CHANGES OF LARVAL FISH FEEDING ECOLOGY IN THE ANTHROPOGENIC-IMPACTED KLANG STRAIT (MALAYSIA) BETWEEN THE TIME PERIODS 1985-86 AND 2013-14

QUAH WEI CHIANG

MASTER OF SCIENCE

FACULTY OF SCIENCE
UNIVERSITI TUNKU ABDUL RAHMAN
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By

QUAH WEI CHIANG

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ABSTRACT

Changes of Larval Fish Feeding Ecology in the Anthropogenic-impacted Klang Strait (Malaysia) between the Time Periods 1985-86 and 2013-14

Quah Wei Chiang

Between time periods 1985-86 and 2013-14, Klang Strait was heavily impacted by anthropogenic activities such as the operation of Kapar Power Station (KPS), shipping, removal of mangroves for industrial and coastal development, housing, agriculture and shrimp farming. This environmental change had collectively caused a shift in the zooplankton community structure, in which large-bodied zooplankton were replaced by small-bodied zooplankton. In order to access KPS impact on fish larvae growth and feeding, fish larvae in the Klang Strait were compared using archived samples collected from this two time periods, 1985-86 and 2013-14. Zooplankton samples were also collected in parallel with fish larvae sampling. A total of 761 fish larvae belonging to seven dominant families (Bregmacerotidae, Callionymidae, Cynoglossidae, Engraulidae, Gobiidae, Leiognathidae and Sciaenidae) were examined in this study. Fish larvae were categorized according to their life history stages: preflexion, flexion and postflexion. Gut content analysis and Index of Relative Importance were used to gain insight of diet composition and rank importance of prey in the diet. Copepods dominated the diet of all fish larval families except Leiognathidae. Three types of feeding habits of fish larvae were identified through Principal

Component Analysis; zooplanktivorous, planktophagous and detrivorous. Callionymidae, Cynoglossidae and Sciaenidae showed a diet preference over small-bodied copepods whereas Bregmacerotidae preferred large-bodied copepods. Gobiidae preferred the younger nauplii compared to adult stages of copepods after 30 years. Engraulidae are planktophagous because copepods and detritus are both important in their diet. Leiognathidae are benthic detrivorous feeders because detritus and polychaete larvae are found to be the main food items in the gut. As shown by Redundancy Analysis, diet of fish larvae was highly correlated with the zooplankton community abundance in the environment. Specialised (Bregmacerotidae and Leiognathidae) or opportunistic (Callionymidae, Cynoglossidae, Engraulidae, Gobiidae and Sciaenidae) feeding behaviour may be a feeding strategy to reduce dietary overlap or to adapt to the changing environment. Understanding the feeding habit of larval fishes in anthropogenic-impacted areas are crucial in fisheries management and conservation to ensure sustainable fish stocks. This study may possibly be the first dietary study comparing time series in dietary composition of larval fishes in the tropics.

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APPROVAL SHEET

This dissertation/thesis entitled "**CHANGES OF LARVAL FISH FEEDING ECOLOGY IN THE ANTHROPOGENIC-IMPACTED KLANG STRAIT (MALAYSIA) BETWEEN THE TIME PERIODS 1985-86 AND 2013-14**" was prepared by QUAH WEI CHIANG and submitted as partial fulfillment of the requirements for the degree of Master of Science at Universiti Tunku Abdul Rahman.

Approved by:

Ooi Ai Lin
(Dr. OOI AI LIN) Date:…28.11.2020……
Supervisor
Department of Agricultural and Food Science
Faculty of Science
Universiti Tunku Abdul Rahman

Teoh Chaiw Yee
(Dr. TEOH CHAIW YEE) Date:…28.11.2020……..
Co-supervisor
Department of Agricultural and Food Science
Faculty of Science
Universiti Tunku Abdul Rahman

Chew Li Lee
(Dr. CHEW LI LEE) Date:…28.11.2020……
Co-supervisor
Faculty of Applied Science
UCSI University Kuala Lumpur

UNIVERSITI TUNKU ABDUL RAHMAN
FACULTY OF SCIENCE

Date: 28/11/2020

SUBMISSION OF DISSERTATION

It is hereby certified that QUAH WEI CHIANG (ID No: ADM1701135) has completed this dissertation entitled "Changes of Larval Fish Feeding Ecology in the Anthropogenic-impacted Klang Strait (Malaysia) between the Time Periods 1985-86 and 2013-14" under the supervision of Dr. OOI AI LIN (Supervisor) from the Department of Agricultural and Food Science, Faculty of Science, Universiti Tunku Abdul Rahman, Dr. TEOH CHAIW YEE (Co-Supervisor) from the Department of Agricultural and Food Science, Faculty of Science, Universiti Tunku Abdul Rahman and Dr. CHEW LI LEE (Co-Supervisor) from the Faculty of Applied Science, UCSI University Kuala Lumpur.

I understand that University will upload softcopy of my final year dissertation in pdf format into UTAR Institutional Repository, which may be made accessible to UTAR community and public.

Yours truly,

(QUAH WEI CHIANG)

DECLARATION

I hereby declare that the dissertation is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

Name ____QUAH WEI CHIANG______

Date ________28/11/2020_____________

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
ANOSIM	Analysis of Similarities
IRI	Index of Relative Importance
KPS	Kapar Power Station
LSD	Least Significance Difference
PCA	Principal Component Analysis
RDA	Redundancy Analysis
SIA	Stable Isotope Analysis
% FO	Percentage Frequency of Occurrence
% N	Percentage Numerical Abundance
% V	Percentage Volumetric

CHAPTER 1

INTRODUCTION

1.1 General Introduction

Larval stage is part of a fish ontogeny development. During this period, fish larvae inhabit nursery areas such as estuaries, mangroves and seagrasses since these areas are high productivity grounds that are also able to provide a refuge for fish larvae from larger predators. It is important to study larval fishes because the fish larvae not only link the base of the food web to higher trophic levels but their survival also ensures the sustainability of coastal fisheries (Ara et al., 2009). The two major causes of mortality of fish larvae is starvation and predation, hence the essential study of feeding ecology to understand how fish larvae forage for food. Larval fishes obtain their food by preying on phytoplankton (e.g. diatoms and dinoflagellates) or zooplankton (e.g. copepods).

Larval fish diet is often poorly resolved as compared to their juvenile and adult stages (Robert et al., 2013). This is because it is hardly possible to observe larval fish foraging in their natural environment. Therefore, analysis of gut content to study the feeding habit has been a common practice in fish ecology (Hyslop, 1980). Analyzing gut contents is able to provide a direct insight on what the larval fish is feeding on (Lagler, 1949), but limitations towards this method include possible regurgitation of prey and the difficulty in identifying digested prey to the lower taxonomic level. Studies all over the world have shown a majority of fish larvae feeding on zooplankton dominated by Copepoda (Sampey et al., 2007; Nunn et al., 2012).

Larval fish feeding is influenced by biotic (prey abundance, food availability, competition, size) and also abiotic factors (water temperature, season, pH, salinity)(Beaugrand et al., 2003; Gracia-Lopez et al., 2004; Ooi and Chong, 2011; Alvarez-Fernandez et al., 2015; Azab et al., 2015). Both morphological and environmental factors, in turn, alter fish larvae growth and survival by causing a shift in behavioural and physiological developmental processes. Past studies on prey abundance and temperature have shown that these are the major factors affecting feeding behaviour (Robert et al., 2009; Fouzai et al., 2015). The changing climate and global warming in the past decades in addition to the increase in anthropogenic impacts had led to the past 30 years being to be warmest, with sea surface temperature rising by 0.11ºC per decade (IPCC, 2014). The increase in temperature have been known to impact these ectothermic phytoplankton, zooplankton and itchyoplankton communities (Hays et al., 2005; Richardson, 2008; Thaxton et al., 2020).

Klang Strait, which is the study area in this study, is heavily affected by the removal of mangroves, operation of Kapar Power Station (KPS), coastal development, shipping and agriculture (Abdullah et al., 1999; Chew et al., 2015). These factors collectively caused a change in the surrounding environment such as increased sea surface temperature, decreased pH and euthrophication. The operation of KPS in 1987 caused a 4.3x increase in relative increment to

Intergovernmental Panel on Climate Change (IPCC)'s projection on sea surface temperature in waters around the KPS zone and 1.5x increase in the surrounding waters of the Klang Strait (Chew et al., 2015) as well as impingement and entrainment of marine organisms in the area (Azila and Chong, 2010).

Zooplankton, which is the favourite food of fish larvae, is also affected when there is a change in the Klang Strait. Chew et al. (2015) found that zooplankton community structure is altered whereby large crustacean zooplankton such as Acartiidae and Luciferidae were replaced by small crustacean (e.g. Oithonidae) and non-crustacean zooplankton (e.g. Oikopleuridae and Salpidae). It is possible that this shift in zooplankton community structure would alter the prey-predator relationship between zooplankton and fish larvae and cause a cascading effect towards higher trophic levels. A study carried out by Chu (pers. comm) showed that fish larvae composition in the Klang Strait have changed slightly. Even though the abundance of fish larvae increased in time period 2013-2014 as compared to three decades before (time period 1985-86), majority of the fish larvae are in their preflexion stage.

In Malaysia, studies regarding feeding habits of fish larvae are only limited to fish larvae ranging in lengths from 1.6mm to 5.2mm. Unlike most studies on larval fish diet, these larval fishes from the families Blenniidae, Clupeidae, Gobiidae, Sparidae and Terapontidae have mainly phytoplankton in their guts (Ara, 2009; Ara, 2010; Ara 2011; Arshad, 2013; Ara, 2016). This finding had led to the conclusion that the larval fish families are herbivorous and do not prey mainly on zooplankton (Ara et al., 2013). However, these studies are only carried out in the mangrove-seagrass habitat in Johor. The understanding of diet of larval fish families are still scarce in Malaysia as well as other neighbouring countries in the tropical regions.

1.2 Significance of Study

The present work aims at contributing a wider knowledge on the dietary composition and feeding habit of marine fish larvae in Malaysia. This study elucidates information about the diet of the seven dominant fish larvae families by identifying and enumerating the larval fish diet composition in the Klang Strait (Straits of Malacca). The larval fish feeding habits were also compared after a time period of nearly 30 years, and is possibly the first study in the tropical region to determine the possible shift in diet after nearly three decades. Klang Strait is also strongly impacted by anthropopressure and this study can show how it affects the larval fish selectivity towards the change in composition of prey in the environment.

CHAPTER 2

LITERATURE REVIEW

2.1 Estuary Ecosystem

2.1.1 Mangroves and Estuary Ecosystem as Nursery Grounds

Mangrove estuaries are highly productive grounds for many species of flora and fauna in Malaysia (Norhayati et al., 2009). As for larval fishes, estuary and mangrove habitats act as nursery and feeding grounds (Ara et al., 2013) for the larvae to obtain food, avoid predators and grow. Growth-related ontogenic changes in diet of fish in mangrove estuaries is reported in several fish species (Nanjo et al., 2008). However, studies regarding feeding ecology of fish in estuaries or mangroves environment were scarce as compared to marine ecosystems or freshwater systems (Braga et al., 2012).

2.1.2 Ecological Impact of Climate Change

Global climate change is known to change foraging patterns in fish. A slight change in temperature can affect the distribution and abundance of fish. An increase in sea water temperature forces fish to adapt, migrate to an area of more optimal range, or die (Barton et al., 2002). This climate warming will also cause a decrease in pH due to ocean being a carbon sink. Extremes in environmental factors, i.e. increase in water temperature, low dissolved oxygen, and changes in salinity and pH all can affect fish foraging, growth and behaviour (Moyle and Cech, 2004) but fish physiological properties are affected greatest by temperature and food quality. A 50-year study by Shan et al. (2013) showed changes in fish assemblage structure due to human-induced disturbance and climate change while Dias et al. (2014) deduced that fish preferred locations with abundant prey even though other environmental variables were not ideal.

2.1.3 Development in the Klang Strait

Klang Strait is the passageway for Port Klang which is made up of three ports (Northport, Southport and Westport) and is the largest and busiest port in the country (Figure 2.1). Klang Strait used to be surrounded by mangrove forests before they were removed for land reclamation, coastal development, agriculture and aquaculture concurrent with the operation of KPS (Chew and Chong, 2016). KPS is the largest power station in Malaysia which began operating in 1987 and is a thermal power station which burns fossil fuel for energy. Coal is the primary fossil fuel used while gas is the secondary fossil fuel used. Carbon gas is emitted as a by-product. As a result, these anthropogenic influences cumulatively caused an increase in surrounding water temperature, euthrophication, low dissolved oxygen and high total suspended solids in the waters of Klang Strait (Chew and Chong, 2016). Other studies carried out in the Klang Strait found that levels of polycyclic aromatic hydrocarbons (PAH) were low and pose minimal ecological risks (Sany et al., 2014), but the waters of Klang Strait were concluded to be eutrophic (Sany et al., 2016) and polluted with heavy metals (Sany et al., 2012; Sany et al., 2013).

Figure 2.1: Google Earth image of the Klang Strait

A decadal study in the Straits of Malacca found that the concentration of chlorophyll-a had been increasing (Siswanto and Tanaka, 2014), whereas a comparison of two studies over a 10-year period in the Selangor coast notes minor changes in fish stock biomass but a tremendous decrease in shrimp stock biomass (Sasekumar and Chong, 2005). Another study which focused on the Klang river showed no significant difference between water parameters and the freshwater fish community (Ashraf et al., 2017), while assemblages in the mudflats of Klang had spatial and temporal variability according to sites, periods, lunar and diel cycles (Lee et al., 2016).

2.1.4 Larval Fishes and their Ecological Roles

Larval fishes are part of the early life stages of fish, which begins after hatching until they metamorphose into juvenile. The stages of fish larvae can be divided into yolk sac stage, preflexion stage, flexion stage and postflexion stage (Figure 2.2). The majority of fish larvae hatched with a yolk sac, and hence, is termed as oviparous. This yolk sac stage differs from the later stages of fish larvae in terms of the type of feeding. The yolk sac stage depends endogenously on the yolk as nourishment; while the preflexion, flexion and postflexion stages require external sources to obtain nutrients. The larval fish is considered in the preflexion stage after the yolk sac has been absorbed. From the preflexion stage onwards until the end of the larval stage is then classified mainly according to the flexion of the notochord (Miller and Kendall, 2009).

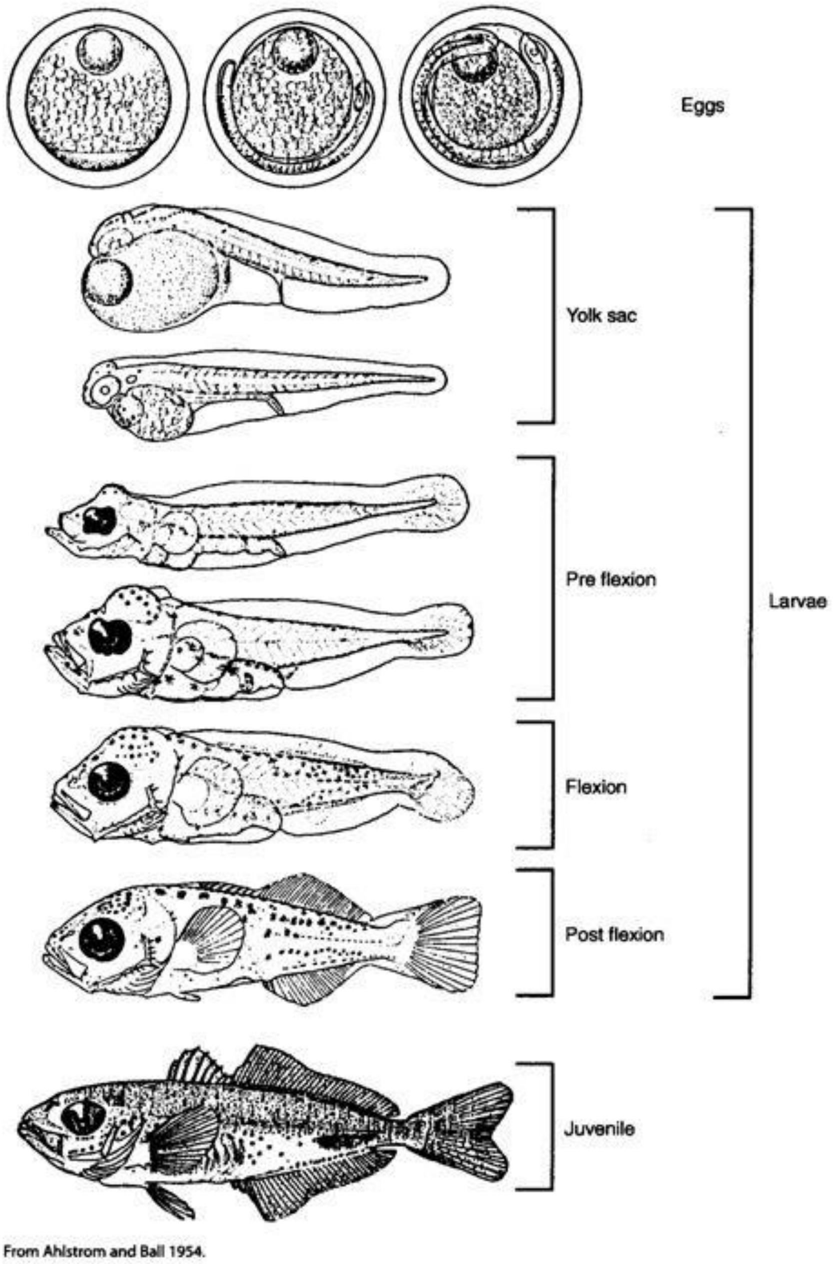

Figure 2.2: Early life stages of a fish (from Ahlstrom and Ball, 1954)

Larval fishes are planktonic and considered part of the zooplankton community. They are found in habitats such as seagrass meadows, salt marshes, mangrove forests and reed beds. Since planktonic fish larvae are food for piscivorous fish larvae and planktonic invertebrates, these habitats provide protection for the fish larvae from potential predators and act as a nursery ground for the fish larvae to grow and develop. Larval fishes being particulate feeders that feed mainly on other zooplanktons have a lower risk of starvation by living in nursery areas that are rich in productivity. Larval and adult stages of fish may differ in food habits such as moving from plankton to benthos due to differences in foraging behaviour, habitat, mouth position, digestive tract morphology, and teeth (Makrakis et al, 2005).

2.2 Feeding Ecology of Larval Fishes

2.2.1 Feeding Ecology

Feeding ecology is defined as a relationship between predator and prey whereby the predator adopts a strategy for optimum foraging on its preferred food (Saikia, 2016) and is a collective view of the fish food habits, foraging habits and its foraging habitat (Gerking, 1994). It is important to study the foods and feeding ecology of larval fish because it can provide information about prey selection, habitat preferences, competition and energy transfer from lower to higher trophics levels (Braga et al., 2012). Trophic groups for mangrove fishes include zooplankton, benthic crustacean, polychaete, fish, detritus, plant and insect feeders (Nanjo et al., 2008). Food habit studies concurrent with food sampling is necessary to allow comparison of both the food consumed by fish and the food availability in the environment. With these studies, it is possible to get an indicator of why the food is selected by the fish and to deduce fish preference over prey. However, the majority of studies neglect the sampling of prey for abundance determination. Mitsuzawa et al. (2017) stated that fish larvae selectively feed on different copepod species depending on fish species and their size.

2.2.2 Critical Period Hypothesis

According to Hjort (1914), transition from endogenous to exogenous feeding is a critical period for fish larvae. The fish larvae is most vulnerable during this period because if the fish larvae is not able to go through its first feeding of external prey, the fish larvae will eventually reach a point of no return and die (Lima et al., 2017). Fish larvae is known to range from not having a stomach to having a functional stomach at the offset of first feeding (Infante et al., 2008; Ronnestad, 2013). Food deprivation is a major cause of fish larvae to be underdeveloped morphologically, such as proteolysis of the intestinal mucosa which will affect the digestive ability (Infante et al., 2008) and eventually growth and survival. Survival of fish larvae through the critical period is necessary to ensure recruitment success of fish population and replenishment of fish stock abundance in the wild.

2.2.3 Larval Fish Food Habits

Most fish larvae are visual feeders that pursue and capture prey, and morphological development during ontogeny can affect their dietary composition (Nunn et al., 2012). Figure 2.3 shows the schematic diagram of some of the major zooplankton prey. The main source of larval food is zooplankton dominated by copepods (Jackson and Lenz, 2016) since copepods are one of the most abundant animals on earth. Other than copepods, cladocerans and rotifers are also commonly preyed by fish larvae (Makrakis et al., 2005). The primary food item for early stage marine fish larvae ranges from phytoplankton (Napiórkowska-Krzebietke, 2017) to copepod nauplii (Mitsuzawa et al., 2017). Bogacka-Kapusta and Kapusta (2014) reported early larval stages of fish species with similar body sizes have different diet, and diet overlap is a result of food abundance in the wild. Dias et al. (2014) suggested fish larvae are opportunistic predators that exploit high prey availability in the wild. Little research have been done in the tropics as compared to temperate regions (Sampey et al., 2007).

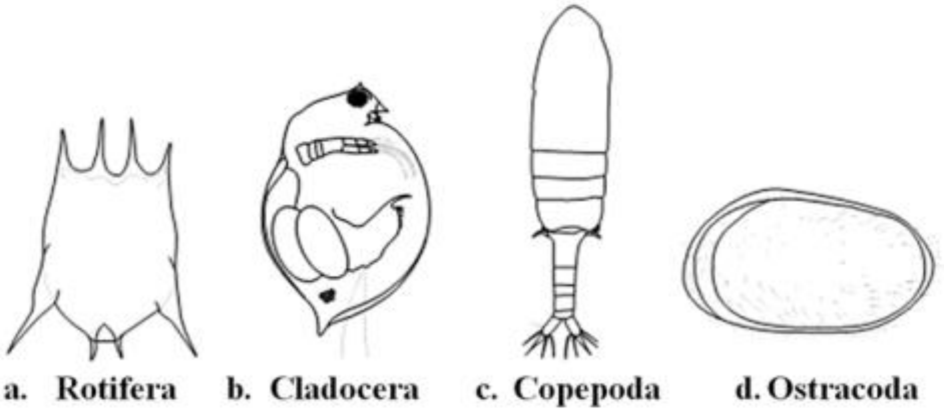

Figure 2.3: Schematic diagram of various groups of zooplanktons (Manickam et al., 2019)

Sampey et al. (2007) elucidated the diets of 50 families of tropical fish larvae and concluded that the majority prey on copepods, in which calanoid copepods were preferred over oithonids. Only a few families such as chaetodontids, nemipterids, tetraodontids and lethrinids feed on predominantly non-copepod prey; selecting chaetognaths, appendicularians, molluscs and polychaetes respectively.

In the Klang Strait, Ong and Sasekumar (1984) reported that fishes of the family Cynoglossidae to be detritivores while fish of the family Leiognathidae were omnivores (Sasekumar and Chong, 2005). Another study by Lee et al. (2019) on juvenile and adult fishes in the coastal mudflats of Klang Strait found that engraulids are shrimp and copepod feeders, sciaenids are shrimp and teleost feeders, cynoglossids are mixed macrobenthos feeders, and leiognathids are copepod feeders.

Feeding incidence is defined as a proportion of examined larvae with food present in the gut. Feeding incidence is important because it describes the degree of feeding success (Llopiz, 2009). Feeding incidence increases with increasing larval size (Sánchez-Velasco, 1998), lower latitudes (Llopiz, 2013) and decreasing temperature (Bachiller et al., 2016). Analysing feeding incidence allows the deduction of whether fish larvae prefer to feed during daytime or night time (Makrakis et al., 2005).

2.2.4 Factors that Influence Feeding

2.2.4.1 Larval Size

Larger predators are able to hunt a larger prey based on the “bigger is better” hypothesis (Litvak and Leggett, 1992). According to Salas-Berrios et al. (2013), larvae with smaller mouth gape have a broader diet overlap as they cannot feed on a wider range of prey (Kurtz and Matsuura, 2001). Thus, food selectivity of fish larvae is biologically highly dependent on their mouth gape and body size (Salas-Berrios et al., 2013). Ontogeny of a fish species allows the larval stage to undergo morphological changes which alter the feeding structure and allows it to capture larger or more energy-rich prey (Makrakis et al., 2005).

2.2.4.2 Type of Prey

Fish larvae may feed on different water column depending on prey preference. This is because different type of prey affects the food quality and nutritional value. For instance, copepods have a better nutritional composition as compared to rotifers and *Artemia* as live feeds (Dhont et al., 2013). However, copepods are considered as fast-moving zooplanktonic organism. Within the Copepoda family, calanoids are larger and have many slow moving species, whereas cyclopoids a have better escape response (Sampey et al., 2007).. Among the calanoids, larger calanoids are seen to have more elusive behaviour (Kristiansen et al., 2009). Food size also has an influence on feeding as larger zooplankton prey have a higher nutritional content and are considered as more nutritious therefore preferred by fish larvae over smaller-sized prey (Dias et al., 2014). The energy expended to search and capture smaller prey in order to meet the daily energy requirement may be greater as well (Gill, 2003).

