NOAA Technical Memorandum NMFS-NE-199

Distribution and Abundance of Fish Eggs Collected during the GLOBEC Broad-scale Georges Bank Surveys, 1995-1999

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
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Distribution and Abundance of Fish Eggs Collected during the GLOBEC Broad-scale Georges Bank Surveys, 1995-1999

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Appendix Table and Figures

ABSTRACT

This regional atlas summarizes and illustrates data on fish eggs collected from the U.S. GLOBEC Georges Bank broad-scale surveys from 1995 through 1999. Distributions and abundances are presented for 26 ichthyoplankton taxa from egg density maps by survey, with accompanying discussion of seasonal patterns and spawning variation.

List of Acronyms

CTD	=	conductivity, temperature, depth
MARMAP	=	Marine Resource Monitoring Assessment and Prediction
MOCNESS	=	Multiple Opening Closing Net Environmental Sampling System
NEFSC	=	Northeast Fisheries Science Center
NOAA	=	National Oceanic and Atmospheric Administration
U.S. GLOBEC	=	United States GLOBal ocean ECosystems dynamics

INTRODUCTION

The U.S. GLOBEC (United States GLOBal ocean ECosystems dynamics) Georges Bank program was designed to address the influence of climate change on productivity, abundance, and distribution of marine organisms on Georges Bank (also referred to within this paper as "the Bank"). Appendix Figure 1 shows the geographic study area. The broad-scale surveys were a principal component of the GLOBEC program, in which bank-wide survey coverage was conducted to monitor changes in both the physical and biological processes that influence the Georges Bank ecosystem. This atlas depicts the distribution and abundance trends of fish eggs collected with a 61-cm bongo plankton sampler from 30 broad-scale surveys during six months each year over five years of study. The abundance and distribution of fish eggs provide valuable information on spawning times, areas, and intensities. The correlation of this information to environmental parameters will help in understanding the factors which influence fluctuations in year-class strength and survival in the early life stages of fish. Pictorial maps displaying abundance and distribution of fish eggs are presented for 26 taxa. This report is the first comprehensive fish egg study to be documented on the Bank since the Marine Resource Monitoring Assessment and Prediction (MARMAP) 1977 to 1987 program.

METHODS

Broad-scale surveys were conducted monthly, surveying the Georges Bank region during the winter through late spring-early summer from 1995 through 1999. Individual survey information along with the cruise (survey) report can be obtained from the U.S. GLOBEC Georges Bank website (http://globec.whoi.edu). The 1995 monthly surveys began in February and ended in July with 38 stations selected to cover Georges Bank, its slope waters, and adjacent Gulf of Maine region. Beginning in 1996, the sampling period began in January and ended in June, and stations were added, resulting in 39 stations for 1996, 40 stations for 1997, and 41 stations for 1998 and 1999. In 1996 (all months but June), the ichthyoplankton sampling density was supplemented with extra bongo tows at new locations within the overall survey scheme. The distribution pattern for supplementary bongo tows was changed again in 1997 to include a bongo tow made halfway between stations on all monthly surveys from January to May. This intermediate bongo tow scheme was retained in 1998 and 1999.

Ichthyoplankton samples were collected with a 0.61-m bongo frame fitted with 333-µm mesh nets (Posgay and Marak 1980). Digital flow meters were suspended in the aperture of each net to determine the volume of water filtered. A 45-kg ball was attached beneath the bongo frame to depress the sampler. A real-time CTD (conductivity, temperature, depth) profiler was attached to the towing wire above the frame to measure temperature and salinity, and to monitor sampling depth in real-time mode. Egg catches were standardized by multiplying the number of eggs collected by a derived haul factor for each station tow to obtain densities per 10 m^2 of sea surface area. The haul factor was derived by:

$$\text{Haul factor} = \frac{\text{maximum tow depth}}{\text{(flowmeter calibration)x (flowmeter revolutions)x(area of net mouth)}}$$

Standard plankton sampling procedures derived from the MARMAP program were used (Jossi and Marak 1983). Tows were smooth oblique from the surface to within a few meters of the bottom or to a maximum tow depth of 200 m while maintaining an approximate 45° wire angle. Vessel speed varied from 1½ to 2 knots. Wire payout was 50 m/min and retrieval was 20 m/min. These rates were adjusted at station depths ≤60 m to ensure a minimum of 100 m^3 of water filtered (Houde 1977). Payout rates were also adjusted during adverse weather conditions to minimize surging of the tow wire. The sample from one net retained for ichthyoplankton analysis was preserved in 5% formalin. The contents from the other net were preserved in 95% ethanol.

All fish eggs were removed and staged according to their development. The following egg-stage classifications were used.

1. "Early" represented the period from spawned to just before blastopore closure.
2. "Middle" represented the period from blastopore closure to tail bud almost free (i.e., slightly undercut).
3. "Late" represented the period from tail bud free to just before hatching.

Late stage *Gadus morhua*, *Melanogrammus aeglefinus*, and *Pollachius virens* eggs were further staged:

a. from tail bud free to tail tip twisted and flexed ≥45°,
b. from tail tip twisted and flexed ≥45° to embryo encircled >3/4 of egg circumference to ≤ embryo full circle of egg,
c. from > full circle of egg to just before hatching.

"Dead before capture" and "abnormal" eggs were also classified. Dead eggs were distinguished by having their yolk material and embryo (if present) degraded and concentrated to a side of the egg chorion. Abnormal eggs were those with an obvious embryonic aberration such as stunted development or two tail buds. Dead and abnormal eggs are not included in this atlas.

The identification of some early-stage eggs could not be established and were categorized as "unidentified." Other eggs included as "unidentified" were of various developmental stages, and their taxonomic identity has yet to be established. These eggs were assigned a type designation. Unidentified eggs are not presented in this atlas but are listed along with eggs staged as early, middle, late, dead,

and abnormal in the fish egg data base located on the U.S. GLOBEC Georges Bank website.

Several species share indistinguishable common early-stage characteristics and cannot be separated. Such features include eggs that overlap in size (diameter), the presence or absence of an oil globule, eggs that overlap in size of egg and oil globule, and eggs with similar pigmentation patterns on the embryo, yolk, or both (refer to Berrien and Sibunka 1999). The groupings of species whose eggs co-occur but could not be distinguished consisted of the following: (1) *Urophycis* spp. and *Peprilus triacanthus*, (2) *Urophycis* spp. and *Enchelyopus cimbrius*, (3) *Limanda ferruginea* and *Tautogolabrus adspersus*, (4) *Scophthalmus aquosus* and *Paralichthys oblongus*, (5) *Gadus morhua* and *Melanogrammus aeglefinus*, and (6) *Gadus morhua*, *Melanogrammus aeglefinus*, and *Glyptocephalus cynoglossus*. The eggs in each grouping were assigned and tabulated to taxa in a proportion based on the proportion of identifiable later stage eggs at the same or from a nearby station.

RESULTS

A total of 26 taxa were identified and are presented in Appendix Table 1. Also included in Appendix Table 1 for each taxon are the total number of tows, the number of positive tows per month(s) when the taxon was collected, and the corresponding monthly density (number per 10 m^2). Maps showing the standard station locations for each of the five survey years are given in Appendix Figure 2. Individual maps are presented for all positive occurrence surveys for the 26 taxa. These maps show the distribution of egg densities for the combined early, middle, and late stage eggs (Appendix Figures 3-28).

Eggs from fishes in the family Pleuronectidae, which included *Limanda ferruginea*, *Glyptocephalus cynoglossus*, *Hippoglossoides platessoides*, and *Pseudopleuronectes americanus*, were the most abundant and comprised 68% of identified eggs collected in five years of survey effort. *Limanda ferruginea* eggs were the most abundant taxon collected (66% of the identified eggs). The order Gadiformes, which included *Gadus morhua*, *Melanogrammus aeglefinus*, *Pollachius virens*, *Brosme brosme*, *Enchelyopus cimbrius*, and the hakes (*Urophycis* spp., *Merluccius bilinearis* and *Merluccius albidus*), were the second most abundant (28% of identified eggs). Eggs of *Gadus morhua* and *Melanogrammus aeglefinus* comprised 10% and 9% of the total egg catch, respectively.

TAXON ACCOUNTS

In the following species accounts, taxa are ordered phylogenetically by convention established in Nelson et al. (2004). For each taxon, information is provided on: (1) the general habitat and geographic range within the Northwest Atlantic, (2) results from the 11-year (1977 through 1987) MARMAP ichthyoplankton surveys (for survey method details see Sibunka and Silverman 1984, 1989), and (3) new results from the GLOBEC ichthyoplankton surveys. Identification notes are also provided when warranted.

Margined snake eel, *Ophichthus cruentifer* (Figure 3)

Adult *Ophichthus cruentifer* range from the Gulf of Maine to Florida, but are uncommon north of Cape Cod, MA (Smith and Tighe 2002). Eggs of *O. cruentifer* were collected during the MARMAP surveys off southern Georges Bank from June to October (Berrien and Sibunka 1999).

Only small numbers of *O. cruentifer* eggs were collected, and these came from three stations located in the southwest portion of the survey area during the June 1999 GLOBEC survey. One early stage egg was taken on the southwest area of Georges Bank, and a second early egg was collected on an adjacent station in the southern portion of the Great South Channel. A single middle stage egg was collected on the southwest shelf slope of the Bank.

Atlantic argentine, *Argentina silus* (Figure 4)

Adult *Argentina silus* are found in deep waters off the continental shelf in southern Labrador to off the southern slope portion of Georges Bank (Klein-MacPhee 2002a). Catch occurrences of *A. silus* eggs during the MARMAP surveys indicate spawning in the eastern portion of the Gulf of Maine during April and May (Berrien and Sibunka 1999).

Small catches of *A. silus* eggs were collected during the April GLOBEC surveys in 1998 and 1999. The catch occurrences for both years were from deep waters in the Gulf of Maine off the northeast portion of Georges Bank.

Atlantic pearlside, *Maurolicus weitzmani* (Figure 5)

Adult *Maurolicus weitzmani* range from southern Newfoundland to the Gulf of Mexico and the Caribbean Sea (Harold et al. 2002). The eggs of *M. weitzmani* were collected during the MARMAP surveys on slope regions of Georges Bank from late summer to early winter (Berrien and Sibunka 1999; taxon referred to as *M. muelleri*).

A single *M. weitzmani* egg was collected in deep water during the March 1995 GLOBEC survey on the southwest shelf-slope region of the Bank.

Fawn cusk-eel, *Lepophidium profundorum* [tentative identification] (Figure 6)

Adult *Lepophidium profundorum* inhabit the outer portion of the continental shelf and are common along the shelf-slope of Georges Bank (cf. map 12 in Collette and Klein-MacPhee 2002). The larvae of *L. profundorum* are prevalent during the summer on the southern part of the Bank (Fahay 1992).

L. profundorum eggs were collected in small numbers on the July 1995 and the June 1999 GLOBEC surveys. These egg catches were made in or near shelf-slope waters along the southern flank of Georges Bank.

Identification Notes

The eggs tentatively identified as *L. profundorum* have characteristics that resemble those described for *Ophidion marginatum* by Fahay (1992). These characteristics include a smooth and slightly-to-noticeably oval chorion (diameter 0.91-0.95 x 0.85-0.92 mm), the absence of an oil globule, a homogenous yolk, and a narrow perivitelline space. In addition, the high myomere counts (50+) made on late-stage embryos from eggs held at the Northeast Fisheries Science Center (NEFSC), along with the locations where these eggs were collected (i.e., Southern New England and Georges Bank), also indicate these eggs are most likely *L. profundorum*.

Fourbeard rockling, *Enchelyopus cimbrius* (Figure 7)

Adult *Enchelyopus cimbrius* range along the eastern coast of North America from Newfoundland to the northern portion of the Gulf of Mexico. Their distribution on Georges Bank is along the northern edge, with the largest concentration toward the western portion and into the Gulf of Maine (cf. Map 15 in Klein-MacPhee 2002b). *E. cimbrius* eggs were collected on the MARMAP surveys along the northern edge of Georges Bank from March to January, with the highest densities occurring in May (Berrien and Sibunka 1999).

E. cimbrius eggs were collected on GLOBEC surveys from February to July. They were distributed on the northern portion of Georges Bank, with small and isolated egg catches made along the southern flank. During the winter and early spring surveys, *E. cimbrius* eggs were caught in small numbers along the northern and southern periphery of Georges Bank. The exception to this trend was the March 1998 survey results, which indicated an increase in spawning activity along the north central and northwest edge area. Both April-May in 1996 to 1999 and May-June in 1995 were peak spawning months during the five-year GLOBEC sampling program. *E. cimbrius* egg catch results for the April and May surveys in 1998 and 1999 show an almost continuous distribution pattern along the entire northern edge region of the Bank. The smallest egg catches during April and May were made in 1995. Spawning effort remained high in June 1995 but had begun to decrease during the other four June surveys, with most eggs collected again on the Bank's northern edge. Although the catch results for the entire 1995 survey season were low, the July catches were smaller than those collected in June. The small egg density values in July further substantiate that the peak spawning period for *E. cimbrius* on Georges Bank had passed. Egg collections were limited in July to only a few stations located on the north central Bank area.

Hake species, *Urophycis* spp. (Figure 8)

Adult *Urophycis* spp. inhabit the North American continental shelf and slope waters from Labrador to North Carolina and stray as far south as Florida (Klein-MacPhee 2002b). *Urophycis* spp. eggs were collected on Georges Bank during the MARMAP surveys in all months except February. The highest egg densities occurred during the summer months on the Bank (Berrien and Sibunka 1999).

Urophycis spp. eggs were collected in high abundance during the GLOBEC surveys in June and July (except June 1996). Small and isolated egg catches occurred during all other months surveyed. Their distribution during years of high abundance extended across Georges Bank. *Urophycis* spp. eggs were collected during the 1995 winter and early spring (February to April) surveys in small and isolated catches along the Bank's shelf-slope area. Most of the May and June catch results for all survey years show either the onset of spawning or an increase in spawning intensity on the Bank. Eggs collected on the May surveys were concentrated along the Bank's southern area. Catch results for all June surveys, except for 1996, indicate an increased level of spawning across the entire Bank, with substantial egg catches along the entire southern and northern region. The large egg catches made in the northern Bank region were concentrated on the upper portion of Cultivator and Georges Shoals. *Urophycis* spp. eggs were also collected both in the Great South Channel and on Browns Bank. The June 1996 survey results indicated limited spawning taking place on the Bank with two large egg catches made just west of Cultivator and Georges Shoals. *Urophycis* spp. egg distribution and abundance for July 1995 was greater than for June of that year and resembled the results of the June 1997 to 1999 surveys.

Identification Notes

Hake eggs were not identified to species but were categorized as *Urophycis* spp. Two adult species of hake, *U. chuss* (red hake) and *U. tenuis* (white hake), are reported to inhabit Georges Bank and the adjacent waters. Both hakes begin spawning in the spring and continue through the summer months (Able and Fahay 1998; Klein-MacPhee 2002b). *U. tenuis* are known to spawn in the continental slope waters off Georges Bank but may not spawn on the Bank or in the Gulf of Maine. Another adult hake, *U. regia* (spotted hake), inhabits the waters from Southern New England through the Middle Atlantic Bight (Klein-MacPhee 2002b). Information from the NEFSC 40-year bottom trawl survey shows that adult *U. regia* occur on the southwest portion of Georges Bank and along the Bank's southern slope-edge (NEFSC unpubl. data[1]). Most *U. regia* spawning takes place in the central and southern Middle Atlantic Bight (Able and Fahay 1998). It is possible that most if not all of the eggs collected on the Bank are *U. chuss* and that those eggs collected on the Bank's shelf-slope region are *U. chuss*, *U. tenuis*, or both.

The larval hakes collected on the broad-scale surveys were identified only to genus, so larval occurrences did not help clarify the species composition of the co-occurring hake eggs.

Offshore hake, *Merluccius albidus* (Figure 9)

Adult *Merluccius albidus* are found off the U.S. Atlantic coast in deep basins within the Gulf of Maine and along the southeastern slope of Georges Bank south to slope waters off Florida (Klein-MacPhee 2002c). *M. albidus* eggs were taken during the MARMAP surveys in all months of the year on Georges Bank. They ranged from the Northeast Channel to along the shelf slope of Georges Bank (Berrien and Sibunka 1999).

M. albidus eggs were collected during all months of the GLOBEC broad-scale program but not on all surveys during a given year. The catch occurrences of *M. albidus* eggs were small and these eggs were collected in small numbers along the shelf-slope of Georges Bank. An increase in egg catch was observed during the late spring, indicating intensified spawning activity during this time. The only catch occurrence of this taxon on Browns Bank took place during the May 1997 survey.

Silver hake, *Merluccius bilinearis* (Figure 10)

Adult *Merluccius bilinearis* are common along the North American coast from southern Newfoundland to South Carolina (Klein-MacPhee 2002c). *M. bilinearis* eggs were collected during the MARMAP surveys on Georges Bank all months of the year except February. *M. bilinearis* egg densities were the highest during the summer months and were distributed across the entire Bank (Berrien and Sibunka 1999).

M. bilinearis eggs were collected on the GLOBEC surveys from January to July, and were distributed over the entire Bank. The eggs were most abundant in late spring and into the summer on the Bank. Spawning generally began along the southern portion of the Bank in April or May. An earlier isolated egg catch occurred on the Bank's southeastern shelf-slope in January 1996. In June, except for 1996, egg densities indicate spawning activity intensified dramatically and spread across Georges Bank. Catches of *M. bilinearis* eggs were also made on Browns Bank in late spring and early summer. In 1996, *M. bilinearis* spawning was either late in starting, low in intensity, or both compared to the results of the other four years. Catch results for the May surveys in 1998 and 1999 show a few eggs were collected at the same station located in the northwest portion of the Bank. These catches may indicate a small and separate spawning event by *M. bilinearis*.

Cusk, *Brosme brosme* (Figure 11)

Adult *Brosme brosme* range along the North American coast from the Newfoundland Banks and the Strait of Belle Isle to New Jersey (Bigelow and Schroeder 1953). *B. brosme* were collected on Georges Bank during the MARMAP surveys from April to October. The largest egg densities on the Bank occurred from spring through mid-summer (Berrien and Sibunka 1999).

B. brosme eggs were collected on GLOBEC surveys from March to July and were generally concentrated along the southern flank and on the Northeast Peak of Georges Bank. Early season *B. brosme* eggs were collected as isolated occurrences along the periphery of the Bank in deep water. Egg distribution and abundance in April and May indicate a marked increase in spawning activity. Egg densities were highest along the southeast central portion of Bank, the Northeast Peak, and Browns Bank. The egg catches during the April 1997 and 1998 surveys were the largest of all five years. By June, catches had decreased, and the eggs collected were mostly concentrated in deep water in the eastern and southern shelf-slope portion of the Bank. Small catches of eggs were also made in the Great South Channel area in June 1997 and 1998. The July survey in 1995 collected a small amount of *B. brosme* eggs at one station in deep water in the north central area of Georges Bank.

Atlantic cod, *Gadus morhua* (Figure 12)

Adult *Gadus morhua* are found along the North American continental shelf from northern Quebec to about Cape Hatteras, NC. They are most abundant from Labrador to southern Cape Cod (Bigelow and Schroeder 1953). *G. morhua* eggs were collected on Georges Bank during the MARMAP surveys in all months of the year except September. The highest egg densities on the Bank occurred between December and April (Berrien and Sibunka 1999).

G. morhua eggs were collected on the GLOBEC surveys from January to June and were sampled over the entire Bank, with the highest densities on the Northeast Peak area. The wide distribution and large number of *G. morhua* eggs in the January broad-scale surveys indicated that spawning was well underway. The highest January abundances of eggs were encountered during 1998 and 1999, when the eggs were more widespread than in the other three years. Egg abundances were lowest in January 1997; these abundances also coincided with the most limited spatial distribution, but the low catch may be attributed to reduced sampling effort during this survey. The highest egg abundances occurred in February and March, indicating that peak spawning occurs at this time. Eggs were widespread in March, with high egg catches occurring on the Northeast Peak and the southern flank. *G. morhua* egg abundances were lower in April than in February and March, indicating that peak spawning had passed. These eggs were concentrated along the southern portion of the Bank. Only three of the five June surveys collected eggs, and catches were both small in number and isolated in distribution. For additional information regarding *G. morhua* egg distribution and abundance during the GLOBEC program, refer to Mountain et al. (2003; unpubl. data[2]).

Haddock, *Melanogrammus aeglefinus* (Figure 13)

Adult *Melanogrammus aeglefinus* range along the North American coast from the Strait of Belle Isle off Labrador to southern New Jersey (Klein-MacPhee 2002b). They are most abundant from the eastern Nova Scotian Banks to Cape Cod (Bigelow and Schroeder 1953). *M. aeglefinus* eggs were collected from January to July during the MARMAP surveys, and the highest egg densities occurred in March and April (Berrien and Sibunka 1999).

M. aeglefinus eggs were collected on the GLOBEC surveys from January to June and were found over the entire Bank. The highest egg densities occurred on the Northeast Peak and the southern flank of Georges Bank. The catch results for the January surveys indicate that *M. aeglefinus* spawning was either already underway at this time or had just begun. Most of the eggs collected during January and February were concentrated on the Northeast Peak and eastern Bank area. By March and April the distribution of *M. aeglefinus* eggs progressed from the Northeast Peak (in February) southwest to the south central Bank region. Additional egg concentrations also occurred on the northwest Bank area and in the Great South Channel. March and April were the peak spawning months for all survey years. The egg catch results for May and June indicate that spawning had begun to decrease on Georges Bank. The May results for 1995 to 1997 show spawning activity limited mostly to the Northeast Peak and eastern Bank. The May results for 1998 and 1999 show that spawning occurred over a broader area than it did during the previous three years. At this time, the *M. aeglefinus* eggs were distributed from the Northeast Peak southwest to about the central Bank area with additional collections along the Bank's northern edge. Egg catches in June show a further decrease in spawning activity, limited to the eastern Bank region. The year 1995 was the poorest for *M. aeglefinus* spawning, followed by increased spawning activity in 1996 and 1997, and with the highest egg catches made in 1998 and 1999. *M. aeglefinus* eggs were also collected on Browns Bank during all survey years. For additional information regarding *M. aeglefinus* egg distribution and abundance during the GLOBEC program refer to Mountain et al. (2003; unpubl. data[3]).

Pollock, *Pollachius virens* (Figure 14)

Adult *Pollachius virens* range from the Hudson and Davis Strait in northern Canada to South Carolina; however, they are more common in areas north of New Jersey (Bigelow and Schroeder 1953; Klein-MacPhee 2002b). *P. virens* eggs were collected on Georges Bank during the MARMAP surveys from October to May, and the highest egg densities occurred in December and January (Berrien and Sibunka 1999).

P. virens eggs were collected on all GLOBEC January surveys. The largest egg concentrations in January were located on the Northeast Peak region. In addition, smaller egg catches were made on the Bank on different survey years. *P. virens* eggs were distributed in January 1996 from the Northeast Peak to the south-central Bank area. Eggs collected in the January 1998 and 1999 surveys ranged from the Northeast Peak west along the northern portion of Georges Bank. The January 1997 egg catches, mainly concentrated in the Northeast Peak area, had the smallest distribution and lowest abundance compared to the other January surveys. The egg catch results for all the February surveys except 1997 indicate that spawning activity may have peaked in January or perhaps earlier and was subsiding by February. The 1997 February *P. virens* egg abundance and distribution were greater than that of the January survey. Egg abundances were the highest in February of all surveys made in that year. *P. virens* eggs collected in February were concentrated in the Northeast Peak area, with smaller egg catches made in the northwest Bank area. The results for the other February surveys also showed that the largest egg concentration occurred on the Northeast Peak region, with smaller collections of egg catches made on the Bank's northwest region. Egg collections further declined to small and isolated during the March and May surveys on the Bank. *P. virens* eggs were also collected on Browns Bank on several of the January to March surveys. No *P. virens* eggs were collected in June or during the one July survey.

Goosefish, *Lophius americanus* (Figure 15)

Adult *Lophius americanus* range off the Canadian and United States coast from the southern and eastern Grand Banks area and the north side of Gulf of St. Lawrence south to Florida, but they are more common north of Cape Hatteras (Caruso 2002). Spawning *L. americanus* shed their eggs in a large (1x10 m) buoyant veil. Individual eggs may become separated and float free in the water column if the integrity of the veil is compromised (Bigelow and Schroeder 1953). *L. americanus* eggs and larvae were rarely collected on the Bank during the MARMAP program sampling (Steimle et al. 1999).

L. americanus eggs were collected on two June surveys during the GLOBEC program. Both occurrences were single late-stage eggs. The egg collected in June of 1995 was from the northwest area of the Bank. The egg collected in 1997 was from the southwest flank region of the Bank.

Northern searobin, *Prionotus carolinus* [tentative identification] (Figure 16)

Adult *Prionotus carolinus* range from the Bay of Fundy to Florida. They are common south of Cape Cod on the continental shelf, but also occur in Massachusetts Bay and on Georges Bank (Klein-MacPhee and McBride 2002; refer to Map 23). Searobin eggs were collected on Georges Bank during the MARMAP surveys from July to August. The catch occurrences on the Bank were sporadic and the corresponding eggs densities small (Berrien and Sibunka 1999; taxa referred to as *Prionotus* spp.).

P. carolinus eggs were first collected on the June 1998 and 1999 GLOBEC surveys. These *P. carolinus* eggs were concentrated in the shoal areas on the north central portion of Georges Bank. The results of the one July survey show that spawning intensity had increased and was again mainly located on the northern shoal area. A small catch of eggs was also taken on the Bank's southwest region during this time.

Identification Notes

Along the United States east coast searobins of the genus *Prionotus* comprise two species: the northern searobin (*P. carolinus*) and the striped sea robin (*P. evolans*). Adult *P. evolans* are common south of Cape Cod from estuaries seaward to the edge of the continental shelf (Able and Fahay 1998; Klein-MacPhee and McBride 2002). North of Cape Cod their occurrence is incidental, and they are found inshore close to the coast. Reported evidence of striped sea robins on Georges Bank is rare; Bigelow and Schroeder (1953) noted a specimen collected from the eastern portion of the Bank and stated that they had not seen a specimen east of Cape Cod.

The frequency of occurrence of larval *Prionotus* spp. on Georges Bank from the MARMAP surveys is low, and those specimens identified to species were all *P. carolinus* (unpubl. data[4]). No larval *Prionotus* spp. were collected on the GLOBEC broad-scale surveys. It is most likely that the *Prionotus* spp. eggs collected on the broad-scale surveys are all *P. carolinus*.

Tilefish, *Lopholatilus chamaeleonticeps* (Figure 17)

Adult *Lopholatilus chamaeleonticeps* are most plentiful from southern Georges Bank to the Gulf of Mexico, and they inhabit the seaward portion of the continental shelf region (Able 2002). *L. chamaeleonticeps* eggs were collected on Georges Bank during the MARMAP cruises from late spring through early fall (Berrien and Sibunka 1999).

A single *L. chamaeleonticeps* egg was collected during the April 1996 GLOBEC survey on the southwest shelf-slope of Georges Bank. This early-stage egg was possibly spawned in deep water near or off the Bank.

Tautogolabrus adspersus, cunner (Figure 18)

Adult *Tautogolabrus adspersus* range along the North American east coast and offshore banks from Newfoundland to the entrance of Chesapeake Bay, MD (Bigelow and Schroeder 1953). *T. adspersus* eggs were collected on Georges Bank during the MARMAP surveys in the summer months with the highest densities occurring in July (Berrien and Sibunka 1999).

T. adspersus eggs were first collected during June on the GLOBEC broad-scale surveys, and distributions and abundance varied over the five survey years. Egg densities were low, and distributions were limited in 1995 and 1996. The 1996 egg catch results were the smallest for all five June surveys. In 1995 and 1996 *T. adspersus* eggs were collected on the north central shoal area of the Bank. The June 1997 to 1999 egg catch results showed both a dramatic increase in spawning intensity and in area. Catches of *T. adspersus* eggs occurred across the Bank's northern half and the entire eastern region including the Northeast Peak. There were only small isolated occurrences of *T. adspersus* egg catches in the southwest Bank area during most of the June surveys. *T. adspersus* egg catch results from the only July survey show an increase in both spawning abundance and distribution for that year. The July catch resembles the June 1997 to 1999 surveys in terms of egg density and distribution.

Scomber scombrus, Atlantic mackerel (Figure 19)

The range of adult *Scomber scombrus* is from southern Labrador to Cape Lookout, NC (Collette 2002). Spawning occurs in June off Cape Cod and north in United States waters and is usually confined near the coast (Bigelow and Schroeder 1953). *S. scombrus* eggs were collected on Georges Bank during the MARMAP surveys from May to August. The highest egg densities occurred in May and June on the Bank (Berrien and Sibunka 1999).

S. scombrus eggs were most abundant during the late spring on the GLOBEC surveys, and they were distributed across the Bank usually in small numbers. Spawning generally began in May with small and sporadic egg catches either along the southern edge of Georges Bank in 1995 or along the northern Bank area and the Northeast Peak in 1997-1999. *S. scombrus* eggs were also taken on Browns Bank in 1995. The May 1996 survey did not collect *S. scombrus* eggs. Egg catches in June varied between survey years as to area of capture and abundance. The results of 1995 and 1998 showed that *S. scombrus* eggs were mainly concentrated along the north and across the south central Bank region. *S. scombrus* eggs were also collected on Browns Bank in 1996. Egg catches for the years 1996 to 1999 indicated spawning occurred mostly in the northern and the north central Bank region, with small and intermittent egg occurrences along the southern Bank area. The July 1995 survey showed that *S. scombrus* spawning had decreased, with only two small catches of eggs taken near the edge of the northwest Bank.

Butterfish, *Peprilus triacanthus* (Figure 20)

The range of adult *Peprilus triacanthus* is from Nova Scotia to the Carolinas. They are summer residents and spawners in the New England offshore waters (Bigelow and Schroeder 1953). *P. triacanthus* eggs were collected during the MARMAP surveys on Georges Bank from May to September. The highest abundances occurred in July and August (Berrien and Sibunka 1999).

The GLOBEC broad-scale program first collected *P. triacanthus* eggs in the spring during the May 1995 and 1999 surveys and in June 1998. No *P. triacanthus* eggs were collected in 1996 or in 1997. The few isolated egg catches from the May and June 1995 and 1999 surveys were taken from slope waters along the southern edge of Georges Bank. The July 1995 survey results are similar to those from the previous June, with *P. triacanthus* eggs again concentrated on the Bank's shoals. Isolated egg catches were also made during this July survey on the Bank's southeastern flank region and on the Northeast Peak. In contrast, *P. triacanthus* eggs collected in June 1998 were from the north central area of the shoals.

Windowpane flounder, *Scophthalmus aquosus* (Figure 21)

Adult *Scophthalmus aquosus* range from the Gulf of St. Lawrence to Florida. Their areas of abundance are on Georges Bank and in the New York Bight (Klein-MacPhee 2002d). *S. aquosus* eggs were collected during the MARMAP surveys on Georges Bank from April to October. The highest egg densities occurred during the summer months (Berrien and Sibunka 1999).

S. aquosus eggs were most abundant during the GLOBEC surveys in early summer on Georges Bank. Spawning began as early as April in 1997 to 1999, with small isolated catches occurring in the northern and shallower area. By May and June spawning intensity had increased, extending across the north, and north central region of the Bank to the Northeast Peak area, with isolated catches of eggs along the Bank's southern edge. The May 1999 survey indicated *S. aquosus* eggs distributed from the central Bank area to the southwest in a narrow belt toward the Great South Channel. The July 1995 survey results indicated intense spawning activity still occurring across most of the Bank. The distribution and abundance of eggs for the July 1995 survey were similar to those for June 1995.

Gulf Stream flounder and smallmouth flounder, *Citharichthys arctifrons* and *Etropus microstomus* (Figure 22)

Adult *Citharichthys arctifrons* (Gulf Stream flounder) and *Etropus microstomus* (smallmouth flounder) are most abundant from Cape Cod to Cape Hatteras. *C. arctifrons* inhabit the outer portion of the continental shelf whereas *E. microstomus* occur on the inner shelf region (Able and Fahay 1998; Klein-MacPhee 2002e). The eggs of these two species are difficult to differentiate (see Identification Notes below), so are here referred to as *C. arctifrons/E. microstomus* eggs. *C. arctifrons/E. microstomus* eggs were collected on Georges Bank during the MARMAP surveys from April to October. The highest egg densities occurred in August; those eggs were distributed across most of the Bank (Berrien and Sibunka 1999; taxa referred to as *Citharichthys/Etropus* spp.).

C. arctifrons/E. microstomus eggs were caught as early as May during the 1995, 1997, and 1999 GLOBEC broad-scale surveys. The distribution of these eggs was concentrated along the Bank's shelf-slope. Small numbers of eggs were also collected from the Northeast Peak in 1997 and in the Great South Channel in 1999. Catch results for the June 1995, 1997, and 1999 surveys indicate an increase in spawning intensity over the previous month. *C. arctifrons/E. microstomus* eggs were collected in June 1996 on the south-central Bank and in June 1998 along the southern flank region and above the shoals. In 1996, *C. arctifrons/E. microstomus* egg distribution and abundance were the lowest of all the five survey years. The catch results for the other four June surveys indicate an increase in egg distribution to the Great South Channel and the Bank's southern flank with the largest egg collections made on the south central and southern shelf-slope to the southwest center area. The single July survey catch results in 1995 show a further increase in spawning intensity on the Bank, from the entire south-central and west Bank areas to the northern Bank above the shoals and in the Great South Channel. The only occurrence of *C. arctifrons/E. microstomus* eggs was taken from Browns Bank during the May to July 1995 surveys.

Identification Notes

The eggs classified as *C. arctifrons/E. microstomus* are difficult to differentiate. Adult *C. arctifrons* spawn mainly during the summer and early fall, but may spawn intermittently throughout the year. They range along the U.S. northeast coast from the southwest portion of Georges Bank to Florida's Gulf coast at water depths greater than 37 m (Klein-MacPhee 2002e; refer to Map 35). Scott and Scott (1988) reported that adult *C. arctifrons* are found further north along the outer continental shelf waters to the Scotian Shelf. *E. microstomus* also spawn in summer to early fall. They range from Cape Cod southward in depths generally less than about 37 m (Klein-MacPhee 2002e). The larval distribution maps based on the MARMAP surveys do not show any *E. microstomus* occurrences on Georges Bank (Able and Fahay 1998). Scott and Scott (1988) reported small catches of smallmouth flounder larvae on the southeast portion of the Bank in the spring. It has been stated that larval *E. microstomus* occur as a stray on the Bank. Two *E. microstomus* larvae were collected by the 1 m^2 MOCNESS (Multiple Opening Closing Net Environmental Sampling System) net on the south central Bank area during the April 1999 broad-scale survey. There were several larval occurrences of *C. arctifrons* larvae and a single catch of *E. microstomus* from the broad-scale surveys (U.S. GLOBEC 2005). It is plausible that a limited amount of *E. microstomus* spawning does occur on Georges Bank, possibly on the shoals from a local population. *C. arctifrons* are assumed to spawn on the shelf-slope of the Bank. It is very likely that the majority of the *C. arctifrons/E. microstomus* eggs collected during the broad-scale program are *C. arctifrons*, particularly those along the shelf-slope of Georges Bank.

Summer flounder, *Paralichthys dentatus* (Figure 23)

Adult *Paralichthys dentatus* range from Nova Scotia to South Carolina, but are most common south of Cape Cod to North Carolina (Able and Fahay 1998). *P. dentatus* eggs were collected during the MARMAP surveys on Georges Bank in October and November, with a small catch in January along the southwestern shelf slope (Berrien and Sibunka 1999).

P. dentatus egg occurrences on the GLOBEC broad-scale program were sporadic, and the number of eggs collected was very small. No eggs were collected on the 1995 and 1997 surveys. One late-stage *P. dentatus* egg was taken from the south central slope-edge of the Bank in May 1996. A single late-stage egg was collected in April 1999 at one station in the extreme southwestern Bank area. During the subsequent May survey, small catches of eggs were taken at two stations located in the southwest portion of the Bank. The June 1998 survey collected a small number of eggs at one station located in the shoal region on the center of the Bank. *P. dentatus* eggs in June 1999 were again collected at one station on the northern shoals and at two stations in the southwest portion of the Bank.

Identification Notes

The identification of all *P. dentatus* eggs except for one early stage was based on late stage development. A few small larvae were also collected on the Bank during late spring in the same regions where eggs were caught (see information regarding fish larval collections on the U.S. GLOBEC Georges Bank website). Prior evidence of *P. dentatus* spawning in the spring on Georges Bank has not been documented. Berrien and Sibunka (1999) reported *P. dentatus* spawning during April and May in the southern portion of the Middle Atlantic Bight, but no *P. dentatus* eggs were collected north of this area. Their findings were based on the MARMAP study of fish eggs.

Fourspot flounder, *Paralichtys oblongus* (Figure 24)

Adult *Paralichthys oblongus* range from Georges Bank to Tortugas, Florida (Gutherz 1967). They are abundant from southern New England to Delaware Bay (Bigelow and Schroeder 1953). *P. oblongus* eggs were collected during MARMAP surveys on Georges Bank from May to October, with the greatest egg densities occurring between July and August (Berrien and Sibunka 1999).

P. oblongus eggs were caught on GLOBEC surveys from May to July and were collected over the entire Bank. The earliest occurrences of eggs were during the May 1995 and 1999 surveys. These catches occurred along the southern shelf-slope of Georges Bank at only one station in 1995 and several stations in 1999. The catch results of the five June surveys varied from small numbers of eggs collected at a few stations in 1995 and 1996 to a substantial increase in egg catches in 1997, 1998, and 1999, indicating a rise in spawning activity on the Bank. The three latter June surveys had similar egg distribution patterns. Egg catches occurred along the southern edge, and north across the Bank's west central area extending onto the shoals. *P. oblongus* eggs were also collected during the June 1995, 1997, 1998, and 1999 surveys in the southern part of the Great South Channel and on Browns Bank in June 1996. The July 1995 results showed a marked increase in egg distribution and abundance from the preceding June survey. Spawning during this time extended across the western Bank and along the Bank's northern shelf and southern shelf-slope area.

