Surveillance, Monitoring and Management of North Atlantic Right Whales in Cape Cod Bay and Adjacent Waters - 2007

Final Report

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EXECUTIVE SUMMARY

In 2007, the right whale surveillance program supported by the Commonwealth of Massachusetts Division of Marine Fisheries (DMF) was conducted in Cape Cod Bay (CCB) and adjacent waters from 1 January through 23 May by the right whale research team at the Provincetown Center for Coastal Studies (PCCS). Weather permitting; the program included bi-weekly aerial surveys and weekly habitat sampling. Upon completion of each survey, all sightings were reported to the NOAA Fisheries Sighting Advisory System (SAS) and the US Army Corps of Engineers Cape Cod Canal Field Station.

During the 2007 winter and spring season, PCCS observers performed 31 aerial surveys totaling 157.4 hours of flight time covering CCB and the near-shore of the outer shore of the cape. Although most identification photographs taken during these flights and during habitat sampling cruises have already been matched to the existing right whale catalogue by two independent experienced researchers, most of the matches are still awaiting final confirmation by the New England Aquarium. Therefore the results outlined in the present report may change slightly once confirmation is obtained.

In 2007, right whales were observed in CCB and adjacent waters during 92 days (from 11 February to 13 May). This period of occupation of the area was similar to previous years (100 days in 2006; 97 days in 2005; 90 days in 2004). However a much larger number of individuals were identified in CCB and adjacent waters than in any previous years of the project. In 2007, 161 different individuals were identified in the area, which is twice the yearly average between 1998 and 2006 ($\bar{x}$=82.3, SD=20.72, range = 49 to 112 individuals). Furthermore, 27 right whales that had never been identified before in the area since photographic records of right whales in the bay in 1958; had been observed in CCB and adjacent waters in 2007. This result may imply that CCB is becoming even more attractive to right whales than it has been in the past, but further surveys will be needed to confirm or infirm this suggestion.

There was an average of 18.4 days between the first and last sighting of individual right whale. This is substantially longer than what was found in 2006 (average of 7.4 days) and in 2005 (average of 13.2 days), suggesting that not only more whales than usual visited CCB and adjacent water in 2007, but their residency time was also longer than in recent years.

Three mother and calf pairs were sighted in CCB and adjacent waters. The residency time of mother and calf pairs was substantially longer than of single females and the residency time of single females was also substantially longer than that of single males. This result was consistent with that of all previous years (1998-2006) suggesting that CCB is an important nursery area and that the habitat is more intensively used by females than by males.

In 2007, a large proportion of right whales was observed in the middle of the bay, between Provincetown and Barnstable. This distribution is similar to what was found in 2004, but contrasts with the 2005 distribution when most whales where in the south of the bay, and with the 2006 distribution when a large proportion of individuals were observed in the west of the bay. However, similarly to 2006, large aggregations of right whales

were observed off Race Point in late April. These results suggest that right whale distribution in CCB vary considerably between years

The largest number of Surface Active Groups (SAGs) was also observed in 2007. Between 1998 and 2006, a yearly average of 9.2 SAGs (SD=4.89, range = 1 to 15) had been reported. In 2007, 30 SAGs were observed while no changes in the methodology of the survey had been made.

Results from analyzing the data for the entire project (1998-2007) reveals frequent whale movements in and out of CCB, movements during which individual right whales may be particularly at risk of collision with ships as they may be crossing the Boston shipping lanes and are traveling in areas devoided of protection. Furthermore, our results suggest that the individuals that are observed in large numbers east of CCB during some years are usually not observed in CCB and seem to be transiting to or from another area. In general, right whale abundance increases slowly during January and February with an average of 3 and 6 individuals per survey/day respectively, peaks in March and April with just over 10 individuals sighted during each survey, and drops dramatically in early May, with only 1.5 individual sighted per survey. This study also demonstrates that individuals stay in the Bay for an average of 10-20 days and that during this time they move on average 13 km from the beginning to the end of their residency period.

One newly entangled whale (#2029) and one previously entangled (#BK01SEUS06) were observed in CCB during the 2007 season. Despite two aerial surveys dedicated to find and stand-by whale #2029, disentanglement was not successful. However, the aerial team provided a detailed photographic assessment of the entanglement. Photographic documentation suggested that whale #BK01SEUS06 was presently gear free.

During the 2007 field season 19 cruises were undertaken to fulfill the goal of describing the zooplankton food resources that control the distribution of right whales within Cape Cod Bay. As in recent years, the focus of this year's 345 zooplankton collections was the characterization of the distribution, composition, and density of the food resource of the right whales. Collections were principally taken by surface and oblique net tows at eight regular stations throughout the bay. Information collected and analyzed during the season was delivered to the Division of Marine Fisheries of the Commonwealth of Massachusetts and to more than 80 colleagues via e-mail in the form of three assessment instruments: the rapidly produced "Preliminary Assessment" and "Right Whale Risk Alert" reports, and the detailed "Right Whale Habitat Assessment" documents. The former reports continue to underpin our effort to alert of the Division of Marine fisheries as too predicted areas of immanent risk of ship strike or entanglement, while the latter provides very detailed background for forecasting aggregation and feeding by right whales. All documents focus on forecasting the locations where right whales and industrial activities may overlap. In 2007 the rapid production of the preliminary assessment instrument resulted in the dissemination of three management advisories intended to alert mariners to the probable presence of right whales performing risky behaviors.

Generally the 2007 zooplankton resource followed previously documented patterns of enrichment and impoverishment with the primary food resources being the three dominant calanoid copepod taxa: *Centropages* ssp., *Pseudocalanus* ssp., and *Calanus finmarchicus*. Generally the pattern of productivity of these three taxa overlapped as in

past years to produce a fairly steady and increasing total zooplankton resource from January through May. The cycle of increased *Centropages* resource in the early winter, likely the remains of the late summer and fall stock, was again observed in 2007. The enrichment by *Pseudocalanus* ssp., usually peaking during March, was also observed, although the resource signal of *Pseudocalanus* was somewhat reduced during 2007 as compared to previous years. Typical of most other years, the *Calanus* resource increased from very low densities before late February to relatively high concentrations in April. The 2007 season, however, was less than typical in that the index of right whale density available from air surveys did not follow the steadily increase in total zooplankton concentration. Additionally, in 2007 right whales left Cape Cod Bay during a period in May when zooplankton, principally *Calanus*, remained broadly available and occasionally at densities exceeding the feeding threshold throughout large areas of the bay system. This pattern, the departure of right whales from a habitat that appeared acceptable, was also observed and noted in previous years (e.g. 2004) and we believe may be explained by the "competition between habitats" that we have proposed in past years. Elaborating on this hypothesis, the fluctuating zooplankton resource during May 2007 coupled with the apparent movement of bursts of high zooplankton density after the first week of May encouraged right whales to seek more stable food sources elsewhere. Because the arrival and departure of right whales in the Cape Cod Bay system is critically important to our ability to predict risk of the co-occurrence of industrial activities and right whales, we advance the hypothesis that in addition to optimizing foraging behaviors that govern the small-scale movements within the bay, the temporal and spatial stability of the zooplankton resource may have a profound influence upon the medium-term acceptability of Cape Cod Bay, particularly in the mid-spring when rich resources will predictably develop east of Cape Cod. The instability in the zooplankton resource observed at the end of the 2007 season appeared, at least in part, to be the result of major counter clockwise flushing currents within the Bay. Because of the importance of determining the departure time of whales, future research will likely focus on comparing the temporal and spatial stability with the distributional stability of the whales within Cape Cod Bay.

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GENERAL INTRODUCTION

The Cape Cod Bay (CCB) ecosystem is one of five known seasonal high-use habitat areas used by right whales (*Eubalaena glacialis*) in the western North Atlantic. The Critical Habitat for the North Atlantic right whale in Cape Cod Bay was federally designated in 1994 (Federal Register 59 FR 28793) in recognition of the seasonal importance of the Bay as an important feeding, socializing, and nursery area for the species (Watkins and Schevill 1979, Schevill *et al.* 1986, Hamilton and Mayo 1990, Mayo and Marx 1990, Kraus and Kenney 1991), and a habitat seasonally visited by a number of cows that are rarely seen in the other three northern habitat areas (Knowlton *et al.* 1992, Brown 1994). Cape Cod Bay has a long history as an important habitat area for right whales. Photographic identifications date from 1959 (Hamilton *et al*. 1997) to the present, and whaling records provide evidence of right whales in this area in the late autumn and winter through late spring from at least the early 1600s (Allen 1916, Mitchell and Reeves 1983, Reeves *et al.* 1999, Reeves *et al*. 2002).

Since the 1980s, right whales have been known to occur in Cape Cod Bay and adjacent waters[*] in all months of the year, with the peak of occurrence from February through April (Schevill *et al.* 1986, Winn *et al.* 1986, Hamilton and Mayo 1990, Payne *et al.* 1990, Brown 1994). Survey data collected in the last two decades suggest annual variation in the numbers of whales visiting the Bay. For the period of 1978 through 1986, using photographed sightings of right whales collected from whale watch boats and research cruises, the total number of individually identified right whales in Cape Cod Bay ranged from a single animal in 1978 to 47 individuals in 1986 (Hamilton and Mayo 1990). Expanded surveillance and monitoring efforts in the winter and spring over the last nine years (1998 – 2006) have confirmed that Cape Cod Bay and adjacent waters are usually important feeding, nursing and socializing areas from late December through early May for as many as 95 individuals during some years, almost a third of the known catalogued population (Brown and Marx 1998, 1999, 2000, Brown *et al*. 2001b, 2002, 2003, Mayo *et al.* 2004, Jaquet *et al.* 2005, 2006).

Range-Wide Concerns

Despite international protection from commercial hunting since 1935, the North Atlantic right whale is the most endangered large whale in the world. No more than 400 individuals remain (CeTAP 1982, Brownell *et al*.1986, Kraus *et al*. 1988, NMFS 1991, Knowlton *et al.* 1994, IWC 2001, Kraus *et al*., 2005, Kraus and Rolland 2007). In the United States, the northern right whale is listed as "endangered" under the Endangered Species Act (ESA) of 1973. Scientists and conservationists have long been concerned about the status of the North Atlantic right whale population and its slow rate of growth (about 2.5% per year in the 1980s, Knowlton *et al*. 1994). Furthermore, recent analyses showing a decrease in the reproductive rate (fewer calves per mature female per year), an increase in the calving interval (Kraus *et al.* 2001, Kraus 2002), and a decline in the survival rate (Caswell *et al.* 1999, Fujiwara and Caswell 2001, Kraus *et al.*, 2005) suggest we should view the present situation with increasing concern.

[*] Adjacent waters include those state waters outside of the Cape Cod Bay Critical Habitat and federal waters over Stellwagen Bank/Wildcat Knoll in Massachusetts Bay, as well as those east of Cape Cod.

The apparent failure of the North Atlantic population to recover has also been attributed to anthropogenic factors including mortality from collisions with ships and entanglements in fixed fishing gear (Kraus 1990, Kenney and Kraus 1993, Knowlton and Kraus 2001, Kraus *et al.*, 2005). A total of 77 right whale deaths were documented from 1970 through May 2007 (Knowlton and Kraus 2001; New England Aquarium unpublished data). Of those 77 mortalities, 28 (36%) were attributed to ship strikes, 9 (12%) were a result of entanglement in fixed fishing gear, 22 (29%) were adult and juveniles that died of unknown causes, and 18 (23%) were calves that died of neonatal or unknown causes. Since December 2006, four right whales deaths have been documented. Two of these were very young calves, one was attributed to a ship strike and the fourth was #1424 whose cause of death is inconclusive, but had been entangled since 2002. Ship collisions kill more right whales than any other documented causes of mortality and more than half of the ship collision mortalities have been recorded since 1990. Entanglements, however, can result in long-term deterioration of health and may be responsible for more deaths than previously thought (Knowlton and Kraus 2001), so that entanglement may be equally responsible for right whale deaths as ship collisions (Kraus 2002). In addition, many animals disappear from the population (The New England Aquarium uses the metric "presumed dead" when a whale is not photographically identified for more than 6 years; this number stands at 119 in May 2007, Hamilton *et al*. 2004, Amy Knowlton pers. com), and it is obvious that not all deaths are seen on the beach (Knowlton and Kraus 2001). Based on the aforementioned information Caswell *et al*. (1999) estimated that if human - caused mortality is not reduced, the North Atlantic right whale population could become extinct in less than 200 years. Upon further analysis, Fujiwara and Caswell (2001) suggested that preventing the death of only two female right whales per year could increase the population growth rate to replacement level.

Right Whales in Cape Cod Bay and Adjacent Waters

The use of the Cape Cod Bay ecosystem by right whales has occurred for hundreds of years (Reeves *et al*. 1999, Reeves *et al*. 2002). Since the cessation of whaling in the late 1800s, other relatively recent human activities have affected the right whales using the area. Right whales are slow moving (particularly when accompanied by a calf) and very difficult for vessel-based observers to see when the whales are feeding at or just below the surface. They do not always appear to avoid approaching vessels, especially when socializing or feeding near the surface. There is a moderate level of commercial shipping in the Critical Habitat with the Cape Cod Canal being one of three entrances into the Port of Boston. There are about 550 transits annually by inbound and outbound vessels through the canal and along the western portion of the Bay (Kite-Powell and Hoagland 2002). The habits of the whales and the moderate level of ship traffic in the region make the right whale vulnerable to collisions with vessels in Massachusetts waters. Knowlton and Kraus (2001) documented two right whales that were likely killed by collisions with ships near this area, one in 1986 (found off Provincetown), the second in 1996 (found near Wellfleet). A third right whale was found dead in Cape Cod Bay in April 1999. A necropsy showed that the cause of death was blunt trauma, likely the result of a collision with a ship (Brown and Marx 1999). In all three events, the location of the collision between vessel and whale was not known. Modeling work using data collected during previous years of this project has been performed to identify areas of potential risk to right whales from shipping traffic in the Bay (Nichols and Kite-Powell 2005).

The model has shown that an average of seven large (>65') vessels transited Cape Cod Bay each day to and from the Cape Cod Canal, the highest volume of which is bound to or from Boston (four/day) and ports in the northern Gulf of Maine (two/day). Furthermore, the results of the simple two-dimensional model suggest that there are approximately 1.5 expected ship/whale encounters (assuming whales are always at the surface and no avoidance behavior is attempted by whales or vessels) in Cape Cod Bay each year; Boston traffic contributing about 46% of this risk, and Gulf of Maine traffic ~35%. Large commercial fishing vessel transits contribute an additional 0.4 expected encounters in Cape Cod Bay each year if assumed to follow the same route as Gulf of Maine traffic, generating a combined total of 1.9 encounters per year (Nichols and Kite-Powell 2005).

Right whales are at risk of entanglement in fixed fishing gear. In response to this, the Massachusetts Division of Marine Fisheries (DMF) has taken management action to mitigate the threat to right whales. In Cape Cod Bay Critical Habitat, the use of gillnet gear is prohibited from January 1 – May 15, while lobster gear fished during that period must be modified to comply with seasonal restrictions. These gear modifications include requiring traps be set in trawls of four pots or more with vertical buoy lines on each end or in "doubles" where two pots are strung together with only one buoy line, and a 500-pound break away link on all buoy lines (322 CMR 12.05). The modified gear is marked with twin orange flags on the buoy stick to identify it. The use of floating groundline in the pot and gillnet fisheries is prohibited year-round in Massachusetts state waters. This sinking groundline requirement went into effect on January 1, 2007. Prior to that, sinking groundline had been a year-round requirement in CCB since 2003 and a seasonal requirement since 1997. In addition to the above conservation measures, the Division of Marine Fisheries has carried out "ghost gear removal" projects in the winter months to further reduce entanglement risk. DMF is also working with the Massachusetts Environmental Police to ensure compliance with the sinking groundline regulations.

Over the last twenty years, more than 70% of the catalogued population of right whales has been photo-documented in Cape Cod and Massachusetts Bays at some time during their lives (PCCS and NEAq, unpublished data). These photographic data have been collected by various means. Recent survey efforts include twice-weekly aerial surveillance flights and weekly vessel-based habitat monitoring cruises conducted annually from January to mid-May during 1998 to 2007 as part of the program described in this report (Brown and Marx 1998, 1999, 2000, Brown *et al*. 2001b, 2002, 2003, Mayo *et al.*, 2004, Jaquet *et al.*, 2005, 2006). Prior to 1998, there were weekly vessel surveys and limited aerial surveys in the winter and spring in 1997 (Hamilton *et al*. 1997, Mayo 1997) and annual studies on foraging of right whales in the winter and spring since 1984 (Mayo and Marx, 1990). Researchers gathered opportunistic sightings from whale watching vessels from April through October from the late 1970s until 1996. The latter platform, which yielded many valuable sightings of right whales (including some rarely seen mothers with calves) in the spring, summer and fall (NEAq unpublished data), and reports of entanglements, is no longer available due to a state- and federally-mandated 500-yard exclusion zone around right whales for non-permitted vessels.

Program Objectives – 2007

To gain a better understanding of both the spatial and temporal distribution of individually identified right whales in Cape Cod Bay, an extensive surveillance and monitoring research program that was begun in the winter and spring of 1998 and has continued for the past ten years (Brown and Marx 1998, 1999, 2000, Brown *et al*. 2001b, 2002, 2003, Mayo *et al*. 2004, Jaquet *et al*., 2005, 2006, this report). The program of research directly addresses concerns identified by the Right Whale Conservation Plan submitted by the Commonwealth of Massachusetts to federal courts in 1996 and by the Northeast Implementation Team, and supports goals in the federal Atlantic Large Whale Take Reduction Plan, the Right Whale Recovery Plan (NMFS 1991), and the ESA. This report consists of the results of the research activities conducted in 2007 as described below. The objectives of the 2007 surveillance, monitoring, and management program in Cape Cod Bay and adjacent waters were:

I) To document right whales in the Cape Cod Bay Right Whale Critical Habitat and adjacent waters from early January through mid-May, using photo-identification techniques to identify individual whales. These data provide information on the age, sex, reproduction, distribution, abundance and patterns of habitat use (residency) of right whales in Cape Cod Bay and help refine long-term, range-wide analyses on presumed mortality, incidence of scarring, demographics and predictability of occurrence. Photographic and sighting data are integrated into the right whale photo-identification catalogue at the New England Aquarium and the sighting database at the University of Rhode Island.

II) To provide sighting data to the National Marine Fisheries Sighting Advisory System. Sighting locations of right whales are reported promptly to NMFS/SAS at the completion of each survey. The goal is to ultimately reduce the probability that right whales will be killed by collisions with large vessels by providing near "real-time" sighting data within Massachusetts waters to port authorities, commercial and military vessels, and other maritime operations. The winter portion of these surveys provide almost all of the data for the NMFS advisory system in the northeast, there are no other surveys being conducted by other states or federal agencies during the winter months (January through March).

III) To monitor right whales in the study area for evidence of entanglement. Each right whale encountered is examined visually for any evidence of attached gear. The disentanglement team is on standby, ready for immediate dispatch in the event an entangled whale is reported.

IV) To collect food resource information on weekly vessel cruises, from January to mid-May, designed to develop an understanding of the characteristics of the habitat to which right whales respond. These data, combined with data from past habitat studies in Cape Cod Bay by the Provincetown Center for Coastal Studies, provide additional information on the conditions that are believed to cue the movements and activities of right whales in Cape Cod Bay and adjacent waters. Management agencies (e.g. MA DMF, NMFS) have used these data to forecast whale movements and residency times within the study area and have issued vessel speed advisories and amended seasonal gear restrictions on a real-time basis in response

to right whale distribution predictions based on controlling characteristics of the food resource in the bay and adjacent waters.

V) To describe the distribution and abundance of any other marine mammals and shipping activity in Cape Cod Bay and adjacent waters from January through mid-May.

Objectives I through III and V are the focus of the first section of this report; Objective IV is discussed in the second and third sections.

SECTION 1: SURVEILLANCE, RESIDENCY AND DEMOGRAPHICS OF NORTH ATLANTIC RIGHT WHALES IN CAPE COD BAY AND ADJACENT WATERS - 2007

1.1. Introduction

The following section addresses Objectives I through III and V of the PCCS/DMF right whale surveillance and monitoring program. Objective IV is discussed in section 2.

During March through mid-May, an additional study was jointly funded by National Geographic, the Peter and Helga Gimbel / Boston Sea Rover Grant and DMF to gain preliminary data on right whale surface/dive behavior, small-scale movements and vocalization rates in relation to demographic group and food resources. Although in the last 20 years, survey data and opportunistic sightings have greatly improved our understanding of the right whale population, individual whales were seldom followed and thus little data is available on variability in behavior and small-scale movements in relation to food resources. An understanding of this aspect of the ecology of right whales will greatly increase our understanding of right whale vulnerability to ship strikes and thus is crucial in the conservation scheme of the species. Furthermore, the power of passive acoustics monitoring programs has been demonstrated for several species of cetaceans and could potentially be very useful for monitoring the presence/absence of right whales in hard-to-reach areas. However, to date, there are little data on the variation in vocalization rates in relation to demographic group, number of animals present, behavior and/or amount of food resources. It is clear that, before passive acoustics can be used as a monitoring tool, it is critical to gain a better understanding of the behaviors during which individuals may be silent as well as an understanding of the proportion of time that various demographic components of the population of right whales are emitting sounds.

1.2. Methods

1.2.1 Aerial Surveys

Aerial surveys were conducted regularly from 1 January 2007 through mid-May 2007 in the Cape Cod Bay Critical Habitat and adjacent waters. The aerial survey protocol for Cape Cod Bay, as described in Kraus *et al.* (1997), was adopted with some modifications. Fifteen track lines were flown latitudinally at 1.5 nautical mile (nm) intervals from the mainland to the Cape Cod Bay shoreline (Fig. 1a). An additional outer Cape Cod track line, 35 nm in length, paralleled the outer coast of Cape Cod from east of Chatham to the eastern end of track line one at a distance of about three nm from shore (Figure 1a, track line number 16). The east-west flight pattern in Cape Cod Bay was chosen for technical and safety reasons. In these latitudes, winter aerial surveys are hampered by low sun angles in the early and late hours of a survey day and this glare is a significant factor in sightability of marine mammals. On east-west track lines, although glare was a factor in one of the forward quadrants of the observers' view, there was always a section of the survey swath that could be observed without being compromised by glare. It was also deemed safer to have the aerial survey track lines begin and end near land. The turn at the end of each track line was initiated and completed about 1.5 nm

from shore in Cape Cod Bay to maximize the opportunity to observe any whales near shore. A total of 306 nm of 'on-track line' miles were flown during each completed survey (Table 1a). "On-track line" miles were those miles flown while surveying due east or due west in Cape Cod Bay and along the outer coast of Cape Cod, but excluded all miles flown between track lines (cross legs) or while circling. Additional track lines were established and flown at various times during the season to respond to reports of right whales in adjacent waters (Table 1b, Figure 1b).

The surveys were flown under visual flight rules conditions up to and including Beaufort sea state four. Surveys were aborted in Beaufort sea state five and/or when visibility decreased below two miles in fog, rain or snow. All aerial surveys originated at Chatham Airport, Chatham, MA, and were conducted in a Cessna 337 Skymaster (N48WP), a twin engine, high-wing aircraft with retractable landing gear. The aircraft was equipped with two GPS (global positioning system) navigation systems, full IFR (instrument flight rules) instrumentation, and a marine VHF radio with external antenna. Safety equipment included a life raft, four immersion suits, a floating ditch kit containing a medical kit, a waterproof VHF radio, a portable 406 MHz EPIRB, and an aircraft mounted ELT (emergency locator transmitter). All occupants wore Nomex flight suits and FAA-approved life vests with the following equipment attached: 406 MHz Personal Locator Beacon (PLB), Helicopter Aircrew Breathing Device (HABD), strobe light, dye marker, knife, and signal mirror. Additional safety measures adopted during the 2003 field season (Brown *et al.* 2003) were continued with minor modifications, most of which were made to comply with NOAA Fisheries Northeast Region Commercial Aviation Services Requirements (CASR, 26 October 2003).

Surveys were conducted at a standard altitude of 750 feet (229 meters) and a ground speed of approximately 100 knots, using methodology developed by CeTAP (Scott and Gilbert 1982, CeTAP 1982). The survey team consisted of two pilots and two observers positioned on each side of the aircraft in the rear seats. The two rear seat observers scanned the water surface from 0° - 90°, out to at least two nautical miles and recorded sightings when they were abeam of the aircraft. In order to maintain a standardized sighting effort, the pilots were instructed not to alert the observers to any sighting of marine mammals until after it had been passed by the aircraft and clearly missed by the observers.

Data were recorded by one observer (the right hand side one) using a laptop computer running an interactive data-logging program (Logger 2000, International Fund for Animal Welfare). Logger 2000 was configured to automatically record an event at 5-second intervals. At each event, latitude, longitude, time, altitude, and heading were obtained through an interface with the aircraft GPS. All sightings were logged by one observer recording the sighting data into a digital voice recorder (Sony ICD-ST10). A distinct voice file was created for each event which included the time to the second (read off the NMEA screen on the laptop), the sighting and the distance of the sighting from plane. The voice recordings were later transcribed into the database created by Logger 2000 with each recording being assigned to the nearest second. As Logger 2000 records an event at 5-second intervals, the event to which a recording is assigned was never more then two seconds from the time recorded. At a survey speed of 100 knots, 102 meters is covered in two seconds. Therefore, the position of the event in the Logger database that the recording was assigned to was never more then 102 meters from the exact position of the sighting. This protocol allowed the observer to enter data without taking his/her eyes from the survey area.

All sightings of marine animals except birds were recorded. Sightings identified as species other than right whales were counted, logged and passed without breaking the track line in order to maximize flight time available for investigating right whale sightings. Sightings of all vessels in the area were recorded by location and type. When an observer sighted a right whale or another large whale not immediately identified by species, the aircraft departed from the track at a left angle to the sighting and circled over the animal to determine species and obtain identification photographs. Photographs were obtained of as many individual right whales within a given aggregation as possible. For each right whale sighting, behavior and interaction with other whales or any nearby vessels or fishing gear was noted. At the conclusion of photographic effort at each sighting, the aircraft returned to the track line at the point of departure as recorded by the pilot's GPS. These methods conform to research protocols followed by the North Atlantic Right Whale Consortium and approved by NOAA Fisheries.

1.2.2. Shipboard Data Collection

The Provincetown Center for Coastal Studies (PCCS) maintains a 40' (12m) long, twin diesel engine research vessel the "*R/V Shearwater"*. The *R/V Shearwater* has been used successfully for habitat sampling and photo-identification in the winter and spring surveillance program in Cape Cod Bay from 1997 through 2006 (Mayo 1997, 1998, Mayo *et al*. 1999, 2000, 2001a, 2001b, 2004, Mayo and Bessinger 2002, Bessinger *et al.* 2003, Jaquet *et al.*, 2005, 2006). The results of this part of the program are reported in section 2 of this report.

Although the primary objective of the vessel cruises was habitat sampling, sightings of marine mammals were recorded on an opportunistic basis. Observers were on watch as often as weather and available personnel permitted, however observers did not follow a strict survey protocol. An observer from the aerial survey team was present on board *R/V Shearwater* whenever possible to aid in opportunistic data collection. Photographs of right whales obtained during habitat cruises were integrated with the photographs collected during aerial surveillance. These vessel-based sightings were also included in the analyses of residency, demographics, and life history.

Data on right whale distribution and identity were also taken during the "acoustic/behavior" study and included in the aerial surveillance database.

1.2.3. Right whale focal follows and acoustic behavior

To investigate right whale surface and diving behavior, small-scale movements, and vocalization rates in relation to demographic group and food resources, we closely followed one or several individuals continuously for up to 10 hours. During the focal follows, the track of the research vessel (*F/V Ezyduzit*, a 32-foot tuna fishing vessel, with a 440 Hp inboard diesel engine and an observation/driving tower about 17 feet above the water) as well as the positions of all right whale sightings were recorded using custom-written software on a Hewlett Packard 200LX palmtop computer linked to a Garmin 12XL GPS. Once in visual contact with right whales, identification photographs were taken using a Canon EOS 20D digital camera and a Sigma100-300 mm zoom lens (f4). Behavior, diving time, and surfacing time of the focal whale was recorded using a Sony digital voice recorder equipped with a time stamp. Simultaneously, we documented the behavior and spatial distribution of all whales in the vicinity using the digital voice recorder. A towed hydrophone array connected to an

amplifier/filter box (Magrec) and then to a Tascam HD-P2 portable high definition solid-state recorder (sample rate 48 kHz) was used to record vocalizations, anthropogenic-related noise and ambient noise continuously. The towed array consisted of three Benthos AQ4 elements with custom preamplifier (gain 30 db), and eight meters separation between the two furthest elements. The array was contained in a plastic tube filled with Isopar M oil, and custom build by Dr. Jonathan Gordon (Ecologic). The array was trailed behind the vessel on 30 meters of cable, and recordings were made continuously. The *F/V Ezyduzit* had been designed for tuna fishing with harpoons and thus engine and propeller noise were minimal; this vessel was ideally suited for acoustic work.

1.2.4. Photo-Identification Techniques

i) Identification Photographs

During aerial and shipboard surveys, photographs were taken using hand-held 35-mm Canon digital cameras equipped with 300-mm telephoto lenses. From the air, photographers attempted to obtain good perpendicular photographs of the entire rostral callosity pattern and back of every right whale encountered as well as any other scars or markings. Photographs were taken from a rear, opening window to prevent distortion of the image. From vessels, photographers attempted to collect good photographs of both sides of the head and chin, the body and the flukes. The data recorder on both platforms was responsible for keeping a written record in the daily log of the image numbers shot by each photographer. Digital images were downloaded and backed up immediately following each flight and cruise.

ii) Photo-Analysis and Matching

Photographs of right whale callosity patterns are used as a basis for identification and cataloguing of individuals, following methods developed by Payne *et al.* (1983) and Kraus *et al.* (1986). The cataloguing of individually identified animals is based on using high quality photographs of distinctive callosity patterns (raised patches of roughened skin on the top and sides of the head), ventral pigmentation, lip ridges, and scars (Kraus *et al.* 1986, Hamilton and Martin 1999, Kraus and Rolland 2007). NEAq has curated the catalogue since 1980 and to the best of their knowledge, all photographs of right whales taken in the North Atlantic since 1935 have been included in NEAq's files. This catalogue allows scientists to enumerate the population, and, from resightings of known individuals, to monitor the animals' reproductive status, births, deaths, scarring, distribution and migrations. Since 1980, a total of 39,619 sightings of 504 individual right whales have been archived, of which 360 were thought to be alive as of 15 June 2007 (Hamilton *et al.* 2004, Philip Hamilton, pers. com).

The matching process consists of separating photographs of right whales into individuals and inter-matching between days within the season. To match different sightings of the same whale, composite drawings and photographs of the callosity patterns of individual right whales are compared to a limited subset of the catalogue that includes animals with a similar appearance. For whales that look alike in the first sort, the original photographs of all probable matches are examined for callosity similarities and supplementary features, including scars, pigmentation, lip crenulations, and morphometric ratios. A match between different sightings is considered positive when the callosity pattern and at least one other feature can be independently matched by at least two experienced researchers (Kraus *et al.* 1986). Exceptions to this multiple identifying feature requirement include whales that have unusual

callosity patterns, large scars or birthmarks, or deformities so unique that matches from clear photographs can be based on only one feature. Preliminary photo-analysis and inter-matching was carried out at PCCS by experienced researchers, with matches confirmed using original photographs catalogued and archived at NEAq.

Once images were submitted to NEAq, analysis was conducted using DIGITS software (developed by Philip Hamilton and colleagues at the New England Aquarium). DIGITS was developed to help right whale researchers process digital images of whales, link them to sighting records, and code those sightings and images for subsequent searching and matching.

All images from a day were downloaded from the camera onto a computer and into a folder labeled with the date and platform. Every right whale photographed in a day was considered a "sighting". Time, latitude, longitude, Eg letter (the whale identifier for the day), and notes for each sighting were entered and the corresponding images were assigned by a simple click and drag feature. Each sighting was coded for behavior, association (mother/calf, Surface Active Group, echelon feeding, etc), and for 26 identification criteria, including callosity pattern, scars, and other notable features. The identification coding allows for future searches and comparison to both identified and unidentified whales. In addition to sighting coding, each image is also coded for quality, body-part visible, view direction and photographer. This coding system aids the matching process and simplifies image access for ongoing studies such as entanglement scar analysis (Marx *et al.* 1998) and health assessment (Pettis *et al.* 2004).

iii) Photographic Data Archiving

Original digital images are kept on file at PCCS on CD-R and two external hard drives. As digital photography has only been used for the last three years, an in-house system that allows image management and archiving in the same manner as slides is not in place at the time of this writing. In the future, DIGITS will be available for use by those outside of NEAq, and similar software will likely be used to manage digital images at PCCS. All PCCS digital images from the 2007 season have been archived at NEAq and are available for access by collaborators per North Atlantic Right Whale Consortium protocols.

1.2.5. Data Management

At the end of each aerial survey and focal follow, data from the voice recorder and track data from the day were downloaded and backed up on CD-R and two external hard drives. Digital voice files were managed and played back using proprietary software (Digital Voice Editor v. 2.13, Sony Corp.). Data recorded in individual voice files during the flight were manually transcribed into corresponding entries in the MS Access database created by Logger 2000. The database was then queried to generate a table formatted for compatibility with the North Atlantic Right Whale Consortium database. Data from aerial surveys and opportunistic sightings were submitted to Dr. Robert D. Kenney, curator of the Consortium Database maintained at the University of Rhode Island.

1.2.6. Data Analyses

All sightings were incorporated and integrated into the right whale catalogue and Consortium database with existing data on life histories for each individual identified by PCCS. Integration of the sighting data collected during these surveys with previously collected data

were used to describe the number, age, sex, and reproductive status of the right whales sighted in Cape Cod Bay in 2007. Sighting data from the aircraft were plotted to establish patterns of distribution and assess the seasonal and spatial residency patterns of right whales in the critical habitat and adjacent waters. The data on vessel locations were plotted for comparison with the locations of right whales to assess the level of overlap between right whales and vessels in the area.

As the amount of effort spent for the identification of individual whales during habitat cruises varied considerably between years, the use of the data collected by vessels could considerably bias the results. Therefore, for comparisons of number of individual whales identified between years, as well as for most detailed analyses, only data collected during aerial surveys were used.

We used the individual identifications of right whales obtained during this study to examine residency and number of days between first and last sighting in Cape Cod Bay. An analysis of the age and sex composition of the winter and spring population was carried out using data from all PCCS surveys to assess demographics and habitat use patterns. Right whales, first identified as calves, ranging in age from one to eight years of age were classified as juveniles, individuals age nine or older were classified as adults (based on classifications by Hamilton *et al*. (1995). Whales that were not first sighted as calves were classified as unknown age for the first eight years of their sighting history and as adults thereafter. All females who had calved were classified as adult. Sexes were assigned based on one of three methods: 1) by direct observation of the genital area; 2) by association with a calf; 3) by testing biopsy samples with a sex-specific DNA marker (Brown *et al.* 1994).

Number of different individuals identified in an area may not accurately reflect the utilization of the area by right whales, as one whale visiting an area for six day would be similar to six whales visiting the area for one day each. Therefore, it is also important to take into account the residency time of individuals and a variable "whale*day" (=the number of different individuals time the number of day each had been identified) was created. Although meaningful, this new variable will be negatively biased by long period of bad weather. Furthermore, the number of different individuals is also important to obtain an understanding of the number of whales that may be threatened by entanglements or ship strike in a particular area. Therefore, in this report, both variables are used to describe habitat utilization of right whales.

For ease of reading and avoid confusion, the details of each particular analysis is given together with its result (see result section). Standard statistical tests were used to determined trends in the data and significant differences between means, and thus t-tests, Chi-square tests, G goodness of fit tests, Pearson correlations, Kruskall Wallis tests etc were widely used in this report (Zar, 1996, Fowler et al., 1998). Significance was accepted at the 5% level and standard deviations (SD) were usually given with means except when standard errors (SE) were more appropriate (see Zar, 1996). To analyze movement patterns and overall individual residency time in CCB, we used the "movement module" of the SOCPROG version 2.3 suit of Matlab programs (written by H. Whitehead and available from http://myweb.dal.ca/~hwhitehe/social.htm).

1.2.7. Notification of Agencies

Prior to and following an aerial survey, both US Coast Guard Sector Southeastern New England and Air Station Cape Cod at Otis Air National Guard Base were notified of our planned survey, departure time, estimated return and a verbal summary of what was seen. In addition, we notified the shift commander at the Pilgrim Nuclear Power Plant of our flights. Following the completion of each aerial survey and habitat sampling cruise, the number of right whales seen and the location of these sightings were verbally reported to the NOAA Fisheries Sighting Advisory System (SAS) coordinator. The NOAA Fisheries/SAS office disseminates this information by fax, e-mail, Navtex, and marine weather radio to the appropriate agencies and mariners. Prior to reporting to the NOAA Fisheries/SAS, on days when any other whale research vessels were operating in Cape Cod Bay and adjacent waters, additional sightings, if any, were added to the report if from an area not already included in the PCCS report. A daily summary of the location and number of right whale sightings was emailed to DMF. In the event that a right whale was seen in Cape Cod Bay, the US Army Corps of Engineers Canal operators were also notified at the completion of a flight so they could relay the sighting location to transiting ships. If right whales were sighted in close proximity to Canal traffic, sightings were relayed during flight via VHF radio.

1.3. Results

1.3.1. Aerial Surveys

In 2007, the PCCS/DMF aerial survey team was in position to survey for 136 days from 1 January through 15 May. Thirty-one full and partial surveys were flown during these 4.5 months: 30 surveys were flown in Cape Cod Bay, with two surveys including a track down the Boston shipping lane east of Cape Cod and one survey including a series of track lines over the Great South Channel (Table 1a, 1b). One survey was flown exclusively over adjacent waters (track lines 1,2 and 16, Table 1a) due to very rapidly deteriorating weather. Out of these 31 surveys, seven were aborted due to inclement weather, one was not completed due to low light at the end of the survey, two were aborted due to involvement with an entangled whale and nine did not include track 15 due to low tide (Figure 1, Table 2). These surveys represented 8,262 miles flown and 157.4 hours of flight. The weather in winter and spring of 2007 was substantially worse for aerial surveys than in 2005 or 2006, especially during the months of January, with the first survey conducted on 24 Jan (Table 2a). However, despite the inclement weather in 2007, we flew an average of 1.5 surveys per week in CCB (excluding the surveys in adjacent waters) compared to 1.6 surveys per week flown in 2006 and 1.9 surveys per week flown in 2005 (Table I).

Table I Summary of aerial survey effort in 2004, 2005, 2006 and 2007

	Number of surveys in CCB (include track 16)	Number of surveys in adjacent waters	Total number of nautical miles flown	Total number of hours flown
2004	25	3	7,164	139
2005	37	4	10,855	175
2006	32	4	9,219	170
2007	30	1	8,262	157

The first flight of 2007 was conducted on 24 January, first good weather day since 2 January. There were several week-long periods of bad weather throughout the survey season which accounts for gaps in survey coverage between 2-23 January, 27 January-7 February, 12 -21 March and 11-21 April. The first right whale was sighted in CCB by the aerial team on 21 February (compared to 7 February in 2006) and the last ones on 13 May (compared to 6 May in 2006). While the whales' arrival in Cape Cod Bay was later then in 2006, they were sighted in adjacent waters on 11 February, making their arrival to the region similar to 2006. However, the whales left the Bay later in 2007 than in 2006.

The average duration of the standard Cape Cod Bay survey was approximately 5.6 hours for surveys that were not aborted early due to an increase in wind speed, sea state (above Beaufort 4) or decrease in sighting conditions (to visibility less than two nm). This duration was about 0.7 hr longer then the mean for 2006, 1 hr longer than the mean for 2005, and equal to the mean for 2004. The increase in average CCB survey duration in 2007 in comparison to 2004-2006 was due to the very high number of right whales present in the Bay during any one day (up to 40 photographed sightings in a single day in 2007, versus a maximum of 37 in 2006, 22 in 2005 and 27 in 2004. Table 2, Jaquet *et al.*, 2005, 2006). Although photographing through an opening window increased the speed at which the photographer obtained identifying photographs, one of our pilots was reasonably new at circling over a large concentration of whales and needed to be trained to stay with a particular animal. Therefore, the average length of time required to identify one individual was similar to previous years.

The standard Cape Cod Bay survey includes track 16 and thus encompasses about 35 nautical miles of survey outside the Bay (Fig. 1). However, as it has been shown in previous reports (Jaquet *et al*., 2005, 2006) that right whales seen on track 16 are seldom observed within the Bay, and as the residency time of individuals on track 16 suggests that these whales are transiting through the area, all the analyses below differentiate between Cape Cod Bay and adjacent waters (outside CCB). According to the delineation of Cape Cod Bay in the Right Whale Consortium photo-identification database, CCB encompasses only the water south of 42°04' and thus only track 3 to 15. However, in previous reports, CCB also included the two tracks just north of CCB (track 1 and 2), therefore, in the present report, it is always stated whether the analysis are for CCB exclusively (track 3 to 15) or whether they also include the water just north of CCB (track 1 to 15). This differentiation allows comparisons with previous years and previous reports (using track 1 to 15), and allows analyses that are compatible with the definitions of the New England Aquarium.

Most of the aerial survey effort was concentrated within CCB with 6,105 miles of transects were flown in CCB (tracks 3-15) while only 2,157 miles were flown in adjacent waters (tracks1, 2, 16).

1.3.2. Shipboard Data Collection

The R/V *Shearwater* completed a total of 19 habitat sampling cruises and one cruise to deploy Chris Clark's pop up buoys between 14 January and 23 May 2007 (Table 3). The primary purpose of habitat cruises was to collect oceanographic data in the Cape Cod Bay Critical Habitat area on a weekly basis to compare distribution and abundance of right whales from aerial surveys with that of the food resource as determined from plankton samples obtained at sea. See section 2 of this report for the results and discussion of this portion of the program. Whenever conditions and numbers of personnel permitted, sightings of marine mammals were recorded on an opportunistic basis. The first right whales documented by the R/V *Shearwater* were sighted on 22 February while deploying pop-up buoys for Cornell University. The first right whales documented during a habitat cruise were sighted on 27 February. Many of the shipboard sightings were initially recorded by the aerial survey team and radioed to the vessel to facilitate collection of photo-identification and behavioral data and oceanographic sampling in the location of feeding whales. Sightings of other species were recorded on an opportunistic basis. The right whale habitat team spent 117 hours at sea in 2007. In addition to the work described above, 11 cruises were conducted to collect data on behavior and vocalizations of individual right whales (focal follows), amounting to over 120 hours at sea.

In addition to habitat sampling and recording opportunistic sighting data, the habitat team also photographed 47 right whale sightings during the habitat and pop up deployment cruises. The focal follow team photographed 80 individual right whales (Table 3 and Table II).

Shipboard photographs are the best means of documenting lip ridges and chin callosities of calves, which are particularly important for matching sightings in subsequent years (Hamilton and Martin 1999). All of the shipboard photographs have been compared to those obtained from the aircraft and were included in the same matching process as described in the methods, the results of which are detailed in the following analyses.

1.3.3. Sightings and Photo-Identification

In 2007, a total of 634 right whale sightings were recorded from all platforms, of which 585 were photographed and analyzed in this report (Tables 2 and 3). From these 585 photographed sightings, 161 different individuals were identified including 3 first year calves. One hundred and thirty-four right whale sightings, consisting of 86 individuals (note that some of these may match whales previously identified) have not yet been matched to known individuals, as the individuals may be new whales or yearlings from last year and thus may not yet have a good record in the catalogue. From these 134 unidentified photographed sightings, 45 were in adjacent waters and 89 in CCB.

The number of photographed sightings and different individuals identified by platform and location are outlined in Table II.

Table II **Number of photographed sightings and individual right whales identified by platform and location in 2007.**

Platform and Location	Photographed sightings	Number of different individuals	Sightings not yet matched	Number of miles flown or number of days on the water
Aerial – CCB (track 3 to 15)	263	104	36	6,105 miles
Aerial – Adjacent waters (track 1,2, 16 and other 2 surveys)	195	108	39	2,157 miles
Habitat Cruises - CCB	47	23	19	19 days
Focal Follow Cruises	80	30	40	11 days
Total	**585**	**161**	**134**	

The total number of different individuals identified is lower than the sum of individuals per platforms and locations as 52 identified individuals were sighted both in CCB and adjacent waters, and as all but one of the identified individuals that were sighted from cruises were also identified from the aerial surveys. Despite a much lower overall aerial survey effort, no shipboard effort and a much smaller area surveyed in adjacent waters than in Cape Cod Bay, as much as 108 individuals were identified in adjacent waters while 105 were identified within CCB by all platforms.

At the time of this writing, 161 individual right whales have been identified from all platforms combined and from all areas (CCB and adjacent waters), representing 45% of the population known to be alive in 2007 (P. Hamilton, Pers. Com.). This is substantially larger than the total number of individual right whales identified in any other year since the beginning of these aerial surveys/habitat cruises in 1998 (Fig I; Brown and Marx 1998, 1999, 2000, Brown *et al.* 2001b, 2002, 2003, Mayo *et al.*, 2004, Jaquet *et al.*, 2005, 2006). This large increase in number of individual right whales observed in CCB and adjacent waters in 2007 is not due to the increase of research effort due to the inclusion of the data from the *F/V Ezyduzit* as only one individual was identified by shipboard platforms and not by the aerial survey.

Out of these 161 individuals identified by all platforms, 53 were seen exclusively in CCB (track 3-15), 56 were seen exclusively in adjacent waters (track 1,2, 16 and adjacent waters) and 52 individuals were observed in both areas. For the sake of comparison, if we include track 1 and 2 in the CCB area (as it had been done in previous reports), 77 individuals were seen exclusively in CCB and/or just north of CCB (track 1-15), 43 individuals were seen exclusively in adjacent water (track 16 and eastern tracks) and 41 individuals were observed in both areas. If we count the number of individuals sighted in an area, regardless of it's other sightings, 105 individuals were seen in CCB (track 3-15), 36 individuals were seen north of Cape Cod (track 1-2) and 84 individuals were seen in adjacent waters (track 16 and eastern tracks).

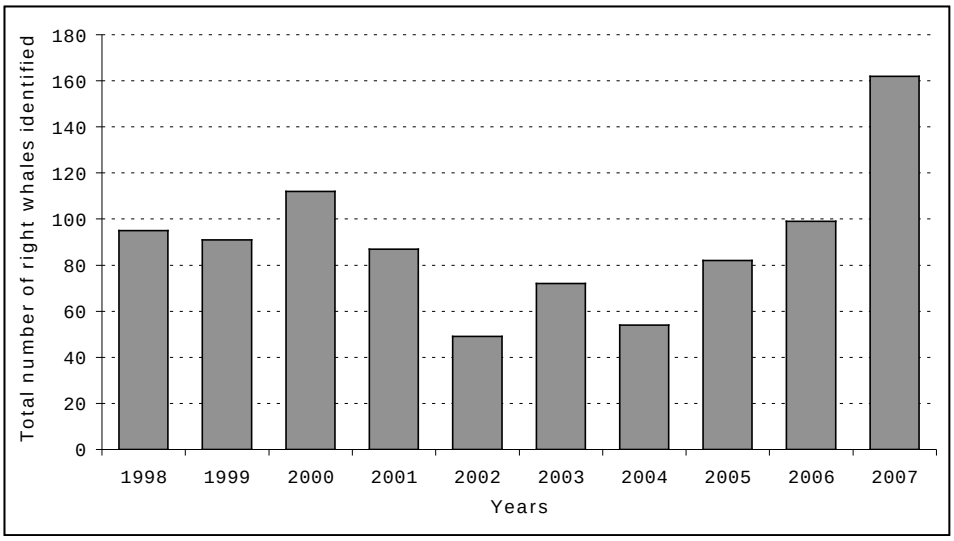


Figure I **Total number of individual right whales identified in both CCB and adjacent waters by all platforms for each year of the project.**

The number of individual whales observed in CCB and just north of CCB in 2007 (118 ind) was substantially larger than 2006 (78 ind, Fig. II). The number of individuals observed exclusively in adjacent waters (as defined in previous reports, so only track 16 and eastern tracks) was also substantially larger in 2007 (43 ind) then in 2006 (21 ind), 2005 (33 ind) and 2004 (1 ind). This increase can be expected as there was an overall substantial increase in the number of right whales utilizing Cape Cod Bay and adjacent waters in 2007 compared to earlier years (Fig. I). However, as transect 16 only covers a strip of water about five nm wide east of Cape Cod Bay, the increase in right whale abundance on this transect can also be due to whales transiting at slightly different distances from shore between years, and thus being more or less easily spotted.

During the ten years of the project, an average of 68.0 individuals (SD=30.14, range 20 to 118, Fig. II) was present each year in CCB and just north of it (tracks 1-15) representing 18.9% of the individuals believed to be currently alive (360 ind, Philip Hamilton pers. com). Figure II also shows that the number of right whales visiting CCB is highly variable between years and that there are no tendencies of CCB being more and more utilized by whales or less and less utilized (slope=0.1576, r^2=0.0003, N.S.).

Figure III show the number of different right whale identified in adjacent waters (track 16 and all tracks east and north east of CCB) over the course of the project (1999-2007), no data could be found for 1998 and thus this year is not represented on Fig. III. As the amount of survey effort in adjacent waters was very variable over the years (min of 1,071 nm in 2004, max of 2,234 nm in 2002, mean=1,687 nm, SD=418.9), the total number of individual identified is meaningless and thus only the number of individuals per 100 nm of survey effort is presented. The shipboard effort in adjacent waters has been negligible for all years and thus is not taken into account. It is evident from Fig. III that the abundance of right whales in adjacent waters is even more variable than in CCB.

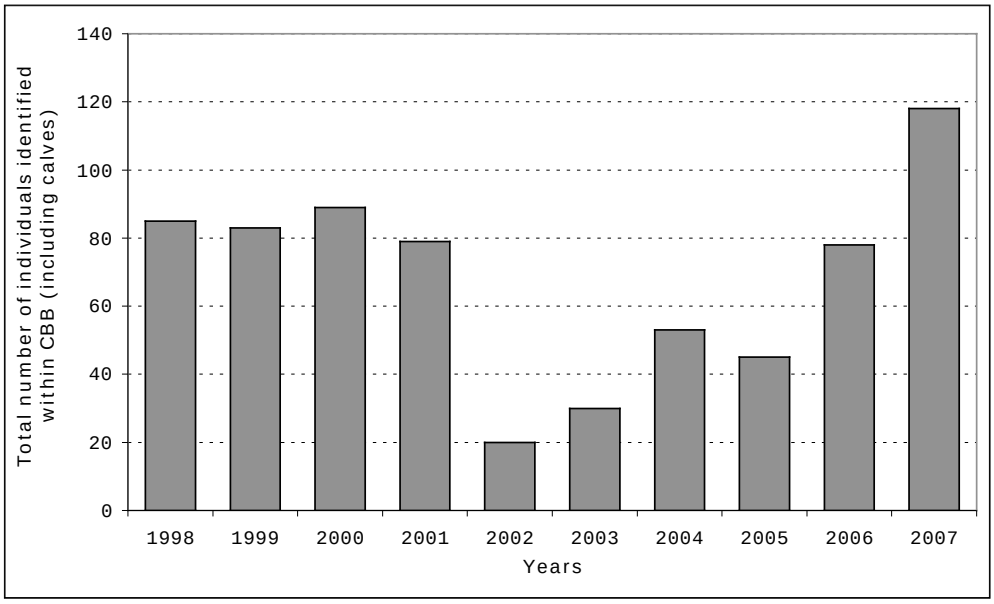


Figure II **Total number of individual right whales identified within CCB each year. For comparison purposes, in this figure, CCB means track 1 to 15.**

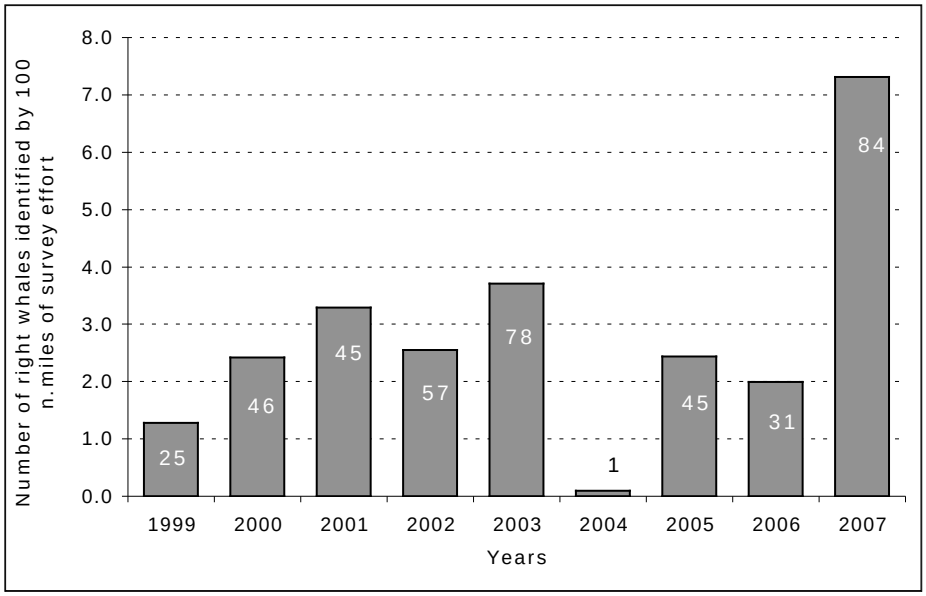


Figure III **Number of right whales identified per 100 nm of survey effort in adjacent waters. For comparison purposes, in this figure, adjacent waters means track 16 and all tracks flown NE, E or SE of CCB. The number in each column represent the number of different individual identified during the year.**

As individual right whales have different residency times within CCB (see section 1.3.7), and as the individual residency time may also depend on the amount of food resources (untested to date), the total number of different individuals identified within CCB each year may not

reflect the yearly utilization of the Bay. Therefore, to take some proxy of the residency time into consideration, for each year, the number of individuals identified have been multiplied by the number of days they have been observed in CCB, providing a new variable called "whale*day" (Figure IV, see also methods section).

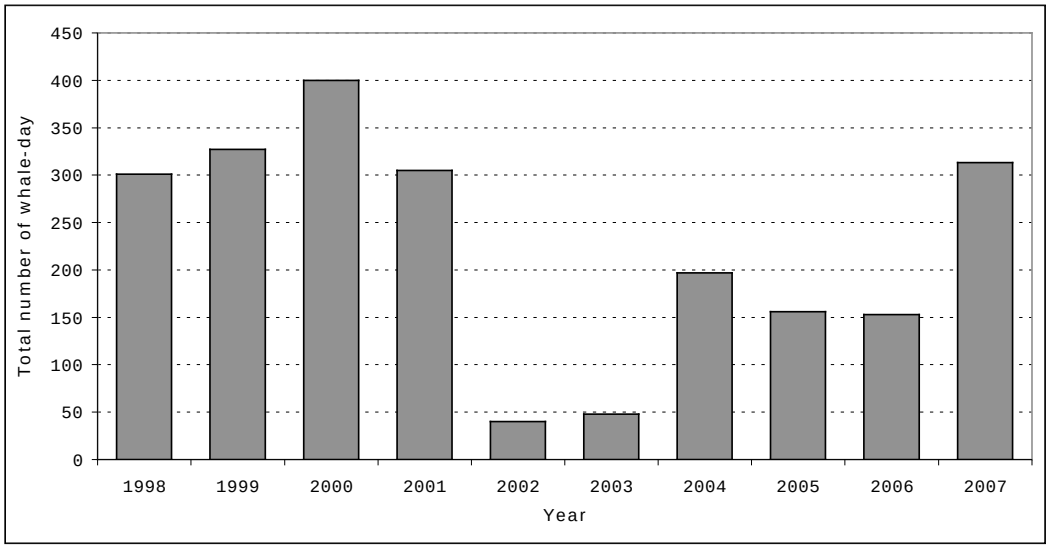


Figure IV **Total number of whale*day in relation to years (see text for explanations of the variable "whale*day). For comparison purposes, in this figure, CCB means track 1 to 15.**

Figure IV suggests that, although in 2007, we identified the largest number of individual right whales in CCB and in waters just north of CCB (tracks 1 to 15) ever recorded, the maximum number of "whale*day" was observed in 2000, suggesting that residency time was shorter in 2007 than in 2000 and 1999. However, the apparent shorter residency time in 2007 is also likely to be the result of the long periods of inclement weather preventing us from surveying the Bay. If individual whales stay for a few days in the Bay, inclement weather will prevent re-identification of the same individuals and thus will suggest shorter residency time.

However, despite the bias associated with residency time, the two variables "number of different individuals" and "whale*day" were well correlated ($r=0.858$, $df=9$, $P<0.001$), suggesting that, on average, both variables are an acceptable proxy to estimate the yearly utilization of CCB by right whales.

Since 1998, 231 different individuals have been identified in CCB (tracks 3 to 15) by all observers and all platforms, and thus over 64% of the right whale population has been sighted in CCB. The discovery curve showing the rate at which "new" individuals are identified within CCB for the duration of the project is shown in Figure V. In the last couple years (2005-2006), the curve was showing sign of a plateau suggesting that most individuals coming into CCB had been identified in the first six-seven years of the project, and that a part of the population may never or very rarely enter CCB (see also Jaquet *et al.* 2006, pages 18-19). However, in 2007, 34 new individuals were identified in CCB, individuals that had never been observed during the first nine year of the project. This recent result could suggest that a larger part of the population is now using CCB in winter/early spring, or that 2007 was an unusual year. However, it is only by conducting surveys during the next few years that it will be

possible to determine whether 2007 was an atypical year or whether CCB is becoming even a more important habitat for right whales than it was in the past.

The new recruitment into the population (i.e. calves) is likely to be responsible for the small increase in the number of new individuals each year shown on the discovery curve (Fig. V), but cannot explain the large increase in 2007.

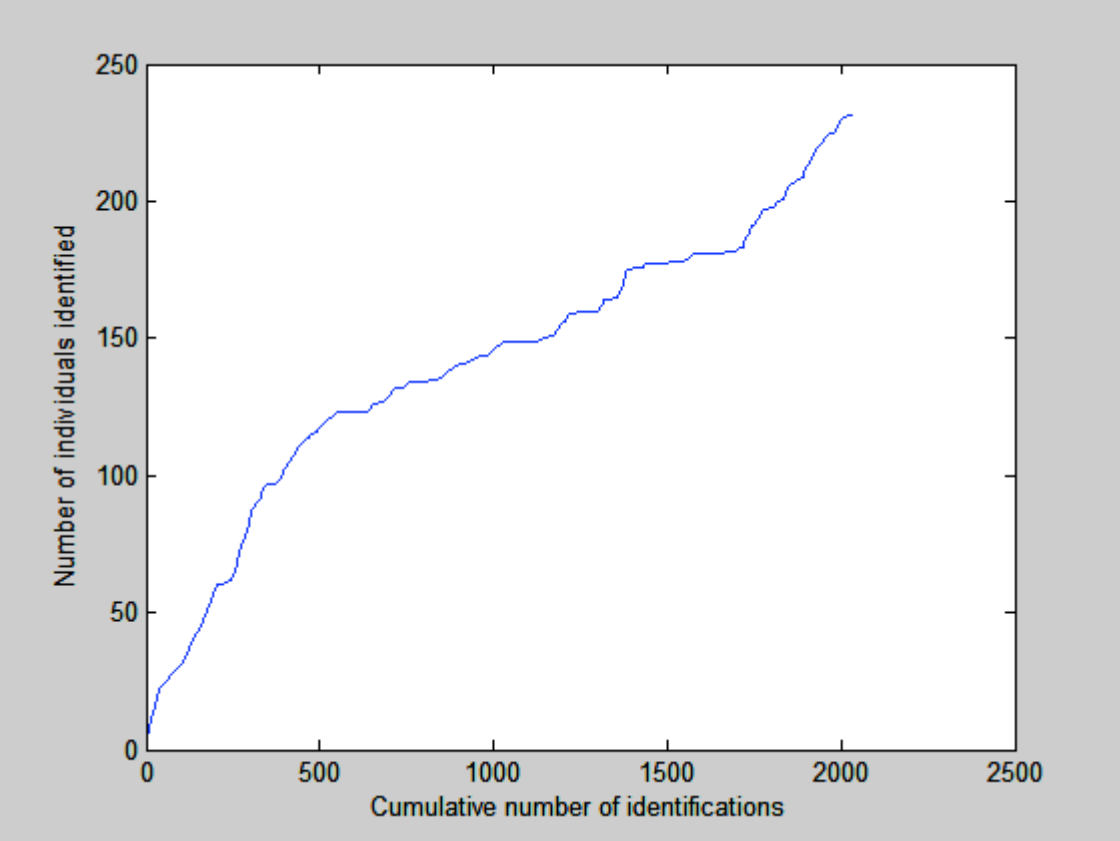


Figure V **Discovery curve for individual right whales identified within CCB (track 3-15) by all observers, but excluding all adjacent waters (track 1, 2, 16 and eastern tracks) for the duration of the project (1998-2007).**

1.3.4. Distribution, Abundance and Seasonality of Right Whales within CCB

Right whales photographed and identified during aerial surveys of Cape Cod Bay and adjacent waters are plotted by two-week periods in Figure 2. In previous reports (1998-2006), these figures included all sightings during aerial surveys and thus included duplicates when the same whale was photographed twice. This can be particularly misleading when large aggregations of whales are present and many individuals are photographed more than once. In this report, only identified individuals are plotted on Figure 2, eliminating the bias due to duplicates, but preventing comparisons with Figures 2 from previous reports.

Sightings recorded from vessels were not collected according to systematic survey protocols and thus were not plotted; however, the distribution of the opportunistic sightings mirrors that of the aerial survey sightings as indicated in Figure 2. The aerial survey team spotted the first right whales within Cape Cod Bay on 21 February 2007. Right whale residency in CCB

extended until 13 May without any large time gap where no whales were observed (the residency period includes shipboard sightings). The exact day of the departure from the Bay is known this year because two surveys of CCB were conducted on consecutive days (13 May and 14 May) with no whales sighted on the second day. Right whale sightings became abundant by late February and continued to increase throughout March. There were two peaks in right whale abundance during the 2007 season: the first during the two-week periods of 26 March – 8 April and the second between 23 April – 6 May. A violent "nor-easter" came through the area in between these peaks, temporarily dispersing the right whale concentration near Race Point. Sightings were especially low directly following the northeasterly gale, with only six whales sighted during a full survey of Cape Cod Bay on 21 April. However right whale sightings quickly began to increase again, causing the second peak in abundance.

Figure VI shows the number of different individual right whale identified per unit effort within CCB (track 3-15) in 2007. Due to the high number of individuals on 23 March, 11 April and 25 April, it seems that there was a low abundance in February. However, in 2006 the abundance did not reach three individuals per 100 nautical miles until mid-March, while this same abundance was already seen by 22 February in 2007. Furthermore, in 2006, the maximum number of individuals identified per 100 nm of survey effort was 9.5, while it reached 15 in 2007. As during previous years, there was high variability in abundance throughout the survey season (Fig. VI). On 26 March the survey had to be aborted due to deteriorating weather and less than half the Bay was surveyed (tracks 1-6). This may explain why no right whales were sighted on this day.

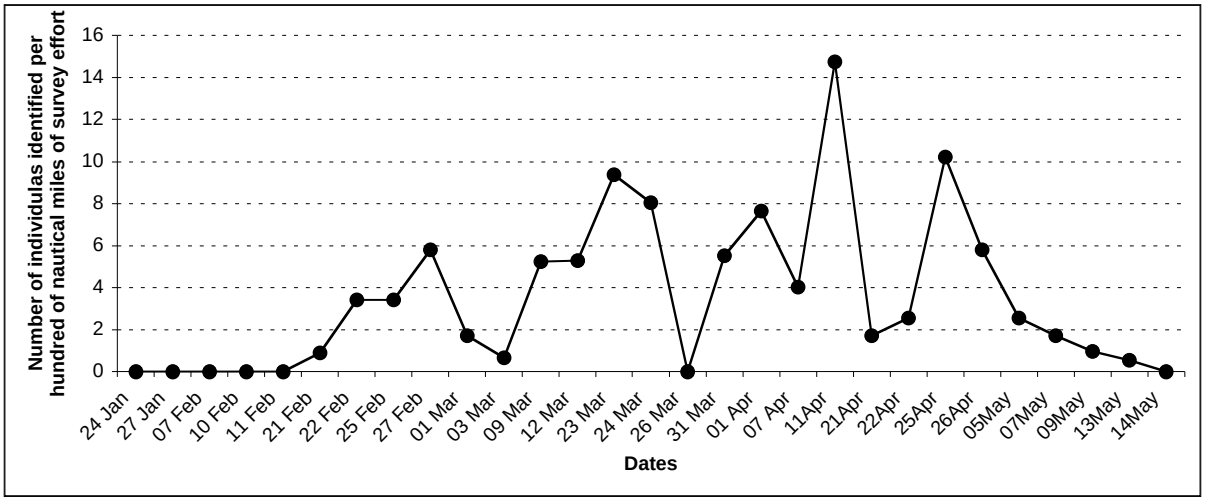


Figure VI **Number of individual right whales identified within CCB (only track 3-15) in 2007 per 100 nautical miles of aerial survey effort.**

No consistent pattern emerges when number of individual right whales per 100 nm of survey effort is plotted for adjacent waters in 2007 (Fig. VII). Right whales were first sighted in adjacent waters on 11 February. Throughout the survey season there was a high variability in right whale abundance with the numbers of individuals per 100nm varying from 0 to 35 (Fig. VII, Table 5). The number of individuals per 100 nm was higher in adjacent waters then in Cape Cod Bay (Fig. VI, Fig VII). While the number of right whales sighted in Cape Cod Bay was consistently higher then in adjacent waters, the average number of miles surveyed in Cape

Cod Bay (209.5 nm) was also substantially higher then in adjacent waters (72.8 nm). This suggests that sightings in adjacent waters consist of large aggregations of right whales in a small area.

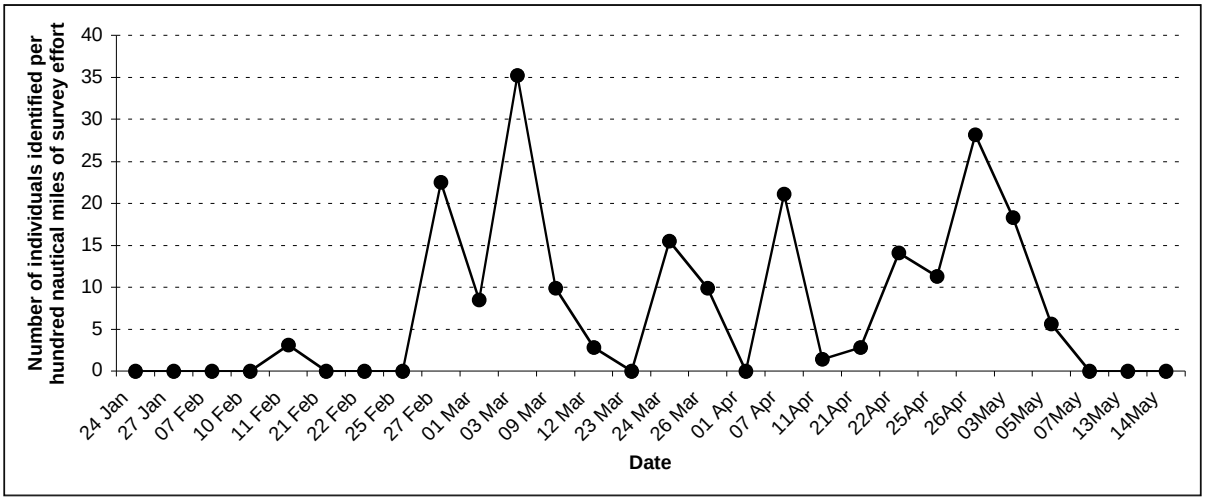


Figure VII **Number of individual right whales identified in adjacent waters (include tracks 1-2, 16 and all north-eastern tracks) in 2007 per 100 nautical miles of aerial survey effort. Note the difference in Y scale between Figure VI and Figure VII.**

Table III shows the date right whales were first and last sighted within CCB. During the 10 years of this study, right whales were present for the longest period during the 1999 season (Table III). The value of 95 days indicated for 2003 is misleading because there was a period of 46 days between 10 February and 28 March during which no right whales were seen in the Bay. Furthermore, the timing of the first survey varied greatly between years (from 9 December for the 2005 season to 24 January for the 2007 season) and therefore it is possible that, during some years, the time period during which right whales were present was longer than the one described in Table III. On average, right whales are observed to be present in CCB for about 96 days (SD=30.3 days) each year; and thus the time period that right whales was present in CCB in 2007 (82 days, Table III), is slightly less then the yearly average.

Except for 2002 when few right whales were sighted within the Bay, the whales seem to enter CCB for the first time between late December and early February and leave the Bay between late April and early May. Therefore there seems to be large variation in the time right whales enter CCB, but little variation in the time they leave it. Furthermore, during all years, whale abundance seemed to increase slowly during the first two months of their residency period, then reach a peak for a couple of weeks to a month, followed by a seemingly abrupt departure.

Table III **Time period when right whales were present in Cape Cod Bay over the 10 years of the project. Numbers in brackets represent the number of individuals identified on the sighting date. Numbers in square brackets represent the total number of individual right whales identified in CCB during the year. For comparison purposes CCB means track 1 to 15 (and thus includes the 2 tracks just north of CCB).**

Year	Date of 1st aerial survey	Date of 1st aerial survey right whales were sighted within CCB	Date of last aerial survey right whales were sighted within CCB	Minimum # of days when right whales were present in CCB
1998	04 Jan 1998 (9)	04 Jan 1998 (9)	21 April 1998 (1)	108 [75]
1999	13 Dec 1998 (5)	13 Dec 1998 (5)	02 May 1999 (1)	140 [86]
2000	20 Jan 2000 (1)	20 Jan 2000 (1)	11 April 2000 (3)	82 [86]
2001	19 Dec 2000 (5)	19 Dec 2000 (5)	29 April 2001 (2)	132 [87]
2002	06 Jan 2002 (0)	7 Feb 2002 (1)	15 March 2002 (3)	36 [24]
2003	10 Dec 2002 (0)	25 Jan 2003 (5)	30 April 2003 (8)	95 [26]
2004	21 Jan 2004 (0)	10 Feb 2004 (2)	10 May 2004 (1)	90 [54]
2005	09 Dec 2004 (0)	30 Jan 2005 (3)	26 April 2005 (6)	86 [45]
2006	10 Jan 2006 (0)	4 Feb 2006 (1)	6 May 2006 (12)	91 [59]
2007	24 Jan 2007 (0)	21 Feb 2007 (2)	13 May 2007 (2)	82 [116]

The average number of individual right whales identified per 100 nm of survey effort during each month between 1998 and 2007 is plotted on Figure VIII, the error bars represent 1 standard deviation. The figure shows the same pattern of slow increase in whale number in January and February, a peak in March and April and a sudden decrease in early May. The large standard deviations are an indication of the large variability in the number of right whales per 100 nm of survey effort within a month. However, despite this high variability, the mean number of individuals per 100 nm of survey effort was significantly smaller in January than in February (t-test: t=3.246, df=113, P=0.0015), and significantly smaller in February than in March (t-test: t=-3.183, df=145, P=0.0018). There were no differences between the mean number of individuals in March and in April (t-test: t=-0.342, df=146, P=0.7331, NS), suggesting that the peak in whale abundance is as likely to occur in March as in April. The mean number of right whales per 100 nm of survey effort in May was much smaller than in March-April, consistent with a rapid decline in right whale abundance in early to mid May.

Out of the 451 identified sightings in 2007, 108 (24%) occurred outside the Critical Habitat. This is less then what was observed in 2006 when 35% occurred in waters outside the Critical Habitat. Although it is significantly more then the percentage observed in 2004 (1%), this year is similar to 2005 when 28% of the sightings occurred in waters outside the Critical Habitat. Within the Bay, few right whales were sighted close to the western edge of the Critical Habitat in 2007 (Fig. 2c, 2f, 2g, 2h). Most of the whales were sighted in the central and north-eastern portions of the Bay. The high concentration of right whales sighted in the north-eastern corner of the Bay in mid April and early May mirrors the distribution of whales during this time period of 2006 (Jaquet *et al.*, 2006, Fig. 3h, 3i). The concentration of whales in the central portion of the Bay is similar to the distribution observed in 2005 (Jaquet *et al.*, 2005, Fig. 3b). The change in distribution between years suggests that right whale small-scale habitat utilization is highly variable between years.

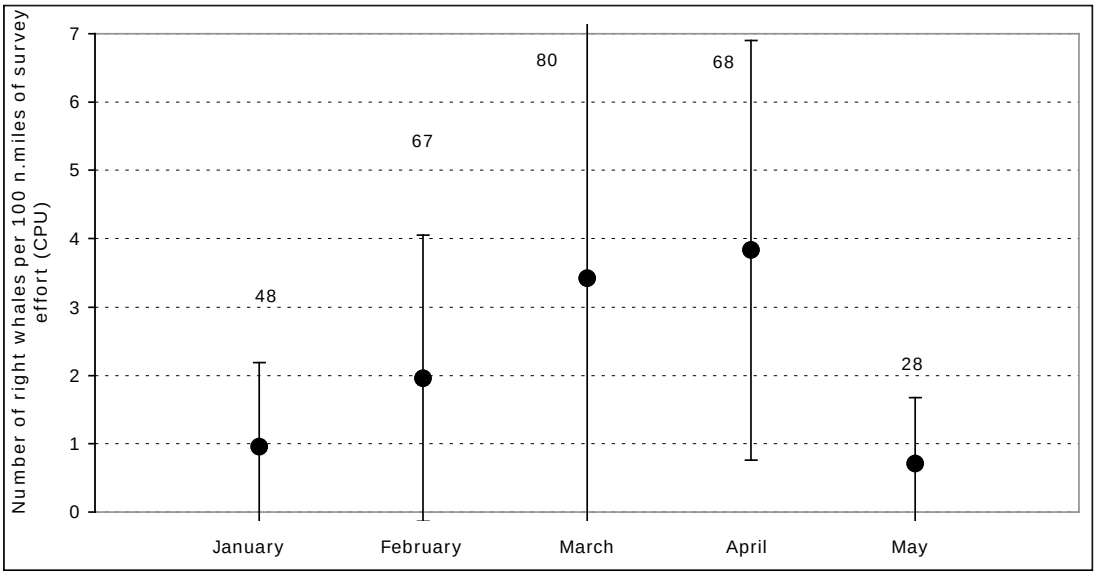


Figure VIII **Average number of individual right whales identified in CCB (track 1-15 for across years comparison) per 100 nautical miles of aerial survey effort during each month between 1998 and 2007. Error bars represent ±1 standard deviation. The number above each month represents the total number of surveys conducted during the month all years combined.**

1.3.5. Mother/Calf Pairs

Three mother/calf pairs were photographed in Cape Cod Bay and adjacent waters in 2007 (Table IV). Table IV shows that two of the mothers that brought their calf to CCB and adjacent waters were first time mothers.

Table IV **Identities, calving histories and residency of the 2007 mothers sighted in CCB and adjacent waters.**

Identification numbers	Number of known calves that the mother had before 2007	Area seen	Number of days seen	Time span in days between first and last sighting
1425	2	CCB + Just north of CCB	5	33
2430	0	CCB	3	12
1814	0	Adjacent waters	1	0

In 2007, 19 mother and calf pairs were observed in the southeastern United States (SEUS), a substantially smaller number than in 2005 (28) and 2001 (31), but similar to what has been observed in 2006 (19) and the three years previous to 2005 (16, 19 and 22 respectively). However one of these calves died in the first few months of its life and thus only 18 calves could have come into CCB. Three (16.6%) out of these 18 mother and calves pairs identified in the SEUS were also observed in CCB and adjacent waters (Fig. IX) in spring 2007, and two of them (11.1%) were identified in CCB and just north of CCB (Fig. X). For comparisons

between years, in the two following figures, CCB means track 1 to 15 and thus include the two track lines just north of CCB.

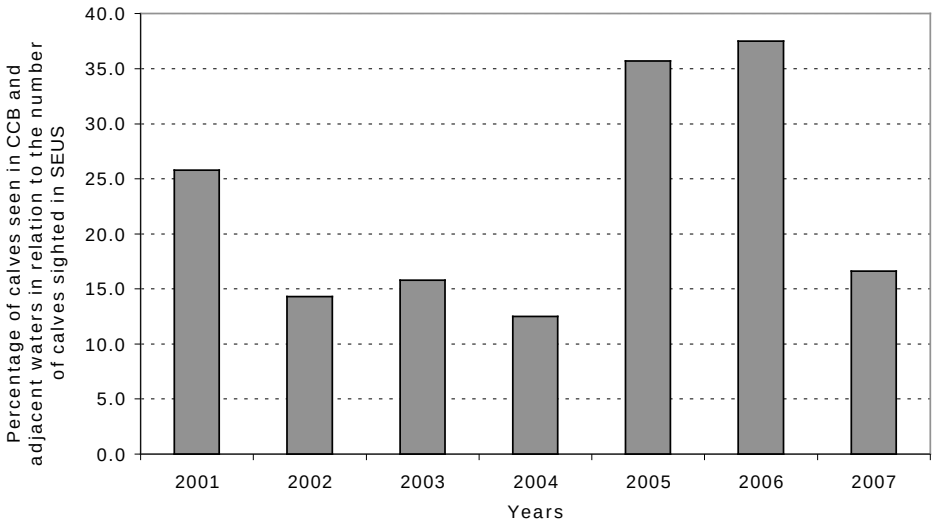


Figure IX **Proportion of calves seen in CCB and adjacent waters in recent years in relation to the total number of calves born in the SEUS.**

Although a lower percentage of mother and calf pairs were observed in CCB and adjacent waters in 2007 then in 2006 and 2005 (Fig. IX), the difference was not statistically significant (χ^2=5.7, df=6, P>0.05). Considering all years from 1998-2007, the average proportion of calves sighted in CCB and adjacent waters was 23.3%. The proportion sighted in 2007 (16.6%) was slightly lower the overall average. The years from 1998 to 2000 are not shown as no calves were sighted in CCB or adjacent waters during these years despite a similar aerial survey effort. However, because few calves were sighted in the SEUS during these years, six in 1998, four in 1999 and only one in 2000 (New England Aquarium unpublished data), it is not surprising that none were observed in CCB.

When only CCB (including the two tracks just north of CCB) is taken into account, the proportion of calves sighted in CCB in relation to the number of calves seen in the SEUS is shown in Figure X.

Since 2001, on average, 15.3% of the calves seen in the SEUS were also sighted within CCB (tracks 1-15). The percentage in 2007 was slightly lower then this, at 11.1%. The proportion of calves sighted in Cape Cod Bay in 2007 (11.1%) is also lower then the proportion sighted in 2004 (12.5%), 2005 (21.4%) and 2006 (31.3%). Due to the high variability in the proportion of mother/calf pairs visiting the Bay every year, the lower proportion in 2007 was not statistically significant (χ^2=7.6, df=6, P>0.05). Fig. X shows the variability in the proportion of mother/calf pairs visiting the Bay. While the increased proportions seen in 2005 and 2006 suggested that more mothers were utilizing Cape Cod Bay as a nursery ground, the lower proportion sighted in 2007 suggests that this was a temporary increase and not a steady trend.

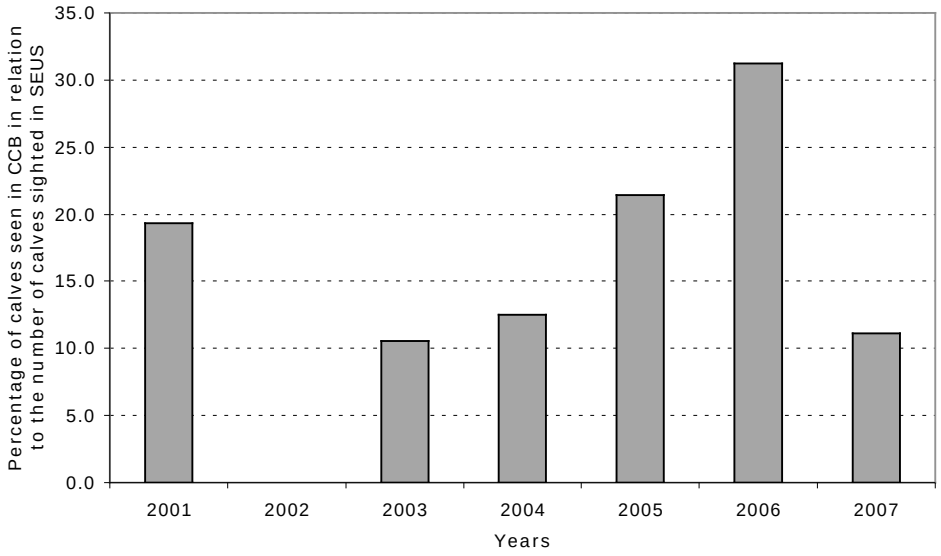


Figure X **Proportion of calves seen in CCB and just north of CCB (track 1-15) in recent years in relation to the total number of calves born in the SEUS.**

1.3.6. Demographics

Overall, a larger number of males (46.1%) than females (22.4%) were seen in Cape Cod Bay and adjacent waters in 2007 (similar to what was observed in 2006, but exactly the reverse to what was observed in 2005 and in 2004), and 31.5% of the individuals identified were of unknown sex. This sex ratio is significantly different from the expected ratio of 1:1 (χ^2=8.479, df=1, p<<0.05). Similarly, when only the individuals of known sex are taken into account, and our study area is divided into CCB (track 3-15) and adjacent waters, significantly more males (63%) than females (37%) were observed within CCB (χ^2=6.76, df=1, p<<0.05). Significantly more males than females were also identified in adjacent waters (73% versus 27%, χ^2=21.16, df=1, p<<0.05). These results suggest that in 2007, more males were observed in both CCB and adjacent waters, which would contrast with previous results suggesting that more males are seen in adjacent waters while more females utilize CCB. However, a large number of individuals are still of unknown sex at the time of writing (32 in CCB and 35 in adjacent waters), and thus it is not possible to draw conclusions on the sex ratio of right whales utilizing CCB or the waters adjacent to it, as the ratio may change dramatically once the sex of these individuals is known.

Out of the 231 individuals ever identified in CCB (Track 3-15) between 1998 and 2007, 76 (32.9%) were females, 105 (45.4%) were males and 50 (21.6%) were of unknown sex. This sex ratio was not significantly different from the expected 50%-50% ratio (χ^2=2.4026, df=1, p>0.05), suggesting that overall, when the ten years are averaged, the same proportion of males and females visit CCB during winter/spring. However, there are large variability in the proportion of males and females visiting the Bay and the water just north of it every year (Fig. XI). In 2001, 2003 and 2007 significantly more males than females were identified in CCB and just north of it (tracks 1-15), while in 2002 and 2005, significantly more females than

males were identified. The absence of any trend or pattern on Fig XI suggests high variability in the number of males and females that visit the Bay every year.

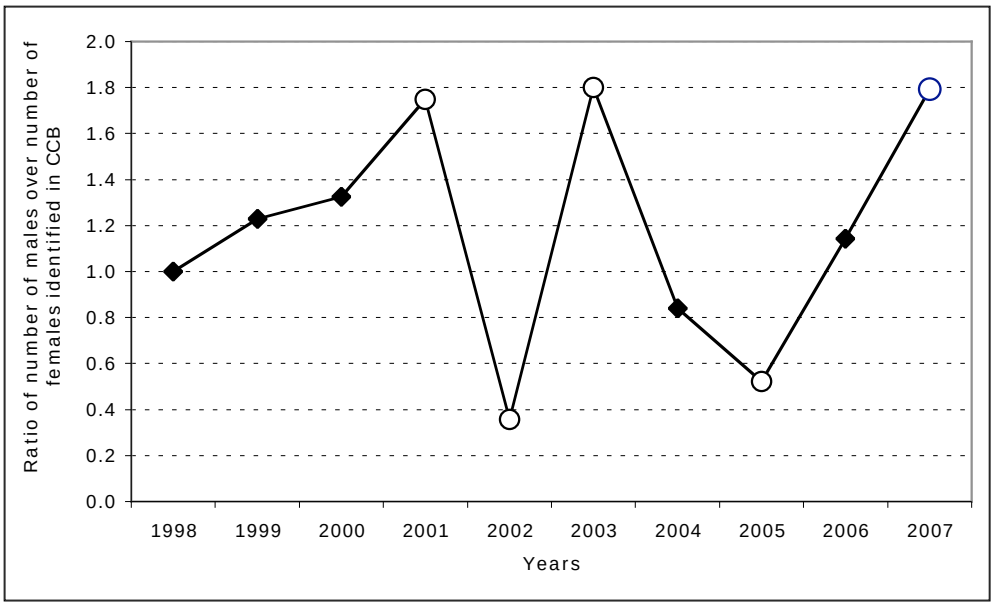


Figure XI **Ratio of number of males over number of females identified in CCB and waters just north of it (track 1-15) during the 10 years of the project. Open dots mean that the ratio was significantly different from 1.**

Although slightly fewer individual females than males visited CCB (track 3-15) during these ten years, females were observed on a significantly larger number of days than males ($\bar{x}$=16.2 days, SD=13.76 and $\bar{x}$=10.4 days, SD=10.0 respectively, t=3.678, df=178, P=0.0003). These results suggest that females are utilizing CCB more than males. Figure XII shows the number of days each of the 231 individual right whales were sighted within CCB. Except for four male, all whales that were observed on 28 days or more were females (n=20).

In 2007, CCB was frequented mainly by adults and by mother and calf pairs as only 15 individuals between 2 and 9 years of age were identified in CCB (Fig. XIII and Table V). The age structure of animals of known age class (criteria defined in Hamilton *et al*. 1998) in the catalogued right whale population consists of approximately 84% adults and 16% juveniles, excluding calves (as of December 2003; Hamilton *et al*. 2004). Therefore, in 2007, out of the animals of known age class and excluding calves, we had 73 adults and 16 juveniles (excluding calves), and thus a proportion of 82.1% of adults versus 17.9% of juveniles. This age structure is very similar to what is found in the right whale catalogue (Hamilton *et al.* 2004). On the other hand, the proportion is substantially higher to that found in 2004 and 2005 (Mayo *et al.*, 2004; Jaquet *et al.*, 2005) when respectively 94% and 93% of the individuals of known age class (excluding calves) were adults and 6% and 7% were juveniles. However, due to the high number of individuals of unknown age, no definite conclusion can be drawn at this point. Comparisons for CCB and adjacent waters between all years from 1998 to 2007 are outlined in Table V.

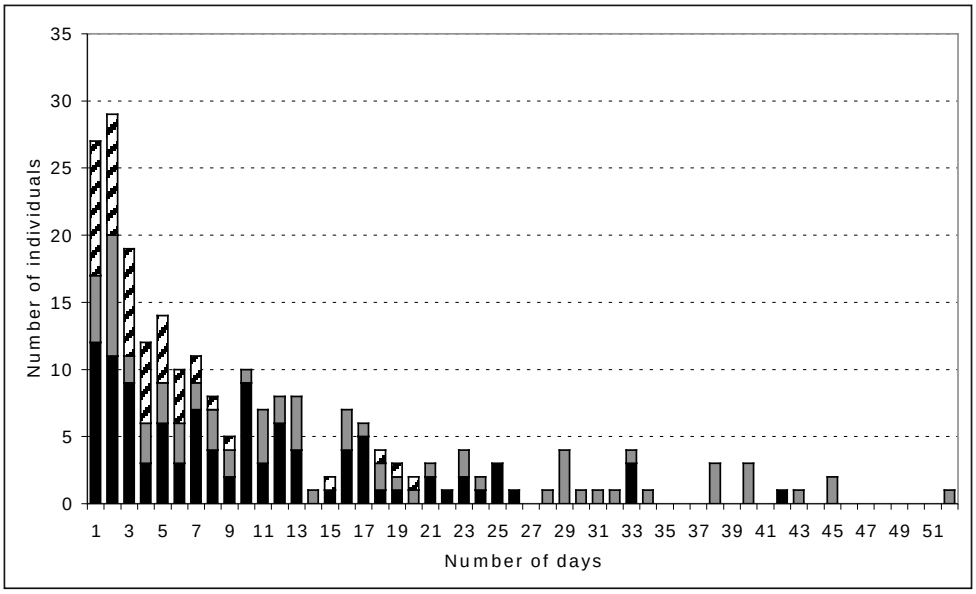


Figure XII **Number of days each of the 231 individuals was sighted in CCB (Track 3 to 15) between 1998 and 2007. Males are in black, females in grey and unknown sex in stripe.**

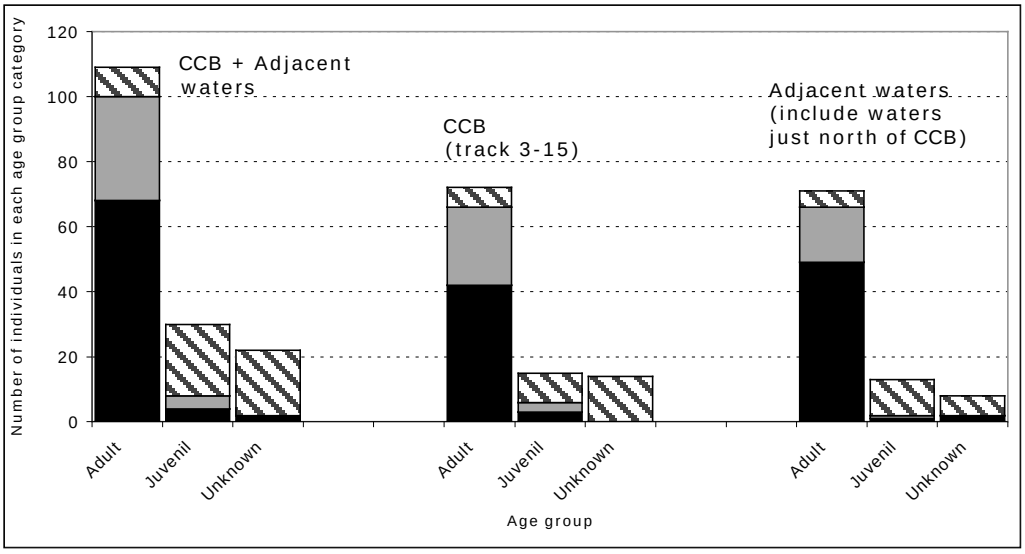


Figure XIII **Number of males (black), females (grey) and whales of unknown sex (stripes) in relation to age groups and areas for 2007. A whale is considered a juvenile from its birth until age nine, and thus the 3 calves identified in 2007 are considered in the "Juvenile" category and were still of unknown sex at the time of writing.**

Table V **Proportion of age groups and sex over the duration of the project (1998 to 2007) in CCB (track 1-15). Data came from previous reports.**

Year	Minimum # individuals	Adult : Juvenile (excluding calves)	# of Calves	# Unknown age	Males : Females	# Unknown sex
1998	75	58 : 15	0	2	28 : 38	9
1999	86	55 : 23	0	8	37 : 35	14
2000	86	64 : 15	0	7	42 : 36	8
2001	87	57 : 05	8	17	40 : 30	10
2002	19	10 : 06	3	0	02 : 12	5
2003	27	21 : 02	3	1	14 : 10	3
2004	54	47 : 03	2	2	22 : 27	5
2005	45	36 : 02	6	1	13 : 23	9
2006	79	61 : 07	5	6	33 : 28	18
2007	118	81 : 20	2	15	52 : 29	37

A timeline depicting the demographic composition of right whales identified in CCB in 2007 and separated into two-week periods by age and sex is presented in Table 4. Males and females were sighted simultaneously within the Bay in 2007. This result contrasts with the results from previous years (2004-2006), when females appeared in CCB several weeks before the males.

Between 1959 and 2006, 288 individual right whales have been identified in CCB (tracks 3-15). In 2007, 27 whales that had never been identified in CCB (track 3-15) were observed; four of them were males, three were females, and 20 were of unknown sex. Due to the intensive biopsie effort from the New England Aquarium, most individuals that are commonly seen in any of the critical habitat have been biopsied to date, providing knowledge about sex. As 74% of the whales that had never been observed in CCB before were of unknown sex, it suggests that most of the new whales observed in CCB in 2007 had seldom been observed in other critical habitats.

During this project (1998-2007), 231 individuals (76 females, 105 males and 50 of unknown sex) have been identified within CCB (track 3-15), 85 individuals (37.1%) only during one year while two individuals (0.9%) were identified during nine years; no individuals have been identified during every year of the project (Figure XIV). Females tended to have a greater site fidelity than males, and a large proportion of males came to the Bay only once during the course of the project, while females tended to return more often (Fig. XIV). In addition, between 1998 and 2007, none of the 105 males that visited Cape Cod Bay during this period are known to have died, while seven of the 76 females have died (confirmed death), and thus less females were available to return in CCB in 2007. This result suggests that CCB is an important habitat for females and that they tend to come back there repetitively.

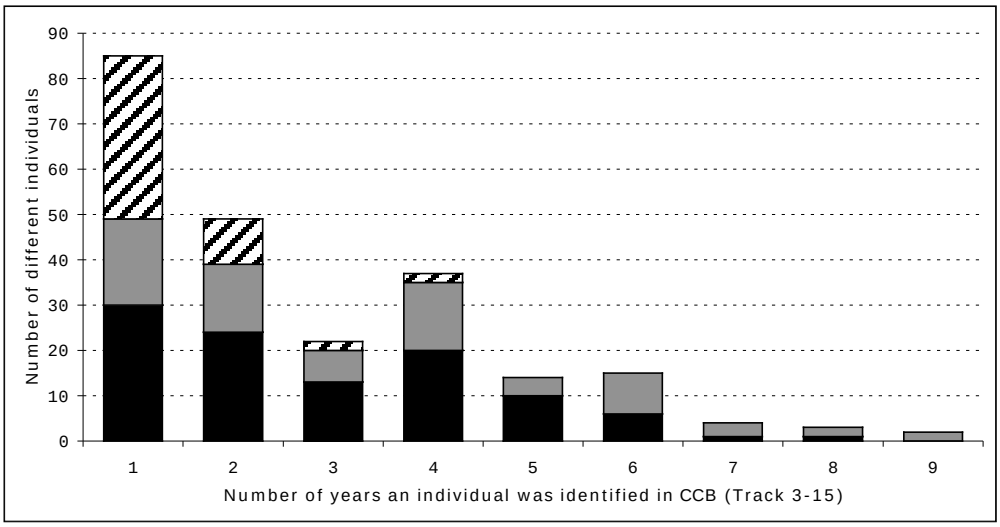


Figure XIV **Numbers of year individual right whales (males in black, female in grey and unknown sex in stripes) were sighted within CCB (Track 3-15) during the duration of the project (1998-2007).**

1.3.7. Individual Residency

As aerial surveys were not conducted every day, when an individual was observed on two or more surveys, we have no way of knowing whether it had been present in the Bay between two surveys or whether it had left CCB and re-entered it at a later date. Therefore we define individual residency time as the time span between the first and the last sighting of an individual whale.

Right whales are often seen multiple times in Cape Cod Bay over a four-and-a-half month field season. Table 5 shows the sighting history for each of the 161 individuals identified in 2007 in CCB and adjacent waters. Right whales were present in CCB and adjacent waters for 92 days in 2007 (11 Feb to 13 May) in comparison to 100 days in 2006 and 97 days in 2005 (Jan 30 to April 29). The longest time span between first and last sighting for a single individual was 75 days ($\bar{x}$=18.4 days; SD=21.35, n=158). This average residency time was considerably larger than in 2006 ($\bar{x}$=7.4 days; SD=13.31, n=93, Jaquet *et al.* 2006), suggesting a much longer individual residency time in 2007 than in 2006. Calves were not included in the analyses as their residency time is not independent of their mother's. There were differences in the number of days seen, and time span from first and last sighting between individuals seen in CCB and individuals seen only in adjacent waters.

Of the 105 right whales identified in Cape Cod Bay (only track 3-15) in 2007, 22 (21.4%) were seen only once (Table VI). The greatest number of days on which individual right whales were identified in CCB was eight (one adult female, one adult male and two juveniles of unknown sex; Table 5). On the other hand, 80.0% of the individuals sighted exclusively in adjacent waters (track 16 and eastern tracks) were identified on a single occasion and no individual were identified on more than three different days (Table VI). This pattern is similar when we include the two tracks just north of CCB into the adjacent waters (track 1, 2, 16 and

eastern tracks): 70.7% of the individuals were seen only once, 22.4% were seen on two different days, 8.6% on three different days, and no individuals were seen on more than three days.

Table VI **Number of days individuals (calves excluded) were identified in CCB (track 3-15) and in adjacent waters (include water just north of CCB).**

Number of days an individual was photographed in 2007	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Number of individuals photographed **in CCB** (n=103)	24	28	18	15	7	4	3	4
Number of individuals photographed **exclusively in adjacent waters** (n=55)	38	12	5	0	0	0	0	0

Therefore, the individuals sighted in CCB were seen on a significantly larger number of days than those identified only in adjacent waters ($\bar{x}$=3.0 days, SD=1.84 days versus $\bar{x}$=1.4, SD=0.41; t=-6583, df=159: P<<0.0001). This result suggests that the individuals identified in CCB were staying or returning in the area over a period of a few days to a few weeks while the individuals identified in adjacent waters must have been transiting to another area. This is confirmed by the time span in days between first and last sighting. In CCB (track 3-15) there was an average of 23.3 days between first and last sighting (SD=21.29 days, median=19 days, range= 1 to 75 days, Figure XV), while in adjacent waters there was an average of 9.8 days between first and last sighting (SD=18.72, median=1 day, range= 1 to 71, Figure XVI). Similarly to single individuals, mother and calf pairs sighted within CCB were identified on multiple occasions (on 3 to 5 different days) and had a residency time of 12 to 33 days, while the mother and calf pair identified exclusively in adjacent waters was sighted only on one day (Table IV). All these results suggest that individuals sighted in adjacent waters are mainly transiting through the area.

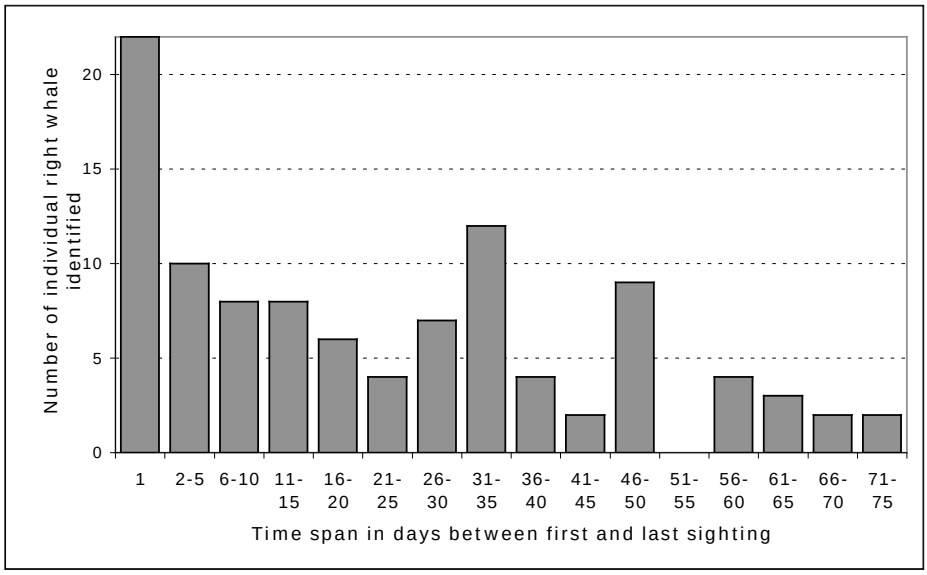


Figure XV **Time span between first and last sightings for right whales identified in CCB (tracks 3-15).**

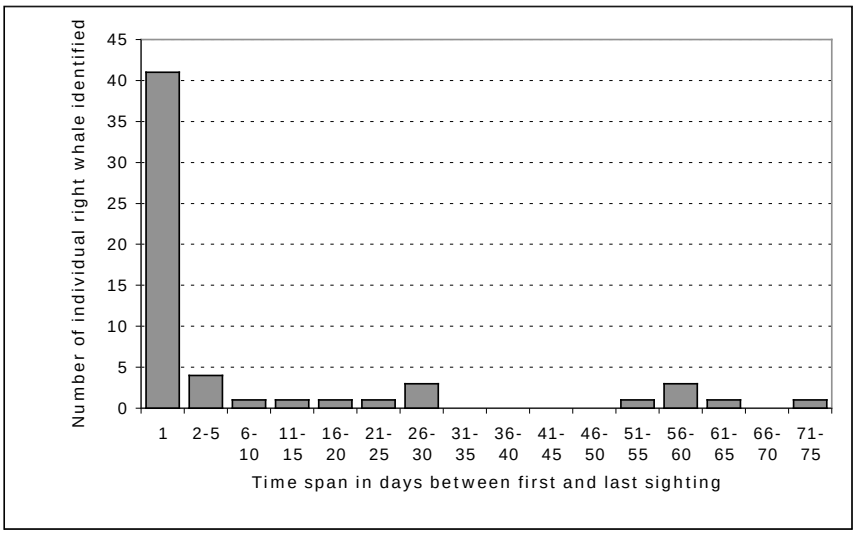


Figure XVI Time span between first and last sightings for right whales identified exclusively in adjacent waters. Note the difference of scale for the Y axis between Figure XV and XVI.

Due to little photo-identification effort in areas other than CCB and the SEUS during winter/early spring, and due to the fact that most of the 2007 sightings from teams other than the PCCS team are still awaiting identification, it is not possible to assess whether the time span between first and last sighting in CCB represents the real residency within CCB or whether there are extensive movements in and out of the Bay between sightings. However, it seems clear that some individuals exited the Bay and re-entered it at a later date.

For example, right whale #3308 was observed in CCB on five consecutive surveys between February 21 and March 1, and observed again on April 22, and 25 (Table 5). It is therefore much more likely that this individual made two different visits to the Bay rather than being missed on all surveys between March 1 and April 22 (Table 5). Table 5 also shows that a large number of individuals showed gaps in their sighting history. This result suggests extensive movements in and out of CCB in 2007, and is similar to what was found in previous years. However, the large number of windy days in March and April meant that six surveys had to be aborted due to deteriorating weather and thus there were often long time gaps between consecutive full surveys (up to 10 days in April). If we assume that an individual whale has left CCB when not sighted during three or more consecutive surveys, then, in 2007, 44.1% of the individuals seen more than once in CCB (n=59) left and re-entered CCB one to three times during their residency period. This is similar to what was observed in 2006, when 39.4% of the individuals seen more than once in CCB left and re-entered the Bay at least once.

When only the residency time within CCB (track 3-15) was considered (and not the gaps in between), right whales had a mean residency time of 9.2 days (SD=8.21). This residency time was slightly longer than in 2005 ($\bar{x}$=8.0 days, SD=9.72), and significantly longer than in 2006 ($\bar{x}$=5.0 days, SD=5.26, t-test: t=-3.104, df=107, P=0.0024). This result suggests that CCB was more utilized by individual right whales in 2007 than in 2006.

In CCB and adjacent waters, there were differences in residency time between demographic groups. Forty-six percent of the males were observed on only one day and the average number of days a male was identified was 2.2 (SD=1.58, n=74). The time span between first and last

sighting for males was on average 17.6 days (SD=21.61, Median=2). In contrast, individual females were identified on a slightly larger number of days ($\bar{x}$=2.8 days, SD=1.78, n=36) and the time span between first and last sighting was considerably larger ($\bar{x}$=21.72 days, SD=23.71). Mother and calf pairs were identified on average on the highest number of days ($\bar{x}$=3, n=3), but had the shorter time span between first and last sighting ($\bar{x}$=15.3 days, SD=16.26).

Within CCB only, there were differences in time span between first and last sightings between males and females, and the mean residency time was slightly longer for females than for males (Table VII).

Table VII **Time span (between first and last sighting) and residency time (excluding gaps when not sighted during ≥3 consecutive surveys) for individuals sighted within CCB (track 3-15) in 2007. Calves are excluded from this analysis.**

	Sample size	Mean Time Span in days (SD)	Median Time Span in days	Mean residency, no gaps ≥ 3 surveys (SD)	Median residency, no gaps ≥ 3 surveys
All (including unknown sex)	103	23.3 (21.13)	19	5.7 (7.42)	1
Males	46	21.5 (21.7)	16	4.6 (7.8)	1
Females	27	24.0 (22.88)	13	6.8 (7.51)	2
Mothers	2	22.5 (14.84)	23	10.5 (2.12)	11

Table VIII **Time span (between first and last sighting) and residency time (excluding gaps when not sighted during ≥3 consecutive surveys) for individuals sighted within CCB during the entire project (1998-2007). Calves are excluded from this analysis.**

	Sample size	Mean Time Span in days (SD)	Median Time Span in days	Mean residency, no gaps ≥ 3 surveys (SD)	Median residency, no gaps ≥ 3 surveys
All	630	21.0 (24.3)	12	9.7 (11.23)	5
Males	293	19.2 (25.42)	9	8.4 (10.19)	5
Females	240	24.0 (24.18)	18	11.4 (12.80)	7
Mothers	23	16.2 (11.42)	15	15.1 (10.89)	15

Overall (1998-2007) there were significant differences in residency time between mother/calf pairs, single females, males and individuals of unknown sex (Kruskal Wallis: K=17.928, df=3, p=0.0005), suggesting that mother/calf pairs stay in CCB the longest, then single females and then males (Table, VIII, Fig. XVII). Mother and calf pairs were the only demographic group that didn't show movements in and out of the Bay between first and last sighting and thus the mean time span was equal to the mean residency time. This discrepancy in residency time between demographic groups suggests that, although as many males as females are visiting the Bay, CCB is a more important habitat for females than for males.

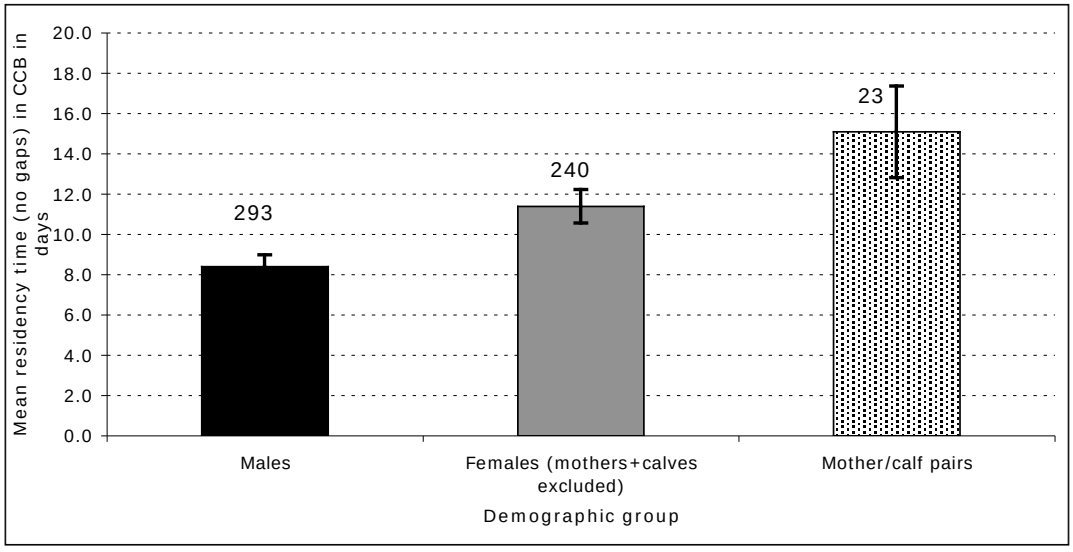


Figure XVII Mean residency time (excluding all gaps) for males, females and mother/calves pairs in CCB, all 10 years combined (1998-2007). Error bars are one Standard Error and the number above is the sample size.

