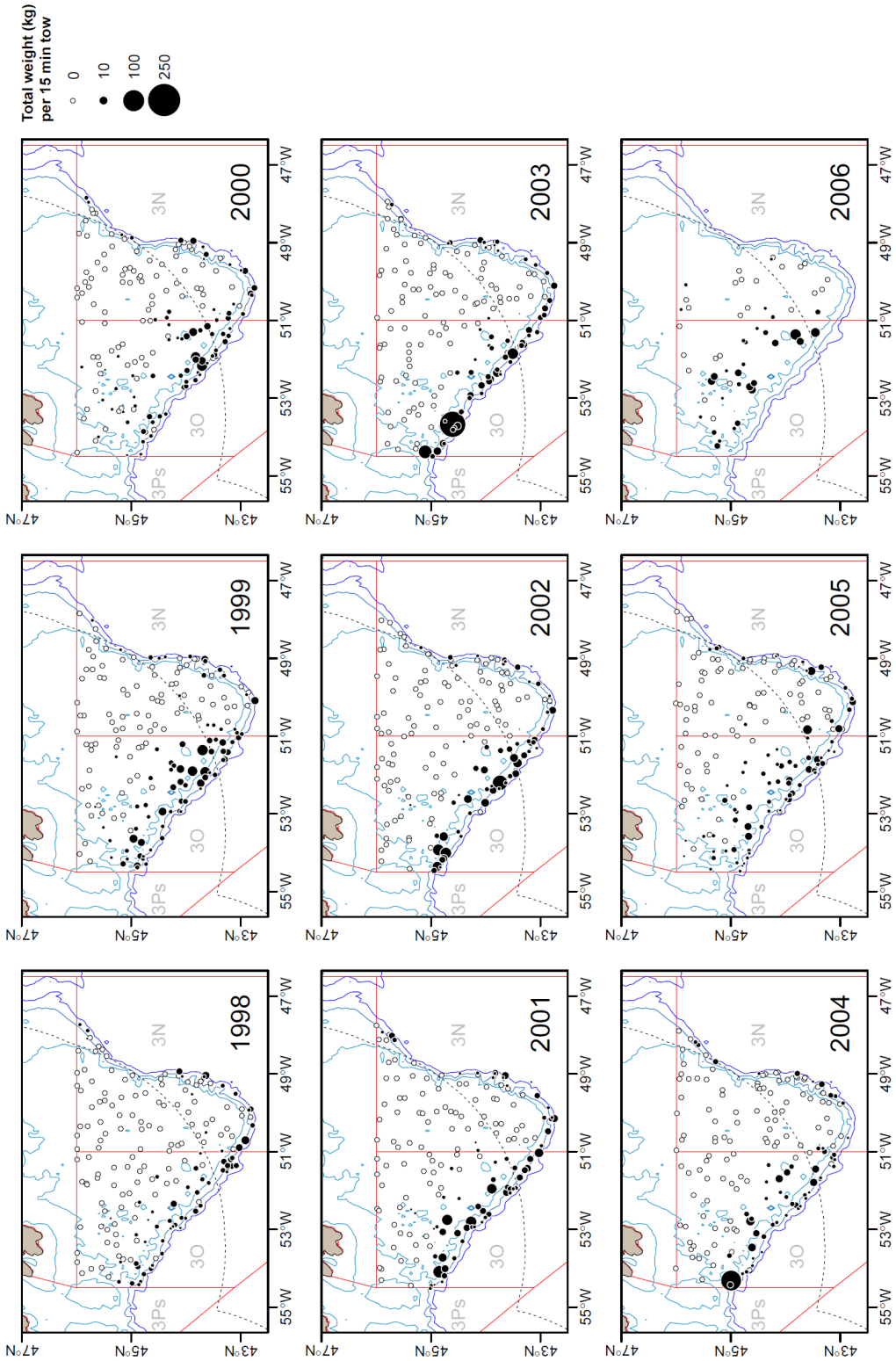
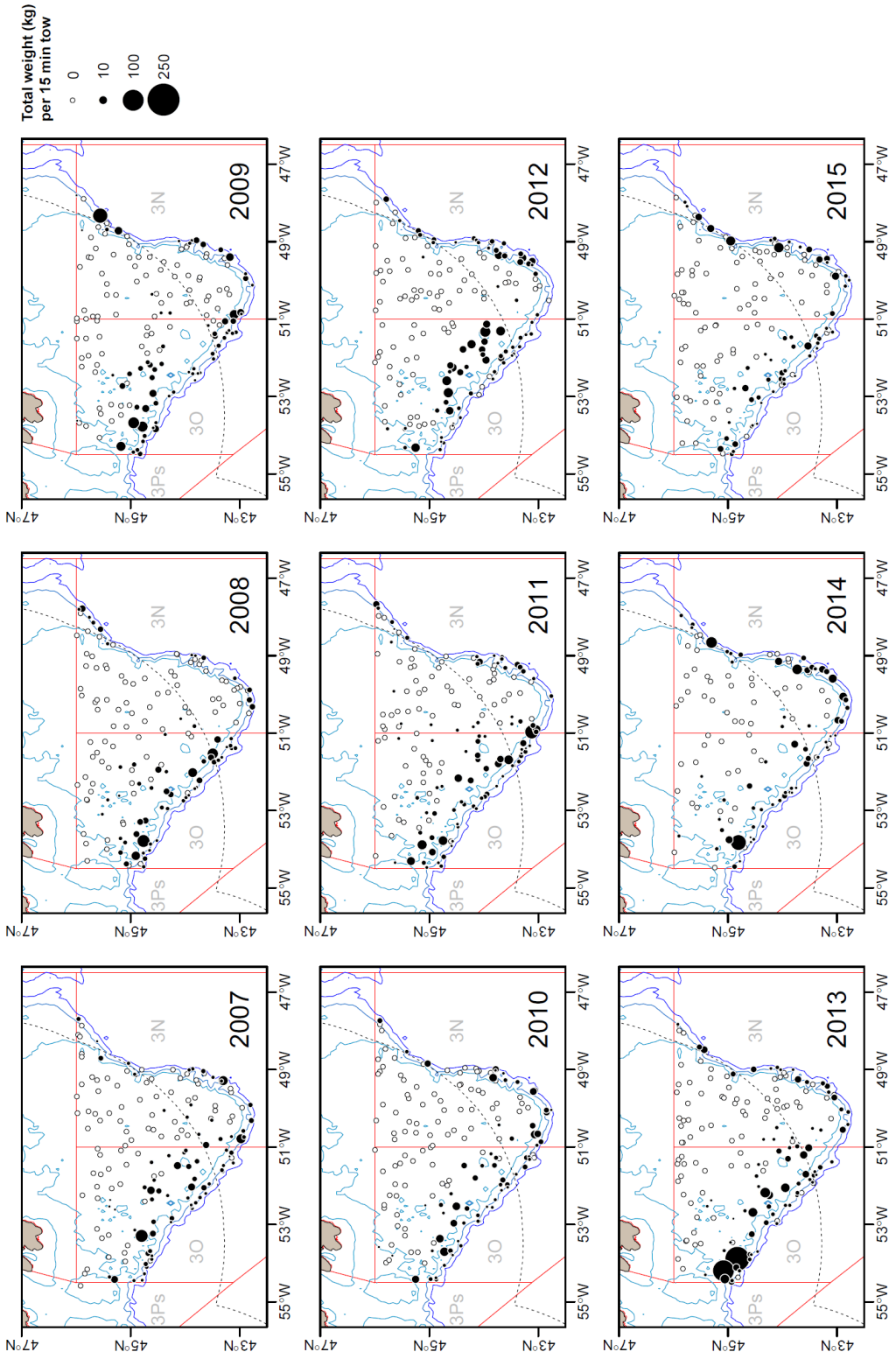


Fig. 7. Distribution plots: 3NO Witch Flounder (*Glyptocephalus cynoglossus*). The symbols demonstrate survey set locations for the Canadian spring multi-species surveys and the total standardized weight of Witch Flounder caught at each location. Symbol area is proportional to catch weight.



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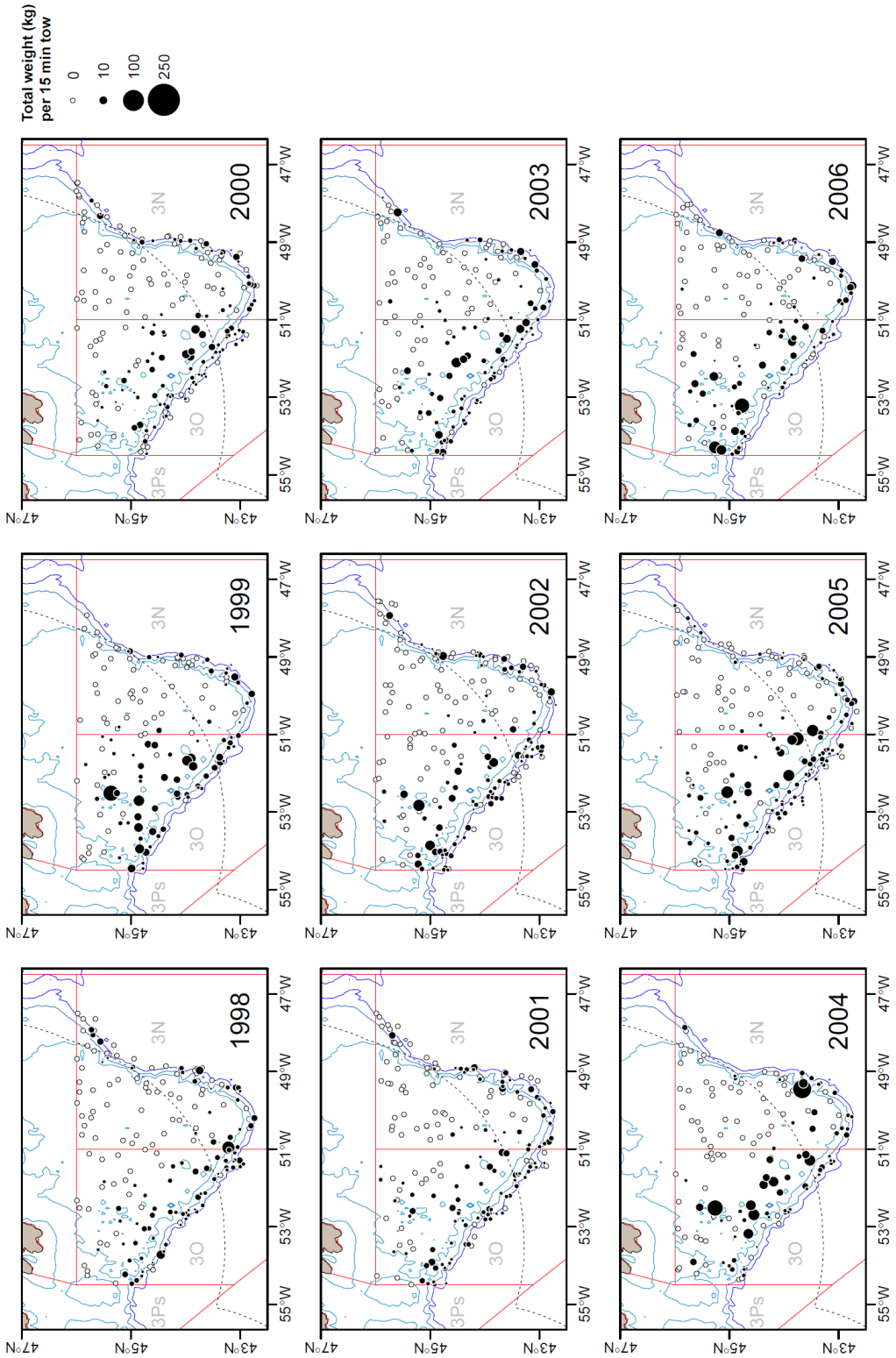
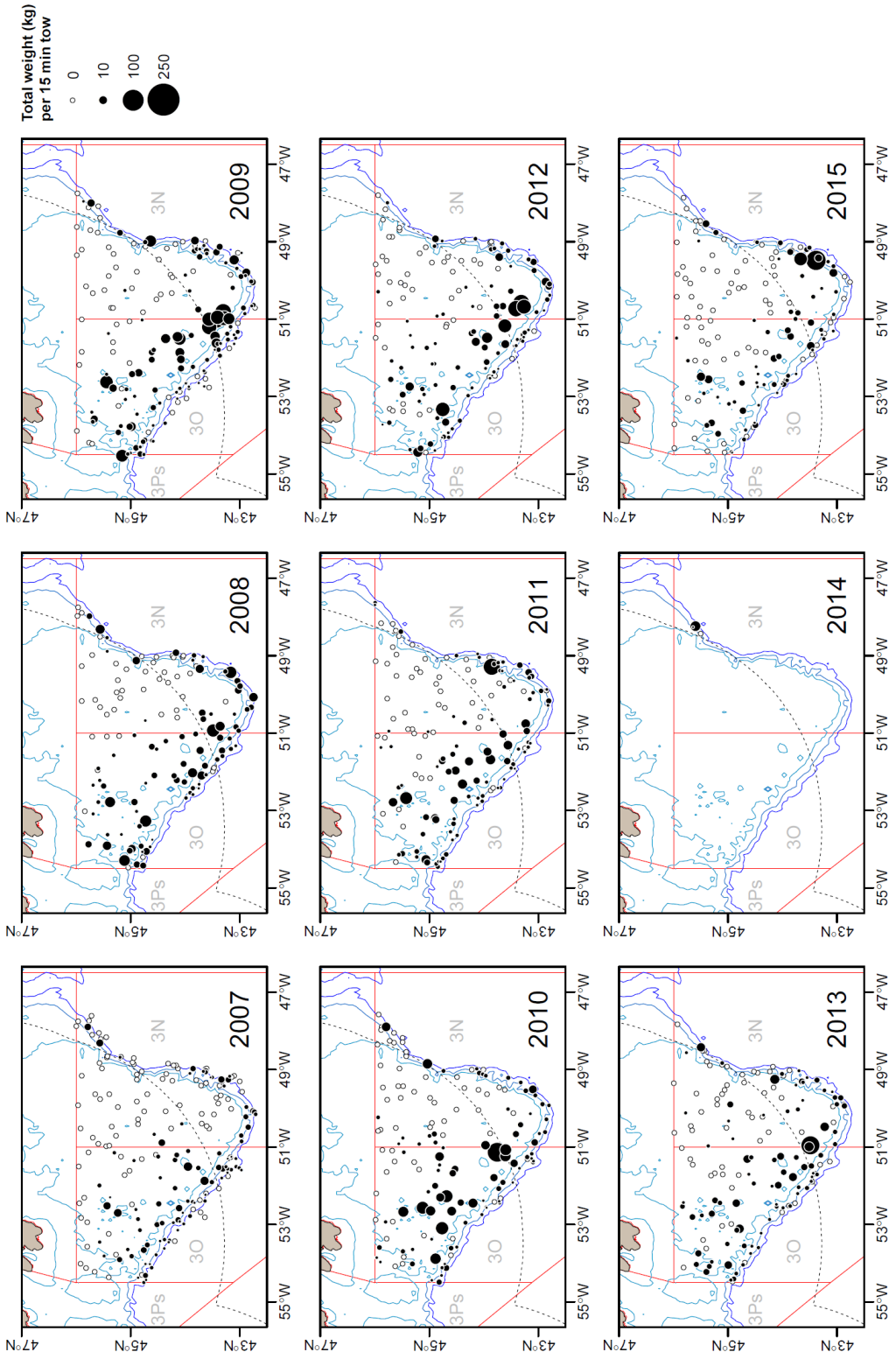


Fig. 8. Distribution plots: 3NO Witch Flounder (*Glyptocephalus cynoglossus*). The symbols demonstrate survey set locations for the Canadian autumn multi-species surveys and the total standardized weight of Witch Flounder caught at each location. Symbol area is proportional to catch weight.