Witch flounder, *Glyptocephalus cynoglossus* (Figure 25)

Adult *Glyptocephalus cynoglossus* range from Labrador to Cape Lookout (Scott and Scott 1988). These fish are late spring and summer spawners in the Gulf of Maine and New England offshore waters (Bigelow and Schroeder 1953). *G. cynoglossus* eggs were collected on Georges Bank during the MARMAP surveys from April to October; however, the highest egg densities occurred in May and June (Berrien and Sibunka 1999).

The GLOBEC broad-scale program collected *G. cynoglossus* eggs on Georges Bank as early as March in 1998, but most eggs were taken later during the spring in May and June. Eggs collected in May and June indicate that most *G. cynoglossus* spawning occurred along the south-central to southwest area of Georges Bank and in the Great South Channel. As the spawning season progressed in 1998, eggs were collected on the northern Bank area above the shoals during the June survey. The only occurrence of *G. cynoglossus* eggs on Browns Bank was during the June 1999 survey. Both the occurrences and the number of eggs collected were highest in 1997 to 1999 and lowest in 1995 and 1996. In 1996 *G. cynoglossus* eggs were first taken during the June survey, which indicates that spawning on the Bank started late that year.

American plaice, *Hippoglossoides platessoides* (Figure 26)

Adult *Hippoglossoides platessoides* range along North America from near the Arctic Circle south into the Gulf of Maine and as an incidental occurrence off Montauk Point on Long Island (Klein-MacPhee 2002f). *H. platessoides* eggs were collected on Georges Bank during the MARMAP surveys from January to June, with the highest egg densities in April (Berrien and Sibunka 1999).

H. platessoides eggs were collected from January to June during the GLOBEC surveys. The highest egg densities were along the southern half of the Bank during March and April. Spawning of *H. platessoides* was already underway on Georges Bank during the January surveys. The egg catches during the January and February surveys show most spawning occurred in the Northeast Peak area and on the eastern portion of the Bank. Small numbers of eggs were also collected intermittently during this time at stations along

the northwest Bank area. The *H. platessoides* egg catches for March and April indicate spawning intensity had increased on the Bank. During this time spawning progressed in a westward direction from the Northeast Peak and was mostly concentrated along the central and southern portion of the Bank. A few small catches of eggs were also taken on the northwest Bank. May and June data indicate that spawning had peaked and was now subsiding, with most catches occurring in the east-central Bank area. There were no *H. platessoides* eggs collected during the one July survey.

Yellowtail flounder, *Limanda ferruginea* (Figure 27)

Adult *Limanda ferruginea* range from the strait of Belle Isle to the lower Chesapeake Bay. They are most abundant from the western areas of the Gulf of Maine and Georges Bank to Southern New England (Bigelow and Schroeder 1953). *L. ferruginea* eggs were collected on Georges Bank during the MARMAP surveys from March to September. The highest egg densities occurred during May and June. (Berrien and Sibunka 1999; taxon referred to as *Pleuronectes ferrugineus*).

L. ferruginea eggs were collected on GLOBEC surveys from March to July and were caught over the entire Bank. The greatest egg distribution occurred in April to June, and the highest densities were on the Bank's eastern portion. *L. ferruginea* eggs were first collected in February for all years of the GLOBEC surveys, except in February 1995 when no eggs were caught. The egg catch results for February indicate that spawning occurred in the Bank's eastern portion. Eggs were also collected on the northwest area in 1997 and 1999. Spawning intensity increased during the months of March to May with egg catches now made on most of the Bank and also in the Great South Channel. The largest concentration of *L. ferruginea* eggs during this time period was on the eastern Bank with additional concentrations in May on the northwest Bank. The catch results for the June surveys indicate that spawning intensity was still high, particularly during 1995 and 1996. Results for June 1997, 1998, and 1999 surveys indicate that spawning on the Bank had decreased and was not as widespread as during the May surveys for those years. The abundance-distribution plots for the June surveys indicate that most spawning is concentrated on the eastern Bank, with some large egg catches made in the northern portion of the Great South Channel. The July survey results indicate a dramatic decrease in *L. ferruginea* spawning on the Bank, with the largest egg catches taken on the Northeast Peak. Egg catches were also made on Browns Bank during late spring and early summer except in 1997, when no eggs were caught.

The survey results indicate the greatest amount of spawning activity for *L. ferruginea* occurred during 1998 and 1999. These two years appear to be similar during the spring for egg distribution and abundances. In these years, intense spawning occurred in May across most of the Bank (Figure 27). The eastern region was again the primary area for *L. ferruginea* spawning, followed by the northwest area and Great South Channel. The southwest area had the lowest egg catches at this time. The least amount of spawning took place during 1995.

Winter flounder, *Pseudopleuronectes americanus* (Figure 28)

Adult *Pseudopleuronectes americanus* range from northern Labrador to Georgia, and are common from the Gulf of St. Lawrence to the Chesapeake Bay. *P. americanus* are reported to form localized populations within their distribution range. One population inhabits Georges Bank; these fish are known in the commercial fishing industry as lemon sole. The onset of *P. americanus* spawning on the Bank is unknown, but they are known to spawn during April and May. *P. americanus* eggs are demersal and adhesive, and they form clusters on the sea bed (Bigelow and Schroeder 1953).

The *P. americanus* eggs collected on the GLOBEC broad-scale surveys were incidental to the catch. They were probably the result of such factors as fishing too close to the sea bed, strong atmospheric storm activity or strong cycloidal currents that agitated the water column and suspended eggs off the sea bottom, and disturbance by bottom feeding adult fish which may disturb the sea bed and suspend the demersal eggs. These data, therefore, should not be considered as a representative index for spawning abundance or as a definitive reference to egg distribution on the Bank, but rather to indicate that Bank-wide spawning occurrences and give limited information on where *P. americanus* eggs are found. Results for the five years of survey data show that while most of the *P. americanus* eggs were collected in March and April, small numbers were also caught both earlier and later in the season. Most eggs were collected on the central shoal Bank area.

ENDNOTES

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APPENDIX

Appendix Table 1. Listing of total number of station tows and the number of stations with eggs for each taxon. Monthly mean catch of taxon per $10m^2$ from 1995 to 1999.

Taxon	Common Name	Total Tows	Total Positive Tows	MONTH (# eggs / $10m^2$) January	February	March	April	May	June	July
Ophichthus cruentifer	margined snake eel	199	3	·	·	·	·	·	0.015	·
Argentina silus	Atlantic argentine	314	2	·	·	·	0.013	·	·	·
Maurolicus weitzmani	Atlantic pearlside	331	1	·	·	0.003	·	·	·	·
Lepophidium profundorum	fawn cusk-eel	237	3	·	·	·	·	·	0.005	0.342
Enchelyopus cimbrius	fourbeard rockling	1791	280	0.009	0.026	0.211	4.155	4.242	2.724	3.447
Urophycis spp.	hake species	1564	199	·	0.015	0.009	0.006	0.937	39.769	91.579
Merluccius albidus	offshore hake	1791	50	0.035	0.062	0.060	0.100	0.170	0.276	0.079
Merluccius bilinearis	silver hake	1120	204	0.004	·	·	0.071	6.326	26.548	148.632
Brosme brosme	cusk	1224	181	·	·	0.015	1.298	0.403	0.327	0.026
Gadus morhua	Atlantic cod	1753	851	10.793	49.279	43.517	7.751	0.755	0.055	·
Melanogrammus aeglefinus	haddock	1753	707	1.516	24.491	27.402	23.922	2.401	0.513	·
Pollachius virens	pollock	1554	325	6.599	1.882	0.160	1.003	0.029	·	·
Lophius americanus	goosefish	199	2	·	·	·	·	·	0.010	·
Prionotus carolinus	northern searobin	237	11	·	·	·	·	·	0.116	0.632
Lopholatilus chamaeleonticeps	tilefish	314	1	·	·	·	0.003	·	·	·
Tautogolabrus adspersus	cunner	237	89	·	·	·	·	·	7.608	11.526
Scomber scombrus	Atlantic mackerel	579	78	·	·	·	·	0.089	1.683	0.079
Peprilus triacanthus	butterfish	579	21	·	·	·	·	0.112	0.714	17.105
Scophthalmus aquosus	windowpane	893	190	·	·	·	0.045	8.401	26.196	8.184
C. arctifrons/E. microstomus	Gulf Stream/smallmouth fldr	584	113	·	·	·	·	1.006	6.000	57.684
Paralichthys dentatus	summer flounder	855	8	·	·	·	0.003	0.014	0.025	·
Paralichthys oblongus	fourspot flounder	579	75	·	·	·	·	0.452	4.814	9.842
Glyptocephalus cynoglossus	witch flounder	1224	133	·	·	0.009	0.243	1.254	0.879	0.158
Hippoglossoides platessoides	American plaice	1753	505	0.093	2.194	9.456	3.913	0.210	0.040	·
Limanda ferruginea	yellowtail flounder	1564	968	·	0.476	31.544	163.877	207.671	168.508	7.105
Pseudopleuronectes americanus	winter flounder	1186	169	·	·	0.894	4.430	2.032	0.005	·

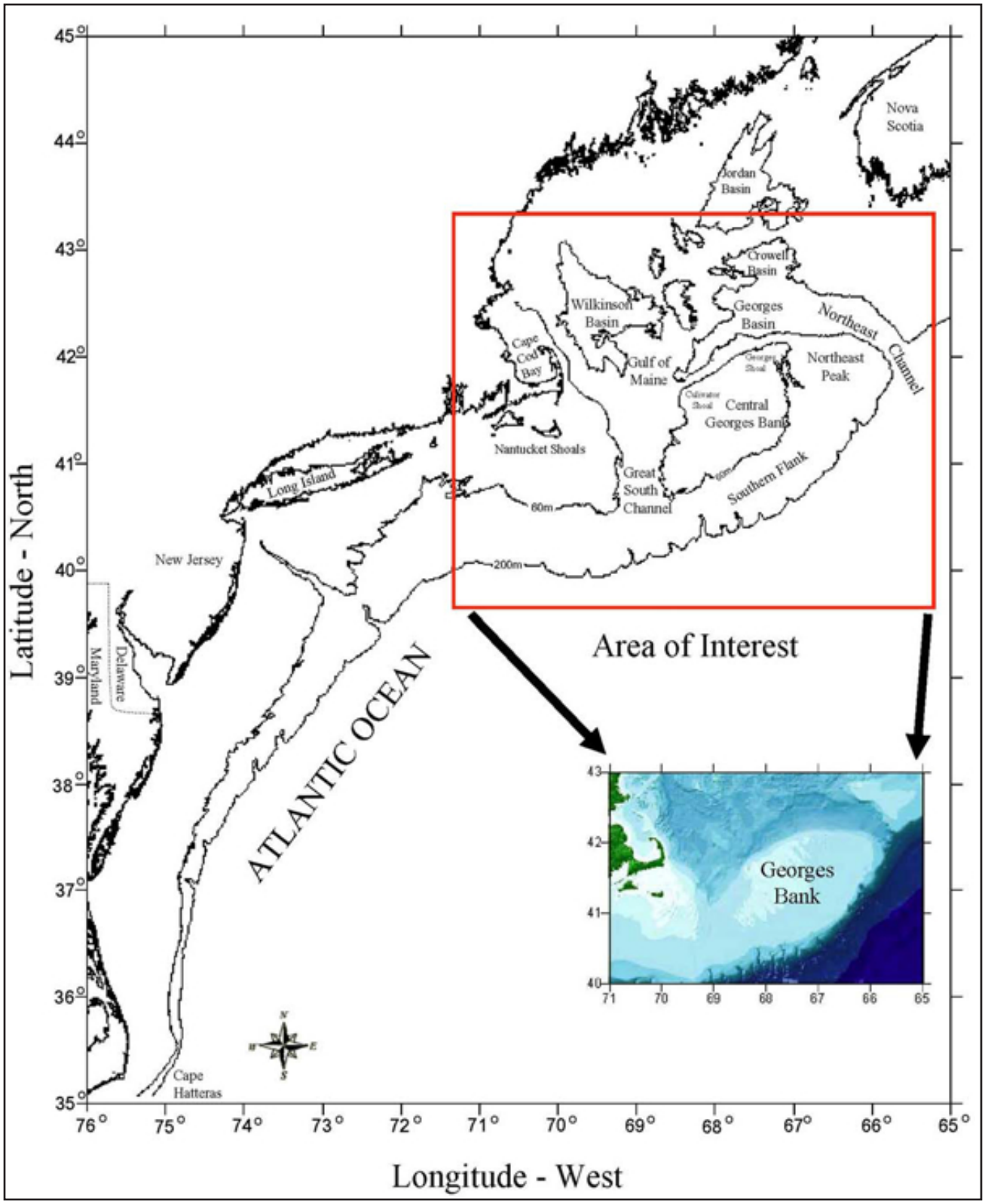


Figure 1. Geographic map of the GLOBEC broad-scale study area 1995-1999.

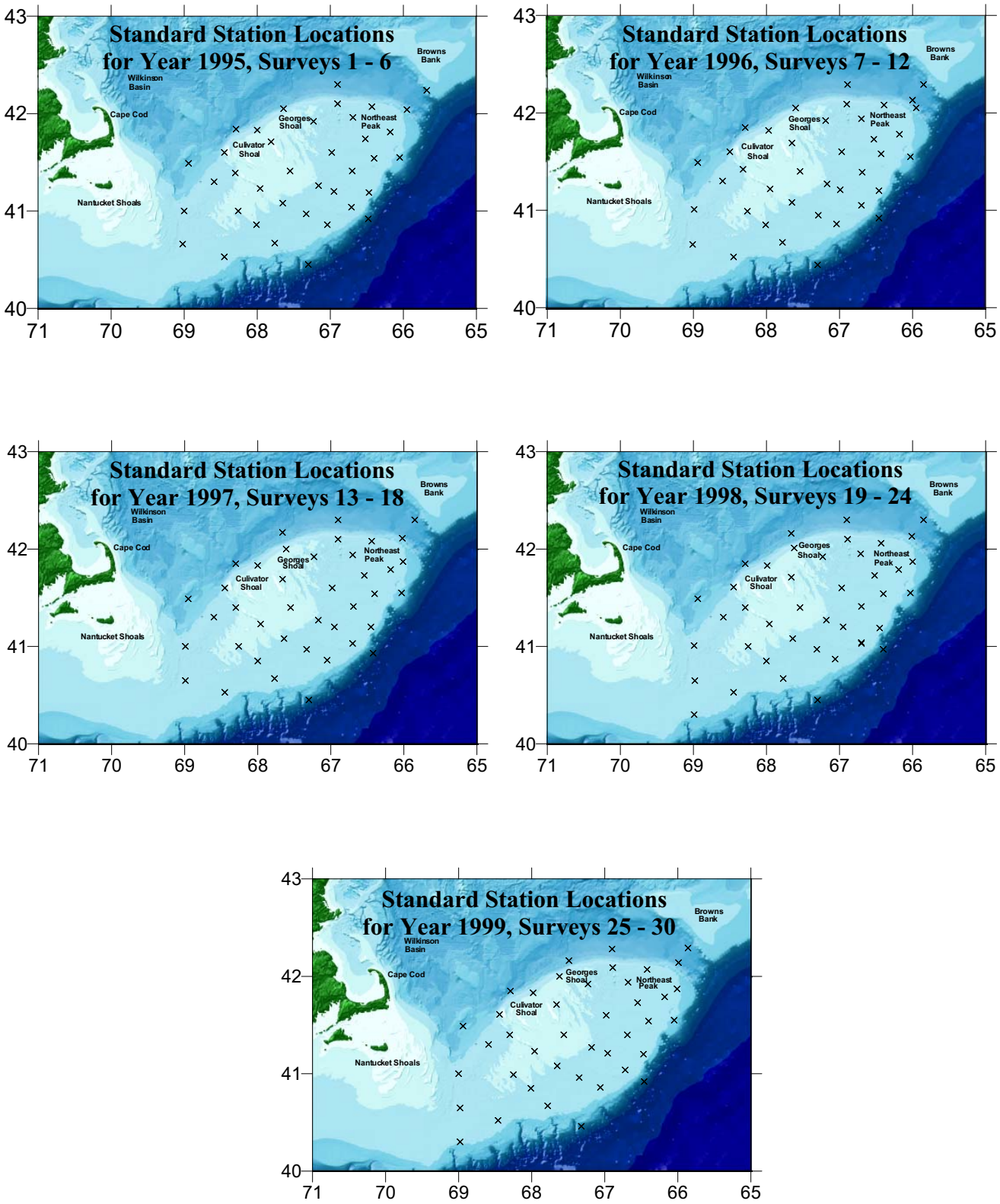


Figure 2. GLOBEC broad-scale survey area with standard stations for the years 1995-1999.

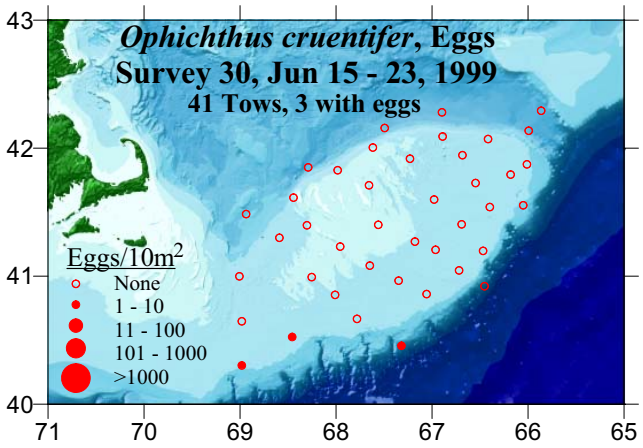


Figure 3. Distribution and abundance of margined snake eel (*Ophichthus cruentifer*) eggs, 1999.

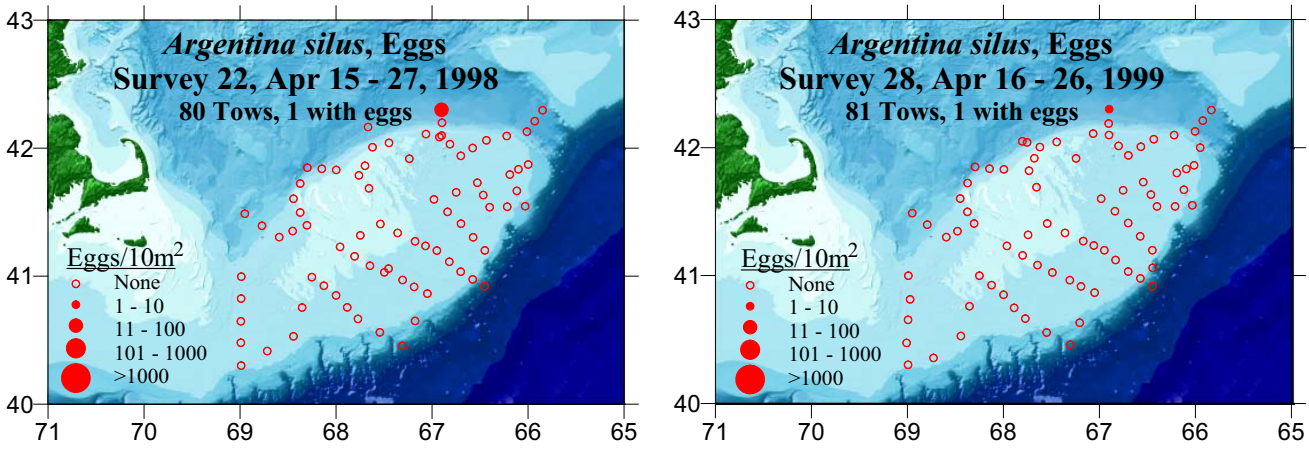


Figure 4. Distribution and abundance of Atlantic argentine (*Argentina silus*) eggs, 1998-1999.

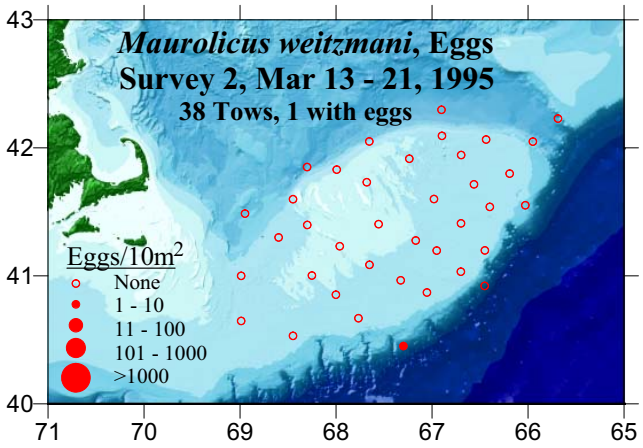


Figure 5. Distribution and abundance of Atlantic pearlside (*Maurolicus weitzmani*) eggs, 1995.

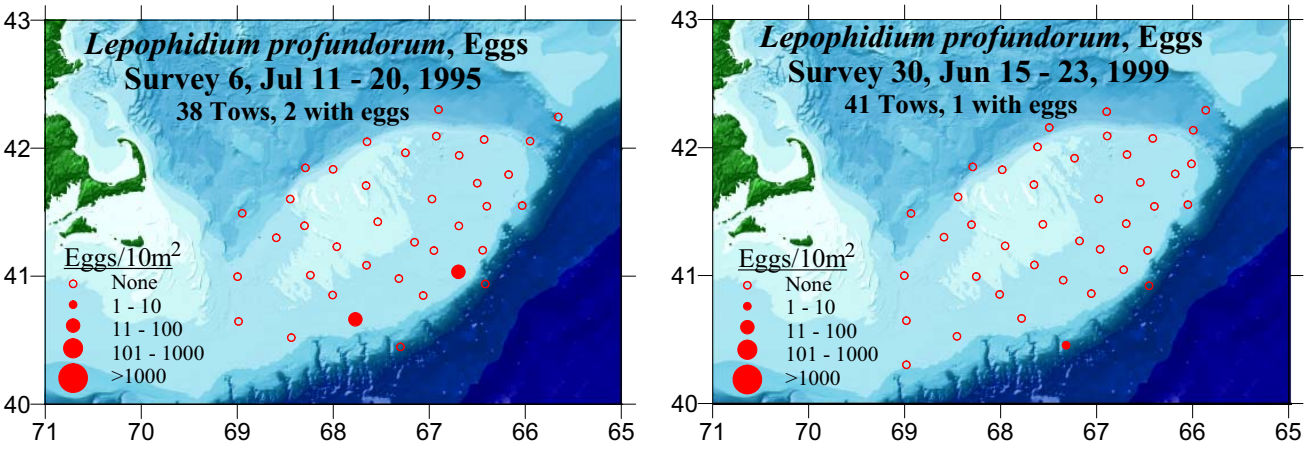


Figure 6. Distribution and abundance of fawn cusk-eel (*Lepophidium profundorum*) eggs, 1995 and 1999.

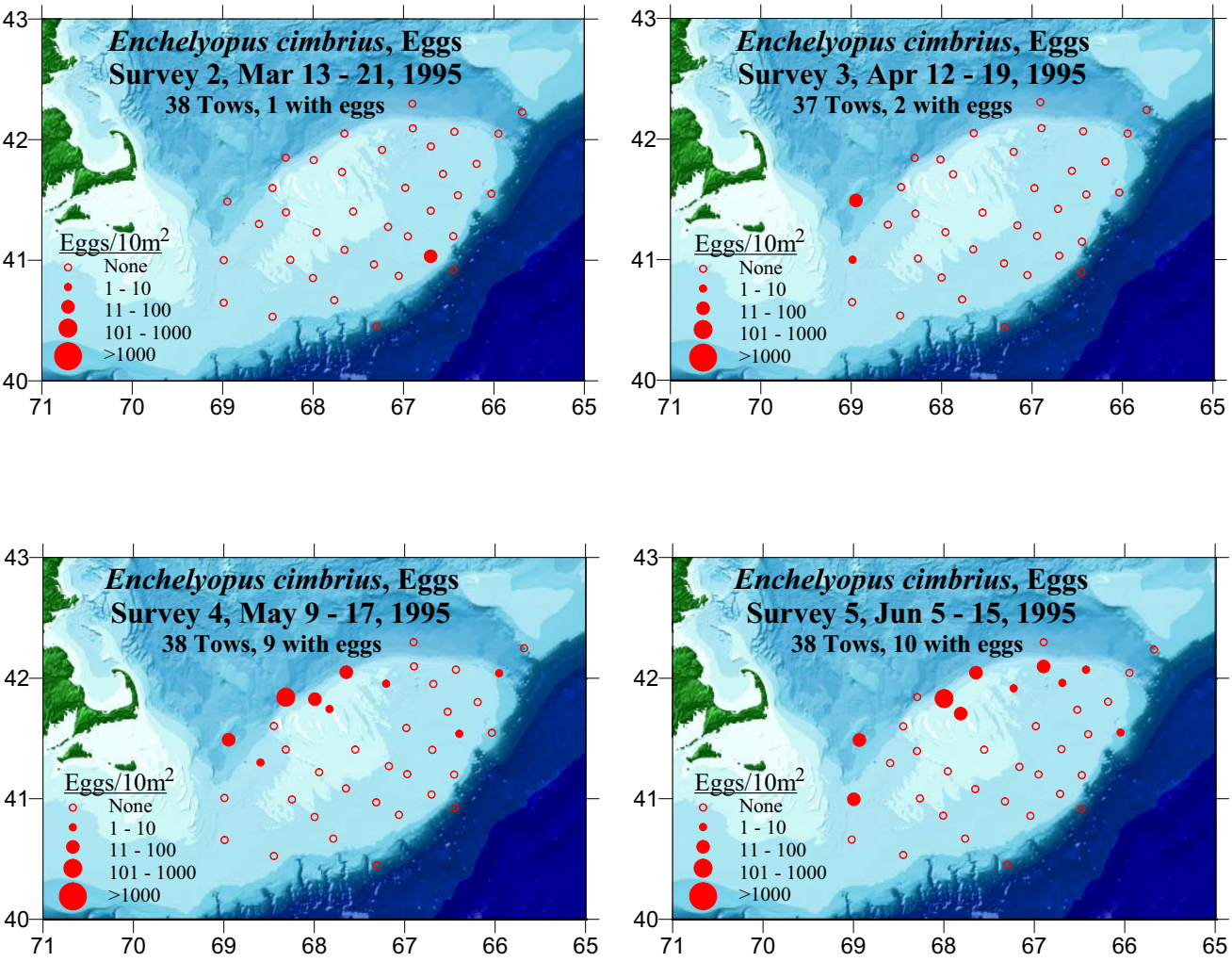
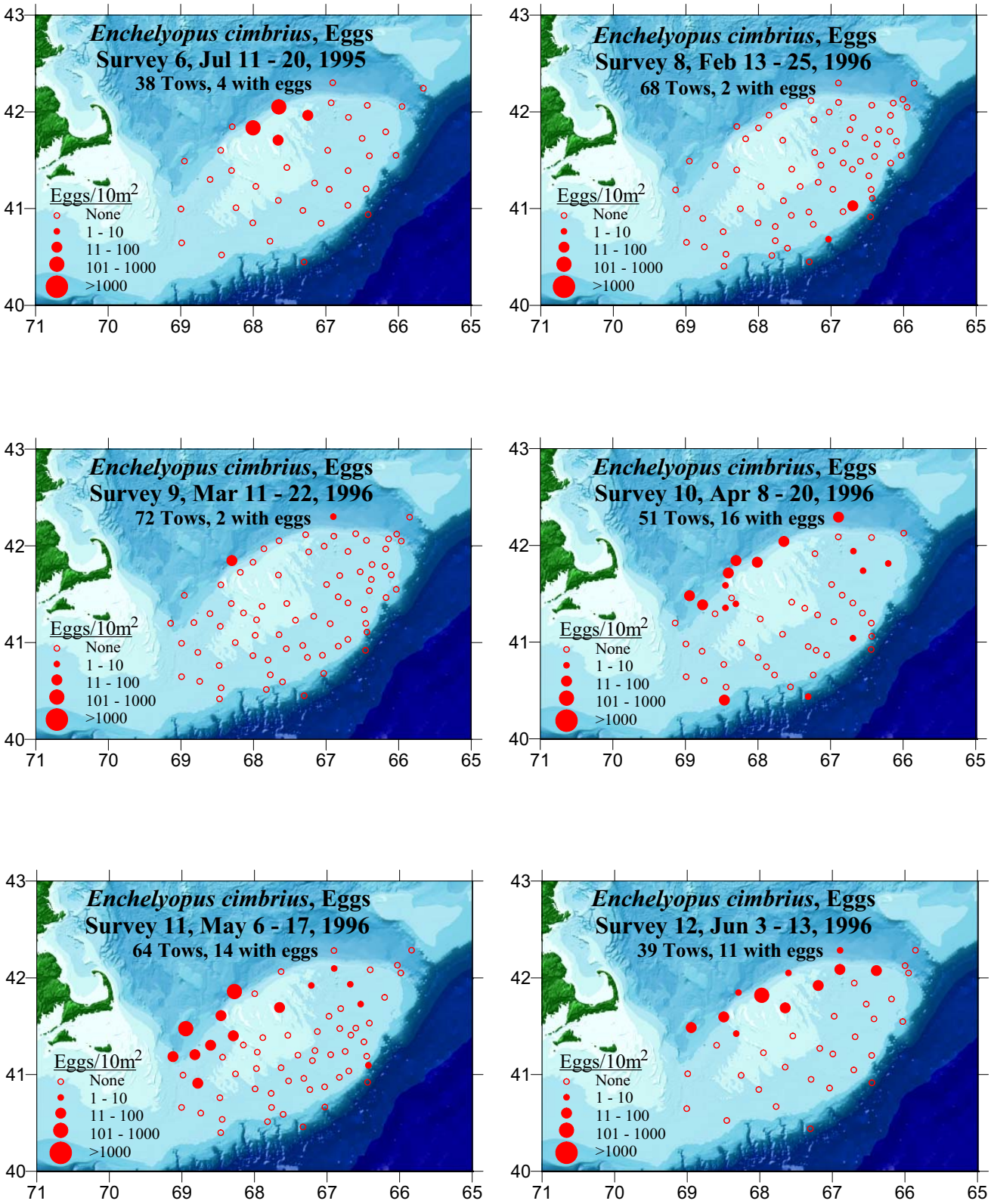


Figure 7. Distribution and abundance of fourbeard rockling (*Enchelyopus cimbrius*) eggs, 1995-1999



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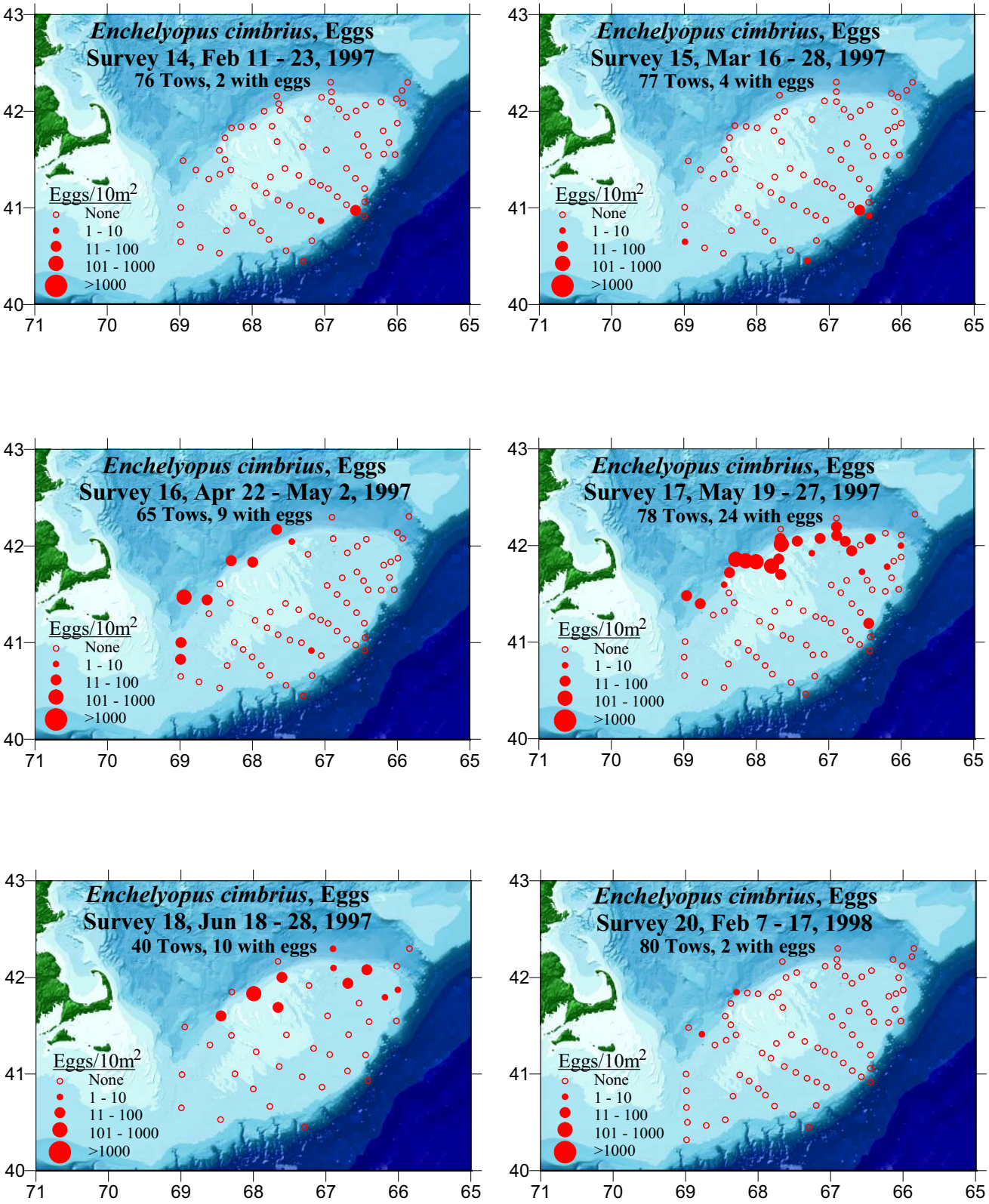

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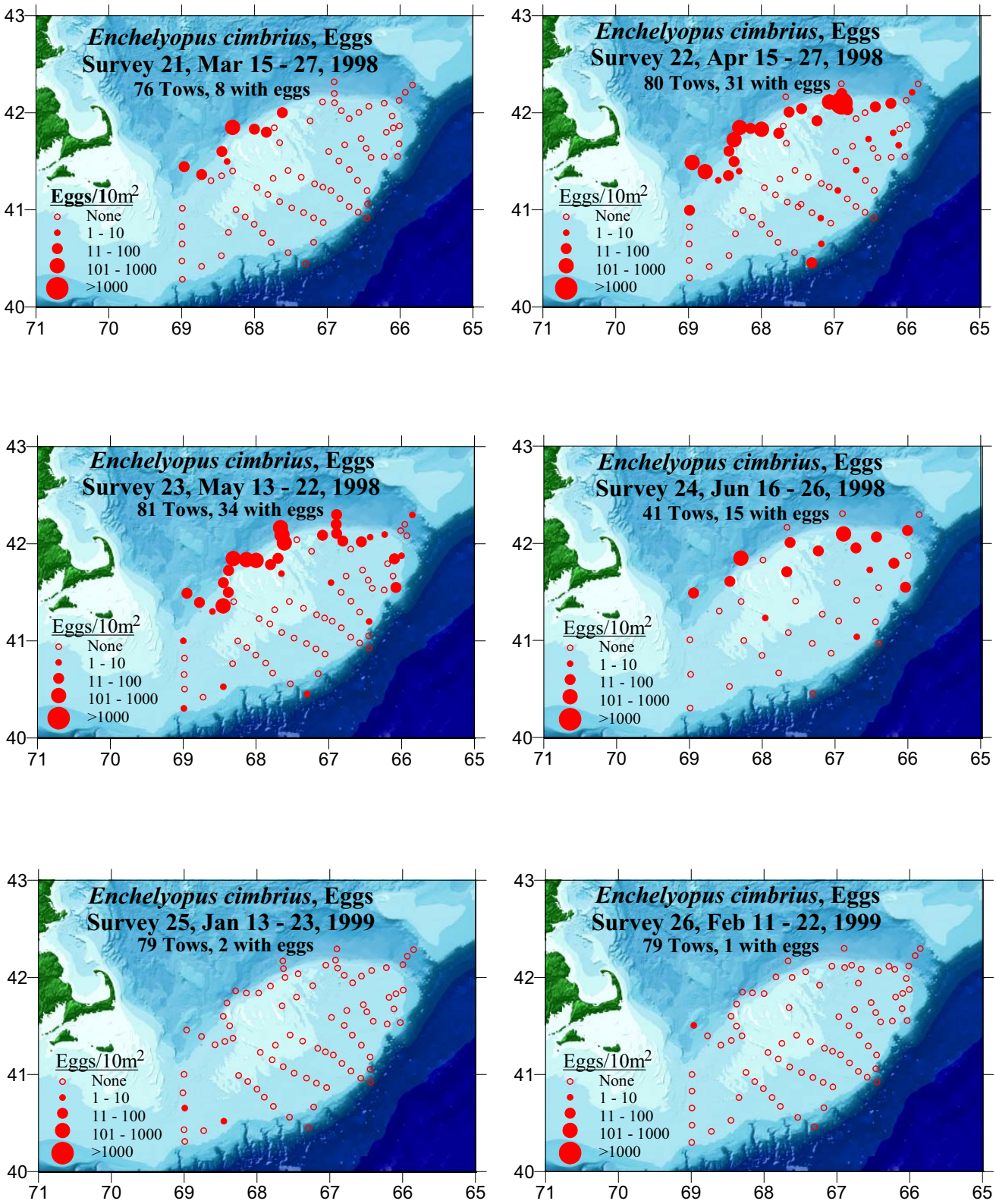