The mean residency time of 9.7 days (SD=11.23) for all individuals (including the ones of unknown sex) in CCB all years combined (1998-2007), is further confirmed by the results of the lagged identification rate analyses (using SOCPROG 2.3, Whitehead, 2001). The lagged identification rate is the probability that if an individual is identified in CCB at any time, it will be identified during any single identification made in CCB after a certain time lag (Whitehead, 2001). For this analysis we used all identification photographs from 1998 to 2007. The maximum time lag was set at 135 days (length of a field season), as we were interested in the number of days individuals stay in CCB within a field season. Standard errors were calculated using 1,000 bootstraps. Several models were fitted to the curve, but the best fitted model (using the Quasi Akaike Information Criterion) was an "emigration + reimmigration" model suggesting that individuals enter CCB, leave it and re-enter it at a later date. These results are consistent with observations, and thus provide confidence in all results and interpretations.

Figure XVIII suggest that individuals use CCB for about 10 to 20 days before leaving the Bay for the season. The fitted model suggests that the average residency time in CCB is 22 days. This is longer than what was calculated using observations of individuals and deleting any gaps of three or more surveys when individuals were not seen (average of 9.6 days, see above). However, both calculations measure something slightly different, the mean residency time without gaps provide the average time that an individual stay in the Bay at any one time, while the results of the above model provide the total time an individual is likely to be in the Bay and thus suggest that, on average, each individual will come and go twice during the course of the field season.

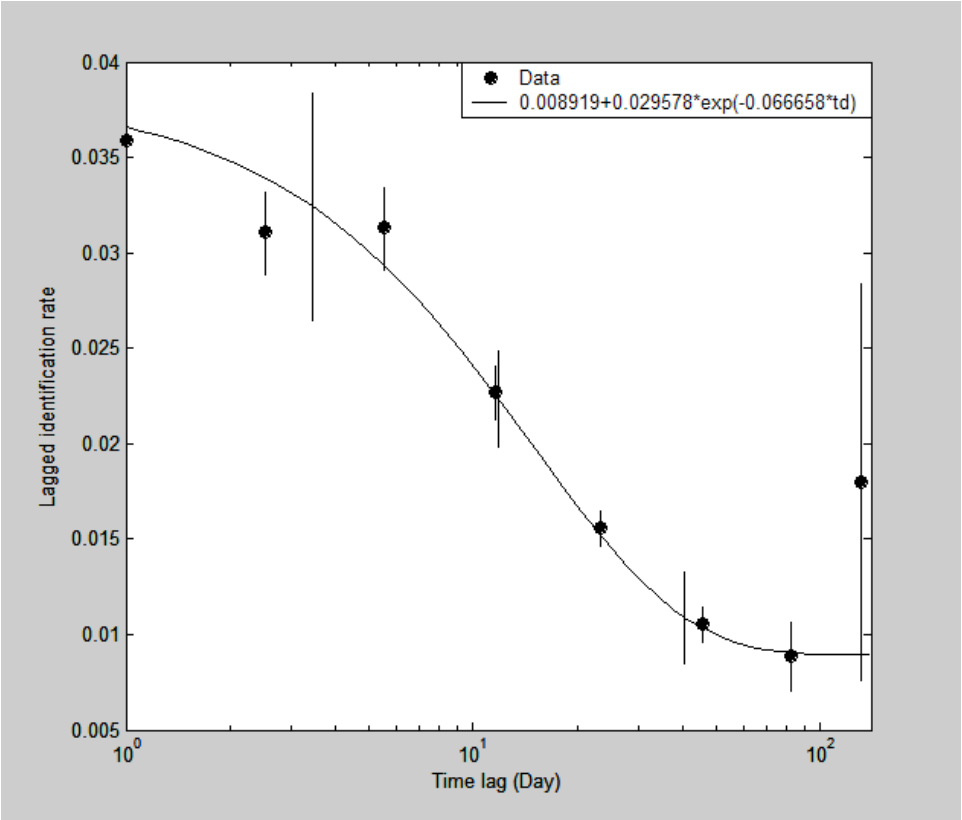


Figure XVIII Lagged Identification Rates for CCB 1998-2007. Error bars represent standard errors, and the blue line is the fitted model

1.3.8. Cluster sizes and occurrence of surface actives groups (SAGs)

Knowledge of the social structure of a species or a population is crucial to understanding many aspect of its ecology. Social structure has a strong influence on gene flow (Whitehead 1998), fitness, habitat use (Baird and Dill 1996; Ersts and Rosenbaum 2003), spread of diseases (Lee 1994), as well as on the manner in which knowledge is retained and distributed amongst members (McComb et al. 2001; Wittemyer et al. 2005). Thus social structure is a key component of any study on population biology. The surface active groups (SAGs, two or more whales interacting at the surface with frequent physical contact, (Kraus and Hatch 2001), is the most striking aspect of right whale social behavior. Although SAGs were thought to be related to reproduction, they have been reported in all critical habitats as well as during 11 months of the year (Parks 2003). Therefore, it is most likely a large proportion of the SAGs does not lead to reproduction and that sexual activity unrelated to conception has some important benefits for right whales, possibly in the form of social bonding (Parks 2003). A better understanding of the yearly and monthly occurrence of SAGs in CCB and adjacent waters will thus shed some important light on when and possibly why SAGs occur, as well as on the importance of sagging behavior for right whales in the Bay.

In baleen whales, groups are usually described as two or more individuals within one or two body length of one another and coordinating their movements. However, such a definition is not always used rigorously and the term group is also often used to refer to a few whales found in the same general proximity. On the other hand, the term “cluster” always refers to a close

association of two or more whales that are coordinating their movements. Therefore, although the term “cluster is not often used for baleen whales, to avoid the confusion associated with the term “group”, in this report we used the term “cluster” to refer to two or more whales that are closely associated spatially and that are coordinating their movements. As a cluster is a voluntary association between individuals, understanding the variability in cluster size may also help unraveling some of the aspects of right whale social organization.

Mean cluster size in CCB and adjacent waters was only calculated for the aerial survey data collected between 1999 and 2007, as cluster size and behavior was not recorded systematically prior to 1999 nor during opportunistic sightings. To investigate whether cluster size was related with number of whale present, and/or with overall amount of food resources, cluster sizes were compared between months. As right whales in adjacent waters appear to be transiting to other areas (Jaquet *et al.* 2005, 2006, this report) and thus to be in a different “general behavior state” than the whales in CCB, cluster size comparisons between CCB and adjacent waters were made to investigate whether the general behavior state had any impact on cluster sizes. Mother and calf pairs are not the result of a voluntary association and thus should not be included in a study of social organization. Therefore, to avoid biasing the results towards larger mean cluster size when many mother/calf pairs were present, mother and calf pair were given a cluster size of “1”.

In all areas surveyed by this project, 81% of the clusters were single individuals (mean cluster size =1.33, SD=964, n=1,645, range =1 to 15) and there were only 6% of the clusters that numbered three or more individuals. However, mean cluster size was significantly larger in adjacent waters than in CCB ($\bar{x}$=1.65 and $\bar{x}$=1.26 respectively, t-value=6.567, df=1643, P<0.0001, Fig. XIX). As in CCB right whales are mainly foraging, and as in adjacent waters a large proportion of individuals seems to be transiting, this result suggests that right whales tend to form smaller cluster when in foraging behavior.

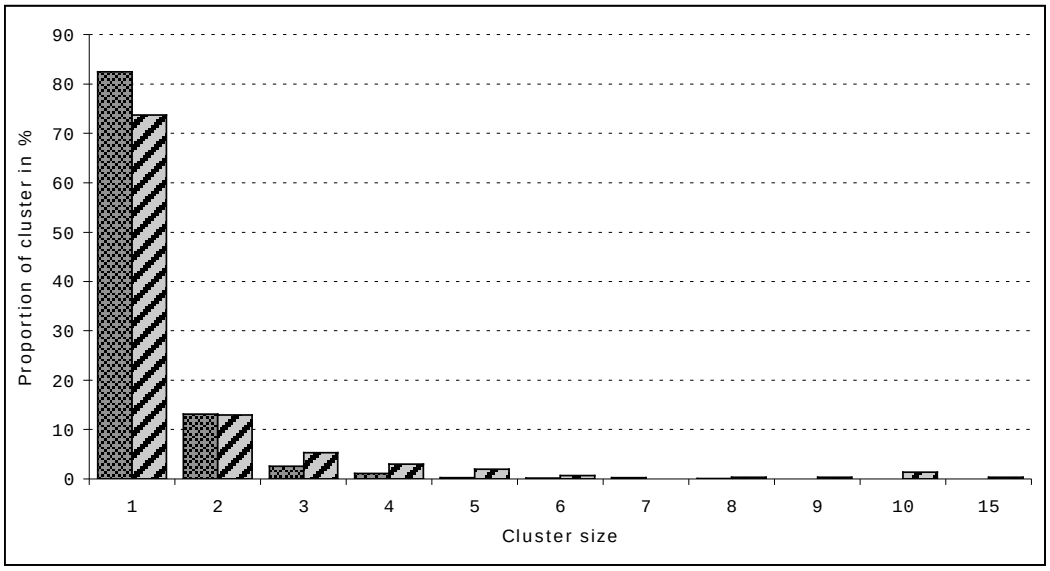


Figure XIX Cluster size comparison between CCB (track 3-15, grey bars) and adjacent waters (striped bars).

In CCB, there significant differences in cluster size between months, with larger clusters observed in January and smaller clusters observed in May (Kruskal Wallis: H=12.753, df=4, P=0,0125, Fig. XX). The slope of the regression line was also significantly different from zero (t=-5.483, P=0.0119) suggesting that cluster size decrease with months.

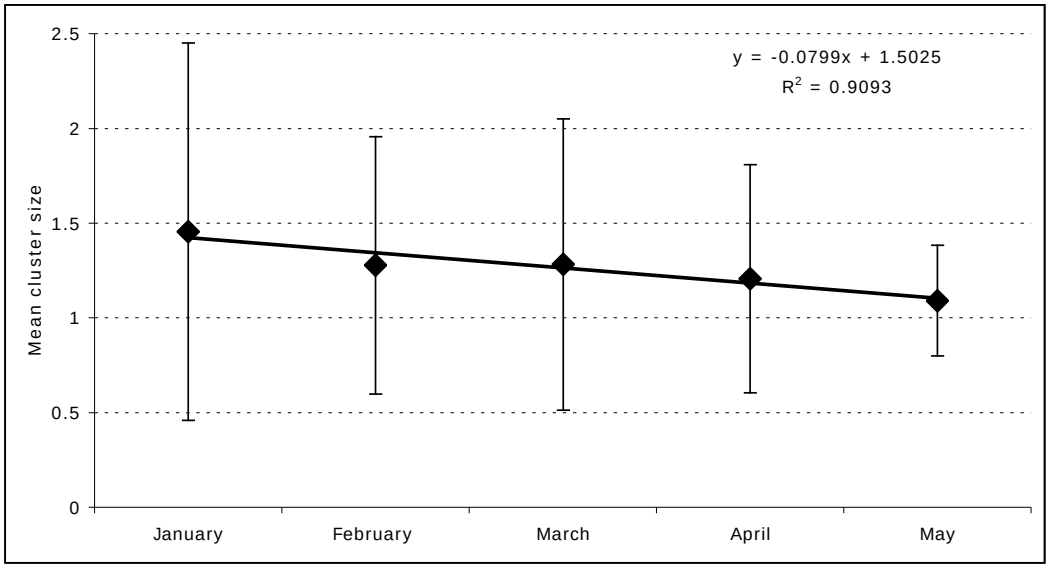


Figure XX **Mean cluster size in relation to months for CCB (track 3-15). The error bars represent ± 1 standard deviation.**

Between 1999 and 2007, 104 SAGs were observed in all areas surveyed (=CCB+adjacent waters) and the mean number of SAGs per year was 11.6 (SD=8.29). There was a large variability in number of SAGs between years, with only one SAG observed in 1999 and 30 in 2007 (Fig. XXI). Despite the fact that few individual right whales were identified in CCB and adjacent waters in 2002 and 2004 (Fig. I), 10 SAGs were observed each year, while very few SAGs were observed in 1999 and 2005 despite a higher number of individuals. However there was no pattern of increase or decrease number of SAGs in relation to years (Fig. XXI).

To investigate the occurrence of SAGs for each month of the project (January to May), we calculated the number of SAG in relation to number of clusters of whales observed. As whales were least abundant in January and May (Fig. VIII), and as no SAG can be observed if no whales are present, the total number of SAG per month is meaningless and only the relative abundance was taken into account.

There were large variations in the relative abundance of SAGs between months, with the highest occurrence of SAGs in January and March (Fig. XXII). However, the daily and yearly variability in SAG occurrence was very large (very large standard deviations), and thus there was no significant difference in the monthly SAG relative occurrence (Kruskal Wallis: H=8.458, df=4, P=0.0762, NS).

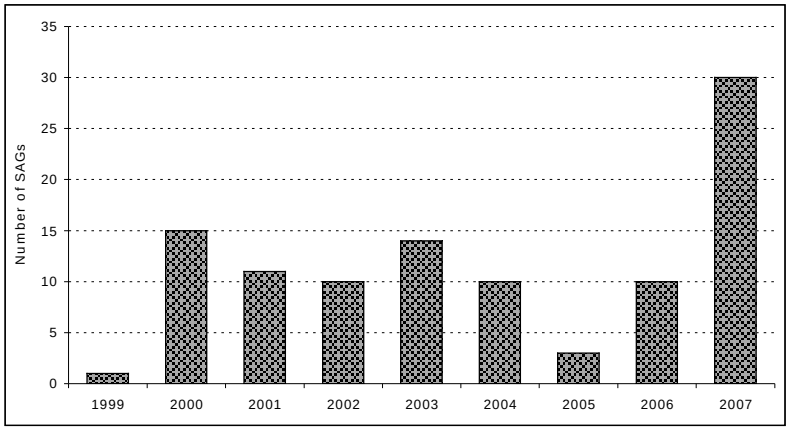


Figure XXI **Number of SAGs observed during the different years of the project for all areas surveyed (=CCB+adjacent waters).**

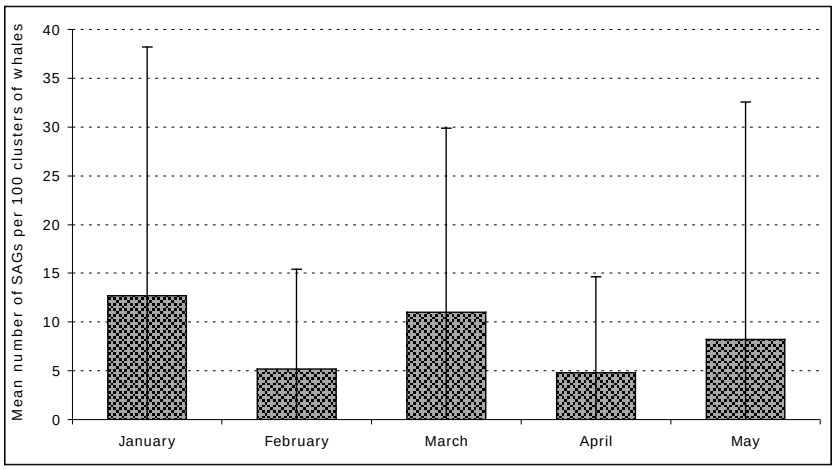


Figure XXII **Proportion of SAGs in relation to total number of clusters observed for every months of the project (1999-2007).**

SAGs were generally small with an average of 3.8 individuals (SD=2.26, median=3, range=2 to 15). However, SAGs were significantly larger in adjacent waters than in CCB ($\bar{x}$=4.8 and $\bar{x}$=3.2 respectively, t =3.830, df=101, P=0.0002). There were no differences in SAG's cluster size amongst months (Kruskal Wallis: H=0.783, df=4, P=0.9406, NS). The identity of a large number of individuals found in SAGs in recent years (2004-2007) has not yet been confirmed by the New England Aquarium and thus no analyses on SAG composition by sex and age class is possible at the time of writing.

1.3.9. Movement patterns and daily displacement of right whales

Knowledge of movement patterns is critical in order to understand how an animal relates to its environment, and data on movements of individual right whales can provide information on spatial use, residency and profitability of foraging. Furthermore, the levels of threat posed by

entanglement in fishing gear and by collision with ships highly depend on the distribution and movements of right whales. Therefore, an understanding of movement patterns over a range of temporal scales is crucial for the conservation of this species, and should be a significant component of management and conservation policies. Using photo-identification data collected systematically during the last ten years, the movement and diffusion rate (Turchin, 1998) of right whales in CCB were calculated using the SOCPROG suite of Matlab programs (Whitehead, 2001). As aerial surveys almost always covered the entire Bay, the probability of re-identifying an individual within CCB was independent on its movement within the Bay, and therefore the standard method of calculating diffusion rates (Turchin, 1998) was appropriate (Whitehead, 2001; Hooker *et al.*, 2002). Standard errors were obtained by jackknifing, omitting consecutive 20-day periods in turn (Efron and Gong, 1983).

Figure XXIII shows the root mean square (rms) displacement of individual right whales within CCB. Although rms displacement is less theoretically justifiable than mean squared displacement, it is more easily interpretable and has been shown to provide meaningful approximations (Whitehead, 2001). The results indicate that on average right whales have a daily displacement of about 9 km, and that this displacement increases slightly during the 10 days or so of their residency within the Bay. Displacement over time lags shorter than one day could not be investigated using the aerial survey data as individuals were very seldom sighted more than once during a single day. Displacement over time lags longer than 20 days were meaningless as individual right whales have a mean residency in the Bay of 10 to 20 days (see section 1.3.7). The result suggests that, during its residency in the Bay, an individual will stay in an area about 12-13 km in diameter, and will not, on average, move extensively throughout the entire Bay. However, these results represent the average movement of individual right whales over a ten-year study period and do not mean that extensive movement covering the entire Bay does not occur at time.

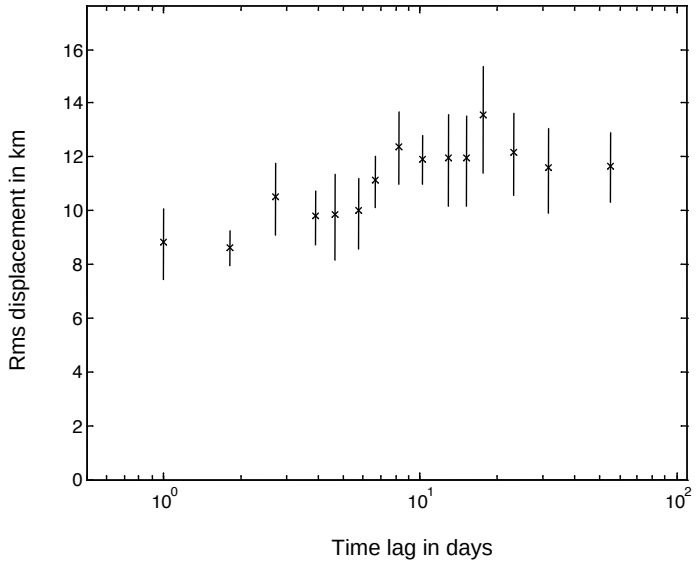


Figure XXIII Root mean square displacement (in km) for right whales within CCB (1998-2007). The maximum time lag of 135 days corresponds to the length of a field season. The error bars represent 1 standard error.

Over time scale of less than a day, movements were investigated by following single individuals for as long as possible, using the focal follow data and collected from the F/V *Ezyduzit*. In 2007, seven individual whales were followed for an average of 7.8 hours each (SD=2.23, range=3.4 to 9.8 hrs). Five individuals were also followed in 2005 and 2006, increasing the sample size to 12 individuals. The results of the small-scale movement patterns for all of these individuals are summarized in Table IX.

Table IX **Summary of small-scale movement patterns for 2005, 2006 and 2007. The straight-line distance represents the net displacement of the individual between the time it was first seen to the time it was last seen. The total distance represents the distance traveled by the individual including all zigzags and back-tracking. The zigzag index is the total distance over the straight-line distance. Numbers between brackets represent standard deviations.**

Date	Straight-line distance km	Total distance in km	Zigzag Index	Speed in km/hr	Time followed in hrs	General behavior
5 April 05	11.3	16.4	1.45	5.5	3.0	Traveling
28 March 06	1.9	7.7	4.04	1.9	4.0	Sagging+apparent feeding
27 April 06	10.9	21.0	1.94	5.3	4.0	Sub-surface feeding
27 April 06	0.6	15.9	27.74	4.5	3.5	Sub-surface feeding
5 May 06	9.1	35.9	3.95	3.9	9.0	Skim feeding
12 March 07	24.5	40.2	1.64	5.2	7.8	Traveling+foraging
23 March 07	3.0	19.4	6.49	3.6	5.4	Sagging+apparent feeding
11 April 07	9.1	21.0	2.30	6.1	3.4	Subsurface feeding
21 April 07	2.8	40.9	14.74	4.3	9.5	Skim feeding
22 April 07	2.3	28.0	12.35	3.2	8.8	Subsurface feeding
25 April 07	2.7	36.9	13.45	4.2	8.8	Skim feeding
26 April 07	9.8	52.4	5.33	5.3	9.8	Skim feeding
3 May 07	2.2	43.4	19.47	4.9	8.8	Skim feeding
Average	**6.9 (6.60)**	**29.2 (13.35)**	**8.8 (8.17)**	**4.5 (1.13)**	**6.6 (2.71)**	

The zigzag index represents an index of how much back-tracking an individual is doing, an index of 1 mean that an individual is traveling in a perfectly straight line, the higher the zigzag index, the more back-tracking an individual is performing. As expected, the lowest zigzag index occurred when whales were traveling (1.45 and 1.64) and the highest when whales were sub-surface or skim feeding. While skim feeding, individual right whales tended to cover large distances (between 35 and 52 km in about 8 to 9 hours), however their net displacement was very small (<10 km) suggesting that they zigzag over a small area. Despite large differences in

net displacement between individuals, the speed for all of these whales was very consistent and was on average 4.5 km/h (similar to the walking speed of human). This means that right whales are mostly moving at the same speed and that the speed is unrelated to behavior. On the other hand, the net displacement (or area used by an individual) was highly related to behavior, and while feeding whales had substantially smaller net displacement than when traveling. The cluster of traveling whales had a net displacement of 11.3 km in just 3 hours, while feeding whales had an average net displacement of 5.1 km over an average of 7 hours.

Root mean square displacements were then calculated for the individuals for which we had detailed small-scale movements patterns and show that the average hourly displacement was about 3 km/hr, 4.6 km for two hours, 5.9 km for three hours, and 7.7 km for 8 hours (Fig. XXIV). These results are consistent with the average daily displacement calculated using all sighting data in CCB from 1998-2007 (see above). Figure XXIV indicates that, already after 6 hours, the net displacement seems to be reaching a plateau at around 8 km. Therefore, although we do not yet have data to calculate root mean square displacement for time lag between 8 and 23 hours, this result suggests that an average net displacement of 9 km over 24 hours is appropriate.

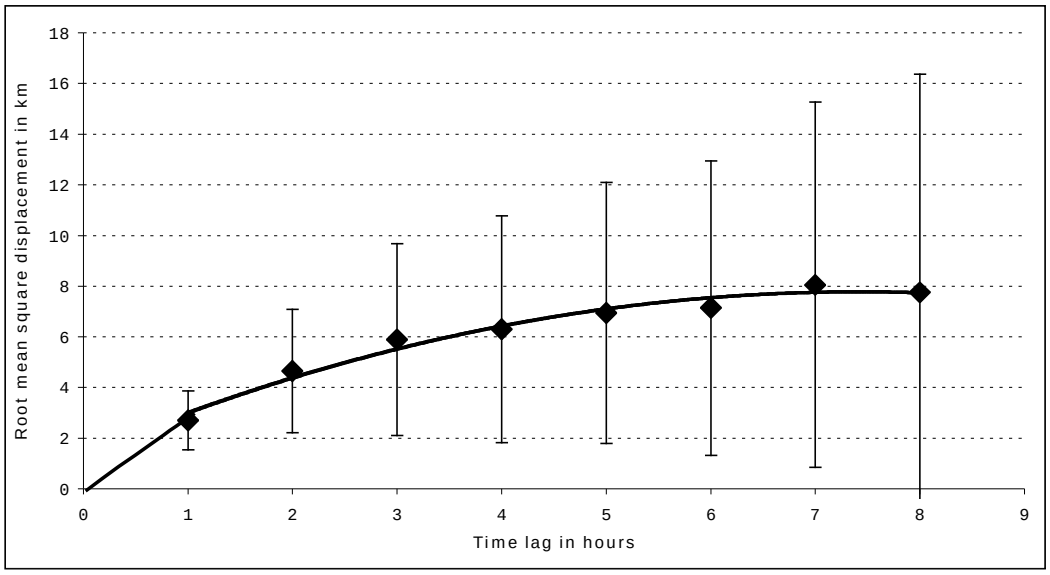


Figure XXIV Root mean square displacement (in km) for right whales within CCB calculated using focal follows data. The error bars represent ±1 standard error.

Figure XXV shows the path of a whale that was followed for 7.8 hours on the 11th of March. Its traveling behavior was interspersed with short bouts of foraging. Figure XXVI shows the details of the same path. During the focal follow time, this whale covered a large distance, almost in a straight line, the small zigzag indicates bouts of foraging. This whale was exiting CCB and in 7.8 hours it had a net displacement of 24.5 km. Figures XXVII and XXVIII show a completely different movement pattern. They show the path of an individual that was skim feeding during the 9.5 hours that it was closely followed. Although this individual covered 41 km during the focal follow time, its net displacement was only 2.8 km. Figure XXVIII suggests the size of the copepod patch the whale must have been feeding upon. As this whale fed in this patch for 9.5 hours, it also suggests that the patch must have been relatively dense.

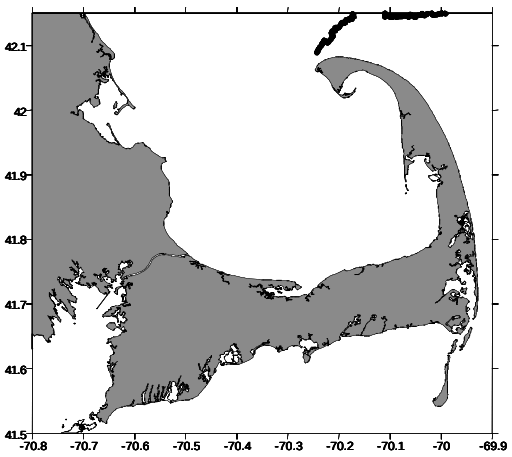


Figure XXV Path of a single right whale followed closely on 12 March 07 while mainly traveling (with bouts of foraging). The missing part of the track represents time when the whale was outside the boundary of the map.

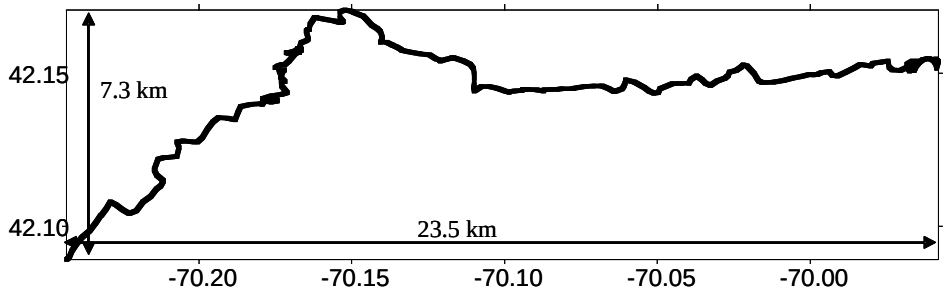


Figure XXVI Details of the small-scale movement pattern of the individual from Figure XXV (12 March 2007, individual was mainly traveling with bouts of foraging).

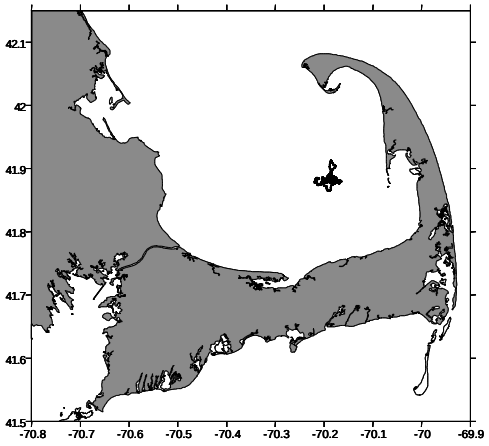


Figure XXVII Path of a single whale followed closely on 21 April 07 while skim feeding.

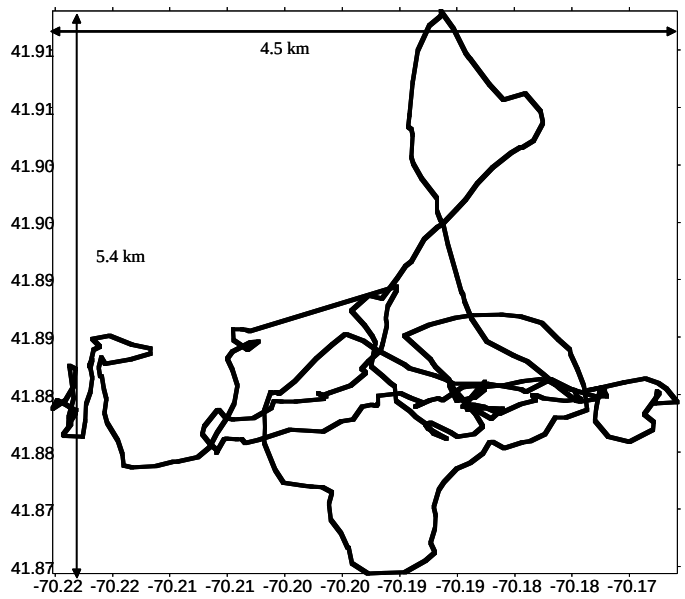


Figure XXVIII Details of the small-scale movement pattern of the individual from Figure XXVII (21 April 2007). This individual was skim feeding. Note the difference in X and Y scale between Figure XXVI and XXVIII.

1.3.10. Acoustic behavior of right whales

Focal follows of individual right whales were conducted during 11 days between 12 March and 3 May 2007, amounting in over 85 hours of recordings (average=7.75 hrs per day, range=5.8 to 9.8 hrs). Behavior and vocalization rates were highly variables between days but as not all the data have been analyzed to date, the following only describes very preliminary observations. In late March-early April, there was a high occurrence of SAGs and we could almost always observed a SAG within two nm of the research vessel. During these five days (March 23, 24, 27 and April 1 and 11), the vocalization rates was very high and periods of silence almost non-existent. On the other hand, a single individual was followed for 7.8 hours on March 12 while traveling and not a single vocalization was recorded during the entire day. During late April-early May, very few SAGs were observed and right whales were observed skim or sub-surface feeding almost continuously. Some of the aggregations of whales were large with over 15 individuals skim feeding off Race Points. However, despite the large number of whales, almost no vocalizations were recorded during these five days (April 21, 22, 25, 26, May 3). These observations suggest that right whales may stay mostly silent when skim feeding, and that most of the vocal activity occur when in social behavior. They also suggest that, when food resources are very high as it occurred during late April-early May in 2007, right whales tend not to engage in social behavior but spend most of their time feeding. However, more data will be needed before any conclusion can be reached.

Preliminary observations suggest little correlation between number of whales and vocalization rates, but high correlation between behavior and vocalization rates. When in SAGs, even when the SAG involves only two to three individuals, screams and gunshots were heard almost

continuously. On the other hand, when exclusively feeding, no calls were usually heard even in the presence of large aggregation of whales.

1.3.11. Monitoring of Entangled Whales

On 12 March 2007, the aerial team conducted a survey over the northern boundary of the Great South Channel in search of entangled right whale #2029. This whale was sighted in this area on 9 March 2007 by the NOAA Twin Otter. This was the first documentation of this entanglement, which runs from the left side of the mouth, across the back and may involve the right flipper. While several right whales were sighted, #2029 was not observed during this day. However, during a survey of Cape Cod Bay on 21 March 2007, #2029 was sighted five miles north of Barnstable Harbor. Photos of the entanglement were obtained and the disentanglement network was notified immediately. A PCCS disentanglement team responded aboard R/V *Ibis* and attempted to attach a telemetry buoy while the survey plane lent aerial support. Due to a moderate sea state and the whale's increasingly evasive behavior, this attempt was unsuccessful. This whale was not observed again during our field season.

With assistance from the New England Aquarium, a previously entangled right whale (known by temporary id number BK01SEUS06) was identified during the analysis of photographed whales on 26 April 2007. This whale was first reported as entangled in the Bay of Fundy in September 2006 and a section of line was removed by members of the disentanglement network on 24 January 2007 (off of North Carolina). At the sighting on 26 April the whale appeared to be gear free, although murky water prevented a clear view of the flippers. Details of the sighting and photographs were passed along to the disentanglement network.

1.3.12. Distribution of Vessel Traffic

The distribution of vessels by type as recorded during aerial surveys during the 2007 season is plotted in Figure 4. One direct whale/vessel interaction was observed on 23 March 2007. This incident involved the fishing trawler *Ann Marie*. The pilots and observers who witnessed the incident described the following:

"The vessel was initially sighted while we were circling on two right whales (11:20am). It was about 1.5 nm to the west, traveling directly east towards the whales. At about 0.75 nm, the vessel changed course to the north, about 20-30 degrees and continued on that course for the duration of the time we were circling above the whales. Shortly after we left the whales (11:24am) the vessel changed course to the south onto a track that came directly at the whales, a course change of more than 90 degrees. At that point we turned to return to the whales and to observe and photograph the vessel. At the time the vessel changed course it was about 0.75 nm north of the whales. The vessel continued its course directly at the location of the whales until it was about two boat lengths from the whales (11:29am). At this point the whales fluked and dove and the vessel slowed to a near stop."

The pilots tried to call the vessel via VHF radio while it was approaching the whales but received no response. This event was reported to DMF who then contacted the Massachusetts Environmental Police and NMFS law enforcement. After investigating the incident and speaking with the captain of the *Ann Marie* it was determined that the captain turned back towards whales while attempting to avoid other whales. He disengaged the engine when he

saw that he was headed towards the whales. He was given information about right whales and reminded of current regulations on approaching whales at this time.

On 12 March 2007, the 2005 calf of 1703 was sighted with a large wound on its right flank. The wound was deemed to be caused by a propeller and was estimated to be about two feet wide and over ten feet long. As the collision resulting in the wound was not witnessed and as no other survey platforms observed this whale during the 2007 season, it is impossible to determine where or when this wound was acquired. The 12 March sighting was the first documentation of this wound. This whale was sighted several times throughout the field season and appeared to be acting normally (Table 5).

On 25 April 2007 a large diesel slick, spanning half a mile, was sighted off of Race Point. The presence of the slick, the location and approximate size was reported to the US Coast Guard by VHF radio. About fifteen right whales were sighted feeding through the edges of the slick.

1.3.13. Notification of Agencies and Management Measures

At the completion of each survey and cruise, the information on the number of right whales and their locations was sent to the coordinator at the SAS office at NOAA Fisheries, Northeast Fisheries Science Center in Woods Hole. Sightings in Cape Cod Bay were reported to the USACE Cape Cod Canal Field Office at the end of each aerial survey. USACE marine traffic controllers transmitted sighting locations to vessel traffic exiting the Canal into the Bay. In order to expedite the distribution of the information to the maritime community, these communications occurred by cell phone at the completion of each survey. During surveys and cruises in Cape Cod Bay, the USACE Field Office was contacted directly by VHF radio or cell phone at the time of a sighting in close proximity to traffic exiting or entering the Cape Cod Canal. A total of 51 emails were sent to the DMF offices in Boston and New Bedford (one email for each aerial survey and habitat sampling cruise in Cape Cod Bay and adjacent waters). Sightings from R/V *Shearwater* were noted, but not plotted, on the emails. The DMF/PCCS surveys are the principal source of right whale sighting information in the northeast region (north of latitude 41° N) for the NOAA Fisheries/SAS program in the months of January through March.

On 25 April, DMF issued an advisory to the maritime community due to the high number of right whales sighted by aerial surveys in close proximity to areas of high vessel traffic off Provincetown (Race Point) and northern Truro. NOAA Fisheries issued a similar advisory on 26 April based on this data. Both advisories recommended that vessels transiting the bay reduce speed to 10 knots, post lookouts, and proceed with caution. Vessel operators were reminded that it is against the law to approach right whales within 500 yards. The advisory was extended on 7 May. DMF lifted the 7 May advisory on 11 May, following the 5 May aerial survey and habitat sampling cruise.

1.3.14. Sightings of Other Species

In addition to right whales, eight other species of cetaceans and two pinniped species were sighted during aerial surveys in 2007 (Table 2). Humpback whales (*Megaptera novaeangliae*, 121 sightings) and fin whales (*Balaenoptera physalus*, 108 sightings) were the most numerous of the large whales sighted in Cape Cod Bay and adjacent waters. In addition, 37 minke

whales (*Balaenoptera acutorostrata*) were sighted. The spatial distribution of the above three species of balaenopterids is plotted in Figure 5a. Fin and humpback whale sightings were largely concentrated toward the northeastern portion of Cape Cod Bay. During the survey of the northern Great South Channel on 12 March, two sperm whales (*Physeter macrocephalus*) and two sei whales (*Balaenoptera borealis*) were sighted. Sei whales have only been sighted once before by the PCCS aerial platform (Brown *et al.* 2002), while sperm whales have never been previously sighted. Of the toothed whales sighted and identified by species, common dolphins (*Delphinus delphis*) were the most common species recorded in Cape Cod Bay (Table 2). A large proportion of toothed whale sightings were recorded as "unidentified dolphin" as the species could not be determined without circling to allow examination of morphological features to facilitate identification. The spatial distribution of toothed whales from aerial surveys is indicated in Figure 5b. Sightings of species other than right whales were also recorded opportunistically during vessel cruises (Table 3).

1.4. Discussion

1.4.1. CCB Right Whale Population: Characteristics, Abundance and Seasonality

In 2007, a much larger number of individual right whales were identified in CCB and adjacent waters than in any of the other nine years of this project, and 45% of the entire right whale population was observed in these waters. However, despite this very large increase in number of right whales visiting CCB in 2007, there was no trend in CCB becoming more and more utilized by right whales over the years. Results of this long-term study show that there is a very large variability in the number of right whales visiting CCB every year. There has been as few as 20 individuals in 2002 and as many as 118 in 2007. Similarly, there is a large variability in the number of individuals observed in the waters just adjacent to CCB, with only one individual in 2004, and as many as 84 in 2007. This yearly variability is unlikely to be due to differences in effort, as effort has stayed relatively constant for the past ten years. This variability is more likely to be due to yearly differences in food resources, but statistical tests will need to be performed to elucidate the spatial and temporal scale of the relationship between zooplankton abundance and right whale abundance. Other factors (unknown to date) are also likely to influence the number of individual right whales coming into the bay every year.

Previous results from this long-term study have suggested that the right whales that visit CCB in winter/early spring is not a random subset of the population but that these individuals have a statistically higher probability to be observed in CCB than in all other areas (Jaquet *et al.* 2006). Similarly, there is a part of the right whale population that has a lower probability to be observed in CCB than in all other areas. It is thus possible to call the individuals that come into CCB a "CCB population". This is consistent with the idea that not all individual right whales are seen in all areas and that individuals show preferences for offshore or inshore areas for example. It is also consistent with Malik *et al.* (1999) who showed that some reproductive females show site fidelity for the Bay of Fundy and that other reproductive females are almost never seen in this area. It is therefore interesting to note that, 27 right whales that had never been identified before in the area since photographic records of right whales began in the bay in 1958; had been observed in CCB and adjacent waters in 2007.

On average, right whales are present into CCB for just over three months every year, and although there is large variability in the time they first enter the Bay, the emerging pattern after the ten years of survey suggests that there is more variability between months than within months. Our results suggest that, on average there are already about three right whales per survey day in January, that this number doubles in February, reaches a peak in March and April with just over 10 individuals on each survey day and drops drastically in early May with only about 1.5 individuals on average on each survey day. This is consistent with the pattern that has been observed during most years of the study: a slow increase in right whale abundance in January and February, a peak during March and April and an "en masse" departure in early May. This result is somewhat puzzling as there are usually more food resources available to right whales in early May then there is in January, but yearly trends in zooplankton abundance still need to be formally quantified. It is possible that, in January, there is little food available for right whales anywhere within their range and thus, that it is still worthwhile for them to forage in CCB even if the number of copepods per m^3 rarely reaches the threshold in January or February (see section 2 of this report for details on feeding threshold). It is also possible that, as monthly copepods abundance shows large yearly variations, right whales come into the Bay early in the season to investigate the state of the resources regardless of the amount of resources. In early May, copepod abundance starts increasing in many areas and large amounts of food resources are usually available for right whales in the Great South Channel. It is therefore possible that right whales leave CCB in early May regardless of the resource present in CCB knowing that better patches could be found elsewhere. However, what seems clear is that the peak in right whale abundance in March and April coincides with the peak of copepod abundance (see section 2 for details).

1.4.2. Right Whales in Adjacent Waters

Right whales are also often observed outside CCB, either just north of the entrance, along the Atlantic side of the Cape (also called "backside") or on the track-lines that are occasionally flown north-east, or east of CCB. However, it is more difficult to characterize these individuals either in term of population or yearly abundance as the effort varies widely among years. Therefore the probability of seeing a particular individual in what we called "adjacent waters" is highly dependent on effort, and not only on the presence or absence of this individual in these waters. Despite this short-coming, the results of this study to date (after ten years of data) strongly suggest that the waters adjacent to Cape Cod Bay are an important area for migrating whales and that a large number of them transit close to CCB to reach different areas. Our results also suggest that most of the whales transiting through the adjacent waters do so in late March, April and early May. To increase our understanding of the utilization of adjacent waters by right whales, it would be interesting in later years to compare the proportion of feeding whales in CCB versus in adjacent waters, to investigate movement patterns, as well as to collect zooplankton samples in these waters.

The yearly abundance of right whales in adjacent waters is more variable (even after correction for effort) than for CCB. It is likely that this high variability is the result of the small strip of waters that is surveyed by plane as part of the bi-weekly survey (a strip of only about five nm wide). It means that if on some days, right whales are transiting only slightly further offshore they would be missed by the survey. Furthermore, it is more difficult to detect transiting individuals by bi-weekly surveys than to detect them in an area where they tend to

stay for about 10 days or so, and thus it is likely that many individuals are missed in adjacent waters.

1.4.3. Demographics

Between 1998 and 2006, 142 calves were born in the SEUS and thus assuming that none died in their first few years of life (which we know to be untrue), 142 juveniles (aged 2 to 8 years) would have been available to come into CCB and adjacent waters in 2007. In 2006, 161 different individuals were observed in CCB and adjacent waters representing 45% of the entire population presumed to be alive (New England Aquarium, unpublished data). Therefore, if all of the 142 calves born between 98 and 2006 were alive, and if juveniles had the same probability than adults to be observed in CCB and adjacent waters in winter/spring 2007, we should have seen 64 juveniles instead of 27. It is most unlikely that all calves born in the last nine years were still alive in winter/spring 2007, however, even if only 50% of them survived, we would still have expected that 32 were observed in the Bay and adjacent waters in 2007. However, first year calves are very difficult to identify and thus juveniles are difficult to match to individuals that were first identified as calves. Therefore a large proportion of the individuals that have not yet been matched to the catalogue is likely to be juveniles, accounting, at least partly, for the deficiency in juveniles seen in recent years. As soon as all the back-logged identification photographs will be matched to the catalogue, it will be possible to re-visit this issue. If the deficiency in juveniles persists after all identifications has been match, it may suggest that a very large proportion of calves die before they reach adulthood, but a formal investigation of survival rate should be performed before conclusions could be reached. However, such a large difference between the number of expected and observed juveniles is unlikely to be explained solely by mortality (as it would mean that 60% of juveniles died before reaching adulthood), and thus this difference may also suggests that juveniles are less likely than adults to visit CCB and adjacent waters.

In 2007, we recorded a lower percentage of mother and calf pairs in CCB and just north of CCB than in 2005 and 2006. However, this percentage was still higher than in 2002, 2003 and 2004, suggesting that there is a high variability in the proportion of mother and calf pairs that come into the area every year. This result suggests that there are no trends in the bay to be more and more attractive to mother and calf pairs or in becoming less and less attractive. On average, about 25% of the entire right whale population is identified in CCB and adjacent waters every year, and about 22% of all the mother calf pairs. Therefore it seems that, although some years a very high proportion (37% in 2006) of the mother and calf pairs are observed in CCB and/or adjacent waters, mother and calf pairs have the same probability to be found in the area than other individuals.

On average, more females than males are observed within CCB (tracks 3-15), individual females have a higher site fidelity than males (meaning they are more likely to come back year after year) and have a significantly longer residency time than males. This is consistent with the work of (Brown *et al.* 2001) who showed strong evidence for geographical segregation by age and sex (in adults). Furthermore, all these observations establish that CCB is a more important habitat for adult females than for adult males. As the death of a female is considered substantially more detrimental to the survival of the species than the death of a male (Fujiwara and Caswell 2001), it means that CCB, as far as management is concerned, is even more important a habitat than previously thought.

1.4.4. Individual Residency of Right Whales in CCB

Analyses of individual residency time have outlined substantial differences between CCB and adjacent waters, with individuals having a significantly longer residency time in CCB (tracks 3-15) than in adjacent waters (tracks 1, 2, 16 and NE, and E tracks). This result suggests that the boundary line for CCB as defined in the Right Whale Consortium photo-identification database (42.0666°N) is also meaningful in terms of right whale distribution and residency and not only in geographic terms. Therefore, it makes sense to analyze data from CCB and adjacent waters separately as trends could be obscured if all data were combined.

During the entire season there is a substantial turn-over of individuals; on average, right whales are present in the Bay for about 94 days, but the individual residency is of only 10-20 days. Furthermore, on average, 49% of the individuals that are observed within CCB on more than one day during a season, leave the Bay and come back at least once during their residency period. These results suggest that individual right whales come into CCB, stay for about 10 days, and after that some of them leave for good and some of them leave and return for another residency in the Bay. Therefore, even during the peak of food resources (most often in March or April, see section 2) not all the "CCB right whale population" is present in the Bay at the same time and none of them stay for the duration of the entire peak. This is most likely due to the per whale profitability of foraging. Obviously, when the number of right whales in CCB increases beyond a certain point, individuals experience diminishing returns (Hooker et al. 2002). Therefore, even if CCB is much richer in terms of copepod abundance in late winter/early spring than most other areas, if too many whales are present, an individual would do better by leaving the bay and feeding in a poorer patch. An Ideal Free Distribution (IFD, Fretwell and Lucas 1970) would be the result of such movements. However, IFD assumes that right whales would have perfect knowledge of the relative availability of food resources, which is most unlikely to be the case. Therefore movements between patches and areas are likely to occur even after an equilibrium has been reached (Hugie and Grand 1998). Right whales enter and leave CCB at variable intervals (average 10-20 days) and therefore potentially fit such a model.

1.4.5. Cluster sizes and occurrence of SAGs

The mean cluster sizes in CCB and adjacent waters for winter-spring1999-2007 (average of 1.3) was very similar to the mean cluster size found by Hamilton (2002) for all critical habitats between 1980 and 2000 (average of 1.4). Furthermore. the percentage of clusters of single individual was the same in both study (81.0% and 81.7%, this study and Hamilton 2002 respectively). This result suggests that, in all areas, most right whales do not associate closely with other individuals. However, Hamilton (2002) found some variability between years, with average cluster size varying from 1.1 to 1.8. Similarly, we found significant differences in cluster size between areas (adjacent waters versus CCB). As right whales in CCB are predominantly feeding, and right whales in adjacent waters predominantly transiting or socializing, this result tends to suggest that right whales may form smaller cluster size when in foraging behavior. Furthermore, our results show a significant decrease in cluster sizes from January to May, with the larger clusters found in January and the smallest in May. In general, we also observed an increase in food resources from January to May, with the least resources in January and the highest in late April early May (see section 2). Therefore this result seems to confirm the above statement suggesting that cluster size is negatively correlated with food

resources. However, more data that could be directly related to behavior would be needed before any firm conclusion could be drawn.

Due to large differences in methodology, it is not possible to compare the occurrence of SAGs using data collected during aerial surveys with the occurrence of SAGs using data collected during vessel-based studies. Unfortunately there are no published data on the occurrence of SAGs determined by aerial survey in any other areas, and thus it is not possible to determine whether the occurrence of SAGs in CCB and adjacent waters is low, high or average in regards to the other critical habitats. Kraus and Hatch (2001) showed that the peak in calving occur between December and February, and, as the gestation length for north Atlantic right whales is likely to be similar to the one for Southern right whales (12-13 months, Best 1994), SAGs leading to conception are expected to occur between November and January. Therefore, one would expect to observe a higher percentage of SAGs per sightings in January than during any other month of the field season. Our results were consistent with this hypothesis as SAGs represented 12.7% of the sightings in January versus 7.3% of the sightings during February-May. However, due to the small sample size and the high variability in the number of SAGs, there were no statistical differences in SAGs occurrence between months.

SAGs observed in CCB and adjacent waters were small and the largest SAG had only 15 individuals in comparison to 40 in the Bay of Fundy (BoF, Parks, 2003). However the mean cluster size for SAGs observed in CCB and adjacent waters was very similar to the mean cluster size of SAGs observed in the BoF (average of 3.8 and 3.7 individuals, this study and Parks 2003 respectively), suggesting that, although very large SAGs occur on occasion, most of them have only 3-4 individuals. There were no differences in SAG's cluster sizes between months, and this result is consistent with Parks (2003) results. These results suggest that SAGs leading to conception do not tend to be larger than SAGs that do not lead to conception. However, other factors could also be responsible for the similarity in SAG's cluster sizes between months, and it is possible that, even during the peak of the reproduction (November-January), only a small proportion of the SAGs leads to conception.

1.4.6. Movement patterns

Independently of their behavior, right whales moved at a mean speed of about 4.5 km/hr. Although the two whales that were followed while traveling were moving at a slightly higher speed (5.5 and 5.2 km/hr), the maximum speed was reached by a subsurface feeding whale (6.1 km/hr) and two skim/subsurface feeding whales were moving at a speed of 5.3 km/hr. Therefore, it seems that traveling whales were not moving any faster than feeding whales. Such a consistent swimming speed that is unrelated to behavior has been observed in other species (i.e. sperm whales, *Physeter macrocephalus*, Whitehead 2003)). This speed presumably represents an optimum largely determined by energetic factors. However, over time periods of a few hours, movement patterns differed substantially between traveling whales and skim/subsurface feeding whales, traveling whales tended to move in a straight line while skim-feeding whales were zigzagging over a small area. A variety of creatures from bacteria to vertebrates have a tendency to turn more often and in tighter semi-circles when in favorable than when in non-favorable patches of food, and this behavior will tend to maintain them within profitable patches (Giraldeau 1996). Such typical movement patterns have also been demonstrated for sperm whales (Whitehead 1996, Jaquet and Whitehead 1999).

Therefore, the extent of the displacement of feeding right whales over a few hours may give us some insight into the size of the copepod patch (Mayo and Marx 1990).

This result shows that depending on their behavior, there are large variations in movement patterns between individual right whales. Furthermore, due to the IFD (see 1.4.4), individual right whales may be traveling in or out of the Bay even during periods of high food resources. Therefore, it is usually impractical to determine the likely movement of a particular whale at a particular time to be able to advise management about how far this particular individual is likely to move, and average displacements are needed to predict likely movements. The results of the root mean squared displacement using the last ten years of data suggested that, over 24 hour, an individual will move on average 9 km from start to finish (straight line distance, so excluding all zigzags), and that this distance does not increase substantially during the next 10-20 days. During their residency period into CCB, individual right whales tend to (on average) stay in an area that is about 13 km in diameter, and thus they tend to use only $1/8^{th}$ of the Bay. Such small displacement is not uncommon amongst coastal species and even smaller net daily movements were found for a pelagic species bottlenose whales (*Hyperoodon ampullatus*) in the Gully (~4-5km/24h, Hooker *et al.* 2002). The high consistency in net daily displacement calculated using two completely different techniques (root-mean squared displacement using data from 1998-2007, and focal follows using data from 2005-2007) gave us great confidence in the validity of our results. Furthermore, these results are very consistent with the finding of (Kenney 1997) who investigated movements of right whales in CCB using a different data set (1979-1996), and different techniques (regression analyses) and showed that individual right whales have a net daily displacement of about 8 km and that this displacement increase of ~500m per day. Therefore, in Kenney's (1997) analyses, after 10 days, an individual whale would have travel ~12.5 km from start to finish.

This net daily displacement in CCB (9 km) is substantially larger than what was found in the Bay of Fundy (~2 km, New England Aquarium and Jaquet, unpublished results) and substantially smaller than what was found in the South East US (~45 km, New England Aquarium and Jaquet, unpublished results). In late summer and early Fall, the Bay of Fundy (BoF) is characterized with very high copepod *Calanus finmarchicus* density forming very dense patches (Baumgartner *et al.* 2003) and thus it makes total sense that individuals have a very small net daily displacement. On the other hand, no feeding takes place in the SEUS, and thus one would expect from the theory that individuals will have much larger daily displacements than in feeding areas. These preliminary results confirm this statement.

1.4.7. Vocal behavior

Very few of the recordings have been analyzed at the time of this writing and thus only very preliminary suggestions are presented here. Furthermore, the sample size of this study is still small and more recordings will need to be collected before the vocal behavior of right whales in Cape Cod Bay can be elucidated.

However, despite these shortcomings, our preliminary data suggest that the vocal behavior of right whales in CCB is similar to that in the BoF (S. Parks, unpublished data). In CCB, no vocalizations were heard for at least eight hours of continuous recording in the presence of four to 10 skim feeding whales, suggesting that, like in BoF, right whales are mainly quiet when feeding. A very large amount of vocalizations (including upcalls, screams and gunshots)

were heard when whales were in a Surface Active Group which is similar to what was observed in other areas, but contradict previous beliefs that a very low proportion of gunshots are ever heard in CCB.

Much more data on vocalization rates in relation to behavior and time of day will need to be collected in the future in all high use areas to be able to obtain an understanding of right whale vocal behavior as well as of the temporal and spatial scale at which they could be detected by "real-time" passive acoustic devices. The determination of the distance at which an average right whale upcall can be heard from a hydrophone in a large spectrum of ambient noise should be one of the first priorities.

1.5. Conclusion

The results of the 2007 field season continue to support the view that CCB is an important habitat for right whales during winter and early spring as up to 45% of the entire right whale population can be observed in this area. Furthermore, this habitat is especially important for adult females and for mother/calf pairs as their residency time in CCB is significantly longer than for males. Although some patterns are beginning to be unraveled thanks to a long-term systematic study, many questions are still unanswered. Adequate protection to right whales can only be provided if sound scientific knowledge of the species exists, and there are many examples all over the world of "conservation measures" that were in fact detrimental to a species as they were implemented before enough knowledge was gathered. As so few right whales are still alive and as the species is so close to extinction, no such mistakes can be made with right whales without tipping the balance the wrong way. It is therefore crucial to try to answer the many remaining questions regarding their distribution, movements (small and large-scales), vocal behavior, reaction to sounds etc, and to thus increase our understanding of the species.

Table 1A. Aerial survey track lines flown over Cape Cod Bay, January to mid-May 2007. For location of track lines, cross-reference by track line number with Figure 1. Cross-leg mileage (between track lines) are not listed for the standard Cape Cod Bay survey (track 1 to 16), as tracks are spaced 1.5 nm apart and the aircraft is turning during at least half of the cross-leg.

Track line Number	Latitude	Longitude West End	Longitude East End	Track line Length (nm)
1	42 06.5	70 37.9	70 10.0	21
2	42 05.0	70 36.3	70 15.8	15
3	42 03.5	70 36.8	70 17.0	15
4	42 02.0	70 35.7	70 07.7	21
5	42 00.5	70 34.2	70 07.0	20
6	41 59.0	70 34.2	70 06.6	21
7	41 57.5	70 34.2	70 06.6	21
8	41 56.0	70 31.6	70 06.3	19
9	41 54.5	70 30.9	70 06.3	18
10	41 53.0	70 30.0	70 06.1	18
11	41 51.5	70 29.5	70 06.1	18
12	41 50.0	70 30.3	70 06.1	18
13	41 48.5	70 30.2	70 06.1	18
14	41 47.0	70 28.3	70 06.1	17
15	41 45.5	70 26.5	70 11.4	11
16*	41 40.0		69 52.0	35
Track line miles in Cape Cod Bay (3-15)				**235**
Track line miles outside Cape Cod Bay (1,2,16)				**71**
Total track line miles, tracks 1-16				**306**

* Track line 16 begins at this point, east of Chatham, continues north parallel to the eastern shore of Cape Cod approximately 3 nautical miles offshore, and joins the eastern end of track line 1 (Fig 1).

Note: Tracks flown on 11 and 22 February 2007:

On these days the usual CCB track-lines were flown (1 to 15), but track 1 was extended from its eastern end (42 06.5, 70 10.0) out to BD buoy, and from the BD buoy, the track followed the Boston shipping lane to the BC buoy.

Table 1B. Aerial survey track lines flown over northern Great South Channel in search of entangled right whale #2029.

Track line Number	Latitude	Longitude West End	Longitude East End	Track line Length (nm)
transit				17
1	41 30.0	69 37.5	69 22.5	14
2	41 33.0	69 37.5	69 22.5	14
3	41 36.0	69 37.5	69 22.0	15
4	41 39.0	69 38.0	69 22.0	15
5	41 42.0	69 38.0	69 22.5	15
6	41 45.0	69 38.0	69 22.5	12
transit				15
Total survey with transits and cross-legs				**117**

Table 1C. Legend of abbreviations and common names for marine mammals listed in report tables

Species Abbreviation	Common Name
Eg	Right Whale
Ba	Minke Whale
Bp	Fin Whale
Bb	Sei Whale
Mn	Humpback Whale
UNLW	Unidentified Large Whale
La	Atlantic White-Sided Dolphin
Dd	Common Dolphin
Gm	Pilot whales
Pp	Harbor Porpoise
UNDO	Unidentified Dolphin/ Porpoise
Hg	Gray Seal
Pv	Harbor Seal
UNSE	Unidentified Seal

Table 2a. Number of marine mammals and other animals seen, hours and track line miles surveyed during aerial surveillance of Cape Cod Bay and adjacent waters during the 2007 season. OS=East of Cape Cod (see note in Table 1A); GSC=Great South Channel. Species abbreviation are explained in Table 1C.

Survey#	Date	Eg Sighted	Eg Photo'd	Ba	Bp	Bb	Mn	Pm	UNLW	La	Dd	Pp	UNDO	UNSE	Pv	Hg	Hours Flown	Distance Flown (nm)	Tracks Completed
PCCS423	24 Jan	0	0	0	7	0	0	0	0	0	0	1	85	4	0	0	3.40	295	1-14,16
PCCS424	27 Jan	0	0	0	3	0	0	0	0	0	0	1	110	0	0	0	1.50	107	1-4,16
PCCS425	07 Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.30	295	1-14,16
PCCS426	10 Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.00	306	1-15,16
PCCS427	11 Feb	3	3	0	2	0	0	0	0	0	0	0	13	1	0	0	5.20	332	1-15, OS
PCCS428	21 Feb	2	2	1	2	0	0	0	0	0	0	0	0	0	0	0	4.30	295	1-14,16
PCCS429	22 Feb	8	8	0	1	0	0	0	0	0	0	1	4	0	0	0	5.50	332	1-15, OS
PCCS430	25 Feb	8	8	0	0	0	0	0	0	0	0	0	1	1	0	0	5.60	306	1-15,16
PCCS431	27 Feb	29	29	1	3	0	0	0	0	0	0	0	0	1	0	0	6.60	295	1-14,16
PCCS432	01 Mar	11	11	0	3	0	0	0	0	0	0	0	0	0	0	0	6.20	306	1-15,16
PCCS433	03 Mar	28	27	0	1	0	0	0	0	0	0	0	0	1	0	0	4.80	224	1-10,16
PCCS434	09 Mar	20	20	0	3	0	0	0	0	0	0	0	8	2	0	0	5.70	224	1-10,16
PCCS435	12 Mar	13	13	1	2	0	2	0	0	0	0	0	0	1	0	0	5.40	260	1-12,16
PCCS435	12 Mar	6	0	0	5	2	5	2	0	0	0	0	105	0	0	0	2.00	117	GSC
PCCS436	21 Mar	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	2.10	28	14-15
PCCS437	23 Mar	24	23	0	4	0	8	0	0	0	0	0	0	1	0	0	6.00	295	1-14,16
PCCS438	24 Mar	38	37	0	3	0	2	0	0	1	0	7	1	1	0	0	6.90	295	1-14,16
PCCS439	26 Mar	7	7	0	3	0	4	0	0	0	40	0	0	0	0	0	3.70	148	1-6,16
PCCS440	31 Mar	18	18	0	6	0	2	0	0	0	0	0	4	2	0	0	7.30	235	3-15
PCCS441	01 Apr	20	20	8	10	0	5	0	1	0	0	2	34	4	0	0	7.00	306	1-15,16
PCCS442	07 Apr	47	37	0	12	0	2	0	0	0	0	0	0	1	0	0	6.90	295	1-14,16
PCCS443	11Apr	38	38	0	5	0	4	0	0	0	8	0	9	2	0	0	8.10	295	1-14,16
PCCS444	21Apr	6	6	3	8	0	0	0	0	0	0	15	7	11	0	0	3.80	306	1-15,16
PCCS445	22Apr	20	20	6	18	0	5	0	0	0	2	7	4	4	0	0	5.80	306	1-15,16

Table 2a. Continued

Survey#	Date	Eg Sighted	Eg Photo'd	Ba	Bp	Bb	Mn	Pm	UNLW	La	Dd	Pp	UNDO	UNSE	Pv	Hg	Hours Flown	Distance Flown (nm)	Tracks Completed
PCCS446	25Apr	39	39	2	9	0	12	0	0	0	4	0	0	1	0	0	6.10	306	1-15,16
PCCS447	26Apr	40	40	13	27	0	3	0	1	0	0	9	9	7	0	0	6.10	295	1-14,16
PCCS448	03May	20	18	1	14	0	14	0	0	0	2	0	24	0	0	0	2.70	71	1-2,16
PCCS449	05May	16	16	8	17	0	25	0	0	0	0	12	13	1	0	0	5.70	306	1-15,16
PCCS450	07May	8	8	8	12	0	13	0	0	0	0	7	1	4	0	0	4.70	306	1-15,16
PCCS451	09May	2	2	1	6	0	0	0	0	0	0	1	0	0	0	0	3.40	209	4-14
PCCS452	13May	2	2	0	6	0	30	0	0	0	32	0	133	0	0	0	3.50	260	1-12,16
PCCS453	14May	0	0	2	4	0	0	0	0	0	0	2	0	2	0	0	4.10	306	1-15,16
Total All Surveys		**479**	**458**	**55**	**196**	**2**	**136**	**2**	**2**	**1**	**88**	**65**	**565**	**52**	**0**	**0**	**157.40**	**8262**	

Table 2b. Number of right whale sightings and photographed, hours and track line miles surveyed during aerial surveillance of Cape Cod Bay (only track 3 to 15). Crossed referenced with Fig. 1 for track numbers.

Survey#	Date	Eg Sighted	Eg Photo'd	Ba	Bp	Bb	Mn	Pm	UNLW	La	Dd	Pp	UNDO	UNSE	Pv	Hg	Hours Flown	Distance Flown (nm)	Tracks Completed
PCCS423	24 Jan	0	0	0	1	0	0	0	0	0	0	1	4	4	0	0	2.30	224	3-14
PCCS424	27 Jan	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0.38	36	3-4
PCCS425	07 Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.41	224	3-14
PCCS426	10 Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.51	235	3-15
PCCS427	11 Feb	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	2.48	235	3-15
PCCS428	21 Feb	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3.11	224	3-14
PCCS429	22 Feb	8	8	0	0	0	0	0	0	0	0	1	0	0	0	0	4.20	235	3-15
PCCS430	25 Feb	8	8	0	0	0	0	0	0	0	0	0	1	1	0	0	4.13	235	3-15
PCCS431	27 Feb	10	10	0	0	0	0	0	0	0	0	0	0	1	0	0	3.90	224	3-14
PCCS432	01 Mar	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	3.85	235	3-15
PCCS433	03 Mar	1	1	0	1	0	0	0	0	0	0	0	0	1	0	0	1.85	153	3-10
PCCS434	09 Mar	10	10	0	0	0	0	0	0	0	0	0	2	2	0	0	3.60	153	3-10
PCCS435	12 Mar	9	9	0	0	0	0	0	0	0	0	0	0	1	0	0	3.18	189	3-12
PCCS436	21 Mar	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0	2.10	28	14-15
PCCS437	23 Mar	24	23	0	0	0	0	0	0	0	0	0	0	1	0	0	4.48	224	3-14
PCCS438	24 Mar	21	21	0	1	0	0	0	0	1	0	7	1	1	0	0	4.30	224	3-14
PCCS439	26 Mar	0	0	0	3	0	1	0	0	0	0	0	0	0	0	0	1.25	77	3-6
PCCS440	31 Mar	18	18	0	6	0	2	0	0	0	0	0	4	2	0	0	7.30	235	3-15
PCCS441	01 Apr	20	20	2	7	0	1	0	0	0	0	1	22	4	0	0	4.80	235	3-15
PCCS442	07 Apr	14	13	0	11	0	1	0	0	0	0	0	0	1	0	0	4.65	224	3-14
PCCS443	11Apr	37	37	0	5	0	4	0	0	0	8	0	1	1	0	0	5.72	224	3-14
PCCS444	21Apr	4	4	2	3	0	0	0	0	0	0	13	7	11	0	0	2.55	235	3-15
PCCS445	22Apr	5	5	1	10	0	2	0	0	0	0	5	1	3	0	0	3.97	235	3-15
PCCS446	25Apr	27	27	0	3	0	0	0	0	0	0	0	0	0	0	0	4.32	235	3-15
PCCS447	26Apr	17	17	4	12	0	3	0	1	0	0	4	0	4	0	0	3.90	224	3-14
PCCS449	05May	10	10	2	9	0	1	0	0	0	0	11	10	0	0	0	4.03	235	3-15
PCCS450	07May	6	6	4	9	0	0	0	0	0	0	5	0	3	0	0	3.37	235	3-15
PCCS451	09May	2	2	1	6	0	0	0	0	0	0	1	0	0	0	0	3.40	209	4-14
PCCS452	13May	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2.23	189	3-12
PCCS453	14May	0	0	2	0	0	0	0	0	0	0	1	0	1	0	0	3.07	235	3-15
Total All Surveys		**265**	**263**	**18**	**87**	**0**	**15**	**0**	**1**	**1**	**8**	**51**	**53**	**43**	**0**	**0**	**103.34**	**6105**	

Table 2c. Number of right whale sightings and photographed, hours and track line miles surveyed during aerial surveillance of Adjacent Waters (tracks 1-2, track 16 and Eastern Tracklines). Crossed referenced with Fig. 1 for track numbers.

Survey#	Date	Eg Sighted	Eg Photo'd	Ba	Bp	Bb	Mn	Pm	UNLW	La	Dd	Pp	UNDO	UNSE	Pv	Hg	Hours Flown	Distance Flown (nm)	Tracks Completed
PCCS423	24 Jan	0	0	0	7	0	0	0	0	0	0	0	81	0	0	0	1.10	71	1-2, 16
PCCS424	27 Jan	0	0	0	3	0	0	0	0	0	0	0	110	0	0	0	1.12	71	1-2, 16
PCCS425	07 Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.99	71	1-2, 16
PCCS426	10 Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.49	71	1-2, 16
PCCS427	11 Feb	3	3	0	2	0	0	0	0	0	0	0	13	0	0	0	2.72	97	1-2,OS
PCCS428	21 Feb	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	1.19	71	1-2, 16
PCCS429	22 Feb	0	0	0	1	0	0	0	0	0	0	0	4	0	0	0	1.30	97	1-2,OS
PCCS430	25 Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.47	71	1-2, 16
PCCS431	27 Feb	19	19	1	3	0	0	0	0	0	0	0	0	0	0	0	2.70	71	1-2, 16
PCCS432	01 Mar	7	7	0	3	0	0	0	0	0	0	0	0	0	0	0	2.35	71	1-2, 16
PCCS433	03 Mar	27	26	0	0	0	0	0	0	0	0	0	0	0	0	0	2.95	71	1-2, 16
PCCS434	09 Mar	10	10	0	3	0	0	0	0	0	0	0	6	0	0	0	2.10	71	1-2, 16
PCCS435	12 Mar	4	4	1	2	0	2	0	0	0	0	0	0	0	0	0	2.22	71	1-2, 16
PCCS435	12 Mar	6	0	0	3	2	5	2	0	0	0	0	105	0	0	0	2.00	117	GSC
PCCS437	23 Mar	0	0	0	4	0	8	0	0	0	0	0	0	0	0	0	1.52	71	1-2, 16
PCCS438	24 Mar	17	16	0	2	0	2	0	0	0	0	0	0	0	0	0	2.60	71	1-2, 16
PCCS439	26 Mar	7	7	0	0	0	3	0	0	0	40	0	0	0	0	0	2.45	71	1-2, 16
PCCS441	01 Apr	0	0	6	3	0	4	0	1	0	0	1	12	0	0	0	2.20	71	1-2, 16
PCCS442	07 Apr	33	24	0	1	0	1	0	0	0	0	0	0	0	0	0	2.25	71	1-2, 16
PCCS443	11Apr	1	1	0	0	0	0	0	0	0	0	0	8	1	0	0	2.38	71	1-2, 16
PCCS444	21Apr	2	2	1	5	0	0	0	0	0	0	2	0	0	0	0	1.25	71	1-2,16
PCCS445	22Apr	15	15	5	8	0	3	0	0	0	0	2	3	1	0	0	1.83	71	1-2,16
PCCS446	25Apr	12	12	2	6	0	12	0	0	0	4	0	0	1	0	0	1.78	71	1-2,16
PCCS447	26Apr	23	23	9	15	0	0	0	0	0	0	5	9	3	0	0	2.20	71	1-2,16
PCCS448	03May	20	18	1	14	0	14	0	0	0	2	0	24	0	0	0	2.70	71	1-2,16
PCCS449	05May	6	6	6	8	0	24	0	0	0	0	1	3	1	0	0	1.67	71	1-2, 16
PCCS450	07May	2	2	4	3	0	13	0	0	0	0	2	1	1	0	0	1.33	71	1-2, 16
PCCS452	13May	0	0	0	6	0	30	0	0	0	32	0	133	0	0	0	1.27	71	1-2, 16
PCCS453	14May	0	0	0	4	0	0	0	0	0	0	1	0	1	0	0	1.03	71	1-2, 16
Total All Surveys		**214**	**195**	**37**	**108**	**2**	**121**	**2**	**1**	**0**	**78**	**14**	**512**	**9**	**0**	**0**	**54.16**	**2157**	

Table 3a. Number of opportunistic marine mammal sightings and hours at sea during vessel-based habitat sampling cruises of Cape Cod Bay, January to mid-May 2007. Species abbreviation are explained in Table 1C.

Cruise	Date 2007	Eg Sighted	Eg Photo'd	Ba	Bp	Bb	Mn	Pm	UNLW	La	Dd	Pp	UNDO	UNSE	Pv	Hg	Hou At S
SW633	14 Jan	0	0	0	3	0	0	0	1	0	15	2	3	0	10	0	7.2
SW634	22 Jan	0	0	0	1	0	0	0	0	0	40	3	67	0	11	2	6.(
SW636	18 Feb	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	6.(
SW637	22 Feb	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	4.3
SW638	27 Feb	6	5	0	0	0	0	0	0	0	0	0	0	1	1	0	8.(
SW639	09 Mar	6	4	0	0	0	0	0	0	0	0	0	0	0	2	1	5.(
SW640	21 Mar	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	6.5
SW641	27 Mar	6	2	0	1	0	2	0	0	0	0	0	3	0	2	0	7.8
SW642	01 Apr	6	6	1	1	0	0	0	0	0	6	0	0	1	4	0	8.3
SW644	10Apr	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1.3
SW645	11Apr	15	10	0	2	0	1	0	0	0	0	0	7	0	1	0	8.(
SW646	21Apr	0	0	2	2	0	0	0	0	0	0	0	0	0	0	1	4.5
SW647	25Apr	5	5	0	0	0	0	0	0	0	0	3	7	0	0	0	7.(
SW648	26Apr	20	7	2	7	0	1	0	0	0	0	36	0	0	6	1	6.3
SW649	02May	1	1	1	2	0	0	0	0	0	0	15	3	0	0	1	7.1
SW650	05 May	5	5	10	5	0	35	0	0	0	0	10	7	0	0	0	6.(
SW651	08May	0	0	0	5	0	2	0	0	0	0	0	0	0	0	0	6.5
IB083	11May	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3.3
SW652	14May	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	6.3
SW653	23May	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.(
Total habitat cruises		**72**	**47**	**17**	**32**	**0**	**41**	**0**	**1**	**0**	**61**	**70**	**97**	**2**	**40**	**8**	**121**

Table 3b. Number of right whale sightings and hours at sea during vessel-based focal follow cruises in Cape Cod Bay, March to mid-May 2007.

Cruise	Date 2007	Eg Sighted	Eg Photo'd	Hours At Sea
EZ-12 Mar	12 Mar	4	2	10.3
EZ-23 Mar	23 Mar	5	4	7.1
EZ-24 Mar	24 Mar	7	7	10.4
EZ-27 Mar	27 Mar	8	8	7.8
EZ-01 Apr	01 Apr	5	5	6.6
EZ-11Apr	11 Apr	20	20	11.1
EZ-21Apr	21Apr	4	4	10.6
EZ-22Apr	22Apr	4	4	10.6
EZ-25Apr	25Apr	16	16	10.5
EZ-26Apr	26Apr	2	2	11.5
EZ-03May	03May	8	8	10.5
Total focal follow cruises		**83**	**80**	**107.0**

Table 4. **Number of survey days, demographic composition and number of right whales identified in all areas (A), in Cape Cod Bay (B) and in adjacent waters (C) from aerial surveys and all cruises (from R/V Shearwater and R/V *Ezyduzit*) in two-week periods from January through late May 2007. The values in this table represent the minimum number of whales, as photo-analysis has not been finalized. The total is lower than the sum of each line as many whales were seen during several 2-week periods. The shaded areas represent 2-week intervals when right whales were observed. Numbers between brackets are the survey days where there was no aerial survey effort (exclusively shipboard effort).**

A) All Areas:

Two week intervals	1-14Jan	15-28Jan	29Jan-11Feb	12-25Feb	26Feb-11Mar	12-25Mar	26Mar-8Apr	9-22Apr	23Apr-6May	7-20May	21-31May	Total
Surveys (all platforms)												
Number of survey days	1(1)	3(1)	3(0)	4(1)	4(0)	4(0)	5(1)	4(1)	5(1)	5(2)	1(1)	39
Number of individuals identified	0	0	2	14	70	46	51	48	53	4	0	161
Demographics												
Male	0	0	0	6	38	8	24	22	20	0	0	74
Female	0	0	2	6	15	12	12	10	11	1	0	36
Unknown Sex	0	0	0	2	17	16	15	16	22	3	0	51
Calf	0	0	0	0	0	0	1	1	2	0	0	3
Juvenile	0	0	0	3	10	11	11	7	13	2	0	27
Adult	0	0	2	11	51	30	33	33	29	1	0	109
Unknown Age	0	0	0	0	9	5	6	7	9	1	0	22

B) Cape Cod Bay track 3 to 15:

Two week intervals	1-14Jan	15-28Jan	29Jan-11Feb	12-25Feb	26Feb-11Mar	12-25Mar	26Mar-8Apr	9-22Apr	23Apr-6May	7-20May	21-31May	Total
Surveys (all platforms)												
Number of survey days	1(1)	3(1)	3(0)	4(1)	4(0)	4(0)	5(1)	4(1)	4(1)	4(1)	1(1)	37
Number of individuals identified	0	0	0	14	20	33	35	35	30	4	0	105
Demographics												
Male	0	0	0	6	9	13	17	16	11	0	0	46
Female	0	0	0	6	7	11	7	7	7	1	0	27
Unknown Sex	0	0	0	2	4	9	11	12	12	3	0	32
Calf	0	0	0	0	0	0	1	1	1	0	0	2
Juvenile	0	0	0	3	3	5	7	6	6	2	0	16
Adult	0	0	0	11	16	24	22	22	19	1	0	73
Unknown Age	0	0	0	0	1	4	5	6	4	1	0	14

C) Adjacent waters (tracks 1-2, track 16 and all eastern tracklines):

Two week intervals	1-14Jan	15-28Jan	29Jan-11Feb	12-25Feb	26Feb-11Mar	12-25Mar	26Mar-8Apr	9-22Apr	23Apr-6May	7-20May	21-31May	Total
Surveys (all platforms)												
Number of survey days	0(0)	2(0)	3(0)	3(0)	4(0)	3(0)	3(0)	3(0)	4(0)	4(1)	0(0)	29
Number of individuals identified	0	0	2	0	52	14	21	13	34	0	0	136
Demographics												
Male	0	0	0	0	31	6	10	6	14	0	0	53
Female	0	0	2	0	8	1	5	3	5	0	0	20
Unknown Sex	0	0	0	0	13	7	6	4	15	0	0	35
Calf	0	0	0	0	0	0	0	0	2	0	0	2
Juvenile	0	0	0	0	7	6	6	1	9	0	0	22
Adult	0	0	2	0	37	7	14	11	17	0	0	70
Unknown Age	0	0	0	0	8	1	1	1	6	0	0	14

Table 5: **Sighting records of identified right whales seen in CCB and adjacent waters, January to mid May 2007. F=female, M=male, J=juvenile, C=calf, U=unknown. "X" denotes the sighting date in CCB (track 3-15), bold "Y" just north of CCB (tracks 1-2) and bold "X" in adjacent waters (track 16 and Eastern track lines). Yellow represents survey not completed due to involvement with an entangled whale. Light blue represents incomplete surveys due to deteriorating weather. Pink represent dates of only shipboard effort. Light green represents incomplete surveys due to too many right whale sightings and not enough day light hours.**

Id #	Sex	Age category	14-Jan-07	22-Jan-07	24-Jan-07	27-Jan-07	7-Feb-07	10-Feb-07	11-Feb-07	18-Feb-07	21-Feb-07	22-Feb-07	25-Feb-07	27-Feb-07	1-Mar-07	3-Mar-07	9-Mar-07	12-Mar-07	21-Mar-07	23-Mar-07	24-Mar-07	26-Mar-07	27-Mar-07	31-Mar-07	1-Apr-07	7-Apr-07	10-Apr-07	11-Apr-07	21-Apr-07	22-Apr-07	25-Apr-07	26-Apr-07	2-May-07	3-May-07	5-May-07	7-May-07	8-May-07	9-May-07	11-May-07	13-May-07	14-May-07	23-May-07	# of days sighted	Time span 1st to last sighting
2310	M	A							X																																1	1
1013	F	A							X																																1	1
1140	F	A							X																				X												2	71
2223	F	A									X	X								X	X		X																		5	35
3308	U	J									X	X	X	X	X														X	X	Y										8	65
2503	F	A										X	X		X																										3	8
1245	F	A										X			X																										2	8
1817	F	A										X		X					X	X											X	X									8	75
Yearling of 1817	U	J										X		X						X											X	X									7	75
1703	F	A										X												X	X		X														4	49
2215	M	A										X		X													X														3	49
1121	M	A											X													Y		X			X	X									5	61
2010	M	A											X	X											X	X			X	X	X		Y								8	68
2140	M	A											X	X				X																							3	16
2530	M	A											X																				Y	X							3	70
3125	M	J											X	X										X	X	X		X													6	46
1968	F	A											X	X				X		X	X										Y	Y									7	61
1706	F	A												X	X																										2	3
2406	M	A												X							X			X	X																	4	34
1419	M	A												X																												1	1
1805	M	A												X																												1	1
1203	M	A												X																												1	1
2681	M	A												X																												1	1
1632	F	A												X		X															Y											3	58

Table 5 continued

Id #	Sex	Age category	14-Jan-07	22-Jan-07	24-Jan-07	27-Jan-07	7-Feb-07	10-Feb-07	11-Feb-07	18-Feb-07	21-Feb-07	22-Feb-07	25-Feb-07	27-Feb-07	1-Mar-07	3-Mar-07	9-Mar-07	12-Mar-07	21-Mar-07	23-Mar-07	24-Mar-07	26-Mar-07	27-Mar-07	31-Mar-07	1-Apr-07	7-Apr-07	10-Apr-07	11-Apr-07	21-Apr-07	22-Apr-07	25-Apr-07	26-Apr-07	2-May-07	3-May-07	5-May-07	7-May-07	8-May-07	9-May-07	11-May-07	13-May-07	14-May-07	23-May-07	# of days sighted	Time span 1st to last sighting
1613	M	A												X										X	X																	3	34
C8YG	U	U												X											X																	2	34
2770	M	A												X																												1	1
2271	M	A												X						X	X	X																				4	28
3532	U	J												X		X																										2	5
2630	M	A												X							X	X																				3	28
BK39	U	U												X		X																										2	5
3292	U	J												X		X					X																					3	26
BOF2006CT02	U	U												X																												1	1
1167	M	A												X																												2	59
1506	M	A												X																												1	1
B2MX	U	U												X		X																										2	5
1712	M	A												X		X																										2	5
1507	M	A												X	Y		X			X	X				X																	6	34
2710	F	A												X																	X	X									3	59
1622	F	A													X	Y		X																							3	12
1970	F	A													X									X																		2	31
3103	F	J													X											Y		X			X	X										5	57
1310	F	A													Y																											1	1
1802	F	A													X		X																									2	9
2904	U	A														X																										1	1
3191	M	U														X															Y											2	54
2135	M	A														X											X															2	40
2940	M	A														X																											1	1
3290	F	J														X																											1	1
1278	F	A														X											X															2	40
2209	M	A														X																											2	62
3040	M	U														X																											1	1
1276	U	A														X																											1	1
3302	U	J														X											X															2	40
1980	M	A														X																											1	1
BK01PCCS2003	U	U														X							X																			2	25

Table 5 continued

Id #	Sex	Age category	14-Jan-07	22-Jan-07	24-Jan-07	27-Jan-07	7-Feb-07	10-Feb-07	11-Feb-07	18-Feb-07	21-Feb-07	22-Feb-07	25-Feb-07	27-Feb-07	1-Mar-07	3-Mar-07	9-Mar-07	12-Mar-07	21-Mar-07	23-Mar-07	24-Mar-07	26-Mar-07	27-Mar-07	31-Mar-07	1-Apr-07	7-Apr-07	10-Apr-07	11-Apr-07	21-Apr-07	22-Apr-07	25-Apr-07	26-Apr-07	2-May-07	3-May-07	5-May-07	7-May-07	8-May-07	9-May-07	11-May-07	13-May-07	14-May-07	23-May-07	# of days sighted	Time span 1st to last sighting
2470	M	A														X																										1	1
1609	M	A														X					X																						2	22
2057	M	A														X																										1	1
1250	M	A														X																										1	1
1283	M	A														X																										1	1
1716	M	A														X										X															2	40
1162	M	A														X																										1	1
1239	M	A															X	X			X																					3	16
3270	U	U															X																									1	1
2340	M	A															X	X												Y	X	Y		Y								6	56
3050	U	U															X										X															2	34
3160	U	J															X				X																					2	16
1056	U	A															X								X																	2	30
1306	M	A															X																									2	56
2753	F	A															X			X	X										X	X										5	48
1280	U	A															X			X	X												X									4	49
1328	M	A															X			X	X				X		X				Y	Y									7	49
1804	M	A															X								X																	2	30
2479	M	A															X										X															2	34
1708	M	A															X	X							X		X															4	34
3414	M	J															X														X			Y								3	58
1408	F	A																X																								1	1
3430	U	J																X																								1	1
2005 calf 1703	U	J																X		X	X					X																4	27
1209	F	A																X								Y		X														3	31
CT01SEUS03	U	U																X							X	X		X	X			X										6	46
3101	F	J																X	X	X				X																		4	20
3190	U	U																X									X					X										3	46
2320	F	A																X	X	X	X																					4	13
SE06CT10	U	U																	X	X	X							X														4	22
1301	F	A																	X		X			X																		3	11
2029	F	A																	X																								1	1

Table 5 continued

Id #	Sex	Age category	14-Jan-07	22-Jan-07	24-Jan-07	27-Jan-07	7-Feb-07	10-Feb-07	11-Feb-07	18-Feb-07	21-Feb-07	22-Feb-07	25-Feb-07	27-Feb-07	1-Mar-07	3-Mar-07	9-Mar-07	12-Mar-07	21-Mar-07	23-Mar-07	24-Mar-07	26-Mar-07	27-Mar-07	31-Mar-07	1-Apr-07	7-Apr-07	10-Apr-07	11-Apr-07	21-Apr-07	22-Apr-07	25-Apr-07	26-Apr-07	2-May-07	3-May-07	5-May-07	7-May-07	8-May-07	9-May-07	11-May-07	13-May-07	14-May-07	23-May-07	# of days sighted	Time span 1st to last sighting
3340	U	J																		X				X																		2	9
1311	M	A																		X	X																					2	2
1821	M	A																		X	X																					2	2
1812	F	A																		X																						1	1
2540	M	A																		X																						1	1
1427	M	A																		X													X									2	42
1146	M	A																		X	X			X																		3	9
1514	M	A																		X	X																					2	2
2006 calf of 2503	U	J																			X			X	Y		X				Y			X	X		X				8	47
2608	M	A																			X																					1	1
BKLH01	U	U																			X																					1	1
3350	U	J																			X			X	X					X												4	30
2005SEUSUnidBK11	U	U																			X										X	Y		Y	Y							5	43
3351	U	J																			X																					1	1
2615	M	A																			X																					1	1
3314	U	J																			X	X			X																	3	9
CTAK01	U	U																				X																				1	1
2440	M	A																				X		X																		2	6
1608	F	A																				X																				1	1
1158	F	A																				X																				1	1
1971	M	A																						X	X																	2	2
2303	M	A																						X							X	X	X									4	27
CT49	U	U																						X							Y											2	25
CALF OF 1425	U	C																						X	X						X	Y		Y								5	33
1425	F	A																						X	X						X	Y		X								5	33
1409	M	A																						X																		1	1
3120	M	J																						X																		1	1
CT42	U	U																						X			X															2	11
1036	M	A																						X																		1	1
2709	M	A																						X	Y		X															3	11
1027	F	A																							X																	1	1
1813	M	A																							X																	1	1

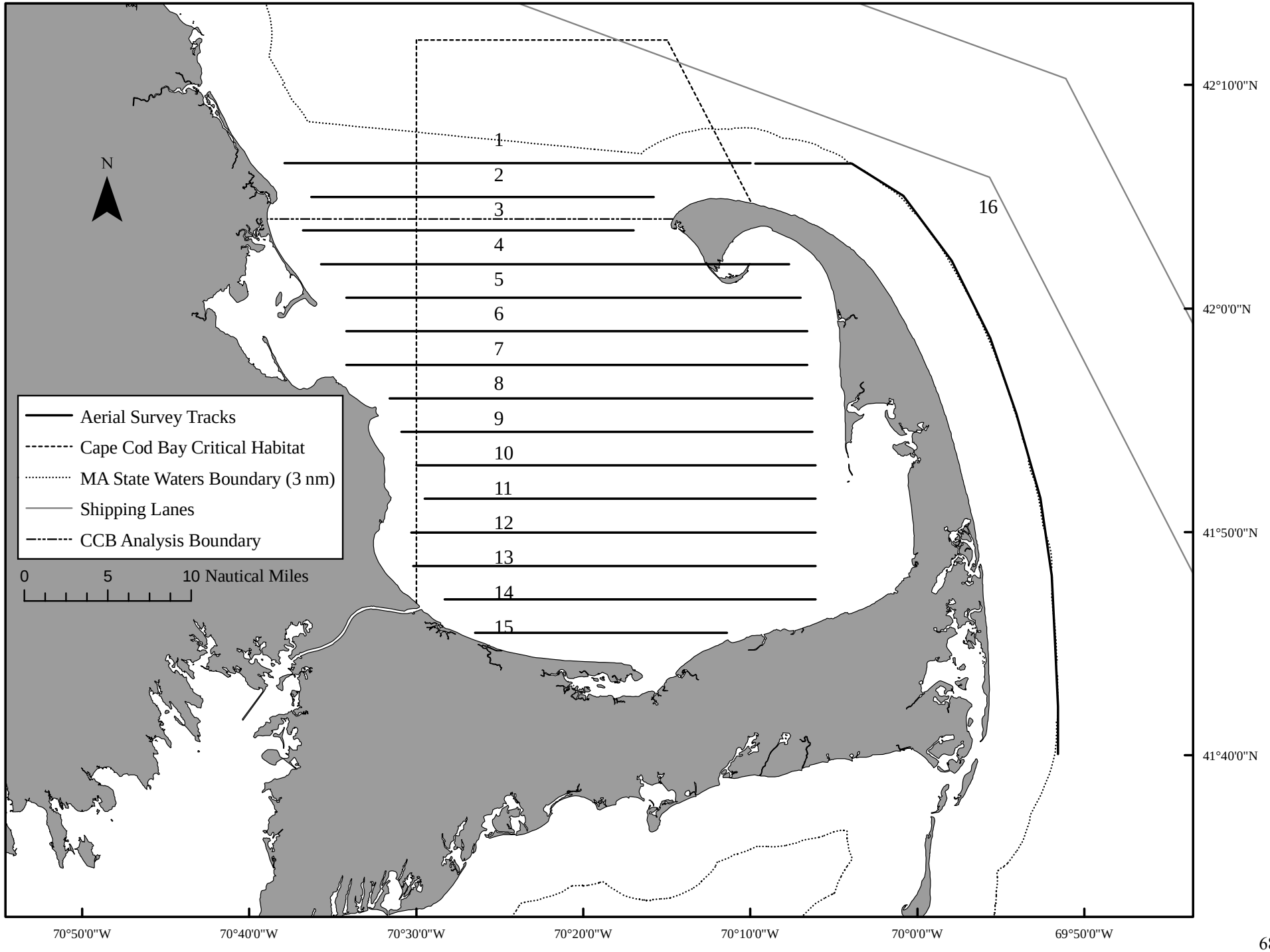
Table 5 continued

Id #	Sex	Age category	14-Jan-07	22-Jan-07	24-Jan-07	27-Jan-07	7-Feb-07	10-Feb-07	11-Feb-07	18-Feb-07	21-Feb-07	22-Feb-07	25-Feb-07	27-Feb-07	1-Mar-07	3-Mar-07	9-Mar-07	12-Mar-07	21-Mar-07	23-Mar-07	24-Mar-07	26-Mar-07	27-Mar-07	31-Mar-07	1-Apr-07	7-Apr-07	10-Apr-07	11-Apr-07	21-Apr-07	22-Apr-07	25-Apr-07	26-Apr-07	2-May-07	3-May-07	5-May-07	7-May-07	8-May-07	9-May-07	11-May-07	13-May-07	14-May-07	23-May-07	# of days sighted	Time span 1st to last sighting
2027	M	A																							Y																	1	1
1042	U	A																							Y		Y															2	5
1403	M	A																							Y						X		Y									3	27
3157	U	J																							Y					X	X			X								4	29
2304	M	A																							Y		X	X	X													4	16
3180	F	J																							X		X				X	X										4	20
CALF OF 2430	U	C																									X	X	X													3	12
2430	F	A																									X	X	X													3	12
1249	M	A																									X															1	1
BK52	U	U																									X															1	1
1131	M	A																									X															1	1
1207	M	A																									X			X			Y									3	23
1612	F	A																									X															1	1
1603	M	A																									X															1	1
1423	U	A																									X															1	1
1048	M	A																									X															1	1
2510	U	A																									X															1	1
1332	M	A																									X															1	1
BKMX01	U	U																										X	X					X								3	15
1204	F	A																										X		X												2	5
1820	M	A																											X	X												2	4
1627	M	A																											X													1	1
2640	U	A																											X	X	X		Y									4	12
2018	M	A																											X													1	1
3405	U	J																												Y	Y											2	2
3540	U	J																												Y												1	1
1122	M	A																												X												1	1
2713	M	A																												X	Y		Y									3	9

Table 5 continued

Id #	Sex	Age category	14-Jan-07	22-Jan-07	24-Jan-07	27-Jan-07	7-Feb-07	10-Feb-07	11-Feb-07	18-Feb-07	21-Feb-07	22-Feb-07	25-Feb-07	27-Feb-07	1-Mar-07	3-Mar-07	9-Mar-07	12-Mar-07	21-Mar-07	23-Mar-07	24-Mar-07	26-Mar-07	27-Mar-07	31-Mar-07	1-Apr-07	7-Apr-07	10-Apr-07	11-Apr-07	21-Apr-07	22-Apr-07	25-Apr-07	26-Apr-07	2-May-07	3-May-07	5-May-07	7-May-07	8-May-07	9-May-07	11-May-07	13-May-07	14-May-07	23-May-07	# of days sighted	Time span 1st to last sighting
1303	F	A																												X	X											2	2
3193	U	U																												X												1	1
BK53	U	U																												X				X	X		X		X			5	19
3291	U	J																													X											1	1
3466	U	J																													X		Y									2	8
3423	M	J																													X											1	1
1032	M	A																													X											1	1
BK01SEUS06	U	U																													X											1	1
1814	F	A																													X											1	1
CALF OF 1814	U	C																													X											1	1
1304	U	A																													X											1	1
1428	M	A																															Y									1	1
2006 calf of 2123	U	J																																Y								1	1

Figure 1a. Cape Cod Bay study area including aerial survey tracks, Critical Habitat and state waters boundaries, shipping lanes, and CCB analysis boundary.



Figures 2a - d. Distribution of right whales in Cape Cod Bay and adjacent waters (sightings from aerial surveys), 15 January – 11 March 2007

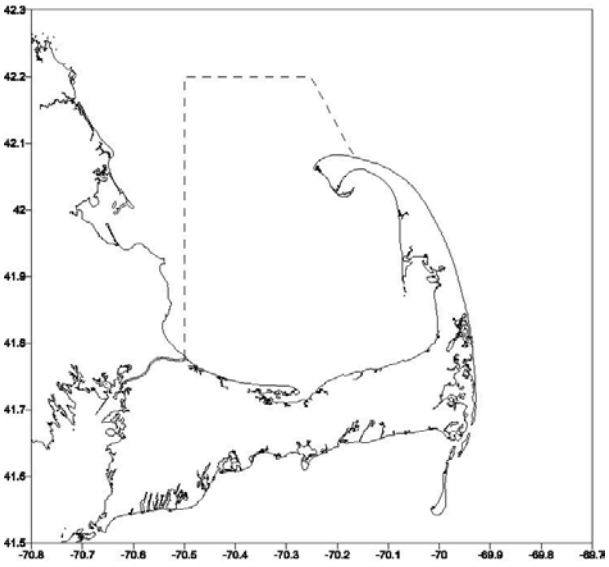


Figure 2a. 15-28 January

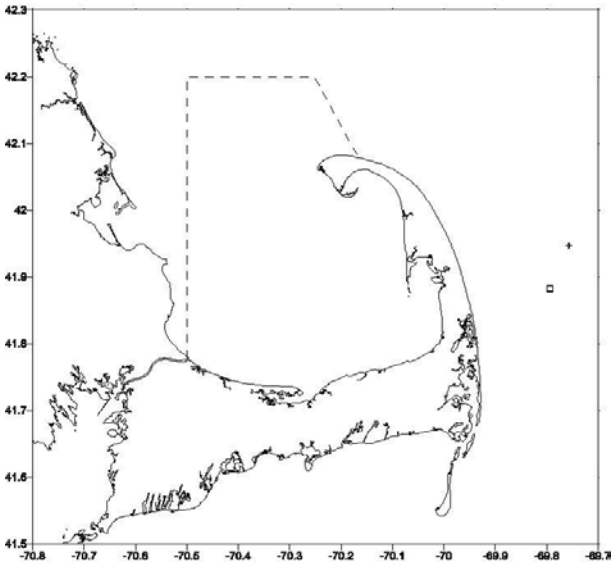


Figure 2b. 29 January- 11 February

------ Cape Cod Bay Critical Habitat
Right Whales: # individuals

+ 1
□ 2
○ 3-7
● 8-10

N

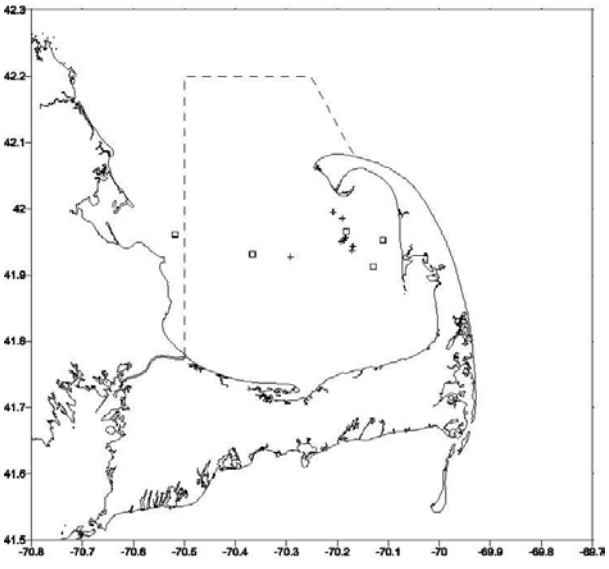


Figure 2c. 12-25 February

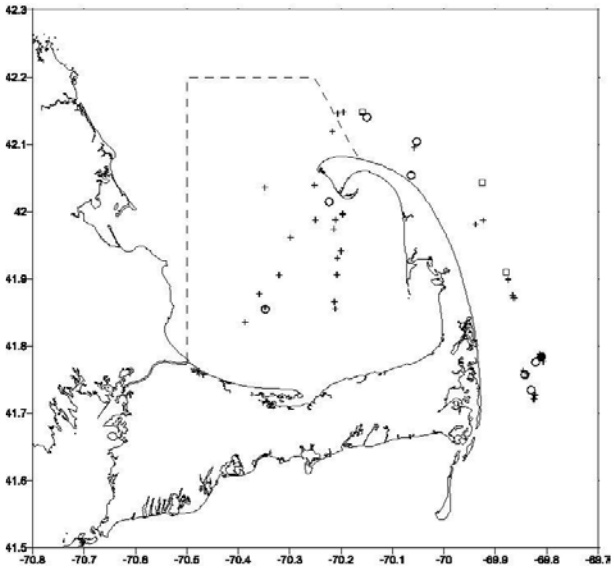


Figure 2e. 26 February – 11 March

Figures 2e – h. Distribution of right whales in Cape Cod Bay and adjacent waters (sightings from aerial surveys), 12 March – 6 May 2007.

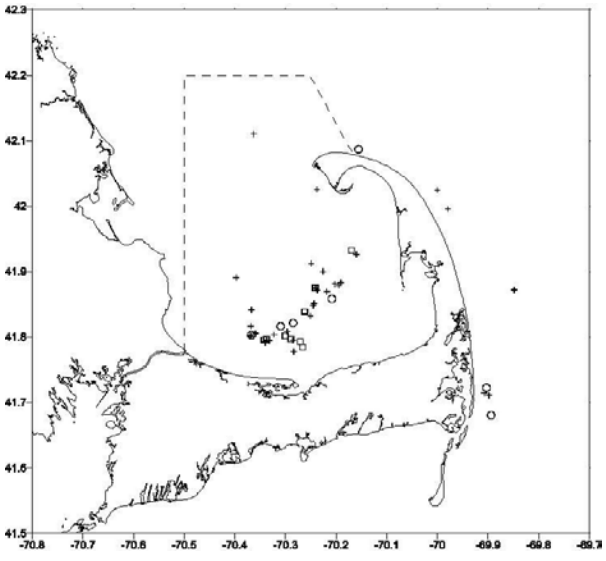


Figure 2e. 12 – 25 March

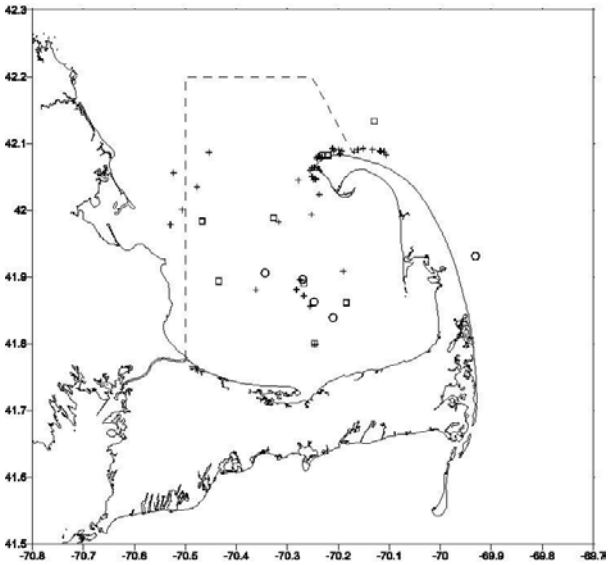


Figure 2f. 26 March – 8 April

------ Cape Cod Bay Critical Habitat
Right Whales: # individuals
+ 1
□ 2
○ 3-7
● 8-10

N

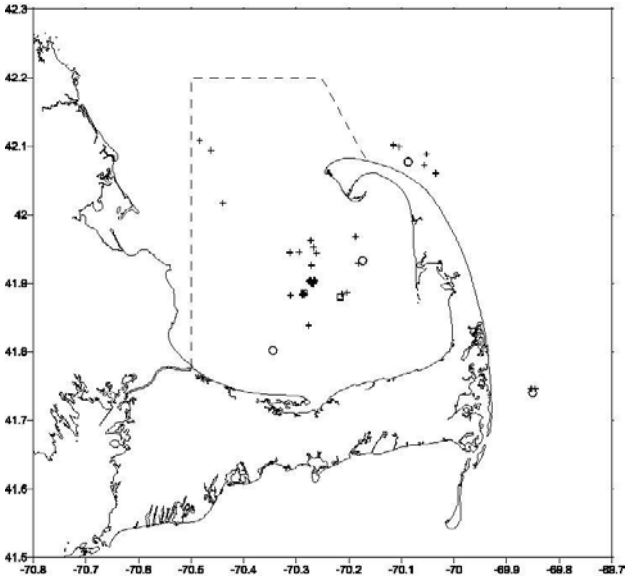


Figure 2g. 9 – 22 April

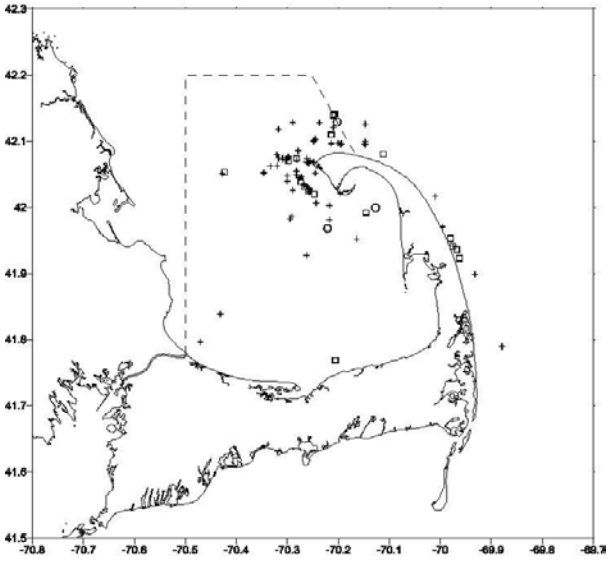


Figure 2h. 23 April – 6 May

Figure 2i . Distribution of right whales in Cape Cod Bay and adjacent waters (sightings from aerial surveys), 7 – 20 May 2007.

