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Vertically migrating micronekton and macrozooplankton communities around Guam and the Northern Mariana Islands

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ABSTRACT

The distribution, biomass, and assemblages of vertically migrating micronekton/macrozooplankton were studied in relation to oceanographic conditions around Guam and the adjacent Northern Mariana Islands during Spring 2010, using 3-m^2 Isaacs-Kidd Midwater Trawl (IKMT). The study area was located within the oligotrophic waters of the westward flowing North Equatorial Current (NEC). However, southern stations of the survey were situated close to the northern boundary of the more productive North Equatorial Countercurrent (NECC), where we observed the highest biomass, abundance, species richness, and diversity of pelagic organisms. Overall, we recorded 85 species from 20 families of mostly mesopelagic species in the area, with lanternfishes (Myctophidae—40 species) and dragonfishes (Stomiidae—18 species) being the most taxonomically diverse groups. Three genera of mesopelagic shrimps, *Sergestes*, *Janicella* and *Sergia*, dominated the decapod crustacean component of the micronekton community numerically and by biomass, while the contribution from cephalopods was relatively minor. Assemblages of major micronekton/macrozooplankton groups, based on biomass and abundance showed principal changes with latitude. However, the classification and ordination analysis, based on taxonomically resolved taxa (fishes and decapod shrimps), indicated additional zonal variation, with areas east and west of the island chain showing different community structure. The mean total micronekton biomass for the area near the productive boundary region between the NEC and NECC was 5.8 mg/m^3, with a mean biomass of 1.2 mg/m^3 obtained for stations in the oligotrophic NEC area. The corresponding biomass of mesopelagic fishes was 0.88 mg/m^3 and 0.24 mg/m^3 for these two areas, respectively. We reviewed and compared the available information on the quantitative distribution of midwater fish biomass in the western tropical Pacific and outlined major patterns of variation in the equatorial Pacific in general.

1. Introduction

Mesopelagic micronekton, a diverse assemblage of fishes, crustaceans and cephalopods ranging in size from 1 to 10 cm, are a prominent component of oceanic pelagic communities (Blackburn, 1968; Parin and Nesis, 1977). These ubiquitous and abundant organisms occupy an important role as prey at intermediate trophic levels for larger organisms, linking primary producers and consumers with top oceanic predators (Sund et al., 1981; Seki and Polovina, 2001; Suntsov and Brodeur, 2008). During day time, numerous micronektonic species spend time in a more or less inactive state at various mesopelagic levels, but are actively migrating to and feeding at epipelagic zone at night (Barham, 1971; Longhurst, 1976). On a global scale, mesopelagic micronekton provides a major contribution to the vertical transport of organic matter from the surface to deeper layers via diel vertical migration (Angel, 1989; Hidaka et al., 2001). An important biological property of micronektonic animals is their ability to form dense aggregations, known as sound-scattering layers (SSL) which can be directly assessed by acoustical methods (Farquhar, 1977; Kashkin, 1977). This, along with significant worldwide biomass and importance as forage organisms, has stimulated significant scientific interest and yielded much of the initial knowledge on micronekton ecology (King and Iversen, 1962; Farquhar, 1971; Anderson and Zahuranec, 1977).

Tropical–subtropical regions of the World Ocean are characterized by the greatest diversity of micronekton communities (Parin and Nesis, 1977). In the North Pacific, most studies of the low-latitude micronekton have been conducted in central parts of the subtropical gyre around Hawaii, centering on particular taxonomic groups, e.g. fishes (Clarke, 1973, 1974), crustaceans

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(Walters, 1976), and cephalopods (Young, 1978), while community level studies addressed micronekton near islands (Maynard et al., 1975; Reid et al., 1991), seamounts (Drazen et al., 2011) or in true pelagic habitats (Barnett, 1983, 1984). In many respects, immense oligotrophic subtropical gyres, with their weak lateral advection and significant stability of physicochemical characteristics, approximate ideal ecosystems where biological communities are controlled by in situ processes (McGowan, 1974). Micronekton communities in these regions are interesting from the theoretical ecology point of view, considering that high diversity of organisms is maintained in an essentially structureless environment, with numerous species sharing the same vertical ranges and food resources (Barnett, 1983).

Much less is known about micronekton on the periphery of subtropical gyres, although certain micronekton groups (e.g. midwater fishes) have been studied in the oceanographically dynamic equatorial Pacific (Legand et al., 1972; Grandperrin and Rivaton, 1966; Parin, 1975). The interface between more productive equatorial regions and oligotrophic gyre waters may represent an important zone of mixing and faunal exchange between different pelagic ecosystems. However, micronekton communities in these boundary zones, where patterns and processes in pelagic communities may be quite different from stable and uniform central gyre regions, remain understudied. Although a number of recent reports have addressed patterns of abundance and community structure of vertically migrating mesopelagic fishes in the transitional region off Japan (Sassa et al., 2002; Yatsu et al., 2005), western tropical Pacific remains practically unexplored in this respect. In the western tropical Pacific, only scattered information is available on faunal composition of fishes (Bekker, 1967; Parin et al., 1977; Kawaguchi and Shimizu, 1978), shrimps (Kikuchi and Nemoto, 1986), and cephalopods (Hidaka and Kubodera, 2000) while very few studies to date have addressed the pelagic habitat and broad spatiotemporal variation in the micronekton community structure and biomass (Hidaka et al., 2003).