2.2.4.3 Time of Feeding

Most fish larvae are visual feeders which prefer to feed during daylight because they depend on sunlight to detect their prey (Kurtz and Matsuura, 2001; Østergaard et al., 2005; Salas-Berrios et al., 2013). However, there are also fish larvae species that seem to be nocturnal feeders such as the black southern cod *Patagonotothen tessellate* (Nototheniidae), having a higher feeding incidence at night as reported by Salas-Berrios et al. (2013).

2.2.4.4 Temperature

Temperature is a key abiotic factor as biochemical reactions of metabolism in body increases with warming temperature. Since fish are ectotherms, their body temperature is similar to the surrounding environmental temperature in which they live in. An increase in temperature is known to elevate the metabolic rate and energy demands (Houde, 1989), which leads to an increase in the swimming speed and feeding activity of fish larvae (Hunter, 1981). Frequent feeding and faster growth (Jenkins and King, 2006) can also be related to a decrease in gastric evacuation time due to higher temperatures (Neverman and Wurtsbaugh, 1994). Rapid growth in turn hastens the developmental rate of larval to metamorphosis (McCormick and Molony, 1993) and causes them to have a decreased size at a given developmental stage, as in the ‘temperature-size rule’ (TSR) (Forster et al, 2011). Since a warmer environment brings about higher metabolic demands, fish larvae reduce their body size which in turn lessens the metabolic costs (Thakur et al., 2017).

2.3 Dietary Assessment Methods

2.3.1 Gut Content Analysis

Gut content analysis is the best method in order to know about the larval fish diet. Analysis of gut content to study the feeding habit has been a common practice in fish ecology (Hyslop, 1980) as it is a relatively simple, straightforward and informative method for prey enumeration and identification (Llopiz, 2013). Gut content analysis reflects a snapshot of recent diet, and this direct insight into what the fish larvae is feeding helps because it is difficult to observe fish larvae foraging in their natural habitat. However, there is a lack of empirical data on diets of fish larvae in the wild (Humphries et al., 1999; Ara et al., 2009) leading to a poorly resolved larval fish diet as compared to their juvenile and adult stages (Robert et al., 2013).

Stable isotope analysis (SIA) is another method to look into the diet of fish (Cresson et al., 2014). SIA works by identifying the food source and trophic level through isotopes of nitrogen (N) and carbon (C). Ratio of the heavier isotopes ^{15}N and ^{13}C over the more abundant ^{14}N and ^{12}C reflect the assimilated food source. The greatest advantage of using SIA over gut content analysis is that SIA requires a smaller sample size, and hence is less time consuming. However, SIA is more costly. On the other hand, the advantage of gut content analysis over SIA is that prey consumed can be identified at the taxonomic level. Other methods for dietary studies include conducting feeding experiments in laboratory and fatty acid analysis (Polito et al., 2011; Davis et al., 2012).

Different fish larvae families have different gut shapes (Table 2.1) (Leis and Carson-Ewart, 2000). Fish larvae with straight gut include those from family Engraulidae and preflexion stages of family Gobiidae. Other families of fish larvae such as Bregmacerotidae, Callionymidae, Cynoglossidae, Leiognathidae and Sciaenidae have a coiled gut. Fish larvae with a straight gut have a lower feeding incidence compared to fish larvae with a coiled gut because fish larvae with a straight gut can regurgitate food upon capture (Yamashita, 1990; Conway et al., 1998). Fish larvae having a looped or coiled gut is found to have a reduced regurgitation amount (Sánchez-Velasco, 1998) and this can lead to a higher feeding incidence. Food evacuation induced by stress upon capture or preservation of fish larvae is not prey-specific (Fernandez and Gonzalez-Quiros, 2006).

Gut structure of larval fishes are either straight guts or rotated guts (Figure 2.4). A straight gut is a very simple intestine. A rotated or coiled gut, on the other hand, forms a loop and functions to increase the gut length without affecting body length. A coiled gut can be divided into the foregut (stomach), midgut and hindgut (Finn and Kapoor, 2008). The stomach is a pouch-like bulb that serves as a short-term food storage. The midgut functions to digest and absorb ingested feed whereas in the hindgut the feed is often not possible to be recognised as prey. Little is known about the processes in the hindgut. According to Khojasteh (2012), in some fishes there is no clear distinction between the midgut and the hindgut. The pyloric caeca may be present between the stomach and the midgut, but its function is uncertain (Kamisaka et al., 2001). There may be differential rates of digestion in the larval gut depending on the type of prey ingested (Young and Davis, 1990).

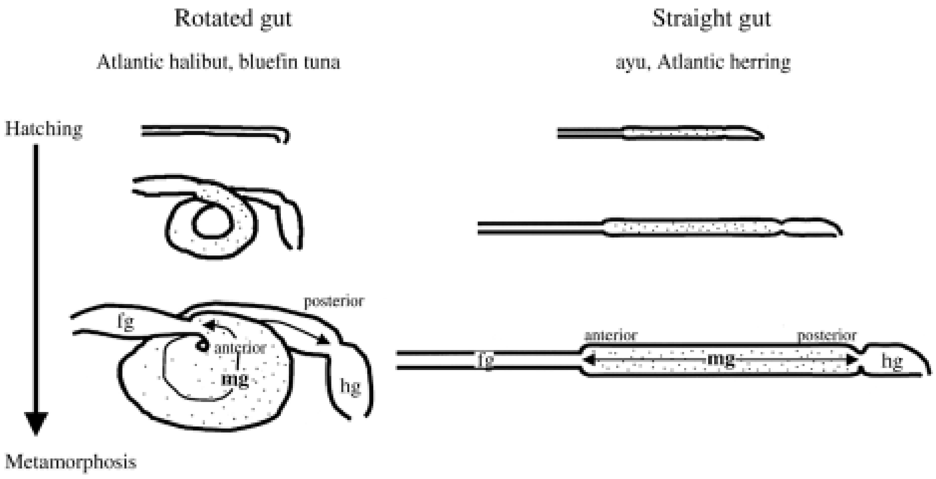

Figure 2.4: Schematic diagram of the different gut structures of larval fishes. fg foregut; mg midgut; hg hindgut

Table 2.1: Gut shape and length of seven dominant fish larvae families (adapted from Leis and Carson-Ewart, 2000)

Family	**Gut**	
	Shape	Length
Bregmacerotidae	Tightly coiled	Moderate length
Callionymidae	Round, coiled	At least midbody to over 75% BL
Cynoglossidae*	Thick, coiled, protruding	Initial 30-40% BL, then 20-30% BL
Engraulidae*	Straight	Moderate to very long (PAL >70%)
Gobiidae	Straight, coil before flexion	PAL ~ 50%
Leiognathidae*	Compact, coiled	PAL < 50%
Sciaenidae*	Compact, coiled	Moderate to long

BL – body length
PAL – pre-anal length
* - fish larvae families with commercial species

2.3.2 Limitations

Prey that are morphologically similar can be difficult to identify since digestion alters their size and shape (Planas and Cunha, 1999). Gut content analyses are also more biased towards recent dietary items and hard bodied prey that do not readily digest (Polito et al., 2011; Davis et al., 2012; Cresson et al, 2014). It is also difficult to quantify amorphous mass.

2.3.3 Gut Content Studies of Fish Larvae in Malaysia

Information about the feeding ecology of fish larvae in Malaysia is scarce. Little to no studies have been carried out to identify the diet of the early life stages of fish larvae from the fish larvae families, but these families have important commercial values or are abundant in the wild. Studies up to date indicate that fish larvae in Malaysian waters have a different feeding habit compared to the majority of larval fish diet studies. According to Ara et al. (2010), Gobiidae larval fish diet was composed of phytoplankton as the dominant prey, concluding that gobiid larvae were herbivorous. Another study by Arshad et al. (2013) showed a dominance of phytoplankton in the gut contents of Terapontidae larval fishes, concluding that the larval fishes in that family were also herbivorous. Phytoplankton was also the dominant food item in the gut content of fish larvae of families Sparidae, Blennidae and Clupeidae in Malaysian waters (Ara et al., 2009; Ara et al., 2011; Ara et al., 2016). Yet, all these studies did not take into account the plankton abundance in the environment in comparison with the diet of fish larvae, nor mention the ontogenic stages of the fish larvae.

2.3.4 Fish Larvae Families in this Study

Dominant fish larvae families in the Klang Strait include Bregmacerotidae, Callionymidae, Cynoglossidae, Engraulidae, Gobiidae, Leiognathidae and Sciaenidae (Chu, pers. comm.)(Figure 2.5). In this context, dominant fish larvae means that it is found to be present in a substantial amount in two time periods: 1985-86 and 2013-14. On top of being abundant in the area, fish larval families Cynoglossidae, Engraulidae, Leiognathidae and Sciaenidae consists of commercial species. Adult fishes from the families Bregmacerotidae and Engraulidae are pelagic whereas the other families Callionymidae, Cynoglossidae, Gobiidae, Leiognathidae and Sciaenidae are demersal (Sasekumar and Chong, 2005; Matsunuma et al., 2011). According to the classification of fishes by Ooi and Chong (2011), fishes can be classified to estuarine group, marine euryhaline group or stenohaline group depending on how the larval stage utilize the estuary. Gobiid fishes tend to be estuarine residents, utilizing the mangrove estuary as spawning and nursery ground. Fishes from the families Callionymidae, Engraulidae, Leiognathidae and Sciaenidae are from the marine euryhaline group that spawn in the sea but utilize the estuary when the fishes are in their larval stage. Fishes from the families Bregmacerotidae and Cynoglossidae are from the stenohaline group, which spawn only in offshore waters and their larvae may enter the estuary during the dry season.

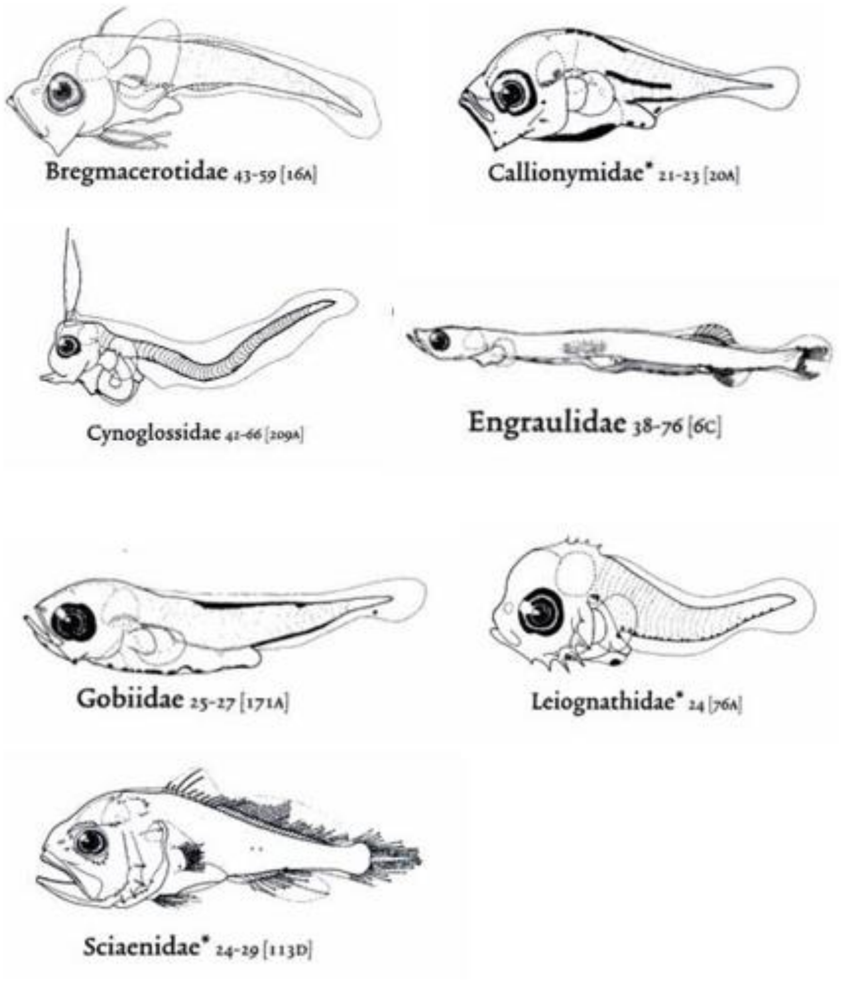

Figure 2.5: Schematic diagram of the anatomical features of larval fish families (from Leis and Carson-Ewart, 2000)

2.3.4.1 Bregmacerotidae

Bregmacerotidae are key coastal pelagic fish species being sought after piscivorous fishes due to its sheer abundance (Morohoshi & Sasaki, 2003; Siordia-Cermeño et al., 2006). Figure 2.6 shows the different ontogenic stages of Bregmacerotidae larvae. However, there are few studies on the diet of Bregmacerotidae larvae. A study by Siordia-Cermeno et al. (2006) showed that copepods dominated the diet of Bregmacerotidae larvae among zooplankton prey. Preflexion stages of Bregmacerotidae larvae prey on copepod nauplii and calanoid copepods before retaining calanoids and shifting towards harpacticoids (*Euterpina* spp.) as preferred prey in later ontogenic stages.

Figure 2.6: (a) Preflexion, (b) flexion and (c) postflexion stage of Bregmacerotidae

2.3.4.2 Callionymidae

Callionymidae fishes are popular in the marine aquarium trade. Adults are carnivores that feed primarily on polychaetes (Lopez-Jamar et al., 1984; King et al., 1994) and crustacean (Griffin et al., 2012). Figure 2.7 shows the different ontogenic stages of Callionymidae larvae. Callionymidae fish larvae are found to have a high daytime feeding incidence (Sánchez-Velasco, 1998), but the feeding habit is still poorly known. Sánchez-Velasco (1998) reported that *Callionymus* sp. larvae prefer copepodites of cyclopoids (*Oithona* spp. and *Oncaea* sp.) followed by copepodites of *Paracalanus* sp.. Sampey et al. (2007) reported copepods of the harpacticoids and cyclopoids (*Oithona*) family as the selected diet of Callionymidae fish larvae.

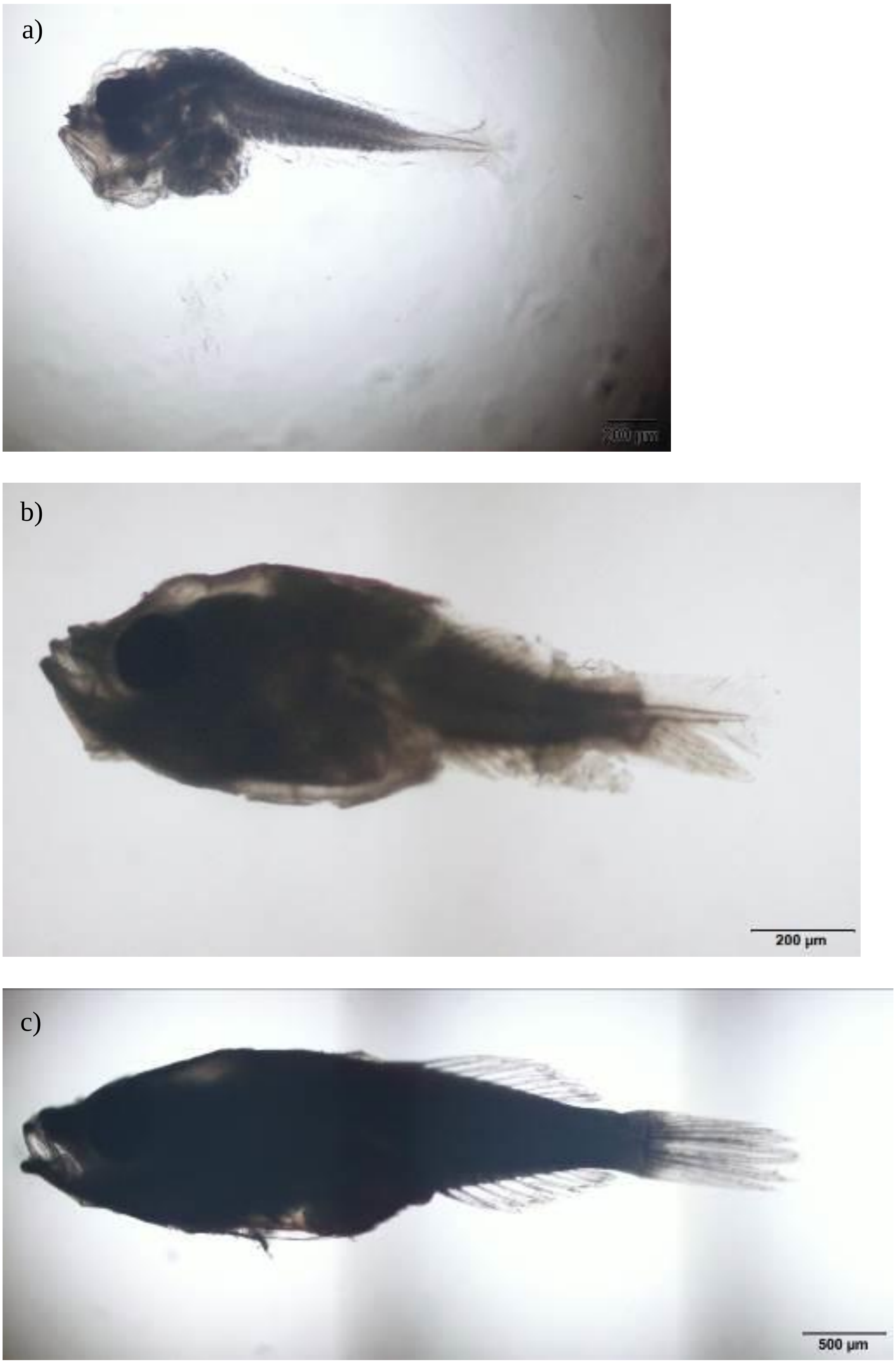

Figure 2.7: (a) Preflexion, (b) flexion and (c) postflexion stage of Callionymidae

2.3.4.3 Cynoglossidae

Adults are benthivores, feeding on amphipods, shrimps, crabs, gastropods, bivalves and ophiuroids (Baeck et al., 2011). Figure 2.8 shows the different ontogenic stages of Cynoglossidae larvae. Atabak (2011) reported that juveniles of Cynoglossidae (*Cynoglossus arel*) have a diet composed mainly of crustaceans, bivalves, amphipods and copepods. *Cynoglossus* sp. is also found to select small-sized prey (nauplii and harpacticoids) and shows increased feeding on Oncaeidae during ontogeny (Ostergaard et al., 2005). Sampey et al. (2007) reported a Cynoglossidae larval diet made up of calanoid, cyclopoid and oncaeid copepods.

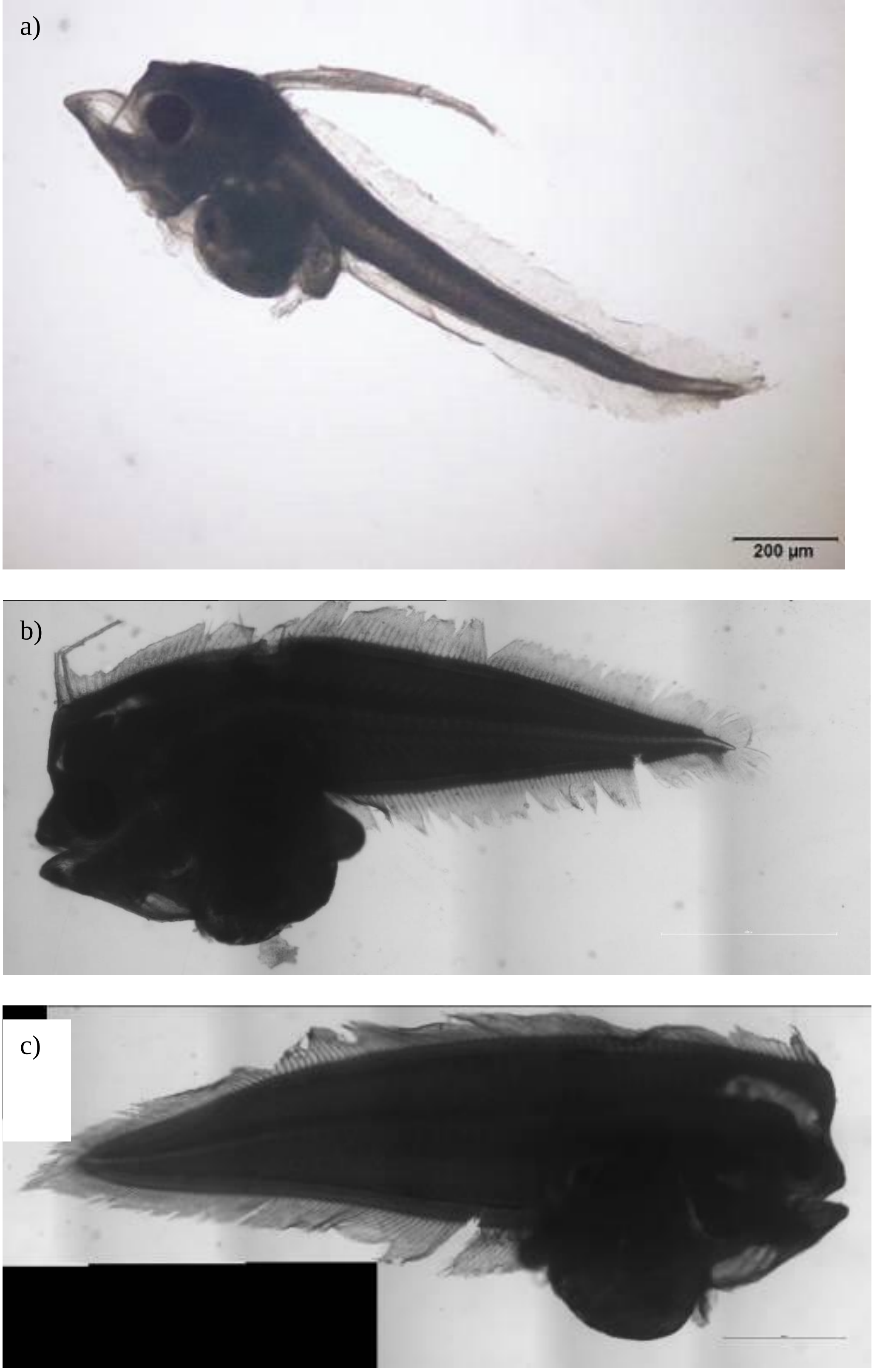

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Figure 2.8: (a) Preflexion, (b) flexion and (c) postflexion stage of Cynoglossidae

2.3.4.4 Engraulidae

Engraulidae are key species in energy transfer from lower to higher trophic levels, as they serve as prey for piscivorous fishes (Silva et al., 2010). Figure 2.9 shows the different ontogenic stages of Engraulidae larvae. Engraulidae larvae are zooplanktophagous, having a long and straight, striated gut and feed primarily on copepods and detritus. Engraulid fishes change their foraging habit from particulate feeding as a larvae to filter feeding as they grow in size. Feeding success is low for early stages of anchovy and highly dependent on prey encounter rate (Lima & Barletta, 2016). A study done by Kurtz and Matsuura (2001) reported a decrease in feeding incidence in engraulid species from preflexion to postflexion larvae stage, and is possibly related to the structure of the engraulid digestive tract, while another study by Choi et al. (2018) found that feeding incidence of engraulid larvae tend to increase with fish larvae size. Lima & Barletta (2016) reported species of this family as opportunistic feeders whereby their feed is dependent on prey abundance. *Cetengraulis edentulus* showed preference over calanoid copepods when the calanoid is the most abundant before shifting to zoeae of *Ucides cordatus* when the latter density is the highest. However, engraulids are seen to be selective in terms of prey size whereby large calanoid copepods are preferred over small copepods such as *Oithona* spp., which is not selected at all even though it is one of the dominant copepod categories in that environment (Suzuki et al., 2014). Choi et al. (2018) reported that ontogenic changes is seen in *Engraulis japonicus* as feeding frequency of copepods increased with increasing body size, while the amount of tintinnids that are initially preyed by engraulid larvae decrease with increasing body size and are absent in the diets of postflexion larvae. Seasonal changes in diet were also observed in the family Engraulidae (Yasue et al., 2011).