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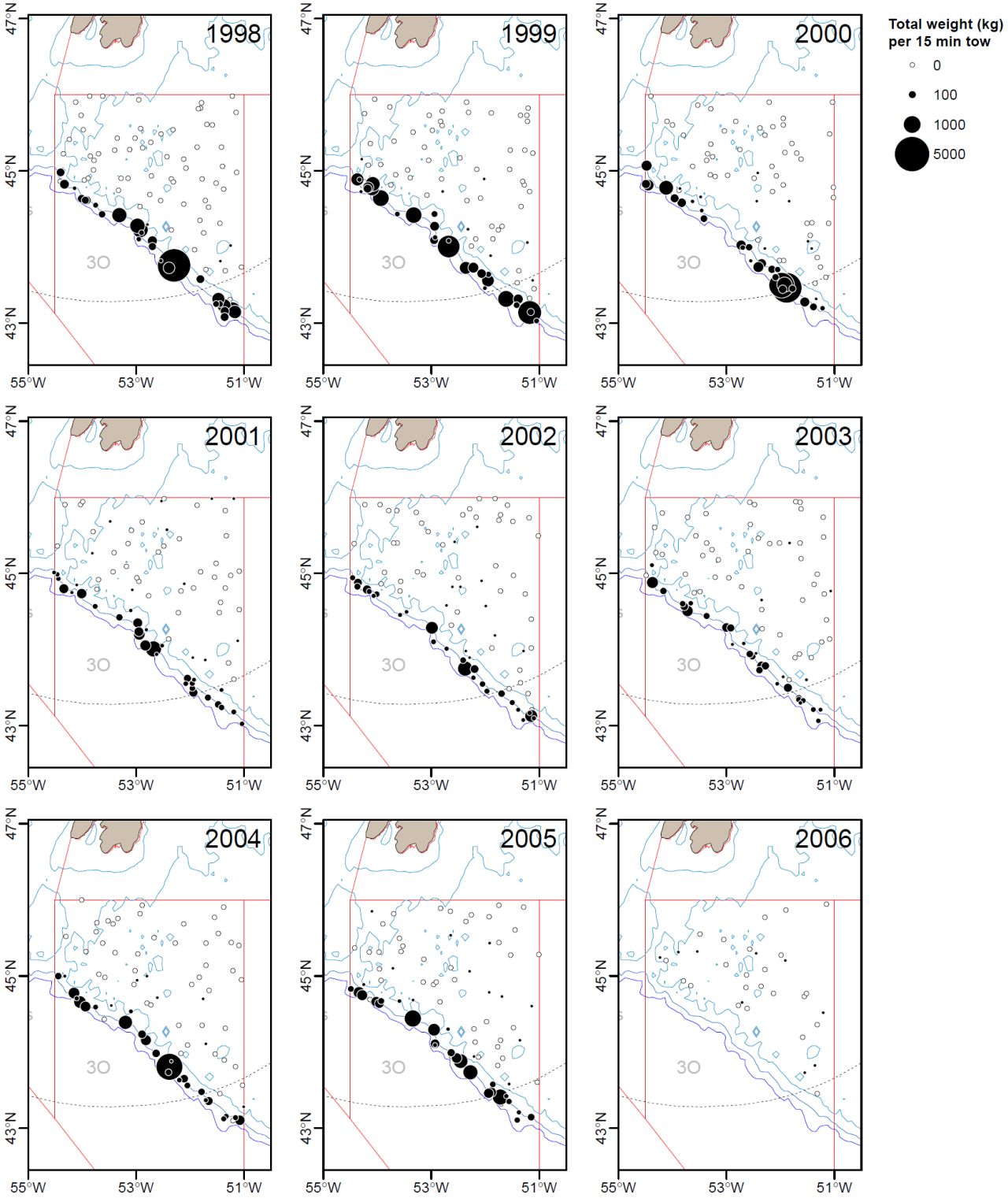
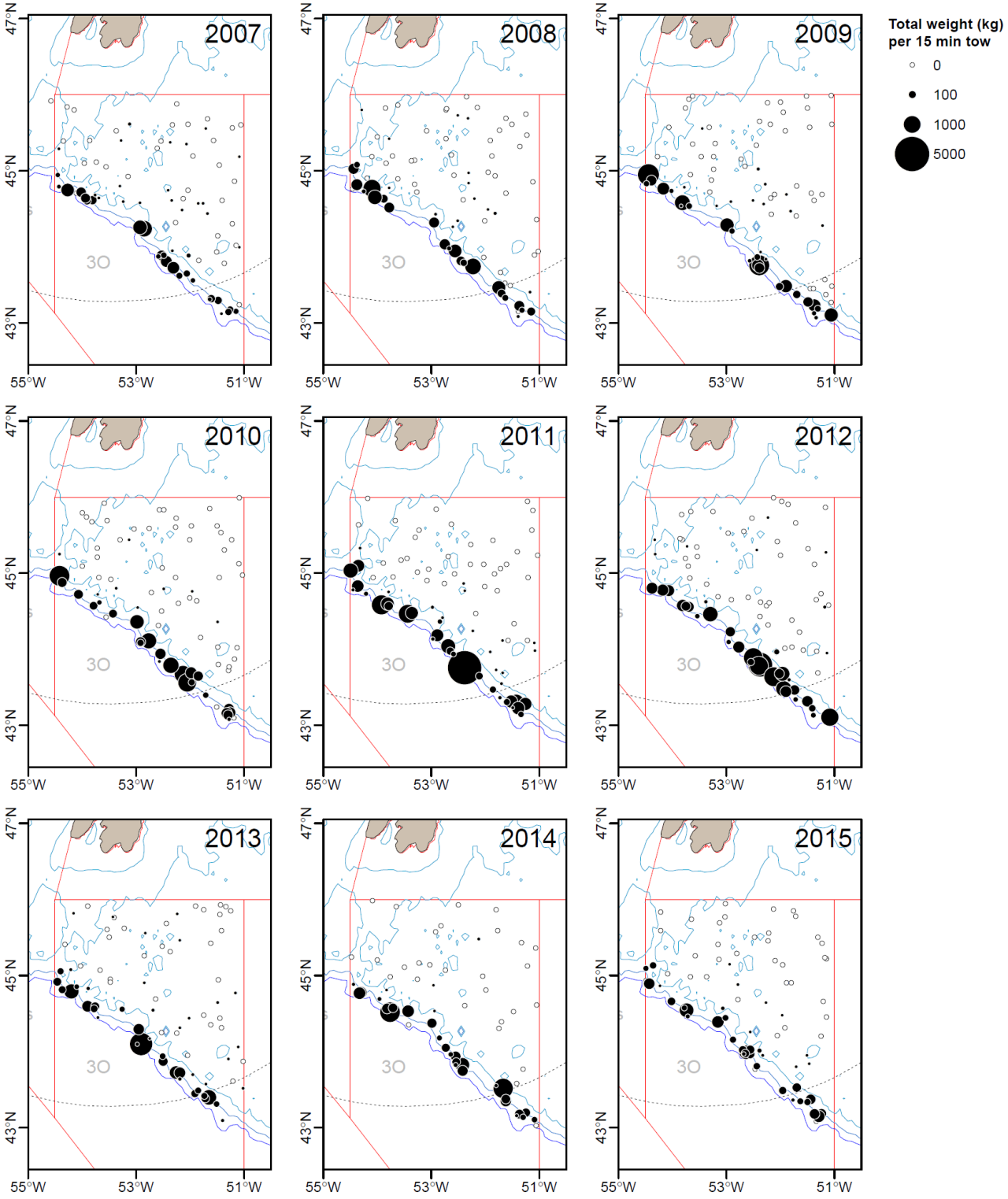


Fig. 9. Distribution plots: 3O Redfish (*Sebastes mentella* and *Sebastes fasciatus*). The symbols demonstrate survey set locations for the Canadian spring multi-species surveys and the total standardized weight of Redfish caught at each location. Symbol area is proportional to catch weight.



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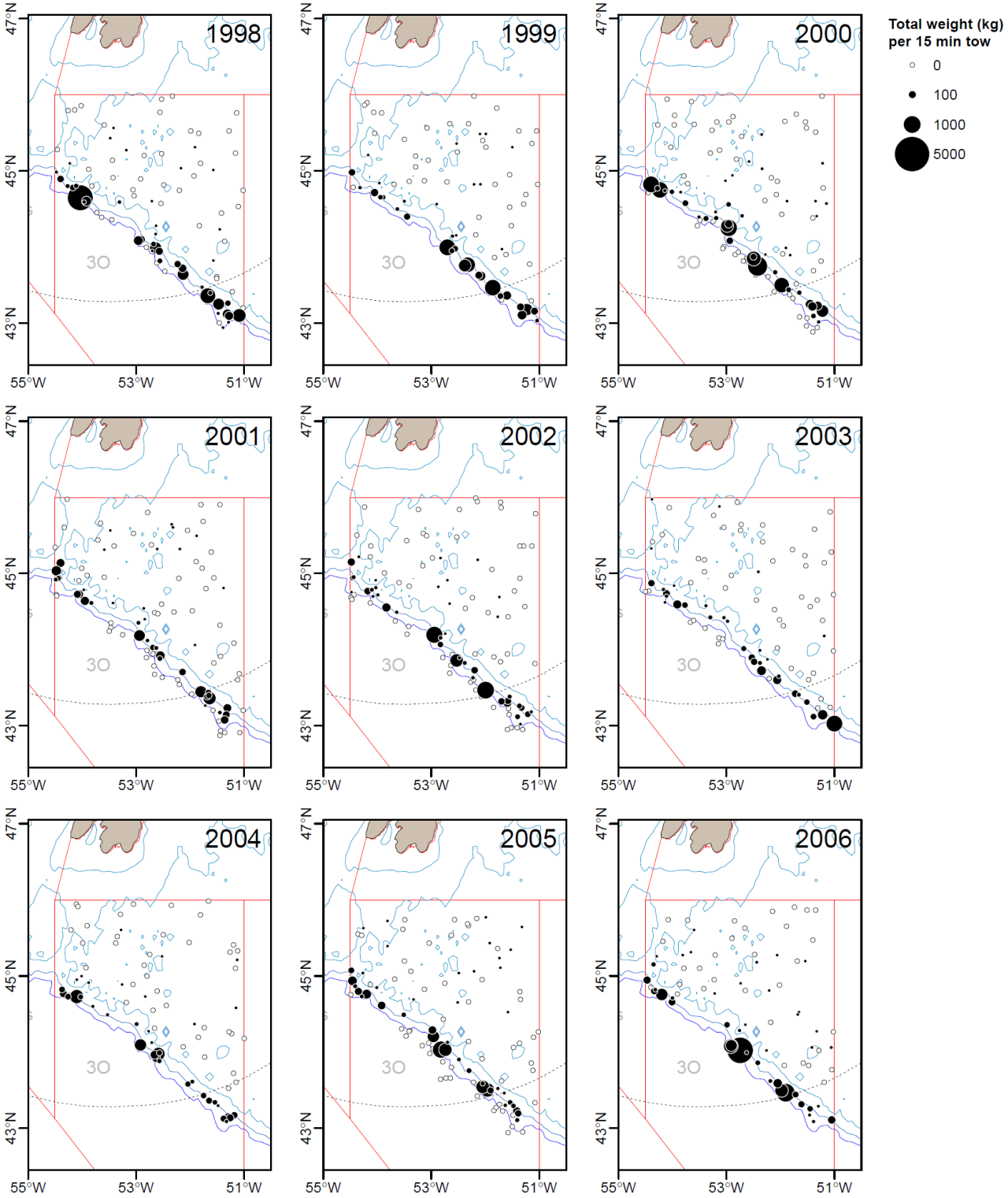
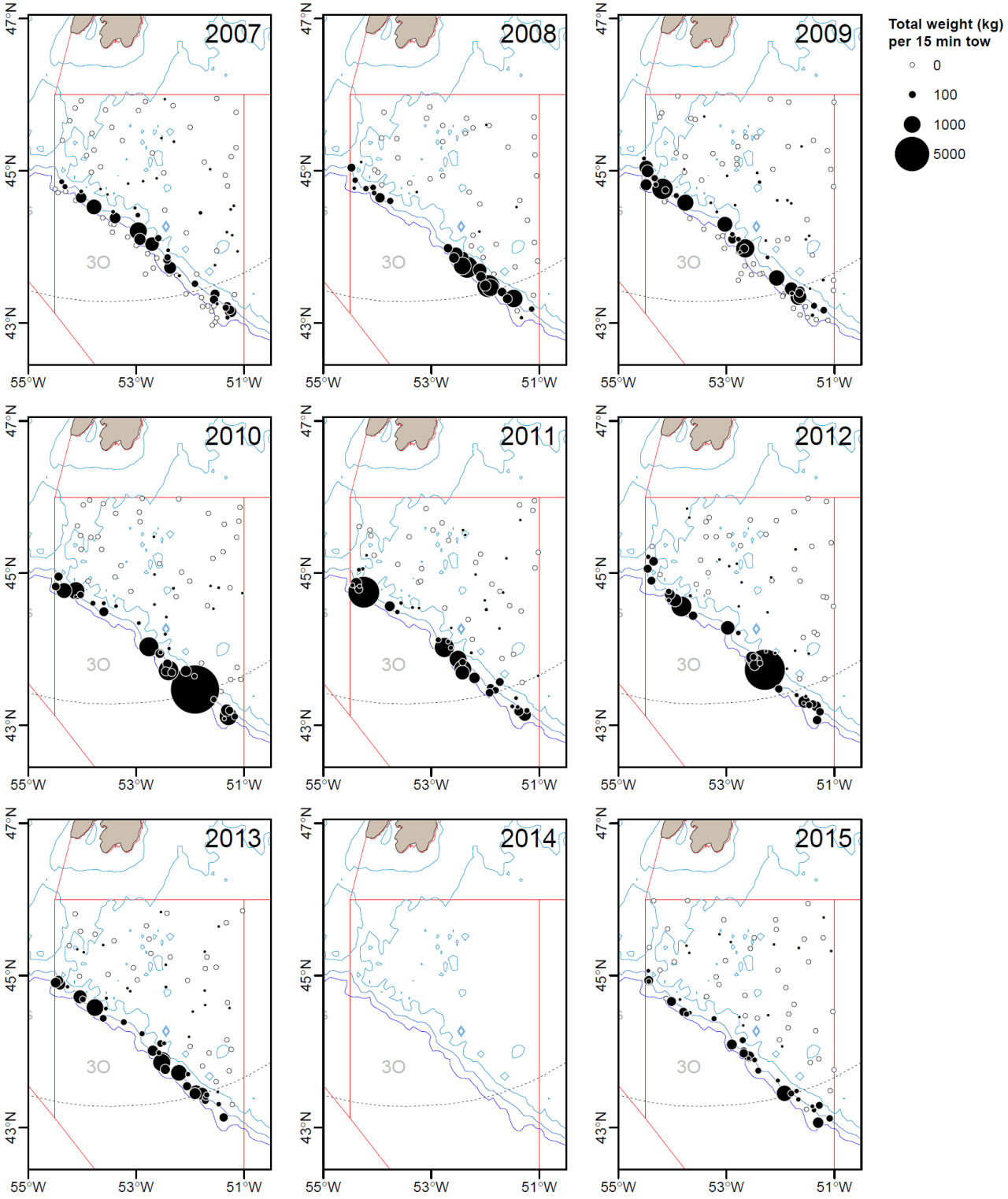


Fig. 10. Distribution plots: 3O Redfish (*Sebastes mentella* and *Sebastes fasciatus*). The symbols demonstrate survey set locations for the Canadian autumn multi-species surveys and the total standardized weight of Redfish caught at each location. Symbol area is proportional to catch weight.