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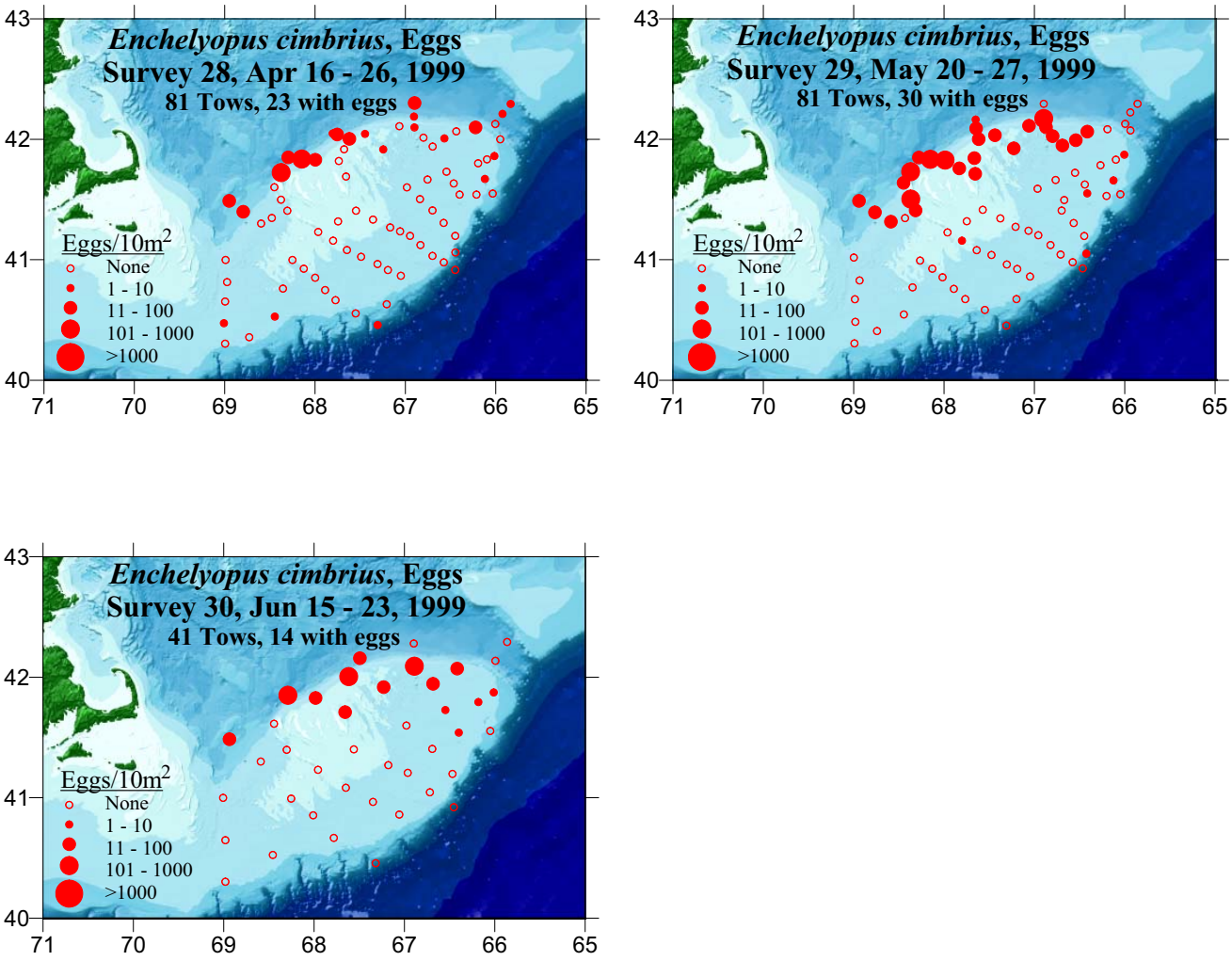

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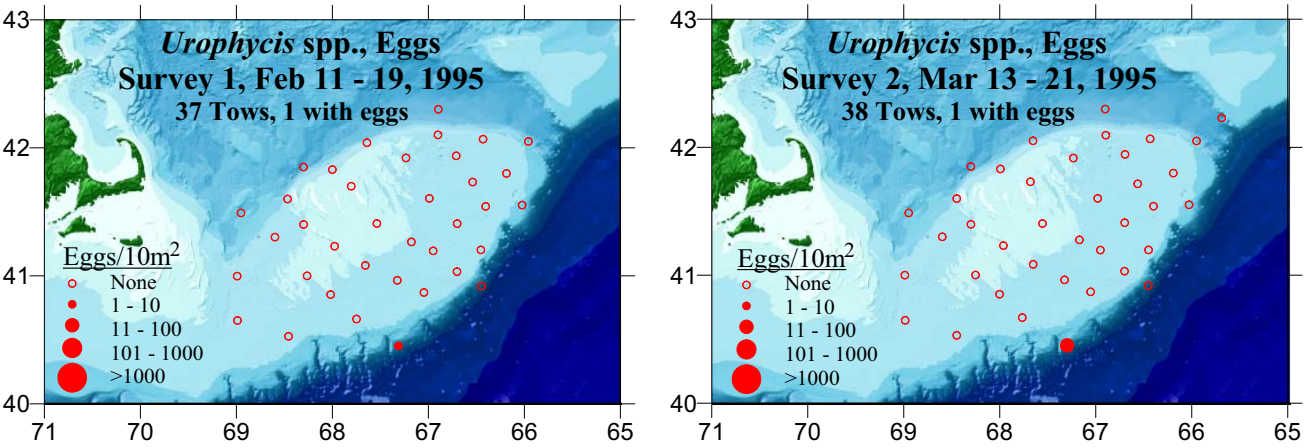
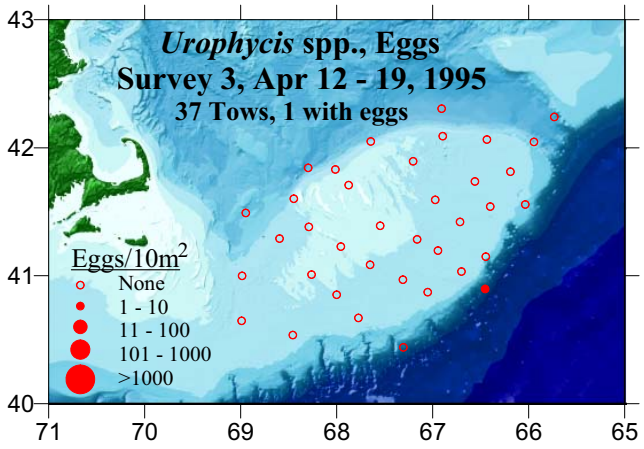
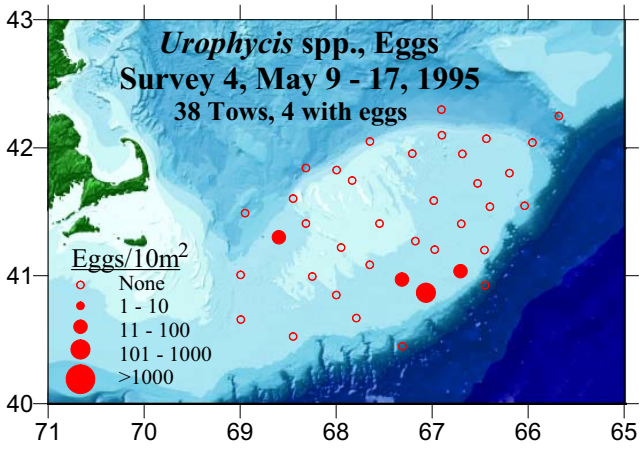
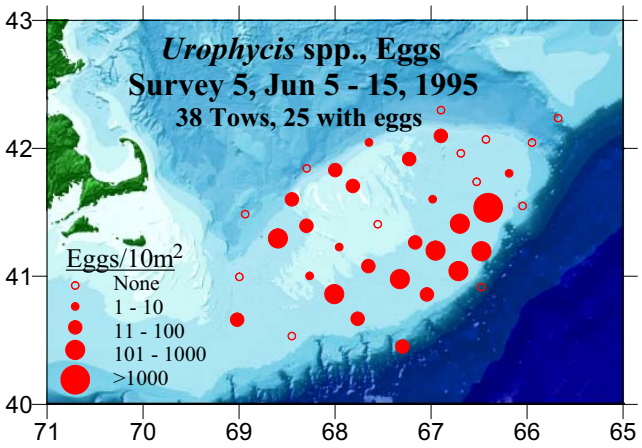
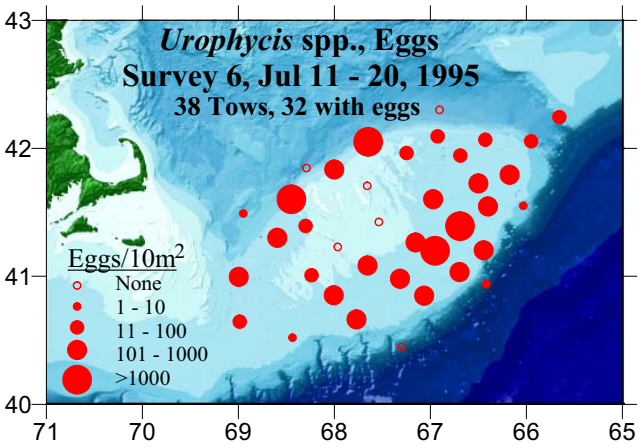


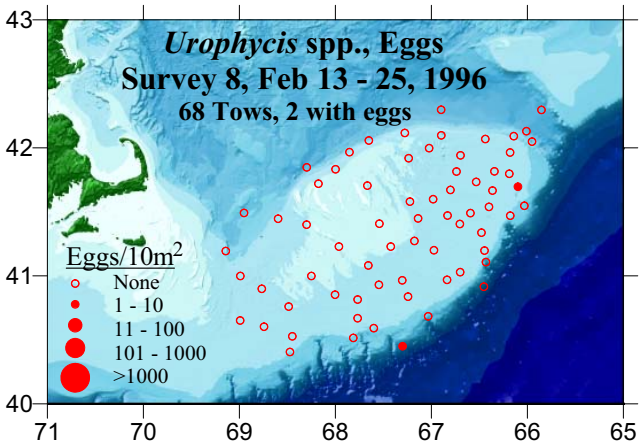
Figure 8. Distribution and abundance of hake species (*Urophycis* spp.) eggs, 1995-1999.

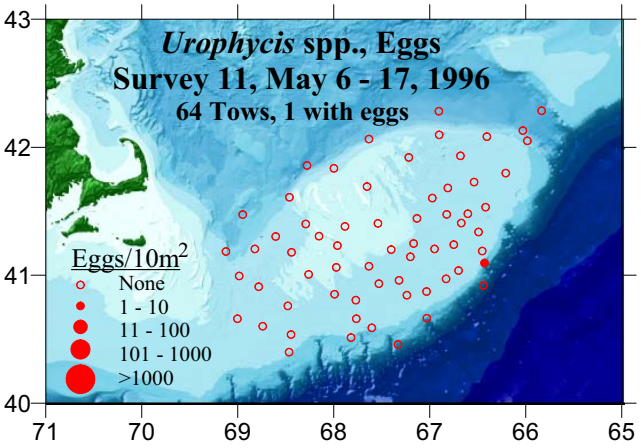












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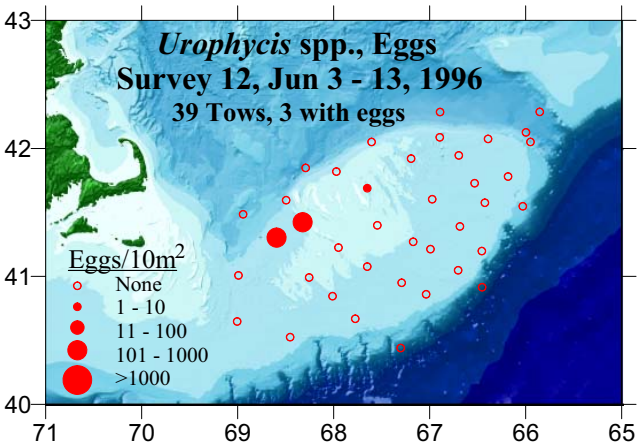

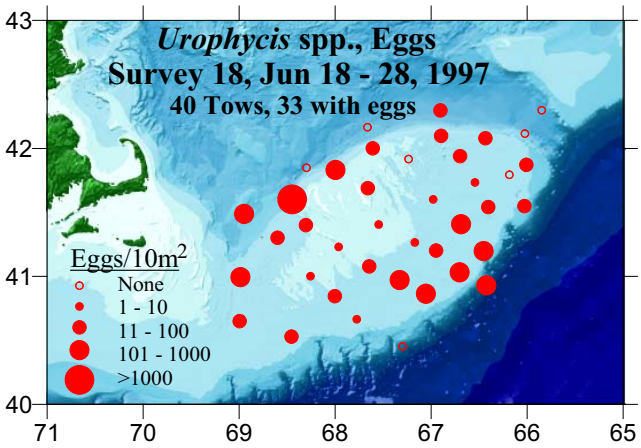

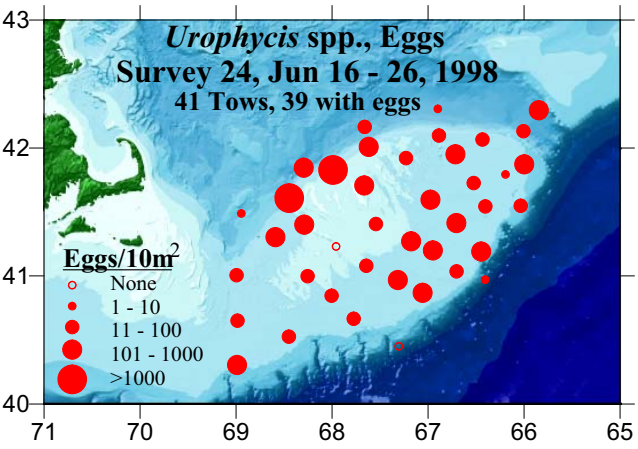

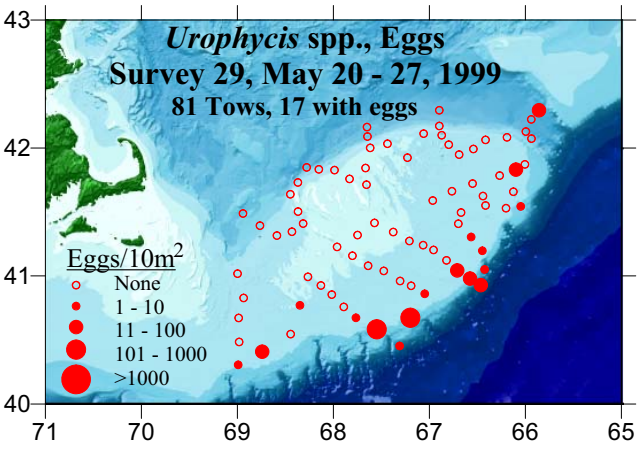

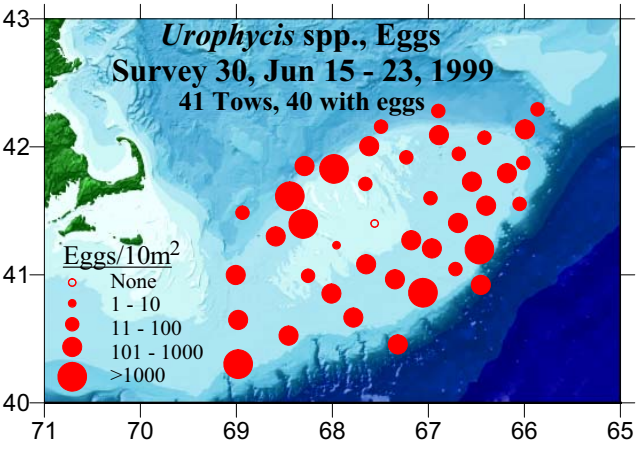

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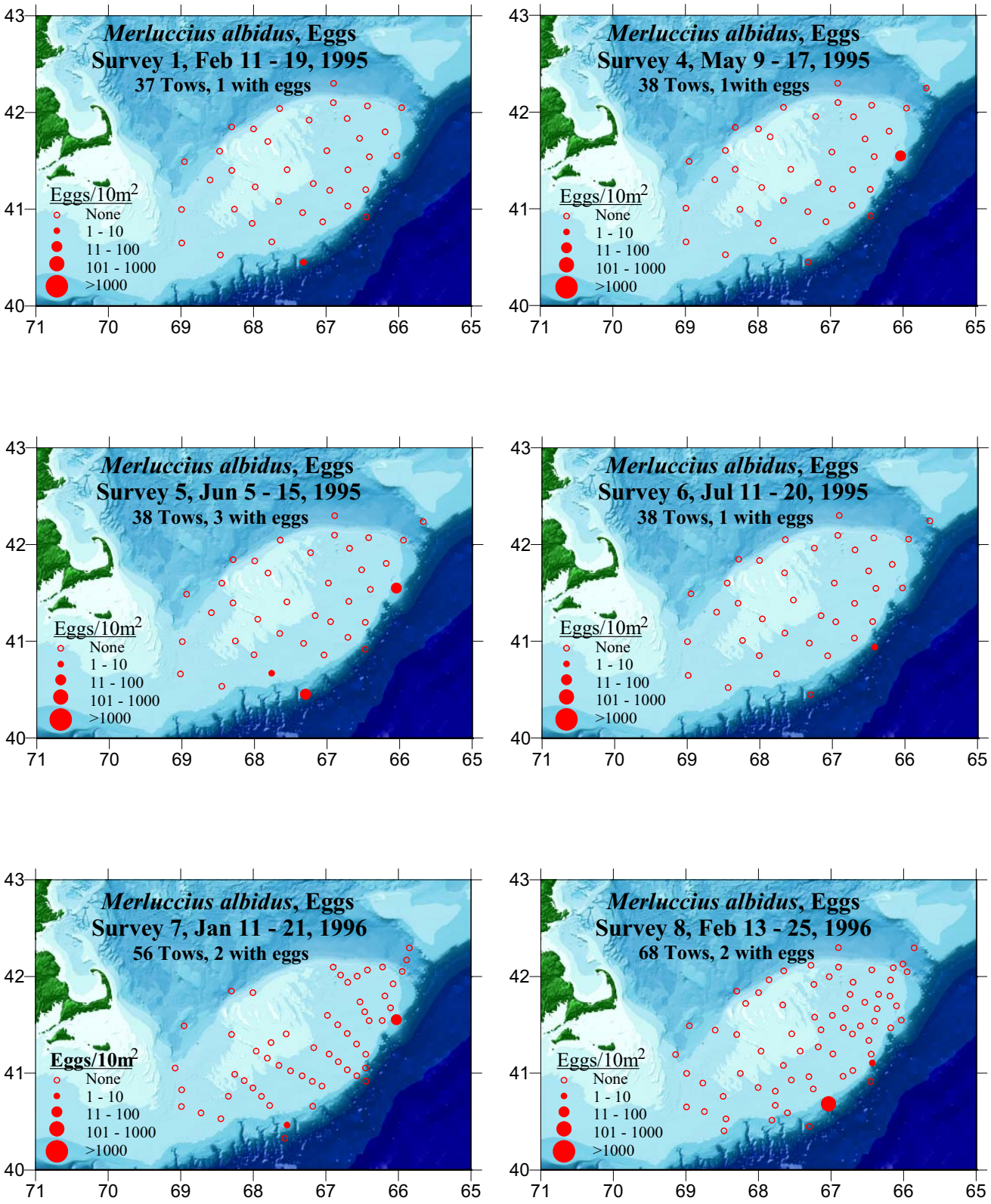
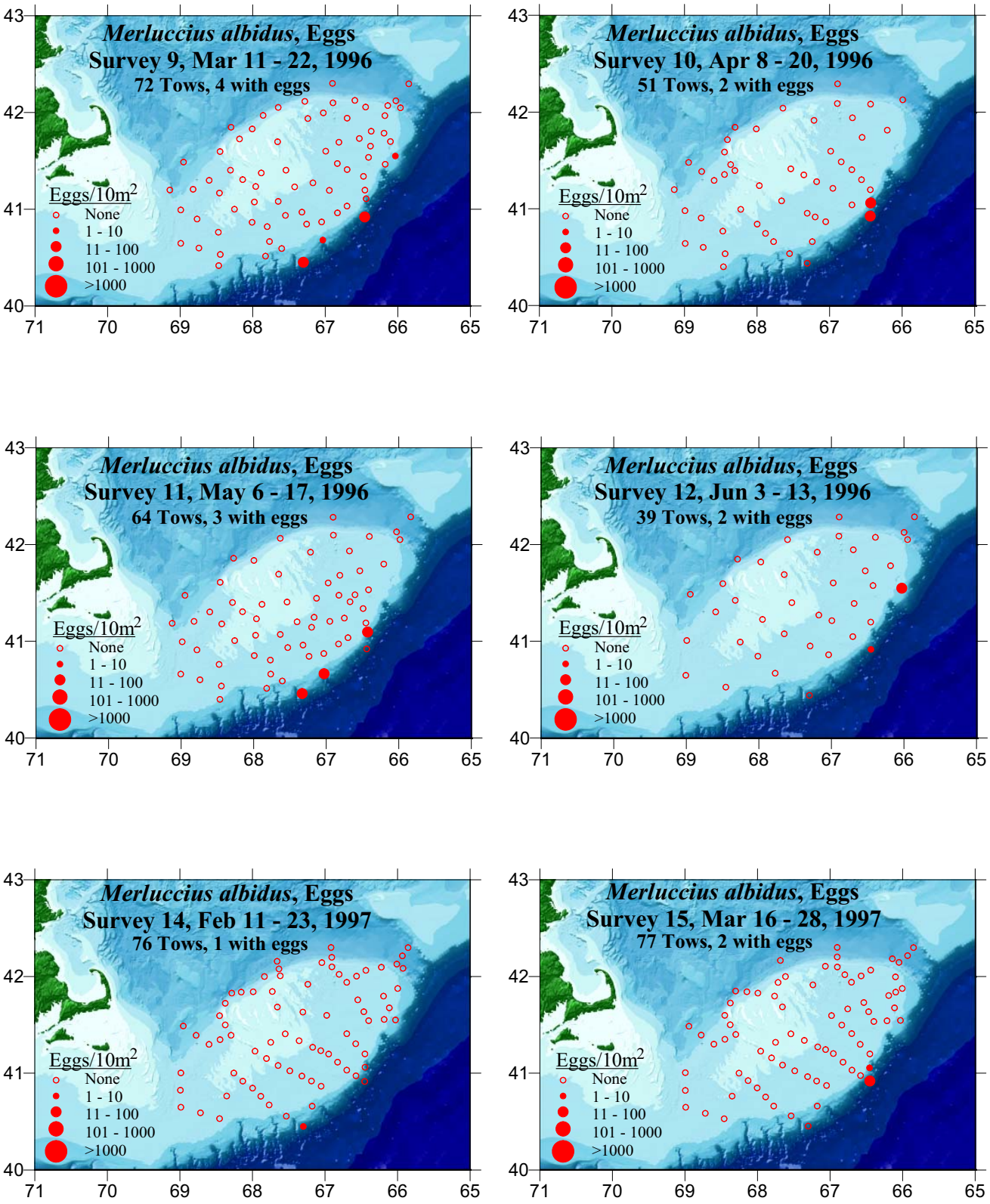


Figure 9. Distribution and abundance of offshore hake (*Merluccius albidus*) eggs, 1995-1999.



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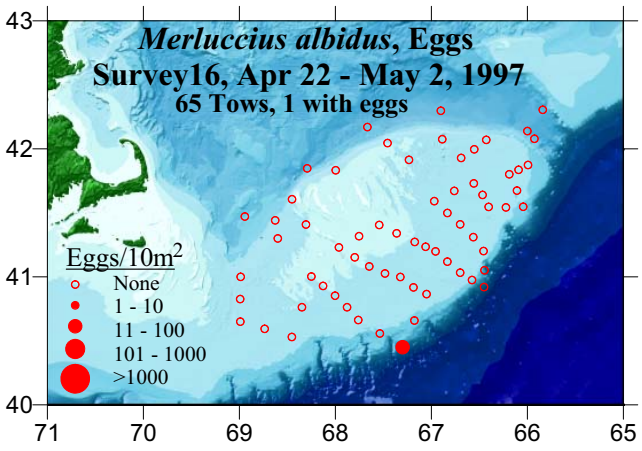

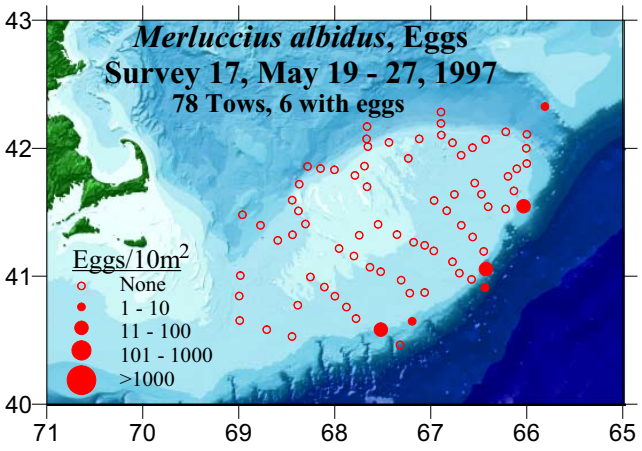

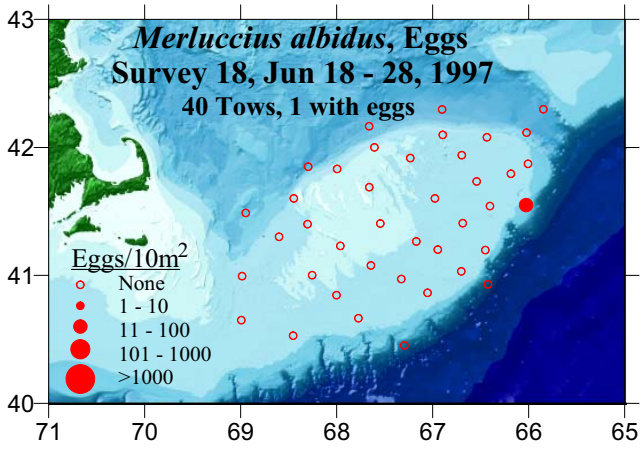

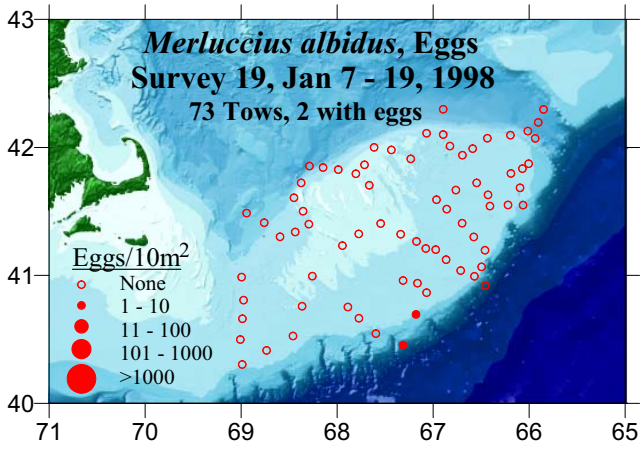

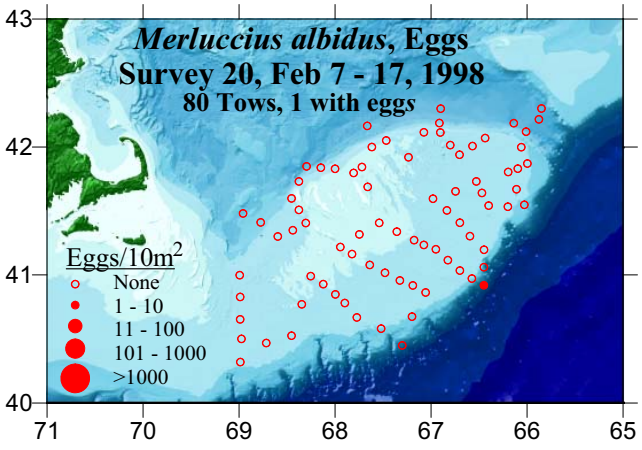

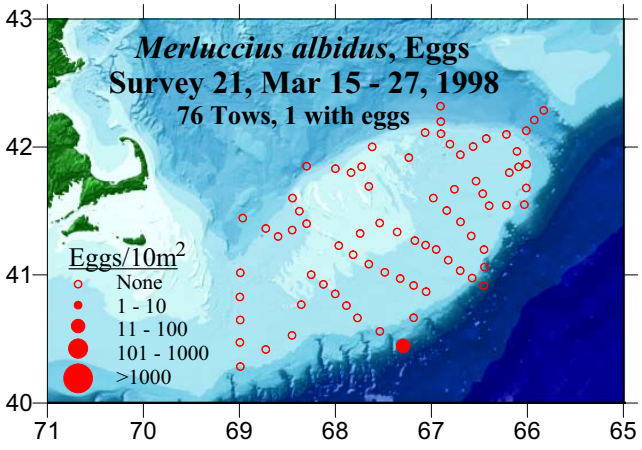

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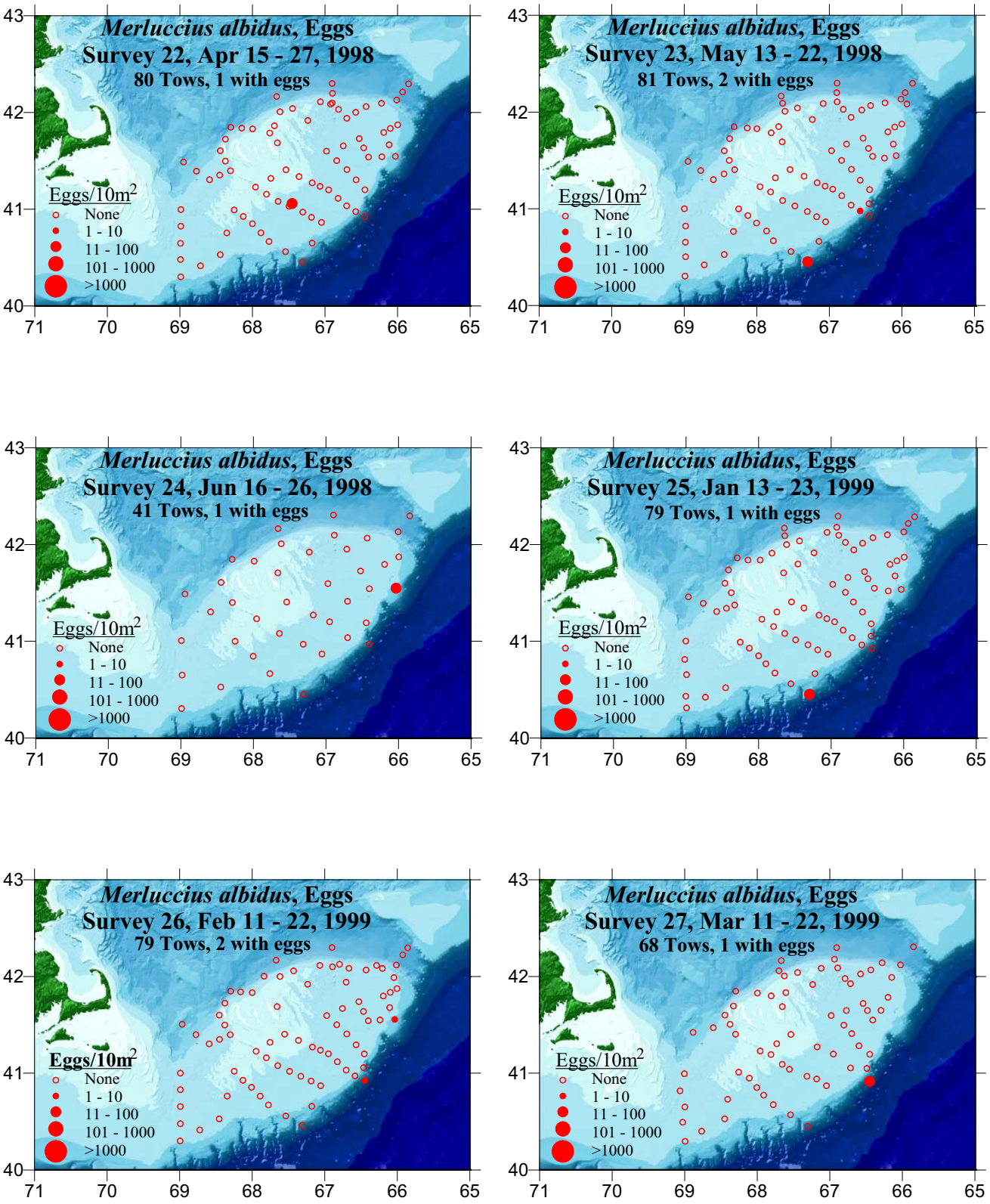

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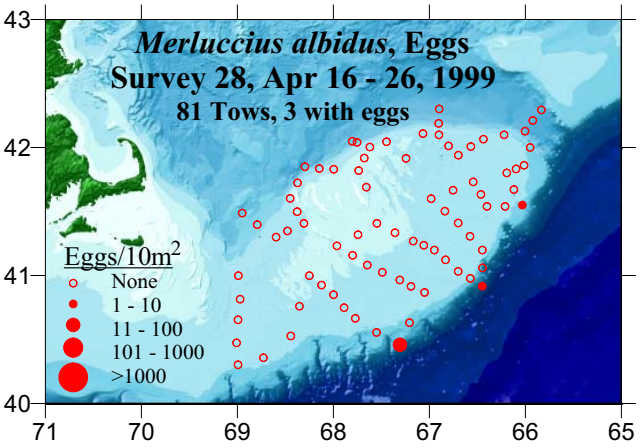

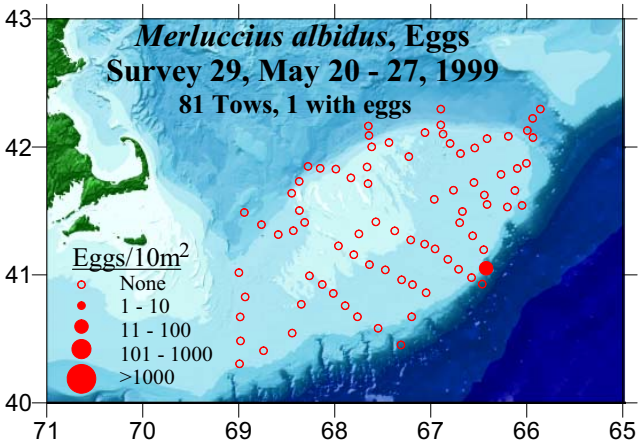

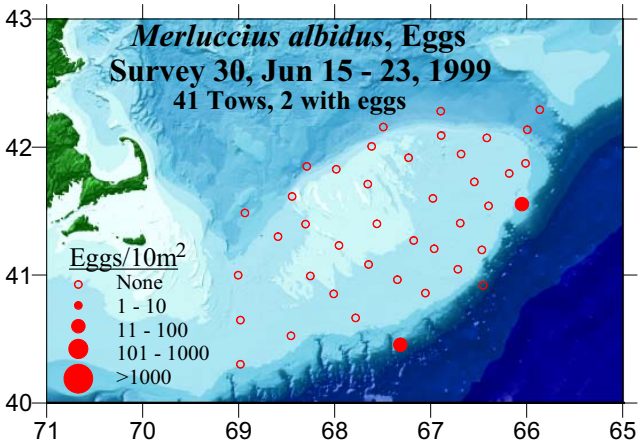

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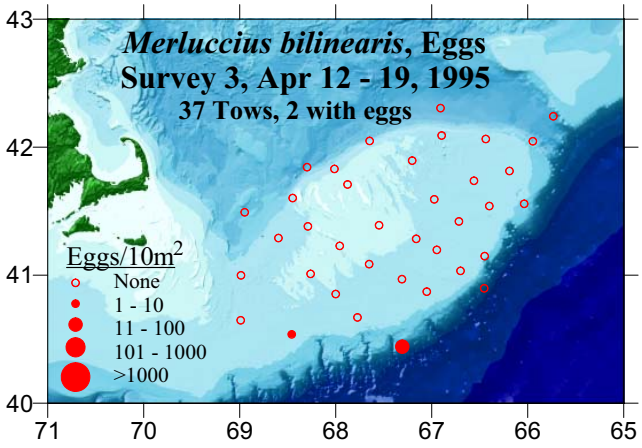


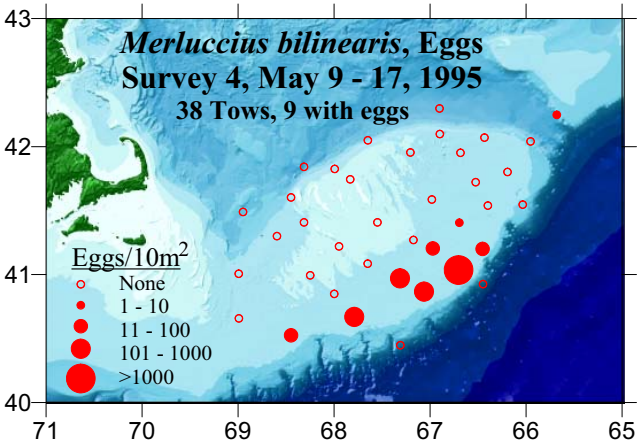
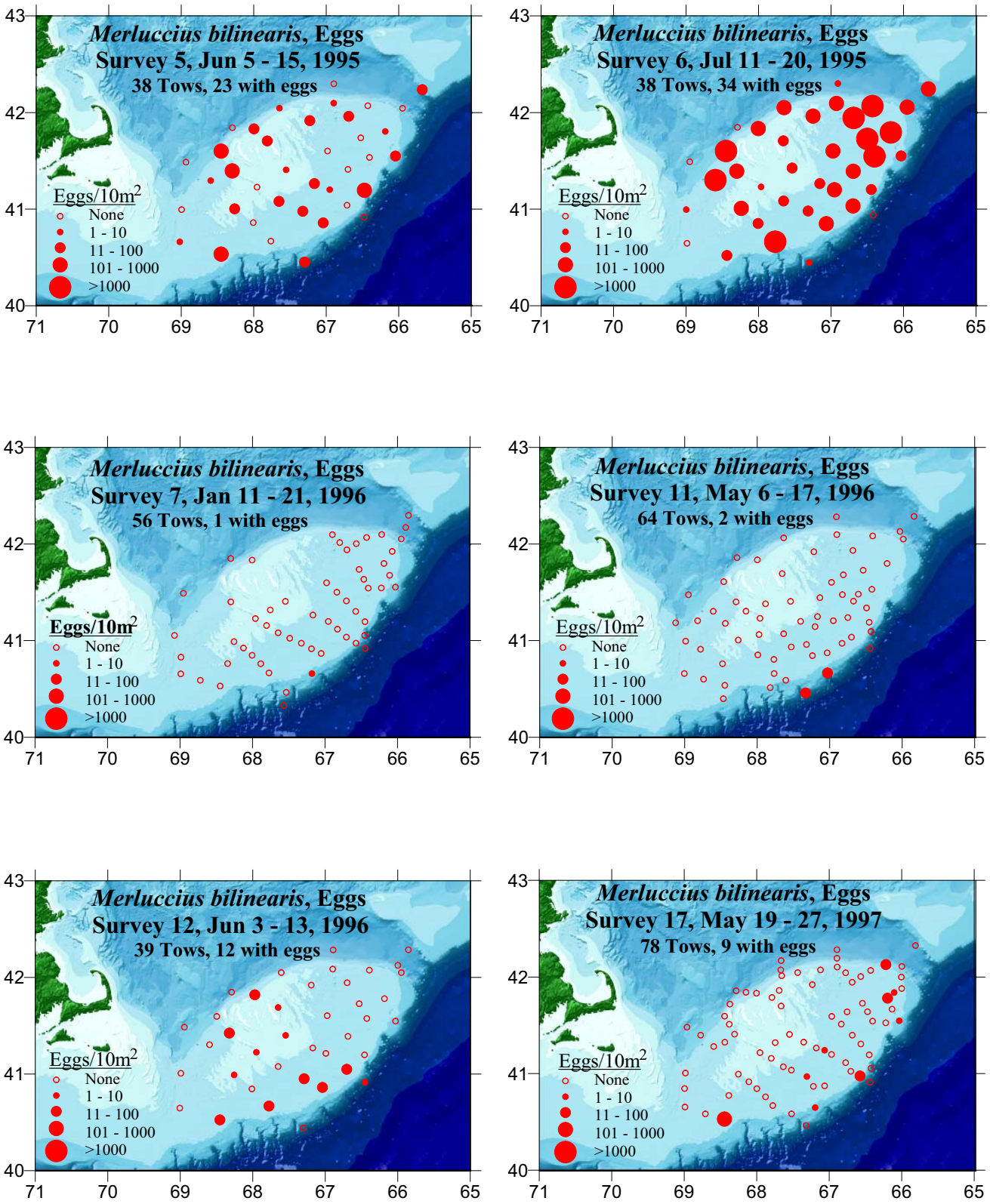


Figure 10. Distribution and abundance of silver hake (*Merluccius bilinearis*) eggs, 1995-1999.