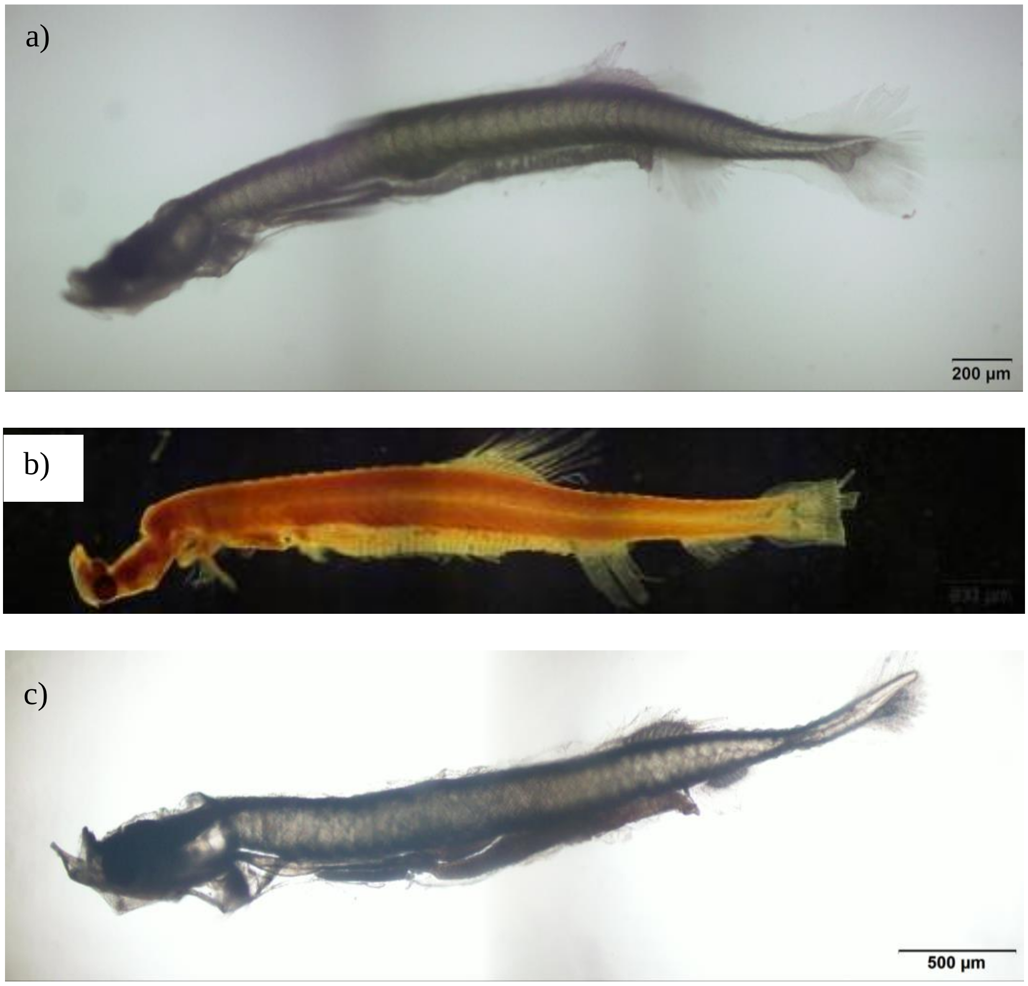

Figure 2.9: (a) Preflexion, (b) flexion and (c) postflexion stage of Engraulidae

2.3.4.5 Gobiidae

Gobiids spend most of their life histories within mangrove estuaries (Yokoo et al., 2009). Diet ranges from polychaetes (Gibson & Ezzi, 1978), to benthos (Costa et al., 2002) or detritus (Rodríguez & Villamizar, 2006). Gobiids are daytime visual feeders (D'Aguillo et al., 2014) and the Gobiidae fish larvae in Malaysia have a straight or gently curved gut (Ara et al., 2013). Figure 2.10 shows the different ontogenic stages of Gobiidae larvae. According to Wasserman (2012), early life stages of gobiids have a large dietary overlap before specialising towards a certain food as they get larger. Sampey et al. (2007) reported that Gobiidae fish larvae specialises on copepod prey with *Bestiolina similis* as their highly preferred prey.

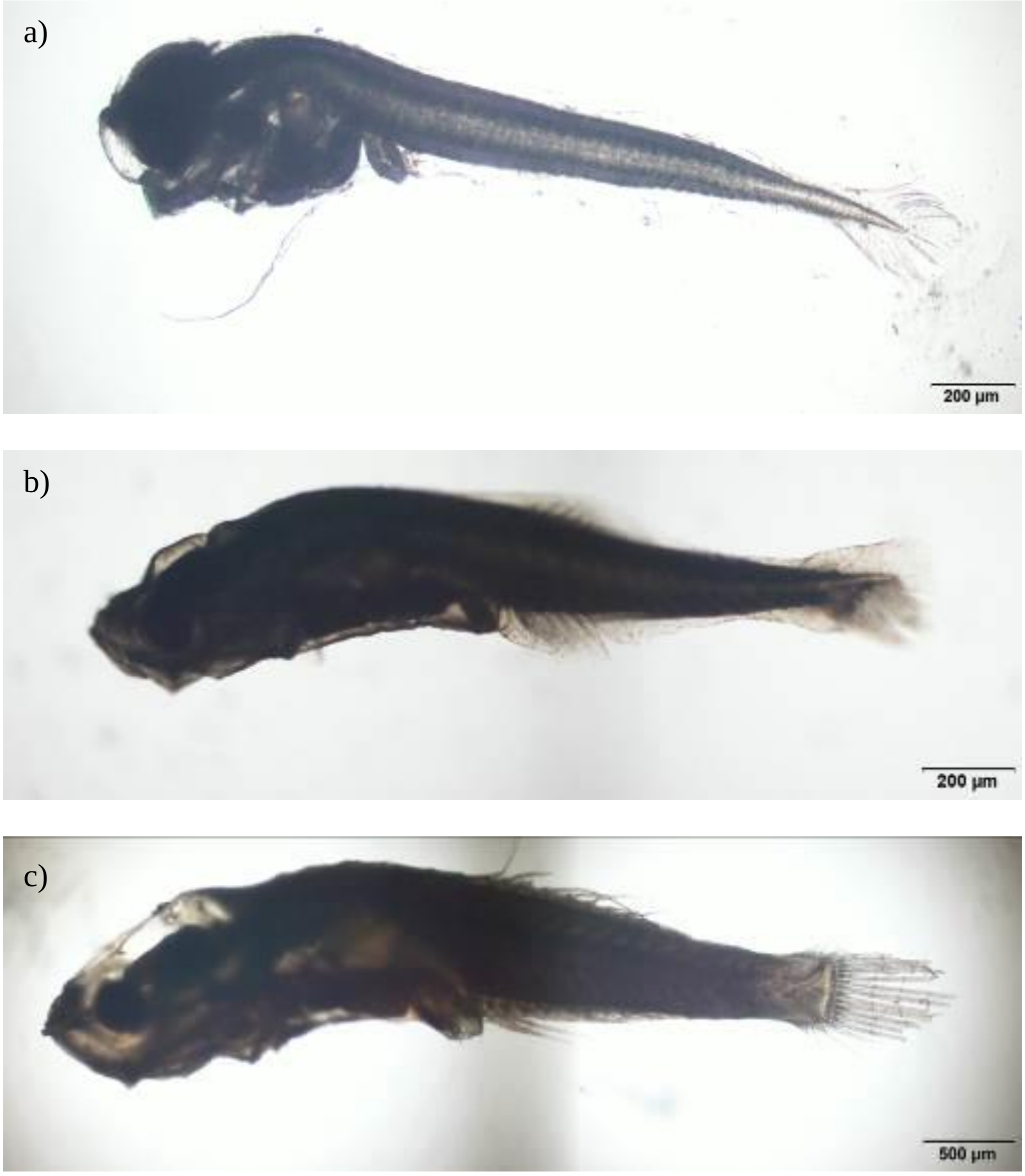

Figure 2.10: (a) Preflexion, (b) flexion and (c) postflexion stage of Gobiidae

2.3.4.6 Leiognathidae

Leiognathidae are benthopelagic fishes in coastal estuarine waters which are commercially important in Asian wild fisheries, but it lacks detailed ichthyological research (Seah et al., 2009). The adults live in coastal estuaries and are prey for commercial fish species (Soars and Leis, 2010). Figure 2.11 shows the different ontogenic stages of Leiognathidae larvae. Larvae of Leiognathidae have a compactly coiled gut (Ara et al., 2013) with flexion stages occurring at sizes ranging from 2.8 mm to 4.0 mm (Soars and Leis, 2010). Diet of this family is composed of primarily detritus, followed by polychaetes and copepods (Seah et al., 2009). Leiognathidae fish larvae highly prefer *Oithona attenuata* as its prey, even though it is not abundant in the environment (Sampey et al., 2007).

Figure 2.11: (a) Preflexion, (b) flexion and (c) postflexion stage of Leiognathidae

2.3.4.7 Sciaenidae

Sciaenidae fishes are from the Order Perciformes. Adult sciaenid species have been found to prey on bony fishes, decapods, non-decapod crustaceans and polychaetes (Willis et al., 2015). Figure 2.12 shows the different ontogenic stages of Sciaenidae larvae. Ontogenic shifts in diet is seen in Sciaenidae larvae. A study by Manetta et al. (2011) found that Sciaenidae larvae in the preflexion stage prefer phytoplankton before shifting to zooplankton (Manetta et al., 2011), while Picapedra et al. (2018) found that the same family of fish larvae selects the cladoceran *Bosmina hagmanni* as prey before shifting to the calanoid copepod *Argyrodiaptomus furcatus* as the fish larvae gets larger in size. The same study showed that young stages of copepods and cyclopoids were not preferred by the sciaenid larvae (Picapedra et al., 2018).

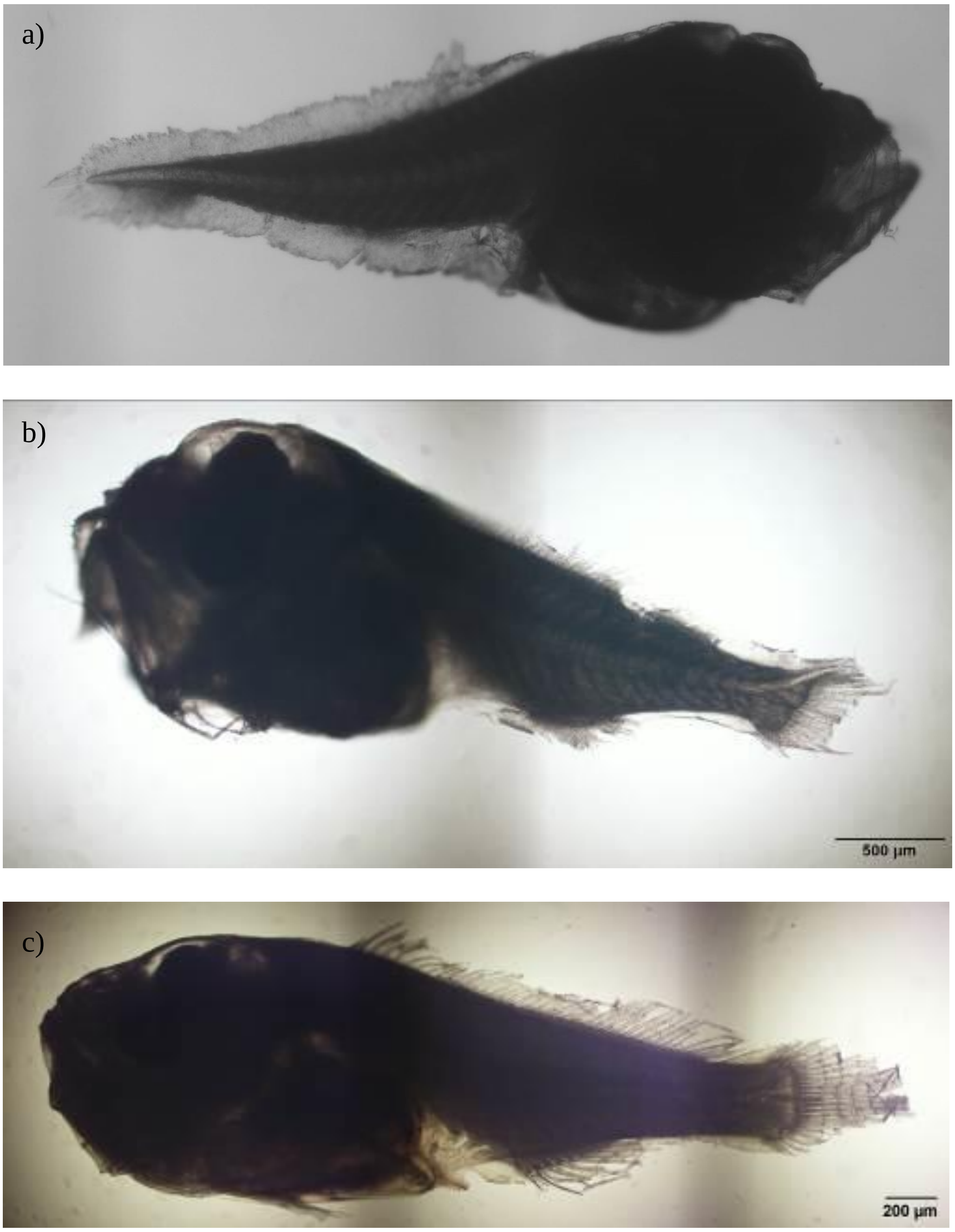

Figure 2.12: (a) Preflexion, (b) flexion and (c) postflexion stage of Sciaenidae

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Site

The study area is located in Klang Strait, the southwest region of Peninsular Malaysia (Figure 3.1) (Chew et al., 2015; Chew and Chong, 2016). The local climate is dictated by monsoons, namely the northeast (NE) (November to March) and the southwest (SW) (May to September) monsoons. The inter-monsoon periods fall in April and October. Mangroves are the main coastal vegetation along Klang Strait, but it has deteriorated due to rapid development including the establishment and operation of the KPS in 1987. KPS is a thermal power station that began operation in 1987 and runs primarily on coal and secondarily on gas.

Five stations (I, C1, C2, C3 and C4) forming an 18-km line transect were selected in this study (Figure 3.1). The control station C4 was located furthest from KPS and assumed to be the least impacted station. The most impacted station (I) was located 45 m from KPS, and the interval distance between two stations was 4.5 km. Each station has at least two sets of replicates in time periods 1985-86 and 2013-14 to examine the ecological impacts in Klang Strait. Water parameters (temperature, salinity, pH and dissolved oxygen) were measured at each station (Chew et al., 2015).

A comparison of physical water parameters in the Klang Strait between the two time periods: in relation to operation of KPS (time period 1985-86) and nearly 30 years after (time period 2013-14) showed an increase in temperature and a decrease in pH but not much changes in salinity (Chew et al., 2015). Operation of KPS concurrent with coastal development, removal of mangroves, euthrophication and other anthropogenic changes collectively caused this change.

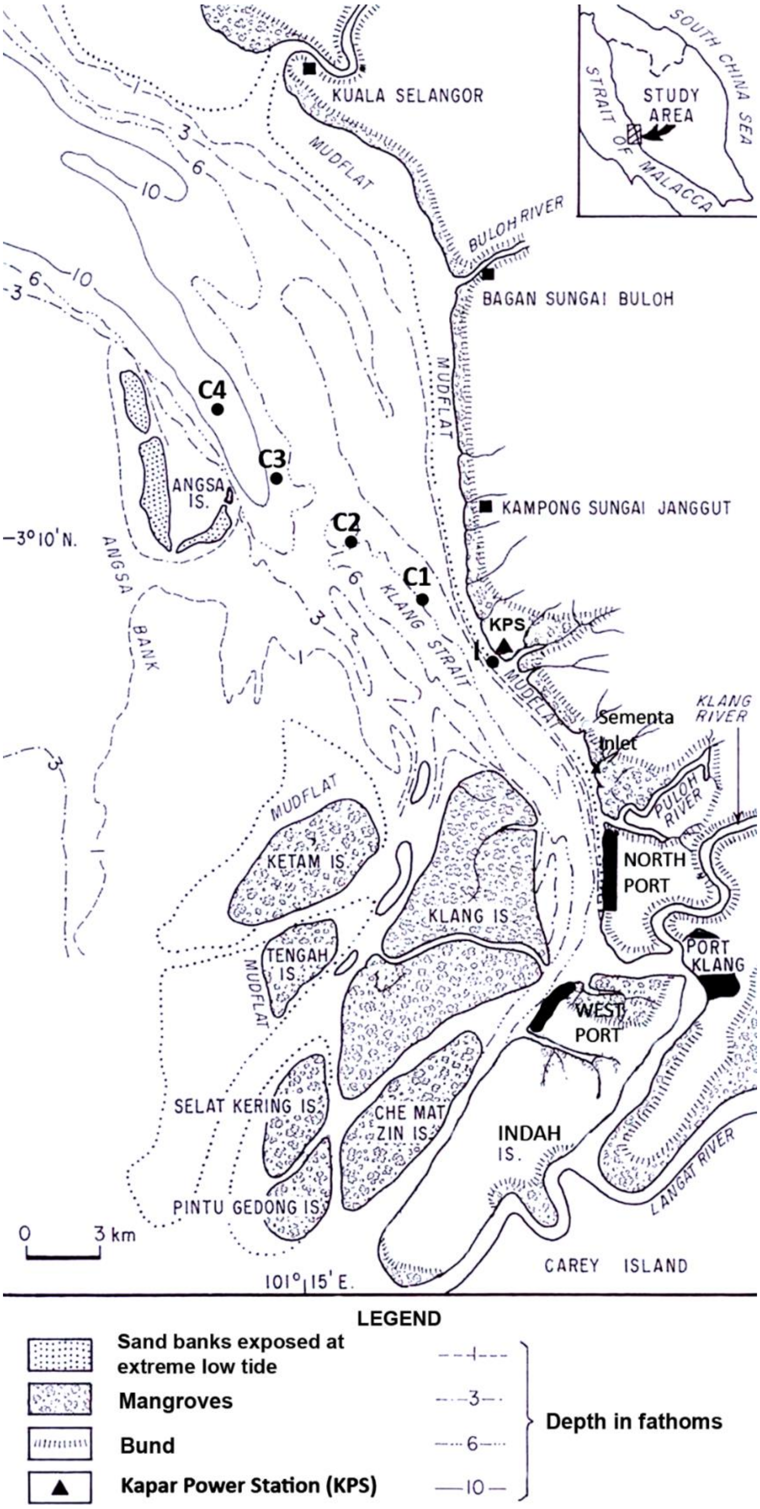

Figure 3.1: Map of sampling locations in Klang Strait (Chew et al., 2015)

3.1.1 Field Sampling

Fish larvae samples were collected during two time periods: in relation to operation of KPS (August 1985 to October 1986) and nearly 30 years after (August 2013 to April 2014). Both archived fish larvae samples were collected by Prof. Chong Ving Ching (in time period 1985-86 before operation of KPS) and Dr. Chew Li Lee (in time period 2013-14). Sampling was conducted at least once per month. The parallel fish larvae and zooplankton samples were collected through 45 cm diameter oblique-towed bongo nets of two sizes (383 µm and 180 µm mesh size, respectively) and preserved using 4% borax-buffered formaldehyde in seawater. The environmental parameters including sea surface temperature, pH and salinity for both time periods were reported in Chew et al. (2015).

3.2 Laboratory Work

3.2.1 Fish Larvae Identification and Measurement

Fish larvae were identified to family level by Chu (PhD in preparation). A total of seven families of fish larvae were examined in this study, which were codlets (Bregmacerotidae), dragonets (Callionymidae), tonguefishes (Cynoglossidae), anchovies (Engraulidae), gobies (Gobiidae), ponyfishes (Leiognathidae) and drums/croakers (Sciaenidae). These seven families were selected because they were present in both time periods 1985-86 and 2013-14, making them the dominant larval fish families in the Klang Strait. Fish larvae samples in their respective time periods are pooled because there is no significant difference in total larval abundance among stations.

The fish larvae were categorized into their life stages based on the flexion of the notochord. The length (notochord length in preflexion and flexion larvae, standard length in postflexion larvae) for each fish was measured using cellSens imaging software under a Olympus BX50-CCD compound microscope (Figure 3.2). For larvae that were not straight and have noticeable bends, the length was measured in successive increments from the tip of the snout of the fish larvae till the tip of the notochord for preflexion and flexion larvae, and till the posterior end of the hypural plate for postflexion larvae. Possible shrinkage in length due to long term preservation was ignored.

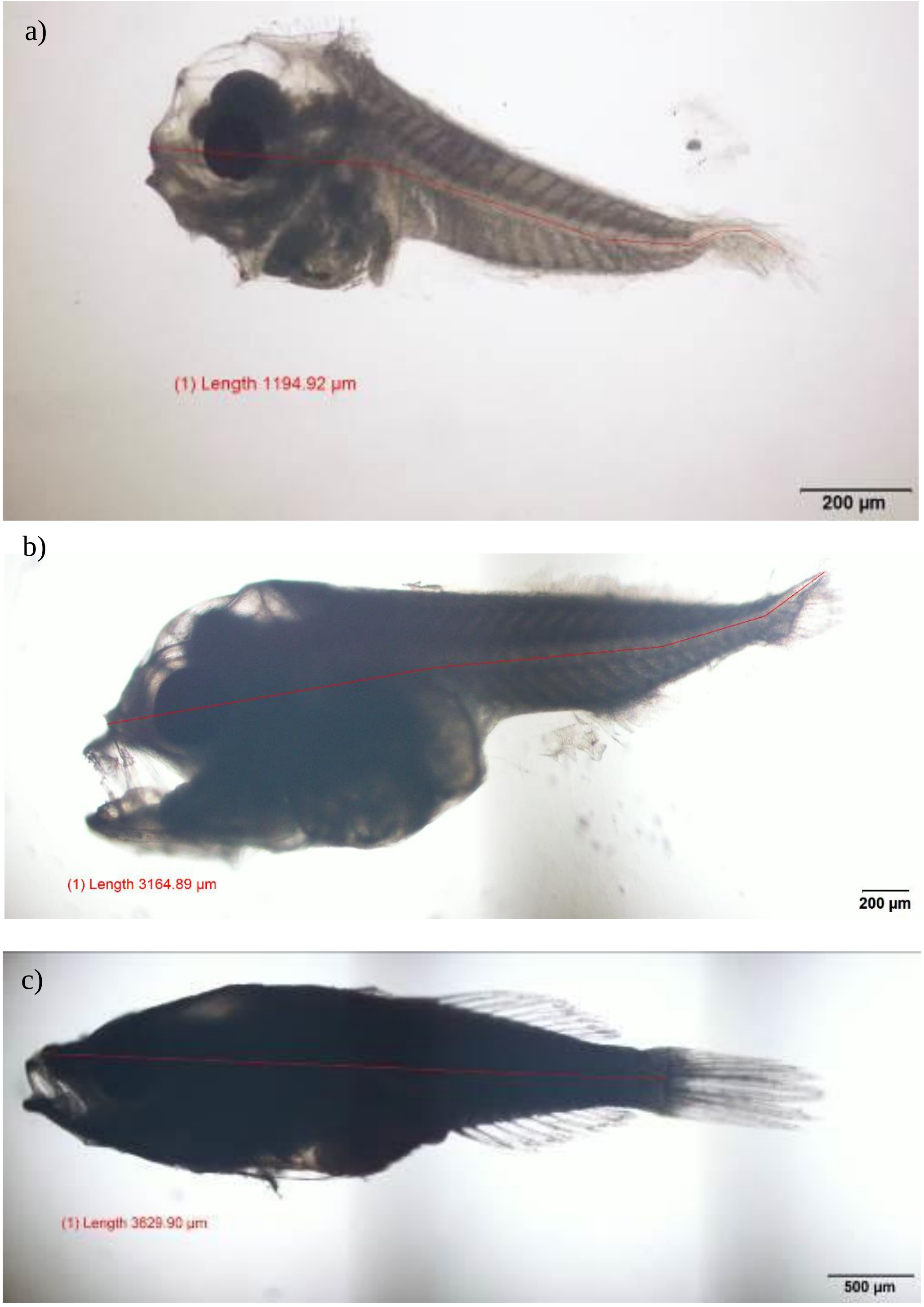

Figure 3.2: Measurement of notochord length in (a) preflexion and (b) flexion larvae, and standard length in (c) postflexion larvae

3.2.2 Examination of Fish Larvae Gut Contents

Gut contents of the identified fish larvae (at family level) from the samples were analysed under a Leica Stereo MZ8 stereo microscope. The whole gut was removed from the fish larvae and dissected using fine needles (Figure 3.3). The whole gut excluding the oesophagus was examined due to the relatively small size of fish larvae with no well-defined stomach. The prey items were enumerated on the Sedgewick Rafter counting cell (Figure 3.3). They were then separated to be photographed under the Olympus BX50-CCD camera.

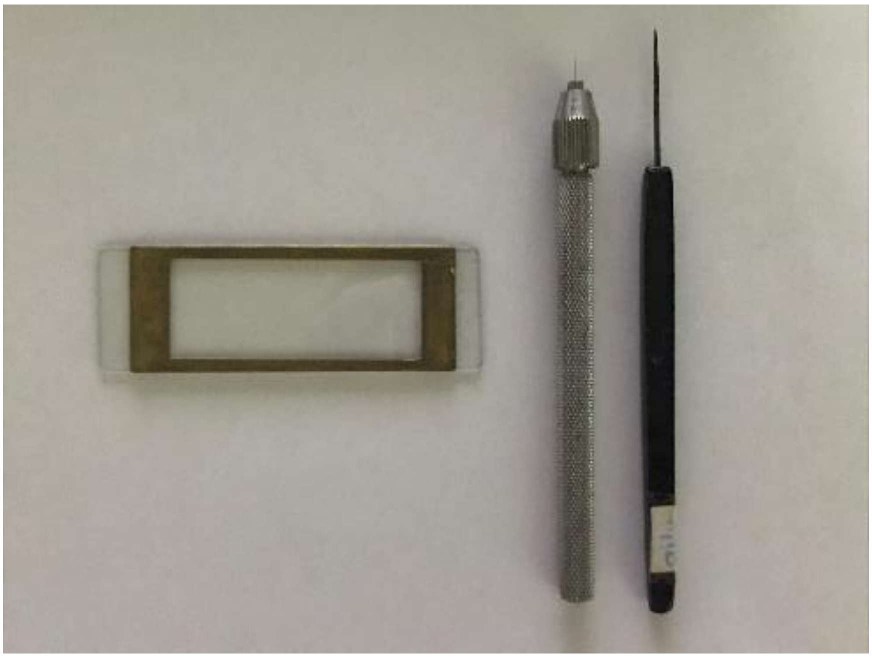

Figure 3.3: Fine needles used for dissection and Sedgewick Rafter counting cell to enumerate prey found in gut of fish larvae

3.2.3 Identification of Major Diet Groups

Gut contents of the fish larvae were identified to the lowest possible taxonomic level depending on the state of digestion. Various food taxa are known to be digested at different rates, for instance e.g. protozoans took a shorter time to be digested in the gut of fish larvae compared to zooplankton. The identified food items were categorized and quantified by area through the cellSens imaging software using Olympus BX50-CCD compound microscope.