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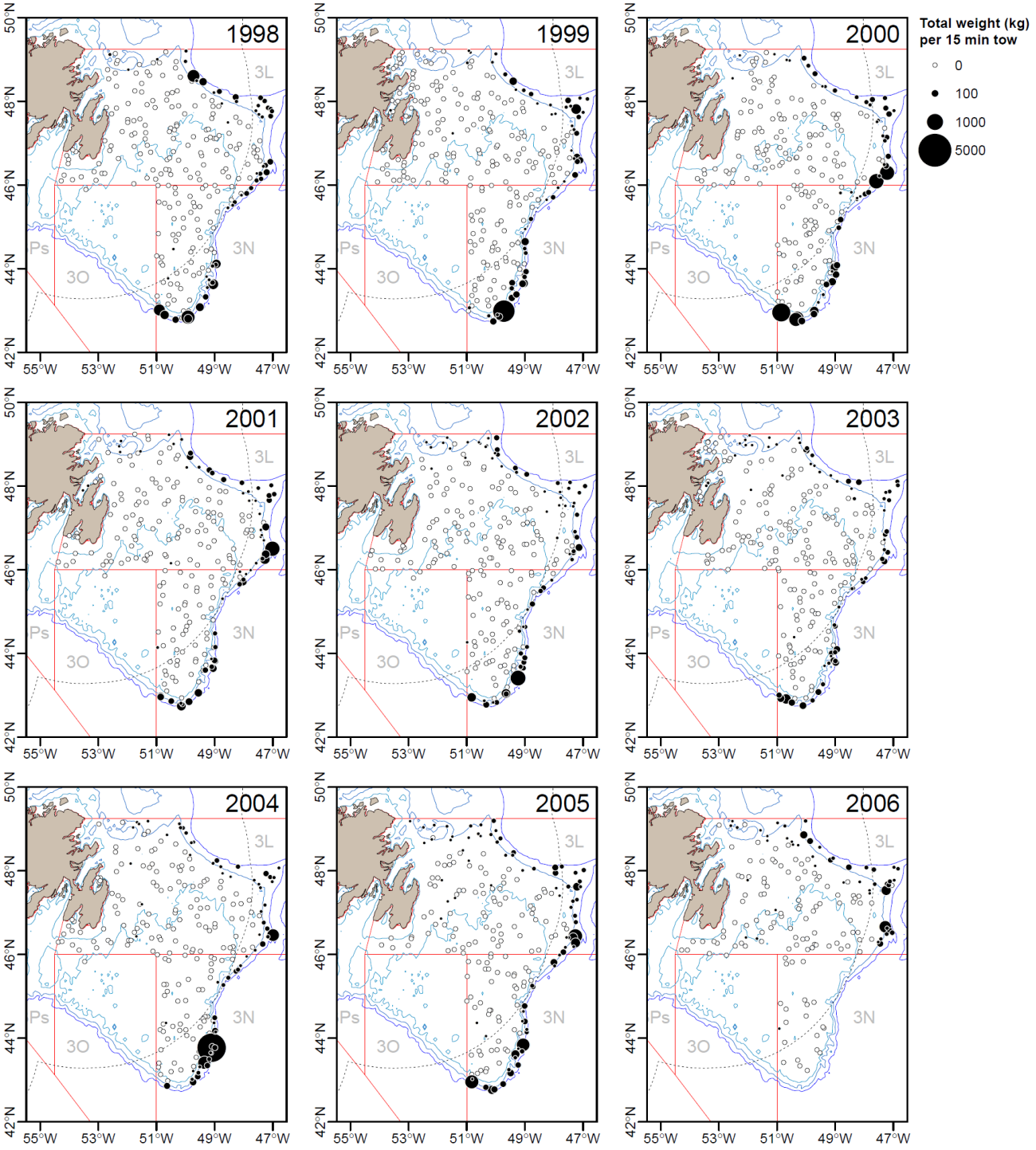
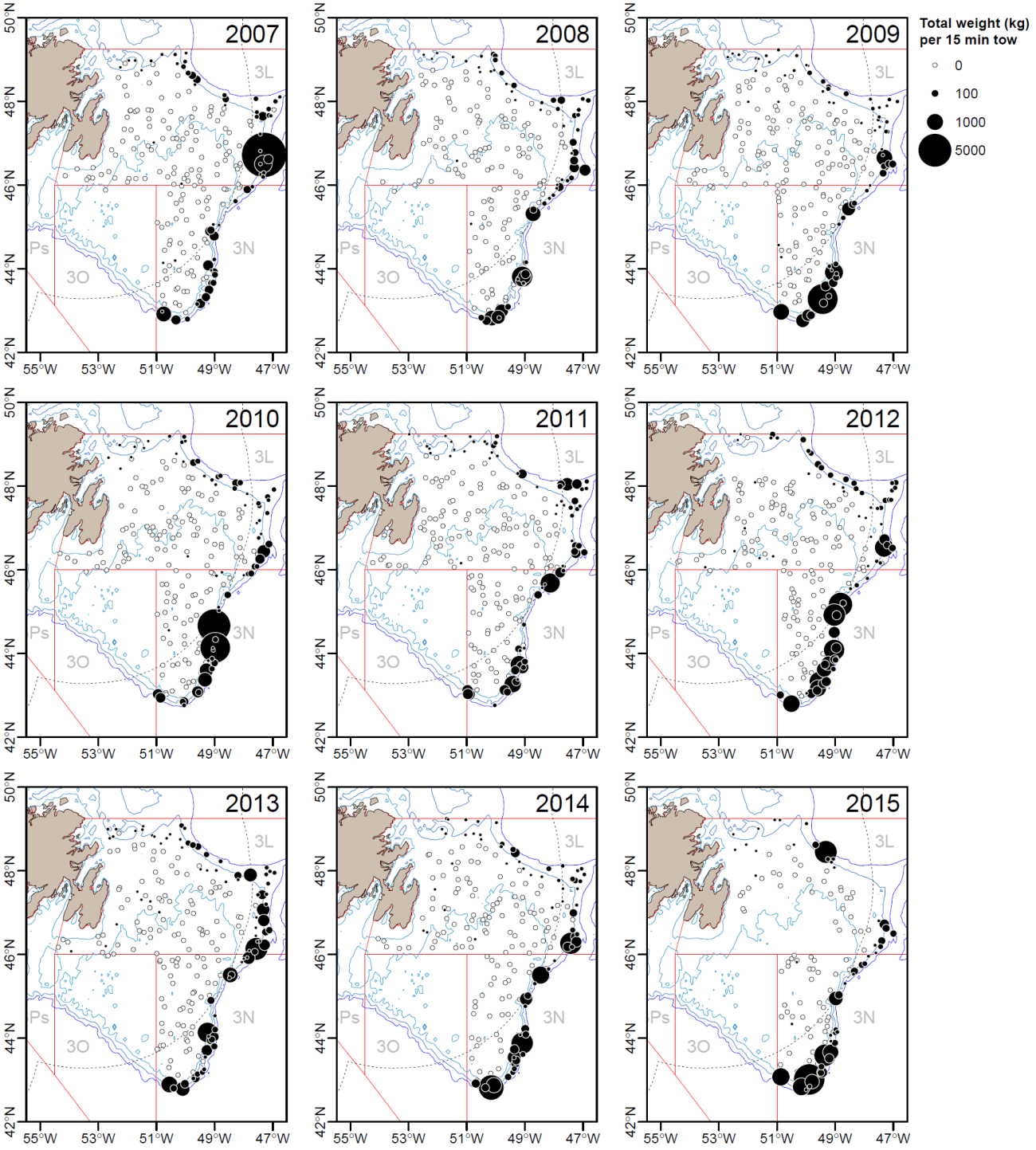


Fig. 11. Distribution plots: 3LN Redfish (*Sebastes mentella* and *Sebastes fasciatus*). The symbols demonstrate survey set locations for the Canadian spring multi-species surveys and the total standardized weight of Redfish caught at each location. Symbol area is proportional to catch weight.



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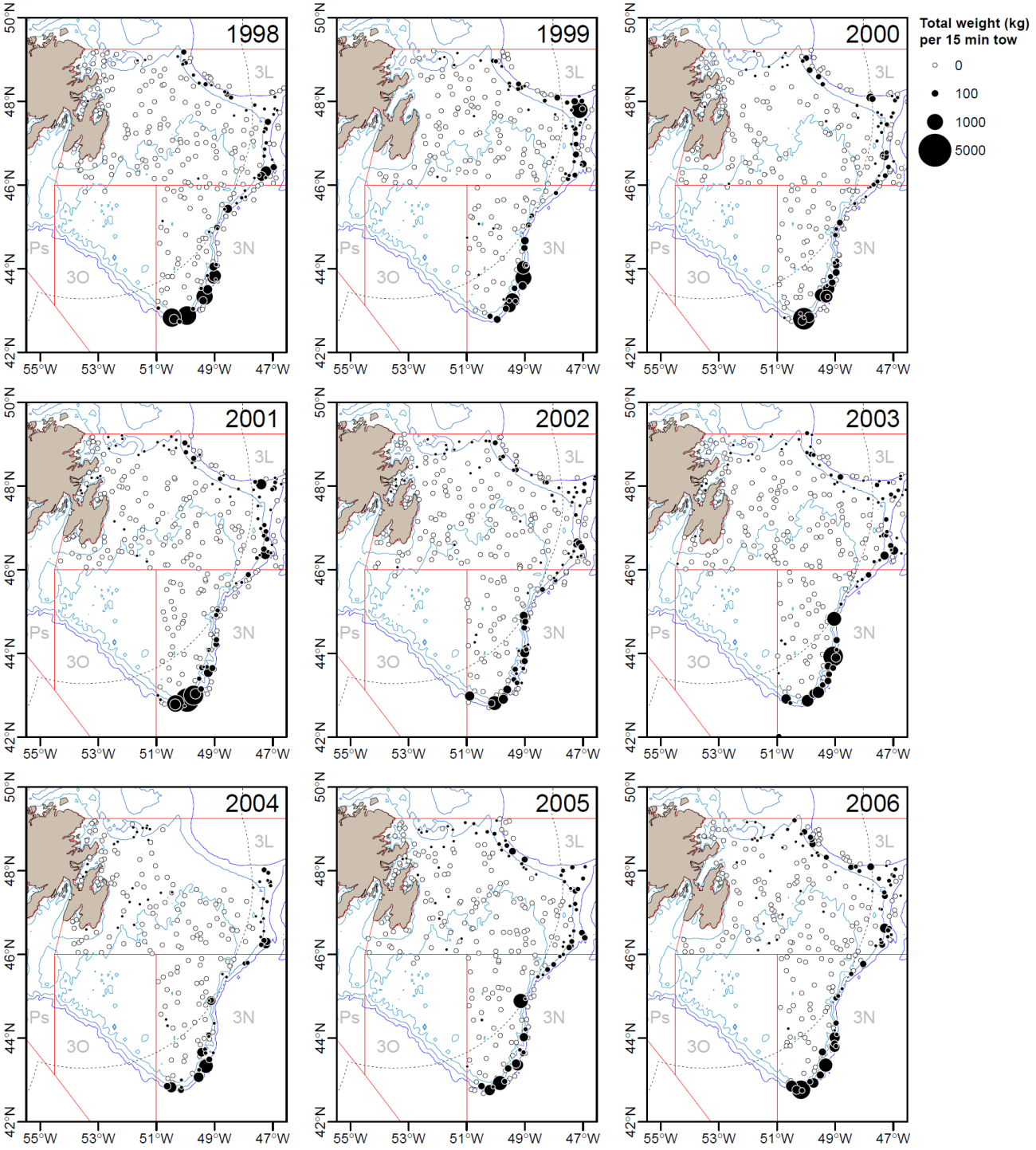
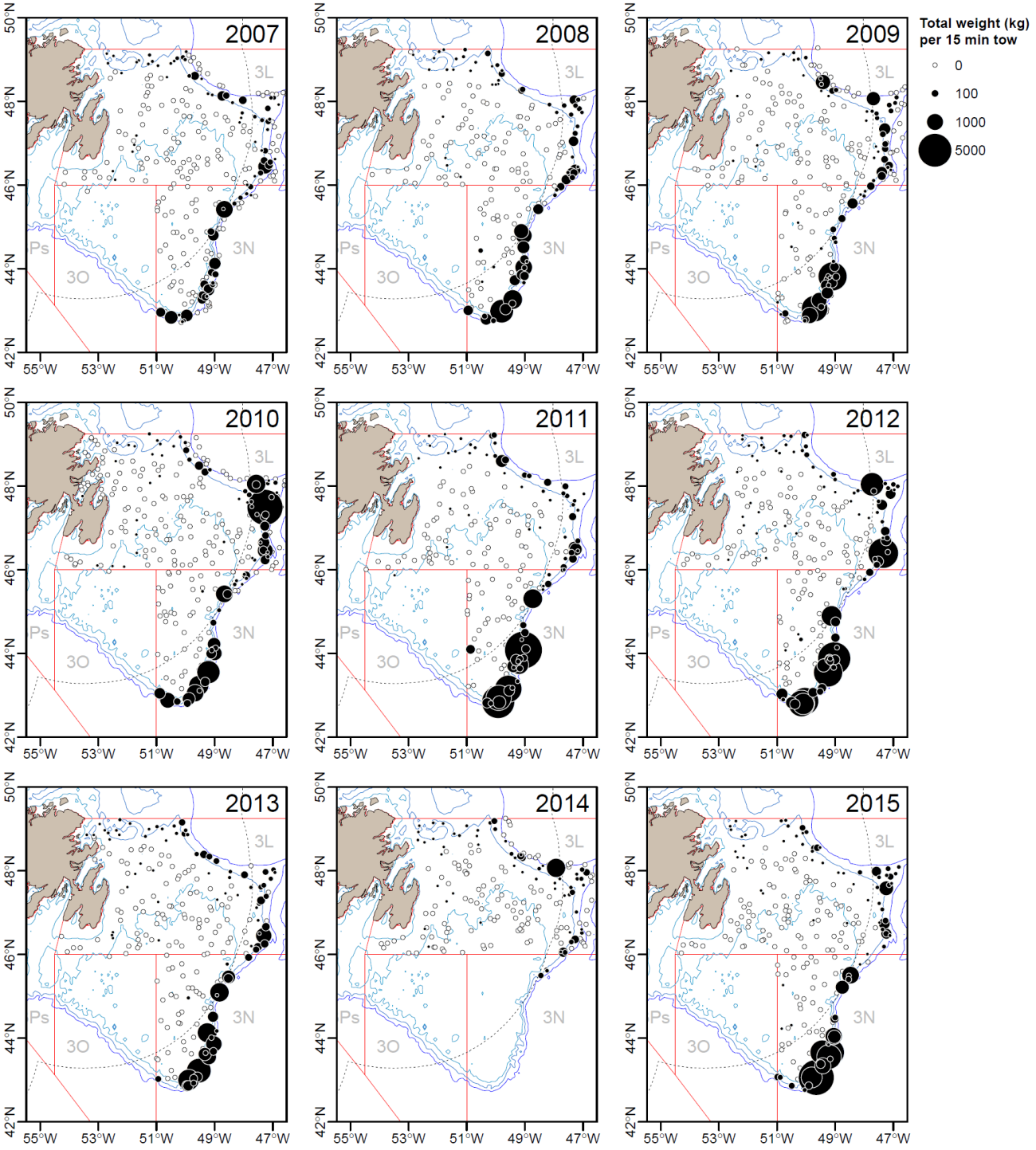