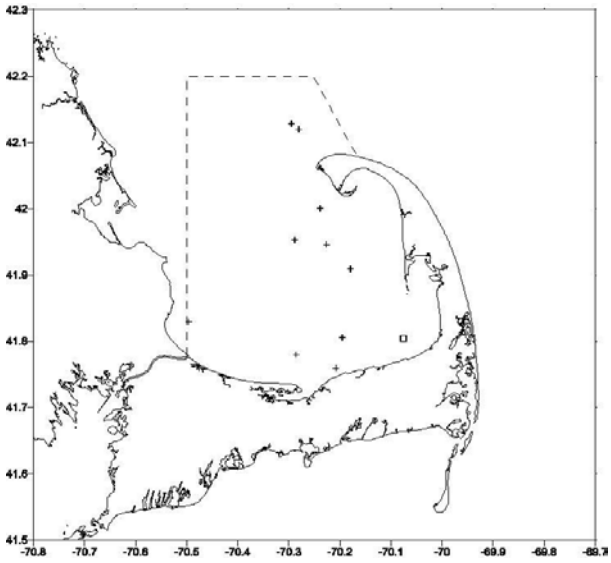


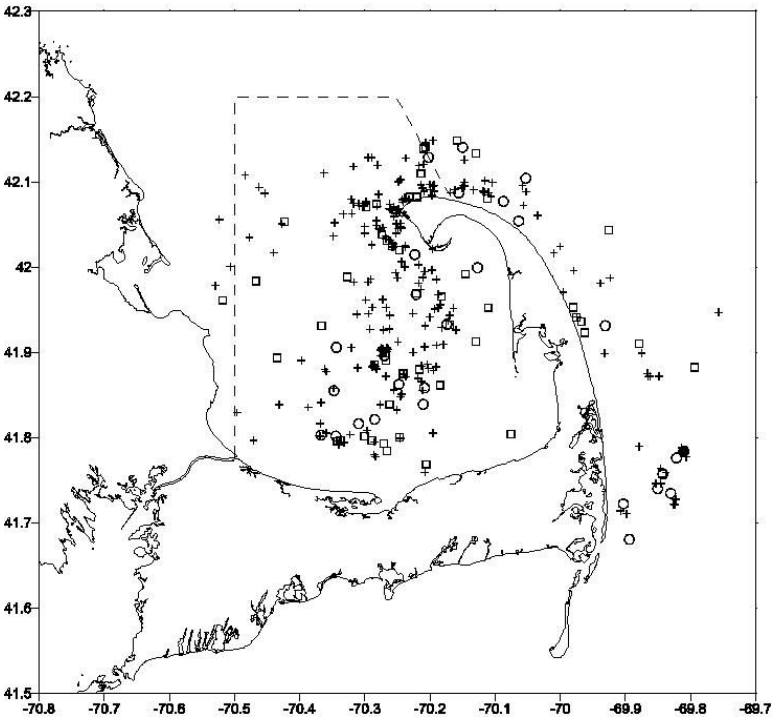
Figure 2i. 7 – 20 May

------ Cape Cod Bay Critical Habitat
Right Whales: # individuals

+ 1
□ 2
○ 3-7
● 8-10

N

Figure 3a – 3b. Distribution of right whales in Cape Cod Bay and adjacent waters (sightings from aerial surveys), 2007 and 2006



------ Cape Cod Bay Critical Habitat
Right Whales: # individuals
+ 1
□ 2
○ 3-7
● 8-10

N

Figure 3a. Right whale distribution in 2007

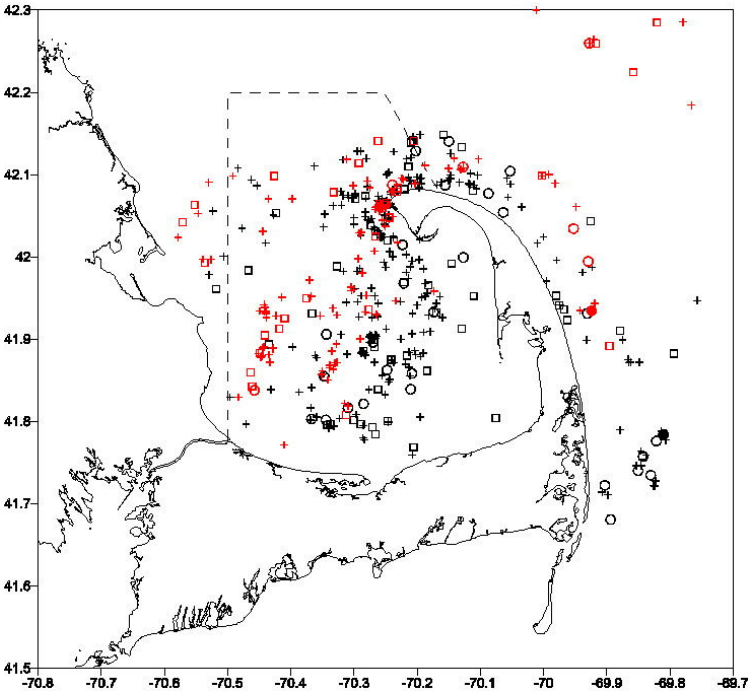
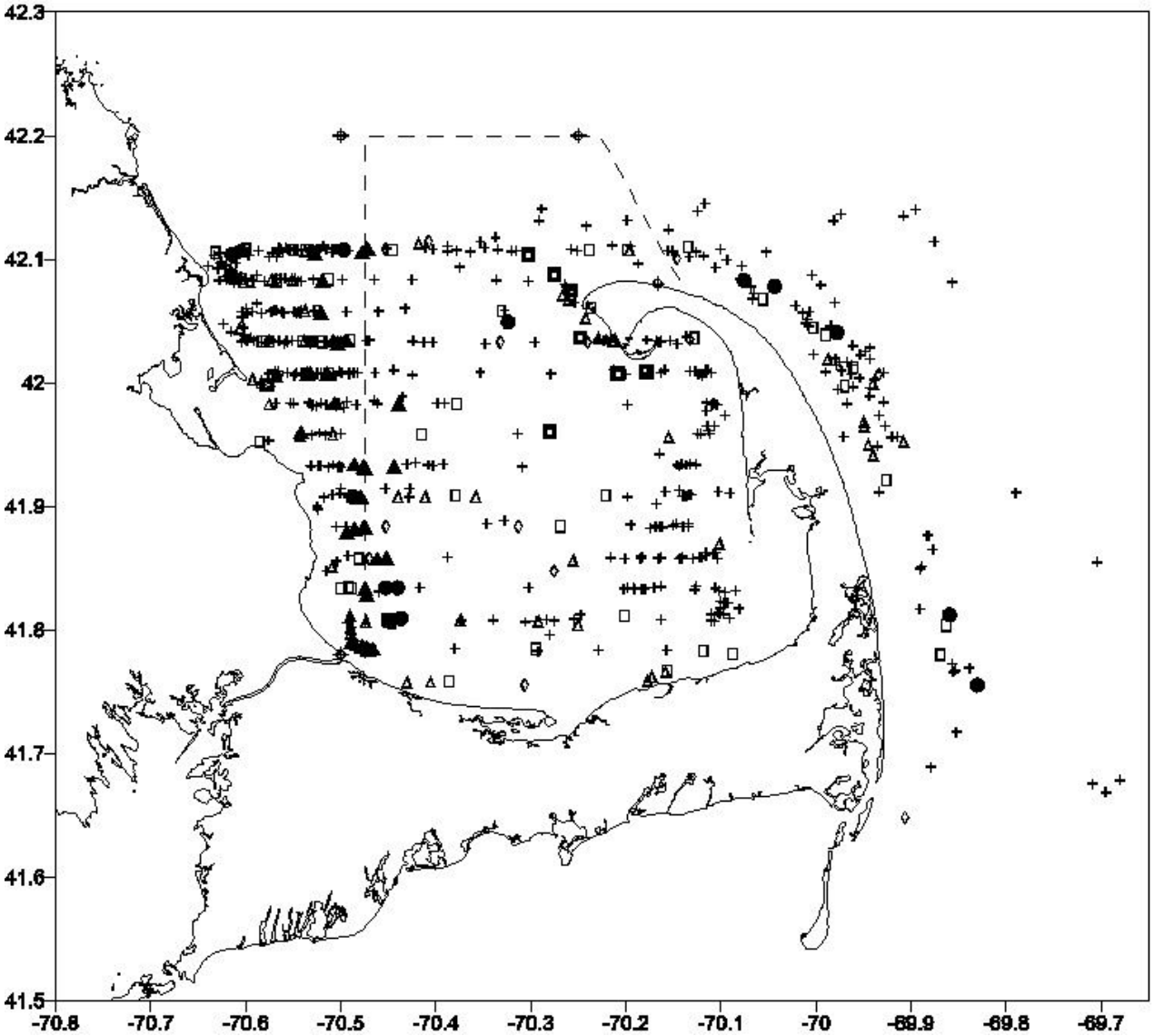


Figure 3b. Right whale distribution in 2006 (shown in red) over 2007 distribution.

Figure 4. Sightings of vessels from aerial surveys of Cape Cod Bay and adjacent waters, 24 January – 14 May.



Vessel Type

◊ Coast Guard

\+ Commercial Fishing Vessel

Δ Recreational Vessel

□ Sport Fishing Vessel

◘ Whale Watch Vessel

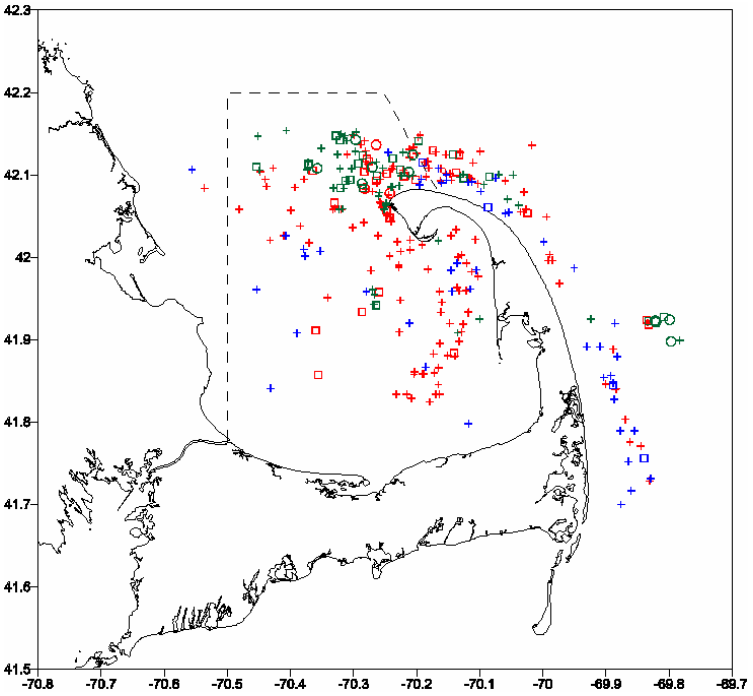
● Large Merchant Vessel

▲ Tug and Barge

------ Cape Cod Bay Critical Habitat

N

Figure 5a. Sightings of balaenopterid whales from aerial surveys of Cape Cod Bay and adjacent waters, 24 January – 14 May 2007.



Fin Whale
# of animals
+ 1
□ 2
○ 3-7

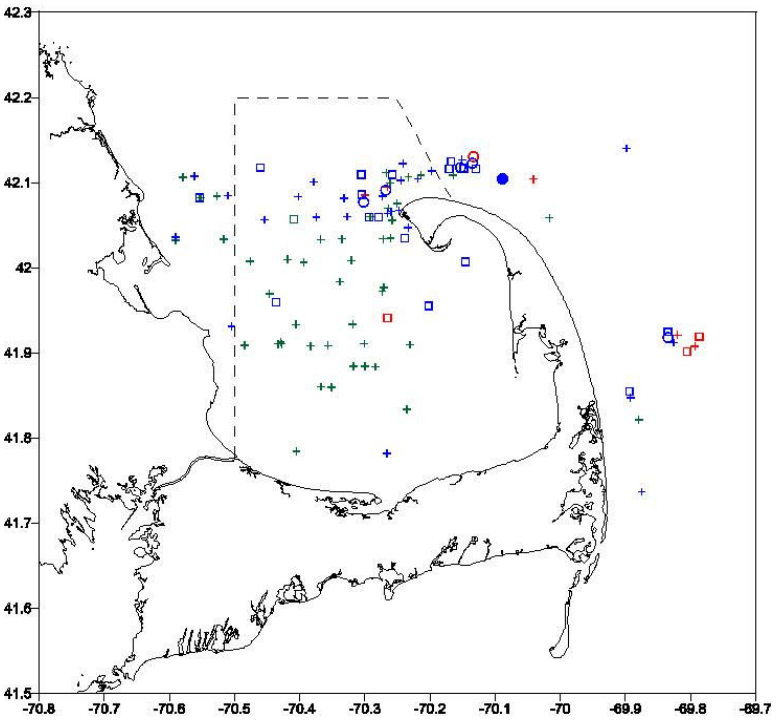
Humpback Whale
# of animals
+ 1
□ 2
○ 3-7

Minke Whale
# of animals
+ 1
□ 2
○ 3-7

------ Cape Cod Bay Critical Habitat

N

Figure 5b. Sighings of toothed whales from aerial surveys of Cape Cod Bay and adjacent waters, 24 January – 14 May 2007.



Common Dolphin
# of animals
+ 1 - 5
□ 6 - 15
○ 16 - 40
● 41 – 100

Harbor Porpoise
# of animals
+ 1 - 5
□ 6 - 15
○ 16 - 40
● 41 – 100

Unidentified Dolphin
# of animals
+ 1 - 5
□ 6 - 15
○ 16 - 40
● 41 – 100

SECTION 2: THE HABITAT OF NORTH ATLANTIC RIGHT WHALES IN CAPE COD BAY: CONDITIONS, ASSESSMENT, AND PREDICTION

2.1 Introduction

During 2007, habitat studies in Cape Cod Bay (CCB) were directed at monitoring the distribution and occurrence of right whales in relation to that of food resources in the federally-designated Right Whale Critical Habitat in an attempt to advance our understanding of the habitat characteristics to which right whales respond. In accordance with the goals set forth in Objective IV by PCCS/DMF (see General Introduction), surveillance and monitoring activities also aimed to provide management agencies with information to assist in their time-critical decision-making (e.g., amendments to seasonal gear restrictions or the issuance of vessel speed restrictions) intended to mitigate human impacts on right whales in the waters of Cape Cod Bay. As in previous years, the reporting strategy of electronically disseminating both immediate post-cruise "Preliminary Assessments" and the more lengthy "Habitat Assessments" to interested managers and colleagues was continued and enhanced in 2007, providing detailed descriptions, analyses and forecasts concerning the interaction of right whales, habitat conditions and potential risks. These habitat assessment instruments have continued to evolve in order to more thoroughly integrate zooplankton distribution and trend data with right whale sightings and to incorporate behavioral observations. To address the need to alert DMF to conditions in Cape Cod Bay deserving their immediate attention, PCCS continued to develop a rapid reporting system, a "Right Whale Risk Alert" document, to support the more time-consuming habitat assessment analyses.

In this Section we review and summarize the foundational relationship between right whales and their prey, the dynamics of the prey fields, and the strategies and movement of whales that result in the predictive parts of the assessment analysis and risk alert warnings. The principal spatial and temporal dynamics that were observed in the Cape Cod Bay habitat in 2007 are also presented, integrating detailed analyses of the zooplankton resource with right whale distributional information.

2.2. Management Process: the Application of Habitat Studies

The investigation of the habitat conditions in Cape Cod Bay during the winter is an integral part of the ongoing surveillance studies used to manage human activities that may threaten right whales. Because right whales respond to the food resource, the distribution of zooplankton may be seen to "control" the distribution and occurrence of the whales within the critical habitat. Therefore, the characteristics of the zooplankton resource may be used to monitor and predict the movement, aggregation, and behavior of the whales, thereby informing management action.

In order to assess the conditions controlling the occurrence of right whales within Cape Cod Bay, the habitat work of the surveillance program has been tasked to explore the

processes that influence the movement of right whales and to develop and disseminate a forecast of movement and occurrence patterns of the whales. The food resource, the "zooplankton", is composed of a rich and complex assemblage of many forms of macroscopic organisms that drift at the surface and within the mid-waters of the Gulf of Maine. Right whales, the largest of all marine filter-feeders, use baleen plates adapted to capture the small prey organisms on which they feed throughout much of the Gulf of Maine. Although the zooplankton concentrations throughout most of the whales' range are far too low to maintain the whales, the zooplankton resource, in response to physical and biological processes, occasionally coalesces into "patches" of exceedingly dense concentrations of organisms rich enough to support the energy needs of right whales. Because of the intimate relationship between zooplankton and right whales, the whales have evolved a variety of forging behaviors that cause them to find and aggregate in the areas where food patches are abundant. It is upon the right whales' forging decisions and movements that their tendency to aggregate depends, and it is in areas where aggregations develop that risk of interaction between industrial activities, particularly fishing and shipping, and the whales may occur. By understanding the fundamental characteristics of the relationship between the zooplankton patches and the movement strategies used by right whales to find food patches, it is possible to predict the distribution patterns of the whales in Cape Cod Bay. If such distribution patterns are predicted with accuracy then human activities can be managed to avoid the co-occurrence of anthropogenic risks and whales.

At the foundation of the forging behavior of right whales are specific decision-making processes that result in the development of aggregations of whales in areas where patches of plankton are rich. Because right whales must optimize their food intake and, further, because they must feed throughout much of the year in order to meet energy requirements, right whales may be seen in two dominant behavioral modes within Cape Cod Bay: feeding and searching. These two modes are based upon simple decision-making processes that dictate very different spatial and temporal distribution patterns. While the searching behavior of the right whale is coarse in spatial scale, critical feeding behaviors appear based upon very small scale decision-making that is responsive to the shape and structure of the food patches. The aggregations of right whales forming over patches of zooplankton are therefore the result of broad-scale searching patterns combined with very small scale feeding behavior, and it is upon this relationship that our predictions, assessments, and alerts to DMF are based.

Using the emerging searching/feeding paradigm, our assessment reporting system is aimed at identifying locations where whales may occur as a reflection of zooplankton patch formation and movement. Weekly habitat cruises characterize the zooplankton resource throughout Cape Cod Bay, providing information (e.g., zooplankton abundance, spatial distribution, and species composition) on which short- to medium-term movement and aggregation of whales may be forecast. Upon analyzing the collected samples, we author and electronically disseminate a "Cape Cod Bay Habitat Assessment" document to inform the DMF and interested agencies of those times and locations where human activities that place whales at risk are likely to occur. For several years these assessment instruments have been developed and refined, contributing significantly to the

management of the Cape Cod Bay Critical Habitat. In response to the need to more rapidly address time-critical management issues (e.g., fisheries or shipping conflicts) our reporting has evolved to include "Preliminary Assessment" and "Right Whale Risk Alert" reports that are delivered to DMF *immediately* following a cruise, the former including a gross evaluation of density and composition of the zooplankton resources, and the latter alerting managers when potentially high-risk conditions involving right whales, their habitat and human activities are observed. These rapid reporting instruments, while slowing the reporting of the detailed habitat assessment analyses, have added an essential component to the documentation and prediction portion of the Cape Cod Bay surveillance program. Nineteen such "Preliminary Assessment" reports and several "Risk Alerts" were distributed in 2007 (compiled in Appendix II), identifying distributions of the food resource that were likely to result in aggregation of right whales in locations where vessel strike risk was particularly high, and resulting in direct action by DMF in several cases. Examples of Risk Alerts, as well as the subsequent DMF formal management Advisories and notification to government agencies and the shipping community, is given in Boxes 1 through 7 at the end of this Section. These exchanges demonstrate the evolving interaction between the PCCS surveillance program and state agencies leading to management action triggered by the habitat assessment studies. Indeed, the Risk Alert reports permit a responsiveness that had not been part of previous assessment strategies, and have added an important component to the reactivity of the program.

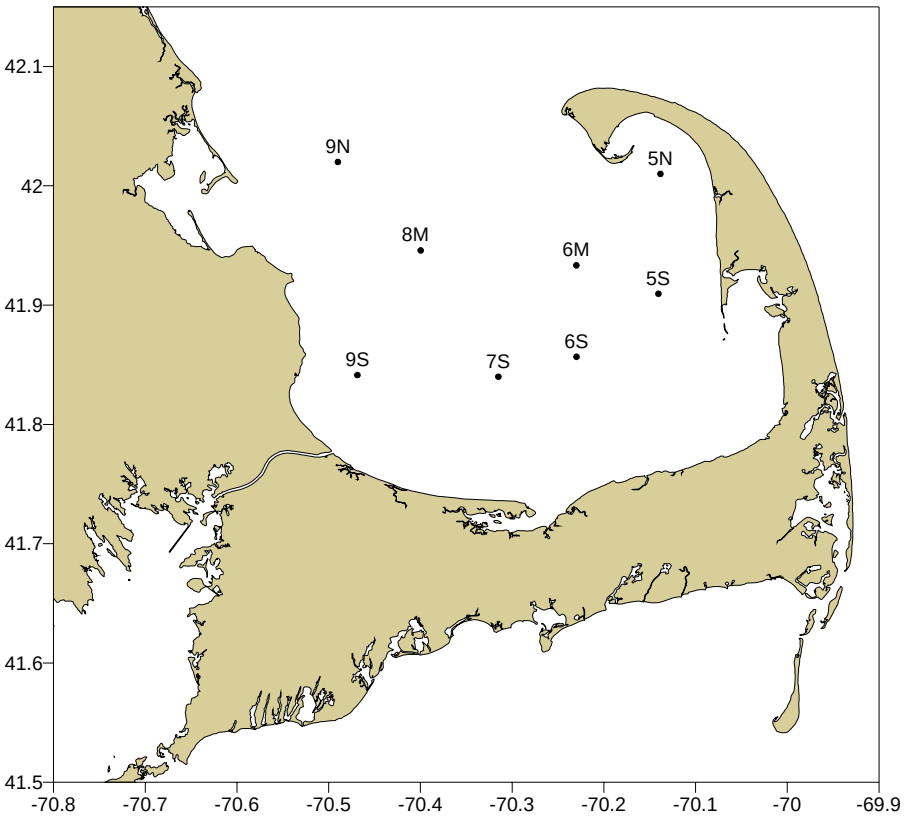
The sentinel role played by habitat assessment and reporting, supported by aircraft survey observations, underpins the capacity of DMF to respond with management action to forecasted changes in whale distribution and occurrence. It is upon the interaction between the assessment teams in the field and the managers charged with protection of right whales within the Critical Habitat that determines the effectiveness of many aspects of the assessment program. Hence, in 2007, we sought to identify those conditions deserving of alert to the DMF. As the exchanges between DMF and PCCS demonstrate, it has proven possible to translate field observations into predictions and those into alerts, which are received by DMF and which the agency reviews, interprets, and, if deemed important, converts into advisories that apply to various user groups. The forecasting of right whale presence and subsequent management action and advisories are unique in the management of threats to whales. Thus, the collection and integration of resource information continues to permit the development of a broad-based program for the management and forecasting of right whale distribution which, when combined with rapid assessment methods, permits the management of human activities in the vicinity of right whales in ways not previously contemplated.

2.3. Methods: Data Collection and General Protocols

Observations reported here are based upon collections and field notes made during Cape Cod Bay habitat surveys and directed sampling on board the R/V *Shearwater* in 2007. R/V *Shearwater* is a 40ft (12m) twin diesel engine research vessel equipped with plankton nets, a vertical plankton pump, and a CTD (Conductivity-Temperature-Depth

profiler) to satisfy the need for a variety of oceanographic and marine biological observations.

The zooplankton samples that form the core of the assessment and risk-alert system were collected at eight fixed ("regular") stations in Cape Cod Bay; the techniques used to sample the surface water have been relatively unchanged since right whale habitat observations started in 1984. The stations, many of which have been sampled by PCCS annually for more than two decades, are located throughout the Bay (see map of station locations below) and provide spatial coverage of the entire system, allowing characterization of zooplankton distribution and dynamics during the season of right whale residency in the Bay. Weather permitting, from 1 January through mid-May the regular stations were visited each week to collect zooplankton from the surface waters and in the upper 19 meters of the water column. Samples were collected using standard 333-micrometer (μm) mesh conical nets fitted with a General Oceanics helical flow meter. At each station, surface sampling involved towing a 30cm-diameter net in a circle horizontally for 5 minutes; towing along a circular path permitted net sampling on the margin of the vessel's wake in relatively undisturbed water.



Map of "regular" sampling stations in Cape Cod Bay that were visited approximately weekly between 1 January and mid-May of 2007.

Water column collections were made by vertically dropping a 60cm-diameter net on-station and retrieving it obliquely through the upper 19 meters of the water column. Because the same surface sampling techniques have been employed every winter since 1984, the collected samples provide an invaluable comparative measure of the conditions that have supported the feeding activities of right whales in Cape Cod Bay for more than two decades.

All field samples were kept in seawater on ice on board the vessel. In the laboratory, the zooplankton samples were preserved in 6-8% formalin and settled overnight in graduated cylinders in order to estimate the "settled volume" as part of the evaluation of the quality of the habitat. Zooplankton were identified and counted within 12-24 hours of collection and the results of the counts were expressed in organisms per cubic meter (organisms/m^3). Estimates of caloric content were made from the zooplankton density estimated from enumeration.

During the 2007 season of right whale residency, the behavior was such that vertical pump sampling was not appropriate for describing the availability of the controlling zooplankton resource. However, the 3-dimensional structure of zooplankton patches upon which whales fed was investigated on several occasions, with collections from pump profiles, both vertical and horizontal, yielding 44 zooplankton samples in addition to the traditional net collections. For vertical pump collections, zooplankton samples were obtained at targeted depths using a pump sampler deployed on a CTD frame, while horizontal samples were collected from the near-surface as the vessel steamed along a horizontal transect. All samples were concentrated by filtering through a 333μm mesh and the volume of the water sampled by the pump system was recorded.

Beyond the regular station sampling regime, directed sampling near feeding right whales was opportunistically conducted to characterize the abundance, species composition, and spatial extent of the zooplankton resource on which the animals were feeding. In particular, a set of sampling transects through a region of active feeding aggregation of whales within the shipping lanes off Provincetown on 26 April and 2 May were used to determine the structure of the zooplankton patches influencing movement of the whales. Such information was then interpreted in order to characterize the durability of the resource and to forecast the likelihood of continued whale aggregation and residency. These analyses were important to the formulation of the assessments and alerts on which appropriate management responses (e.g., delineating zones where vessel speeds should be limited) were made by DMF.

Although the intensive collection of food resource data from Cape Cod Bay did not permit the application of traditional survey methods for systematically sighting whales, all observations of right whales during the cruises were both recorded and, as possible, photographed by observers aboard *Shearwater*. These vessel-based opportunistic whale observations, including identifying photographs and location information, were integrated within the residency, demographic, and life history analyses contained in Section 1, as well as in subsequent plots of whale locations presented in this section of the report. However, because R/V *Shearwater* surveys were non-systematic, such opportunistically

collected data were not included as part of analyses that yield right whale density estimates used in both sections of this report. The photographic information collected from *Shearwater* was processed in much the same fashion as that collected from the aerial surveillance effort, and ultimately all vessel-collected ID information was pooled to permit the development of a more complete view of right whale presence in Cape Cod Bay.

Using a computer data logging system developed by PCCS, information on other species of marine mammals and on a variety of human activities in Cape Cod Bay was collected on all cruises in 2007. In particular, because of the interest of DMF in fixed fishing gear, special note was made of the types and locations of fixed fishing gear which might pose a risk to right whales. After every cruise, DMF was informed via a post-cruise report of the activities of the day and of the observation of fixed fishing gear. Observations of immediately threatening conditions were relayed to DMF via cell phone and in post-cruise Risk Alert reports. In support of the general goal of documenting any conditions that may deserve management action, PCCS maintained a database including extensive observations on fixed fishing gear and vessel locations throughout the 2007 surveillance season.

Post-cruise sample analysis, data processing, and reporting were conducted as rapidly as possible with the goal of delivering to DMF time-critical information that could assist in the management of the Critical Habitat. During each cruise and in the laboratory analyses particular attention was paid to food resource distribution and right whale aggregation when conditions were predicted to place whales at a significant risk of ship strike and entanglement. As in previous years, the more exhaustive Habitat Assessment analyses focused on evaluating in fine detail the quantity and quality of the zooplankton resource in the Bay, both in terms of spatial distribution and temporal dynamics. The regular "Habitat Assessment" reports were typically circulated within several days following the completion of each cruise, while "Preliminary Assessments" were distributed immediately following all cruises. "Right Whale Risk Alert" reports were issued only when surveillance and sampling revealed right whale behaviors and distributions placing them at particularly elevated risk to human activities.

2.4. Results and Discussion

2.4.1. Habitat Cruises and Reporting, 2007

R/V *Shearwater* and R/V *Ibis* completed 18 and 1 habitat sampling cruises, respectively, in the Cape Cod Bay Right Whale Critical Habitat and adjacent waters between 1 January and 23 May 2007. On each *Shearwater* cruise the data logging computer was used to record information on sample collections, right whale observations, information on other marine mammals, and a wide variety of physical, biological and human activity information that form the underpinning of the study. During the 2007 cruises, a total of 345 zooplankton samples were collected and analyzed (Table 1). CTD profiles were recorded on-station during cruises paired with the PCCS Cape Cod Bay Monitoring Program. Such profiles have been archived within the Monitoring Program's database.

During the 2007 season, 47 right whale sightings were photographed opportunistically during habitat sampling cruises for inclusion in the analysis of individual whales. A total of 23 individual right whales were represented in these photographs.

Maps detailing the spatial dynamics of zooplankton distributions throughout the sampling season are compiled in Appendix I, Figures A1 through A17. To review the actual assessment reports circulated after each cruise, the reader is referred to Appendix II where all Habitat Assessment, Preliminary Assessment and Risk Alert documents are reproduced.

2.4.2. Zooplankton Analysis

The conceptual basis for the relationship between habitat assessment and management of right whales is thoroughly detailed in the 2006 report (see Sections 2.4.1 – 2.4.3 of the 2006 report) and summarized briefly in the Introduction to this Section. A simplified version of the concept follows.

In this section of the report we present basic information on the character of the zooplankton resource which was made available to DMF and to the wider list of coordinating agencies and individuals through preliminary and final assessment documents sent via email after analysis of the food resource collected during each cruise. In this section we also evaluate the season as a whole in light of the resource-based paradigm used to predict the occurrence of right whales in Cape Cod Bay. As a foundation for this discussion, we here summarize the resource conditions that influenced right whale distribution and activity during the 2007 season.

2.4.2.1. General Pattern of Zooplankton Productivity

Central to an understanding of the distribution patterns of right whales is a knowledge of the patterns of zooplankton composition and density observed through the period of right whale residency within Cape Cod Bay. The gross average density presented in Figure 1 follows the general pattern that has been observed in previous years. One recurrent theme for 2007 and throughout the years of study is apparent: that of the low density found within the surface layers as compared to mid-water samples. This characteristic is typical of the last five years of habitat studies and is generally characterized by very low surface zooplankton densities seen through much of the January through March period, followed by a distinct enrichment of the surface layers usually occurring by mid April. Exceptions to that pattern seen in Figure 1 (surface) are those samples from 2004 when two dramatic peaks in total surface zooplankton density appeared between the 60th and 90th Julian days (middle- to late-March, 2004). The surface observations are contrasted in Figure 1 with those collected from the water column during the last five years. As with surface samples, a general increase in zooplankton density is seen in the water column as the season progresses into spring, although at any date within a year the zooplankton density is generally significantly higher within the water column. While there are particular exceptions to the pattern of zooplankton density in the water column,

most notably again in 2004 when sharp very high spikes in density were observed, broadly 2007 appeared similar to previous years. Taken together, the surface and water column zooplankton resources increase as the season progresses, broadly fitting with the observed entry of right whales into Cape Cod Bay.

An important management consequence of the seasonal pattern of zooplankton density should be noted. Because the feeding activity of whales appears strictly controlled by the density of zooplankton in Cape Cod Bay, it stands to reason that early arriving whales, those entering the Bay between January and mid-March, generally encounter higher concentrations of zooplankton in the water column. Previous studies supported by DMF have demonstrated that water column concentrations of zooplankton often form bottom layers of high zooplankton density that probably elicit active bottom feeding. The pattern of zooplankton enrichment during the season suggests that whales that enter the Bay in the latter part of the winter are more likely to encounter high concentrations of zooplankton in the upper water column. Conversely, those whales that enter the Bay in the early- to mid-winter are likely to be feeding at depth, possibly along the bottom. These observations suggest that in Cape Cod Bay the time when feeding at the bottom or in the near bottom portion of the water column, when entanglement in floating ground lines would be the most threatening, would likely happen in the first three months of the winter.

2.4.2.2. General Pattern of Zooplankton Species Composition and Cycles

Another feature of the gross density plots in Figure 1 is elevated zooplankton concentrations regularly appearing both in the surface and mid-water environments during the very early winter of many years, including 2007. These early winter resources are likely a reflection of the tail end of an annual productivity cycle of late summer and fall species of copepods. This early winter copepod productivity is an example of the importance of the value of developing an understanding of the species composition of the food resource of the right whales in Cape Cod Bay.

As previously reported, three genera of copepods appear to have the greatest influence on occurrence and behavior of whales and Cape Cod Bay: *Centropages* spp., *Pseudocalanus* spp. and *Calanus finmarchicus;* this assertion is again supported by the 2007 observations. In Figure 2 the three panels show the mean surface densities recorded from individual cruises for the three controlling copepod genera. Although each year has its own characteristics, it is apparent that 2007, shown in these panels as red triangles, broadly follows the pattern reported in past years. As noted previously, right whales entering Cape Cod Bay appear dependent for foraging success upon the cycling of the three genera. *Centropages* plays the role of the fall and early winter dominant taxon, and is responsible for the early winter zooplankton productivity noted in Figure 1, while *Pseudocalanus* is relatively ubiquitous with no strict peak. The *Pseudocalanus* resource however fills in between the early winter *Centropages* and the peaking of the early spring *Calanus*. While all three genera appear to release feeding behavior in right whales, it is clear that the three taxa of copepods exhibit seasonal abundance patterns that together

spread out the occurrence of right whales over the entire winter and controls their pattern of distribution within the Bay.

Density information for the three genera found in the water column is presented in Figure 3 and shows very similar patterns to those found in the surface. Regular oblique net sampling was instituted at every station starting in 2003 hence the data presented cover only the last five years. Nonetheless, differences between the two sets of panels in Figures 2 and 3 generally demonstrate higher concentration within the water column, as previously noted. The information from the water column is also suggestive that there is a peak in *Pseudocalanus* around the middle of March.

Figures 4 and 5 summarize and compare the patterns of enrichment for the three principal copepod genera. The trend lines compare the 1999 through 2006 data with those for 2007, suggesting very broadly that the same patterns are found each year of the study. The only potentially significant difference between 2007 surface collections and those collected in the preceding eight years of aggregated data appears in the trends of *Pseudocalanus,* with the latter showing the hint of a resource peak that fills in between enrichment by a *Centropages* and *Calanus.* Notwithstanding the information in *Pseudocalanus,* the broad pattern of 2007 appears relatively similar to the pattern of enrichment since 1999 in surface waters. Water column samples shown in Figure 5 again show very similar patterns of enrichment and decline for the taxa at the shoulders of the season while *Pseudocalanus* generally shows a peak around Julian day 80 (in mid- to late-March).

The dependency of right whales upon the overlapping cycles of three genera of Gulf of Maine copepods suggests that a poor cohort of any one of the three could substantially reduce the value of Cape Cod Bay to forging right whales. Because the highest concentrations of whales are found at the end of the *Pseudocalanus* peak and throughout the period of *Calanus* enrichment, our data suggest that right whales would be particularly sensitive to changes in the productivity of those two genera. In 2007 the stock of the three genera in the water column appears relatively similar the aggregated trend of the previous four years with the exception that higher concentrations during May of both *Centropages* and *Pseudocalanus* appear in 2007.

Interestingly, when the trends in resource density for each year are taken alone, (Figures 6 and 7), the *Pseudocalanus* mid-winter fill-in that appears to be important to the support of early entering right whales shows two distinct patterns implied in previous reports: 1) a peak in resource (as in 2004 and 2007), and 2) a low and relatively flat trend (as in 2005 and 2006). These differences in pattern likely control the appearance of right whales in the Bay and influence the degree of early entry and residency in Cape Cod Bay.

Taken as a whole the results of our review of the richness of the 2007 food resources in Cape Cod Bay confirm the previous stated view that right whale movement and aggregation and Cape Cod Bay is dependent upon the overlapping enrichment and impoverishment cycles of three different genera that dominate the Bay system during the winter. Doubtless the predictability of the seasonal cycles of zooplankton enrichment in

the Bay is an important contributor to the predictability of the occurrence of right whales; for the right whales, roaming a largely impoverished environment, such predictability is an important support for optimizing foraging strategies.

2.4.2.3. The Zooplankton Resource and the Occurrence of Right Whales

When the density index for sightings of right whales (see Section 1 of this report) are superimposed upon the densities of the three different taxa both at the surface and in the mid-waters (Figure 8) it is apparent that the late-season *Calanus* enrichment may, as it is believed to in other habitats, play a central role in the influx of more stable aggregations of right whales during the late winter and early spring. Interestingly, the greatest density of right whales enters Cape Cod Bay during most years at the time of the peak enrichment by *Pseudocalanus*. This time in the cycles of Cape Cod Bay, as mentioned above, precedes the increase in *Calanus* that will eventually dominate Cape Cod Bay's second trophic level productivity during the early- to mid-spring.

A recurring theme displayed in Figure 8, seen in 2007 but repeated many years in the past, is the unexpected departure of right whales (shown in the sharp decline of the relative density index) at a time when zooplankton resources in the form of *Calanus* are relatively high. In the past we have ascribed this pattern, which seems to be a feature of the end of the right whales season and Cape Cod Bay, to a "competition" between habitats. As detailed in the 2006 report to DMF, it is probably that the departure of whales during a period when their primary food source is higher than when the whales entered the Bay a month or more before is due to attractions not measurable in the limited confines of Cape Cod Bay. The only clear explanation for this counterintuitive event in an environment that would otherwise generally support right whales forging is that other habitats have become super-enriched during early-to mid-May and that, queuing on the changes in the season, associated memories, or some undocumented far-field sense, the whales move to offshore areas that seasonally and predictably increase in resource value late in the Cape Cod Bay season. Notwithstanding this explanation, it remains a mystery as to why whales that are so faithful to our resource-driven paradigm will depart the Bay when their principal food resource, *Calanus*, is in relatively high concentrations within the Bay. The importance of determining – and thereby developing the capability to predict – the departure of whales is important in our support of the DMF management program because the end of right whales season in the Bay marks the time when the risk of entanglement drops dramatically but could increase if whales remained to feed on an ample resource that may be found through May and June.

Comparing the right whale density index with total zooplankton density at the surface (Figure 9) and in the water column (Figure 10), the patterns of whale sightings which in the previous four years had well approximated the rise and fall in the bay- wide mean zooplankton concentrations, in 2007 demonstrated minimal matching of trends. The dramatic rise and fall in right whale sightings reported in Section 1 of this report is in no way reflective of either the mean surface or water column zooplankton data. While the fitted curves shown in Figure 8 vaguely follow the scatter displayed therein, the individual data points for 2007 show remarkable inconsistency. Furthermore, the

unexpected departure of whales with no similar drop in food resource mentioned above is apparent in both surface (Figure 9) and water column data (Figure 10); the other year that showed a similar pattern, when mean zooplankton was high and whales departed, was 2004.

A summation of the zooplankton density quadrant reports presented in the individual cruise assessment forms is found in Figure 11. These quadrant views of Cape Cod Bay demonstrate several previously mentioned aspects of the zooplankton resource that control the right whales in the Bay. Generally, in 2007 the northwest quadrant was more impoverished than the eastern quadrants of the Bay, supporting the general pattern of resource distribution and the historic record of right whale distribution from the last 20 years. An additional spatial pattern apparent in Figure 11 is the difference between surface and water column stock of copepods. As seen in all earlier referenced figures, the water column resource throughout all of the quadrants of the Bay, even during periods of low total resource, consistently exceeded surface concentrations. While the most dramatic and probably most risky behavior seen in Cape Cod today is that of surface feeding, the consistent long-term pattern for the greatest densities to be found beneath the upper meter of the water column suggests that the distribution of the Cape Cod Bay zooplankton resource probably elicits more subsurface feeding than is usually assumed. Occasional very high water column densities found particularly in the southeast and southwest quadrants from the 80th through the 143rd Julian day suggests that while much surface feeding is seen during that period, general forging behavior beneath the surface is likely dominant.

2.4.2.4. Zooplankton and Right Whale Distribution and Prediction, 2007

We include as part of our descriptive results a number of resource descriptions in Appendix I of this report. An interpolated estimation of the spatial density distribution of zooplankton through the 2007 season and the net change in density between any two cruises is found in Appendix I, figures A1 through A17. These depictions play a central role in the assessment and prediction reports.

From the earliest observations on 14 January 2007 through to 9 March (Figures A1-A5) both water column and surface samples indicated a relatively impoverished environment, not likely to support right whale residency anywhere within the Bay. Although the cruise on 9 March was curtailed because of weather, indications from the water column sampling coupled with sightings from the air survey team suggested that an increase in mid-water copepod densities could be expected and that Cape Cod Bay was becoming acceptable to right whale feeding, that a change and resources and, hence, a change in the distribution and occurrence of right whales was at hand. A long period of very bad weather intervened; however, on 21 March water column densities of zooplankton increased dramatically above those recorded 12 days earlier (Figure A6) and the high density of zooplankton recorded in the southeast corner of the Bay coupled with a dense aggregation of right whales in the south-central part of the Bay indicated that the forecast changes had indeed occurred. By 27 March (Figure A7) the zooplankton productivity remained strong in the southeast corner of the Bay and right whales remained in that

location, however the net change in zooplankton density between 21 and 27 of March indicated that conditions again would be changing. On 1 April the estimated concentration of zooplankton in the southeast corner had substantially collapsed and right whale distribution spread widely over the Bay. Yet another change in the zooplankton resource was documented on 11 April when a dramatic enrichment to density values exceeding the estimated threshold for feeding my right whales in the southwest quadrant was again observed (Figure A9). By 21 April the remaining whales and the resource had moved east to occupy eastern quadrants of the Bay where net change exceeded 4000 organisms per cubic meter (Figure A10). On 25 April a truncated cruise found that only in the northeast quadrant was the zooplankton resource high enough to release feeding behavior (Figure A11). On the subsequent day, 26 April, sampling showed very high densities of zooplankton at the surface in the vicinity of Race Point (Figure A12), apparently being flushed out of the bay by the counterclockwise currents. It appeared clear that the rich resources of the Southern Bay had moved north into the region around Race Point. Another impulse of resource appeared to enter the water column of Cape Cod Bay from the north as documented on 2 May (Figure A13). While the zooplankton signal in the western and southern part of the bay was strong on 2 May and the plot of changes in zooplankton concentration indicated that the resource, already acceptable to foraging right whales, was rising, only one right whale was observed in the area. By 8 May (Figure A14) the surface and mid-water resource had spread somewhat eastward and oblique samples exceeded the threshold throughout most of what was sampled in the southern and southeastern portions. Nevertheless, right whale densities remained low and even though Cape Cod Bay was rich enough to support extensive feeding, the bulk of the right whales had departed the area. In keeping with our responsibility to predict right whale occurrence based upon the density of food within the system, we forecast that right whales could again aggregate and feed within the southern reaches of the bay. On 11 May we undertook a sampling cruise around the outside margins of Cape Cod Bay in an effort to locate resources that might influence a re-entry of whales into the deeper parts of the Bay. Generally the surface samples collected did not support such a reentry (Figure A15). By 14 May, resources that only six days earlier had been extremely dense at the surface and within the water column had again shifted to the north part of the Bay (Figure A16) to reach the levels that could have supported the right whale feeding and aggregation in the northeast and northwest quadrants. Sampling for the final assessment of the habitat took place on 23 May (Figure A17) when once again very rich resources seen in the north half of the bay had rotated counterclockwise to fill the southeastern corner of the bay both at the surface and in the water column. At this end of the season was a clear indication within spatial plots of zooplankton density that right whales had moved on into other habitats, probably east of Cape Cod, even though conditions within the Bay remained relatively attractive.

These serial observations of changes in the ecosystem of Cape Cod Bay hint at one possible explanation for the departure of right whales from the Bay. It seems likely that a large grazing animal with substantial energetic demands would seek environments that are relatively stable and predictable at least over short periods of time. This hypothesis is based on simple foraging theory that suggests that the best habitats are both rich and require relatively little searching on a daily basis to optimize feeding success. What we

observed, particularly in the latter part of the season of 2007 starting on 1 April, was an environment whose zooplankton resources were in a state of flux throughout the water column. Future work should look at the possibility that fluctuations in the resources within small areas of the Bay may shape the behavior of searching and forging whales. Other habitats known to be important in mid-spring may become more attractive to right whales that would Cape Cod Bay during years, such as 2007, if they seasonally develop more stable and therefore predictable regions of patches. If this emerging hypothesis is correct then an understanding of small scale horizontal variability in the richness of the resource may be an essential component in the decision-making processes of right whales. Upon these decisions, of course, depends the stability of the right whale aggregations that we observe. Under this hypothesis right whales feeding actively during May 2007 confronted periods of hours or days when a local zooplankton concentrations had dropped below the feeding threshold and these fluctuating conditions encouraged whales to look elsewhere for more predictable and stable resources.

2.4.2.5. Zooplankton Summary by Station

The pairs of surface and water column descriptions from individual stations (Figures A18 through A33) reinforce previous comments that:

- The surface zooplankton resource is generally less rich than in the water column except during the early spring when right whale near-surface feeding is more common.
- The three genera of copepods that have been most implicated in feeding activities followed somewhat the same pattern of enrichment and impoverishment seen in previous years with the possible exception that *Pseudocalanus* may have been less well represented during 2007 than in most of the previous years.
- Copepod resources in the eastern portion of Cape Cod Bay are more abundant than in the west, particularly late in the season of right whale residence.

A side-by-side comparison of the composition of surface and water column samples at the eight stations in the study (Figures A34 through A41) present a different perspective with the same conclusions. Broadly the patterns of species composition tend to be similar, but comparisons between collections from individual stations on any given cruise often reveal intriguing anomalies, most notably when total zooplankton concentrations are impoverished. These treatments show again the consistent difference between surface and water column zooplankton densities are in many cases quite dramatic, as noted earlier.

Table 1. 2007 Cape Cod Bay Habitat Cruises and Collected Zooplankton Samples.

		ZOOPLANKTON SAMPLES					
Cruise	**Date**	**On-Station Surface Tows**	**Off-Station Surface Tows**	**On-Station Oblique Tows**	**Off-Station Oblique Tows**	**Pump Samples***	**Total**
SW633	14 Jan	8	.	8	.	.	**16**
SW634	22 Jan	8	.	8	.	.	**16**
SW636	18 Feb	8	.	8	.	.	**16**
SW638	27 Feb	8	2	8	3	.	**21**
SW639	9 Mar	4	1	4	2	.	**11**
SW640	21 Mar	8	.	8	.	.	**16**
SW641	27 Mar	8	1	8	1	8	**26**
SW642	1 Apr	8	1	8	1	.	**18**
SW644	10 Apr	1	2	1	2	.	**6**
SW645	11 Apr	7	1	7	3	.	**18**
SW646	21 Apr	8	.	8	.	.	**16**
SW647	25 Apr	4	3	4	2	36	**49**
SW648	26 Apr	.	14	.	13	.	**27**
SW649	2 May	8	1	8	.	.	**17**
SW650	5 May	.	12	.	2	.	**14**
SW651	8 May	6	4	6	4	.	**20**
IB083	11 May	.	4	.	2	.	**6**
SW652	14 May	8	.	8	.	.	**16**
SW653	23 May	8	.	8	.	.	**16**
	Totals	**110**	**46**	**110**	**35**	**44**	**345**

* collected by filtering a pumped volume of water from either 1) the near-surface as the vessel steamed along a horizontal transect, or 2) specific depths in the water column while the vessel was on-station

Right Whale Risk Alert
24 April 2007

Information from DMF/PCCS aircraft and shore surveys over the past week indicates that right whales are aggregating and feeding close to the outer shore of Cape Cod. The behavior observed suggests whales are feeding near or at the surface through much of the day and are, therefore, at high risk of vessel strike. **The area of greatest concern is located along the outer shore of Cape Cod from Long Point to Race Point in Provincetown and beyond to Cape Cod Light (Highland Light) in Truro within 3 miles of the outer shore, an area heavily used by in- and out-bound vessel traffic.** Strong tidally-influenced advective fronts near shore are likely capturing and concentrating zooplankton in the area delineated, causing the aggregations and behavior observed. As weather improves we anticipate sampling the zooplankton distribution through the area in order to assess the quality of the controlling food resource and to forecast the location and timing of the feeding aggregations.

Because of risk to right whales feeding in the nearshore high-traffic area, for the next 5 days or until further zooplankton sampling indicates otherwise vessel speeds should be reduced and crews should be on alert for potential collisions with whales throughout the area delineated.

* * * * * * * * * *

These observations are considered preliminary pending detailed analysis and final assessment reporting. The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Box 1. Example of a "Right Whale Risk Alert" delivered on 24 April 2007 to notify DMF of resource and right whale distribution conditions that place the whales at a significantly elevated risk ship strike.

Cape Cod Bay Right Whale Habitat Preliminary Assessment Report: SW647
25 April 2007

With excellent sighting conditions and flat calm sea Cruise SW647 was directed at locating whales and assessing the zooplankton resource that has been controlling right whale distribution and behavior over the past days of windy weather. Three regular and 5 special stations (resulting in more than 45 zooplankton samples) were visited. A concentration of more than 35 whales was located by DMF/PCCS air and vessel survey teams. The greatest aggregation of whales was located in the near-shore waters between Race Point and Long Point in Provincetown. Intensive sampling indicates that the zooplankton in the region is dominated by late stages of *Calanus finmarchicus* organized into linear patches of very high density, many times the estimated threshold for releasing right whale feeding behavior. It appears that localized small-scale frontal activity along the outer shore of Provincetown and Truro is creating conditions favorable to the formation of linear near-surface patches and that these areas of dense resources are continually foraged upon by an increasingly concentrated aggregation of whales. The characteristics of the zooplankton resource suggests that right whale aggregation and surface and near-surface feeding coupled with occasional bouts of social activity will continue and may move south into the northeast quadrant of Cape Cod Bay. Zooplankton samples collected at stations along the eastern portion of the bay south of the identified feeding area are also dense and will occasionally attract aggregations of feeding whales to the eastern central portion of the bay.

The vertical distribution of the zooplankton resource determined from pump sampling confirms that the patches triggering whale aggregation are composed principally of calanoid copepods concentrated in the upper 2 meters of the water column. Such patch structure strongly favors surface and near-surface feeding activities, placing whales at a high risk of vessel strike. We anticipate that surface feeding will continue to dominate right whale activities in the area for the next 4-7 days.

Preliminary assessment of zooplankton resources strongly supports our alert issued on 24 April:

The area of greatest concern is located along the outer shore of Cape Cod from Long Point to Race Point in Provincetown and beyond to Cape Cod Light (Highland Light) in Truro.

We modify yesterday's alert from a band 3 miles wide:

To extend the band of greatest risk of vessel strike to 5 miles from the shore throughout the area delineated.

In the next days future assessment will track the potential movement of the resource, and hence the whales, into Cape Cod Bay. Such movement may extend the area of vessel strike risk to include Cape Cod Bay south of Provincetown and Truro.

* * * * * * * * * *

These observations are considered preliminary pending detailed analysis and final assessment reporting. The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Box 2. The Risk Alert of 24 April 2007 (Box 1) was followed by Cape Cod Bay resource sampling and an aerial survey on 25 April. The "Preliminary Assessment" presented here was delivered to DMF immediately following the completion of that day's habitat cruise (SW647) to reiterate that observations of zooplankton and whale distribution continued to show the animals at a significantly elevated risk to vessel strike.

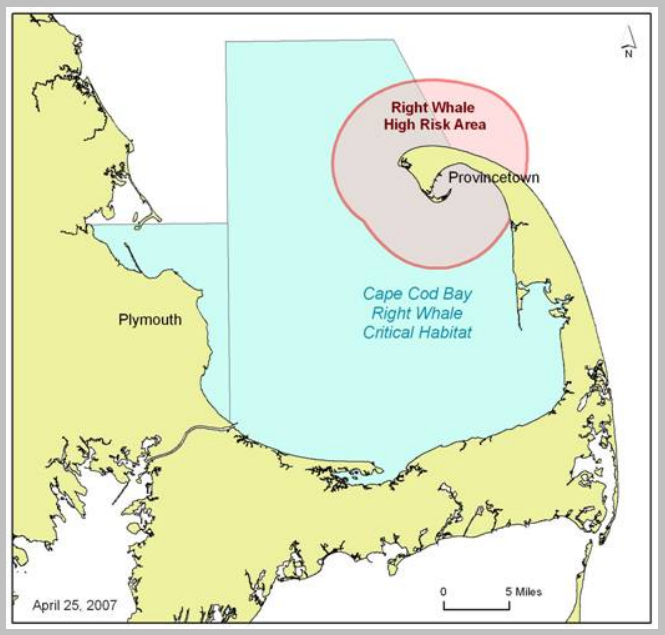
Commonwealth of Massachusetts
Division of Marine Fisheries
251 Causeway Street, Suite 400
Boston, MA 02114
(617) 626.1520

Paul J. Diodati
Director

April 25, 2007
ADVISORY TO MARINERS

AGGREGATIONS OF RIGHT WHALES IN PROVINCETOWN AREA

An aggregation of right whales in Cape Cod Bay has prompted the Division of Marine Fisheries (*MarineFisheries*) to issue an advisory to all vessel operators. Vessel operators are advised to reduce speed (as slow as 10 knots), post lookouts, and proceed with caution to avoid colliding with this highly endangered whale. During the past week, the Center for Coastal Studies (CCS) aerial survey team reported an aggregation of up to 20 right whales sub-surface feeding in the area around Provincetown. A bay-wide habitat sampling cruise confirmed that plankton patches in this area are stable and extensive, supporting feeding right whales. It is recommended that vessels transiting this area use extreme caution. When right whales depart the area, the advisory will be lifted.



Whales that are sub-surface feeding on dense blooms of plankton (copepods) are notoriously difficult to detect. Scientists believe feeding right whales may be oblivious to their surroundings, thereby unable to avoid an oncoming vessel. Sub-surface feeding right whales are particularly vulnerable to ship strikes. More vessel traffic is expected in this area over the next few weeks with seasonal increases in recreational and commercial fishing, as well as whale watching, and passenger ship activity. Right whales are the most endangered of the large whales in the western Atlantic Ocean, with a population of only about 350 animals. Ship strikes are believed to be the primary cause of human-induced mortality to the right whale. Vessels are prohibited by state and federal regulations from approaching within 500 yards of a right whale. Massachusetts Environmental Police and U.S. Coast Guard are authorized to enforce the 500- yard rule…

Box 3. Subsequent DMF "Advisory to Mariners" that was disseminated to government agencies and the shipping community on 25 April 2007 as a direct response to the Risk Alert and Preliminary Assessment put out by PCCS in Boxes 1 and 2, respectively.

Cape Cod Bay Right Whale Habitat Preliminary Assessment Report: SW650
5 May 2007

With declining resources in Cape Cod Bay as documented on 2 May and an indication from the air survey that right whales have aggregated along the outer shore of Cape Cod, cruise SW650 was directed at collections to assess the quality of the food resource between Cape Cod Light and Race Point. Conditions during the cruise were excellent with calm seas and clear visibility. A total of 26-35 humpback whales, 6-8 minke whales, 3-7 right whales and several small cetaceans were sighted. All right whales were feeding at the surface in the Race Rips and between Race Point and Peaked Hill in Provincetown. Twelve sampling stations were completed during SW650.

The zooplankton resource along the outer shore of Provincetown and Truro within 4 km of the beach was patchy and associated with strong local tidal fronts. Most of the samples collected were estimated above the right whale feeding threshold, while samples from tidal fronts being foraged by right whales were particularly rich, as much as an order of magnitude more than the threshold concentration. The composition of the resource was dominated by stage 3-4 *Calanus finmarchicus* with an important contribution from both stage 5 *Calanus* and *Pseudocalanus*.

The strength of the zooplankton resource at the entrance to Cape Cod Bay suggests that right whale aggregation and feeding in the area will persist for at least 4-5 days. Zooplankton composition and distribution continue to favor near-surface and surface feeding behavior and aggregation of whales within 5 miles of land, coincidentally an area actively used by commercial and recreational vessels. Therefore, the previous alert for a risk of vessel collision continues. **Mariners using the near shore area from Cape Cod Light (Highland Light) west to and including the area around Race Point should exercise considerable caution because the behavior of the right whales places both whales and fast moving vessels at high risk of catastrophic collision.**

Movement of significant numbers of right whales into Cape Cod Bay, where resource assessment over the past week suggests a habitat of modest attractiveness continues to be possible. However, continued aggregation along the strong frontal areas at the margin of the Bay, as delineated, will be favored for the 4-5 day period. We anticipate a decline in the zooplankton resources in areas of strong tidal flux after that time.

* * * * * * * * * *

These observations are considered preliminary pending detailed analysis and final assessment reporting. The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Box 4. "Preliminary Assessment" of 5 May 2007 documenting the persistence of resource conditions favorable to right whale aggregation and surface feeding in the Advisory area (Box 3).

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May 7, 2007
***Marine Fisheries* ADVISORY**

AGGREGATION OF RIGHT WHALES FROM LONG POINT TO HIGHLAND LIGHT
Updated Advisory to Mariners

An aggregation of right whales off Provincetown has prompted the Division of Marine Fisheries (*MarineFisheries*) to re-issue an advisory to all vessel operators. Operators are advised to reduce speed (10 knots), post lookouts, and proceed with caution to avoid colliding with this highly endangered whale. On April 25, *MarineFisheries* issued an initial advisory for this area. The DMF/CCS aerial survey team reported an aggregation of 20 right whales surface feeding around the tip of Cape Cod. Survey efforts conducted on May 5 established that right whales are still present and feeding in this area. Whales that are surface feeding on dense blooms of plankton (copepods) are at great risk for vessel strike. We will re-evaluate the level of risk after analyzing whether the plankton resources in this region remains high enough to support right whale feeding, aggregation, and residency. When right whales depart the area, the advisory will be lifted.

Vessels are prohibited by state and federal law from approaching within 500 yards of a right whale. Massachusetts Environmental Police and U.S. Coast Guard are authorized to enforce the 500-yard rule. Fishermen are reminded that the approach rule also prohibits them from starting fishing operations (setting or hauling gear) within 500 yards of a right whale.

Right whales are the most endangered large whale in the North Atlantic, with a population of approximately 350 animals. Ship strikes are a major cause of human-induced mortality for right whales and more vessel traffic is expected in this area over the next few weeks with seasonal increases in recreational and commercial fishing, as well as whale watching, and passenger ship activity. On March 12, 2007, the CCS aerial surveillance team spotted a juvenile right whale off Provincetown with deep propeller wounds. It is unknown where this vessel interaction took place, but based on the condition of the wound, the injury likely occurred only weeks prior to the sighting. This sighting highlights the risk posed to right whales by vessel traffic…

Box 5. DMF-issued "Updated Advisory to Mariners" that was disseminated to government agencies and the shipping community on 7 May 2007 based on the PCCS "Preliminary Assessment" of 5 May (Box 4).

Cape Cod Bay Right Whale Habitat Preliminary Assessment Report: IB083
11 May 2007

Cruise IB083, aboard R/V *Ibis* during a disentanglement training, was used to opportunistically collect zooplankton samples in order to assess the potential for vessel collision in the area of the outer shore of Provincetown and Truro, the subject of recent alerts and advisories. Visibility during the morning was hampered by areas of dense fog with southwest winds below 15 knots. During the cruise three fin whales were sighted close to the current fronts along the shore where sampling stations were located. Six zooplankton samples were collected during the cruise and preliminarily evaluated in order to forecast the potential for entanglement and ship strike.

The food resource at surface in the vicinity of the tidal front within 2 km. of land is dominated by *Calanus finmarchicus,* principally oil-rich stage 4 copepodites. Both stage 3 and 5 *Calanus* were also identified in the samples, along with smaller taxa of calanoids including the genera *Acartia* and *Pseudocalanus.* Generally, the taxonomic composition of the zooplankton resource remains similar to that reported from the Cape Cod Bay assessment cruise SW651 and is judged to be acceptable for right whale feeding.

The density of zooplankton along the outer shore has declined from the high levels reported from cruise SW650 on 5 May, densities that triggered the alert of potential vessel collision on that day. The resource at the surface, however, remains patchy and at or near the feeding threshold for right whales, much as it was as reported from SW651 on 8 May in eastern and southern Cape Cod Bay. It appears therefore that the eastern quadrants of the bay and the outer shore as far east as Truro will remain moderately attractive to whales in the area; however conditions do not favor significant aggregation, surface feeding, or residency by right whales. It remains likely that occasional feeding will be seen in locations throughout eastern Cape Cod Bay and along the outer near-shore region for at least 3-5 days.

In view of the declining resource, the increased patchiness of the zooplankton and the declining number of right whales reported during the last DMF/PCCS aircraft survey, the risk of vessel collision or entanglement in fishing gear has declined. Therefore: **The alert for elevated risk of vessel strike and entanglement in the area of the north end of Cape Cod Bay and paralleling the outer shore of Provincetown and Truro is no longer appropriate.** With the occasionally-attractive patches of oil-rich taxa of calanoid copepods lingering in the eastern bay and along the outer shore, mariners in the area of the previous alert should remain on the lookout for near-surface feeding right whales that may continue to pose a risk of vessel collision.

The next cruises will be directed at verification of the declining attractiveness of Cape Cod Bay and on assessment of the offshore resources now influencing the movement and behavior of the right whales.

* * * * * * * * * *

These observations are considered preliminary pending detailed analysis and final assessment reporting. The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Box 6. PCCS notification of degraded resource conditions in the high-risk area where right whales had been aggregating and feeding, warranting the termination of the DMF Advisory.

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May 14, 2007

***Marine Fisheries* ADVISORY**

RIGHT WHALE AGGREGATION DEPARTS RACE POINT AREA
Advisory to Mariners Lifted

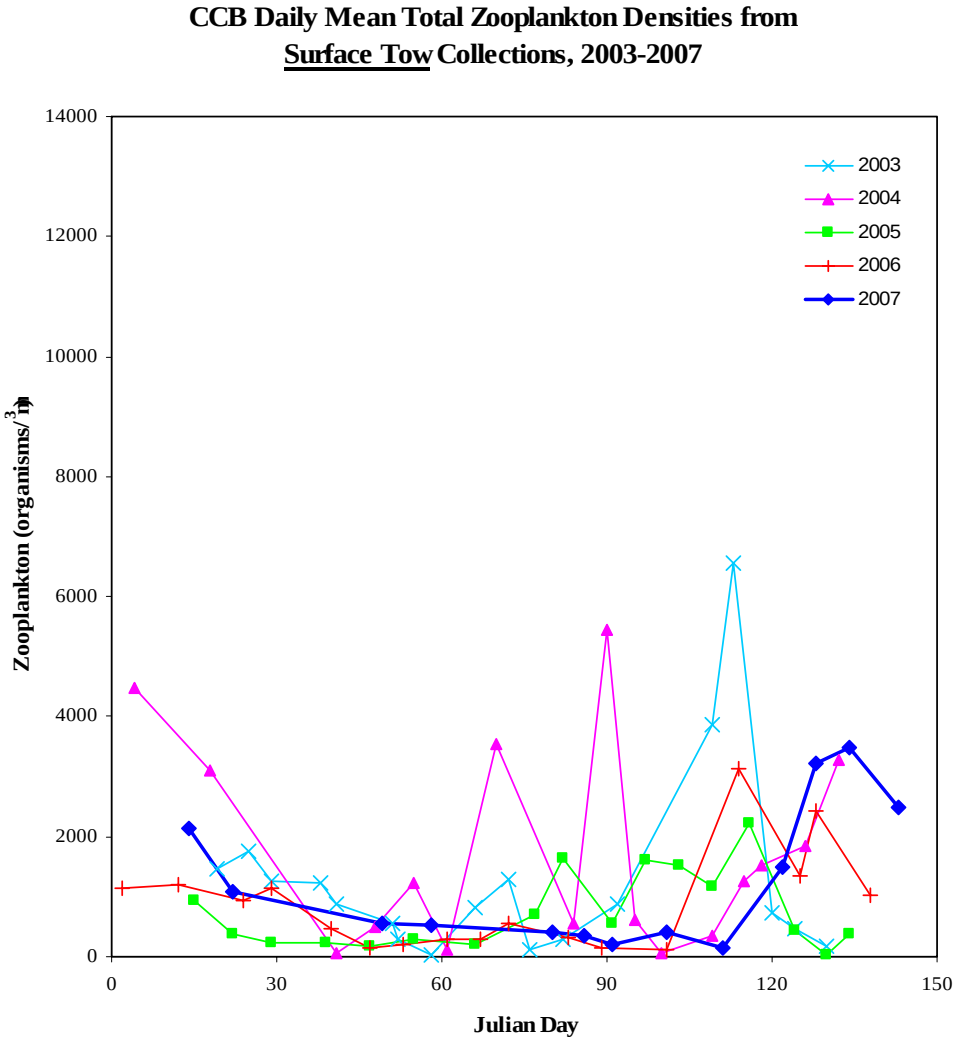
Recent survey efforts by the Center for Coastal Studies (CCS) and the Division of Marine Fisheries (*MarineFisheries*) have determined that the large aggregation of right whales observed off Provincetown and Truro have departed. With the departure of these animals the Commonwealth is lifting the April 25 and May 5th advisories to mariners in the Race Point area. *MarineFisheries* would like to thank fishermen, whale watch companies, and others for their assistance and compliance with measures designed to protect this highly endangered animal.

MarineFisheries monitors the presence of right whales in Cape Cod Bay through aerial surveys, habitat sampling, and acoustic monitoring. Sightings observed through these efforts allow *MarineFisheries* to address threats to right whales on a real-time basis. No right whales have been sighted recently from aircraft or boat, and habitat monitoring revealed a decline in the zooplankton resource, suggesting that right whale aggregations are not likely to return in the near future. The zooplankton resource remains patchy, but it is possible that the occasional right whale will be seen feeding in the outer near-shore region for 3-5 days. Mariners should remain on the lookout for any lingering right whale activity. We greatly appreciate the diligence and alertness of mariners and our surveillance team during the 2007 season.

* * * * * * * * * *

The National Marine Fisheries Service (NOAA Fisheries) issues warnings to mariners and others through the Northern Right Whale Sighting Advisory System (SAS). Advisories regarding Cape Cod Bay and surrounding waters can be viewed at the NOAA Fisheries Northeast Region web site (http://www.nero.noaa.gov/ro/doc/whale.htm) and are broadcast over NOAA weather radio (http:// 205.156.54.206/nwr/).

Box 7. DMF disseminated this final notice to government agencies and the shipping community on 14 May 2007, lifting the previous Advisories in response to PCCS surveys, sampling and reporting (Box 6).



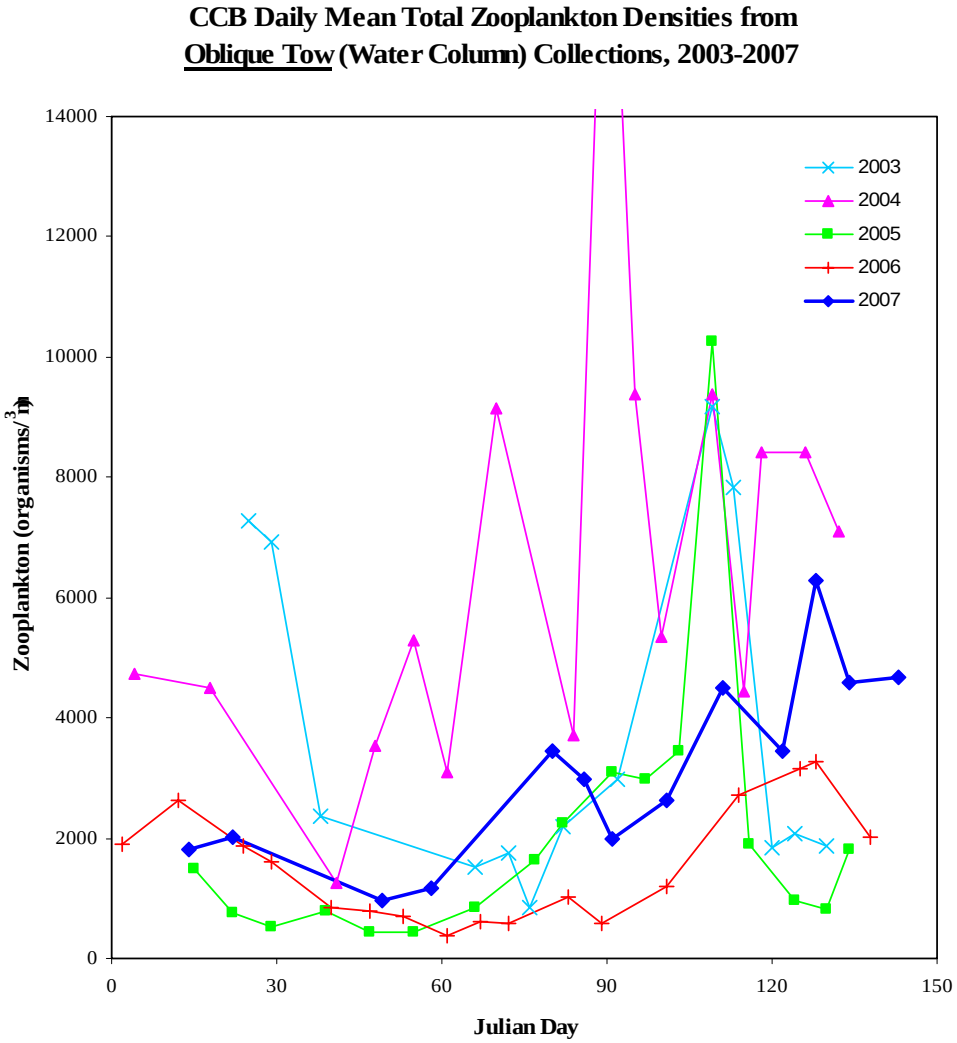


Figure 1. **Temporal progression of the daily mean total zooplankton density in Cape Cod Bay surface waters (left graph) and in the water column (right graph), January to mid-May for each year 2003-2007.**

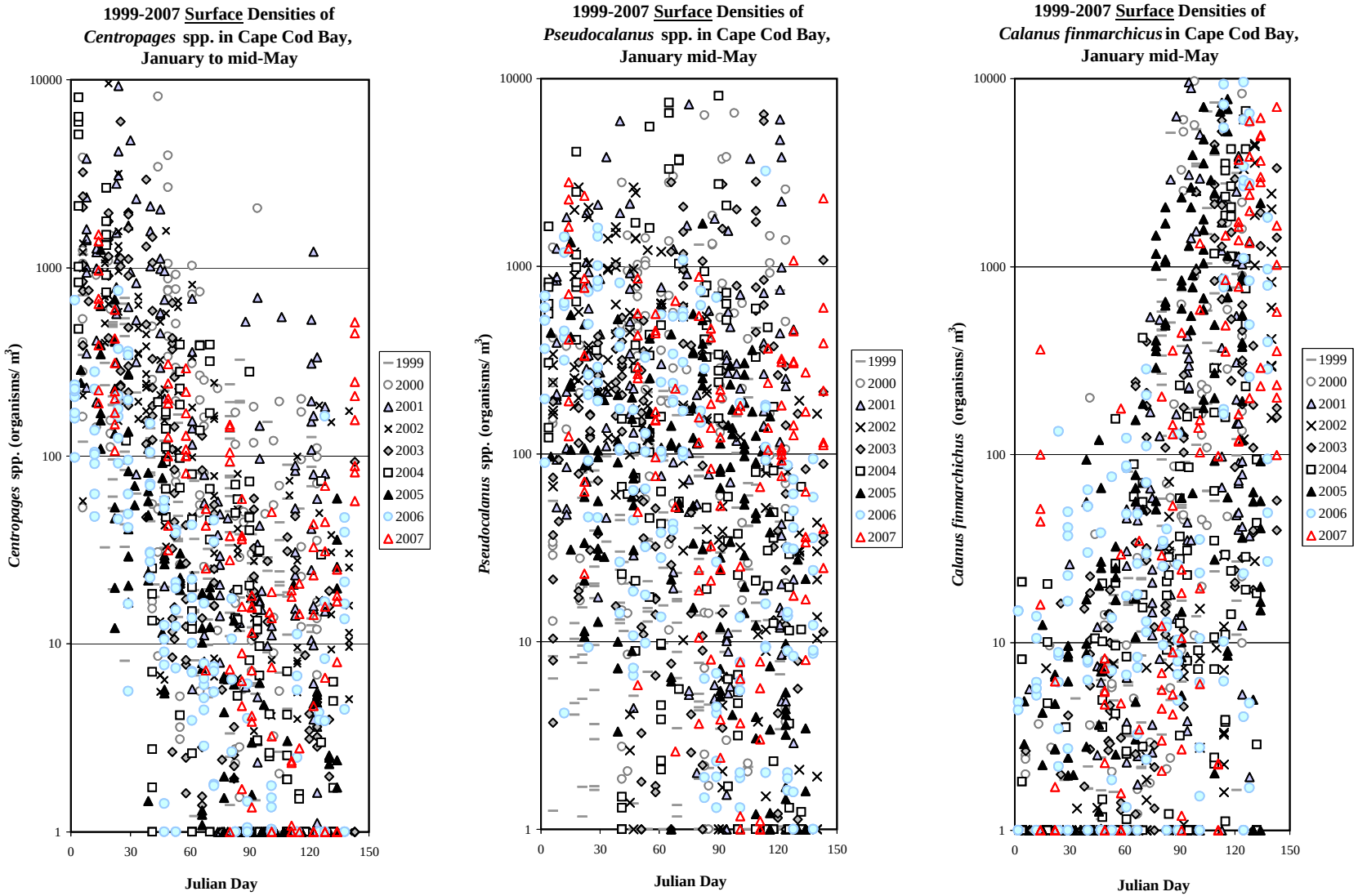


Figure 2. Scatter plots showing temporal changes in surface densities of the three principal copepod taxa at Cape Cod Bay sampling stations: *Centropages* spp. (left plot), *Pseudocalanus* spp. (center plot) and *Calanus finmarchicus* (right plot). Note that all axes have identical scales.

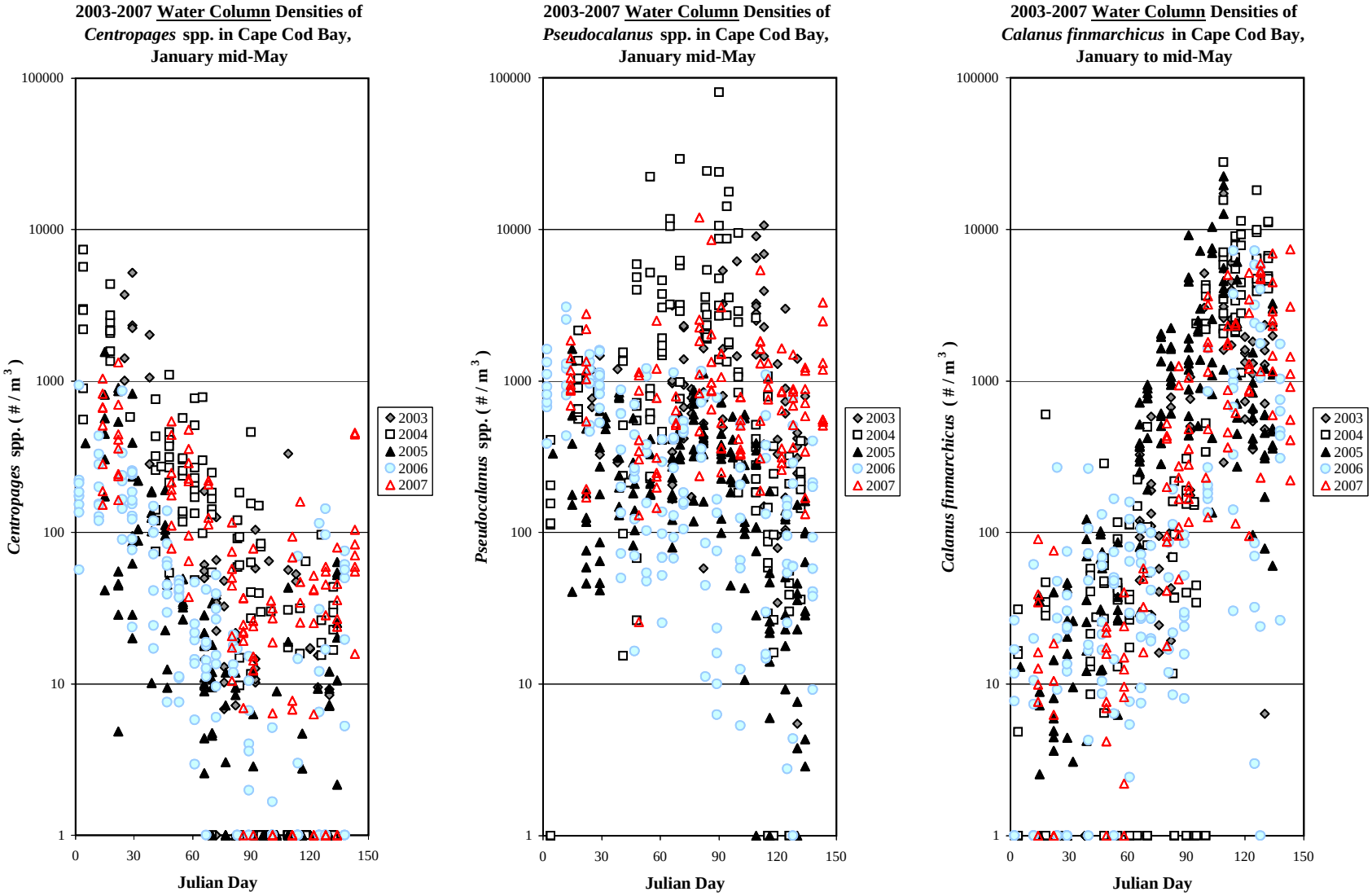


Figure 3. Scatter plots showing temporal changes in water column densities of the three principal copepod taxa at Cape Cod Bay sampling stations: *Centropages* spp. (left plot), *Pseudocalanus* spp. (center plot) and *Calanus finmarchicus* (right plot). Note that all axes have identical scales.

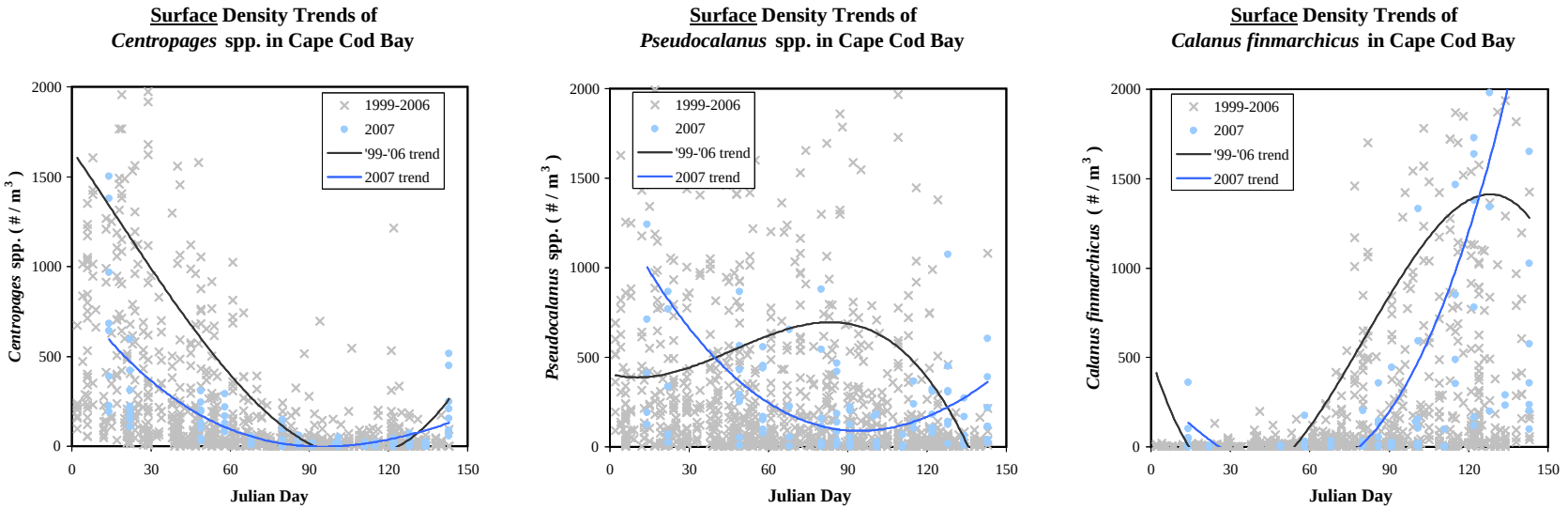


Figure 4. Comparison of 2007 trend against 1999-2006 trend in the temporal progression of Cape Cod Bay surface densities of the three principal copepod taxa. All values of surface abundance for 1999-2006 are combined to illustrate the "typical" progression for the given taxa. Trend lines represent a 3rd-order polynomial regression treatment of the Cape Cod Bay surface density values for 2007 and for the period 1999-2006.

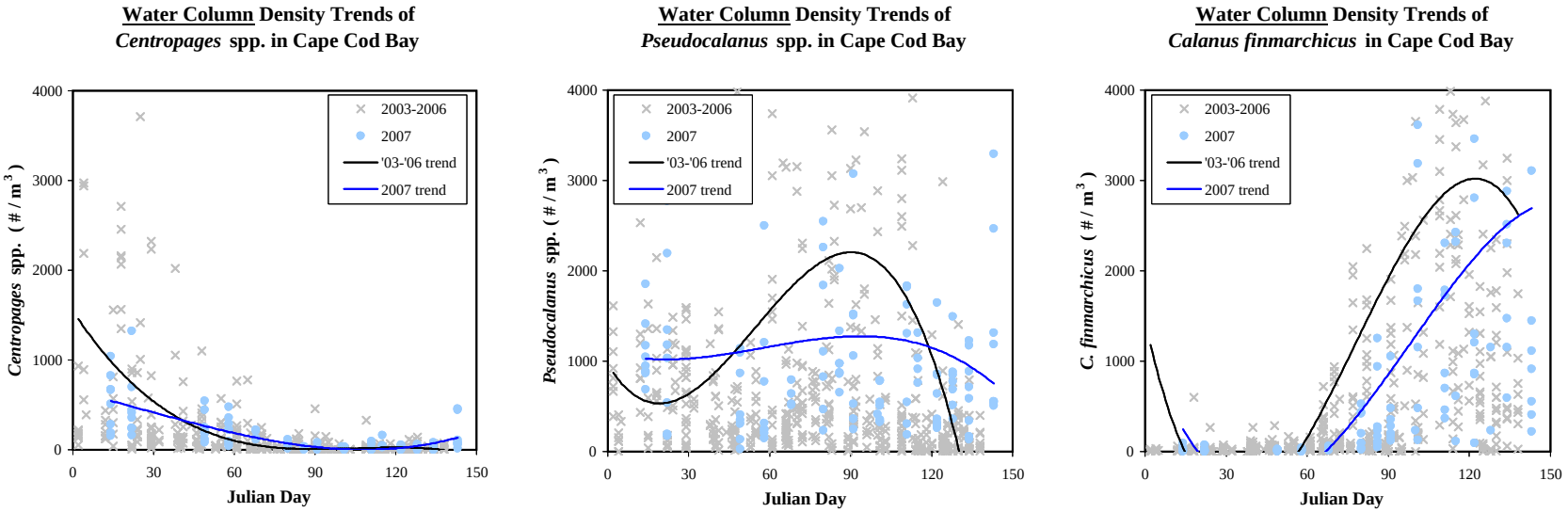


Figure 5. Comparison of 2007 trend against 2003-2006 trends in the temporal progression of Cape Cod Bay water column densities of the three principal copepod taxa. All individual measurements of water column abundance for 2003-2006 are combined to illustrate the "typical" progression for the given taxa. Trend lines represent a 3rd-order polynomial regression treatment of surface density values from Cape Cod Bay samples for 2007 and for the period 2003-2006.

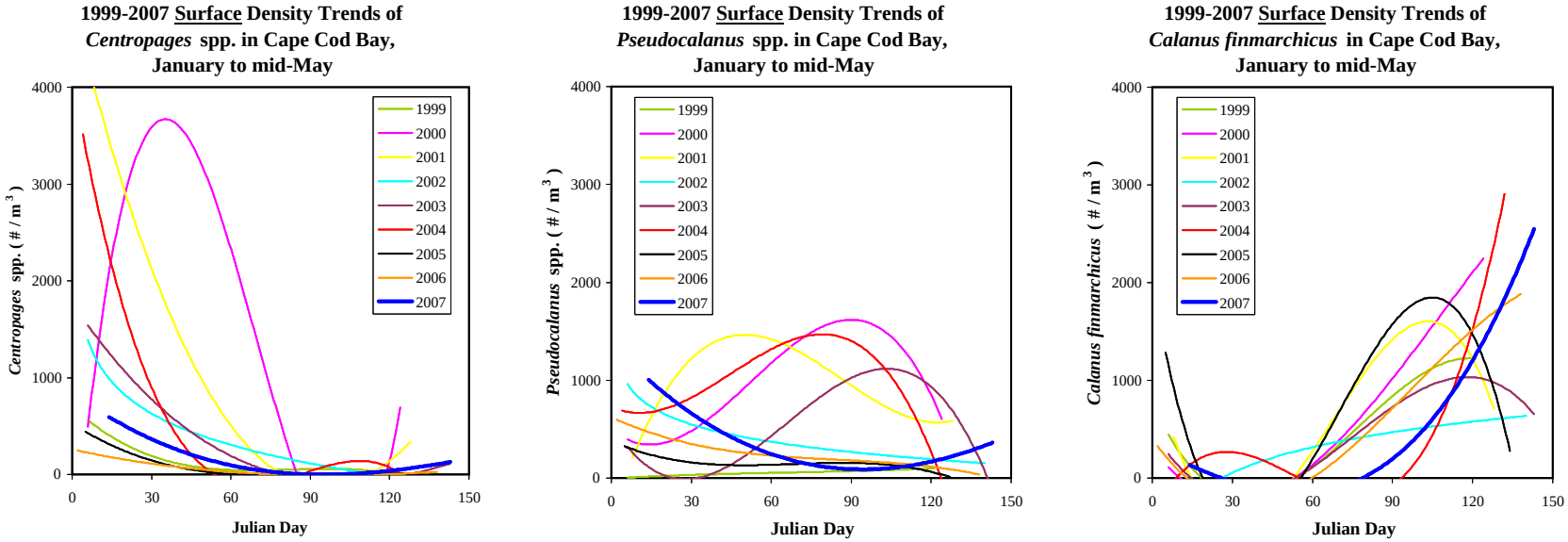


Figure 6. Comparison of 2007 trend against 1999-2006 annual trends in the temporal progression of surface densities of the three principal copepod taxa in Cape Cod Bay. Individual yearly trends are presented for the period 1999-2006 to show historical inter-annual variations in the temporal trends. Each trend lines represents a 3rd-order polynomial regression treatment of all surface density measurements from Cape Cod Bay station sampling for the specified year.

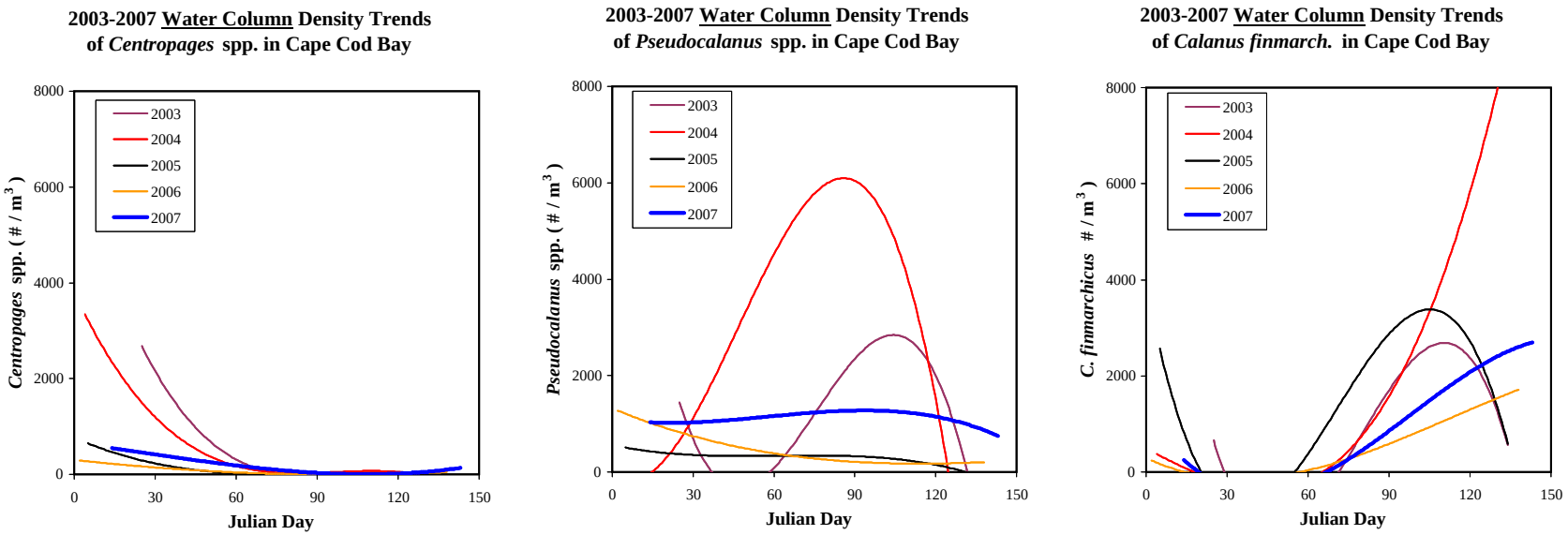


Figure 7. Comparison of 2007 trend against 2003-2006 annual trends in the temporal progression of Cape Cod Bay water column densities of the three principal copepod taxa. Individual yearly trends are shown for the period 2003-2006 to show historical inter-annual variations in the temporal trends. All trend lines represent a 3rd-order polynomial regression treatment of of all water column density measurements from Cape Cod Bay station sampling for the specified year.

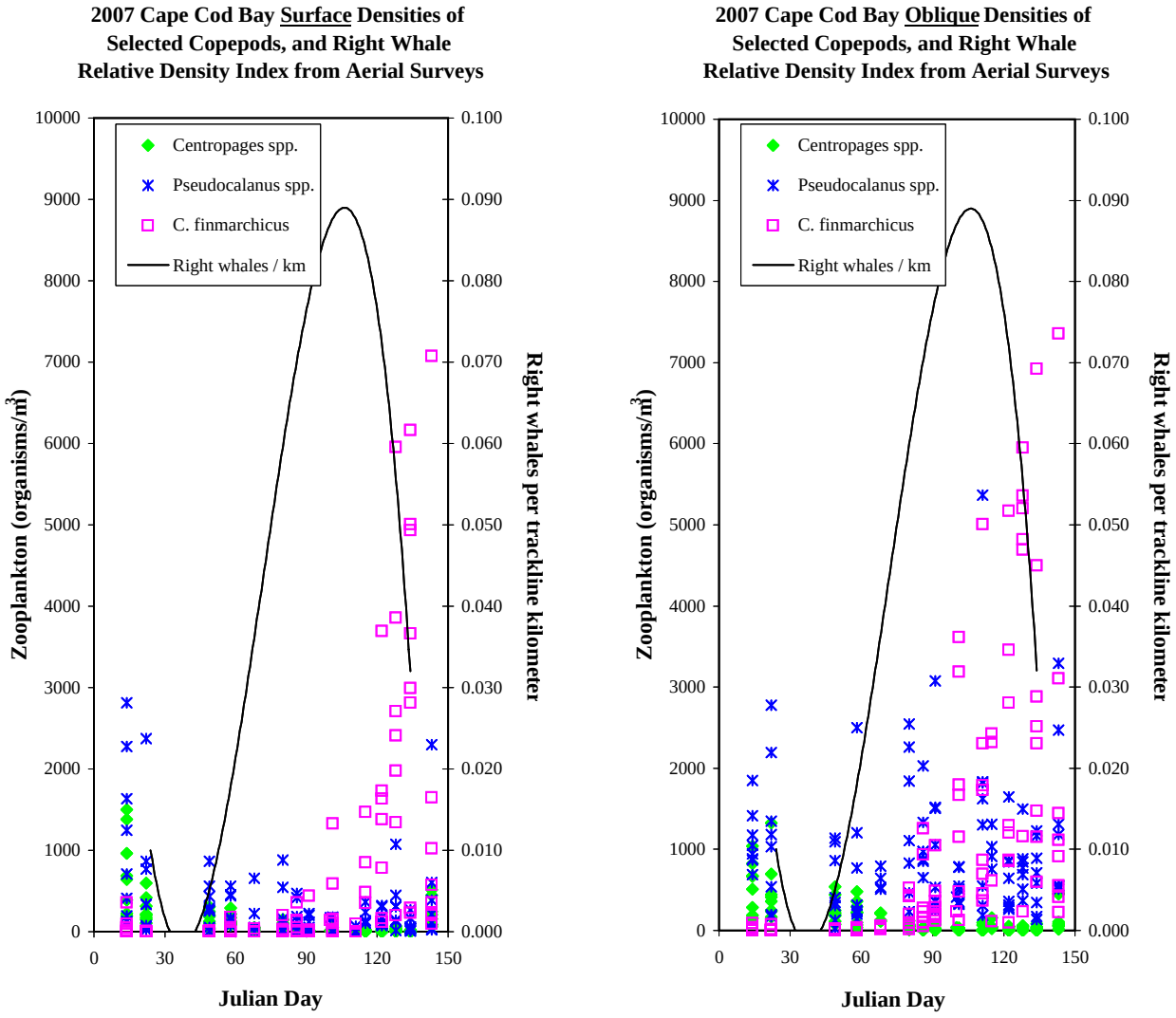


Figure 8. **2007 comparison of right whale relative density index from aerial surveys with the densities of selected copepod taxa in Cape Cod Bay surface waters (left graph) and the water column (right). Right whale relative density index is displayed as a trend line, computed as a 3rd-order regression of 30 daily values of right-whales-per-trackline-kilometer from 2007 aerial surveys. Zooplankton species densities from on-station samples collected between January and mid-May 2007.**

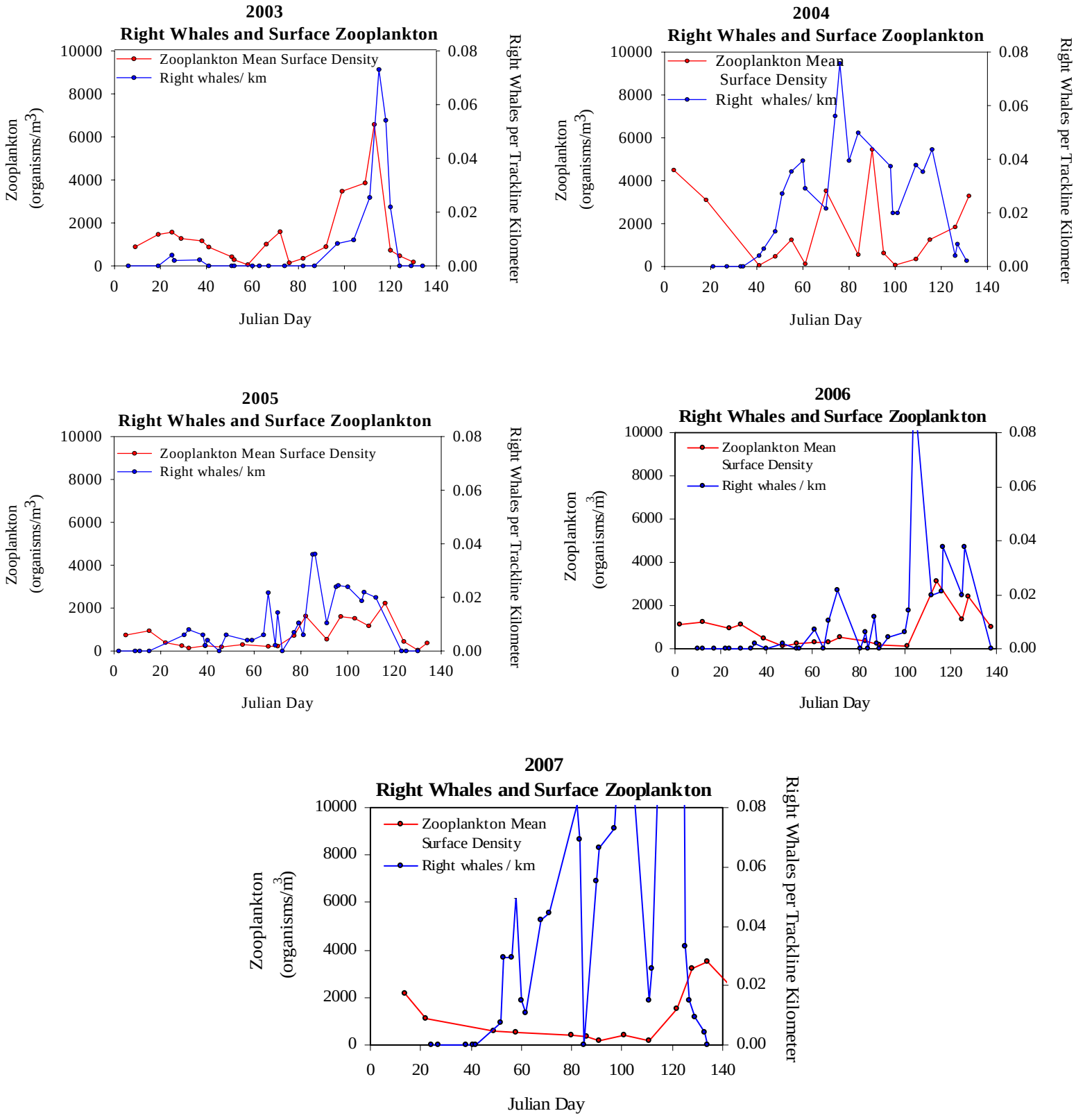


Figure 9. **Comparison of right whale sightings and daily mean <u>surface</u> zooplankton densities in Cape Cod Bay, 2003-2007.**

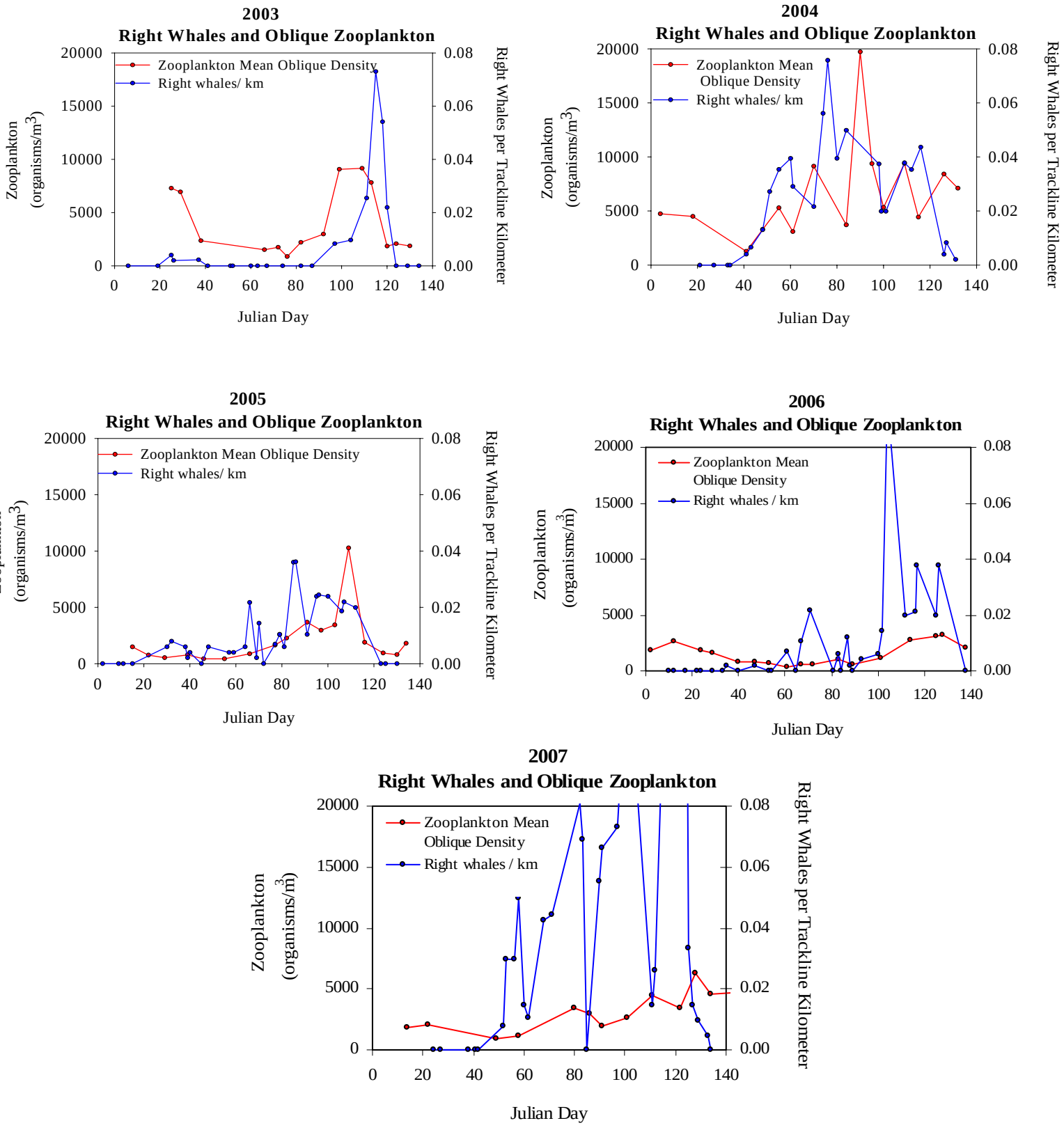


Figure 10. Comparison of right whale sightings and daily mean water column zooplankton densities in Cape Cod Bay, 2003-2007.

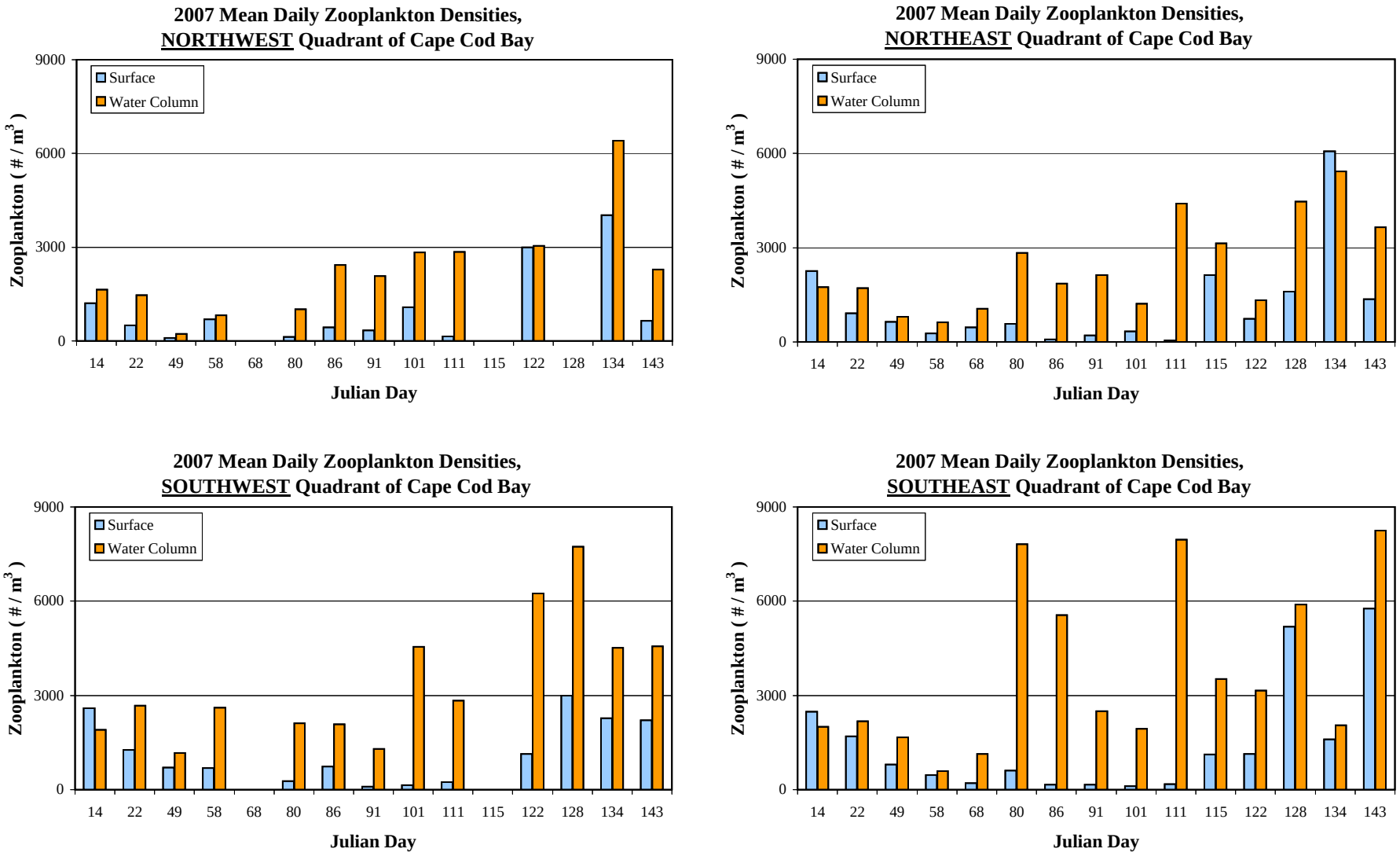


Figure 11. Temporal progression of the daily mean density of surface and water column total zooplankton in each quadrant of Cape Cod Bay. Note that axes in all graphs have identical scales.

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Appendix I

Supplemental Figures for Habitat Assessment
2007

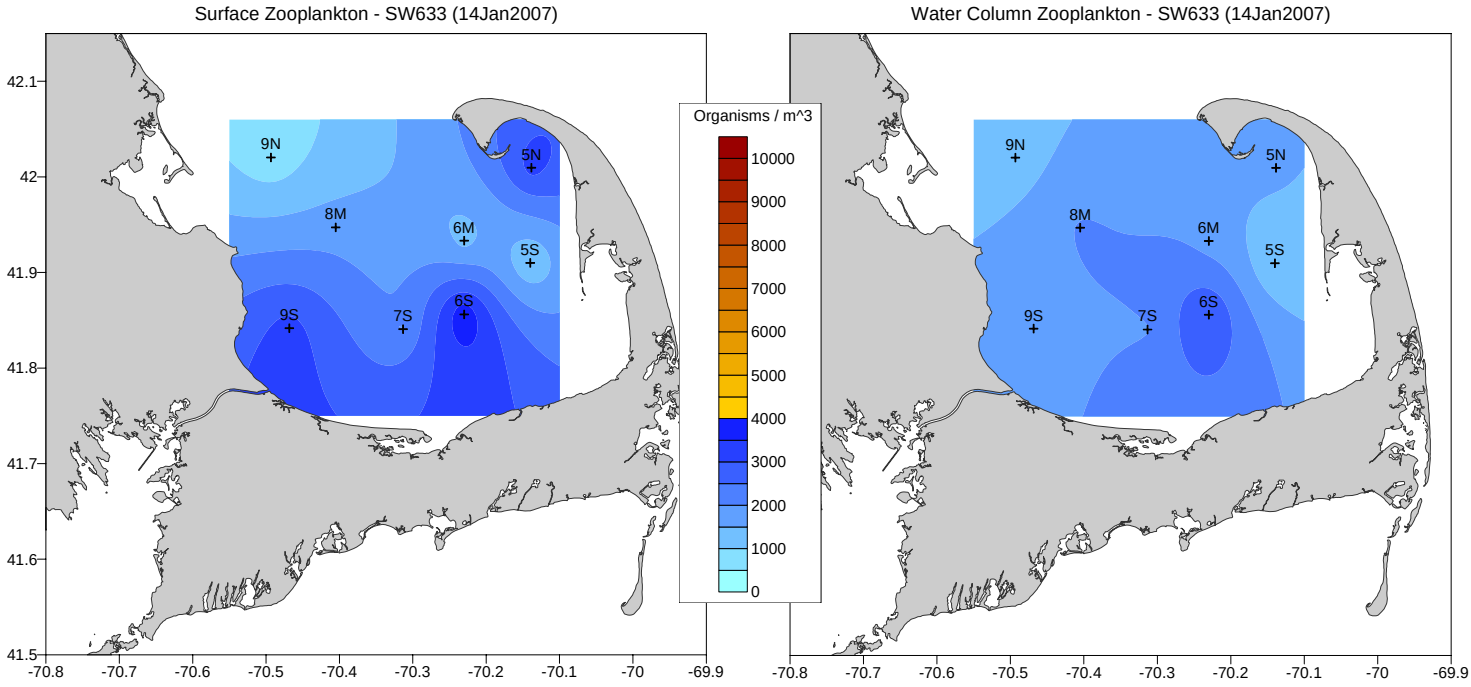


Figure A1. Zooplankton density distribution in Cape Cod Bay on 14 January 2007 from surface (left) and water column (right) collections. Sampling station locations are indicated with a "+" symbol.

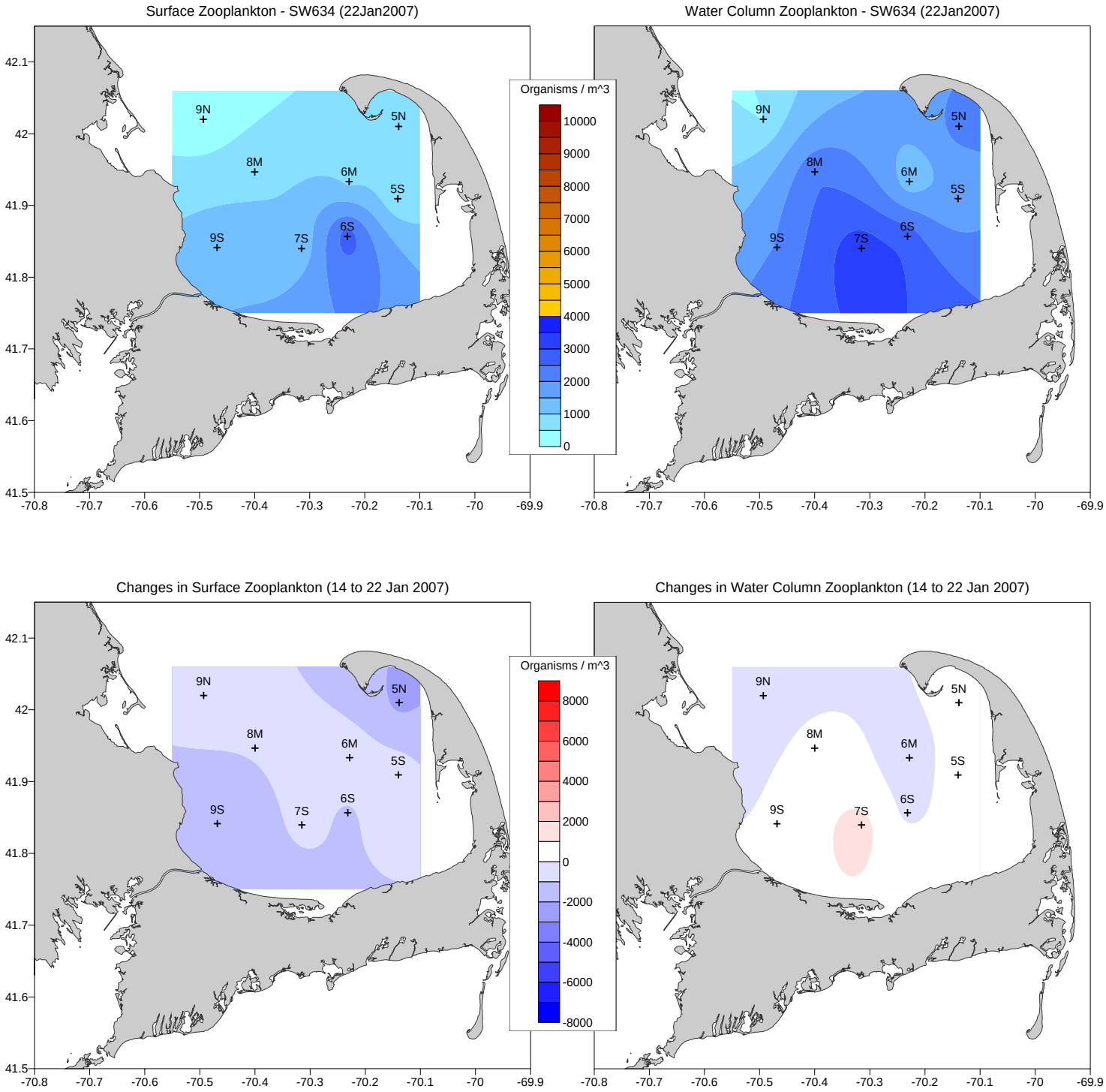


Figure A2. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 22 January 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 14 and 22 January 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol.