3.3 Data Analysis

3.3.1 Feeding Incidence

Feeding incidence was calculated as

Percentage feeding incidence = $(n/n_i) \times 100$

where n is the number of larvae that had prey present in the gut and n_i is the total number of larvae examined

3.3.2 Quantification of Diet Composition

Composition of the stomach contents was quantified using frequency of occurrence (% FO), percentage numerical abundance (% N) and volumetric percentage (% V).

Percentage frequency of occurrence (% FO) = $(N/N_i) \times 100$

where N is the number of stomachs containing one or more prey taxa and N_i is the number of non-empty stomachs.

Percentage numerical abundance (% N) = $n_i \sum n_i \times 100$

where n is the number of prey taxa in each diet group and n_i is the total number of prey items.

Percentage volumetric (% V) = $(V/V_i) \times 100$

where V is the volume of each prey taxa and V_i is the total volume of gut contents.

Area of the prey items found in the gut was measured using the cellSens imaging software over the Sedgewick Rafter counting cell. The height of the Sedgewick Rafter counting cell is 1 mm therefore the volume of the prey taxa was estimated to be Area x 1mm.

Percentage Index of Relative Importance (% IRI) was then used to quantify the importance of different prey items in the fish larvae diet. IRI was calculated using the formula below (Cortes, 1997).

IRI = (% N + % V) × % FO

whereby % N, % V and % FO represent percentages of numerical abundance, volumetric and frequency of occurrence, respectively.

Prey taxa with percentage frequency of occurrence contribution of <1% for either periods 1985-86 or 2013-14 were grouped into a category called ‘Others’.

3.3.3 Multivariate Analysis

One-way analysis of variance (ANOVA) was used to test any significant differences between the length of fish larvae families during the time period 1985-86 and time period 2013-14 (Picquelle and Mier, 2011). For fish larvae families that showed a significant difference in length, Fisher’s post hoc least significant difference (LSD) test was then used to determine which of the stages of fish larvae have a significant effect (Fisher, 1935). ANOVA and Fisher’s LSD tests were performed using Statistica Version 8 software. Analysis of similarities (ANOSIM) was used to test for significant dietary composition of larval fishes between two time periods as well as ontogenic shift in diet of these larval fishes in their respective sampling period (Clarke, 1993; Clarke and Warwick, 2001). Prior to ANOSIM, % IRI data was arcsine-transformed and used to construct a resemblance matrix based on Bray-Curtis similarity coefficient (Bray and Curtis, 1957). ANOSIM test was performed using PRIMER 6 software. A two-dimensional principal component analysis (PCA) was then generated from the arcsine-transformed % IRI data to show feeding patterns among the fish larvae families. Fish larvae were separated according to time periods, families and ontogenic stages. Prey taxa subjected to PCA were selected when the % IRI contribution was >1%. Redundancy Analysis (RDA) was used to illustrate the correlation between zooplankton prey in the gut of larval fishes and zooplankton abundance in the environment. Environmental data used to run the RDA was the zooplankton abundance data obtained from Chew (pers. comm) in the Klang Strait for both time periods. Twenty-one zooplankton families, which were important in terms of abundance and occurrence in the Klang Strait were selected for this analysis. Prior to RDA, prey abundance data were $\log_{10}$ (x+1) and arcsine-transformed, respectively. Both PCA and RDA were performed using Canoco 4.5 software (Ter Braak and Smilauer, 2002).

CHAPTER 4

RESULTS

4.1 Length and Stage of Fish Larvae

The length and stages of fish larvae examined for the time periods 1985-86 and 2013-14 were tabulated (Table 4.1). In this study, fish larvae were separated into three ontogenic stages: preflexion, flexion and postflexion stages depending on the flexion of the notochord.

In time period 1985-86, the highest number of fish larvae examined that were in their preflexion stage compared to other stages were of families Bregmacerotidae, Callionymidae and Cynoglossidae. In time period 2013-14, gobiids and sciaenids were the larval families with highest number of fish larvae examined to be in their preflexion stage. Engraulidae in their preflexion stages is the highest number examined for both time periods. More numbers of postflexion stages of fish larvae were examined for bregmacerotids and callionymids compared to other ontogenic stages in time period 2013-14.

Table 4.1: Length and stages of fish larvae examined for time periods 1985-86 and 2013-14 in the Klang Strait

Fish larvae family **Stage**	**Total**	**Average length range (mm)**
Bregmacerotidae		
1985-86		
Preflexion	39	2.28 ± 1.07
Flexion	15	4.68 ± 0.81
Postflexion	16	6.71 ± 3.72
2013-14		
Preflexion	8	2.26 ± 1.37
Flexion	15	5.76 ± 0.83
Postflexion	17	8.16 ± 0.72
Callionymidae		
1985-86		
Preflexion	4	1.14 ± 0.16
Flexion	1	2.66
Postflexion	3	1.71 ± 0.41
2013-14		
Preflexion	13	1.88 ± 0.26
Flexion	18	2.50 ± 0.42
Postflexion	29	3.17 ± 0.66
Cynoglossidae		
1985-86		
Preflexion	13	2.03 ± 0.79
Flexion	3	4.01 ± 0.21
Postflexion	1	5.53
2013-14		
Preflexion	41	1.80 ± 0.73
Flexion	26	3.31 ± 0.70
Postflexion	8	5.15 ± 0.88
Engraulidae		
1985-86		
Preflexion	17	3.53 ± 0.72
Flexion	2	5.21 ± 0.22
Postflexion	7	4.77 ± 0.22
2013-14		
Preflexion	13	4.07 ± 0.75
Flexion	6	4.24 ± 0.82
Postflexion	4	4.98 ± 1.17

Table 4.1 (continued)

Fish larvae family Stage	**Total**	**Average length range (mm)**
Gobiidae		
1985-86		
Preflexion	20	1.31 ± 0.31
Flexion	18	1.95 ± 0.61
Postflexion	65	2.73 ± 1.76
2013-14		
Preflexion	77	1.17 ± 0.45
Flexion	22	1.85 ± 0.78
Postflexion	9	2.27 ± 0.78
Leiognathidae		
1985-86		
Preflexion	11	1.72 ± 0.30
Flexion	14	2.50 ± 0.83
Postflexion	5	1.95 ± 0.55
2013-14		
Preflexion	6	1.66 ± 0.54
Flexion	6	2.20 ± 0.67
Postflexion	4	2.46 ± 0.55
Sciaenidae		
1985-86		
Preflexion	31	1.55 ± 0.67
Flexion	26	2.31 ± 0.73
Postflexion	40	3.04 ± 0.98
2013-14		
Preflexion	56	1.92 ± 0.58
Flexion	19	2.59 ± 0.68
Postflexion	13	3.72 ± 0.57

Comparison of fish larvae size between time period 1985-86 and 2013-14 found that there is a significant increase in size for fish larvae families Bregmacerotidae ($p<0.01$), Engraulidae ($p<0.05$) and Sciaenidae ($p<0.01$) but a significant decrease in size for gobiids ($p<0.01$)(Table 4.2). Post hoc Fisher’s LSD test showed that only the postflexion stage of Bregmacerotidae larvae and the preflexion and postflexion stages of Sciaenidae larvae showed a significant difference in length after 30 years.

Table 4.2: Results of ANOVA test on length of fish larvae families between the time periods 1985-86 and 2013-14

Analysis of Variance	**Variable**	**LSD test**		
Fish larvae families	**Length**	**Preflexion**	**Flexion**	**Postflexion**
Bregmacerotidae	**	ns	ns	*
Callionymidae	ns	*	ns	**
Cynoglossidae	ns	ns	ns	Ns
Engraulidae	*	ns	ns	Ns
Gobiidae	**	ns	ns	Ns
Leiognathidae	ns	ns	ns	Ns
Sciaenidae	**	*	ns	**

*p<0.05, **p<0.01

4.2 Feeding Incidence

Feeding incidence of the 7 dominant fish larvae families in the Klang Strait for time periods 1985-86 and 2013-14 is shown in Table 4.3. The feeding incidence of fish larvae families Callionymidae, Cynoglossidae and Sciaenidae was higher than families such as Engraulidae, Gobiidae and Leiognathidae. For time period 2013-14, there was a higher feeding incidence across all stages for family Bregmacerotidae but a lower feeding incidence across all stages for family Callionymidae as compared to time period 1985-86. Gobiidae, Leiognathidae and Sciaenidae larvae families showed the lowest feeding incidence for preflexion stages as compared to their older stages for both time periods. All flexion engraulid larvae examined for time period 1985-86 had empty guts. Engraulid larvae in time period 1985-86 showed an increase in feeding incidence whereas they showed a decrease in feeding incidence in time period 2013-14 as they were going through their ontogenic stages.

Table 4.3: Feeding incidence of 7 dominant fish larvae families in the Klang Strait for time periods 1985-86 and 2013-14

Family	Ontogenic Stage	Total dissected	Number of empty guts	Non-empty guts	Feeding Incidence (%)
Bregmacerotidae					
1985-86	Total	70	23	47	67.14
	Preflexion	39	11	28	71.79
	Flexion	15	4	11	73.33
	Postflexion	16	8	8	50.00
2013-14	Total	40	4	36	90.00
	Preflexion	8	0	8	100.00
	Flexion	15	2	13	86.67
	Postflexion	17	2	15	88.24
Callionymidae					
1985-86	Total	8	0	8	100.00
	Preflexion	4	0	4	100.00
	Flexion	1	0	1	100.00
	Postflexion	3	0	3	100.00
2013-14	Total	60	6	54	90.00
	Preflexion	13	4	9	69.23
	Flexion	18	1	17	94.44
	Postflexion	29	1	28	96.55
Cynoglossidae					
1985-86	Total	17	2	15	88.24
	Preflexion	11	0	11	100.00
	Flexion	3	0	3	100.00
	Postflexion	3	2	1	33.33
2013-14	Total	75	4	70	93.33
	Preflexion	40	4	36	90.00
	Flexion	26	0	26	100.00
	Postflexion	8	0	8	100.00
Engraulidae					
1985-86	Total	26	7	19	73.08
	Preflexion	17	4	13	76.47
	Flexion	2	2	0	0.00
	Postflexion	7	1	6	85.71
2013-14	Total	23	7	16	69.57
	Preflexion	13	3	10	76.92
	Flexion	6	2	4	66.67
	Postflexion	4	2	2	50.00

Table 4.3 (continued)

Family	Ontogenic Stage	Total dissected	Number of empty guts	Non-empty guts	Feeding incidence (%)
Gobiidae					
1985-86	Total	103	31	72	69.90
	Preflexion	20	9	11	55.00
	Flexion	18	5	13	72.22
	Postflexion	65	17	48	73.85
2013-14	Total	108	41	67	62.04
	Preflexion	77	33	44	57.14
	Flexion	22	5	17	77.27
	Postflexion	9	3	6	66.67
Leiognathidae					
1985-86	Total	30	9	21	70.00
	Preflexion	11	7	4	36.36
	Flexion	14	1	13	92.86
	Postflexion	5	1	4	80.00
2013-14	Total	16	4	12	75.00
	Preflexion	6	3	3	50.00
	Flexion	6	1	5	83.33
	Postflexion	4	0	4	100.00
Sciaenidae					
1985-86	Total	97	5	92	94.85
	Preflexion	31	2	29	93.55
	Flexion	26	1	25	96.15
	Postflexion	40	2	38	95.00
2013-14	Total	88	7	81	92.05
	Preflexion	56	7	49	87.50
	Flexion	19	0	19	100.00
	Postflexion	13	0	13	100.00

4.3 Dietary Composition for both time periods 1985-86 and 2013-14

A total of 611 guts containing food items were examined in seven fish larvae families. There were 46 prey items identified among the 13 different major groups of food items such as Bivalvia, Chaetognatha, Cirripedia, Copepoda, Decapoda, detritus, diatoms, foraminiferans, Ostracoda, plant matter, protozoa, Sabellariidae and unidentified materials (Table 4.4). Table 4.5 shows the taxonomy of identified prey in guts of fish larvae in the Klang Strait whereas Figure 4.1 (a), (b) and (c) shows the prey from gut contents of fish larvae in the Klang Strait. The group Bivalvia was only found in the gut of fish larvae family Cynoglossidae. The group Chaetognatha was also only found in the gut of one fish larvae family, Engraulidae. Cirripedia was found in the gut of three fish larvae families; Callionymidae, Cynoglossidae and Sciaenidae; which was further identified to its nauplii or cyprids stage. Copepoda was found in the gut of all the fish larvae families examined. Copepoda identified in the gut was represented by 15 families. Decapoda was found in the gut of three fish larvae families; Bregmacerotidae, Cynoglossidae and Sciaenidae; which was further identified as brachyuran zoeae or Diogenidae zoeae. Detritus was found in the gut of all the fish larvae families. Diatom was found in the gut of Callionymidae, Cynoglossidae, Gobiidae, Leiognathidae and Sciaenidae. Foraminiferans were only found in the gut of gobiids. Ostracoda was found in the gut of one fish larvae family as well, Cynoglossidae. Plant matter was found in the gut of five fish larvae families; Callionymidae, Cynoglossidae, Engraulidae, Gobiidae and Sciaenidae. Protozoa was found in the gut of two fish larvae families; Bregmacerotidae and Sciaenidae. Sabellariidae was found in the gut of four fish larvae families; Callionymidae, Cynoglossidae, Leiognathidae and Sciaenidae. Unidentified materials were found in the gut of all fish larvae families except Sciaenidae. Prey taxa in the gut of fish larvae with percentage frequency of occurrence contribution of <1% for either periods 1985-86 or 2013-14 consisted of bivalves, arrow worms, cirripede nauplii and cyprids, brachyuran zoeae, Diogenidae zoeae, diatoms, foraminiferans, ostracods, plant matter, protozoa and unidentified materials.

Table 4.4: Major food items found in the guts of fish larvae in the Klang Strait

Major group	Food items
1. Bivalvia	Bivalves
2. Chaetognatha	Arrow worms
3. Cirripedia	Cirripede nauplii, cirripede cyprids
4. Copepoda	Acartiidae, Paracalanidae, Centropagidae, copepod egg, copepod nauplii, Corycaeidae, Euchaetiidae, Euterpinidae, Clausidiidae, Pontellidae, Ectinosomatidae, Oithonidae, Pseudodiaptomidae, Macrochironidae, Eucalanidae, Tortanidae
5. Decapoda	Brachyuran zoeae, Diogenidae zoeae
6. Detritus	Detritus
7. Diatom	Diatom
8. Foraminiferan	Foraminiferans
9. Ostracoda	Ostracods
10. Plant matter	Plant matters
11. Protozoa	Protozoa
12. Sabellariidae	Polychaete larvae
13. Unidentified materials	Unidentified materials

Table 4.5: Taxonomy of identified prey in gut of fish larvae in the Klang Strait

Order	**Family**	**Genus, Species, common name**	**Abbreviation**
Bivalvia		bivalve	Biv
Chaetognatha		chaetognath	Chae
Cirripedia	Cirripedia	cirripede cyprids	CirC
		cirripede nauplii	CirN
Copepoda		Copepod egg	CE
		Copepod fragments	CF
		Copepod nauplii	CN
	Acartiidae	*Acartia* sp.	AS
	Calanidae	*Cantocalanus pauper*	Cp
	Centropagidae	*Centropages furcatus*	Cf
	Corycaeidae	*Corycaeus andrewsi*	Ca
		Corycaeus sp.	CS
		Ditrichocorycaeus asiaticus	Da
	Euchaetiidae	*Euchaeta concinna*	Ec
	Euterpinidae	*Euterpina acutifrons*	Ea
	Clausidiidae	*Hemicyclops* sp.	HS
	Pontellidae	*Labidocera* sp.	LS
	Ectinosomatidae	*Microsetella norvegica*	Mn
	Oithonidae	*Oithona attenuata*	Oa
		Oithona brevicornis	Ob
		Oithona dissimilis	Od
		Oithona simplex	Os
		Oithona sp.	OS

Table 4.5 (continued)

Order	Family	Genus, Species, common name	Abbreviation
Copepoda	Paracalanidae	*Acrocalanus gibber*	Ag
		Bestiolina similis	Bs
		Paracalanus aculeatus	Pa
		Paracalanus sp1	Ps1
		Parvocalanus crassirostris	Pc
		Paracalanus sp.	PS
	Pseudodiaptomidae	*Pseudodiaptomus bowmani*	Pb
		Pseudodiaptomus nauplii	Pbn
	Macrochironidae	*Pseudomacrochiron* sp.	Pseu
	Eucalanidae	*Subeucalanus subcrassus*	Ss
		Subeucalanus subcrassus copepodite	Ssc
		Subeucalanus subcrassus nauplii	Ssn
	Tortanidae	*Tortanus* sp.	TS
Decapoda	Decapoda	brachyuran zoeae	Bra
	Diogenidae	diogenid zoeae	Dio
Detritus		detritus	Det
Diatom		diatom	Dia
Foraminiferan		foraminiferans	For
Ostracoda		ostracod	Ost
Plant		plant matter	Pla
Protozoa		ciliates	Pro
Sabellariidae		polychaete larvae	Poly
Unidentified		unidentified	UI

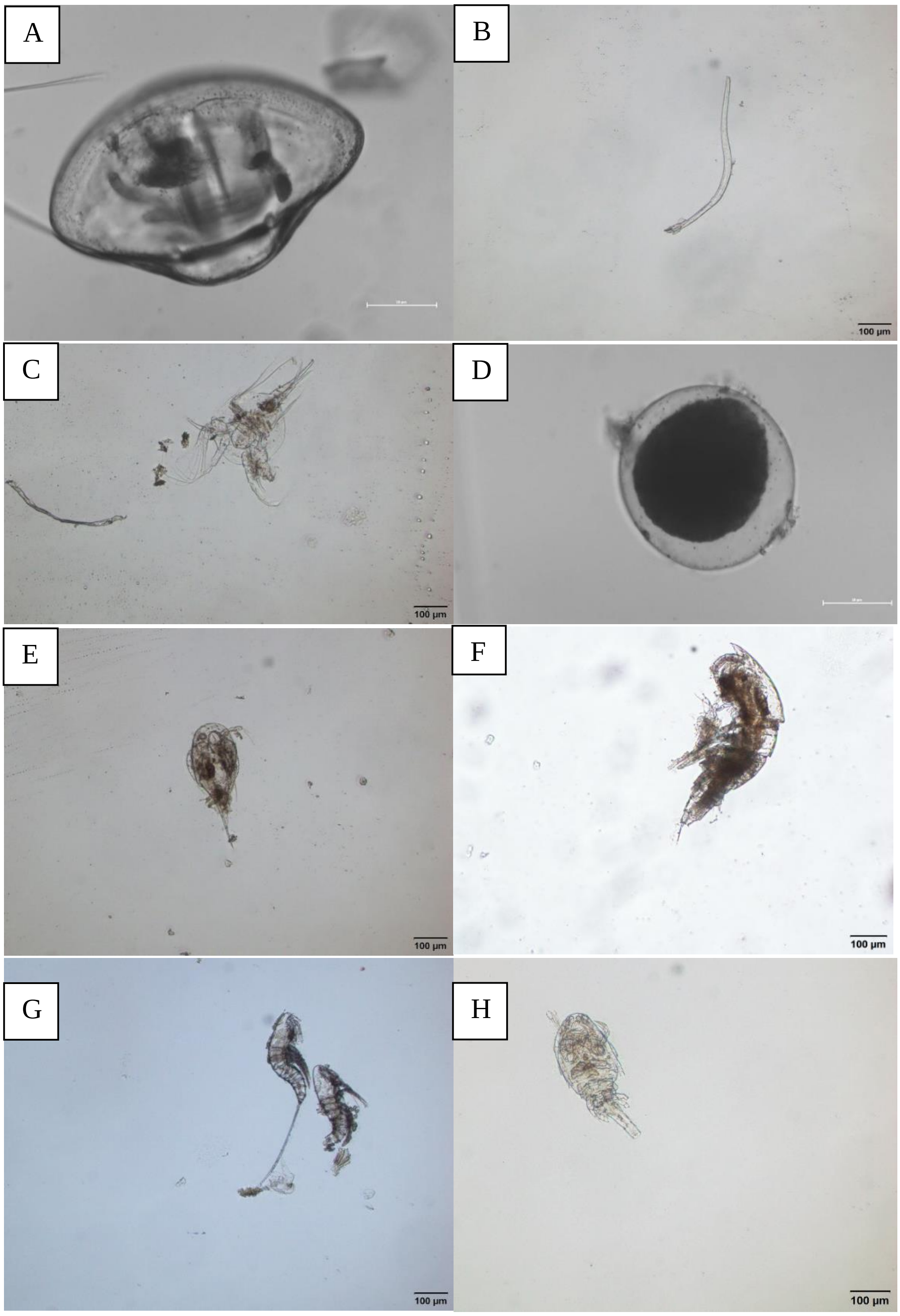

Figure 4.1(a): Identified prey taxa from gut contents of fish larvae in the Klang Strait. A Bivalve. B Arrow worm. C Cirripede nauplii. D Copepod egg. E Copepod nauplii. F *Euterpina acutifrons*. G *Microsetella norvegica*. H *Oithona* sp.

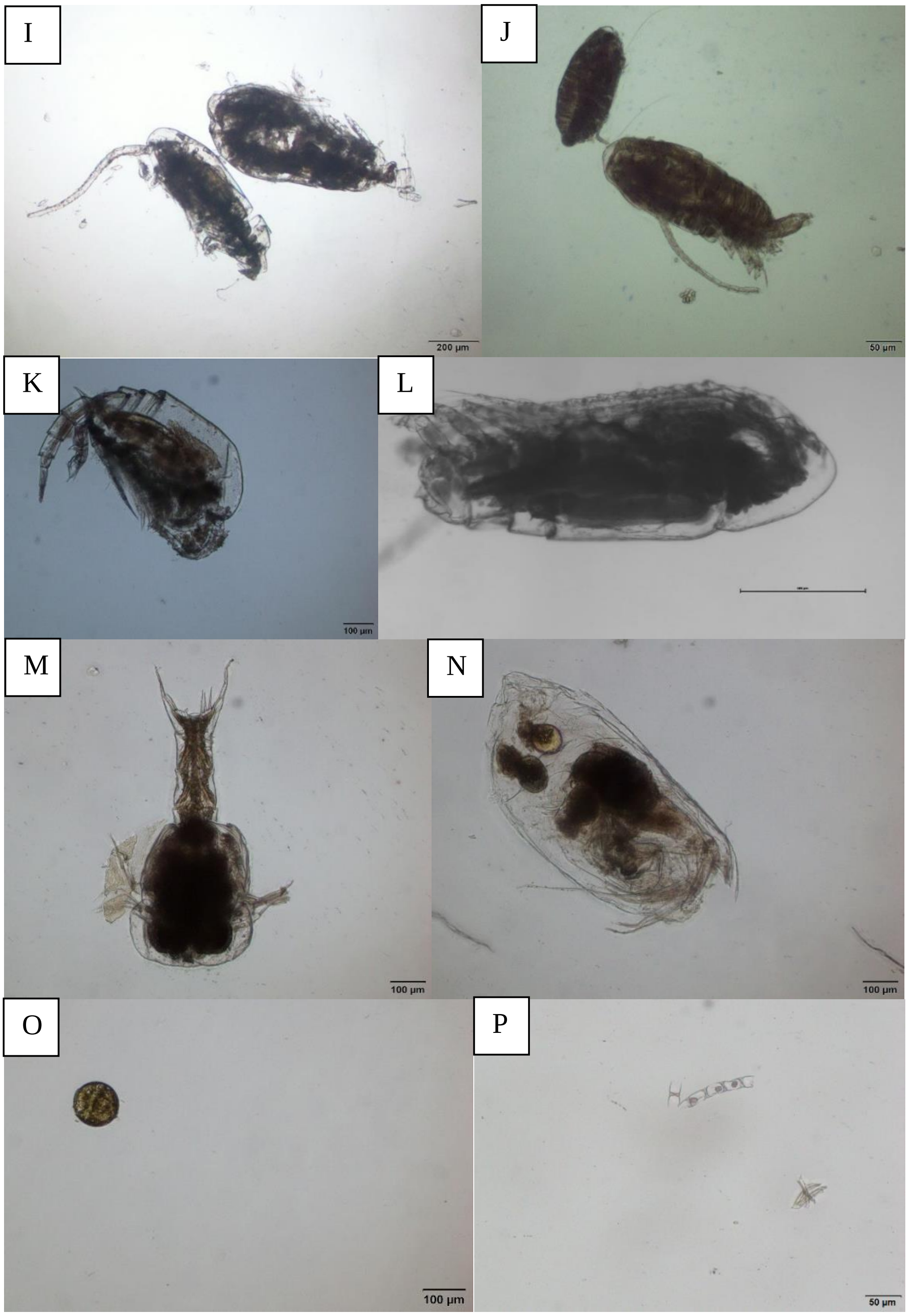

Figure 4.1(b): Identified prey taxa from gut contents of fish larvae in the Klang Strait. I *Paracalanus aculeatus* & *Acrocalanus gibber*. J *Paracalanus aculeatus* & *Parvocalanus crassirostris*. K *Pseudodiaptomus bowmani*. L *Subeucalanus subcrassus*. M Brachyuran zoeae. N Ostracod. O & P Diatom

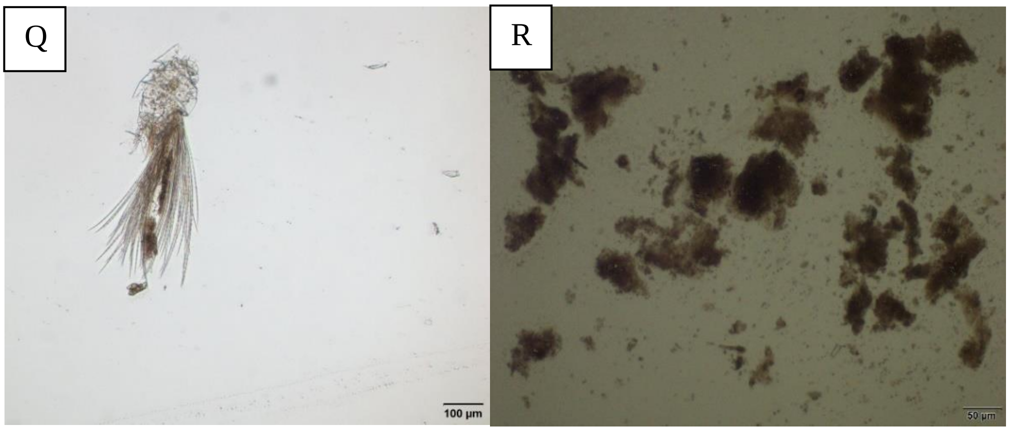

Figure 4.1(c): Identified prey taxa from gut contents of fish larvae in the Klang Strait. Q Polychaete setae. R Detritus

4.4 Diet of Larval Fish Families

4.4.1 Bregmacerotidae

Figure 4.2 shows the diet composition for Bregmacerotidae fish larvae in the Klang Strait. Copepods, decapods, detritus, protozoa and unidentified materials were the five major groups identified in the gut of Bregmacerotidae larvae. Other than detritus that was only found in the gut of Bregmacerotidae larvae in time period 1985-86 and protozoa that was only found in the gut of Bregmacerotidae larvae in time period 2013-14, the remaining major groups were found present in the gut for both time periods. A total of seven families of copepods that made up of Acartiidae, Paracalanidae, Calanidae, Corycaeidae, Pontellidae, Pseudodiaptomidae and Eucalanidae were preyed upon by Bregmacerotidae larvae in time period 1985-86. Four copepod families that were preyed upon in time period 2013-14 were the Centropagidae, Oithonidae, Paracalanidae and Eucalanidae.

