Seasonal Flux and Assemblage Composition of Planktic Foraminifera from the Northern Gulf of Mexico, 2008–2010

By Jessica W. Spear, Caitlin E. Reynolds, and Richard Z. Poore

Open File Report 2011–1215

U.S. Department of the Interior
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Suggested, citation:
Spear, J.W, Reynolds, C.E.., and Poore, R.Z., 2011, Seasonal flux and assemblage composition of planktic foraminifera from the northern Gulf of Mexico, 2008 - 2010: U.S. Geological Survey Open-File Report 2011-1215, 19 p.

Contents

Figures

Tables

Seasonal Flux and Assemblage Composition of Planktic Foraminifera from the Northern Gulf of Mexico, 2008–2010

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Abstract

The U.S. Geological Survey anchored a sediment trap in the northern Gulf of Mexico to collect seasonal time-series data on the flux and assemblage composition of live planktic foraminifers. This report provides an update of the previous time-series data to include results from 2010. Ten species, or varieties, of planktic foraminifers constituted ~90 percent of the assemblage: *Globigerinoides ruber* (pink and white varieties), *Gs. sacculifer*, *Globigerina calida*, *Globigerinella aequilateralis*, *Globorotalia menardii* group, *Gt. truncatulinoides*, *Pulleniatina* spp., *Orbulina universa*, and *Neogloboquadrina dutertrei*. The mean daily flux was 219 tests per square meter per day (m^{-2} day^{-1}), with maximum fluxes of >600 tests m^{-2} day^{-1} during late December and minimum fluxes of <40 tests m^{-2} day^{-1} during late August. *Globorotalia truncatulinoides* showed a clear preference for the winter, consistent with data from 2008 and 2009. *Globigerinoides ruber* (white variety) flux data for 2010 (average 29 tests m^{-2} day^{-1}) showed a steady increase of about a factor of 3 since 2009 (average 11 tests m^{-2} day^{-1}), and an almost 10-fold increase from the 2008 flux (average 3 tests m^{-2} day^{-1}). The progressive increase in flux resulted in a relatively large increase in percent abundance of total assemblage from 2008 (1.5 percent) to 2010 (12. 4 percent). In addition, though *Gs. ruber* (white) percent abundance increased from 4.9 percent in 2009 to over 12 percent in 2010, it continued to occur in lower abundance than the 20-30 percent indicated by dead-assemblage records from nearby sediments.

Introduction

A sediment trap was moored in the northern Gulf of Mexico in January 2008 as part of a U.S. Geological Survey (USGS) Mendenhall Postdoctoral Fellowship project. The trap, equipped with an automated sampling system, has continuously collected material in the water column from January 2008 to the present and is currently deployed. Information on the trap, trap mooring, planktic foraminifers as climate proxies, and the results from the first year are detailed in Tedesco and others (2009). In this paper, we update results from the sediment-trap series to include material collected between January and December of 2010. The paper presents the data without interpretation.

Regional Setting

The Gulf of Mexico is a semi-enclosed basin surrounded by the Gulf Coast of the United States, Mexico, and Cuba (fig. 1). Sea-surface temperature (SST) at the trap site ranges from a winter low of around 21°C to a high of 30°C (World Ocean Atlas 2009 data cited in Locarnini and others, 2010). Sea-surface salinity (SSS) ranges from about 35 practical salinity units (psu) in the winter to 33 psu in the summer (World Ocean Atlas 2005 data cited in Antanov and others, 2010).

The Gulf of Mexico is connected to the Caribbean and tropical North Atlantic through the Loop Current. The Loop Current is a surface current that enters the Gulf of Mexico between Cuba and the Yucatan Peninsula and typically loops east and south before exiting through the Florida Straits.
The Gulf of Mexico, Caribbean Sea, and western tropical North Atlantic compose the Atlantic Warm Pool, the Atlantic portion of the Western Hemisphere Warm Pool. The Atlantic Warm Pool is defined by the region covered by water warmer than 28.5 ºC and constitutes a large part of the tropical heat engine, supplying moisture to the atmosphere and latent heat to North America from early spring to early fall (Wang and Enfield, 2001; Wang and others, 2006). World Ocean Atlas 2009 climatology

indicates the trap site is part of the Atlantic Warm Pool during July, August, and September (summer) (Locarnini and others, 2010).