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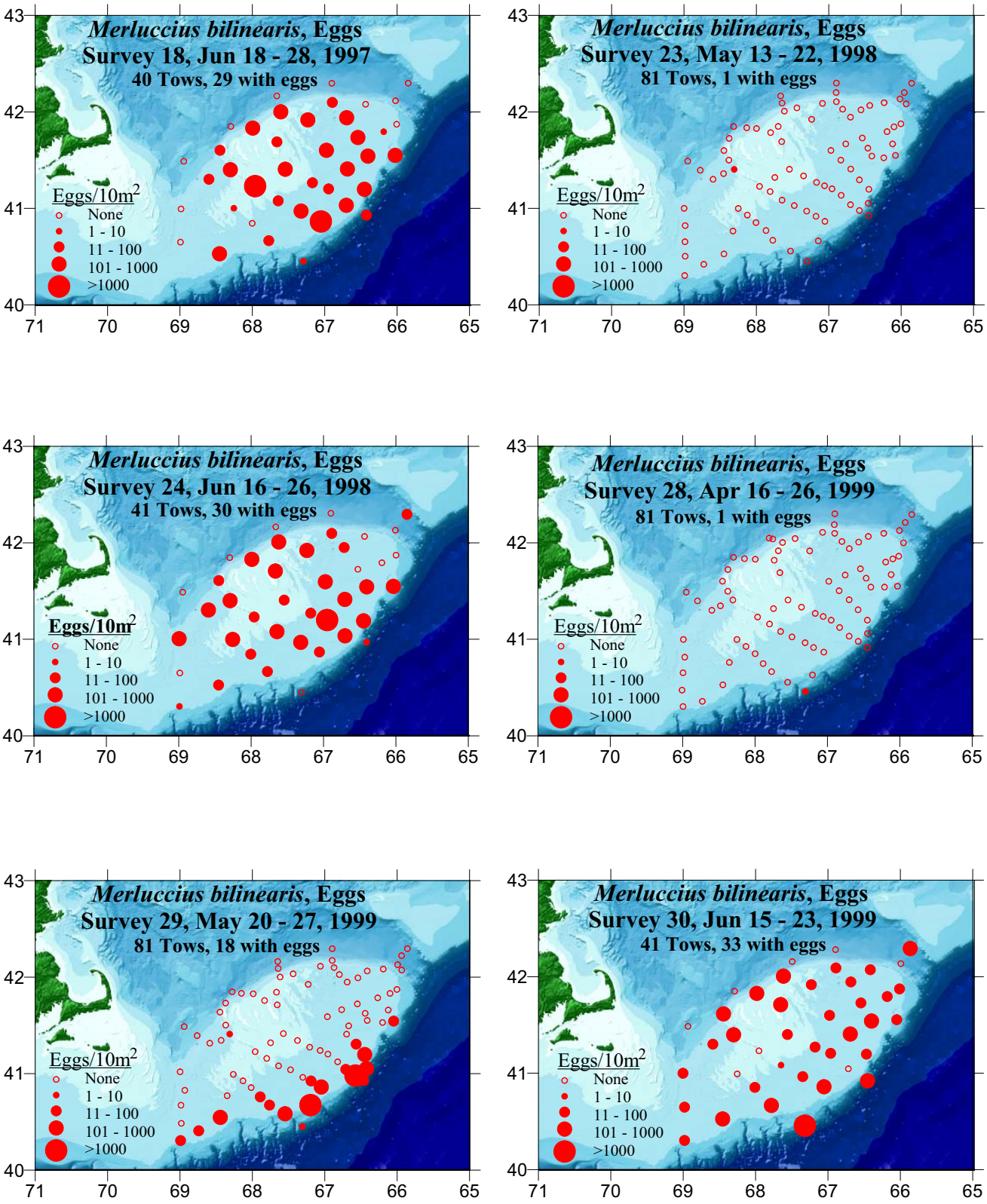

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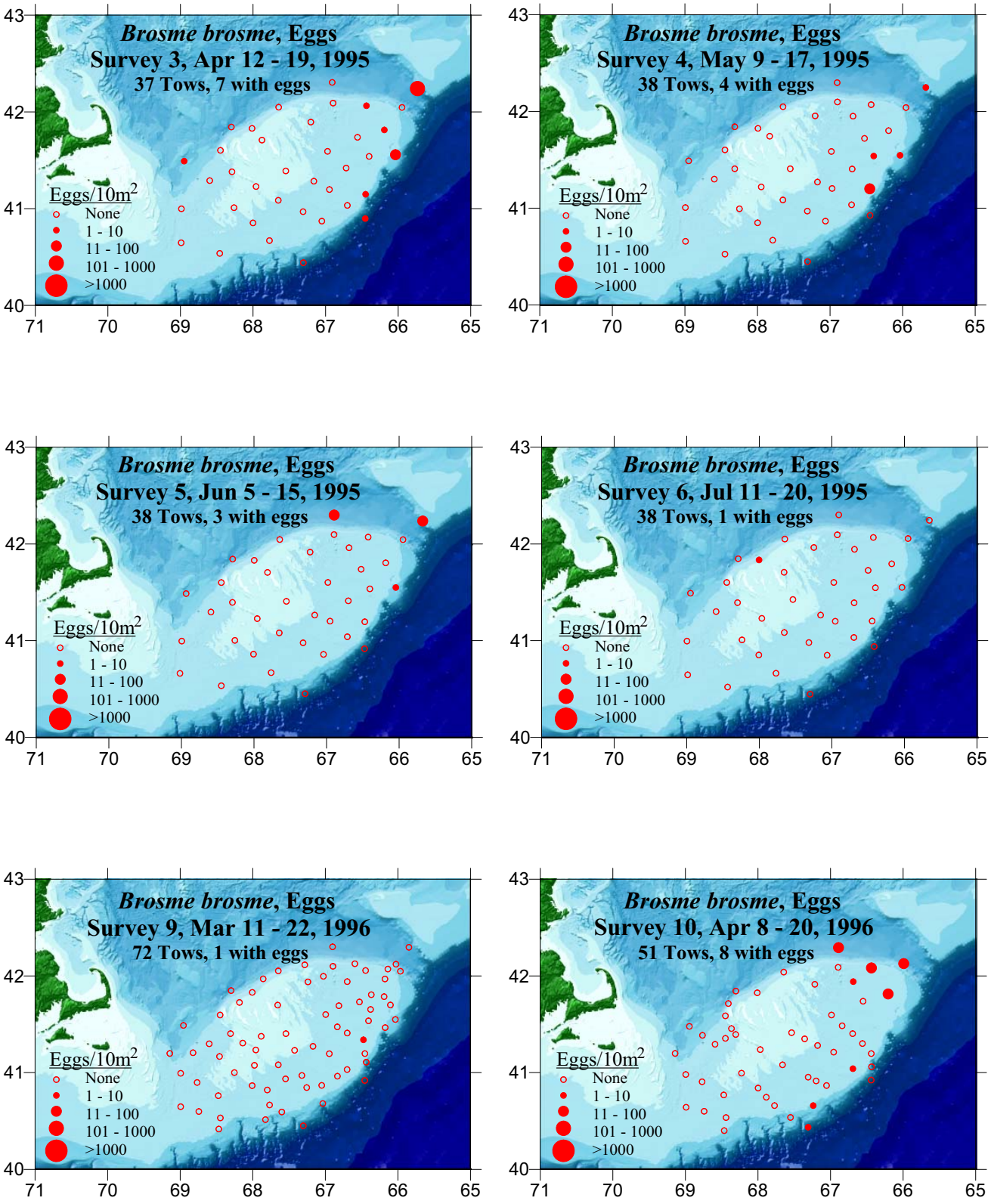
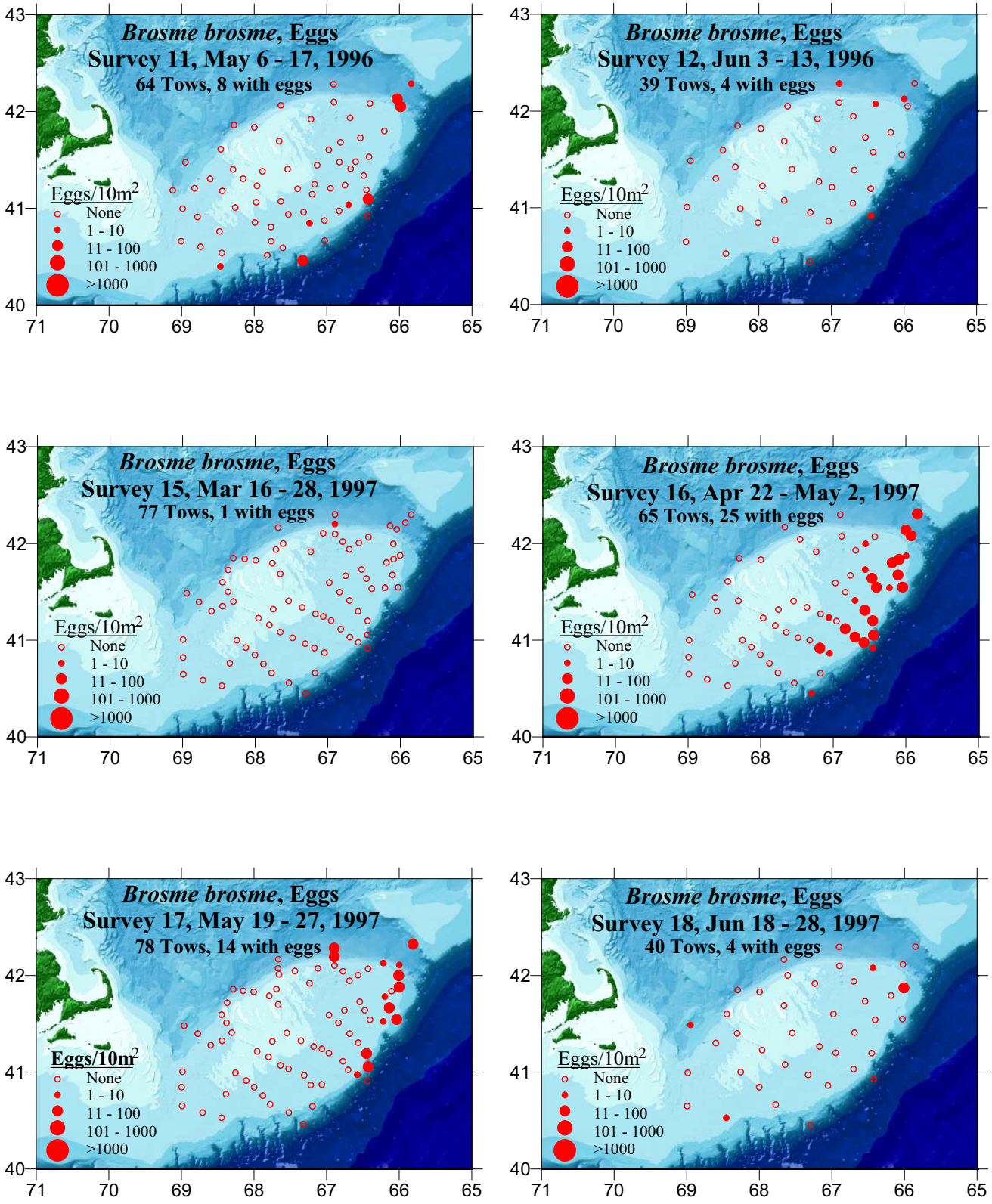


Figure 11. Distribution and abundance of cusk (*Brosme brosme*) eggs, 1995-1999.



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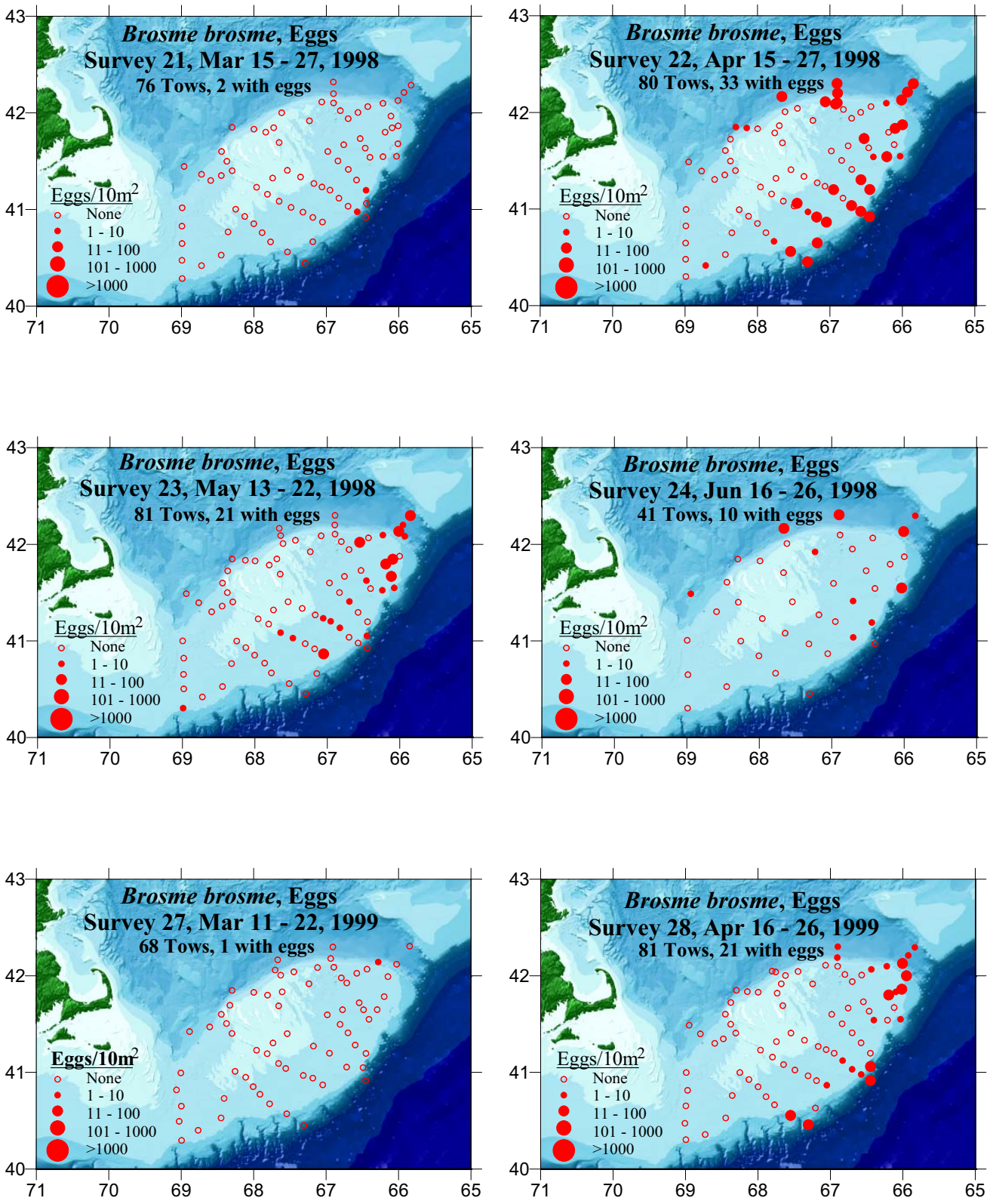

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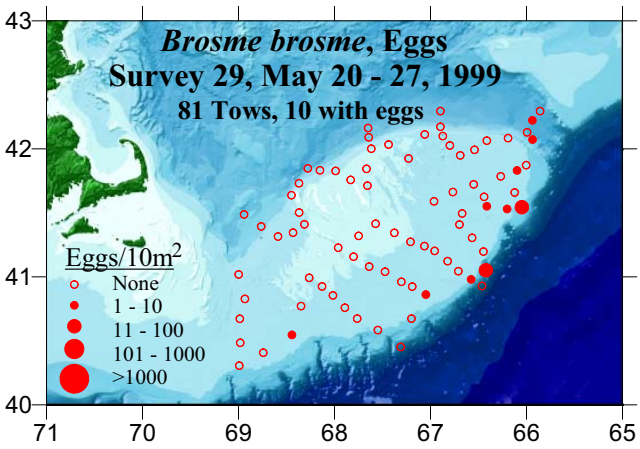

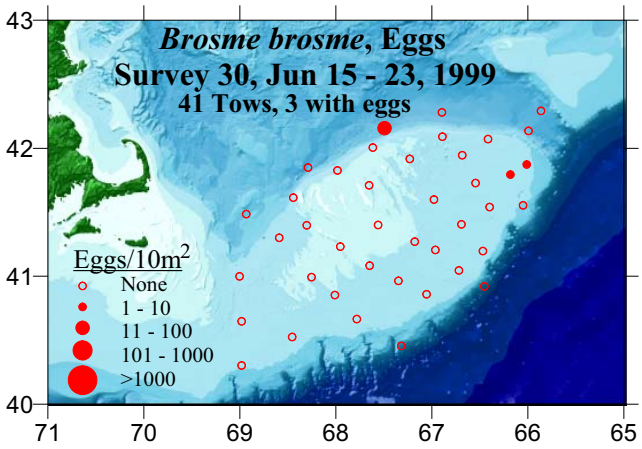

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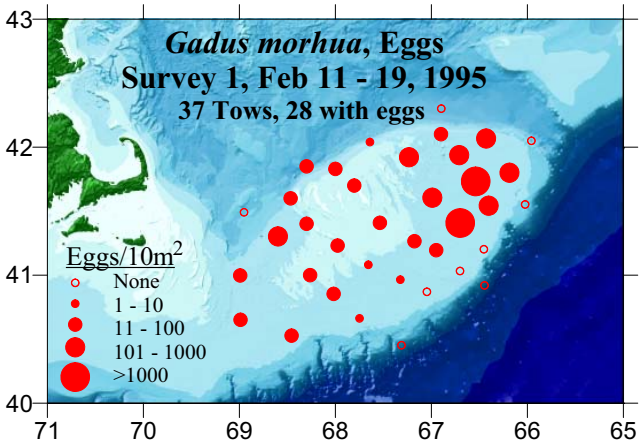
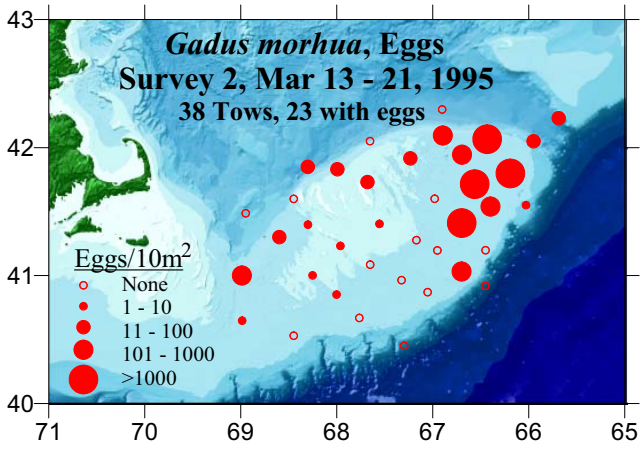
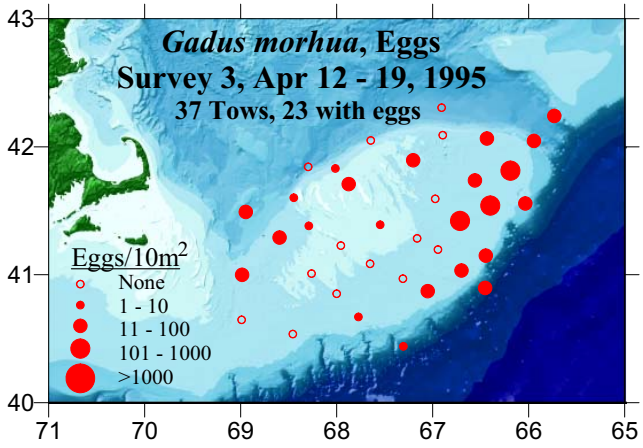






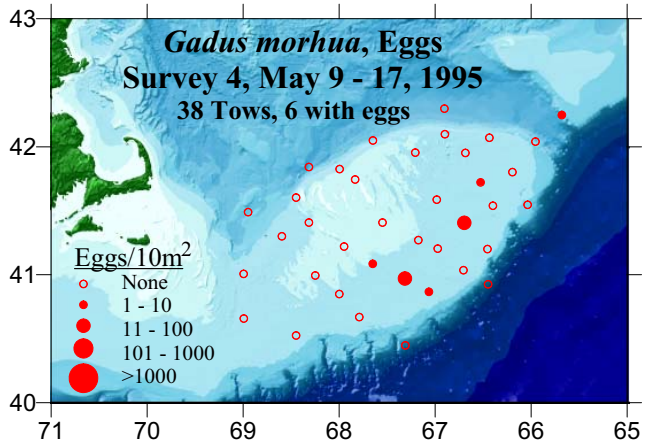
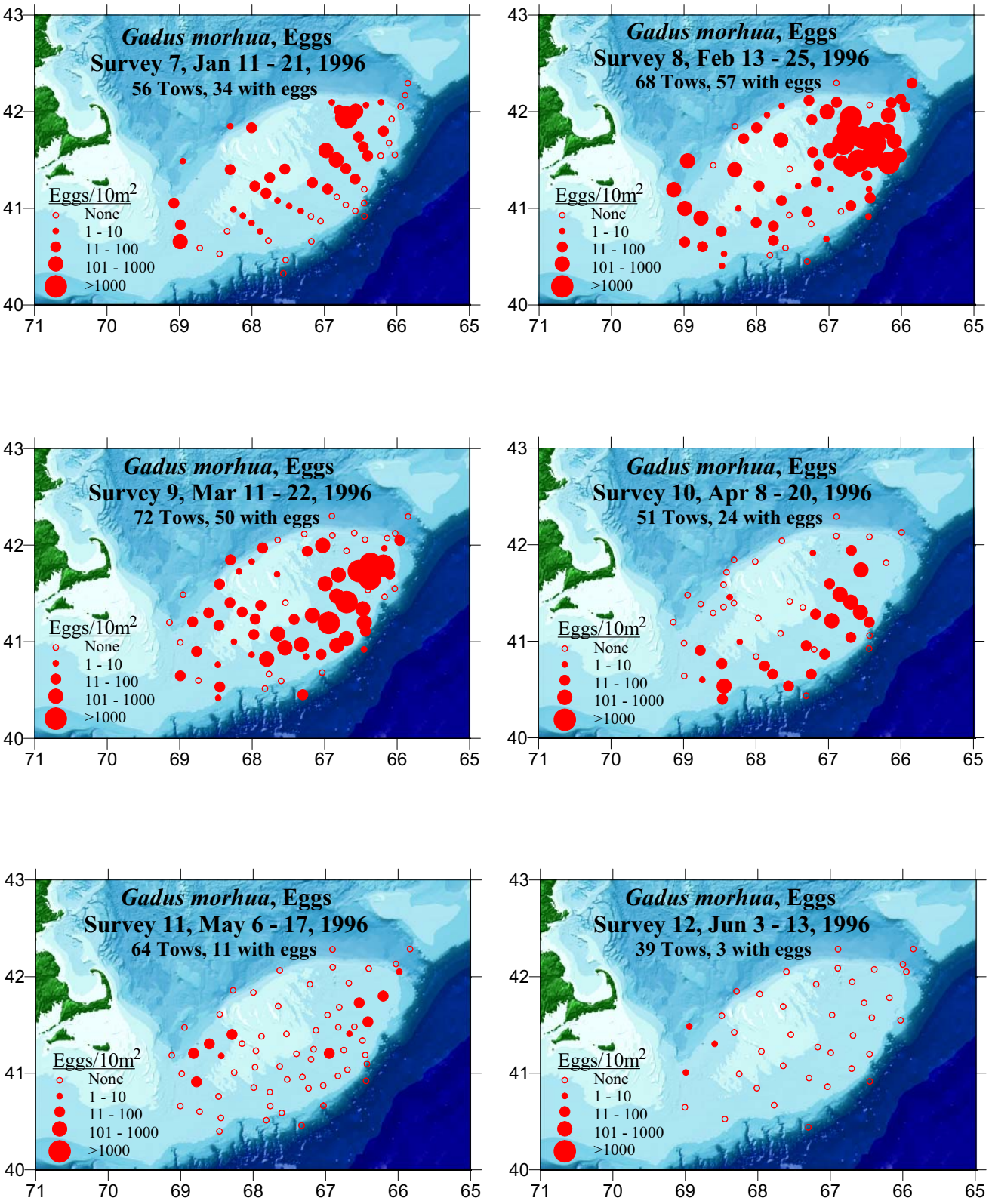


Figure 12. Distribution and abundance of Atlantic cod (*Gadus morhua*) eggs, 1995-1999.



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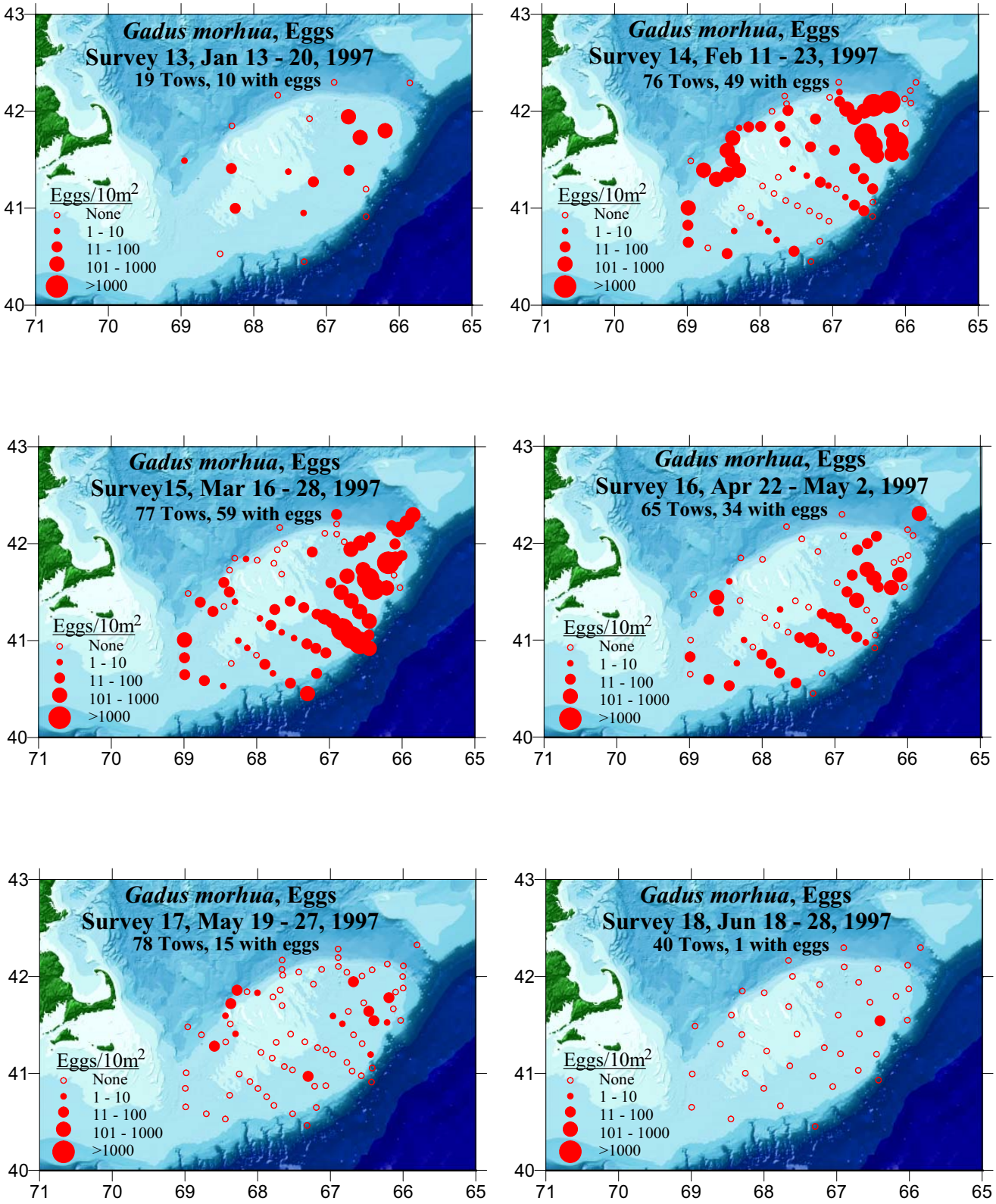

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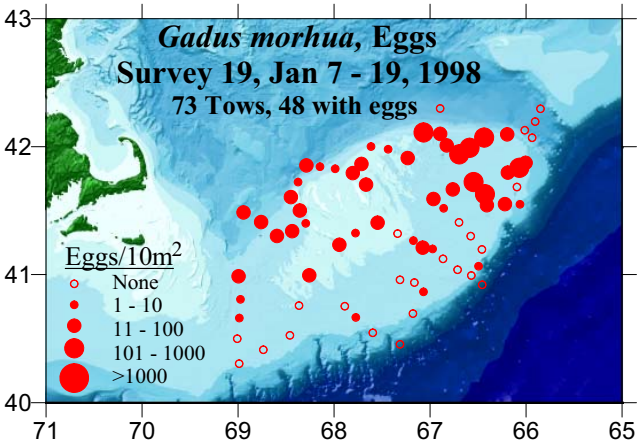

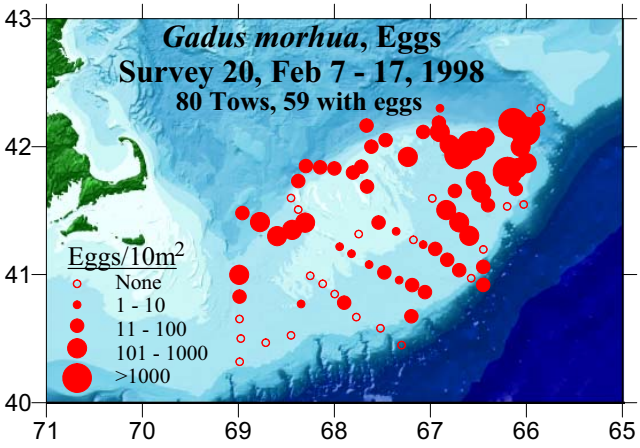

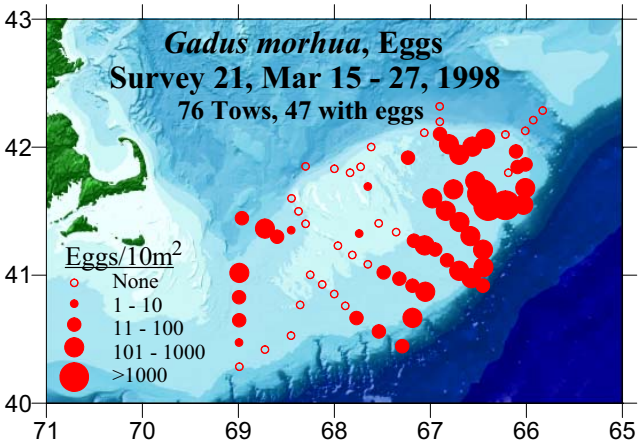

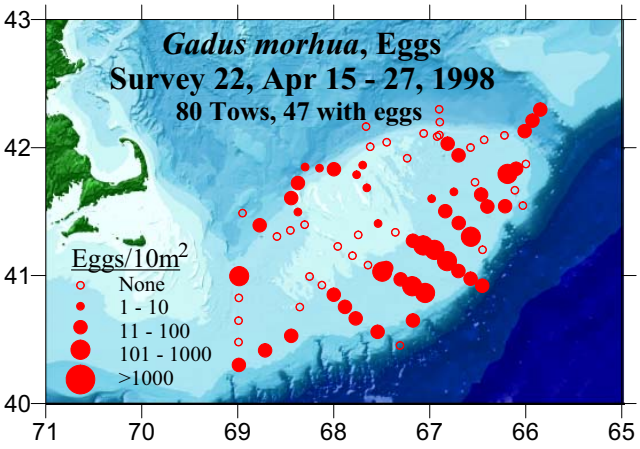

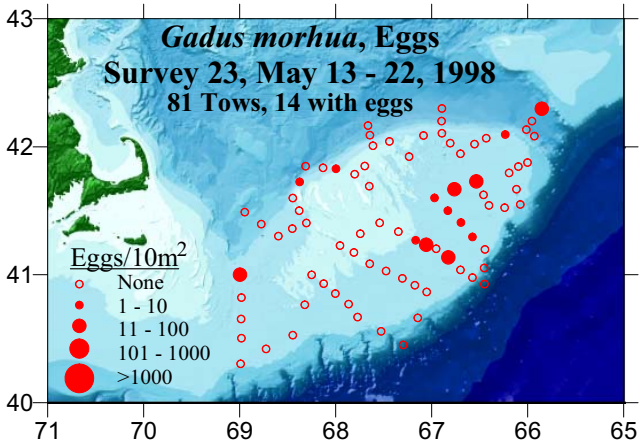

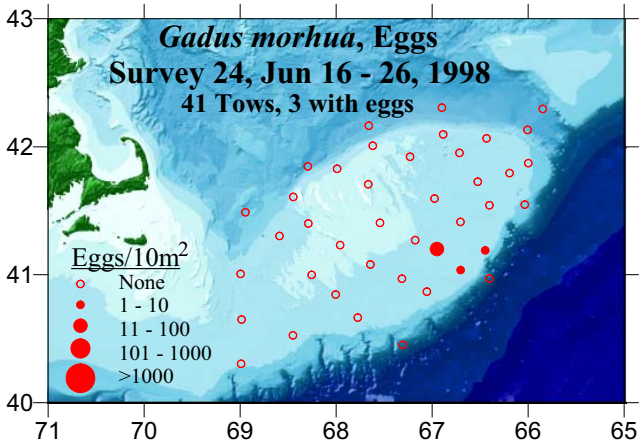

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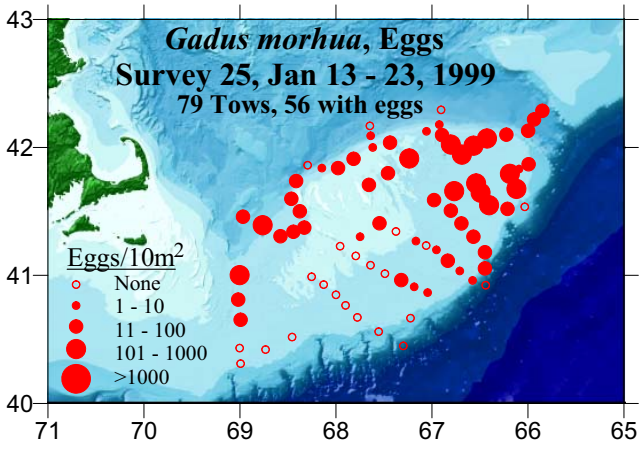