Families of copepods not found in the gut of Bregmacerotidae larvae in time period 2013-14 were Acartiidae, Calanidae, Corycaeidae, Pontellidae and Pseudodiaptomidae which are the large-bodied copepods. Oithonidae being small-bodied copepods that composed of 6.11% IRI and 1.66% IRI were found in the gut of flexion and postflexion stages of Bregmacerotidae larvae in time period 2013-14 but not found in the gut of all ontogenic stages of Bregmacerotidae larvae in time period 1985-86.

There is a significant change in diet composition when comparing between time period 1985-86 and 2013-14 ($p<0.01$) (Table 4.6). All stages of bregmacerotids showed significant differences in diet composition after nearly 30 years ($p<0.01$)(Table 4.7). Copepod fragments were ranked as the most important prey for time period 1985-86 for preflexion (84.94% IRI), flexion (92.40% IRI) and postflexion (86.22% IRI) stages of Bregmacerotidae larvae. They fed mainly on family Paracalanidae, where the top three identified prey were *Paracalanus* sp., *Paracalanus aculeatus* and *Parvocalanus crassirostris,* based on the calculated % N, % V and % FO (Appendix). In time period 2013-14, copepods of the family Paracalanidae (81.26% IRI) ranked the highest as the most important prey for the preflexion larvae and was replaced by *Subeucalanus subcrassus* in the flexion (55.64% IRI) and postflexion (87.16% IRI) stages of Bregmacerotidae larvae.

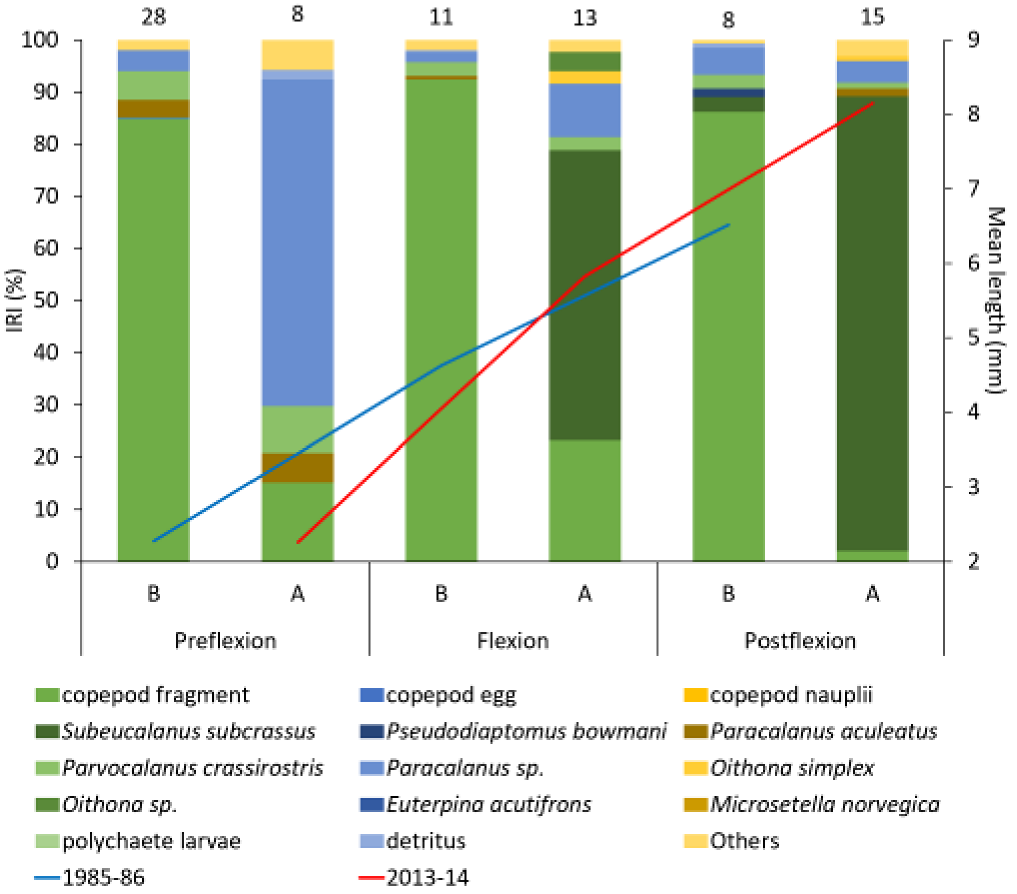

Figure 4.2: Diet composition of Bregmacerotidae larvae based on IRI according to stages and time periods 1985-86 (B) and 2013-14 (A). Number on top of bar represents total fish larvae examined with prey present in gut

4.4.2 Callionymidae

Figure 4.3 shows the diet composition for fish larvae of the family Callionymidae. Diet of Callionymidae larvae in time period 1985-86 consisted of four major groups which are copepods, detritus, diatoms and unidentified materials. The diet increased to seven major groups in time period 2013-14, incorporating cirripedes, plant matter and polychaete larvae. Four copepod families (Ectinosomatidae, Pseudodiaptomidae, Eucalanidae and Tortanidae) were found in the gut of Callionymidae larvae in time period 2013-14 on top of the four families (Paracalanidae, Corycaeidae, Oithonidae and Euterpinidae) found in the gut of Callionymidae larvae during time period 1985-86. Larvae of Callionymidae showed a more diverse diet in time period 2013-14 as compared to time period 1985-86.

Copepod fragments (47.82% IRI) and *Parvocalanus crassirostris* (31.13% IRI) were the main prey items for preflexion and postflexion stages of Callionymidae larvae in time period 1985-86, respectively. In time period 2013-14, copepod nauplii (48.93% IRI) become the main prey item for preflexion stages while postflexion stages preferred Oithonids (32.33% IRI). Only one flexion larvae from time period 1985-86 was examined and *Oithona* sp. (60.10% IRI) and *Euterpina acutifrons* (39.90% IRI) were found in its gut. In time period 2013-14, *Parvocalanus crassirostris* (41.08% IRI) was the main prey item for Callionymidae larvae in their flexion stage based on IRI. There was a significant ontogenic shift in diet between preflexion and flexion larval stages in time period 2013-14 ($p<0.01$) (Table 4.9).

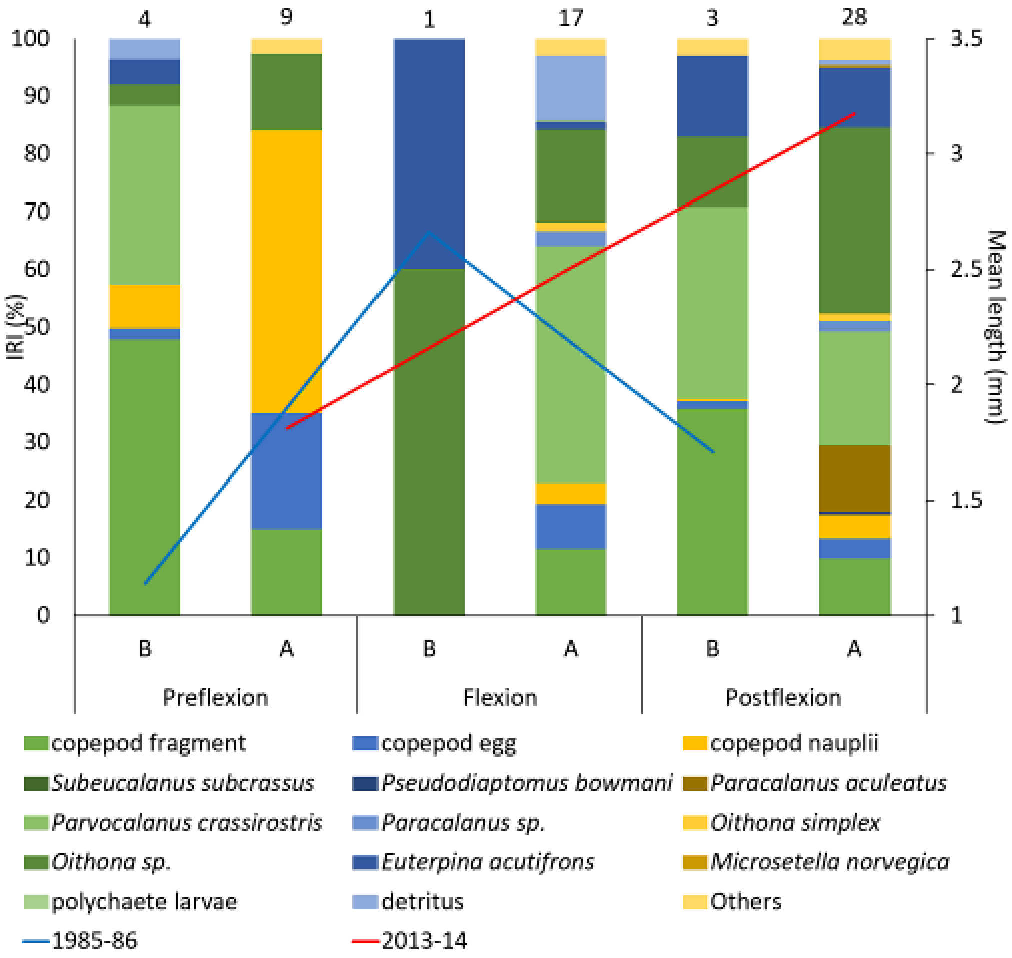

Figure 4.3: Diet composition of Callionymidae larvae based on IRI according to stages and time periods 1985-86 (B) and 2013-14 (A). Number on top of bar represents total fish larvae examined with prey present in gut

4.4.3 Cynoglossidae

Figure 4.4 shows Cynoglossidae larvae diet composition for time period 1985-86 and 2013-14 according to their stages. A total of five major groups which consisted of cirripedes, copepods, diatom, polychaete larvae and unidentified materials were preyed by Cynoglossidae larvae for both time periods. Ostracods (2.59% IRI in gut of preflexion larvae and 1.01% IRI in gut of flexion larvae) and plant matter (0.39% IRI in gut of preflexion larvae) were only found in time period 1985-86 whereas bivalves (0.09% IRI in gut of flexion larvae), decapods (0.10% IRI Brachyuran in gut of flexion larvae and 0.48% IRI Diogenid in gut of postflexion larvae) and detritus (0.99% IRI in gut of preflexion larvae and 0.94% IRI in gut of flexion larvae) were only found in time period 2013-14.

Copepods dominated the diet followed by polychaete larvae and ostracods. Copepod families that were found in the gut of Cynoglossidae larvae for both time periods were Paracalanidae, Oithonidae, Euterpinidae, Ectinosomatidae and Eucalanidae. Copepods of the family Corycaeidae were only preyed on in time period 2013-14. The main food items in the guts of preflexion cynoglossids in time period 1985-86 were copepod fragments (28.99% IRI) and *Parvocalanus crassirostris* (20.63% IRI). In time period 2013-14, copepod nauplii (28.49% IRI), *Microsetella norvegica* (19.37% IRI) and polychaete larvae (16.42% IRI) were of higher importance in the diet of the preflexion cynoglossids. *Parvocalanus crassirostris* (30.16% IRI), *Paracalanus* sp1 (16.88% IRI) and *Oithona* sp. (27.07% IRI) were found to be important prey for flexion cynoglossids in time period 1985-86. *Microsetella norvegica* gained importance in the diet of flexion cynoglossids from 1.06% IRI in time period 1985-86 to 27.31% IRI in time period 2013-14 whereas *Parvocalanus crassirostris* (26.74% IRI) still remained as one of the main prey after 30 years. As for postflexion cynoglossids, only one fish larvae were examined in time period 1985-86 and cirripede cyprids, copepod fragments (9.09% IRI), *Euterpina acutifrons* (19.93% IRI), *Oithona* sp. (7.82% IRI), *Paracalanus aculeatus* (15.12% IRI), *Paracalanus* sp. (15.57% IRI) and unidentified materials (8.27% IRI) were found in its gut. *Paracalanus aculeatus* (22.96% IRI) and *Parvocalanus crassirostris* (18.84% IRI) were the most important prey for postflexion cynoglossids in time period 2013-14 followed by *Euterpina acutifrons* (14.31% IRI), *Oithona* sp. (13.16% IRI) and copepod egg (12.25% IRI).

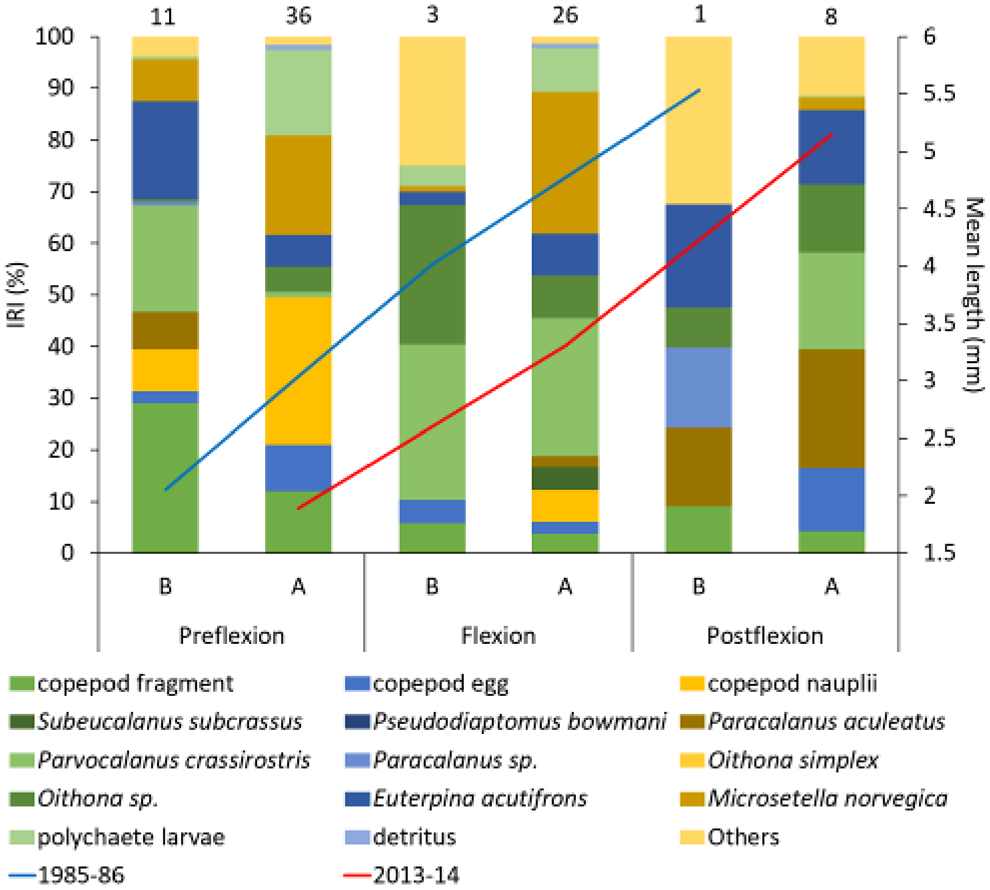

Figure 4.4: Diet composition of Cynoglossidae larvae based on IRI according to stages and time periods 1985-86 (B) and 2013-14 (A). Number on top of bar represents total fish larvae examined with prey present in gut

4.4.4 Engraulidae

Diet composition of fish larvae for Family Engraulidae by stages according to Index of Relative Importance (% IRI) in the Klang Strait is shown in Figure 4.5. Diet of fish larvae for family Engraulidae in time period 1985-86 consisted of chaetognaths, copepods, plant matter and unidentified materials whereas the diet consisted of only copepods and detritus in time period 2013-14. There was also a drop of copepod families being preyed on from Paracalanidae, Oithonidae and Euterpinidae in time period 1985-86 to only paracalanids and oithonids in time period 2013-14.

A comparison in diet composition between both time periods showed a significant change ($p<0.01$) (Table 4.6). Engraulid larvae preyed mainly on copepods in time period 1985-86 and there was a shift in feeding from oithonids to paracalanids as they metamorphosed into older stages. In time period 2013-14, oithonids retained their importance in engraulid larvae diet across all stages. Detritus that composed of 33.79% IRI and 66.38% IRI were also found in the gut of preflexion and flexion stages of engraulid larvae, but not present in the gut of postflexion engraulids.

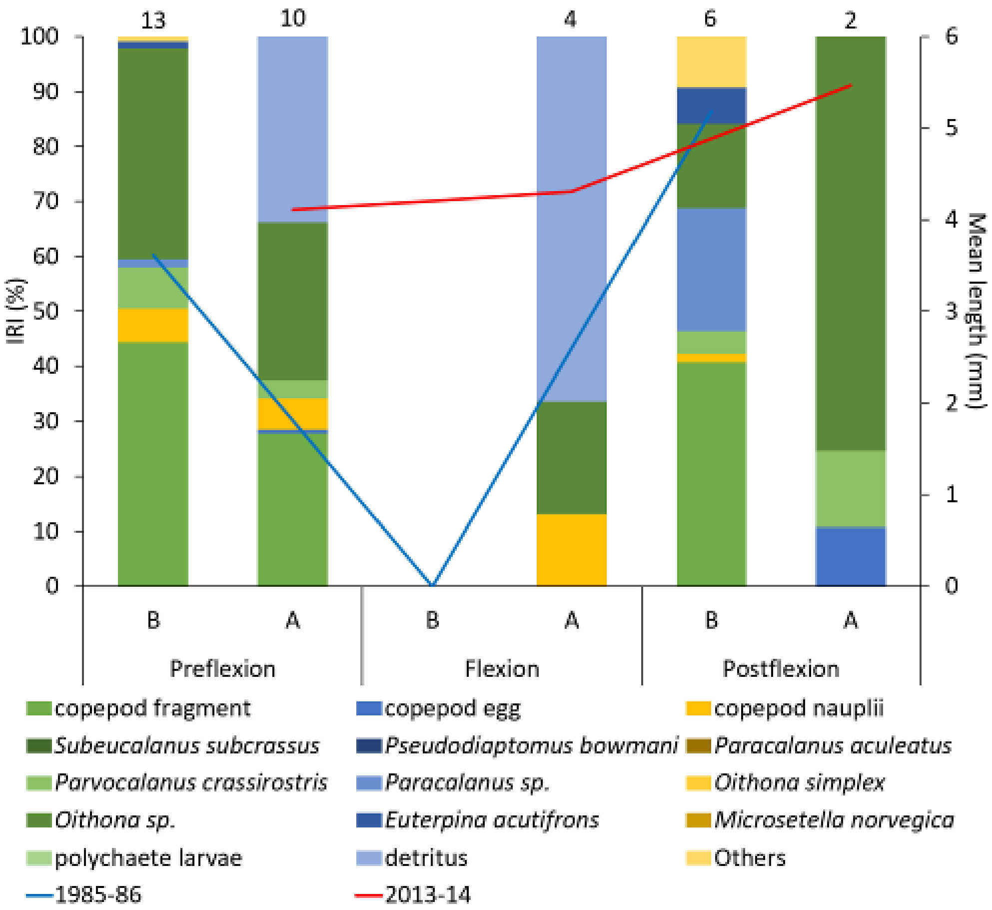

Figure 4.5: Diet composition of Engraulidae larvae based on IRI according to stages and time periods 1985-86 (B) and 2013-14 (A). Number on top of bar represents total fish larvae examined with prey present in gut

4.4.5 Gobiidae

Diet composition of fish larvae for Family Gobiidae according to Index of Relative Importance (% IRI) in the Klang Strait is shown in Figure 4.6. Foraminiferans and plant matter were only found in time period 1985-86 in the gut of Gobiidae larvae whereas diatoms were only found in time period 2013-14 in the gut. Copepods, detritus and unidentified materials were the major groups found in the gut of gobiid larvae for both time periods. Out of the six copepod families (Paracalanidae, Pseudodiaptomidae, Pontellidae, Oithonidae, Euterpinidae and Ectinosomatidae) that were preyed on by gobiid larvae in time period 1985-86, two copepod families (Pontellidae and Ectinosomatidae) were no longer preyed in time period 2013-14.

Gobiids exhibited a significant change in feeding after 30 years ($p<0.01$) (Table 4.6). Further tests according to larval stages showed postflexion gobies to have significant differences in diet after 30 years ($p<0.05$) (Table 4.7). In time period 1985-86, *Oithona* sp. that made up of 41.26% IRI and 61.20% IRI ranked highest in importance as prey item for both preflexion and flexion gobiids before being replaced by *Parvocalanus crassirostris* as the most important prey item with 46.89% IRI for postflexion gobiids. ANOSIM tests showed significant ontogenic differences in diet between their flexion and postflexion stages ($p<0.05$) (Table 4.8). In time period 2013-14, copepod nauplii is an important prey item for gobiid larvae across all stages, constituting 48.03% IRI, 28.04% IRI and 17.62% IRI in its preflexion, flexion and postflexion stage, respectively. *Parvocalanus crassirostris* and *Oithona* sp. still constituted part of the diet of gobiid larvae after 30 years, but the harpacticoids (*Euterpina acutifrons* and *Microsetella norvegica*) were no longer fed on.