Figure 1. Location of the sediment-trap mooring (inverted triangle) in the northern Gulf of Mexico at approximately 27.5°N. latitude and 90.3°W. longitude.

Materials and Methods

A McLane PARFLUX Mark 78 automated sediment trap was deployed in early January 2008 in approximately 1,150 meters (m) of water at about 27.5ºN. latitude and 90.3ºW. longitude. The trap is positioned at a depth of 700 m on the mooring to guarantee the collection of deeper-dwelling species of planktic foraminifers (for example, *Globorotalia* spp.). The trap is equipped with 21 collection cups that are mounted on a rotating plate that is programmed to rotate every 7 to 14 days. Sample cups from 2008 to late May 2009 contained a buffered formalin solution made with filtered (0.44-micrometer (µm) filter) seawater, with a salinity of approximately 33 psu. Sample cups for September 2009 to the present contain a density-gradient solution with a salinity of approximately 44 psu. Formalin (3.7 percent) and sodium borate are added to the density-gradient solution to poison and preserve the samples. Each trap sample represents a 1- to 2-week collection period. The trap was recovered and redeployed every 3 months during 2008, and approximately every 6 months thereafter, depending on sampling frequency. A gap in our sampling occurred from late May to late September 2009 due to scheduling problems. Nine samples from the weeks of March 17, April 7, May 5, October 22, November 19, and December 10 of 2009, and January 7, February 14 and 24 of 2010 were not recovered due to loss of the cups during deployment/recovery. During visits to the trap site, conductivity-temperature-depth (CTD) measurements were collected using a Sea-Bird Electronics SBE9*plus* (figs. 2 and 3).

Sediment-trap samples were wet split into four aliquots using a precision rotary splitter at the University of South Carolina, stored in buffered deionized water, and then refrigerated. A quarter split was wet sieved over a 150-μm sieve and subsequently wet picked for all foraminifers. To supplement total test counts in intervals with less than 300 foraminifers, we sieved and picked an additional one-quarter split and summed the counts. All planktic foraminifers were identified to species. The species counts are reported as flux in tests per square meter per day. Flux was calculated by multiplying the individual species counts by number of splits, then dividing by sampling length, which was typically 7 or 14 days. Percent abundance is reported weekly and for each season. Seasonal flux is the total flux for each individual species. Seasons are defined as winter (January, February, and March), spring (April, May, and June), summer (July, August, and September), and fall (October, November, and December). Relative seasonal abundances were calculated by dividing the individual species total seasonal flux by the total seasonal flux for all planktic foraminifers.