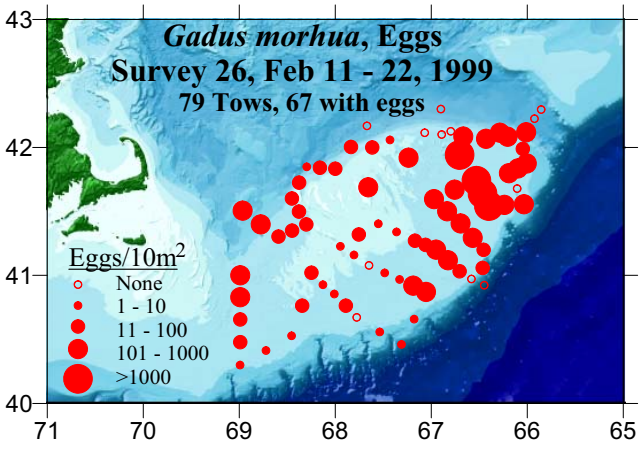

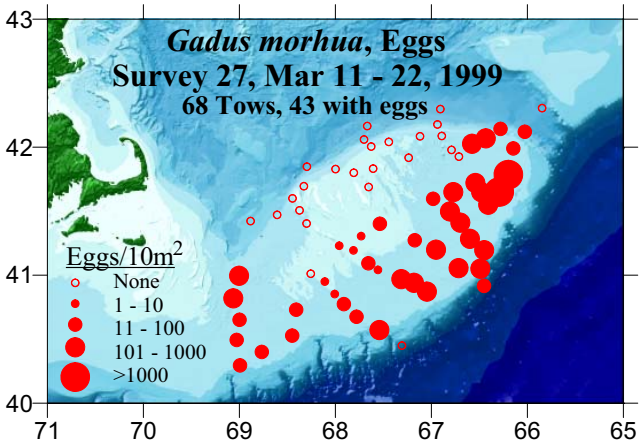

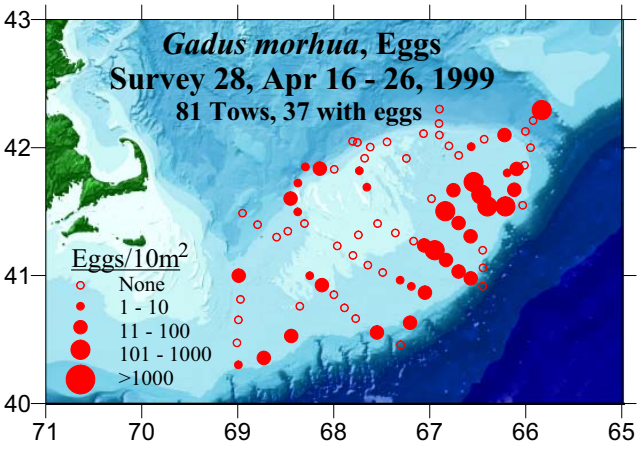

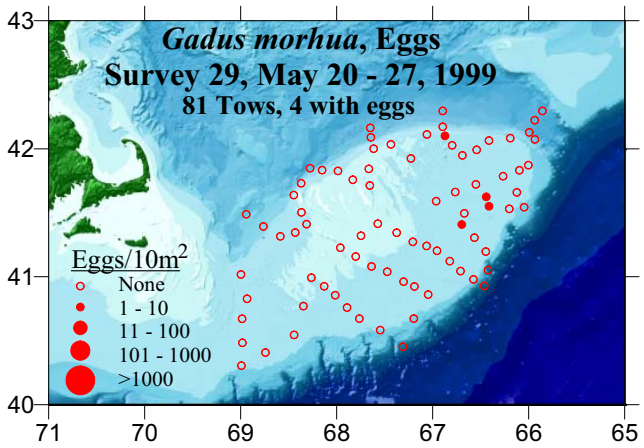

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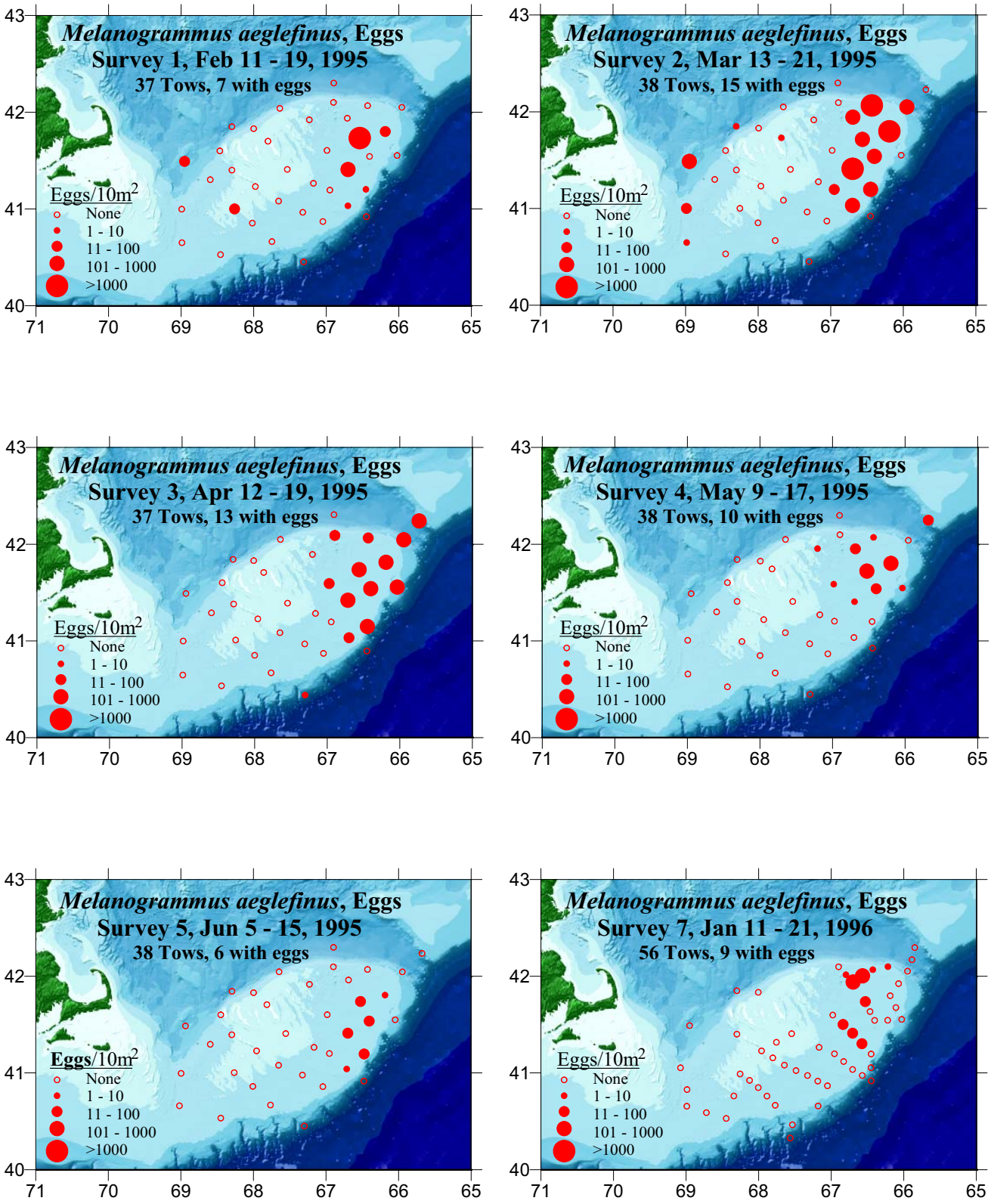
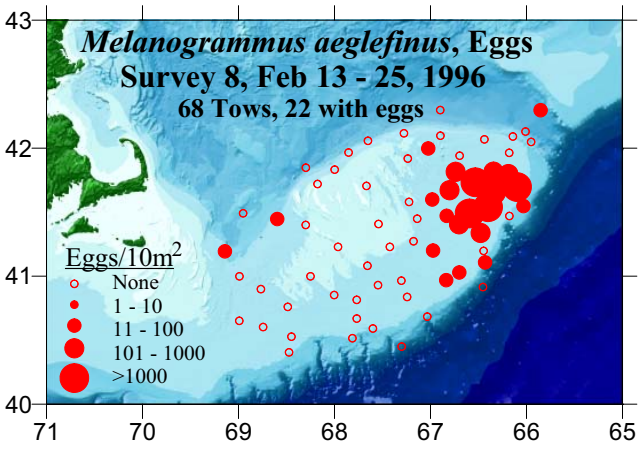
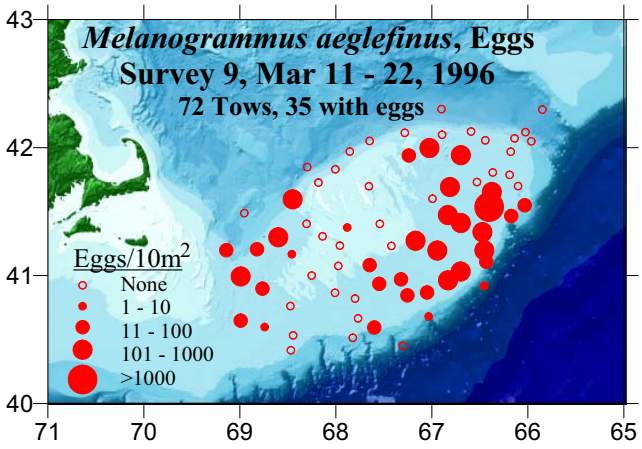
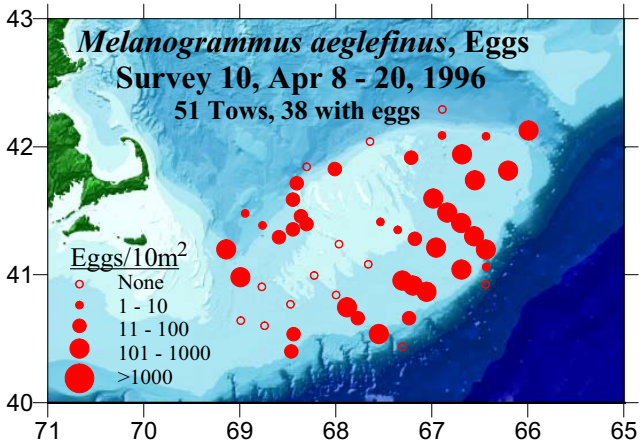
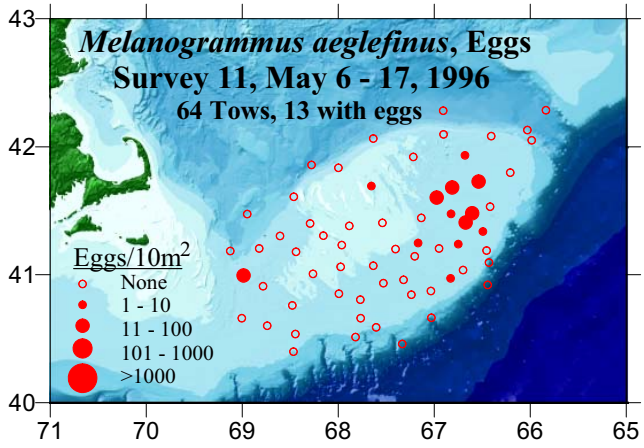


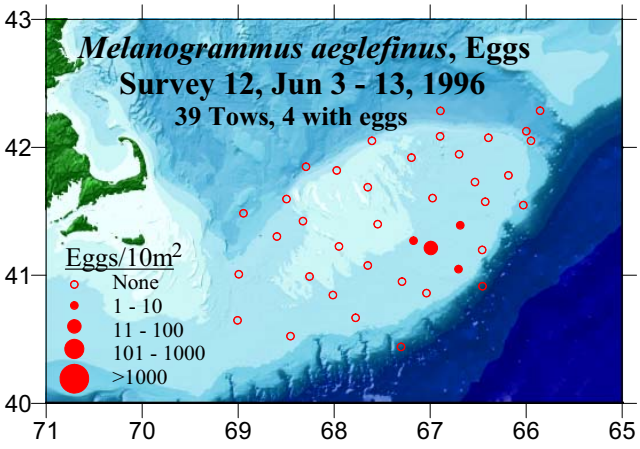
Figure 13. Distribution and abundance of haddock (*Melanogrammus aeglefinus*) eggs, 1995-1999.

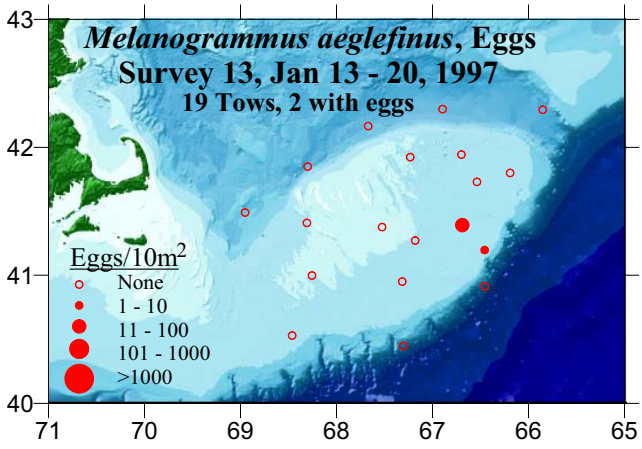












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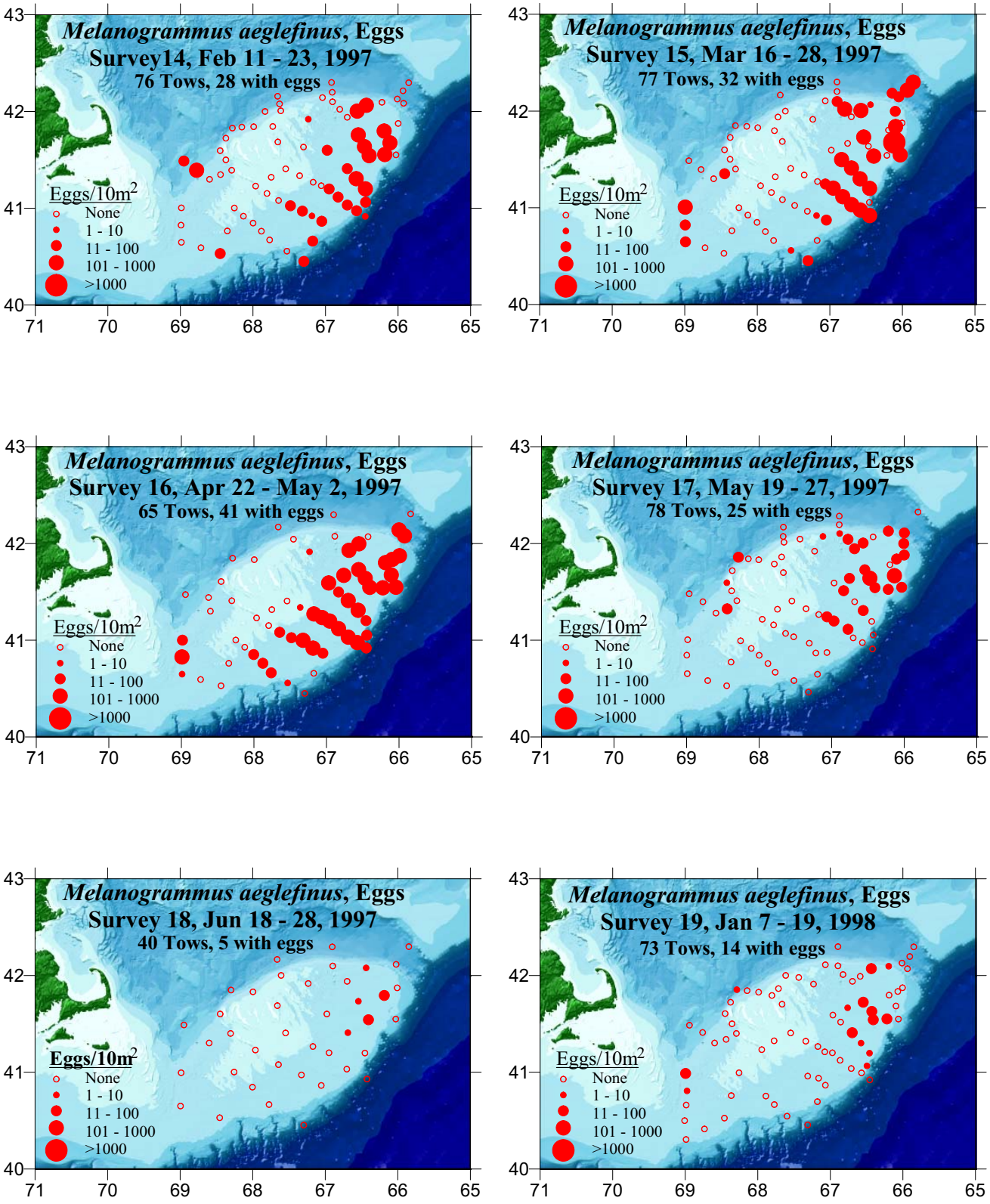

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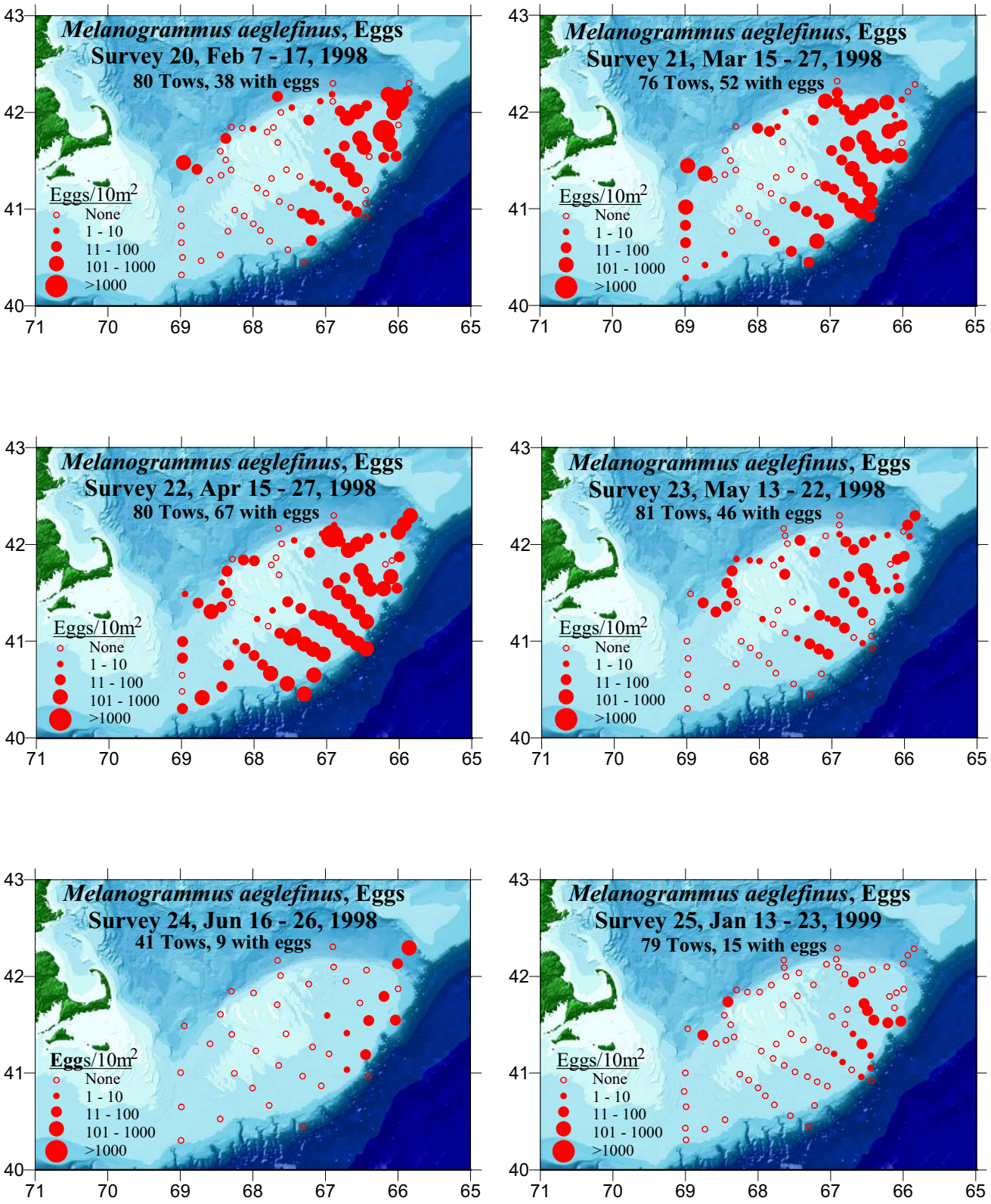

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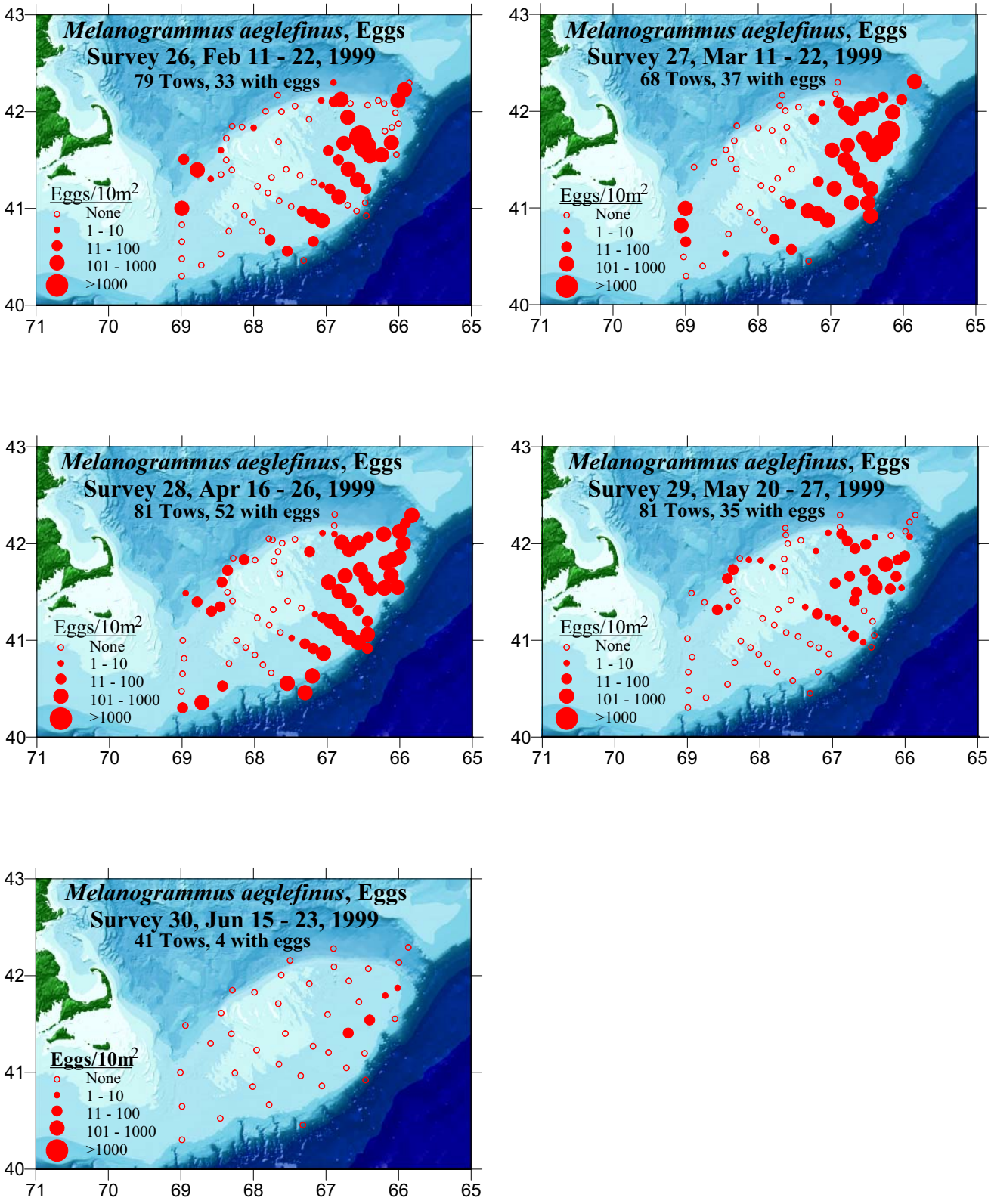

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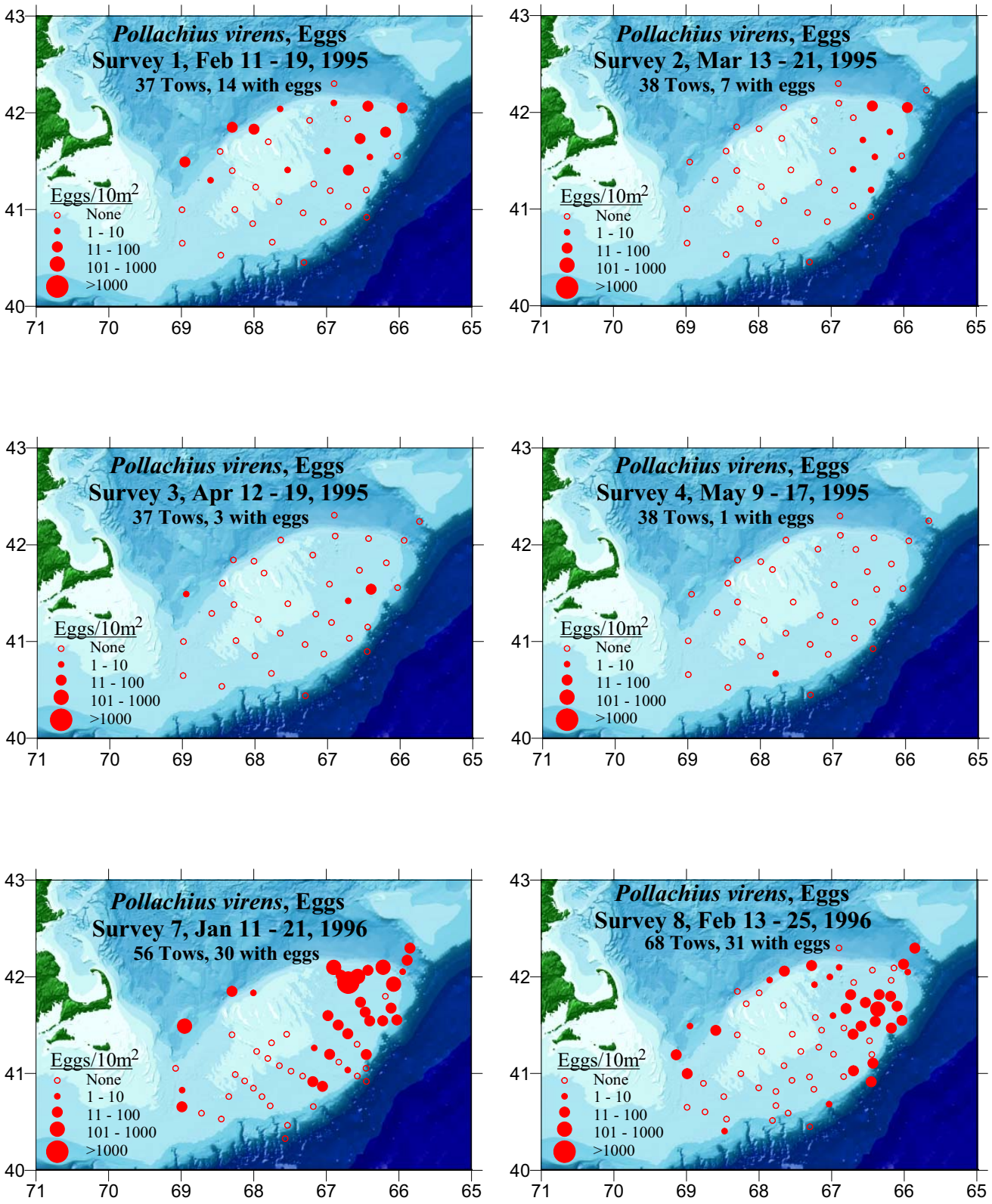
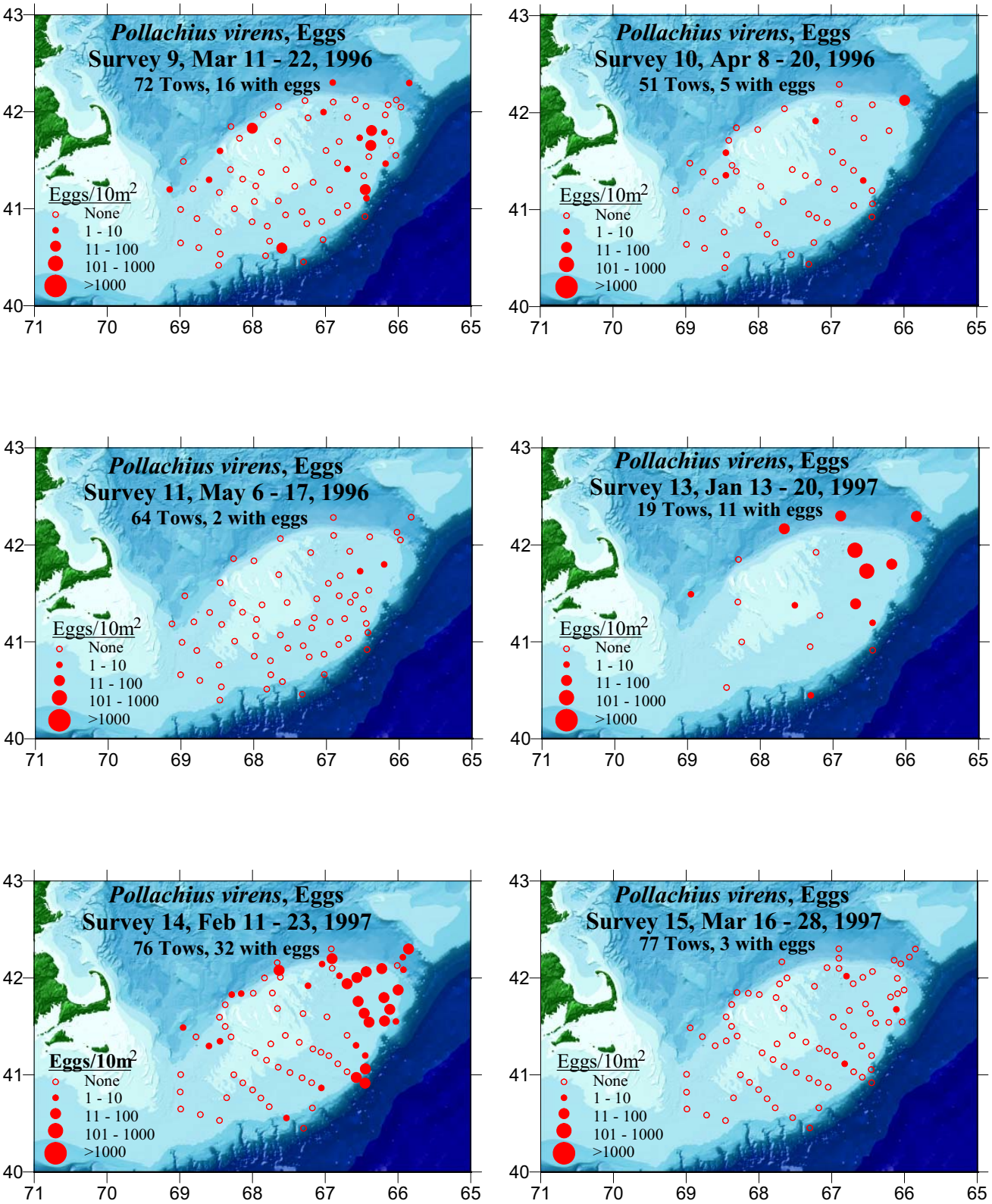


Figure 14. Distribution and abundance of pollock (*Pollachius virens*) eggs, 1995-1998.



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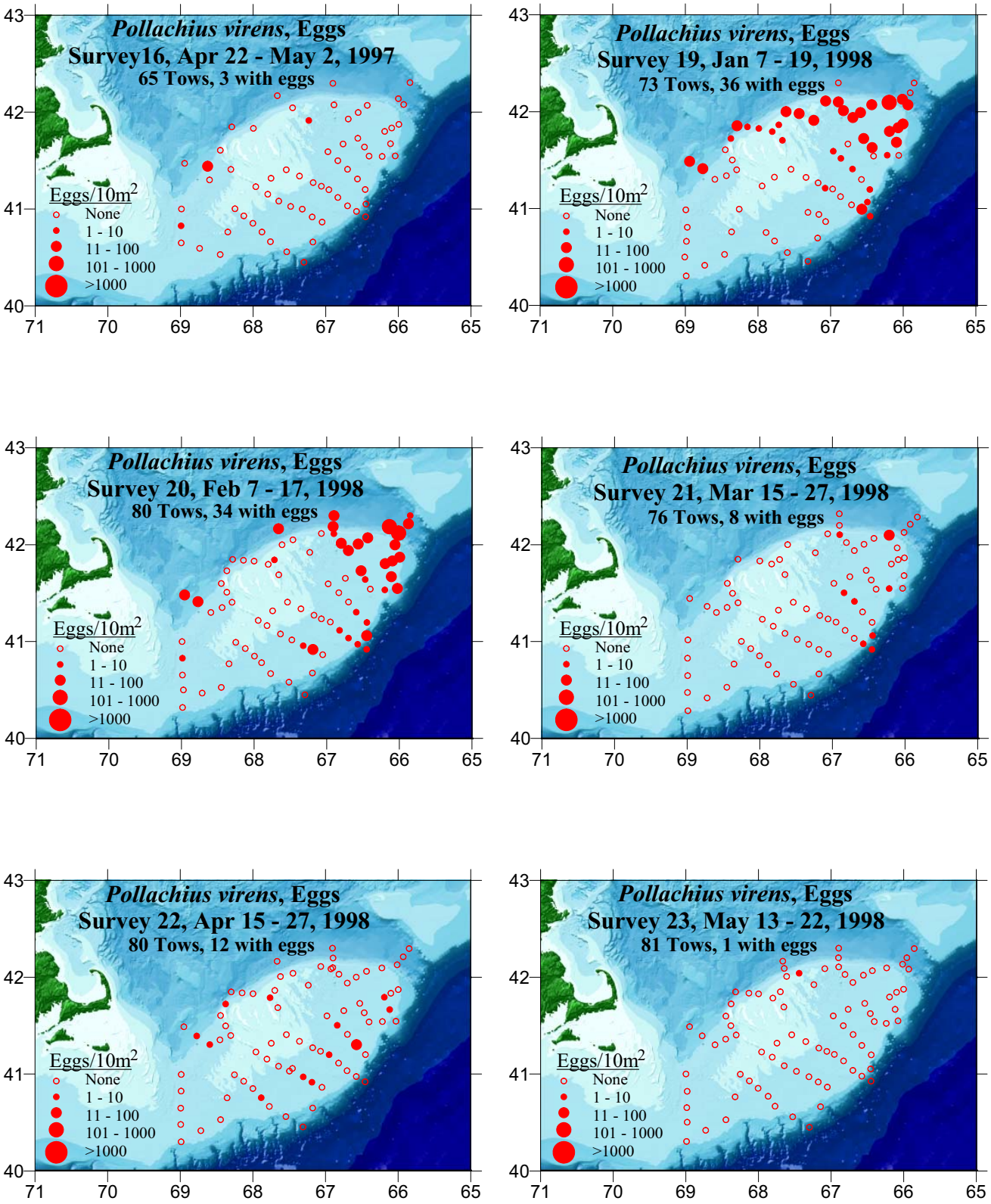

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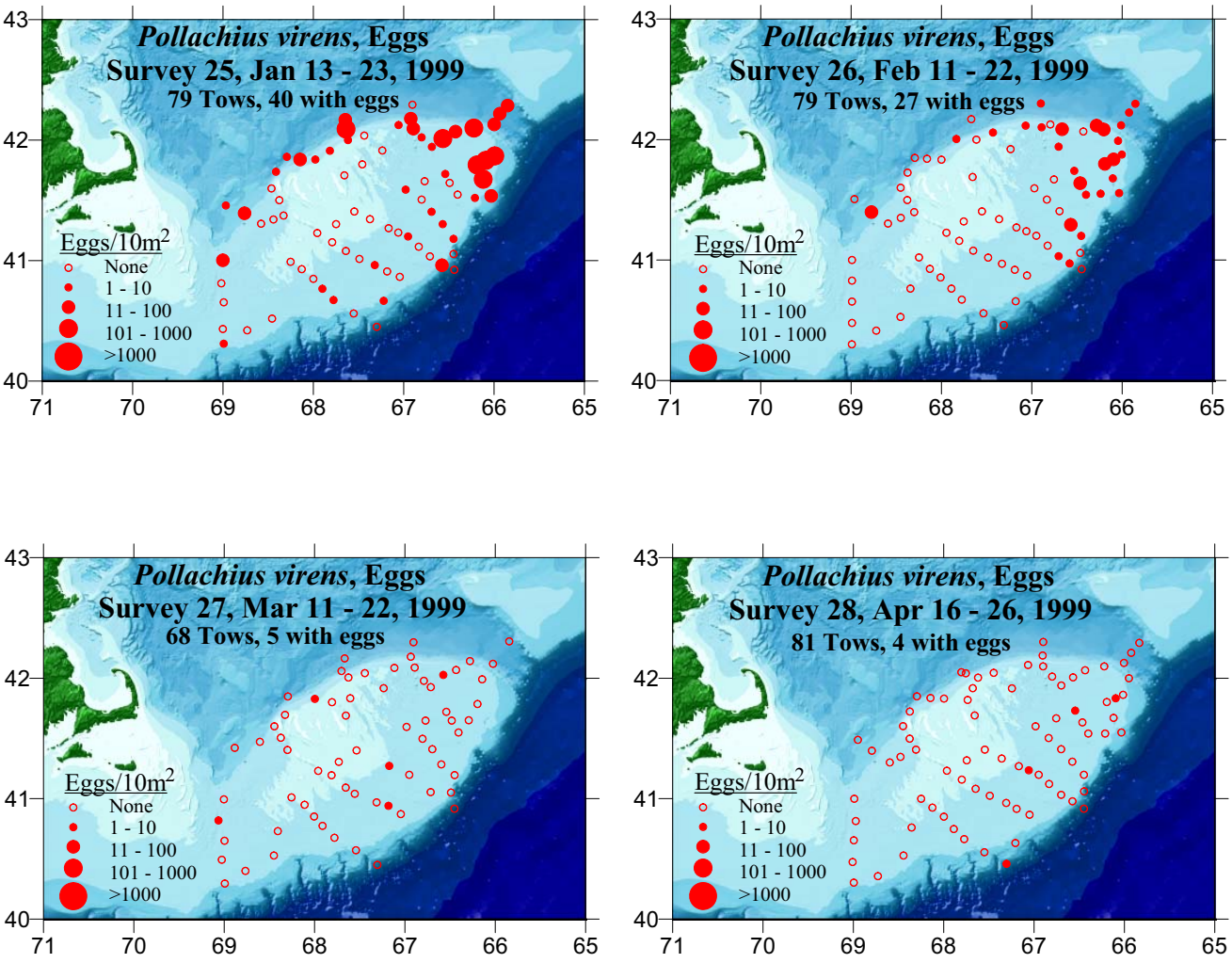

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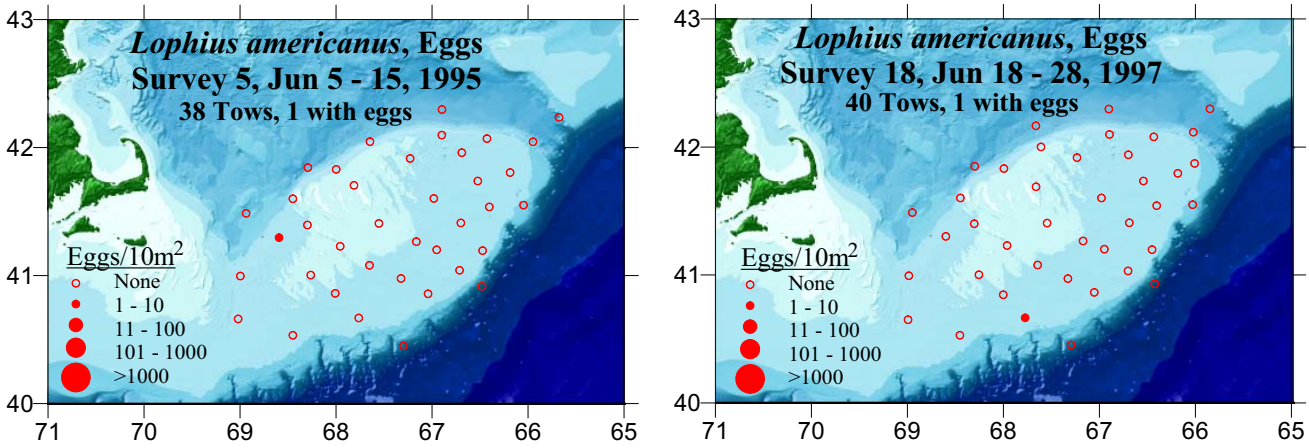


Figure 15. Distribution and abundance of goosefish (*Lophius americanus*) eggs, 1995 and 1997.