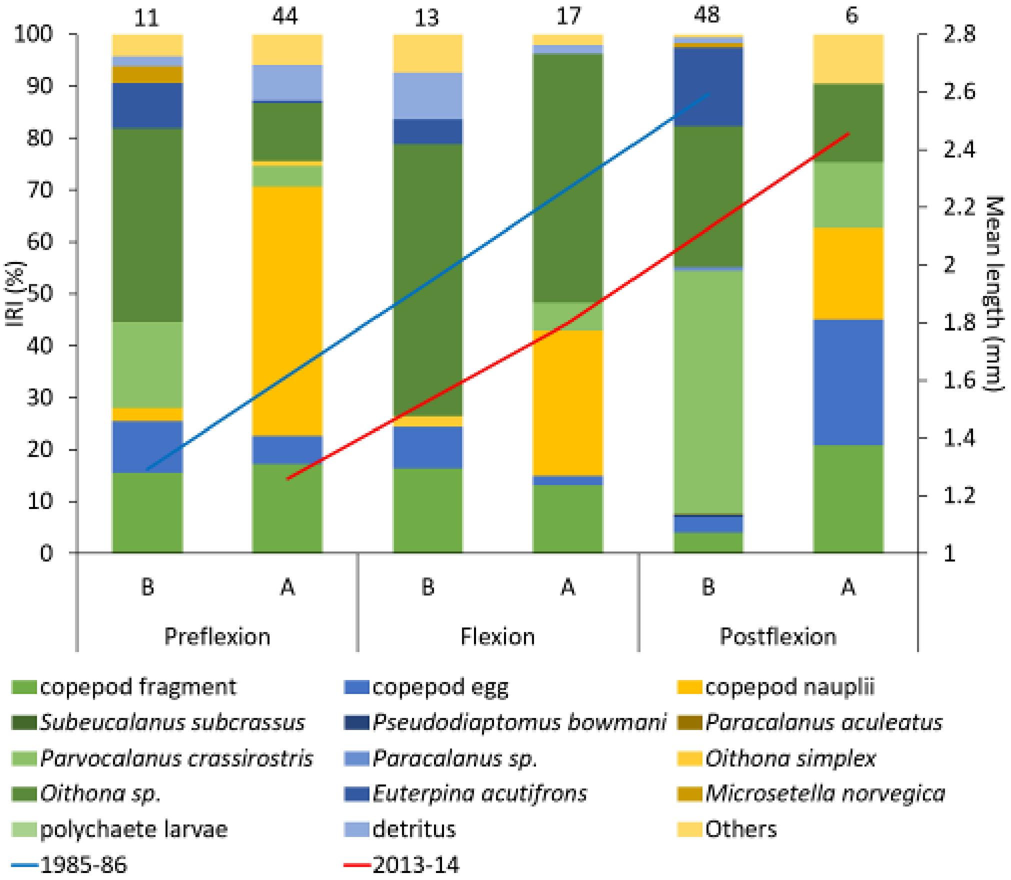

Figure 4.6: Diet composition of Gobiidae larvae based on IRI according to stages and time periods 1985-86 (B) and 2013-14 (A). Number on top of bar represents total fish larvae examined with prey present in gut

4.4.6 Leiognathidae

Figure 4.7 shows the diet composition of fish larvae for Family Leiognathidae according to stages in the Klang Strait. Leiognathidae larvae preyed on four major groups: copepods, detritus, polychaete larvae and unidentified materials during both time periods 1985-86 and 2013-14. Diatoms were only found in the gut of Leiognathidae larvae in time period 2013-14. Copepods comprising two families being preyed on were Paracalanidae and Oithonidae and they were only found in the gut of flexion and postflexion Leiognathidae larvae during time period 1985-86.

Detritus was the most important prey item for preflexion and flexion Leiognathidae larvae for both time periods. As for postflexion leiognathids, polychaete larvae were the most important prey item. Significant ontogenic shift in diet was found between flexion and postflexion stages of leiognathids in time period 1985-86 ($p<0.05$) (Table 4.8).

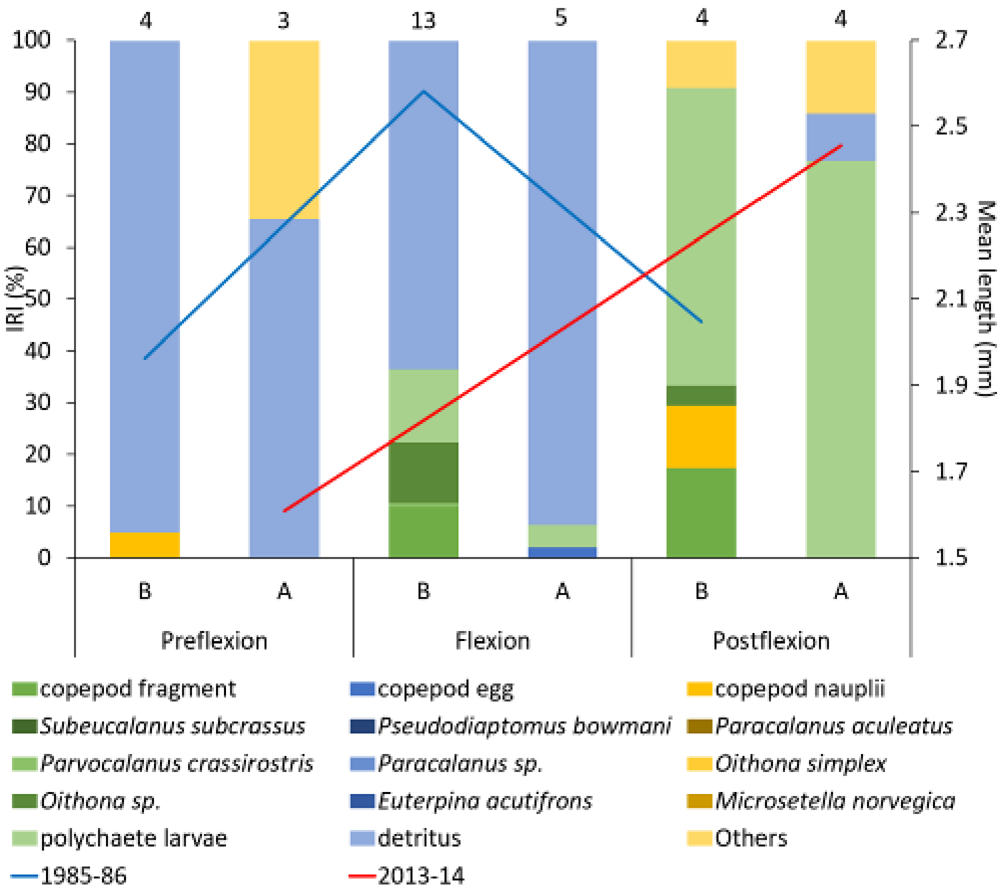

Figure 4.7: Diet composition of Leiognathidae larvae based on IRI according to stages and time periods 1985-86 (B) and 2013-14 (A). Number on top of bar represents total fish larvae examined with prey present in gut

4.4.7 Sciaenidae

Figure 4.8 shows the diet composition of fish larvae for family Sciaenidae in the Klang Strait. Diet of fish larvae for family Sciaenidae in time period 1985-86 consisted of seven major groups: cirripedes, copepods, decapods, detritus, plant matter, protozoans and polychaete larvae; and were reduced to six major groups in time period 2013-14, with plant matter and protozoans being absent in the gut and diatoms were present. Copepods made up of twelve families being preyed on in time period 1985-86: Acartiidae, Paracalanidae, Centropagidae, Corycaeidae, Euchaetiidae, Euterpinidae, Clausidiidae, Pontellidae, Ectinosomatidae, Oithonidae, Pseudodiaptomidae and Eucalanidae. The number of copepod families found in the gut of sciaenid larvae in time period 2013-14 were reduced from twelve to six, namely Corycaeidae, Paracalanidae, Oithonidae, Euterpinidae, Pseudodiaptomidae, and Eucalanidae.

Sciaenids showed a significant change in diet composition when comparing between time period 1985-86 and 2013-14 ($p<0.01$) (Table 4.6). When broken down to the respective fish larval stages, preflexion sciaenids showed significant differences after 30 years ($p<0.05$) (Table 4.7). Preflexion sciaenids have a high amount of copepod fragments in the guts in time period 1985-86 and a high amount of copepod eggs in the guts in time period 2013-14. Flexion sciaenids fed highly on *Euterpina acutifrons* (34.04% IRI) and *Parvocalanus crassirostris* (36.92% IRI) but in time period 2013-14 *Oithona* sp (39.44% IRI) became the most important prey. ANOSIM tests showed significant ontogenic differences in the diet between preflexion and flexion stages of sciaenids in time period 1985-86 ($p<0.01$) (Table 4.8). The larger benthic harpacticoid *Euterpina acutifrons* was selected as prey by sciaenids instead of *Microsetella norvegica*. Paracalanidae gained importance as prey as the fish larvae entered the postflexion stage even though oithonids remained a substantial prey in the diet of all stages. *Pseudodiaptomus bowmani* (27.76% IRI) which was previously one of the most important prey in the postflexion sciaenids diet in time period 1985-86 was no longer preferred after 30 years.

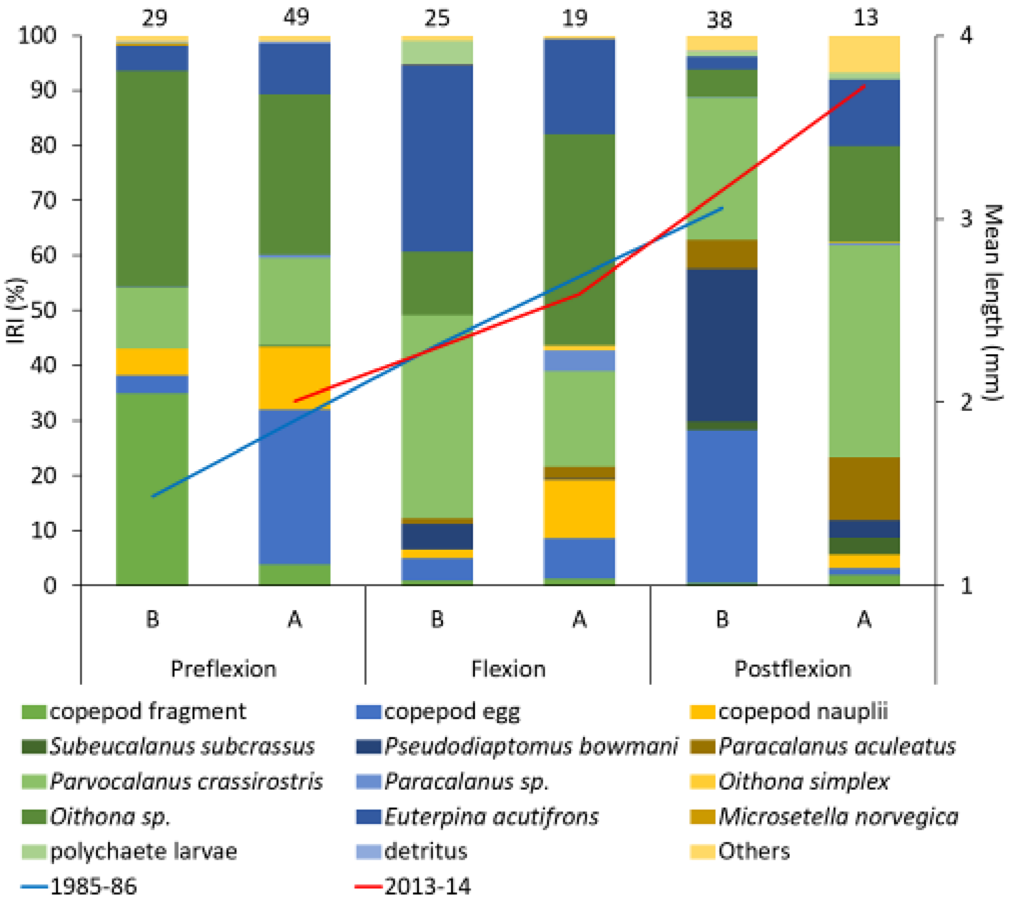

Figure 4.8: Diet composition of Sciaenidae larvae based on IRI according to stages and time periods 1985-86 (B) and 2013-14 (A). Number on top of bar represents total fish larvae examined with prey present in gut

Table 4.6: Results of ANOSIM tests on dietary composition of fish larvae families according to time periods and stages

Factors	1985-86 and 2013-14 (1)		Stages (2)		1 x 2	
	R	p	R	p	R	p
Bre	0.324	**	0.098	**	0.243	**
Cal	-0.21	ns	0.125	**	0.068	ns
Cyn	-0.016	ns	0.024	ns	0.034	ns
Eng	0.141	**	0.056	ns	0.09	ns
Gob	0.112	**	0.06	**	0.076	**
Lei	0.043	ns	0.201	**	0.152	*
Sci	0.035	**	0.084	**	0.105	**

Table 4.7: Results of ANOSIM tests on dietary composition of fish larvae families comparing the same ontogenic stages between two time periods

Factors	1985-86 and 2013-14					
	Pre		Flex		Post	
	R	p	R	p	R	p
Bre	0.314	**	0.181	**	0.369	**
Cal	0.015	ns	0.118	ns	-0.335	ns
Cyn	0.038	ns	-0.047	ns	-0.196	ns
Eng	0.053	ns	N/A	N/A	0	ns
Gob	-0.045	ns	0.039	ns	0.177	*
Lei	0.083	ns	-0.059	ns	0	ns
Sci	0.067	*	0.046	ns	0.075	ns

Abbreviations: Bre Bregmacerotidae, Cal Callionymidae, Cyn Cynoglossidae, Eng Engraulidae, Gob Gobiidae, Lei Leiognathidae Sci Sciaenidae, Pre Preflexion, Flex Flexion, Post Postflexion, P P-value, R R-statistic, ns not significant, *p< 0.05, **p<0.01.

Table 4.8: Results of pairwise ANOSIM tests comparing differences in dietary composition of fish larvae families among ontogenic stages in time period 1985-86

Factors	Before					
Pairwise comparison	Pre-Flex		Flex-Post		Pre-Post	
	R	p	R	p	R	p
Bre	-0.059	ns	-0.052	ns	-0.057	ns
Cal	0.458	ns	1	ns	-0.167	ns
Cyn	-0.109	ns	0.111	ns	-0.078	ns
Eng	N/A	N/A	N/A	N/A	0.018	ns
Gob	-0.065	ns	0.127	*	0.017	ns
Lei	0.004	ns	0.212	*	0.396	ns
Sci	0.179	**	0.066	ns	0.258	**

Table 4.9: Results of pairwise ANOSIM tests comparing differences in dietary composition of fish larvae families among ontogenic stages in time period 2013-14

Factors	After					
Pairwise comparison	Pre-Flex		Flex-Post		Pre-Post	
	R	p	R	p	R	p
Bre	0.105	ns	0.021	ns	0.333	**
Cal	0.212	**	0.076	ns	0.272	**
Cyn	0.042	ns	-0.001	ns	0.126	*
Eng	-0.117	ns	0.821	ns	0.016	ns
Gob	-0.06	ns	-0.009	ns	-0.064	ns
Lei	0.164	ns	0.316	ns	0.12	ns
Sci	-0.036	ns	0.067	ns	0.114	*

Abbreviations: Bre Bregmacerotidae, Cal Callionymidae, Cyn Cynoglossidae, Eng Engraulidae, Gob Gobiidae, Lei Leiognathidae Sci Sciaenidae, Pre Preflexion, Flex Flexion, Post Postflexion, P P-value, R R-statistic, ns not significant, *p< 0.05, **p<0.01.

4.5 Principal Component Analysis (PCA)

The first three components in the Principal Components Analysis (PCA) explained 58.8% of the variation (Table 4.10). The PCA plot have eigenvalues of 0.267 and 0.191 for the first two axes (of the PCA which explained 45.9% of the total variation. Horizontal and vertical axes were named PCA1 and PCA2, respectively.

Figure 4.9 is the PCA plot that shows the correlation between stages of fish larvae families in time periods 1985-86 and 2013-14 with prey found in their gut. From the PCA, all stages of Bregmacerotidae larvae in both time periods 1985-86 and 2013-14 were positioned on the positive side of the second principal component (PCA2) and were the fish larvae family that showed the most correlation with PCA2. Bregmacerotidae larvae in time period 1985-86 is positioned higher on the axis compared to Bregmarotidae larvae in time period 2013-14. As for the variables, copepod fragments were the most extreme on the positive axis of PCA2 followed by *Paracalanus* sp. and *Subeucalanus subcrassus*. The PCA indicated that Bregmacerotidae larvae diet shifted from mainly copepod fragments in time period 1985-86 to *Subeucalanus subcrassus* in time period 2013-14. However, fish larvae during both time periods still consumed *Paracalanus* sp. as one of the substantial prey.

All stages of Leiognathidae larvae in both time periods 1985-86 and 2013-14 were positioned on the right side of the graph, showing that they were positively correlated with the first principal component (PCA1). Detritus was the most extreme variable on PCA1. Leiognathidae larvae from their preflexion to flexion stages indicated a greater dependence over detritus in time period 2013-14 compared to when in time period 1985-86. Polychaete larvae was the second positive variable on PCA1 and is more related to part of the diet of postflexion leiognathids in time period 2013-14 as compared to postflexion leiognathids in time period 1985-86.

All stages of engraulid larvae in time period 1985-86 were positioned on the top left side of the graph correlated with larger copepods. All stages of engraulid larvae in time period 2013-14 were negatively correlated with PCA2. Preflexion and flexion engraulids that were positioned on the bottom right part of the graph positively correlated with detritus whereas postflexion engraulids that were positioned on the bottom left part of the graph were positively correlated with smaller copepods such as oithonids.

All stages of Callionymidae, Cynoglossidae and Sciaenidae larvae were negatively correlated with the first principal component with the exception of preflexion cynoglossids in time period 2013-14, and this suggested the preference of these fish larvae families over copepods as prey. After 30 years, all stages of fish larvae in these families indicated a shift towards preying on smaller copepods.

Table 4.10: PCA eigenvalues and percentage of variability for fish larvae families with their volumetric prey in both time periods 1985-86 and 2013-14

Axes	1	2	3	4	Total variance
Eigenvalues	0.267	0.191	0.129	0.094	1.000
Cumulative percentage variance of species data	26.7	45.9	58.8	68.2	

Sum of all eigenvalues : 1.000

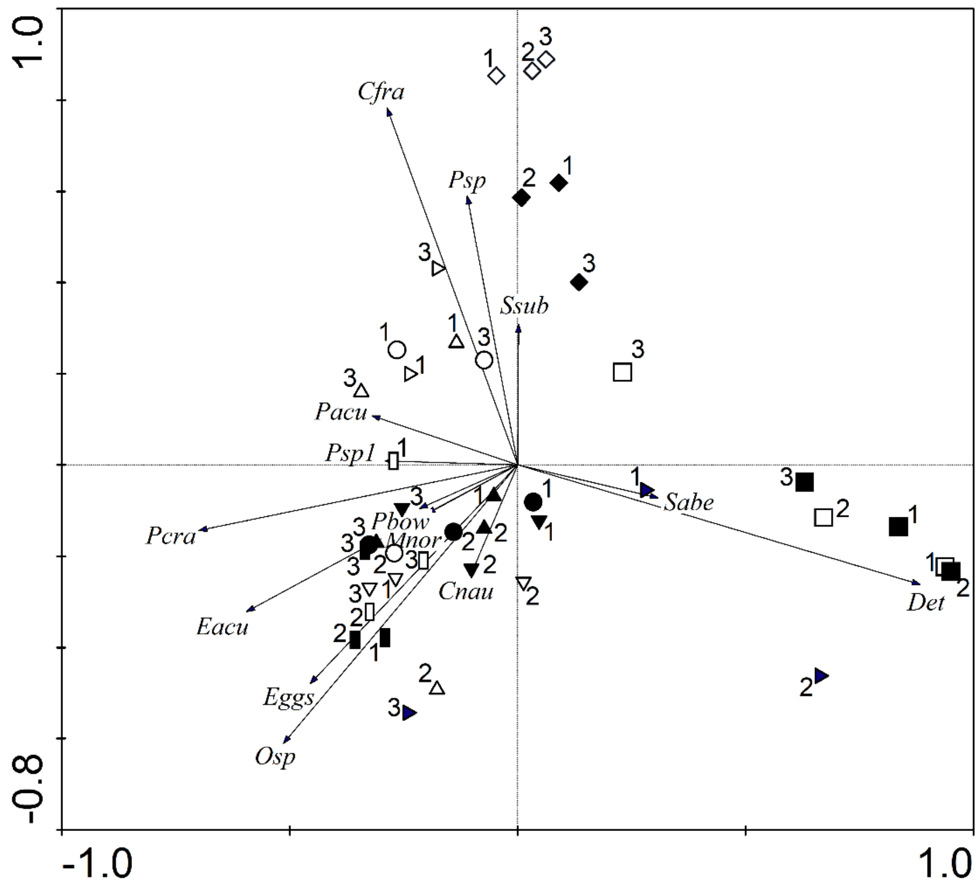

Figure 4.9: PCA biplot of seven key families of fish larvae with their IRI prey according to three ontogenic stages and two time periods. Empty symbols denote before-impact and filled symbols denote after-impact. Symbols: ♦ - Bregmacerotidae, ▲- Callionymidae, ●- Cynoglossidae, ► - Engraulidae, ▼- Gobiidae, ■- Leiognathidae and ▌- Sciaenidae. Abbreviations: Cfra Copepod fragments, Cnau copepod nauplii, Eggs copepod egg, Pcra *Parvocalanus crassirostris*, Psp *Paracalanus* sp., Pacu *Paracalanus aculeatus*, Osp *Oithona* sp., Pbow *Pseudodiaptomus bowmani*, Ecu *Euterpina acutifrons*, Mnor *Microsetella norvegica*, Ssub *Subeucalanus subcrassus*, Sabe Sabellariidae larvae, and Det Plant detritus. Numerical letters 1, 2 and 3 denote larval stages of preflexion, flexion and postflexion, respectively.

4.6 Redundancy Analysis (RDA)

The Redundancy Analysis (RDA) plot visualizes the correlation between volumetric prey in the gut of fish larvae and the zooplankton abundance in the environment (Figure 4.10). The first three components in the Redundancy explained 77.9% of the variation for the relationship between prey in the gut of fish larvae and the prey abundance in the environment (Table 4.11). The RDA plot have eigenvalues of 0.120 and 0.090 for the first two axes of the RDA which explained 61.8% of the total variation. Horizontal and vertical axes were named RDA1 and RDA2, respectively.

With few exceptions, RDA1 is positively correlated with sampling stations in time period 1985-86 and negatively correlated with sampling stations in time period 2013-14. RDA1 is also positively correlated with opportunistic copepod families and negatively correlated with vulnerable copepod families as the most extreme variable followed by resilient copepod families and non-copepod zooplankton families. There is a strong correlation of opportunistic prey families Oithonidae and Ectisomatidae in the gut of fish larvae with their abundance in the environment (Figure 4.10).

Paracalanidae found in the gut of fish larvae families were positively correlated with abundance of paracalanids in the environment along the positive axis of RDA2, whereas polychaete larvae showed a strong correlation between gut prey and abundance in the environment along the negative axis of RDA2. At the bottom-left quadrant, vulnerable families Acartiidae and Corycaeidae and resilient families Euterpinidae and Pseudodiaptomidae showed positive correlation with their abundance in the environment.

Table 4.11: RDA eigenvalues and percentage of variability for prey in fish larvae gut with prey abundance in environment in both time periods 1985-86 and 2013-14

Axes	1	2	3	4	Total variance
Eigenvalues	0.120	0.090	0.055	0.032	1.000
Species-environment correlations	0.695	0.630	0.535	0.618	
Cumulative percentage variance of species data	12.0	21.0	26.5	29.7	
Cumulative percentage variance of species-environment relation	35.3	61.8	77.9	87.3	
Sum of all eigenvalues : 1.000					

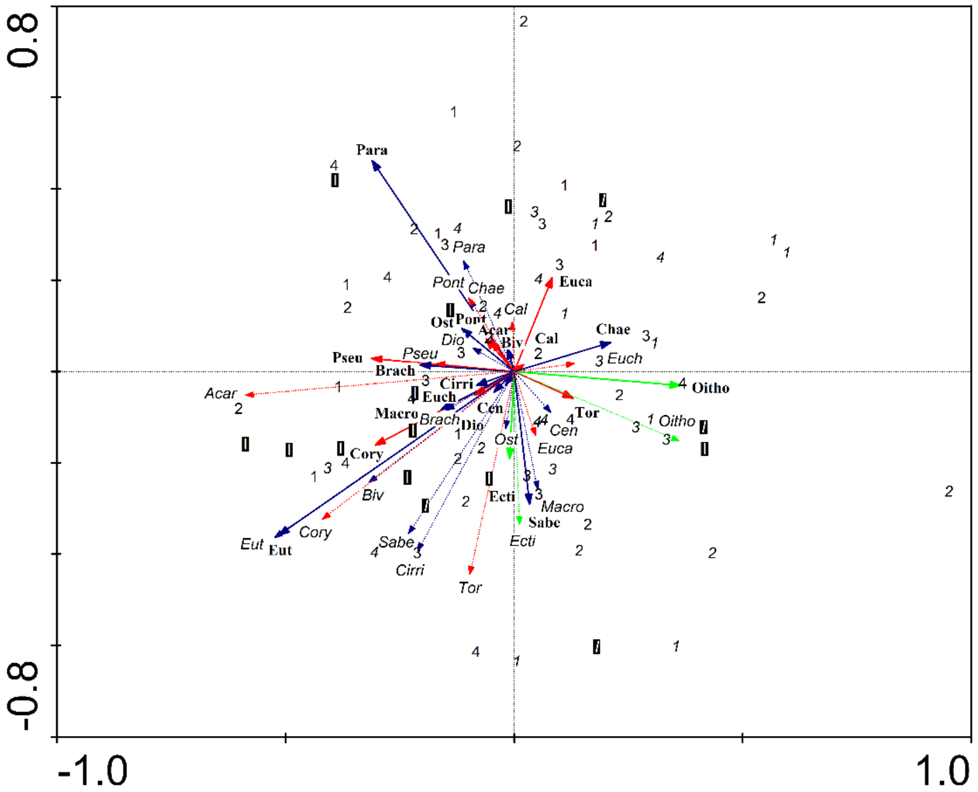

Figure 4.10: Redundancy analysis (RDA) triplot between volumetric prey in the gut of fish larvae, abundance of key zooplankton families parallel to fish larvae sampling, and sampling sites in time periods 1985-86 and 2013-14. Dotted arrows with italic variables denote zooplankton abundance while solid arrows with regular variables denote zooplankton preys in the guts of fish larvae. Red, blue and green arrows denote vulnerable, resilient and opportunistic zooplankton taxa, respectively. Alphabetical I denotes impacted station and numerical letters 1-4 denote control 1-4 stations, respectively. Regular numerals denote before-impact, and italic numerals denote after-impact. Abbreviations: Acar Acartiidae, Cal Calanidae, Cory Corycaeidae, Euca Eucalanidae, Euch Euchaetiidae, Tort Tortanidae, Cen Centropagidae, Eut Euterpinidae, Macro Macrochironidae, Para Paracalanidae, Pseu Pseudodiaptomidae, Ecti Ectinosomatidae, Oitho Oithonidae, Pont Pontellidae, Biv Bivalvia, Brach Brachyuran, Chae Chaetognatha, Cirri Cirripedia, Dio Diogenidae, Sabe Sabellariidae and Ost Ostracoda

CHAPTER 5

DISCUSSION

5.1 Feeding Incidence of Fish Larvae

The feeding incidence for each Bregmacerotidae larvae stage in this study is higher than the previous study by Siordia-Cermeño et al. (2006) which had feeding incidence of 12%, 11% and 38% in the preflexion, flexion and postflexion stages of Bregmacerotidae larvae respectively. There is an increase in both the size and feeding incidence of fish larvae family Bregmacerotidae across all stages after 30 years. The increase in feeding incidence is supported with the finding by Siordia-Cermeño et al. (2006) which also showed an increase in feeding incidence with size of Bregmacerotidae larvae. This increase in size of the fish larvae had likely caused the shift in diet from paracalanids to the larger eucalanid *Subeucalanus subcrassus*, as the study by Juanes (2016) found that there is an increase in prey size with larval fish size. There is also a reduction in competition for *Subeucalanus subcrassus* as prey as no other fish larvae families selected the copepod family Eucalanidae as one of its main diet. It is possible that an increase in temperature induces growth of the Bregmacerotidae larvae, which in turn led them to be more capable of hunting larger prey and have a more specialized feeding niche.