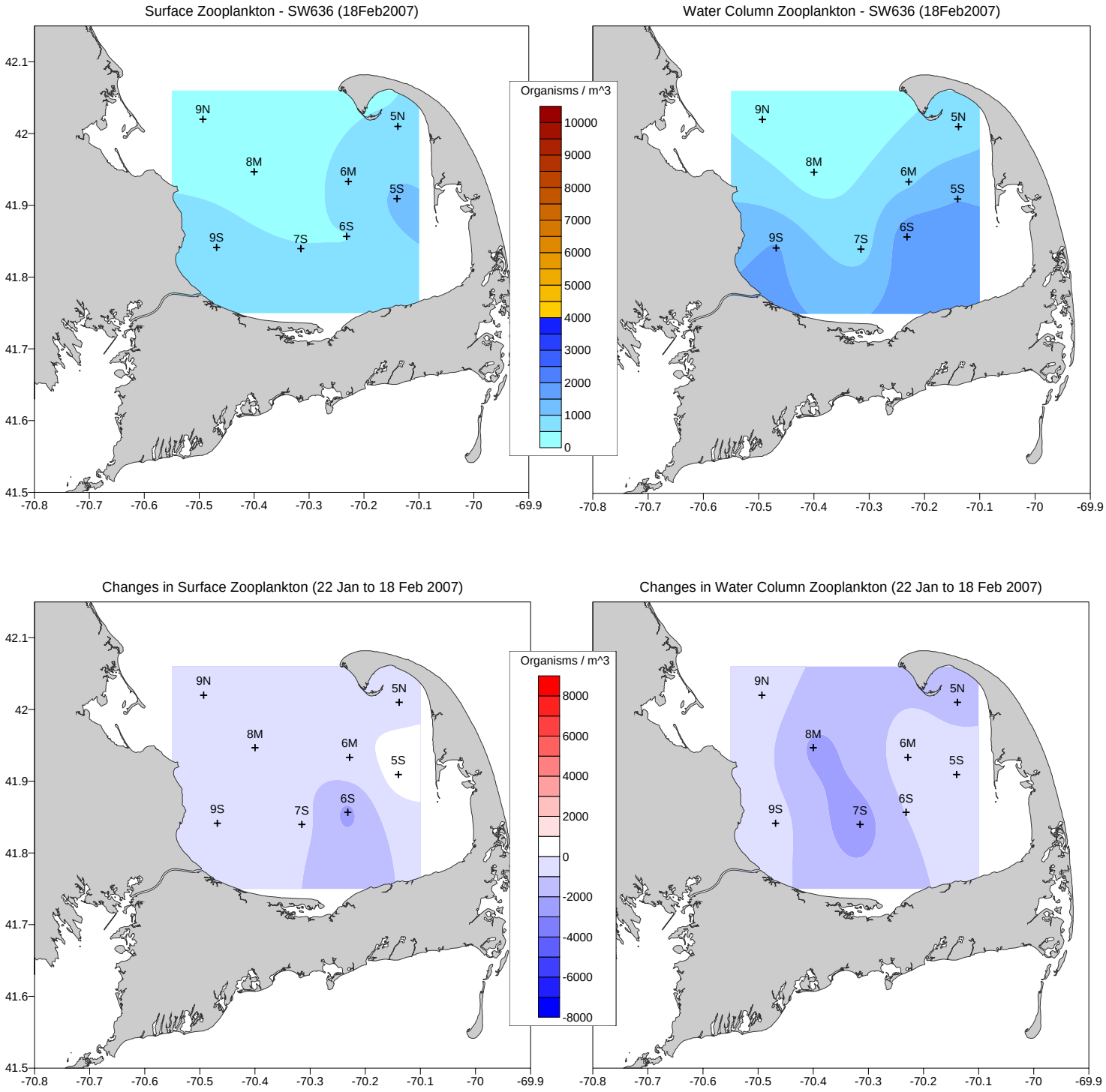


Figure A3. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 18 February 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 22 January and 18 February 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol.

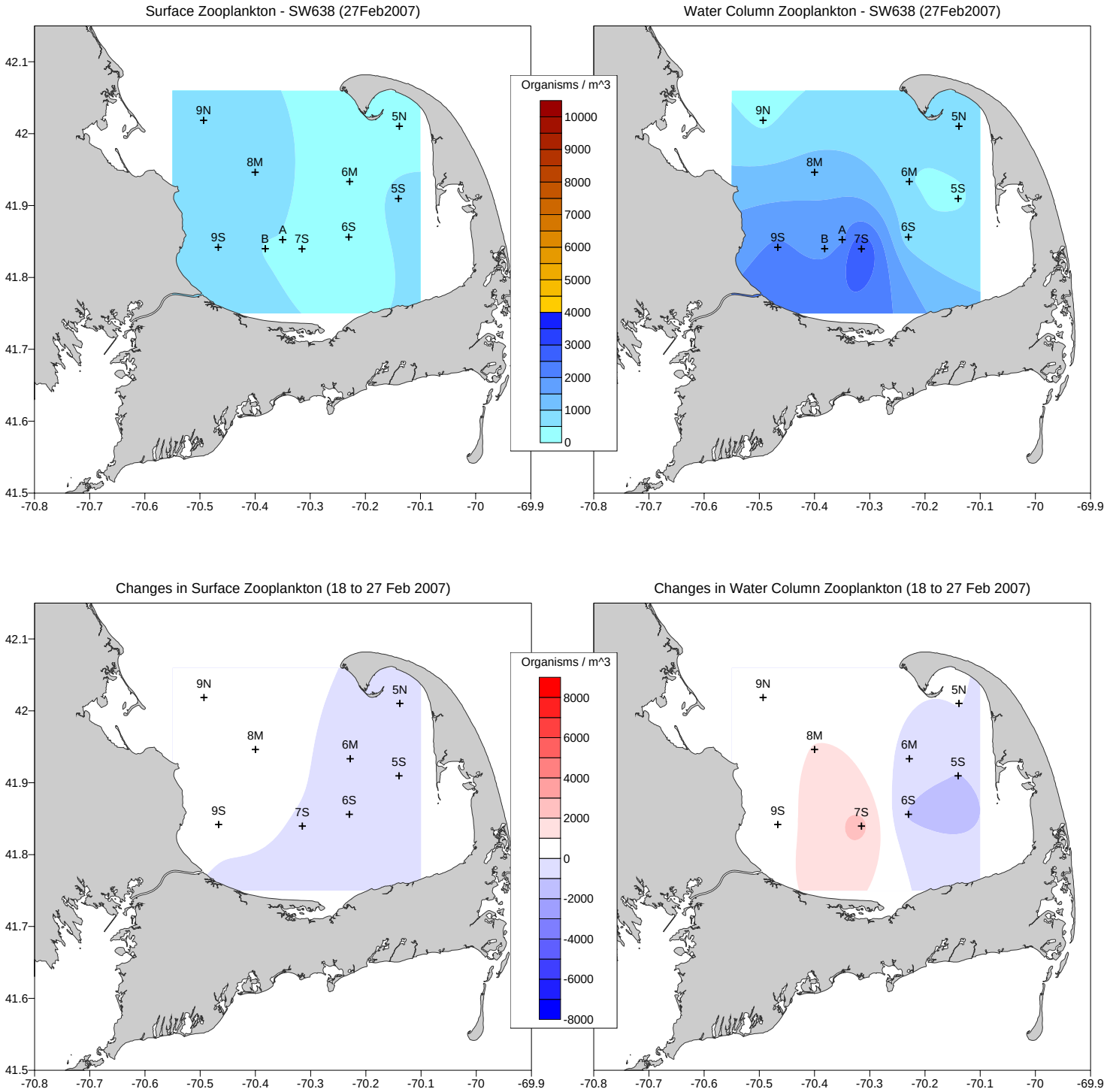


Figure A4. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 27 February 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 18 and 27 February 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol.

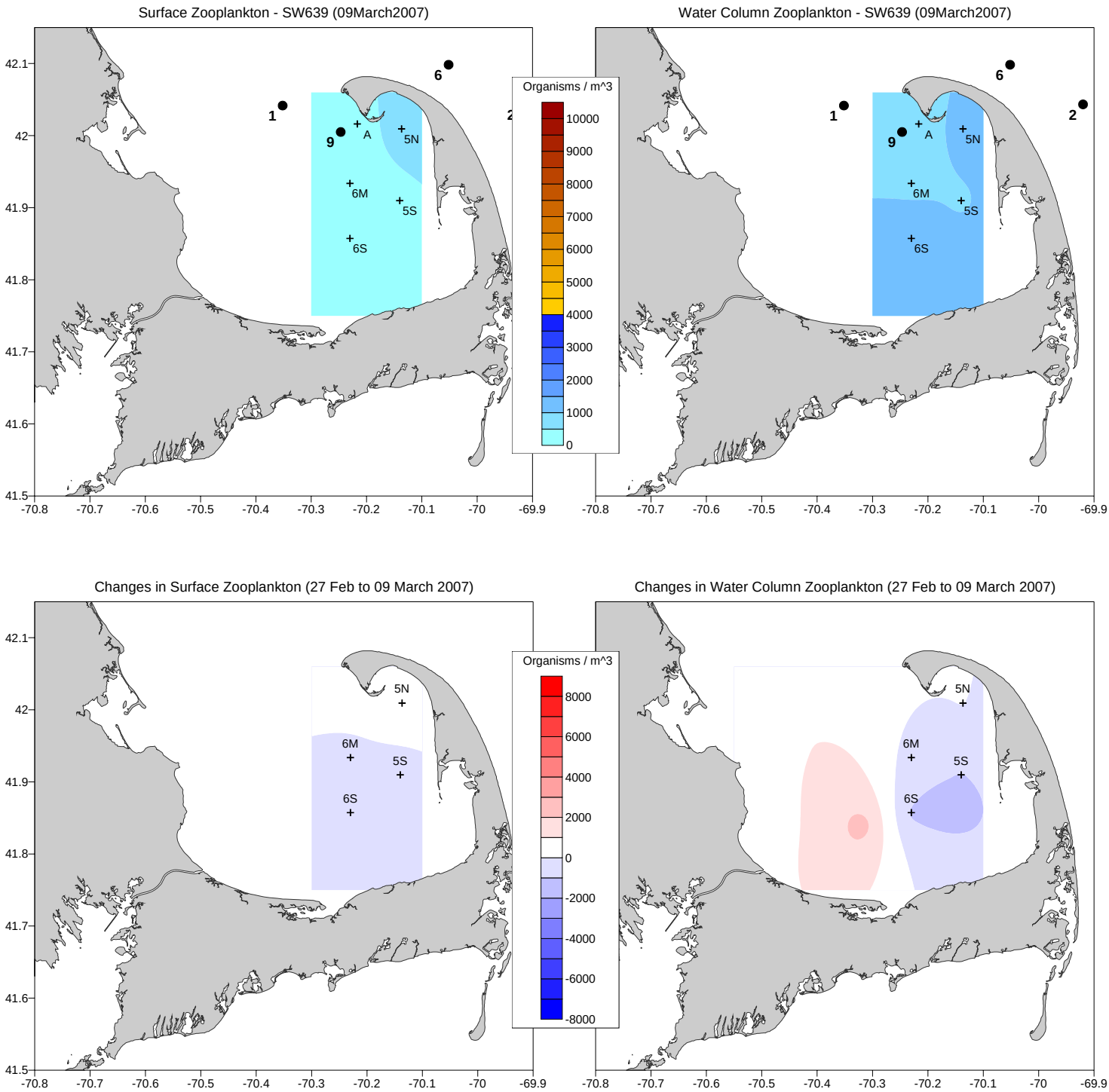


Figure A5. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 09 March 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 27 February and 09 March 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol. Approximate right whale locations are labeled with a "•" symbol and the number of individuals sighted, generally within a 2nm area.

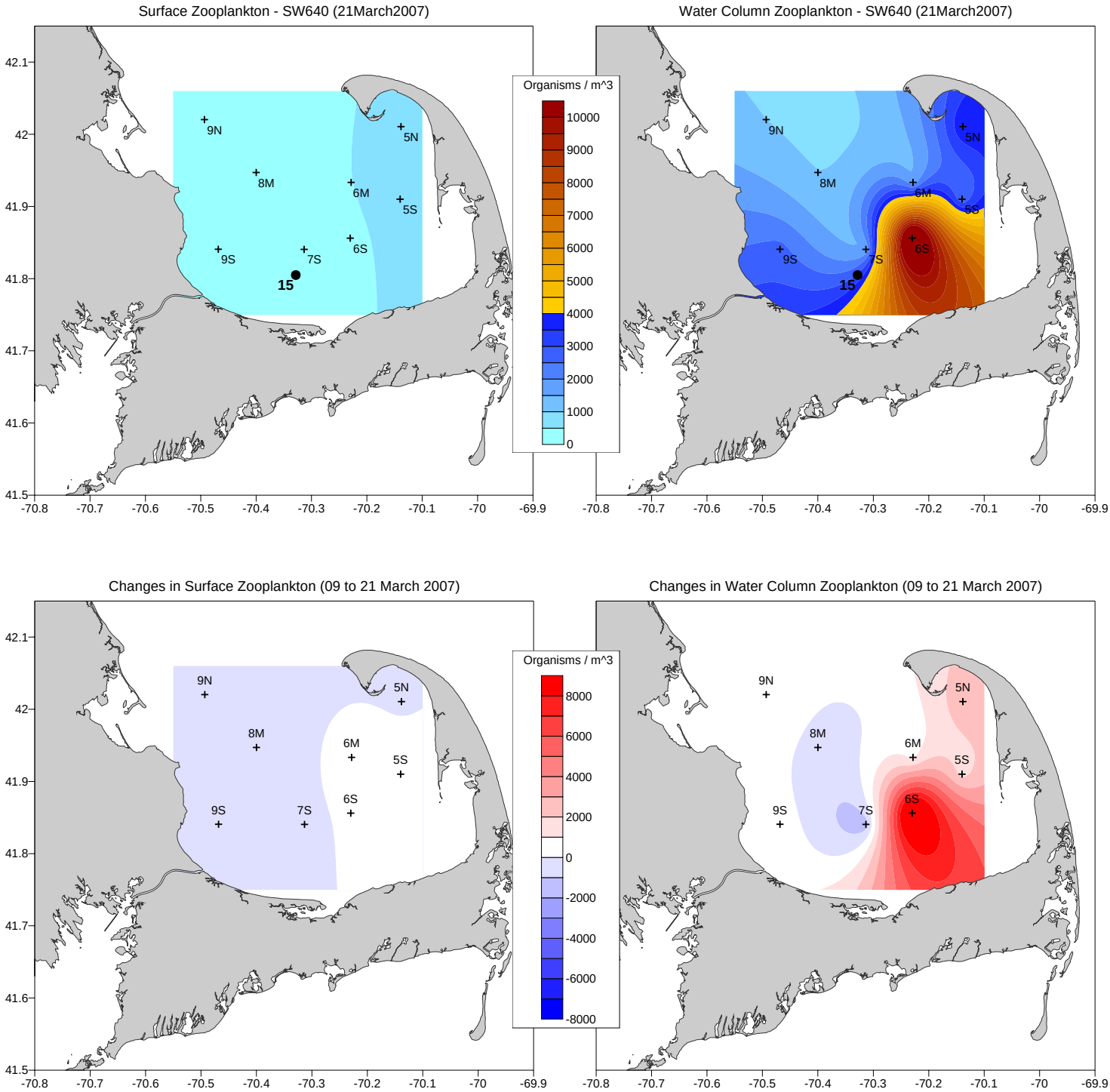


Figure A6. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 21 March 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 09 and 21 March 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol. Approximate right whale locations are labeled with a "•" symbol and the number of individuals sighted, generally within a 2nm area.

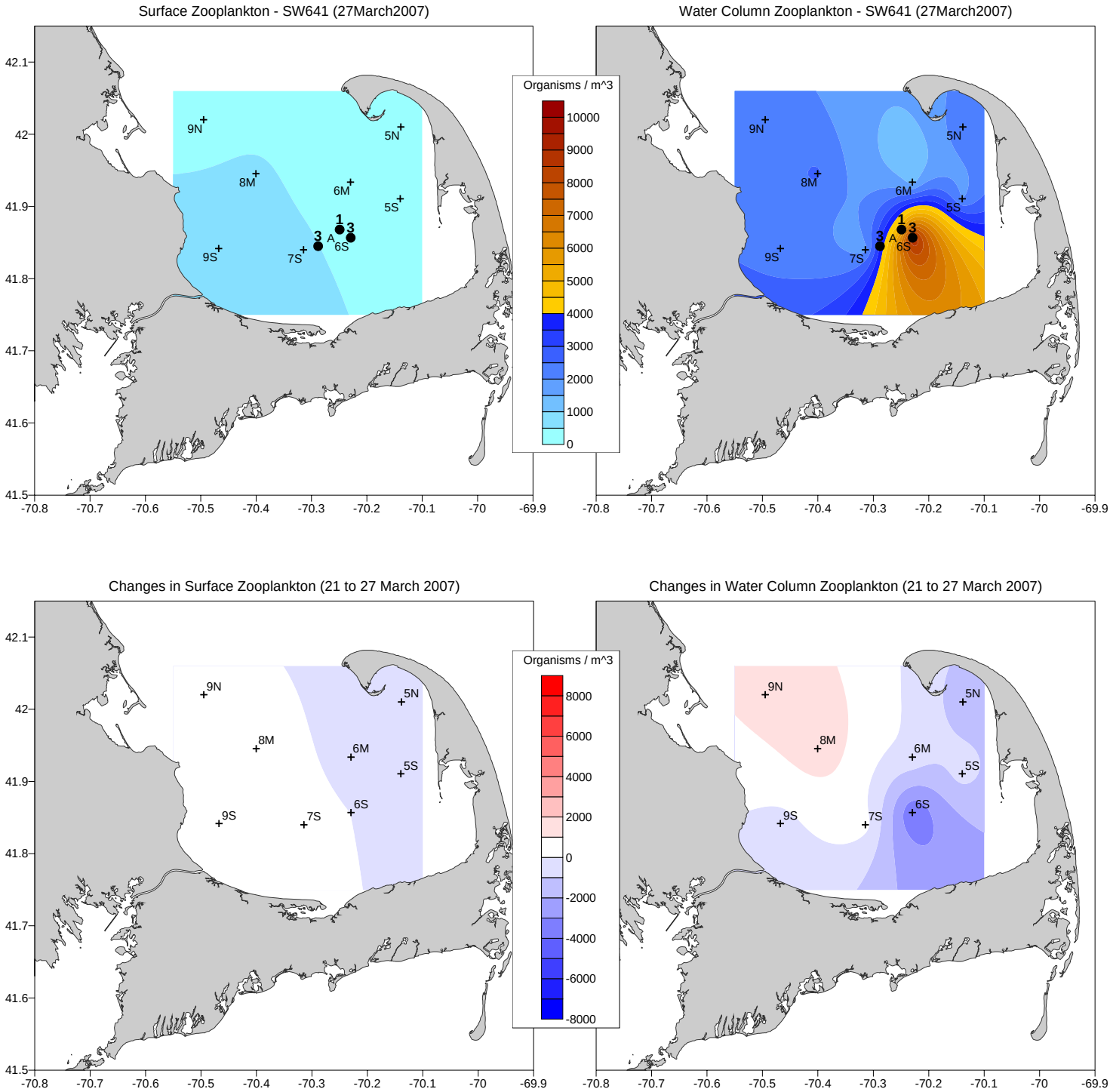


Figure A7. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 27 March 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 21 and 27 March 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol. Approximate right whale locations are labeled with a "•" symbol and the number of individuals sighted, generally within a 2nm area.

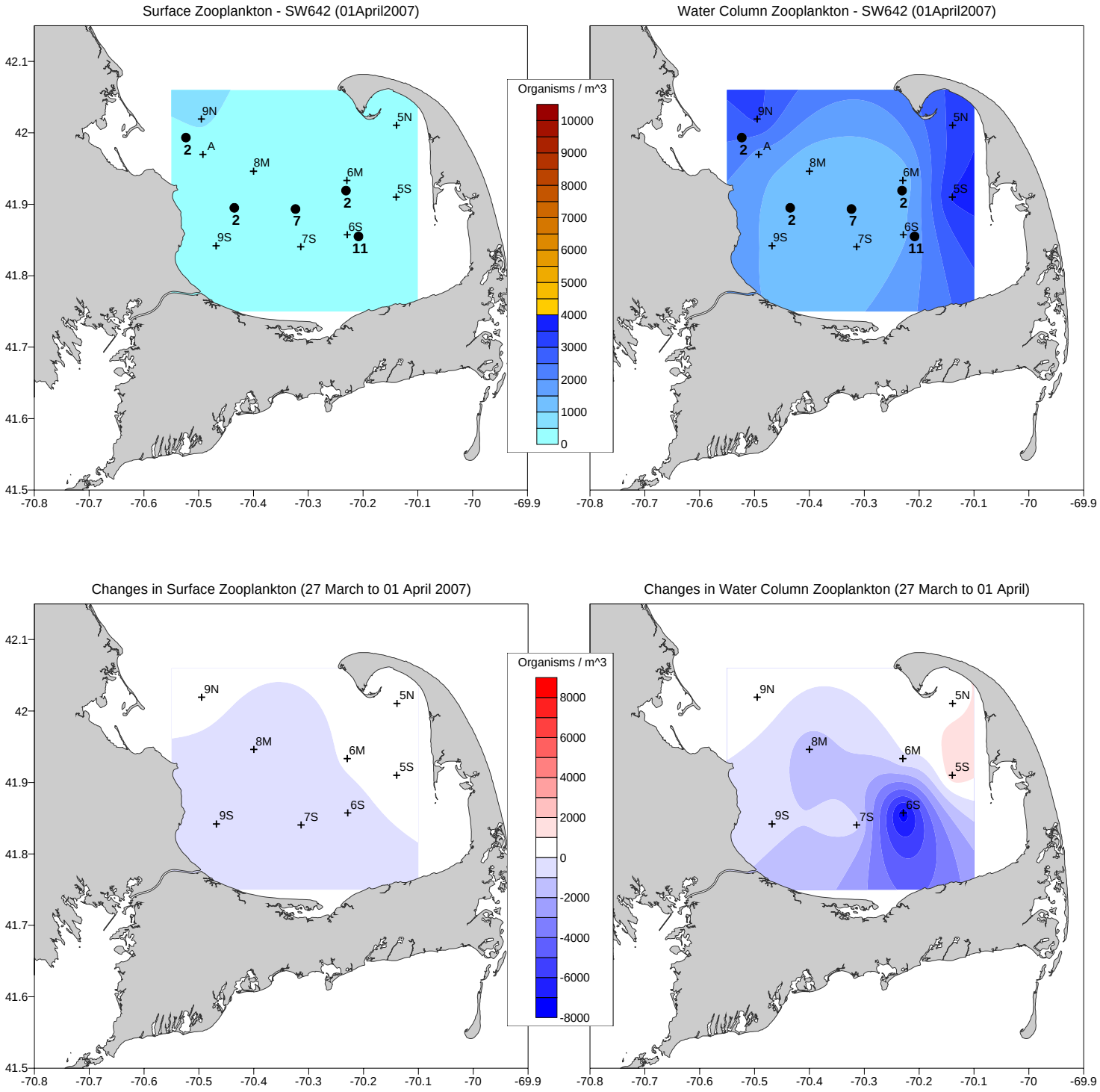


Figure A8. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 01 April 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 27 March and 01 April 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol. Approximate right whale locations are labeled with a "•" symbol and the number of individuals sighted, generally within a 2nm area.

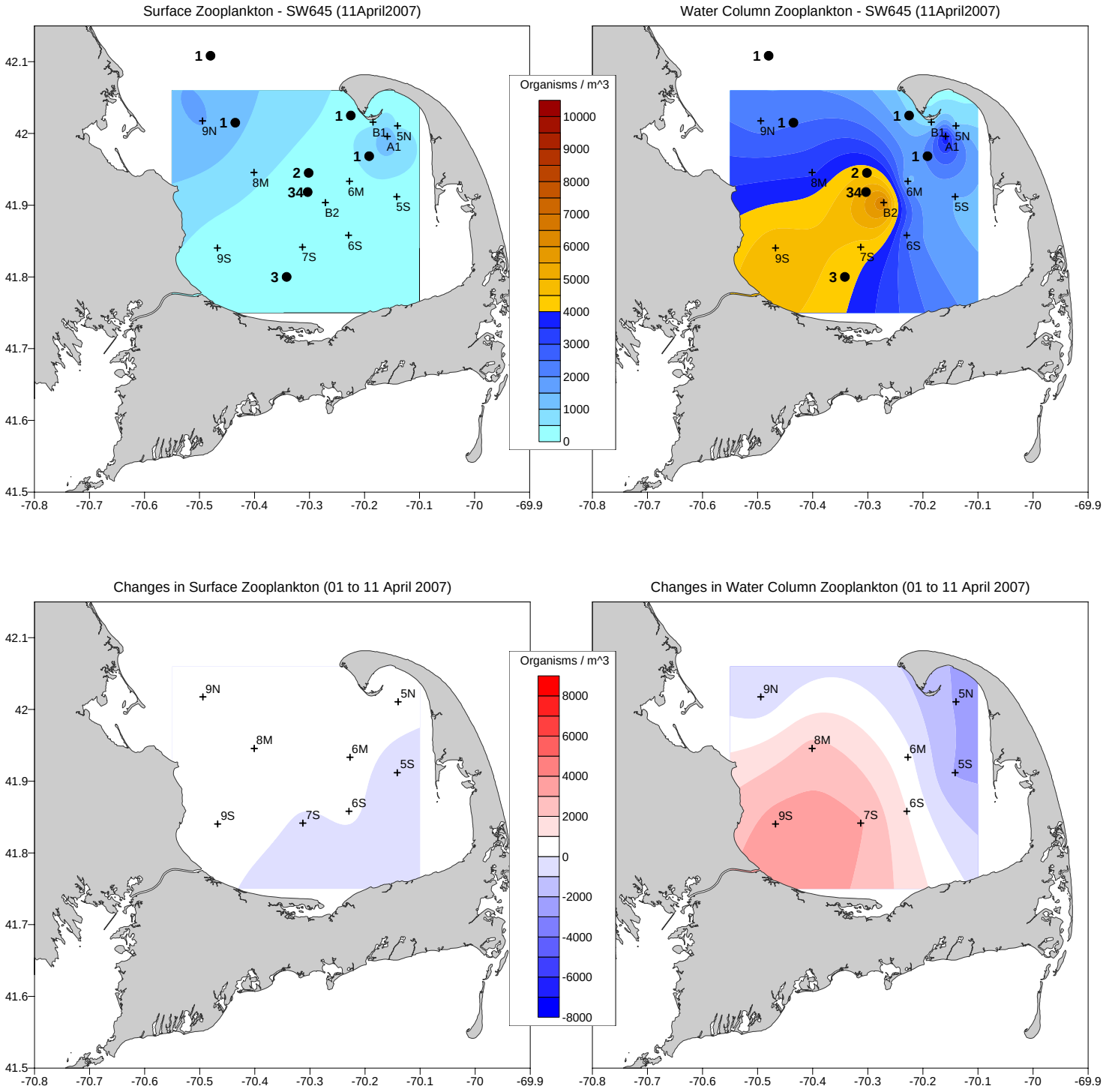


Figure A9. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 11 April 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 01 and 11 April 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol. Approximate right whale locations are labeled with a "•" symbol and the number of individuals sighted, generally within a 2nm area.

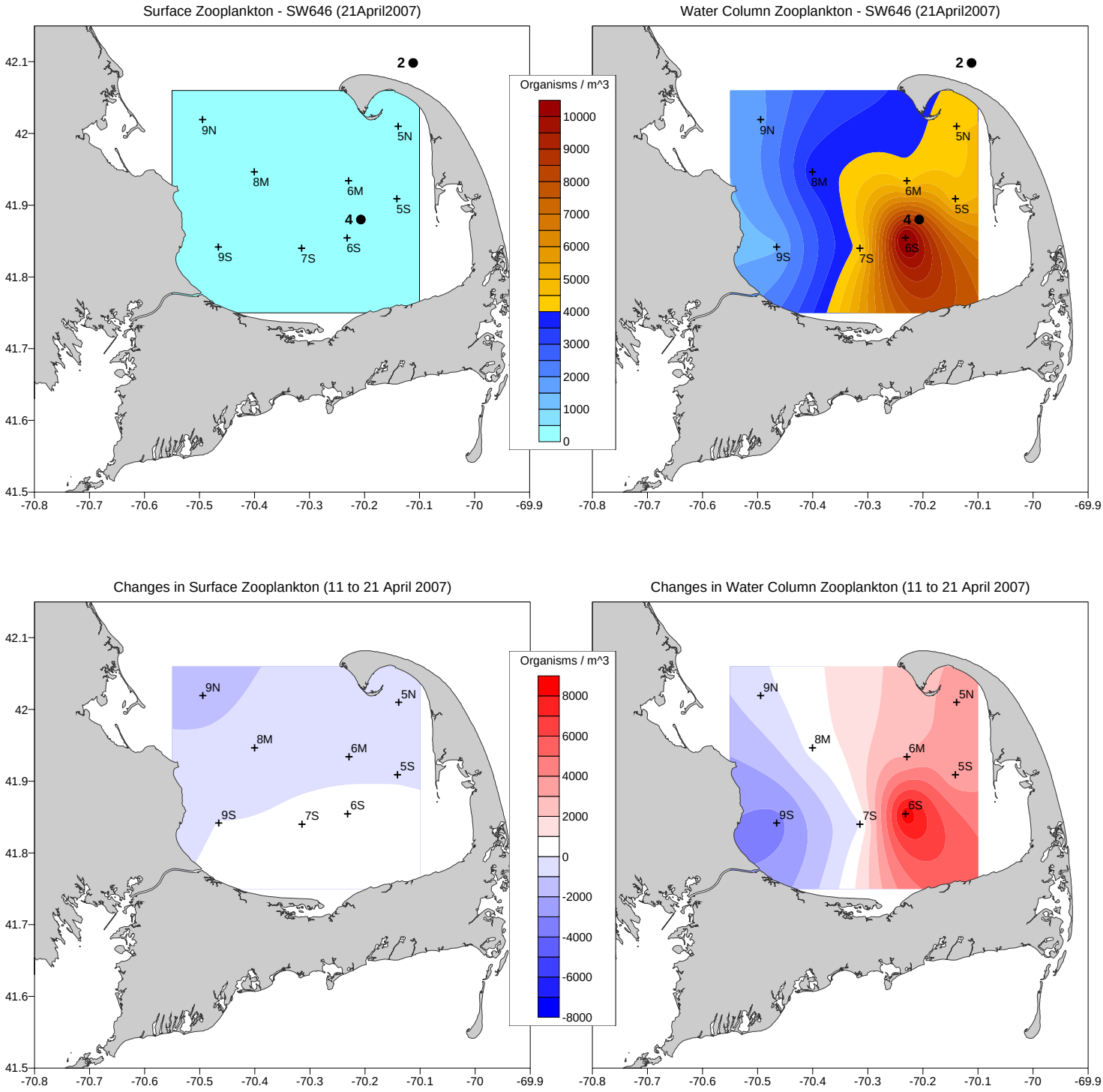


Figure A10. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 21 April 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 11 to 21 April 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol. Approximate right whale locations are labeled with a "●" symbol and the number of individuals sighted, generally within a 2nm area.

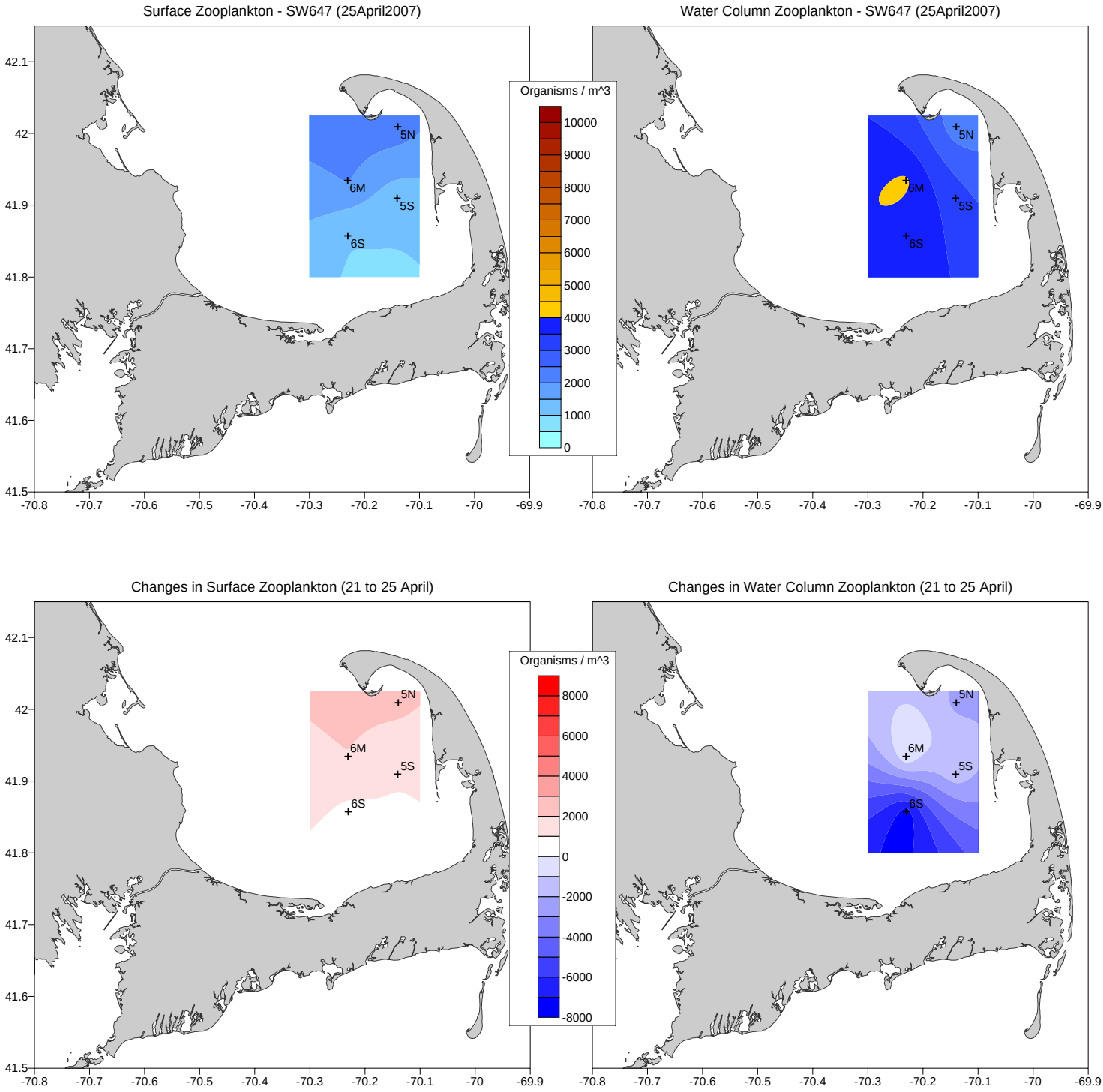


Figure A11. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 25 April 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 21 to 25 April 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol.

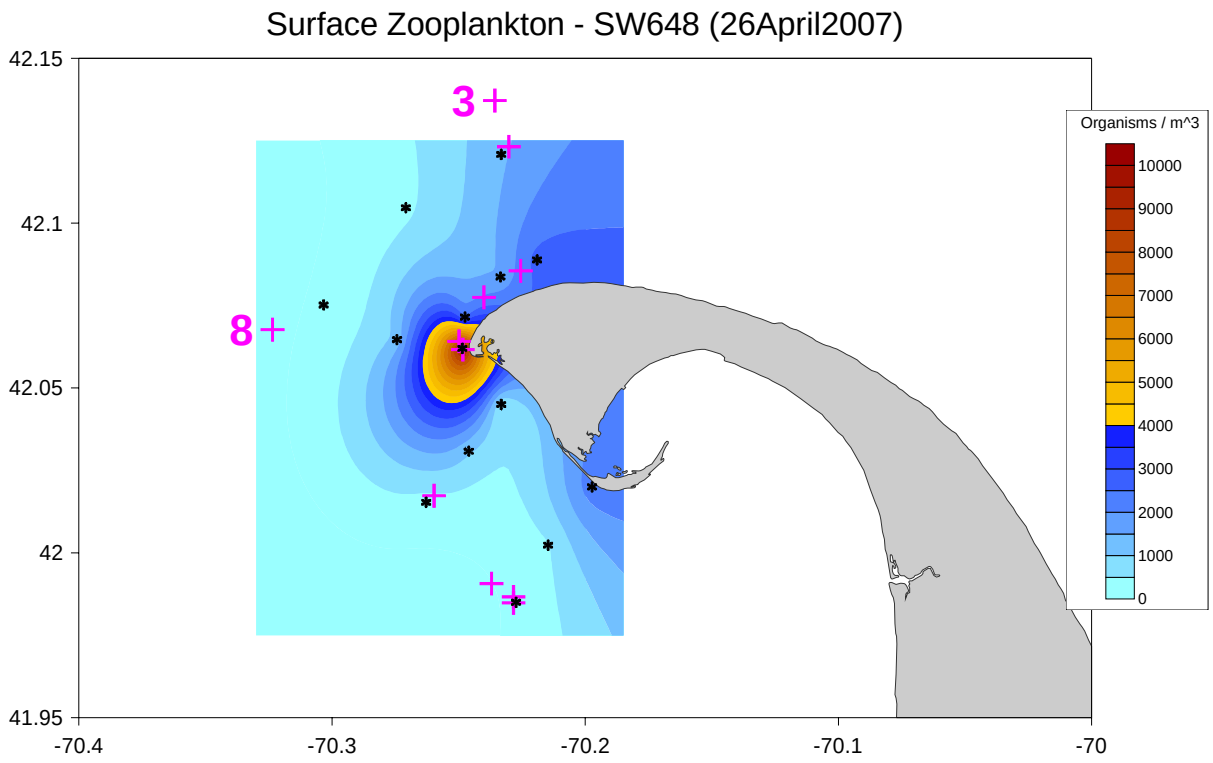


Figure A12. Zooplankton density distribution from intense resource sampling around the tip of Cape Cod on 26 April 2007, with shore-perpendicular transects (2-3 stations per transect) beginning near Wood End and extending around Race Point along the backside to the Race Point coast guard station. Sampling station locations are indicated with a "✱" symbol. Approximate right whale locations are labeled with a "+" symbol and the number of individuals sighted, generally within a 2nm area (if no number is presented, the sighting represents a single animal).

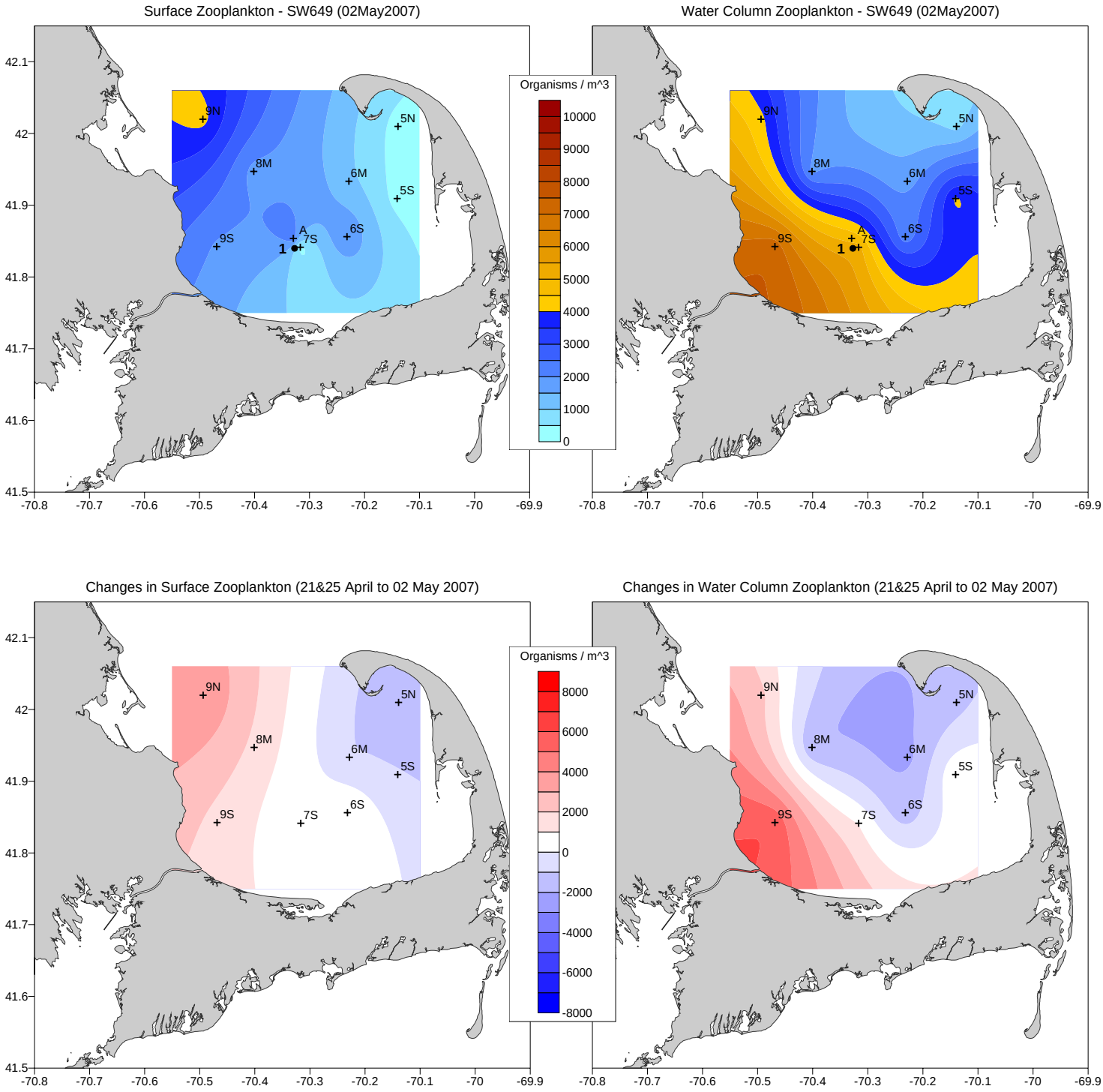


Figure A13. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 02 May 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 21&25 April and 02 May 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol. Approximate right whale locations are labeled with a "•" symbol and the number of individuals sighted, generally within a 2nm area.

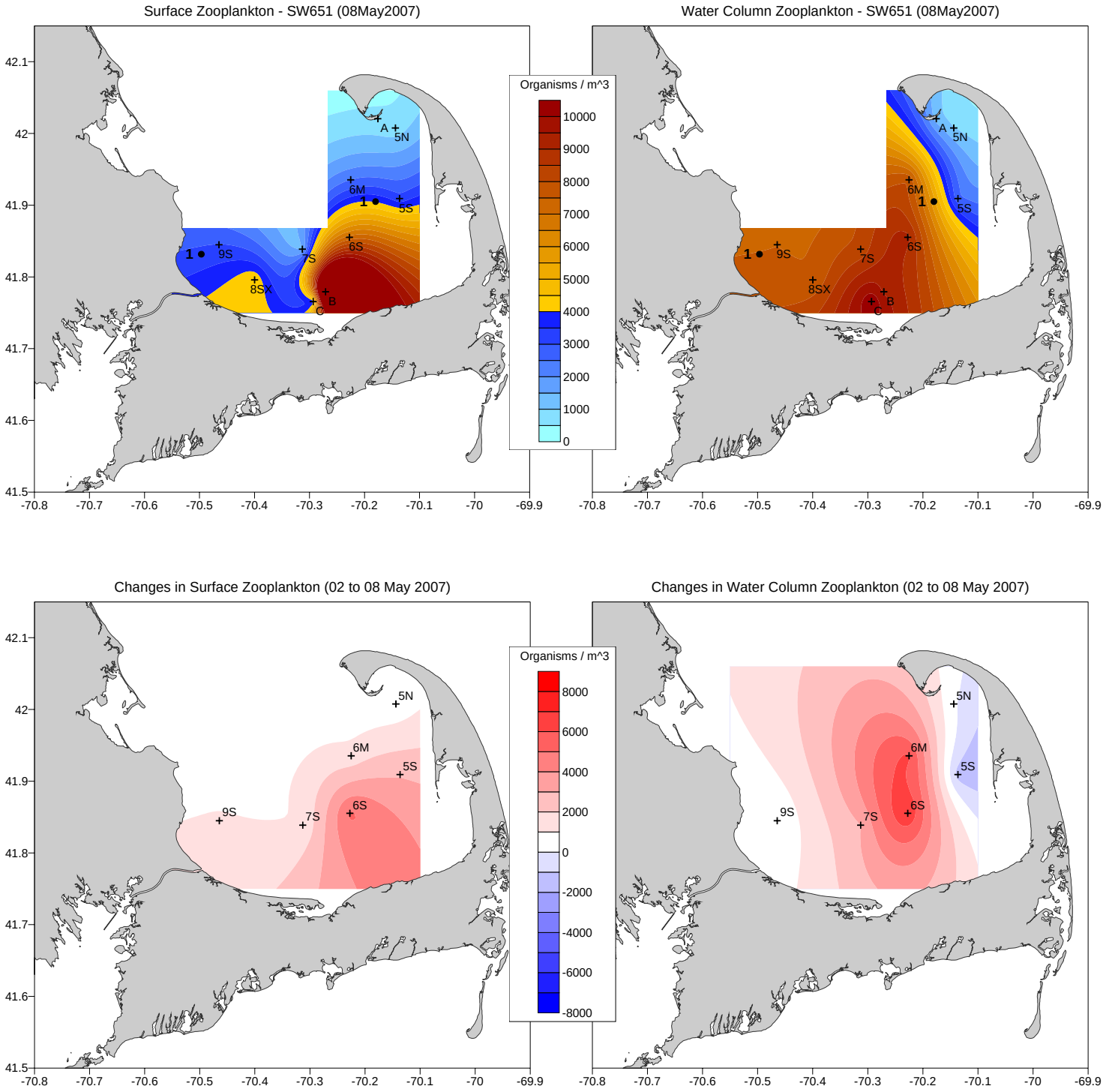


Figure A14. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 08 May 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 02 and 08 May 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol. Approximate right whale locations are labeled with a "•" symbol and the number of individuals sighted, generally within a 2nm area.

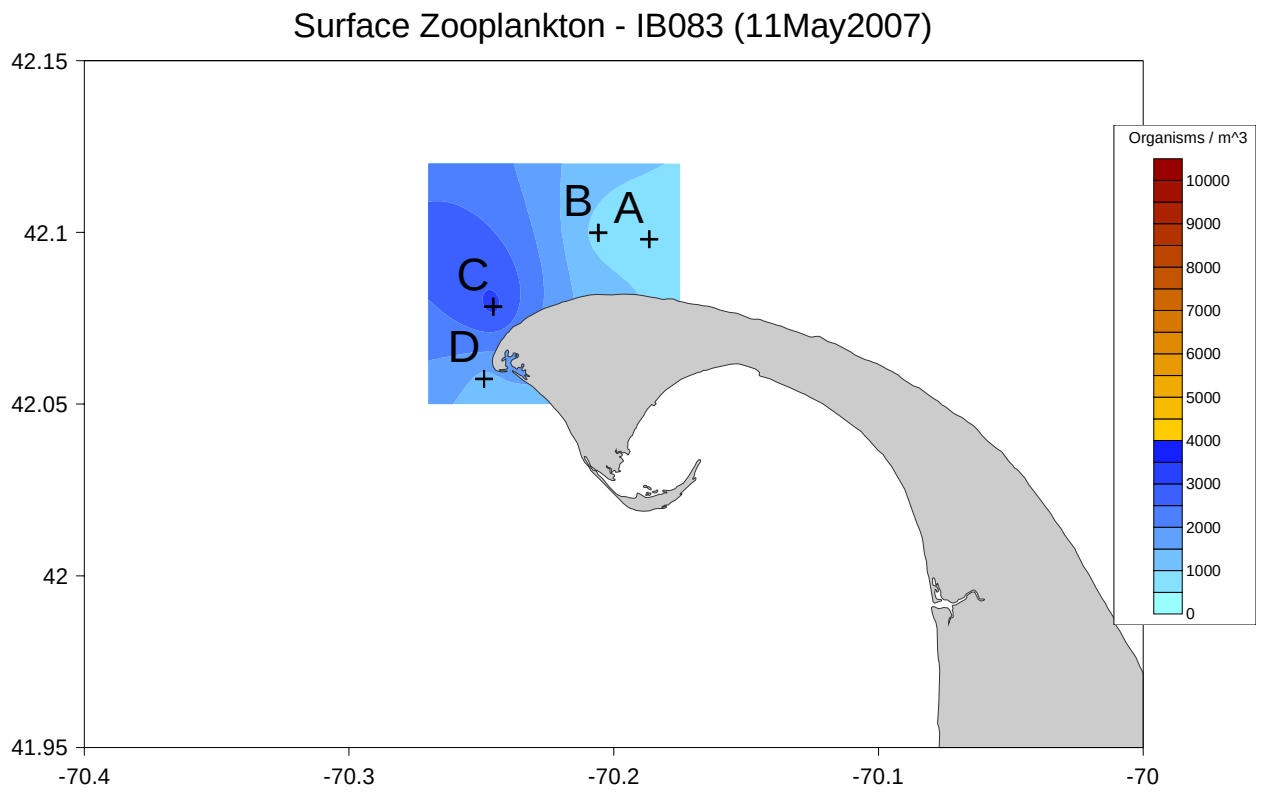


Figure A15. Zooplankton density distribution around the tip of Cape Cod on 11 May 2007 from surface collections. Sampling station locations are indicated with a "+" symbol.

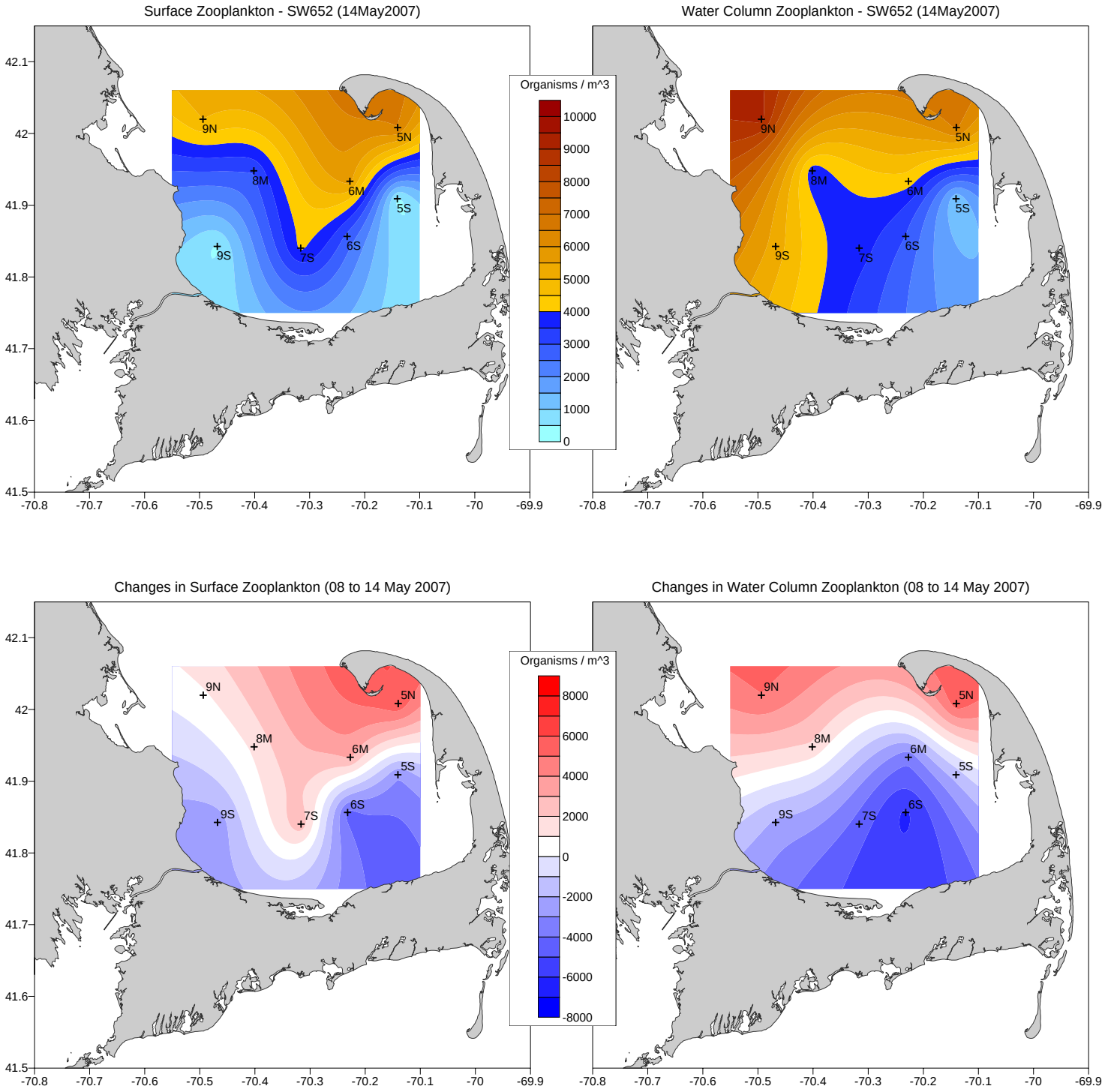


Figure A16. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 14 May 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 08 and 14 May, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol.

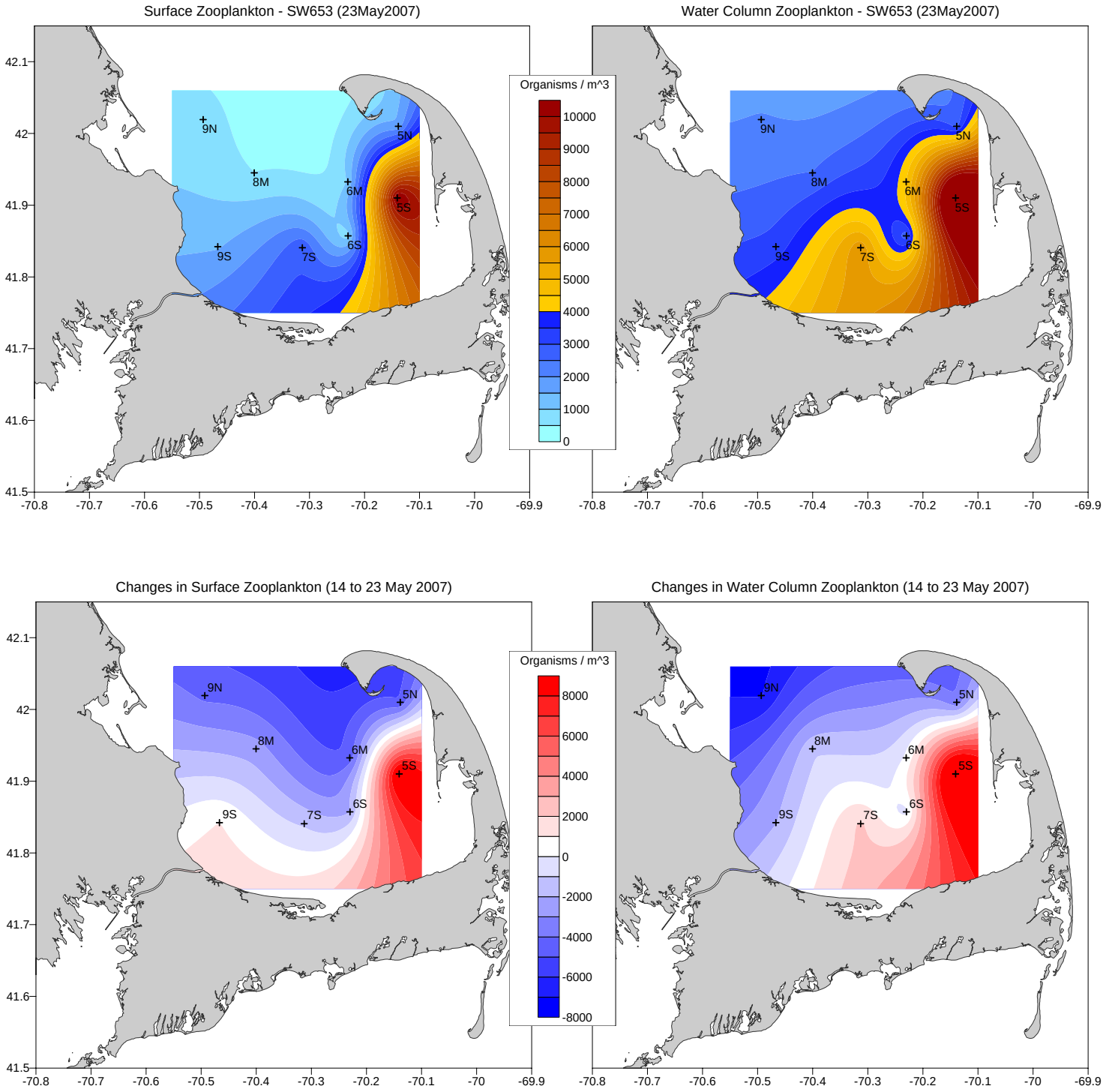


Figure A17. *Upper plots*: **Zooplankton density distribution** in Cape Cod Bay on 23 May 2007 from surface (left) and water column (right) collections. *Lower plots*: Spatial distribution of **zooplankton density changes** between 14 and 23 May 2007, with surface density changes displayed at left and water column density changes presented at right. Sampling station locations are indicated with a "+" symbol.

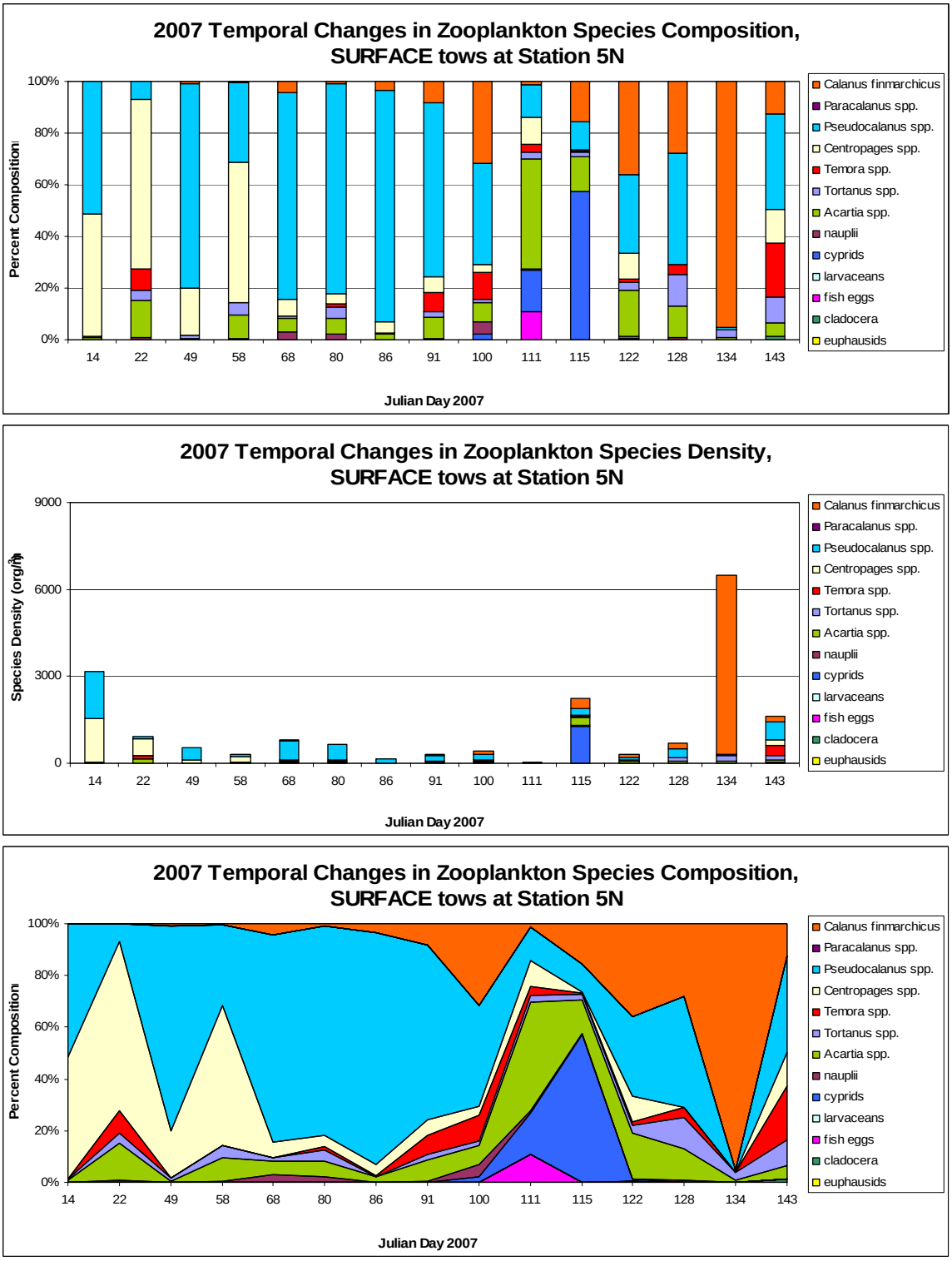


Figure A18. Temporal progression of <u>surface</u> zooplankton species at Station 5N in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)

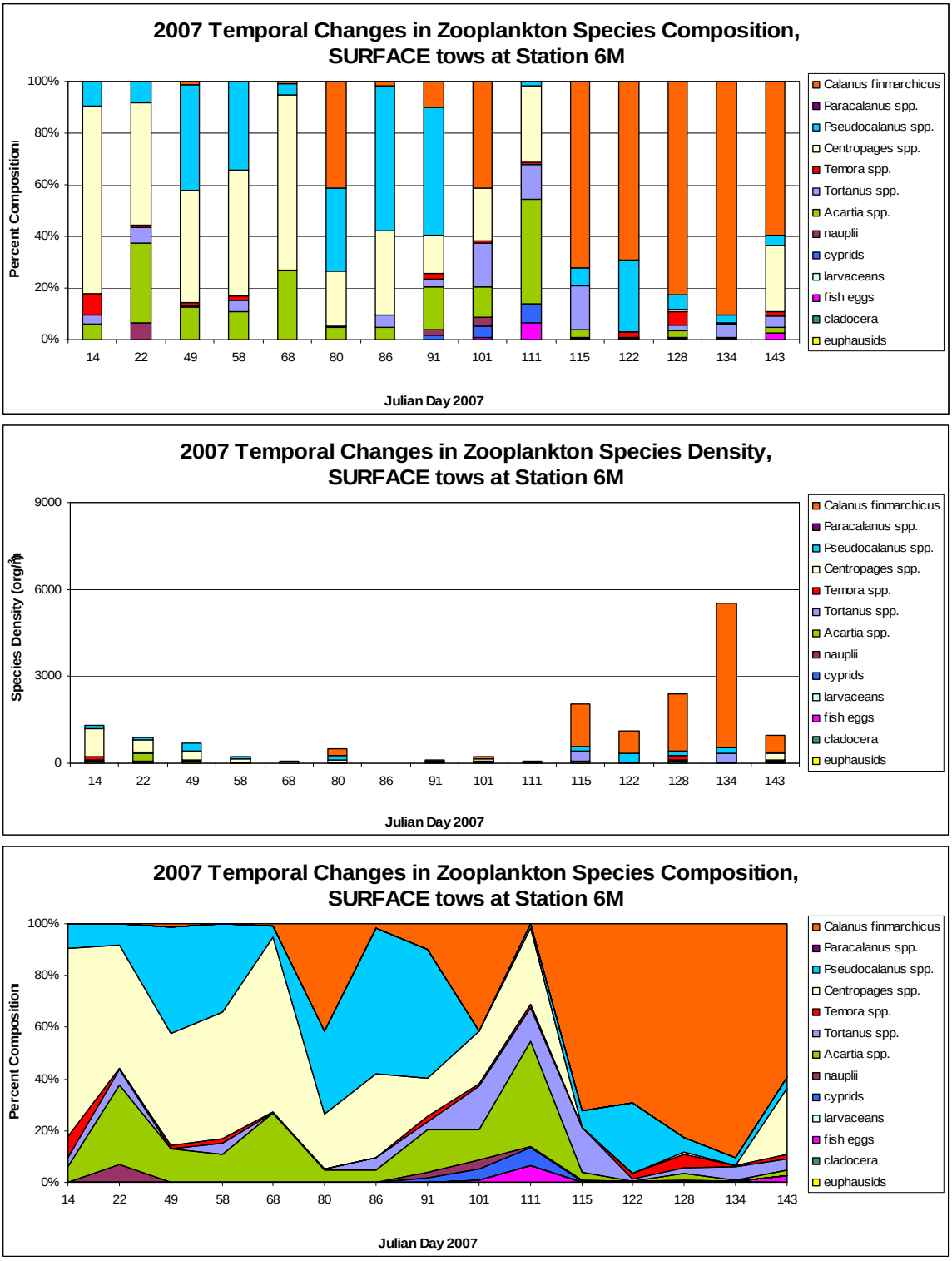
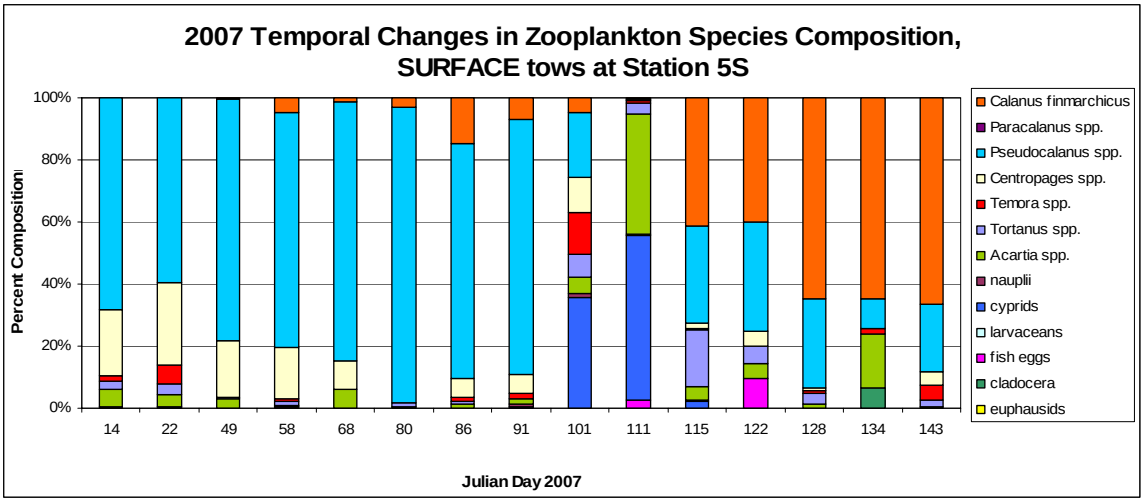
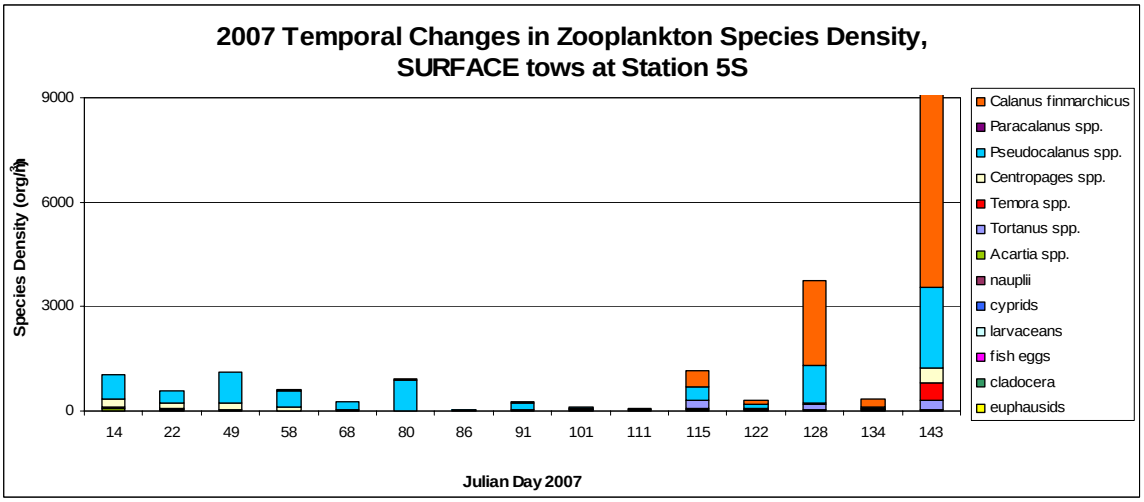


Figure A19. Temporal progression of <u>surface</u> zooplankton species at Station 6M in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)





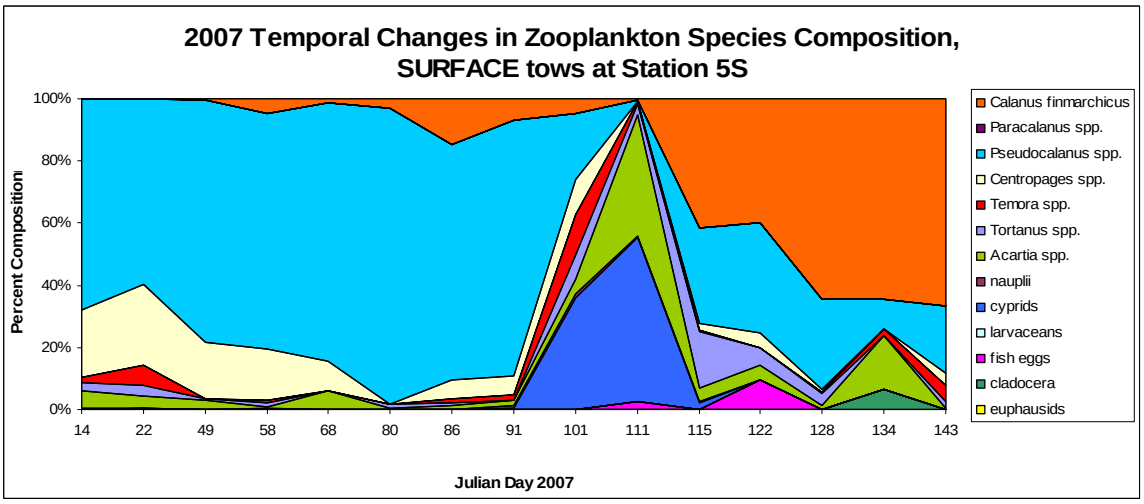


Figure A20. Temporal progression of <u>surface</u> zooplankton species at Station 5S in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)

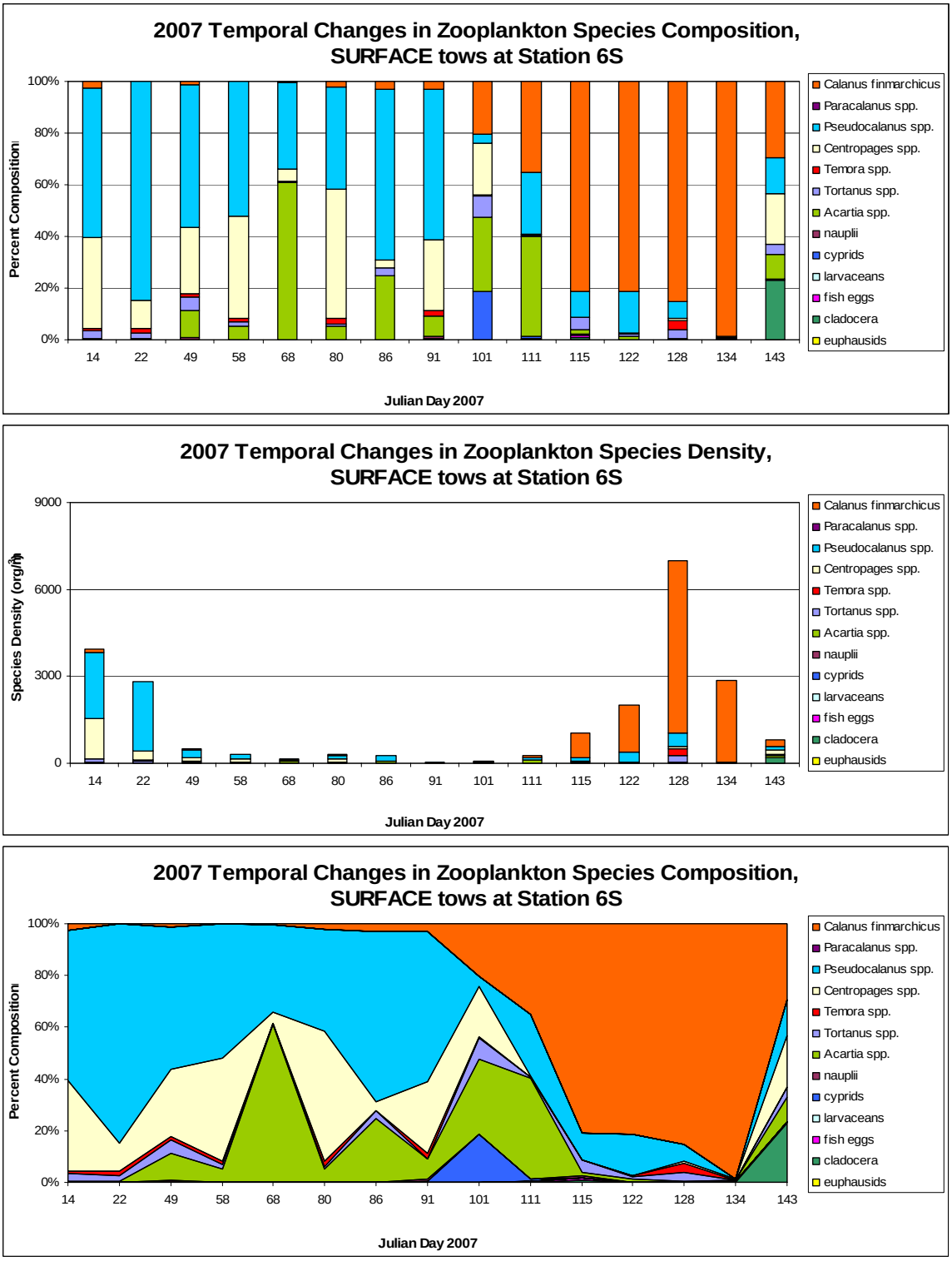


Figure A21. Temporal progression of <u>surface</u> zooplankton species at Station 6S in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)

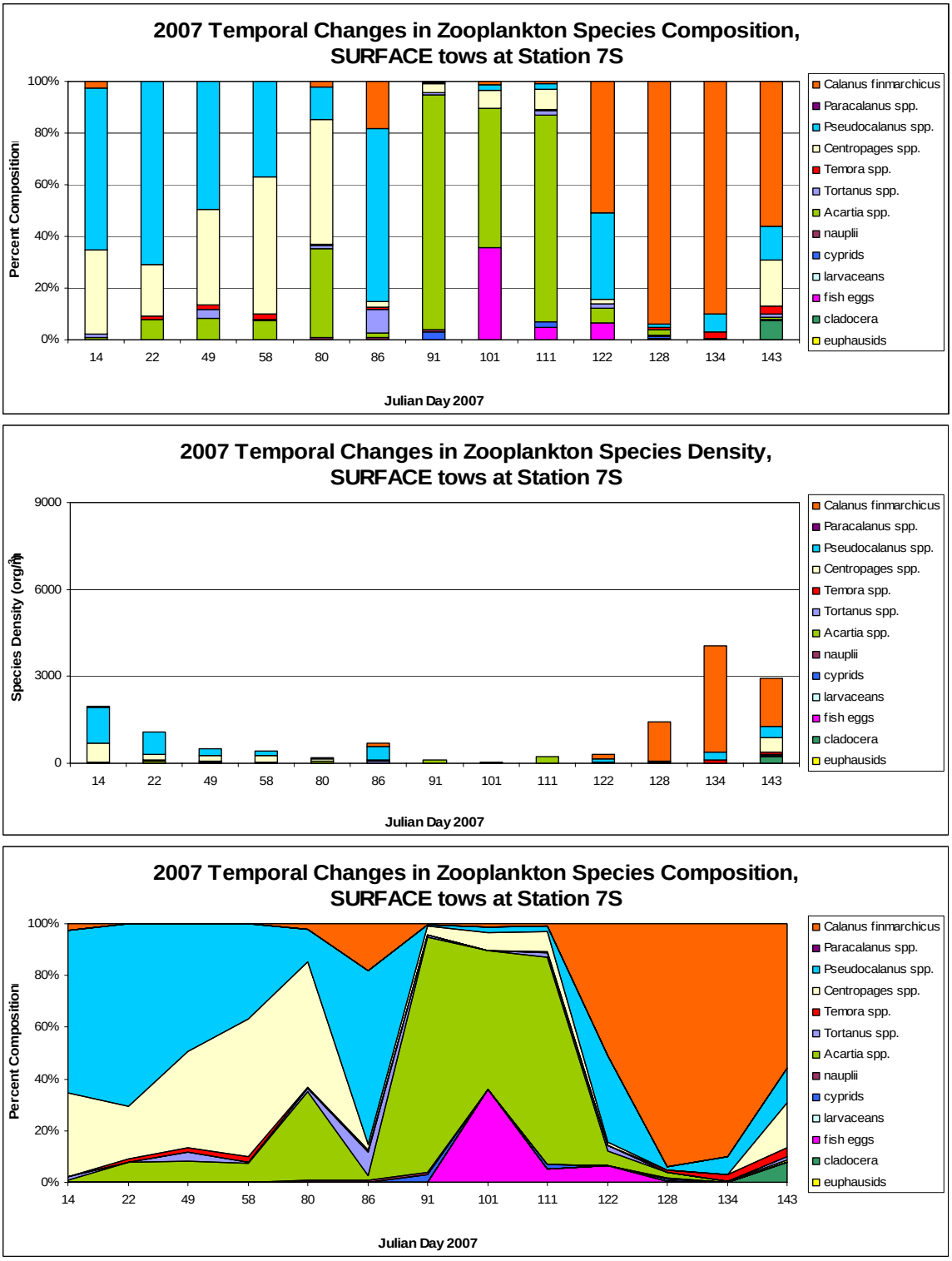
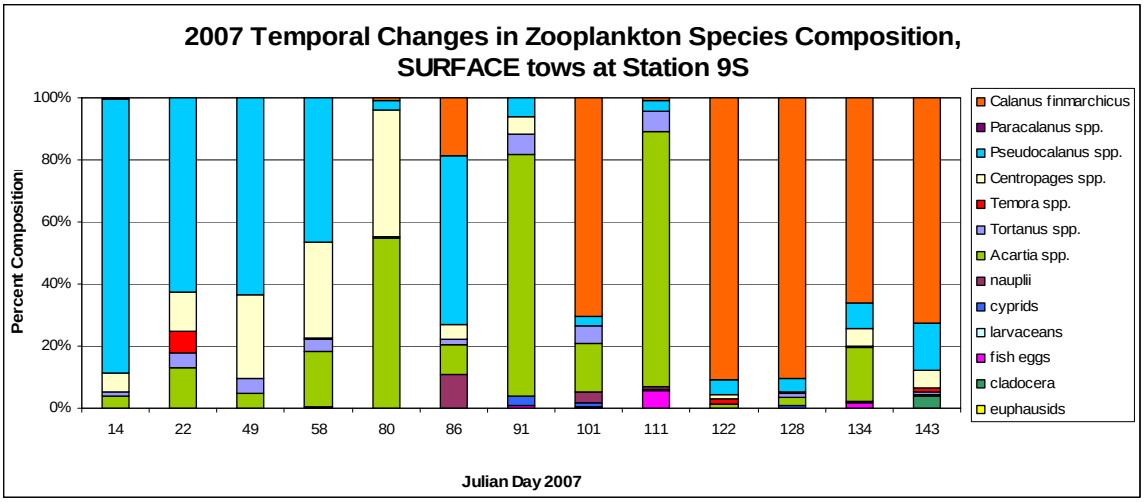
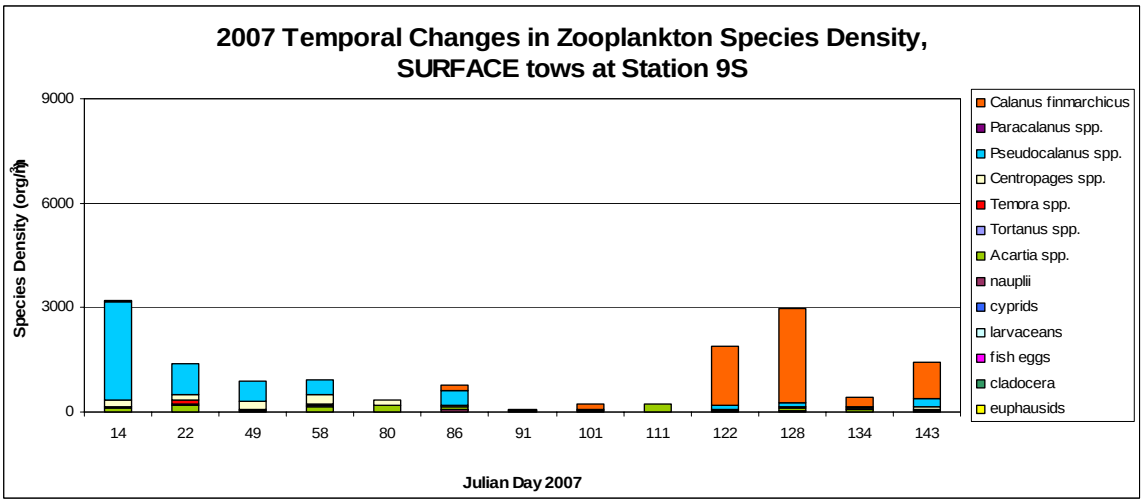


Figure A22. Temporal progression of <u>surface</u> zooplankton species at Station 7S in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)





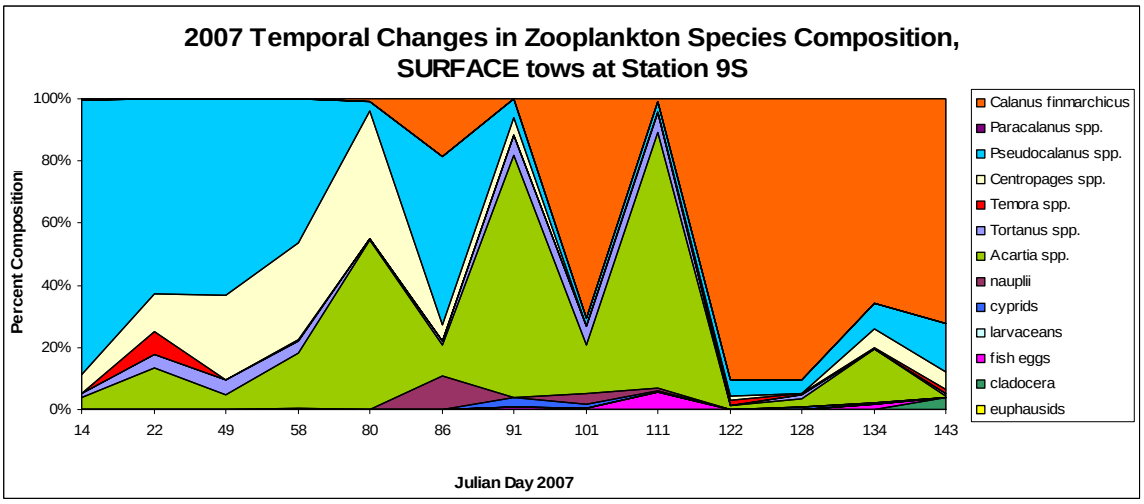


Figure A23. Temporal progression of <u>surface</u> zooplankton species at Station 9S in 2007;
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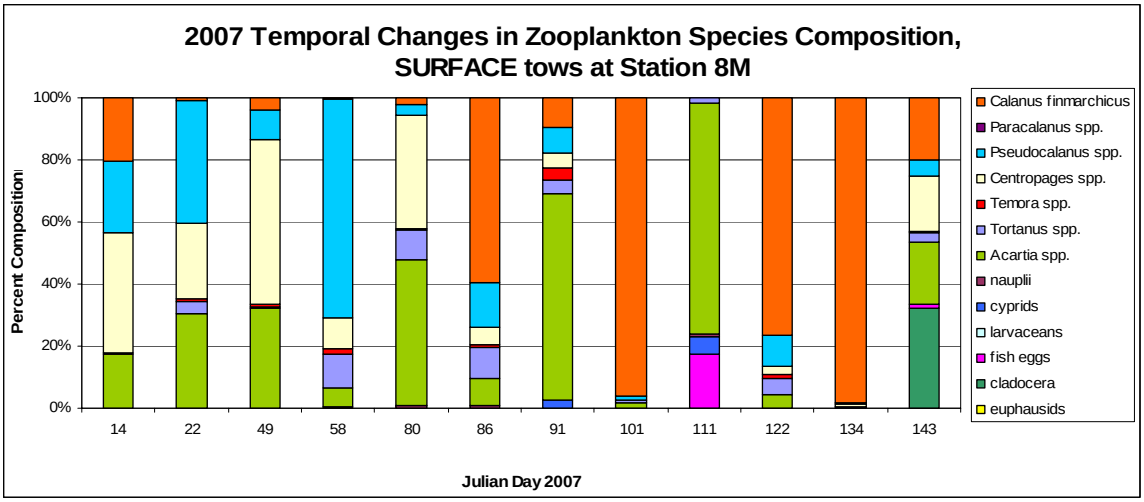
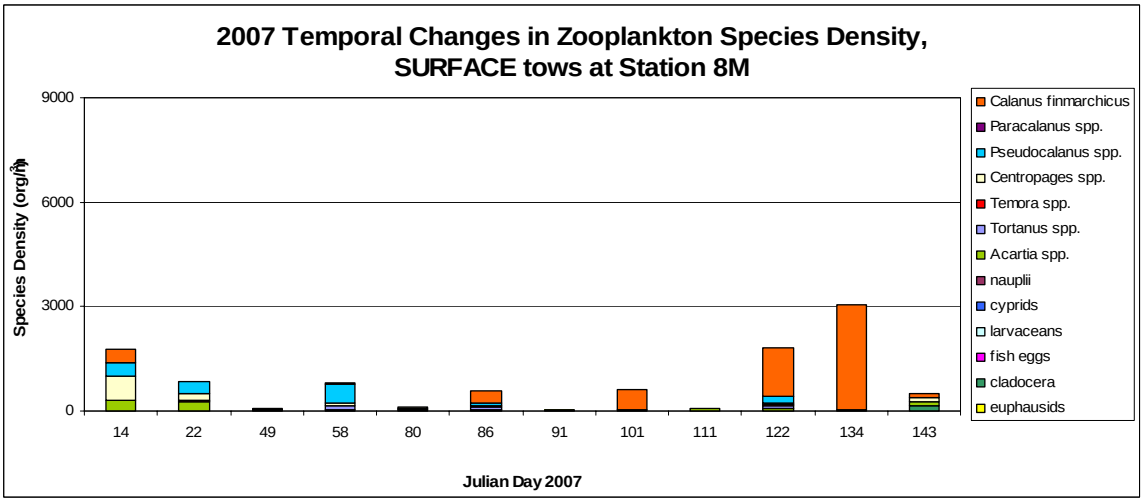
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)





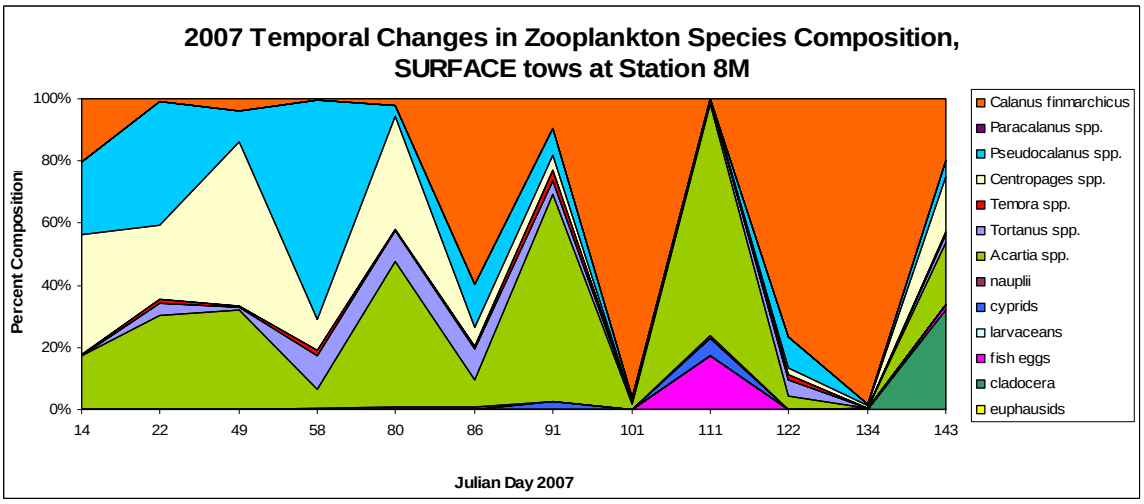
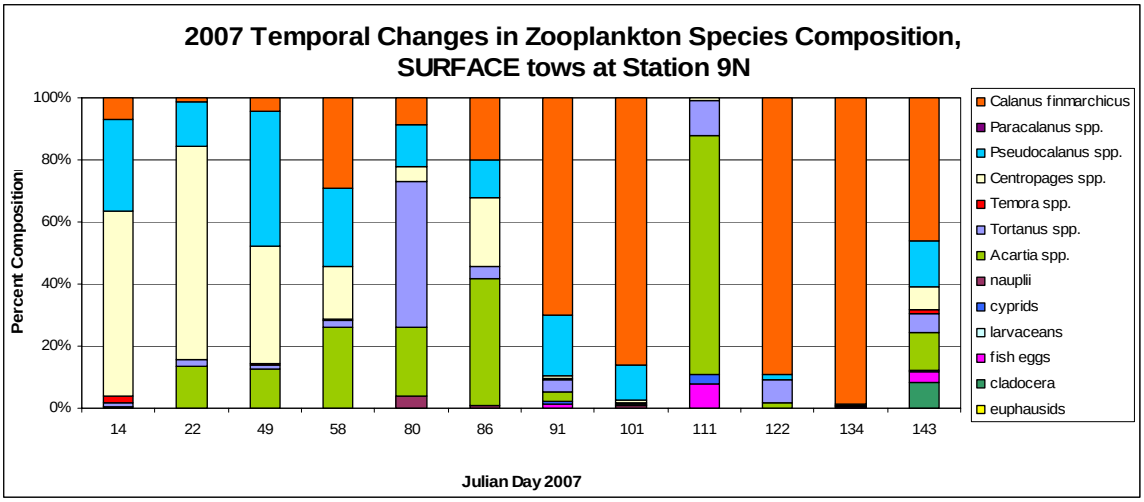
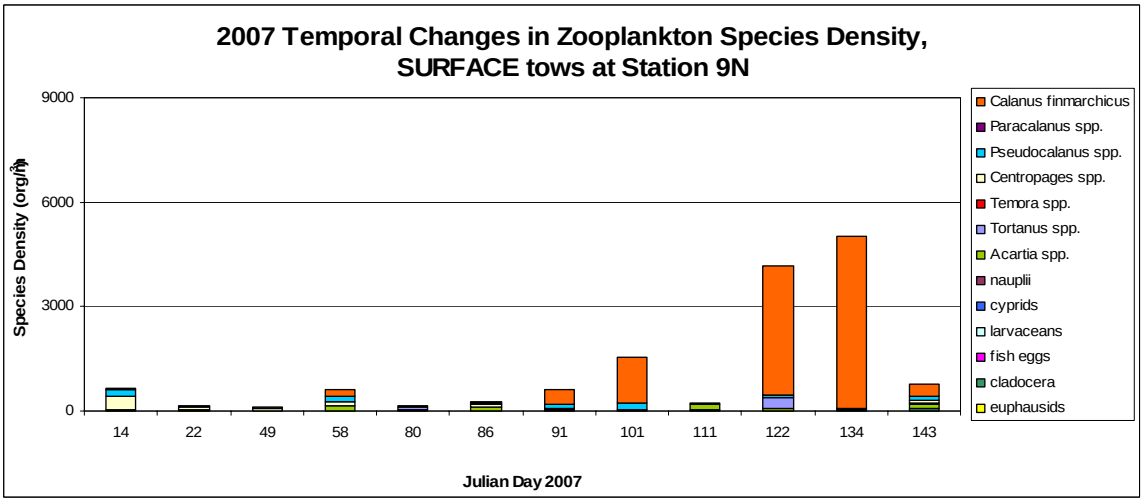


Figure A24. Temporal progression of <u>surface</u> zooplankton species at Station 8M in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)





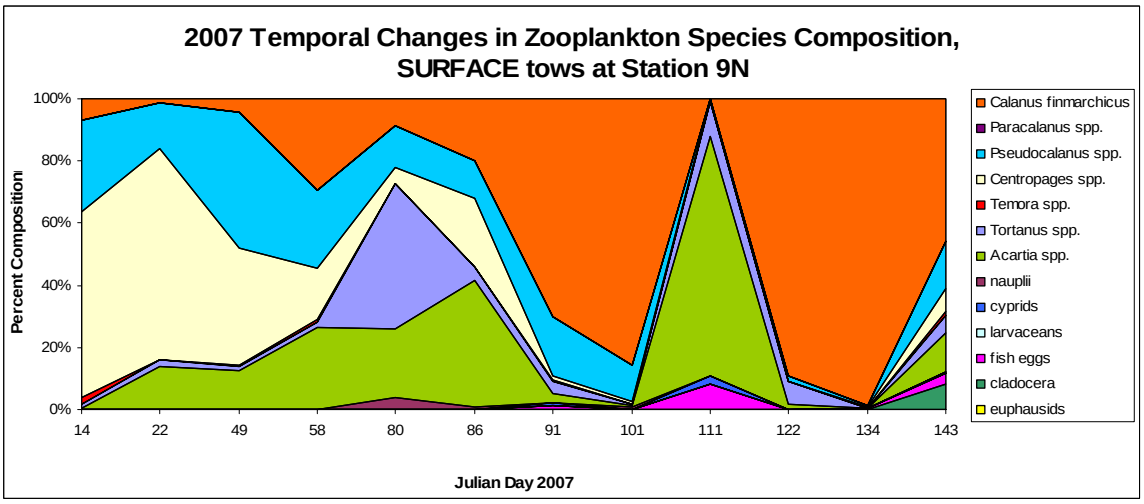


Figure A25. Temporal progression of <u>surface</u> zooplankton species at Station 9N in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)

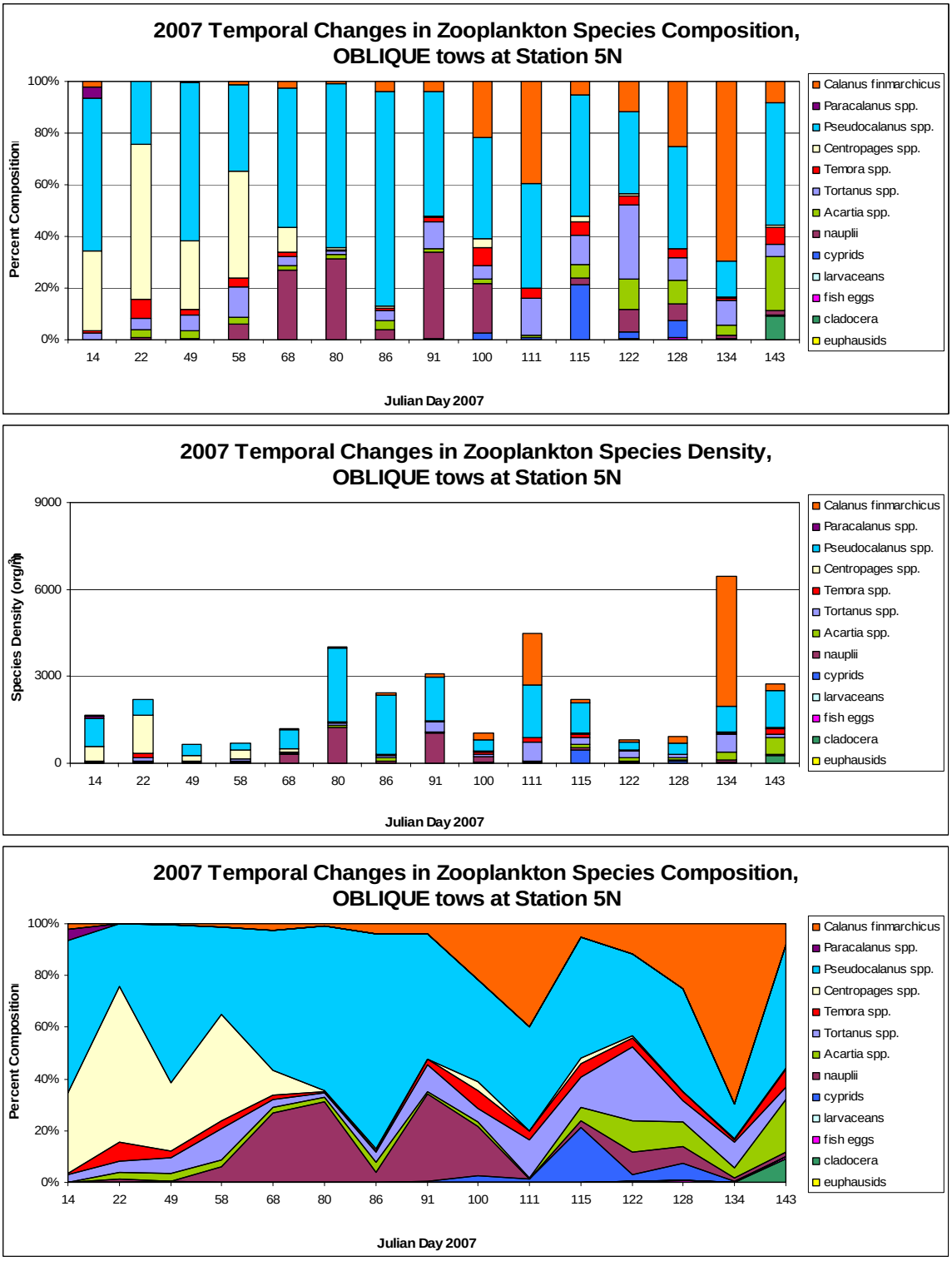
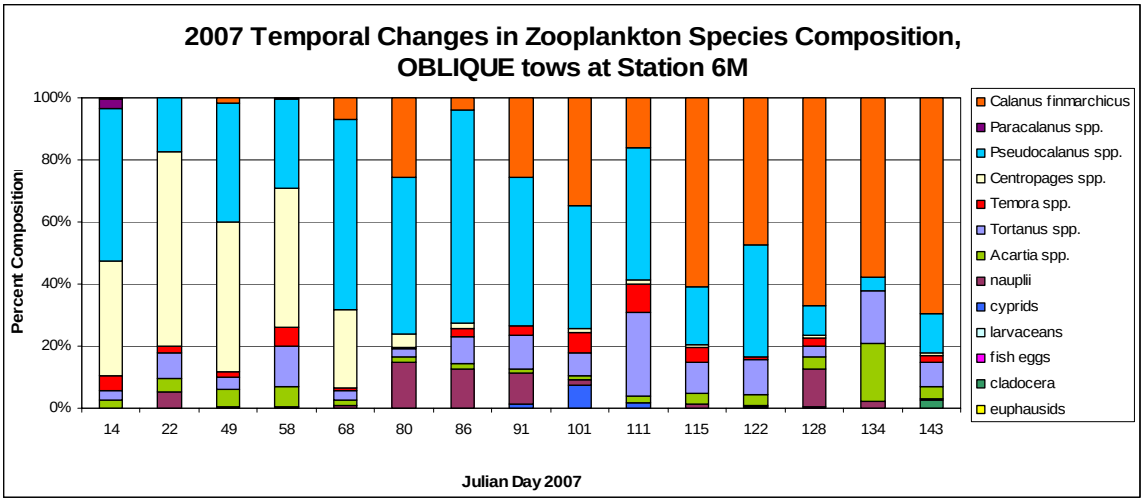
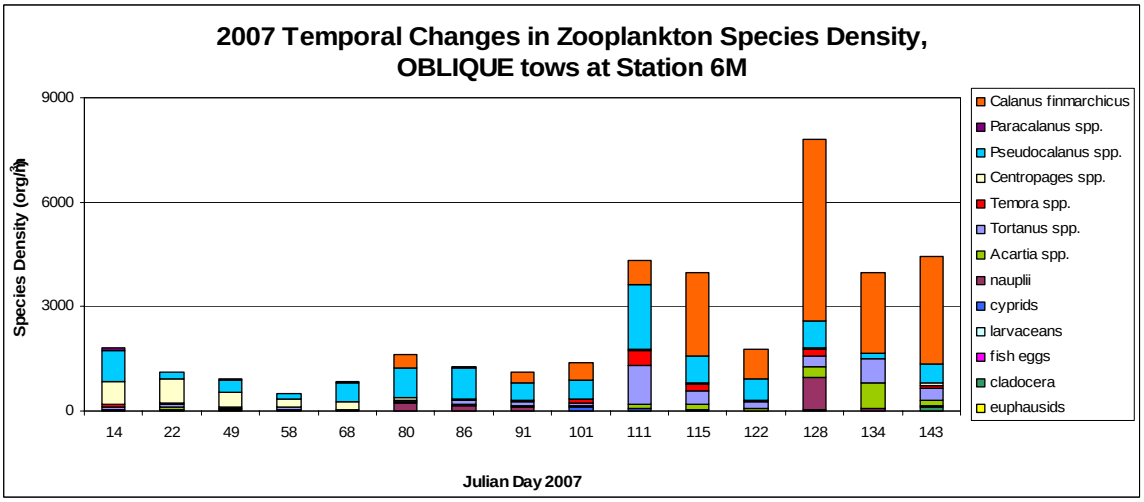


Figure A26. Temporal progression of <u>water column</u> zooplankton species at Station 5N in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)





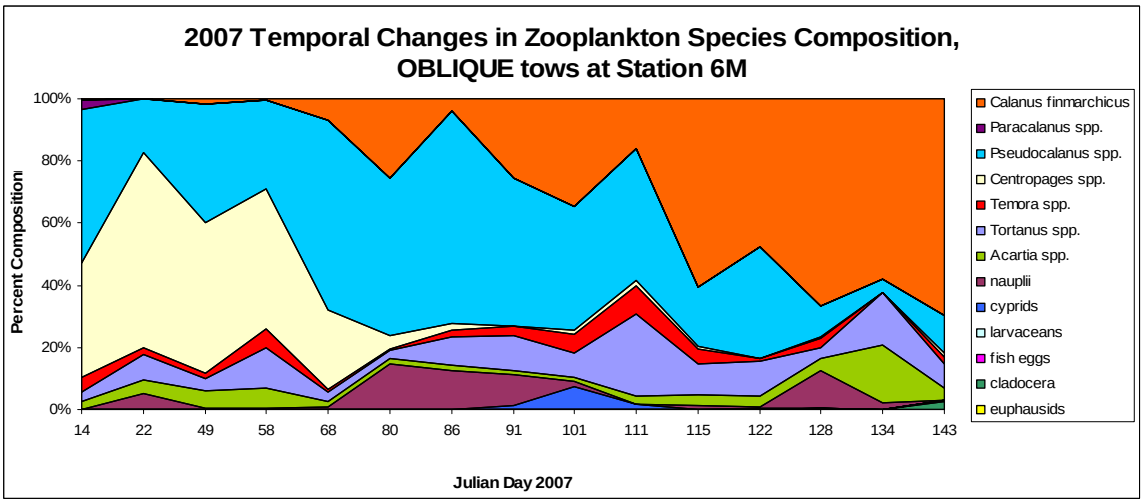


Figure A27. Temporal progression of <u>water column</u> zooplankton species at Station 6M in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)