Fig. 12. Distribution plots: 3LN Redfish (*Sebastes mentella* and *Sebastes fasciatus*). The symbols demonstrate survey set locations for the Canadian autumn multi-species surveys and the total standardized weight of Redfish caught at each location. Symbol area is proportional to catch weight.



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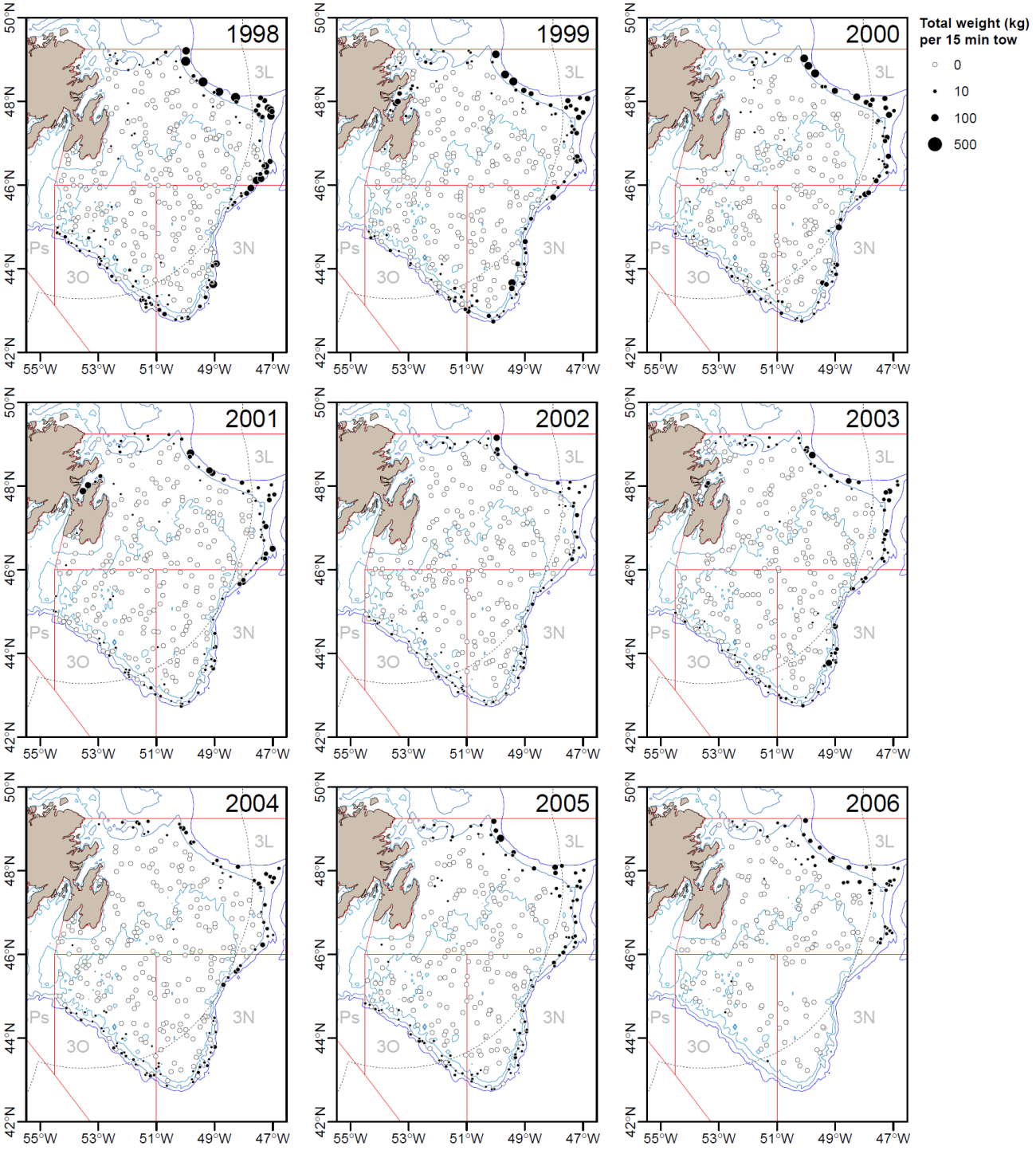
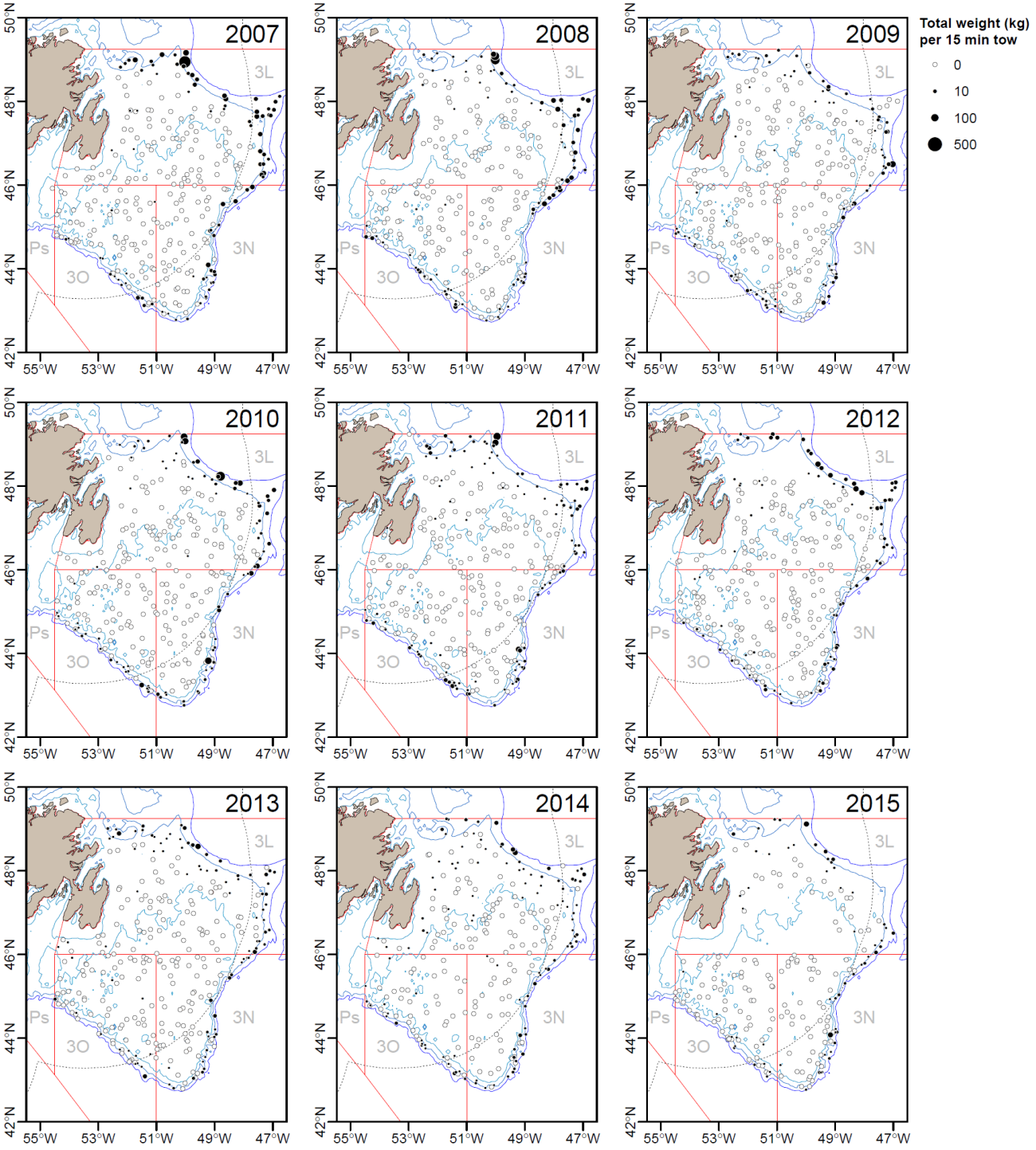


Fig. 13. Distribution plots: SA2+3KLMNO Greenland Halibut (*Reinhardtius hippoglossoides*). The symbols demonstrate survey set locations for the Canadian spring multi-species surveys and the total standardized weight of Greenland Halibut caught at each location. Symbol area is proportional to catch weight. Note that the Canadian spring multi-species survey does not cover the portion of the stock north of Div. 3L.



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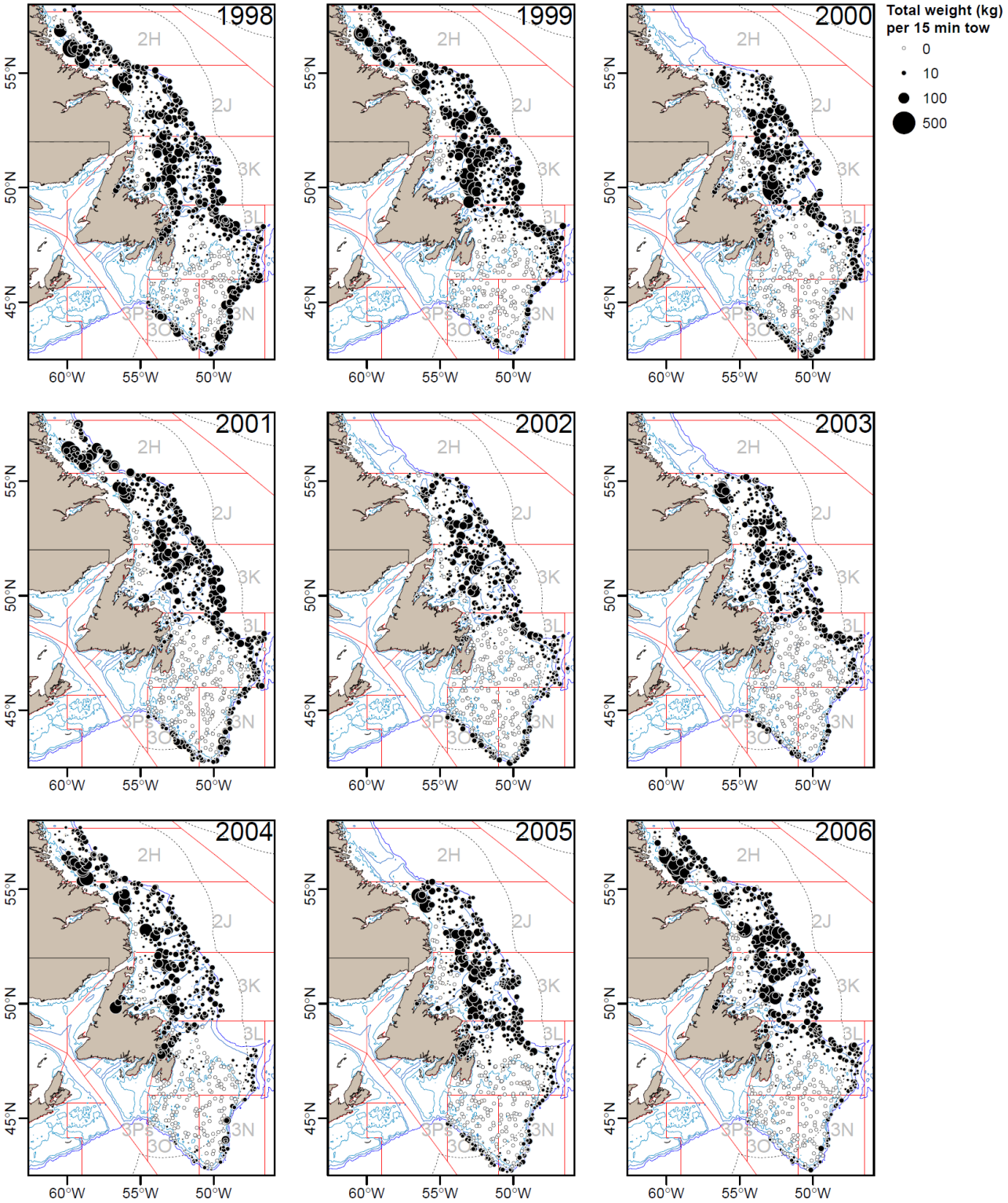
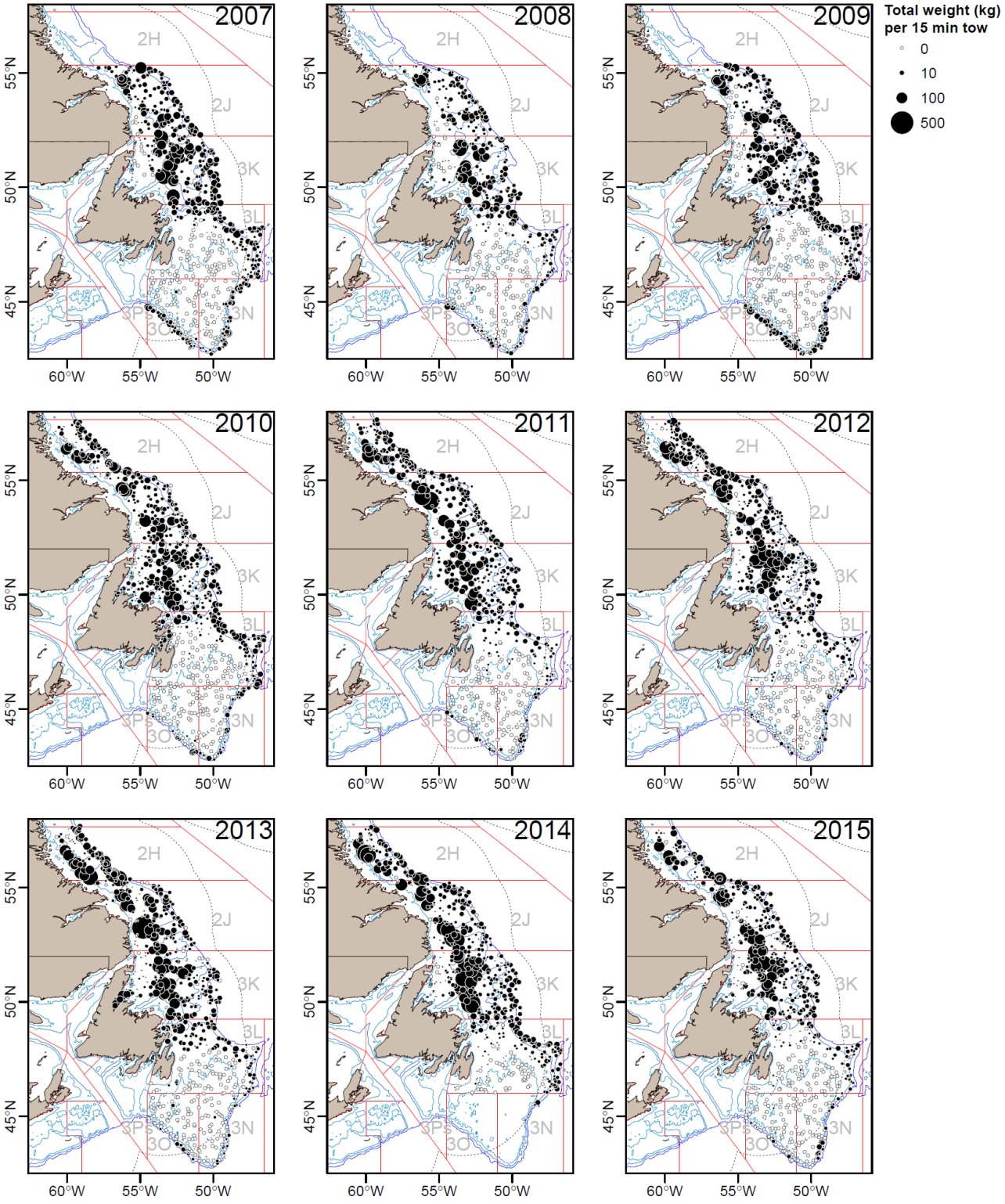