The feeding incidence of fish larvae from family Callionymidae increased as the fish larvae increased in size during both time periods 1985-86 and 2013-14, and this finding coincides with a previous study in 1998 by Sánchez-Velasco showing that fish larvae from the same family also had an increase in feeding incidence with size, up to 98.8% in feeding incidence for its postflexion stage. Apart from that, the same study showed that the smallest larvae (with length interval of 2mm) had the lowest feeding incidence (74.3%) for family Callionymidae, and it is similar with the findings of the present study that Callionymidae larvae in its preflexion stage during the time period 2013-14 had a mean notochord length of close to 2mm, which had the lowest feeding incidence (69.23%) as well (Sánchez-Velasco, 1998). Comparing between the two time periods 1985-86 and 2013-14 showed an increase in size of fish larvae across different stages but a decrease in the feeding incidence for the family Callionymidae, and this may be due to a low number of Callionymidae larvae examined in time period 1985-86.

Fish larvae of the families Callionymidae, Cynoglossidae and Sciaenidae have a very high feeding incidence (more than 85%) for both time periods 1985-86 and 2013-14, and is possibly affected by these families having a coiled gut which reduces regurgitation amount. A similar finding of high feeding incidence had also been reported in previous studies of the same fish larvae families; Callionymidae (Sánchez-Velasco, 1998; Sampey et al., 2007), Cynoglossidae (Ostergaard et al., 2005; Sampey et al., 2007) and Sciaenidae (Ocana-luna and Sanchez-Ramirez, 1998). However, other studies on Sciaenidae larvae reported a low feeding incidence of 14.8% (McMichael and Peters, 1989) and 15.5%

(Peters and McMichael, 1987) but it is highly likely because most of the fish larvae of both studies are sampled at night. The low percentage of feeding incidence in postflexion cynoglossids in time period 1985-86 may be due to the small number of larvae examined.

Fish larvae of the families Engraulidae, Gobiidae and Leiognathidae have a lower feeding success compared to other fish larvae families. This is probably due to preflexion stage of gobiid larvae and all stages of engraulid larvae having a straight gut in contrast with other fish larvae families, which induces regurgitation of prey during capture or preservation (Yamashita, 1990; Conway et al., 1998). The preflexion stages of both families Gobiidae and Leiognathidae also had the lowest feeding incidence compared to their later stages, which is similar to the finding by Wasserman (2012) that most empty stomachs of the Gobiidae larvae come from smaller size classes. Sampey et al. (2007) who examined Gobiidae in their postflexion stage and Leiognathidae in their flexion and postflexion stages also found that fish larvae in the later stages have a high feeding incidence.

The present study on engraulid larvae found a relatively high feeding incidence (73.08% in total across all stages in time period 1985-86 and 69.57% in total across all stages in time period 2013-14) in comparison with other studies which showed a much lower feeding incidence ranging from 0% to 46.9% (Brewer and Kleppel, 1986; Vasconcellos et al., 1998; Freire and Castello, 2000; Sampey et al., 2007). This study also found that Engraulidae larvae had an increase in feeding incidence with size in time period 1985-86, which is in line with the previous study by Freire and Castello (2000) that showed engraulid larvae up to 8mm had an increased feeding incidence with size. However, the opposite was found in time period 2013-14 whereby there was a decrease in feeding incidence with Engraulidae larvae size.

There is a decrease in size of Gobiidae larvae after 30 years. The increase in feeding incidence with size in time period 1985-86 coincided with the previous study by Harding (1999) that found Gobiidae larvae feeding incidence increase with age. This study also found that there was an increase in feeding incidence from the preflexion to flexion stage for Gobiidae larvae in time period 2013-14 but a decrease in feeding incidence when the fish larvae are in their postflexion stage, and this might be due to the lower number of postflexion stages examined as compared to other stages.

5.2 Dietary Composition during two time periods 1985-86 and 2013-14

Forty-six prey items were identified to belong to 13 different major groups of food items. Bivalvia, Chaetognatha, Cirripedia, Copepoda, Decapoda, detritus, diatom, foraminiferan, Ostracoda, plant matter, protozoa, Sabellariidae and unidentified materials. Apart from copepods, detritus and polychaete larvae, the rest of the food items are not as significant (< 5% FO). Chew et al. (2015) reported a total of 9 key zooplankton taxa (Paracalanidae, Oithonidae, Acartiidae, Centropagidae, Eucalanidae, Euterpinidae, Cirripedia, Luciferidae, Chaetognatha and Oikopleuridae) found to be predominant among zooplankton in both time periods in the Klang Strait, but Luciferidae and Oikopleuridae were not found in the diet of fish larvae in this study.

The order Copepoda was found in the gut of all the fish larvae families, and dominated in the fish larvae diet for previous studies as well (Ostergaard et al., 2005). Copepods were composed of six families out of the nine key zooplankton taxa in the Klang Strait. There was an increase in abundance of families Paracalanidae and Oithonidae but no significant differences in abundance of families Euterpinidae and Eucalanidae when comparing between the two time periods, 1985-86 and 2013-14 (Chew et al., 2015). These four copepod families were highly preyed upon by fish larvae families examined in this study, and a previous study by Kurtz and Matsuura (2001) found selective feeding of fish larvae towards *Paracalanus* and *Oithona* even though they are not dominant in the environment. Other copepod families from the nine key zooplankton taxa are the Centropagidae that increased in abundance in time period 2013-14 as compared to in 1985-86, but copepods of this family were only found in the guts of postflexion Sciaenidae larvae in time period 1985-86 and in the guts of flexion and postflexion stages of Bregmacerotidae in time period 2013-14. The decrease in numbers of the family Acartiidae might indicate that it was a non-preferable prey, as this study showed that copepods of this family were only found in the gut of fish larvae families Bregmacerotidae (preflexion stage) and Sciaenidae (postflexion stage) in time period 1985-86 and were not observed in any of the fish larval families in time period 2013-14.

Detritus was also found in the guts of all fish larvae families, and it is likely the high amount of detritus in the mangrove-estuary Klang Strait led to accidental ingestion or through active feeding of fish larvae. Polychaete larvae were only preyed by fish larvae families Callionymidae, Cynoglossidae, Leiognathidae and Sciaenidae, and it is likely because these families are part of the benthic community.

Despite Cirripedia being abundant in the Klang Strait (Chew et al., 2015), cirripede nauplii and cirripede cyprids were found in low quantities in the diet of fish larvae. Only the postflexion stage of Cynoglossidae larvae fed on the cyprids stage of cirripedes in time period 1985-86 and the stage that was found to have cyprids cirripede present in the gut was reduced to flexion in time period 2013-14. The nauplii stage of cirripedes was only found in the gut of preflexion and postflexion stages of Cynoglossidae in time period 2013-14. It is likely that mouth gape and size of the larval fish are the limiting factors, since cirripedes increased in abundance in the environment but all stages of cynoglossids larvae decreased in length after 30 years. Other families that had cirripede nauplii present in the gut were all ontogenic stages of sciaenids in time period 1985-86 and postflexion callionymids, preflexion and postflexion sciaenids in time period 2013-14.

Zoeae stages of brachyuran or Diogenidae families were found in the gut of fish larvae families Bregmacerotidae, Cynoglossidae and Sciaenidae. Bivalvia and Ostracoda were only found in the gut of Cynoglossidae, and Chaetognatha and Foraminiferans were present in the gut of Engraulidae and Gobiidae larvae respectively. Plant matter was found in the gut of fish larvae families Callionymidae, Cynoglossidae, Engraulidae, Gobiidae and Sciaenidae in time period 1985-86 but was absent in the gut of all the fish larvae families except for family Callionymidae in 2013-14 whereas diatoms were found in the gut of fish larvae families Callionymidae, Cynoglossidae, Gobiidae, Leiognathidae and Sciaenidae in time period 2013-14 but only found in the gut of fish larvae families Callionymidae and Cynoglossidae in 1985-86. As the numbers of these phytoplankton and non-copepod zooplankton prey were very low in comparison to copepods, it is possible that they were accidentally consumed when the fish larvae were foraging for their preferred prey.

5.3 Diet of Larval Fish

5.3.1 Bregmacerotidae

The present study suggested that digestion for Bregmacerotidae larvae in time period 1985-86 occurred fast as there was a high percentage of copepod fragments in its diet. The families of copepods preyed by Bregmacerotidae larvae for both time periods showed a general preference over larger sized copepods. The calanoid copepods (Paracalanidae) were already preyed upon when the Bregmacerotidae larvae was in the preflexion stage before shifting its diet towards the larger calanoid Eucalanidae (*Subeucalanus subcrassus*) as the fish larvae grew in size. Nauplii stages of copepods were not found in the diet of Bregmacerotidae larvae except for the nauplii stage of *Subeucalanus subcrassus* in time period 1985-86. However, the nauplii and copepodite stages of *Subeucalanus subcrassus* were absent in the diet of Bregmacerotidae larvae in time period 2013-14. This might be due to the increase in size of Bregmacerotidae larvae, hence the possibility of ontogenic shift in diet from small calanoid copepods to much larger calanoids. This finding is similar to the previous study by Siordia-Cermeño et al. (2006) on Bregmacerotidae larvae which indicated preference towards copepod nauplii in the early stage before shifting to calanoid copepods when the fish larvae reached their flexion and postflexion stages. All stages of Bregmacerotidae larvae in time period 1985-86 did not feed on cyclopoid group Oithonidae, but the species of Oithonidae that could be identified in the diet of Bregmacerotidae larvae in time period 2013-14, were *Oithona attenuata*, *Oithona simplex*, *Oithona dissimilis* and *Oithona* sp.. This shift in the diet could be related to the increase in cyclopoid copepods in the environment in the latter time period (Chew and Chong, 2016), with *Oithona attenuata* and *Oithona simplex* being predominant, suggesting that Bregmacerotidae larvae in time period 1985-86 might select prey not merely based on size but also abundance. Bregmacerotidae larvae for both time periods did not prey on harpacticoids which indicate that they are not benthic feeders or do not have any preference towards harpacticoids in this study, as opposed to the larval diet of *Bregmaceros bathymaster* which showed the presence of *Euterpina* sp. in all the larval stages (Siordia-Cermeño et al., 2006).

5.3.2 Callionymidae

A high percentage of copepod fragments might be due to Callionymidae larvae being able to feed at any time (Sa´nchez-Velasco, 1998), hence digestion of prey had occurred upon capture and preservation. The more diverse family of copepods preyed by Callionymidae larvae after 30 years included larger sized copepods such as Pseudodiaptomidae, Eucalanidae and Tortanidae and this finding coincides with the increase in fish larvae size which made it possible to hunt larger sized prey. *Parvocalanus crassirostris* is the main prey of callionymids in time period 1985-86 and remained substantial in the diet in 2013-14. The increase in feeding on smaller sized oithonids after 30 years is highly likely affected by the increase in abundance of oithonids in the environment. This finding coincide with a previous study by Sa´nchez-Velasco (1998) that found that *Callionymus* sp. had the tendency to select *Oithona* spp. as its dominant prey. Another finding by Sampey et al. (2007) showed that harpacticoids and cyclopoid of the genus *Oithona* are selected as the diet of Callionymidae larvae, but the harpacticoids *Euterpina acutifrons* and *Microsetella norvegica* were consumed in lower numbers in this study. Preflexion stage of Callionymidae larvae in time period 2013-14 fed mainly on copepod nauplii and copepod egg, unlike 30 years ago whereby the same stage preferred *Parvocalanus crassirostris*. The more diverse diet in Callionymidae larvae in time period 2013-14 indicates a shift towards more opportunistic behaviour, that is similar to a feeding strategy shown by *Callionymus lyra* in the United Kingdom. (Griffin et al., 2012).

5.3.3 Cynoglossidae

There is an increase in importance of copepod nauplii and *Microsetella norvegica* as part of the diet of preflexion and flexion stage of Cynoglossidae. Cynoglossids are known benthic feeders that have a small mouth size (Østergaard et al., 2005), and the change in diet is likely caused by the decrease in size of this fish larvae family after 30 years in line with the benthic harpacticoid prey *Microsetella norvegica* that became common and abundant in the environment in time period 2013-14 (Chew and Chong, 2016), hence the selection and preference for this prey over other prey in the area. Østergaard et al. (2005) found that harpacticoids were also selected by the early larval stages of *Cynoglossus* sp. before the fish larvae shows a shift in diet towards Oncaeidae during ontogeny. Postflexion cynoglossids in this study also showed an ontogenic shift in diet when *Microsetella norvegica* was no longer selected as part of its diet in both time periods, whereas the fish larvae selected the larger sized copepods such as the harpacticoid *Euterpina acutifrons* and the paracalanids.

5.3.4 Engraulidae

The gut contents of Engraulidae larvae in time period 1985-86 had a high percentage of copepod fragments, which indicates that digestion had commenced upon capture and preservation. Engraulidae larvae in time period 1985-86 were mainly zooplanktivorous before shifting its diet to planktophagous in time period 2013-14, feeding primarily on detritus and zooplankton. It is possible that Engraulidae larvae in time period 1985-86 actively capture prey while Engraulidae larvae in time period 2013-14 filter feeds, according to the two types of engraulid feeding stated by Duque and Acero (2003). Therefore, this explains the high amount of detritus in the gut contents of engraulids larvae in time period 2013-14 while none was found present in the gut in time period 1985-86. Engraulidae larvae for both time periods had *Oithona* sp. as the main zooplankton prey showing no change in zooplankton food selectivity. This finding is in contrast with the study done by Suzuki et al. (2014) in the Chikugo River estuary, southwestern Japan which showed that small copepods such as *Oithona* spp. were not selected as part of engraulid larvae diet even though oithonids made up one of the dominant categories in that environment. The diet of Engraulidae in this study is also highly specialized, feeding only on *Paracalanus* sp., *Parvocalanus crassirostris*, *Oithona* sp. and *Euterpina acutifrons* in time period 1985-86 and only *Parvocalanus crassirostris* and *Oithona* sp. in time period 2013-14. This finding is similar to Yasue et al. (2011) whereby copepods are mainly preyed by Engraulidae larvae but differs from other studies in which Engraulidae larvae showed a preference of larger calanoid copepods (Suzuki et al., 2014; Lima and Barletta, 2016) or the harpacticoid *Microsetella* sp. (Morote et al., 2010). Copepod nauplii is the first food of anchovy (Arthur, 1976) and it is preyed upon by the preflexion and flexion stages of engraulids in this study, similar to the finding by Kurtz and Matsuura (2001) that showed the predominance of copepod nauplii in the diet of these two engraulid larval stages.

5.3.5 Gobiidae

In the time period 1985-86, oithonids were the most important prey item for preflexion and flexion stages of gobiids before being replaced by the larger *Parvocalanus crassirostris* as the fish larvae reached their postflexion stage. Even though the abundance of *Parvocalanus crassirostris* and *Oithona* sp. is high in the wild (Chew and Chong, 2016) and still constituted a major part of the gobiid larvae diet after 30 years, copepod nauplii became the most important prey across all stages of gobiid larvae in time period 2013-14. This finding coincides with the previous study by Campfield and Houde (2011) which reported that copepod nauplii is an important prey for gobiid larvae when nauplii is abundant in the environment. Copepod nauplii is also found to dominate the preflexion larvae diet in other fish species (Kurtz and Matsuura, 2001), and the preference for the earlier stages of copepods as prey might also correlate with the decrease in size of gobiids in this study. Harpacticoids (*Euterpina acutifrons* and *Microsetella norvegica*) are not the main prey of Gobiid larvae. Polychaete is reported to be a minor part of Gobiidae larvae diet (Sampey et al., 2007), but in this study they were not observed in the larval gobiids.

5.3.6 Leiognathidae

Leiognathidae larvae showed a preference for detritus and polychaete larvae indicating that it is mainly a benthic feeder. According to Moyle (2002), a high amount of detritus in the gut reflects the preference of fish larvae capturing prey living on soft bottoms. Leiognathidae larvae did not consume copepods as its main prey, unlike Sampey et al. (2007) who reported that Leiognathidae larvae highly preferred *Oithona attenuata* as its prey even though it is not abundant in the environment. Only copepods of the calanoid family Paracalanidae and the cyclopoid Oithonidae were found in the gut of Leiognathidae larvae in this study. Unlike other fish larvae families, the occurrence of detritus in the gut of Leiognathidae larvae in substantial quantities and the absence of benthic harpacticoids suggests that it may already be detrivorous in its larval stages. However, the predominance of detritus only in the preflexion and flexion stages might be due to the fish larvae being too small to prey on polychaete larvae. The change from detritus to polychaete larvae as the most important prey item was observed when the fish larvae reached their postflexion stage. A previous study on the diet of six adult Leiognathidae fish species in Malaysia showed detritus as the main food item in all six species, followed by polychaetes and copepods (Seah et al., 2009; Seah et al., 2011). This observation may indicate that the larval and adult stages of Leiognathidae fishes have the same feeding habit.

5.3.7 Sciaenidae

Sciaenidae are opportunistic compared to other fish larvae families, preying on a wide range of copepods in line with Peters and McMichael (1987) who reported that Sciaenidae larvae fed mainly on copepods. Sciaenidae larvae in this study showed ontogenic shifts in the diet and preferred prey that are abundant in the environment such as *Parvocalanus crassirostris*, *Oithona* sp. and *Euterpina acutifrons*. The preflexion stage of Sciaenidae showed preference for preying on zooplankton in addition to an increase in feeding on copepod eggs after 30 years in contrast to a study by Manetta et al. (2011) showing that phytoplankton was preferred as prey during the early larval stages. Picapedra et al. (2018) found cladocerans to be the most important prey item for preflexion sciaenids and this diet shifted to calanoid copepods as the fish larvae metamorphose into their later stages. Younger stages (nauplii and copepodites) and cyclopoid copepods are not preferred (Picapedra et al., 2018). In this study, postflexion sciaenids no longer preyed on *Pseudodiaptomus bowmani* when this coastal large bodied calanoid species decreased in the environment (Chew and Chong, 2016).

5.4 Feeding Strategies of Larval Fish in Klang Strait

The PCA biplot for fish larvae families in the two time periods 1985-86 and 2013-14 showed that feeding habit differs among the fish larvae families in the Klang Strait, and can be grouped into zooplanktivorous, planktophagous and detritivorous. Fish larvae of families Bregmacerotidae, Callionymidae, Cynoglossidae, Gobiidae and Sciaenidae are zooplanktivores. However, Bregmacerotidae larvae fed mainly on large-sized calanoid copepods in both time periods, which were not the preferred prey of other fish larvae families. Other fish larvae families Callionymidae, Cynoglossidae and Sciaenidae showed a shift in preference towards feeding on smaller sized copepods. Gobiidae larvae that used to feed on small-sized copepods changed to preying on the nauplii stage of copepods. Engraulidae larvae are plankthophagous feeders because they prey on copepods and detritus. Leiognathidae larvae are detritivorous as they consumed detritus and polychaete larvae as their main diet. The copepod fragments obtained in this study were most likely large calanoids.

Siordia-Cermeño et al. (2006) found that copepods that are commonly found in the environment tend to dominate the diet of fish larvae in the same area, and since temperature can change the composition of zooplankton prey (Moore et al., 1996; Carter et al., 2017), the diet of fish larvae may vary as well. RDA showed that there is a strong connection between food abundance in environment and food consumed by fish larvae. The vulnerable copepod species are not the preferred food of fish larvae. Instead the fish larvae tend to prey on Oithonidae when it is highly abundant in the environment, and this finding is supported by an earlier study showing cyclopoid copepods as common prey in the diet of fish larvae when their numbers are high in the environment (Campfield and Houde, 2011). The change in larval fish diet during the two time periods in the Klang Strait showed that fish larvae exhibited opportunistic behaviour in response to the abundance of zooplankton especially copepod prey.

5.5 Limitations of Present Study

The limitations of this study included the lack of archived samples of some larval fish families, i.e. Engraulidae and Leiognathidae. The fish larvae examined could only be identified up to family level, and digestion of food items made identification of prey to the lowest taxa difficult. Molecular analysis is suggested for quantification of easily digestible organisms such as aloricate tunicates and gelatinous zooplankton. Future dietary studies would be recommended to incorporate not only the zooplankton availability in the wild but also the possible impacts of a changing environment towards the physiology of the fish larvae, which can affect the behaviour and selectivity of fish larvae towards the available prey. Measuring the larval fish mouth gape size is also important as it can be a factor for the fish larvae in choosing its prey.

CHAPTER 6

CONCLUSION

This study is possibly the first study in the tropical region to look at the possible shift in diet after nearly three decades. These larval fish families had been able to adapt to the increasingly anthropogenic-impacted Klang Strait. Even though there are changes in the growth of some larval fish families in terms of body length, all these larval fish families do not seem to be negatively impacted by the ecological changes in the Klang Strait in terms of feeding. Most fish larvae families are zooplanktivorous preying heavily on copepods. The top copepod families fed are the calanoid Paracalanidae, cyclopoid Oithonidae and to a lesser extent the harpacticoid Euterpinidae. The larval fishes retained preying on these top copepod families but there is a clear dietary shift among different ontogenic stages and after 30 years. Many of these families (Callionymidae, Cynoglossidae, Gobiidae and Sciaenidae) are found to rely more on the more abundant small-bodied opportunistic copepods that has increased in the environment over the last 30 years. These resilient and opportunistic copepod groups appear to dominate the zooplankton community as well. Fish larvae of the family Bregmacerotidae are the only one who retain their preference over large-bodied copepods. Engraulids and leiognathids are seen to be planktophagous and detrivorous feeders, respectively. The present study is focused only on fish larvae identified to family level which is used as the ecological unit. Nevertheless, even at this level, new knowledge on the feeding habits of tropical larval fishes has emerged and is relevant to fishery and coastal resource management. In view of the increase in anthropogenic activities disrupting ecosystem health in the tropics, this finding is vital to enforce strict regulatory measures before there is further loss of ecosystem functions and services.