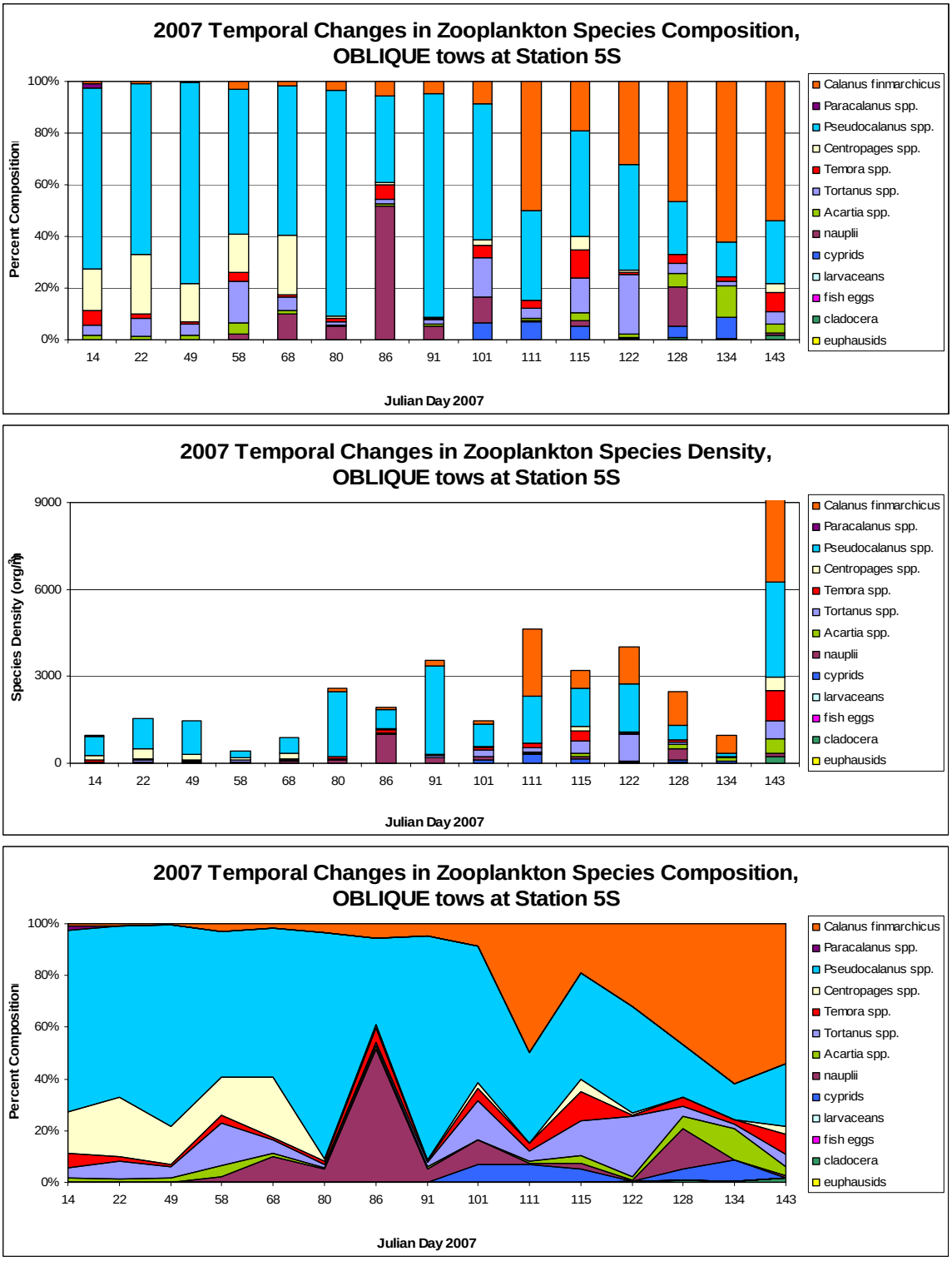
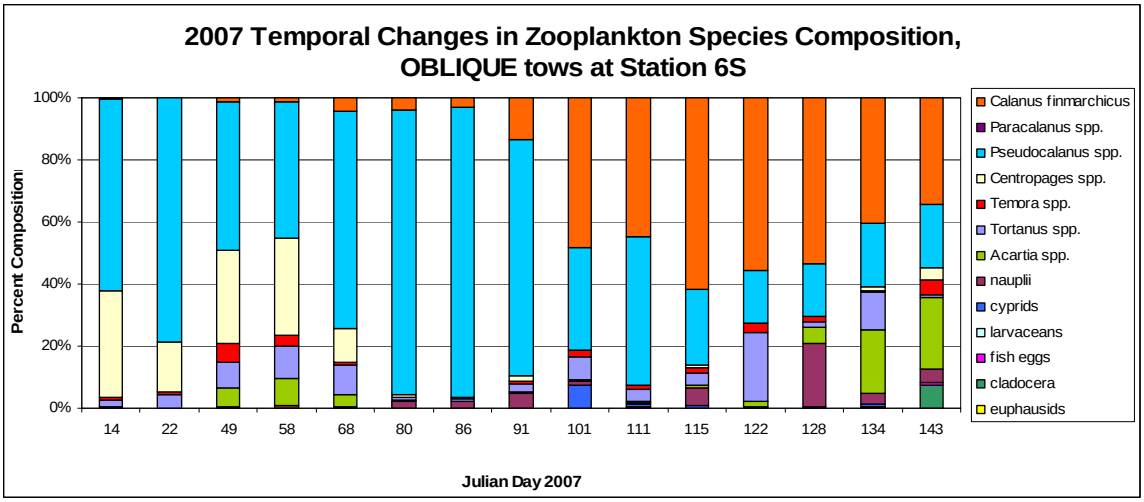
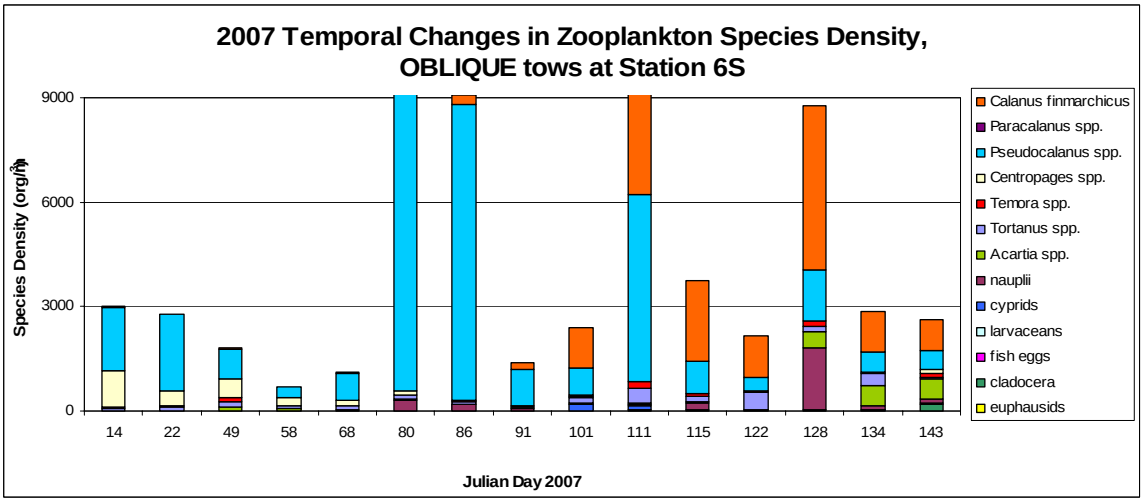


Figure A28. Temporal progression of <u>water column</u> zooplankton species at Station 5S in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)





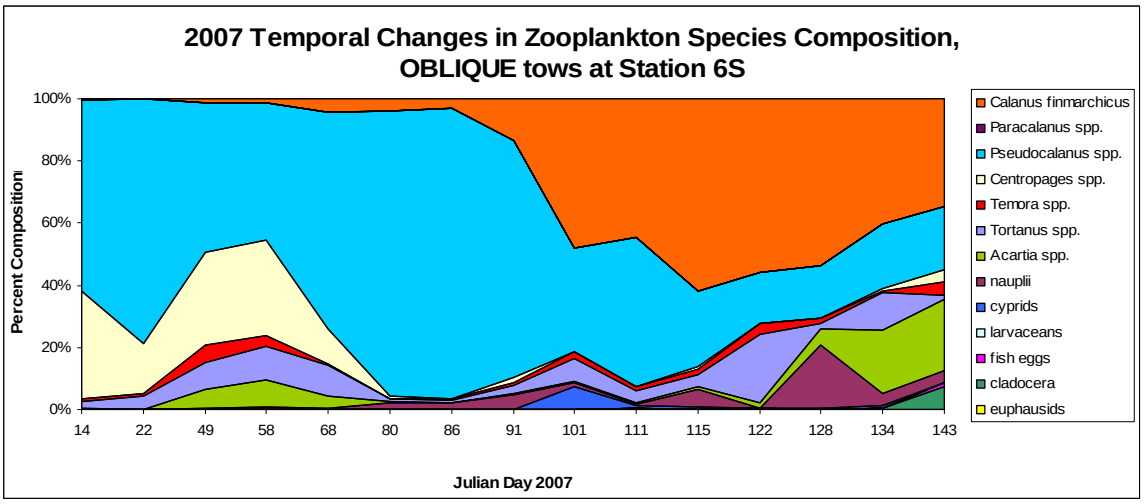


Figure A29. Temporal progression of <u>water column</u> zooplankton species at Station 6S in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)

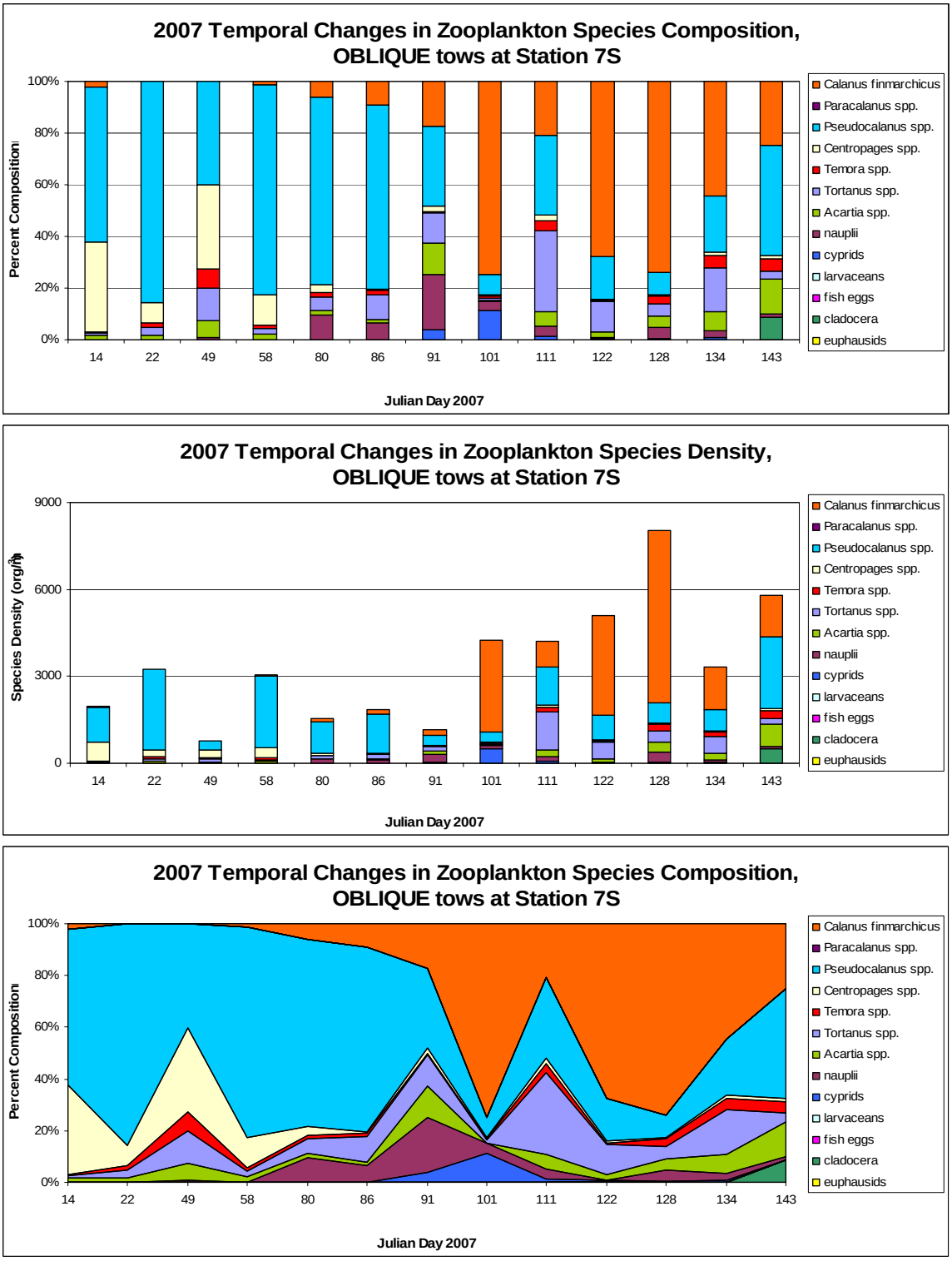
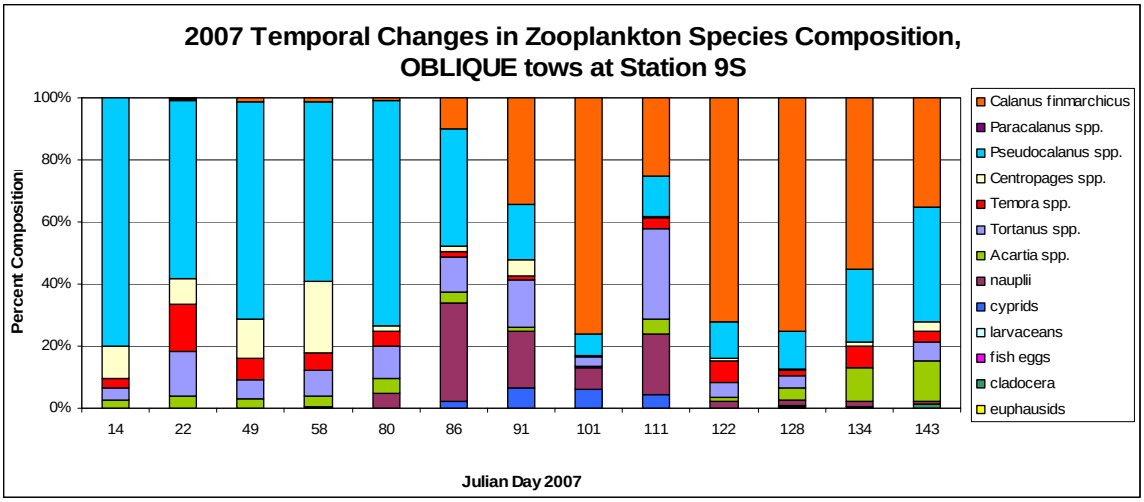
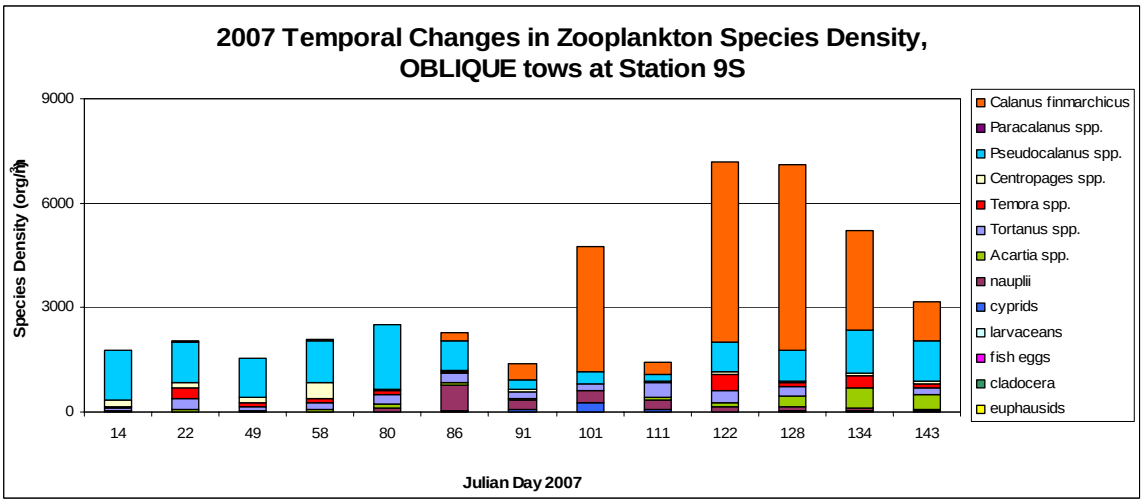


Figure A30. Temporal progression of <u>water column</u> zooplankton species at Station 7S in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)





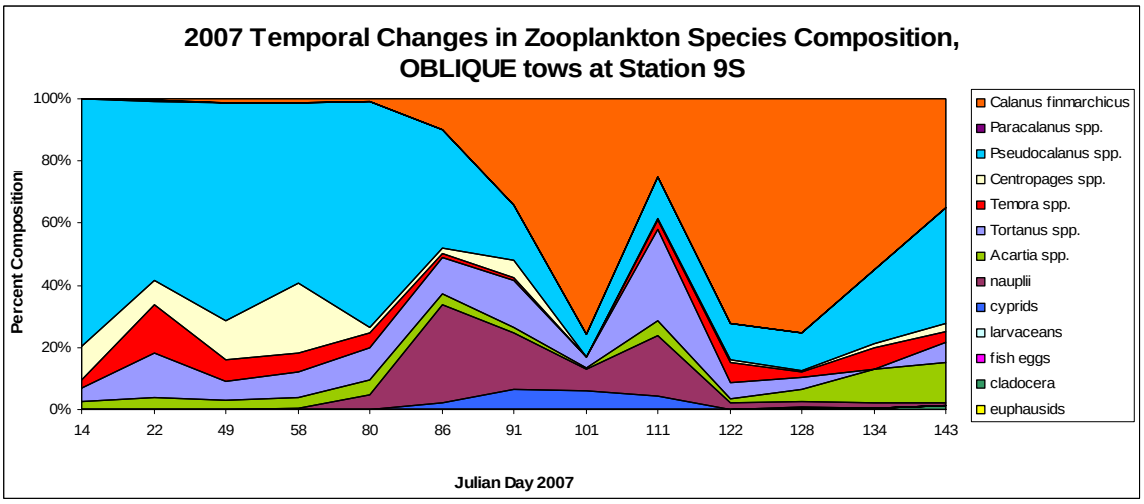


Figure A31. Temporal progression of <u>water column</u> zooplankton species at Station 9S in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)

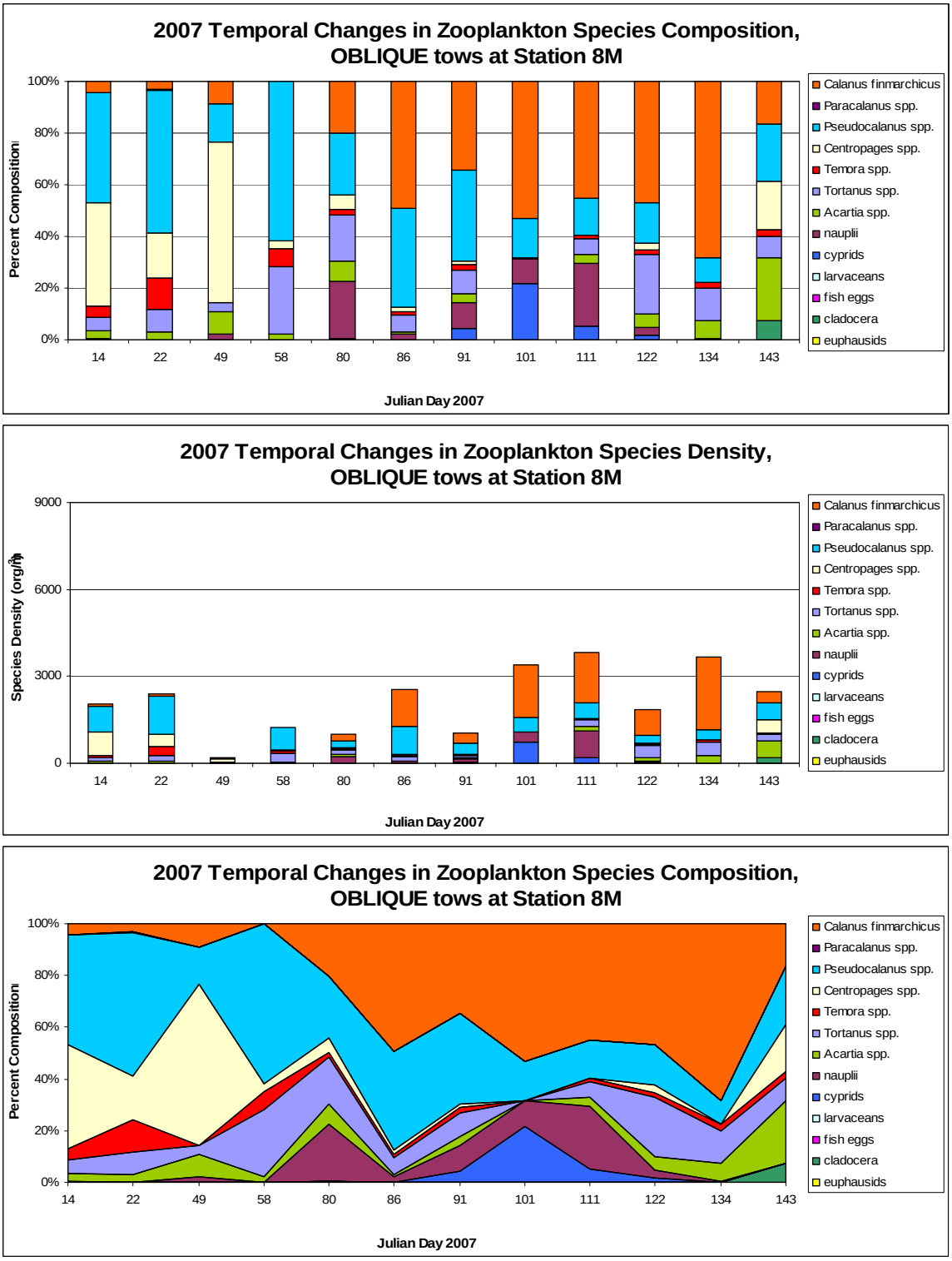


Figure A32. Temporal progression of <u>water column</u> zooplankton species at Station 8M in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)

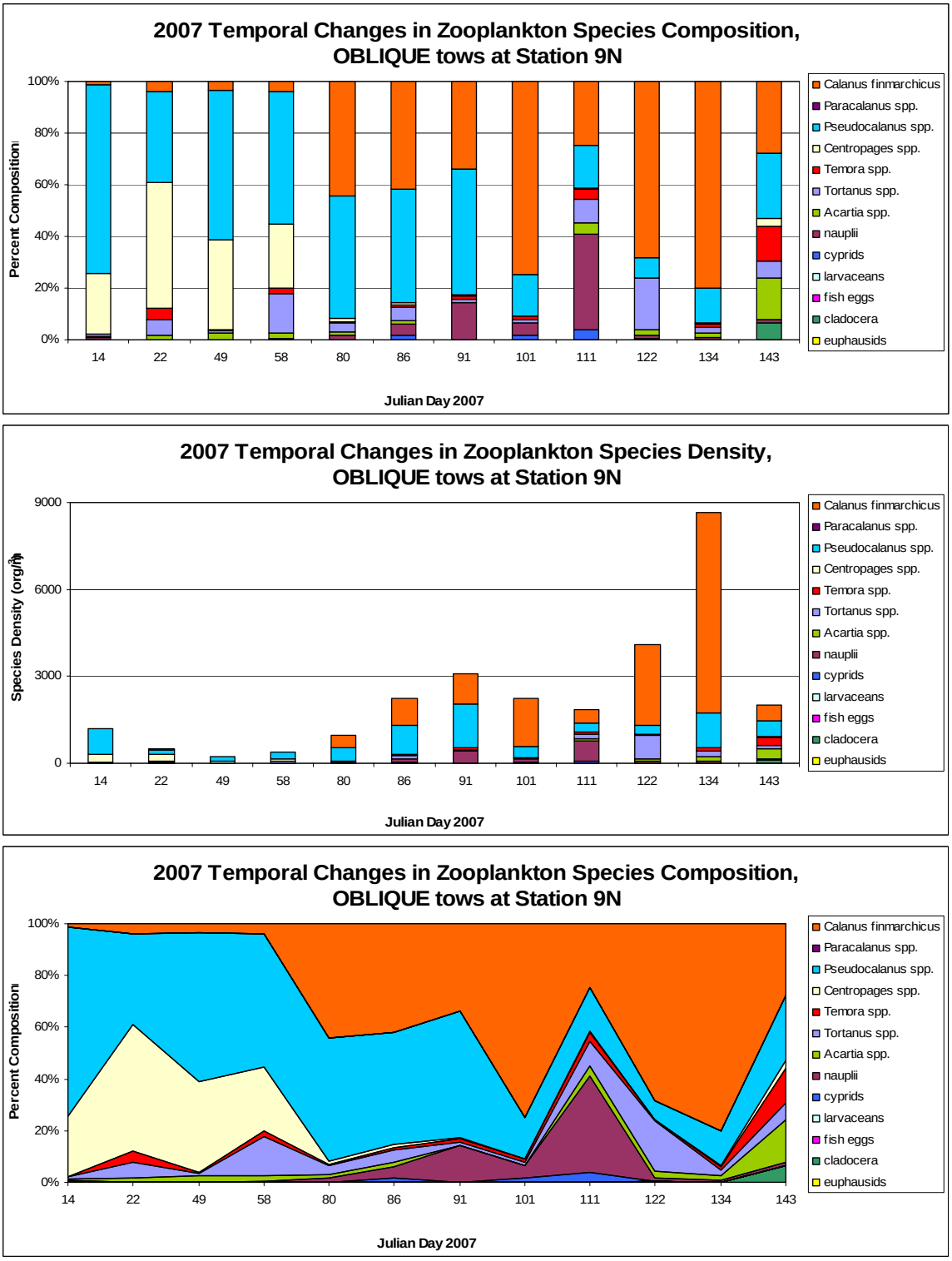
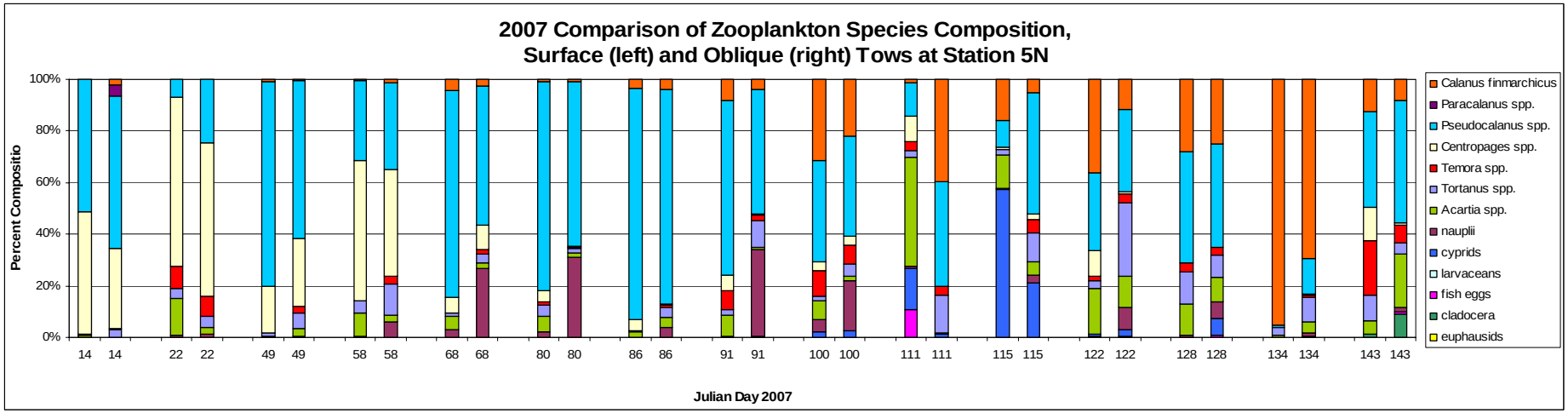


Figure A33. Temporal progression of <u>water column</u> zooplankton species at Station 9N in 2007;
Panel A (top) – Zooplankton species composition through time
Panel B (middle) – Zooplankton species densities through time
Panel C (bottom) – Zooplankton species composition (alternate visualization)



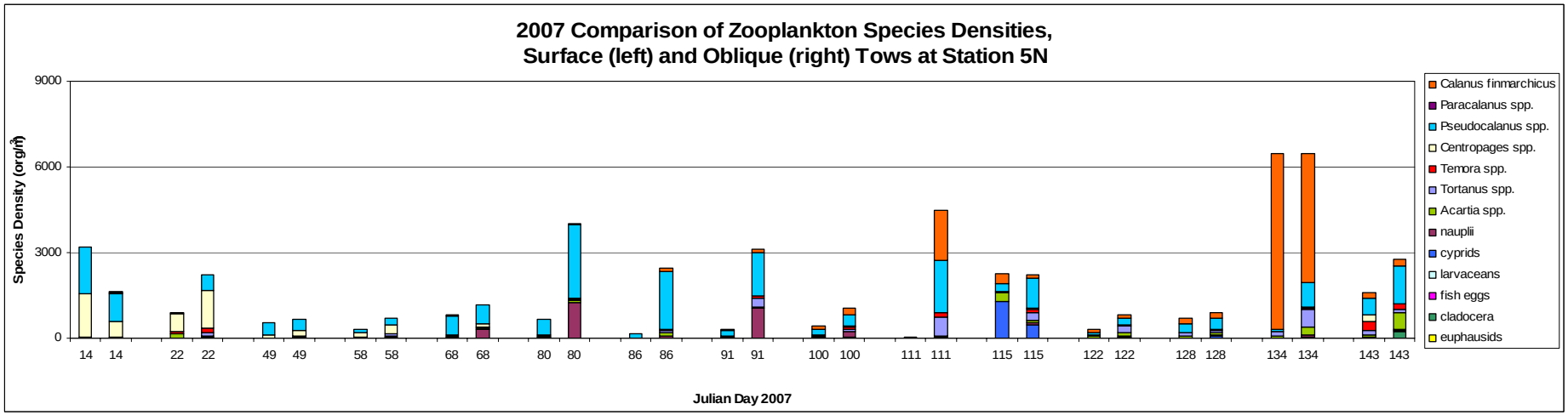
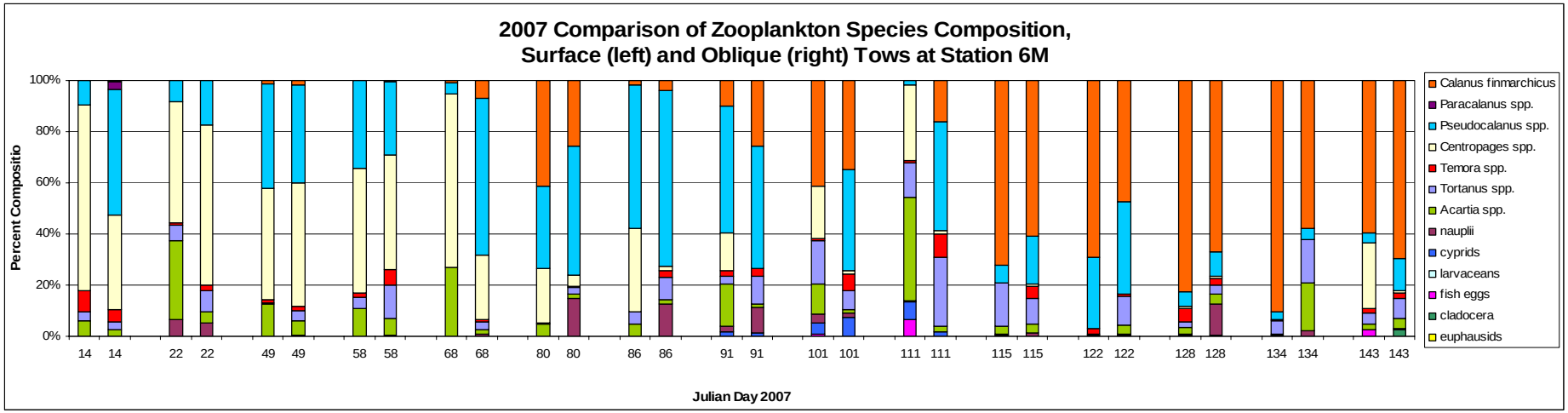


Figure A34. Comparison of surface and oblique zooplankton collections at Station 5N in 2007:
Panel A (top) – Zooplankton species composition through time
Panel B (bottom) – Zooplankton species densities through time



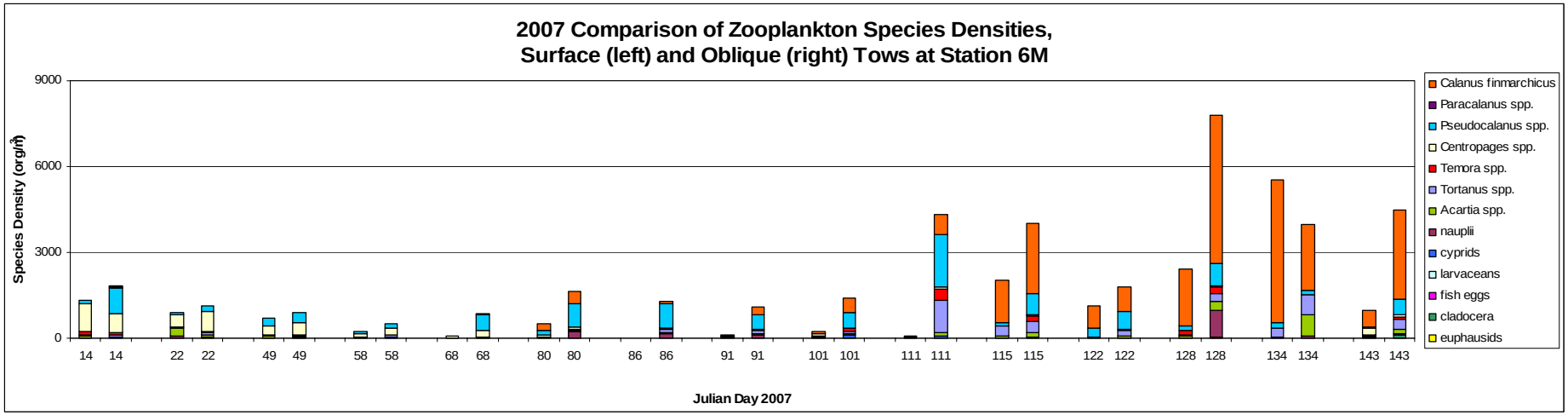
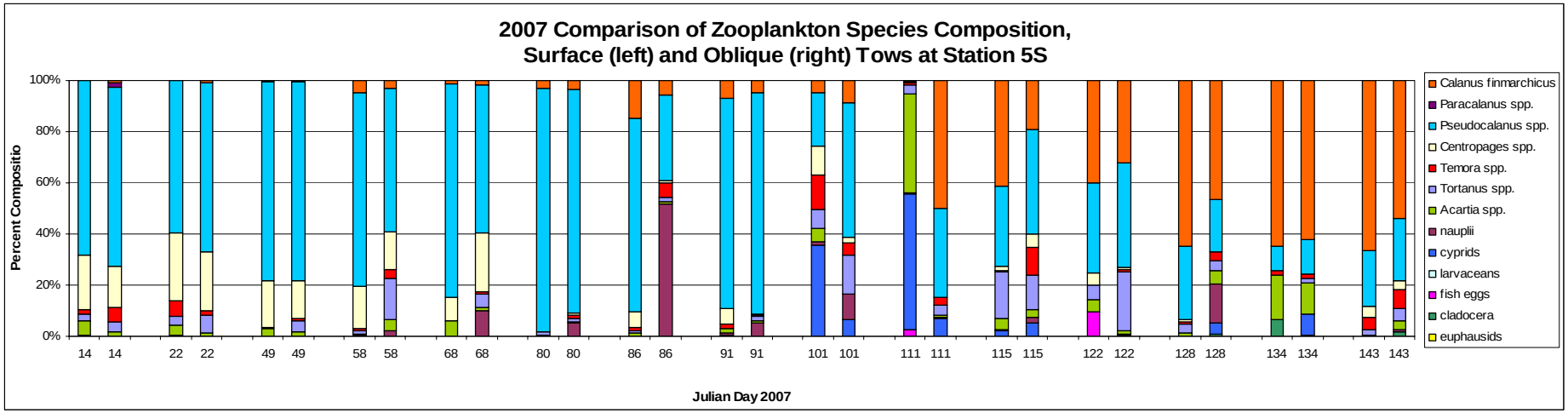


Figure A35. Comparison of surface and oblique zooplankton collections at Station 6M in 2007:
Panel A (top) – Zooplankton species composition through time
Panel B (bottom) – Zooplankton species densities through time



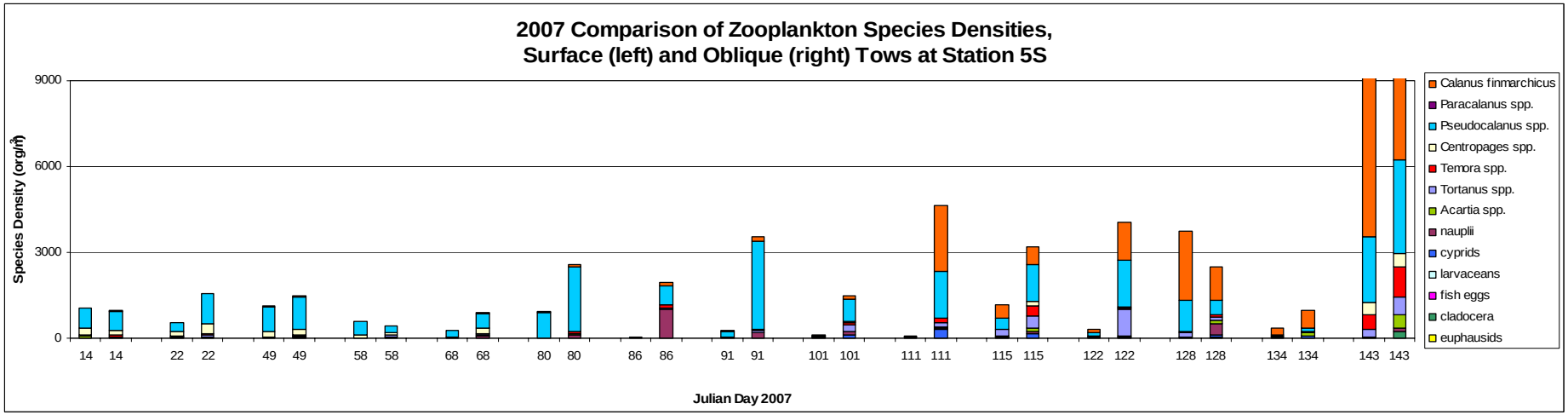
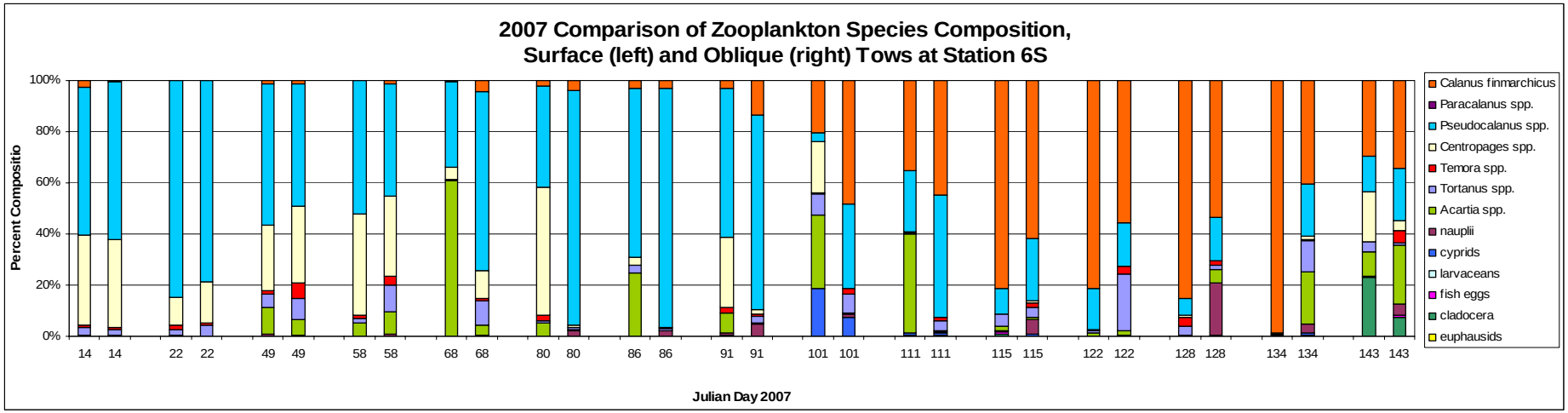


Figure A36. Comparison of surface and oblique zooplankton collections at Station 5S in 2007:
Panel A (top) – Zooplankton species composition through time
Panel B (bottom) – Zooplankton species densities through time



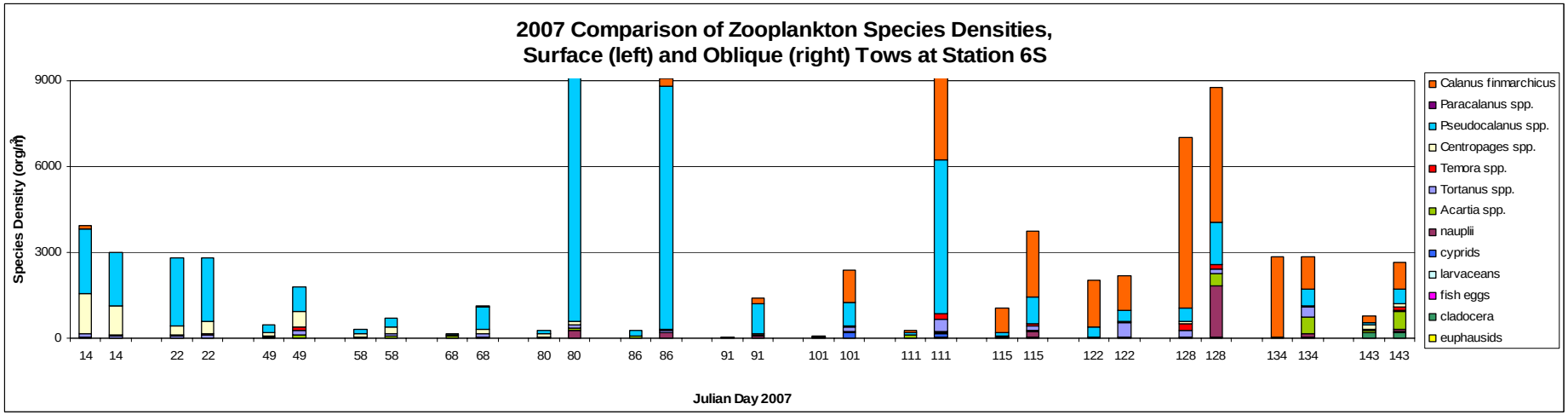
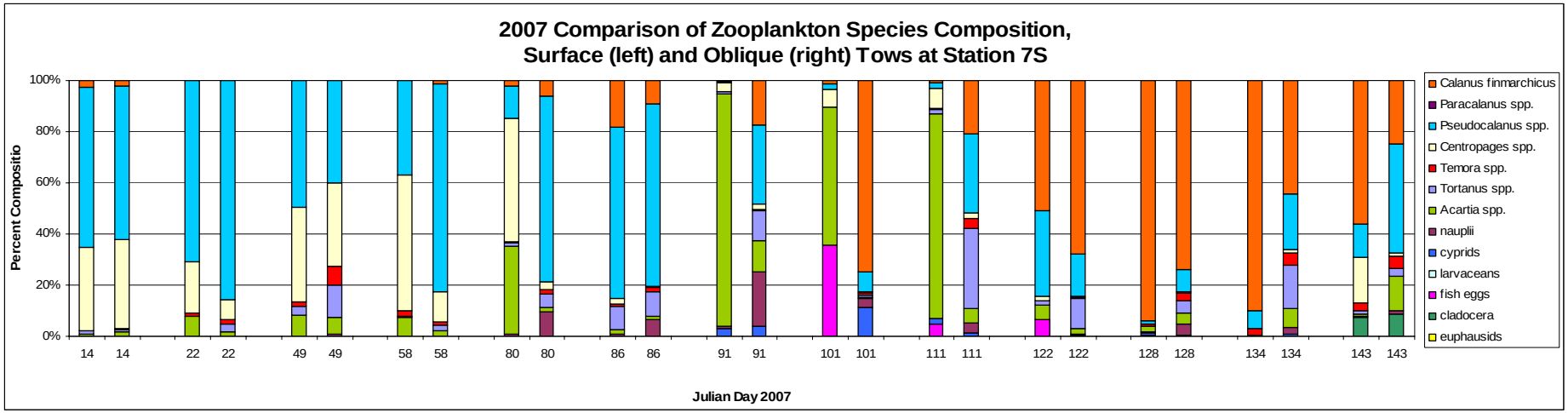


Figure A37. Comparison of surface and oblique zooplankton collections at Station 6S in 2007:
Panel A (top) – Zooplankton species composition through time
Panel B (bottom) – Zooplankton species densities through time



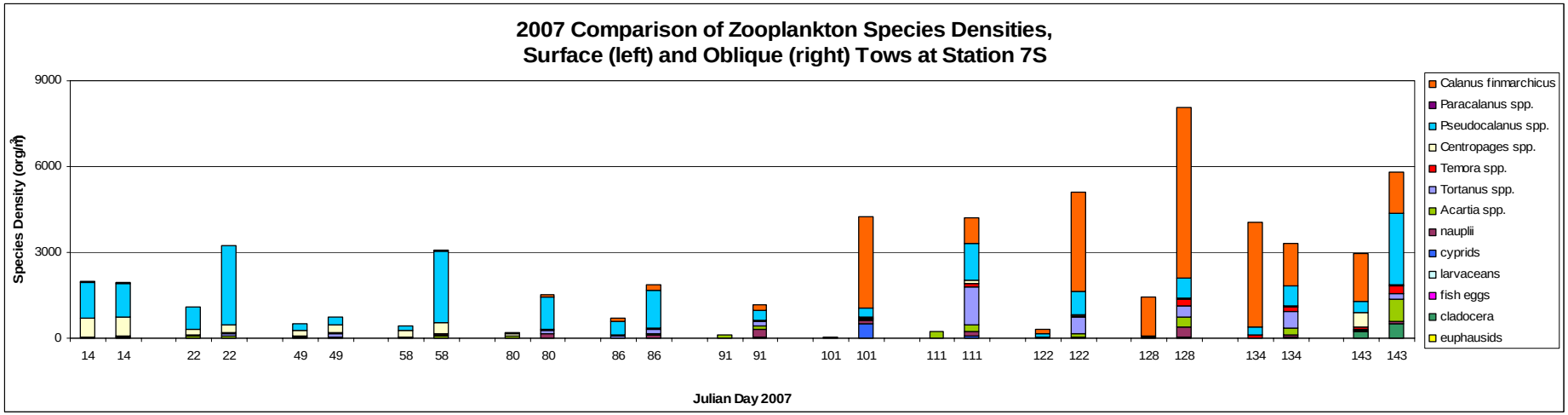
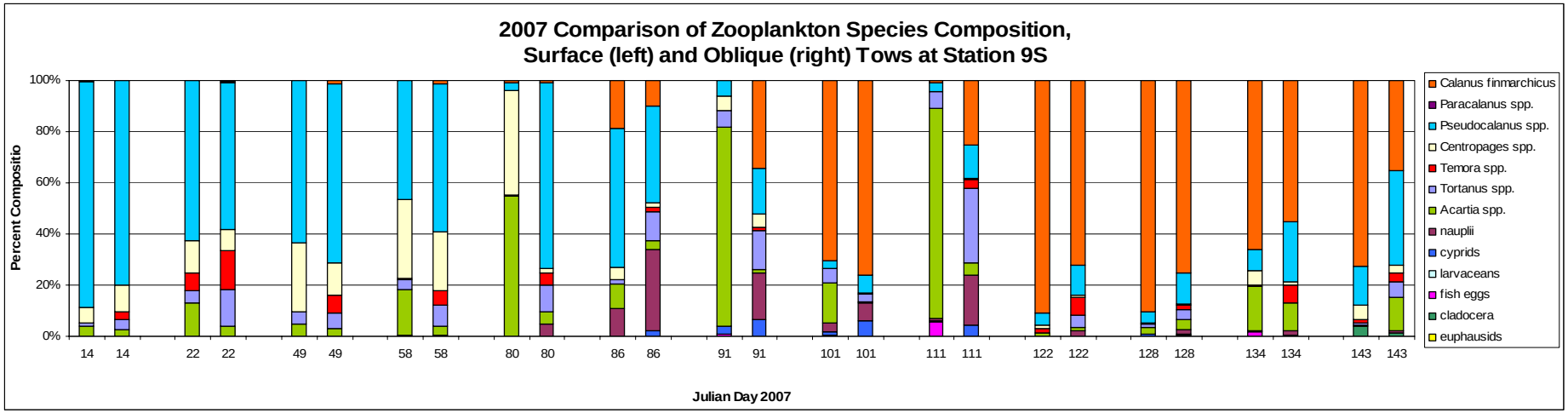


Figure A38. Comparison of surface and oblique zooplankton collections at Station 7S in 2007:
Panel A (top) – Zooplankton species composition through time
Panel B (bottom) – Zooplankton species densities through time



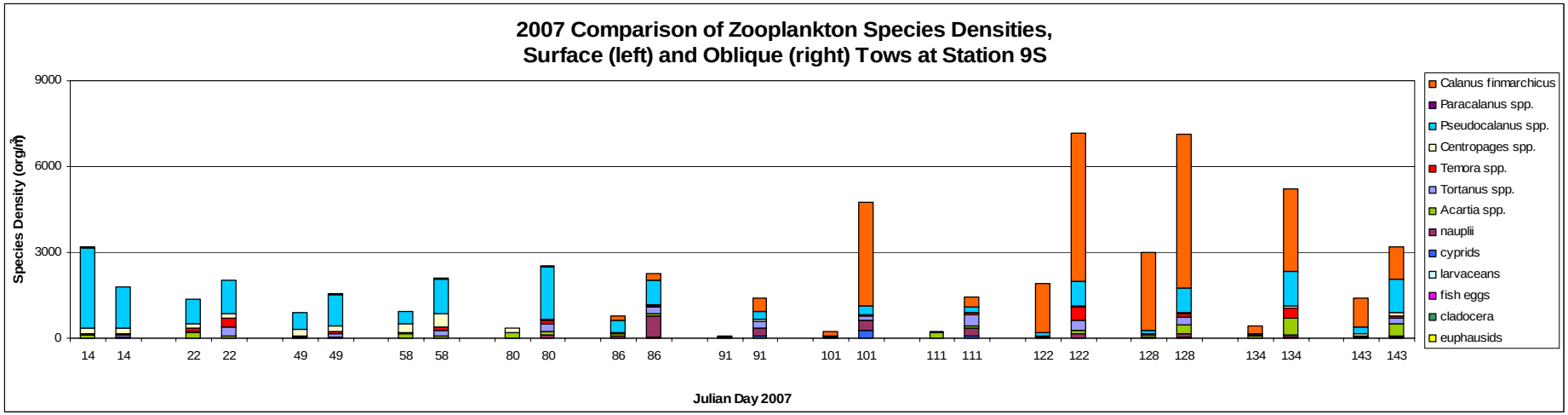
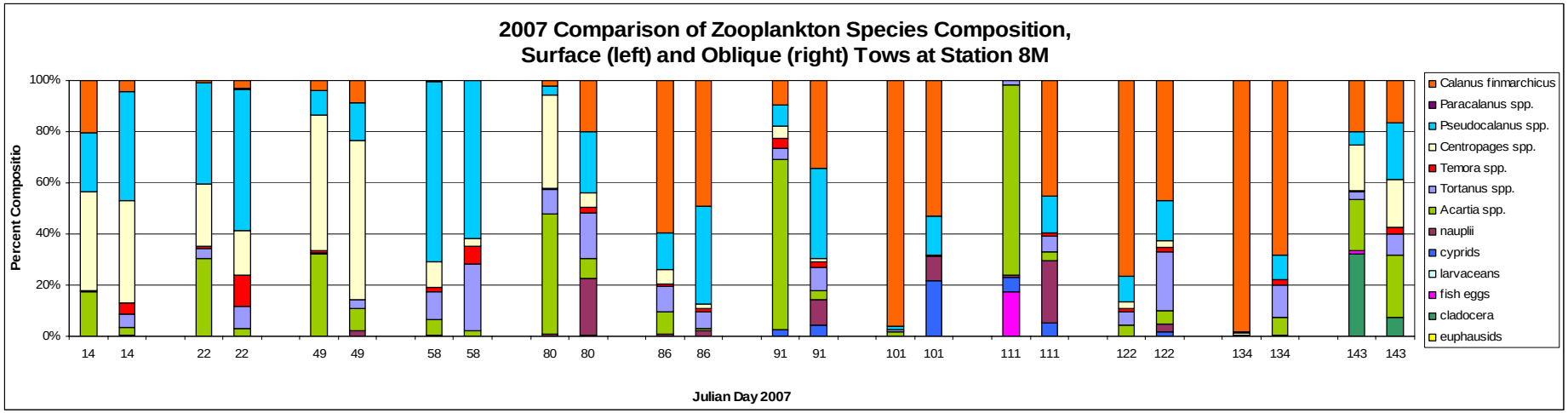


Figure A39. Comparison of surface and oblique zooplankton collections at Station 9S in 2007:
Panel A (top) – Zooplankton species composition through time
Panel B (bottom) – Zooplankton species densities through time



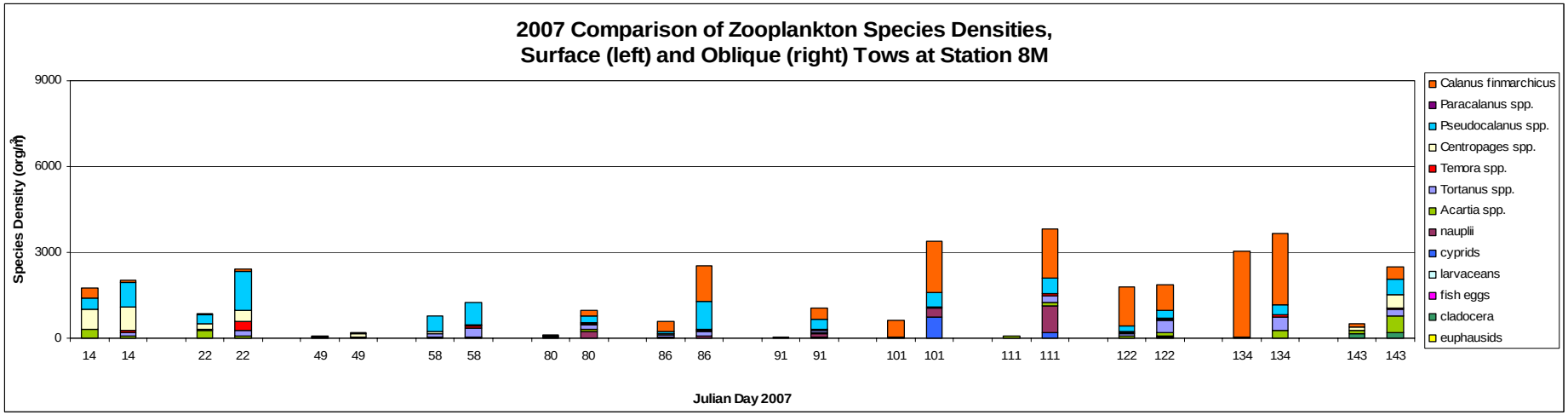
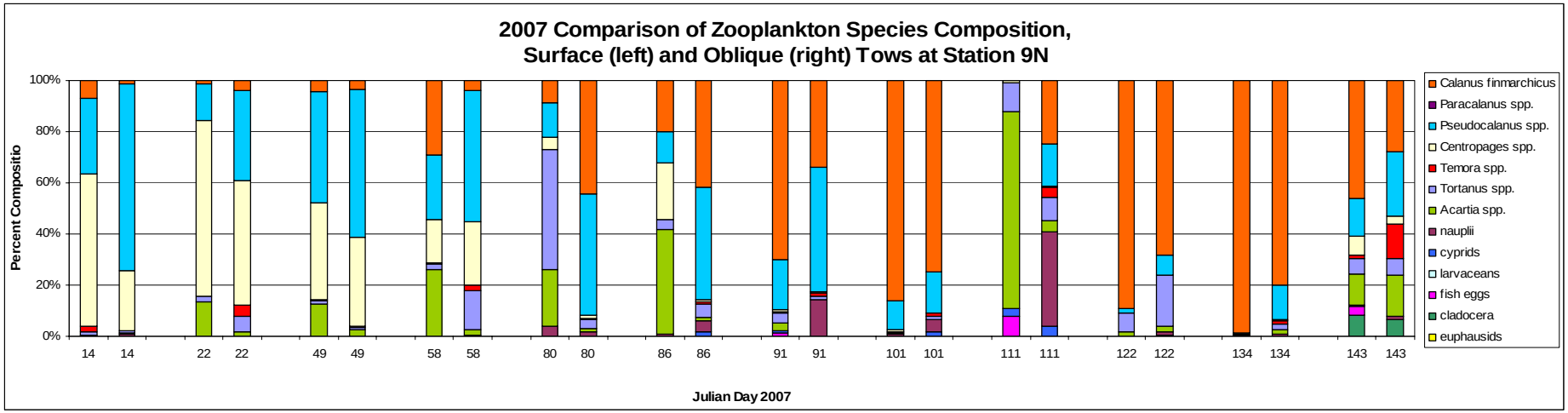


Figure A40. Comparison of surface and oblique zooplankton collections at Station 8M in 2007:
Panel A (top) – Zooplankton species composition through time
Panel B (bottom) – Zooplankton species densities through time



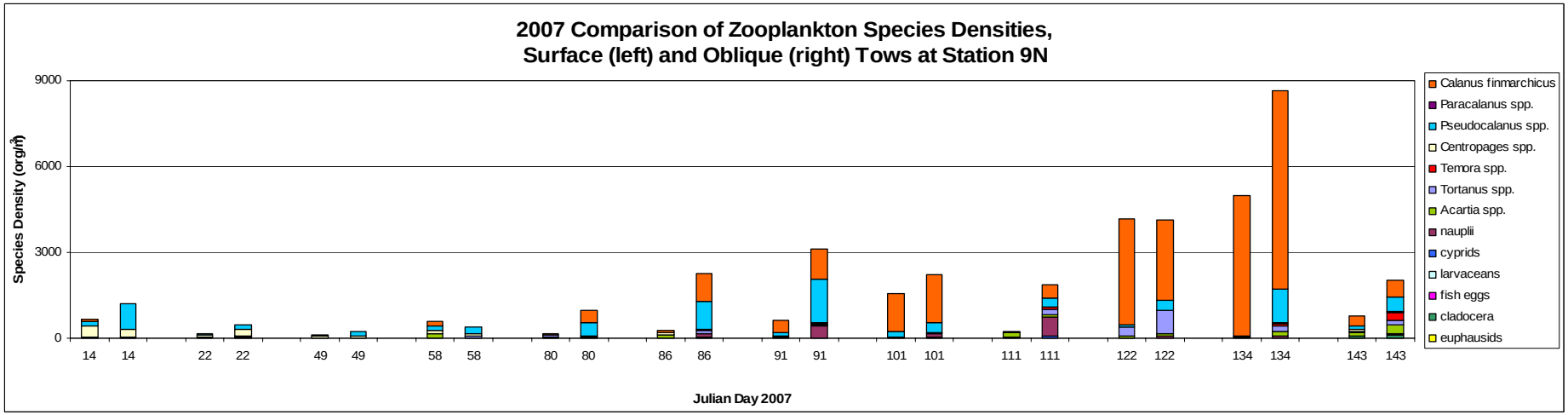


Figure A41. Comparison of surface and oblique zooplankton collections at Station 9N in 2007:
Panel A (top) – Zooplankton species composition through time
Panel B (bottom) – Zooplankton species densities through time

Appendix II

Habitat Assessment and Prediction Documents
2007

Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: Cruise SW633
14 January 2007

Cruise SW633, the first of the winter season of 2007, was conducted in light rain and fog. All assessment stations in Cape Cod Bay were sampled by both surface and oblique net collection methods. A preliminary review of the collected zooplankton shows a habitat that has a higher standing stock, particularly at the surface, than in the mid-winter of recent years. These elevated densities of small zooplankters appear to be wide-spread through all stations sampled. Although zooplankton densities were estimated to be below the threshold for right whale feeding, the elevated concentrations of the food resource at (particularly at station 8M approximately 8 miles SSE of Plymouth, as well as in the southern central Bay) raise the possibility that early-season patches of zooplankton may become dense enough to support aggregations of right whales. While the observed zooplankton levels do not suggest that stable right whale aggregations will form in the near future, occasional right whales may be searching the area while densities remain elevated. The possibility that patches rich enough to release feeding behavior may develop will be the focus of future cruises.

A preliminary view of the zooplankton indicates that the samples are dominated by the small calanoid copepods *Pseudocalanus* and *Centropages*, taxa that have in the past supported right whale feeding when occurring in dense patches.

No right whales were observed during cruise SW633, however sighting conditions during the cruise were poor because of light rain and fog. Nevertheless, three fin whales and approximately 20 dolphins (predominantly Commons) were sighted during the cruise. The DMF-PCCS aircraft survey was not able to fly because of low ceiling and precipitation.

Water temperatures throughout Cape Cod Bay were above 6.0 degrees C. with some stations in the southeast portion of the bay exceeding 7 degrees. These temperatures compare with averages between –1 and 3 degrees C observed at the same stations during mid-January over the previous 20 years of study.

Phytoplankton captured in the 333 micron zooplankton nets was unusually dense for collections during mid-winter.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Cape Cod Bay Habitat Assessment

ACTIVITIES: 2 – 14 January, 2007

Vessel-Based Monitoring

After two weeks of waiting for the winds and seas to calm, a Cape Cod Bay habitat monitoring cruise (SW633) was at last feasible on 14 January. R/V *Shearwater* visited all eight regular stations, and zooplankton samples were collected from net tows at the surface and through the water column (to 19 meters depth) at each location. Auxiliary on-station sampling consisted of CTD profiles and water collection for nutrient analysis. Sighting conditions were moderate to poor, with overcast skies, intermittent rain and occasional fog. While no right whales were seen by vessel-based observers, marine mammal sightings included several fin whales, approximately 20 common dolphins, a dozen harbor seals and a single harbor porpoise.

Air Surveillance

As of this writing, no DMF-PCCS aerial surveys have yet been flown in 2007 due to relentless winds and precipitation.

GENERAL ASSESSMENT

As detailed in the following pages, zooplankton samples from both the surface and water column revealed moderately high densities throughout Cape Cod Bay waters on 14 January. The observed abundances were typical of early January collections, ranging between approximately 1000 and 2000 organisms/m^3. Although these densities are generally too low to promote right whale aggregation or support feeding, elevated zooplankton densities that approached or even exceeded the estimated right whale feeding threshold of 3750 org/m^3 were documented at several locations. The southern-central area of the Bay, at station 6S, had the highest abundance of both surface and water column zooplankton (3931 and 3018 org/m^3, respectively), raising the possibility that even a modest coalescence or further enrichment of the resource could result in this region becoming attractive to right whales.

The Bay's zooplankton assemblage was dominated by the small calanoid copepods *Pseudocalanu*s and *Centropages*. These taxa have in the past supported right whale feeding when occurring in dense patches; however, their caloric deficiency (i.e. per organism when compared to *Calanus finmarchicus*) will likely require higher densities of organisms than those documented on 14 January to accommodate stable right whale aggregation and long-term residency. The uncharacteristic presence of late stage *Calanus* in the northwestern and southern-central regions of Cape Cod Bay offers some compensation for the relative caloric deficiencies of the principal taxa in the zooplankton assemblage, and while densities remain elevated in these areas may increase the likelihood of right whales entering the Bay to feed.

<u>Interpreted likelihood (1-10) of</u>:
Aggregation: Low (2)
Residency: Low (2)
Near-surface feeding: Low (2)
Feeding in the water column: Low (2)
Trends in above: Increasing
Quadrant Quality/Attractiveness: NW(2), SW(2), SE(3), NE(2)

HABITAT ASSESSMENT AUTHORSHIP:
OSTERBERG, MAYO (DMF-FUNDED PCCS HABITAT STUDIES PROGRAM)

SURFACE RESOURCE

		14 Jan 2007	
Bay-wide mean surface density:		2138	zpl/m^3
Range of densities for individual stations:			
	Low	648	[sta 9N]
	High	3931	[sta 6S]
Mean surface densities by quadrant:			
	NE	2262	
	NW	1208	
	SE	2489	
	SW	2592	

Inter-annual bay-wide comparison:

year	date	cruise	mean sfc density	
2004	18 Jan	SW391	3104	zpl/m^3
2005	15 Jan	SW516	944	
2006	12 Jan	SW587	1211	
2007	14 Jan	SW633	2138	

Surface Resource Summary:

- Surface zooplankton samples collected on cruise SW633 revealed densities that at most stations ranged between 1000 and 2000 organisms/m^3, which is consistent with mid-January observations from previous years.
- Significantly elevated densities were recorded in several areas of the Bay. At station 6S in the southern-central region, the surface zooplankton abundance of 3931 organisms/m^3 exceeded the estimated threshold density for right whale feeding (3750 org/m^3). Other locations had densities approaching threshold, particularly in the far southwest and northeast (stations 9S and 5N, respectively; each with surface densities near 3200 org/m^3). Figure 1 provides a map of the zooplankton density distribution for visualization of these spatial patterns.
- For a second consecutive year *Pseudocalanus* spp. anomalously dominated mid-January surface samples from Cape Cod Bay, representing 55% of the bay-wide mean zooplankton assemblage, while the typical winter dominant, *Centropages* spp., comprised 35%. Although the *Centropages* present in SW633 samples were often larger than *Pseudocalanus* individuals, the latter taxon is generally considered to be a more attractive food resource for right whales based on their higher caloric content and larger lipid sac.
- The important copepod *Calanus finmarchicus*, which usually does not appear in samples until March, was present in samples from the northwest (stations 8M and 9N) and in collections from the central region of the southern Bay (6S and 7S). Late stage *Calanus* were particularly prominent at station 8M, representing 20% of the total zooplankton at this location and creating an area of considerably elevated caloric richness compared to that in the rest of the Bay.

WATER COLUMN RESOURCE FROM OBLIQUE TOWS (surface to 19 meters)

		14 Jan 2007	
Bay-wide mean oblique density:		1823	zpl/m^3
Range of densities for individual stations:			
	Low	978	[sta 5S]
	High	3018	[sta 6S]
Mean oblique densities by quadrant:			
	NE	1747	
	NW	1639	
	SE	1998	
	SW	1909	

Inter-annual bay-wide comparison:

year	date	cruise	mean obl density	
2004	18 Jan	SW391	4495	zpl/m^3
2005	15 Jan	SW516	1489	
2006	12 Jan	SW587	2630	
2007	14 Jan	SW633	2138	

Water Column Resource Summary:

- In contrast to the relative heterogeneity observed in the surface waters (with significantly elevated densities in several areas), water column zooplankton abundances from SW633 were more uniform and showed only a single area where the density was anomalously high. At station 6S in the southern-central region of the Bay the zooplankton density exceeded 3000 organisms/m^3, while the remaining stations averaged 1650 org/m^3. All stations had water column densities below the level thought to trigger right whale feeding (3750 org/m^3).
- As seen in the surface zooplankton assemblage, 2007 began with the uncharacteristic mid-winter dominance of *Pseudocalanus* spp. in the water column, comprising approximately 60% of the mean total zooplankton while *Centropages* spp. only accounted for 30%. The implications of this shift in species dominance – both for future zooplankton species dynamics and for right whale feeding – will be watched closely in the coming weeks and months.

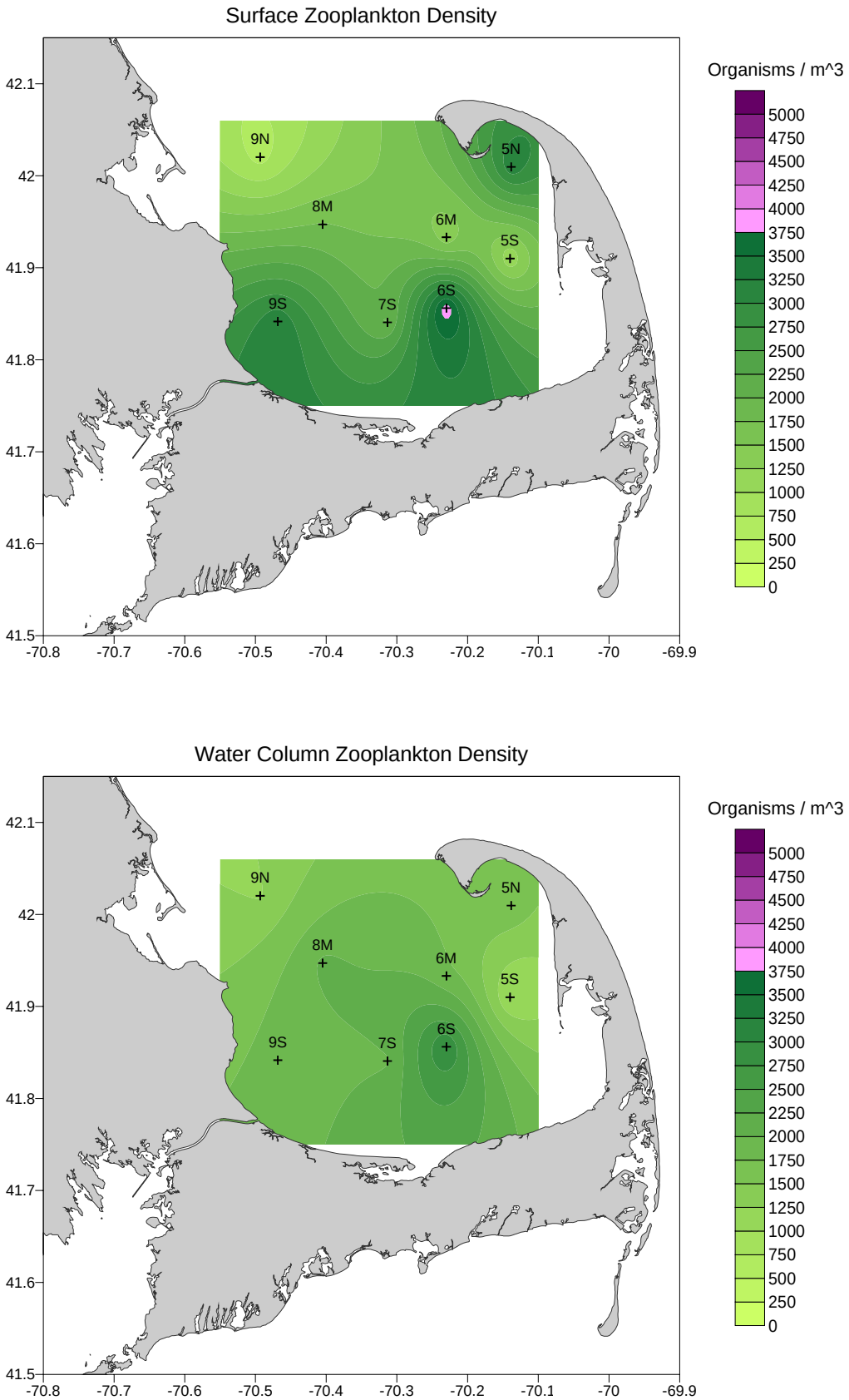


Figure 1. Spatial plots of zooplankton densities from surface (upper plot) and oblique (lower plot) tows conducted during cruise SW633 on 14 January 2007. Sampling station locations are indicated with a "+" symbol.

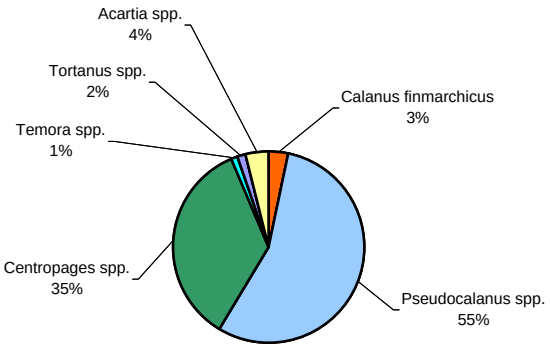
Surface Zooplankton Assessment: Cruise SW633 (14 Jan 2007) Julian Day 14

Recent aerial right whale sightings: No aerial surveys have yet been flown to date in 2007 — *SW633 vessel sightings: 0 right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	3193.86	1.25	270.24	0.0523
Surface Tow	6M	1330.76	0.75	170.45	0.0329
Surface Tow	8M	1767.34	1.54	467.05	0.0783
Surface Tow	9N	648.05	0.48	101.52	0.0188
Surface Tow	5S	1048.22	0.30	73.38	0.0144
Surface Tow	6S	3930.68	1.38	357.83	0.0690
Surface Tow	7S	1980.60	0.87	171.22	0.0339
Surface Tow	9S	3202.72	0.88	189.14	0.0373
Cruise Average:		**2137.78**	**0.93**	**225.10**	**0.0421**
12 Jan 2006 Average:		1211.30	0.42	72.54	0.0144

Zooplankton Species Avg. % Composition: SW633 All Stations, *Surface Tows*

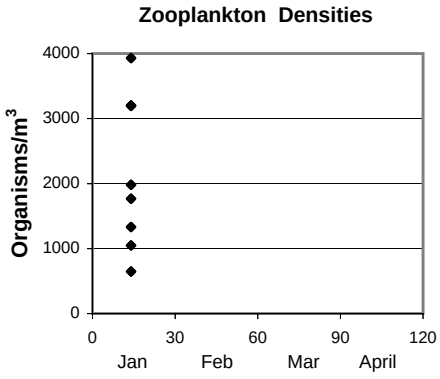


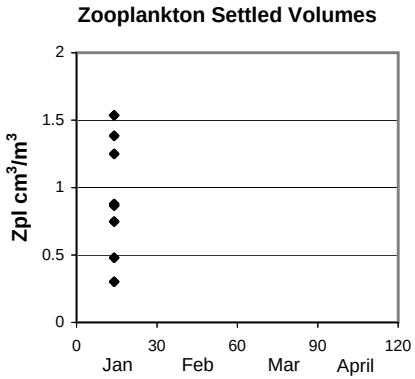
Other zooplankton present in low numbers:
Oithona spp.
Metridia spp.
nauplii

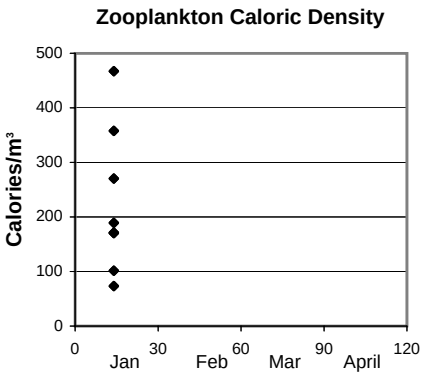
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

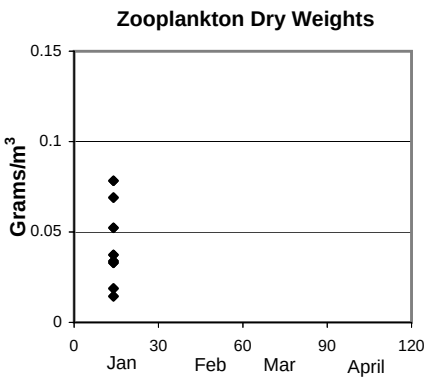
Entire Cape Cod Bay:

Note that scales are identical between surface and oblique graphs

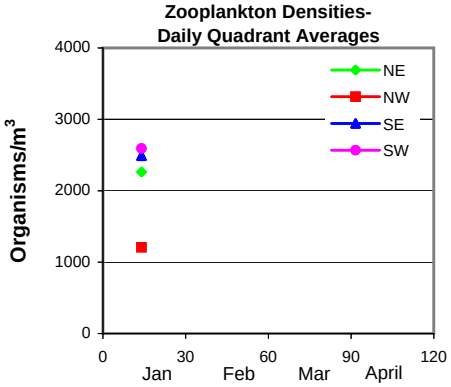


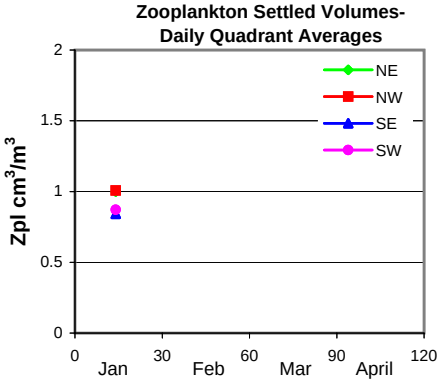


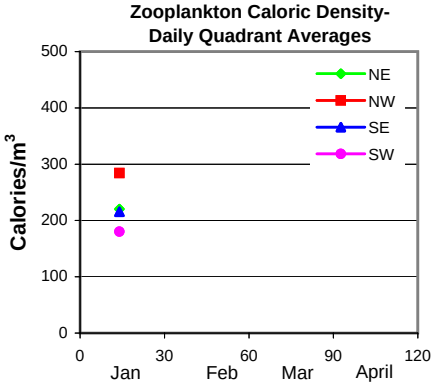


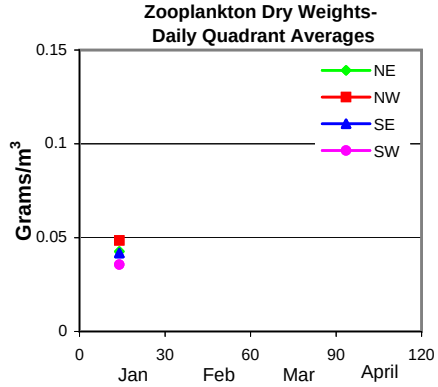


Geographic Quadrants:









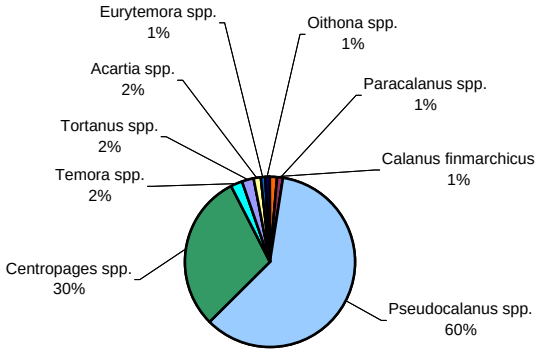
Water Column Zooplankton Assessment: Cruise SW633 (14 Jan 2007) Julian Day 14

Recent aerial right whale sightings: No aerial surveys have yet been flown to date in 2007 — *SW633 vessel sightings: 0 right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	1671.46	0.78	124.90	0.0252
Surface Tow	6M	1823.18	0.85	150.24	0.0298
Surface Tow	8M	2044.02	1.42	264.90	0.0486
Surface Tow	9N	1233.37	0.71	107.76	0.0202
Surface Tow	5S	977.56	0.42	73.93	0.0144
Surface Tow	6S	3018.31	1.10	241.97	0.0473
Surface Tow	7S	1974.99	1.05	194.91	0.0371
Surface Tow	9S	1842.82	0.84	125.58	0.0247
Cruise Average:		**1823.21**	**0.90**	**160.52**	**0.0309**
12 Jan 2006 Average:		2629.67	0.74	181.17	0.0372

Zooplankton Species Avg. % Composition: SW633 All Stations, *Oblique Tows*

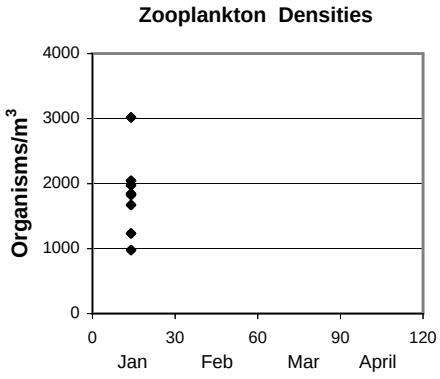


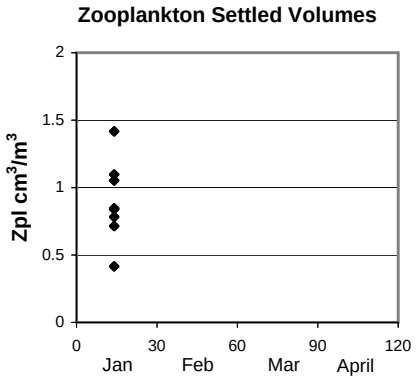
Other zooplankton present in low numbers:
Metridia spp.
nauplii
fish larvae

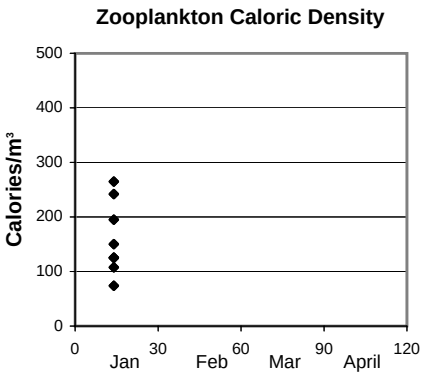
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

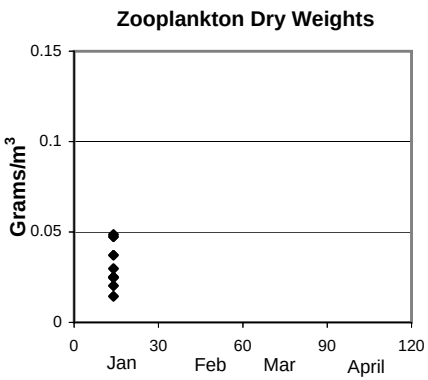
Entire Cape Cod Bay:

Note that scales are identical between surface and oblique graphs

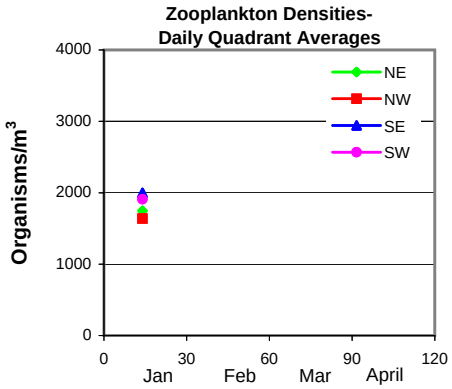


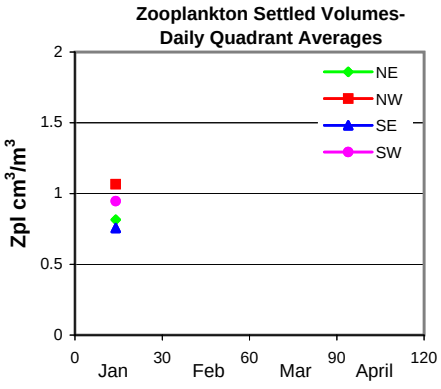


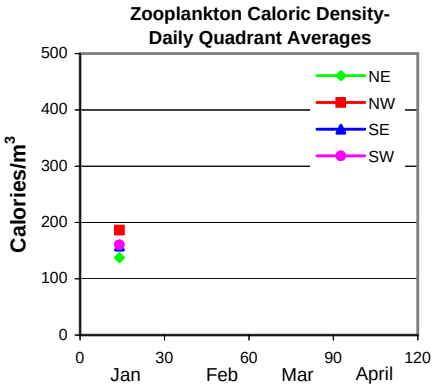


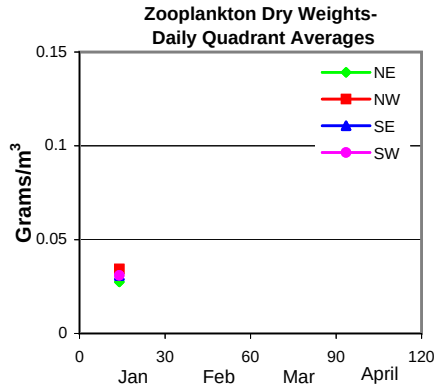


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: Cruise SW634
22 January 2007

Cruise SW634 for the assessment of food resources and prediction of right whale presence in Cape Cod Bay was carried out in cold conditions with occasional snow showers. All regular sampling stations in the Bay were sampled using both surface and oblique net collection methods. The zooplankton community continues to be dominated by the smaller taxa of calanoid copepods *Pseudocalanus* and *Centropages*, at concentrations that are, while estimated below the threshold for right whale feeding, modestly higher than early-season densities reported during the last two years. Since SW633 on 14 January it appears that the resource has declined slightly overall and has become more uniformly distributed in the water column, with the copepod resource in the southern-central region of the Bay continuing to approach feeding threshold concentrations. The unusual appearance of late-stage Calanus reported in western stations from SW633 was not seen during preliminary review of samples collected on SW634.

Present resource conditions continue to suggest that Cape Cod Bay could become marginally attractive to right whales, particularly in the southern-central area around station 6S, should the zooplankton become concentrated into dense patches. While there is a great enough standing stock of *Pseudocalanus* and *Centropages* to form such patches, the lack of stratification in the water column and periods of strong turbulence and advection due to winter storms are expected to reduce the potential for whales aggregating and feeding in the near future. Therefore, neither surface feeding nor aggregation of right whales are predicted for the coming week.

No right whales were observed during SW634 with sighting conditions fair to good. More than 100 dolphins (identification of most unclear because of distance, but probably *Lagenorhynchus acutus* or *Delphinus delphis*) in small schools were observed, primarily in the northern quadrants of the Bay. Sightings also included one fin whale, three harbor porpoises, approximately a dozen harbor seals and one grey seal. The DMF-PCCS survey aircraft was not able to fly because of low ceiling and snow.

Surface water temperatures throughout Cape Cod Bay continue to be higher than during previous years, ranging between 4.7 and 5.3 C.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Cape Cod Bay Habitat Assessment

ACTIVITIES: 15 – 24 January, 2007

Vessel-Based Monitoring

The second habitat monitoring cruise of 2007 (cruise SW634) was conducted on 22 January in frigid conditions with occasional snow showers. Sighting conditions were good during most of the day, with Beaufort 1 seas affording excellent distance visibility. While no right whales were seen by vessel-based observers, marine mammal sightings included 25 harbor seals, several harbor porpoises, a fin whale and more than 100 common dolphins. All eight regular stations were visited, and surface and oblique (to 19 meters depth) zooplankton samples were collected at each. No auxiliary sampling (e.g. CTD deployment, water collection for nutrient analysis) was conducted due to time constraints.

Air Surveillance

The aerial surveillance program completed their first survey of Cape Cod Bay on January 24. The survey was conducted under good sighting conditions. The sea state averaged a Beaufort 2 and the visibility was clear throughout the day. Though no right whales were sighted during this survey, several lunge feeding fin whales and multitudes of dolphins were sighted west of Race Point, Provincetown.

GENERAL ASSESSMENT

Although zooplankton concentrations on 22 January were modestly higher than early-season observations reported during the last two years, densities remained below the estimated threshold for right whale feeding (3750 organisms/m^3) at all sampling locations. Since the previous cruise the resource experienced declines in surface abundances bay-wide, while water column zooplankton densities increased slightly in many areas, most notably in the southern-central region of the Bay where concentrations exceeded 3300 org/m^3, approaching feeding threshold.

The zooplankton community in Cape Cod Bay was again dominated by the smaller taxa of calanoid copepods *Pseudocalanus* and *Centropages*. The presence of late-stage *Calanus* in samples from the northwestern Bay on 14 January was considerably reduced in SW634 collections from this area.

Present resource conditions continue to suggest that Cape Cod Bay could become marginally attractive to right whales, particularly in the southern-central area near stations 7S and 6S, should the zooplankton become concentrated into dense patches. While there is a great enough standing stock of *Pseudocalanus* and *Centropages* to form such patches, the lack of stratification in the water column and periods of strong turbulence and advection due to winter storms are expected to reduce the potential for whales aggregating and feeding in the near future. Therefore, neither surface feeding nor aggregation of right whales are predicted for the coming week.

<u>Interpreted likelihood (1-10) of</u>:
Aggregation: Low (2)
Residency: Low (2)
Near-surface feeding: Low (1)
Feeding in the water column: Low (2)
Trends in above: No change
Quadrant Quality/Attractiveness: NW(1), SW(3), SE(2), NE(2)

HABITAT ASSESSMENT AUTHORSHIP:
OSTERBERG, MAYO (DMF-FUNDED PCCS HABITAT STUDIES PROGRAM)
BROWNING, JAQUET (DMF-FUNDED PCCS AIR SURVEILLANCE PROGRAM)

SURFACE RESOURCE

		Currently **22 Jan 2007**		*Recently* **14 Jan 2007**	
Bay-wide mean surface density:		1090	zpl/m^3	2138	zpl/m^3
Range of densities for individual stations:					
	Low	159	[sta 9N]	648	[sta 9N]
	High	2817	[sta 6S]	3931	[sta 6S]
Mean surface densities by quadrant:					
	NE	907		2262	
	NW	502		1208	
	SE	1690		2489	
	SW	1261		2592	

Inter-annual bay-wide comparison:

year	date	cruise	mean sfc density	
2004	18 Jan	SW391	3104	zpl/m^3
2005	22 Jan	SW517	387	
2006	24 Jan	SW588	928	
2007	22 Jan	SW634	1090	

Surface Resource Summary:

- Surface collections from 22 January revealed that the zooplankton abundance *decreased at every sampling station* since the previous week's cruise. All individual station densities were below the estimated threshold density for right whale feeding (3750 organisms/m^3).
- Despite experiencing a decrease of over 1000 org/m^3, station 6S in the southeast recorded the highest surface density for a second consecutive week. This was the only location in the Bay where the abundance exceeded the feeding threshold on 14 January, and the observed density losses now place this station well below the level thought to trigger feeding.
- Station 5N in the northeast and station 9N in the far northwest were two locations where the surface abundance had exceeded 3000 org/m^3 on 14 January, showing potential as areas that with modest enrichment could have become attractive to right whales; however, in the past week both stations recorded surface zooplankton density decreases of approximately 2000 org/m^3, making these areas unsuitable for right whale aggregation or feeding. Maps of the spatial distribution of zooplankton densities and the changes thereof since the last cruise are presented in Figures 1 and 2.
- Species composition notes:
    - The small copepod genus *Pseudocalanus* continued to dominate surface zooplankton samples on 22 January, representing 55% of the bay-wide mean zooplankton assemblage despite experiencing significant decreases at several stations (losses of approximately 2000 and 1600 *Pseudocalanus*/m^3 at stations 9S and 5N, respectively).
    - Density declines were recorded at all stations for the usual mid-winter dominant taxon, *Centropages* spp., reducing its representation in the Bay's surface zooplankton from 35% (SW633) to 25% (SW634).
    - Late-stage *Calanus finmarchicus* had been particularly prominent in the surface waters at station 8M on 14 January (comprising 20% of the total zooplankton at this location), but only a few *Calanus* per cubic meter were apparent in samples from the northwest by 22 January.

WATER COLUMN RESOURCE FROM OBLIQUE TOWS (surface to 19 meters)

		Currently **22 Jan 2007**		*Recently* **14 Jan 2007**	
Bay-wide mean oblique density:		2010	zpl/m^3	1823	zpl/m^3
Range of densities for individual stations:					
	Low	493	[sta 9N]	978	[sta 5S]
	High	3309	[sta 7S]	3018	[sta 6S]
Mean oblique densities by quadrant:					
	NE	1720		1747	
	NW	1462		1639	
	SE	2183		1998	
	SW	2675		1909	

Inter-annual bay-wide comparison:

year	date	cruise	mean obl density	
2004	18 Jan	SW391	4495	zpl/m^3
2005	22 Jan	SW517	763	
2006	24 Jan	SW588	1875	
2007	22 Jan	SW634	2010	

Water Column Resource Summary:

- The bay-wide mean abundance in the water column *increased slightly* since the last cruise. Although no single station had a water column density that exceeded the estimated right whale feeding threshold (3750 organisms/m^3), the widespread but modest increases resulted in five of the eight stations recording densities over 2000 org/m^3.
- As was observed in the surface samples, the southern-central and southeastern stations of the Bay (7S and 6S, respectively) had the highest water column zooplankton densities on 22 January. In particular, station 7S experienced an increase of over 1300 org/m^3 to reach a near-threshold abundance of 3309 org/m^3. The water column zooplankton density distribution and dynamics are presented in Figures 1 and 2.
- Species composition notes:
    - The uncharacteristic mid-winter dominance of *Pseudocalanus* spp. in the water column continued to be seen on 22 January, as it comprised approximately 60% of the mean total zooplankton. The location with the highest total zooplankton density, station 7S, was particularly rich in *Pseudocalanus*, having gained 1600 org/m^3 of this taxon since the last cruise.
    - *Centropages* spp., the typical mid-winter dominant copepod, only accounted for 24% of the mean total zooplankton in SW634 samples.
    - Late-stage *Calanus finmarchicus* were again recorded at station 8M in the northwest, albeit at reduced concentrations, representing 3% of the total zooplankton at this location. These calorically-rich copepods had also been noted in water column samples from the southern-central area (stations 7S and 6S) of the Bay on 14 January, but were not present in samples collected on 22 January.

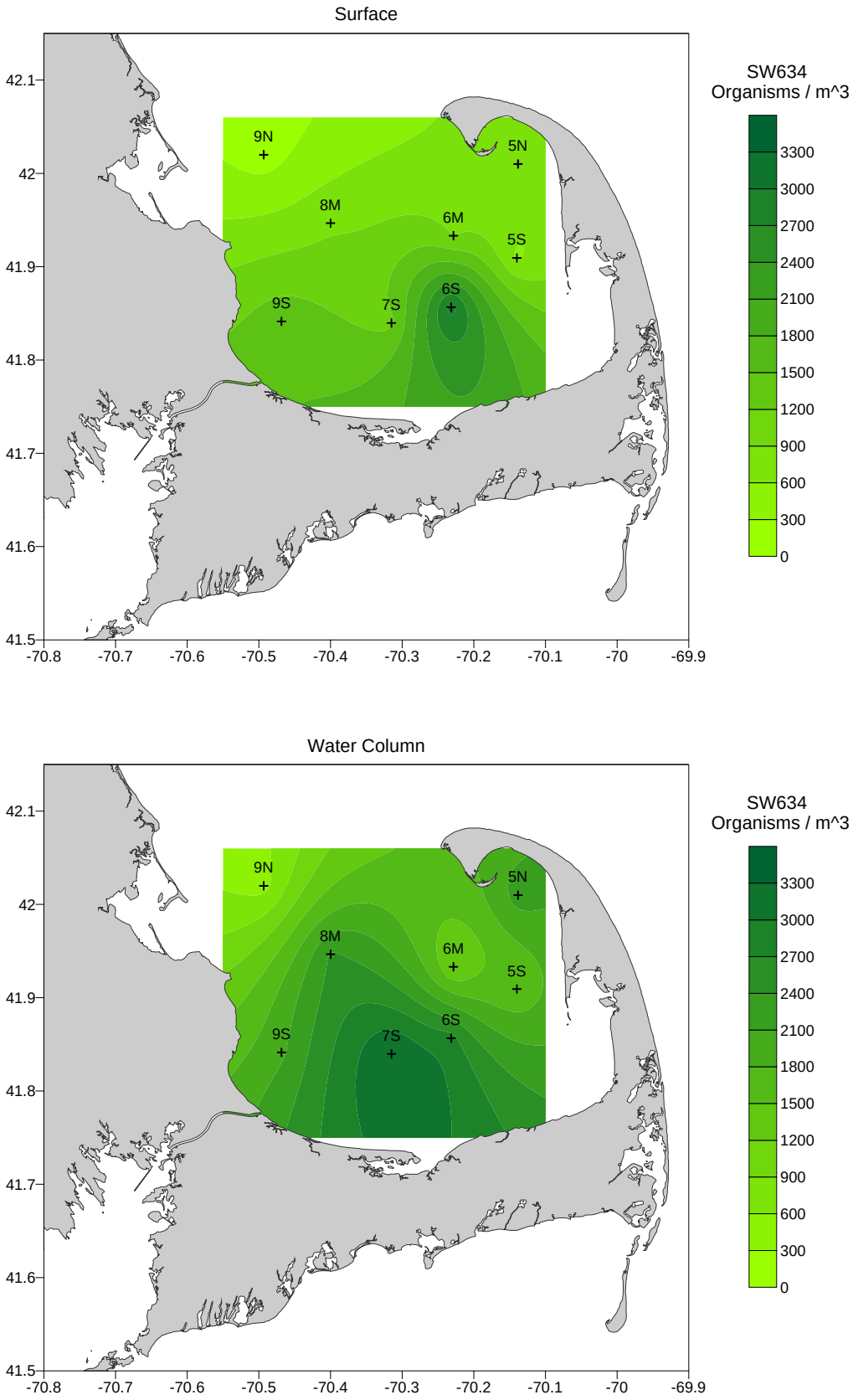


Figure 1. Spatial plots of **zooplankton densities** from surface (upper plot) and oblique (lower plot) tows conducted during cruise SW634 on 22 January 2007. Sampling station locations are indicated with a "+" symbol.

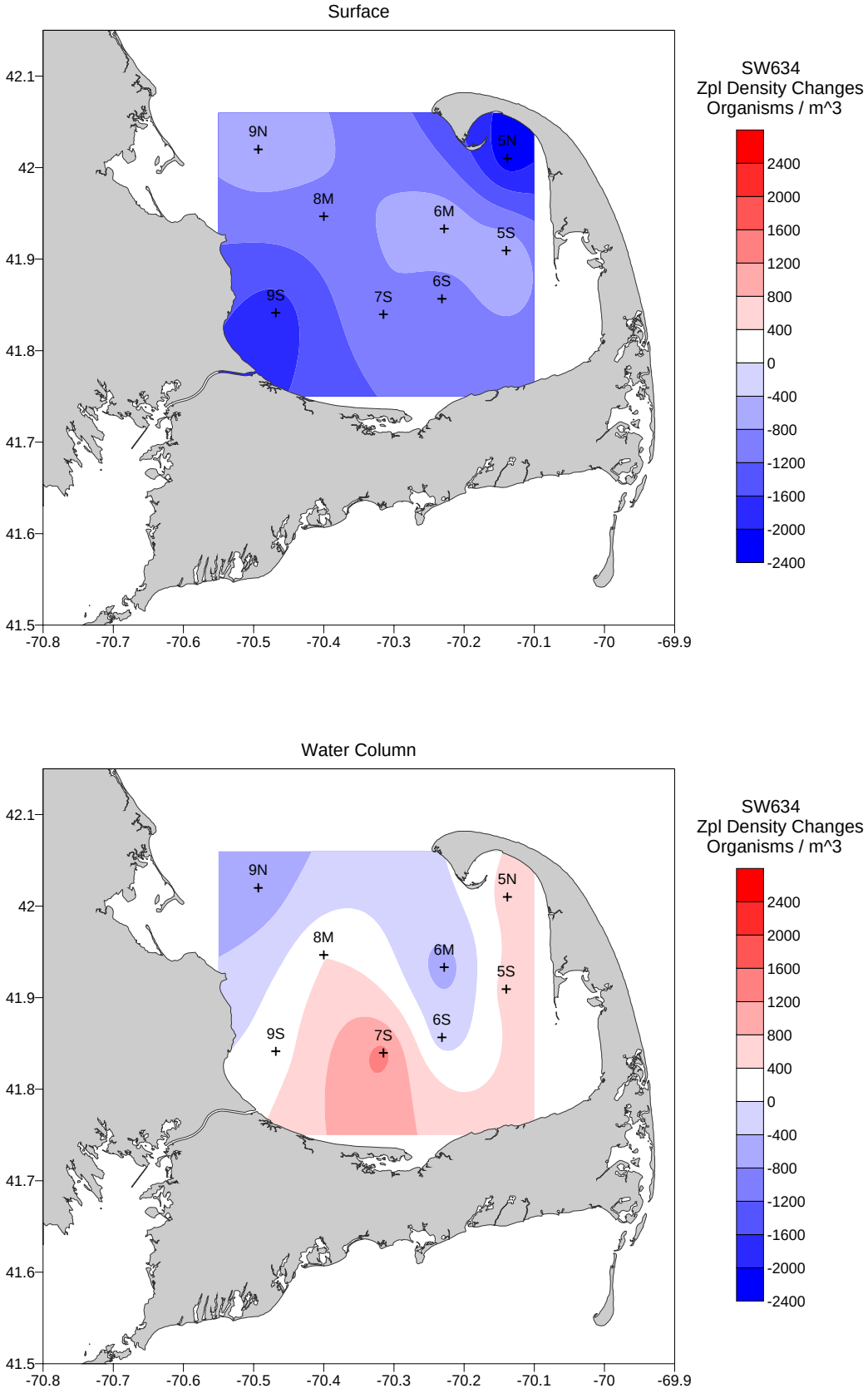


Figure 2. Spatial plots of the **changes in zooplankton densities** between the previous cruise (SW633 on 14 January) and the latest sampling cruise (SW634 on 22 January). Changes in *surface* density are displayed in the upper plot, while changes in *water column* density are plotted below. Sampling station locations are indicated with a "+" symbol.

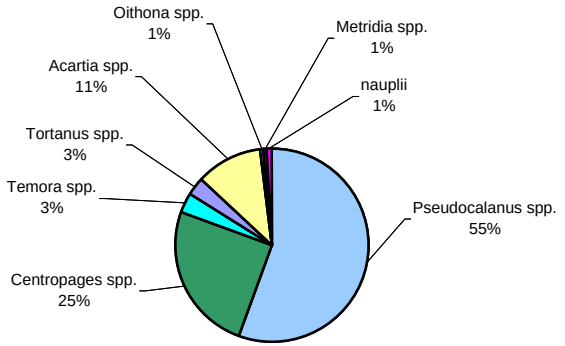
Surface Zooplankton Assessment: Cruise SW634 (22 Jan 2007) Julian Day 22

Recent aerial right whale sightings: No aerial surveys have yet been flown to date in 2007 — *SW634 vessel sightings: 0 right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	920.54	0.54	100.29	0.0197
Surface Tow	6M	893.88	0.33	78.85	0.0154
Surface Tow	8M	846.36	0.31	67.96	0.0133
Surface Tow	9N	159.37	1.23	16.95	0.0033
Surface Tow	5S	563.56	0.22	43.53	0.0086
Surface Tow	6S	2816.55	0.67	173.59	0.0343
Surface Tow	7S	1141.60	0.37	74.15	0.0146
Surface Tow	9S	1379.52	0.47	101.84	0.0204
Cruise Average:		**1090.17**	**0.52**	**82.14**	**0.0162**
Previous Cruise Average:		2137.78	0.93	225.10	0.0421

Zooplankton Species Avg. % Composition: SW634 All Stations, *Surface Tows*

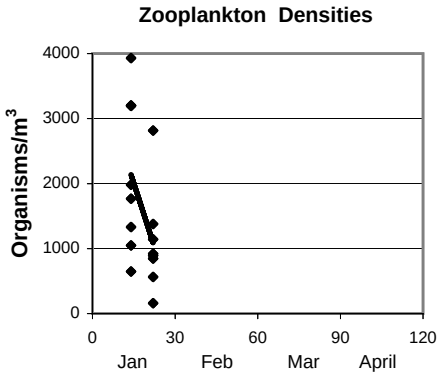


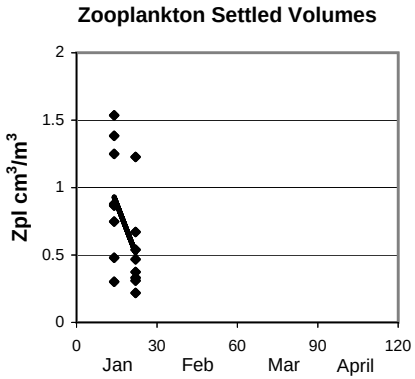
Other zooplankton present in low numbers:
Calanus finmarchicus
nauplii
fish larvae

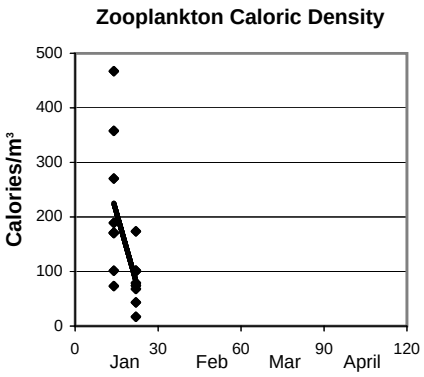
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

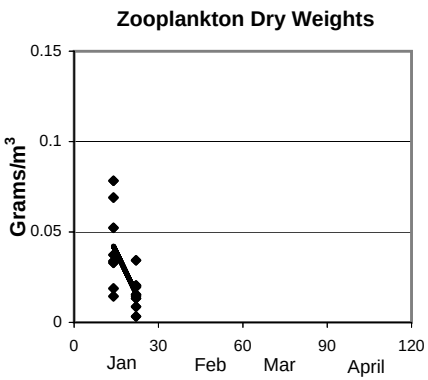
Entire Cape Cod Bay:

Note that scales are identical between surface and oblique graphs

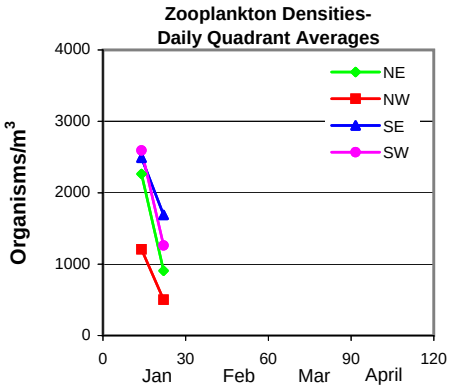


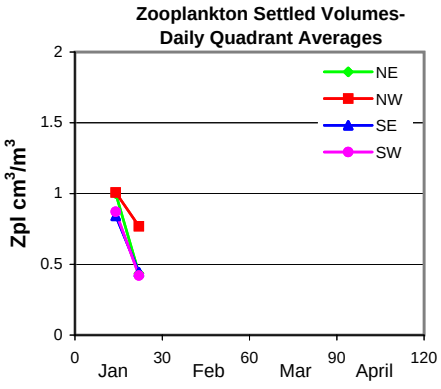


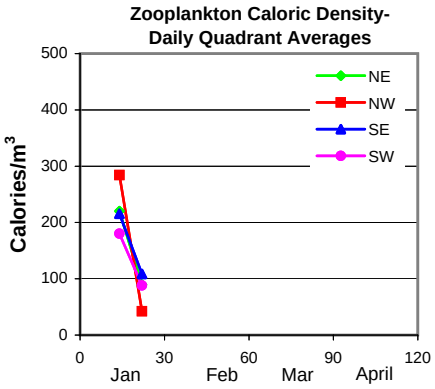


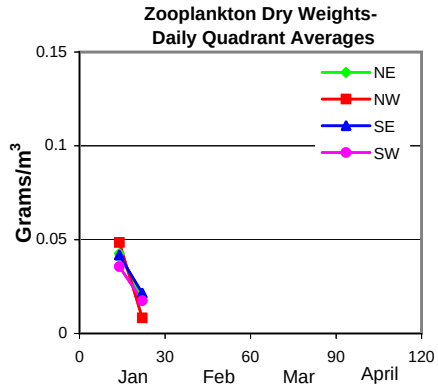


Geographic Quadrants:









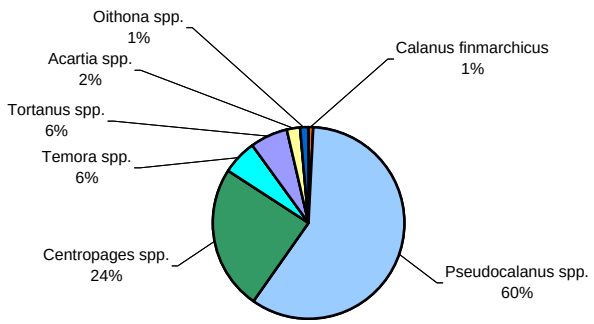
Water Column Zooplankton Assessment: Cruise SW634 (22 Jan 2007) Julian Day 22

Recent aerial right whale sightings: No aerial surveys have yet been flown to date in 2007 — *SW634 vessel sightings: 0 right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	2241.02	1.06	238.44	0.0465
Surface Tow	6M	1198.94	0.59	137.50	0.0262
Surface Tow	8M	2430.02	1.22	270.45	0.0510
Surface Tow	9N	493.37	0.53	59.89	0.0113
Surface Tow	5S	1558.05	0.58	130.75	0.0251
Surface Tow	6S	2808.51	0.90	192.48	0.0377
Surface Tow	7S	3309.27	1.14	201.61	0.0399
Surface Tow	9S	2040.68	1.13	189.75	0.0377
Cruise Average:		**2009.98**	**0.89**	**177.61**	**0.0344**
Previous Cruise Average:		1823.21	0.90	160.52	0.0309

Zooplankton Species Avg. % Composition: SW634 All Stations, *Oblique Tows*

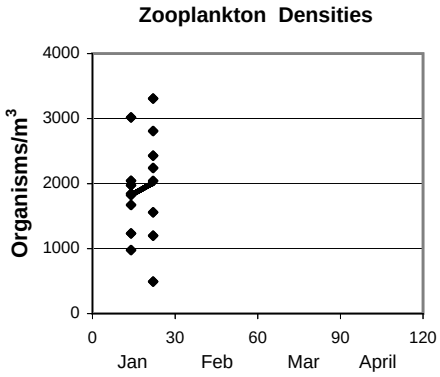


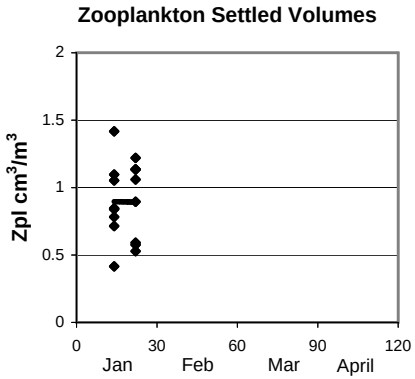
Other zooplankton present in low numbers:
Paracalanus spp.
Metridia spp.
nauplii
fish larve

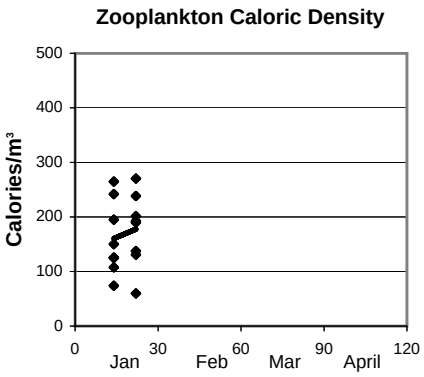
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

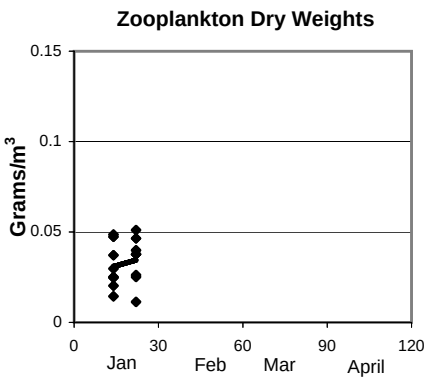
Entire Cape Cod Bay:

Note that scales are identical between surface and oblique graphs

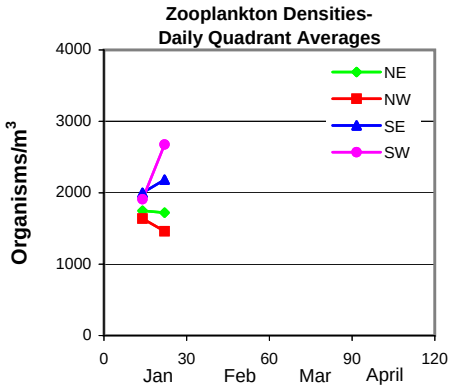


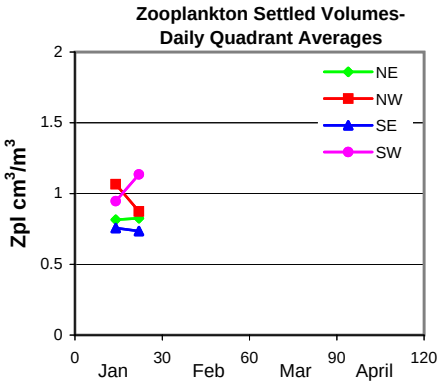


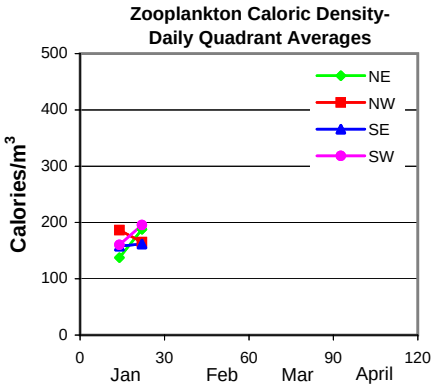


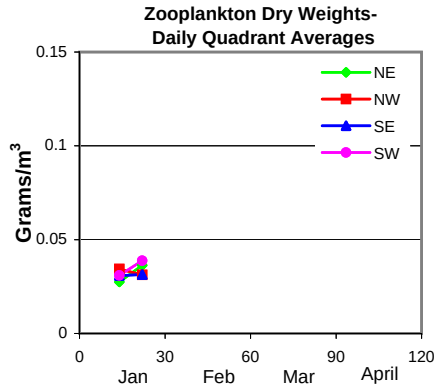


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: Cruise SW636
18 February 2007

Cruise SW636 for the assessment of food resources and prediction of right whale presence in Cape Cod Bay was mounted in moderate conditions with occasional snow showers. SW636 was the first cruise in 27 days due to high winds and icing conditions. Surface and oblique zooplankton net tows were completed at all sampling stations in the Bay.