Fig. 14. Distribution plots: SA2+3KLMNO Greenland Halibut (*Reinhardtius hippoglossoides*). The symbols demonstrate survey set locations for the Canadian autumn multi-species surveys and the total standardized weight of Greenland Halibut caught at each location. Symbol area is proportional to catch weight.



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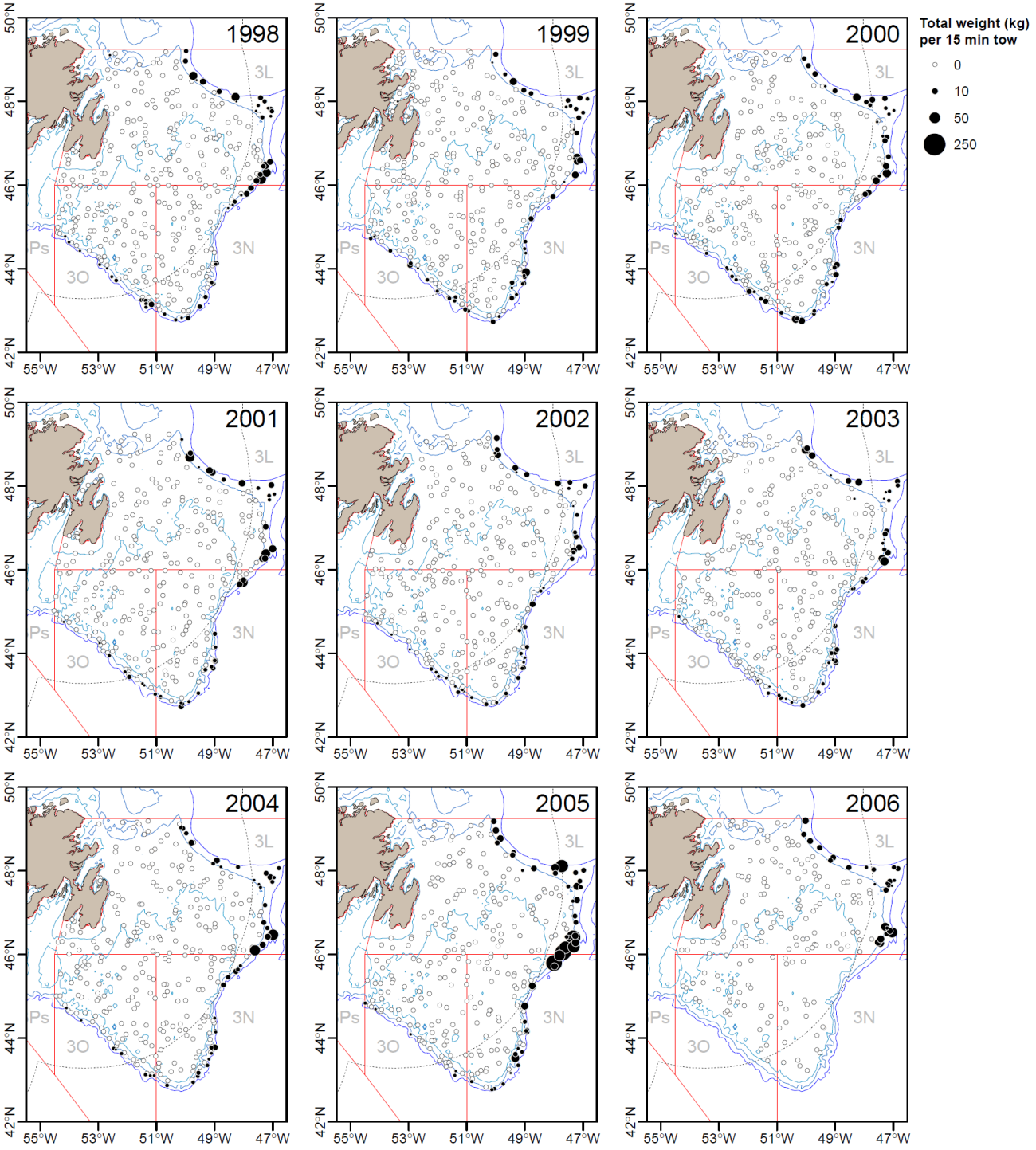
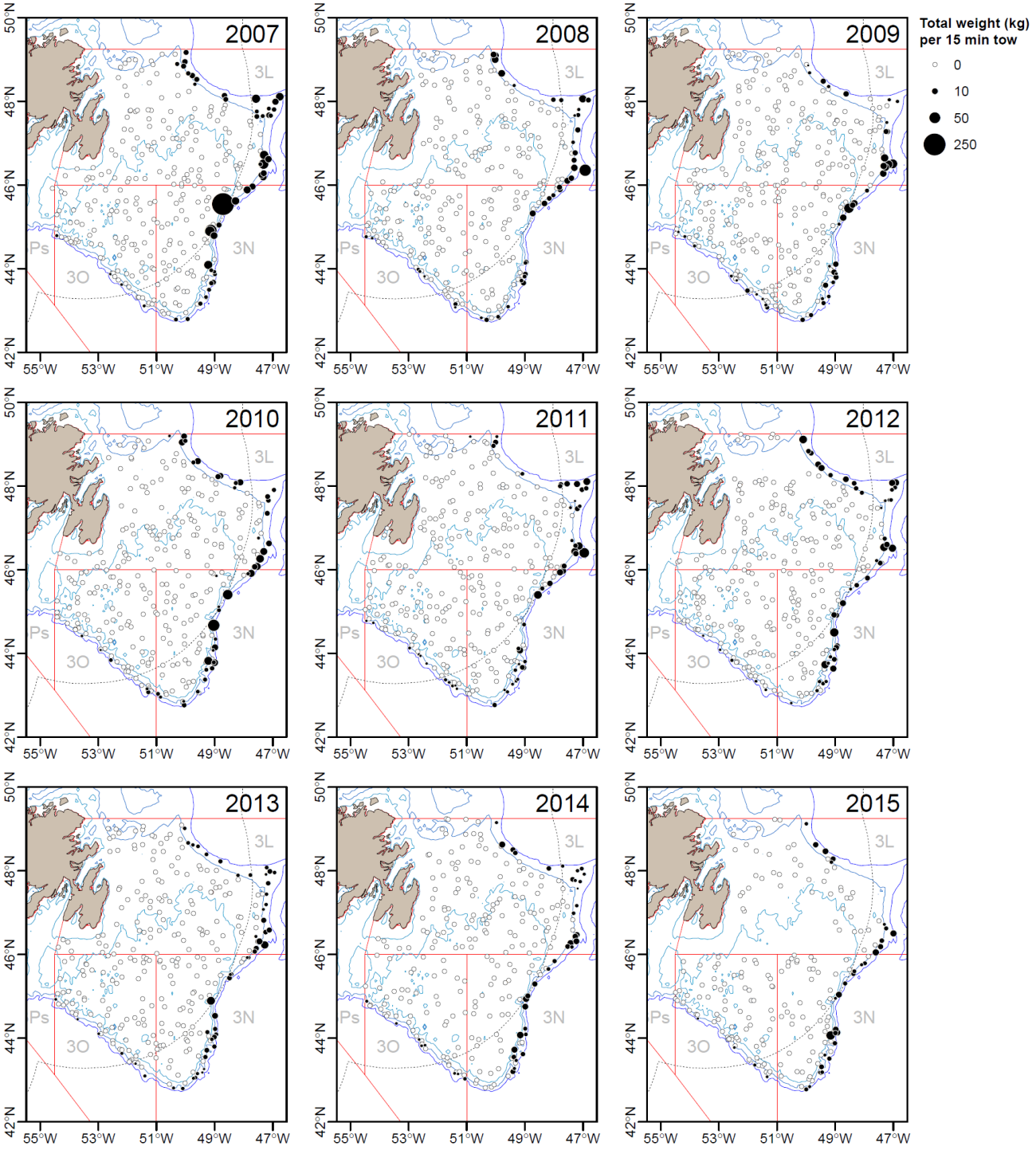


Fig. 15. Distribution plots: SA2+3 Roughhead Grenadier (*Macrourus berglax*). The symbols demonstrate survey set locations for the Canadian spring multi-species surveys and the total standardized weight of Roughhead Grenadier caught at each location. Symbol area is proportional to catch weight. Note that the Canadian spring multi-species survey does not cover the portion of the stock north of Div. 3L.