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APPENDICES

Bregmacerotidae

Preflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	3.57	4.30	0.12	0.18	0.00	0.00	0.00	0.00
Copepod fragments	78.57	48.39	47.23	84.94	25.00	16.67	20.19	15.09
Copepod nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acartia sp.	3.57	2.15	2.08	0.17	0.00	0.00	0.00	0.00
Cantocalanus pauper	3.57	1.08	6.16	0.29	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	3.57	1.08	0.50	0.06	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	7.14	2.15	2.16	0.35	0.00	0.00	0.00	0.00

Bregmacerotidae

Preflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrocalanus gibber	3.57	2.15	7.08	0.37	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	14.29	6.45	14.03	3.31	12.50	8.33	19.19	5.63
Paracalanus sp1	0.00	0.00	0.00	0.00	12.50	8.33	10.87	3.93
Parvocalanus crassirostris	21.43	13.98	8.97	5.56	25.00	16.67	5.43	9.05
Paracalanus sp.	21.43	8.60	7.94	4.01	50.00	33.33	43.17	62.65
Pseudodiaptomus bowmani	3.57	1.08	0.75	0.07	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Bregmacerotidae

Preflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	3.57	1.08	0.96	0.08	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	3.57	1.08	0.72	0.07	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	3.57	1.08	0.20	0.05	0.00	0.00	0.00	0.00
diogenid zoeae	3.57	1.08	0.12	0.05	0.00	0.00	0.00	0.00
detritus	0.00	0.00	0.00	0.00	12.50	8.33	0.79	1.87
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified	7.14	4.30	0.99	0.43	12.50	8.33	0.36	1.78

Bregmacerotidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod fragments	81.82	64.71	67.47	92.40	30.77	17.39	28.87	23.21
Copepod nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	7.69	4.35	5.98	1.29
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	9.09	2.94	4.08	0.55	0.00	0.00	0.00	0.00

Bregmacerotidae

Flexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	15.38	8.70	0.99	2.43
Oithona sp.	0.00	0.00	0.00	0.00	15.38	13.04	1.61	3.68
Acrocalanus gibber	9.09	2.94	4.98	0.61	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	9.09	2.94	5.46	0.65	0.00	0.00	0.00	0.00
Paracalanus sp1	9.09	2.94	2.78	0.44	7.69	4.35	3.64	1.00
Parvocalanus crassirostris	18.18	11.76	5.58	2.70	15.38	8.70	1.18	2.48
Paracalanus sp.	18.18	5.88	6.80	1.97	23.08	17.39	9.91	10.28
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Bregmacerotidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	46.15	26.09	47.83	55.64
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	9.09	2.94	1.91	0.38	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	9.09	2.94	0.94	0.30	0.00	0.00	0.00	0.00
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Bregmacerotidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod fragments	75.00	60.00	52.48	86.22	13.33	10.53	2.36	2.06
Copepod nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	6.67	2.63	2.15	0.38
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Bregmacerotidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona attenuata	0.00	0.00	0.00	0.00	6.67	2.63	0.29	0.23
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	6.67	5.26	0.67	0.47
Oithona simplex	0.00	0.00	0.00	0.00	13.33	5.26	0.66	0.95
Oithona sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	13.33	5.26	4.09	1.50
Paracalanus sp1	0.00	0.00	0.00	0.00	6.67	2.63	1.33	0.32
Parvocalanus crassirostris	12.50	16.00	5.00	2.68	13.33	5.26	1.98	1.16
Paracalanus sp.	25.00	8.00	12.39	5.21	20.00	7.89	9.12	4.08
Pseudodiaptomus bowmani	12.50	4.00	8.23	1.56	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Bregmacerotidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	12.50	4.00	18.54	2.88	66.67	31.58	77.34	87.16
Subeucalanus subcrassus copepodite	12.50	4.00	1.71	0.73	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	12.50	4.00	1.64	0.72	0.00	0.00	0.00	0.00
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	6.67	21.05	0.02	1.69
polychaete larvae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Callionymidae

Preflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	25.00	5.56	2.02	1.95	33.33	34.48	6.00	20.17
Copepod fragments	50.00	44.44	48.28	47.82	33.33	10.34	19.67	14.95
Copepod nauplii	50.00	11.11	3.50	7.53	44.44	34.48	39.19	48.93
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	25.00	5.56	11.18	4.31	0.00	0.00	0.00	0.00
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Callionymidae

Preflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	25.00	5.56	8.69	3.67	22.22	13.79	26.47	13.37
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parvocalanus crassirostris	75.00	16.67	23.58	31.13	0.00	0.00	0.00	0.00
Paracalanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Callionymidae

Preflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	25.00	11.11	2.75	3.57	0.00	0.00	0.00	0.00
diatom	0.00	0.00	0.00	0.00	11.11	6.90	8.67	2.59
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Callionymidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	0.00	0.00	0.00	0.00	29.41	14.29	1.34	7.78
Copepod fragments	0.00	0.00	0.00	0.00	29.41	11.11	12.06	11.54
Copepod nauplii	0.00	0.00	0.00	0.00	17.65	7.94	4.30	3.65
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	5.88	4.76	12.53	1.72
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	100.00	33.33	46.47	39.90	11.76	3.17	3.90	1.41
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Callionymidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	11.76	3.17	4.16	1.46
Oithona sp.	100.00	66.67	53.53	60.10	35.29	14.29	12.72	16.13
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parvocalanus crassirostris	0.00	0.00	0.00	0.00	52.94	17.46	28.38	41.08
Paracalanus sp.	0.00	0.00	0.00	0.00	11.76	3.17	9.79	2.58
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Callionymidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	0.00	0.00	0.00	0.00	29.41	14.29	8.32	11.25
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	5.88	1.59	0.35	0.19
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	5.88	1.59	0.14	0.17
unidentified	0.00	0.00	0.00	0.00	11.76	3.17	2.00	1.03

Callionymidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	7.14	1.45	1.51	0.32
Copepod egg	33.33	6.35	0.32	1.29	25.00	8.70	0.31	3.44
Copepod fragments	100.00	25.40	36.25	35.86	42.86	9.18	6.02	9.96
Copepod nauplii	33.33	1.59	0.47	0.40	32.14	6.28	1.98	4.06
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	7.14	0.97	1.37	0.26
Corycaeus sp.	33.33	1.59	1.00	0.50	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	3.57	0.48	1.82	0.13
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	66.67	17.46	18.66	14.01	42.86	7.25	8.62	10.40
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Callionymidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	10.71	1.45	0.75	0.36
Oithona attenuata	0.00	0.00	0.00	0.00	3.57	0.97	0.82	0.10
Oithona brevicornis	33.33	1.59	1.28	0.56	10.71	2.42	2.19	0.76
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	17.86	2.90	1.92	1.32
Oithona sp.	100.00	12.70	8.23	12.17	64.29	20.77	12.11	32.33
Acrocalanus gibber	0.00	0.00	0.00	0.00	3.57	0.48	1.15	0.09
Bestiolina similis	33.33	1.59	4.74	1.23	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	25.00	5.80	24.02	11.40
Paracalanus sp1	0.00	0.00	0.00	0.00	14.29	1.93	4.72	1.45
Parvocalanus crassirostris	100.00	28.57	28.62	33.27	42.86	16.91	13.32	19.81
Paracalanus sp.	0.00	0.00	0.00	0.00	10.71	3.38	7.29	1.75
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	7.14	0.97	3.19	0.45
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	3.57	0.48	0.75	0.07

Callionymidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	3.57	0.48	1.66	0.12
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	3.57	1.45	2.01	0.19
Tortanus sp.	0.00	0.00	0.00	0.00	3.57	0.48	1.12	0.09
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	0.00	0.00	0.00	0.00	14.29	2.90	0.96	0.84
diatom	33.33	1.59	0.06	0.32	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	33.33	1.59	0.38	0.38	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	3.57	0.48	0.14	0.03
unidentified	0.00	0.00	0.00	0.00	10.71	1.45	0.25	0.28

Cynoglossidae

Preflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	2.70	0.80	0.66	0.08
Copepod egg	18.18	6.52	0.59	2.24	18.92	20.80	2.88	8.95
Copepod fragments	45.45	21.74	15.02	28.99	27.03	8.80	13.50	12.04
Copepod nauplii	27.27	15.22	2.02	8.16	43.24	17.60	15.39	28.49
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	2.70	0.80	3.99	0.26
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	36.36	15.22	14.71	18.88	13.51	8.00	14.86	6.17
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cynoglossidae

Preflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	27.27	8.70	8.47	8.12	32.43	14.40	15.50	19.37
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	9.09	2.17	1.42	0.57	18.92	7.20	5.70	4.87
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	18.18	4.35	18.77	7.30	0.00	0.00	0.00	0.00
Paracalanus sp1	9.09	2.17	3.05	0.82	0.00	0.00	0.00	0.00
Parvocalanus crassirostris	36.36	15.22	17.47	20.63	8.11	3.20	3.44	1.08
Paracalanus sp.	9.09	2.17	2.16	0.68	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cynoglossidae

Preflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	0.00	0.00	0.00	0.00	5.41	4.00	5.19	0.99
diatom	0.00	0.00	0.00	0.00	8.11	3.20	4.74	1.29
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	9.09	2.17	14.23	2.59	0.00	0.00	0.00	0.00
plant matter	9.09	2.17	0.29	0.39	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	9.09	2.17	1.81	0.63	32.43	11.20	14.15	16.42
unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cynoglossidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	3.85	0.83	0.38	0.09
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	3.85	0.83	4.09	0.36
cirripede nauplii	0.00	0.00	0.00	0.00	3.85	1.65	3.05	0.35
Copepod egg	33.33	14.29	0.65	4.48	23.08	4.96	0.31	2.33
Copepod fragments	66.67	5.36	4.25	5.77	19.23	6.61	3.64	3.78
Copepod nauplii	0.00	0.00	0.00	0.00	26.92	9.09	2.90	6.19
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	3.85	0.83	1.69	0.19
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	33.33	3.57	4.94	2.56	26.92	8.26	7.49	8.14
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cynoglossidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	33.33	1.79	1.74	1.06	50.00	19.83	8.63	27.31
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	66.67	25.00	20.06	27.07	26.92	9.92	6.09	8.27
Acrocalanus gibber	33.33	1.79	7.24	2.71	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	11.54	2.48	6.89	2.07
Paracalanus sp1	66.67	8.93	19.18	16.88	3.85	0.83	1.79	0.19
Parvocalanus crassirostris	66.67	19.64	30.56	30.16	42.31	17.36	15.59	26.74
Paracalanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cynoglossidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	11.54	4.13	15.64	4.38
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	33.33	3.57	8.66	3.67	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	3.85	0.83	0.54	0.10
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	0.00	0.00	0.00	0.00	3.85	2.48	10.28	0.94
diatom	33.33	1.79	0.41	0.66	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	33.33	1.79	1.57	1.01	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	33.33	12.50	0.74	3.98	23.08	8.26	10.92	8.50
unidentified	0.00	0.00	0.00	0.00	3.85	0.83	0.09	0.07

Cynoglossidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	100.00	12.50	35.90	24.20	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	0.00	0.00	0.00	0.00	25.00	33.33	2.01	12.25
Copepod fragments	100.00	12.50	5.68	9.09	25.00	3.51	8.68	4.23
Copepod nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	100.00	25.00	14.86	19.93	50.00	8.77	11.87	14.31
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cynoglossidae

Postflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	25.00	5.26	1.69	2.41
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	100.00	12.50	3.14	7.82	37.50	15.79	9.52	13.16
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	100.00	12.50	17.73	15.12	37.50	8.77	35.39	22.96
Paracalanus sp1	0.00	0.00	0.00	0.00	37.50	5.26	14.77	10.41
Parvocalanus crassirostris	0.00	0.00	0.00	0.00	50.00	14.04	13.13	18.84
Paracalanus sp.	100.00	12.50	18.65	15.57	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Cynoglossidae

Postflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	12.50	1.75	1.03	0.48
detritus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	12.50	1.75	0.30	0.36
unidentified	100.00	12.50	4.04	8.27	12.50	1.75	1.61	0.58

Engraulidae

Preflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	7.69	2.04	1.40	0.33	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	0.00	0.00	0.00	0.00	10.00	3.85	0.38	0.67
Copepod fragments	53.85	32.65	32.56	44.30	40.00	23.08	20.73	27.88
Copepod nauplii	23.08	16.33	4.97	6.20	20.00	11.54	6.14	5.63
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	15.38	4.08	2.36	1.25	0.00	0.00	0.00	0.00
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Engraulidae

Preflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	53.85	28.57	27.86	38.34	30.00	30.77	29.31	28.68
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parvocalanus crassirostris	23.08	8.16	17.58	7.50	10.00	7.69	13.41	3.36
Paracalanus sp.	7.69	4.08	11.07	1.47	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Engraulidae

Preflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	0.00	0.00	0.00	0.00	40.00	23.08	30.02	33.79
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	7.69	2.04	1.10	0.30	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified	7.69	2.04	1.10	0.30	0.00	0.00	0.00	0.00

Engraulidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod fragments	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod nauplii	0.00	0.00	0.00	0.00	50.00	26.67	12.62	13.12
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Engraulidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	0.00	0.00	0.00	0.00	50.00	26.67	34.70	20.50
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parvocalanus crassirostris	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Engraulidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	0.00	0.00	0.00	0.00	100.00	46.67	52.68	66.38
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Engraulidae

Postflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	0.00	0.00	0.00	0.00	50.00	33.33	1.10	10.73
Copepod fragments	50.00	38.24	24.05	40.66	0.00	0.00	0.00	0.00
Copepod nauplii	16.67	5.88	1.39	1.58	0.00	0.00	0.00	0.00
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	33.33	8.82	6.34	6.60	0.00	0.00	0.00	0.00
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Engraulidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	50.00	14.71	8.82	15.36	100.00	50.00	70.88	75.34
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parvocalanus crassirostris	16.67	8.82	10.18	4.13	50.00	16.67	28.02	13.93
Paracalanus sp.	33.33	5.88	45.47	22.35	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Engraulidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	33.33	17.65	3.75	9.31	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Gobiidae

Preflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	18.18	31.48	1.99	9.91	13.64	11.25	1.21	5.44
Copepod fragments	36.36	9.26	17.01	15.56	20.45	15.00	11.21	17.16
Copepod nauplii	18.18	5.56	2.78	2.47	31.82	23.75	23.41	48.03
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	27.27	7.41	12.15	8.69	2.27	2.50	4.19	0.49
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Gobiidae

Preflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	18.18	5.56	5.63	3.31	0.00	0.00	0.00	0.00
Oithona attenuata	18.18	3.70	9.57	3.93	6.82	3.75	5.23	1.96
Oithona brevicornis	0.00	0.00	0.00	0.00	4.55	3.75	13.70	2.54
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	4.55	2.50	4.33	0.99
Oithona sp.	54.55	20.37	21.64	37.32	13.64	10.00	15.36	11.07
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parvocalanus crassirostris	27.27	11.11	26.26	16.60	9.09	5.00	8.72	3.99
Paracalanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	2.27	1.25	0.69	0.14
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Gobiidae

Preflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	18.18	3.70	2.68	1.89	11.36	12.50	6.60	6.95
diatom	0.00	0.00	0.00	0.00	2.27	6.25	4.98	0.82
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified	9.09	1.85	0.29	0.32	4.55	2.50	0.36	0.42

Gobiidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	15.38	19.23	5.76	7.99	11.76	7.32	0.83	1.77
Copepod fragments	23.08	11.54	22.56	16.35	23.53	19.51	10.59	13.10
Copepod nauplii	0.00	0.00	0.00	0.00	41.18	24.39	12.43	28.04
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	7.69	15.38	14.00	4.70	0.00	0.00	0.00	0.00
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Gobiidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona attenuata	15.38	7.69	13.11	6.65	5.88	2.44	11.72	1.54
Oithona brevicornis	0.00	0.00	0.00	0.00	5.88	2.44	2.23	0.51
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	7.69	3.85	8.95	2.05	0.00	0.00	0.00	0.00
Oithona sp.	46.15	26.92	27.83	52.51	35.29	31.71	41.70	47.92
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parvocalanus crassirostris	0.00	0.00	0.00	0.00	11.76	7.32	17.56	5.41
Paracalanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Gobiidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	23.08	11.54	7.41	9.08	11.76	4.88	2.95	1.70
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	7.69	3.85	0.37	0.67	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Gobiidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	10.42	14.97	0.83	2.89	33.33	29.41	5.90	24.24
Copepod fragments	16.67	6.80	7.20	4.10	33.33	17.65	12.69	20.83
Copepod nauplii	0.00	0.00	0.00	0.00	33.33	17.65	8.02	17.62
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	31.25	12.24	15.41	15.17	0.00	0.00	0.00	0.00
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	4.17	1.36	2.50	0.28	0.00	0.00	0.00	0.00

Gobiidae

Postflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	10.42	3.40	1.41	0.88	0.00	0.00	0.00	0.00
Oithona attenuata	0.00	0.00	0.00	0.00	16.67	5.88	22.08	9.60
Oithona brevicornis	2.08	2.04	1.59	0.13	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	39.58	21.09	17.95	27.14	16.67	23.53	20.45	15.10
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	2.08	0.68	3.21	0.14	0.00	0.00	0.00	0.00
Paracalanus sp1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parvocalanus crassirostris	43.75	25.85	35.19	46.89	16.67	5.88	30.86	12.61
Paracalanus sp.	4.17	2.04	7.26	0.68	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	4.17	1.36	4.75	0.45	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	4.17	1.36	1.05	0.18	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Gobiidae

Postflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	8.33	5.44	1.45	1.01	0.00	0.00	0.00	0.00
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	2.08	0.68	0.10	0.03	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	2.08	0.68	0.10	0.03	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Leiognathidae

Preflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod fragments	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod nauplii	25.00	20.00	6.81	4.91	0.00	0.00	0.00	0.00
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Leiognathidae

Preflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parvocalanus crassirostris	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Leiognathidae

Preflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	75.00	80.00	93.19	95.09	33.33	50.00	80.88	65.44
diatom	0.00	0.00	0.00	0.00	33.33	25.00	14.34	19.67
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
unidentified	0.00	0.00	0.00	0.00	33.33	25.00	4.78	14.89

Leiognathidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	0.00	0.00	0.00	0.00	20.00	12.50	1.17	2.03
Copepod fragments	30.77	15.79	13.50	9.86	0.00	0.00	0.00	0.00
Copepod nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Leiognathidae

Flexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	30.77	21.05	14.20	11.87	0.00	0.00	0.00	0.00
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parvocalanus crassirostris	7.69	2.63	5.01	0.64	0.00	0.00	0.00	0.00
Paracalanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Leiognathidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	61.54	42.11	52.23	63.53	80.00	75.00	82.77	93.73
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	38.46	18.42	15.06	14.09	20.00	12.50	16.06	4.24
unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Leiognathidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod egg	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Copepod fragments	50.00	25.00	5.69	17.36	0.00	0.00	0.00	0.00
Copepod nauplii	50.00	16.67	4.55	12.00	0.00	0.00	0.00	0.00
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Leiognathidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona attenuata	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona brevicornis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	25.00	8.33	5.60	3.94	0.00	0.00	0.00	0.00
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Parvocalanus crassirostris	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Leiognathidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	0.00	0.00	0.00	0.00	25.00	18.18	18.99	9.08
diatom	0.00	0.00	0.00	0.00	25.00	27.27	8.92	8.84
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	50.00	25.00	76.72	57.53	75.00	45.45	59.26	76.73
unidentified	25.00	25.00	7.45	9.18	25.00	9.09	12.84	5.36

Sciaenidae

Preflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.31	0.00
cirripede nauplii	6.90	1.40	3.34	0.46	2.04	0.49	0.00	0.02
Copepod egg	17.24	12.59	0.75	3.25	42.86	35.92	4.06	28.24
Copepod fragments	51.72	16.08	31.66	34.95	14.29	6.31	9.71	3.77
Copepod nauplii	27.59	10.49	1.98	4.87	34.69	12.62	7.35	11.42
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	20.69	7.69	7.89	4.56	26.53	8.74	12.34	9.22
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	3.45	0.70	2.50	0.16	0.00	0.00	0.00	0.00

Sciaenidae

Preflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	6.90	2.80	1.07	0.38	0.00	0.00	0.00	0.00
Oithona attenuata	3.45	0.70	0.53	0.06	6.12	2.43	5.62	0.81
Oithona brevicornis	0.00	0.00	0.00	0.00	4.08	0.97	1.62	0.17
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona sp.	51.72	30.77	22.97	39.34	42.86	17.48	23.84	29.18
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus sp1	0.00	0.00	0.00	0.00	2.04	0.49	2.01	0.08
Parvocalanus crassirostris	27.59	6.99	21.39	11.08	32.65	10.19	19.30	15.88
Paracalanus sp.	3.45	0.70	1.67	0.12	6.12	1.46	4.64	0.61
Pseudodiaptomus bowmani	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sciaenidae

Preflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	2.04	0.49	5.59	0.20
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	3.45	0.70	0.61	0.06	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	6.90	1.40	1.19	0.25	4.08	1.94	3.35	0.36
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	3.45	6.29	0.07	0.31	0.00	0.00	0.00	0.00
polychaete larvae	3.45	0.70	2.38	0.15	2.04	0.49	0.26	0.03
unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sciaenidae

Flexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	8.00	1.07	0.37	0.14	0.00	0.00	0.00	0.00
Copepod egg	24.00	13.37	0.84	4.04	26.32	20.16	1.46	7.32
Copepod fragments	12.00	2.67	3.92	0.94	15.79	4.03	2.14	1.25
Copepod nauplii	20.00	4.81	1.65	1.53	36.84	14.52	7.89	10.62
Acartia sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus andrewsi	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Corycaeus sp.	8.00	1.07	3.87	0.47	0.00	0.00	0.00	0.00
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	4.00	0.53	1.08	0.08	0.00	0.00	0.00	0.00
Euterpina acutifrons	64.00	21.39	23.48	34.04	52.63	11.29	14.28	17.30
Hemicyclops sp.	4.00	0.53	0.18	0.03	0.00	0.00	0.00	0.00
Labidocera sp.	4.00	0.53	0.93	0.07	0.00	0.00	0.00	0.00

Sciaenidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	8.00	1.07	0.30	0.13	0.00	0.00	0.00	0.00
Oithona attenuata	4.00	0.53	0.26	0.04	5.26	0.81	0.23	0.07
Oithona brevicornis	0.00	0.00	0.00	0.00	5.26	0.81	1.15	0.13
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	0.00	0.00	0.00	0.00	15.79	2.42	1.81	0.86
Oithona sp.	40.00	17.65	6.48	11.44	68.42	24.19	19.43	38.38
Acrocalanus gibber	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	12.00	1.60	5.50	1.01	10.53	4.03	11.62	2.12
Paracalanus sp1	4.00	0.53	2.41	0.14	5.26	1.61	4.22	0.39
Parvocalanus crassirostris	60.00	22.46	29.44	36.92	42.11	11.29	20.74	17.34
Paracalanus sp.	0.00	0.00	0.00	0.00	21.05	3.23	10.89	3.82
Pseudodiaptomus bowmani	24.00	3.21	13.49	4.75	5.26	0.81	3.79	0.31
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sciaenidae

Flexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
diatom	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	28.00	6.95	5.79	4.23	5.26	0.81	0.35	0.08
unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sciaenidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
bivalve	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
chaetognath	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede cyprids	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
cirripede nauplii	2.63	0.21	0.09	0.01	7.69	1.37	0.30	0.21
Copepod egg	50.00	40.72	5.01	27.74	15.38	4.11	0.16	1.09
Copepod fragments	10.53	1.27	2.32	0.46	15.38	2.74	5.09	2.00
Copepod nauplii	7.89	0.84	0.17	0.10	23.08	5.48	1.30	2.59
Acartia sp.	2.63	0.21	0.20	0.01	0.00	0.00	0.00	0.00
Cantocalanus pauper	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Centropages furcatus	2.63	0.21	0.50	0.02	0.00	0.00	0.00	0.00
Corycaeus andrewsi	2.63	0.21	0.19	0.01	0.00	0.00	0.00	0.00
Corycaeus sp.	13.16	1.05	3.15	0.67	7.69	1.37	3.28	0.59
Ditrichocorycaeus asiaticus	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euchaeta concinna	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Euterpina acutifrons	26.32	3.59	3.67	2.32	30.77	13.70	10.08	12.13
Hemicyclops sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Labidocera sp.	7.89	0.84	2.12	0.28	0.00	0.00	0.00	0.00

Sciaenidae

Postflexion

Genus, Species, common name	1985 - 86				2013-14			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Microsetella norvegica	2.63	0.21	0.07	0.01	0.00	0.00	0.00	0.00
Oithona attenuata	7.89	0.63	0.44	0.10	7.69	2.74	1.51	0.54
Oithona brevicornis	0.00	0.00	0.00	0.00	7.69	1.37	0.18	0.20
Oithona dissimilis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Oithona simplex	5.26	0.42	0.13	0.04	7.69	1.37	0.77	0.27
Oithona sp.	34.21	8.23	3.61	4.91	38.46	20.55	6.73	17.40
Acrocalanus gibber	5.26	0.42	1.55	0.13	0.00	0.00	0.00	0.00
Bestiolina similis	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Paracalanus aculeatus	28.95	4.43	10.62	5.29	30.77	6.85	15.55	11.43
Paracalanus sp1	13.16	2.11	5.38	1.20	23.08	4.11	7.21	4.33
Parvocalanus crassirostris	68.42	18.14	13.02	25.87	53.85	21.92	21.16	38.47
Paracalanus sp.	7.89	0.84	1.01	0.18	7.69	1.37	1.29	0.34
Pseudodiaptomus bowmani	55.26	8.86	32.54	27.76	15.38	2.74	9.92	3.23
Pseudodiaptomus nauplii	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Pseudomacrochiron sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Sciaenidae

Postflexion

Genus, Species, common name	**1985 - 86**				**2013-14**			
	% F	% N	% V	% IRI	% F	% N	% V	% IRI
Subeucalanus subcrassus	13.16	1.05	8.39	1.51	15.38	2.74	9.02	3.00
Subeucalanus subcrassus copepodite	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Subeucalanus subcrassus nauplii	7.89	1.27	1.91	0.30	0.00	0.00	0.00	0.00
Tortanus sp.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
brachyuran zoeae	5.26	0.42	0.74	0.07	7.69	1.37	3.80	0.66
diogenid zoeae	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
detritus	2.63	0.84	0.79	0.05	0.00	0.00	0.00	0.00
diatom	0.00	0.00	0.00	0.00	7.69	1.37	0.25	0.21
foraminiferans	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
ostracod	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
plant matter	2.63	0.21	0.14	0.01	0.00	0.00	0.00	0.00
ciliates	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
polychaete larvae	15.79	2.74	2.26	0.96	15.38	2.74	2.42	1.32
unidentified	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00