The zooplankton community continues to be dominated by the smaller genera of calanoid copepods, *Pseudocalanus* and *Centropages*, at concentrations that appear slightly below those recorded during the last sampling cruise in January, continuing the declining trend that was first reported in mid-January. The zooplankton resource appears relatively evenly distributed through the unstratified water column.

With resource densities moderate and declining and no stations judged to be above or near the estimated threshold for feeding, we do not anticipate aggregation or residency of right whales in the Bay in the near future. Lack of zooplankton stratification reinforces the estimate that patch formation is not likely and that feeding behavior and feeding aggregations of right whales are not likely in the near future.

Though only moderate in concentration, the richest food resources in Cape Cod Bay appear broadly distributed throughout stations within the southern half of the Bay. Nevertheless, densities in those stations remain too low to result in right whale residency.

No right whales were observed during SW636 with sighting conditions fair to good. The only marine mammals recorded by spotters were four seals. Under the threat of show showers, a companion aircraft survey was not attempted.

A detailed analysis and assessment of the food resource and prediction of right whale occurrence based on collections made during SW636 will be issued within several days.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Cape Cod Bay Habitat Assessment

ACTIVITIES: 25 January - 18 February, 2007

Vessel-Based Monitoring

The third habitat monitoring cruise of 2007 (cruise SW636) was conducted on 18 February in frigid conditions and Beaufort 2-3 seas. Sighting conditions were good during most of the day, with visibility slightly diminishing towards the end of the cruise as occasional snow squalls passed through the area. No right whales were seen by vessel-based observers, and marine mammal sightings were limited to four harbor and grey seals. All eight regular Cape Cod Bay stations were visited, and surface and oblique (to 19 meters depth) zooplankton samples were collected at each. No auxiliary sampling (e.g. CTD deployment, water collection for nutrient analysis) was conducted due to time constraints.

Air Surveillance

The PCCS aerial surveillance program completed four aerial surveys of Cape Cod Bay since the previous assessment. On 27 January track 16 along the eastern shore of the Cape and the four northern-most track lines were completed. Upon the completion of the fourth track line, snow forced the team to abandon the survey. Numerous dolphins and several fin whales were sighted off of Race Point during this partial survey. The other three surveys, which were complete surveys of Cape Cod Bay, were conducted in early February (7 Feb, 10 Feb, 11 Feb). No cetaceans were sighted in Cape Cod Bay during these flights. On 11 February, the survey team completed the standard survey of Cape Cod Bay and then flew from the BD buoy (42 08.5/69 53.5) to the BC buoy (41 42.0/69 40.0), covering the shipping lane east of Cape Cod. Three right whales were sighted and photographed near the northern end of this leg. One of the three was sighted in the shipping lane, swimming in a south-eastern direction. The other two were sighted west of the shipping lane, feeding beneath the surface.

GENERAL ASSESSMENT

Since January the zooplankton resource experienced declines in abundance bay-wide and at all depths, resulting in very low densities throughout Cape Cod Bay on 18 February (maximum density of 1850 organisms/m^3). Although the observed abundances in both the surface waters and the water column were consistent with records from mid- to late-February from previous years, densities were far below the estimated threshold for right whale feeding (3750 organisms/m^3) at all sampling locations.

The zooplankton community in Cape Cod Bay continues to be dominated by the smaller genera of calanoid copepods, *Pseudocalanus* and *Centropages*. Early-stage *Calanus finmarchicus* were also present in nearly all collections, albeit at very low densities. The richest food resources were distributed at stations in the southern corners of the Bay, though densities at those locations remain too low to support right whale feeding.

With resource densities low and no stations above or near the estimated threshold for feeding, right whale aggregation or residence in the Bay is not anticipated in the near future. Lack of water column stratification reinforces the estimate that patch formation is not likely and that feeding behavior and feeding aggregations of right whales are not probable in the near future.

Interpreted likelihood (1-10) of:

Aggregation: Low (1) **Near-surface feeding: Low (1)**
Residency: Low (1) **Feeding in the water column: Low (2)**
Quadrant Quality/Attractiveness: NW(1), SW(2), SE(2), NE(1)

HABITAT ASSESSMENT AUTHORSHIP:
OSTERBERG, MAYO (DMF-FUNDED PCCS HABITAT STUDIES PROGRAM)
BROWNING, JAQUET (DMF-FUNDED PCCS AIR SURVEILLANCE PROGRAM)

SURFACE RESOURCE

		Currently **18 Feb 2007**		*Recently* **22 Jan 2007**	
Bay-wide mean surface density:		556	zpl/m^3	1090	zpl/m^3
Range of densities for individual stations:					
	Low	60	[sta 8m]	159	[sta 9N]
	High	1111	[sta 5S]	2817	[sta 6S]
Mean surface densities by quadrant:					
	NE	633		907	
	NW	89		502	
	SE	799		1690	
	SW	704		1261	

Inter-annual bay-wide comparison:

year	date	cruise	mean sfc density	
2003	20 Feb	SW314	548	zpl/m^3
2004	17 Feb	SW396	502	
2005	16 Feb	SW523	185	
2006	16 Feb	SW591	146	
2007	18 Feb	SW636	556	

Surface Resource Summary:

- Surface collections from 18 February revealed that, with the exception of one location in the southeastern region of Cape Cod Bay, the zooplankton abundance *decreased at every sampling station* since the previous cruise conducted in late January.
- All individual station densities were far below the estimated threshold density (3750 organisms/m^3) for right whale feeding; in fact, none exceeded 1200 org/m^3. These observations of low surface zooplankton concentrations are consistent with mid- to late-February records from recent years.
- While surface densities were low throughout the Bay, the northwestern stations were particularly depleted, with stations 9N and 8M averaging only 89 org/m^3. This area was also notable in that diatoms were prevalent in both surface and water column collections.
- The largest-magnitude decrease in surface abundance was recorded at station 6S where the density had approached 3000 org/m^3 in late January. Indeed, the southern-central Bay had been an area where modest coalescence of the resource might have attracted right whales, but collections from 18 February show this location to have declined in excess of 2300 org/m^3 since January, making this area unsuitable for right whale aggregation or feeding. Maps of the spatial distribution of zooplankton densities and the changes thereof since the last cruise are presented in Figures 1 and 2.
- Species composition notes:
    - The small copepod genus *Pseudocalanus* continued to dominate surface zooplankton samples on 18 February, representing 60% of the bay-wide mean zooplankton assemblage. *Pseudocalanus* dominance was uniform throughout the Bay's surface waters except in the northwestern region, where total zooplankton densities were extremely low (an average of 89 org/m^3 at stations 9N and 8M).
    - The relative contribution of all subordinate copepod taxa was essentially unchanged since late January; refer to the pie chart on page 6 of this document for details of the bay-wide average percent composition of each taxa.
    - Early-stage *Calanus finmarchicus* were present in very low densities in all but the southwest quadrant of Cape Cod Bay (stations 9S and 7S).

WATER COLUMN RESOURCE FROM OBLIQUE TOWS (surface to 19 meters)

		Currently **18 Feb 2007**		*Recently* **22 Jan 2007**	
Bay-wide mean oblique density:		966	zpl/m^3	2010	zpl/m^3
Range of densities for individual stations:					
	Low	258	[sta 9N]	493	[sta 9N]
	High	1843	[sta 6S]	3309	[sta 7S]
Mean oblique densities by quadrant:					
	NE	803		1720	
	NW	222		1462	
	SE	1668		2183	
	SW	1170		2675	

Inter-annual bay-wide comparison:

year	date	cruise	mean obl density	
2004	17 Feb	SW396	3547	zpl/m^3
2005	16 Feb	SW523	451	
2006	16 Feb	SW591	782	
2007	18 Feb	SW636	966	

Water Column Resource Summary:

- Collections from 18 February revealed that the zooplankton density in the water column *decreased at all stations* since late-January, with the bay-wide mean abundance in the water column declining by over 1000 organisms/m^3. The widespread decreases resulted in all individual stations recording densities below 2000 org/m^3; thus, the entire Bay was well below the estimated right whale feeding threshold (3750 org/m^3).
- All water column samples had higher zooplankton densities than their corresponding surface collections. In most cases the difference was on the order of a couple hundred organisms per cubic meter, but at several southern stations (6S and 9S) the discrepancy was more pronounced (1350 and 675 org/m^3, respectively).
- As was noted for the surface samples, the southern-central area of the Bay (stations 7S and 6S) had shown promise in late-January as an area where the concentration of the resource into patches could potentially have fostered right whale feeding. Although the highest zooplankton density recorded in Cape Cod Bay on 18 February was from the water column at station 6S (approximately 1800 org/m^3), absent a significant enrichment this southern-central area is not likely to attract right whales. The water column zooplankton density distribution and dynamics are presented in Figures 1 and 2.
- Species composition notes:
    - Lacking stratification and continuously being mixed by winter winds, Cape Cod Bay had a zooplankton assemblage that was nearly identical in the surface waters and in the water column, with *Pseudocalanus* spp. representing 57% of the mean total zooplankton.
    - As was observed in the surface samples, early-stage *Calanus finmarchicus* was present in low densities in all water column samples from 18 February except at station 7S in the southwest. Slightly different, however, was the appearance of low densities of early- and late-stage *Calanus* at station 9S in the southwest, whereas no *Calanus* were recorded in the surface sample at this location.

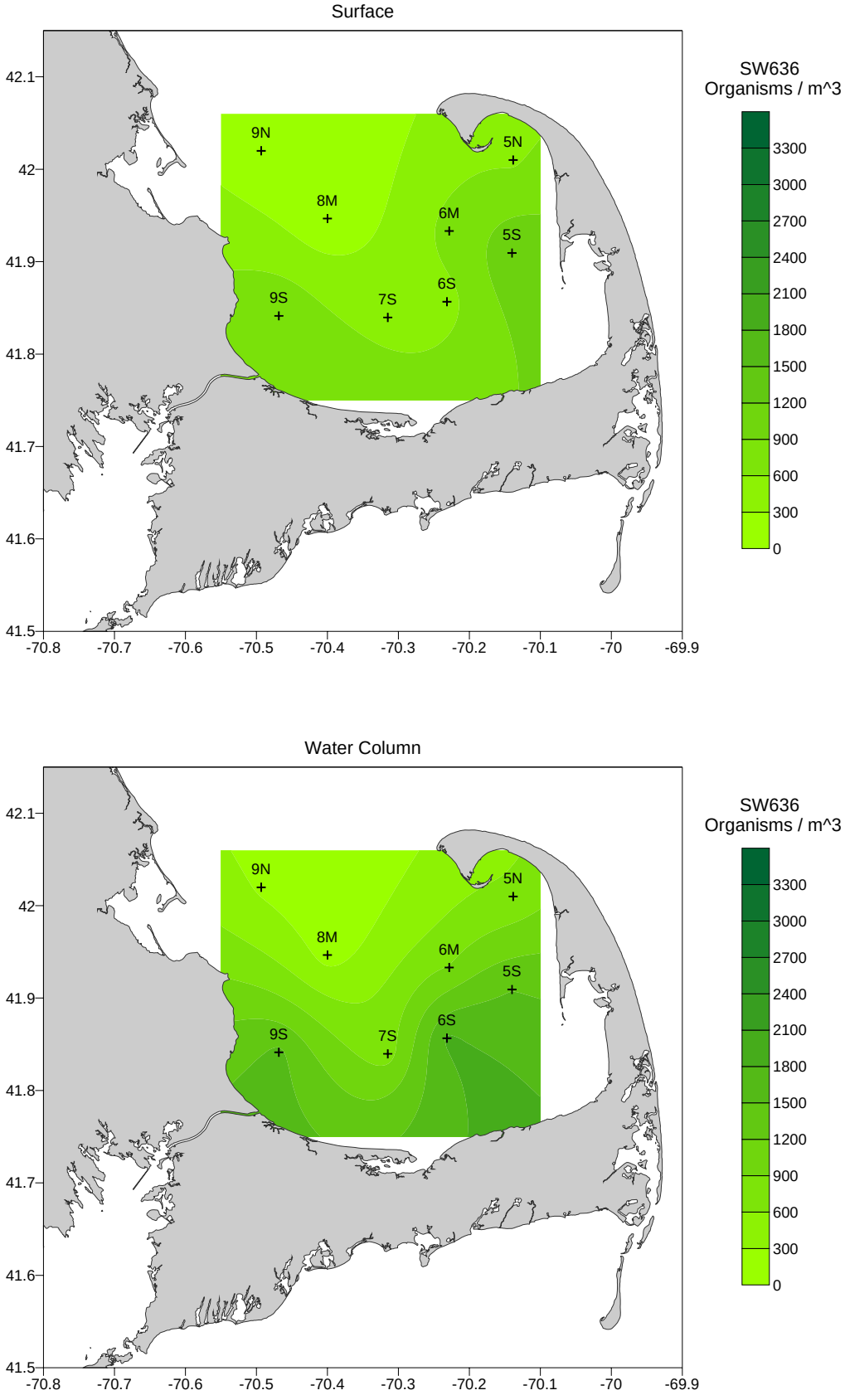


Figure 1. Spatial plots of **zooplankton densities** from surface (upper plot) and oblique (lower plot) tows conducted during cruise SW636 on 18 February 2007. Sampling station locations are indicated with a "+" symbol.

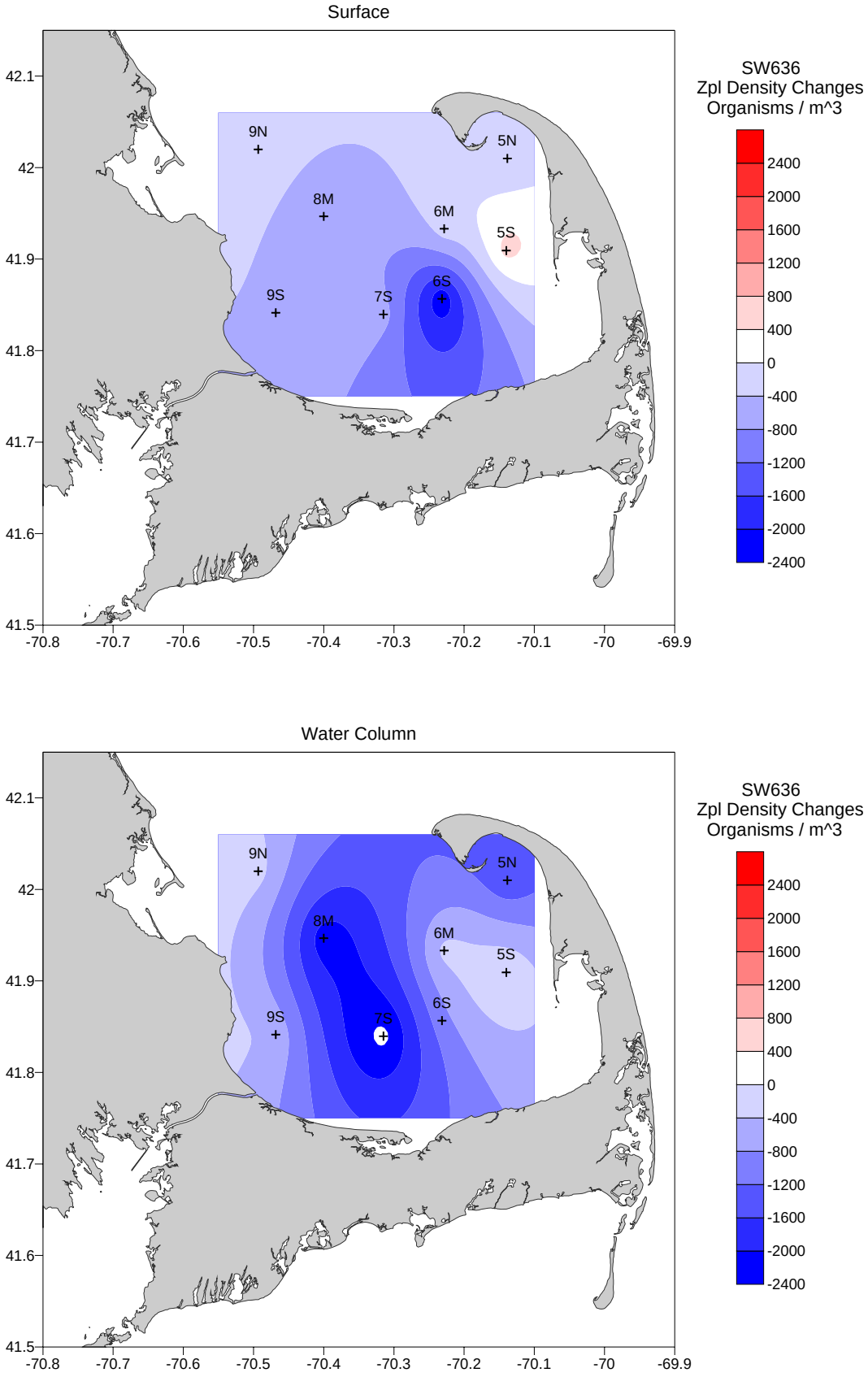


Figure 2. Spatial plots of the **changes in zooplankton densities** between the previous cruise (SW634 on 22 January) and the latest sampling cruise (SW636 on 18 February). Changes in *surface* density are displayed in the upper plot, while changes in *water column* density are plotted below. Sampling station locations are indicated with a "+" symbol.

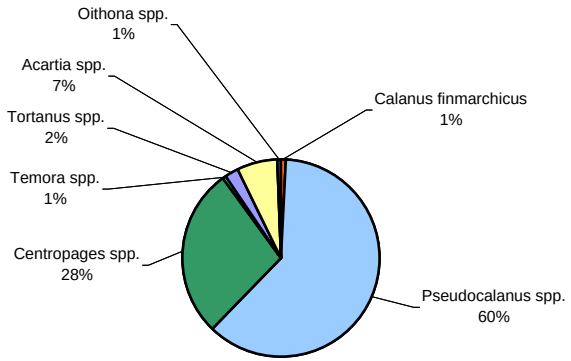
Surface Zooplankton Assessment: Cruise SW636 (18 Feb 2007) Julian Day 49

Recent aerial right whale sightings: 3 animals along the back side of Cape Cod on 11 Feb — *SW636 vessel sightings: 0 right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	556.66	0.26	40.21	0.0077
Surface Tow	6M	709.64	0.32	69.59	0.0135
Surface Tow	8M	59.59	0.09	6.59	0.0013
Surface Tow	9N	118.53	0.10	10.49	0.0022
Surface Tow	5S	1110.60	0.30	75.89	0.0150
Surface Tow	6S	487.22	0.21	42.55	0.0084
Surface Tow	7S	518.03	0.28	47.89	0.0093
Surface Tow	9S	889.34	0.36	77.30	0.0149
Cruise Average:		**556.20**	**0.24**	**46.31**	**0.0090**
Previous Cruise Average:		1090.17	0.52	82.14	0.0162

Zooplankton Species Avg. % Composition: SW636 All Stations, *Surface Tows*

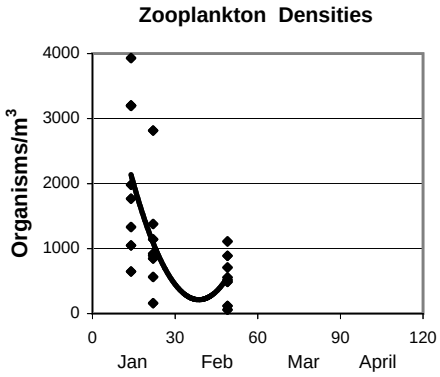


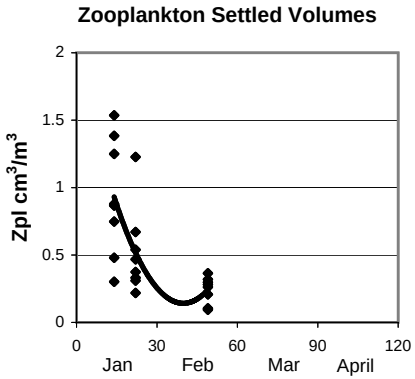
Other zooplankton present in low numbers:
Metridia spp.
nauplii
molluscs

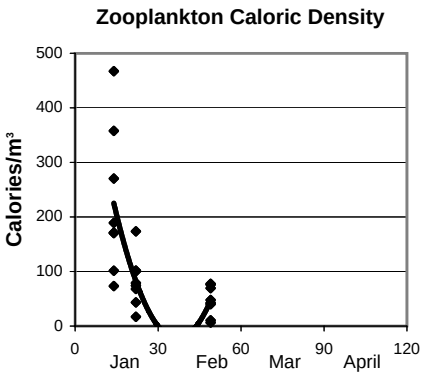
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

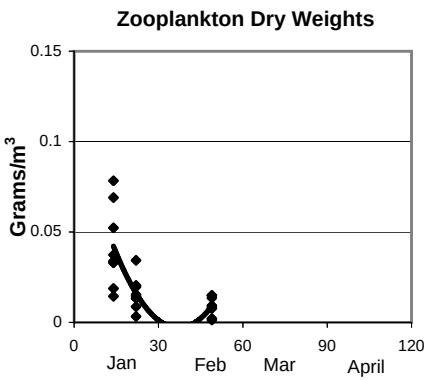
Entire Cape Cod Bay :

Note that scales are identical between surface and oblique graphs









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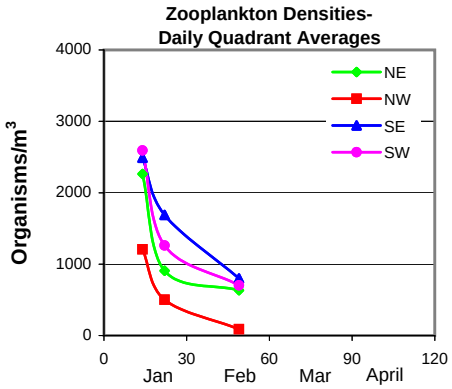
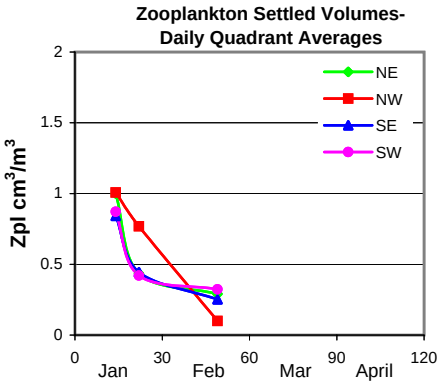
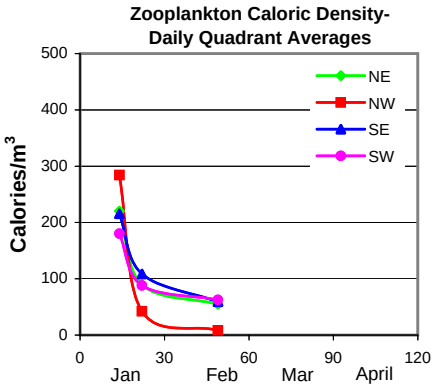
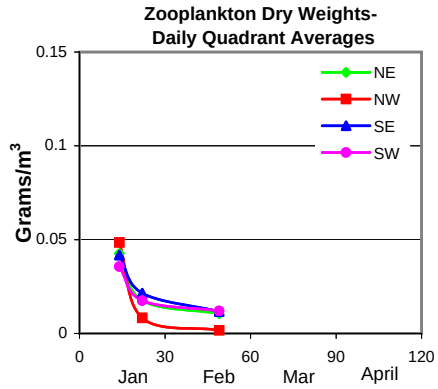








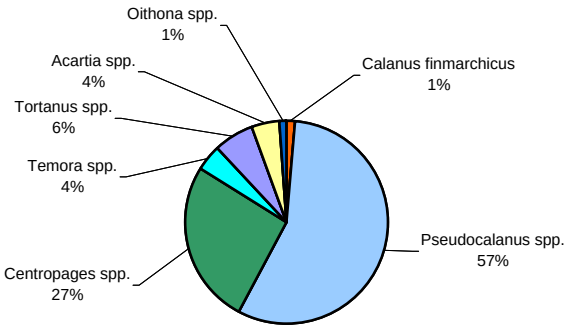
Water Column Zooplankton Assessment: Cruise SW636 (18 Feb 2007) Julian Day 49

Recent aerial right whale sightings: 3 animals along the back side of Cape Cod on 11 Feb — *SW636 vessel sightings: 0 right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	692.27	0.46	60.25	0.0117
Surface Tow	6M	913.77	0.52	96.75	0.0190
Surface Tow	8M	185.57	0.23	27.02	0.0052
Surface Tow	9N	257.86	0.23	21.66	0.0042
Surface Tow	5S	1492.51	0.55	108.02	0.0212
Surface Tow	6S	1842.94	0.37	182.43	0.0355
Surface Tow	7S	776.89	0.41	78.59	0.0153
Surface Tow	9S	1562.53	0.69	135.58	0.0263
Cruise Average:		**965.54**	**0.43**	**88.79**	**0.0173**
Previous Cruise Average:		2009.98	0.89	177.61	0.0344

Zooplankton Species Avg. % Composition: SW636 All Stations, *Oblique Tows*

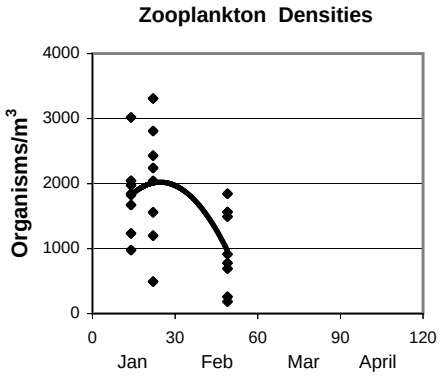


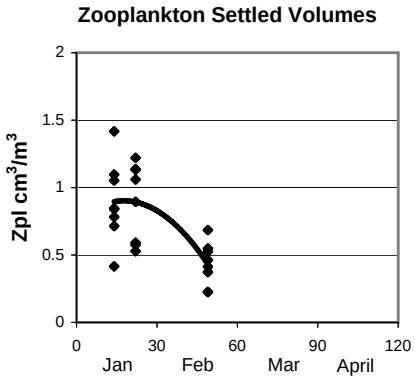
Other zooplankton present in low numbers:
Metridia spp.
nauplii
fish larvae
cyprids

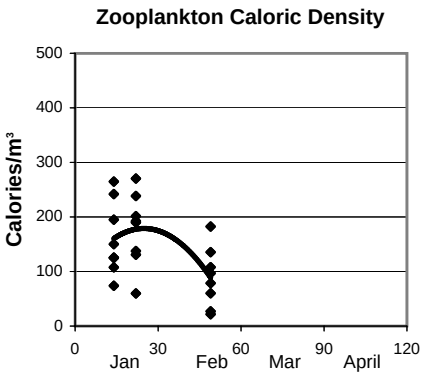
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

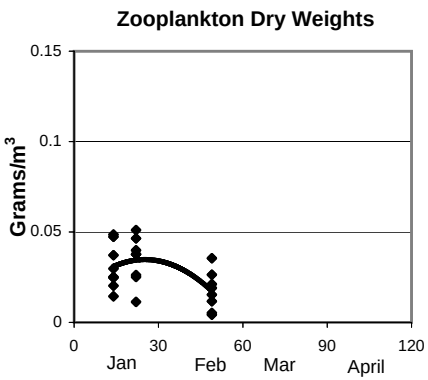
Entire Cape Cod Bay:

Note that scales are identical between surface and oblique graphs

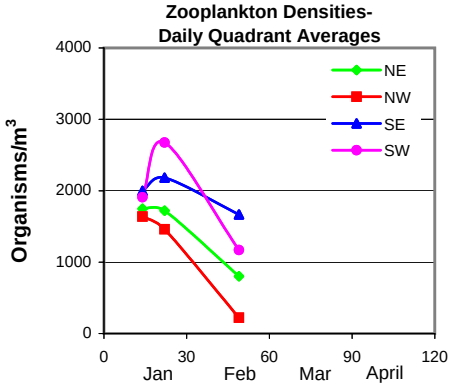


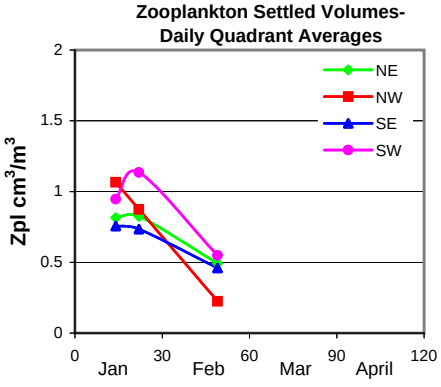


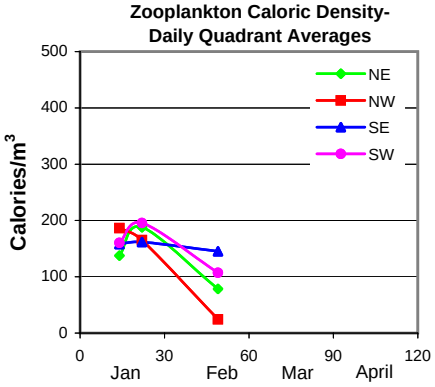


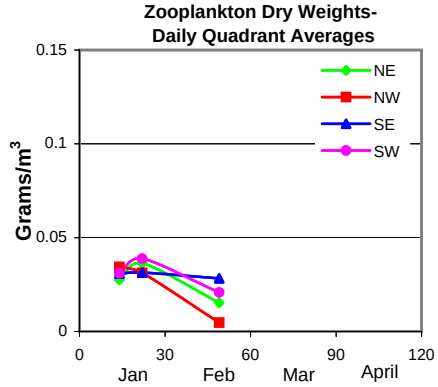


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW638
27 February 2007

After a period of high winds and recent reports by the PCCS surveillance aircraft of right whales entering Cape Cod Bay, cruise SW638 was carried out in partial sun and moderate seas. All regular stations in the Bay were sampled using both surface and oblique net collection methods. Additional zooplankton collections were made at two stations where right whales were sighted.

The zooplankton community throughout the Bay continues to be dominated by the smaller taxa of calanoid copepods *Pseudocalanus* and *Centropages*, at concentrations somewhat greater than recorded thus far this year, yet densities remain below the threshold for right whale feeding. With one important exception *Calanus finmarchicus* was poorly represented in all samples. Net sampling at stations along the southern margin of the Bay both in the vicinity of a social group of 5 whales (surface and 26-meter oblique tows) and in the path of a non-feeding whale (surface and 19-meter oblique tows) similarly showed modest food densities. Although the densities were higher than usual for late February, the abundance of the zooplankton food resource as collected in surface and mid-water tows does not explain the presence of whales in the Bay. We hypothesize that the relative stability of the present group of whales within the Bay is likely encouraged by a rich zooplankton resource present in the engybenthic layer of the southern quadrants, as has been documented in past years. Future cruises will employ vertical sampling protocols to determine the distribution of food resources at or very near the bottom substrate where the zooplankton layer sometimes forms. While the mid-water and surface zooplankton distribution is not rich enough to support feeding or aggregation of right whales, modest densities of calanoid copepods in the south and southwest parts of the bay suggest that rich patches could coalesce, and perhaps already have, at the sediment-water interface. Considering the possibility of near-bottom feeding, buoyant ground lines (not permitted in Cape Cod Bay by the Massachusetts Division of Marine Fisheries) would represent a risk of entanglement.

An exceptional surface sample from station 9N, unique among those samples collected on SW638, documents an unusual resource composition in the northwestern portion of the Bay. The surface net collection from that location captured a rich concentration of late-stage *Calanus finmarchicus* copepodites. The density of zooplankton in this sample was judged on preliminary analysis to approach that of the right whales' feeding threshold.

Based on surface and mid-water zooplankton distribution throughout the Bay, with the exception of the aforementioned sample, conditions continue to suggest that Cape Cod Bay may become marginally attractive to right whales in the south and southwestern areas should the zooplankton become concentrated into dense patches. However, at present the mid-water samples are not rich enough to support long-term stable aggregations of whales or surface feeding. Until we have collected samples definitively demonstrating the occurrence of a rich bottom layer in the southern Bay we cannot predict a long-term aggregation of whales in the area in spite of their documented presence.

Seven right whales were observed from the R/V *Shearwater* during SW638 in excellent sighting conditions. The DMF-PCCS survey aircraft flew tracks along the eastern outer shore of the Cape and completed all tracks in Cape Cod Bay. In addition to sighting a total of ten right whales in Cape Cod Bay the aerial team also reported 18 right whales east of the Cape, with observations of feeding near Chatham and a small group of socializing animals northeast of Truro.

Surface water temperatures throughout Cape Cod Bay reached the lowest level seen during the winter of 2007, with 1.1 degrees C. recorded in the northeastern quadrant.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Cape Cod Bay Habitat Assessment

ACTIVITIES: 19 February - 1 March, 2007

Vessel-Based Monitoring

Habitat monitoring cruise SW638 was conducted on 27 February in Cape Cod Bay. Beaufort 1-2 seas and partly cloudy skies afforded excellent visibility, and seven right whales were sighted by vessel-based observers. Six of these animals were associated with a surface active group (SAG) and a lone right whale was observed on long dives. While feeding was not evident, surface and water column zooplankton collections were acquired in the vicinity of the SAG and the individual in order to assess whether the resource might encourage residency. Net tows were also conducted at the eight regular Cape Cod Bay stations, with surface and oblique (to 19 meters depth) zooplankton samples collected at each. Auxiliary sampling consisted of water collection for nutrient analysis. **A preliminary assessment and prediction document was distributed immediately following cruise SW638.**

Air Surveillance

The PCCS aerial surveillance program completed five surveys of Cape Cod Bay since the previous assessment. Right whales were sighted within Cape Cod Bay during all of these flights. The sightings began on 21 February with two right whales seen a few miles south of the Wood End lighthouse. In the flights since then, the number of right whales within the Bay increased from 5-11, with 11 sighted on 27 February. The right whales within Cape Cod Bay were observed in SAGs and on long dives (15 minutes or greater). One whale, preliminarily matched to 1817, has been observed with her yearling on several occasions. At their first sighting on 22 February, the yearling appeared to be nursing, alternating sides as it dove beneath its mother. While no feeding behavior has been observed within the Bay, skim feeding in echelon formation was observed east of Nauset Beach on 27 February and north of Race Point on 01 March.

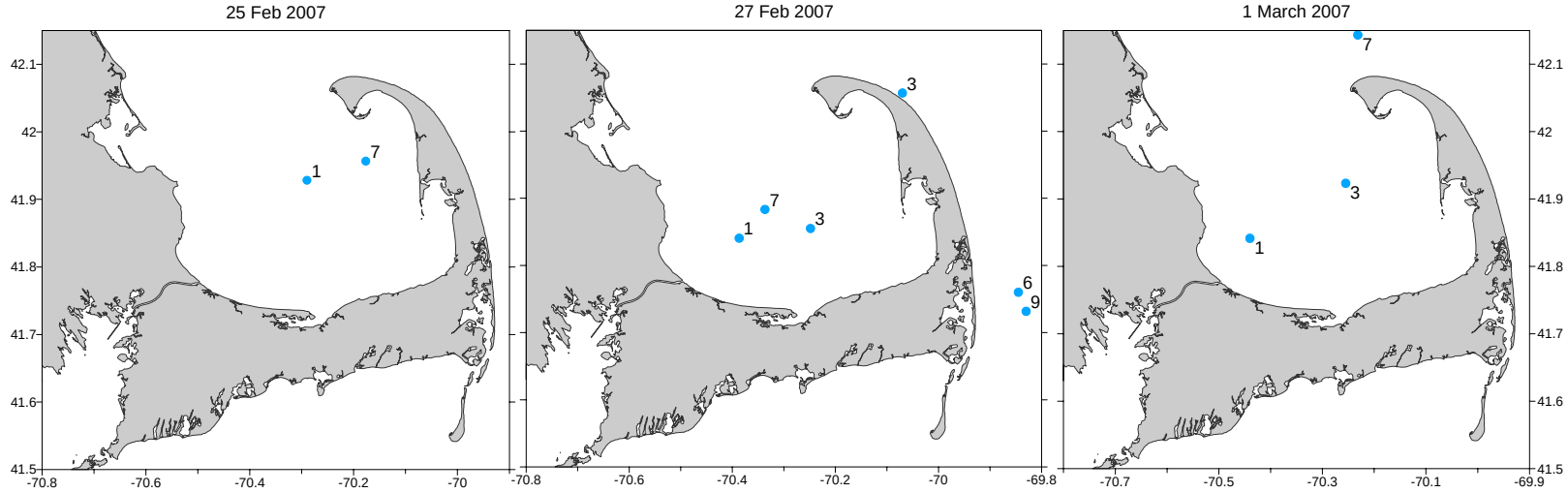


Figure 1. Right whale sightings from surveys conducted on (left to right) 25 February, 27 February and 01 March.

HABITAT ASSESSMENT AUTHORSHIP:
OSTERBERG, MAYO (DMF-FUNDED PCCS HABITAT STUDIES PROGRAM)
BROWNING, JAQUET (DMF-FUNDED PCCS AIR SURVEILLANCE PROGRAM)

GENERAL ASSESSMENT

The zooplankton community throughout Cape Cod Bay continues to be dominated by the smaller taxa of calanoid copepods, *Pseudocalanus* and *Centropages,* at concentrations slightly greater than recorded previously on 18 February; nonetheless, densities remain below the estimated threshold for right whale feeding. Net sampling at stations along the southern margin of the Bay both in the vicinity of a social group (tows at the surface and to a depth of 26 meters) and in the path of a non-feeding whale (surface and 19-meter oblique tows) showed only modest food quantities.

Although water column zooplankton densities were higher than usual for late February, the abundance of the food resource does not explain the presence of whales in the Bay. In past years we have documented a rich zooplankton resource at or very near the bottom substrate (an "engybenthic" layer) capable of supporting early-season right whale feeding, and it is possible that the relative stability of the present group of whales within the Bay is encouraged by such a feature in the southern-central region. Standard net sampling techniques cannot be used to document the engybenthic layer due to the difficulty of deploying nets close to the sea floor, as well as the integration of the sample over the entire water column (which may mask dense layers by essentially diluting their apparent importance). Future cruises will employ vertical pump sampling protocols to determine the distribution of food resources near the bottom.

Conditions continue to suggest that Cape Cod Bay may become marginally attractive to right whales in the southern-central and southwestern areas should the zooplankton become concentrated into dense patches. However, at present the resource is not rich enough to support long-term stable aggregations of whales or surface feeding. Until we have collected samples definitively demonstrating the occurrence of a rich bottom layer in the southern Bay we cannot predict a long-term aggregation of whales in the area in spite of their documented presence.

Interpreted likelihood (1-10) of:
Aggregation: Low (2)
Residency: Low (2)
Near-surface feeding: Low (1)
Feeding in the water column: Low (2)
Quadrant Quality/Attractiveness: NW(1), SW(2), SE(1), NE(1)

SURFACE RESOURCE

		Currently **27 Feb 2007**		*Recently* **18 Feb 2007**	
Bay-wide mean surface density:		529	zpl/m^3	556	zpl/m^3
Range of densities for individual stations:					
	Low	226	[sta 6M]	60	[sta 8M]
	High	952	[sta 9S]	1111	[sta 5S]
Mean surface densities by quadrant:					
	NE	369		633	
	NW	690		89	
	SE	483		799	
	SW	575		704	

Inter-annual bay-wide comparison:

year	date	cruise	mean sfc density	
2003	27 Feb	SW316	40	zpl/m^3
2004	1 Mar	SW399	114	
2005	24 Feb	SW524	300	
2006	2 Mar	SW594	292	
2007	27 Feb	SW638	529	

Surface Resource Summary:

- Although the bay-wide mean surface abundance on 27 February was slightly higher than observations from past years, zooplankton densities were nonetheless far below the estimated threshold that would trigger right whale feeding (3750 organisms/m^3). Indeed, no individual station's surface abundance even exceeded 1000 org/m^3.
- Station 9S in the far southwest continued to support elevated surface densities relative to other areas of the Bay, having ranked among the highest on each of the four sampling dates thus far in 2007. On 27 February this location had the richest surface density in the Bay with 952 org/m^3.
- Changes in surface density from those recorded on 18 February were minimal at all stations. The pattern of these changes, however, showed a contrast between the eastern and western regions of the Bay, with the east being an area where surface zooplankton densities uniformly decreased, while western stations recorded either increases or approximately no change. Maps of the spatial distribution of zooplankton densities and the changes thereof since the last cruise are presented in Figures 2 and 3.
- The greatest increases in zooplankton density since the previous cruise were found in the northwest at stations 8M and 9N, where the surface abundance had been extremely low (average of 89 org/m^3) on 18 February, gaining approximately 700 and 500 org/m^3, respectively, by 27 February.
- Species composition notes:
    - The small copepod genus *Pseudocalanus* continued to dominate surface zooplankton samples on 27 February, representing 50% of the bay-wide mean zooplankton assemblage. This dominance was diminished since the previous cruise (60%), with declines occurring throughout the southern and eastern regions of the Bay. With this small decrease in *Pseudocalanus* dominance, the relative contribution of several subordinate copepod taxa increased slightly since mid-February, including *Acartia* spp. (11% of the mean total zooplankton, up from 7%), *Calanus finmarchicus* (5%, up from 1%) and *Tortanus discaudatus* (4%, up from 2%).
    - Unique among samples collected on SW638, the surface collection from station 9N revealed an exceptional species composition in which late-stage *Calanus finmarchicus* represented 30% of the total zooplankton. While the total zooplankton density in this sample was low (approximately 600 organisms/m^3), the anomalous composition resulted in its rivaling the caloric richness of the most dense *Pseudocalanus*-dominated samples.

WATER COLUMN RESOURCE FROM OBLIQUE TOWS (surface to 19 meters)

		Currently **27 Feb 2007**		*Recently* **18 Feb 2007**	
Bay-wide mean oblique density:		1159	zpl/m^3	966	zpl/m^3
Range of densities for individual stations:					
	Low	394	[sta 9N]	258	[sta 9N]
	High	3104	[sta 7S]	1843	[sta 6S]
Mean oblique densities by quadrant:					
	NE	623		803	
	NW	821		222	
	SE	587		1668	
	SW	2603		1170	

Inter-annual bay-wide comparison:

year	date	cruise	mean obl density	
2004	1 Mar	SW399	3093	zpl/m^3
2005	24 Feb	SW524	426	
2006	2 Mar	SW594	374	
2007	27 Feb	SW638	1159	

Water Column Resource Summary:

- The bay-wide average density of zooplankton in the water column increased slightly since 18 February to approximately 1150 organisms/m^3 on 27 February. While notably higher than records from 2005 and 2006, the observed abundance at all stations was well below the density thought to release right whale feeding (3750 org/m^3).
- At most stations water column densities continued to be considerably higher than their corresponding surface densities. In most cases the difference was on the order of 3-500 organisms per cubic meter, but at the two southwestern stations (7S and 9S) the discrepancy was more pronounced (2700 and 1150 org/m^3, respectively).
- As observed in the surface samples, a distinct contrast was apparent in the eastern versus the western Bay in terms of changes in water column density since the previous cruise. Density gains were recorded for all western stations, while eastern stations uniformly experienced declines. These changes resulted in a density distribution that was similarly divided, with the highest water column densities recorded in the west. See Figures 2 and 3 for maps of water column abundance and the dynamics thereof.
- The highest density area in the Bay on 27 February was recorded in the southwest where stations 7S and 9S recorded water column densities of 3100 and 2100 org/m^3, respectively. Station 7S has undergone large-magnitude density changes (both positive and negative) between every sampling cruise to date in 2007, and with further enrichment or coalescence of the resource into patches this location could become attractive to right whales.
- Species composition notes:
    - The higher-density water column (relative to surface densities) was again strongly dominated by *Pseudocalanus* spp., which comprised 62% of the mean total zooplankton. *Pseudocalanus* density decreases at all eastern stations were offset by large increases at several western stations (2194 *Pseudo*/m^3 gained at 7S, and 745 *Pseudo*/m^3 at 8M)
    - While most subordinate taxa remained relatively constant, the abundance of *Centropages* spp. declined in the eastern Bay, representing 19% of the bay-wide mean total zooplankton (down from 27% on 18 Feb). *Tortanus discaudatus* increased at stations throughout Cape Cod Bay; these gains were particularly notable at station 8M in the northwest where it represented 26% of the total zooplankton in the water column.
    - Both early- and late-stage *Calanus finmarchicus* were present in low concentrations in water column collections from all stations except 8M in the northwest.

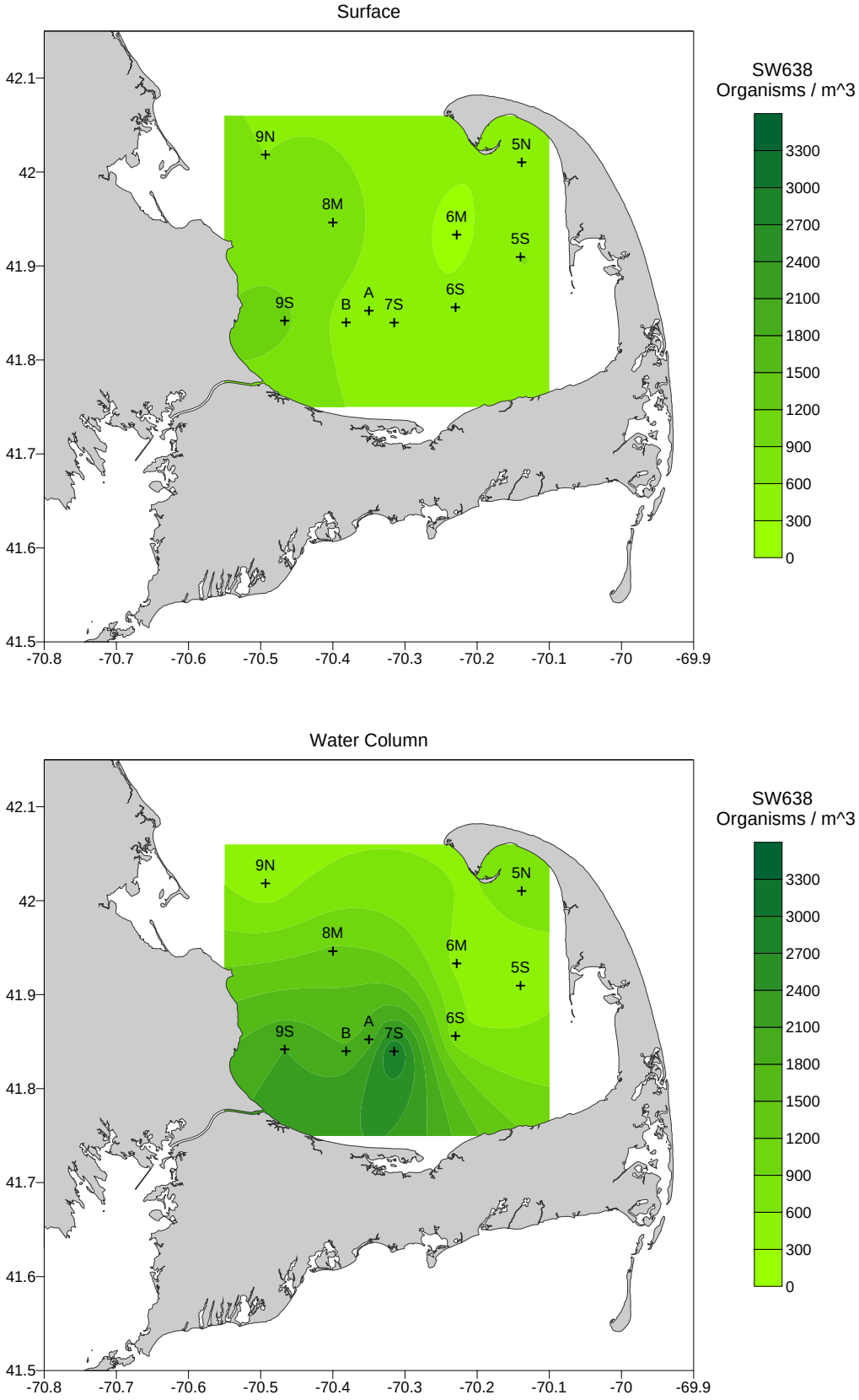


Figure 2. Spatial plots of **zooplankton densities** from surface (upper plot) and oblique (lower plot) tows conducted during cruise SW638 on 27 February 2007. Sampling station locations are indicated with a "+" symbol. Auxiliary tows (both surface and oblique) were conducted at special station A near a surface active group of five right whales, and also at station B in the path of a lone right whale that had been swimming slowly at the surface between long dives.

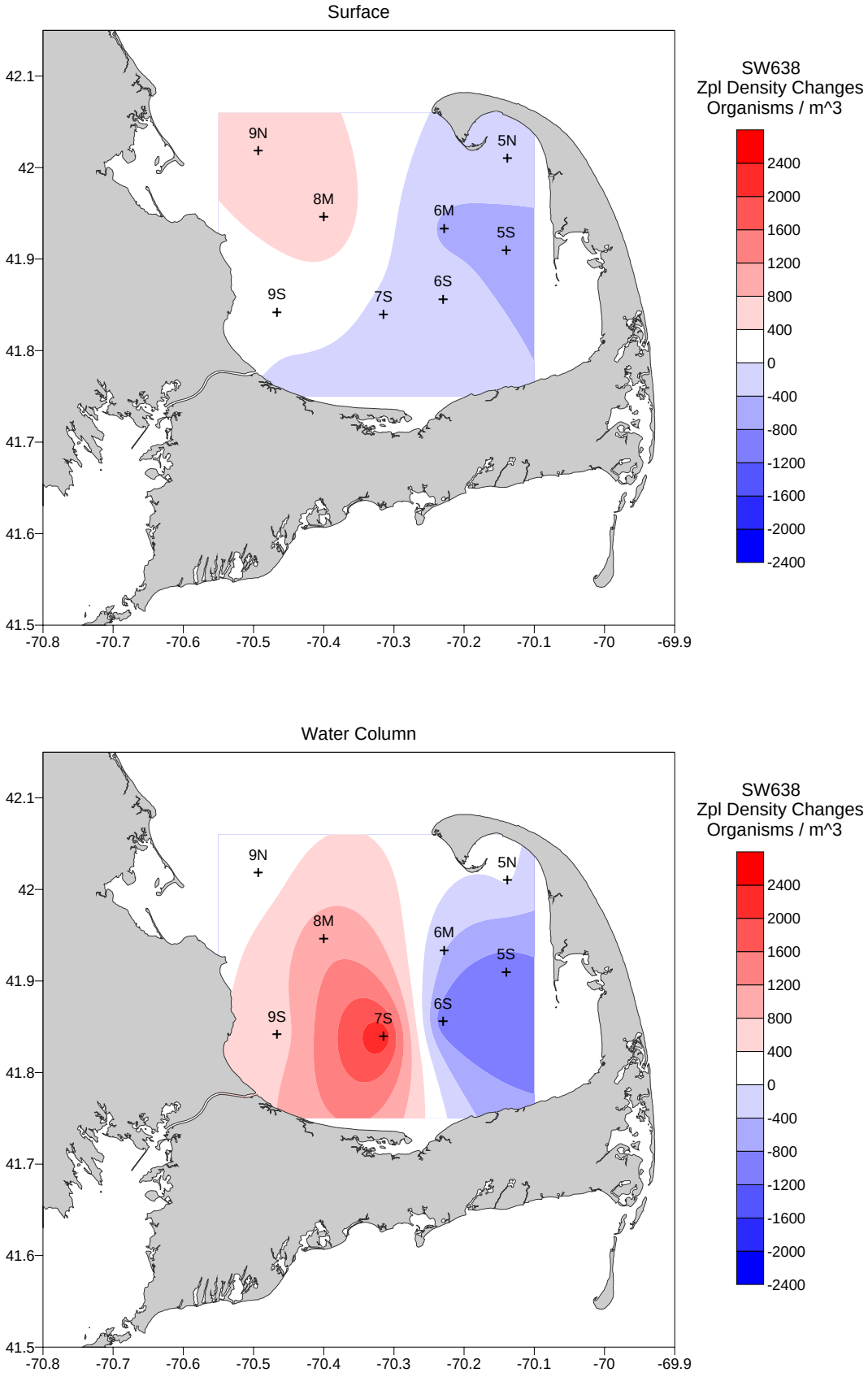


Figure 3. Spatial plots of the **changes in zooplankton densities** between the previous cruise (SW636 on 18 February) and the latest sampling cruise (SW638 on 27 February). Changes in *surface* density are displayed in the upper plot, while changes in *water column* density are plotted below. Sampling station locations are indicated with a "+" symbol.

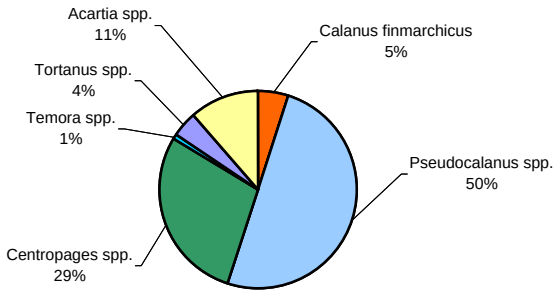
Surface Zooplankton Assessment: Cruise SW638 (27 Feb 2007) Julian Day 58

Recent aerial NARW sightings: 18 animals along the back side of Cape Cod and 10 in CCB on 27 Feb — ***SW638 vessel NARW \sightings: 7 right whales***

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	312.32	0.21	33.08	0.0064
Surface Tow	6M	225.55	0.17	21.39	0.0041
Surface Tow	8M	795.32	0.42	62.16	0.0122
Surface Tow	9N	598.81	0.78	182.40	0.0305
Surface Tow	5S	613.48	0.27	45.13	0.0095
Surface Tow	6S	323.44	0.16	28.77	0.0056
Surface Tow	7S	412.81	0.26	42.43	0.0082
Surface Tow	9S	951.82	0.51	84.33	0.0163
Cruise Average:		**529.19**	**0.35**	**62.46**	**0.0116**
Previous Cruise Average:		556.20	0.24	46.31	0.0090

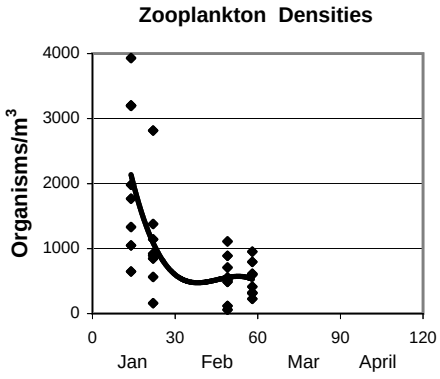
Zooplankton Species Avg. % Composition: SW638 All Stations, *Surface Tows*

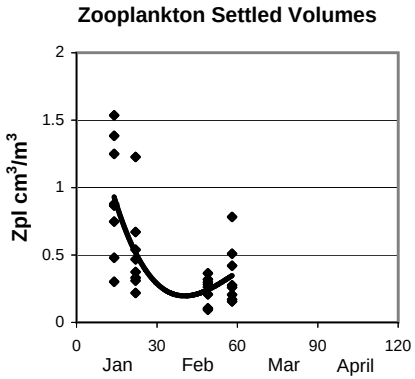


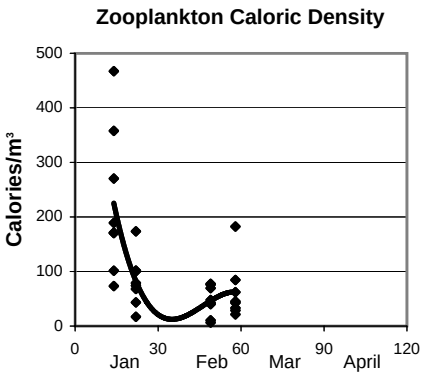
Other zooplankton present in low numbers:
Eurytemora spp.
Oithona spp.
nauplii

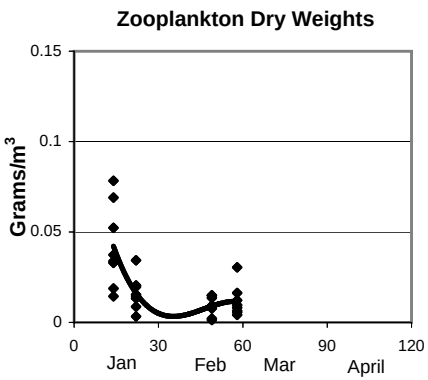
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

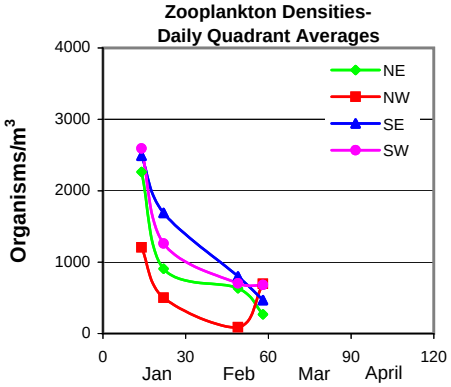


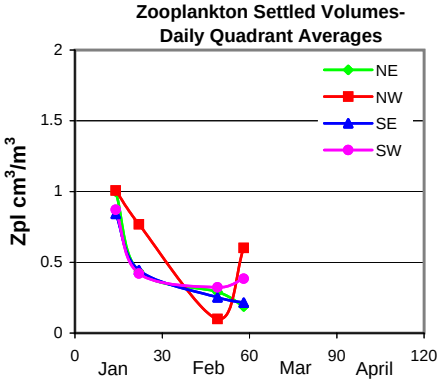


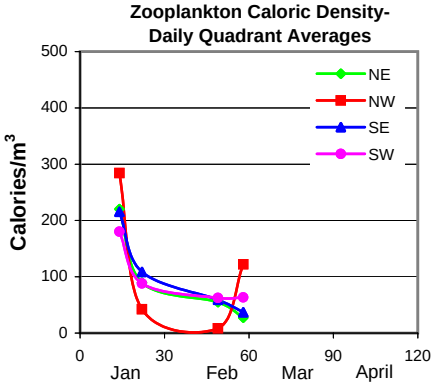


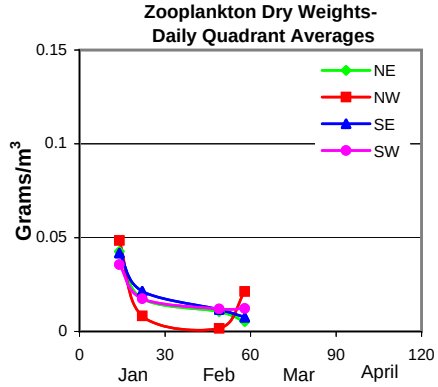


Geographic Quadrants:









Water Column Zooplankton Assessment: Cruise SW638 (27 Feb 2007) Julian Day 58

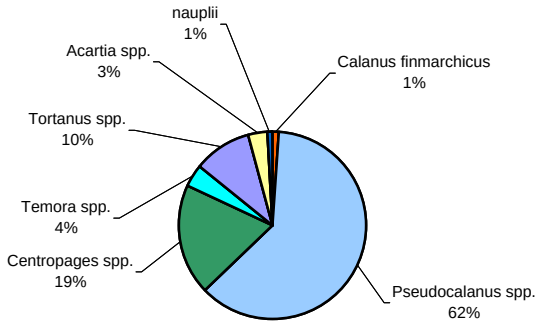
Recent aerial NARW sightings: 18 animals along the back side of Cape Cod and 10 in CCB on 27 Feb — *SW638 vessel NARW sightings: 7 right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	726.92	0.57	79.87	0.0153
Oblique Tow	6M	518.95	0.40	55.81	0.0109
Oblique Tow	8M	1247.67	0.75	121.13	0.0235
Oblique Tow	9N	394.46	0.43	48.89	0.0090
Oblique Tow	5S	466.83	0.32	42.14	0.0084
Oblique Tow	6S	707.46	0.46	73.23	0.0140
Oblique Tow	7S	3103.78	0.94	220.70	0.0432
Oblique Tow	9S	2103.19	0.88	190.56	0.0378
Cruise Average:		**1158.66**	**0.59**	**104.04**	**0.0202**
Previous Cruise Average:		965.54	0.43	88.79	0.0173

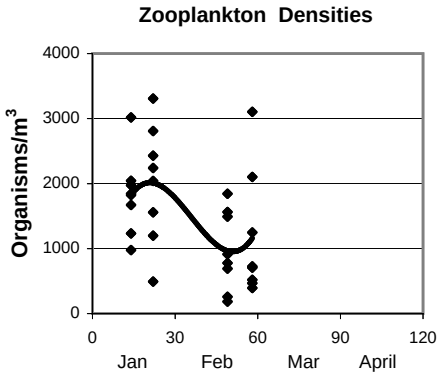
Zooplankton Species Avg. % Composition: SW638 All Stations, *Oblique Tows*

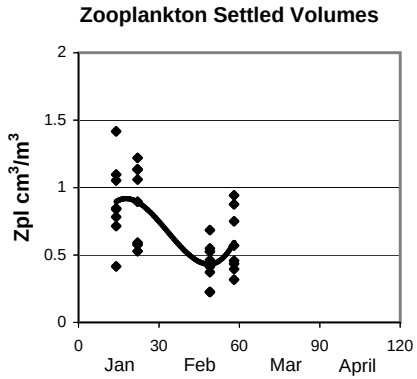
Other zooplankton present in low numbers:
Eurytemora spp.
Oithona spp.
Metridia spp.
fish larve
molluscs

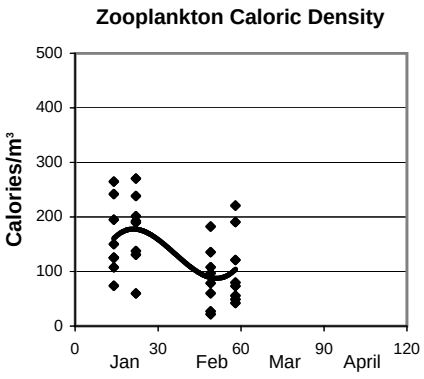


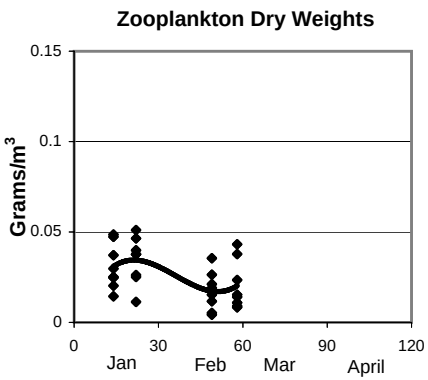
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

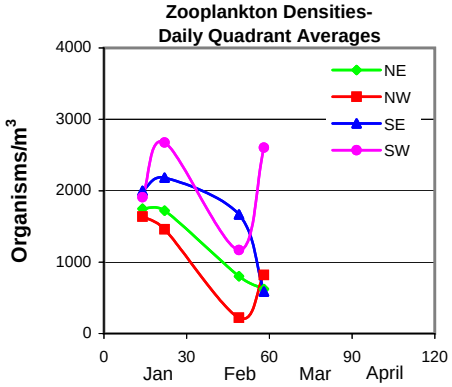


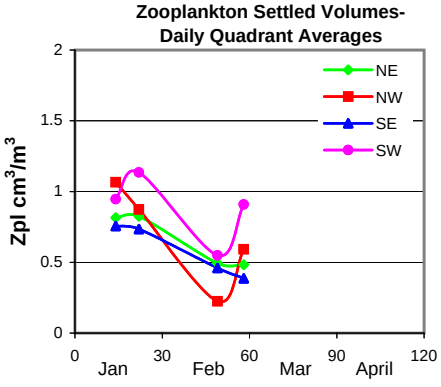


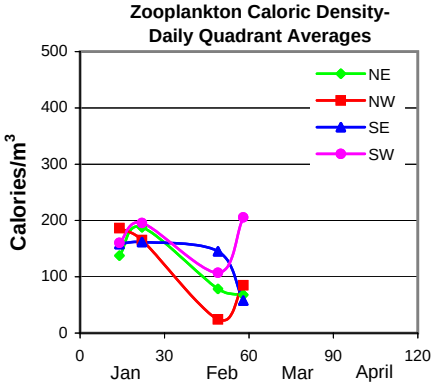


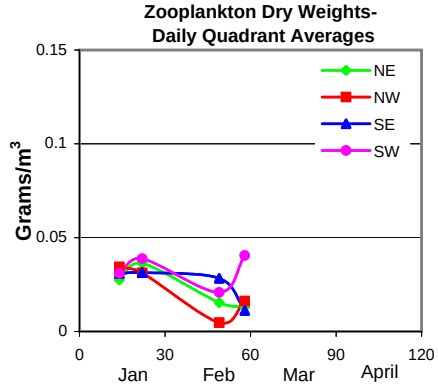


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW639
9 March 2007

After a period of high winds and with occasional reports by the PCCS/DMF surveillance aircraft of right whales at the north margin or just outside Cape Cod Bay, cruise SW639 was carried out in low temperatures with occasional freezing spray and moderate seas. The late start of the cruise, to avoid icing conditions, allowed resource sampling at only the 4 eastern Bay stations and at several locations west and southwest of Provincetown in an area where a scattering of 6-10 right whales were sighted by vessel and aircraft teams.

The zooplankton community throughout the eastern Bay continues to be dominated by the smaller taxa of calanoid copepods *Pseudocalanus* and *Centropages,* with a substantial additional resource of larval gastropods (all zooplankter forms known to release feeding behavior in right whales). Zooplankton concentrations in both the upper water column and the mid water of eastern bay stations remain modest and well below the threshold for right whale feeding behavior. Special zooplankton collection stations among socializing and diving whales showed modest food densities not rich enough to support long-term stable aggregations of whales or feeding. As with samples from SW638 (27 February), the low densities of food resource cannot explain the relative stability of the present group of whales within the north margin of the Bay. We continue to hypothesize that the observed aggregation is encouraged by a rich zooplankton resource forming a layer at the sea-sediment interface. Such zooplankton layers have been documented during the mid- and late-winter during past seasons and are thought to stimulate feeding at the bottom. On the next cruise we expect to employ vertical pump sampling protocols to determine the species composition and the small-scale distribution of food resources near the bottom substrate.

Six right whale sightings (representing 4 to 6 individuals) were recorded during SW639. The DMF-PCCS survey aircraft flew tracks along the eastern outer shore of the Cape and completed nearly all tracks in Cape Cod Bay. Included in the final report for SW639 will be a summary of the aircraft sightings for this day.

The maritime community should be advised that buoyant ground lines between fishing gear, if used in an area where right whales are aggregating and where near-bottom feeding is suspected (such ground lines are not permitted in Cape Cod Bay by order of the Massachusetts Division of Marine Fisheries), would pose a risk of mouth entanglement. Further, boating interests should exercise particular caution in the area where whales have been observed throughout the northeastern portion of Cape Cod Bay and particularly where whales were observed during the cruise (an area approximately bounded by $42^{o}03'$ / $41^{o}55'$ latitude and $70^{o}10'$ / $70^{o}17'$ longitude). In this area, whale activity included the risky behavior of near-surface swimming and socializing, which behaviors could pose a risk of ship strike. At present zooplankton densities do not suggest the occasion of the most risky behavior, skim feeding, however mariners should be advised to slow vessel speed and keep lookout for whales. Until we can establish the depth of the food layer and assess the richness, composition, and movement of the resource it will not be possible to more accurately forecast the areas of risk.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Cape Cod Bay Habitat Assessment

ACTIVITIES: 2 March - 9 March, 2007

Vessel-Based Monitoring

Habitat monitoring cruise SW639 was conducted on 9 March in Cape Cod Bay. Due to very low temperatures during the night and morning, the cruise was started late in the day in order to avoid icing conditions. Beaufort 1 and 2 seas and mostly clear skies afforded good visibility, and 6-8 right whales on long dives were sighted by vessel-based observers, primarily in the northeast quadrant off Herring Cove, Provincetown. While feeding was not evident, surface and water column zooplankton collections were acquired in the vicinity of these whales to assess whether the resource might encourage residency. Rapidly deteriorating weather and sea state in the afternoon allowed for sampling at only the four eastern stations during SW639, with surface and oblique (to 19 meters depth) zooplankton samples collected at each. **A preliminary assessment and prediction document was distributed immediately following the cruise.**

Air Surveillance

The PCCS aerial surveillance program conducted two surveys of Cape Cod Bay since the previous assessment, and right whales were sighted within Cape Cod Bay during both flights. On 03 March, 23 right whales were sighted off the back side of the Cape and a single right whale was spotted in the western-central area of the Bay before the survey had to be aborted (after track 10) due to increasing winds and sea state. All of these whales were either individuals or in SAGs, and only one whale was seen feeding (one of five whales found within 2nm of the location labeled "5" on the map below). The next flight on 09 March similarly had to be aborted after track 10 due to worsening conditions, yet observers managed to locate and photograph 18 right whales (10 in the Bay and 8 off the back side) during the abbreviated flight. All of the right whales within Cape Cod Bay were observed on long dives or socializing.

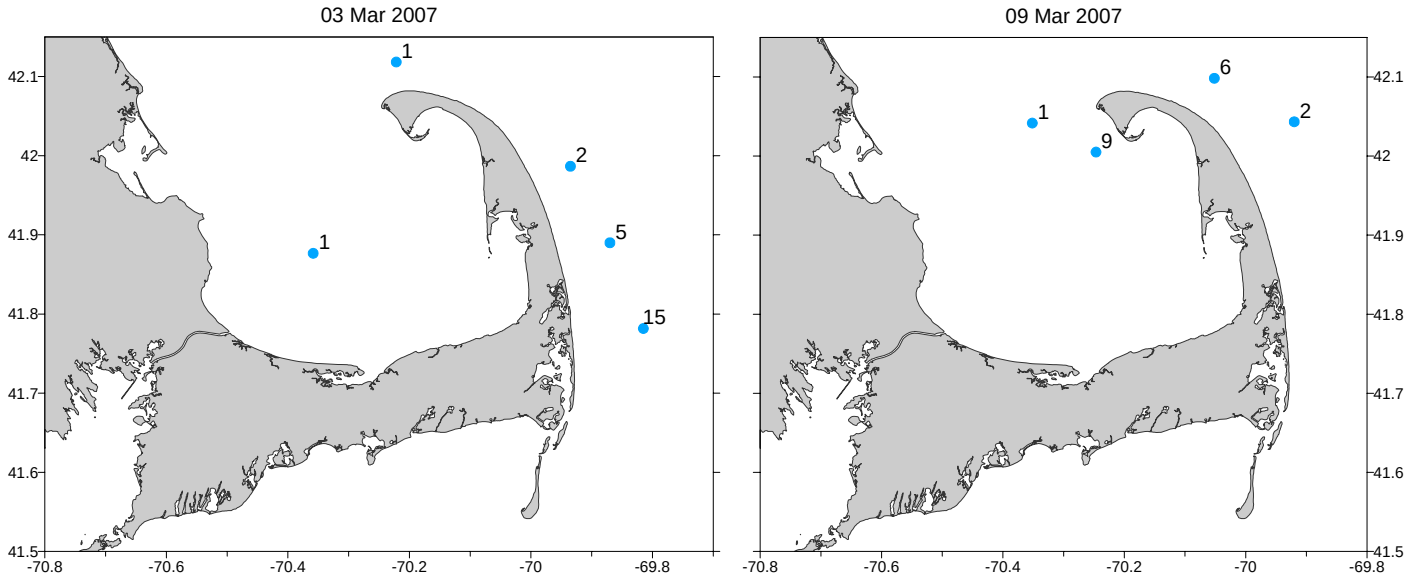


Figure 1. Right whale sightings from surveys conducted on 03 March (left) and 09 March (right).

HABITAT ASSESSMENT AUTHORSHIP:
OSTERBERG, MAYO (DMF-FUNDED PCCS HABITAT STUDIES PROGRAM)
BROWNING, JAQUET (DMF-FUNDED PCCS AIR SURVEILLANCE PROGRAM)

GENERAL ASSESSMENT

Resource sampling at the four eastern stations in Cape Cod Bay on 09 March revealed a zooplankton community that continues to be dominated by the smaller taxa of calanoid copepods *Pseudocalanus* and *Centropages*, with a substantial additional resource of larval gastropods (all zooplankton forms known to release feeding behavior in right whales). Zooplankton concentrations in both the surface waters and the water column remain modest and well below the threshold for right whale feeding behavior. Special zooplankton collection stations among 6-10 socializing and long-diving whales showed modest food densities not rich enough to support long-term, stable aggregations of whales or feeding. As with samples from the previous cruise (SW638 on 27 February), the *low densities of food resource cannot explain the relative stability of the present group of whales along the north margin of the Bay*. We continue to hypothesize that the observed aggregation is encouraged by a rich zooplankton resource forming a layer at the sea-sediment interface. Such zooplankton layers have been documented during the mid- and late-winter during past seasons and are thought to stimulate feeding at the bottom. On the next cruise we expect to employ vertical pump sampling protocols to determine the species composition and the small-scale distribution of food resources within 30 centimeters of the bottom substrate.

<u>Interpreted likelihood (1-10) of</u>:
Aggregation: Low (2)
Residency: Low (2)
Near-surface feeding: Low (1)
Feeding in the water column: Low (2)
Quadrant Quality/Attractiveness*: SE(1), NE(1)

*Note: Sampling was completed only in the eastern quadrants.

ALERT OF ELEVATED RISK

The maritime community should be advised that buoyant ground lines between fishing gear, if used in an area where right whales are aggregating and where near-bottom feeding is suspected (such ground lines are not permitted in Cape Cod Bay by order of the Massachusetts Division of Marine Fisheries), would pose a risk of mouth entanglement. Further, boating interests should exercise particular caution in the area where whales have been observed throughout the northeastern portion of Cape Cod Bay and particularly where whales were observed during the cruise (an area approximately bounded by 42°03' / 41°55' latitude and 70°10' / 70°17' longitude). In this area, whale activity included the risky behavior of near-surface swimming and socializing, which behaviors could pose a risk of ship strike. At present zooplankton densities do not suggest the occasion of the most risky behavior, skim feeding, however mariners should be advised to slow vessel speed and keep a lookout for whales. Until we can establish the depth of the food layer and assess the richness, composition, and movement of the resource it will not be possible to more accurately forecast the areas of risk.

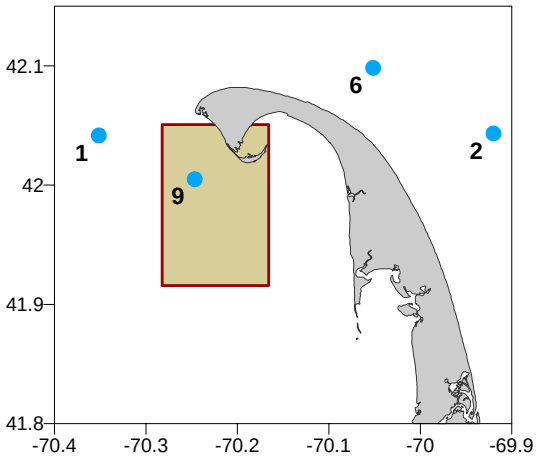


Figure 2. General area (shaded) where right whales were observed socializing and near-surface swimming on 09 March. Such behaviors place the whales at an elevated risk to ship strike, and due caution is advised.

SURFACE RESOURCE

		Currently **09 March 2007**		*Recently* **27 Feb 2007**	
EASTERN STATIONS, mean surface density:		337	zpl/m^3	369	zpl/m^3
Range of densities for EASTERN STATIONS:					
	Low	63	[sta 6M]	226	[sta 6M]
	High	862	[sta 5N]	613	[sta 5S]
Mean surface densities by quadrant:					
	NE	462		369	
	SE	212		483	

Inter-annual comparison, EASTERN STATIONS:

year	date	cruise	mean sfc density	
2003	07 Mar	SW318	545	zpl/m^3
2004	10 Mar	SW401	3318	
2005	07 Mar	SW525	380	
2006	08 Mar	SW595	171	
2007	09 Mar	SW638	337	

Surface Resource Summary:

- With the exception of station 5N in the far northeast, the surface zooplankton concentration declined at all eastern stations since the previous cruise on 27 February. The observed concentrations on 09 March – none of which even exceeded 1000 organisms/m^3 – were far below the estimated threshold that would trigger right whale feeding (3750 org/m^3).
- The highest surface abundance (862 org/m^3) was recorded at station 5N, having gained approximately 550 org/m^3 since last measured on 27 Feb. A map of the spatial distribution of zooplankton densities in the eastern Bay on 09 March is presented in Figure 3.
- In an area where 6-10 right whales were observed on long dives and socializing, the surface tow revealed an extremely low density of zooplankton, 154 org/m^3. The surface waters in this area were also highly turbid, likely having been mixed by the previous week of strong winds.
- Species composition notes:
    - The low-density surface assemblage of 09 March was dominated by the small copepod genus *Pseudocalanus*, which represented 71% of the mean total zooplankton in the eastern Bay. This dominance was manifest primarily along the far eastern margin of the Bay where at stations 5N and 5S *Pseudocalanus* densities were 655 and 223 *Pseudo*/m^3 (comprising 76 and 83% of the total surface zooplankton at these locations), respectively. In contrast, at stations 6M and 6S densities in the surface samples were only 3 and 52 *Pseudo*/m^3 (4 and 34% of the total surface zooplankton, respectively).
    - Marked spatial heterogeneity of the surface assemblage was also apparent in the sub-dominant taxa, with *Acartia* spp. representing 61% of the total zooplankton at 6S, and *Centropages* spp. dominating the ultra-low-density sample at 6M (68% of the total zooplankton).
    - *Centropages* spp. concentrations declined at all stations sampled on 09 March, possibly indicating the onset of the typical early-Spring decline of this taxon from its elevated winter abundance.
    - *Calanus finmarchicus* were scarce in all surface samples, with the highest densities recorded in the sample from station 5N (35 *Calanus*/m^3, or 4% of the total zooplankton at that location). Both early- and late-stage individuals were present in this sample.

WATER COLUMN RESOURCE FROM OBLIQUE TOWS (surface to 19 meters)

		Currently **09 March 2007**		*Recently* **27 Feb 2007**	
EASTERN STATIONS, mean oblique density:		1092	zpl/m^3	605	zpl/m^3
Range of densities for EASTERN STATIONS:					
	Low	875	[sta 6M]	467	[sta 5S]
	High	1323	[sta 6S]	727	[sta 7S]
Mean oblique densities by quadrant:					
	NE	1050		623	
	SE	1134		587	

Inter-annual comparison, EASTERN STATIONS:

year	date	cruise	mean obl density	
2003	07 Mar	SW318	1168	zpl/m^3
2004	10 Mar	SW401	5656	
2005	07 Mar	SW525	951	
2006	08 Mar	SW595	300	
2007	09 Mar	SW639	1092	

Water Column Resource Summary:

- The density of zooplankton in the water column *increased* at all eastern stations since 27 February, gaining nearly 500 organisms/m^3 on average. Nonetheless, the observed abundance at all stations remained well below the density thought to release right whale feeding (3750 org/m^3).
- At all stations water column densities continued to be considerably higher than their corresponding surface densities. The magnitude of these differences ranged from approximately 350 org/m^3 (at station 5N) to as much as 1150 org/m^3 (at station 6S).
- The spatial distribution of water column abundance was consistent throughout the eastern Bay, with only minor variation among stations. The maximum observed density was in the sample from station 6S where a density of 1323 org/m^3 was recorded. Please see Figure 3 for a map of the water column zooplankton abundance distribution.
- Species composition notes:
    - Compared to the heterogeneity observed in the low-density surface samples, water column zooplankton collections showed little variation in species composition. The small calanoid copepod *Pseudocalanus* remained the dominant taxon (57% of the mean total zooplankton in the eastern Bay), followed by *Centropages* spp. (15%). Subordinate taxa in the assemblage were more diverse than had been seen to date in 2007, with barnacle nauplii and molluscs appearing in significant densities for the first time.
    - *Pseudocalanus* dominance was bolstered by density gains at all eastern stations, with increases averaging nearly 400 *Pseudo*/m^3 in the eastern Bay.
    - Molluscs were particularly prevalent in the water column sample from station 6S, where their density was at least 150 org/m^3. Meanwhile, barnacle nauplii were notably dense at station 5N where their abundance measured approximately 320 org/m^3. The near-shore proximity of these stations may explain the observed abundance of such larval forms of benthic taxa.
    - *Calanus finmarchicus* (the majority of which were early-stage individuals) represented 4% of the mean total zooplankton in the eastern Bay.

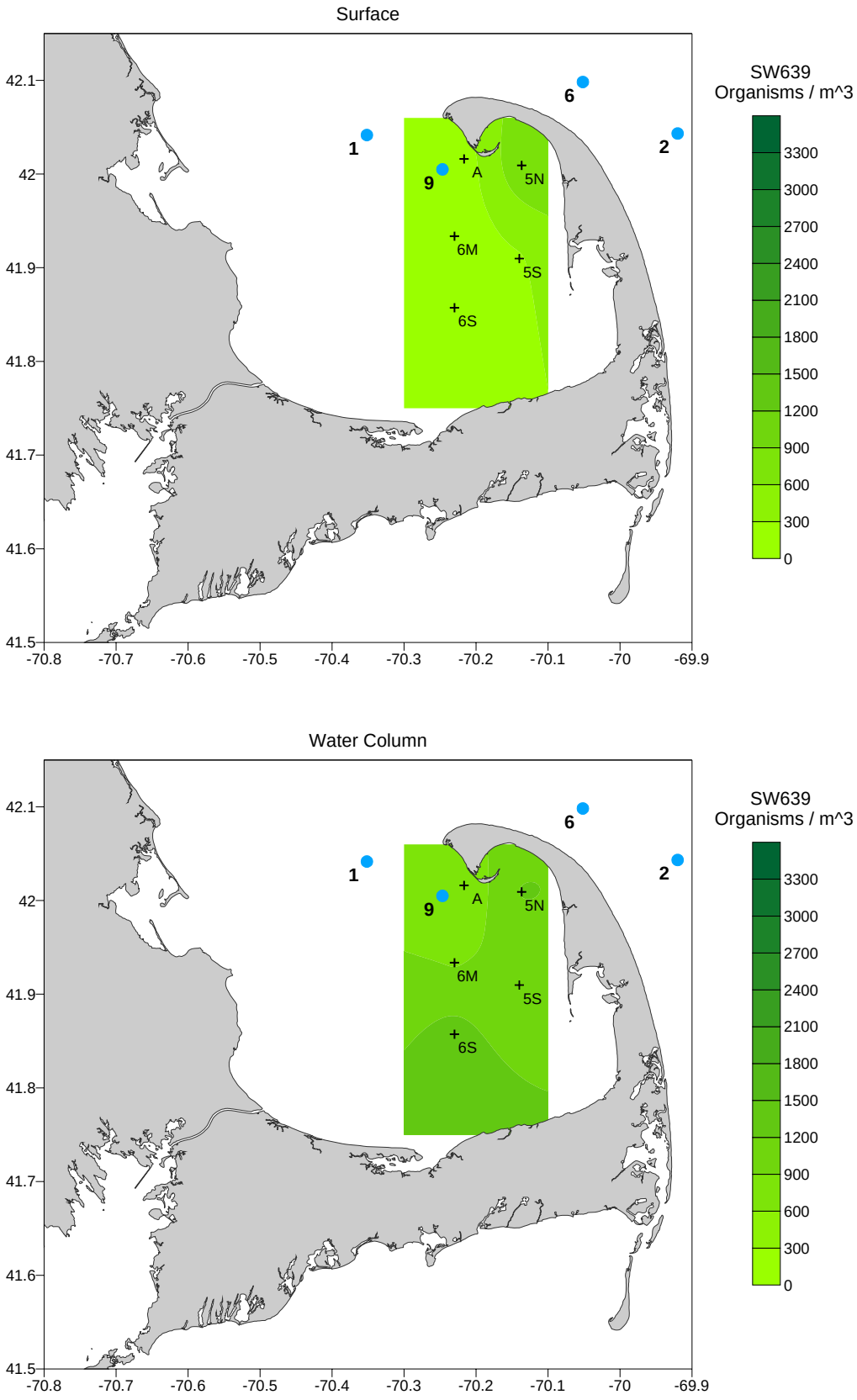


Figure 3. Spatial plots of **zooplankton densities** from surface (upper plot) and oblique (lower plot) tows conducted during cruise SW639 on 09 March 2007. Sampling station locations are indicated with a "+" symbol, and approximate right whale locations (within 1-2 nm) from vessel and aircraft surveys on 09 March are labeled with a "•" symbol and the number of individuals sighted. Auxiliary tows (both surface and oblique) were conducted at special station A in the vicinity of long-diving right whales.

Surface Zooplankton Assessment: Cruise SW639 (09 March 2007) Julian Day 68

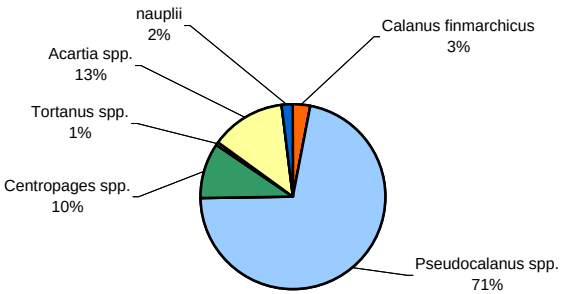
Recent aerial NARW sightings: 8 animals along the back side of Cape Cod and 10 in CCB on 09 March — *SW639 vessel NARW \sightings: 6-8 right whales*

MEASURES:

ONLY EASTERN STATIONS WERE SAMPLED

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	861.52	0.41	59.22	0.0118
Surface Tow	6M	62.54	0.09	8.55	0.0016
Surface Tow	8M	--	--	--	--
Surface Tow	9N	--	--	--	--
Surface Tow	5S	268.95	0.16	16.86	0.0034
Surface Tow	6S	155.37	0.10	8.04	0.0017
Surface Tow	7S	--	--	--	--
Surface Tow	9S	--	--	--	--
Cruise Average:		**337.10**	**0.19**	**23.17**	**0.0046**
Previous Cruise Average:		529.19	0.35	62.46	0.0116

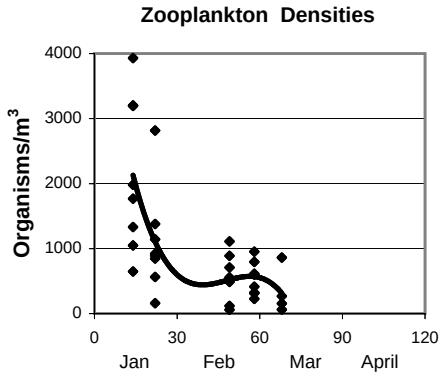
Zooplankton Species Avg. % Composition: SW639 All Stations, *Surface Tows*

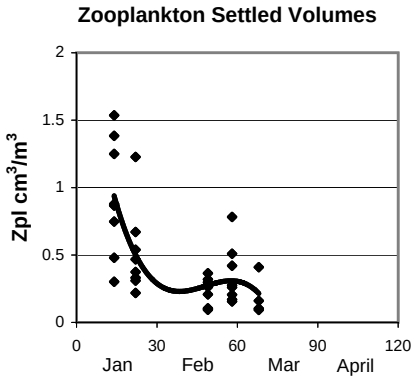


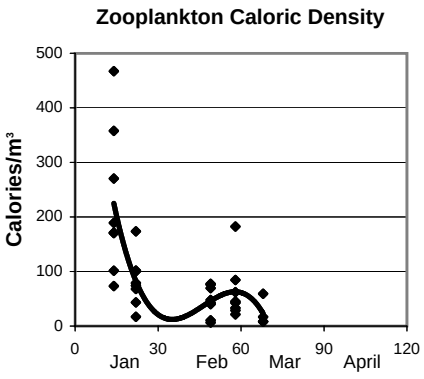
Other zooplankton present in low numbers:
Temora spp.
Oithona spp.

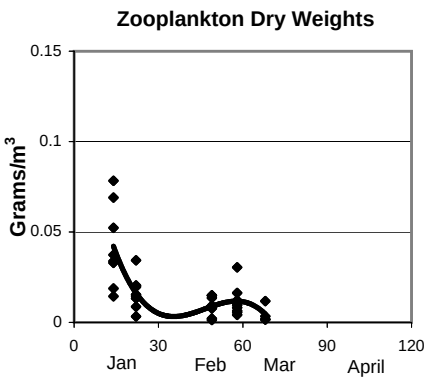
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

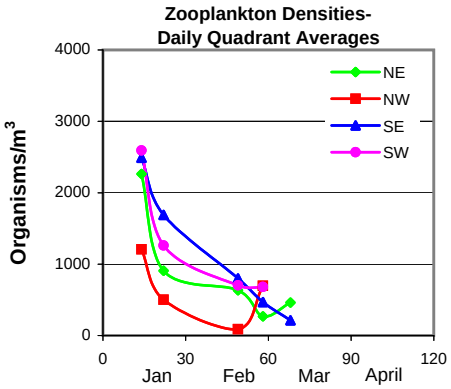


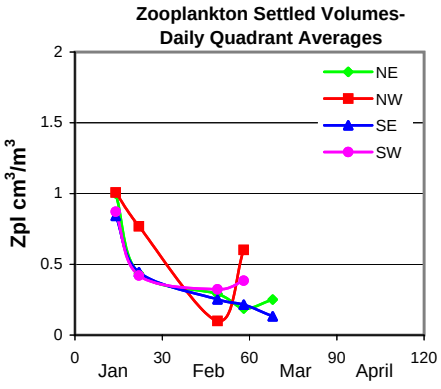


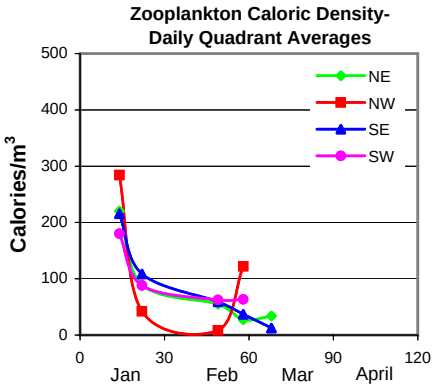


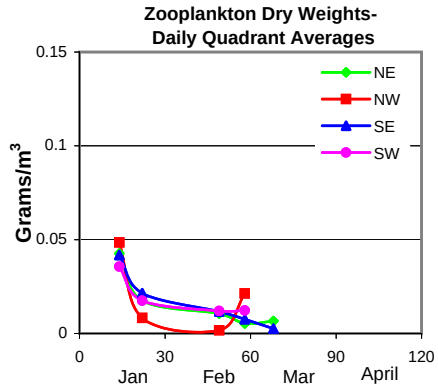


Geographic Quadrants:









Water Column Zooplankton Assessment: Cruise SW639 (09 March 2007) Julian Day 68

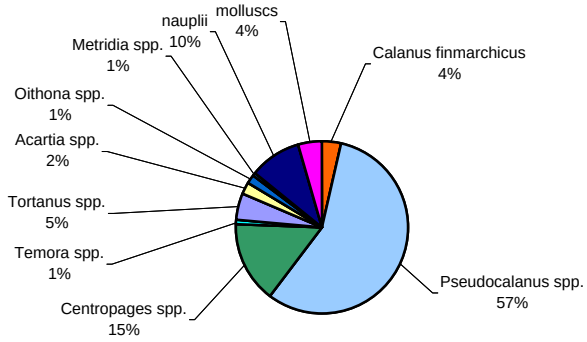
Recent aerial NARW sightings: 8 animals along the back side of Cape Cod and 10 in CCB on 09 March — *SW639 vessel NARW sightings: 6-8 right whales*

MEASURES:

ONLY EASTERN STATIONS WERE SAMPLED

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	1224.36	0.56	78.54	0.0152
Oblique Tow	6M	875.35	0.44	84.43	0.0169
Oblique Tow	8M	--	--	--	--
Oblique Tow	9N	--	--	--	--
Oblique Tow	5S	945.98	0.53	66.99	0.0134
Oblique Tow	6S	1322.74	0.87	96.66	0.0196
Oblique Tow	7S	--	--	--	--
Oblique Tow	9S	--	--	--	--
Cruise Average:		**1092.11**	**0.60**	**81.65**	**0.0163**
Previous Cruise Average:		1158.66	0.59	104.04	0.0202

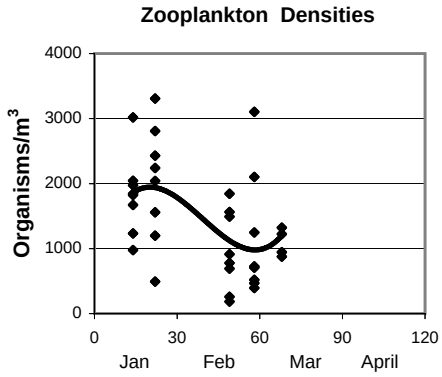
Zooplankton Species Avg. % Composition: SW639 All Stations, *Oblique Tows*

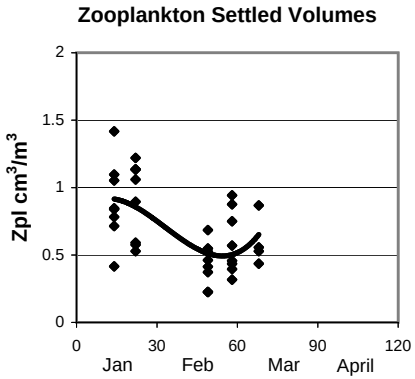


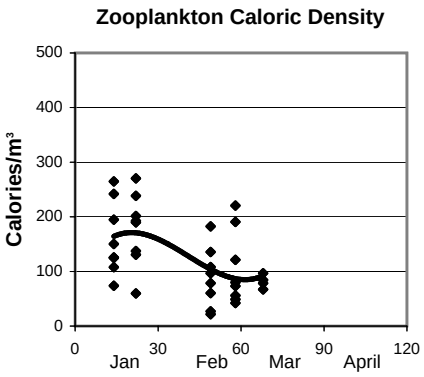
Other zooplankton present in low numbers:
hyperiid amphipods

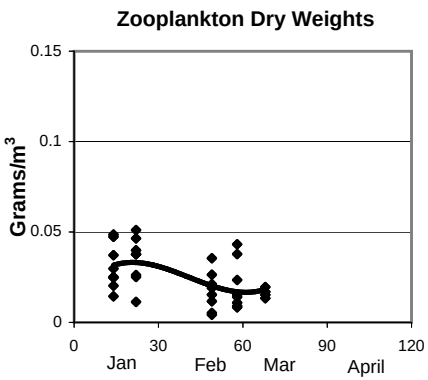
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

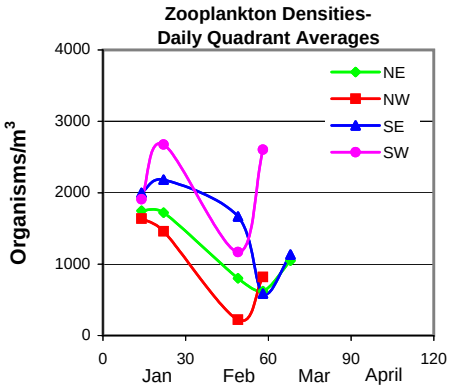


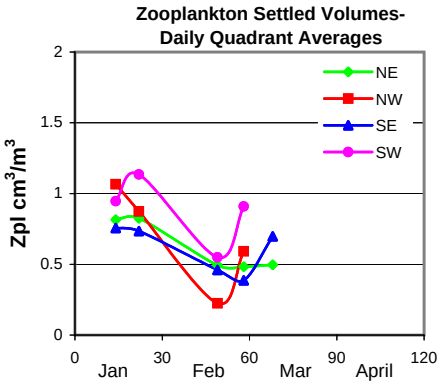


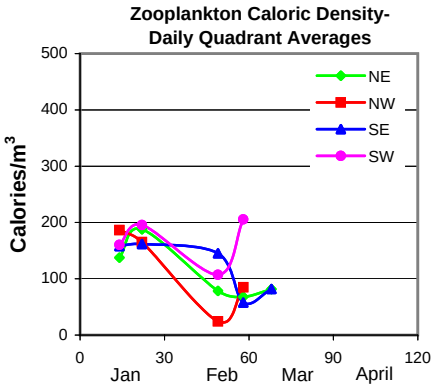


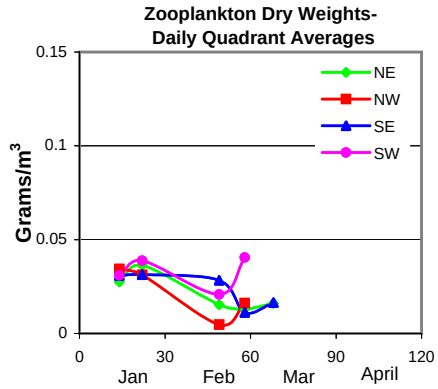


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW640
21 March 2007

Resource sampling conducted on 21 March revealed increased zooplankton densities from those observed in February and early March. While the zooplankton abundance in the surface waters remains low, the mid-water resource appears significantly enriched in some areas, particularly in the southern-central and southwestern areas of the Bay where water column densities approached or exceeded the estimated threshold for right whale feeding. The DMF-PCCS aircraft reported approximately 15 right whales in the southwestern Bay with several observations of feeding in the upper water column, suggesting the coalescence of the resource into localized patches capable of supporting right whale feeding. At the observed mid-water zooplankton densities, only a modest enrichment would be necessary to encourage stable right whale aggregations.

The zooplankton community in Cape Cod Bay continues to be dominated by the smaller taxa of calanoid copepods *Pseudocalanus* and *Centropages*, although there appears to be increased spatial heterogeneity in both species composition and diversity. The aforementioned areas of elevated water column abundance were consistently dominated by *Pseudocalanus*, which is the typical early-Spring taxa and has in the past released feeding behavior in right whales.

An entangled right whale, believed to be #2029, was sighted by the aerial surveillance team near midday in the southern-central Bay. The aircraft remained with the whale and with the PCCS disentanglement team for the remainder of the day, assisting with efforts to document, assess and repeatedly re-locate the whale.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW641
27 March 2007

Cruise SW641 was started in calm conditions and moderate temperatures with encouraging reports by the PCCS/DMF surveillance aircraft of right whales remaining in the south-central area of Cape Cod Bay as recently as 24 March. During the cruise a rising wind and spreading overcast decreased the efficiency of sighting during the mid-afternoon. Zooplankton collections were made at all 8 regular stations using surface and mid-water net sampling techniques. Additional net samples were collected in the vicinity of fluking right whales in the southern Bay where the vertical distribution of the zooplankton resource was characterized using a vertical pump system.

As it has been for the last two months, the zooplankton community throughout the Bay continues to be dominated by the smaller taxa of calanoid copepods, particularly by *Pseudocalanus*. The contribution of larval gastropods to the zooplankton community, reported from earlier cruises, has declined sharply. Zooplankton concentrations in the water column throughout the southeastern and southern-central part of the Bay show increases to levels preliminarily judged to be at or above the threshold for releasing right whale feeding behavior. A special zooplankton collection station in a region of the south and southeastern Bay among diving whales showed mid-water zooplankton densities favorable to whale aggregation and feeding. Surface collections in the vicinity of diving whales and throughout the Bay, however, remain very low. Discrete-depth pump collections used to characterize the vertical zooplankton profile suggest a low resource density in the bottom 3-5 meters of the water column with no significant bottom layer and a moderately rich layer of zooplankton dispersed throughout the 5 – 15 m depth. It is likely that the whales observed diving in the area were feeding on layers of zooplankton at these mid depths.

The food resource in the southwestern quadrant of the bay, in the area of the southern end of the Boston Shipping Channel, is weaker than in the other quadrants. In contrast, the resource density in mid-water samples from the northwestern bay, also in the vicinity of the Boston Shipping Channel, appears to approach that found with the whales in the south and could, when coalesced, attract right whales during the next week.

In summary, we anticipate that whales will remain associated with the southeastern quadrant and may show increasing aggregation and near surface feeding. Further, it is likely that slow coalescence of the resource coupled with a movement to the east will cause aggregation of whales in the southern-central and, eventually, southeast portion of the bay. The possibility that the strong zooplankton resource in the northwest will attract whales should also be considered during the next week.

The progression of dominant taxa during the 2007 winter season and the enrichment of the zooplankton resource are following the general pattern observed over the past two decades. Conditions presently are more favorable for late March aggregation of whales than seen in recent years. However, the development of a strong *Calanus finmarchicus* resource that usually fills in the seasonal decline in *Pseudocalanus* during the early- to mid-spring has not yet appeared. Should *Calanus* not appear and *Pseudocalanus* collapse, conditions in the bay could become unfavorable to right whale aggregation and feeding during the next several weeks.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Cape Cod Bay Habitat Assessment

ACTIVITIES: 21 March - 27 March, 2007

Mid- to late-March was a busy period for both the air surveillance and habitat monitoring teams at PCCS. The following assessment document summarizes observations from surveys and sampling during that time period. Preliminary assessments were disseminated immediately following all cruises to inform managers of time-critical information concerning right whale and resource distributions, and to forecast the likelihood of aggregation, feeding and residency in Cape Cod Bay.

Air Surveillance

21 March An estimated 15 right whales were sighted in the southern-central area of Cape Cod Bay (see Figure 1 on the following page for maps of sighting locations), including entangled right whale 2029, which had been last seen in the Great South Channel on 09 March by NMFS. The aerial survey plane broke from its planned survey to assist the PCCS disentanglement team as they tried to attach a telemetry buoy to the whale. While assisting the disentanglement team, the 2005 calf of right whale 1703 – previously observed and photographed on 12 March with deep propeller wounds on its right flank – was also sighted. No photos of the scarred whale were obtained, but observers noted that the whale appeared to be behaving normally and in good condition. At least three right whales were observed feeding subsurface periodically throughout the day.

23 March A complete survey of Cape Cod Bay was conducted in good sighting conditions. While 24 right whales were documented and photographed, right whale 2029 was not sighted. The 2005 calf of 1703 was sighted actively participating in a SAG, and photos were obtained for ID and health assessment purposes. No feeding behavior was observed during this flight.

24 March 37 right whales were sighted and photographed during this full survey of Cape Cod Bay. Nine right whales were seen subsurface feeding in the southern-central region of the Bay. Seven separate SAGs were documented, varying in size from two to five animals (3 of these SAGs were sighted off the eastern shore of the Cape). The 2005 calf of 1703 was sighed in one of these SAGs. Right whale 2029 has not been sighted since 21 March.

26 March This flight surveyed the eastern shore of Cape Cod and the six northern tracks in Cape Cod Bay, but was then aborted due to increasing winds and sea state. Six right whales were observed in social groups along the outer shore during the survey. Neither 2029 nor the 2005 calf of 1703 were sighted.

Vessel-Based Monitoring

21 March [Cruise SW640] The aerial team communicated sightings of several right whales in the southern-central region of the Bay (south of sampling stations 6S and 7S), at least one of which had been observed feeding in the upper water column; however, directed sampling of the resource was not conducted in that area so as to avoid interfering with the disentanglement effort. Transiting north of that area, vessel-based observers did not see any right whales, nor were any sighted in the rest of Cape Cod Bay. Zooplankton samples were collected at all eight regular stations, with surface and oblique (to 19 meters depth) net tows conducted at each.

27 March [Cruise SW641] Zooplankton samples were again collected from the surface waters and the water column at each of the regular CCB habitat stations. At least 6 right whales were sighted in the southern-central area of the Bay near station 6S, with all animals

HABITAT ASSESSMENT AUTHORSHIP:
OSTERBERG, MAYO (DMF-FUNDED PCCS HABITAT STUDIES PROGRAM)
BROWNING, JAQUET (DMF-FUNDED PCCS AIR SURVEILLANCE PROGRAM)

either on long dives or socializing. Recent aerial surveys had observed occasional feeding in the upper water column in this area, and while no feeding was apparent during this cruise, additional zooplankton collections were made to better assess the distribution of the resource. Surface and oblique tows were conducted at special station "A" in the vicinity of three right whales on long dives, and vertical pump collections were also made to obtain a profile of the resource in the water column at this location.