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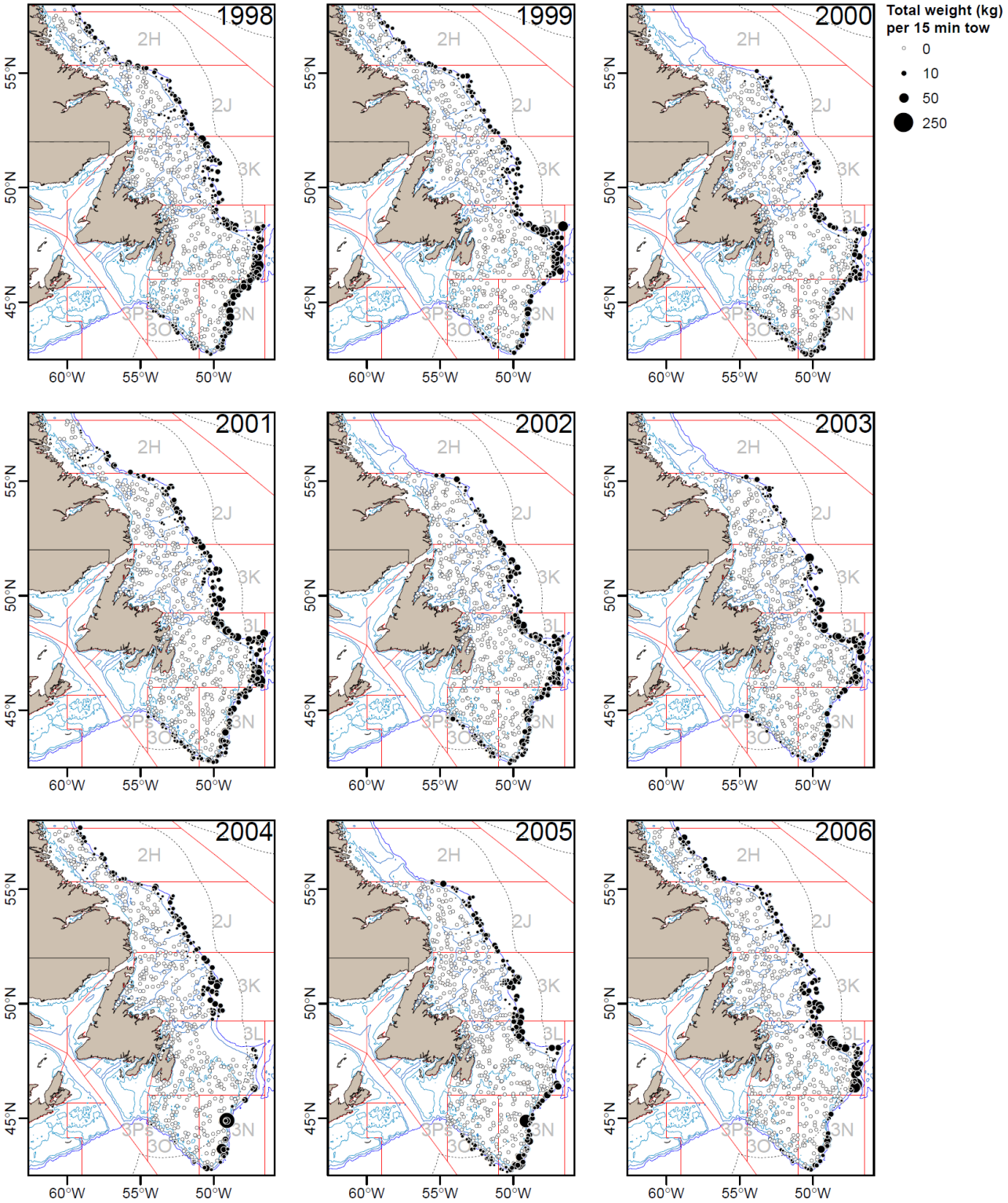
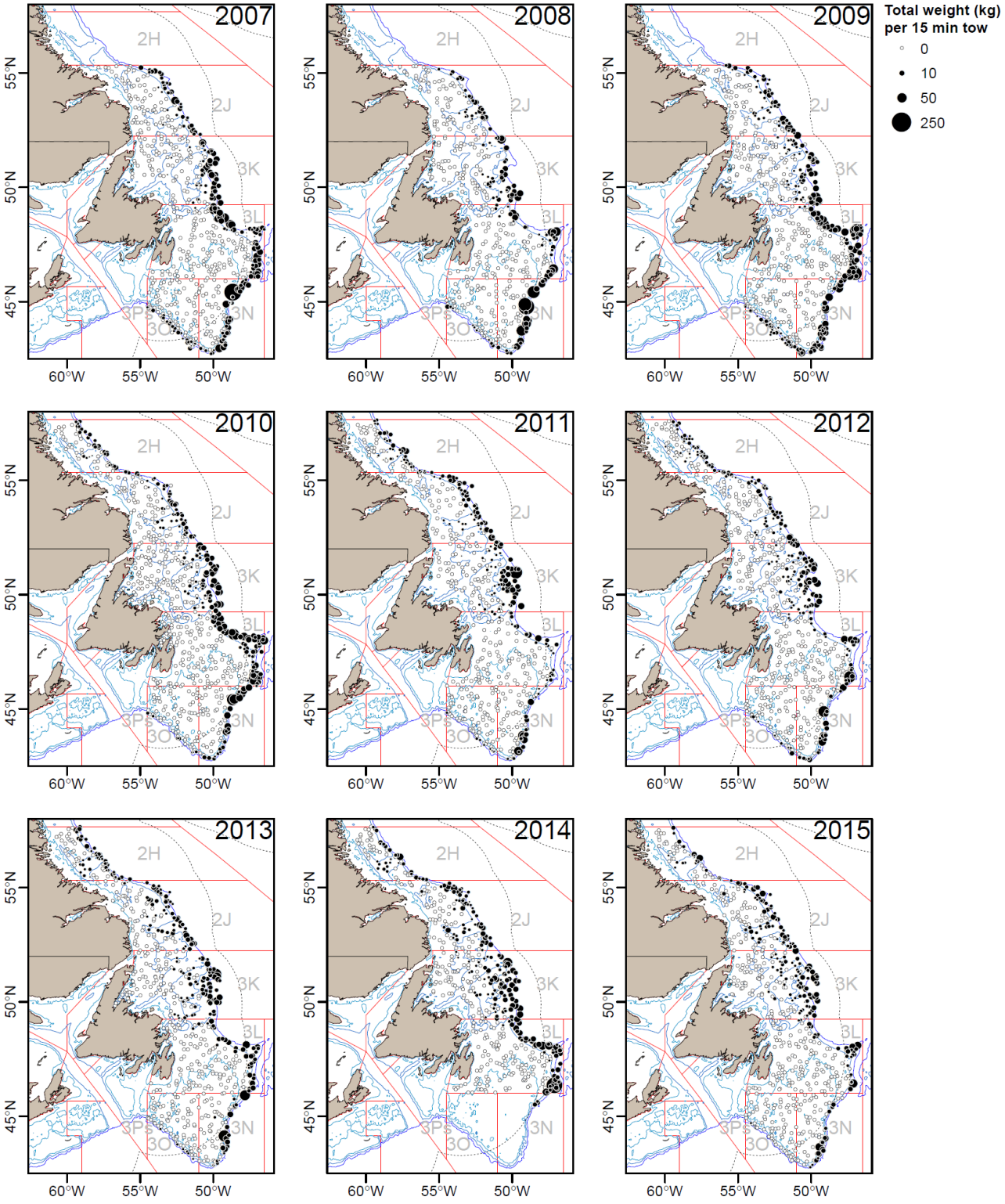


Fig. 16. Distribution plots: SA2+3 Roughead Grenadier (*Macrourus berglax*). The symbols demonstrate survey set locations for the Canadian autumn multi-species surveys and the total standardized weight of Roughead Grenadier caught at each location. Symbol area is proportional to catch weight.



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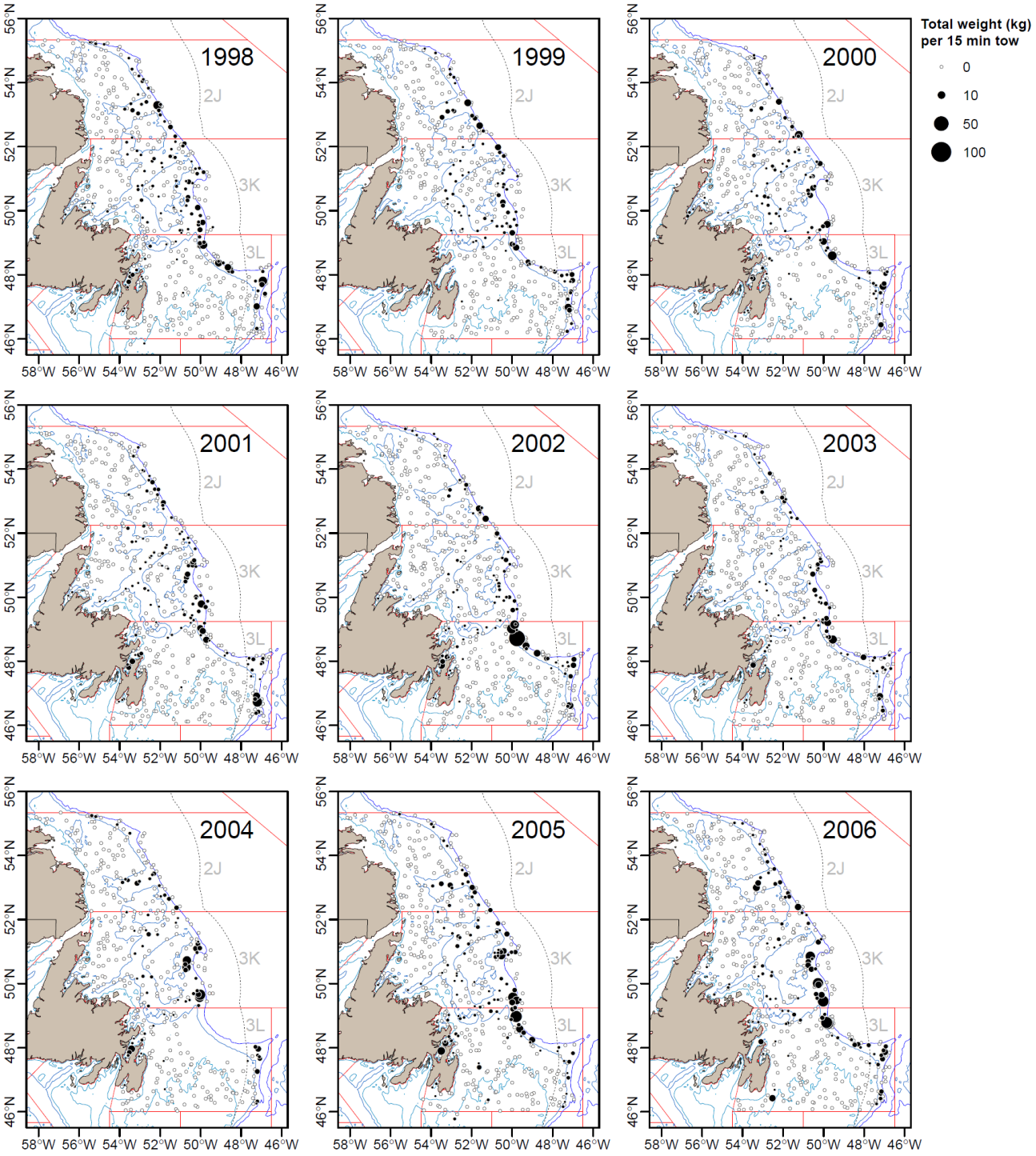
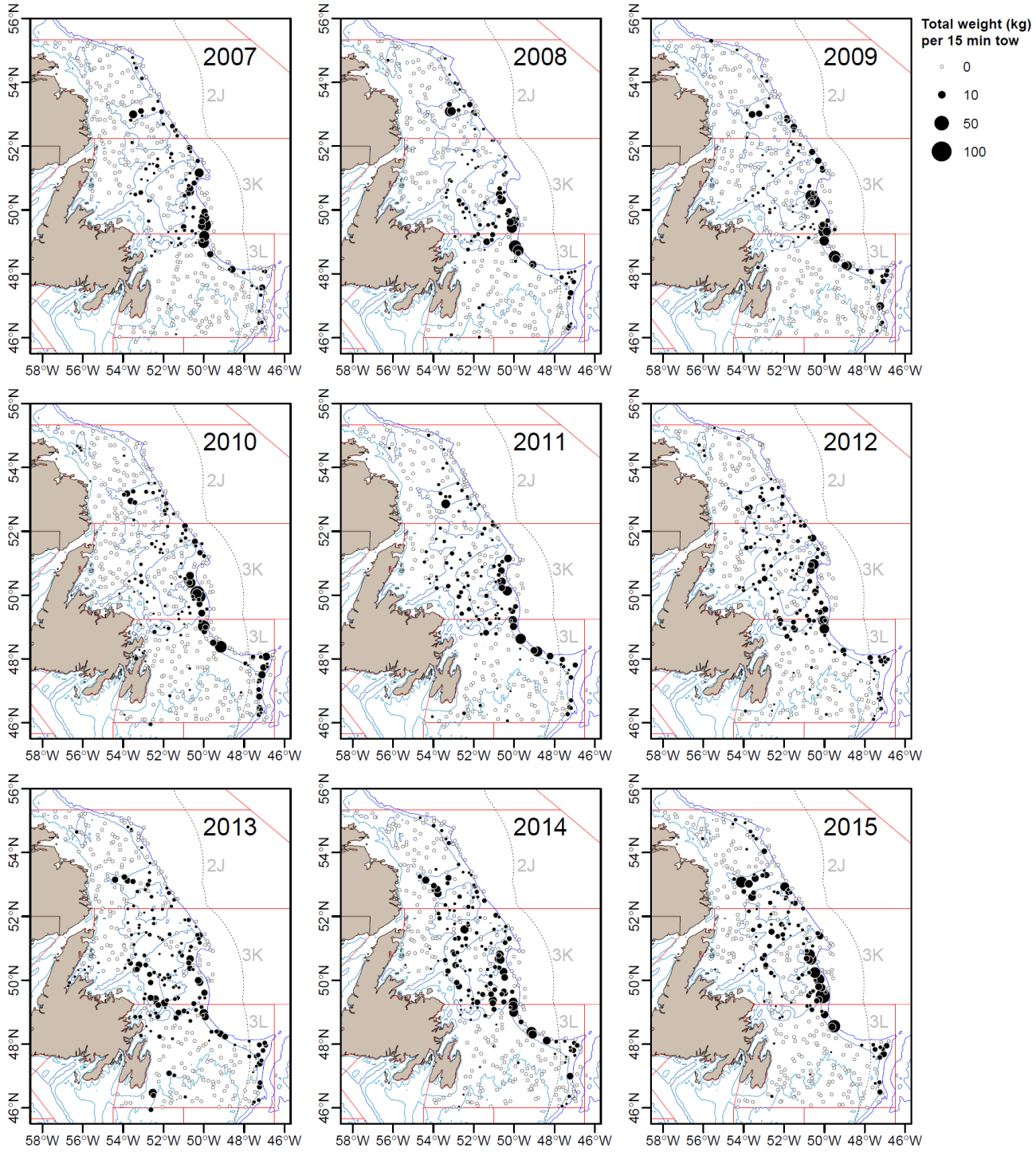


Fig. 17. Distribution plots: 2J3KL Witch Flounder (*Glyptocephalus cynoglossus*). The symbols demonstrate survey set locations for the Canadian autumn multi-species surveys and the total standardized weight of Witch Flounder caught at each location. Symbol area is proportional to catch weight.



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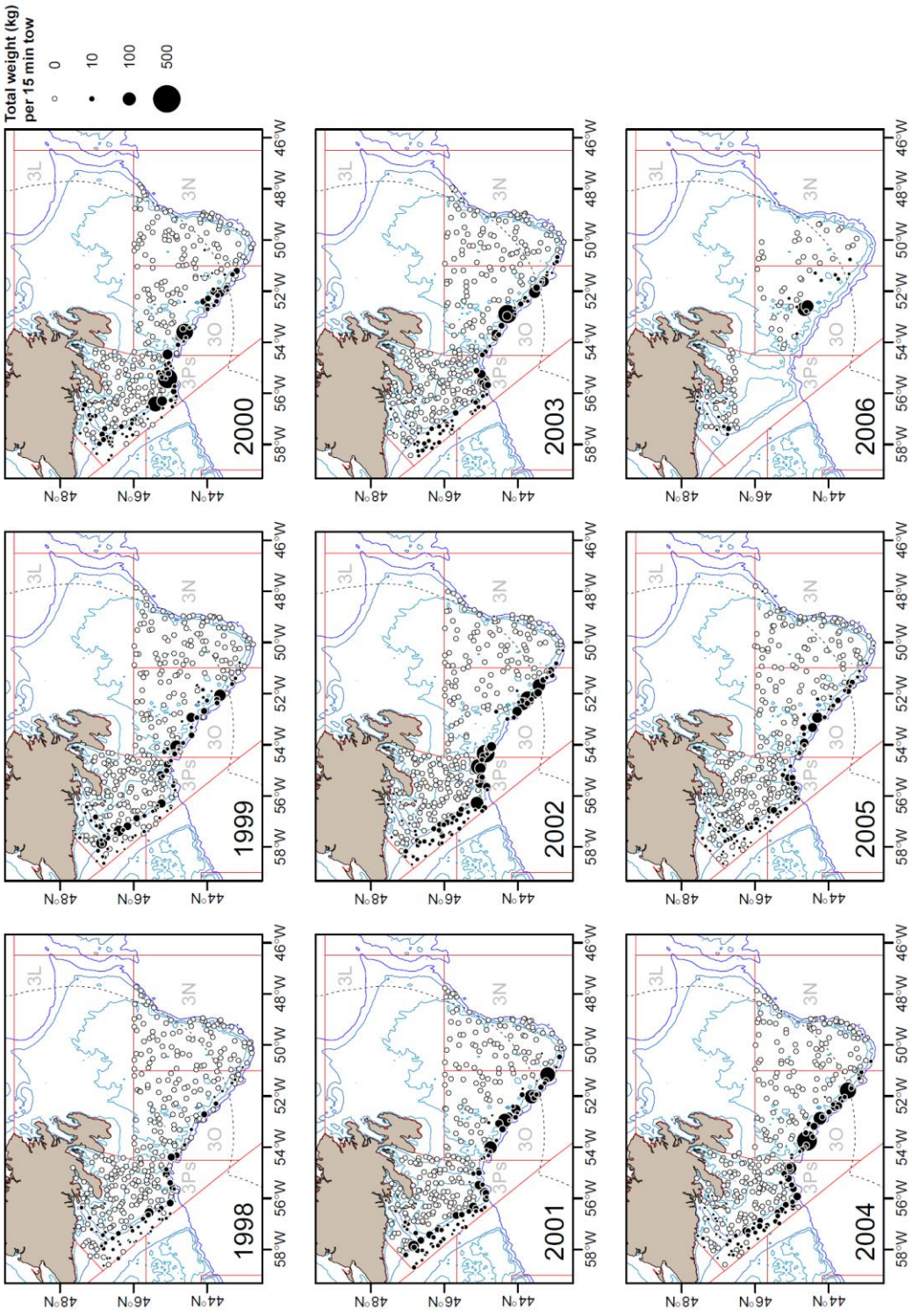

Fig. 18. Distribution plots: 3NOPs White Hake (*Urophycis tenuis*). The symbols demonstrate survey set locations for the Canadian spring multi-species surveys and the total standardized weight of White Hake caught at each location. Symbol area is proportional to catch weight. Note that NAFO manages the portion of this stock in Divs. 3NO while the portion of the stock in Subdiv. 3Ps is managed by Canada.