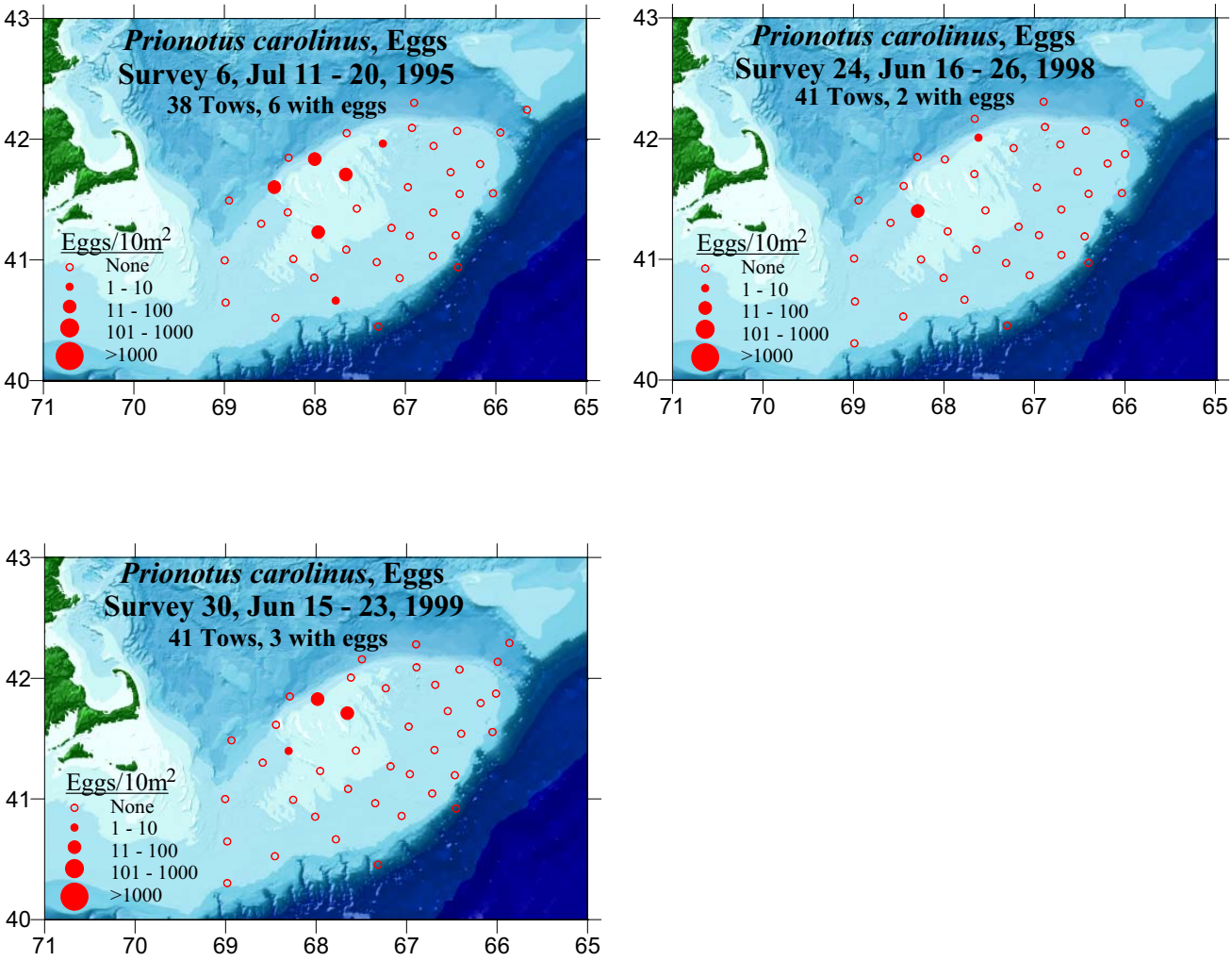


Figure 16. Distribution and abundance of northern searobin (*Prionotus carolinus*) eggs, 1995 and 1998-1999.

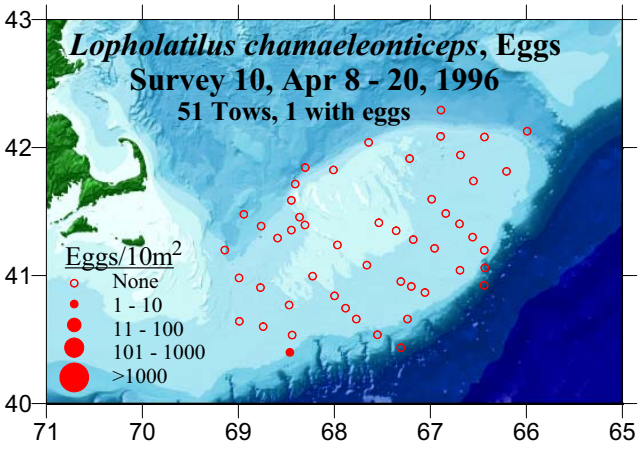


Figure 17. Distribution and abundance of tilefish (*Lopholatilus chamaeleonticeps*) eggs, 1996.

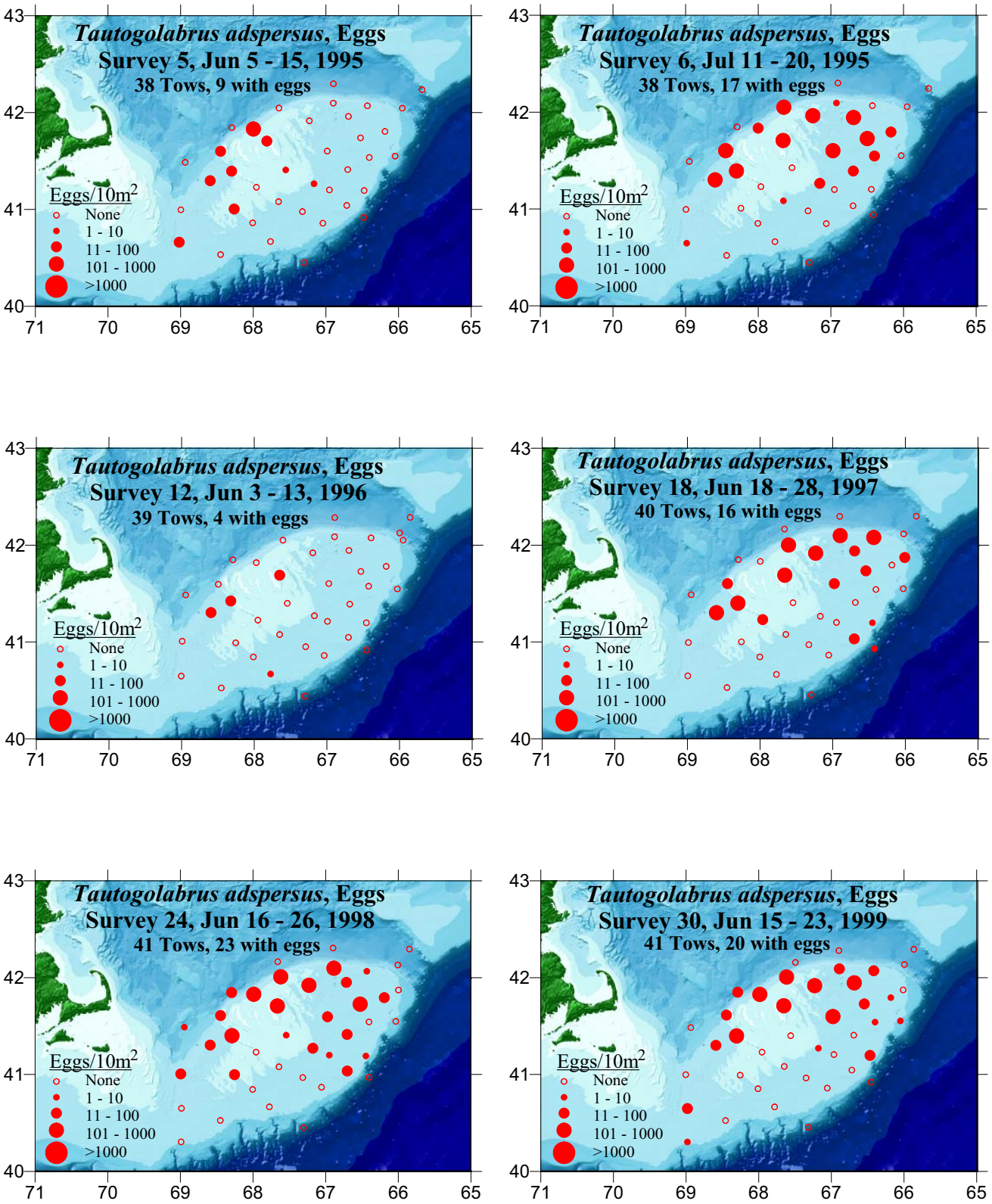


Figure 18. Distribution and abundance of cunner (*Tautogolabrus adspersus*) eggs, 1995-1999.

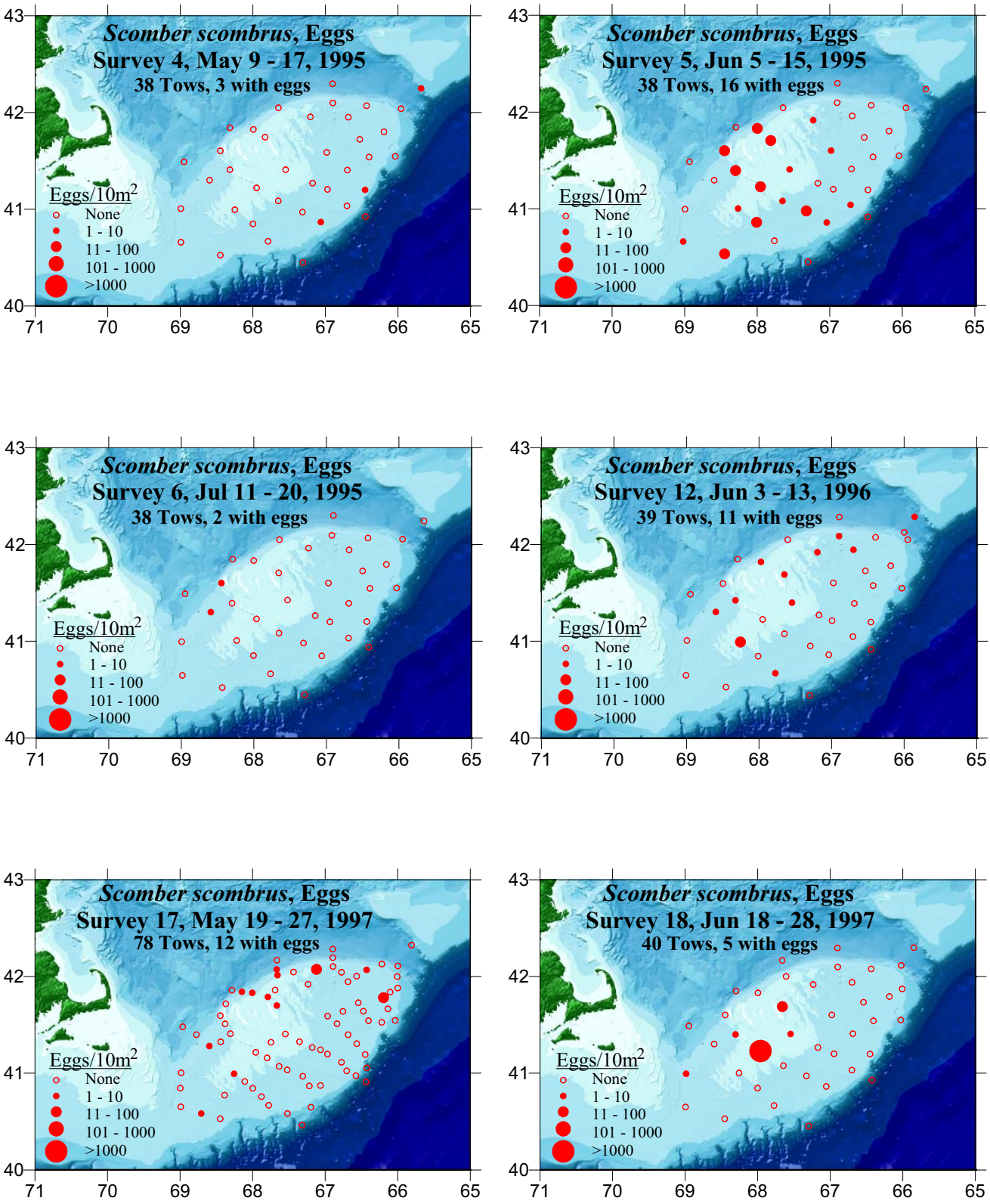
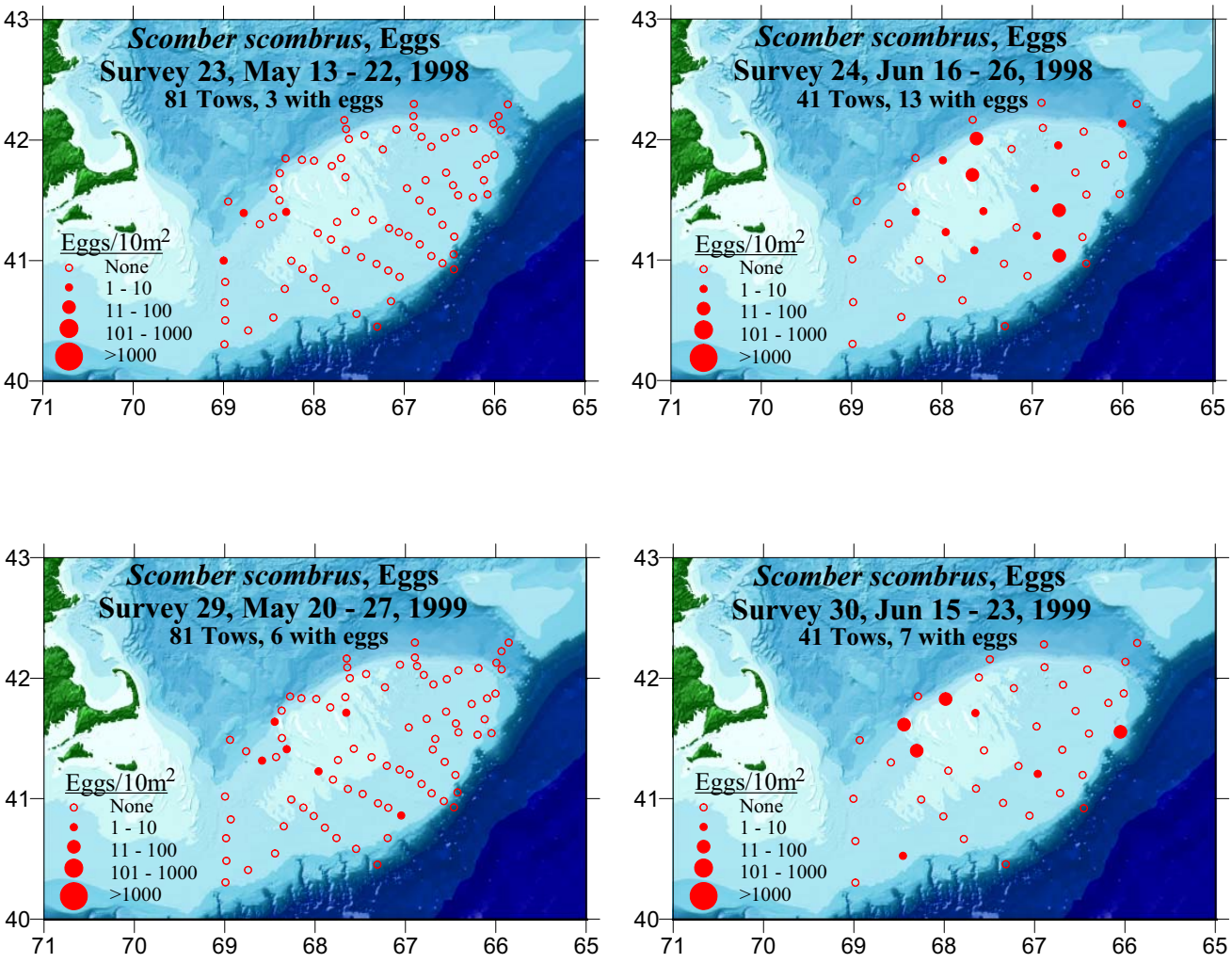


Figure 19. Distribution and abundance of Atlantic mackerel (*Scomber scombrus*) eggs, 1995-1999.



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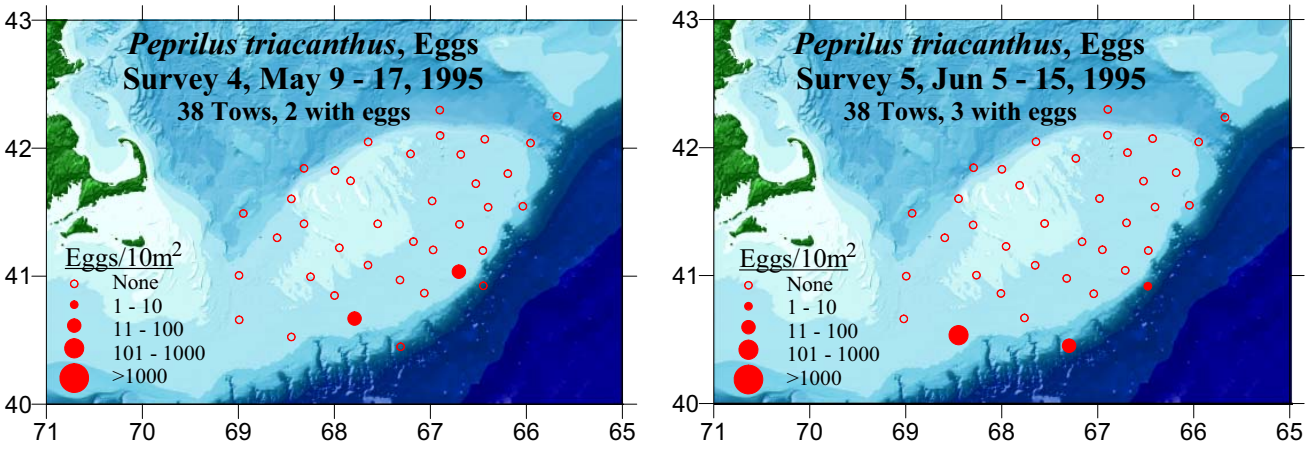
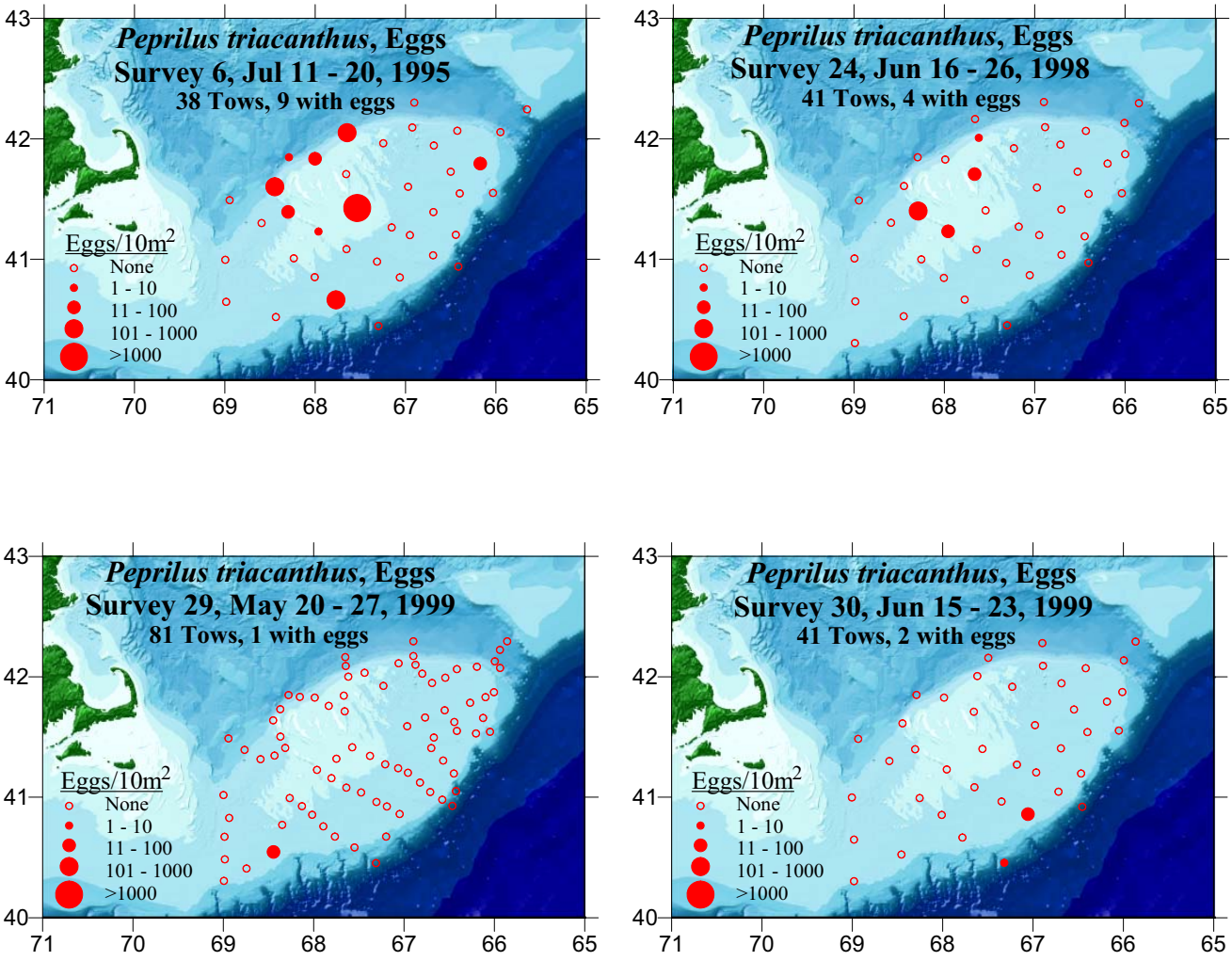


Figure 20. Distribution and abundance of butterfish (*Peprilus triacanthus*) eggs, 1995 and 1998-1999.



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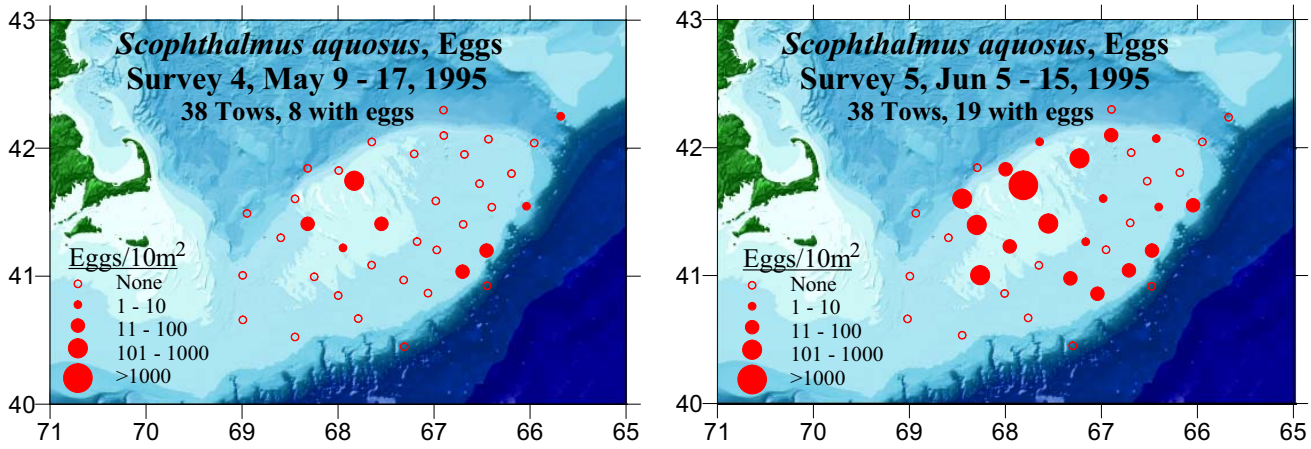
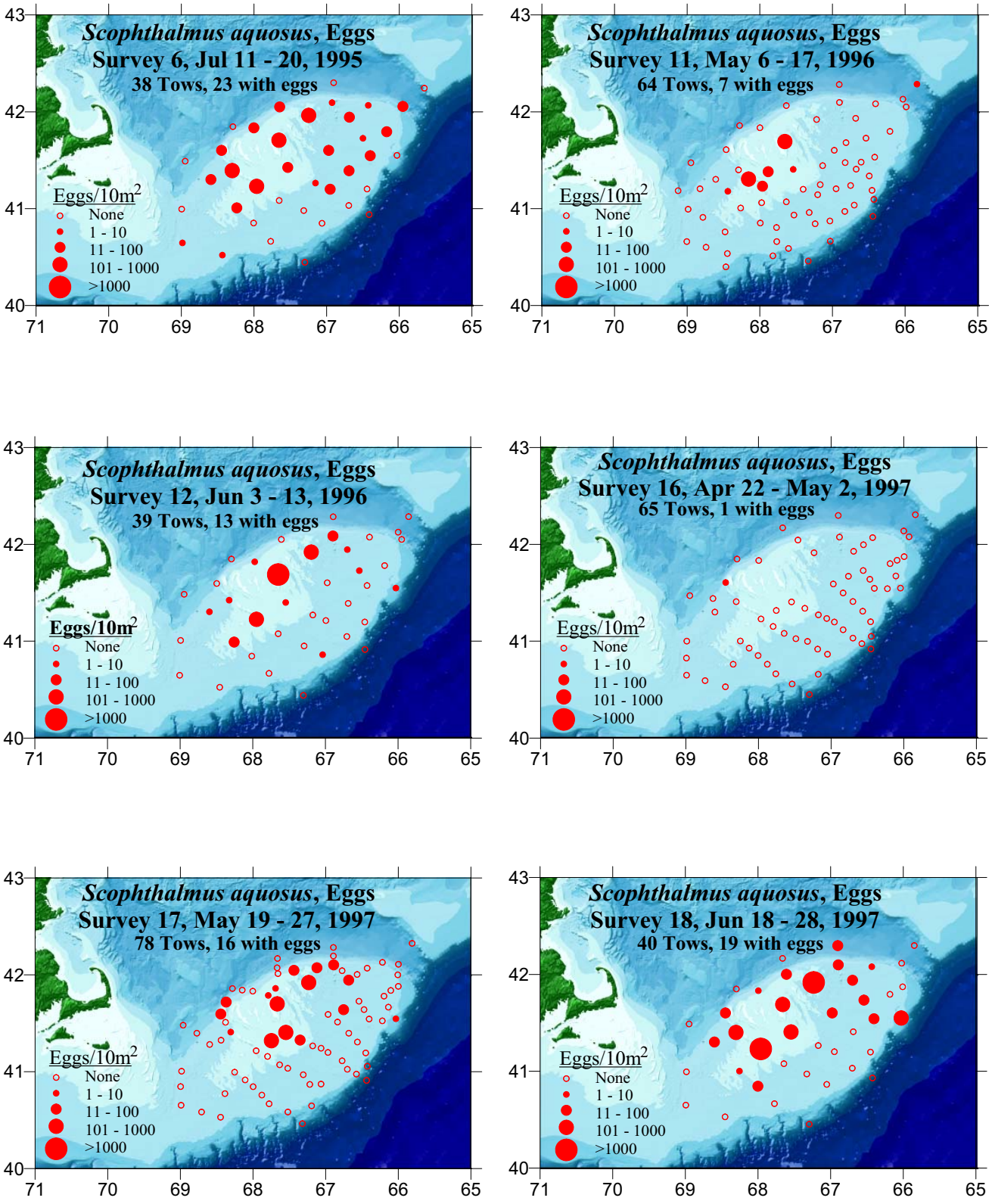


Figure 21. Distribution and abundance of windowpane flounder (*Scophthalmus aquosus*) eggs, 1995-1997.



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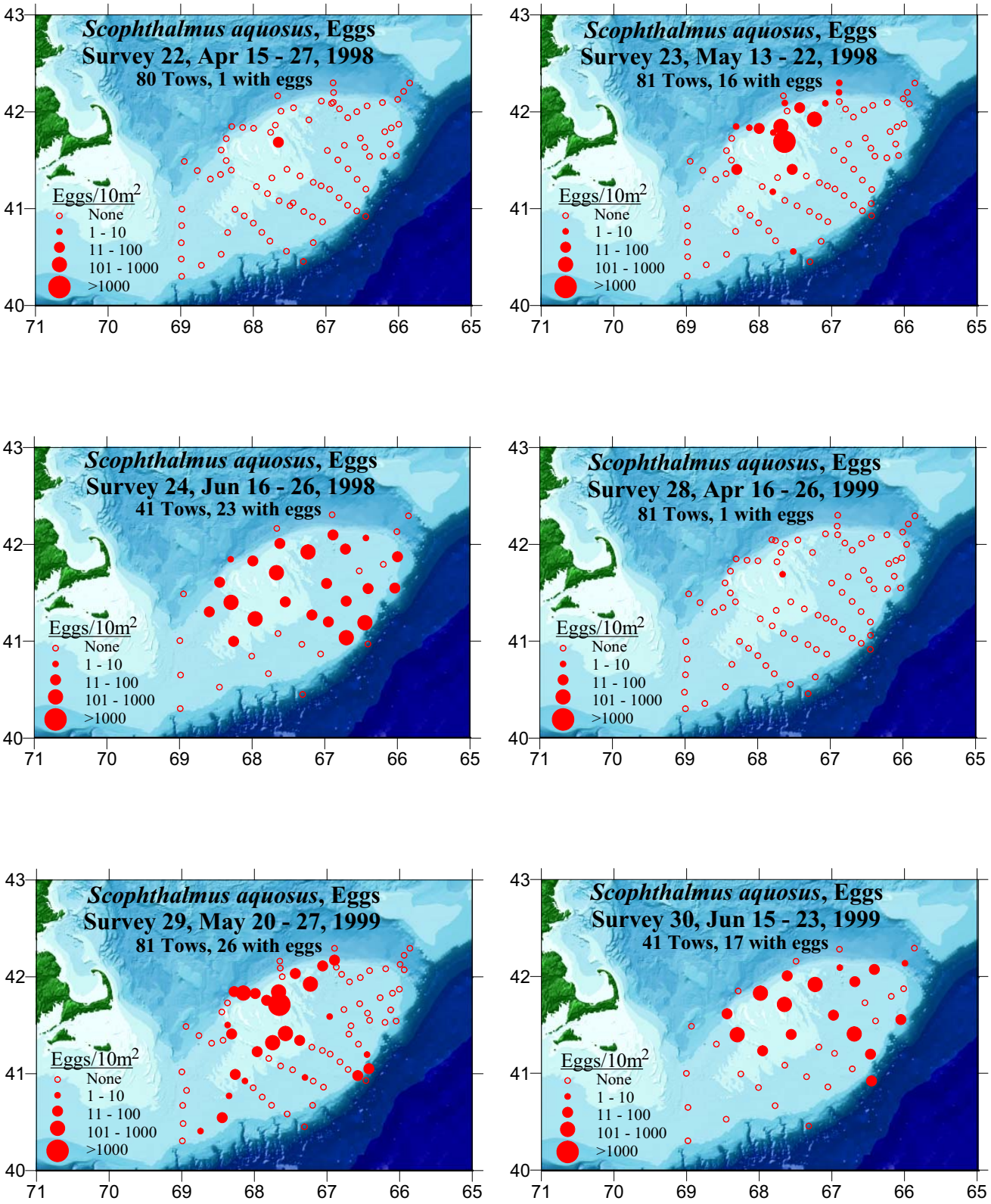

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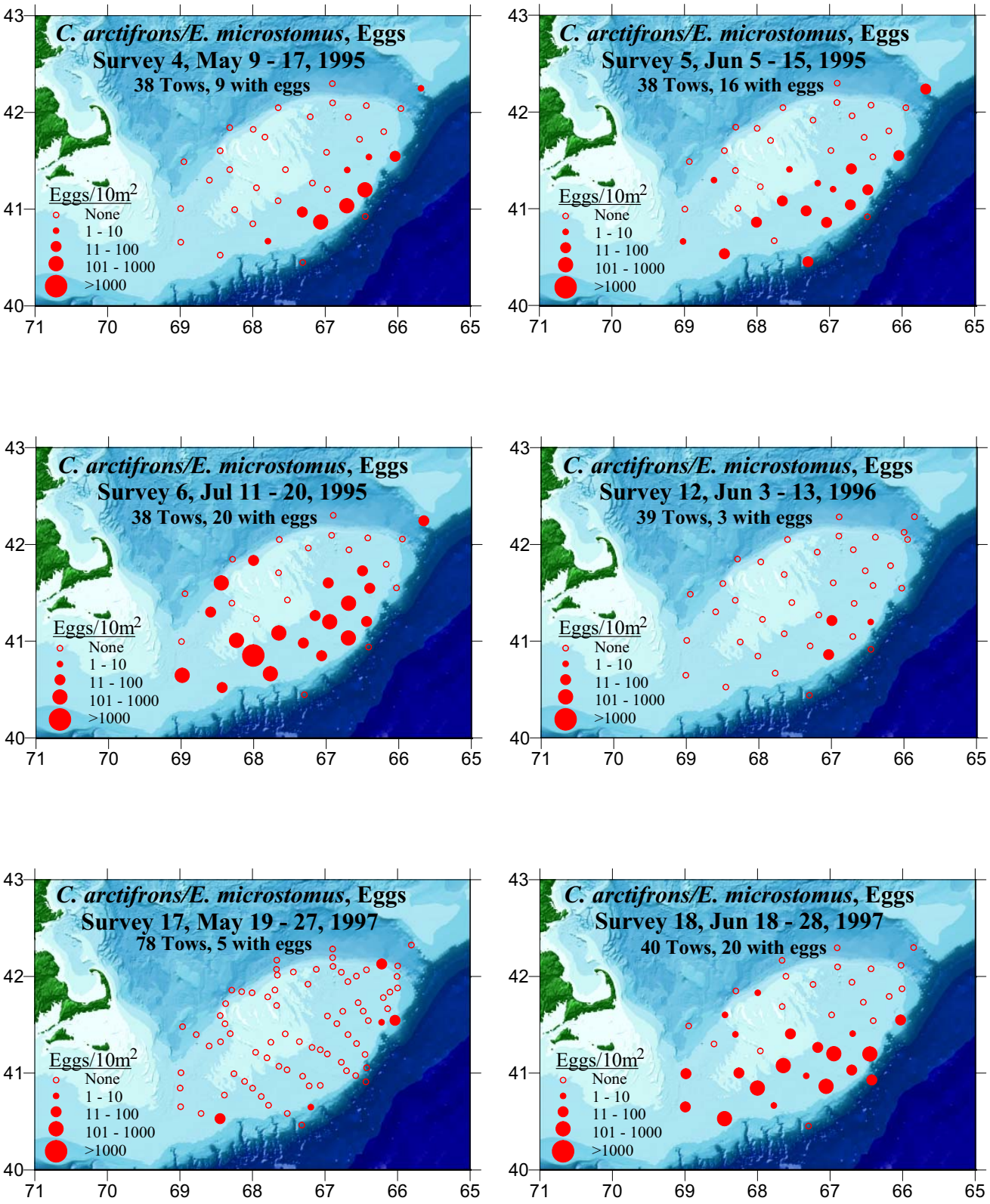
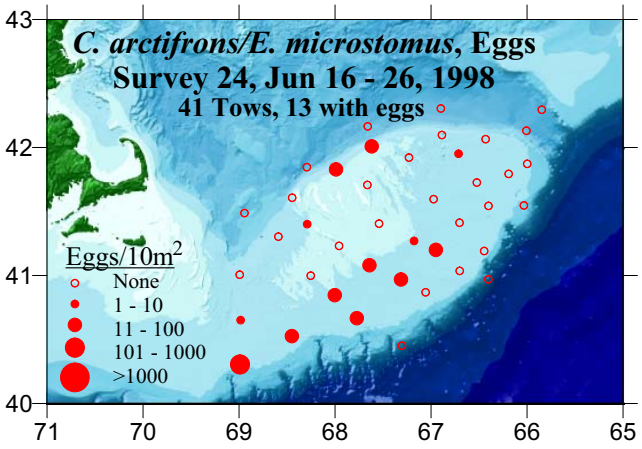
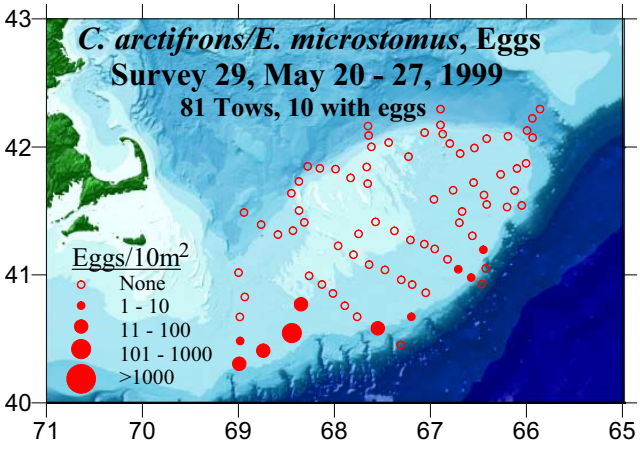
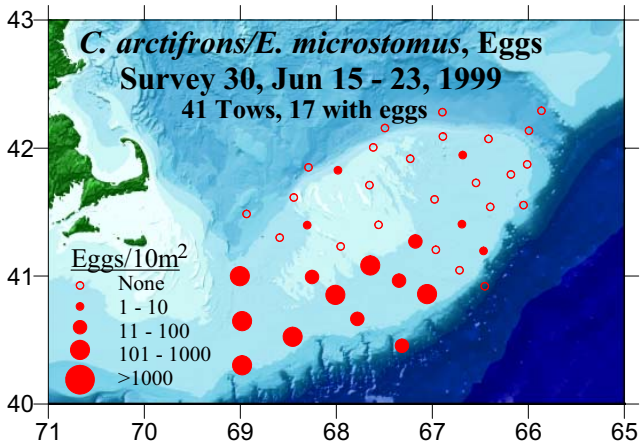


Figure 22. Distribution and abundance of Gulf Stream flounder and smallmouth flounder (*Citharichthys arctifrons* and *Etropus microstomus*) eggs, 1995-1999.