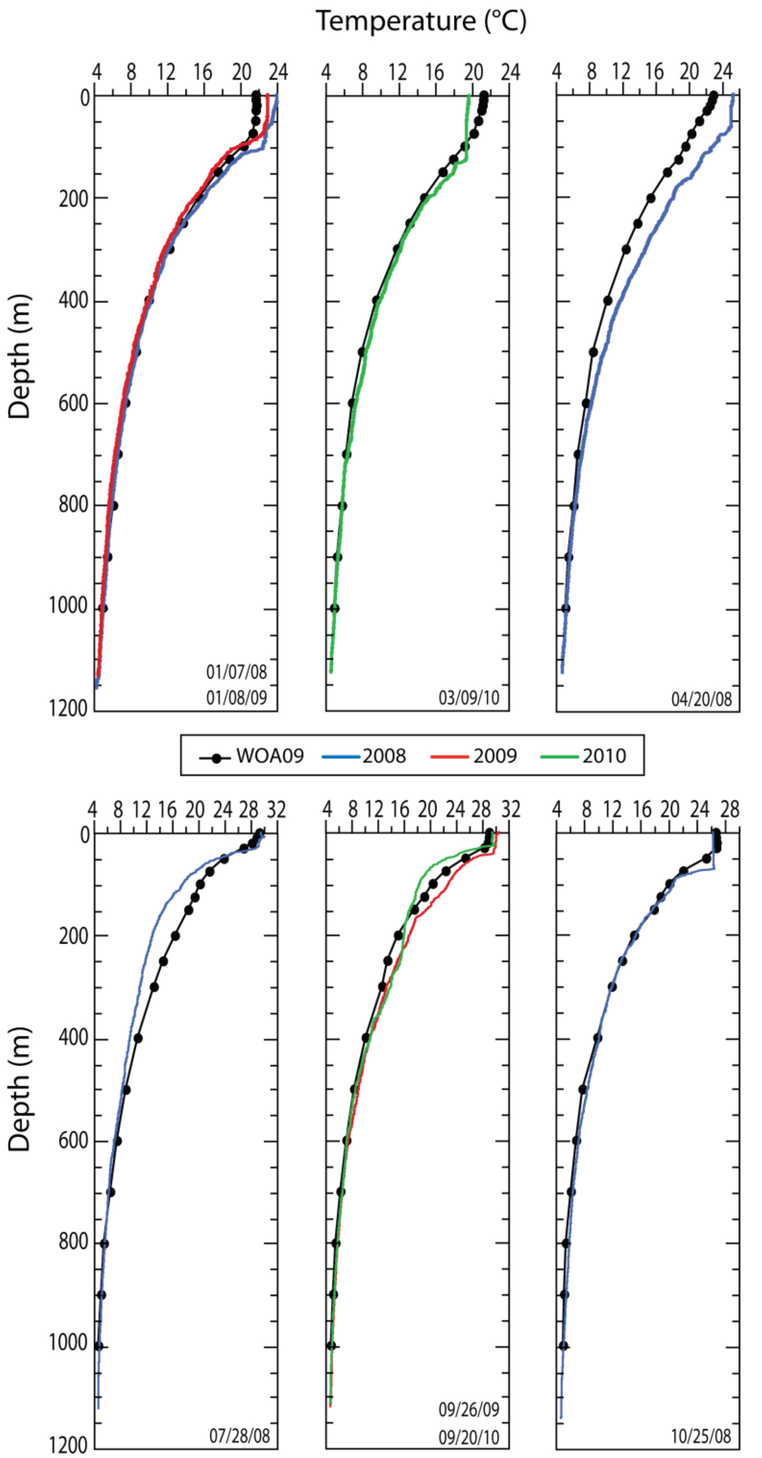

Figure 2. Temperature depth profiles of World Ocean Atlas 2009 climatology (WOA09) (black line with circles) and this study for the trap site during 2008 (blue lines), 2009 (red lines), and 2010 (green lines). m, meters.