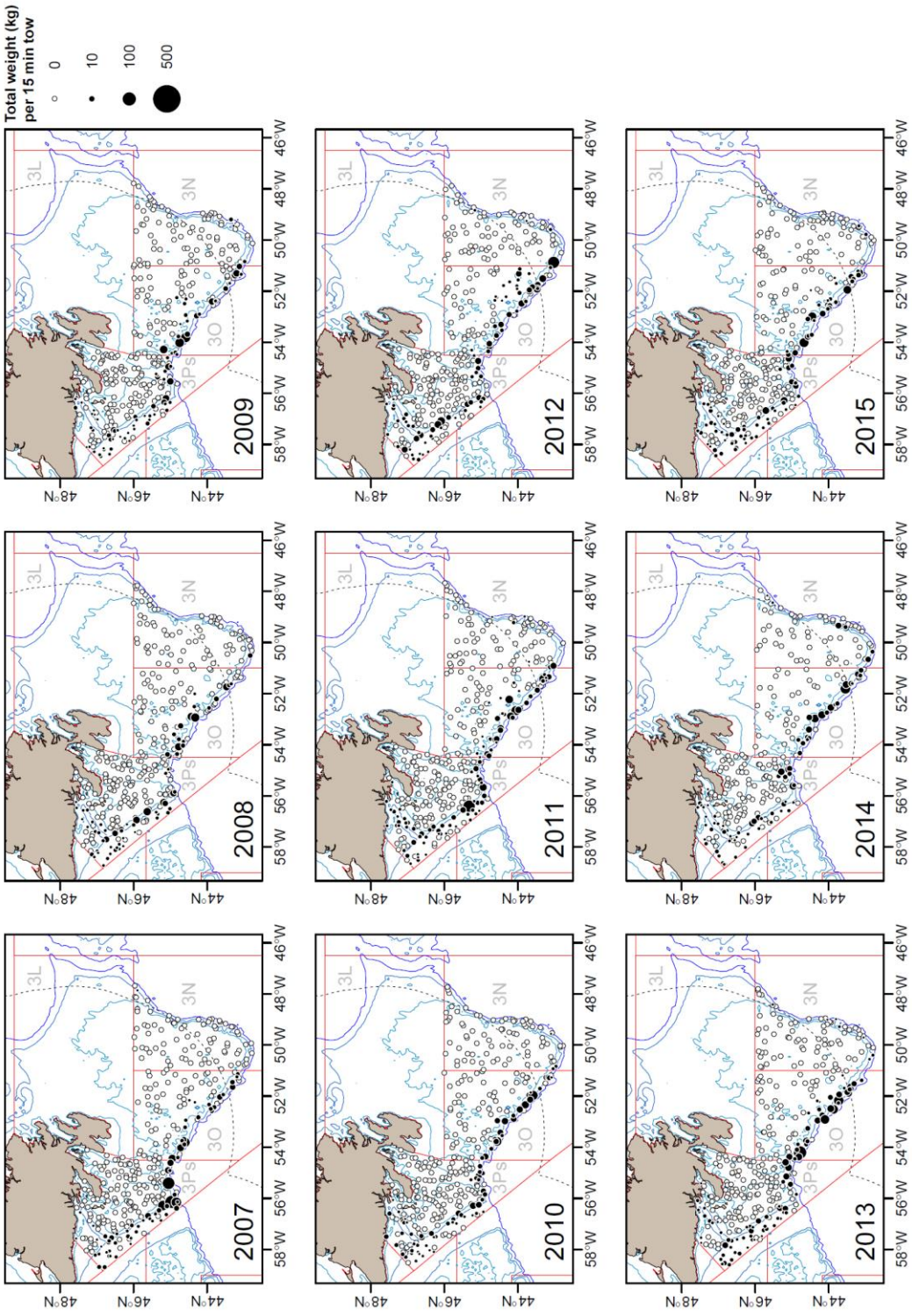

Fig. 18. Continued…

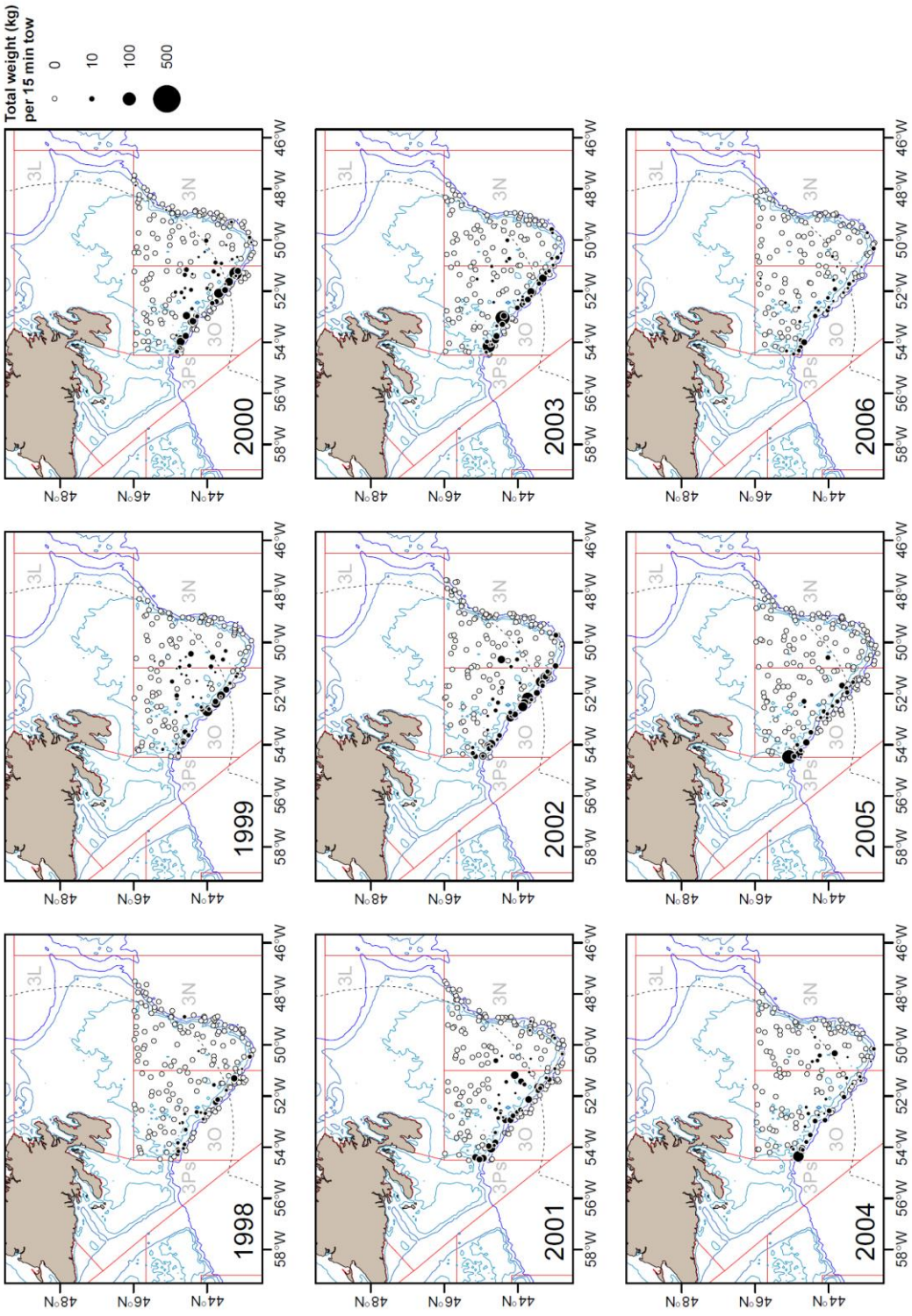

Fig. 19. Distribution plots: 3NOPs White Hake (*Urophycis tenuis*). The symbols demonstrate survey set locations for the Canadian autumn multi-species surveys and the total standardized weight of White Hake caught at each location. Symbol area is proportional to catch weight. Note that NAFO manages the portion of this stock in Divs. 3NO while the portion of the stock in Subdiv. 3Ps is managed by Canada.