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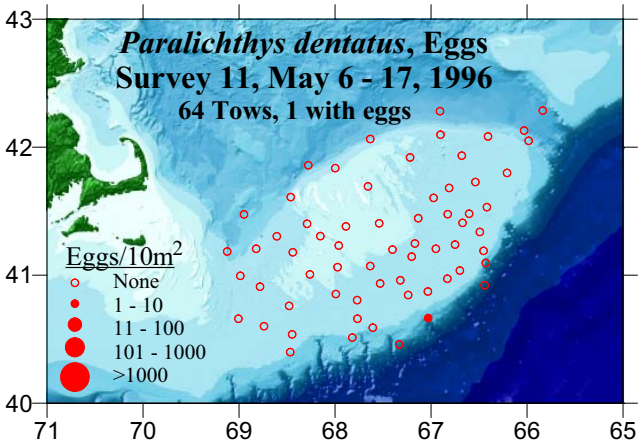


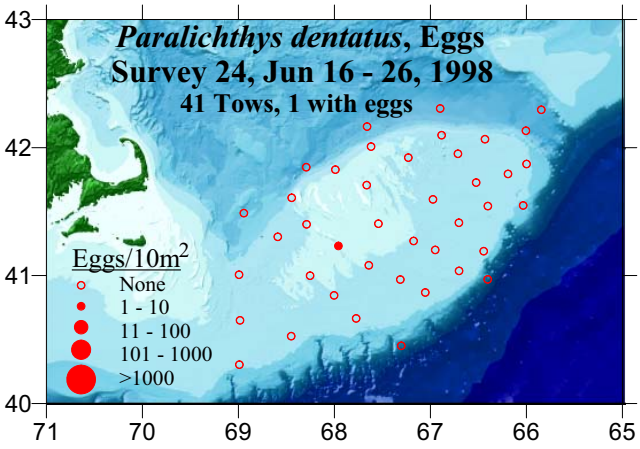
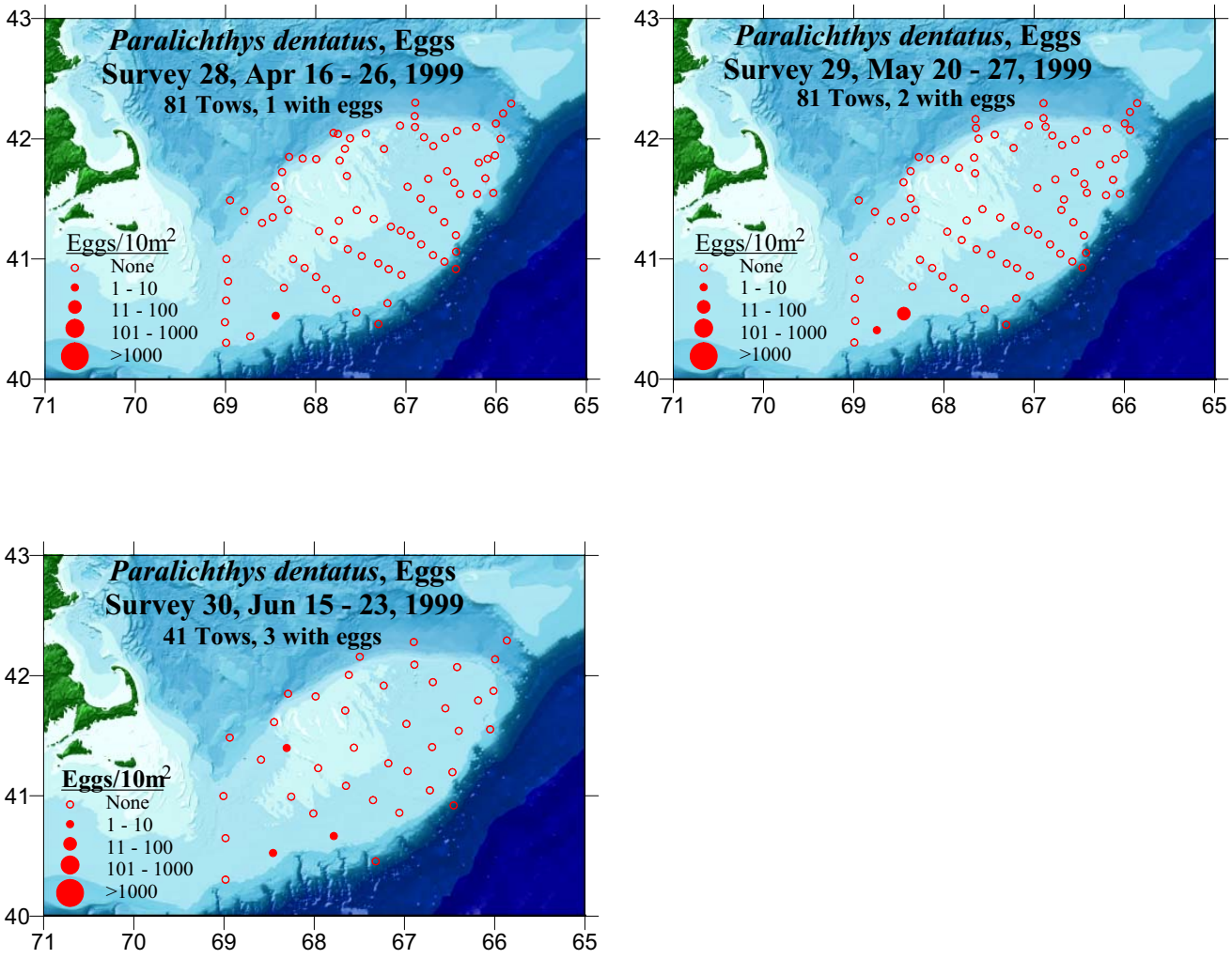


Figure 23. Distribution and abundance of summer flounder (*Paralichthys dentatus*) eggs, 1996 and 1998-1999.



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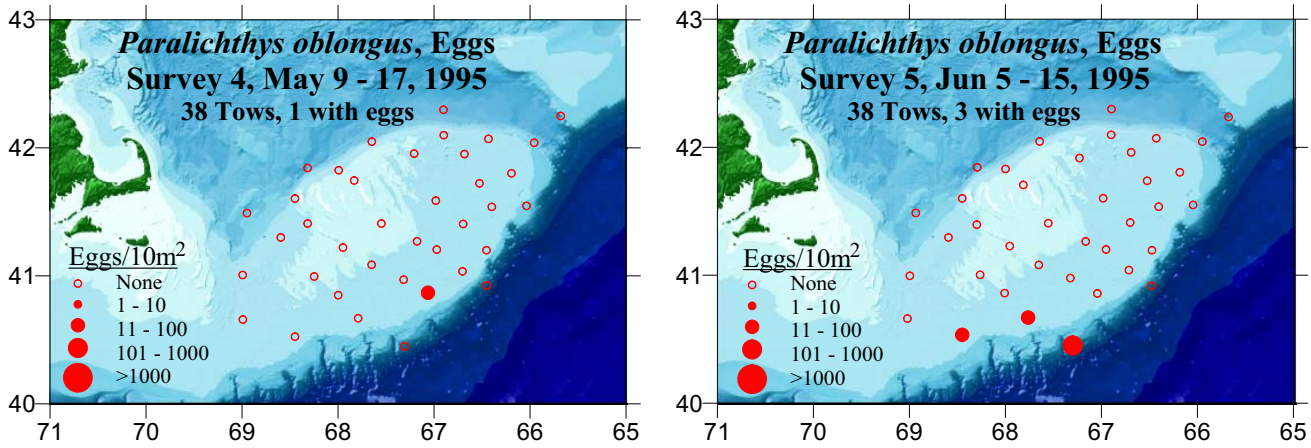
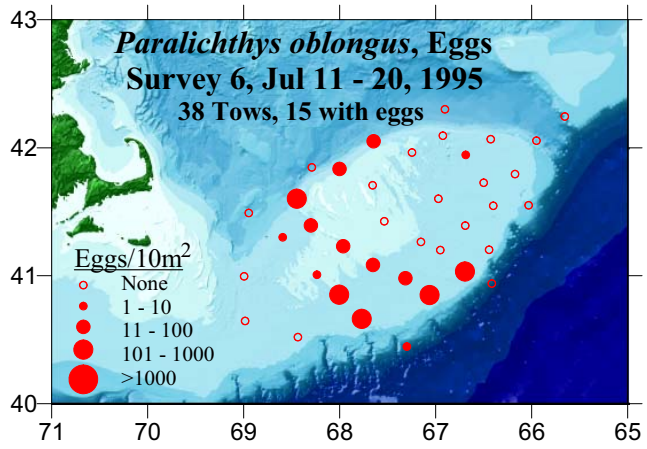
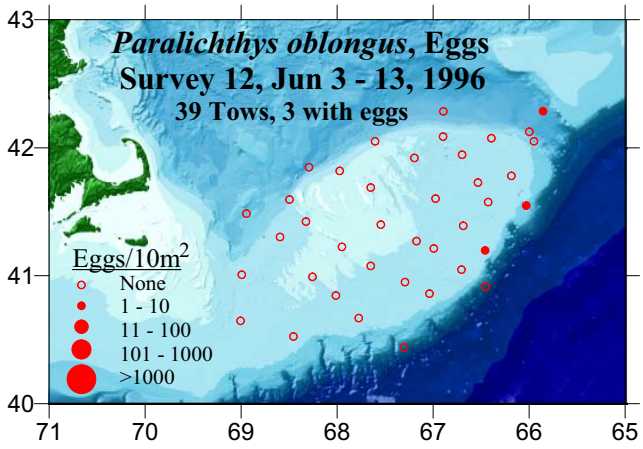
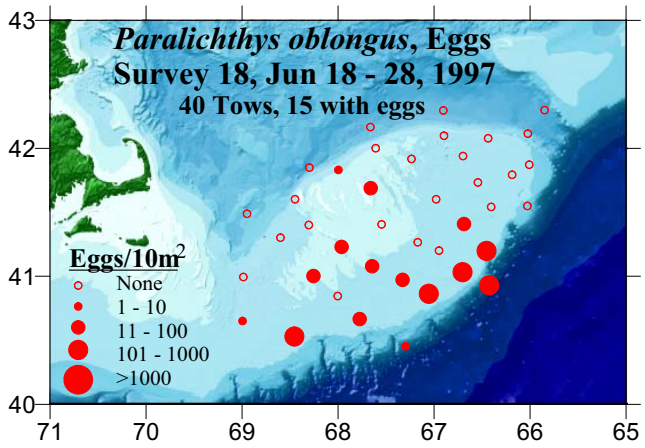
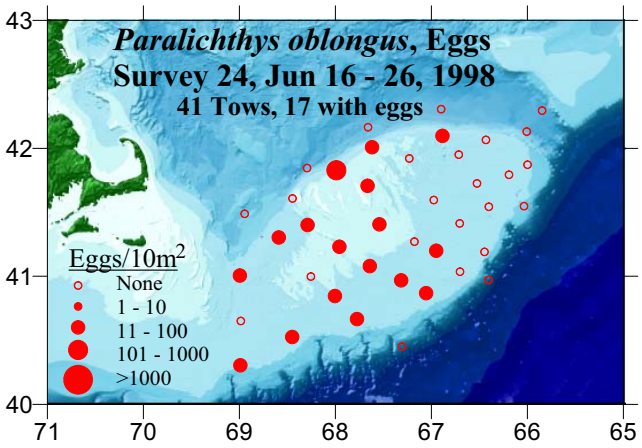


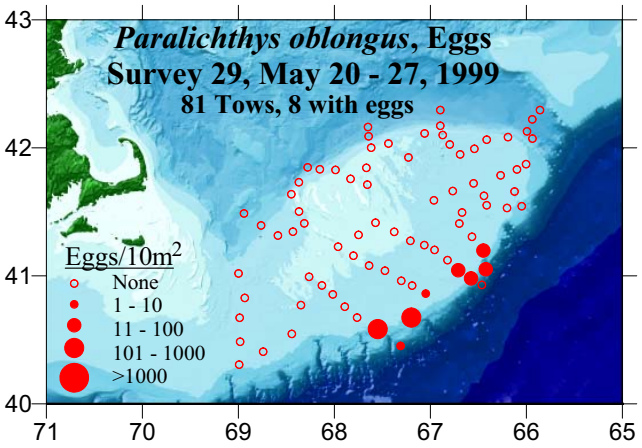
Figure 24. Distribution and abundance of fourspot flounder (*Paralichthys oblongus*) eggs, 1995-1999.

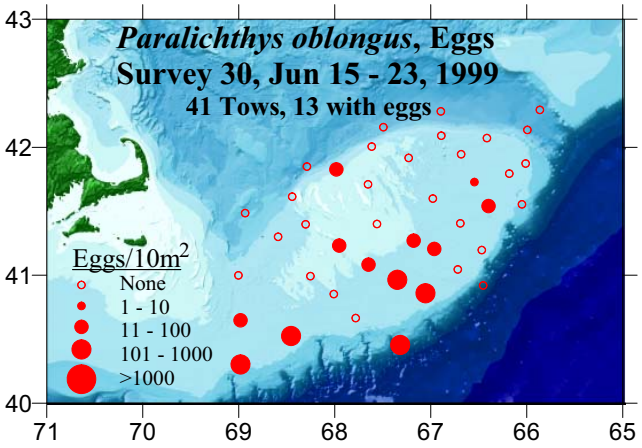












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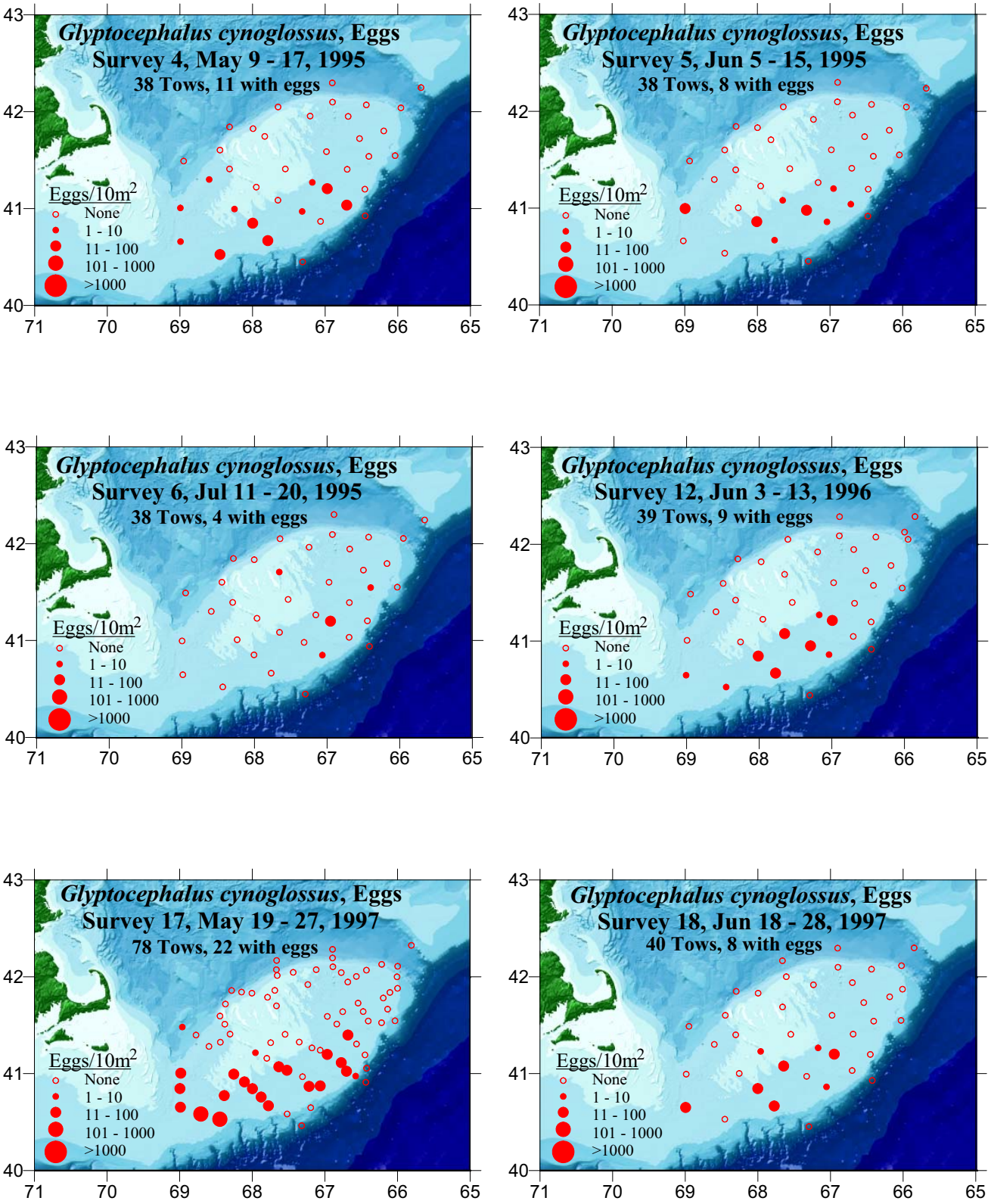
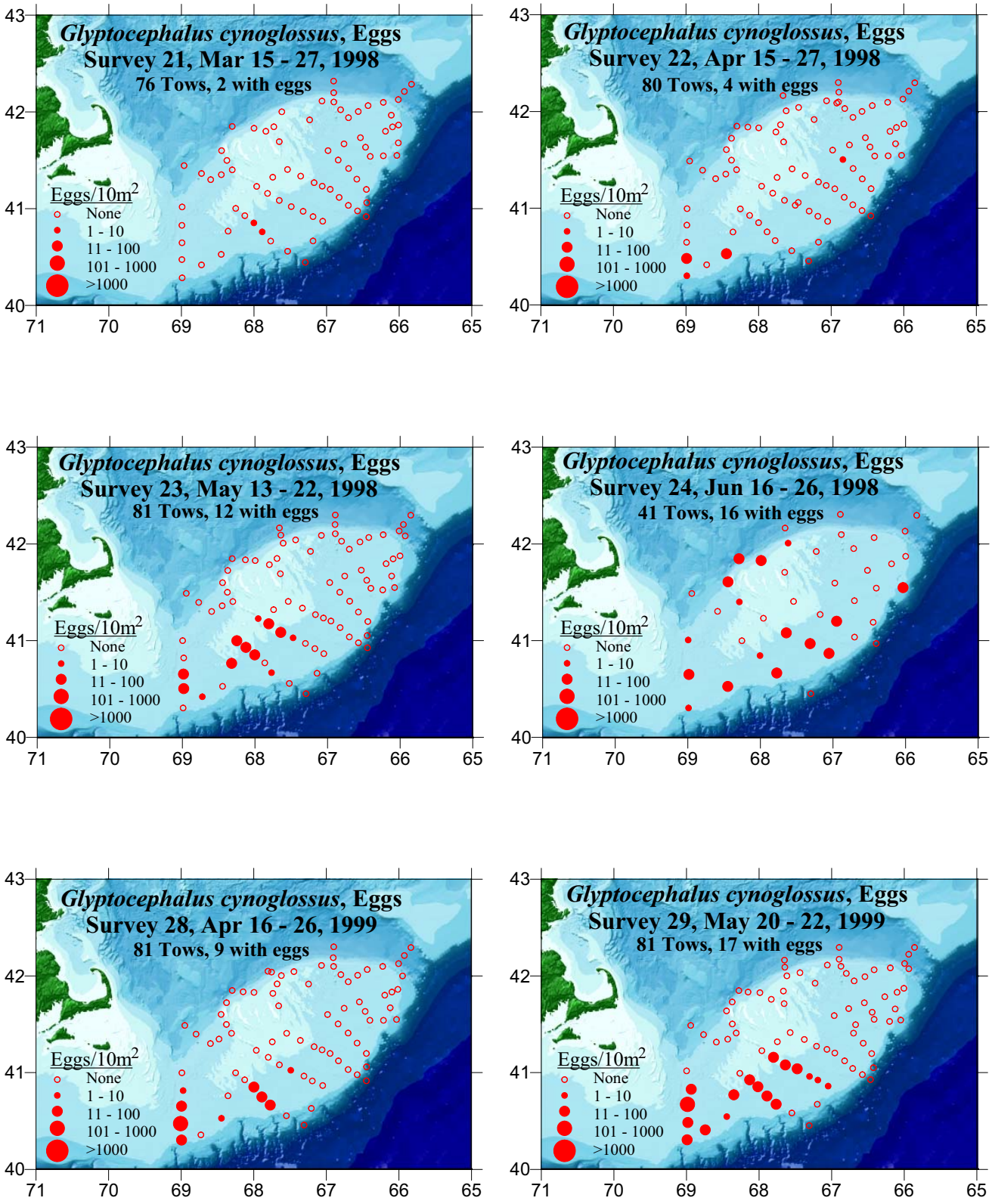


Figure 25. Distribution and abundance of witch flounder (*Glyptocephalus cynoglossus*) eggs, 1995-1999.



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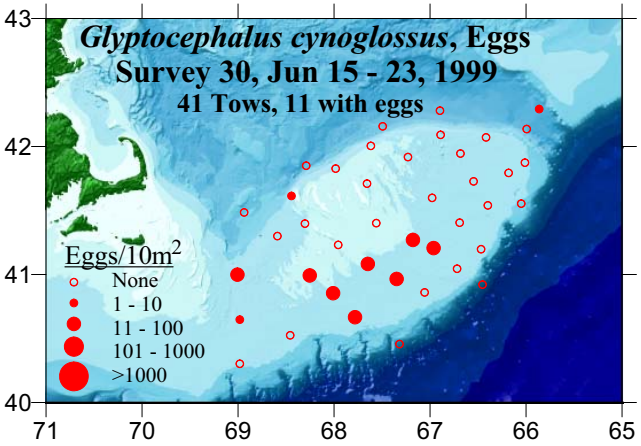


Figure 25 *continued.*

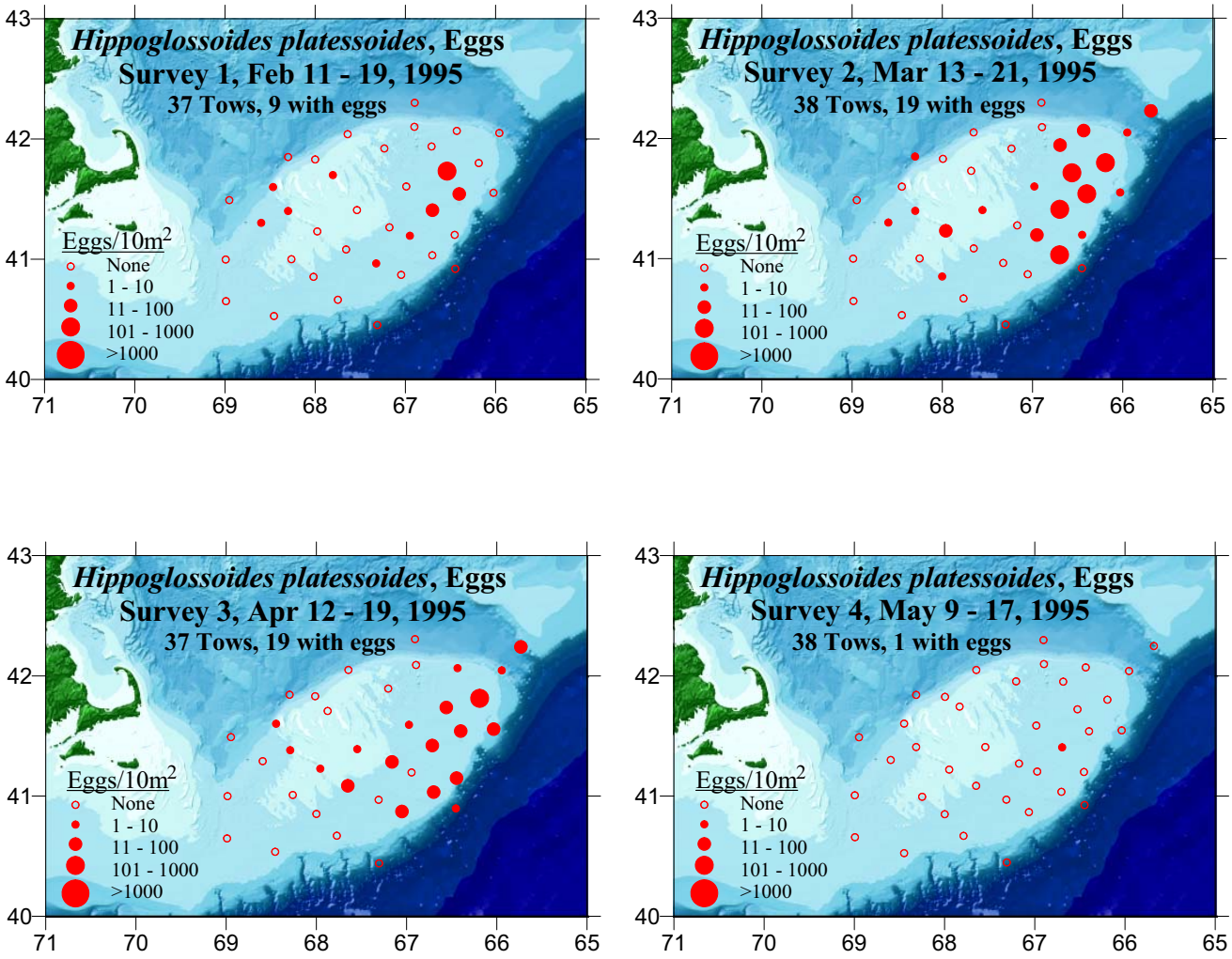
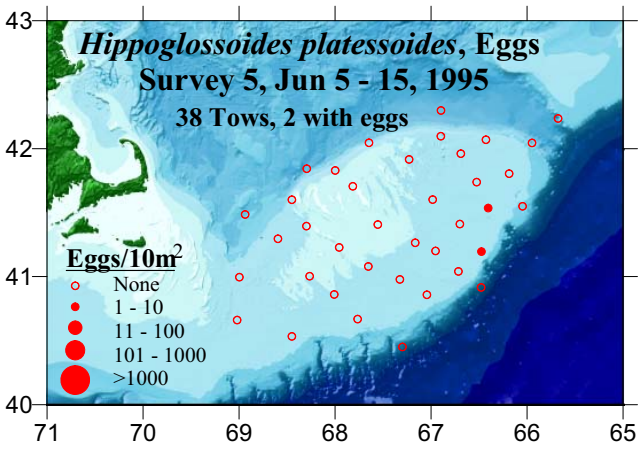
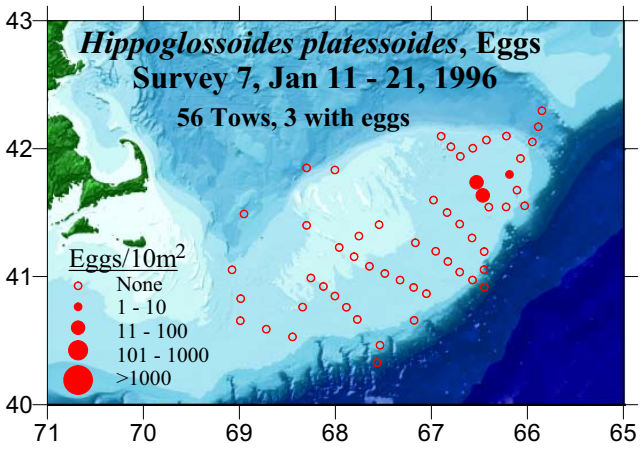
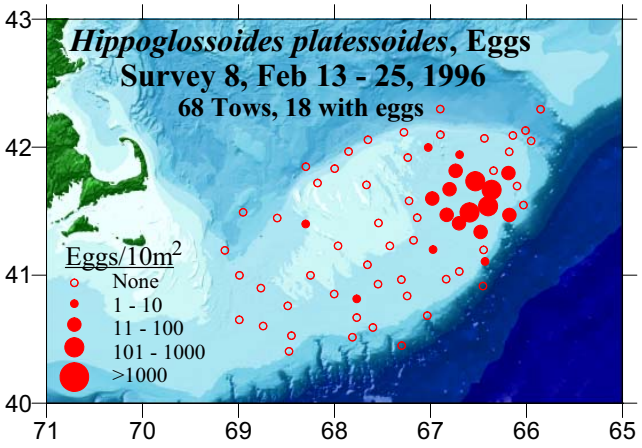
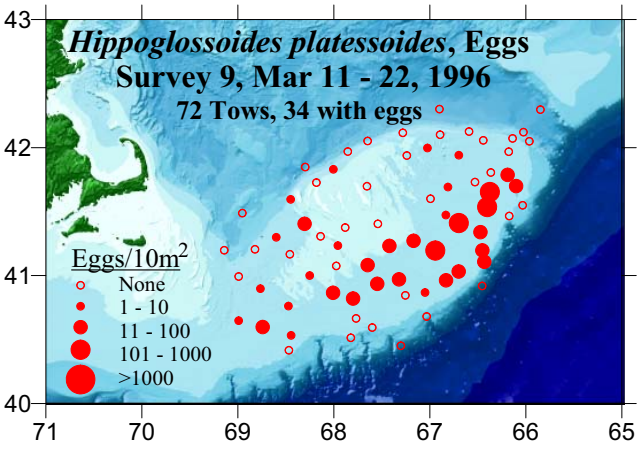


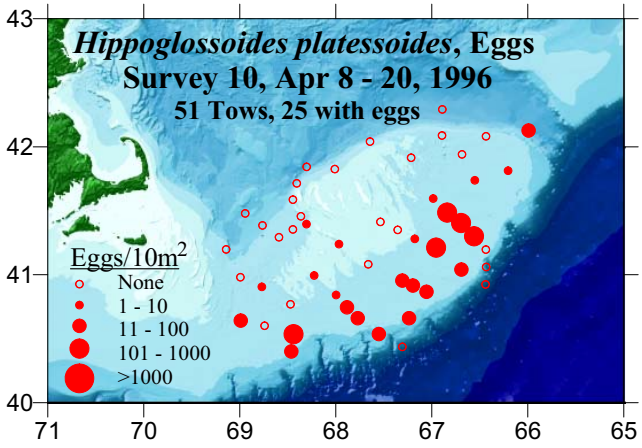
Figure 26. Distribution and abundance of American plaice (*Hippoglossoides platessoides*) eggs, 1995-1999.











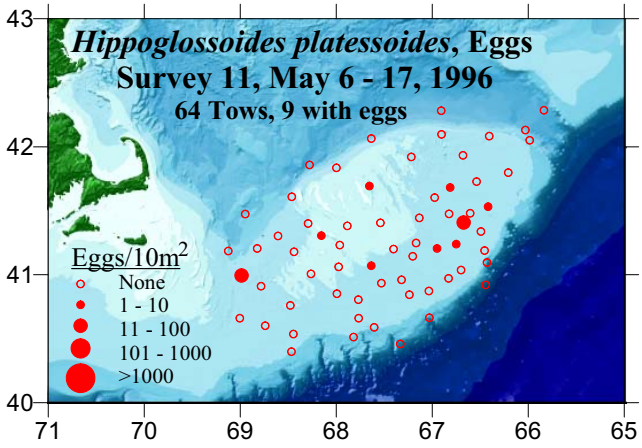
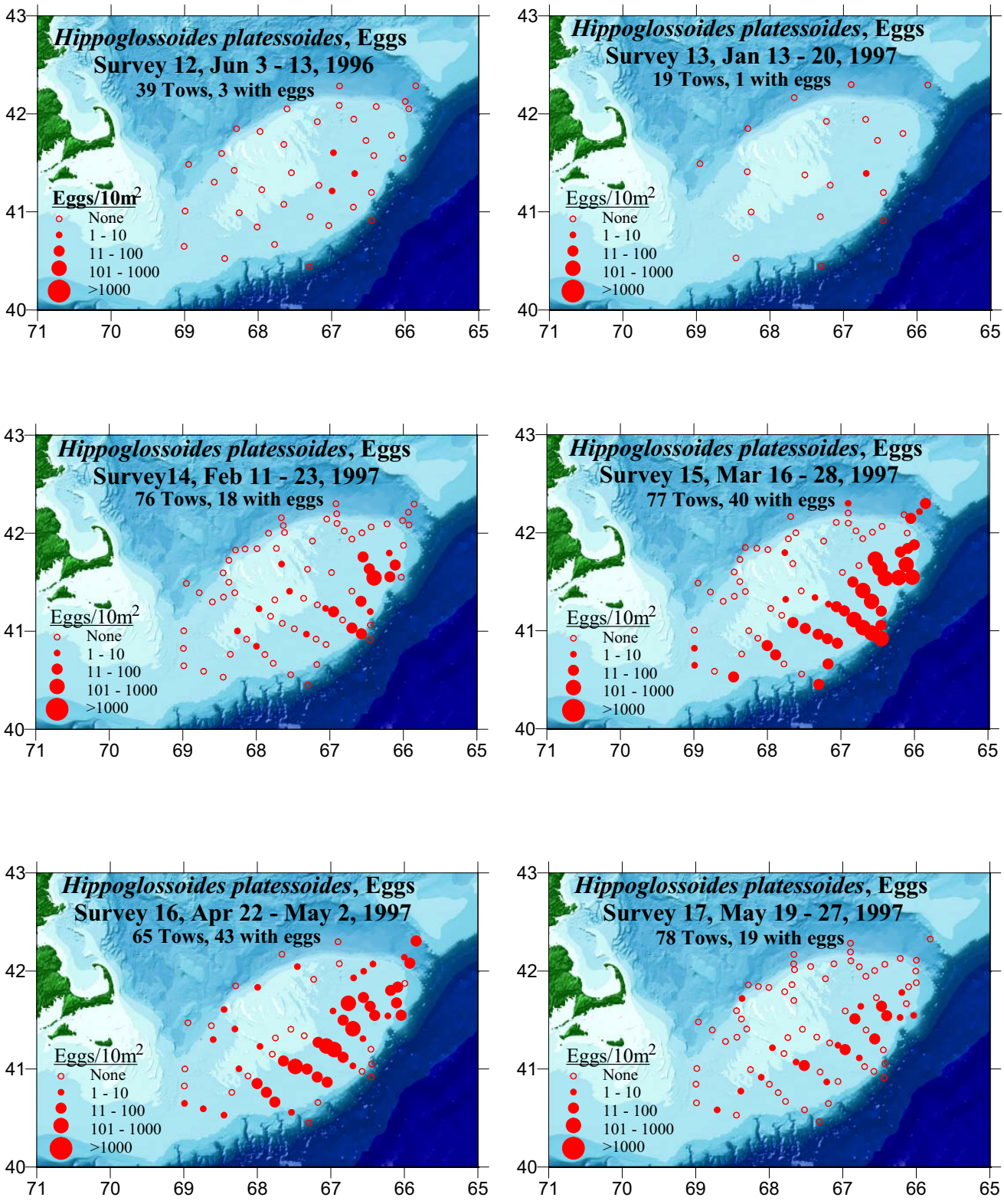


Figure 26 *continued*.



