General Summary

The biomass of mesopelagic fishes in the Kuroshio region is approximately 10 million-ton. Mesopelagic fishes serve as a vital link between the lower and upper trophic level and are key components in the marine ecosystems. Some of them constitute the main prey source of marine predators and commercially important fishes like the blue fin tuna. As such, a considerable number of studies have accumulated over the past decade around the Kuroshio waters – most of which are seasonal in either fixed or several stations from 100–2000 m and not include the depths target of the present study (<100 m). Although they are mainly inhabitant at the deeper waters (>100 m), their larvae migrate to the more advantageous shelf areas than the mesopelagic zone to prey on zooplankton for higher survival during the critical period. However, the distribution, occurrence, and dispersion in the shelf waters remained unknown in the Kuroshio region, particularly in Tosa Bay.

Chapter 1: To fill these gaps and to test the hypotheses of nearshore dispersion by the current, a three-year ichthyoplankton study was carried out in central Tosa Bay from collections in the five fixed stations with varying bottom depths ranging 40–200 m. Examination of the community structure, diversity and assemblages then followed using the collected samples. A total of 7,511 larvae belonging to 9 families, 35 genera, and 66 species were identified showing a high abundance during late winter to early summer (March–July). Myctophid larvae (ca. 67%) mainly comprised the bulk of the collected samples, which recorded 44 species or types belonging to 15 genera, including 21 potentially undescribed specimens. The nine most abundant species accounted for ca. 88% of the total catch and exhibited five occurrence patterns related to temperature change associated with the seasonal cycles. These include winter (*Notoscopelus* sp.), late

winter–spring (*Maurolicus japonicus*), spring–summer (*Diaphus* stubby type, *Myctophum asperum*), spring (*Diaphus* slender type, *Diaphus* stubby-A), and autumn (*Sigmops* sp., *Vinciguerria nimbria* & *Cyclothone* sp.) groups. Species diversity and mean annual density appeared at the highest value in 2017 than in other years, as a result of frequent upwelling, nearshore flow path of the Kuroshio Current, and strong upward movement of ADCP current near the bottom. This subsequently resulted to a shoreward intrusion of numerous mesopelagic fish larvae along the bay. The colder winter phenomenon during the earlier months of 2018 has caused a pronounced decline in the overall abundance and species diversity. Hence, to determine whether this phenomenon also affects the cold-loving (*M. japonicus*) and cold to warm–loving (*M. asperum*) species, detailed examination on their pattern, trend, abundance, and distribution were made using similar ichthyoplankton samples. Additional information on diel vertical distribution was elucidated from the collections in 2014–2015 at a 130 m depth station.

Chapter 2: Eggs and larvae of *M. japonicus* (Chapter 2) mainly inhabit in waters deeper than 100 m and advected nearshore when the Kuroshio Current approached near the bay and an upwelling developed. Occasional dispersion during high water turbulence was related to their position along the water column and more evident in larvae than in eggs. Eggs mostly in A and B-stages aggregated at 30–70 m depths in both day and night, while the A and C-stages from seasonal collections at 50–100 m strata in the 200 m station. Eggs were twice as abundant at night- than daytime, suggesting that this species spawns at night. Larvae primarily in preflexion and flexion stages occurred in the 70–110 m and 90–130 m during the day- and nighttimes, respectively, and located at even deeper strata between 100–150 m in the daytime around the continental shelf area. While the seasonal data showed an occurrence in spring parallel to an upwelling event, long term data further revealed a prolonged seasonality from winter to spring with

conspicuous annual variability influenced by hydrographic conditions. Highest egg and larval abundance occurred during the period of frequent upwelling and nearshore flow of the Kuroshio Current but apparently decline (ca. 86% and 84%, respectively) during the colder winter event in 2018.

Chapter 3: Since Tosa Bay yielded a diversity of mesopelagic species particularly the Myctophids, interspecific competition, both at temporal and spatial scale, likely occur. Compared with the early stages of *M. japonicus* that accumulated in areas deeper than 100 m, the *M. asperum* of the family Myctophidae, were equally found in all the stations, horizontally dispersed irrespective of the upwelling and Kuroshio Current flow path, and vertically aggregated near the surface in both day- and nighttimes. This distribution pattern was also common in *Sigmops* sp. (Gonostomatidae), *V. nimbria* (Phosichthyidae), and *Diaphus* stubby type (Myctophidae). *M. asperum* displayed a prolonged occurrence showing a peak of spawning activity from spring to early summer which indicates a wider temperature range for this species, yet the abundance also showed a significant decline (ca. 75%) during the colder winter event in 2018.

Chapter 4: Mesopelagic fishes in Tosa Bay was structured based on temperature changes associated with seasonal cycle. Although mesopelagic, yet they equally occurred in areas shallower than 100 m which vary depending on their position across the water column (i.e., vertical distribution) and the Kuroshio Current flow path (i.e., distance) resulting to high annual variations. The novel results displayed by *M. japonicus* and *M. asperum* to colder winter phenomenon highlight their vulnerability to climatic changes and can serves as an indicator species of temperature regime shift in the marine ecosystems.