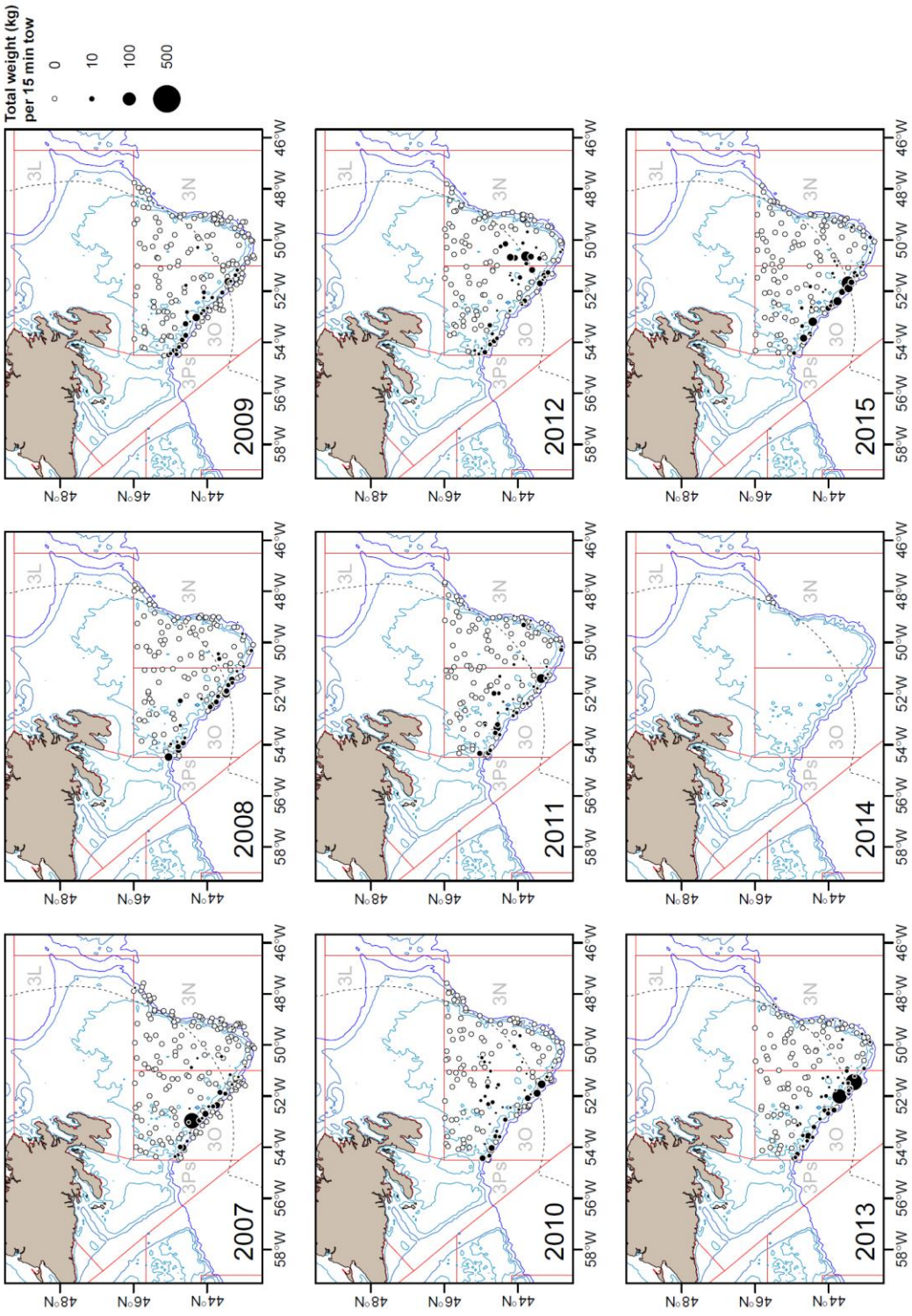

Fig. 19. Continued…

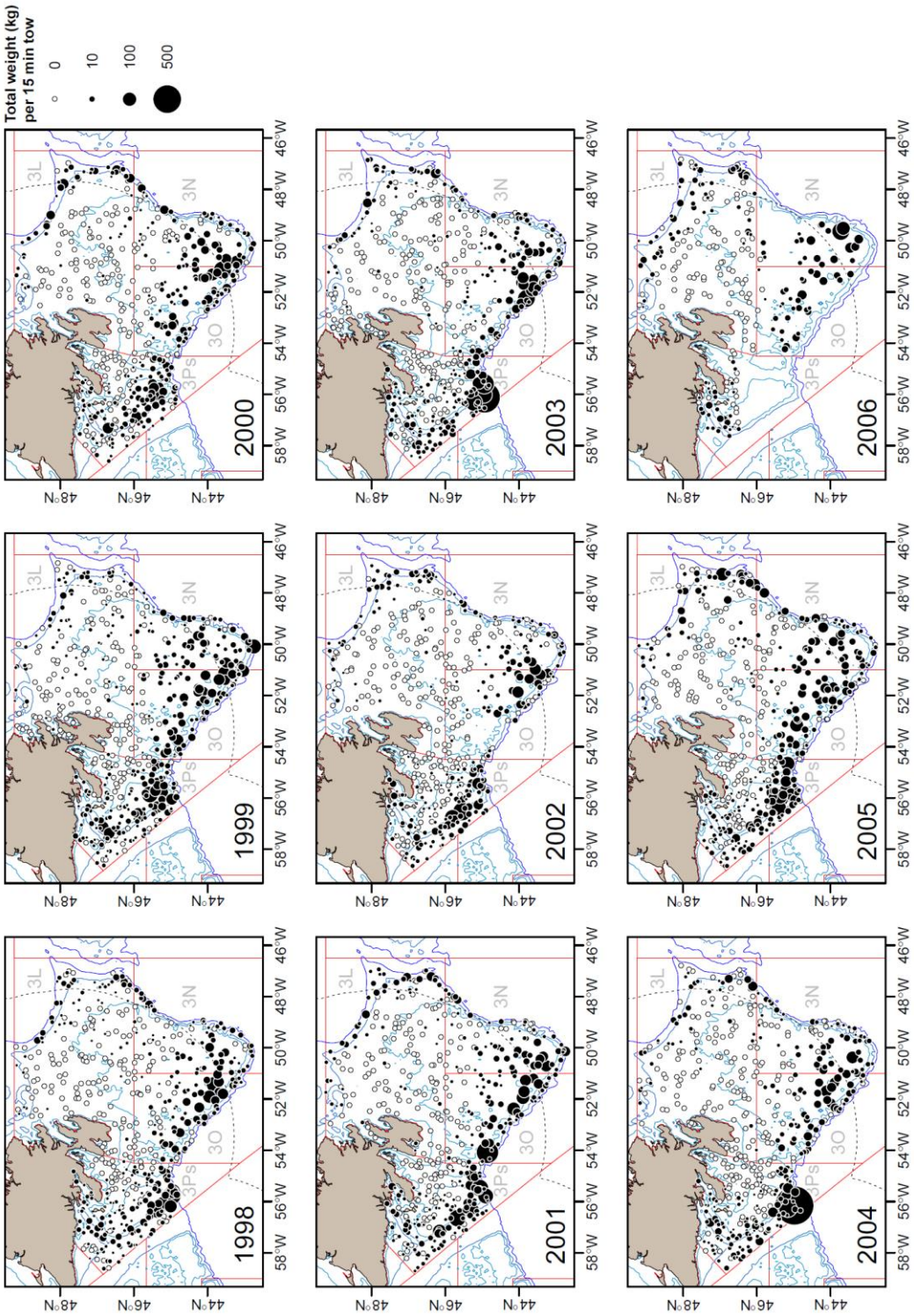

Fig. 20. Distribution plots: 3LNOPs Thorny Skate (*Amblyraja radiata*). The symbols demonstrate survey set locations for the Canadian spring multi-species surveys and the total standardized weight of Thorny Skate caught at each location. Symbol area is proportional to catch weight. Note that NAFO manages the portion of this stock in Divs. 3LNO while the portion of the stock in Subdiv. 3Ps is managed by Canada.

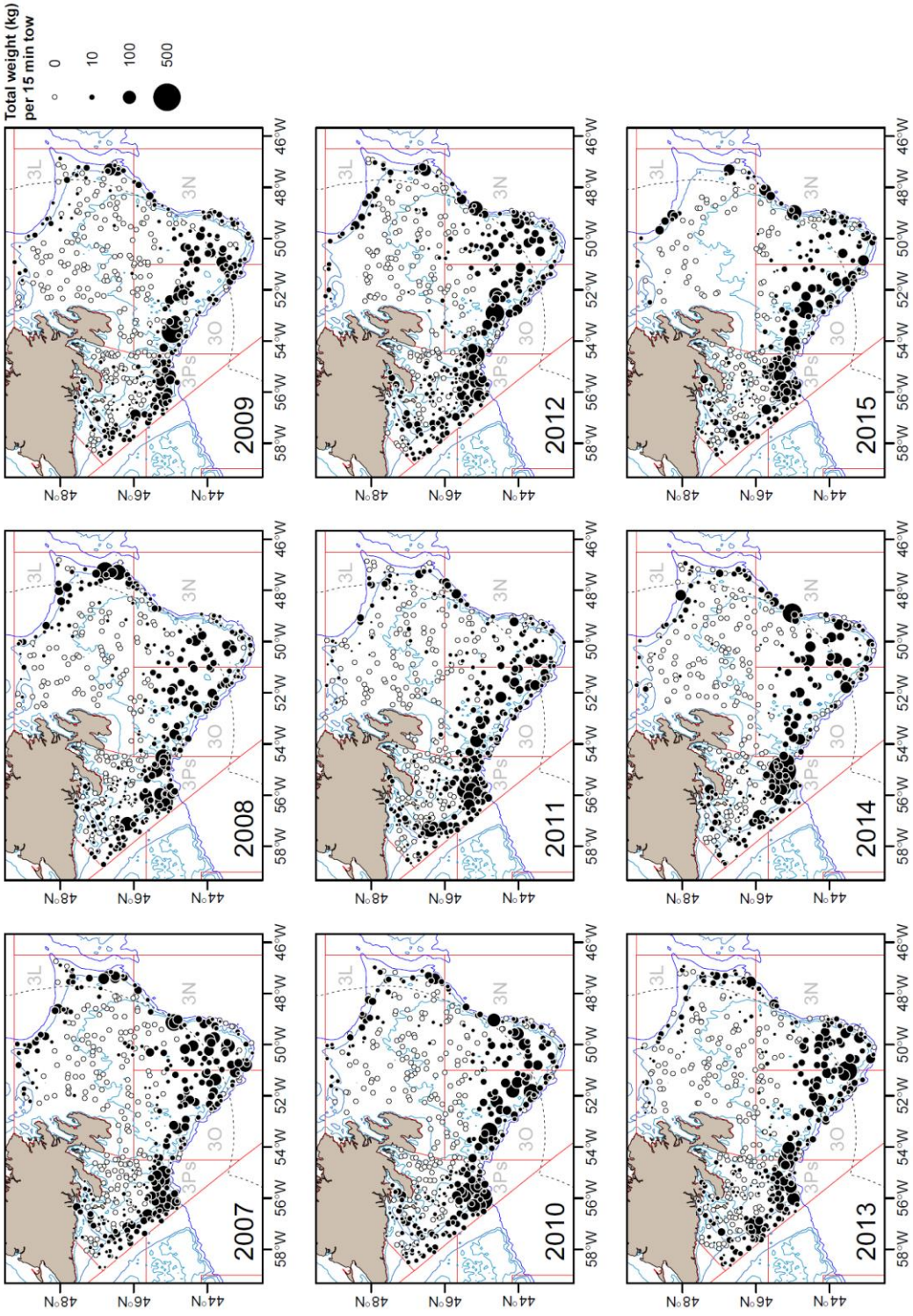

Fig. 20. Continued…

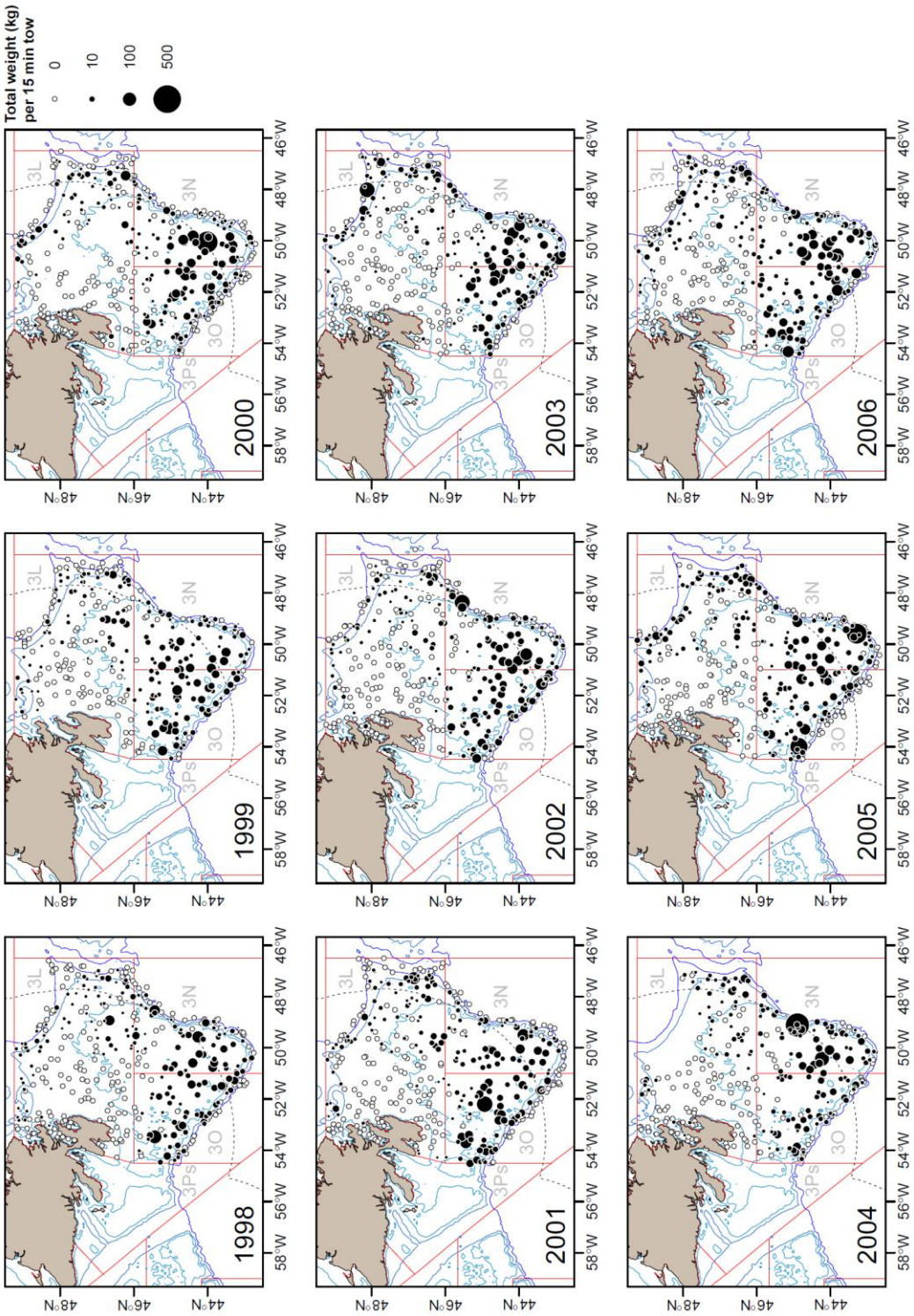

Fig. 21. Distribution plots: 3LNOPs Thorny Skate (*Amblyraja radiata*). The symbols demonstrate survey set locations for the Canadian autumn multi-species surveys and the total standardized weight of Thorny Skate caught at each location. Symbol area is proportional to catch weight. Note that NAFO manages the portion of this stock in Divs. 3LNO while the portion of the stock in Subdiv. 3Ps is managed by Canada.

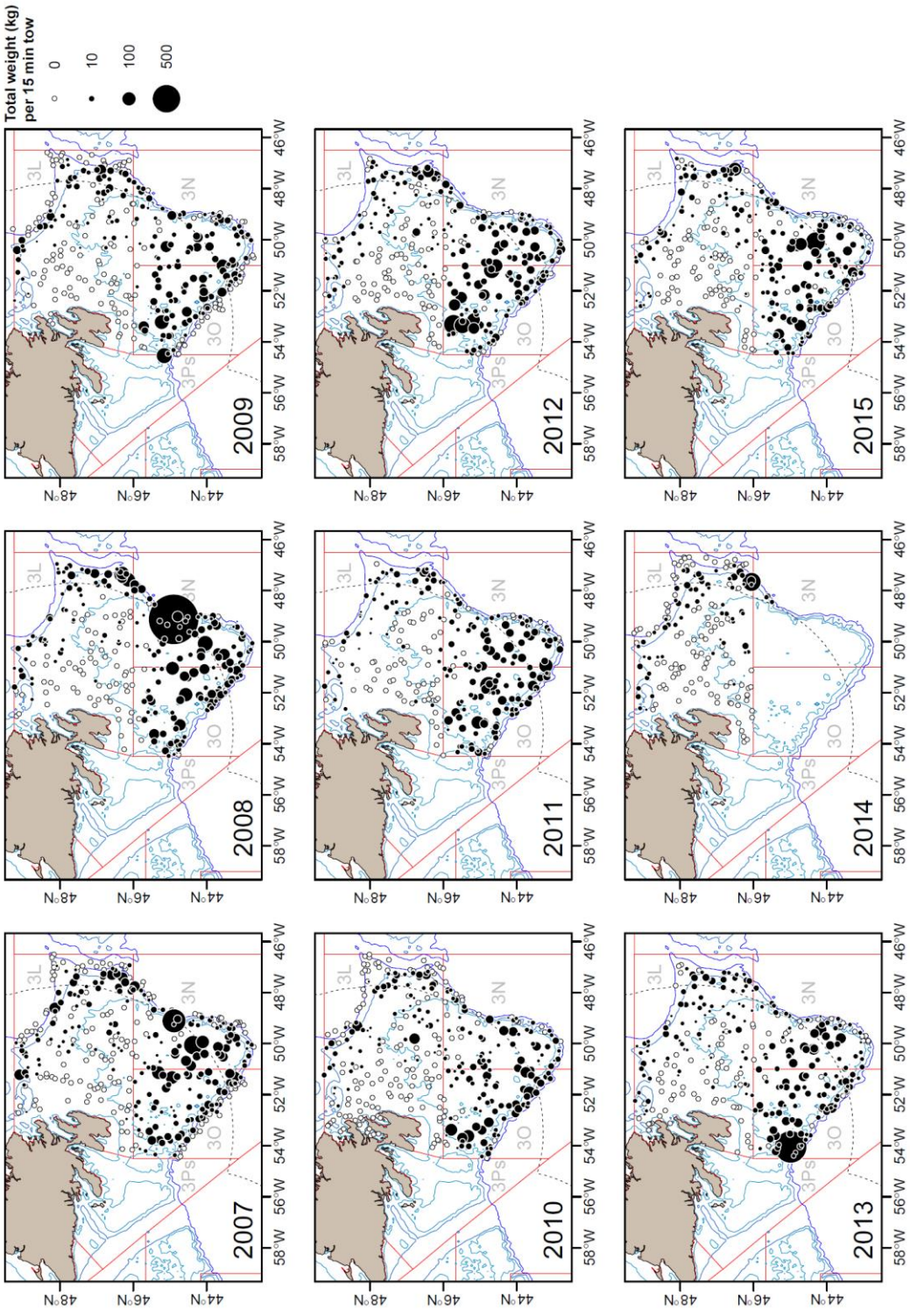

Fig. 21. Continued…