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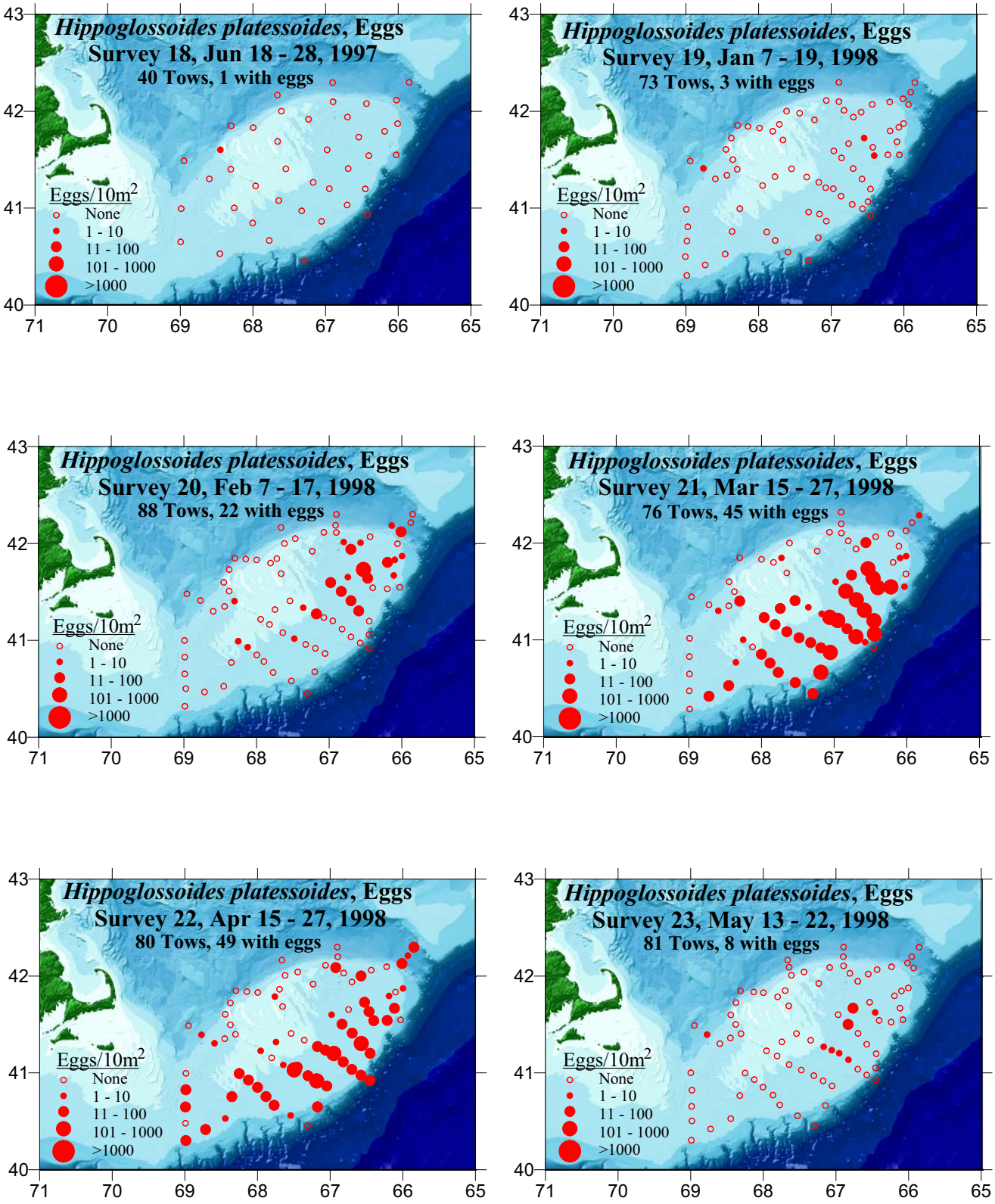
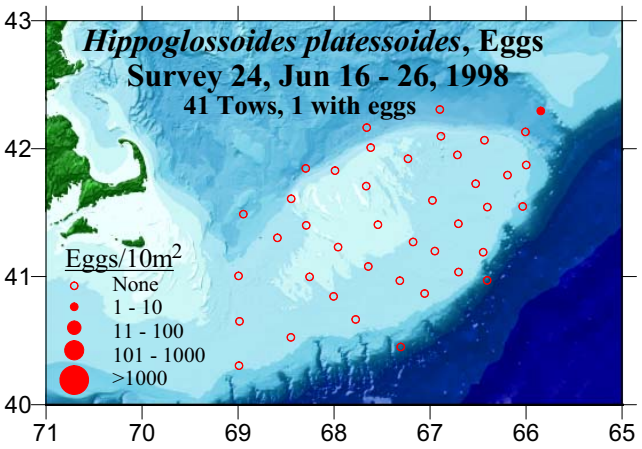
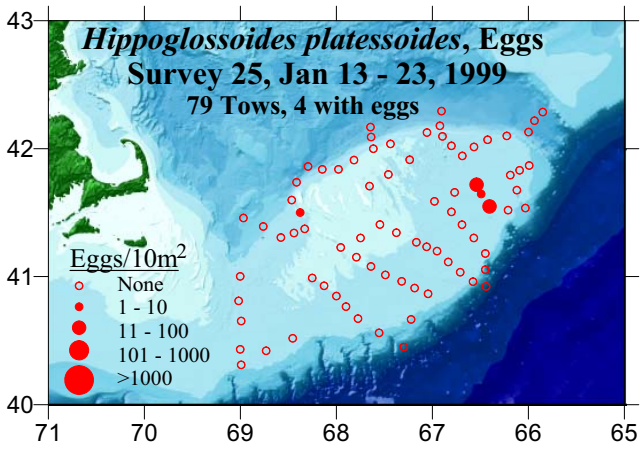
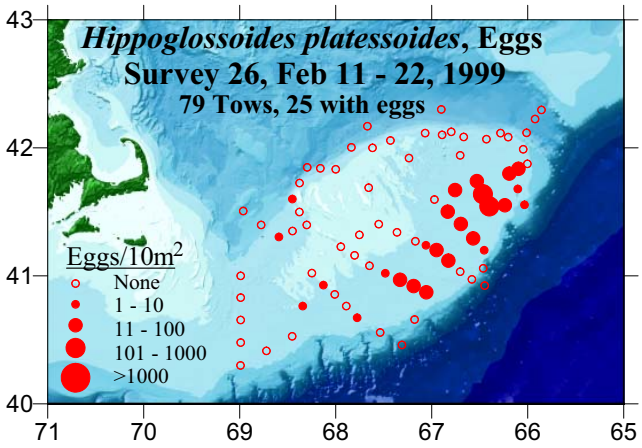
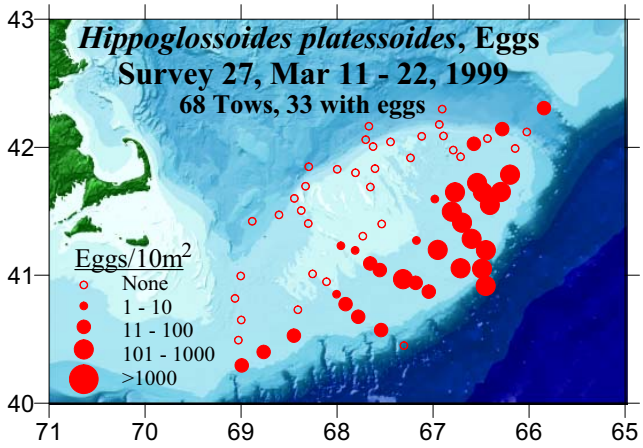


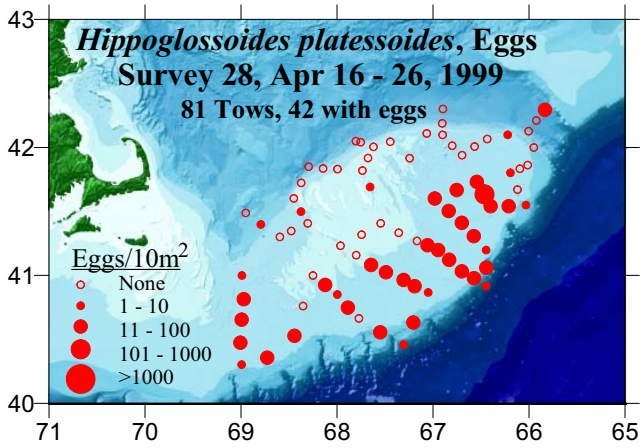
Figure 26 *continued*.

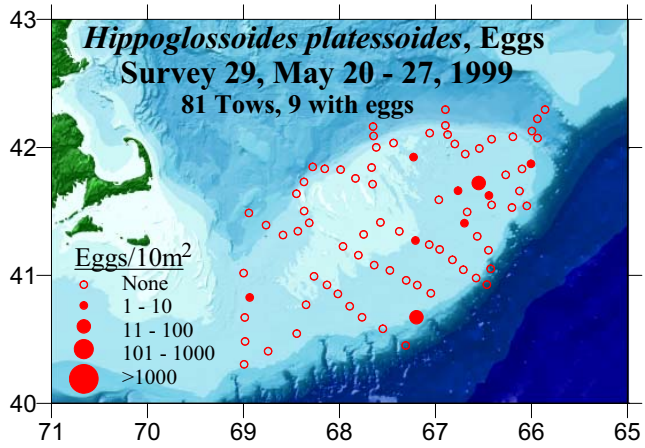












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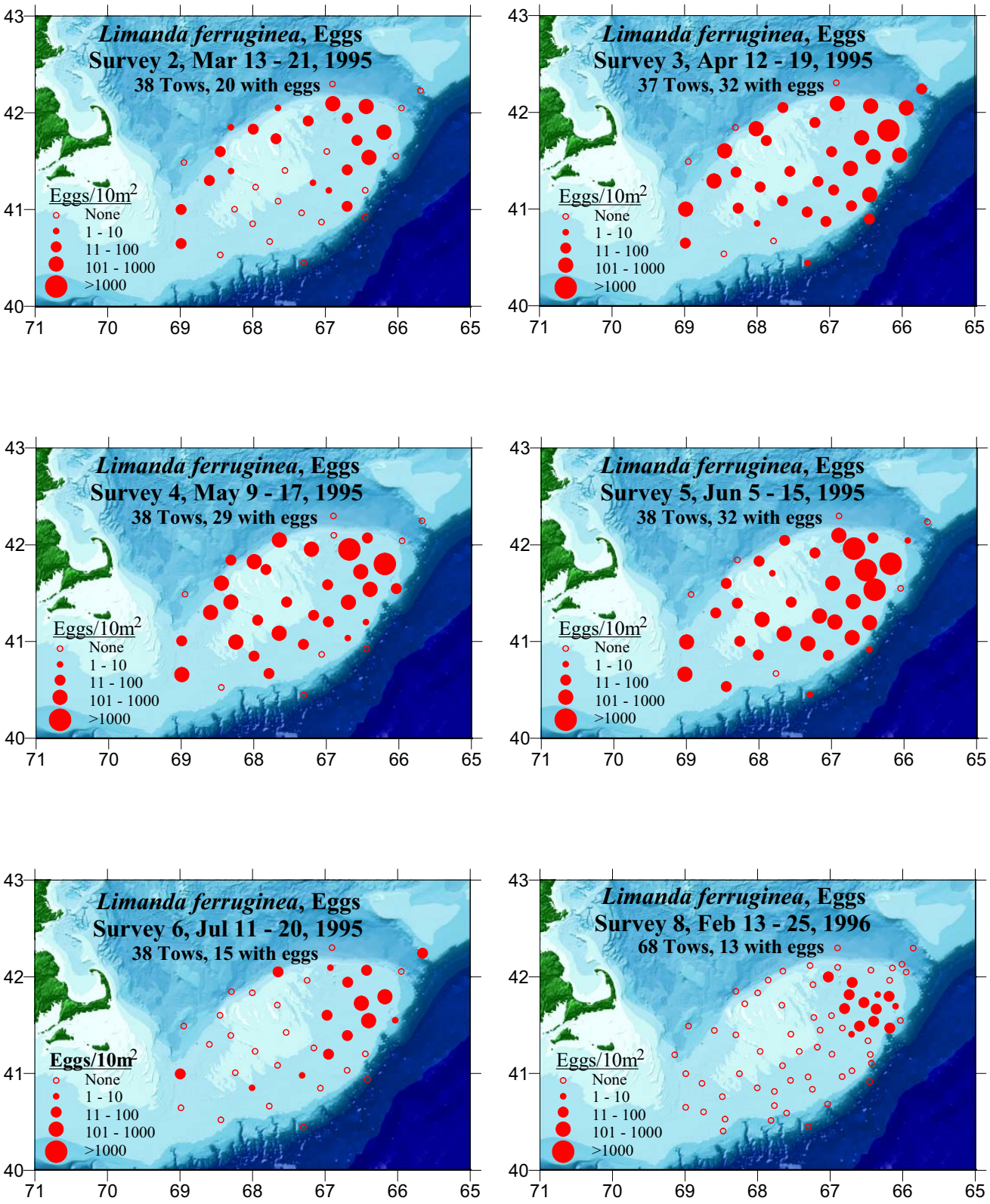
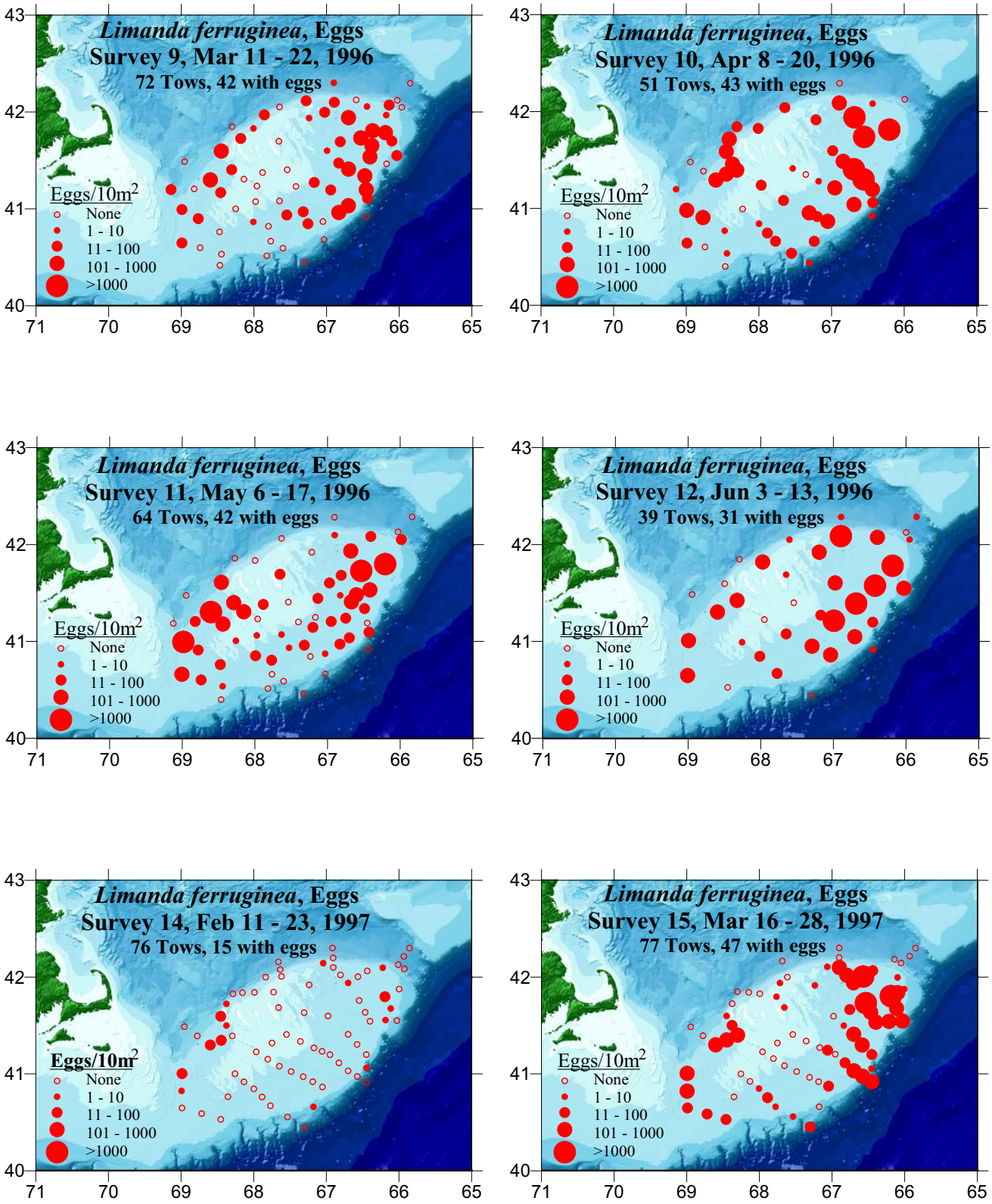


Figure 27. Distribution and abundance of yellowtail flounder (*Limanda ferruginea*) eggs, 1995-1999.



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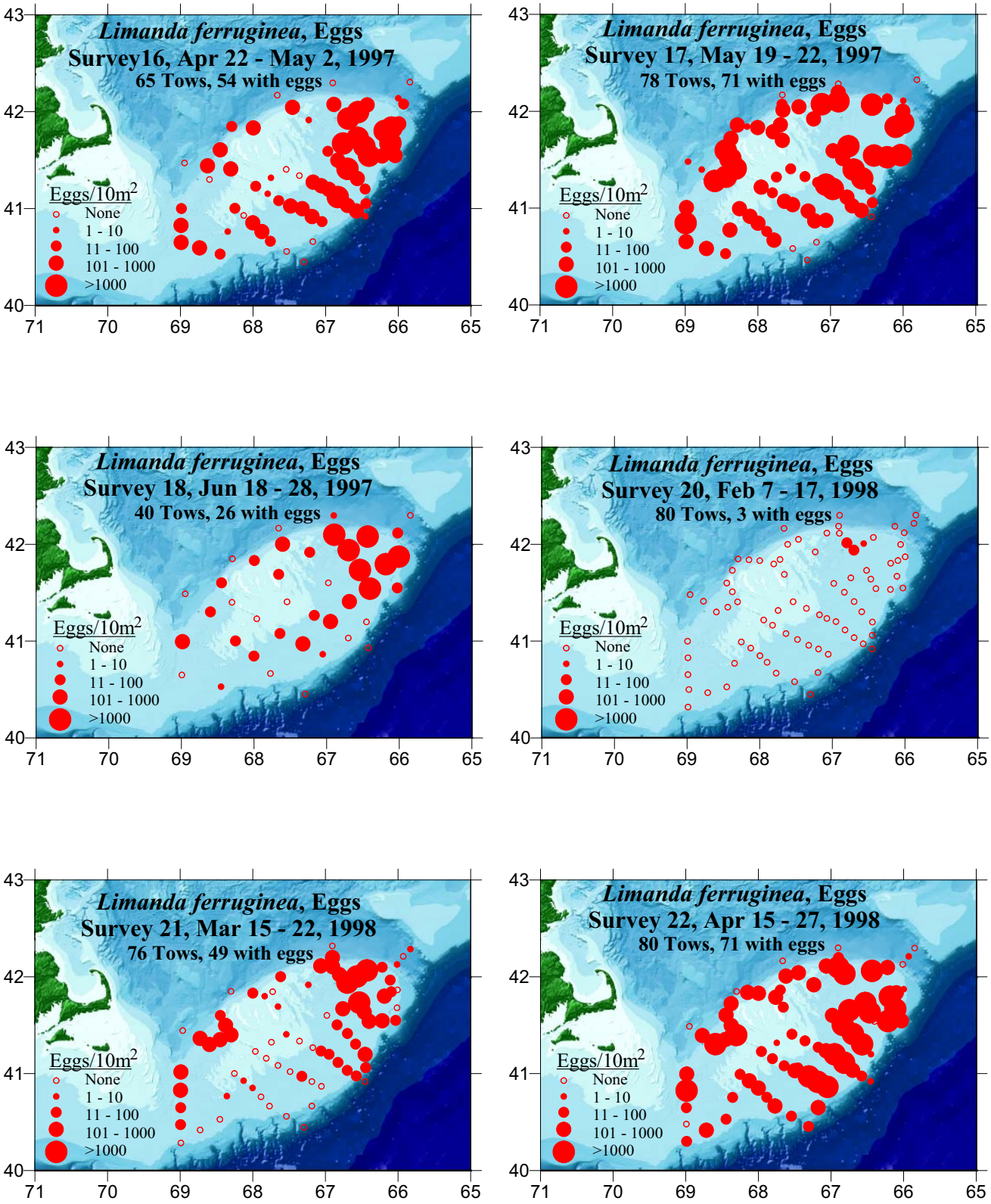

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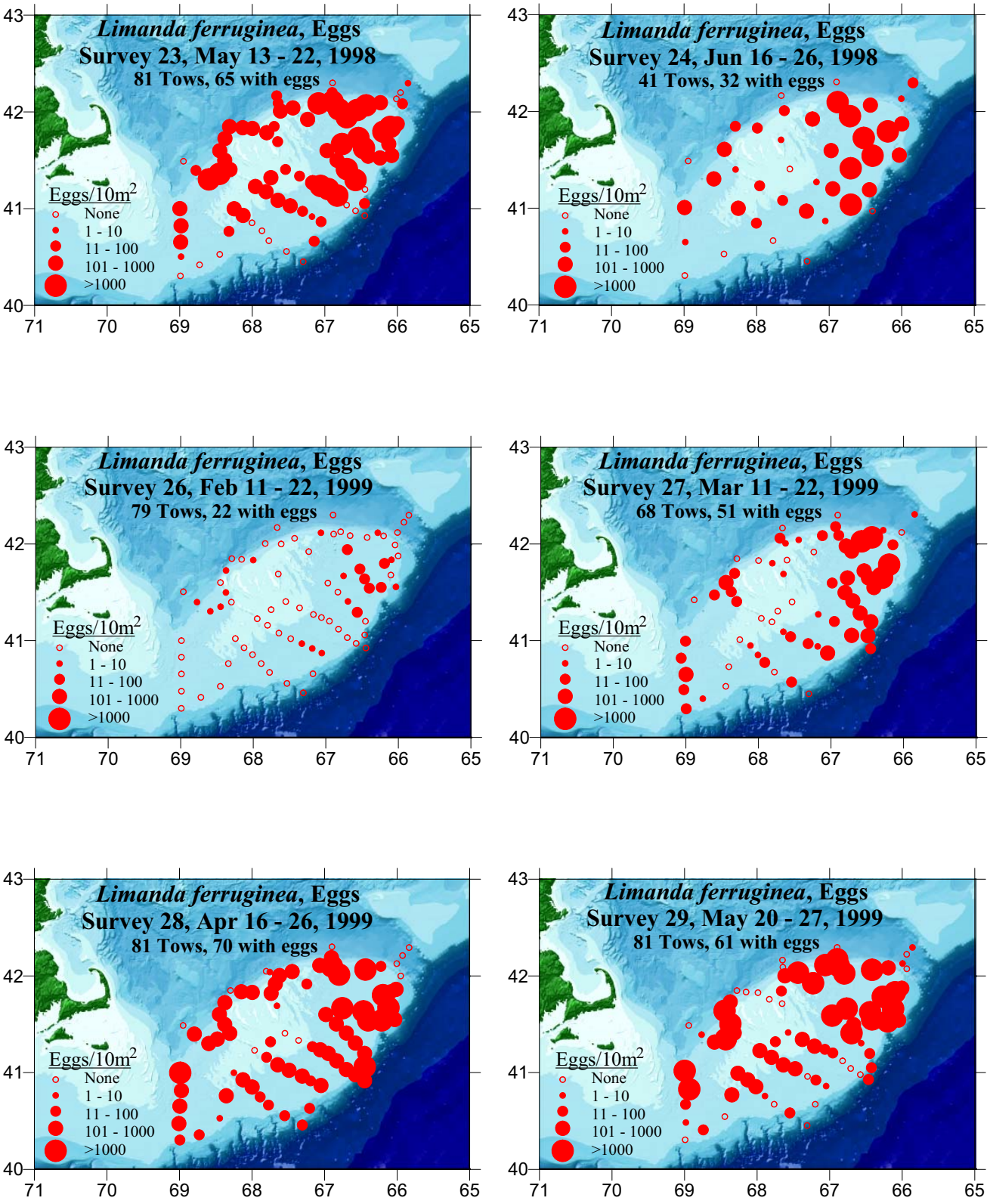

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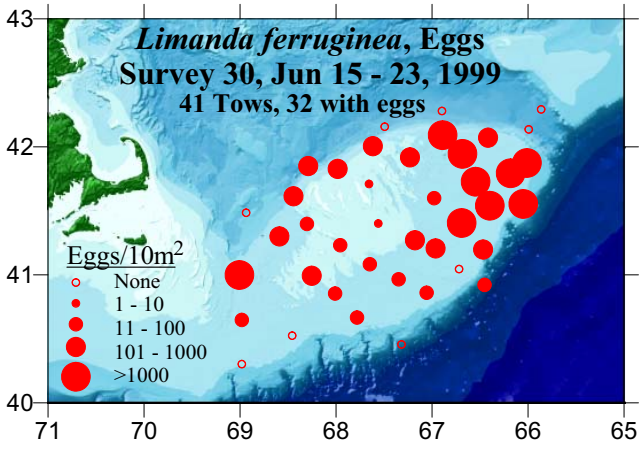

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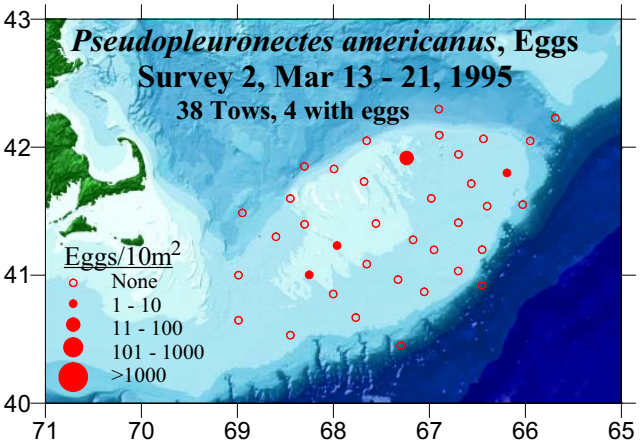
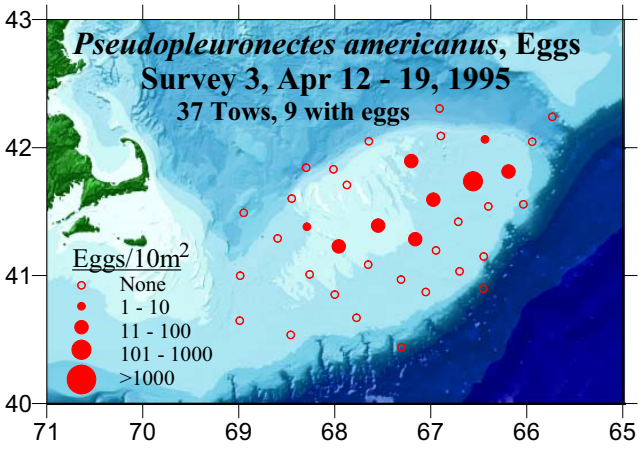
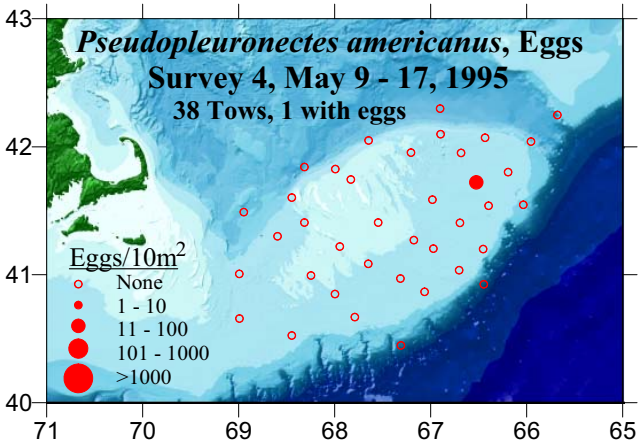






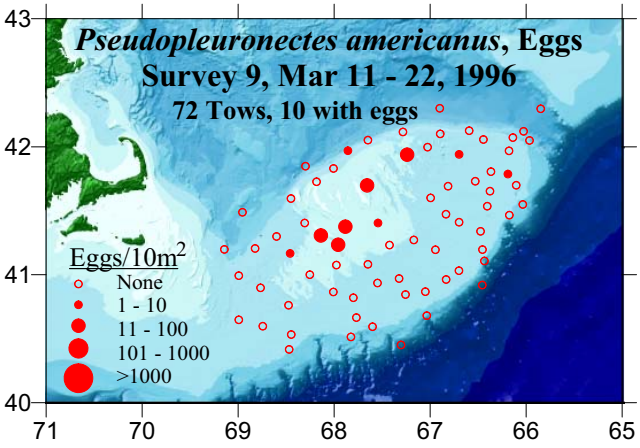
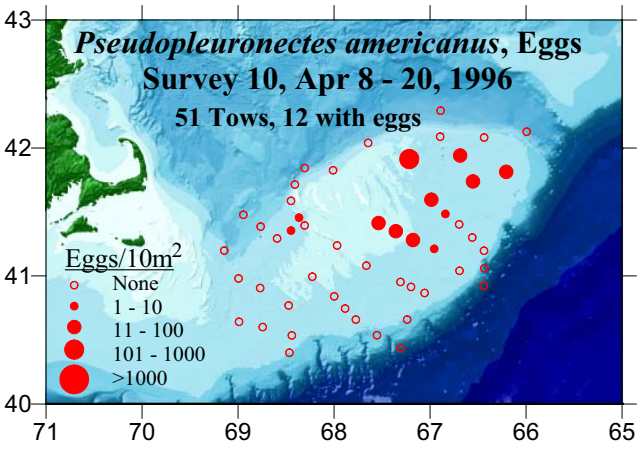
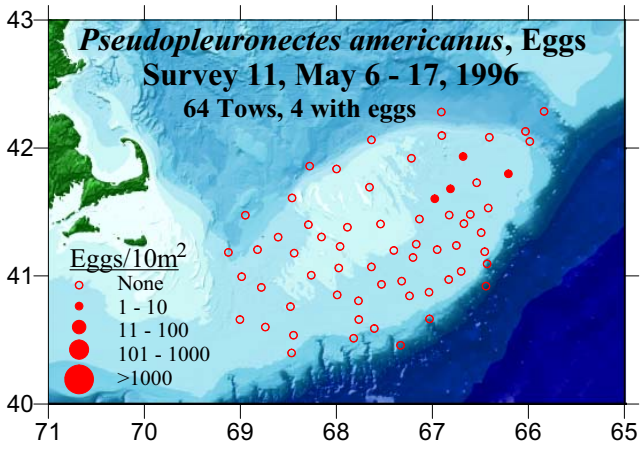
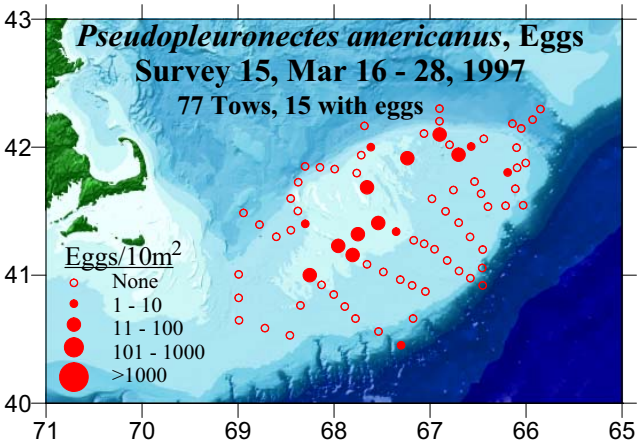
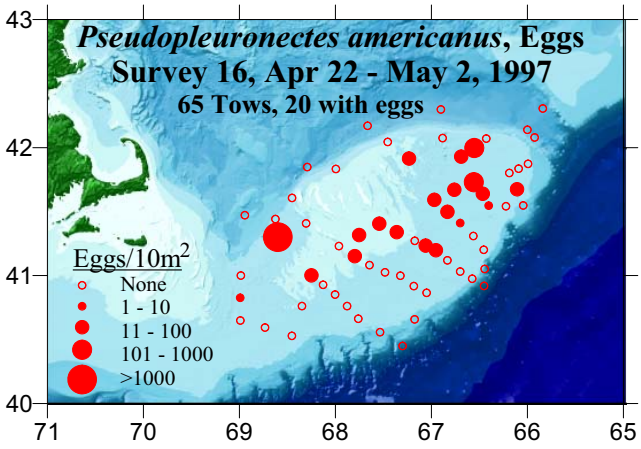


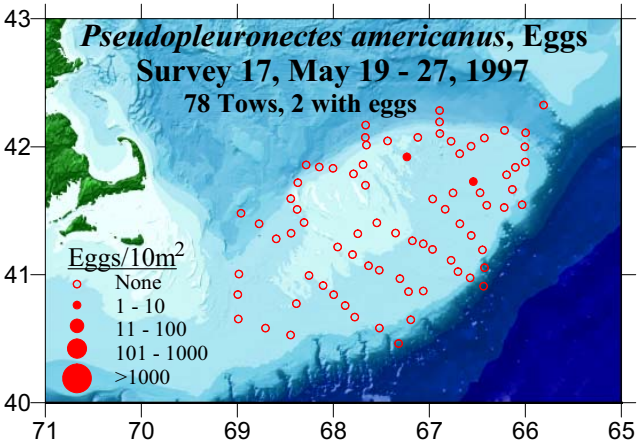
Figure 28. Distribution and abundance of winter flounder (*Pseudopleuronectes americanus*) eggs, 1995-1999.

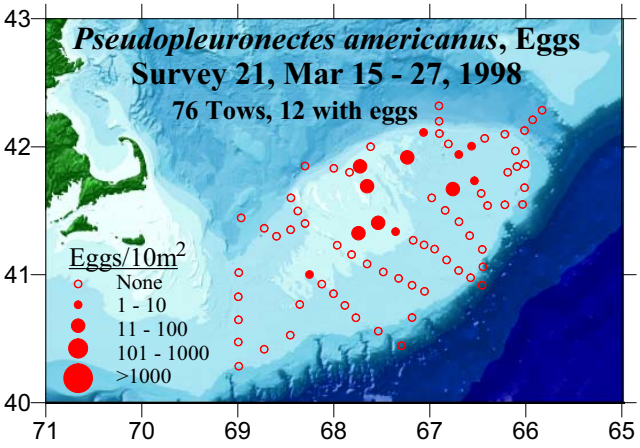












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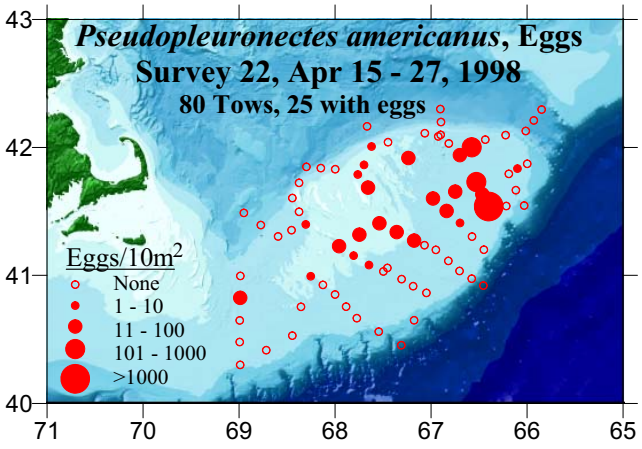

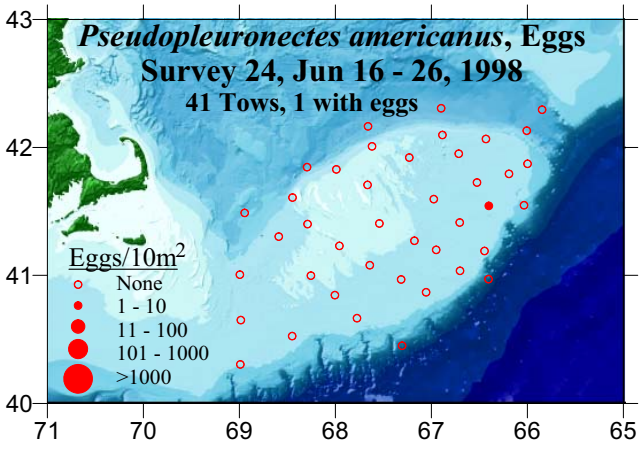

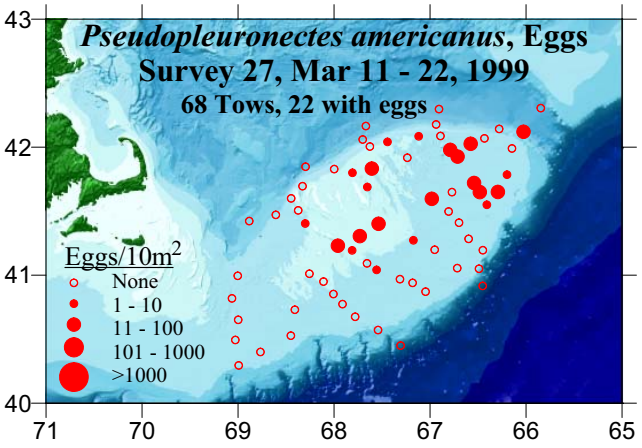

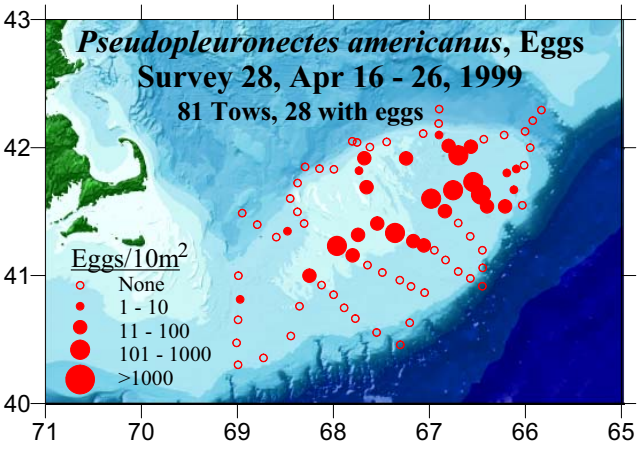

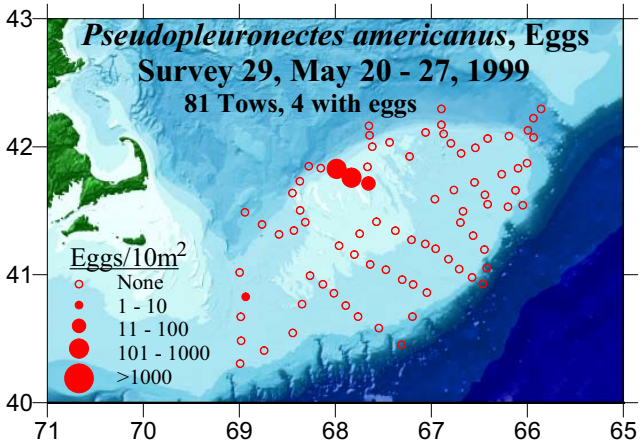

Figure 28 *continued*.

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