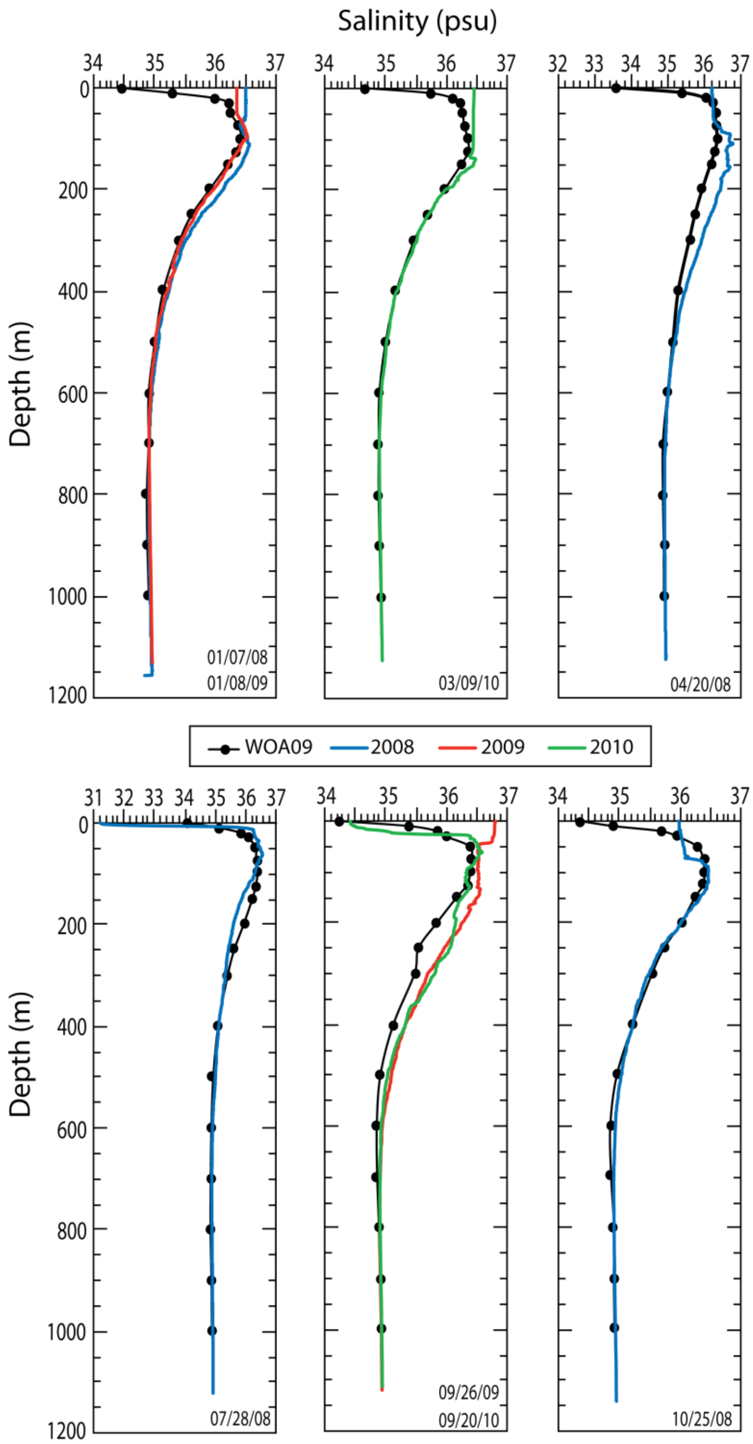

Figure 3. Salinity depth profiles of World Ocean Atlas 2009 climatology (WOA09) (black line with circles) and this study for the trap site during 2008 (blue lines), 2009 (red lines), and 2010 (green lines). m, meters; psu, practical salinity units.

Results from 2010

More than 25 species of planktic foraminifers were identified in the sediment-trap material. Ten species, or varieties, constituted ~90 percent of the 2010 assemblage*: Globigerinoides ruber* (d'Orbigny) (pink and white varieties), *Gs. sacculifer* (Brady), *Globigerina calida* (Parker), *Globigerinella aequilateralis* (Brady), *Globorotalia menardii* group [The *Gt. menardii* group includes *Gt. menardii* (Parker, Jones, and Brady), *Gt. tumida* (Brady), and *Gt. ungulata* (Bermudez)], *Orbulina universa* (d'Orbigny), *Gt. truncatulinoides* (d'Orbigny), *Pulleniatina* spp., and *Neogloboquadrina dutertrei* (d'Orbigny) (table 1, figs. 3 and 4).

The mean daily flux of planktic foraminifers recovered from the trap in 2010 was 219 tests m^{-2} day^{-1} (table 1and fig. 3). The winter (January and March; February is missing) flux contributed about 30 percent of the annual flux and ranged from 173 to 489 tests m^{-2} day^{-1}, with a mean flux of 379 tests m^{-2} day^{-1}. Spring (April, May, and June) flux contributed about 22 percent of the annual flux and ranged from 38 to 417 tests m^{-2} day^{-1}, with a mean flux of 162 tests m^{-2} day^{-1}. Summer (July, August, and September) flux contributed about 11 percent of the annual flux and ranged from 38 to 201 tests m^{-2} day^{-1}, with a mean flux of 116 tests m^{-2} day. The fall (October, November, and December) flux contributed about 37 percent of the annual flux and ranged from 111 to 681 tests m^{-2} day^{-1}, with a mean flux of 249 tests m^{-2} day^{-1}.

Globorotalia truncatulinoides was the most abundant species in the early winter season, comprising >70 percent of the assemblage during January (fig. 4). The spinose species *Gs. ruber* (pink), *Gs. ruber* (white), and *G. calida* comprised the bulk of the spring assemblage (~60 percent). The summer season was dominated by *G. ruber* (white and pink), which made up >60 percent of the total assemblage. *Gs. ruber* (pink) (11 percent), *Gs. ruber* (white) (15 percent), *Gt. menardii* group (15 percent), *N. dutertrei* (13 percent), *Pulleniatina* spp. (10 percent), and *G. falconensis* (12 percent) accounted for about 80 percent of the fall assemblage composition.

Table 1. Planktic foraminiferal flux (tests per square meter per day, m^{-2} d^{-1}) and percent contribution (in parentheses) to the total assemblage for the 14 most common species, northern Gulf of Mexico. Table is separated by season (that is, winter, spring, summer, and fall) and year. The first 10 species listed comprised about 90 percent of the total flux. Particularly low fluxes (that is, <50 tests m^{-2} d^{-1}) are denoted with an asterisk next to the mid-week collection date.

Discussion

Knowing the modern seasonal range, flux, and abundance of species of planktic foraminifers commonly used as proxies for past low- to mid-latitude paleotemperature construction can help with the interpretation of the foraminiferal assemblage records archived in nearby sediments. For example, *Gs. ruber* (white) is typically used in proxy reconstructions of mean annual sea-surface conditions in the low latitudes (for example, Richey and others, 2007; Schmidt and others, 2004). The relative percent abundance of *Gs. ruber* (white) in 2008-2009, 1.5-5 percent, was anomalously low compared to Holocene planktic foraminiferal assemblages from nearby basins that show *Gs. ruber* (white) comprises ~20-30 percent of the total assemblage (Kennett and others, 1985; LoDico and others, 2006; Poore and others, 2011). However, though *Gs. ruber* occurred in lower abundance during 2008-2010 than the 20-30 percent indicated by assemblages archived in deep-sea sediments, its essentially year-round presence, consistent with sediment-trap data from the Sargasso Sea (Deuser and others, 1987), supports the assumption that it provides a record of mean annual conditions.

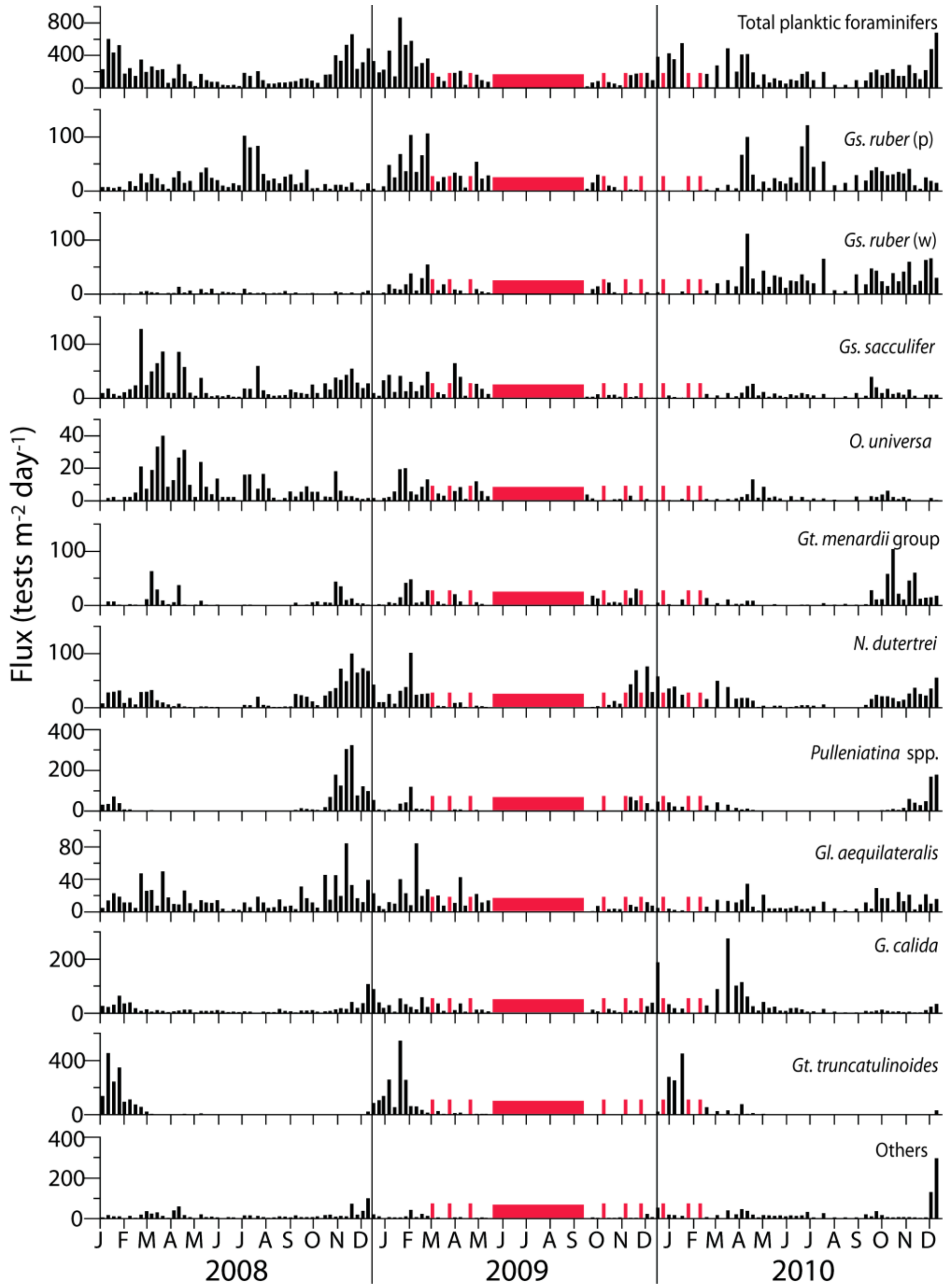

Figure 4. Average daily flux (tests per square meter per day, m^{-2} day^{-1}) of 7- to 14-day-long sampling intervals of all planktic foraminifers and the 10 most abundant species/groups during 2010. Note the scale change in the y axes. The tick marks on the x axis denote the 15th day of each month. There was a gap in sampling from late May to late September 2009 (red rectangle) and loss of nine sample cups (red bars).

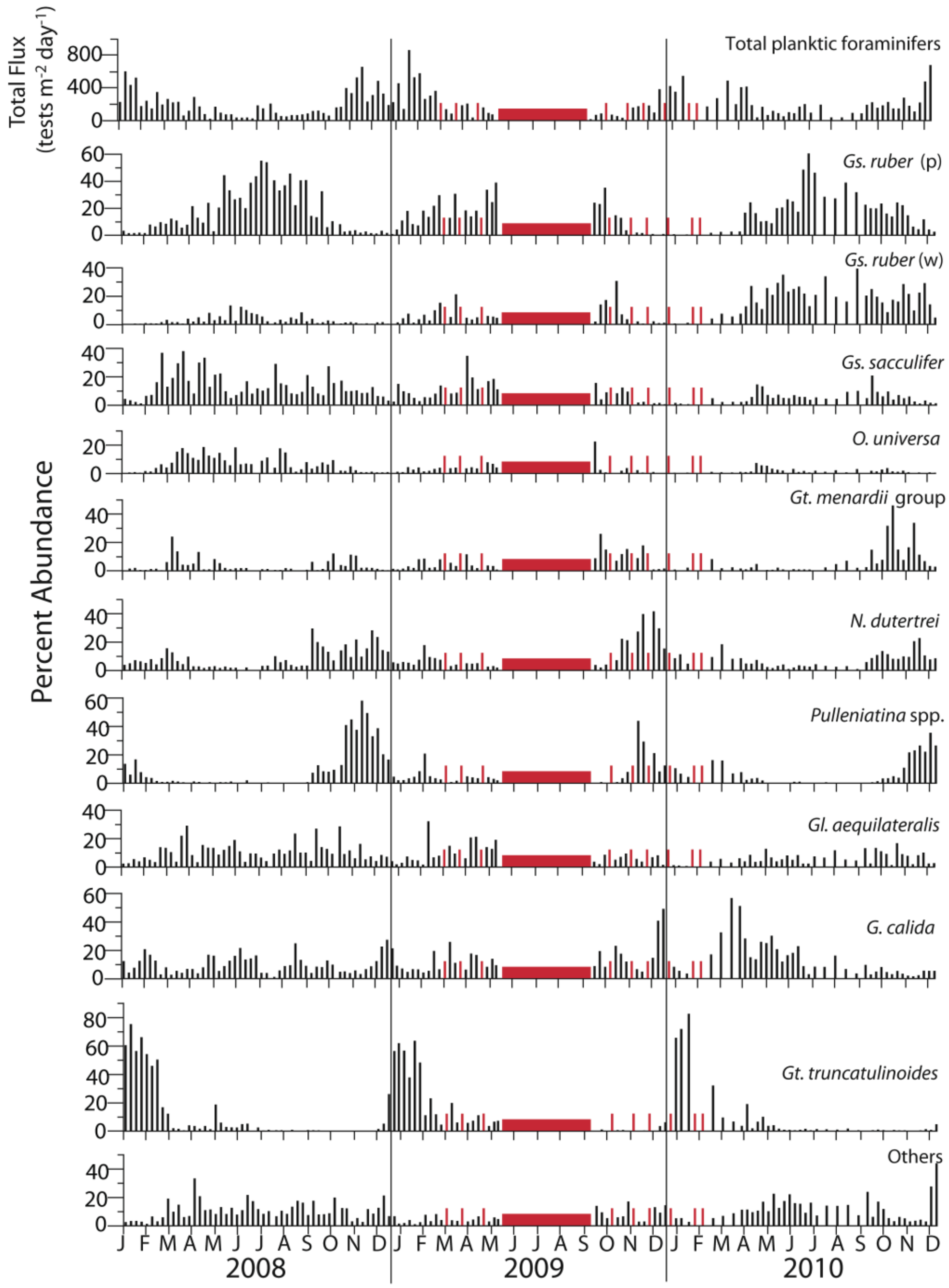

Figure 5. Average daily flux for all planktic foraminifers (tests per square meter per day, $m^{-2}\ day^{-1}$) (top panel) and weekly percent abundance of the 10 most common species/groups of planktic foraminifers during 2010. Note scale change in the y axes. The tick marks on the x axis denote the 18th day of each month. There was a gap in sampling from late May to late September 2009 (red rectangle) and loss of nine sample cups (red bars).

Since changes in faunal assemblage records are generally thought to represent changes in local environmental parameters, such as temperature and salinity (Tedesco and others, 2009), longer time series of modern flux and abundance provide better understanding of planktic foraminifer ecology, and thus our interpretation of paleoceanographic conditions. A gap in sampling during June to late September 2009 made a comparison of 2008 and 2009 flux and percent abundance difficult. The addition of 2010 data provides a better understanding of the range in inter- and intra-annual variability in flux and percent abundance. For example, the seasonal preferences indicated by the 2010 data for *Gt. truncatulinoides* (winter) and *N. dutertrei* (fall-winter) are consistent with 2008 and 2009 data (Tedesco and others, 2009; Spear and Poore, 2011). For other species, such as *Gs. ruber* (white), for which a comparison of 2008 and 2010 data show inter- and intra-annual variability relatively high, a longer time series is necessary to discern the natural range.

Conclusions

Open-ocean sediment-trap material collected from January to December of 2010 shows that more than 25 species of planktic foraminifers were present in our samples. Of that, 10 species/groups comprised ~90 percent of the total flux. *Gt. truncatulinoides* flux data continue to indicate that this species almost exclusively prefers the winter season (particularly January and February). Though abundance and flux of *Gs. ruber* (white) increased by a factor of 3 since 2009, and almost an order of magnitude since 2008, it still occurs in lower abundance than that indicated by sediment assemblage records.

Acknowledgments

We thank Eric Tappa, Don Hickey, Chris Reich, Joe Malbrough, and the crew of the R/V *Pelican* for assistance in deploying the sediment-trap mooring, and Bob Thunell for technical support and advice.

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