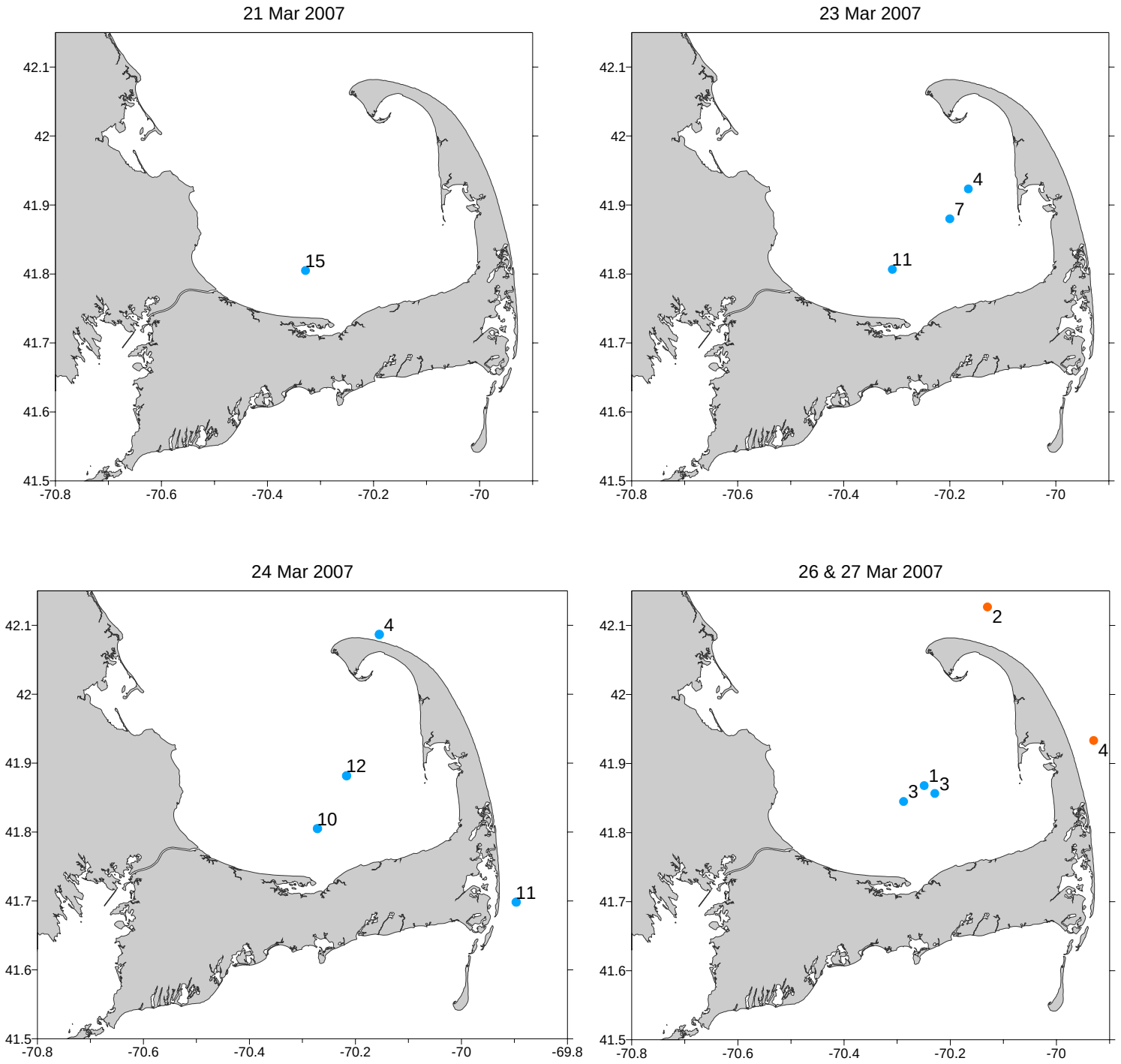


Figure 1. Right whale sightings from aircraft and vessel surveys conducted from 21 March through 27 March. Right whale locations are labeled with a "•" symbol and the number of individuals sighted, generally within 2nm. Whales marked by a "•" symbol indicate sightings from the abbreviated aerial survey on 26 March during which only the eastern shore and tracks 1-6 in the north were flown.

GENERAL ASSESSMENT

Resource sampling conducted on 21 March revealed zooplankton densities increased from those observed in February and early March. While the zooplankton abundance in the surface waters remained low, the mid-water resource was significantly enriched in some areas, particularly in the southern-central Bay and extending along the southern and eastern margins. The highest zooplankton concentration was found in the water column collection from station 6S, where a density measuring 13000 organisms/m^3 was the highest yet recorded in the Bay in 2007, well above the estimated threshold that would trigger right whale feeding (3750 org/m^3). Indeed, observations by the aerial team of several right whales feeding in the upper water column to the west of this location suggest a rich yet patchily-distributed resource in the southern-central Bay on this date.

Through the following week, the stability of the right whale aggregation in the southern-central Bay was undoubtedly encouraged by the persistence of the high-density mid-water resource. By 27 March a number of whales had moved slightly to the east, as would be expected from the predominant counter-clockwise circulation in Cape Cod Bay, and an opportunistic photo taken while sampling near station 6S showed a surfacing right whale in the act of closing its mouth – a strong indication of continued feeding in the upper water column. A special zooplankton collection station at this location showed mid-water zooplankton densities favorable to right whale aggregation and feeding, and discrete-depth pump collections used to characterize the vertical zooplankton profile revealed rich concentrations at depths of 5 and 10 meters, as well as in the near-bottom waters. It is likely that the whales observed diving in the area were feeding on layers of zooplankton at these mid-depths and possibly in the engybenthic waters. Meanwhile, surface collections in the vicinity of whales and throughout the Bay remained very low.

In both the surface waters and in the water column, the small calanoid copepod taxon *Pseudocalanus* spp. continued to dominate the zooplankton assemblage, although seasonal shifts in the sub-dominant species composition were apparent in these late-March samples. While the abundance of the typical winter-dominant taxon, *Centropages* spp., was in steep decline during this period, the expected increase in the usual mid- to late-spring dominant, *Calanus finmarchicus*, appeared incipient, particularly in the northwestern quadrant. Indeed, the recorded increase of total zooplankton abundance in the northwest and the influx of *Calanus* to that area combined to produce a region of elevated (and increasing) estimated caloric richness that could soon encourage right whale feeding and aggregation.

SURFACE RESOURCE

		27 March 2007		21 March 2007	
Bay-wide mean surface density:		353	zpl/m^3	396	zpl/m^3
Range of densities for individual stations:					
	Low	15	[sta 6M]	103	[sta 8M]
	High	778	[sta 9S]	924	[sta 5S]
Mean surface densities by quadrant:					
	NE	84		583	
	NW	434		122	
	SE	156		609	
	SW	737		271	

Inter-annual bay-wide comparison:

year	Date	cruise	mean sfc density	
2003	2 Apr	SW323	884	zpl/m^3
2004	30 Mar	SW404	5453	
2005	1 Apr	SW530	558	
2006	30 Mar	SW600	157	
2007	27 Mar	SW641	353	

Surface Resource Summary:

- Surface zooplankton concentrations remained very low throughout Cape Cod Bay in late-March. The observed concentrations were far below the estimated threshold that would trigger right whale feeding (3750 organisms/m^3), with no individual station sample even exceeding 1000 org/m^3 during this time period.
- The highest surface abundance was recorded in the southeast at station 5S on 21 March, and then in the southwest at station 9S on 27 March. While surface densities were elevated in these locations relative to other areas of the Bay, the impoverished state of the bay-wide surface resource renders such spatial differences insignificant to right whale distribution and dynamics. Maps of the distribution of zooplankton densities in late-March are presented in Figure 3, and the temporal changes in surface density distribution are shown in Figure 4.
- Species composition notes:
    - The low-density surface assemblage continued to be dominated by the small copepod genus *Pseudocalanus* through the late-March period. On 21 March there was marked heterogeneity in *Pseudocalanus* distribution in that the highest-density stations in the Bay, all found in the east, were very strongly dominated by *Pseudocalanus*, while at the ultra-low-density western stations (all with total zooplankton densities <400 org/m^3) the *Pseudocalanus* contribution to the total zooplankton was minimal. The taxa *Centropages* and *Acartia* represented a much higher fraction of the total zooplankton in western Bay surface samples, and *Tortanus discaudatus* comprised an anomalously high percentage (47%) of the total zooplankton at station 9N in the far northwest.
    - By 27 March *Pseudocalanus*, while remaining the dominant taxon in samples from stations in the eastern quadrants, had become dominant in all areas of the Bay except in the northwest. Seasonal transitions were apparent in the taxonomic composition of the zooplankton, with declines in abundance of the typical winter dominant, *Centropages* spp., recorded at almost every station, and with early-stage *Calanus finmarchicus* notably increasing at all western stations.

WATER COLUMN RESOURCE FROM OBLIQUE TOWS (surface to 19 meters)

		27 March 2007		21 March 2007	
Bay-wide mean oblique density:		2985	zpl/m^3	3445	zpl/m^3
Range of densities for individual stations:					
	Low	1286	[sta 6M]	1003	[sta 9N]
	High	9144	[sta 6S]	13049	[sta 6S]
Mean oblique densities by quadrant:					
	NE	1864		2833	
	NW	2433		1009	
	SE	5556		7819	
	SW	2088		2117	

Inter-annual bay-wide comparison:

year	date	cruise	mean obl density	
2003	2 Apr	SW323	2975	zpl/m^3
2004	30 Mar	SW404	19718	
2005	1 Apr	SW530	3084	
2006	30 Mar	SW600	585	
2007	27 Mar	SW641	2985	

Water Column Resource Summary:

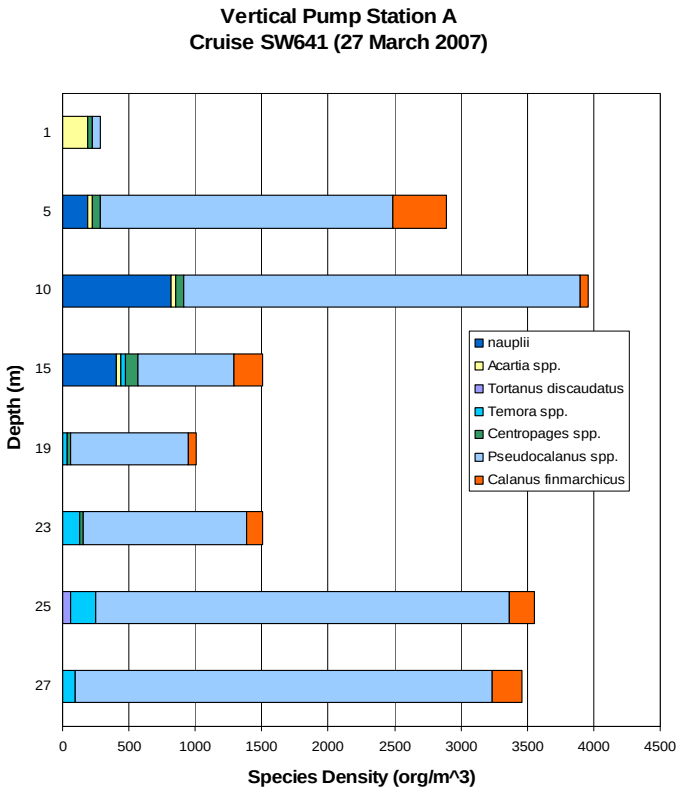
- The abundance of zooplankton in the water column *increased considerably* in mid- to late-March, with several areas sustaining densities at or in excess of the estimated right whale feeding threshold (3750 organisms/m^3) during this time period.
- At all stations water column densities continued to be considerably higher than their corresponding surface densities.
- On 21 March the zooplankton distribution featured a "hotspot" at station 6S in the southern-central area of the Bay where the measured water column zooplankton density of approximately 13000 org/m^3 was well above feeding threshold. Elevated densities at or near threshold were also recorded in the far northeast (>4000 org/m^3 at station 5N) and in the far southwest (~2700 org/m^3 at 9S). While zooplankton collected at station 7S, several miles to the northeast of the location where right whales were reportedly feeding, revealed densities insufficient to support right whale feeding, it is likely that the resource throughout the southern and eastern margins of the Bay was characterized by a patchy distribution with scattered areas of high zooplankton abundance suitable for feeding. The lowest water column densities on this date were found in the northwestern Bay, where at stations 9N and 8M the measured concentrations were approximately 1000 org/m^3.
- By 27 March the "hotspot" in the southern-central and southeastern Bay remained, though densities in that area were slightly reduced from those observed on the previous cruise (9150 org/m^3 at station 6S and 5200 org/m^3 at station "A" approximately 1nm to the northwest of 6S). With water column densities still well above the right whale feeding threshold in that area and an opportunistic photograph of a right whale in the process of closing its mouth as it surfaced near station "A," it is likely that the persistence of whale aggregation in the area was promoted by the presence of a suitable resource in the upper water column. Elsewhere in the Bay water column densities remained high, and while no other abundance measurements exceeded threshold, most were within the range 1900 to 2600 org/m^3. Please see Figures 3&4 for maps of the water column zooplankton density distribution and changes thereof during this time period.
- Species composition notes:
    - Compared to the marked spatial differences in taxonomic composition observed in the low-density surface samples, water column zooplankton collections showed little spatial variation in species composition on 21 March. The small copepod genus *Pseudocalanus* continued to strongly dominate the water column assemblage, comprising 78% of the mean total

zooplankton in the Bay. The contribution of the typical winter dominant copepod, *Centropages* spp., declined from that observed in late-February and early-March, representing only 1% of the mean total zooplankton (down from 29% and 19%, respectively). Seasonal changes were also evident with the prevalence of early-stage *Calanus finmarchicus* in samples collected at northern stations. Nauplii, both barnacle and copepod, that are of limited value to feeding right whales, also made a significant contribution to the assemblage at several northern stations, representing 31% of the total water column zooplankton at station 5N and 21% at station 8M.

- By 27 March, few changes in the water column zooplankton assemblage were apparent. *Pseudocalanus* declines in much of southern Cape Cod Bay – especially at the high density station 6S, but also at 5S and 9S – were offset by gains in the northwest, resulting in the continued dominance of this taxon (70% of the mean total zooplankton). The northwest was also augmented by increases in *Calanus finmarchicus*, with primarily early-stage *Calanus* copepodites representing 49% and 41% of the total water column zooplankton at stations 8M and 9N, respectively. Coupled with increasing densities, this species composition yielded one of the highest measurements of caloric richness in the Bay on this date, rivaling even the caloric richness at the high-density "hotspot" (station 6S) in the southern-central region.

SPECIAL STATION "A"

Surface and oblique tows were conducted approximately 1nm to the northwest of station 6S in the vicinity of several right whales on long dives. While sampling, an opportunistic photo captured one animal in the process of closing its mouth as it surfaced, suggesting that it had been feeding in the upper water column. Surface densities at this location were very low (<200 organisms/m^3), but the water column density (5200 org/m^3) was well above the estimated threshold for right whale feeding (3750 org/m^3). The species composition in these samples were comparable to those found nearby at station 6S and to the bay-wide average composition.



A vertical pump profile was conducted to resolve whether there were high-density layers capable of supporting right whale feeding at this location. Samples from discrete depths revealed two zones of elevated zooplankton concentrations that approached or exceeded the feeding threshold, the first in the depth range of 5 to 10 meters, and another below 25 meters (depth of the water column was approximately 27 meters). The dominant copepod genus *Pseudocalanus* and the calorically-rich copepod *Calanus finmarchicus* were prominent at all depths except at the immediate surface. *Calanus* was particularly dense in the 5-meter depth sample, with over 400 *Calanus*/m^3 present.

Figure 2. Densities of various zooplankton taxa at discrete depths in the water column. Collections were made using a pump system and were filtered through 333μm-mesh netting.

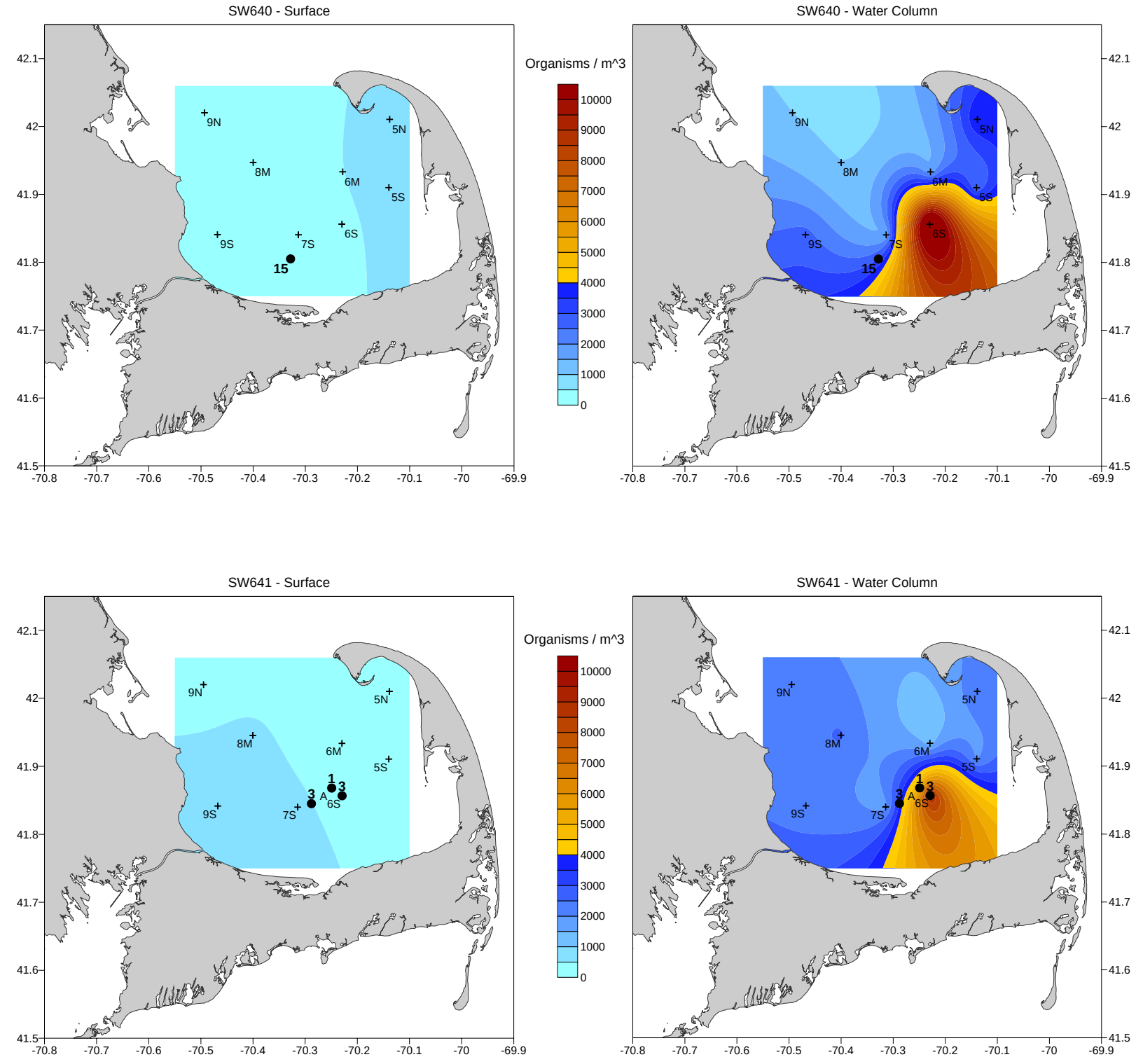


Figure 3. Spatial plots of **zooplankton densities** from surface (left plots) and oblique (right plots) tows, with sampling locations indicated by a "+" symbol. Approximate right whale locations are labeled with a "•" symbol and the number of individuals sighted, generally within 2nm. The upper plots show densities on 21 March 2007 (cruise SW640), during which the aerial team observed at least three animals feeding in the upper water column sporadically throughout the day while the team circled on an entangled whale in the southern-central region. The lower plots present densities on 27 March 2007 (cruise SW641), during which vessel-based observers photographed a right whale in the process of closing its mouth as it surfaced near station "A," likely indicating feeding in the upper water column as well.

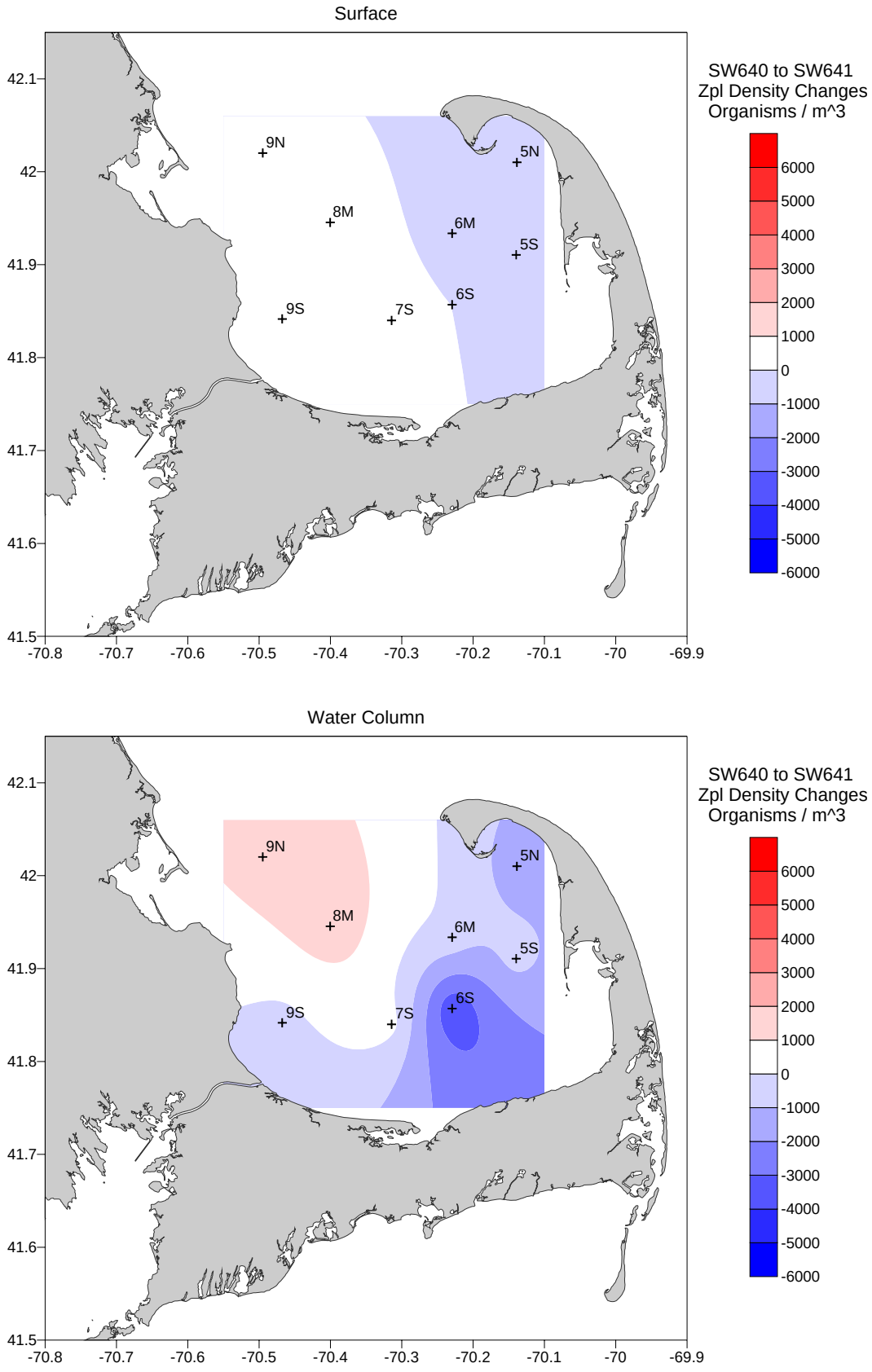


Figure 4. Spatial plots of the **changes in zooplankton densities** occurring in late March 2007 (between cruise SW640 on 21 March and cruise SW641 on 27 March). Changes in *surface* density are displayed in the upper plot, while changes in *water column* density are plotted below. Sampling station locations are indicated with a "+" symbol.

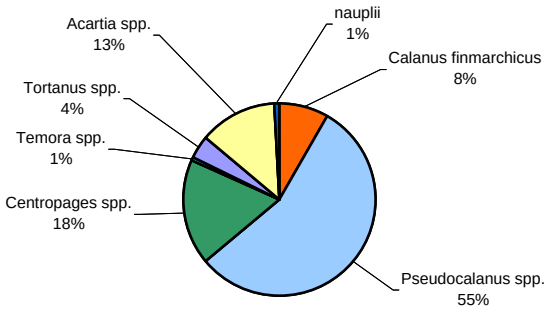
Surface Zooplankton Assessment: Cruise SW640 (21 March 2007) Julian Day 80

Recent aerial NARW sightings: 15 animals in the southern-central Bay on 21 March (incomplete survey) — ***SW640 vessel NARW sightings: 0 right whales***

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	676.99	0.27	40.93	0.0082
Surface Tow	6M	489.32	0.38	76.98	0.0196
Surface Tow	8M	102.51	0.12	12.42	0.0023
Surface Tow	9N	140.80	0.27	22.38	0.0043
Surface Tow	5S	923.52	0.40	53.59	0.0113
Surface Tow	6S	293.58	0.28	31.38	0.0061
Surface Tow	7S	193.40	0.12	21.51	0.0043
Surface Tow	9S	348.10	0.23	33.43	0.0066
Cruise Average:		**396.03**	**0.26**	**36.58**	**0.0078**
Previous Cruise Average:		513.39	0.34	58.00	0.0107

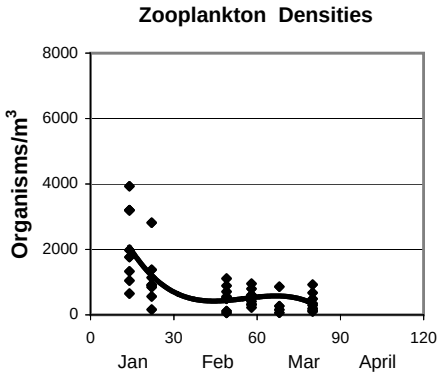
Zooplankton Species Avg. % Composition: SW640 All Stations, *Surface Tows*

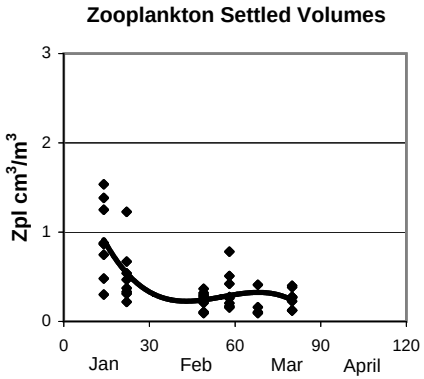


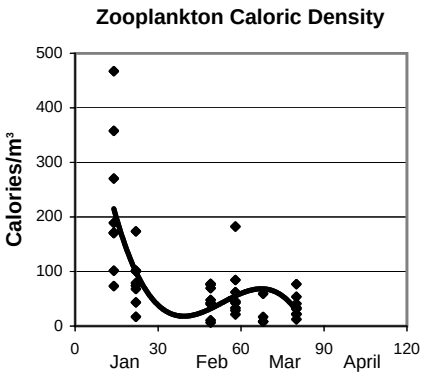
Other zooplankton present in low numbers:
Oithona spp.
harpacticoids

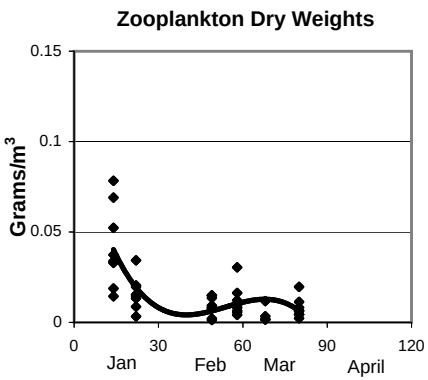
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

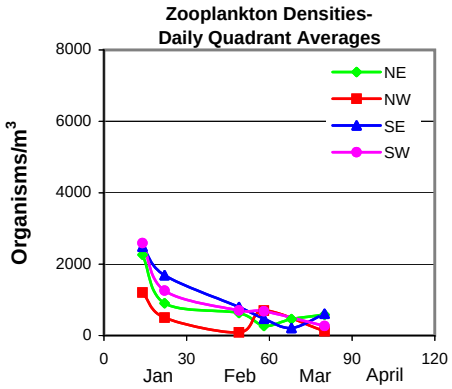


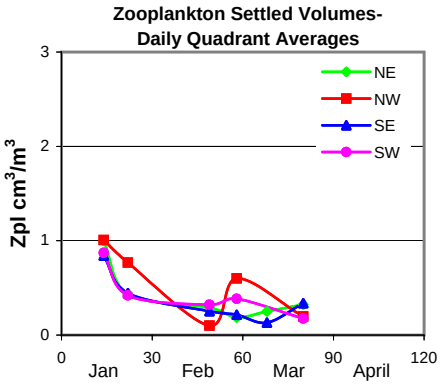


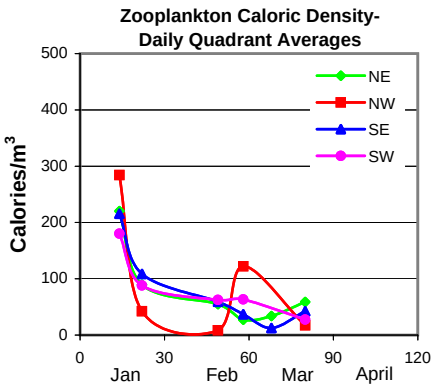


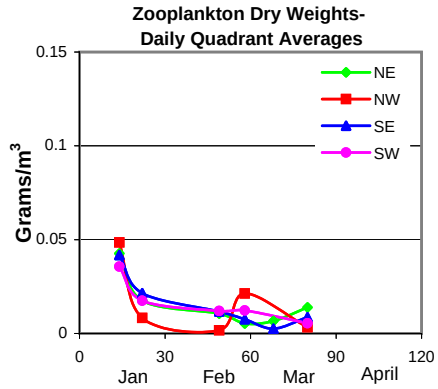


Geographic Quadrants:









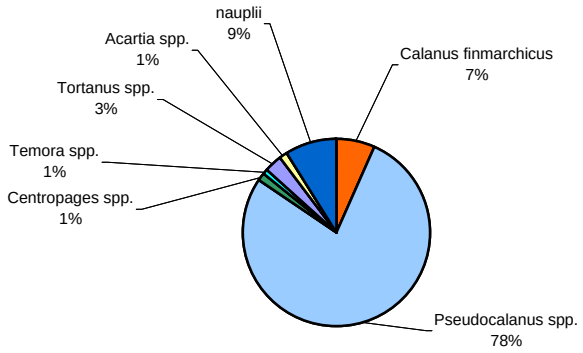
Water Column Zooplankton Assessment: Cruise SW640 (21 March 2007) Julian Day 80

Recent aerial NARW sightings: 15 animals in the southern-central Bay on 21 March (incomplete survey) — ***SW640 vessel NARW sightings: 0 right whales***

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	4028.11	1.07	157.31	0.0323
Oblique Tow	6M	1638.23	0.87	201.76	0.0461
Oblique Tow	8M	1016.04	0.73	123.08	0.03
Oblique Tow	9N	1002.75	0.64	164.65	0.04
Oblique Tow	5S	2589.44	0.83	151.20	0.0318
Oblique Tow	6S	13048.83	4.34	802.15	0.1676
Oblique Tow	7S	1536.58	0.56	109.90	0.02
Oblique Tow	9S	2696.72	1.27	180.64	0.04
Cruise Average:		**3444.59**	**1.29**	**236.34**	**0.0505**
Previous Cruise Average:		1158.66	0.59	104.04	0.0202

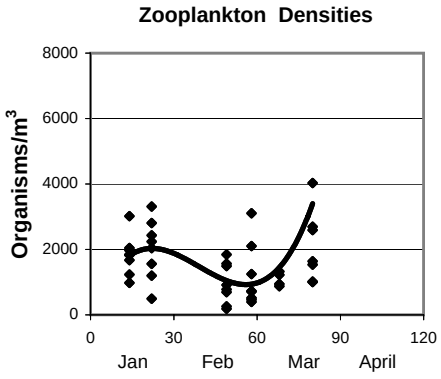
Zooplankton Species Avg. % Composition: SW640 All Stations, *Oblique Tows*

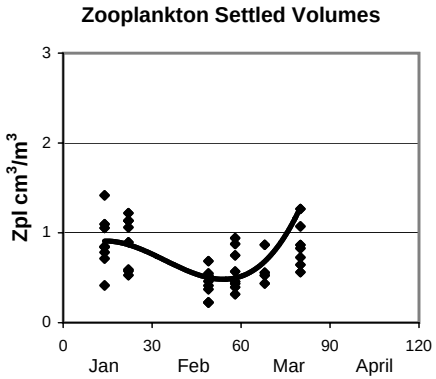


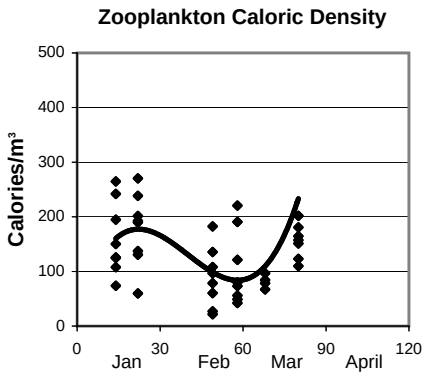
Other zooplankton present in low numbers:
Oithona spp.
fish larvae
molluscs
medusae
fish eggs
mysids

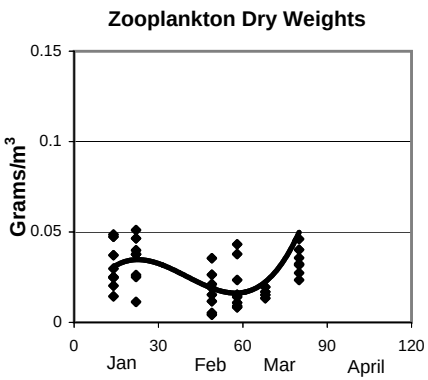
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

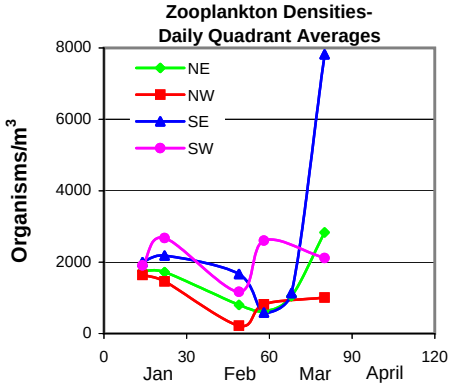


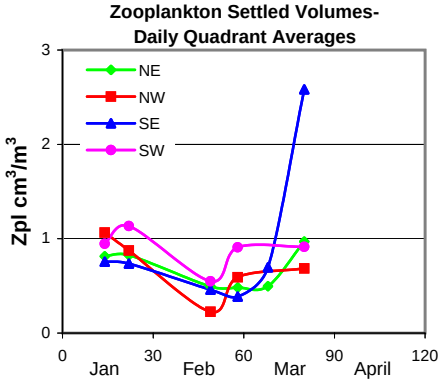


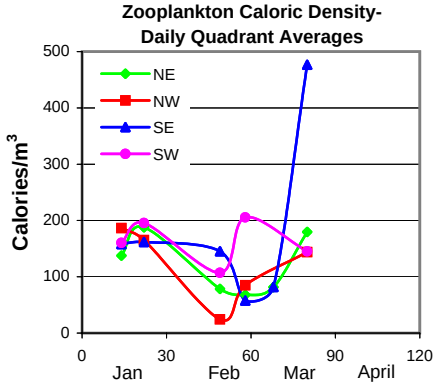


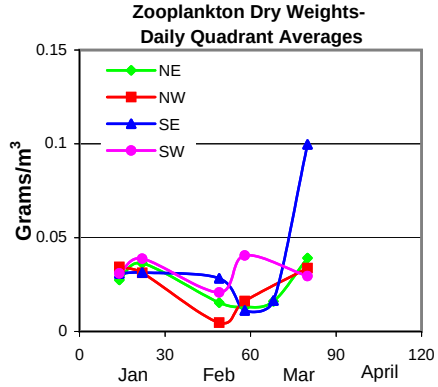


Geographic Quadrants:









Surface Zooplankton Assessment: Cruise SW641 (27 March 2007) Julian Day 86

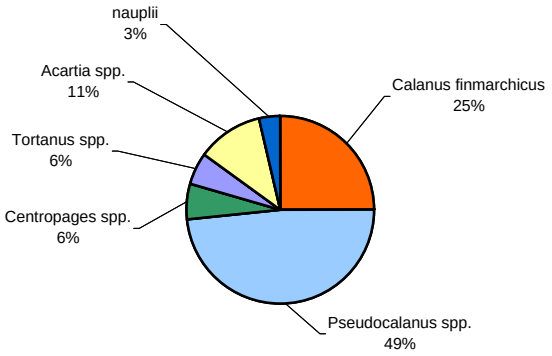
Recent aerial NARW sightings: 22 animals in the southern-central Bay on 24 March

SW641 vessel NARW \sightings: at least 6 right whales

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	153.47	0.08	9.25	0.0020
Surface Tow	6M	14.73	0.04	1.40	0.0003
Surface Tow	8M	599.61	0.40	124.49	0.0315
Surface Tow	9N	272.01	0.24	36.78	0.0080
Surface Tow	5S	27.99	0.04	2.45	0.0006
Surface Tow	6S	283.49	0.17	16.95	0.0036
Surface Tow	7S	697.00	0.40	83.64	0.0182
Surface Tow	9S	777.86	0.33	79.17	0.0179
Cruise Average:		**353.27**	**0.21**	**44.27**	**0.0102**
Previous Cruise Average:		396.03	0.26	36.58	0.0078

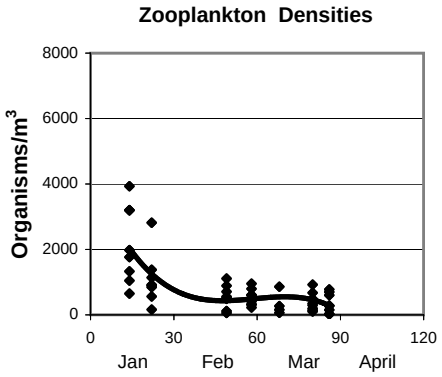
Zooplankton Species Avg. % Composition: SW641 All Stations, *Surface Tows*

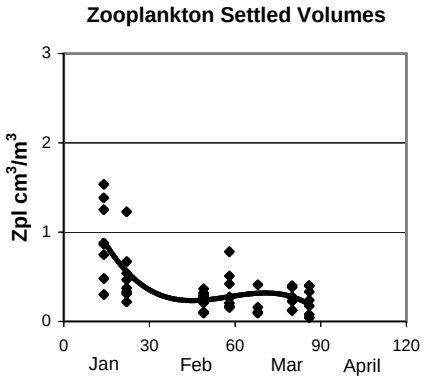


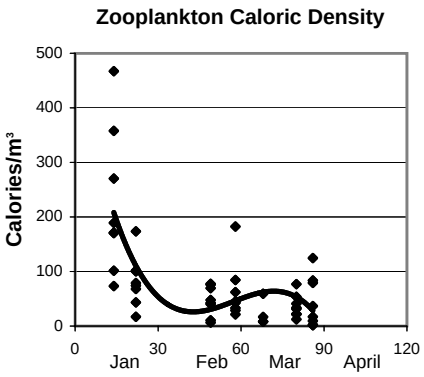
Other zooplankton present in low numbers:
Temora spp.
Eurytemora spp.
Oithona spp.
medusae

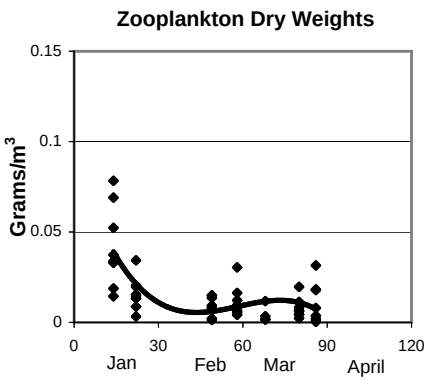
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

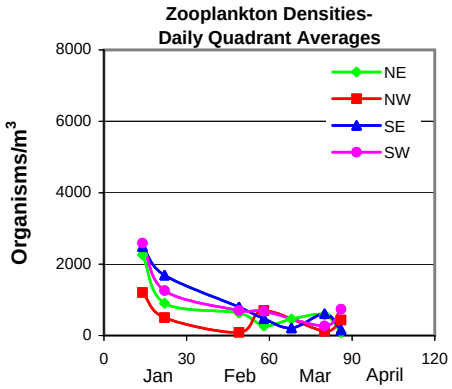


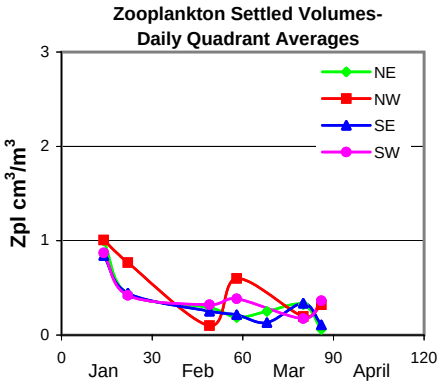


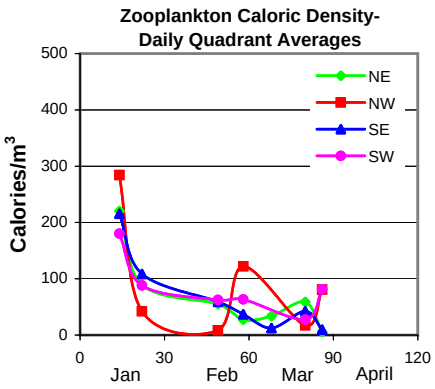


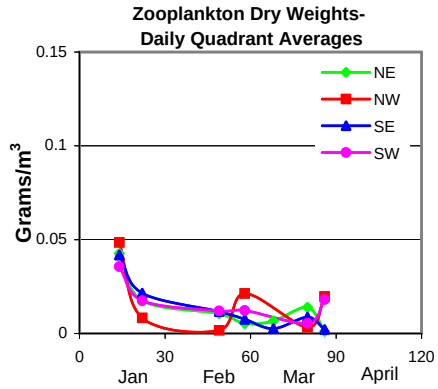


Geographic Quadrants:









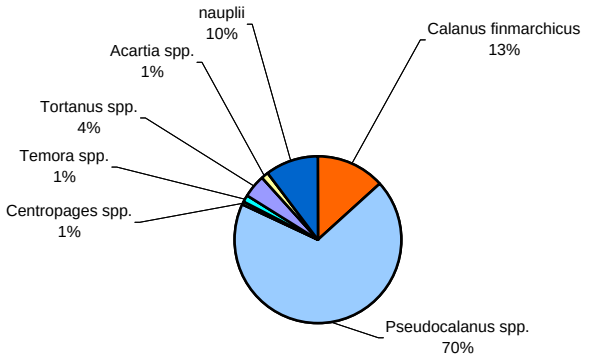
Water Column Zooplankton Assessment: Cruise SW641 (27 March 2007) Julian Day 86

Recent aerial NARW sightings: 22 animals in the southern-central Bay on 24 March — *SW641 vessel NARW sightings: at least 6 right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	2441.89	0.91	153.61	0.0326
Oblique Tow	6M	1285.73	0.74	98.24	0.0193
Oblique Tow	8M	2567.35	0.75	454.23	0.11
Oblique Tow	9N	2299.45	1.46	337.08	0.09
Oblique Tow	5S	1967.68	0.88	86.74	0.0196
Oblique Tow	6S	9143.81	3.13	516.32	0.1088
Oblique Tow	7S	1873.35	0.75	154.10	0.03
Oblique Tow	9S	2303.23	2.21	181.22	0.04
Cruise Average:		**2985.31**	**1.35**	**247.69**	**0.0564**
Previous Cruise Average:		3444.59	1.29	236.34	0.0505

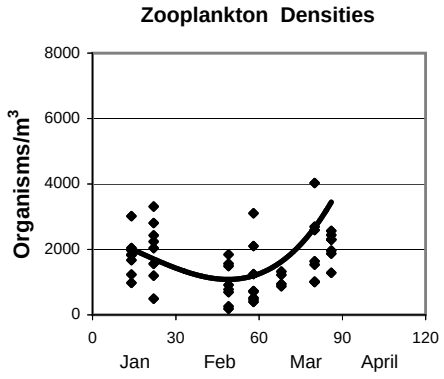
Zooplankton Species Avg. % Composition: SW641 All Stations, *Oblique Tows*

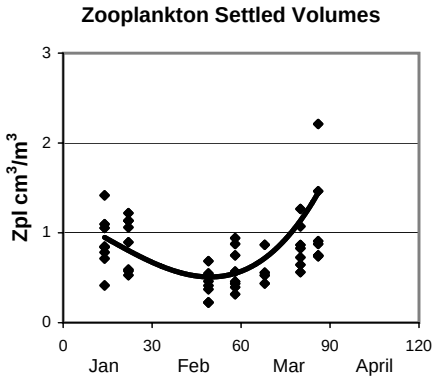


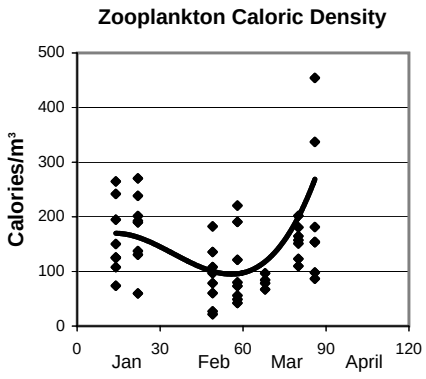
Other zooplankton present in low numbers:
Oithona spp., Metridia spp., cyprids, molluscs

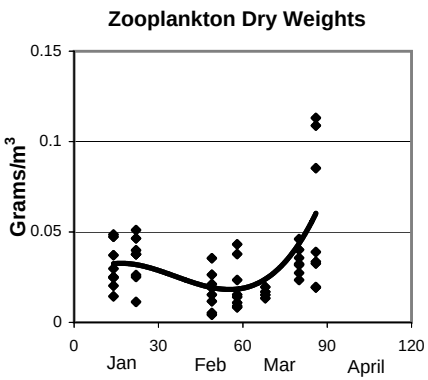
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

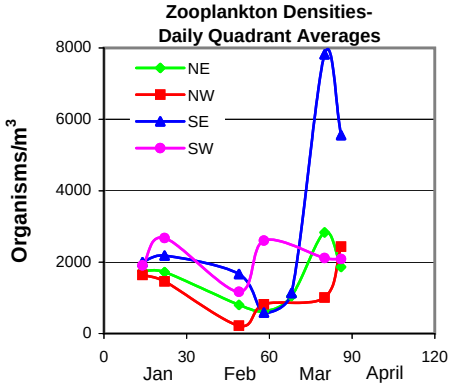


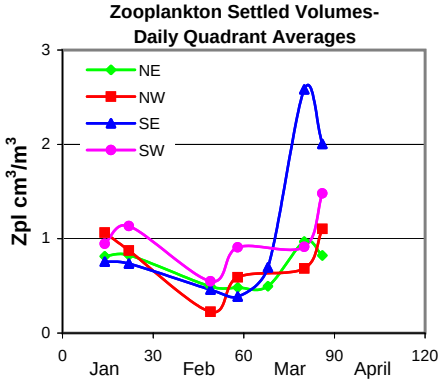


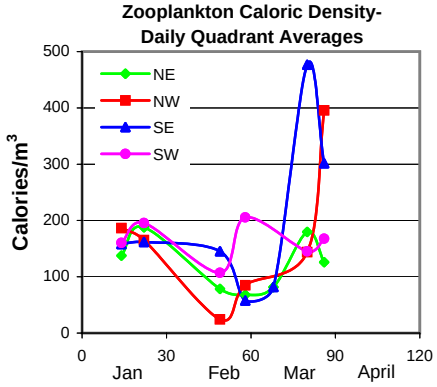


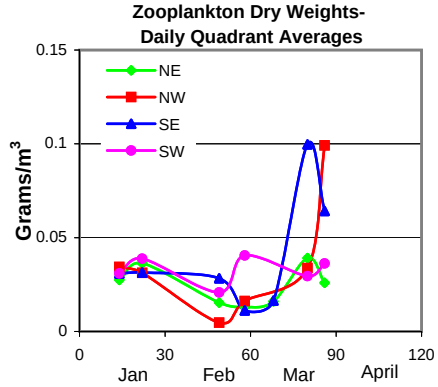


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW642
1 April 2007

Calm conditions and moderate temperatures prevailed during cruise SW642. Recent reports from the PCCS/DMF survey team suggested that right whales have remained in the southern-central portion of the Bay and along the western margin, as predicted. Zooplankton collections were made at all 8 regular stations using surface and mid-water net sampling techniques. An additional sampling station was established in the northwestern quadrant where the survey aircraft reported two right whales feeding during the morning. This special station was sampled 3-4 hours after the sighting, although the whales were not resighted in the area at the time of zooplankton collection.

The zooplankton community throughout the Bay continues to be dominated by the small taxon of calanoid copepod *Pseudocalanus*, with a very limited contribution to the calanoid resource by small, early-stage *Calanus finmarchicus*. The samples collected continued to lack the significant numbers of late-stage *Calanus* that usually begin to appear in early April. The concentration of zooplankton at the surface of the Bay at all stations remains low, thus the potential for whales to feed close to the surface, thereby increasing the risk of vessel collision, is reduced. Mid-water zooplankton densities have become moderate throughout the Bay and the previous heterogeneous distribution of resources, with the higher concentration of zooplankton in the southeast and northwest quadrants seen on 27 March, no longer the case. Thus mid-water food densities have become more uniform throughout the Bay, generally at or near the predicted threshold, and nowhere concentrated enough to suggest an area of long-term aggregation and residency. The dispersal of the resource, the continuing absence of a strong *Calanus finmarchicus* signal, and the lack of a well established region of strong resource suggest that right whale distribution will disperse through the Bay and that numbers of whales may be expected to decline absent the advective entry and establishment of both a strong *Calanus finmarchicus* resource and its concentration into patches and layers. Compatible with our assessment, zooplankton resources in the vicinity of socializing whales in the south central portion of the Bay and at special station A where whales had been reported feeding by air survey observers, the zooplankton stock appeared modest, close to the feeding threshold, but unremarkable in composition and density.

In summary, we anticipate that right whales will disperse rather than aggregate in Cape Cod Bay, unless either late-stage *Calanus finmarchicus* enters the bay or the existing resource forms rich patches and layers. Absent the processes to cause these conditions of coalescence of the food resource, we anticipate the slow decline in whale numbers. The apparent dispersal of the small-taxa calanoid resource reported for SW642 supports the view presented in the previous (SW641) preliminary assessment that "conditions in the bay could become unfavorable to right whale aggregation and feeding during the next 2 weeks ….. should *Calanus* not appear and *Pseudocalanus* collapse".

Vessel sightings for the day included 5 seals, one small pod of common dolphins, 2 fin whales, 1 minke whale, and at least 5 right whales. An additional wonderful sighting of a juvenile Pterodactyl with an estimated 9-meter wingspan, at the time feeding on schooling tuna with a concentration estimated at or above the established flying dinosaur feeding threshold, was recorded in the northeastern quadrant of Cape Cod Bay. This sighting was immediately reported to the Associated Pterodactyl Reporting, Institute for Legitimate and Future Observations Of Large Landanimals for dissemination through the World Wide Web to Pterodactyl watchers everywhere.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Cape Cod Bay Habitat Assessment

ACTIVITIES: 28 March - 1 April, 2007

Air Surveillance

The aerial surveillance team completed a partial survey of Cape Cod Bay (tracks 3-15) on 31 March. Survey efforts were aborted at 1800 due to low light. Eleven of the 19 right whales sighted were concentrated in the southern-central region of the bay. Of the remaining 7 whales, 2 were sighted in the northwestern corner of the Bay and 5 were sighted off of Provincetown. The two whales in the northwest were the only whales observed subsurface feeding. Neither 2029 nor the 2005 calf of 1703 were sighted during this survey. The next flight on 1 April was a complete survey of Cape Cod Bay, and 21 right whales were documented and photographed. Two right whales were again observed subsurface feeding in the northwestern corner of the Bay. Many of the remaining whales were sighted as solitary animals, though three small SAGs were also observed. The first mother-calf pair to be sighted in Cape Cod Bay in 2007 was also documented, with the mother believed to be Eg #1425. She and her calf were sighted and darted in the southeastern U.S. this winter.

Vessel-Based Monitoring

Cruise SW642 was a full CCB habitat cruise during which all eight regular stations were sampled, with surface and oblique (to 19 meters depth) net tows conducted at each. Mostly clear skies and a sea state of Beaufort 1 or less for most of the day afforded excellent visibility, and at least 5 right whales were sighted. These right whales were observed on long dives, socializing, and logging at the surface. A coincident aerial survey reported subsurface feeding in the northwestern area of Cape Cod Bay, and while no right whales were sighted by vessel-based observers in this region several hours later, zooplankton samples revealed that concentrations of the resource (especially in the water column) in the far northwest were indeed elevated compared to other areas of the Bay. **A preliminary assessment and prediction document was distributed immediately following cruise SW642.**

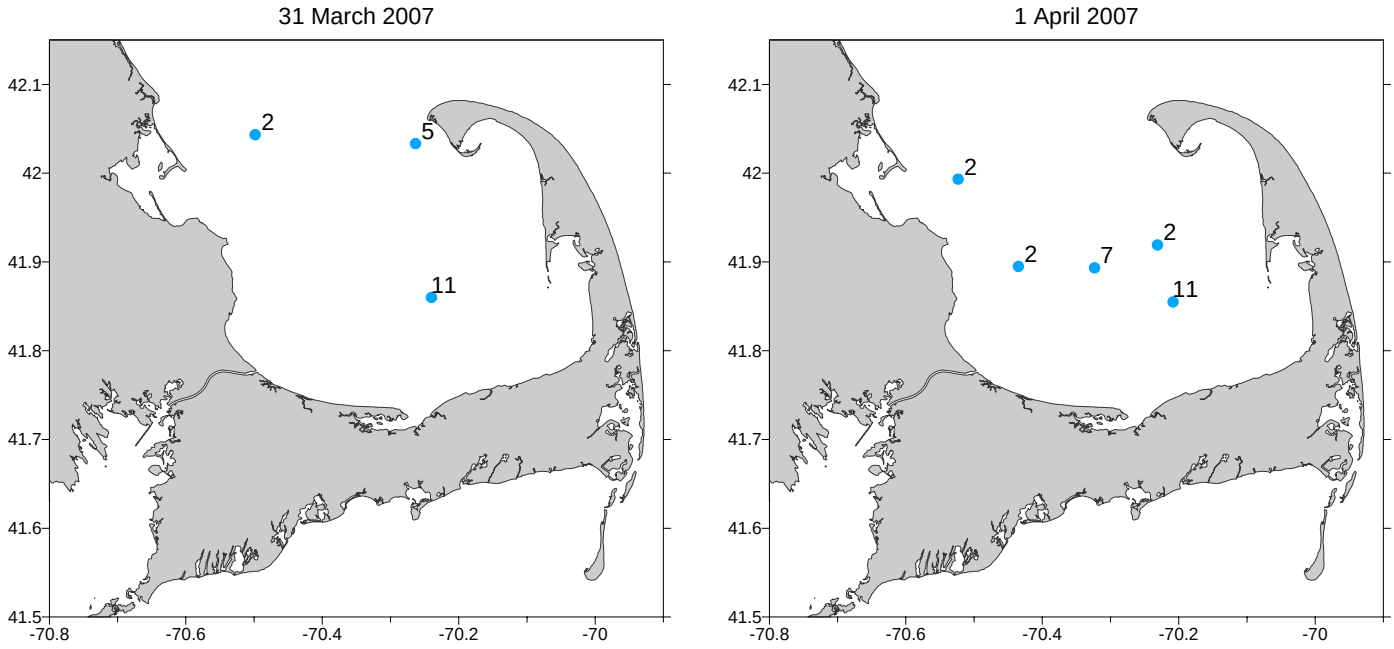


Figure 1. Right whale sightings from surveys conducted on 31 March (left) and 1 April (right).

HABITAT ASSESSMENT AUTHORSHIP:
OSTERBERG, MAYO (DMF-FUNDED PCCS HABITAT STUDIES PROGRAM)
BROWNING, JAQUET (DMF-FUNDED PCCS AIR SURVEILLANCE PROGRAM)

GENERAL ASSESSMENT

Whereas late March was characterized by the persistent aggregation of right whales in the southern-central area of Cape Cod Bay, the inception of April found a more dispersed distribution, with animals observed throughout the central region of the Bay and into the northwest. Concurrently, the very dense mid-water zooplankton resource in the southern-central Bay that had promoted aggregation in late March had largely dissipated by 1 April. New areas of elevated water column zooplankton abundance were documented along the eastern margin of the Bay and in the far northwest, with densities in these areas approaching the estimated threshold for right whale feeding. Several observations of feeding in the northwest suggest that the resource there was likely patchily distributed and that ephemeral, spatially-limited patches may present a suitable resource for feeding. Despite these intermittent high-density patches, the resource was nowhere concentrated enough to encourage long-term aggregation and residency.

In stark contrast to the mid-water resource, the concentration of zooplankton in the surface waters of the Bay at all stations declined to the lowest level yet recorded in 2007, with the bay-wide mean surface density measuring only 196 organisms/m^3. As such, there remains little potential for whales to feed at the surface, however the risk of vessel collision remains moderate due to continuing observations of social behavior at the surface.

The zooplankton community throughout Cape Cod Bay continues to be dominated by the small taxon of calanoid copepod *Pseudocalanus*, with an increasing contribution to the calanoid resource by early-stage *Calanus finmarchicus*. The samples collected continued to lack the significant numbers of late-stage *Calanus* that usually begin to appear in early April.

The dispersal of the resource, the continuing absence of a strong *Calanus finmarchicus* signal, and the lack of a well-established region of strong resource suggest that right whale distribution will continue to disperse through the Bay and that numbers of whales may be expected to decline absent the advective entry and establishment of both a strong *Calanus finmarchicus* resource and its concentration into patches and layers.

Interpreted likelihood (1-10) of:
Aggregation: Moderate (3)
Residency: Moderate (3)
Near-surface feeding: Low (1)
Feeding in the water column: Moderate (3)
Quadrant Quality/Attractiveness: NW(4), SW(2), SE(4), NE(4)

SURFACE RESOURCE

		Currently **1 April 2007**		*Recently* **27 March 2007**	
Bay-wide mean surface density:		196	zpl/m^3	353	zpl/m^3
Range of densities for individual stations:					
	Low	29	[sta 8M]	15	[sta 6M]
	High	634	[sta 9N]	778	[sta 9S]
Mean surface densities by quadrant:					
	NE	202		84	
	NW	331		434	
	SE	156		156	
	SW	94		737	

Inter-annual bay-wide comparison:

year	date	cruise	mean sfc density	
2003	2 Apr	SW323	884	zpl/m^3
2004	30 Mar	SW404	5453	
2005	1 Apr	SW530	558	
2006	30 Mar	SW600	157	
2007	1 Apr	SW642	196	

Surface Resource Summary:

- The low surface zooplankton abundance that had persisted during March decreased further to extremely low densities on 1 April. The bay-wide mean surface density of 196 organisms/m^3 was the lowest yet recorded in 2007. Individual station densities ranged between 29 and 634 org/m^3, thus remaining far below the estimated right whale feeding threshold of 3750 org/m^3.
- Significant density declines were observed in areas that had hosted slightly higher surface densities (relative to the impoverished state of the surface resource bay-wide) on 27 March. These losses were most pronounced in the west, where station 9S declined from 778 to 66 org/m^3 since the previous cruise, station 7S decreased from 697 to 123 org/m^3 and station 8M fell from 600 down to 29 org/m^3. Maps of the spatial distribution of zooplankton densities and the changes thereof since the last cruise are presented in Figures 2 and 3.
- Species composition notes:
    - The dominance of the small copepod genus *Pseudocalanus* in the surface waters continued to show evidence of weakening on 1 April, with its contribution to the bay-wide mean total zooplankton dropping to 41% (down from 49% on 27 March). *Pseudocalanus* dominance remained most apparent in the eastern Bay.
    - The aforementioned density declines observed at many western stations represented significant changes in species composition at these locations, with the bulk of these declines attributed to *Pseudocalanus*, *Calanus finmarchicus* and *Centropages* losses. The remaining zooplankton assemblage in these areas was markedly different from that seen in eastern samples, with *Acartia* strongly dominant numerically in the ultra-low density samples.
    - The marked spatial heterogeneity of the species composition of the surface assemblage was also apparent in the far northwest at the highest-density station, 9N, where *Calanus* (primarily early-stage individuals) comprised 70% of the total zooplankton in the surface sample.

WATER COLUMN RESOURCE FROM OBLIQUE TOWS (surface to 19 meters)

		Currently **1 April 2007**		*Recently* **27 March 2007**	
Bay-wide mean oblique density:		1999	zpl/m^3	2985	zpl/m^3
Range of densities for individual stations:					
	Low	1039	[sta 8M]	1286	[sta 6M]
	High	3589	[sta 5S]	9144	[sta 6S]
Mean oblique densities by quadrant:					
	NE	2132		1864	
	NW	2074		2433	
	SE	2492		5556	
	SW	1298		2088	

Inter-annual bay-wide comparison:

year	date	cruise	mean obl density	
2003	2 Apr	SW323	2975	zpl/m^3
2004	30 Mar	SW404	19718	
2005	1 Apr	SW530	3084	
2006	30 Mar	SW600	585	
2007	1 Apr	SW642	1999	

Water Column Resource Summary:

- Concentrations of zooplankton in the water column declined slightly from the high densities that were observed in late March. While the bay-wide mean density decreased to 2000 organisms/m^3 (from approximately 3000 org/m^3 on 27 March), several areas of Cape Cod Bay – particularly in the east and in the far northwest – nonetheless had densities that approached the estimated right whale feeding threshold of 3750 org/m^3.
- Water column zooplankton densities decreased at many southern stations, most notably in the southern-central area (particularly near station 6S) where densities of 13000 and 9100 org/m^3 had been recorded on 21 and 27 March, respectively. These high densities had been supporting right whale feeding and aggregation in the area for several weeks; however, on 1 April the abundance at 6S appeared insufficient to further support feeding, with a water column density of only 1400 org/m^3.
- Coincident with the above-mentioned abundance decline at station 6S was an increase in water column density at station 5S to approximately 3600 org/m^3, approaching the estimated feeding threshold for right whales. This suggests that the resource in the southeast may still be patchily distributed with localized areas of high zooplankton densities, which probably explain the continued presence of right whale aggregations in this area.
- Elevated water column densities approaching feeding threshold were also found in the northeast at station 5N (~3100 org/m3) and in the far northwest at station 9N (~3150 org/m^3). Indeed, near the latter station the aerial surveillance team reported observations of two right whales feeding in the upper water column early in the day on 1 April. Although no right whales were sighted in that area several hours later and a water column zooplankton sample revealed a concentration (~1800 org/m^3) insufficient to support feeding, it is likely that occasional coalescence of the resource into high-density patches creates localized and ephemeral areas where the resource is suitable for right whale foraging and aggregation.
- Species composition notes:
    - The higher-density water column (relative to surface densities) continued to be dominated by *Pseudocalanus* spp., though this dominance was substantially weaker than it had been in late March. *Pseudocalanus* density declines were recorded at all but two stations (9N in the far northwest and 5S in the southeast), with the largest losses documented at station 6S in the southern-central Bay (a decline of over 3400 *Pseudocalanus*/m^3).

- *Calanus finmarchicus* had an increased presence throughout the Bay on 1 April, representing 18% of the bay-wide mean total zooplankton count in the water column, up from 13% on 27 March. *Calanus* continued to be present in slightly higher concentrations in samples from the northwest and west, where it comprised 34% of the total zooplankton at three separate stations (9N, 8M and 9S). Bay-wide, *Calanus* were predominantly early-stage individuals.

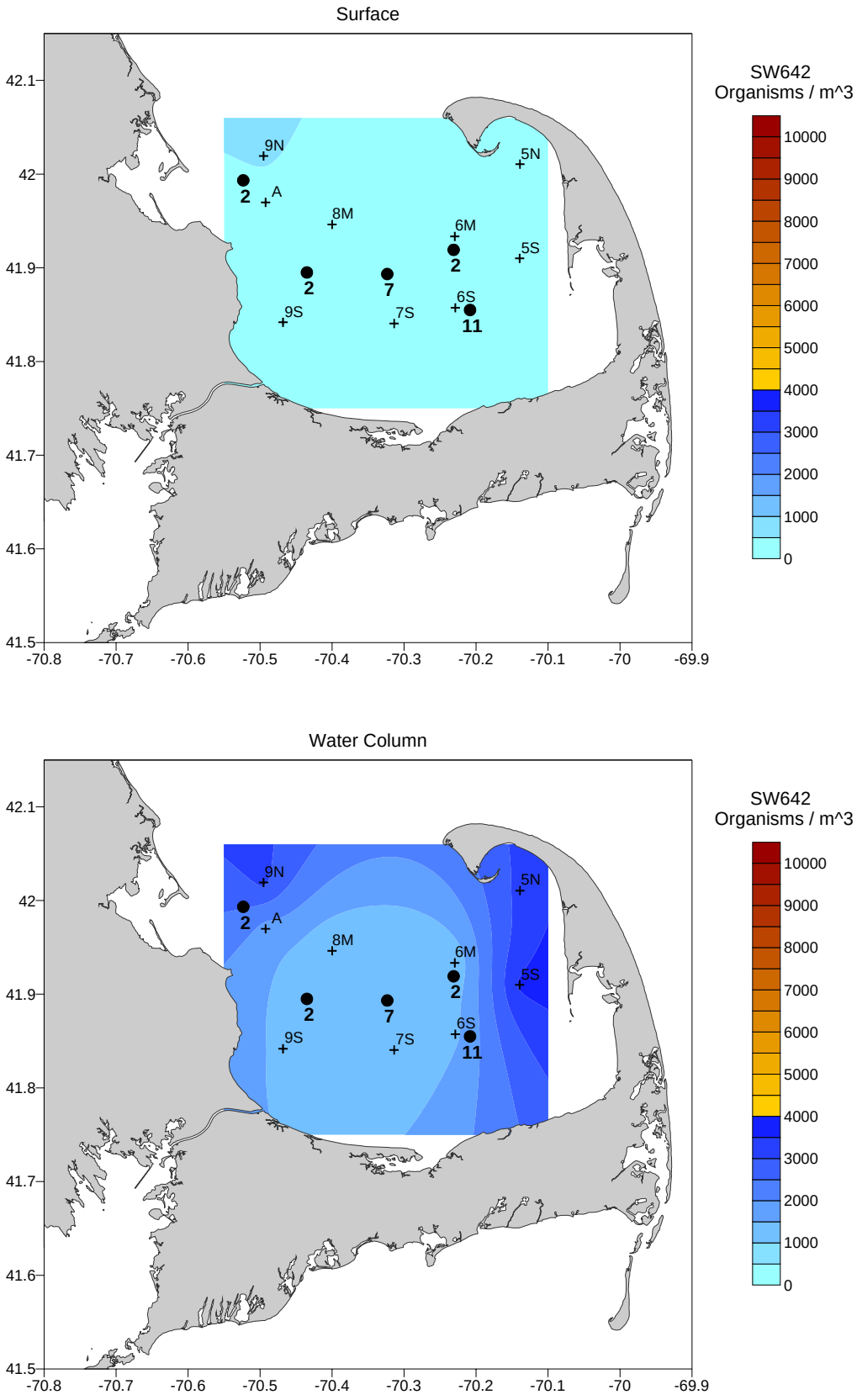


Figure 2. Spatial plots of **zooplankton densities** from surface (upper plot) and oblique (lower plot) net tows conducted during cruise SW642 on 1 April 2007. Sampling station locations are indicated with a "+" symbol. Approximate right whale locations are labeled with a "•" symbol and the number of individuals sighted, generally within 2nm. Auxiliary tows (both surface and oblique) were conducted at special station A near the location where two right whales had been observed feeding in the upper water column earlier in the day.

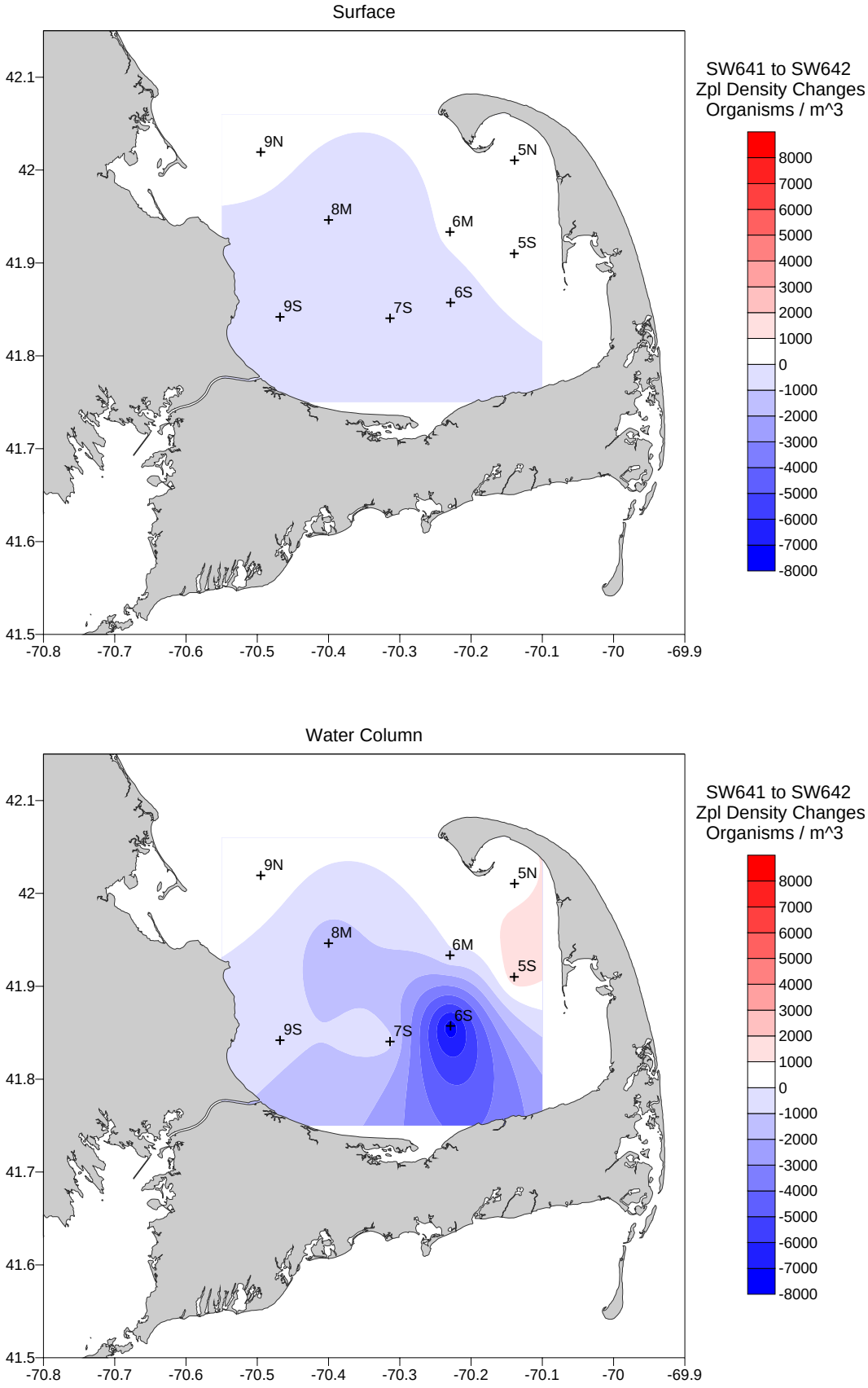


Figure 3. Spatial plots of the **changes in zooplankton densities** between the previous cruise (SW641 on 27 March) and the latest sampling cruise (SW642 on 1 April). Changes in *surface* density are displayed in the upper plot, while changes in *water column* density are plotted below. Sampling station locations are indicated with a "+" symbol.

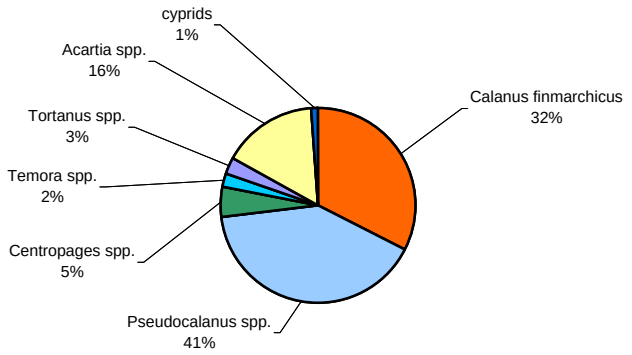
Surface Zooplankton Assessment: Cruise SW642 (1 April 2007) Julian Day 91

Recent aerial NARW sightings: 22 animals in Cape Cod Bay on 1 April — *SW642 vessel NARW sightings: at least 5 right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	297.88	0.18	23.69	0.0053
Surface Tow	6M	106.59	0.08	9.57	0.0021
Surface Tow	8M	29.13	0.04	3.67	0.0007
Surface Tow	9N	634.07	0.80	175.85	0.0400
Surface Tow	5S	270.28	0.18	18.54	0.0041
Surface Tow	6S	41.78	0.04	3.69	0.0007
Surface Tow	7S	122.95	0.10	5.43	0.0012
Surface Tow	9S	65.48	0.06	3.70	0.0008
Cruise Average:		**196.02**	**0.19**	**30.52**	**0.0069**
Previous Cruise Average:		353.27	0.21	44.27	0.0102

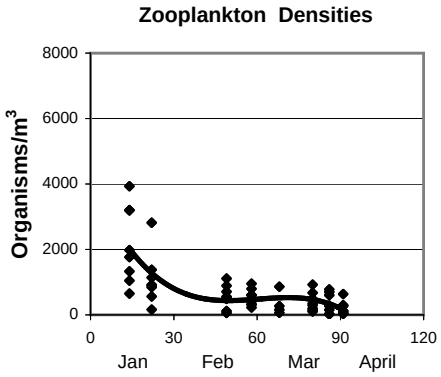
Zooplankton Species Avg. % Composition: SW642 All Stations, *Surface Tows*

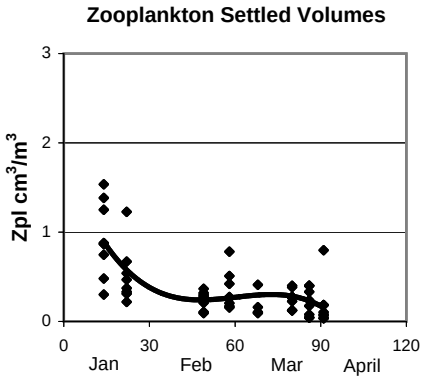


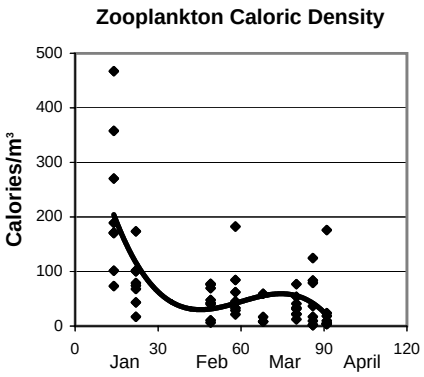
Other zooplankton present in low numbers:
Eurytemora spp., Oithona spp., Metridia spp., nauplii, fish eggs

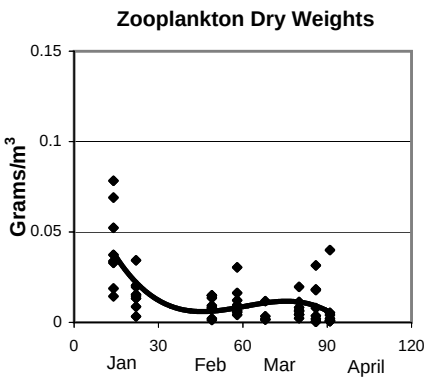
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

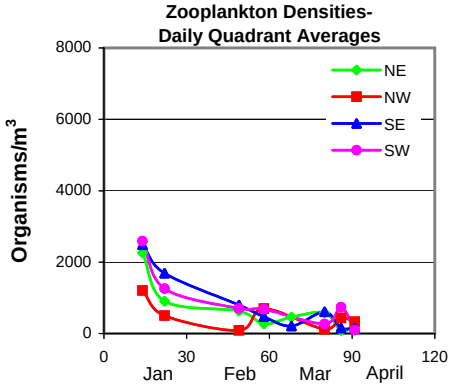


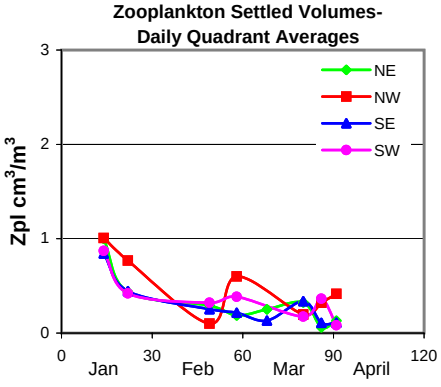


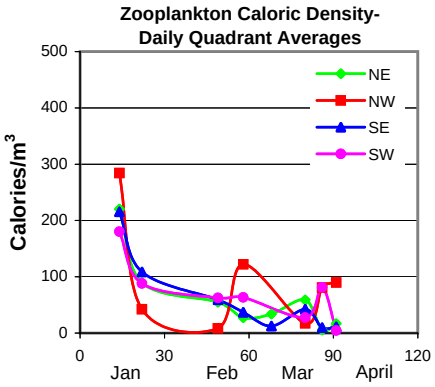


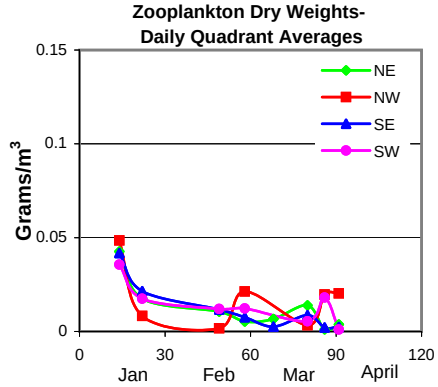


Geographic Quadrants:









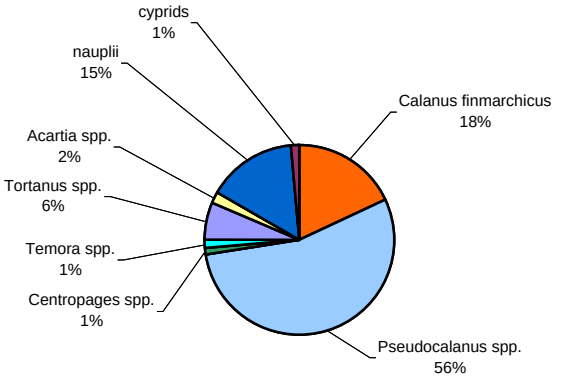
Water Column Zooplankton Assessment: Cruise SW642 (1 April 2007) Julian Day 91

Recent aerial NARW sightings: 22 animals in Cape Cod Bay on 1 April — *SW642 vessel NARW sightings: at least 5 right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	3146.09	1.36	183.09	0.0380
Oblique Tow	6M	1117.07	0.75	125.95	0.0310
Oblique Tow	8M	1039.18	0.77	144.62	0.04
Oblique Tow	9N	3108.34	1.89	410.33	0.10
Oblique Tow	5S	3588.96	1.39	212.31	0.0459
Oblique Tow	6S	1394.58	0.72	111.39	0.0262
Oblique Tow	7S	1168.19	0.85	105.14	0.03
Oblique Tow	9S	1427.10	1.10	195.32	0.05
Cruise Average:		**1998.69**	**1.10**	**186.02**	**0.0437**
Previous Cruise Average:		2985.31	1.35	247.69	0.0564

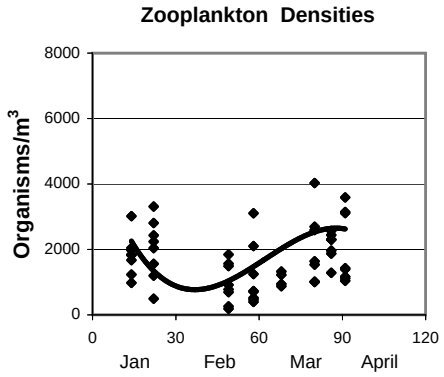
Zooplankton Species Avg. % Composition: SW642 All Stations, *Oblique Tows*

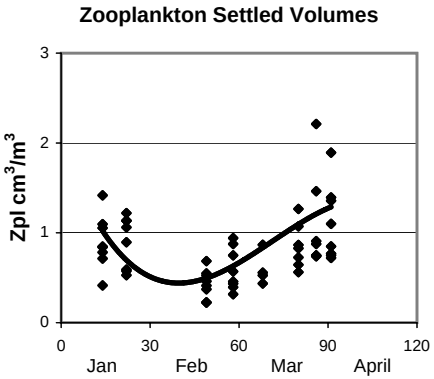


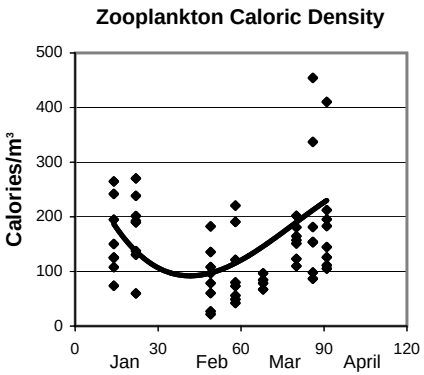
Other zooplankton present in low numbers:
Oithona spp.
fish larvae
molluscs

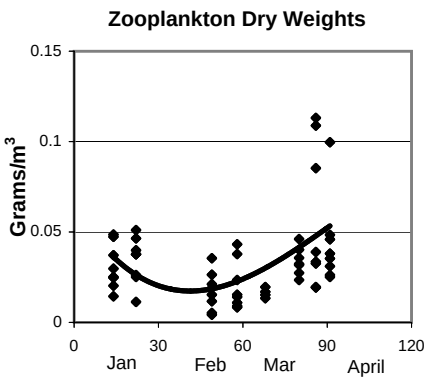
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

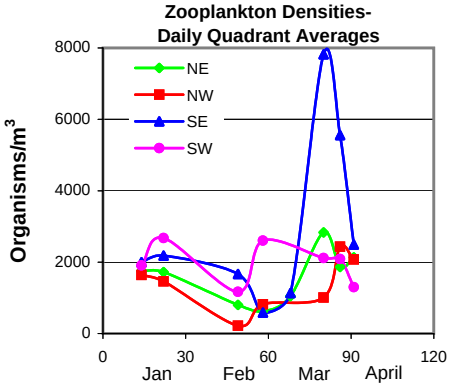


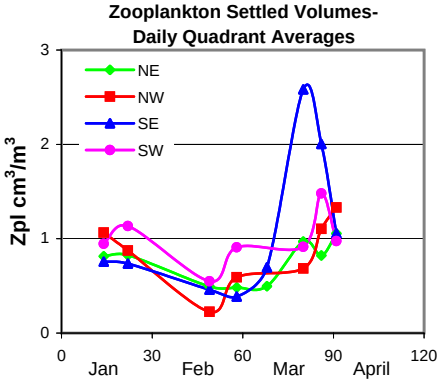


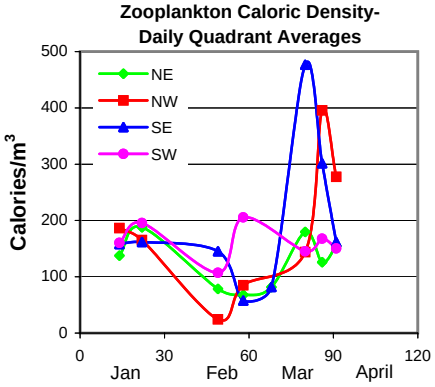


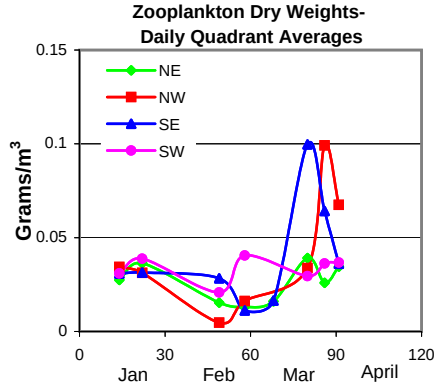


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW644
10 April 2007

In strong and increasing winds, SW644 was mounted early on 10 April. Conditions limited the range of the cruise and only 3 stations close to Provincetown Harbor were sampled. SW644 was canceled at 1000 hrs because of rough seas. A planned air survey was also canceled.

The zooplankton densities assessed in the limited sampling on SW644 appear to have declined since collections on 1 April, before the strong cold front passed over the region. The taxonomic composition of the food resource close to the land continues to be dominated by *Pseudocalanus*, a small calanoid copepod that, though important in influencing the distribution, feeding, and aggregation of right whales, is of lower caloric and bulk value than the late-stage *Calanus* resource that is usually richly abundant in both mid-water and surface samples during the early spring. Thus the samples collected on SW644 suggest that the northern portions of the northeast quadrant of the bay will not support aggregation, residency, and feeding by right whales. DMF/PCCS air survey data from 7 April suggest that right whales had moved from a southern in Cape Cod Bay to a rich food resource outside Cape Cod Bay, suggesting that the modest zooplankton resource dominated by small taxa seen over the past 3 weeks was no longer attractive to whales previously seen deep in the bay. Given a change in the severe weather pattern, anticipated zooplankton sampling at regular stations within the bay and in areas north and east of Cape Cod will clarify this apparently key time in tracking and forecasting the distribution of the whales. Absent collections from the larger region, our limited information from SW644 suggests that that a low abundance of *Calanus finmarchicus* and the decline in a modest *Pseudocalanus* resource has further reduced the possibility of aggregation and feeding by right whales.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW645
11 April 2007

With the possibility that right whales had departed Cape Cod Bay on the 7 April as suggested by aircraft survey observations, R/V *Shearwater* cruise SW645 was designed to assess the bay-wide resource. Sea conditions during the cruise were poor to fair and visibility was good. The DMF/PCCS aircraft survey on 11 April located a dense concentration of whales near the middle of the Bay, many sub-surface feeding and occasionally socializing.

While surface zooplankton concentrations during the last week remain low, a significant increase in bay-wide total zooplankton concentration and change in taxonomic composition in the mid-waters was documented. The taxonomic composition in samples, particularly in the west has begun the anticipated change to mid- and late-stage *Calanus finmarchicus*. Only in the far southeast does *Pseudocalanus* remain numerically dominant. This change in taxonomic composition, typical of early spring, will likely continue now that it has begun and may be expected to support right whale aggregation and feeding for the next week or more. The numerical density of zooplankton available to right whales has similarly increased throughout the Bay, and is estimated to substantially surpass the feeding threshold in mid-water collections from the central and southwestern regions of the Bay.

The source of the recent enrichment of the Bay that has profoundly influenced the distribution and behavior of right whales remains remarkable and unclear. It seems likely that the aggregation of whales observed on 7 April north of the Bay was an indicator of the entry of a substantial zooplankton resource into the area from the north and east. The observed distribution of whales on 7 April suggests that the 15-20 whales previously present in Cape Cod Bay moved north out of the deep Bay to "meet" an offshore resource. By 11 April it appears that the offshore zooplankton of a distinctly greater richness than found previously within Cape Cod Bay had moved into and spread over much of the Bay, bringing with it many of the whales associated with it on 7 April. What was not anticipated was the movement of the controlling zooplankton resource into the Bay from the area around Race point, contrary to the advective models' prediction that net transport of mid-water resources in Cape Cod Bay is counter-clockwise.

In summary, the sudden and substantial enrichment of the mid-water resources in Cape Cod Bay suggests that aggregations of feeding right whales will be associated with the central bay for the near future. Although the increasing turbulence and transport resulting from the passage of a strong ocean storm may have unforeseen impacts, we generally forecast the continued presence of high zooplankton concentrations, an increase in the *Calanus* resource (coupled with increases in energy-rich stage 5 copepodites), aggregation of whales, and increased likelihood of surface and near-surface feeding. At present, not considering the influence of predicted gale-force winds, the area of aggregation will likely drift from the center of the Bay slowly to the south to spread along the south margin of the bay, probably to the east.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

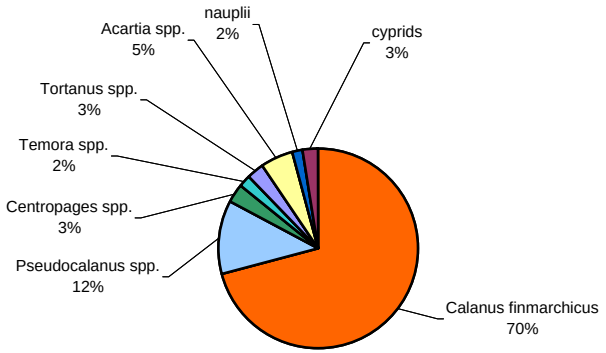
Surface Zooplankton Assessment: Cruise SW645 (11 April 2007) Julian Day 101

Recent aerial NARW sightings: 43 animals in Cape Cod Bay on 11 April — *SW645 vessel NARW sightings: at least 14 right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	439.19	0.20	52.94	0.0138
Surface Tow	6M	247.29	0.16	43.70	0.0108
Surface Tow	8M	616.12	0.28	156.33	0.0435
Surface Tow	9N	1547.80	0.83	353.97	0.0988
Surface Tow	5S	119.31	0.11	8.43	0.0018
Surface Tow	6S	95.45	0.10	10.85	0.0026
Surface Tow	7S	51.51	0.10	1.79	0.0004
Surface Tow	9S	221.68	0.13	42.47	0.0118
Cruise Average:		**417.29**	**0.24**	**83.81**	**0.0229**
Previous Cruise Average:		196.02	0.19	30.52	0.0069

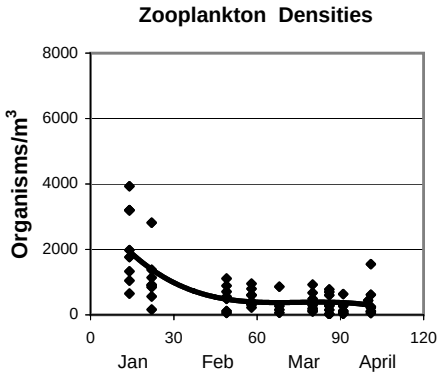
Zooplankton Species Avg. % Composition: SW645 All Stations, *Surface Tows*

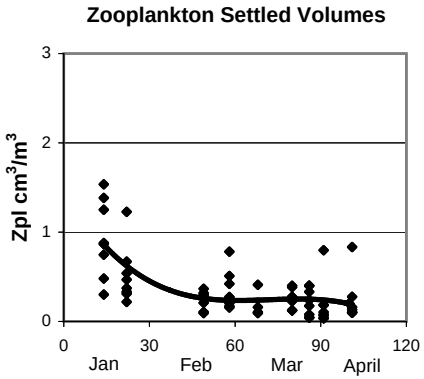


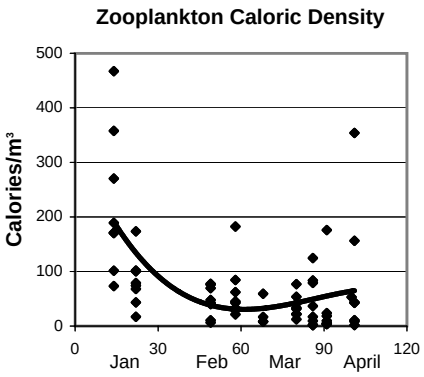
Other zooplankton present in low numbers:
Eurytemora spp., Oithona spp., ctenophores, fish eggs, harpacticoids

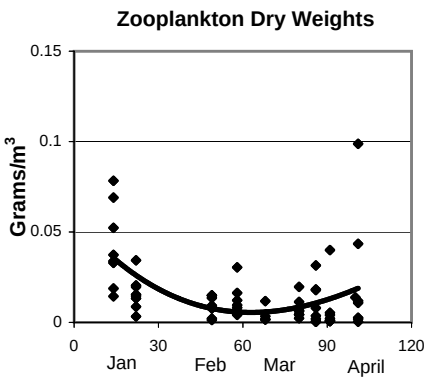
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

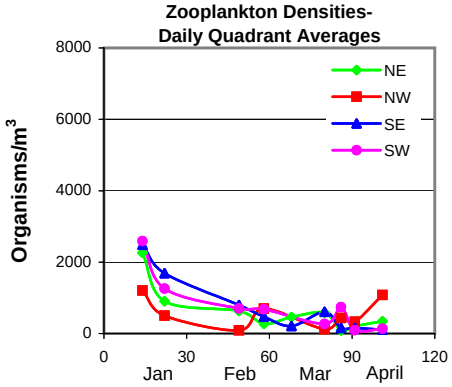


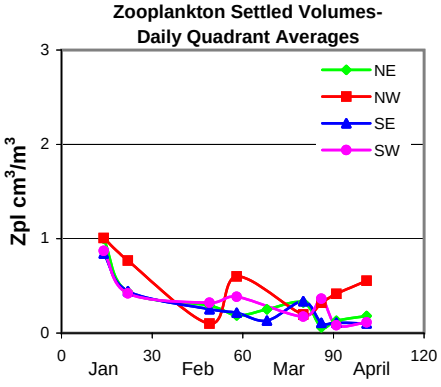


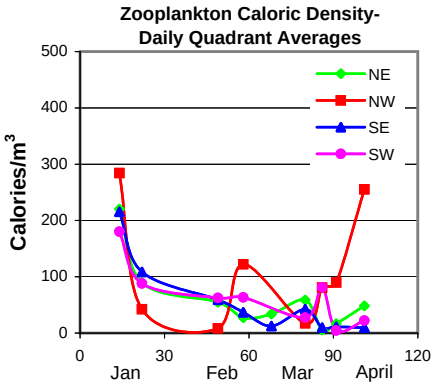


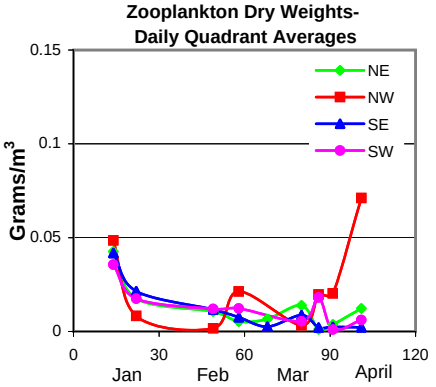


Geographic Quadrants:









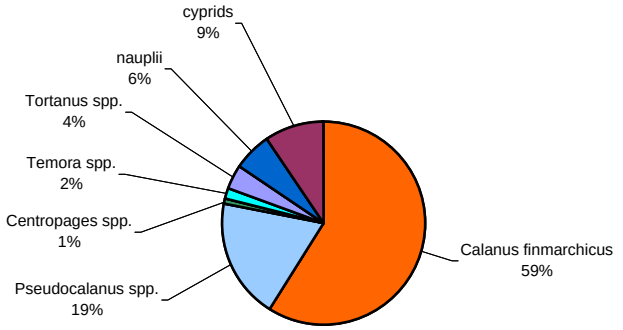
Water Column Zooplankton Assessment: Cruise SW645 (11 April 2007) Julian Day 101

Recent aerial NARW sightings: 43 animals in Cape Cod Bay on 11 April — *SW645 vessel NARW sightings: at least 14 right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	1048.11	0.38	107.21	0.0263
Oblique Tow	6M	1386.71	0.80	187.02	0.0475
Oblique Tow	8M	3410.42	1.72	484.80	0.14
Oblique Tow	9N	2242.26	1.58	468.80	0.13
Oblique Tow	5S	1487.82	0.59	128.93	0.0280
Oblique Tow	6S	2403.54	0.97	373.70	0.0990
Oblique Tow	7S	4256.41	2.37	873.38	0.24
Oblique Tow	9S	4841.66	1.95	965.63	0.27
Cruise Average:		**2634.62**	**1.29**	**448.68**	**0.1218**
Previous Cruise Average:		1998.69	1.10	186.02	0.0437

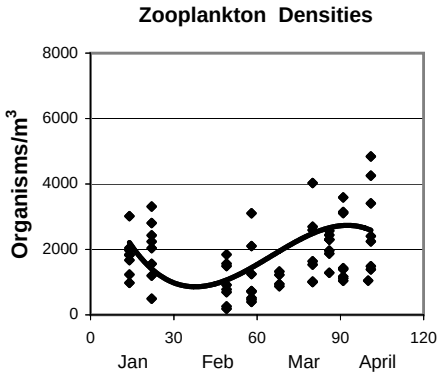
Zooplankton Species Avg. % Composition: SW645 All Stations, *Oblique Tows*

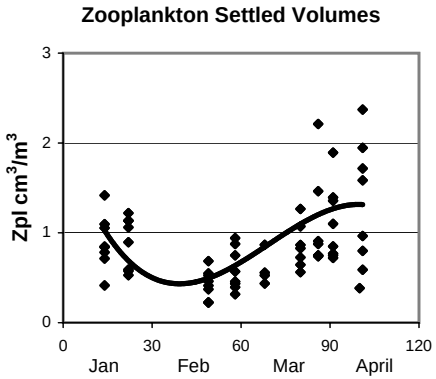


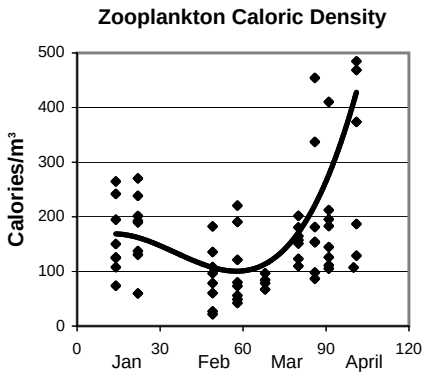
Other zooplankton present in low numbers:
Acartia spp., Eurytemora spp., Oithona spp., Metridia spp., zoea, mysids, harpacticoids

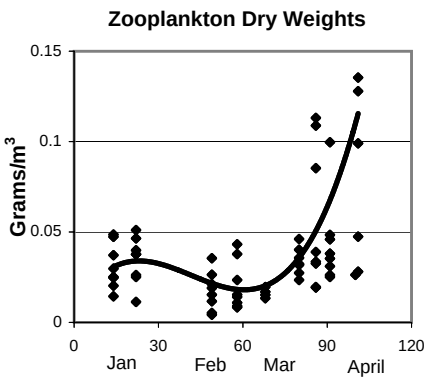
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

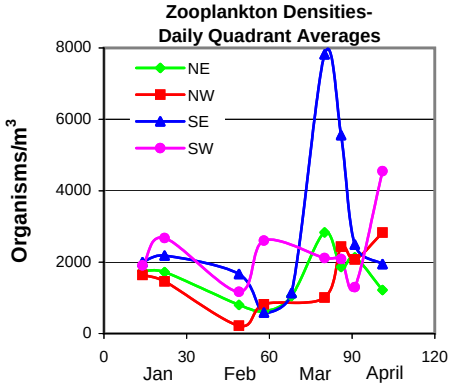


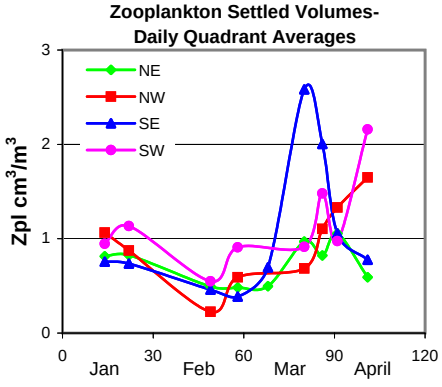


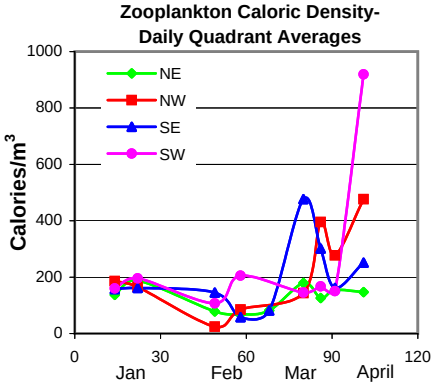


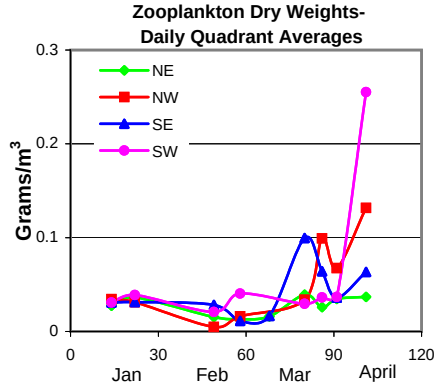


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW646
21 April 2007

After more than one week of gale- and storm-force northeasterly winds, calm arrived on 21 April. Cruise SW646 was completed in excellent sighting conditions with all regular assessment stations completed. During the period of heavy weather the zooplankton character of the bay changed markedly, as did the density of right whales.

Preliminary review of the zooplankton collections continues to indicate a surface food resource well below the estimated right whale feeding density while water column samples showed areas of strong resource in the southeast quadrant of the Bay. A particularly high mid water resource, far above the feeding threshold, at station 6S was complimented by a rich zooplankton at adjacent stations in the southern Bay. Several kilometers to the east of this station the DMF/PCCS aircraft survey team documented 4 right whales feeding beneath the surface.

Both at surface and in the mid waters the zooplankton composition varied among the stations, however particularly high concentrations of late stage copepodites of *Calanus finmarchicus* contributed to the food resource in the southeastern quadrant. Oil-rich stage 5 copepodites, believed to be the most influential food of the right whales, were significantly represented in the samples. A rising background of *Acartia*, a smaller less energy rich genus representative of more neritic and estuarine conditions, was also noted in surface samples throughout the Bay. Both aircraft and vessel-based observers noted the turbidity of the water in much of the Bay, the result of the intense turbulence of the last week.