The Mariana Islands represent the southern part of a submerged mountain range extending from Guam to near Japan (Riegl et al., 2008). The southern group of Mariana Islands consists of five coralline limestone islands: Guam, Rota, Aguijan, Tinian, and Saipan. The oceanography in the area is governed by the western flowing North Equatorial Current (NEC), the lower branch of the North Pacific central gyre, occupying a broad region between 10° and 20°N. South of the NEC, the eastward flowing North Equatorial Countercurrent (NECC) is usually found between 5° and 10°N (Lukas, 2001). The surface layer in the NEC is composed of southern low-salinity water less than 34.2 psu and northern high-salinity tropical water greater than 34.8 psu, with a distinct salinity front separating these two water masses at around 15°. The position of the salinity front is not stationary and is correlated with the Southern Oscillation Index (Kimura et al., 2001).

The western tropical Pacific is an important fisheries area for several tuna species, while the NEC and NECC regions are known as spawning areas for Japanese eels, *Anguilla japonica* and certain highly prized tuna species (Ueyanagi, 1969; Nishikawa et al., 1978; Tsukamoto, 1992). During March–April 2010, the NOAA Pacific Islands Fisheries Science Center (PIFSC) carried out a survey to examine the oceanographic conditions and assess micronekton and macrozooplankton habitat/biomass around Guam and adjacent Northern Mariana Islands. Here, we describe the distribution and biomass of vertical migratory micronekton and macrozooplankton in the area by focusing on net sample results, with special reference to mesopelagic fishes.

2. Materials and methods

2.1. Environmental data

Temperature, salinity, dissolved oxygen, chloropigment concentrations, and density were collected via conductivity–temperature–depth (CTD) casts from the NOAA Ship *Oscar Elton Sette* along three latitudinal transects around Guam and the adjacent Mariana Islands: along 146°40′E (Eastern Transect), 145°15′E (Central Transect), and 143°48′E (Western Transect), between 10° and 17°N, 10° and 13°30′N, and 10° and 16°45′N, respectively. Data were collected

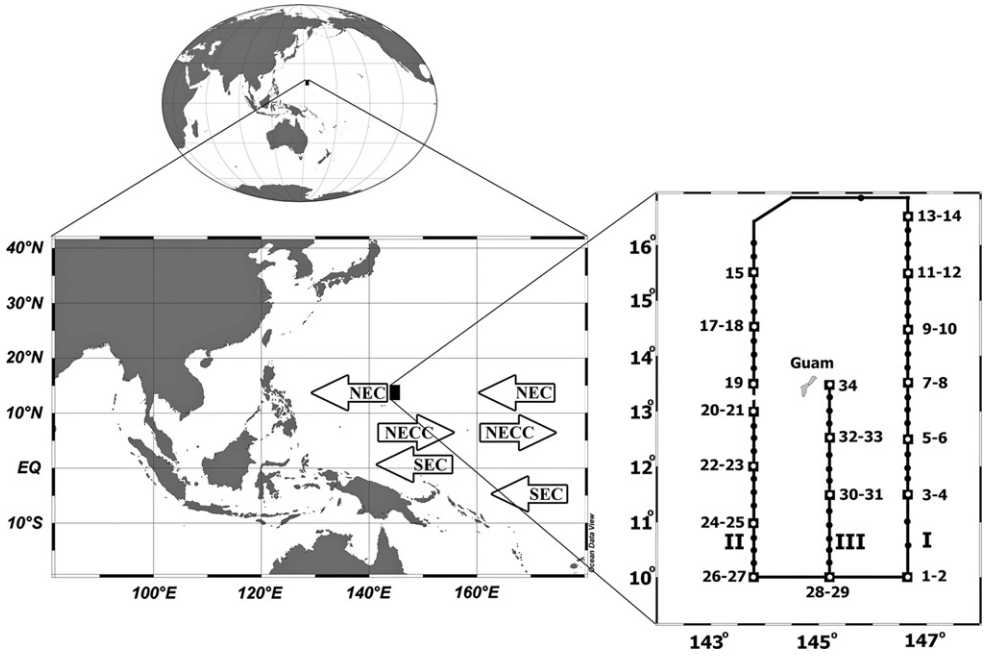

Fig. 1. Cruise track of the *Oscar Elton Sette* (SE 10-03) and sampling locations around Guam and adjacent Northern Mariana Islands during March 22–April 14, 2010. Black squares—IKMT sampling locations (numbers—consecutive IKMT tows), black circles—CTD stations. I–III—Eastern, Western and Central transects. Major currents (modified after Lukas, 2001) shown with arrows. NEC—North Equatorial Current, NECC—North Equatorial Countercurrent, SEC—South Equatorial Countercurrent.