The preliminary review suggests that the strong food resources found in the southeast quadrant will continue to anchor the right whales that remain within the Bay. Because seasonal enrichment of the zooplankton takes place over the entire region luring whales to areas east and south of Cape Cod, the attractiveness of Cape Cod Bay can't be assured. However, the local conditions taken alone favor residency and increasing aggregation of whales and the likelihood of near-surface feeding in an area approximately 5x5 kilometers in the southeastern part of the Bay. Both surface and mid-water samples in the northwest quadrant rule out aggregation and feeding in that area of high fishing and shipping activities. We anticipate that the forecast weather and the advective processes in the Bay will cause the resource and hence the whales to move to the northeast over the next week. Although conditions in the southeastern Bay are conducive to aggregation and near-surface feeding, the relative lack of fishing and shipping activity in that area makes the risk of ship strike and entanglement lower than in other areas of the Bay.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

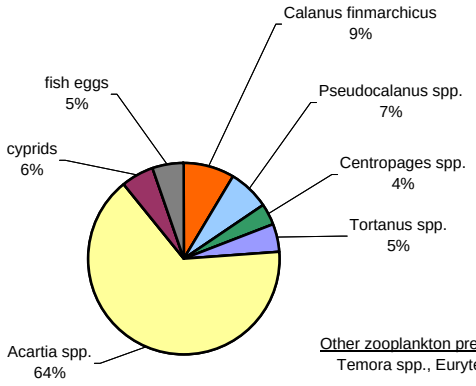
Surface Zooplankton Assessment: Cruise SW646 (21 April 2007) Julian Day 111

Recent aerial NARW sightings: 4 in Cape Cod Bay on 21 April — *SW646 vessel NARW sightings: no right whales*

MEASURES:

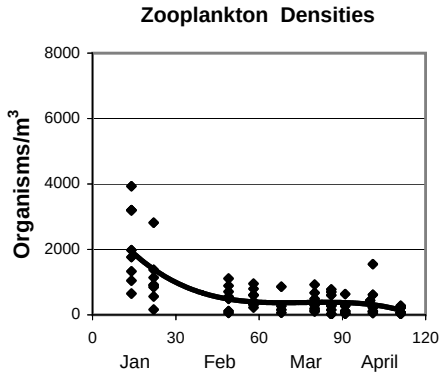
Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	23.69	0.01	1.26	0.0003
Surface Tow	6M	60.22	0.03	5.73	0.0011
Surface Tow	8M	65.62	0.08	2.18	0.0005
Surface Tow	9N	217.54	0.20	11.98	0.0025
Surface Tow	5S	78.74	0.03	1.97	0.0004
Surface Tow	6S	279.37	0.29	83.95	0.0143
Surface Tow	7S	250.45	0.12	13.04	0.0028
Surface Tow	9S	238.73	0.14	12.69	0.0027
Cruise Average:		**151.79**	**0.11**	**16.60**	**0.0031**
Previous Cruise Average:		417.29	0.24	83.81	0.0229

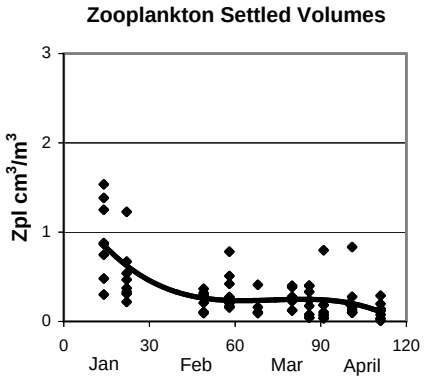
Zooplankton Species Avg. % Composition: SW646 All Stations, *Surface Tows*

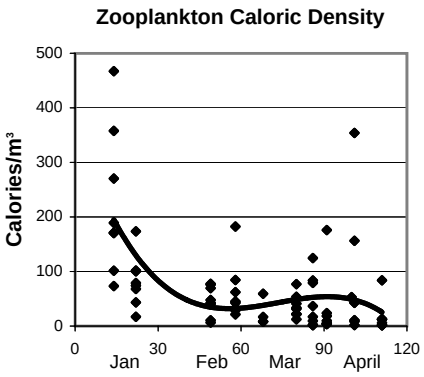


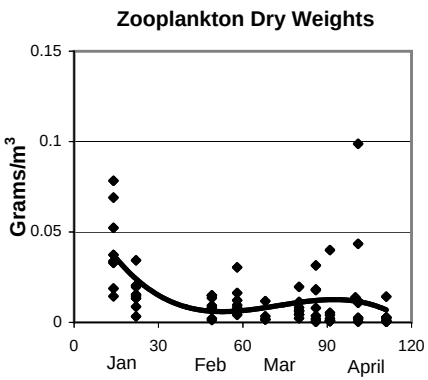
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

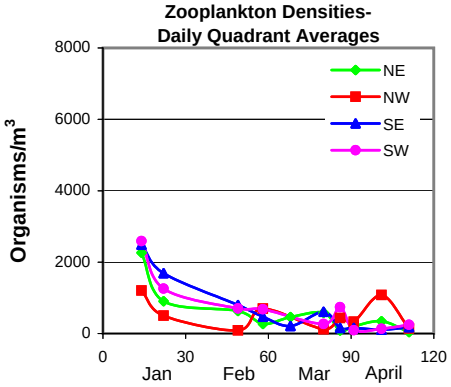


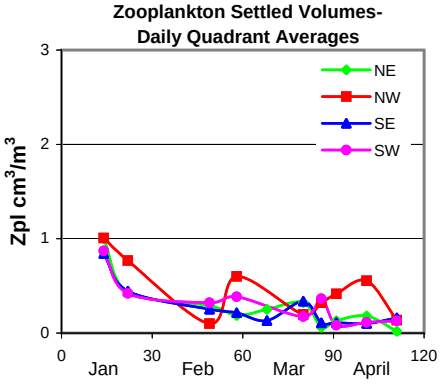


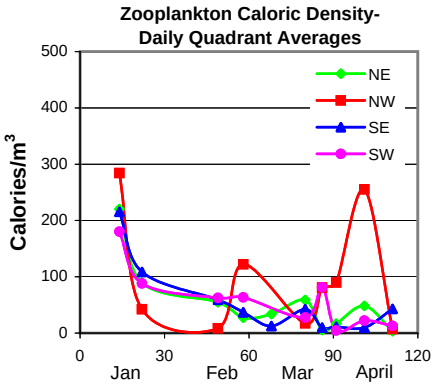


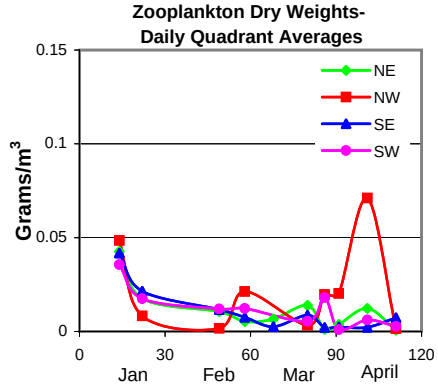


Geographic Quadrants:









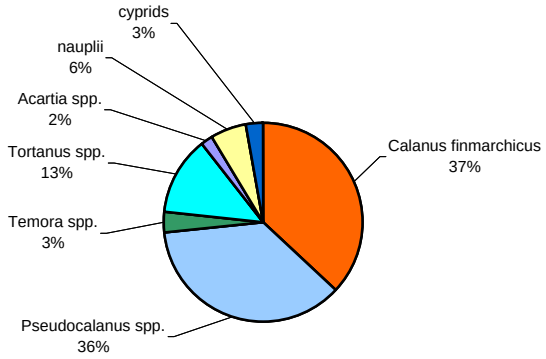
Water Column Zooplankton Assessment: Cruise SW646 (21 April 2007) Julian Day 111

Recent aerial NARW sightings: 4 in Cape Cod Bay on 21 April — *SW646 vessel NARW sightings: no right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	4495.96	3.34	731.37	0.1797
Oblique Tow	6M	4322.37	1.66	558.22	0.1247
Oblique Tow	8M	3837.07	1.99	517.09	0.14
Oblique Tow	9N	1867.38	1.08	176.66	0.05
Oblique Tow	5S	4647.01	2.53	807.86	0.2029
Oblique Tow	6S	11281.89	5.58	1751.73	0.4473
Oblique Tow	7S	4207.74	1.47	593.55	0.13
Oblique Tow	9S	1448.26	0.54	194.74	0.05
Cruise Average:		**4513.46**	**2.27**	**666.40**	**0.1649**
Previous Cruise Average:		2634.62	1.29	448.68	0.1218

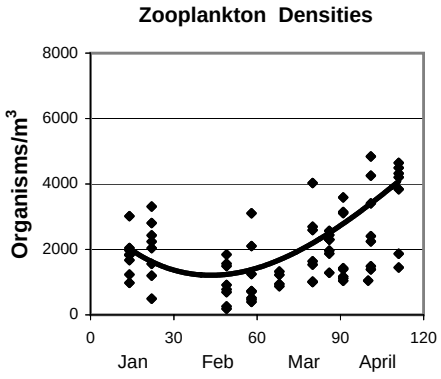
Zooplankton Species Avg. % Composition: SW646 All Stations, *Oblique Tows*

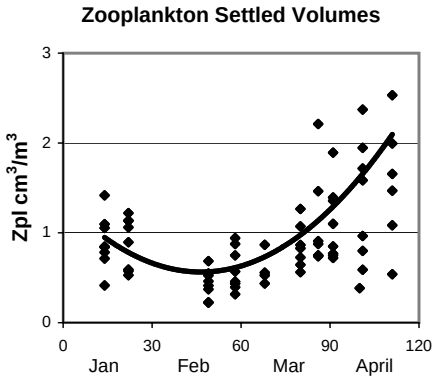


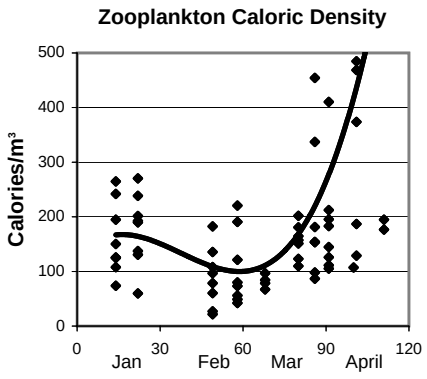
Other zooplankton present in low numbers:
Centropages spp., Oithona spp., Metridia spp., fish larvae, fish eggs, mysids

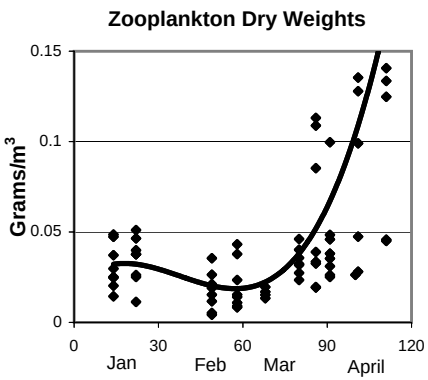
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

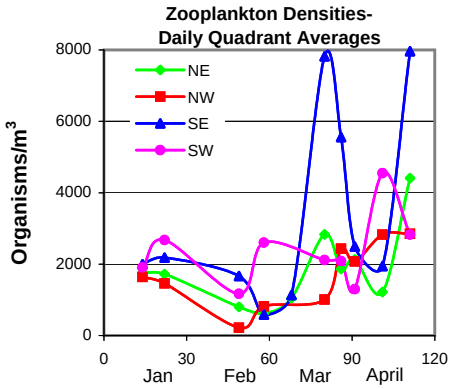


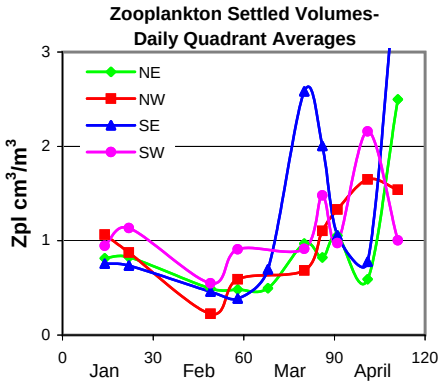


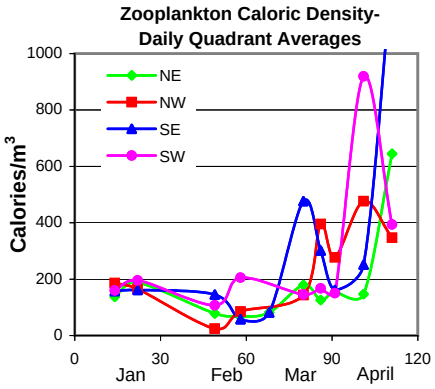


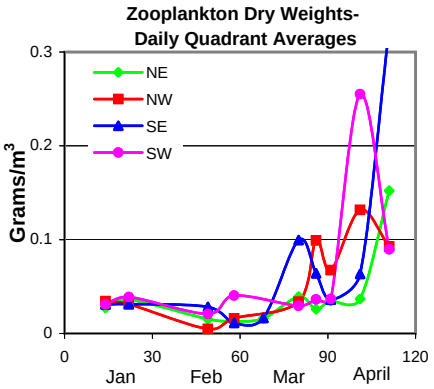


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW647
25 April 2007

With excellent sighting conditions and flat calm sea Cruise SW647 was directed at locating whales and assessing the zooplankton resource that has been controlling right whale distribution and behavior over the past days of windy weather. Three regular and 5 special stations (resulting in more than 45 zooplankton samples) were visited. A concentration of more than 35 whales was located by DMF/PCCS air and vessel survey teams. The greatest aggregation of whales was located in the near-shore waters between Race Point and Long Point in Provincetown. Intensive sampling indicates that the zooplankton in the region is dominated by late stages of *Calanus finmarchicus* organized into linear patches of very high density, many times the estimated threshold for releasing right whale feeding behavior. It appears that localized small-scale frontal activity along the outer shore of Provincetown and Truro is creating conditions favorable to the formation of linear near-surface patches and that these areas of dense resources are continually foraged upon by an increasingly concentrated aggregation of whales. The characteristics of the zooplankton resource suggests that right whale aggregation and surface and near-surface feeding coupled with occasional bouts of social activity will continue and may move south into the northeast quadrant of Cape Cod Bay. Zooplankton samples collected at stations along the eastern portion of the bay south of the identified feeding area are also dense and will occasionally attract aggregations of feeding whales to the eastern central portion of the bay.

The vertical distribution of the zooplankton resource determined from pump sampling confirms that the patches triggering whale aggregation are composed principally of calanoid copepods concentrated in the upper 2 meters of the water column. Such patch structure strongly favors surface and near-surface feeding activities, placing whales at a high risk of vessel strike. We anticipate that surface feeding will continue to dominate right whale activities in the area for the next 4-7 days.

Preliminary assessment of zooplankton resources strongly supports our alert issued on 24 April:

The area of greatest concern is located along the outer shore of Cape Cod from Long Point to Race Point in Provincetown and beyond to Cape Cod Light (Highland Light) in Truro.

We modify yesterday's alert from a band 3 miles wide:

To extend the band of greatest risk of vessel strike to 5 miles from the shore throughout the area delineated.

In the next days future assessment will track the potential movement of the resource, and hence the whales, into Cape Cod Bay. Such movement may extend the area of vessel strike risk to include Cape Cod Bay south of Provincetown and Truro.

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These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Surface Zooplankton Assessment: Cruise SW647 (25 April 2007) Julian Day 115

Recent aerial NARW sightings: >35 in Cape Cod Bay on 25 April — *SW647 vessel NARW sightings: at least 25 right whales*

MEASURES:

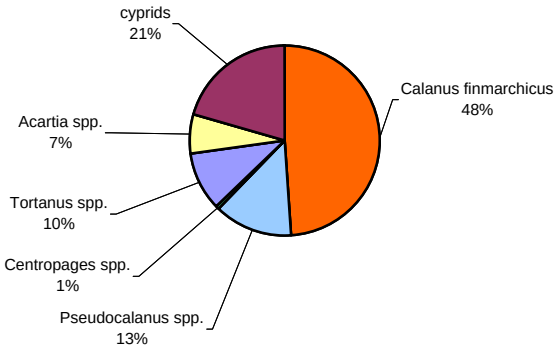
ONLY EASTERN STATIONS WERE SAMPLED

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	2241.35	0.61	148.58	0.0353
Surface Tow	6M	2031.81	1.10	468.35	0.1225
Surface Tow	5S	1186.80	0.52	193.82	0.0483
Surface Tow	6S	1049.45	0.59	228.69	0.0641
Cruise Average:		**1627.35**	**0.71**	**259.86**	**0.07**

Special Stations: (in-path tows conducted behind feeding right whales)

Surface Tow	A	**25360**	n/a	6128.37	1.5982
Surface Tow	B	**58742**	n/a	14063.47	3.7513
Surface Tow	D	**15958**	n/a	4230.75	1.0992

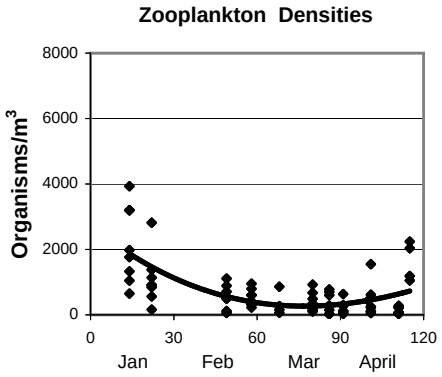
Zooplankton Species Avg. % Composition: SW647 Eastern Stations, *Surface Tows*

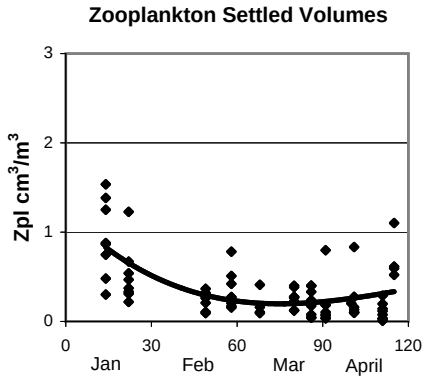


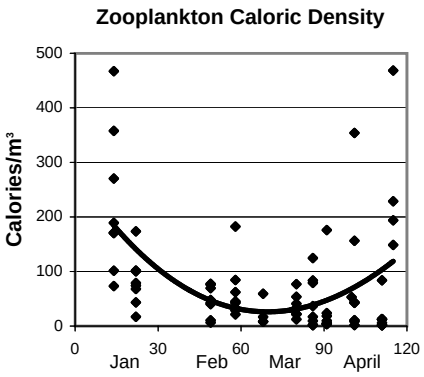
Other zooplankton present in low numbers:
Temora spp., Oithona spp., Metridia spp., nauplii, fish eggs, cladocera, polychaetes

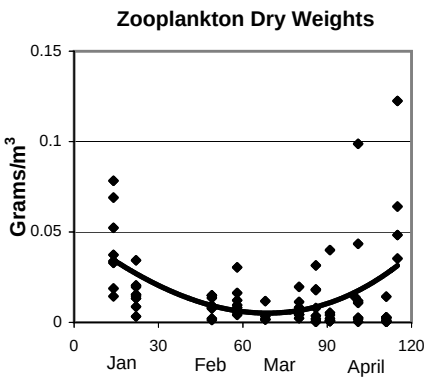
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

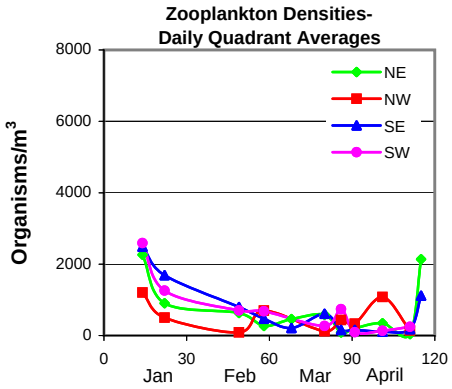


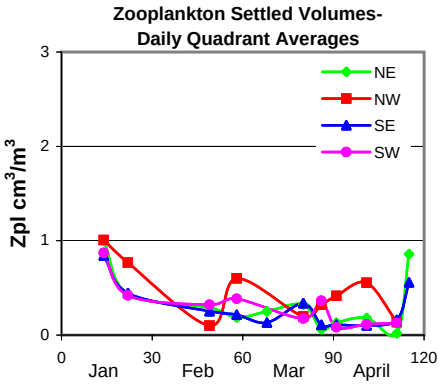


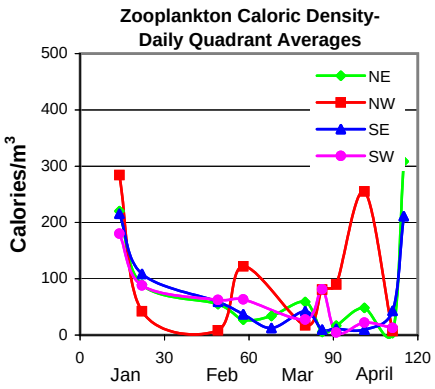


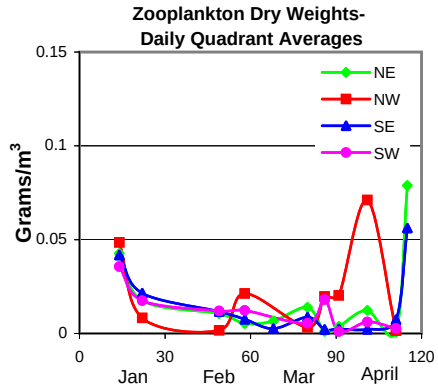


Geographic Quadrants:









Water Column Zooplankton Assessment: Cruise SW647 (25 April 2007) Julian Day 115

Recent aerial NARW sightings: >35 in Cape Cod Bay on 25 April — *SW647 vessel NARW sightings: at least 25 right whales*

MEASURES:

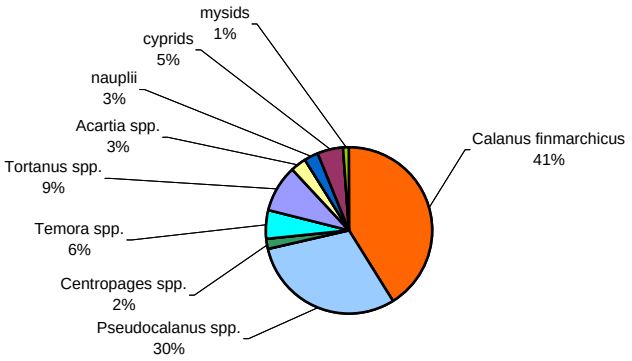
ONLY EASTERN STATIONS WERE SAMPLED

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	4495.96	3.34	731.37	0.1797
Oblique Tow	6M	4322.37	1.66	558.22	0.1247
Oblique Tow	5S	3837.07	1.99	517.09	0.14
Oblique Tow	6S	1867.38	1.08	176.66	0.05
Cruise Average:		**3630.70**	**2.02**	**495.83**	**0.12**

Special Stations: (in-path tows conducted behind feeding right whales)

Oblique Tow	A	**11422**	n/a	2655.63	0.6855
Oblique Tow	B	**16065**	n/a	3521.67	0.9421

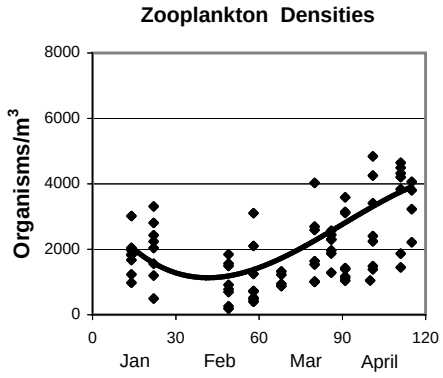
Zooplankton Species Avg. % Composition: SW647 Eastern Stations, *Oblique Tows*

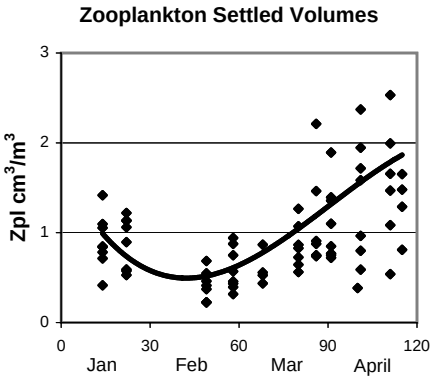


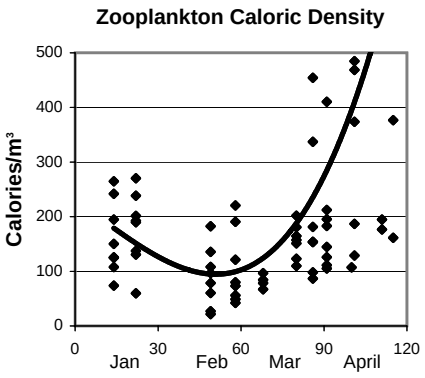
Other zooplankton present in low numbers:
Metridia spp., molluscs,harpacticoids

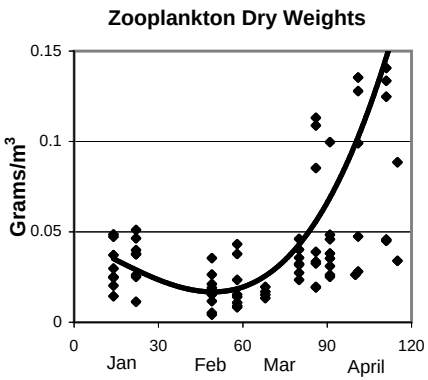
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

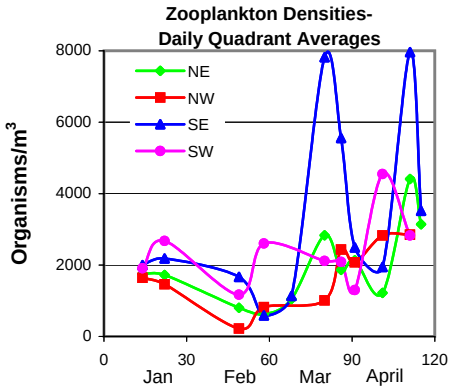


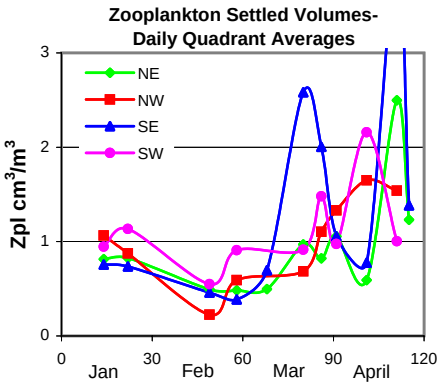


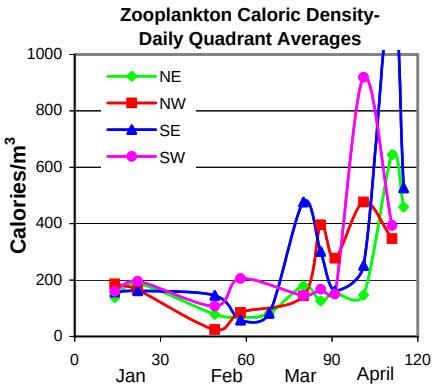


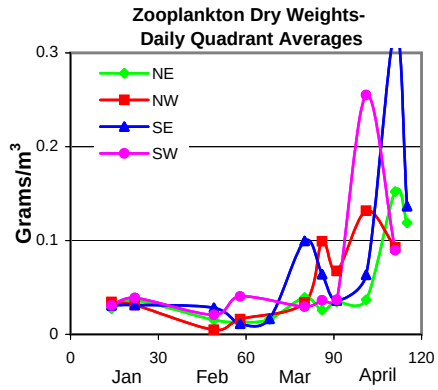


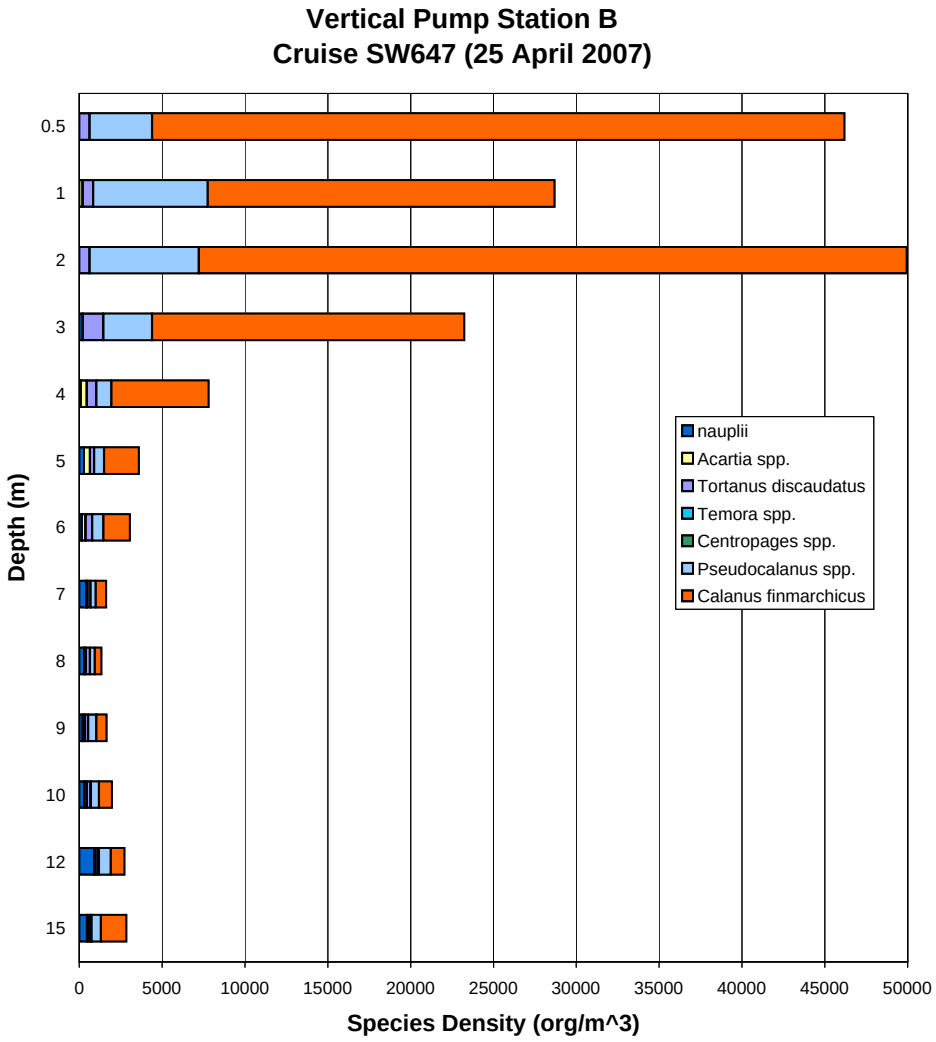
Geographic Quadrants:

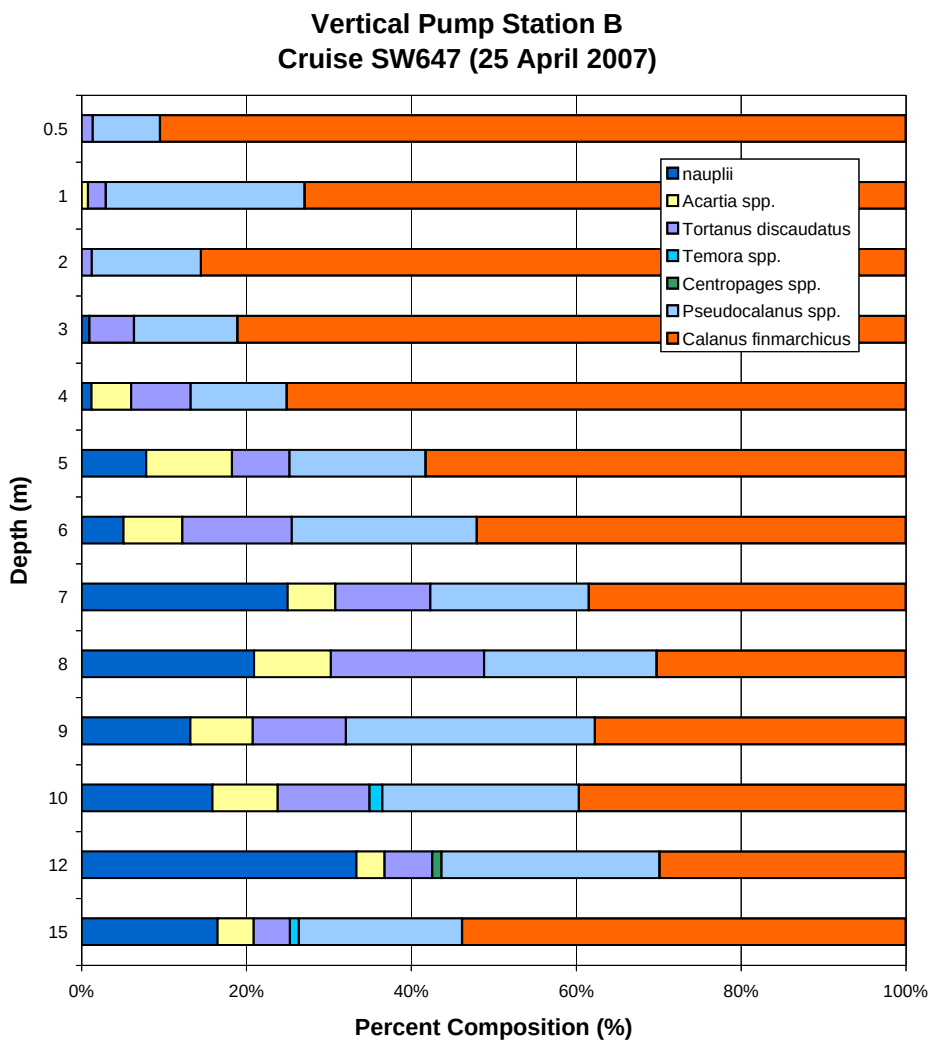


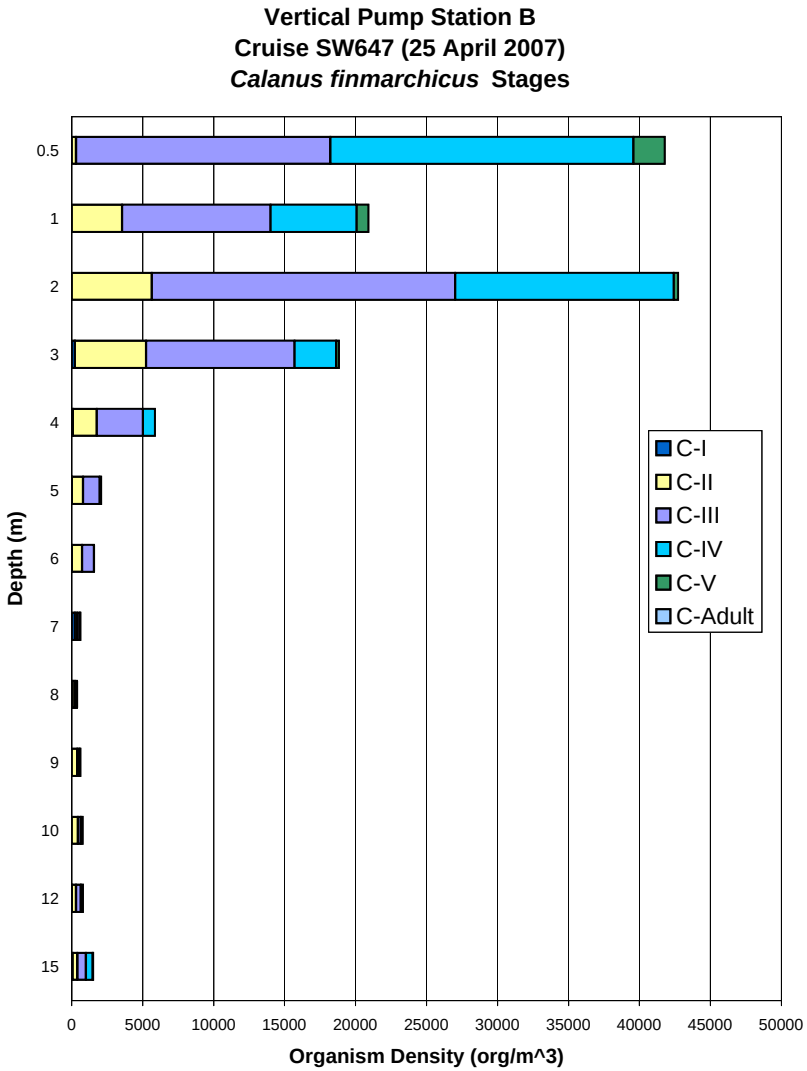


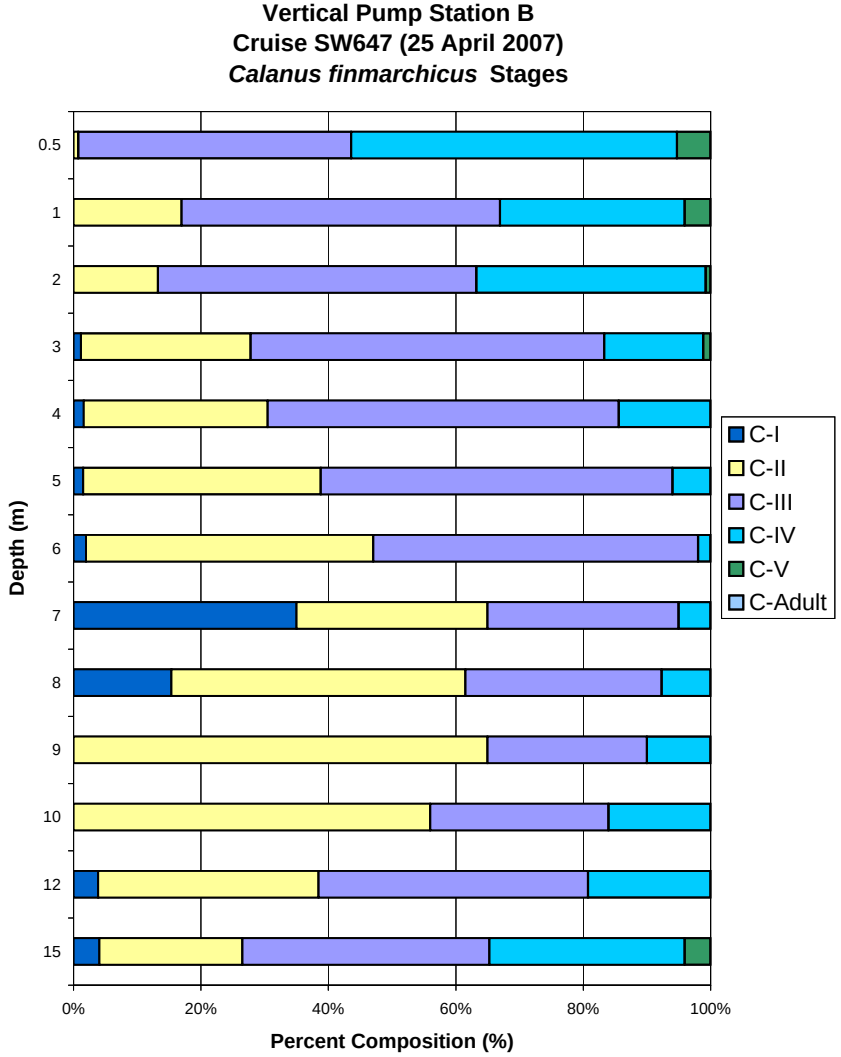





Vertical Pump Station B
Cruise SW647 (25 April 2007)
Depth (m)
0.5
1
2
3
4
5
6
7
8
9
10
12
15
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Species Density (org/m^3)
nauplii
Acartia spp.
Tortanus discaudatus
Temora spp.
Centropages spp.
Pseudocalanus spp.
Calanus finmarchicus


Vertical Pump Station B
Cruise SW647 (25 April 2007)
Depth (m)
0.5
1
2
3
4
5
6
7
8
9
10
12
15
0%
20%
40%
60%
80%
100%
Percent Composition (%)
nauplii
Acartia spp.
Tortanus discaudatus
Temora spp.
Centropages spp.
Pseudocalanus spp.
Calanus finmarchicus


Vertical Pump Station B
Cruise SW647 (25 April 2007)
Calanus finmarchicus Stages
Depth (m)
0.5
1
2
3
4
5
6
7
8
9
10
12
15
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
50000
Organism Density (org/m^3)
C-I
C-II
C-III
C-IV
C-V
C-Adult


Vertical Pump Station B
Cruise SW647 (25 April 2007)
Calanus finmarchicus Stages
Depth (m)
0.5
1
2
3
4
5
6
7
8
9
10
12
15
0%
20%
40%
60%
80%
100%
Percent Composition (%)
C-I
C-II
C-III
C-IV
C-V
C-Adult

Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW649
2 May 2007

Cruise SW649 began in light rain, calm winds, and excellent sighting conditions and ended in sunny clear weather. During the cruise all eight stations were sampled at surface and through the water column in order to assess the quality of the food resource. During the cruise one right whale was sighted in the southern-central area of the Bay; the DMF/PCCS survey team was not able to fly because of precipitation and low ceiling.

The total zooplankton resource throughout the Bay remains relatively rich, though substantially less than that observed during the previous cruise in the vicinity of high concentrations of right whales. The distribution of the controlling zooplankton community has become patchy with a strong resource signal found at station 9N at the surface in the northwest quadrant, at all depths at 9S in the southwestern quadrant, at all depths at station 6S in the southeast, and at the surface in the central part of the Bay (6M). The composition of the rich resource in the eastern stations is composed of calanoid copepods dominated by late stage *Calanus finmarchicus*, a species favored by right whales

The pattern of patchiness indicates that areas of Cape Cod Bay will remain attractive to right whales for at least 5 more days and that the greatest potential for surface feeding will be in areas of the Bay where oceanographic processes concentrate the resource. Particular management attention should be paid to the far western portion of the northwest quadrant, a location where ship traffic is common during the spring and where surface feeding may be encouraged by a strong surface resource. Additionally, high resource concentrations in the southeast and east-central part of the Bay still have the potential to cause whale aggregation and feeding.

Note: Future cruises will seek to verify the previously issued alert of a potential of vessel-strike risk in the area within 5 miles of the outer shore of Cape Cod from Long Point in Provincetown to Cape Cod Light in Truro.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

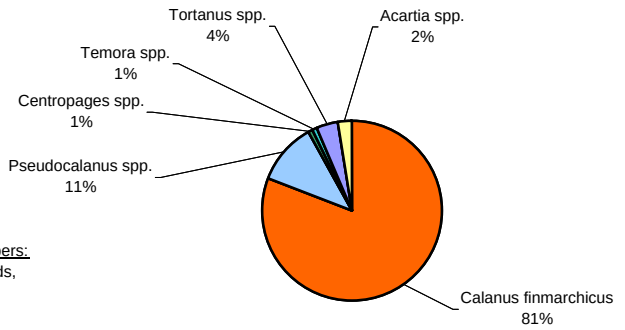
Surface Zooplankton Assessment: Cruise SW649 (2 May 2007) Julian Day 122

Recent aerial NARW sightings: 22 around Race Point on 3 May — *SW649 vessel NARW sightings: 1 right whale*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	326.57	0.24	46.94	0.0117
Surface Tow	6M	1135.51	1.26	294.62	0.0687
Surface Tow	8M	1819.96	0.61	384.71	0.1068
Surface Tow	9N	4168.08	2.79	1094.24	0.2889
Surface Tow	5S	298.68	0.36	66.83	0.0135
Surface Tow	6S	1988.54	1.83	581.91	0.1380
Surface Tow	7S	342.19	0.43	58.72	0.0144
Surface Tow	9S	1928.58	2.16	533.99	0.1364
Cruise Average:		**1501.01**	**1.21**	**382.74**	**0.10**

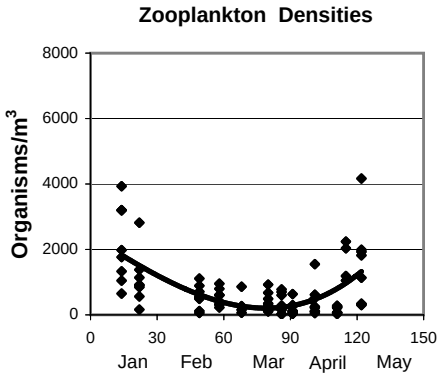
Zooplankton Species Avg. % Composition: SW649 All Stations, *Surface Tows*

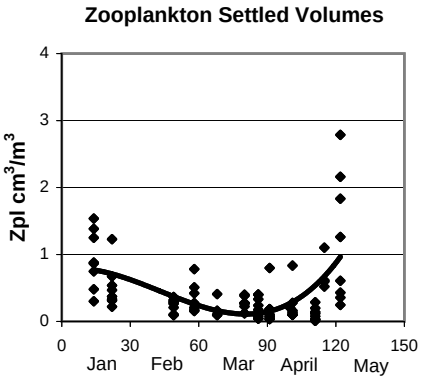


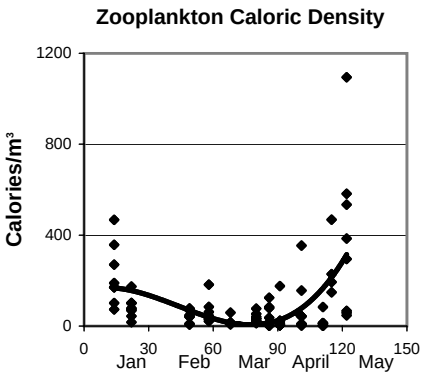
Other zooplankton present in low numbers:
Eurytemora spp., Oithona spp., cyprids, fish eggs, mysids

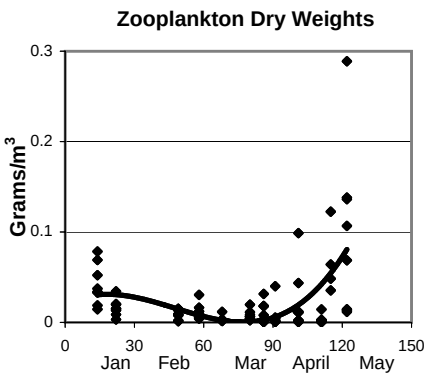
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

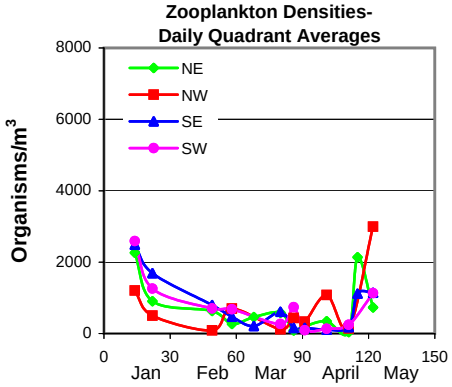


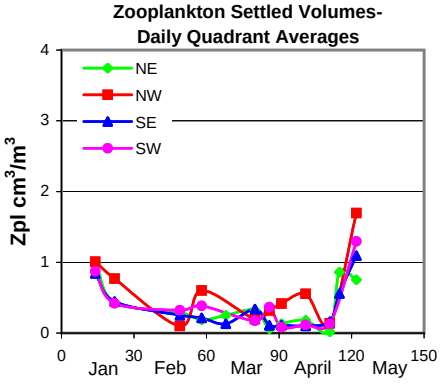


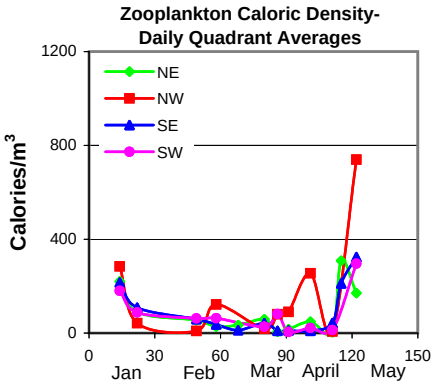


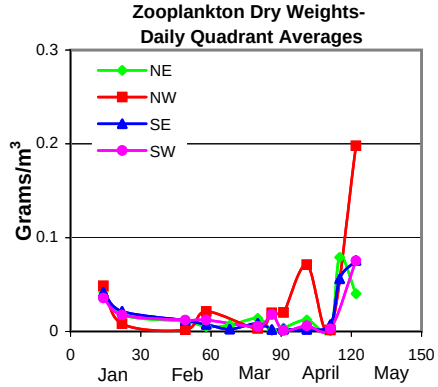


Geographic Quadrants:









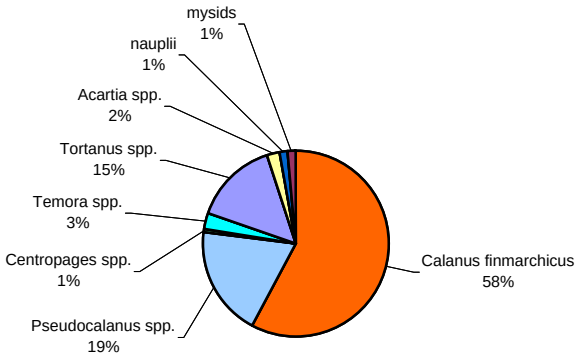
Water Column Zooplankton Assessment: Cruise SW649 (2 May 2007) Julian Day 122

Recent aerial NARW sightings: 22 around Race Point on 3 May — *SW649 vessel NARW sightings: 1 right whale*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	852.27	0.49	91.73	0.0199
Oblique Tow	6M	1795.80	1.75	302.23	0.0773
Oblique Tow	8M	1923.61	1.44	345.50	0.0858
Oblique Tow	9N	4152.69	1.83	902.23	0.2376
Oblique Tow	5S	4088.44	1.86	625.70	0.1488
Oblique Tow	6S	2212.64	2.65	466.83	0.1147
Oblique Tow	7S	5164.93	2.15	1055.84	0.2833
Oblique Tow	9S	7319.42	4.23	1590.67	0.4211
Cruise Average:		**3438.73**	**2.05**	**672.59**	**0.1735**

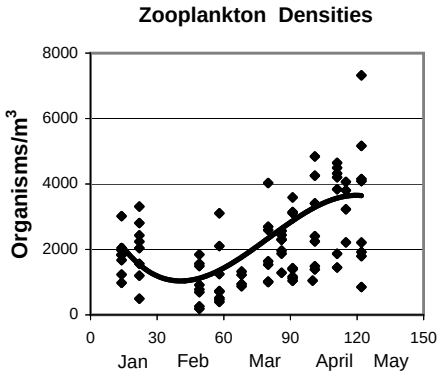
Zooplankton Species Avg. % Composition: SW649 All Stations, *Oblique Tows*

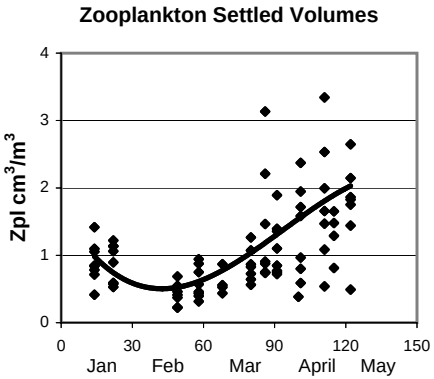


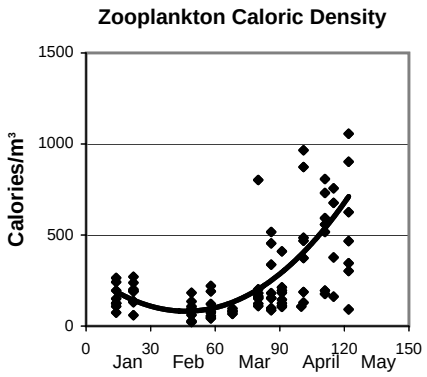
Other zooplankton present in low numbers:
Oithona spp., Metridia spp., cyprids, molluscs, fish eggs, cladocera, zoea

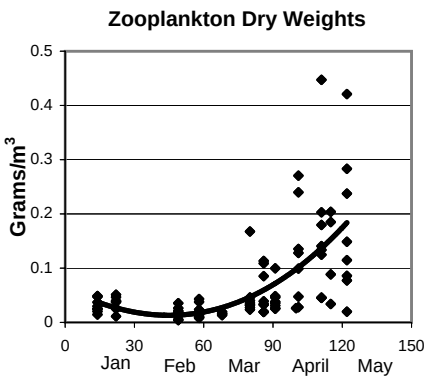
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

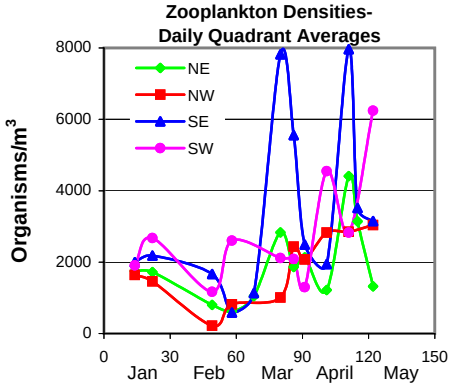


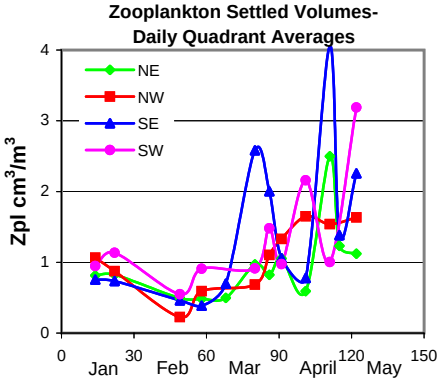


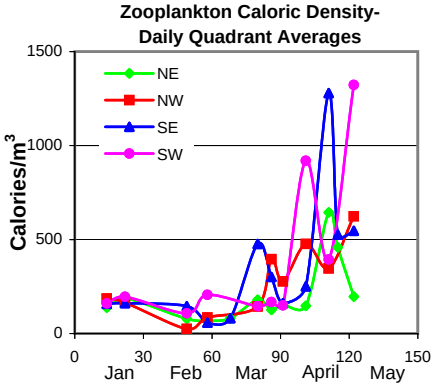


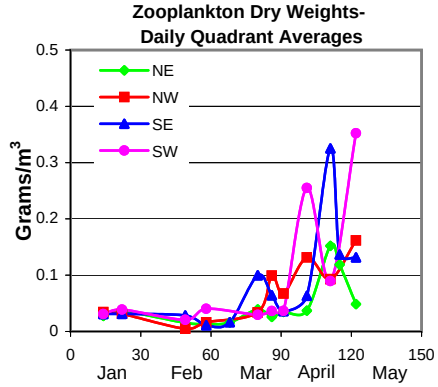


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW650
5 May 2007

With declining resources in Cape Cod Bay as documented on 2 May and an indication from the air survey that right whales have aggregated along the outer shore of Cape Cod, cruise SW650 was directed at collections to assess the quality of the food resource between Cape Cod Light and Race Point. Conditions during the cruise were excellent with calm seas and clear visibility. A total of 26-35 humpback whales, 6-8 minke whales and, 3-7 right whales and several small cetaceans were sighted. All right whales were feeding at the surface in the Race Rips and between Race Point and Peaked Hill in Provincetown. Twelve sampling stations were completed during SW650.

The zooplankton resource along the outer shore of Provincetown and Truro within 4 km of the beach was patchy and associated with strong local tidal fronts. Most of the samples collected were estimated above the right whale feeding threshold, while samples from tidal fronts being foraged by right whales were particularly rich, as much as an order of magnitude more than the threshold concentration. The composition of the resource was dominated by stage 3-4 *Calanus finmarchicus* with an important contribution from both stage 5 *Calanus* and *Pseudocalanus*.

The strength of the zooplankton resource at the entrance to Cape Cod Bay suggests that right whale aggregation and feeding in the area will persist for at least 4-5 days. Zooplankton composition and distribution continue to favor near-surface and surface feeding behavior and aggregation of whales within 5 miles of land, coincidentally an area actively used by commercial and recreational vessels. Therefore, the previous alert for a risk of vessel collision continues. **Mariners using the near shore area from Cape Cod Light (Highland Light) west to and including the area around Race Point should exercise considerable caution because the behavior of the right whales places both whales and fast moving vessels at high risk of catastrophic collision.**

Movement of significant numbers of right whales into Cape Cod Bay, where resource assessment over the past week suggests a habitat of modest attractiveness continues to be possible. However, continued aggregation along the strong frontal areas at the margin of the Bay, as delineated, will be favored for the 4-5 day period. We anticipate a decline in the zooplankton resources in areas of strong tidal flux after that time.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW651
8 May 2007

Cruise SW651 was started in windy weather with the likelihood that conditions would prevent a full survey of Cape Cod Bay. With an unforecast decrease in the wind during the morning, zooplankton samples were collected from the surface and the water column at 6 stations in the eastern and southern Bay and at 4 special stations in areas where right whales had been observed by a DMF groundfish survey vessel near Barnstable Harbor. The DMF/PCCS survey aircraft did not fly because of high winds.

In the areas surveyed, the zooplankton resource was preliminarily assessed as patchy with a strong resource restricted to an area along the southern margin of Cape Cod Bay. Particularly notable were collections where right whales had been reported, a location where surface zooplankton density appeared to be many times the predicted feeding threshold. In addition to this location in the far southern margin of the Bay, modestly rich samples at or near threshold were collected at station 5S, in the southern part of the southeast quadrant.

The resource in areas of high zooplankton density, along the southern part of the Bay, continues to be dominated by mid-stages of *Calanus finmarchicus* (S3 and S4). Stage 5 copepodites of *Calanus*, particularly attractive to right whales, remain a minor component of the zooplankton community at all depths.

The scattered distribution of rich patches of calanoid copepods suggests that Cape Cod Bay remains moderately attractive to right whales. Nevertheless, because of the locally rich patches we predict that occasional aggregation and feeding by right whales will occur, particularly in the southern quadrants of the Bay for the next week. However, because the zooplankton is patchy throughout the area, movement of whales and aggregation is possible anywhere in the eastern quadrants of the bay. We anticipate that during the next week the density of right whales will decline from those observed in recent air surveys, as individual whales lose contact with the patchy resource. Should the area of rich resource drift west toward the east entrance of the Cape Cod Canal, concern for increased risk of vessel strike will be warranted; presently such movement is not anticipated.

With improved sea conditions over the next week we will be reassessing the quality of the controlling zooplankton resource along the eastern outer shore of Cape Cod and in the western margin of the Bay in order to update previous vessel strike alerts.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

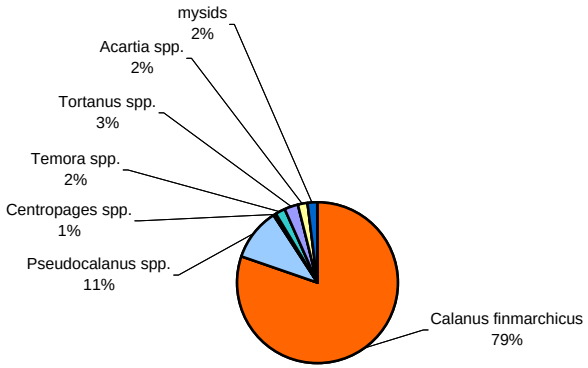
Surface Zooplankton Assessment: Cruise SW651 (8 May 2007) Julian Day 128

Recent aerial NARW sightings: 8 whales on 07 May

SW651 vessel NARW sightings: no right whales

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	721.77	0.45	89.24	0.0221
Surface Tow	6M	2485.00	1.70	591.57	0.1563
Surface Tow	5S	3203.69	2.33	705.59	0.1923
Surface Tow	6S	7167.07	4.98	1671.62	0.4576
Surface Tow	7S	1463.21	1.13	346.60	0.0979
Surface Tow	8SX	4480.71	2.83	1001.28	0.2842
Surface Tow	9S	3023.35	2.48	714.42	0.2001
Cruise Average:		**3220.69**	**2.27**	**731.48**	**0.2015**
Special Stations: (auxiliary surface tows)					
	A	691.22	0.33	54.53	0.0110
	B	17029.89	15.33	5139.10	1.2751
	C	3651.39	3.30	883.64	0.2411

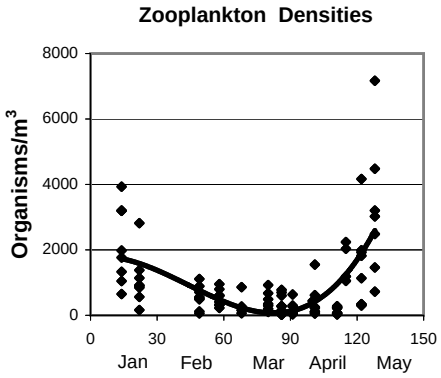
Zooplankton Species Avg. % Composition: SW651 Regular Stations, *Surface Tows*

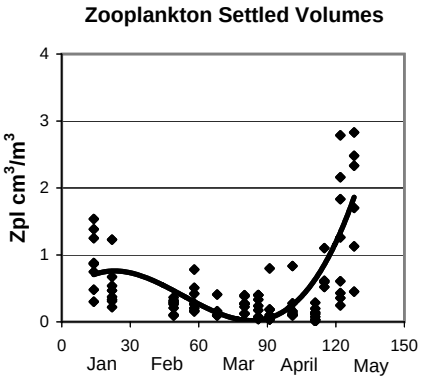


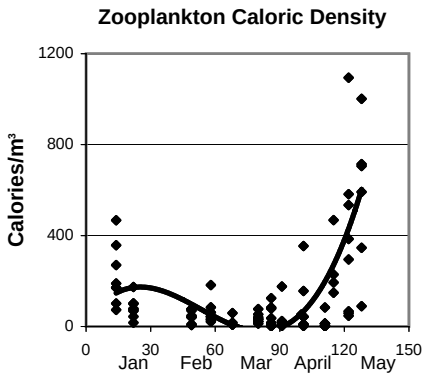
Other zooplankton present in low numbers:
Eurytemora spp., Metridia spp., nauplii, fish larvae, cyprids, fish eggs

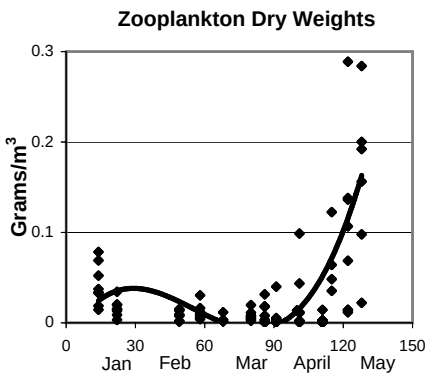
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

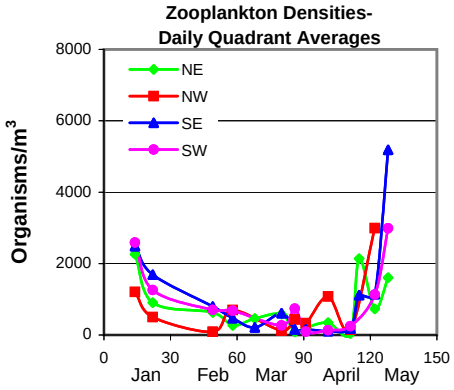


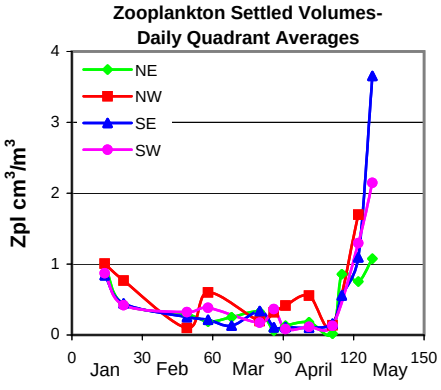


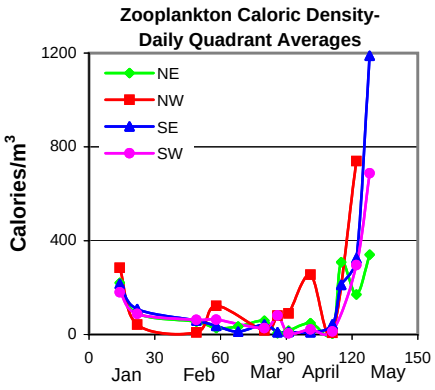


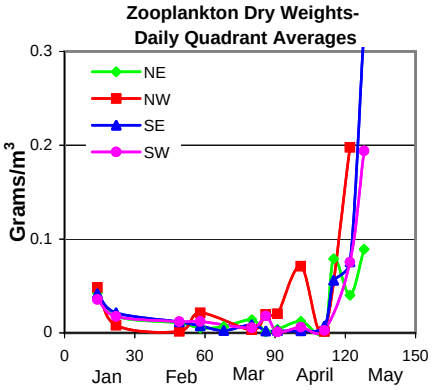


Geographic Quadrants:







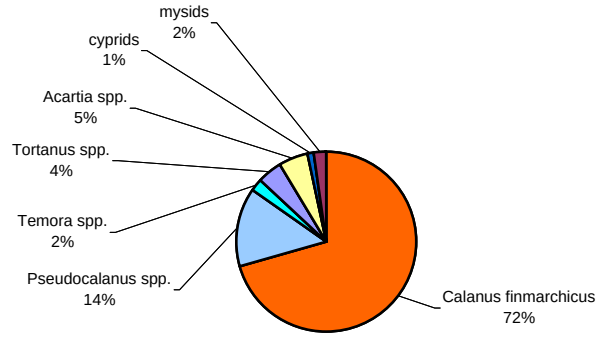


Water Column Zooplankton Assessment: Cruise SW651 (8 May 2007) Julian Day 128

Recent aerial NARW sightings: 8 whales on 07 May — *SW651 vessel NARW sightings: no right whales*

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	1017.17	0.70	98.45	0.0247
Oblique Tow	6M	7909.93	4.03	1458.34	0.4036
Oblique Tow	5S	2646.86	1.39	348.99	0.0951
Oblique Tow	6S	9145.77	3.47	1334.21	0.3677
Oblique Tow	7S	8155.87	3.73	1705.02	0.4653
Oblique Tow	8SX	7547.19	3.16	1364.00	0.3771
Oblique Tow	9S	7493.03	3.42	1470.11	0.4104
Cruise Average:		**6273.69**	**2.84**	**1111.30**	**0.3063**
Special Stations: (auxiliary oblique tows)					
	A	1277.93	0.77	148.91	0.0313
	B	9404.00	8.18	2071.63	0.5515
	C	10454.45	5.78	2139.79	0.5883

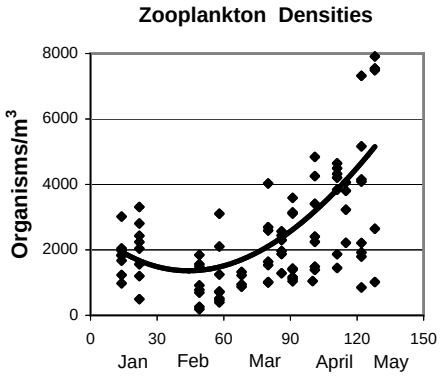
Zooplankton Species Avg. % Composition: SW651 All Stations, *Oblique Tows*

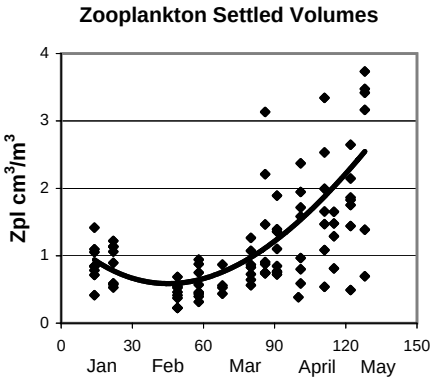


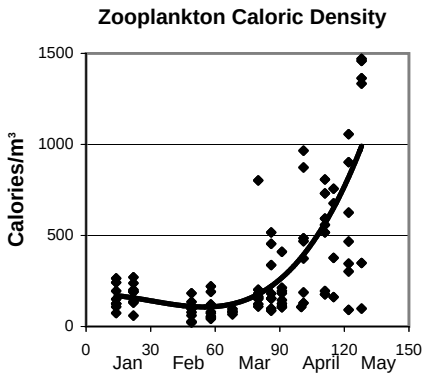
Other zooplankton present in low numbers:
Centropages spp., Oithona spp., Metridia spp., nauplii, molluscs, fish eggs, cladocera, polychaetes, zoea

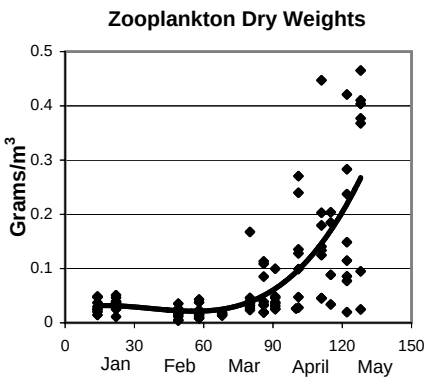
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

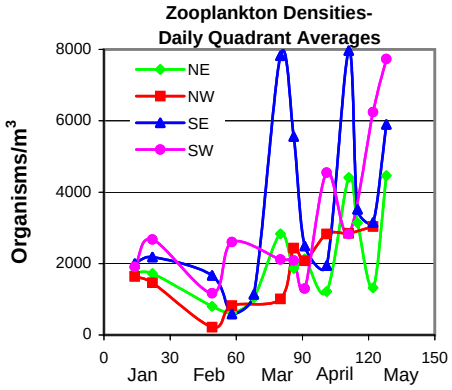


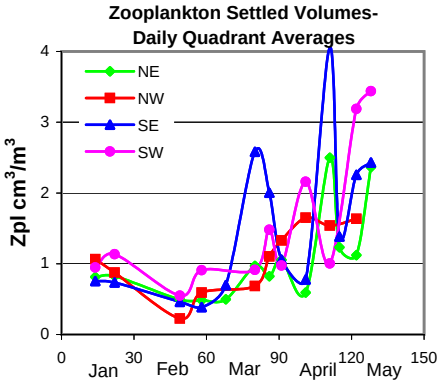


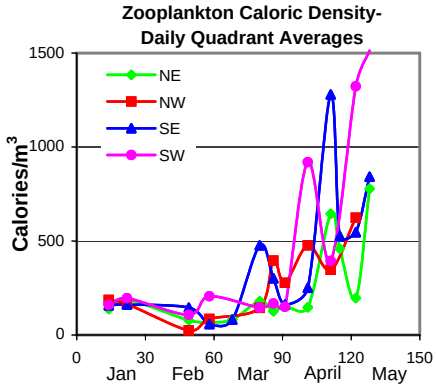


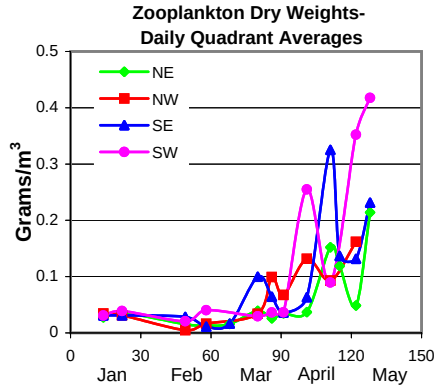


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: IB 083
11 May 2007

Cruise IB083, aboard R/V *Ibis* during a disentanglement training, was used to opportunistically collect zooplankton samples in order to assess the potential for vessel collision in the area of the outer shore of Provincetown and Truro, the subject of recent alerts and advisories. Visibility during the morning was hampered by areas of dense fog with southwest winds below 15 knots. During the cruise three fin whales were sighted close to the current fronts along the shore where sampling stations were located. Six zooplankton samples were collected during the cruise and preliminarily evaluated in order to forecast the potential for entanglement and ship strike.

The food resource at surface in the vicinity of the tidal front within 2 km. of land is dominated by *Calanus finmarchicus*, principally oil-rich stage 4 copepodites. Both stage 3 and 5 *Calanus* were also identified in the samples, along with smaller taxa of calanoids including the genera *Acartia* and *Pseudocalanus.* Generally, the taxonomic composition of the zooplankton resource remains similar to that reported from the Cape Cod Bay assessment cruise SW651 and is judged to be acceptable for right whale feeding.

The density of zooplankton along the outer shore has declined from the high levels reported from cruise SW650 on 5 May, densities that triggered the alert of potential vessel collision on that day. The resource at the surface, however, remains patchy and at or near the feeding threshold for right whales, much as it was as reported from SW651 on 8 May in eastern and southern Cape Cod Bay. It appears therefore that the eastern quadrants of the bay and the outer shore as far east as Truro will remain moderately attractive to whales in the area; however conditions do not favor significant aggregation, surface feeding, or residency by right whales. It remains likely that occasional feeding will be seen in locations throughout eastern Cape Cod Bay and along the outer near-shore region for at least 3-5 days.

In view of the declining resource, the increased patchiness of the zooplankton and the declining number of right whales reported during the last DMF/PCCS aircraft survey, the risk of vessel collision or entanglement in fishing gear has declined. Therefore: **The alert for elevated risk of vessel strike and entanglement in the area of the north end of Cape Cod Bay and paralleling the outer shore of Provincetown and Truro is no longer appropriate.** With the occasionally-attractive patches of oil-rich taxa of calanoid copepods lingering in the eastern bay and along the outer shore, mariners in the area of the previous alert should remain on the lookout for near-surface feeding right whales that may continue to pose a risk of vessel collision.

The next cruises will be directed at verification of the declining attractiveness of Cape Cod Bay and on assessment of the offshore resources now influencing the movement and behavior of the right whales.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

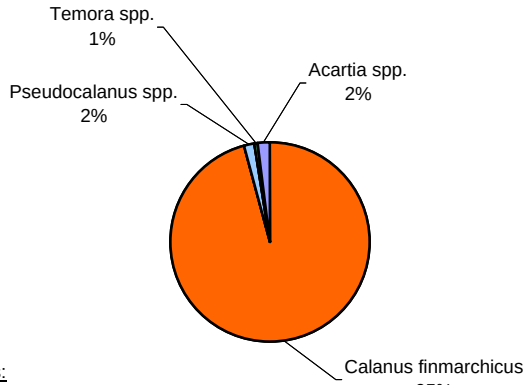
Surface Zooplankton Assessment: Cruise IB083 (11 May 2007) Julian Day 131

Recent aerial NARW sightings: 2 whales on 09 May — *IB083 vessel NARW sightings: no right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	A	975.28	0.82	240.31	0.0648
Surface Tow	B	811.07	0.59	197.92	0.0551
Surface Tow	C	3160.18	2.11	787.87	0.2231
Surface Tow	D	1320.69	1.42	335.52	0.0929
Cruise Average:		**1566.80**	**1.23**	**390.40**	**0.1090**

Zooplankton Species Avg. % Composition: IB083 *Surface Tows*



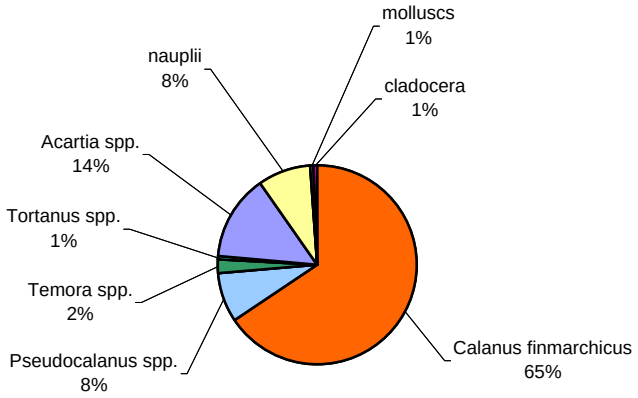
Other zooplankton present in low numbers:
Centropages spp., Tortanus discaudatus, Oithona spp., Metridia spp., nauplii, cyprids, fish eggs, mysids

Water Column Zooplankton Assessment: Cruise IB083

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	A	3780.25	0.00	731.22	0.2049
Surface Tow	C	3683.60	0.00	618.80	0.1705
Cruise Average:		**3731.92**	**0.00**	**675.01**	**0.1877**

Zooplankton Species Avg. % Composition: IB083 *Oblique Tows*



Other zooplankton present in low numbers:
cyprids

Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW652
14 May 2007

Cruise SW652 was carried out in clear, warm conditions with light to moderate winds and a goal of assessing the distribution and quality of the zooplankton resources that have been influencing a small number of right whales remaining in the Bay. All eight assessment stations were visited and samples from the water column and surface were collected at each. Excellent sighting conditions prevailed throughout the day, however no right whales were sighted from either the DMF/PCCS aircraft or from the vessel.

The regional enrichment of the Cape Cod Bay system continues to be moderately attractive to right whales in localized areas, particularly in the northwest quadrant at the surface and at the surface and in the water column in the northeast and north-central Bay. It appears that the strong regional enrichment of the Bay system, while declining from that typical of late winter and early spring condition, remains patchy and of fair quality. The zooplankton continues to be dominated by *Calanus finmarchicus*, with stage 3 and stage 4 the most common copepodites. In the northwestern portion of the northwest quadrant (station 9N) and in the northeast (stations 5N and 6M) these later stages were particularly abundant; the greatest concentrations of zooplankters, exceeding the right whale threshold for feeding, were found at the surface in these northern quadrants. Surface feeding is likely if right whales are present in these areas.

For the next several days to a week the northern half of Cape Cod Bay will be attractive to right whales and will remain so as long as localized zooplankton patch densities remain high. Earlier in the spring such conditions would be considered particularly attractive to aggregation and feeding by right whales; however, the patchiness of the zooplankton in the Bay and the strong attraction from resources likely developing east of Cape Cod suggests that aggregation of whales will be minimal and ephemeral unless an increase in the extent and quality of the resource is seen in the near future.

The next assessment cruises will be directed again at sampling the northern Bay and the region east of Cape Cod in order to determine the attractiveness of areas of "competing" resources in coastal waters.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

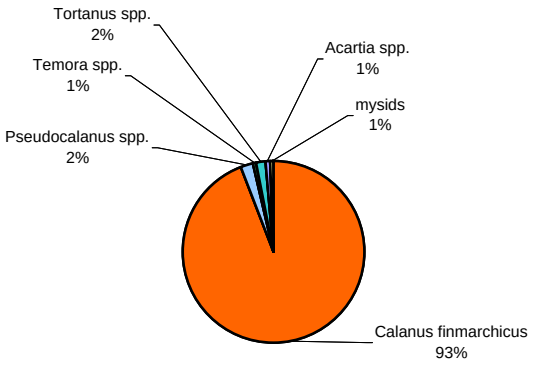
Surface Zooplankton Assessment: Cruise SW652 (14 May 2007) Julian Day 134

Recent aerial NARW sightings: no whales on 14 May — *SW652 vessel NARW sightings: no right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	6481.02	3.93	1816.89	0.4756
Surface Tow	6M	5647.23	5.24	1319.83	0.3722
Surface Tow	8M	3046.68	2.74	773.79	0.2179
Surface Tow	9N	5004.83	4.52	1468.02	0.3796
Surface Tow	5S	358.36	0.42	63.78	0.0178
Surface Tow	6S	2853.18	2.53	732.48	0.2052
Surface Tow	7S	4095.97	3.88	975.83	0.2724
Surface Tow	9S	438.14	0.41	89.91	0.0235
Cruise Average:		**3490.67**	**2.96**	**905.07**	**0.2455**
Previous Cruise Average:		3220.69	2.27	731.48	0.2015

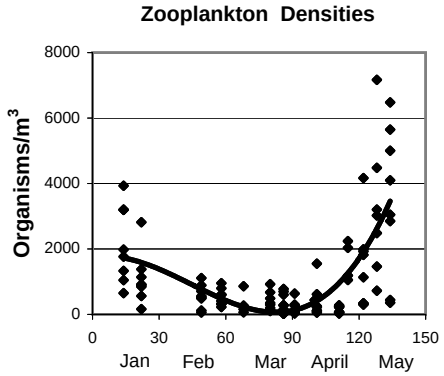
Zooplankton Species Avg. % Composition: SW652 All Stations, *Surface Tows*

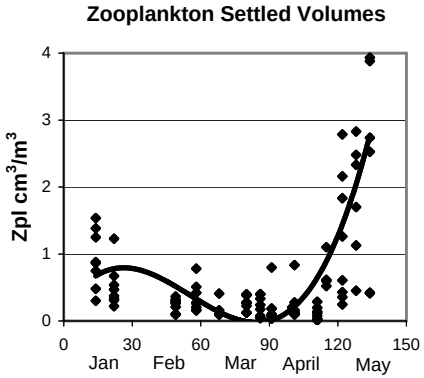


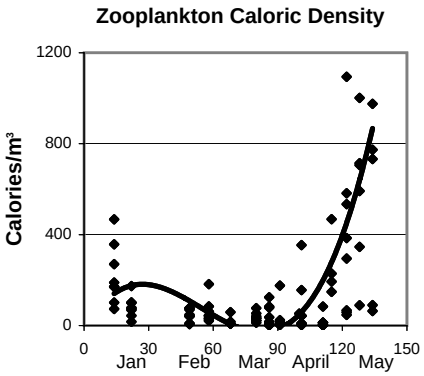
Other zooplankton present in low numbers:
Centropages spp., cyprids, fish eggs, cladocera, zoea, mysids

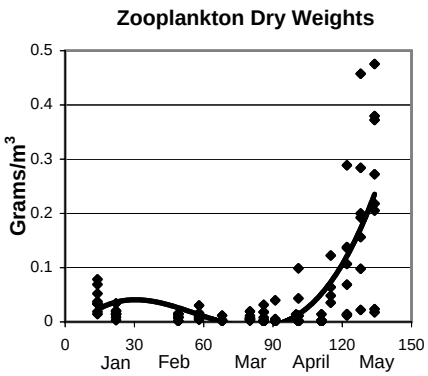
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

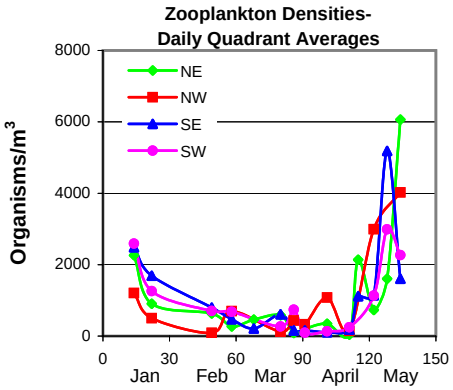


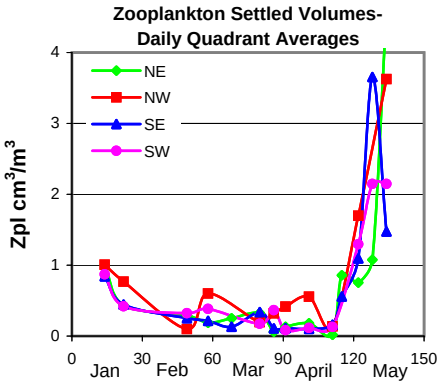


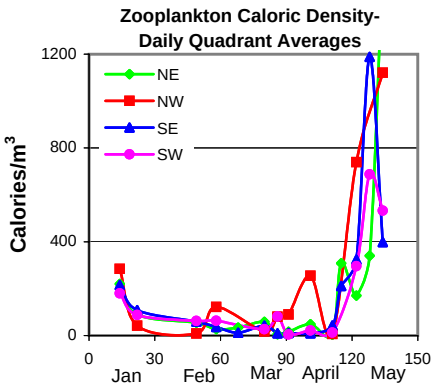


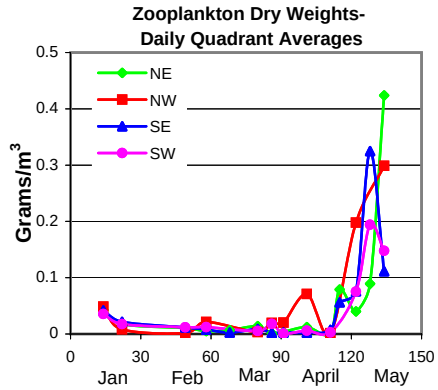


Geographic Quadrants:









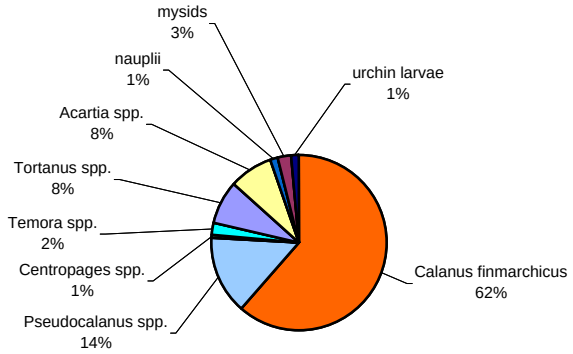
Water Column Zooplankton Assessment: Cruise SW652 (14 May 2007) Julian Day 134

Recent aerial NARW sightings: no whales on 14 May — *SW652 vessel NARW sightings: no right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	6594.74	3.01	1329.98	0.3607
Oblique Tow	6M	4250.47	2.85	792.15	0.2033
Oblique Tow	8M	3704.95	2.29	759.45	0.2058
Oblique Tow	9N	9123.64	5.97	1886.83	0.5250
Oblique Tow	5S	1114.86	0.89	165.57	0.0462
Oblique Tow	6S	2992.24	1.35	417.25	0.1082
Oblique Tow	7S	3734.53	2.06	572.48	0.1437
Oblique Tow	9S	5288.65	2.67	871.35	0.2378
Cruise Average:		**4600.51**	**2.64**	**849.38**	**0.2288**
Previous Cruise Average:		6273.69	2.84	1111.30	0.3063

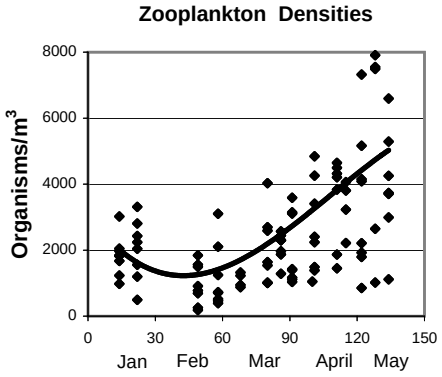
Zooplankton Species Avg. % Composition: SW652 All Stations, *Oblique Tows*

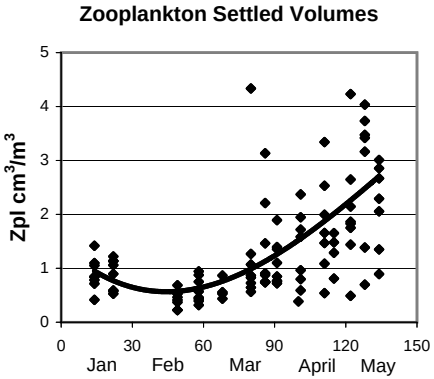


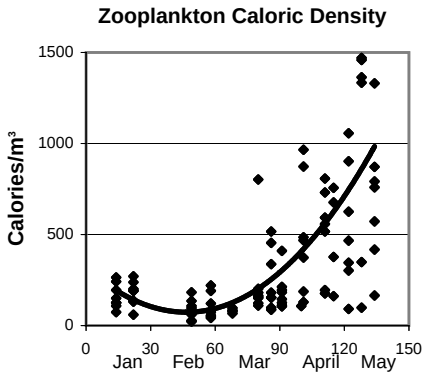
Other zooplankton present in low numbers:
Oithona spp., Metridia spp., cyprids, molluscs, cladocera, zoea

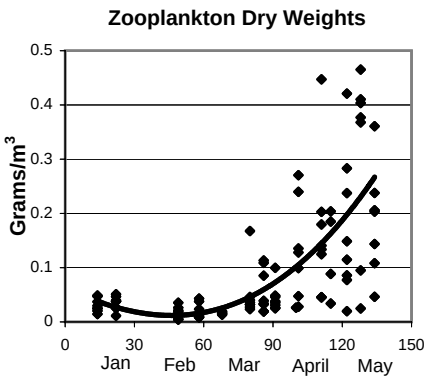
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

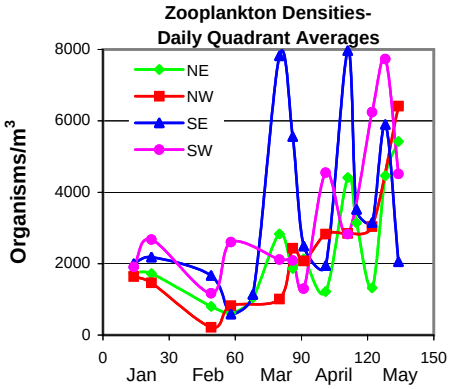


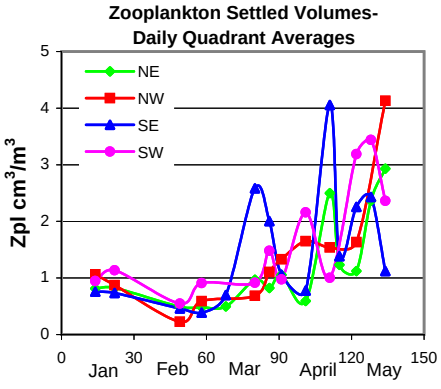


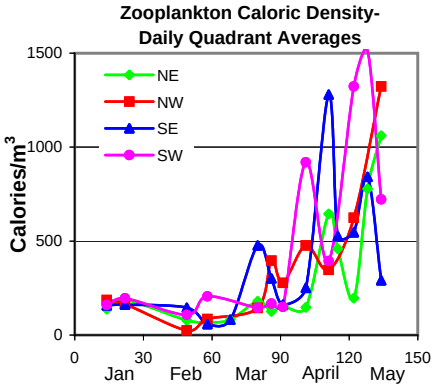


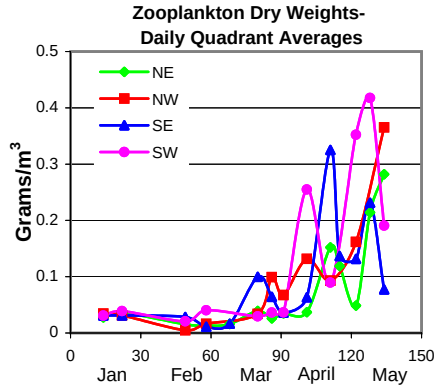


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: SW652
14 May 2007

Cruise SW652 was carried out in clear, warm conditions with light to moderate winds and a goal of assessing the distribution and quality of the zooplankton resources that have been influencing a small number of right whales remaining in the Bay. All eight assessment stations were visited and samples from the water column and surface were collected at each. Excellent sighting conditions prevailed throughout the day, however no right whales were sighted from either the DMF/PCCS aircraft or from the vessel.

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The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

Surface Zooplankton Assessment: Cruise SW652 (14 May 2007) Julian Day 134

Recent aerial NARW sightings: no whales on 14 May — *SW652 vessel NARW sightings: no right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	6481.02	3.93	1816.89	0.4756
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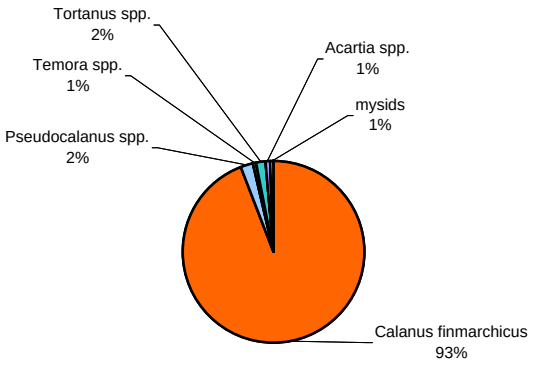
Zooplankton Species Avg. % Composition: SW652 All Stations, *Surface Tows*



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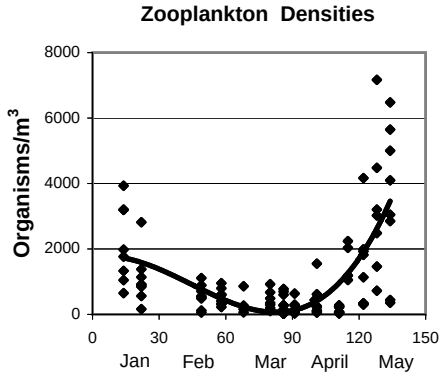
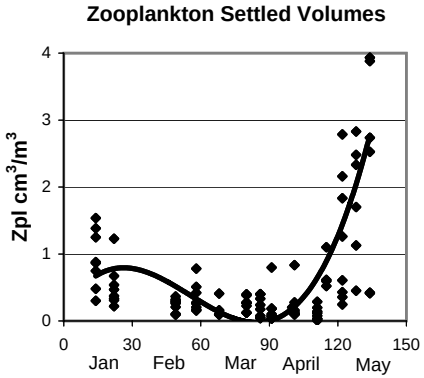
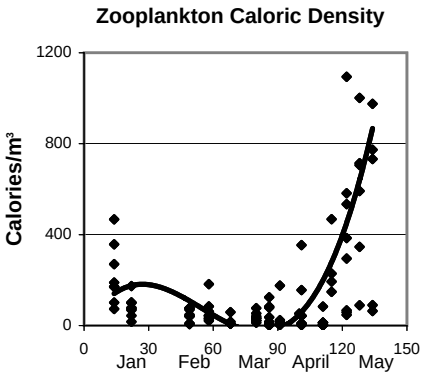
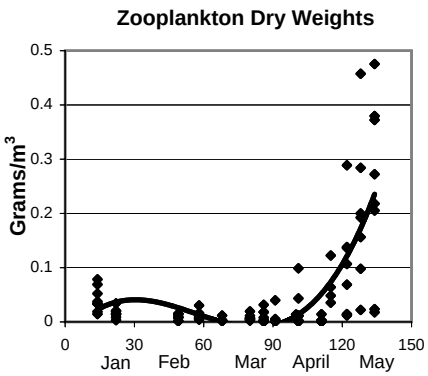
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

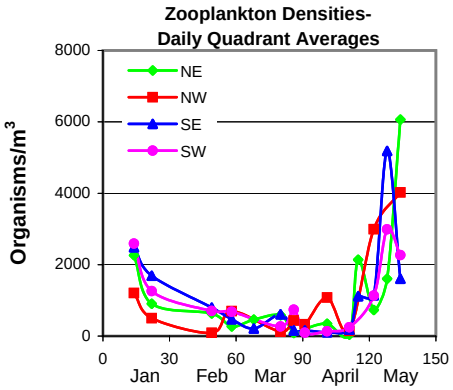


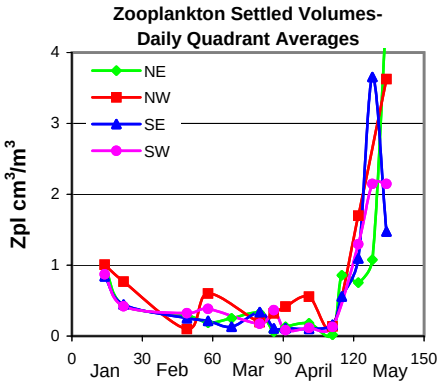


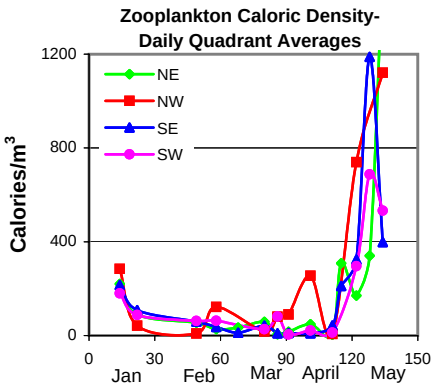


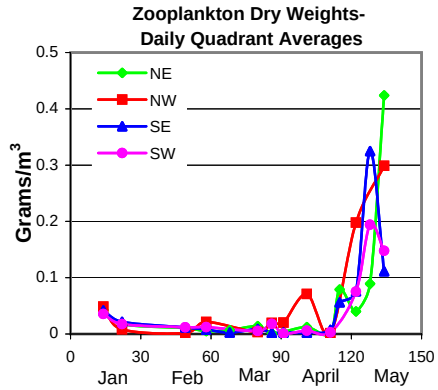


Geographic Quadrants:









Water Column Zooplankton Assessment: Cruise SW652 (14 May 2007) Julian Day 134

Recent aerial NARW sightings: no whales on 14 May — *SW652 vessel NARW sightings: no right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	6594.74	3.01	1329.98	0.3607
Oblique Tow	6M	4250.47	2.85	792.15	0.2033
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Oblique Tow	9N	9123.64	5.97	1886.83	0.5250
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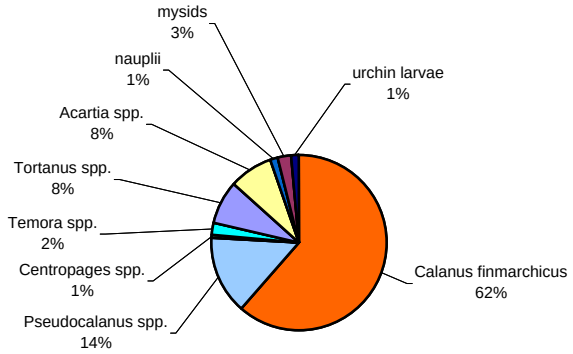
Oblique Tow	7S	3734.53	2.06	572.48	0.1437
Oblique Tow	9S	5288.65	2.67	871.35	0.2378
Cruise Average:		**4600.51**	**2.64**	**849.38**	**0.2288**
Previous Cruise Average:		6273.69	2.84	1111.30	0.3063

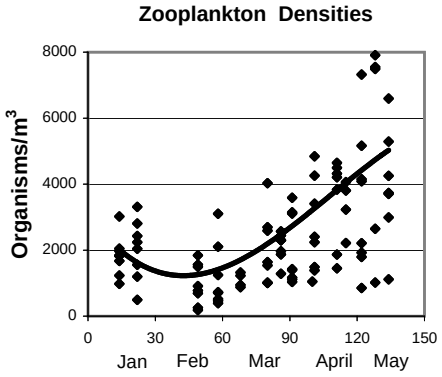
Zooplankton Species Avg. % Composition: SW652 All Stations, *Oblique Tows*

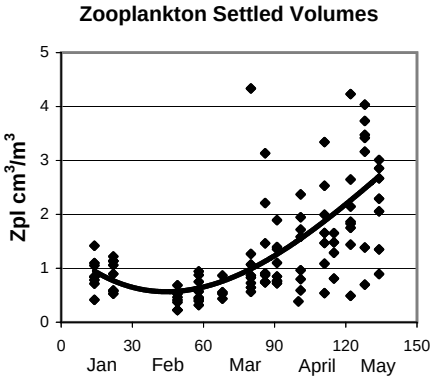


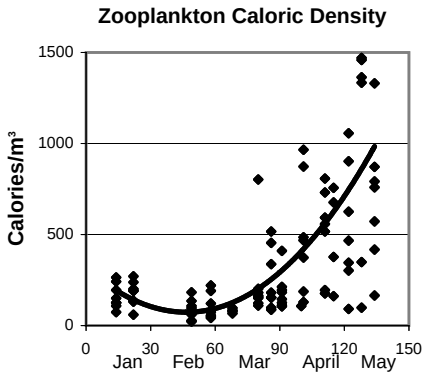
Other zooplankton present in low numbers:
Oithona spp., Metridia spp., cyprids, molluscs, cladocera, zoea

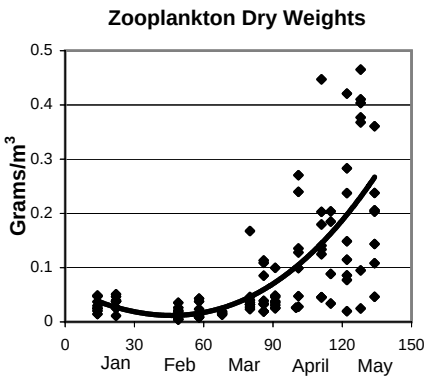
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

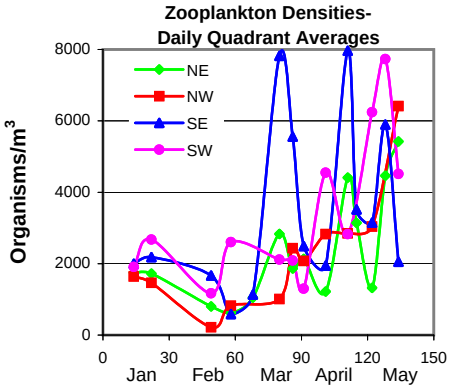


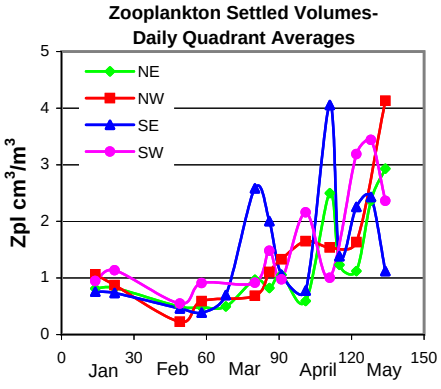


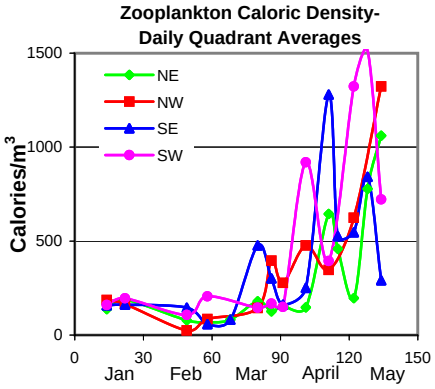


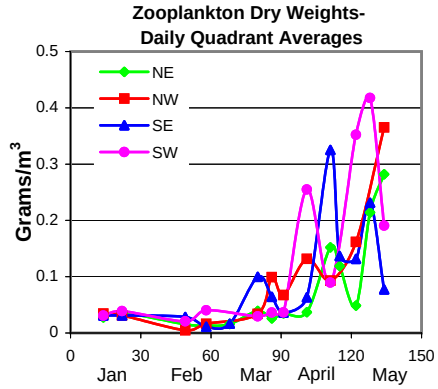


Geographic Quadrants:









Cape Cod Bay Right Whale Habitat
Preliminary Assessment Report: Cruise SW653
23 May 2007

Cruise SW653 started in cloudy conditions with a moderate southwest wind and ended in rough seas, freshening wind, and a partly cloudy sky; the sighting conditions were excellent and no right whales were sighted. Focusing on assessing the previously patchy zooplankton resource, all eight assessment stations were visited and samples from the water column and surface were collected. No aircraft observations were available because the regular DMF/PCCS aircraft survey has ended for the season.

The localized enrichment of the zooplankton in Cape Cod Bay continues at all depths in the vicinity of stations 5S and, to a lesser degree, at station 7S. At these stations *Calanus finmarchicus* stages 3-5 were dominant. Zooplankton resources at the remaining stations throughout the bay are fair to poor and unacceptable for right whale aggregation and feeding. The strong local zooplankton resource in the southeastern and southern-central portions of Cape Cod Bay could lead to aggregation and surface feeding by right whales that may enter Cape Cod Bay. If the regions east of Cape Cod that have historically provided rich zooplankton resources during the mid-spring again attract aggregations of right whales it is unlikely that whales will aggregate in significant numbers Cape Cod Bay. Conversely, short-term residency and feeding by right whales in the southern portions of the bay are likely should the controlling zooplankton resource in the area of the Provincetown Slope and the north end of the Great South Channel not develop.

These observations are considered preliminary pending detailed analysis and final assessment reporting.

The assessment and prediction reports are a product of the Right Whale Surveillance Program at the Provincetown Center for Coastal Studies – a management study supported by the Division of Marine Fisheries of the Commonwealth of Massachusetts and funded by the National Marine Fisheries Service, NOAA, Department of Commerce. (study conducted under NMFS research permit #633-1483-06)

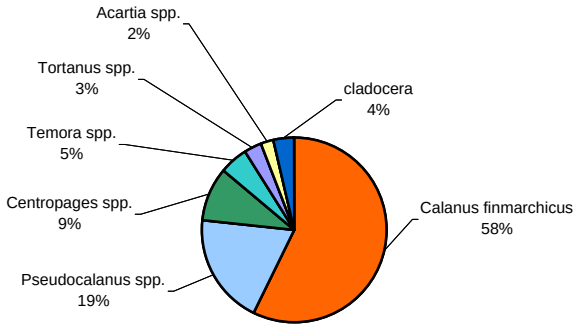
Surface Zooplankton Assessment: Cruise SW653 (23 May 2007) Julian Day 143

Recent aerial NARW sightings: no whales on 14 May — *SW653 vessel NARW sightings: no right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Surface Tow	5N	1673.31	n/a	196.86	0.0437
Surface Tow	6M	1059.92	n/a	199.07	0.0510
Surface Tow	8M	505.86	n/a	44.57	0.0110
Surface Tow	9N	776.37	n/a	127.30	0.0321
Surface Tow	5S	10720.76	n/a	2222.99	0.5842
Surface Tow	6S	796.21	n/a	96.30	0.0239
Surface Tow	7S	2952.16	n/a	523.68	0.1390
Surface Tow	9S	1458.57	n/a	287.18	0.0791
Cruise Average:		**2492.89**	**n/a**	**462.24**	**0.1205**
Previous Cruise Average:		3490.67	2.96	905.07	0.2455

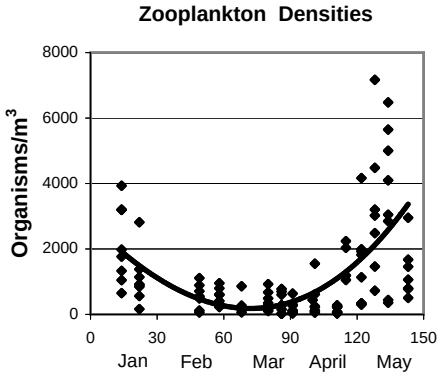
Zooplankton Species Avg. % Composition: SW653 All Stations, *Surface Tows*

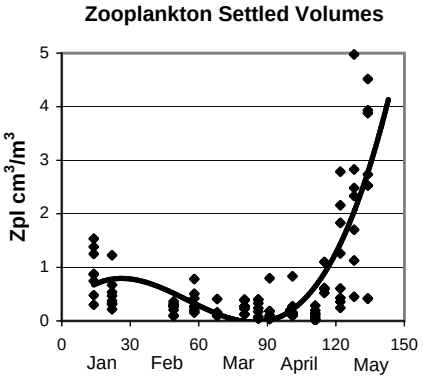


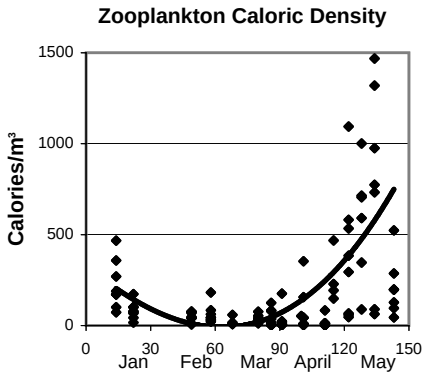
Other zooplankton present in low numbers:
Eurytemora spp., Oithona spp., Metridia spp., fish larvae, cyprids, chaetognaths, fish eggs, zoea, mysids

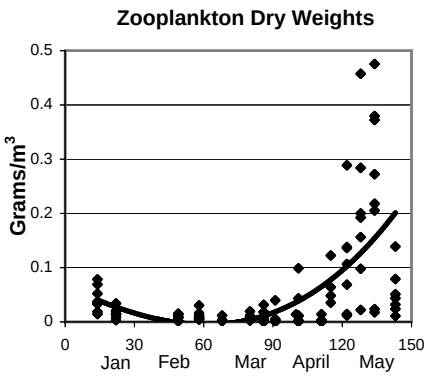
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:

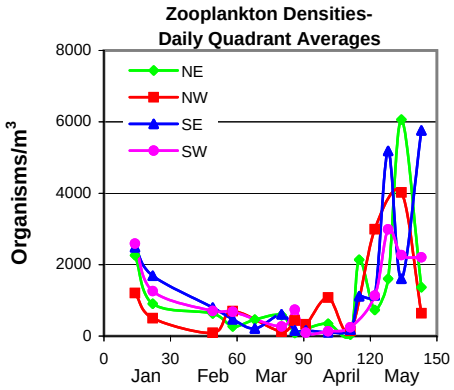


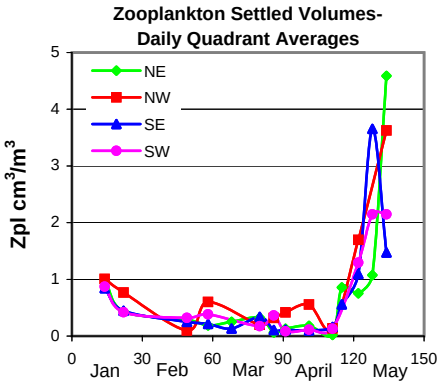


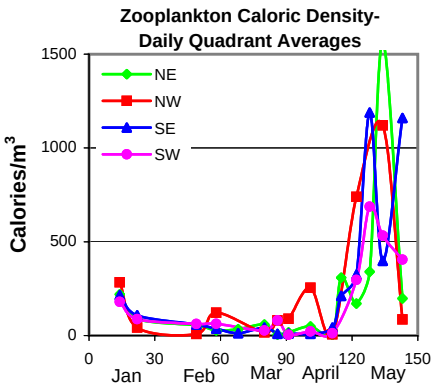


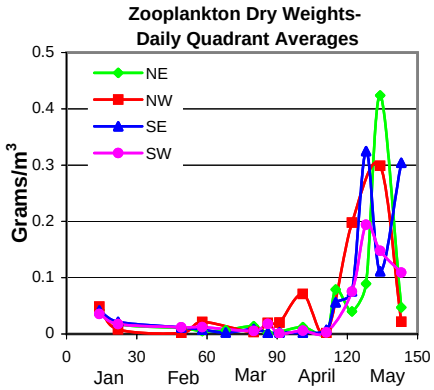


Geographic Quadrants:









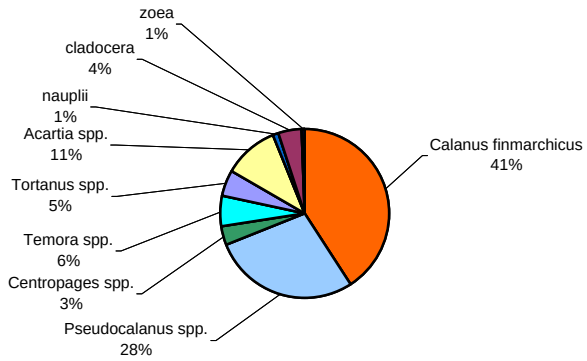
Water Column Zooplankton Assessment: Cruise SW653 (23 May 2007) Julian Day 143

Recent aerial NARW sightings: no whales on 14 May — *SW653 vessel NARW sightings: no right whales*

MEASURES:

Technique	Station	Total Zpl/m^3	Settled Vol/m^3	Total Calories/m^3	Total Dry Wt./m^3
Oblique Tow	5N	2845.36	n/a	194.75	0.0447
Oblique Tow	6M	4461.35	n/a	936.33	0.2507
Oblique Tow	8M	2514.43	n/a	274.95	0.0633
Oblique Tow	9N	2057.73	n/a	245.98	0.0622
Oblique Tow	5S	13774.28	n/a	2415.24	0.6382
Oblique Tow	6S	2716.79	n/a	325.27	0.0848
Oblique Tow	7S	5886.78	n/a	610.81	0.1531
Oblique Tow	9S	3236.13	n/a	428.51	0.1092
Cruise Average:		**4686.61**	**n/a**	**678.98**	**0.1758**
Previous Cruise Average:		4600.51	2.64	849.38	0.2288

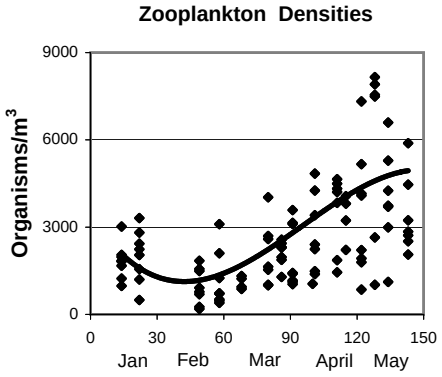
Zooplankton Species Avg. % Composition: SW653 All Stations, *Oblique Tows*

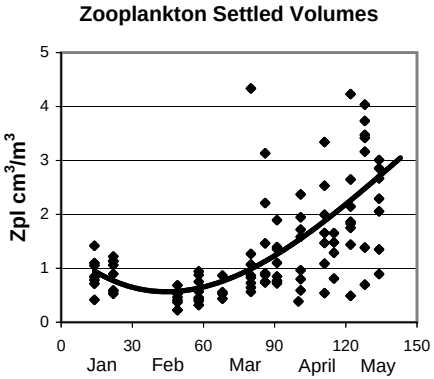


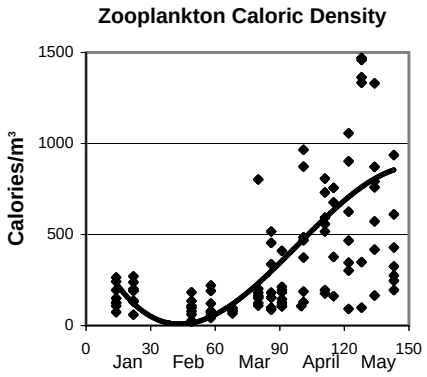
Other zooplankton present in low numbers:
Centropages spp., Oithona spp., Metridia spp., nauplii, molluscs, fish eggs, cladocera, polychaetes, zoea

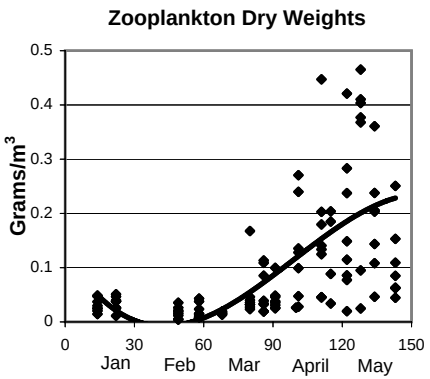
2007 SEASONAL TRENDS: x-axis values are expressed as Julian days in all graphs

Entire Cape Cod Bay:









Geographic Quadrants: