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Concentration and Composition of Organic Contaminants in Blackfin Tuna, Yellowfin Tuna, and the Common Clubhook Squid in the Western Gulf of Mexico

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by

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ABSTRACT

Cephalopods are an important component of pelagic food webs. They play ecological roles not only as predators but also as prey. However, their role as prey in the trophic transfer of organic contaminants to apex predators such as tunas in the Gulf of Mexico (GoM) is not well known. To investigate the importance of cephalopods in tuna diets, stomach samples were collected in February 2020 from tunas caught by rod and reel aboard the F/V Gulf Eagle near two large offshore floating oil/gas platforms in the northwestern GoM. Cephalopod samples were obtained from gut content analysis of 41 tunas caught during the cruise. My study examined the concentration and composition of 159 targeted organic contaminants by predator species and prey species. I compared liver and muscle tissues of 15 Blackfin Tuna (*Thunnus atlanticus*) and 10 Yellowfin Tuna (*Thunnus albacares*) and the mantle tissue of 20 cephalopods from their stomach contents. In particular, the prey analyses focused on the Common Clubhook squid, *Onychoteuthis banksii*, because of its prevalence in tuna stomachs. I quantified oil-derived polycyclic aromatic hydrocarbons (PAHs) and their oxidation products (OPAHs), polychlorinated biphenyls (PCBs), organochlorinated pesticides (OCPs), and emerging contaminants of concern (ECCs). Analysis was completed using accelerated solvent extraction (ASE) with gas chromatography and tandem mass spectrometry in multiple monitoring reaction mode (GC/MS/MS/MRM).

This study found that the mean total concentrations in all tissue types (mantle, liver, and muscle) followed the same trend (∑ECCs > ∑PAHs > ∑OCPs > ∑PCBs), except in Blackfin Tuna muscle tissue (∑ECCs > ∑PAHs > ∑PCBs > ∑OCPs). PAH sourcing predominantly identified petrogenic sources for all species. Both tuna demonstrated that OPAHs were products of PAH

metabolism. Opposite trends in lipid storage were observed between tuna liver and muscle tissue, which may relate to behavioral and metabolic differences between the species. Compound group correlations with lipids and standard length (SL) indicated bioaccumulation of ∑PCBs and ∑OCPs in Blackfin Tuna and ∑ECCs in Yellowfin Tuna. Squid discovered in Blackfin Tuna were smaller compared to those in Yellowfin Tuna. The squid from Blackfin Tuna stomachs exhibited significantly higher ∑PAHs and ∑OCPs than those from Yellowfin Tuna stomachs. There was a negative correlation between mantle length (ML) and ∑PAHs as well as ∑OCPs, indicating a growth-dilution effect for the Common Clubhook Squid. The mean trophic position for Blackfin Tuna (3.95) and Yellowfin Tuna (4.03) aligns with findings from other studies. Biomagnification factors of the tuna/squid food web based on trophic level indicated that the highest BMF values were consistent for both tuna: PCBs (82, 187, 183), Metolachlor (OCP), and benzo(b)fluoranthene (PAH), which supports evidence of biomagnification of these analytes in other results. Overall, this study indicates that tuna are capable of metabolizing or excreting the majority of organic contaminants examined.

CHAPTER 1: INTRODUCTION

Gulf of Mexico

The GoM began forming during the Middle Jurassic when seafloor spreading along a mid ocean ridge (MOR) created a small ocean basin (Galloway et al., 2011). Today, it is considered a semi-enclosed ocean basin and is bordered by the United States, Mexico and Cuba. The GoM is about ~1,500 km (900 mi) along its widest in diameter, with a surface area of 1.58×10^6 km^2 reaching depths of 3,750 m (Darnell, 2015). This basin has a rich history of tectonic activity, salt domes, an asteroid impact, and heavy sedimentation that all contribute to this unique environment. Geographically the GoM is split by the Tropic of Cancer creating a subtropical to temperate region in the northern half and a subtropical region in the southern portion (Darnell, 2015).

Approximately ~160-150 Ma, sea-level fell below what was thought to be a ~1,000 m sill in the emerging GoM allowing the basin to evaporate and leave behind salt deposits (Bird et al., 2005). Over time, tectonic uplift and fluvial deltas contributed to the accumulation of lithogenous sediment throughout the basin (Galloway and Ganey-Curry, 2000). These salt deposits, buried underneath layers of sediment, formed salt diapirs. Rising through the sediments, these salt diapirs create areas of low pressure where hydrocarbons such as oil and natural gas could accumulate and concentrate. They can be found on every continent except Antarctica. Some of the largest accumulations of hydrocarbons were discovered in sedimentary basins around the world including in the North Sea, Campos and Santos, Lower Congo, and the GoM (Drachev, 2014). Reservoirs of petroleum can accumulate into terrestrial and marine environments through the upward seepage of oil and gas through the salt diapirs because of tectonic activity.

An estimated 47 million gallons of liquid hydrocarbons seep into the waters of North America with the largest seeps in the GoM and offshore southern California (Kennicutt, 2017). Natural oil seeps are numerous throughout the northern GoM. Underwater plumes, sea surface slicks, and gas bubbles are often a sign of the location of a seep. These seeps also serve as evidence that valuable resources are available in waters of the GoM which has become a hot-spot for petroleum exploration and development (Weimer et al., 2017)

The U.S. Energy Information Administration's Gulf of Mexico Fact Sheet states that 14% (Release date: September 4, 2024) of the total USA crude oil production comes from offshore production in the GoM (U.S. Energy Information Administration). Accessing these oil reserves continues to push technology deeper and deeper in the GoM and is challenging due to the complexity of the geological history of the basin (S. Murawski et al., 2020). Weimer's overview of 226 oil and gas discoveries in depths > 457 m focuses on the 86 fields of the Mississippi Canyon and Atwater Valley and notes that the deepest well in the GoM is Toledo located in the Alaminos Canyon at 3,051 m (Weimer, et al., 2017).

The *Deepwater Horizon* (DWH) was a mobile offshore drilling unit (MODU) located in the Macondo oil prospect of the Mississippi Canyon owned by Transocean and operated by The British Petroleum Company (BP)and Anadarko Oil. Tragedy struck the rig on April 20, 2010, when the wellhead experienced a failure at the blowout preventer causing the drill ship to explode, burn and eventually sink to the seafloor. The event killed 11 workers, injured 17 others, and killed countless wildlife. It also triggered the largest offshore oil spill in U.S. history, the *Deepwater Horizon* Oil Spill (DWHOS). For 84 days, more than 200 million gallons of oil flowed from the wellhead into the GoM (Ramseur, 2010). Responses to the spill included *in-situ* burning, skimming, use of chemical dispersants at the sea surface, and for the first time injected at the blowout preventer 1,500 m below the sea surface, use of booms, and shore clean-ups with sorbents and manual removal (National

Academies of Sciences Engineering Medicine, 2022b). Through recovery methods, 17% was recovered at the well, 5% was consumed from *in-situ* burning, 3% was skimmed, 16% was chemically dispersed and another 37% were naturally attenuated (Ramseur, 2010). The remaining 22% either dispersed in the water column, was ingested by microbes, or was transported to the sediments with the balance having an unknown fate (Ramseur, 2010).

Oil spills from pipelines, tankers, barges, storage facilities, and refineries occur in the GoM on varying scales and magnitude (National Academies of Sciences Engineering Medicine, 2022a). These types of widespread ecological disasters create exposure risks to wildlife at the sea surface, in the water column and in the benthos. At its largest extent, the surface oil slick from the DWHOS covered more than 40,000 km^2 creating an exposure risk that was generally short to medium term in duration (S. Murawski et al., 2016). After the spill, an unexpected spring phytoplankton bloom and heavy sedimentation event lead to what became known as MOSSFA (marine oil snow sedimentation and flocculant accumulation)(Daly et al., 2016; P. Schwing et al., 2017). Marine snow is an aggregate of organic and inorganic particles held together by a mucous-like matrix that fall to the seafloor thus contributing to sedimentation. The more damaging and long-lasting impacts of the spill are related to contaminated sediments in the marshes, beaches, and open ocean (Montagna et al., 2013; Fisher et al., 2016; S. A. Murawski et al., 2021). Effects were clear on some benthic communities where deep-sea corals and sea fans experienced mortality events while other communities had declines and shifts in biodiversity and abundances (Montagna, et al., 2013; Fisher, et al., 2016; S. Murawski, et al., 2016; Prouty et al., 2016; Reuscher et al., 2017; Brooks et al., 2020; P. T. Schwing et al., 2020). Contaminated sediments can be remobilized into the water column by bioturbation, storms, turbidity currents, and other disturbances prolonging the exposure to benthic inhabitants and other animals that rely on them as a food source (Brooks, et al., 2020).

The GoM also acts as a sink for nonpoint source pollutants as it receives nearly half of the United States (US) watersheds discharge (Chen, 2017). Rivers in the US bring 1.26 x 10^{11} m^3 of freshwater to the GoM each year and the largest contributor, the Mississippi River, delivers 1.03 x 10^{11} m^3/yr. of freshwater and an annual sediment load of 4.54 x 10^{11} kg (Darnell, 2015). The Mississippi River watershed is the fourth largest in the world, draining 3.2 million km^2 (~40%) of the U.S. and parts of Canada (National Park Service, 2024). Pollution from industry, agriculture, and urban environments contaminates the terrestrial environment. Rain and melting snow collect these contaminants, carrying them into waterways and rivers. As they travel downstream, these pollutants may become buried in sediments, where disturbances from bioturbation, storms, and turbidity currents can reintroduce them into the water column.

Organic Pollutants

Organic pollutants are toxic carbon-based chemicals that can be transported and cycled through the air, soil, and water. They persist in the environment for long periods due to their slow rates of decomposition, stability, and long half-life (Sharma et al., 2019). The Clean Water Act (CWA) of 1972 was created to regulate pollutants that are discharged into the waters of the US and to set water quality standards. The EPA added a list of high-priority pollutants to the CWA in the late 1970s, and currently provides analytical testing methods for the 126 pollutants on the list (United States Environmental Protection Agency, 2015, 2024). Through a global effort of over 90 countries, the Stockholm Convention (treaty) was signed in 2001 to stop the use and production of 12 persistent organic pollutants (POPs) dubbed the "Dirty Dozen". The original list included compounds that were both intentionally and unintentionally produced because of combustion and industrial processes including aldrin, chlordane, dichloro-diphenyl-trichloroethane (DDT) dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene, PCBs, polychlorinated dibenzo-p-dioxins

(dioxins), and polychlorinated dibenzofurans (furans) (United States Environmental Protection Agency, 2002).

While some of these pollutants are no longer in use or discarded into our waterways, some nevertheless persist as "legacy pollutants" in the marine environment. Marine fauna can bioaccumulate these compounds in their tissues (United States Environmental Protection Agency, 2002). Bioaccumulation takes place in marine settings as organisms absorb organic pollutants from various sources, including water, sediments, and diet, surpassing their capacity to eliminate these toxins. As organisms age and grow, the concentration of the contaminant rises over time (Weis, 2024). Organic contaminants (e.g., PCBs, OCPs, etc.) are lipophilic which accumulate in fatty tissues. Biomagnification is the trophic transfer of these contaminants that move through food webs, increasing concentrations from prey to higher trophic level predators through diet (Weis, 2024). The octanol-water partition (K_{OW}) has been used as a biomagnification factor (BMF) to predict the solubility of an analyte between lipid and water phases with K_{OW} >4 more likely to accumulate in tissues (Mackay and Clark, 1991; Alava and Gobas, 2012; Sun et al., 2024). The BMF is another measure of biomagnification where concentrations in the predator are divided by the prey and values >1 suggest biomagnification in the food web, <1 trophic dissolution, and =1 no change (Sun, et al., 2024). The BMF has also been calculated using the trophic level of prey and predator in conjunction with concentrations to indicate an analyte's biomagnification propensity in a food web (Alava and Gobas, 2012). This study focuses on a subset of both legacy and currently used toxic chemicals including: polycyclic aromatic hydrocarbons (PAHs), their alkylated homologs (OPAHs), Polychlorinated biphenyls (PCBs), organochlorinated pesticides (OCPs), and emerging contaminants of concern (ECCs) such as phthalates and UV filters (the primary component of sun screens).

Polycyclic aromatic hydrocarbons (PAHs)

Anthropogenetic use of fossil fuels has increased the concentration of polycyclic aromatic hydrocarbons (PAHs) in the environment. The GoM is at an even greater risk of PAH exposure with the prevalence of offshore oil drilling and attendant oil discharges, as well as, the potential for future oil spills. Oil spill related compounds such as BTEX (benzene, toluene, ethylbenzene, and xylenes) and PAHs make up the bulk of crude oil (S. Murawski, et al., 2016). And while both are toxic to marine animals, BTEX is less concerning as it degrades quickly in seawater while PAHs can persist for long periods in sediments. There are 16 PAHs on the EPAs Toxic Pollutant List: Acenaphthene (ACE), Acenaphthylene (ACL), Anthracene (AN), Benzo(a)pyrene (BAPY), Benzo (b)fluoranthene (BBFL), Benzo (g,h,i)perylene (BGP), Benzo (k)fluoranthene (BKFL), Chrysene (CHR), Dibenz(a,h)anthracene (DA), Fluoranthene (FL), Fluorene (F), Indeno (1,2,3-c,d)pyrene (ID), Naphthalene (N), Phenanthrene (P), and Pyrene (PY).

PAHs are compounds that have two or more aromatic rings with shared carbon atoms. PAHs with two or three rings are classified as low molecular weight (LMW) PAHs and those with four to six rings high molecular weight (HMW) PAHs. Because these compounds are lipophilic, they are easily absorbed into the gastrointestinal tract of animals and distributed throughout the body in a wide variety of fatty tissues. These compounds can be derived from both natural and anthropogenic sources and can have toxic, mutagenic, and carcinogenic effects in contaminated organisms. (Meador et al., 1995; Van Der Oost et al., 2003; Abdel-Shafy and Mansour, 2016).

PAHs are generally classified into three source groupings: petrogenic, pyrogenic, and natural. Petrogenic sources originate from petroleum products such as crude oil and fuels released into the environment from urban runoff and accidental oil spills, for example (Stogiannidis and Laane, 2015). Pyrogenic sources are released as exhaust and residues from high-temperature combustion of fossil fuels and biomass, and can be released by volcanoes and forest fires. PAHs are introduced

into marine ecosystems through atmospheric deposition, rivers, coastal runoff, and directly through accidental releases (Stogiannidis and Laane, 2015). Lastly, PAHs can also be produced naturally through biogenesis and diagenesis in the degradation of organic materials or by plants, algae, and other microorganisms (Stogiannidis and Laane, 2015). The composition of PAHs is useful in determining the origin of the PAHs found within the tissues of marine animals (Gomes et al., 2013; Romero et al., 2018; Pulster et al., 2020).

PAHs can degrade in the environment and transform through the metabolism of biota to produce derivatives of PAHs such as nitro-, oxy-, and hydroxy- PAHs (Layshock et al., 2010; Clergé et al., 2019; Nowakowski et al., 2022). Oxidized polycyclic aromatic hydrocarbons (OPAHs) are more bioavailable, able to bond with proteins and DNA, and deemed more toxic than their parental PAHs exhibiting characteristics of endocrine disruption, mutagenicity, and carcinogenicity (Layshock, et al., 2010; Bandowe and Meusel, 2017; Clergé, et al., 2019; Nowakowski, et al., 2022).

Organochlorinated Pesticides (OCPs)

In the agricultural industry, plant protection is paramount as it's estimated that 45% of crops are lost annually to pest infestation (Sharma, et al., 2019). This necessitates the use of chemical pesticides, fungicides, and herbicides, collectively known as OCPs, to safeguard crops and to protect property from destructive pests. These compounds can persist in the environment, bioaccumulate in fatty tissues and biomagnify up the food chain (Chopra et al., 2011). One example, DDT, is a well-known banned pesticide that was used in the US and globally (Van Den Berg et al., 2017). DDT applications were primarily used to control mosquitos and sandflies for protection against malaria and leishmaniasis. Due to its widespread use, this chemical and its metabolites accumulated in the environment. Exposure of wildlife to these toxins can lead to liver tumors, reproduction issues, eggshell thinning, and embryo death in birds, and is highly toxic to aquatic species, affecting systems including the heart and brain (Kwong et al., 2008; Blus, 2011; Chopra, et al., 2011). DDT is still

being produced and applied in some countries, however, usage after the Stockholm Convention has diminished significantly as alternative insecticides have been developed and some pests have gained resistance to DDT (Van Den Berg, et al., 2017; Sharma, et al., 2019).

Polychlorinated Biphenyls (PCBs)

PCBs are man-made chemical compounds used for commercial and industrial purposes. Examples of PCB usage were in hydraulic and electrical equipment, paints, plastics, dyes, and carbonless paper (United States Environmental Protection Agency, 2021). PCBs were banned in the US in 1979 as part of the Toxic Substances Control Act (TSCA). However, they can still be found in products produced before that date and released into the environment through improper disposal, leaking landfills, and the burning of hazardous waste. The health effects of PCBs are wide-ranging from cancer, immune, reproductive, neurological, endocrine effects as well as dermal and ocular effects in monkeys and humans (Nakamura et al., 2005; Agency for Toxic Substances and Disease Registry 2014; Robertson and Hansen, 2014; United States Environmental Protection Agency, 2021).

Emerging Contaminants of Concern (ECCs)

In addition to the well known and highly regulated pollutants discussed above, there are a number of pollutants that are only now being considered as potentially harmful. Anthropogenic activities can impact marine environments from the introduction of toxic compounds via plastics and sunscreens leaching into marine environments. Microplastics can be vectors for transporting other sorbed POPs and through leaching of phthalates (plasticizers) that find their way into the ocean and accumulate in marine organisms with potentially harmful effects (Guerranti et al., 2016; Auta et al., 2017). Sources of these chemicals accumulating in the ocean can include direct deposition, effluent from wastewater management, winds, currents, and runoff from land (Giokas et al., 2007; Auta, et al., 2017). Microplastics may be categorized by source (primary or secondary), size

(< 5 mm), density, and chemical properties. Microplastics can originate from a variety of sources such as household products, children's toys, synthetic apparel, medical equipment, antifouling paints used on boat, drilling fluids and sunscreens among other sources (Graham, 1973; Auta, et al., 2017). Secondary microplastics come from the degradation of primary plastics. Of concern are the plasticizers used to make the plastics more durable and flexible such as phthalate esters (PAEs). Phthalates such as BBP are commonly added to paints, plastics, and other products to increase their durability and flexibility (Wang et al., 2024).

PAEs are released into the environment during fragmentation and degradation of plastics. Phthalates can be adsorbed to other materials or POPs and expose biota through inhalation, dermal contact, or ingested as food (Graham, 1973; Auta, et al., 2017; Godoy et al., 2021). Phthalates can then bioaccumulate and magnify up the food chain (Auta, et al., 2017) with the potential to increase lipid content and inflame the liver, cause endocrine disruption, result in developmental abnormalities, and affect nervous system function (Auta, et al., 2017; Hidalgo-Serrano et al., 2022). The U.S. Congress placed an interim limit on the concentration of certain phthalates present in childcare items and children's toys through the Consumer Product Safety Improvement Act (2008) with the final ruling occurring in 2018 (Cpsc, 2019).

Sunscreens are an important protection from sun exposure. However, additives such as organic ultraviolet (UV) filters can be toxic to marine life (Gilbert et al., 2013; Lebaron, 2022). These additives are used to absorb or reflect light; however, they can cross cell membranes due to their organic, low molecular weight, lipophilic nature (Gilbert, et al., 2013; Fivenson et al., 2021). In marine systems, they can degrade and accumulate in primary producers and magnify up the food chain (Lebaron, 2022). Toxicity effects of UV filters include cellular stress, damage to DNA and the immune system, endocrine disruption, developmental abnormalities, and bleaching in corals (Fivenson, et al., 2021; Lebaron, 2022).

Pelagic fishes of the Gulf of Mexico

The GoM has a diverse range of habitats from coastal zones to the open ocean allowing for high species richness in fishes. Finfish species biodiversity varies but have been reported to be 1,443 species as noted by Chen (2017), 66 of which were endemic to the GoM, 1,541 species by Mceachran (2009) and FishBase has the current species count at 1,133 (listed as incomplete) (Froese, 1990). Based on water column usage and habitat needs, FishBase categorizes fish habitats into seven groups: bathydemersal, bathypelagic, benthopelagic, demersal, pelagic-oceanic, pelagic-neritic, and reef-associated. Fish, such as tunas and billfish that live in the water column on and seaward of the continental shelf in the GoM are considered oceanic pelagic fish (National Oceanic and Atmospheric Administration, 2023b).

Blackfin Tuna and Yellowfin Tuna

Blackfin Tuna (*Thunnus atlanticus*) and Yellowfin Tuna (*Thunnus albacares*) support recreationally and economically important fisheries in the GoM with several hundred metric tons of catch each year for 2020-2023 (National Oceanic and Atmospheric Administration, 2023a) (Table 1.1). Management of Yellowfin Tuna falls under NOAA Fisheries and the Atlantic Highly Migratory Species Division which requires commerical fisherman to obtain a permit to harvest them along with gear restrictions, closures, and size limits (National Oceanic and Atmospheric Administration, 2024). Blackfin Tuna have bag (2 fish per person) and vessel limits (or 10 per vessel) for recreational fishermen (Florida Fish and Wildlife Conservation Commission).

Oceanic tunas (such as Blackfin Tuna and Yellowfin Tuna) are frequently found in the epipelagic both above and below the thermocline, can be in mixed schools with other pelagic fishes. Spawning varies by species occurring year-round or during summer months (Collette and Nauen, 1983; Chen, 2017). Species distribution of Blackfin Tuna is from the Western Atlantic: Martha's Vineyard, Massachusetts south to Trinidad Island and Rio de Janeiro, Brazil, while Yellowfin Tuna

are found worldwide in tropical and subtropical seas, but absent from the Mediterranean Sea (Horton et al., 2021).

Exposures to organic contaminants in fishes can occur from direct contact with contaminated waters through the dermis and gills and through their diet. Incardona et al. (2014) found cardiac effects from oil spills in larval pelagic fish including Bluefin (*Thunnus thynnus*) and Yellowfin Tuna. Additional evidence of larval impacts from oil exposure includes swimming performance degradation in Dolphinfish (*Coryphaena hippurus*) (Fisher, et al., 2016; S. Murawski, et al., 2016). In addition to the mortality from larval effects, fish can experience lesions externally and internally as well as DNA damage and reproductive impairment (Romero, et al., 2018). Pelagic oceanic predators (ex: tunas, mackerels, and swordfish) feed on other fish, squids, shrimps, and crabs, have few predators themselves, and tend to have higher trophic positions (i.e., trophic levels 4 and 5) (Collette and Nauen, 1983; Chen, 2017). Yellowfin Tuna were found to have the highest biliary PAH concentrations of all species tested in a comprehensive seven year study of GoM fishes (Pulster, et al., 2020).

Cephalopods in the Gulf of Mexico

Cephalopods (phylum Mollusca) are a generic term including decapodiforms (squids and cuttlefish), octopodiforms (vampire squid and octopods), and chambered nautiluses. They are strictly marine organisms, both benthic and pelagic, and are found worldwide from coastal habitats to the depths of over 5,000 m (Vecchione, 2002). Most cephalopods have a life span from six months to two years, longer for larger or cold water species (Vecchione, 2002).

Some cephalopod species participate in diel vertical migrations (DVM) residing in deeper depths during the day and migrating to near the surface at night. Other cephalopods species experience ontogenic shifts in depth during their life cycles. Judkins and Vecchione (2020) surveyed 4,000 individual cephalopods in the GoM using multiple opening and closing nets and found that of

the 39 species examined, 37 species (95%) live or move through the 1000-1400 m depth zone, where most of the deep oil plumes generated by the DWHOS was located (Judkins and Vecchoine, 2020).

Understanding the migration patterns of these animals is key to understanding their potential contaminant exposure. Cephalopod species studied from pre- and post-DHWOS collections showed a shift in PAH composition to a more petrogenic source that continued to the end of the study period in 2016 (Romero et al., 2020). Oil spill-related factors such as trophic shifts, migration through oil residues in the water column, and resuspended contaminated sediments potentially contribute to the persistence of oil-related pollutants in some species of the deep-sea environment when compared to a similar study of mesopelagic fishes (Romero, et al., 2020).

Cephalopod prey items include shrimp, fish, crabs, and other cephalopods, as well as cannibalism (Arkhipkin, 2013; Hoving et al., 2014; Villanueva et al., 2017). Squid play an important role in the food web as a prey item for whales, pelagic fishes, and birds (Piatkowski et al., 2001; Logan et al., 2013; Hoving, et al., 2014; Judkins et al., 2015; Sluis et al., 2021). Additionally, more than 3 million tons of squid are caught globally each year for human consumption (Vecchione, 2002).

Common Clubhook squid (Onychoteuthis banksii)

The Common Clubhook Squid, *Onychoteuthis banksii,* is a medium sized (~ 120 cm dorsal mantle length) found in Gulf of Guinea, central north Atlantic, and the GoM in depths from 0 – 1500 m. (Bolstad et al., 2010; Judkins and Vecchoine, 2020) . This species has hooked tentacles and unique photophores on its eye and in its viscera (Roper and Sweeney, 1984). They are considered a week vertical migrator with no ontogenic shifts and are not currently a managed as a fishery. *Onychoteuthis banksii* was the most abundant cephalopod in the stomachs of the sampled tunas I examined and have been found in the diet of Bluefun Tuna (*Thunnus thynnus*) and Albacore Tuna

(*Thunnus alalunga*) and Giant Red Shrimp (*Aristaeomorpha foliacea*) in the Mediterranean Sea (Bello and Pipitone, 2002; Salman and Karakulak, 2009; Battaglia et al., 2013)

Importance and Aim of This Study

The GoM epipelagic and mesopelagic systems are connected through the DVM of species potentially increasing exposure to organic pollutants (Romero, et al., 2018; Cook et al., 2020; Judkins and Vecchoine, 2020). The goal of this study is to determine the concentration and composition of organic pollutants (e.g., PAHs, OPAHs, PCBs, OCPs, and ECCs) in apex predators (i.e., tunas) in the GoM and in squid prey as trophic connectivity through predator (tuna) and prey (squid) interactions.

Specific research objectives are:

1) Determine the exposure and accumulation of organic contaminants in the liver and muscle tissues of the tuna species studied.

2) To determine the concentrations of organic contaminants in Common Clubhook Squid mantle tissue.

3) To examine the role of Common Clubhook Squid in the potential trophic transfer of organic contaminants to tuna species.

This is the first study to examine organic pollutants in Common Clubhook Squid from the stomach contents of pelagic fishes in the GoM. Comparing the accumulation of organic contaminants in the mantle tissue of Common Clubhook Squid to those of their predators, such as tuna (i.e., liver), will provide some insight into the potential for trophic transfer from prey to predators, although other prey sources (other cephalopod species and fishes) were not examined. Calculating the biomagnification factor between tuna and their prey, Common Clubhook Squid will help identify the trophic transfer of organic contaminants in prey and predators.

Tables

Table 1.1: Reported recreational and commercial landings for Blackfin Tuna and Yellowfin Tuna in the GoM for years 2020 – 2023. Landings for 2022 recreational Yellowfin Tuna were not reported at the time of this study. (National Oceanic and Atmospheric Administration, 2023a).

Species	Fishery	Year	Metric Tons	Dollars
Blackfin Tuna ***Thunnus atlanticus***	Commercial	2020	7	20,897
		2021	30	90,495
		2022	51	191,822
		2023	50	212,472
	Recreational	2020	786	
		2021	223	
		2022	955	
		2023	315	
Yellowfin Tuna ***Thunnus albacares***	Commercial	2020	189	1,645,783
		2021	160	1,525,131
		2022	106	1,031,278
		2023	70	684,080
	Recreational	2020	108	
		2021	308	
		2023	149	

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CHAPTER 2: MATERIALS AND METHODS

Sample Collection and Selection

Fish samples were obtained aboard the recreational "headboat" F/V *Gulf Eagle* from 2/16/2020 to 2/18/2020 in the northwestern Gulf of Mexico (GoM). Fish were collected at three stations associated with offshore oil and gas platforms: Nansen, Perdido (Table 2.1, Figure 2.1). Fish were collected by trolling, jigging, and casting with rod and reel. Nansen is located 150 miles south of Houston, TX operating since 2002 at 1200 m depth, and Perdido oil platform is located 198 miles south of Freeport, TX operating since 2010 at 2,743 m depth (Offshore Technology, 2000; N S Energy, 2020; Offshore Technology, 2021). (A total of 32 Blackfin Tuna (*Thunnus atlanticus*) and 41 Yellowfin Tuna (*Thunnus albacares*), and other fish species were collected, identified, and processed. The time, depth, latitude, and longitude were recorded for each fish occurrence. Biometric data included sex, standard length (SL), fork length (FL), and total length (TL) (cm), total body weight, liver weight, gastrointestinal weight, and gonad weight (kg) were recorded (Table A.1, Table A.2). Fish were dissected and the full stomachs and section of the muscle tissue and the whole liver were kept on ice until the conclusion of the fishing trip then immediately frozen (-20°C) and later transported (June 2021) to the Murawski Lab at the University of South Florida College of Marine Science St. Petersburg, FL for further processing.

The fish stomachs were thawed, dissected, and prey items identified to the lowest taxonomic level, measured, weighed, and re-frozen for future analysis. Cephalopods were rethawed in the Judkins Invertebrate Lab and identification was reconfirmed to the lowest taxonomic level. If the cephalopod prey were too digested to identify, it was listed as unidentified squid (unid squid). If beaks were found whole (upper and lower beak) attached to partial body tissue they were classified

as unid squid. Squid samples were then stored individually in labeled vials. Individual upper and lower beaks were found in the stomachs, they were classified as beaks, then counted and divided by two, and collectively stored together in a labeled vial for each respective tuna specimen. *Onychoteuthis banksii* was the most abundant prey item identified to species (n = 52) (Table A.3). See Table A.4 for a complete listing of cephalopods for each fish.

For organic analysis, only female tunas were selected due to their ability to offload contaminants through the material transfer of lipids during spawning. Fifteen Blackfin Tuna and ten Yellowfin Tuna were randomly selected for this study. From the stomach contents of these selected fish, twenty the Common Clubhook Squid were randomly chosen for chemical analysis: twelve squid from Blackfin Tuna (average ML: 34, range: 18 – 57) and eight from Yellowfin Tuna (average ML: 68, range: 46 – 105). The squid samples were in various stages of digestion, and only mantle tissue was available for analysis due to their condition.

Tissue Extraction

Tuna liver and muscle samples (approximately 2 – 3 g) of each sampled fish and squid mantle tissue (approximately 2 g when possible) were added to pre-weighed acid washed vials and weighed again to calculate wet weight (ww). Samples (tunas n = 50 [e.g., muscle and liver], squid n = 20) were then placed in Labonco ® 7754040 vacuum freeze-drier for approximately five days. The samples were re-weighed to obtain dry weight (dw) and then homogenized to prepare for solvent extraction using an Accelerated Solvent Extraction (ASE) system (ASE 200®, Dionex). In preparation for analysis, glass fiber filters, sand, and silica gel (high purity grade, 100-200 mesh, pore size 30A, Sigma Aldrich, St. Louis, MO USA) were combusted at 450°C for 4 h then the silica gel was deactivated by adding 2% by weight of MilliQ water. Surrogate standards were prepared and including d10-acenaphthene, d10-phenanthrene, d10-fluoranthene, d12-benz(a)anthracene, d12-benzo(a)pyrene, d14-dibenz(ah)anthracene (Ultra Scientific ISM-750-1), tetrachloro-m-xylene (Cat#

32027, Restek, Bellafonte, PA, USA), biphenyl d10 (Cat# 72058, Absolute Standards, Hamden, CT, USA), and d4-di-n-octyl-phthalate and d4-di-n-butyl-phthalate (Sigma Aldrich, St. Louis, MO, USA). The samples were separated into six sets (two muscle, two liver, two mantle). Each sample in a set and two control blanks were prepared in 5 ml cells packed with a glass fiber filter, followed by 3 g silica gel, glass fiber filter, freeze-dried homogenized sample (~0.1 g muscle tissue, ~ 0.1 g liver tissue, ~0.01 – 0.06 g mantle tissue), surrogate standards, and sand. Cells were placed on the ASE for extraction at 120°C, pressure of 1500 psi, and solvent 7:3 hexane:dichloromethane (Romero, 2018; Romero et al., 2018). Extracts were then concentrated with a RapidVap (LABONCO RapidVap® VertexTM evaporator model 73200 series) and finished by hand under nitrogen gas to a volume of ~100 µL for muscle and mantle tissue, and ~ 200 µL for liver tissue.

Total Lipid Content

Briefly, lipid extraction of the freeze-dried and homogenized samples (*n=70*) for calculating the total lipid content were prepared in six sets (two tuna muscle, two tuna liver, and two squid mantle) in 5 ml ASE cells packed with glass fiber filters, sample (~0.25 – 0.5 g for liver, ~ 0.25 – 0.4 muscle, ~0.001 – 0.1 g for mantle), and sand (samples were encapsulated by filters for later retrieval). Both the glass fiber filters and sand were pre-combusted at 450°C for 4 h. Glass extraction collection vials (60 ml, pre-combusted at 450 for 4 h) were labeled and pre-weighed. The ASE was run at 120°C, pressure 1500 psi with 100% dichloromethane solvent. Extraction vials were evaporated to dryness with the RapidVap and re-weighed to calculate Total lipid content (TLC). Tissue samples were retrieved from ASE cells after extraction and stored in 20 ml glass vials (pre-combusted at 450°C for 4 h) for later use in stable isotope analysis (SIA).

Stable Isotope Analysis

Squid mantle, tuna liver and muscle tissues retreived from lipid content processing were used for SIA using elemental analyzer continuous flow istotope ratio monitoring mass spectrometry (EA-

irms). Reference materials NIST 1577b (Bovine Liver) was used for quality control, NIST 8573 l-glutamic acid and NIST 8574 l-glutamic acid were used for isotope scale calibration and elemental calibration. Tissue samples ranging from 0.30 mg to 1.0 mg were placed into 3.3 x 5 mm tin capsules and weighed using a Mettler-Toledo microbalance. Encapuluation of tissue samples, reference materials and blanks were completed by folding the capsules into a rounded form and then placed into the sample tray for processing. Bulk carbon and nitrogen isotopes were measured on Carlo-Erba EA1108 elemental analyzer with a ThermoFinnagan delta +XL IRMS.

Analytical Method, Quality Assurance and Quality Control (QA/QC)

Analytical method followed modified protocols (QA/QC) of EPA methods 8270D and 8015C for the extraction of organic compounds. A gas chromatograph (GC) Agilent 7680B paired with an Agilent 7010 triple quadrupole mass spectrometer (MS) in Multiple Reaction Monitoring mode (GC-MS/MS-MRM) were used for analysis of extracted samples. Samples analysis of 1 µL in splitless injection mode was conducted with inlet temperature of 295°C, flow rate 1 mL/min, and 250°C MS detector temperature. Gas chromatograph column RXi-5sil (Restek Corporation, PA, United States) was used, UHP helium as carrier gas, and UHP argon gas as collision gas (1 mTorr pressure). The GC temperature and time progressed from 60°C for two min, 60 to 200°C at a rate of 8°C/min, 200 to 300 at a rate of 4°C/min then hold for four minutes, 300 to 325°C at a rate of 10°C/min then hold for five minutes.

Each analyzed set included laboratory blanks every five samples, spiked control standards, daily tuning of the MS/MS to perfluorotributylamine (PFTBA), calibration with reference material, and re-analysis when recoveries were low or exceeded ± 20% for precision and accuracy. Recoveries of reference standards ranged within 50-130% of QA/QC and each targeted compounds identification and performance were compared with a 5-point calibration curve (1.0, 2.0, 3.0, 4.0 $ng \cdot \mu L$). SRM 2779 (NIST, Gaithersburg, MD, USA), PAH standard mix (US-106-N-1, Agilent, Santa

Clara, CA,USA), M-508.1-X1 and M-508.1-X2 (Acustandard, New Haven, CT, USA), EPA phthalate esters mix 48231, avobenzone, homosalate, oxybenzone, 2-hydroxy-4-methoxybenzophenone, and octinoxate (Sigma Aldrich, St. Louis, MO, USA) reference standards were used for this method. Targeted compounds (Table 2.2, *n = 159*) consisted of PAHs and their alkylated homologs, PCBs, OCPs, ECCs based on previous methods and studies (Romero, 2018; Romero et al., 2020).

Data Analysis

Mean total concentrations ± 95% confidence interval (CI) are reported in ng/g ww (wet weight) for comparison with other studies and safety guidelines. Data were transformed from dry weight (dw) to ww by multiplying the concentration and the dryness fraction. Lipid-normalized concentrations (ng/g lw) were calculated by dividing the concentration ng/g dw by the lipid fraction. The partition coefficient for each analyte was determined by dividing the muscle concentration (lw) by the liver concentration (lw) for each fish. For statistical analysis, data were transformed (lipid fraction: $ArcSine\ \sqrt{[lipid\ fraction]}$, length: $\log_{10} length$, mean total concentrations: $\log_{10}[mean\ total\ concentration + 1]$) to approach normal distribution. Bivariate T-tests were used to examine differences in the percentage of lipids and mean total concentrations for each compound group (such as PAHs, PCBs, etc.) between tuna species. Differences in % lipids and mean total concentrations between species (tuna and squid) were examined using one-way ANOVA, followed by Tukey's HSD test. Bivariate T-tests were used to analyze the correlations of mean total concentration with % lipids and length (SL/ML). The composition of each compound group (e.g., PAHs, PCBs, etc.) is expressed as the relative abundance (percentage of total) of each analyte within that group.

PAH ratios (mean values based on wet weight concentrations) were used to determine natural, petrogenic, and pyrogenic sources. Calculations include LMW PAHs: the sum of 2 – 3 ring

PAHs, HMW PAHs: the sum of 4 – 6 ring PAHs, %Re: to identify natural sources, Pyrogenic index (PI) and ratios of Parent/alkyl and Fluoranthene/Pyrene: indicative of petrogenic and pyrogenic sources, Fluoranthene/(Fluoranthene & Pyrene) ratio: determine combustion type (fossil fuel, wood or coal) and PAH weathering by using ratios of LMW/HWM PAHs (Wang et al., 1999; Yunker et al., 2002; Romero et al., 2015; Stogiannidis and Laane, 2015; Romero et al., 2021).

The biomagnification factor is a ratio between the concentration of organic contaminants in the predator and their prey and has been used in aquatic environments to assess the transport of contaminants in a food web (Alava and Gobas, 2012). BMF ratios >1 indicate a contaminants ability to biomagnify and <1 trophic dissolution. Biomagnification between predator and prey was calculated in two ways: biomagnification factor (BMF) and biomagnification factor trophic position (BMF_{TP}) (Le-Alvarado et al., 2021). The first equation, BMF, is based on the following equation, $BMF = C_{Predator}/C_{Prey}$ where *C* is the lipid-normalized (lw) concentration of each analyte for predator and prey. The BMF_{TP} was calculated in two parts. First, the trophic position for each species (TP_X: $TP_{Blackfin\ Tuna}$, $TP_{Yellowfin\ Tuna}$; TP_{Squid}) was calculated using the following equation (Le-Alvarado, et al., 2021):

$$TP_x = \left(\frac{\delta^{15}N_x - \delta^{15}N_{Baseline}}{TEF}\right) + TP_{Baseline}$$

where $\delta^{15}N_x$ are the $\delta^{15}N$ values determined in this study for each tuna species (muscle tissue) and squid (mantle tissue), $\delta^{15}N_{Baseline}$ is the reference value of 6.8 (the $\delta^{15}N$ of zooplankton), TEF (trophic enrichment factor) is 1.9 (the isotopic difference between predator and prey), and $TP_{Baseline}$ is 2 (the tropic position of zooplankton) from the Le-Alvarado, et al. (2021) study. Then, the biomagnification factor normalized by trophic position (BMF_{TP}) was calculated with the following equation (Alava and Gobas, 2012):

$$BMF_{TP} = \frac{(C_{Predator}/C_{Prey})}{TP_{Predator} - TP_{Prey}}$$

where organic contaminant values for $C_{Predator}$ and C_{Prey} are lipid normalized (lw) concentrations for each analyte and $TP_{Predator}$ and TP_{Prey} are calculated as described above. The biomagnification factor calculation BMF_{TL} cannot be used in predator-prey calculations where trophic differences are small (e.g., < 0.11) or when the predator has a lower trophic level than the prey (Alava and Gobas, 2012). Significance for all tests was set at $p < 0.05$. Analyses were completed using JMP 17.0.0 statistical software (JMP Statistical Discovery LLC, Cary, NC)

Tables

Table 2.1: Sampling date, time, geographic coordinates, water depth and tuna samples by station.

Station	Date	Time	Latitude	Longitude	Water depth (m)	Blackfin Tuna	Yellowfin Tuna
Nansen	17-Feb-20	14:13	27° 29' 595" N	-95° 08' 367" W	1200	12	0
Perdido	17-Feb-20	15:29	26° 08' 040" N	-94° 54' 180" W	2743	3	10

Table 2.2: List of target compounds and abbreviations.

Polycyclic Aromatic Hydrocarbons (PAHs)	
N	Naphthalene
N-1	C1 naphthalene
N-2	C2 naphthalene
N-3	C3 naphthalene
N-3	C4 naphthalene
ACL	Acenaphthylene
ACE	Acenaphthene
F	Fluorene
F-1	C1 fluorene
F-2	C2 fluorene
F-3	C3 fluorene
Re	Retene
AN	Anthracene
P	Phenanthrene
P/AN1	C1 phenanthrene-anthracene
P/AN2	C2 phenanthrene-anthracene
P/AN3	C3 phenanthrene-anthracene
P/AN4	C4 phenanthrene-anthracene
D	Dibenzothiophene
D-1	C1 dibenzothiophene
D-2	C2 dibenzothiophene
D-3	C3 dibenzothiophene
D-4	C4 dibenzothiophene
FL	Fluoranthene
PY	Pyrene
FL/PY1	C1 fluoranthene-pyrene
FL/PY2	C2 fluoranthene-pyrene
FL/PY3	C3 fluoranthene-pyrene
FL/PY4	C4 fluoranthene-pyrene
BAA	Benz[a]anthracene
CHR	Chrysene
BAA/CHR1	C1 benz[a]anthracene-chrysene
BAA/CHR2	C2 benz[a]anthracene-chrysene
BAA/CHR3	C3 benz[a]anthracene-chrysene
BAA/CHR4	C4 benz[a]anthracene-chrysene
BBFL	Benzo(b)fluoranthene
BKFL	Benzo(k)fluoranthene
BEPY	Benzo(e)pyrene
BAPY	Benzo(a)pyrene
Pe	Perylene
ID	Indeno(1,2,3)pyrene
DA	Dibenz[ah]anthracene
BGP	Benzo(ghi)perylene
BP/PER1	C1 benzopyrene-perylene
BP/PER2	C2 benzopyrene-perylene
BP/PER3	C3 benzopyrene-perylene

Oxidized Polycyclic Aromatic Hydrocarbons (OPAHs)	
1, 4-NQ	1,4-naphthoquinone
1-NH	1-naphthaldehyde
2-NH	2-naphthaldehyde
9-FLO	9-fluorenone
9, 10-ANT	9,10-anthrone
9-XA	9-xanthone
9, 10-PQ	9,10-phenanthroquinone
NH	Napththaldehydes
FLO	Fluorenones
ANT	Anthrones
XA	Xanthones
NQ	Naphthoquinones
1-NN	1-nitronaphthalene
2-NN	2-nitronaphthalene
2-NF	2-nitrofluorene
9-NAN	9-nitroanthracene
9-NP	9-nitrophenanthrene
3-NFL	3-nitrofluoranthene
1-NPY	1-nitropyrene
6-NCHR	6-nitrochrysene
6-NBAPY	6-nitrobenzo(a)pyrene
NN	Nitronaphthalenes
NF	Nitrofluorenes
NAN/NP	Nitroanthracene-phenanthrenes
NFL/NPY	Nitrofluoranthene-pyrene
NCHR	Nitrochrysenes
NBAPY	Nitrobenzopyrenes
2, 3-HP	2,3-hydroxyphenanthrene
4, 9-HP	4,9-hydroxyphenanthrene
1-HN	1-hydroxynaphthalene
2-HN	2-hydroxynaphthalene
HN	hydroxynaphthalenes
HP	Hydroxyphenanthrenes

Emerging Contaminants of Concern (ECCs)	
DMP	Dimethyl phthalate
DEP	Diethyl phthalate
BBP	Benzyl butyl phthalate
DEHP	di-2-ethylhexyl phthalate
DnOP	Di-n-octyl phthalate
DBP	Di-n-butyl phthalate
CH	Cis-Homosalate
TH	Trans-Homosalate
OB	Oxybenzone
OC	Octinoxalate
AVO	Avobenzone

Organochlorinated Pesticides (OCPs)	
a-BHC	Alpha-hexachlorocyclohexane
b-BHC	Beta-hexachlorocyclohexane
g-BHC	Gamma-hexachlorocyclohexane
d-BHC	Delta-hexachlorocyclohexane
HEP	Heptachlor
ALD	Aldrin
HEP-epox	Heptachlor epoxide
g-CHL	g-Chlordane/trans-chlordane
a-CHL	a-Chlordane/cis-chlordane
EDS-II	Endosulfan I
EDS-II	Endosulfan II
EDS-sul	Endosulfan sulfate
DDE	p,p'-Dichlorodiphenyl dichloroethylene
DDD	p,p'-Dichlorodiphenyl dichloroethane
DDT	p,p'-Dichlorodiphenyl trichloroethane
DLD	Dieldrin
END	Endrin
END-AL	Endrin aldehyde
MOXC	Methoxychlor
HCCPD	Hexachlorocyclopentadiene
CBL	Chlorobenzilate
cis-PERM	cis-Permethrin
trans-PERM	trans-Permethrin
ETR	Etridiazole
CNB	Chloroneb
BHC	Hexachlorobenzene
CTN	Chlorothalonil
TRI	Trifluralin
DCPA	Dimethyl tetrachloroterephthalate
PPC	Propachlor
SMZ	Simazine
ATA	Atrazine
MEB	Metribuzin
ALA	Alachlor
MOAC	Metolachlor
CYA	Cyanazine

Polychlorinated biphenyls (PCBs)	
PCB 8	PCB 8 - di
PCB 28	PCB 28 - tri
PCB 37	PCB 37 - tri
PCB 52	PCB 52 - tetra
PCB 44	PCB 44 - tetra
PCB 49	PCB 49 - tetra
PCB 77	PCB 77 - tetra
PCB 74	PCB 74 - tetra
PCB 70	PCB 70 - tetra
PCB 66	PCB 66 - tetra
PCB 60	PCB 60 - tetra
PCB 126	PCB 126 - penta
PCB 87	PCB 87 - penta
PCB 99	PCB 99 - penta
PCB 101	PCB 101 - penta
PCB 114	PCB 114 - penta
PCB 118	PCB 118 - penta
PCB 82	PCB 82 - penta
PCB 105	PCB 105 - penta
PCB 156	PCB 156 - hexa
PCB 128	PCB 128 - hexa
PCB 153	PCB 153 - hexa
PCB 169	PCB 169 - hexa
PCB 158	PCB 158 - hexa
PCB 138	PCB 138 - hexa
PCB 166	PCB 166 - hexa
PCB 183	PCB 183 - hepta
PCB 179	PCB 179 - hepta
PCB 180	PCB 180 - hepta
PCB 170	PCB 170 - hepta
PCB 187	PCB 187 - hepta
PCB 189	PCB 189 - hepta

Figures

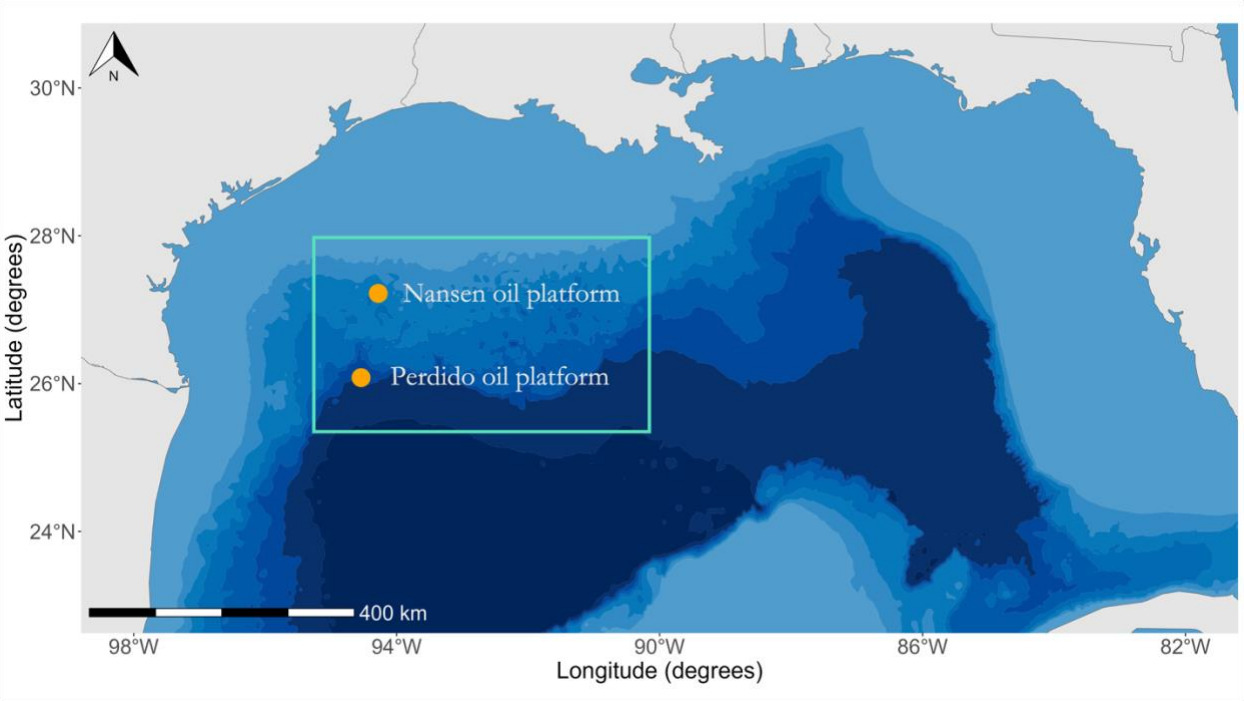

Figure 2.1: Tuna (n = 25) sampling locations 27° 29' 595" N, -95° 08' 367" W near the Nansen oil platform and 26° 08' 040" N , -94° 54' 180" W near the Perdido oil platform in the northwestern GoM.

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CHAPTER 3: RESULTS

Blackfin Tuna and Yellowfin Tuna

The fish analyzed in this study correspond to two size classes (50–65 cm SL and 73–87 cm SL; Table 3.1, Figure 3.1). All Blackfin Tuna range in size from 50 to 65 cm SL, except for one fish measuring 83 cm SL. Similarly, all Yellowfin Tuna range in size from 73 to 87 cm SL, with the exception of one fish measuring 105 cm SL.

As expected, for both fish species, the mean (± 95% CI) % lipids was higher in liver (Blackfin Tuna: 10.4 ± 3.0 %, range 4.3 – 22.9 %; Yellowfin Tuna: 6.2 ± 2.0 %, range 3.7 – 11.8 %) than muscle tissue (Blackfin Tuna: 1.5 ± 0.7 %, range 0.5 – 5.7 %; Yellowfin Tuna: 0.9 ± 0.3 %, range 0.36 – 1.4 %) (Table 3.2). There was no significant difference in the muscle/liver ratio of % lipids between tuna species ($p = 0.23$) (Figure 3.2). Similarly, we found no significant difference in % lipids in the muscle tissue between species ($p = 0.18$). In contrast, the % lipids in the liver tissue was significantly different between species ($p = 0.03$), with Blackfin Tuna having higher mean % lipids (Table 3.2).

The large range in % lipids observed in the muscle and liver tissues was explained by the large range in SL for both species, but with different trends (Figure 3.3). In Blackfin Tuna, SL and % lipids correlation was negative in the liver tissue ($R^2 = 0.41$; $p = 0.01$; Figure 3.3), but positive in the muscle tissue ($R^2 = 0.44$; $p = 0.007$; Figure 3.3). An opposite trend was observed in Yellowfin Tuna, with a negative correlation between SL and % lipids in the muscle tissue ($R^2 = 0.33$; $p = 0.08$; Figure 3.3) and a positive correlation in the liver tissue ($R^2 = 0.40$; $p = 0.05$; Figure 3.3).

When comparing tuna species, significant differences were observed in the mean $\delta^{13}C$ values for both muscle ($p = 0.0027$; mean $\delta^{13}C$ Blackfin Tuna: -17.423; Yellowfin Tuna: -17.703) and liver ti$p = 0.0013$; mean $\delta^{13}C$ Blackfin Tuna: -18.827; Yellowfin Tuna: -18.339). In contrast, no significant difference was found in $\delta^{15}N$ values between the species (muscle: $p = 0.7621$; liver: $p = 0.5447$) (Table 3.3).

Fish Tissue Concentrations

Contaminants were measured in samples of tuna liver and muscle tissue from both Blackfin Tuna ($n = 15$) and Yellowfin Tuna ($n = 10$). In Blackfin tuna, compound group concentrations (ww) in the muscle tissue followed the order ∑ECCs > ∑PAHs > ∑PCBs > ∑OCPs, differing from the liver tissue (∑ECCs > ∑PAHs > ∑OCPs > ∑PCBs) (Table 3.4, Figure 3.4). In contrast, compound group concentrations (ww) in Yellowfin Tuna have a similar trend for both the muscle and liver tissues: ∑ECCs > ∑PAHs > ∑OCPs > ∑PCBs (Table 3.4, Figure 3.4). Interspecies comparisons of compound group concentrations indicated that only ∑PAHs in the liver tissues were significantly different between the tuna species ($p = 0.0062$; Table 3.4). All the other compound group concentrations were similar between species in the muscle tissue ($p = > 0.05$; Table 3.5). In addition, we found that oxidized PAHs were significantly correlated with PAHs ($p < 0.05$; Figure 3.5, Figure 3.6), indicating that they are a product of PAH metabolism in both species of tuna. In Blackfin Tuna liver, LMW Nitro-PAHs, HMW Nitro-PAHs, and both Oxi- and Hydroxy-PAHs were significantly correlated ($p < 0.05$) with LMW PAHs, HMW PAHs, and ∑PAHs, respectively (Figure 3.5). A similar pattern was observed in Yellowfin Tuna, except that the only nitro-PAH found was nitro-chrysene (Figure 3.6). In Yellowfin Tuan, the only statistically significant correlation identified between the compound groups was ∑PAHs and ∑OCPs in liver tissue ($p = <0.0001$). In Blackfin Tuna, no correlations were observed between compound groups in muscle tissue (Table 3.7, Figure A.7). Statistically significant correlations were observed in Blackfin Tuna muscle tissue between

∑OCPs and ∑PAHs (p = 0.0059), ∑PCBs (p = 0.0047), and ∑ECCs (p = 0.0500), while no correlations were detected between compound groups in liver tissue (Table 3.7, Figure A.7).

Compound group concentrations (ww) varied differently relative to SL and %lipids between the fish species (Table 3.6). For example, in Blackfin Tuna, ∑PAHs were significantly correlated with %lipids (R^2 = 0.52; p < 0.05, positive correlation) and SL (R^2 = 0.42; p < 0.05, negative correlation), indicating larger animals present lower %lipids and ∑PAHs in their livers with no significant bioaccumulation in the muscle tissue (for PAHs and SL: R^2 = 0.01; p > 0.05) (Table 3.6). ∑PCBs in Blackfin Tuna, showed a significant correlation with SL in the muscle tissue (R^2 = 0.73; p < 0.0001) and with %lipids in both muscle (R^2 = 0.54; p = 0.0018) and liver (R^2 = 0.31; p = 0.0472) tissues, indicating bioaccumulation in the muscle tissue of larger animals (Table 3.6). ∑OCPs also indicate bioaccumulation in larger animals (muscle tissue: R^2 = 0.50, p < 0.05), although not necessarily associated with % lipids (muscle tissue: R^2 = 0.14, p < 0.05; Table 3.6). This pattern was not observed in Yellowfin Tuna (Table 3.6). Very different to the other compound groups in Blackfin tuna, no significant correlations were found between ∑ECCs and SL or % lipids (Table 3.6). In contrast, in Yellowfin Tuna showed no significant correlations between compound group concentrations (ww), and SL and % lipids, except for ∑ECCs in the liver tissue (R^2 = 0.56; p = 0.0125; negative correlation; Table 3.6, Appendix G).

Normalized Lipid Weight Concentrations in Fish Species

Concentration of compound groups normalized by lipid content (lw) showed a different pattern than concentrations normalized by wet weight (ww) (Figure 3.7, Figure 3.4). Normalized lipid weight contaminant concentrations followed the same trend (∑ECCs > ∑PAHs > ∑PCBs > ∑OCPs) in liver and muscle tissue for both tuna species. Between tuna species, significant differences were seen in ∑PCBs (ww) in muscle tissue (p = 0.0343, higher in Yellowfin Tuna) and ∑PAHs in liver tissue (p = 0.0376, higher in Blackfin Tuna).

The partition coefficient (PC) between muscle and liver tissues for each organic contaminant measured (lw; normalized to lipid content) revealed analytes that had higher concentrations in the muscle tissue than in the liver tissue across all compound groups in both tuna species. The highest PC values were observed for PAHs, specifically C3 fluoranthene-pyrene in Blackfin Tuna and for anthracene in Yellowfin Tuna (Table 3.9). Blackfin Tuna had 17 PAHs in common across all samples, with the highest PCs found in C3 fluoranthene-pyrene, followed by anthracene and C2 benz(a)anthracene-chrysene. Yellowfin tuna had 14 PAHs in common among samples, with the highest PCs found in anthracene, C3 naphthalene, and C2 naphthalene (Table 3.9). The tuna species exhibited the same 11 PCB analytes (PCBs 28, 52, 44, 74, 126, 87, 114, 156, 153, 179, and 170) with higher concentrations in muscle tissue than in liver tissue across all sampled Blackfin and Yellowfin Tuna. This suggests a tendency for these analytes to accumulate in the muscle tissue. The highest PC values (PC > 3) for PCBs in Blackfin Tuna were PCBs 183, 44, 49, 52, and the highest PC values (PC > 8) in Yellowfin Tuna were PCBs 44, 49, 74, and 166 (Table 3.9). In terms of OCPs, Metolachlor, Chloroneb, and DDT presented the highest PC values (PC > 2) in Blackfin Tuna. In contrast, DDT, Metribuzin, and d-BHC have the highest PC values (PC > 14) in Yellowfin tuna (Table 3.9). For ECCs, di-2-ethylhexyl phthalates and benzyl butyl phthalates had the highest PCs (PC > 4) in Blackfin Tuna, while benzyl butyl phthalates and diethyl phthalate were the highest in Yellowfin Tuna (PC > 6) (Table 3.9).

Variability of Analyte Composition

The PAH composition in both species and tissue types mainly consists of low-molecular-weight (2 – 3 ring) PAHs. The most abundant PAHs in both tuna species were phenanthrene, C1-phenanthrene-anthracene, and pyrene. Although both species exhibit similar patterns across tissue types, variations in the abundance of analytes and alkylated homologs are evident. Notably, differences are observed in the liver of Yellowfin Tuna, where naphthalene C1-C4 shows lower

levels, along with nearly 10% higher abundance of phenanthrene compared to Blackfin Tuna liver (Figure 3.8). Analysis of PAH analyte ratios in tuna liver indicated that both species had mostly petrogenic sources (Table 3.8).

For PCBs, both species exhibited the same trend in liver tissue following the order for the most abundant analytes: PCB 156 > PCB 170 > PCB 179 > PCB 153. In muscle tissue, the tuna species shared only the top two most abundant PCBs (Blackfin Tuna: PCB 156 > PCB 170 > PCB 126 > PCB 28; Yellowfin Tuna: PCB 156 > PCB 170 > PCB 128 > PCB 179; Figure 3.9). Out of the 32 identified PCBs, many showed higher levels in muscle tissue than in liver tissue (Blackfin Tuna: 14, Yellowfin Tuna: 25). Among these, 12 PCBs (PCB 28, 44, 49, 70, 74, 77, 99, 101, 126, 158, 183, 189) were identified as common to both species of tuna.

The composition of OCPs varied beween tuna species, with differences in abundance across tissue types (muscle, liver) (Figure 3.10). Overall, herbicides (Alachlor, Cyanazine, and Simazine) and insecticides (cis- and trans-Permethrin, and Endrin) were the most abundant in Blackfin Tuna. In comparison, insecticides (cis- and trans-Permethrin) were the predominant OCPs in Yellowfin Tuna. Several insecticides (DDE, DDT, and Aldrin) and herbicides (Alachlor, Metribuzin, and Metolachlor) exhibited higher % abundance in muscle tissue than in liver tissue in Blackfin Tuna. Similarly, Yellowfin Tuna also had insecticides (cis-Permethrin and DDT and its derivatives) and herbicides (Metribuzin, Cyanazine, and Metolachlor) with greater % abundance in muscle tissue compared to liver tissue (Figure 3.10).

Comparable patterns in the % abundance of ECCs were found across species and tissue types (Figure 3.11). In both tuna species, phthalates such as Dimethyl phthalate and Benzyl butyl phthalate were the most abundant (Blackfin Tuna: 56%, 40%; Yellowfin Tuna: 49%, 62%, respectively). Similarly, UV filters, cis- and trans-homosalate (Blackfin Tuna: <1%, <1%; Yellowfin Tuna: 3%, 6%, respectively) were the most abundant in both species. A consistent trend was

observed in muscle tissue (Benzyl butyl phthalate > Di-2-ethylhexyl phthalates > Di-n-butyl phthalates) and in liver tissue (Dimethyl phthalate > Di-n-butyl phthalate > Benzyl butyl phthalate) (Figure 3.11).

Common Clubhook Squid

The squid samples analyzed (n = 20) range in size from 18 to 105 mm in ML. The average ML of the squid varies among tuna species; The squid found in the Blackfin Tuna were smaller (33.8 ± 6.9 mm) than the specimens found in the Yellowfin Tuna (67.8 ± 16.3 mm) (Table 3.10). There was no significant difference in % lipids in the mantle tissue of squid collected from both tuna species (p = 0.08) (Table 3.11). Squid samples (n = 20) revealed a negative correlation between ML and % lipids (R^2 = 0.33; p = 0.007) (Figure 3.12). Stable isotope analysis of $\delta^{15}N$ and $\delta^{13}C$ in squid mantle tissue revealed no significant differences ($\delta^{13}C$: p = 0.3281; $\delta^{15}N$: p = 0.7643) in isotope values regardless of their predator (Table 3.3).

Squid Tissue Concentrations

The concentrations of compound groups was found to follow the order: ∑ECCs > ∑PAHs > ∑OCPs > ∑PCBs for squid from both tuna species (Figure 3.13). Higher significant differences in the concentration of ∑PAHs (p = 0.0006) and ∑OCPs (p = 0.0009) were found in squid from Blackfin Tuna stomachs (Table 3.5). No significant correlation was detected between compound group concentrations in the mantle tissue and %lipids (p > 0.05) (Table 3.5, Figure A.8). Among all compound groups, only ∑PAH (R^2 = 0.45; p = 0.0012) and ∑OCPs (R^2 = 0.55; p = 0.0002) showed a significant negative correlation with ML, suggesting no bioaccumulation in larger squid in this study (Table 3.6).

Variability of Analytes in Squid

PAH composition mainly consisted of LMW (2 – 3 ring) PAHs. The most abundant analytes from squid obtained from Blackfin Tuna were phenanthrene, C1-phenanthrene-anthracene, and

naphthalene, while those from Yellowfin Tuna were phenanthrene, C1-phenanthrene-anthracene, and fluorene (Figure 3.14). Analysis of PAH ratios in squid mantle tissue indicated that the sources are mostly petrogenic (Table 3.8).

The composition of PCBs in squid varied depending on their fish predator. Squid from Blackfin Tuna showed PCB abundance in the order PCB 74 > PCB 114 > PCB 126 > PCB 44, while squid from Yellowfin Tuna the order was PCB 52 > PCB 74 > PCB 114 > PCB 126 (Figure 3.15).

The squid mantle tissue primarily contained currently-in-use OCPs, showing a low percentage of legacy contaminants. This pattern was consistent among all the squid, where the most abundant OCPs were insecticides (cis- and trans-Permethrin), followed by herbicides (Propachlor, Cyanazine, and Alachlor), regardless of the predator (Figure 3.16).

The composition of ECCs in squid mantle tissue was similar in all squid samples regardless of fish predator, with the majority consisting of phthalates (> 99%) and low abundance (< 0.1%) of UV filters. All squid shared the most abundant analyte (Benzyl butyl phthalate), but trends differed depending on their predator (Blackfin Tuna: Benzyl butyl phthalate > Di-n-butyl phthalate > Diethyl phthalate; Yellowfin Tuna: Benzyl butyl phthalate > Dimethyl phthalate > Di-n-butyl phthalate) (Figure 3.17).

Trophic Connectivity between Common Clubhook Squid, and Blackfin Tuna and Yellowfin Tuna

Comparison of contaminant concentrations between squid and tuna liver tissues indicate that only ∑PCBs (ng/g lw) showed significant differences ($R^2 = 0.28$, $p = 0.0015$; Tukey's HSD test: $p < 0.0011$) with mantle tissue ∑PCBs lower than and tuna liver tissue (Figure 3.18). Similar composition was found for ∑PAHs, ∑OCPs, and ∑ECCs between squid and tuna livers (Figure 3.19, Figure 3.22, Figure 3.23). In contrast, the ∑PCB profiles differed between the squid and fish

liver tissues (Figure 3.20). Specifically, mantle tissue PCBs followed the order PCB 74 > PCB 114 > PCB 126 > PCB 99, while the tuna profiles were PCB 156 > PCB 170 > PCB 126 > PCB 28 (Figure 3.20). Additionally, the profiles related to PCB backbone chlorination (where chlorination levels are defined as: tri = 3, tetra = 4, penta = 5, hexa = 6, hepta = 7) varied between the tissue types, with mantle tissue following the order of penta > tetra > hexa > tri > hepta, and the tuna liver order was hexa > hepta > penta > tetra > tri (Figure 3.21). Results show that the tuna in this study has a higher abundance of more chlorinated PCBs (hexa and hepta) than squid mantle tissue (Blackfin Tuna ~67%, Yellowfin Tuna ~61%, squid ~19%) (Figure 3.21).

The calculated trophic position for tuna species (Blackfin Tuna: 3.07 – 5.38; Yellowfin Tuna: 3.05 – 5.21) had similar mean values: Blackfin Tuna: 3.95 ± 0.34; Yellowfin Tuna: 4.03 ± 0.60. In contrast, squid had a much smaller range (3.22 – 3.67) with a mean value of 3.42 ± 0.06, which was used as TP_{squid} in the BMF_{TP} calculation (Table 3.12). Blackfin Tuna samples N13 and N24, as well as Yellowfin Tuna samples P04, P20, P30, and P42, were excluded from the BMF_{TP} calculations as their trophic position was lower than squid (Table 3.12).

The majority of analytes showed results suggesting that biomagnification may occur in these predator-prey relationships, though not consistently across all tuna samples (Table 3.13). Analytes with the highest biomagnification factors followed the trend (PCBs > OCPs > PAHs > ECC) for both tuna species and both methods used (BMF and BMF_{TP}). The highest BMF values for PCBs (PCB 82, PCB 187, PCB 183), along with the highest OCP (Metolachlor) and PAH (benzo(b)fluoranthene), were consistent for both tuna species and both methods used (BMF and BMF_{TP}). Among the compound groups, PCBs had the largest number of samples with analytes exhibiting BMF values > 1, suggesting biomagnification in this food chain, while ECCs had the fewest. BMFs > 1 for all Blackfin Tuna samples (using both methods) consisted solely of PCB analytes for the BMF_{TP} method and included both PCBs and pyrene for the BMF method. In

contrast, Yellowfin Tuna had not only PCBs but also OCPs (including DDT, DDD, and DDE) as well as PAHs that were > 1 for all samples using both methods. For BMFs that were zero across all samples, both methods agreed that analytes b-BHC and simazine were absent from Blackfin Tuna, while Alachlor, DCPA, and dimethyl phthalate were absent from Yellowfin Tuna (Table 3.13).

Tables

Table 3.1: Sample list and measurements of the Blackfin Tuna (n = 15) and Yellowfin Tuna (n = 10) used in this study including sex, standard length (SL), fork length (FL), and total length (TL) in cm, total weight, and liver weight in g.

Tuna samples								
Station	**Fish ID**	**Species**	**Sex**	**SL (cm)**	**FL (cm)**	**TL (cm)**	**Total Body Wt. (g)**	**Liver Wt. (g)**
Nansen	N3	Blackfin Tuna	F	65	71	78	6,300	40
Nansen	N7	Blackfin Tuna	F	62	66	71	5,800	52
Nansen	N8	Blackfin Tuna	F	59	62	67	3,500	30
Nansen	N9	Blackfin Tuna	F	56	58	61	5,200	34
Nansen	N10	Blackfin Tuna	F	55	59	66.5	9,000	22
Nansen	N12	Blackfin Tuna	F	55.5	58.5	65	3,800	26
Nansen	N13	Blackfin Tuna	F	56	58.5	61	5,200	32
Nansen	N14	Blackfin Tuna	F	55	58	63	5,500	20
Nansen	N16	Blackfin Tuna	F	59	62	69	5,000	30
Nansen	N19	Blackfin Tuna	F	55	57.5	63	7,000	40
Nansen	N23	Blackfin Tuna	F	54	57	62	3,000	16
Nansen	N24	Blackfin Tuna	F	50	53	58	6,500	32
Perdido	P27	Blackfin Tuna	F	59	61	64	3,750	38
Perdido	P28	Blackfin Tuna	F	83	90	106	12,800	82
Perdido	P43	Blackfin Tuna	F	55	58	64	7,500	28
Perdido	P4	Yellowfin Tuna	I	79	86	101	11,200	74
Perdido	P13	Yellowfin Tuna	F	73.5	80	95.5	8,600	59
Perdido	P20	Yellowfin Tuna	F	75	81	98	9,300	67
Perdido	P29	Yellowfin Tuna	F	77.5	83.5	98	9,800	57
Perdido	P30	Yellowfin Tuna	F	105	115	135	26,800	153
Perdido	P33	Yellowfin Tuna	F	86	93	104	13,400	89
Perdido	P39	Yellowfin Tuna	F	76.5	83.5	94.5	11,500	79
Perdido	P41	Yellowfin Tuna	F	75.2	83	99	9,800	65
Perdido	P42	Yellowfin Tuna	F	78	81.5	91	8,200	56
Perdido	P45	Yellowfin Tuna	F	87	92	104	13,200	54
Blackfin Tuna		Mean ± CI		58.6 ± 4.2	62 ± 4.9	67.9 ± 6.4	5,990 ± 1,380	35 ± 9
		Range		50 – 83	53 – 90	58 – 106	3,000 – 12,800	16 – 82
Yellowfin Tuna		Mean ± CI		81.3 ± 6.8	87.9 ± 7.5	102 ± 8.8	12,200 ± 3,9900	75 ± 21
		Range		73.5 – 105	80 – 115	91 – 135	8,200 ± 26,800	54 – 153

Table 3.2: % lipids of tuna used in this study (n = 25).

Station	Fish ID	Species	% Lipids Muscle	Muscle Lipid Fraction	% Lipids Liver	Liver Lipid Fraction
Nansen	N3	Blackfin Tuna	1.12	0.011	4.28	0.043
Nansen	N7	Blackfin Tuna	1.30	0.013	6.84	0.068
Nansen	N8	Blackfin Tuna	0.47	0.005	9.76	0.098
Nansen	N9	Blackfin Tuna	1.09	0.011	12.06	0.121
Nansen	N10	Blackfin Tuna	3.07	0.031	16.70	0.167
Nansen	N12	Blackfin Tuna	0.93	0.010	4.87	0.049
Nansen	N13	Blackfin Tuna	1.04	0.010	14.01	0.140
Nansen	N14	Blackfin Tuna	1.04	0.010	7.12	0.071
Nansen	N16	Blackfin Tuna	2.53	0.025	8.12	0.081
Nansen	N19	Blackfin Tuna	0.99	0.010	9.94	0.099
Nansen	N23	Blackfin Tuna	1.30	0.013	18.57	0.186
Nansen	N24	Blackfin Tuna	0.92	0.010	22.88	0.229
Perdido	P4	Yellowfin Tuna	0.62	0.006	3.84	0.038
Perdido	P13	Yellowfin Tuna	1.22	0.012	4.16	0.042
Perdido	P20	Yellowfin Tuna	1.32	0.013	9.56	0.096
Perdido	P27	Blackfin Tuna	0.61	0.006	8.26	0.083
Perdido	P28	Blackfin Tuna	5.74	0.057	4.50	0.045
Perdido	P29	Yellowfin Tuna	1.26	0.013	3.95	0.040
Perdido	P30	Yellowfin Tuna	0.36	0.004	11.76	0.118
Perdido	P33	Yellowfin Tuna	1.40	0.014	8.63	0.086
Perdido	P39	Yellowfin Tuna	0.97	0.010	5.22	0.052
Perdido	P41	Yellowfin Tuna	0.84	0.008	4.76	0.048
Perdido	P42	Yellowfin Tuna	0.92	0.010	6.10	0.061
Perdido	P43	Blackfin Tuna	0.70	0.007	7.72	0.077
Perdido	P45	Yellowfin Tuna	0.52	0.005	3.73	0.037
	Blackfin Tuna	Mean ± CI	1.52 ± 0.75	Mean ± CI	10.38 ± 3.04	
		Range	0.47 – 5.74	Range	4.28 – 22.88	
	Yellowfin Tuna	Mean ± CI	0.94 ± 0.26	Mean ± CI	6.17 ± 2.02	
		Range	0.36 – 1.40	Range	3.73 – 11.76	

Table 3.3: Results of stable isotope analysis (SIA) for Blackfin Tuna, Yellowfin Tuna, and O. banksii samples used in this study.

Station	Fish ID	Species	Tissue Type	$d^{15}N$ (‰, AT-Air)	$d^{13}C$ (‰, VPDB)	N%	C%	N (µmol)	C (µmol)	C:N (mass)	C:N (molar)
Nansen	N03	Blackfin Tuna	Liver	10.40	-17.65	12.07	44.38	4.85	20.81	3.68	4.29
Nansen	N07	Blackfin Tuna	Liver	9.28	-18.31	11.36	45.41	5.13	23.94	4.00	4.66
Nansen	N08	Blackfin Tuna	Liver	9.50	-18.27	11.77	45.01	3.39	15.10	3.82	4.46
Nansen	N09	Blackfin Tuna	Liver	9.54	-19.15	12.18	46.23	5.53	24.48	3.79	4.43
Nansen	N10	Blackfin Tuna	Liver	8.51	-19.25	11.13	44.91	2.75	12.94	4.04	4.71
Nansen	N12	Blackfin Tuna	Liver	9.23	-18.67	12.17	45.59	4.08	17.84	3.74	4.37
Nansen	N13	Blackfin Tuna	Liver	9.12	-19.06	11.18	45.48	5.97	28.33	4.07	4.75
Nansen	N14	Blackfin Tuna	Liver	9.42	-19.01	11.31	45.11	5.97	27.76	3.99	4.65
Nansen	N16	Blackfin Tuna	Liver	9.82	-18.71	11.93	45.24	4.11	18.19	3.79	4.42
Nansen	N19	Blackfin Tuna	Liver	9.18	-18.61	11.18	44.50	4.05	18.78	3.98	4.64
Nansen	N23	Blackfin Tuna	Liver	9.92	-19.16	12.09	45.41	6.88	30.14	3.76	4.38
Nansen	N24	Blackfin Tuna	Liver	8.84	-19.34	9.82	45.80	4.02	21.89	4.66	5.44
Perdido	P04	Yellowfin Tuna	Liver	8.49	-18.41	12.23	44.89	6.71	28.75	3.67	4.28
Perdido	P13	Yellowfin Tuna	Liver	8.97	-18.17	12.45	44.00	4.61	19.02	3.53	4.12
Perdido	P20	Yellowfin Tuna	Liver	8.46	-18.49	12.12	43.89	5.27	22.25	3.62	4.23
Perdido	P27	Blackfin Tuna	Liver	9.06	-18.92	12.48	45.32	5.25	22.22	3.63	4.24
Perdido	P28	Blackfin Tuna	Liver	11.18	-18.60	11.81	43.67	4.81	20.76	3.70	4.31
Perdido	P29	Yellowfin Tuna	Liver	10.43	-18.32	11.38	41.50	4.31	18.35	3.65	4.25
Perdido	P30	Yellowfin Tuna	Liver	8.93	-17.63	12.35	45.09	5.40	23.01	3.65	4.26
Perdido	P33	Yellowfin Tuna	Liver	11.70	-18.73	11.80	39.85	6.27	24.69	3.38	3.94
Perdido	P39	Yellowfin Tuna	Liver	11.04	-18.53	12.27	43.55	4.61	19.11	3.55	4.14
Perdido	P41	Yellowfin Tuna	Liver	9.28	-18.40	11.77	44.03	5.77	25.18	3.74	4.37
Perdido	P42	Yellowfin Tuna	Liver	8.44	-18.46	12.42	44.51	4.00	16.72	3.59	4.18
Perdido	P43	Blackfin Tuna	Liver	8.82	-18.95	12.07	44.87	3.21	13.90	3.72	4.34
Perdido	P45	Yellowfin Tuna	Liver	11.23	-18.24	11.47	43.59	6.04	26.75	3.80	4.43
		Overall mean (tuna liver tissue)		9.55 ± 0.94	-18.60 ± 0.45	11.79 ± 0.59	44.47 ± 1.37	4.92 ± 1.08	21.64 ± 4.71	3.78 ± 0.25	4.41 ± 0.29
		Mean: Blackfin Tuna		9.46 ± 0.67	-18.78 ± 0.45	11.64 ± 0.66	45.13 ± 0.62	4.67 ± 1.15	21.14 ± 5.20	3.89 ± 0.26	4.54 ± 0.30
		Mean: Yellowfin Tuna		9.70 ± 1.26	-18.34 ± 0.29	12.02 ± 0.39	43.49 ± 1.62	5.30 ± 0.90	22.38 ± 3.99	3.62 ± 0.12	4.22 ± 0.14
Nansen	N03	Blackfin Tuna	Muscle	13.21	-17.11	14.40	45.31	7.40	27.16	3.15	3.67
Nansen	N07	Blackfin Tuna	Muscle	10.19	-17.12	14.58	45.71	7.06	25.84	3.14	3.66
Nansen	N08	Blackfin Tuna	Muscle	10.07	-16.91	13.91	43.48	4.95	18.03	3.13	3.65
Nansen	N09	Blackfin Tuna	Muscle	10.16	-17.37	14.47	45.80	7.71	28.45	3.16	3.69
Nansen	N10	Blackfin Tuna	Muscle	9.80	-17.44	14.36	45.20	5.30	19.46	3.15	3.67
Nansen	N12	Blackfin Tuna	Muscle	10.26	-17.48	14.49	45.34	7.29	26.62	3.13	3.65
Nansen	N13	Blackfin Tuna	Muscle	9.56	-17.50	14.55	45.41	6.97	25.37	3.12	3.64
Nansen	N14	Blackfin Tuna	Muscle	9.93	-17.76	14.38	45.43	7.50	27.65	3.16	3.69
Nansen	N16	Blackfin Tuna	Muscle	11.45	-17.45	14.49	44.78	4.41	15.88	3.09	3.60
Nansen	N19	Blackfin Tuna	Muscle	9.96	-17.53	14.64	45.00	3.17	11.35	3.07	3.59
Nansen	N23	Blackfin Tuna	Muscle	10.90	-17.80	14.68	45.56	6.96	25.19	3.10	3.62
Nansen	N24	Blackfin Tuna	Muscle	8.84	-17.38	14.20	45.36	7.59	28.29	3.20	3.73
Perdido	P04	Yellowfin Tuna	Muscle	9.38	-17.09	14.67	45.24	6.66	23.96	3.08	3.60
Perdido	P13	Yellowfin Tuna	Muscle	10.00	-17.23	14.54	45.14	3.44	12.48	3.11	3.62
Perdido	P20	Yellowfin Tuna	Muscle	8.81	-16.75	14.89	46.00	6.39	23.02	3.09	3.60
Perdido	P27	Blackfin Tuna	Muscle	10.51	-17.75	14.67	45.51	6.89	24.93	3.10	3.62
Perdido	P28	Blackfin Tuna	Muscle	12.81	-17.25	14.59	45.91	6.54	24.00	3.15	3.67

Table 3.3: (Continued)

Perdido	P29	Yellowfin Tuna	Muscle	11.91	-17.26	14.75	45.97	6.27	22.81	3.12	3.64
Perdido	P30	Yellowfin Tuna	Muscle	8.91	-16.52	14.69	46.17	9.18	33.68	3.14	3.67
Perdido	P33	Yellowfin Tuna	Muscle	12.62	-17.33	14.79	46.35	6.83	24.97	3.13	3.66
Perdido	P39	Yellowfin Tuna	Muscle	12.91	-17.20	14.47	45.08	4.98	18.09	3.12	3.63
Perdido	P41	Yellowfin Tuna	Muscle	10.54	-16.97	14.71	45.72	5.52	20.02	3.11	3.63
Perdido	P42	Yellowfin Tuna	Muscle	9.40	-17.31	14.75	45.83	7.88	28.58	3.11	3.63
Perdido	P43	Blackfin Tuna	Muscle	9.77	-17.48	14.66	46.30	5.72	21.05	3.16	3.68
Perdido	P45	Yellowfin Tuna	Muscle	12.18	-17.07	14.63	45.51	7.69	27.89	3.11	3.63
		Overall mean (tuna muscle tissue) ± SD		10.56 ± 1.33	-17.28 ± 0.30	14.56 ± 0.20	45.48 ± 0.58	6.41 ± 1.43	23.39 ± 5.30	3.12 ± 0.03	3.65 ± 0.03
		Mean: Blackfin Tuna ± SD		10.49 ± 1.18	-17.42 ± 0.25	14.47 ± 0.21	45.34 ± 0.63	6.36 ± 1.35	23.29 ± 1.35	3.13 ± 0.03	3.65 ± 0.04
		Mean: Yellowfin Tuna ± SD		10.66 ± 1.60	-17.07 ± 0.26	14.69 ± 0.12	45.70 ± 0.44	6.48 ± 1.61	23.55 ± 5.91	3.11 ± 0.02	3.63 ± 0.02

Station	**Prey ID**	**Species**	**Tissue Type**	**$d^{15}N$ (‰, AT-Air)**	**$d^{13}C$ (‰, VPDB)**	**N%**	**C%**	**N (µmol)**	**C (µmol)**	**C:N (mass)**	**C:N (molar)**
Nansen	N07-15	*O. banksii*	Mantle	9.37	-18.53	12.40	39.12	6.46	23.78	3.15	3.68
Nansen	N07-16	*O. banksii*	Mantle	9.25	-18.65	12.90	40.51	5.02	18.38	3.14	3.66
Nansen	N09-05	*O. banksii*	Mantle	9.96	-18.55	13.03	41.80	4.89	18.31	3.21	3.74
Perdido	P27-11	*O. banksii*	Mantle	9.25	-19.07	12.31	39.73	8.09	30.47	3.23	3.76
Perdido	P27-12	*O. banksii*	Mantle	9.48	-18.92	12.68	40.72	4.21	15.77	3.21	3.75
Perdido	P27-13	*O. banksii*	Mantle	9.29	-18.93	12.11	38.20	6.39	23.51	3.15	3.68
Perdido	P29-01	*O. banksii*	Mantle	9.79	-17.56	13.48	41.84	6.94	25.12	3.11	3.62
Perdido	P29-02	*O. banksii*	Mantle	9.43	-18.67	7.34	23.50	2.21	8.26	3.20	3.73
Perdido	P39-11	*O. banksii*	Mantle	9.29	-18.96	12.96	41.52	5.57	20.81	3.20	3.74
Perdido	P39-12	*O. banksii*	Mantle	9.78	-18.84	13.01	41.46	5.13	19.06	3.19	3.72
Perdido	P41-14	*O. banksii*	Mantle	9.91	-17.96	13.28	41.27	7.39	26.77	3.11	3.62
Perdido	P41-17	*O. banksii*	Mantle	9.35	-18.69	13.15	40.31	2.94	10.51	3.07	3.58
Perdido	P41-18	*O. banksii*	Mantle	9.25	-18.89	13.47	41.90	6.61	24.00	3.11	3.63
Perdido	P41-19	*O. banksii*	Mantle	9.13	-18.91	9.89	31.62	3.51	13.11	3.20	3.73
Perdido	P43-20	*O. banksii*	Mantle	9.51	-18.74	13.51	42.62	9.44	34.74	3.16	3.68
Perdido	P43-17	*O. banksii*	Mantle	9.52	-18.30	13.33	40.11	3.37	11.82	3.01	3.51
Perdido	P43-24	*O. banksii*	Mantle	9.59	-18.84	13.40	41.43	4.90	17.66	3.09	3.61
Perdido	P43-19	*O. banksii*	Mantle	9.93	-18.81	13.41	40.99	6.77	24.13	3.06	3.57
Perdido	P43-25	*O. banksii*	Mantle	9.65	-18.73	13.10	41.10	4.68	17.11	3.14	3.66
		Mean (mantle tissue) ± SD		9.51 ± 0.26	-18.66 ± 0.37	12.57 ± 1.51	39.46 ± 4.53	5.50 ± 1.85	20.17 ± 6.83	3.14 ± 0.06	3.67 ± 0.07

Table 3.4: Mean Total concentrations (ng/g ww) of organic compounds by sampled species by tissue type. Data are shown as mean total concentrations +/- 95% confidence interval (CI).

Abbreviations	Blackfin Tuna Liver			Blackfin Tuna Muscle			Yellowfin Tuna Liver			Yellowfin Tuna Muscle			*O. banksii* Mantle		
ECCs															
DMP	1967.13	±	1250.08	8.73	±	18.73	1921.16	±	1439.36	0.00	±	0.00	839.43	±	1146.97
DEP	63.31	±	130.35	8.97	±	9.38	3.29	±	7.44	6.24	±	6.92	307.21	±	146.71
BBP	128.99	±	57.58	37.33	±	29.48	72.94	±	62.73	45.45	±	35.96	870.26	±	437.73
DEHP	6.41	±	12.69	53.31	±	61.65	329.33	±	745.00	3.21	±	3.75	258.99	±	350.86
DnOP	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	8.45	±	8.25
DBP	384.63	±	215.85	16.19	±	23.86	544.08	±	285.48	2.92	±	6.60	923.41	±	1147.80
CH	6.09	±	3.13	0.07	±	0.15	8.14	±	4.75	0.48	±	0.57	2.59	±	2.40
TH	10.46	±	5.53	0.04	±	0.08	14.81	±	8.62	0.83	±	1.04	3.99	±	3.87
OB	25.97	±	29.74	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	1.09	±	1.20
OC	0.02	±	0.04	0.00	±	0.00	0.39	±	0.28	0.00	±	0.00	1.41	±	2.87
AVO	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
Total ECCs ± CI	**2593.00**	**±**	**1425.70**	**124.64**	**±**	**82.68**	**2894.13**	**±**	**1945.45**	**59.12**	**±**	**36.17**	**3216.83**	**±**	**2596.50**
OPCs															
a-BHC	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
b-BHC	0.46	±	0.33	0.00	±	0.00	0.04	±	0.04	0.01	±	0.02	0.04	±	0.05
g-BHC	0.05	±	0.05	0.01	±	0.01	0.00	±	0.00	0.01	±	0.01	0.12	±	0.12
d-BHC	0.18	±	0.14	0.01	±	0.02	0.01	±	0.02	0.02	±	0.02	0.01	±	0.01
HEP	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
ALD	0.15	±	0.15	0.05	±	0.06	0.02	±	0.04	0.00	±	0.01	0.13	±	0.14
HEP-epox	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
g-CHL	0.22	±	0.19	0.02	±	0.02	0.01	±	0.02	0.01	±	0.02	0.03	±	0.04
a-CHL	0.14	±	0.16	0.04	±	0.06	0.05	±	0.06	0.01	±	0.01	0.10	±	0.10
EDS-II	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.02	±	0.03
EDS-II	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
EDS-sul	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
DDE	0.70	±	0.42	0.41	±	0.78	2.01	±	1.45	0.32	±	0.30	0.21	±	0.12
DDD	1.01	±	0.45	0.15	±	0.30	0.71	±	0.48	0.16	±	0.14	0.22	±	0.10
DDT	0.25	±	0.14	0.08	±	0.10	0.03	±	0.01	0.10	±	0.07	0.48	±	0.15
DLD	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.65	±	1.14
END	13.51	±	13.51	0.24	±	0.36	0.41	±	0.51	0.01	±	0.01	0.06	±	0.12
END-AL	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.14	±	0.30
MOXC	2.88	±	2.32	0.01	±	0.02	4.69	±	7.00	0.08	±	0.06	0.56	±	0.48
HCCPD	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
CBL	0.83	±	0.51	0.05	±	0.09	0.04	±	0.03	0.05	±	0.04	0.44	±	0.78
cis-PERM	11.91	±	9.98	0.32	±	0.22	4.26	±	3.51	0.55	±	0.31	16.56	±	6.90
trans-PERM	12.02	±	6.53	0.46	±	0.42	13.47	±	4.03	0.98	±	0.36	32.04	±	14.68
ETR	0.59	±	0.51	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
CNB	0.08	±	0.08	0.01	±	0.01	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00

Table 3.4: (Continued)

BHC	0.02	±	0.02	0.00	±	0.00	0.00	±	0.00	0.01	±	0.01	0.01	±	0.01
CTN	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.02	±	0.03
TRI	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
DCPA	0.10	±	0.10	0.01	±	0.01	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
PPC	16.29	±	14.18	0.00	±	0.00	5.90	±	3.17	0.00	±	0.00	124.13	±	67.12
SMZ	120.62	±	121.96	0.00	±	0.00	0.00	±	0.00	0.01	±	0.03	15.44	±	9.68
ATA	5.19	±	3.17	0.11	±	0.15	0.58	±	0.41	0.00	±	0.00	13.11	±	6.45
MEB	0.34	±	0.30	0.14	±	0.10	0.00	±	0.00	0.27	±	0.20	0.15	±	0.14
ALA	0.09	±	0.19	1.25	±	0.94	0.00	±	0.00	0.00	±	0.00	2.28	±	2.85
MOAC	0.25	±	0.19	0.11	±	0.15	0.02	±	0.03	0.08	±	0.09	0.02	±	0.03
CYA	9.52	±	7.04	0.06	±	0.06	0.70	±	0.70	0.45	±	0.64	6.18	±	6.42
Total OCPs ± CI	**197.39**	±	**152.57**	**3.67**	±	**2.24**	**32.97**	±	**13.90**	**3.13**	±	**1.44**	**213.18**	±	**68.17**
PCBs															
PCB 8	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
PCB 28	0.78	±	0.27	0.15	±	0.06	0.44	±	0.09	0.18	±	0.06	0.30	±	0.20
PCB 37	0.67	±	0.35	0.06	±	0.03	0.01	±	0.01	0.02	±	0.02	0.23	±	0.14
PCB 52	0.64	±	0.23	0.19	±	0.10	0.48	±	0.17	0.12	±	0.08	0.38	±	0.12
PCB 44	0.38	±	0.17	0.13	±	0.12	0.43	±	0.27	0.15	±	0.07	0.46	±	0.15
PCB 49	0.29	±	0.19	0.14	±	0.08	0.09	±	0.08	0.18	±	0.06	0.18	±	0.08
PCB 77	0.48	±	0.30	0.10	±	0.05	0.17	±	0.13	0.04	±	0.04	0.25	±	0.12
PCB 74	0.86	±	0.30	0.17	±	0.12	0.36	±	0.27	0.12	±	0.09	0.86	±	0.35
PCB 70	0.51	±	0.23	0.12	±	0.13	0.43	±	0.28	0.12	±	0.10	0.35	±	0.19
PCB 66	0.37	±	0.21	0.03	±	0.06	0.12	±	0.11	0.05	±	0.05	0.00	±	0.00
PCB 60	0.55	±	0.59	0.03	±	0.04	0.01	±	0.02	0.02	±	0.04	0.00	±	0.00
PCB 126	1.37	±	0.73	0.42	±	0.57	1.52	±	1.11	0.45	±	0.28	0.73	±	0.29
PCB 87	1.01	±	0.51	0.26	±	0.40	1.22	±	0.91	0.26	±	0.19	0.15	±	0.15
PCB 99	0.88	±	0.80	0.38	±	0.57	1.75	±	1.52	0.42	±	0.33	0.49	±	0.28
PCB 101	0.29	±	0.19	0.05	±	0.04	0.00	±	0.00	0.03	±	0.04	0.10	±	0.09
PCB 114	1.41	±	0.77	0.26	±	0.46	1.28	±	0.87	0.39	±	0.29	0.83	±	0.28
PCB 118	0.51	±	0.40	0.02	±	0.03	0.00	±	0.00	0.07	±	0.05	0.08	±	0.06
PCB 82	0.70	±	0.36	0.11	±	0.14	0.39	±	0.34	0.10	±	0.15	0.00	±	0.00
PCB 105	0.80	±	0.74	0.12	±	0.20	0.49	±	0.27	0.18	±	0.15	0.15	±	0.11
PCB 156	4.53	±	2.45	1.30	±	2.12	6.23	±	3.49	1.42	±	1.40	0.22	±	0.10
PCB 128	1.70	±	1.32	0.53	±	0.94	2.84	±	2.00	0.72	±	0.60	0.47	±	0.40
PCB 153	1.76	±	0.84	0.39	±	0.62	1.82	±	0.91	0.37	±	0.38	0.20	±	0.14
PCB 169	0.22	±	0.27	0.00	±	0.01	0.02	±	0.03	0.04	±	0.05	0.02	±	0.02
PCB 158	0.76	±	0.42	0.18	±	0.24	0.49	±	0.49	0.20	±	0.24	0.00	±	0.00
PCB 138	0.82	±	0.48	0.08	±	0.11	0.25	±	0.22	0.11	±	0.11	0.00	±	0.00
PCB 166	0.58	±	0.59	0.02	±	0.03	0.01	±	0.03	0.10	±	0.10	0.00	±	0.00
PCB 183	0.37	±	0.25	0.10	±	0.13	0.23	±	0.24	0.06	±	0.07	0.00	±	0.01
PCB 179	2.17	±	1.17	0.52	±	0.91	2.72	±	1.57	0.72	±	0.69	0.11	±	0.12

Table 3.4: (Continued)

PCB 180	0.71	±	0.37	0.12	±	0.23	0.40	±	0.38	0.15	±	0.17	0.05	±	0.06
PCB 170	2.61	±	1.33	0.70	±	1.13	3.40	±	1.83	0.97	±	0.88	0.10	±	0.10
PCB 187	1.28	±	0.63	0.27	±	0.52	0.80	±	0.69	0.35	±	0.35	0.02	±	0.03
PCB 189	0.33	±	0.36	0.11	±	0.09	0.00	±	0.00	0.05	±	0.08	0.13	±	0.18
Total PCBs ± CI	**30.33**	**±**	**13.72**	**7.03**		**10.04**	**28.38**	**±**	**17.82**	**8.17**	**±**	**6.80**	**6.85**	**±**	**1.98**
PAHs														**±**	
N	19.41	±	9.99	1.09	±	0.69	4.99	±	2.89	1.52	±	1.09	19.57	±	7.46
N-1	17.97	±	12.49	0.82	±	0.63	0.00	±	0.00	2.43	±	0.99	7.71	±	3.38
N-2	11.53	±	6.65	0.55	±	0.33	1.04	±	1.63	1.14	±	0.59	6.17	±	2.46
N-3	6.30	±	4.13	0.75	±	0.27	0.61	±	1.09	0.82	±	0.44	7.59	±	1.84
N-3	11.43	±	7.58	0.76	±	0.29	0.49	±	0.57	0.80	±	0.42	8.33	±	2.72
ACL	0.06	±	0.08	0.01	±	0.01	0.00	±	0.00	0.00	±	0.00	0.14	±	0.14
ACE	1.15	±	0.63	0.27	±	0.07	0.46	±	0.11	0.16	±	0.10	1.74	±	0.53
F	15.32	±	5.87	0.83	±	0.38	4.61	±	1.07	1.85	±	0.83	17.28	±	6.27
F-1	8.19	±	3.59	1.02	±	0.26	2.41	±	1.01	0.97	±	0.32	6.58	±	1.96
F-2	8.80	±	3.66	1.71	±	0.46	2.37	±	0.82	1.72	±	0.56	10.29	±	1.64
F-3	11.55	±	5.33	2.00	±	0.56	3.09	±	0.75	2.41	±	2.09	14.64	±	4.14
Re	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	2.98	±	0.76
AN	0.10	±	0.06	0.22	±	0.07	0.16	±	0.13	0.30	±	0.13	0.34	±	0.12
P	33.52	±	7.70	7.05	±	1.89	19.34	±	4.70	6.77	±	2.23	60.98	±	10.07
P/AN1	17.78	±	7.12	5.16	±	1.93	9.39	±	3.98	6.07	±	5.30	38.76	±	26.29
P/AN2	9.79	±	6.12	2.02	±	0.44	1.17	±	0.73	1.38	±	0.63	11.93	±	2.89
P/AN3	7.18	±	4.07	1.53	±	0.37	0.89	±	0.59	1.64	±	1.31	9.78	±	2.73
P/AN4	26.78	±	17.69	1.28	±	0.27	0.75	±	0.84	1.44	±	0.85	14.04	±	4.61
D	3.11	±	1.23	0.41	±	0.12	1.17	±	0.33	0.38	±	0.14	2.02	±	0.86
D-1	5.52	±	3.00	0.45	±	0.15	1.06	±	0.58	0.53	±	0.42	3.54	±	0.93
D-2	21.04	±	12.80	1.44	±	0.38	2.11	±	0.85	1.02	±	0.39	8.13	±	1.61
D-3	6.35	±	5.71	0.58	±	0.15	0.35	±	0.14	0.35	±	0.14	3.52	±	0.85
D-4	2.16	±	1.73	0.25	±	0.12	0.01	±	0.02	0.24	±	0.18	1.48	±	0.59
FL	10.78	±	2.05	2.98	±	0.62	6.33	±	1.15	3.21	±	0.91	15.95	±	6.26
PY	10.18	±	2.21	5.51	±	1.20	8.25	±	1.62	5.65	±	2.08	20.51	±	15.77
FL/PY1	9.77	±	6.11	1.03	±	0.51	1.02	±	0.86	2.64	±	3.71	10.47	±	5.34
FL/PY2	4.14	±	3.23	0.31	±	0.18	0.07	±	0.15	0.42	±	0.36	4.14	±	1.83
FL/PY3	1.54	±	1.29	0.28	±	0.16	0.08	±	0.17	0.38	±	0.23	1.77	±	0.76
FL/PY4	1.76	±	1.49	0.25	±	0.16	0.02	±	0.05	0.35	±	0.26	1.64	±	0.63
BAA	0.12	±	0.12	0.02	±	0.01	0.09	±	0.10	0.03	±	0.04	0.00	±	0.00
CHR	0.53	±	0.34	0.02	±	0.01	0.09	±	0.04	0.03	±	0.02	0.39	±	0.17
BAA/CHR1	0.91	±	0.92	0.14	±	0.13	0.08	±	0.19	0.18	±	0.18	0.93	±	0.40
BAA/CHR2	0.72	±	0.76	0.28	±	0.21	0.09	±	0.20	0.47	±	0.33	1.48	±	0.77
BAA/CHR3	0.72	±	0.93	0.15	±	0.11	0.18	±	0.40	0.29	±	0.21	1.37	±	0.65
BAA/CHR4	1.70	±	2.46	0.18	±	0.21	0.00	±	0.00	0.49	±	0.32	1.80	±	1.05

Table 3.4: (Continued)

BBFL	0.76	±	0.60	0.05	±	0.03	0.05	±	0.08	0.02	±	0.03	0.01	±	0.03
BKFL	0.07	±	0.07	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.01	±	0.03
BP/PER1	0.41	±	0.63	0.13	±	0.23	0.00	±	0.00	0.34	±	0.30	1.98	±	1.10
BP/PER2	1.35	±	1.61	0.60	±	0.47	0.49	±	1.10	1.13	±	0.72	7.20	±	3.00
BP/PER3	0.61	±	0.72	0.22	±	0.10	0.38	±	0.87	0.37	±	0.17	4.41	±	1.86
Total PAHs ± CI	**291.11**	**±**	**135.12**	**42.32**	**±**	**9.60**	**73.69**	**±**	**20.17**	**49.98**	**±**	**22.34**	**331.60**	**±**	**70.74**
OPAHs															
1, 4-NQ	0.11	±	0.09	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
1-NH	11.37	±	11.34	0.06	±	0.09	0.95	±	0.61	0.02	±	0.04	2.33	±	1.51
2-NH	2.09	±	0.92	0.04	±	0.04	0.76	±	0.18	0.02	±	0.05	1.14	±	0.65
9-FLO	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
9, 10-ANT	26.67	±	18.04	0.00	±	0.00	12.05	±	20.68	0.00	±	0.00	37.84	±	30.74
9-XA	23.81	±	19.41	0.56	±	1.26	5.41	±	10.15	0.09	±	0.24	14.92	±	34.42
9, 10-PQ	26.53	±	26.28	0.00	±	0.00	0.00	±	0.00	0.06	±	0.15	3.77	±	7.07
NH	29.61	±	20.63	0.00	±	0.00	0.54	±	0.61	0.00	±	0.00	0.99	±	1.64
FLO	459.80	±	164.55	2.12	±	4.80	990.80	±	490.04	5.09	±	11.05	357.73	±	521.28
ANT	2867.22	±	2003.49	80.21	±	82.29	390.90	±	159.19	14.96	±	31.56	425.76	±	427.93
XA	1017.12	±	988.05	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	12.52	±	28.88
NQ	409.95	±	280.90	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
1-NN	5.28	±	5.10	1.24	±	1.57	0.00	±	0.00	0.08	±	0.22	2.44	±	3.11
2-NN	21.16	±	24.37	2.63	±	3.86	6.39	±	4.00	0.09	±	0.18	2.95	±	6.80
2-NF	1.18	±	1.55	0.13	±	0.20	0.20	±	0.16	0.14	±	0.15	3.03	±	2.64
9-NAN	8.53	±	11.49	2.27	±	3.74	0.11	±	0.20	0.22	±	0.15	2.91	±	2.35
9-NP	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00	0.00	±	0.00
3-NFL	0.93	±	1.02	1.67	±	3.04	0.00	±	0.00	0.00	±	0.01	0.86	±	0.61
1-NPY	0.68	±	1.19	0.25	±	0.42	0.00	±	0.00	0.07	±	0.11	0.75	±	0.88
6-NCHR	13.46	±	15.97	40.88	±	53.98	9.02	±	5.07	58.52	±	50.87	43.22	±	28.85
6-NBAPY	37.81	±	83.23	56.13	±	86.34	0.00	±	0.00	3.10	±	7.97	102.76	±	184.66
NN	440.38	±	448.02	91.56	±	140.72	0.00	±	0.00	10.59	±	17.25	428.97	±	248.37
NF	28.49	±	27.05	5.49	±	10.49	0.07	±	0.16	0.35	±	0.55	12.33	±	7.84
NAN/NP	164.53	±	162.91	19.83	±	31.74	9.48	±	8.93	4.09	±	3.70	65.61	±	43.47
NFL/NPY	11.54	±	14.48	9.02	±	13.64	0.00	±	0.00	0.91	±	1.32	29.12	±	24.09
NCHR	24.23	±	28.81	23.93	±	34.96	13.39	±	10.00	19.83	±	13.70	88.93	±	59.98
NBAPY	1.35	±	2.53	2.54	±	4.31	0.00	±	0.00	0.18	±	0.45	5.93	±	6.21
2, 3-HP	2917.00	±	3191.18	386.15	±	745.52	33.49	±	47.16	33.62	±	46.95	452.45	±	361.30
4, 9-HP	299.89	±	444.34	57.64	±	103.23	0.00	±	0.00	13.75	±	12.43	60.15	±	93.35
1-HN	273.73	±	260.99	136.10	±	163.00	113.04	±	38.80	23.64	±	11.55	243.35	±	234.21
2-HN	24114.93	±	24508.05	40.14	±	47.02	187.88	±	147.69	0.00	±	0.00	561.06	±	915.83
HN	76863.62	±	77488.59	2123.65	±	3760.27	806.45	±	656.28	309.50	±	605.39	7180.60	±	5976.03
HP	15459.78	±	15982.47	3136.29	±	6005.24	44.69	±	103.07	269.85	±	251.36	4693.28	±	3304.33
Total OPAHs ± CI	**136966.69**	**±**	**134856.70**	**6220.54**	**±**	**11239.02**	**2625.64**	**±**	**1106.78**	**768.75**	**±**	**923.44**	**14837.70**	**±**	**10439.14**

Table 3.5: Summary of one-way analyses of variance (ANOVA) between compound group concentrations, and % lipids and tissue type (muscle, liver, mantle). Mantle tissue was compared based on the predator stomach (Blackfin Tuna or Yellowfin Tuna) from which the squid was collected. Data was transformed (% lipids: arcsine square root [lipid fraction], concentrations: log_{10} [mean total concentration]). Where statistically significant differences were found between the groups, results are bold, and the species with the higher concentration is noted (+/-).

		Compound Group			
Tissue Type	**% Lipids**	**∑PAHs**	**∑PCBs**	**∑OCPs**	**∑ECCs**
Muscle	R^2 = 0.08; p = 0.1794	R^2 = 0.01; p = 0.5817	R^2 = 0.07; p = 0.2163	R^2 = 0.01; p = 0.5878	R^2 = 0.004; p = 0.7781
Liver	***R^2 = 0.22; p* = 0.0251 (+) Blackfin Tuna**	***R^2 = 0.41; p* = 0.0009 (+) Blackfin Tuna**	R^2 = 0.01.; p = 0.6578	R^2 = 0.17; p = 0.0515	R^2 > 0.00; p = 0.9989
Mantle by predator stomach	R^2 = 0.17; p = 0.0757	***R^2 = 0.49; p* = 0.0006 (+) Blackfin Tuna**	R^2 = 0.14; p = 0.1063	***R^2 = 0.46; p* = 0.0009 (+) Blackfin Tuna**	R^2 = 0.01; p = 0.6574

Table 3.6: Summary of correlations between compound group concentrations, and % lipids and length (SL, ML). Correlations were conducted by species (Blackfin Tuna, Yellowfin Tuna, squid). Data was transformed (% lipids: arcsine square root [lipid fraction], concentrations: log_{10} [mean total concentration], length: log_{10} [SL or ML]). Where statistically significant relationships are indicated, results are bold, and the sign of the correlation coefficient (r = positive or negative) is shown (+/-).

			Compound Group			
	Species	**Tissue Type**	**∑PAHs**	**∑PCBs**	**∑OCPs**	**∑ECCs**
% Lipids	Blackfin Tuna	Muscle	r = 0.08; p = 0.7777	***r* = 0.74; *p* = 0.0018 (+)**	r = 0.37; p = 0.1774	r = -0.25; p = 3730
		Liver	***r* = 0.72; *p* = 0.0057 (+)**	***r* = 0.56; *p* = 0.0472 (+)**	***r* = 0.74; *p* = 0.0035 (+)**	r = 0.27; p = 0.3642
	Yellowfin Tuna	Muscle	r = 0.30; p = 0.3932	r = 0.46; p = 0.1823	r = 0.24; p = 0.5067	r = 0.06; p = 0.8777
		Liver	r = 0.25; p = 0.4935	r = -0.23; p = 0.5306	r = 0.09; p = 0.8121	r = -0.44; p = 0.2021
	Squid	Mantle	r = 0.28; p = 0.2273	r = 0.33; p = 0.1536	r = 0.40; p = 0.0832	r = -0.01; p = 0.9504
Standard Length	Blackfin Tuna	Muscle	r = 0.08; p = 0.7658	***r* = 0.86; *p* < 0.0001 (+)**	***r* = 0.70; *p* = 0.0036 (+)**	r = 0.09; p = 0.7564
		Liver	***r* = -0.65; *p* = 0.0168 (-)**	r = 0.14; p = 0.6519	***r* = -0.62; *p* = 0.0246 (-)**	r = -0.25; p = 0.4078
	Yellowfin Tuna	Muscle	r = -0.23; p = 0.5206	r = -0.10; p = 0.7890	r = -0.17; p = 0.6404	r = -0.37; p = 0.2933
		Liver	r = 0.05; p = 0.8985	r = 0.20; p = 0.5824	r = 0.35; p = 0.3275	***r* = -0.75; *p* = 0.0125 (-)**
Mantle Length	Squid	Mantle	***r* = -0.67; *p* = 0.0012 (-)**	r = -0.26; p = 0.2729	***r* = -0.74; *p* = 0.0002 (-)**	r = 0.07; p = 0.7557

Table 3.7: Summary of correlations comparing each compound group to the other compound groups. Results are organized by species and tissue type; significant correlations are bold.

			Compound Group			
	Tissue Type		**∑PAHs**	**∑PCBs**	**∑OCPs**	**∑ECCs**
Blackfin Tuna	Liver	**∑PAHs**		r = 0.32, p = 0.2901	**r = 0.89, p < 0.0001**	r = - 0.14, p = 0.6478
		∑PCBs	r = 0.32, p = 0.2901		r = 0.38, p = 0.2041	r = 0.15, p = 0.6225
		∑OCPs	**r = 0.89, p < 0.0001**	r = 0.38, p = 0.2041		r = - 0.08, p = 0.7891
		∑ECCs	r = - 0.14, p = 0.6478	r = 0.15, p = 0.6225	r = - 0.08, p = 0.7891	
	Muscle	**∑PAHs**		r = 0.37, p = 0.1782	r = 0.31, p = 0.2679	r = 0.45, p = 0.0913
		∑PCBs	r = 0.37, p = 0.1782		r = 0.51, p = 0.0546	r = 0.23, p = 0.4046
		∑OCPs	r = 0.31, p = 0.2679	r = 0.51, p = 0.0546		r = - 0.07, p = 0.7988
		∑ECCs	r = 0.45, p = 0.0913	r = 0.23, p = 0.4046	r = - 0.07, p = 0.7988	
Yellowfin Tuna	Liver	**∑PAHs**		r = - 0.16, p = 0.6571	r = - 0.43, p = 0.2211	r = - 0.12, p = 0.7479
		∑PCBs	r = - 0.16, p = 0.6571		r = 0.42, p = 0.2273	r = - 0.20, p = 0.5887
		∑OCPs	r = - 0.42, p = 0.2211	r = 0.42, p = 0.2273		r = - 0.58, p = 0.0782
		∑ECCs	r = - 0.12, p = 0.7479	r = - 0.20, p = 0.5887	r = - 0.58, p = 0.0782	
	Muscle	**∑PAHs**		r = 0.54, p = 0.1107	**r = 0.80, p = 0.0059**	**r = 0.65, p = 0.0425**
		∑PCBs	r = 0.53, p = 0.1107		**r = 0.81, p = 0.0047**	r = 0.33, p = 0.3555
		∑OCPs	**r = 0.80, p = 0.0059**	**r = 0.81, p = 0.0047**		**r = 0.63, p = 0.0500**
		∑ECCs	**r = 0.65, p = 0.0425**	r = 0.33, p = 0.3555	**r = 0.63, p = 0.0500**	
Squid	Mantle	**∑PAHs**		**r = 0.66, p = 0.0017**	**r = 0.86, p < 0.0001**	r = 0.09, p = 0.7065
		∑PCBs	**r = 0.66, p = 0.0017**		**r = 0.49, p = 0. 270**	r = 0.12, p = 0.6075
		∑OCPs	**r = 0.86, p < 0.0001**	**r = 0.49, p = 0.0270**		r = 0.04, p = 0.8654
		∑ECCs	r = 0.09, p = 0.7065	r = 0.12, p = 0.6075	r = 0.04, p = 0.8654	

Table 3.8: Summary of PAH source analysis in tuna liver tissue. Results shown are % Retene and Perylene (ng/g ww) of ∑PAHs, ratios of HMW/LWM, Pyrogenic Index (PI), parental + alkylated PAHs, Phenanthrene/Anthracene, and Anthracene/(Phenanthrene + Anthracene).

			PAH Ratios				
Tuna species	**% Re**	**% Pe**	**HMW/LMW**	**Pyrogenic Index (PI)**	**Parental/Alkylated**	**P/An**	**An/P+An**
Blackfin Tuna	0	0	0.22 ± 0.05	0.15 ± 0.6	0.92 ± 0.45	787 ± 755	0.003 ± 0.001
Yellowfin Tuna	0	0	0.32 ± 0.65	0.30 ± 0.07	1.9 ± 0.4	463 ± 397	0.010 ± 0.003
Squid	0.9	0	0.29 ± 0.07	0.15 ± 0.06	0.85 ± 0.18	464 ± 346	0.006 ± 0.002

Table 3.9: Summary of the partition coefficient (PC) of organic contaminants between muscle and liver tissue. Data are organized by compound group and presented as the mean partition coefficient ± CI for each analyte by species, n = number of samples. PC values > 1 = accumulation higher concentration in muscle tissue than liver, < 1 = higher concentration in liver tissue than muscle, = 1 are neutral between the tissues, and 0 = no accumulation in muscle tissue. Where n = 0, n/a is listed as the PC, where n = 1, n/a is listed for CI.

	BLACKFIN TUNA				YELLOWFIN TUNA			
PCBs								
Analyte	**Partition Coefficient**			***n***	**Partition Coefficient**			***n***
PCB 28	2.06	±	0.88	12	3.43	±	2.01	11
PCB 37	0.67	±	0.30	10	0.00	±	0.00	3
PCB 52	3.02	±	2.16	12	1.88	±	0.70	11
PCB 44	3.72	±	2.97	12	10.15	±	14.17	11
PCB 49	3.40	±	1.50	10	8.89	±	7.27	5
PCB 77	2.31	±	1.45	12	4.49	±	3.56	9
PCB 74	1.57	±	0.46	12	8.86	±	10.14	11
PCB 70	2.08	±	1.69	11	2.37	±	1.83	10
PCB 66	0.10	±	0.21	11	3.13	±	2.14	6
PCB 60	2.87	±	6.13	8	4.78	±	20.55	3
PCB 126	1.95	±	1.06	12	5.55	±	5.27	11
PCB 87	1.57	±	1.26	12	3.15	±	2.38	11
PCB 99	2.67	±	1.45	11	4.44	±	4.64	10
PCB 101	1.33	±	1.89	8	n/a	±	n/a	0
PCB 114	0.40	±	0.27	12	3.66	±	2.11	11
PCB 118	0.00	±	0.00	9	7.20	±	n/a	1
PCB 82	1.47	±	1.86	12	2.87	±	3.08	8
PCB 105	0.42	±	0.56	6	2.85	±	2.65	8
PCB 156	1.48	±	0.83	12	1.15	±	0.71	11
PCB 128	2.41	±	2.56	11	2.41	±	1.32	11
PCB 153	0.91	±	0.36	12	1.31	±	0.88	11
PCB 169	0.09	±	0.22	8	1.92	±	24.41	2
PCB 158	1.20	±	1.26	10	2.33	±	3.72	5
PCB 138	0.34	±	0.23	11	1.09	±	1.45	8
PCB 166	0.00	±	0.00	7	8.69	±	n/a	1
PCB 183	15.98	±	35.55	9	1.72	±	2.64	4
PCB 179	0.85	±	0.58	12	1.46	±	0.85	11
PCB 180	0.15	±	0.24	11	1.87	±	2.03	6
PCB 170	1.30	±	0.90	12	1.62	±	0.93	11
PCB 187	0.11	±	0.25	11	2.07	±	2.17	7
PCB 189	1.88	±	2.29	4	n/a	±	n/a	0

	BLACKFIN TUNA				YELLOWFIN TUNA			
OCPs								
Analyte	**Partition Coefficient**			***n***	**Partition Coefficient**			***n***
b-BHC	0.00	±	0.00	11	1.62	±	3.73	9
g-BHC	0.04	±	0.11	5	n/a	±	n/a	0
d-BHC	0.77	±	1.86	6	14.74	±	63.42	3
Aldrin	0.62	±	1.61	6	0.00	±	0.00	2
trans-chlordane	1.66	±	4.07	6	0.00	±	0.00	3
cis-chlordane	0.66	±	1.21	4	1.09	±	3.02	5
DDE	1.27	±	1.10	11	2.43	±	3.58	10
DDD	0.09	±	0.15	12	2.29	±	1.87	11
DDT	2.16	±	1.36	12	85.02	±	144.35	11
Endrin	0.39	±	0.94	7	0.00	±	0.00	5
Methoxychlor	0.47	±	1.02	12	5.44	±	8.66	10
Chlorobenzilate	0.49	±	0.72	12	4.84	±	3.62	7
cis-Permethrin	0.31	±	0.29	11	4.75	±	4.59	10
trans-Permethrin	0.15	±	0.16	11	1.80	±	2.56	11
Etridiazole	0.92	±	2.36	6	0.00	±	0.00	2
Chloroneb	2.30	±	3.21	6	n/a	±	n/a	0
Hexachlorobenzene	0.00	±	0.00	5	n/a	±	n/a	0
DCPA	0.80	±	1.37	5	n/a	±	n/a	0
Propachlor	0.00	±	0.00	4	n/a	±	n/a	0
Simazine	0.00	±	0.00	4	n/a	±	n/a	0
Metribuzin	2.07	±	3.03	7	16.59	±	n/a	1
Alachlor	0.00	±	n/a	1	n/a	±	n/a	0
Metolachlor	10.69	±	17.01	8	2.66	±	11.45	3
Cyanazine	0.07	±	0.07	12	2.15	±	2.33	6
ECCs								
Dimethyl phthalate	0.17	±	0.39	10	0.00	±	0.00	8
Diethyl phthalate	0.27	±	3.39	2	6.28	±	n/a	1
Benzyl butyl phthalate	4.05	±	5.97	12	8.04	±	6.52	11
di-2-ethylhexyl phthalate	30.57	±	48.50	4	0.00	±	0.00	1
Di-n-butyl phthalate	0.62	±	1.26	12	0.07	±	0.16	11
Cis-Homosalate	0.02	±	0.04	12	1.36	±	2.43	11
Trans-Homosalate	0.01	±	0.01	12	1.20	±	2.11	11

Table 3.9: (Continued)

	BLACKFIN TUNA				YELLOWFIN TUNA			
	PAHs							
Analyte	**Partition Coefficient**			***n***	**Partition Coefficient**			***n***
naphthalene	0.97	±	0.98	11	4.84	±	4.29	11
C1 naphthalene	1.55	±	2.09	10	1.98	±	n/a	1
C2 naphthalene	0.93	±	0.92	10	50.68	±	134.12	5
C3 naphthalene	2.45	±	1.58	10	3.18	±	7.45	3
C4 naphthalene	1.56	±	1.61	11	94.36	±	178.42	7
acenaphthylene	3.09	±	5.93	4	n/a	±	n/a	0
acenaphthene	4.12	±	2.11	12	3.54	±	3.77	11
fluorene	0.64	±	0.17	12	3.91	±	3.20	11
C1 fluorene	1.91	±	0.93	12	4.17	±	2.65	11
C2 fluorene	2.65	±	1.51	12	6.94	±	4.03	11
C3 fluorene	2.55	±	2.01	12	5.66	±	4.44	11
anthracene	40.48	±	28.16	9	492.14	±	956.43	11
phenanthrene	2.62	±	1.53	12	3.19	±	2.33	11
C1 phenanthrene-anthracene	4.36	±	3.98	12	5.62	±	4.22	11
C2 phenanthrene-anthracene	6.54	±	4.61	12	11.84	±	8.83	10
C3 phenanthrene-anthracene	4.01	±	2.86	12	21.49	±	22.84	10
C4 phenanthrene-anthracene	3.38	±	3.38	12	26.93	±	51.84	6
dibenzothiophene	1.48	±	0.49	12	2.82	±	1.87	11
C1 dibenzothiophene	1.56	±	1.36	12	4.88	±	5.74	9
C2 dibenzothiophene	1.42	±	1.34	12	3.82	±	1.32	11
C3 dibenzothiophene	2.59	±	1.89	12	11.20	±	8.77	11
C4 dibenzothiophene	4.85	±	8.94	7	12.43	±	125.84	2
fluoranthene	3.41	±	2.04	12	3.85	±	1.28	11
pyrene	7.03	±	3.98	12	5.41	±	3.06	11
C1 fluoranthene-pyrene	3.67	±	4.95	11	7.49	±	10.11	7
C2 fluoranthene-pyrene	5.53	±	7.62	10	2.27	±	18.95	2
C3 fluoranthene-pyrene	110.75	±	265.63	7	3.93	±	14.73	2
C4 fluoranthene-pyrene	1.46	±	0.88	6	7.12	±	58.50	2
benz[a]anthracene	4.27	±	4.67	7	7.93	±	12.43	7
chrysene	0.82	±	0.56	12	2.58	±	2.47	9
C1 benz[a]anthracene-chrysene	1.26	±	2.42	5	2.25	±	0.66	2
C2 benz[a]anthracene-chrysene	11.21	±	29.63	4	3.15	±	21.92	2
C3 benz[a]anthracene-chrysene	0.80	±	1.68	3	9.54	±	101.42	2
C4 benz[a]anthracene-chrysene	1.42	±	3.34	4	n/a	±	n/a	0
benzo(b)fluoranthene	3.65	±	5.20	9	0.09	±	0.37	3
benzo(k)fluoranthene	0.00	±	0.00	9	n/a	±	n/a	0
C1 benzopyrene-perylene	0.00	±	n/a	1	1.10	±	n/a	1
C2 benzopyrene-perylene	1.34	±	17.07	2	1.49	±	5.92	2
C3 benzopyrene-perylene	0.40	±	1.87	2	1.30	±	7.37	2

Table 3.10: Sample list of O. banksii (n = 20).

***Onychoteuthis banksii* samples**					
Station	Predator ID	Tuna Species	Squid Sample ID	Prey ID	Mantle Length (mm)
Nansen	N7	Blackfin Tuna	2020-NAN-07-BF-15	15	36.5
Nansen	N7	Blackfin Tuna	2020-NAN-07-BF-16	16	43
Nansen	N9	Blackfin Tuna	2020-NAN-09-BF-5	5	32
Perdido	P27	Blackfin Tuna	2020-PER-27-BF-1	11	38.5
Perdido	P27	Blackfin Tuna	2020-PER-27-BF-2	12	35.5
Perdido	P27	Blackfin Tuna	2020-PER-27-BF-3	13	29.2
Perdido	P27	Blackfin Tuna	2020-PER-27-BF-5	15	34
Perdido	P29	Yellowfin Tuna	2020-PER-29-YF-1	1	105
Perdido	P29	Yellowfin Tuna	2020-PER-29-YF-2	2	46
Perdido	P39	Yellowfin Tuna	2020-PER-39-YF-11	11	48
Perdido	P39	Yellowfin Tuna	2020-PER-39-YF-12	12	52
Perdido	P41	Yellowfin Tuna	2020-PER-41-YF-14	14	78
Perdido	P41	Yellowfin Tuna	2020-PER-41-YF-17	17	75
Perdido	P41	Yellowfin Tuna	2020-PER-41-YF-18	18	70
Perdido	P41	Yellowfin Tuna	2020-PER-41-YF-19	19	68
Perdido	P43	Blackfin Tuna	2020-PER-43-BF-5	17	39.5
Perdido	P43	Blackfin Tuna	2020-PER-43-BF-7	19	23.5
Perdido	P43	Blackfin Tuna	2020-PER-43-BF-1	20	57
Perdido	P43	Blackfin Tuna	2020-PER-43-BF-8	24	18
Perdido	P43	Blackfin Tuna	2020-PER-43-BF-9	25	19
				Overall Mean ± CI	47.4 ± 10.5
				Range	18 – 105
			Blackfin Tuna stomachs	Mean ± CI	33.8 ± 6.9
				Range	18 – 57
			Yellowfin Tuna stomachs	Mean ± CI	67.75 ± 16.3
				Range	46 - 105

Table 3.11: % lipid content of O. banksii (n = 20).

Sample ID	**Station**	**Fish ID**	**Prey ID**	**Species**	**% Lipids**	**Lipid Fraction**
2020-NAN-07-BF-15-MT	Nansen	N7	15	*O. banksii*	9.51	0.095
2020-NAN-07-BF-16-MT	Nansen	N7	16	*O. banksii*	7.06	0.071
2020-NAN-09-BF-5-MT	Nansen	N9	5	*O. banksii*	5.51	0.055
2020-PER-27-BF-1-MT	Perdido	P27	11	*O. banksii*	4.83	0.048
2020-PER-27-BF-2-MT	Perdido	P27	12	*O. banksii*	2.19	0.022
2020-PER-27-BF-3-MT	Perdido	P27	13	*O. banksii*	8.59	0.086
2020-PER-27-BF-5-MT	Perdido	P27	15	*O. banksii*	3.06	0.031
2020-PER-29-YF-1-MT	Perdido	P29	1	*O. banksii*	4.67	0.047
2020-PER-29-YF-2-MT	Perdido	P29	2	*O. banksii*	2.56	0.026
2020-PER-39-YF-11-MT	Perdido	P39	11	*O. banksii*	7.47	0.075
2020-PER-39-YF-12-MT	Perdido	P39	12	*O. banksii*	5.03	0.050
2020-PER-41-YF-14-MT	Perdido	P41	14	*O. banksii*	8.79	0.088
2020-PER-41-YF-17-MT	Perdido	P41	17	*O. banksii*	3.58	0.036
2020-PER-41-YF-18-MT	Perdido	P41	18	*O. banksii*	5.60	0.056
2020-PER-41-YF-19-MT	Perdido	P41	19	*O. banksii*	5.20	0.052
2020-PER-43-BF-7-MT	Perdido	P43	7	*O. banksii*	9.57	0.096
2020-PER-43-BF-5-MT	Perdido	P43	17	*O. banksii*	6.72	0.067
2020-PER-43-BF-1-MT	Perdido	P43	20	*O. banksii*	7.98	0.080
2020-PER-43-BF-8-MT	Perdido	P43	24	*O. banksii*	13.70	0.137
2020-PER-43-BF-9-MT	Perdido	P43	25	*O. banksii*	16.11	0.161
				Mean ± CI	6.89 ± 1.66	
				Range	2.19 – 16.11	

Table 3.12: Trophic position of Blackfin Tuna, Yellowfin Tuna, and O. banksii from this study.

Species	Fish ID	Trophic Position	Squid ID	Trophic Position
Blackfin Tuna	N03	5.38	N09-05	3.67
Blackfin Tuna	N07	3.78	P41-14	3.64
Blackfin Tuna	N08	3.72	P41-17	3.34
Blackfin Tuna	N09	3.77	P41-18	3.29
Blackfin Tuna	N10	3.58	P41-19	3.22
Blackfin Tuna	N12	3.82	P43-01	3.43
Blackfin Tuna	N13	3.45	P43-05	3.43
Blackfin Tuna	N14	3.65	P43-08	3.47
Blackfin Tuna	N16	4.45	P43-09	3.50
Blackfin Tuna	N19	3.66	P43-07	3.65
Blackfin Tuna	N23	4.16	P27-02	3.41
Blackfin Tuna	N24	3.07	P27-03	3.31
Blackfin Tuna	P27	3.95	N07-15	3.35
Blackfin Tuna	P28	5.16	N07-16	3.29
Blackfin Tuna	P43	3.56	P27-01	3.29
Yellowfin Tuna	P04	3.36	P27-05	3.33
Yellowfin Tuna	P13	3.68	P29-01	3.57
Yellowfin Tuna	P20	3.06	P29-02	3.38
Yellowfin Tuna	P29	4.69	P39-11	3.31
Yellowfin Tuna	P30	3.11	P39-12	3.57
Yellowfin Tuna	P33	5.06	Mean	3.42 ± 0.06
Yellowfin Tuna	P39	5.21		
Yellowfin Tuna	P41	3.97		
Yellowfin Tuna	P42	3.37		
Yellowfin Tuna	P45	4.83		
Blackfin Tuna	Mean	3.95 ± 0.34		
Yellowfin Tuna	Mean	4.03 ± 0.60		

Table 3.13: Comparison of BMF_{TP} and BMF for Blackfin Tuna and Yellowfin Tuna in the GoM. Data are presented as a range of ratios (minimum – maximum) of the predator/prey relationship between Blackfin Tuna/squid and Yellowfin Tuna/squid.

		BMF-TP										BMF									
Analyte	Log K_{ow}	Blackfin Tuna (n = 13)			> 1	0	< 1	Yellowfin Tuna (n = 6)			>1	0	< 1	Blackfin Tuna (n = 15)			>1	0	< 1	Yellowfin Tuna (n = 10)			> 1	0	< 1
PCBs																									
PCB 28	5.67	2.0	-	71.6	13	0	0	5.0	-	59.0	6	0	0	2.1	-	23.0	15	0	0	6.5	-	26.1	10	0	0
PCB 37	5.83	0.0	-	23.9	9	2	2	0.0	-	15.6	3	3	0	0.0	-	14.8	11	2	2	0.0	-	4.4	4	6	0
PCB 52	5.84	0.0	-	91.5	12	1	0	3.2	-	17.3	6	0	0	0.0	-	29.4	14	1	0	2.2	-	15.8	10	0	0
PCB 44	5.75	0.5	-	28.1	12	0	1	2.9	-	17.8	6	0	0	0.2	-	7.6	12	0	3	0.6	-	12.6	9	0	1
PCB 49	5.85	3.8	-	87.5	13	0	0	8.1	-	72.8	6	0	0	1.5	-	18.7	15	0	0	3.9	-	31.2	10	0	0
PCB 77	6.36	0.5	-	71.9	12	0	1	0.0	-	8.2	3	2	1	0.5	-	19.0	14	0	1	0.0	-	15.0	5	4	1
PCB 74	6.2	1.2	-	15.6	13	0	0	0.7	-	6.6	4	0	2	0.4	-	5.0	12	0	3	0.8	-	7.7	8	0	2
PCB 70	6.2	0.0	-	52.8	8	4	1	2.2	-	12.2	6	0	0	0.0	-	17.0	10	4	1	0.0	-	19.0	8	1	1
PCB 126	6.89	1.1	-	40.5	13	0	0	7.0	-	28.3	6	0	0	0.7	-	17.4	14	0	1	3.2	-	30.8	10	0	0
PCB 87	6.29	0.0	-	127.6	11	1	1	16.1	-	84.6	6	0	0	0.0	-	56.1	12	1	2	4.4	-	78.0	10	0	0
PCB 99	6.39	0.9	-	40.6	12	0	1	17.9	-	30.2	6	0	0	0.9	-	28.6	14	0	1	1.2	-	46.1	10	0	0
PCB 101	6.38	0.0	-	177.0	7	6	0	0.0	-	13.3	3	3	0	0.0	-	56.9	8	7	0	0.0	-	24.1	4	6	0
PCB 114	6.65	0.0	-	8.0	7	5	1	4.5	-	19.3	6	0	0	0.0	-	10.8	7	5	3	1.8	-	26.9	10	0	0
PCB 118	6.74	0.0	-	144.7	3	9	1	0.0	-	57.9	5	1	0	0.0	-	23.8	3	10	2	0.0	-	47.9	7	3	0
PCB 82	6.2	0.0	-	6915.8	10	3	0	0.0	-	8359.8	3	3	0	0.0	-	6086.1	11	4	0	0.0	-	15163.9	4	6	0
PCB 105	6.65	0.0	-	66.2	8	5	0	13.4	-	53.8	6	0	0	0.0	-	33.8	9	5	1	3.1	-	97.5	10	0	0
PCB 156	7.18	9.5	-	142.1	13	0	0	50.2	-	204.7	6	0	0	6.5	-	184.7	15	0	0	11.6	-	371.2	10	0	0
PCB 128	6.74	0.0	-	41.8	9	3	1	22.3	-	55.3	6	0	0	0.0	-	48.2	11	3	1	1.6	-	100.3	10	0	0
PCB 153	6.92	0.0	-	36.9	12	1	0	8.3	-	78.4	6	0	0	0.0	-	65.1	14	1	0	1.8	-	112.6	10	0	0
PCB 169	7.42	0.0	-	7.0	1	12	0	0.0	-	457.7	3	3	0	0.0	-	49.2	2	13	0	0.0	-	180.9	3	7	0
PCB 183	7.2	0.0	-	6123.9	5	8	0	133.6	-	771.9	6	0	0	0.0	-	1968.3	7	8	0	0.0	-	1400.1	7	3	0
PCB 179	6.73	5.6	-	79.3	13	0	0	41.5	-	194.1	6	0	0	1.3	-	139.9	15	0	0	4.6	-	352.2	10	0	0
PCB 180	7.36	0.0	-	53.0	2	11	0	11.3	-	134.6	6	0	0	0.0	-	93.5	3	12	0	0.0	-	244.1	6	4	0
PCB 170	7.27	4.0	-	260.8	13	0	0	99.5	-	313.2	6	0	0	4.2	-	229.8	15	0	0	0.0	-	568.2	9	1	0
PCB 187	7.17	0.0	-	335.4	3	10	0	157.9	-	1009.6	6	0	0	0.0	-	591.9	3	12	0	0.0	-	1433.5	6	4	0
PCB 189	7.71	0.0	-	201.9	5	7	1	0.0	-	61.3	2	4	0	0.0	-	64.9	8	7	0	0.0	-	35.3	2	8	0
OCPs																									
b-BHC	3.7	0.0	-	0.0	0	13	0	0.0	-	119.8	1	5	0	0.0	-	0.0	0	15	0	0.0	-	33.8	1	9	0
g-BHC	3.7	0.0	-	20.0	3	9	1	0.0	-	33.5	3	3	0	0.0	-	11.1	2	10	3	0.0	-	9.4	4	6	0
d-BHC	3.7	0.0	-	769.0	3	10	0	0.0	-	325.1	1	5	0	0.0	-	247.1	3	12	0	0.0	-	91.7	2	8	0
Aldrin	5.52	0.0	-	66.5	3	10	0	0.0	-	1.4	1	5	0	0.0	-	35.2	5	10	0	0.0	-	2.5	1	9	0
trans-chlordane	6	0.0	-	475.8	3	10	0	0.0	-	27.9	1	5	0	0.0	-	152.9	4	11	0	0.0	-	96.5	2	8	0
cis-chlordane	6	0.0	-	11.6	2	11	0	0.0	-	7.8	1	5	0	0.0	-	22.9	3	12	0	0.0	-	14.2	1	9	0
DDE	6.09	0.0	-	36.2	12	1	0	14.4	-	42.4	6	0	0	0.0	-	63.9	11	2	2	3.6	-	70.6	10	0	0
DDD	6.22	0.0	-	13.3	3	10	0	3.6	-	39.5	6	0	0	0.0	-	23.5	2	12	1	1.4	-	35.1	10	0	0
DDT	6.38	0.0	-	10.1	10	1	2	1.7	-	8.3	6	0	0	0.0	-	4.4	6	1	8	1.2	-	12.6	10	0	0

Table 3.13: (Continued)

Endrin	5.16	0.0	-	1029.5	2	11	0	0.0	-	28.4	1	5	0	0.0	-	393.8	2	13	0	0.0	-	16.1	1	9	0
Methoxychlor	5.08	0.0	-	13.7	3	8	2	0.3	-	9.8	4	0	2	0.0	-	3.4	3	10	2	0.5	-	8.7	6	0	4
Chlorobenzilate	3.05	0.0	-	59.5	4	8	1	0.0	-	25.3	4	2	0	0.0	-	30.1	4	10	1	0.0	-	7.5	7	3	0
cis-Permethrin	6.6	0.0	-	6.1	4	4	5	0.1	-	1.5	3	0	3	0.0	-	1.2	2	6	7	0.1	-	2.0	3	0	7
trans-Permethrin	6.6	0.0	-	3.9	3	5	5	0.2	-	1.6	3	0	3	0.0	-	1.3	1	6	8	0.2	-	2.0	2	0	8
Hexachlorobenzene	5.47	0.0	-	24.2	1	12	0	0.0	-	254.8	2	4	0	0.0	-	13.4	1	14	0	0.0	-	81.7	5	5	0
DCPA	4.4	0.0	-	891.1	2	11	0	0.0	-	0.0	0	6	0	0.0	-	787.6	3	12	0	0.0	-	0.0	0	10	0
Simazine	2.11	0.0	-	0.0	0	13	0	0.0	-	2.1	1	5	0	0.0	-	0.0	0	15	0	0.0	-	2.8	1	9	0
Metribuzin	1.7	0.0	-	131.4	10	3	0	8.1	-	342.5	6	0	0	0.0	-	50.3	10	5	0	13.4	-	96.6	10	0	0
Alachlor	3.3	0.0	-	55.5	6	7	0	0.0	-	0.0	0	6	0	0.0	-	14.8	7	8	0	0.0	-	0.0	0	10	0
Metolachlor	3.11	0.0	-	3752.1	5	8	0	0.0	-	1130.4	1	5	0	0.0	-	1205.9	5	10	0	0.0	-	318.7	4	6	0
Cyanazine	2.22	0.0	-	3.0	3	7	3	0.0	-	5.5	2	2	2	0.0	-	1.1	1	9	5	0.0	-	10.0	3	4	3
PAHs																									
naphthalene	3.37	0.0	-	16.4	4	3	6	0.0	-	7.7	3	1	2	0.0	-	5.3	4	3	8	0.0	-	3.4	5	2	3
C1 naphthalene	3.72	0.0	-	53.7	5	6	2	1.1	-	12.5	6	0	0	0.0	-	17.3	6	7	2	1.5	-	11.7	10	0	0
C2 naphthalene	n/a	0.0	-	26.0	5	4	4	0.0	-	13.0	4	1	1	0.0	-	8.4	7	4	4	0.0	-	5.7	7	2	1
C3 naphthalene	n/a	0.0	-	19.8	9	1	3	0.0	-	5.6	4	1	1	0.0	-	6.4	8	1	6	0.0	-	3.5	7	2	1
C4 naphthalene	n/a	0.0	-	24.0	9	1	3	0.1	-	6.7	4	0	2	0.0	-	7.7	7	1	7	0.0	-	4.1	7	1	2
acenaphthylene	4	0.0	-	17.4	5	6	2	0.0	-	4.3	3	3	0	0.0	-	6.4	6	6	3	0.0	-	3.0	4	6	0
acenaphthene	3.92	0.0	-	15.7	10	1	2	0.2	-	7.3	2	0	4	0.0	-	5.1	12	1	2	0.0	-	5.9	6	1	3
fluorene	4.18	0.1	-	3.7	7	0	6	0.0	-	8.6	3	1	2	0.0	-	1.0	0	0	15	0.0	-	6.1	7	1	2
C1 fluorene	n/a	0.4	-	26.2	10	0	3	0.8	-	11.3	5	0	1	0.5	-	8.4	11	0	4	1.0	-	5.8	9	0	1
C2 fluorene	n/a	0.5	-	26.0	10	0	3	0.7	-	11.2	5	0	1	0.5	-	8.3	13	0	2	0.9	-	6.4	9	0	1
C3 fluorene	n/a	0.4	-	29.8	11	0	2	0.4	-	6.5	4	0	2	0.3	-	9.6	10	0	5	0.5	-	11.8	8	0	2
anthracene	4.54	0.3	-	58.8	12	0	1	1.1	-	78.2	6	0	0	0.5	-	21.0	14	0	1	1.4	-	40.2	10	0	0
phenanthrene	4.57	0.3	-	18.5	10	0	3	0.8	-	8.1	3	0	3	0.5	-	6.0	9	0	6	0.9	-	5.4	9	0	1
C1 phenanthrene-anthracene	5.16	0.3	-	36.1	11	0	2	0.4	-	6.6	4	0	2	0.3	-	11.6	9	0	6	0.6	-	12.0	8	0	2
C2 phenanthrene-anthracene	5.54	0.3	-	32.7	11	0	2	0.4	-	8.0	4	0	2	0.5	-	10.5	12	0	3	0.4	-	4.4	8	0	2
C3 phenanthrene-anthracene	5.85	0.2	-	37.6	11	0	2	0.6	-	6.7	4	0	2	0.4	-	12.1	12	0	3	0.8	-	11.3	8	0	2
C4 phenanthrene-anthracene	n/a	0.1	-	18.1	9	0	4	0.3	-	5.2	4	0	2	0.2	-	5.8	10	0	5	0.4	-	5.3	7	0	3
dibenzothiophene	4.38	0.4	-	21.4	10	0	3	1.3	-	12.0	6	0	0	0.5	-	6.9	13	0	2	1.1	-	8.6	10	0	0
C1 dibenzothiophene	4.84	0.3	-	30.8	9	0	4	0.5	-	9.6	4	0	2	0.1	-	9.9	11	0	4	0.4	-	10.5	8	0	2
C2 dibenzothiophene	n/a	0.3	-	41.8	11	0	2	0.5	-	6.7	4	0	2	0.5	-	13.4	12	0	3	0.6	-	7.2	8	0	2
C3 dibenzothiophene	n/a	0.4	-	36.7	11	0	2	0.5	-	7.0	4	0	2	0.7	-	11.8	12	0	3	0.7	-	3.8	9	0	1
C4 dibenzothiophene	n/a	0.0	-	61.1	9	1	3	0.0	-	10.9	4	1	1	0.0	-	19.6	11	1	3	0.0	-	10.3	7	2	1
fluoranthene	5.22	0.4	-	27.0	11	0	2	1.8	-	8.9	6	0	0	0.6	-	5.8	14	0	1	1.5	-	6.8	10	0	0
pyrene	5.18	0.6	-	38.6	12	0	1	1.6	-	17.4	6	0	0	1.0	-	8.4	15	0	0	2.1	-	9.9	10	0	0
C1 fluoranthene-pyrene	n/a	0.2	-	30.9	10	0	3	0.1	-	16.2	4	0	2	0.1	-	9.9	6	0	9	0.1	-	29.4	6	0	4

Table 3.13: (Continued)

C2 fluoranthene-pyrene	n/a	0.0	-	38.0	7	0	6	0.0	-	6.2	4	1	1	0.1	-	12.2	7	0	8	0.0	-	8.1	7	2	1
C3 fluoranthene-pyrene	n/a	0.0	-	64.5	8	3	2	0.0	-	19.7	4	1	1	0.0	-	20.7	9	3	3	0.0	-	8.6	7	2	1
C4 fluoranthene-pyrene	n/a	0.0	-	67.7	8	3	2	0.0	-	12.7	4	1	1	0.0	-	21.8	8	3	4	0.0	-	11.3	6	3	1
chrysene	5.56	0.0	-	7.8	4	3	6	0.0	-	6.8	2	1	3	0.0	-	2.3	4	3	8	0.0	-	2.6	6	2	2
C1 benz[a]anthracene-chrysene	6.24	0.0	-	95.2	4	6	3	0.0	-	10.7	4	2	0	0.0	-	30.6	6	7	2	0.0	-	14.5	6	4	0
C2 benz[a]anthracene-chrysene	6.6	0.0	-	95.3	7	3	3	0.0	-	20.7	4	1	1	0.0	-	30.6	8	3	4	0.0	-	17.2	8	2	0
C3 benz[a]anthracene-chrysene	7.01	0.0	-	53.9	4	5	4	0.0	-	31.0	4	1	1	0.0	-	17.3	6	6	3	0.0	-	9.2	8	2	0
C4 benz[a]anthracene-chrysene	n/a	0.0	-	77.5	4	8	1	0.0	-	31.1	4	2	0	0.0	-	24.9	5	9	1	0.0	-	11.3	7	3	0
benzo(b)fluoranthene	5.8	0.0	-	1405.3	9	4	0	0.0	-	69.6	3	3	0	0.0	-	451.7	11	4	0	0.0	-	159.1	4	6	0
C1 benzopyrene-perylene	n/a	0.0	-	93.5	2	10	1	0.0	-	13.3	4	2	0	0.0	-	30.1	2	12	1	0.0	-	12.2	7	3	0
C2 benzopyrene-perylene	n/a	0.0	-	48.3	5	5	3	0.0	-	14.7	4	1	1	0.0	-	15.5	6	5	4	0.0	-	6.2	6	2	2
C3 benzopyrene-perylene	n/a	0.0	-	12.0	8	3	2	0.0	-	5.7	3	1	2	0.0	-	2.0	3	4	8	0.0	-	2.8	7	1	2
ECCs																									
Dimethyl phthalate	1.60	0.0	-	1.9	1	12	0	0.0	-	0.0	0	6	0	0.0	-	1.5	1	14	0	0.0	-	0.0	0	10	0
Diethyl phthalate	2.42	0.0	-	19.2	3	7	3	0.0	-	3.1	2	2	2	0.0	-	6.2	2	8	5	0.0	-	1.8	1	4	5
Benzyl butyl phthalate	4.73	0.0	-	24.2	5	1	7	0.0	-	2.5	3	0	3	0.0	-	7.8	5	1	9	0.0	-	3.3	4	0	6
di-2-ethylhexyl phthalate	7.27	0.0	-	65.0	4	3	6	0.0	-	0.2	0	5	1	0.0	-	32.1	5	3	7	0.0	-	0.9	0	6	4
Di-n-butyl phthalate	4.50	0.0	-	0.1	0	11	2	0.0	-	0.2	0	5	1	0.0	-	2.0	1	12	2	0.0	-	0.3	0	9	1
Cis-Homosalate	6.27	0.0	-	0.5	0	12	1	0.0	-	5.3	1	5	0	0.0	-	0.9	0	14	1	0.0	-	17.4	3	7	0
Trans-Homosalate	6.27	0.0	-	0.2	0	12	1	0.0	-	5.1	1	5	0	0.0	-	0.3	0	14	1	0.0	-	22.1	3	7	0

Figures

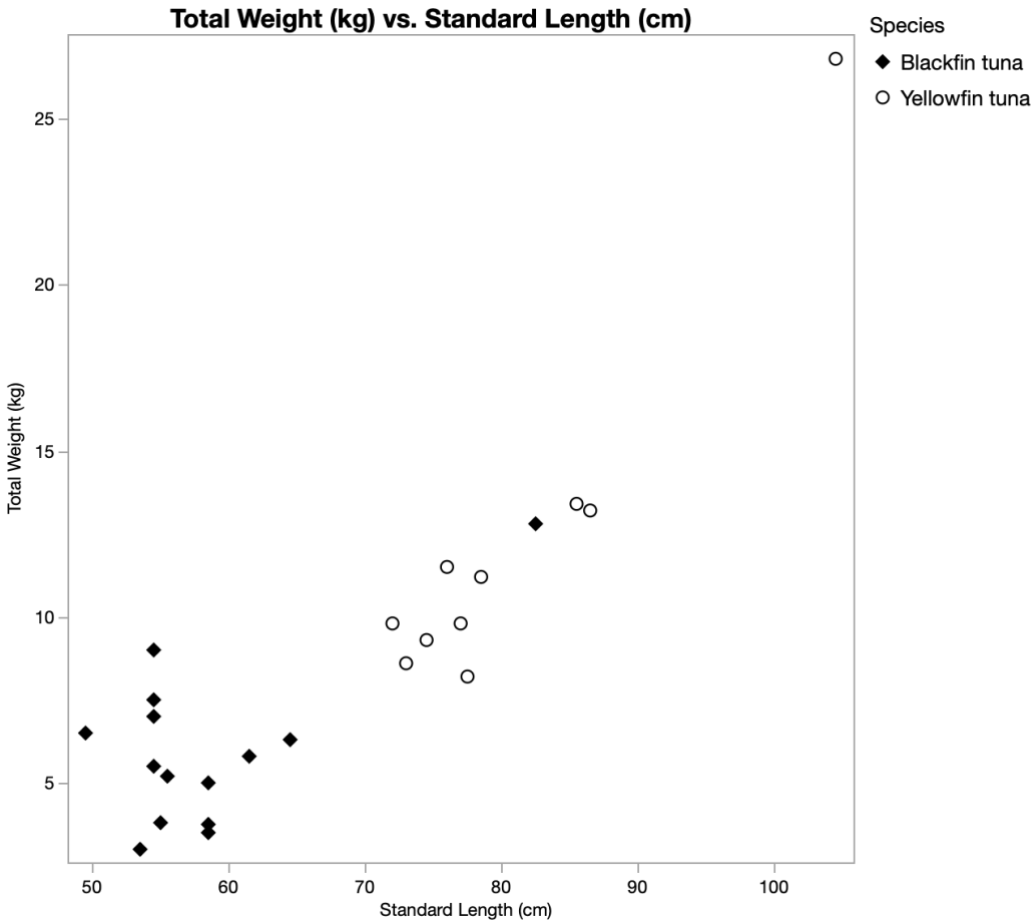

Figure 3.1: Total body weight vs. standard length (SL) of Blackfin Tuna and Yellowfin Tuna

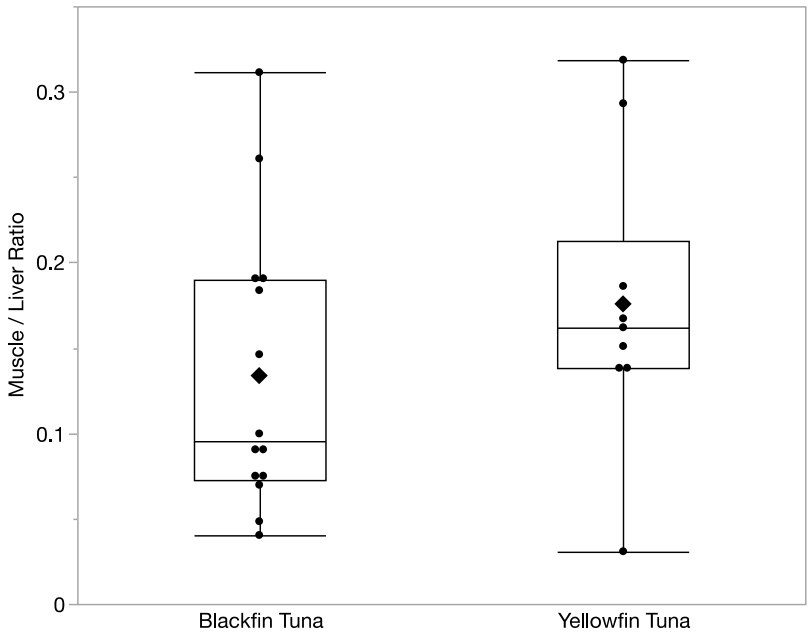

Figure 3.2: Comparison of muscle/liver lipid fraction ratios between Blackfin Tuna and Yellowfin Tuna. Dots represent individual samples; diamond represents the mean.

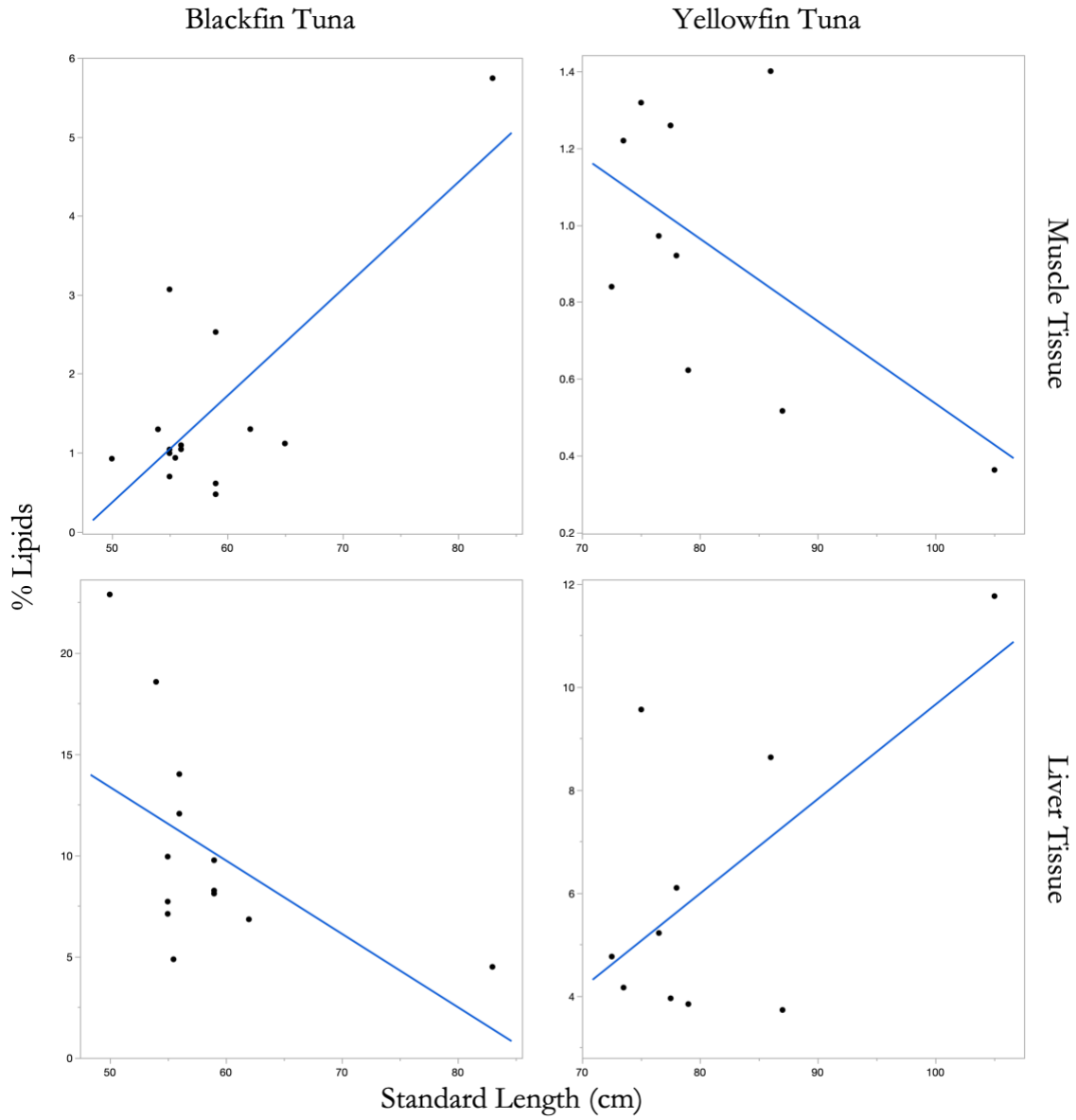

Figure 3.3: % lipids in muscle and liver tissue of Blackfin Tuna and Yellowfin Tuna by standard length (cm). Black dots represent individual samples and blue line represents line of fit.

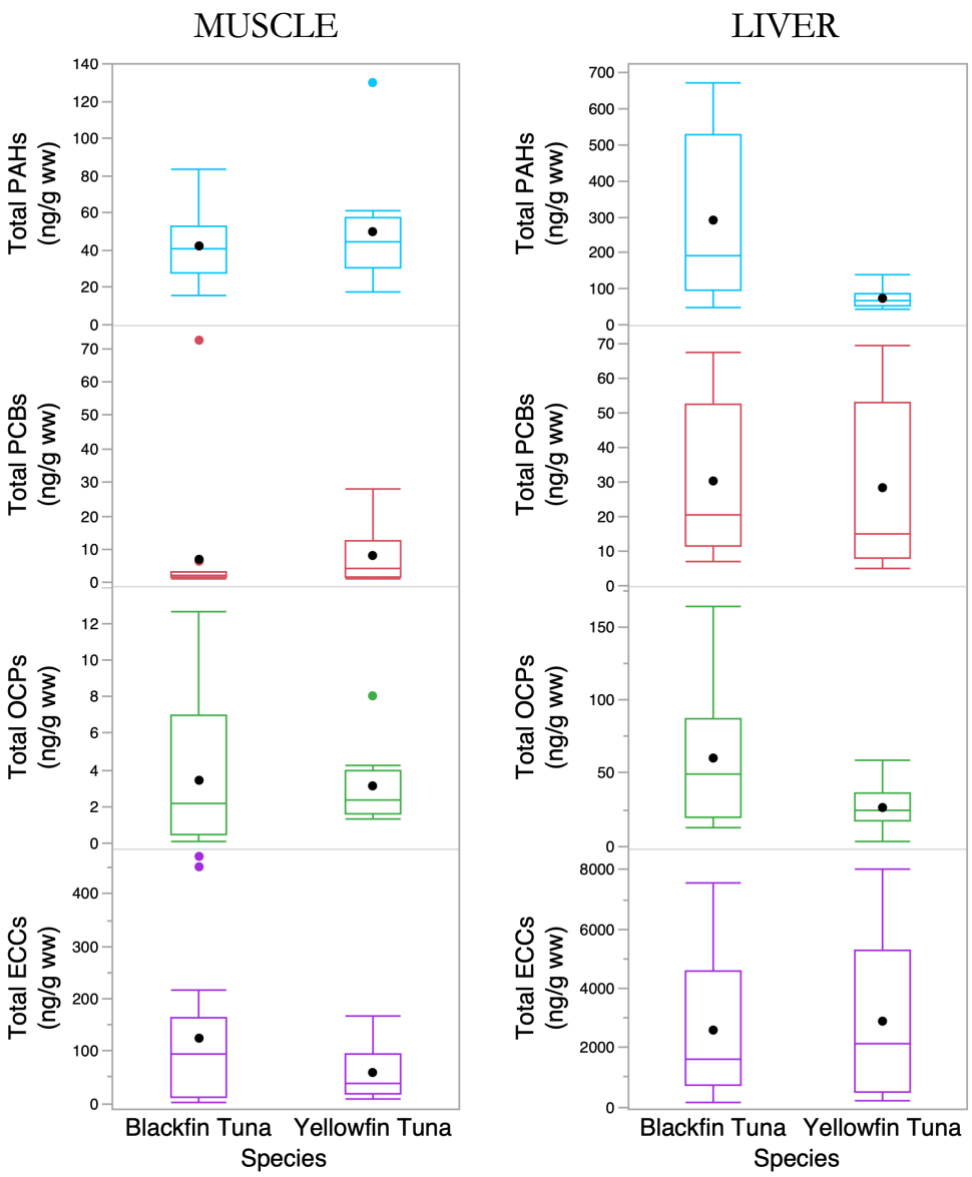

Figure 3.4: Average concentrations (ng/g ww) of each compound group analyzed (Blackfin Tuna and Yellowfin Tuna (liver and muscle)). The black dots represent the mean, colored dots represent outliers, whiskers represent the 95% confidence interval in each respective category. Total concentrations refer to 2-6 ring polycyclic aromatic hydrocarbons and their alkylated homologs for PAHs, polychlorinated biphenyls congeners of 2-7 chlorine atoms for PCBs, Phthalates: di-methyl phthalate, di-ethyl phthalate, di-n-butyl-phthalate, benzyl-butyl phthalate, di-2-ethylhexyl phthalate, and di-n-octyl phthalate, and UV filters: cis-homosalate, trans-homosalate, oxybenzone, Octinoxalate, and avobenzone.

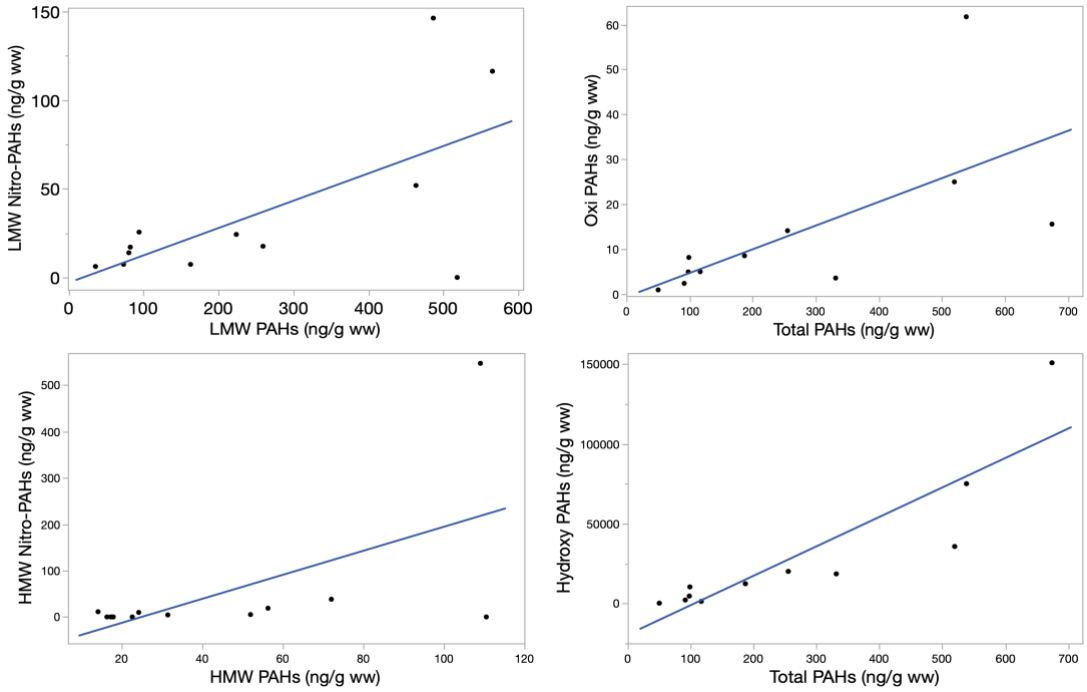

Figure 3.5: Comparative analysis of ∑PAHs and low molecular weight nitro-PAHs, high molecular weight nitro-PAHs, oxi-PAHs, and Hydroxy-PAHs in Blackfin Tuna liver.

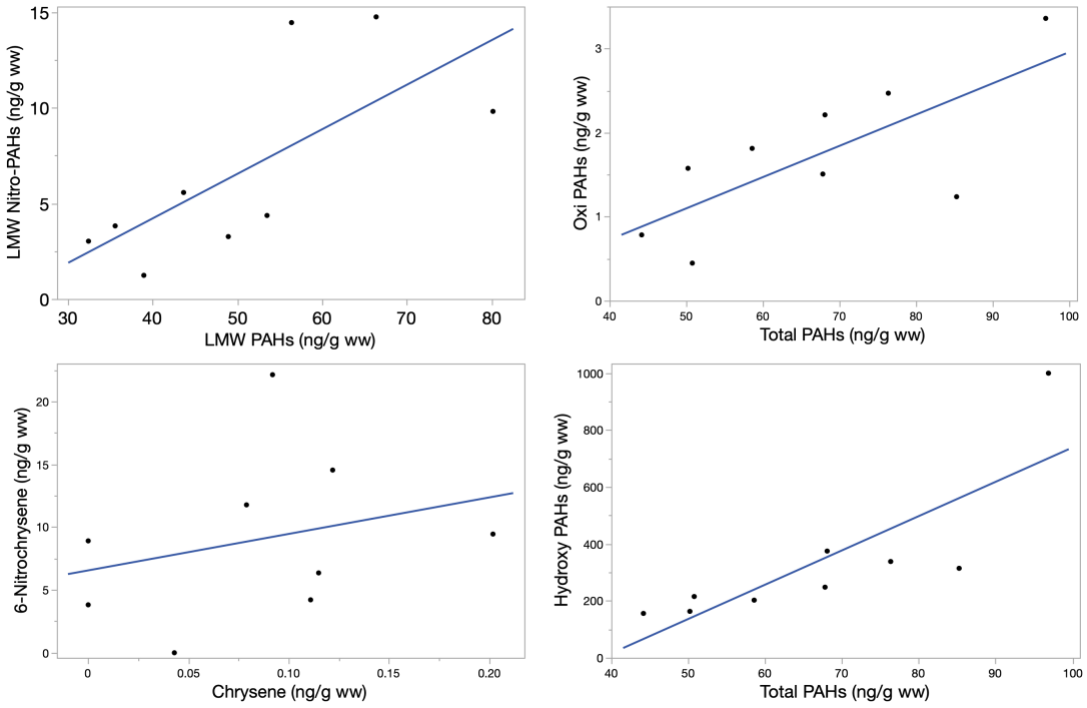

Figure 3.6: Comparative analysis of ∑PAHs and low molecular weight nitro-PAHs, high molecular weight nitro-PAHs, oxi-PAHs, and hydroxy-PAHs in Yellowfin Tuna liver.

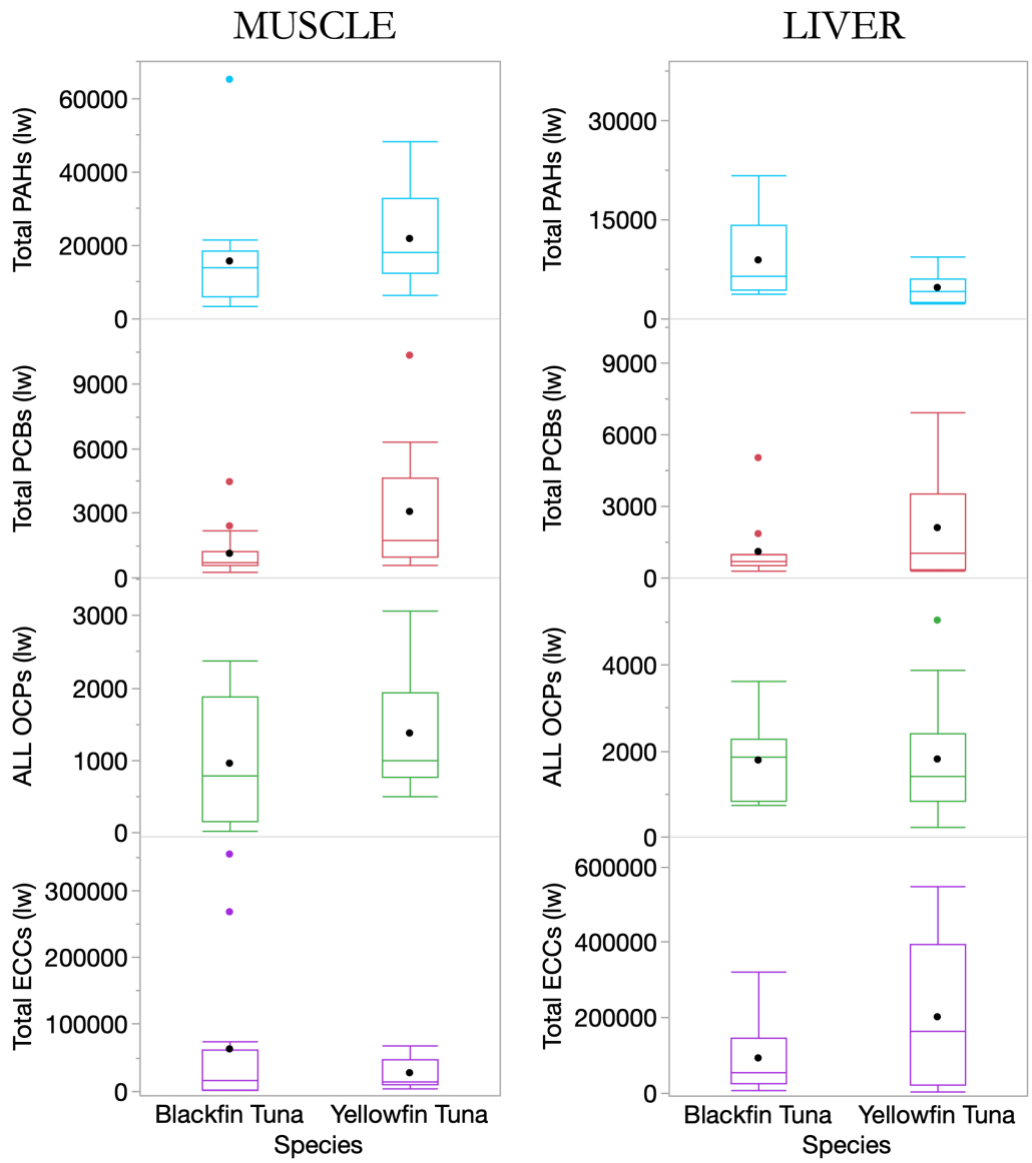

Figure 3.7: Average concentrations (lipid normalized) of each compound group analyzed (Blackfin Tuna and Yellowfin Tuna (liver and muscle)). The black dots represent the mean, colored dots represent outliers, whiskers represent the 95% confidence interval in each respective category. Total concentrations refer to 2-6 ring polycyclic aromatic hydrocarbons and their alkylated homologs for PAHs, polychlorinated biphenyls congeners of 2-7 chlorine atoms for PCBs, Phthalates: di-methyl phthalate, di-ethyl phthalate, di-n-butyl-phthalate, benzyl-butyl phthalate, di-2-ethylhexyl phthalate, and di-n-octyl phthalate, and UV filters: cis-homosalate, trans-homosalate, oxybenzone, Octinoxalate, and avobenzone.

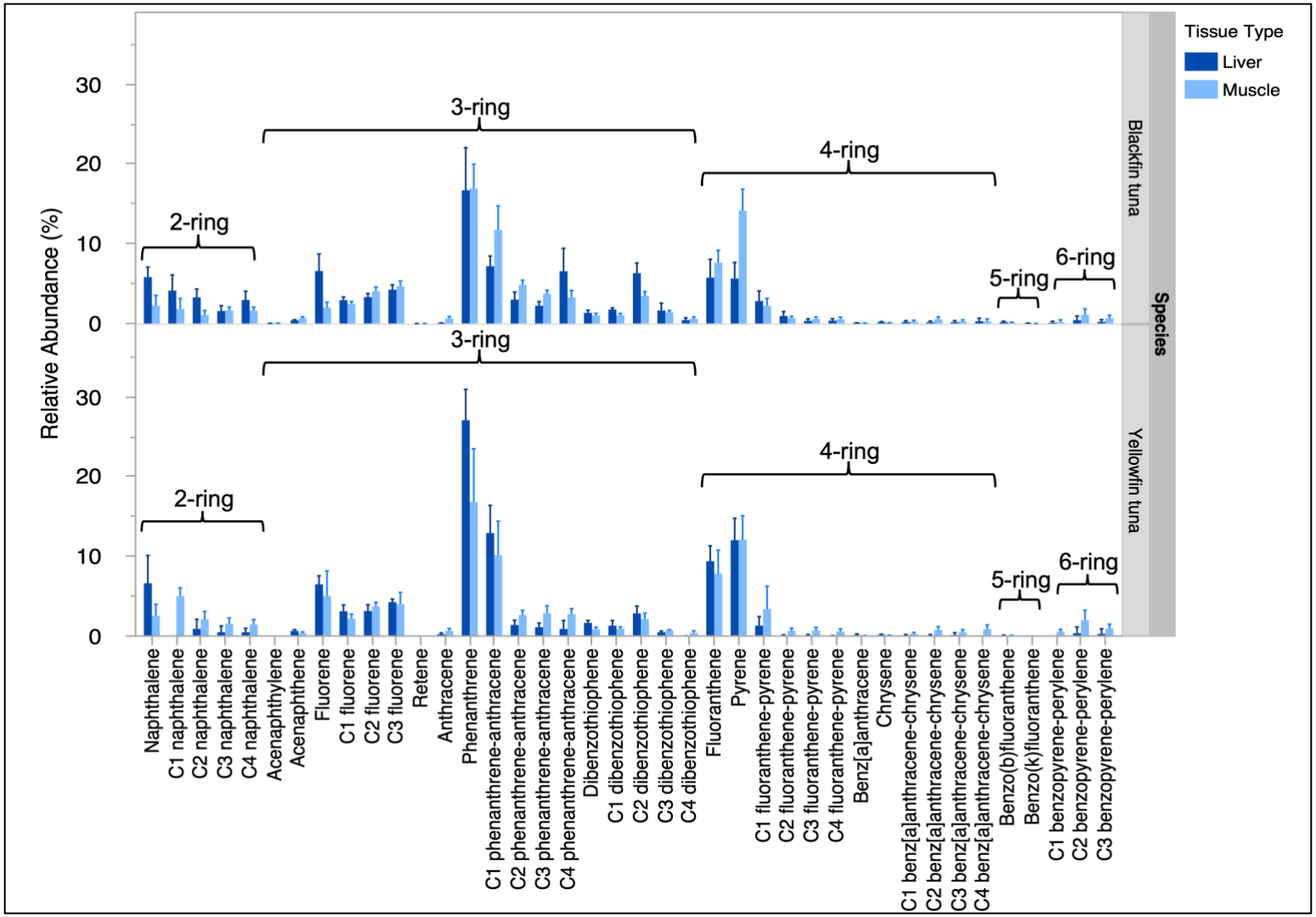

Figure 3.8: Composition of PAHs in the liver (dark blue) and muscle tissue (light blue) of Blackfin Tuna and Yellowfin Tuna. Error bars shown as mean ± 95% confidence interval.

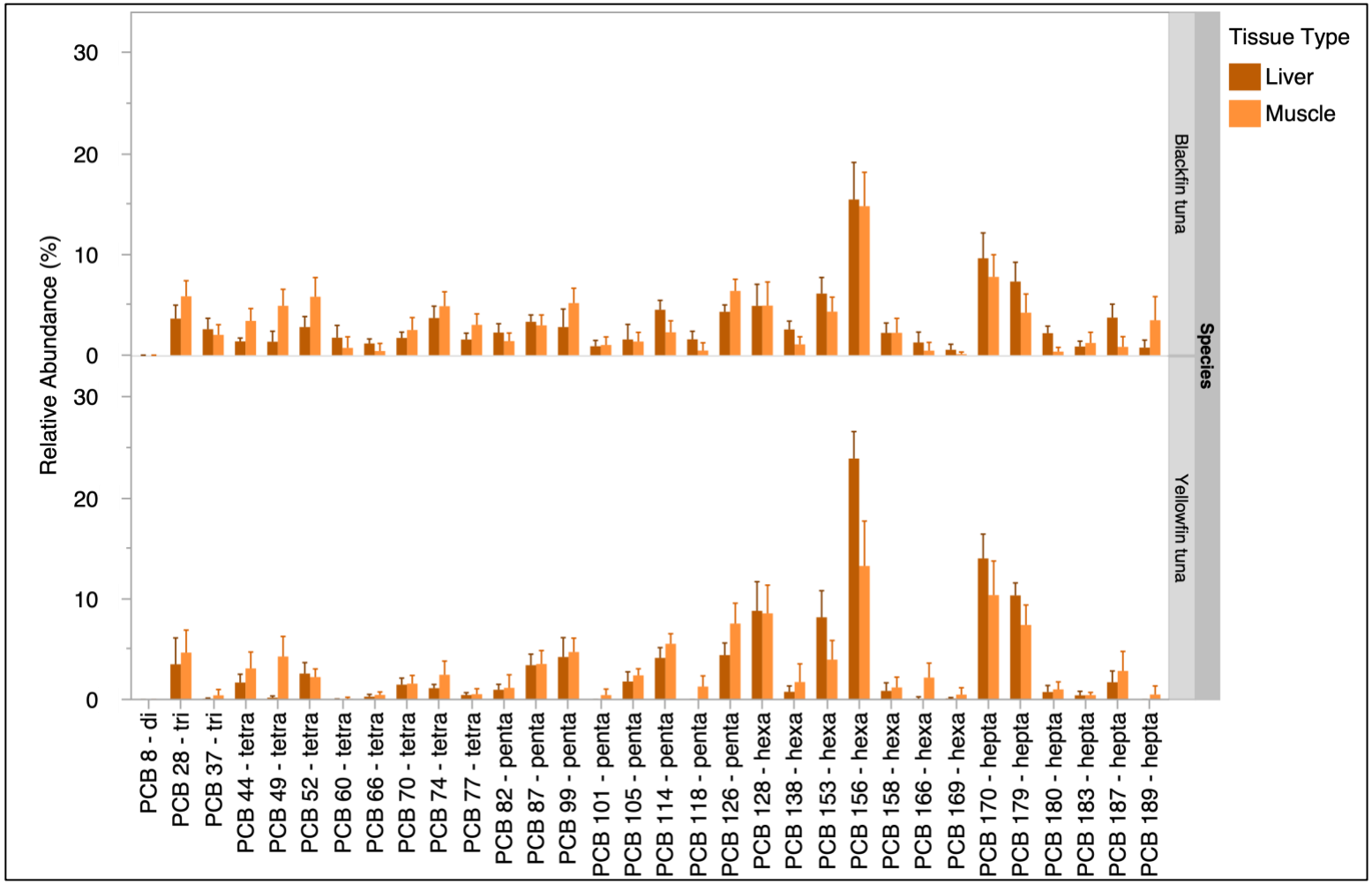

Figure 3.9: Composition of PCBs in the liver (dark orange) and muscle tissue (light orange) of Blackfin Tuna and Yellowfin Tuna. Error bars shown as mean ± 95% confidence interval.

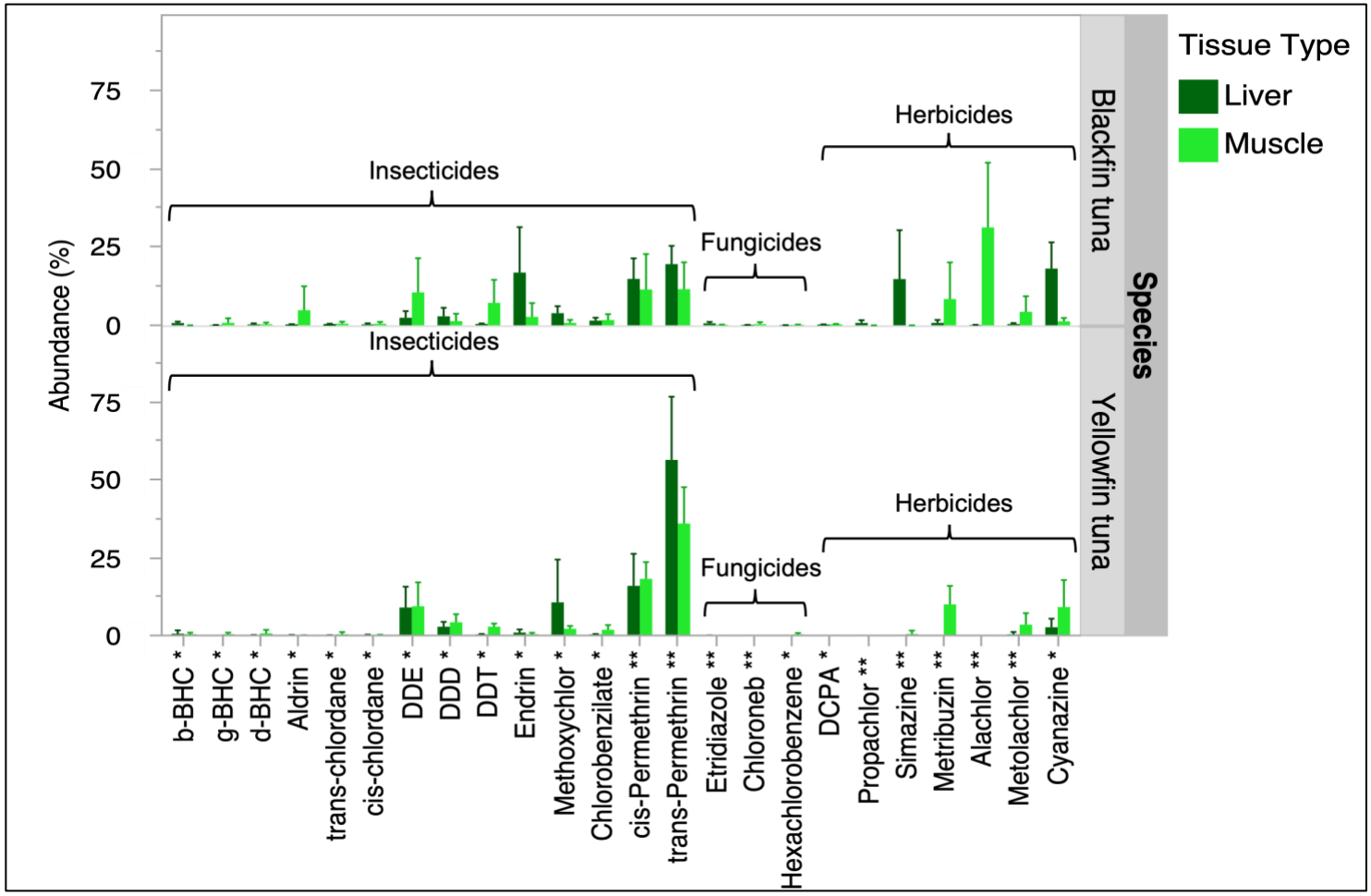

*Figure 3.10: Composition of OCPs in the liver (dark green) and muscle tissue (light green) of Blackfin Tuna and Yellowfin Tuna. Error bars shown as mean ± 95% confidence interval, * indicates banned pesticides, ** indicates currently in-use pesticides.*

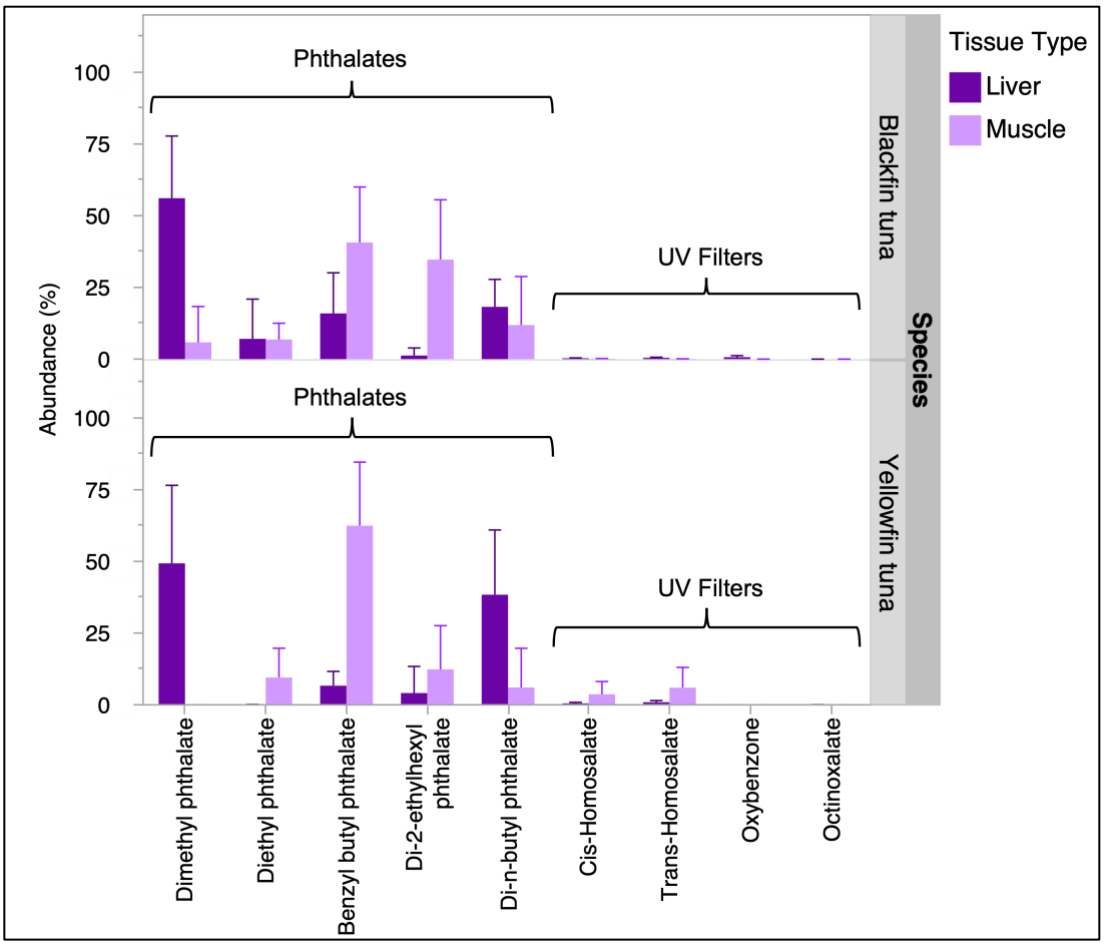

Figure 3.11: Relative abundance shown as a percentage of selected ECC compounds in the liver (dark purple) and muscle tissue (light purple) of Blackfin Tuna and Yellowfin Tuna sampled in this study. Error bars shown as mean ± 95% confidence interval. Banned phthalates (2008): diethylhexyl phthalate (DEHP), dibutyl phthalate (DBP), and butyl benzyl phthalate (BBP) banned in HI and Key West (2018-2019): Oxybenzone (BP-3) and octinoxate (OMC)

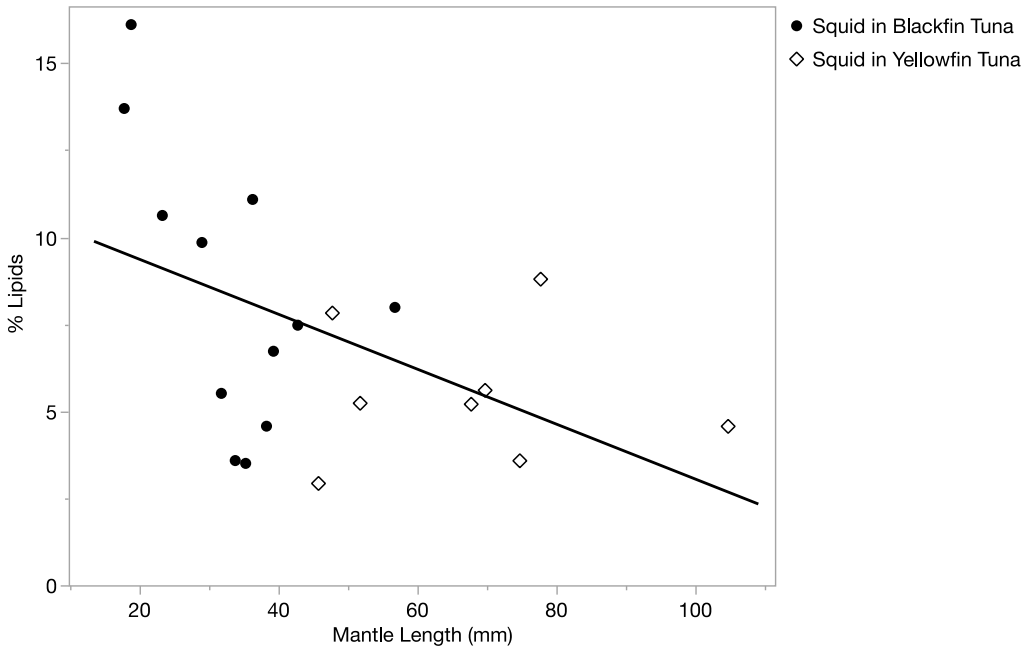

Figure 3.12: Percent lipids in squid mantle tissue by mantle length (mm). Black dots represent squid obtained from Blackfin Tuna stomachs, and open diamonds represent squid obtained from Yellowfin Tuna stomachs, and the solid line represents the line of fit.

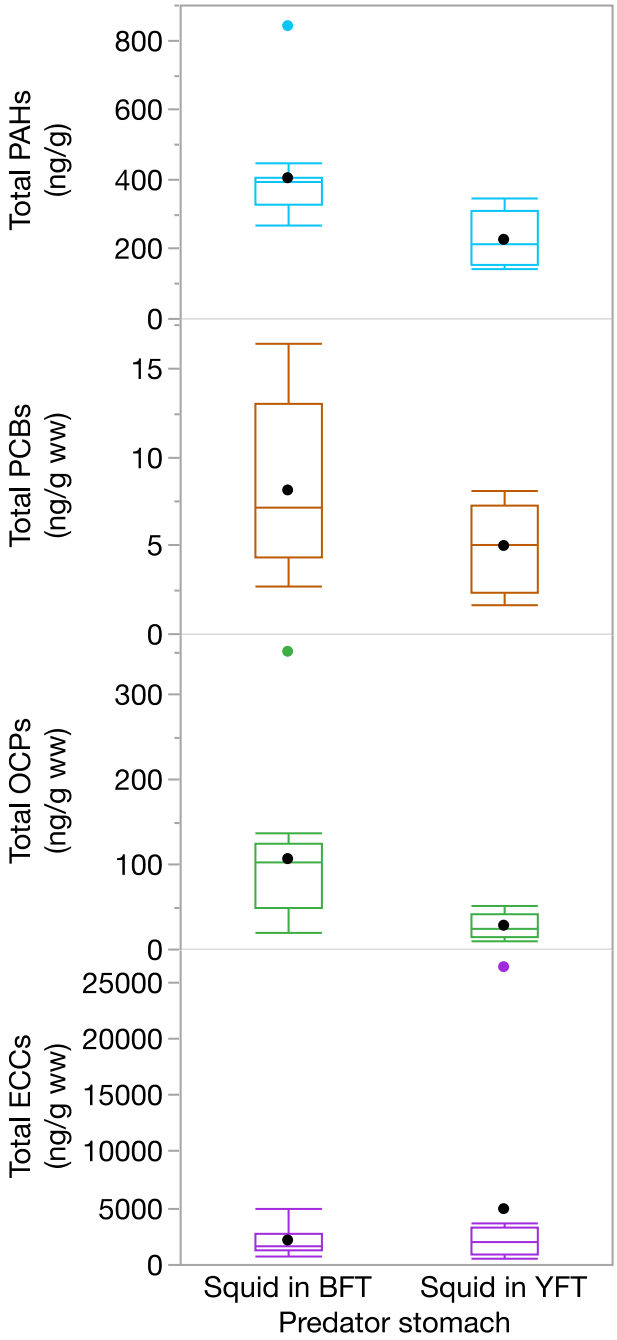

Figure 3.13: Average concentrations (ng/g ww) of each compound group analyzed for O.banskii mantle tissue separated by tuna species. The black dots represent the mean, colored dots represent outliers, whiskers represent the 95% confidence interval in each respective category. Total concentrations refer to 2-6 ring polycyclic aromatic hydrocarbons and their alkylated homologs for PAHs, the oxidation products of PAHs (16 samples were excluded from analysis) for OPAHs, organochlorine pesticides, PCBs, polychlorinated biphenyls congeners of 2-7 chlorine atoms for PCBs, Phthalates di-methyl phthalate, di-ethyl phthalate, di-n-butyl-phthalate, benzyl-butyl phthalate, di-2-ethylhexyl phthalate, and di-n-octyl phthalate, and UV filters cis-homosalate, trans-homosalate, oxybenzone, Octinoxalate, and avobenzone.

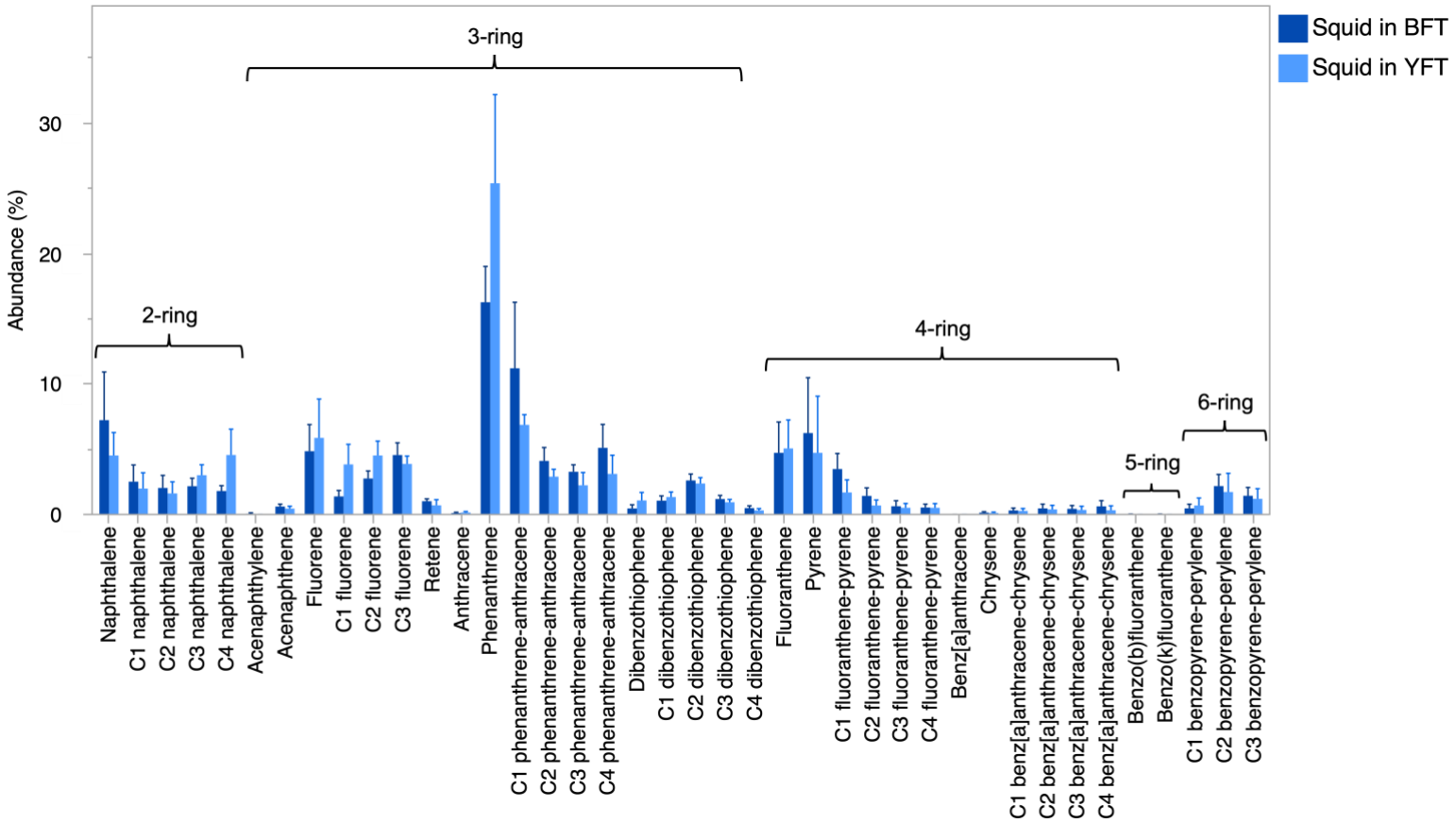

Figure 3.14: Composition of PAHs in the mantle tissue of O. banksii. Dark blue bars represent squid obtained from Blackfin Tuna (BFT) stomachs and light blue bars represent squid obtained from Yellowfin Tuna (YFT) stomachs. Error bars shown as mean ± 95% confidence interval.

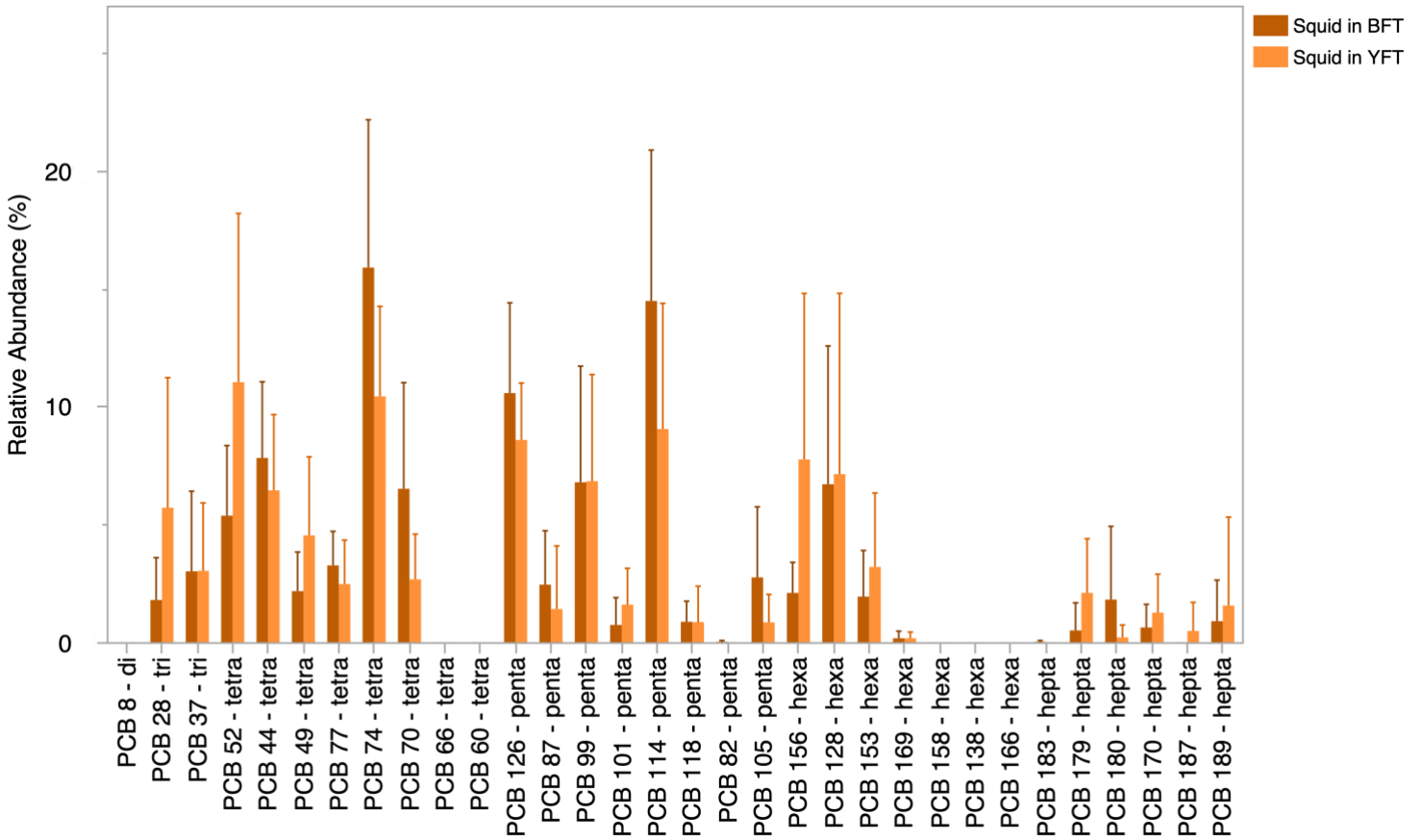

Figure 3.15: Composition of PCBs in the mantle tissue of O. banksii. Dark orange bars represent squid obtained from Blackfin Tuna (BFT) stomachs and light orange bars represent squid obtained from Yellowfin Tuna (YFT) stomachs. Error bars shown as mean ± 95% confidence interval.

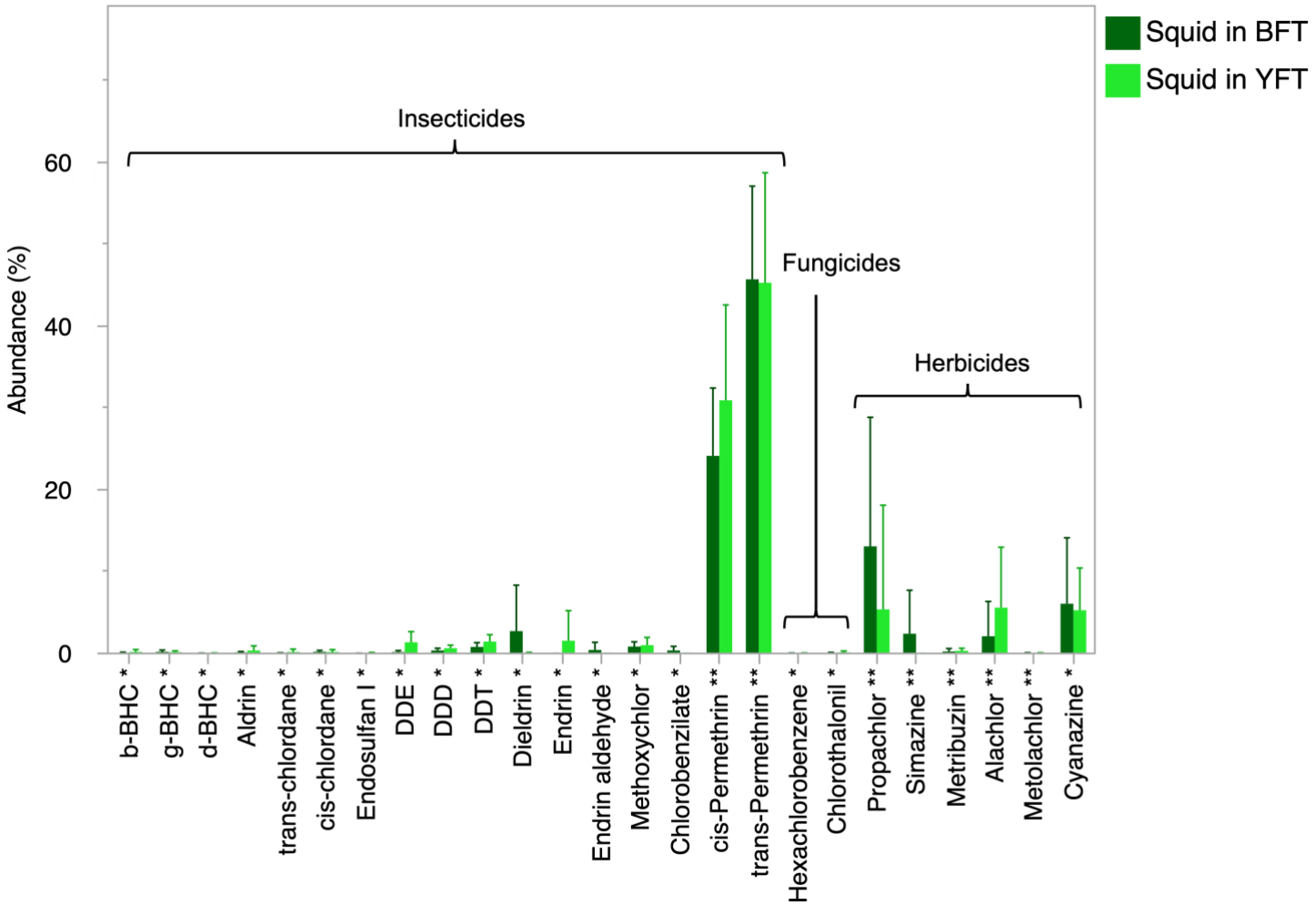

*Figure 3.16: Composition of OCPs in the mantle tissue the O. banksii. Analytes marked with: * are banned OCPs, ** are currently in use OCPs. Dark green bars represent squid obtained from Blackfin Tuna (BFT) stomachs and light green bars represent squid obtained from Yellowfin Tuna (YFT) stomachs. Error bars shown as mean ± 95% confidence interval.*

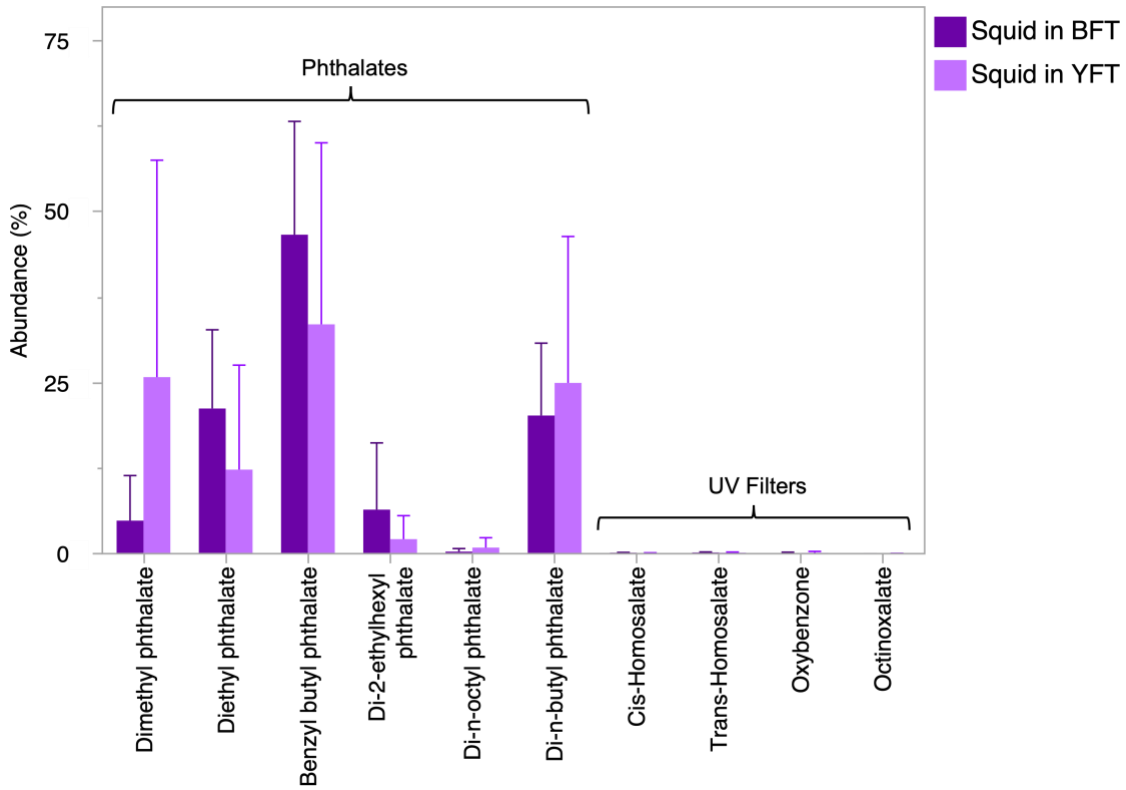

Figure 3.17: Composition of selected ECCs in the mantle tissue of O. banksii. Banned phthalates (2008): diethylhexyl phthalate (DEHP), dibutyl phthalate (DBP), and butyl benzyl phthalate (BBP) banned in HI and Key West (2018-2019): Oxybenzone (BP-3) and octinoxate (OMC) Dark purple bars represent squid obtained from Blackfin Tuna (BFT) stomachs and light purple bars represent squid obtained from Yellowfin Tuna (YFT) stomachs. Error bars shown as mean ± 95% confidence interval.

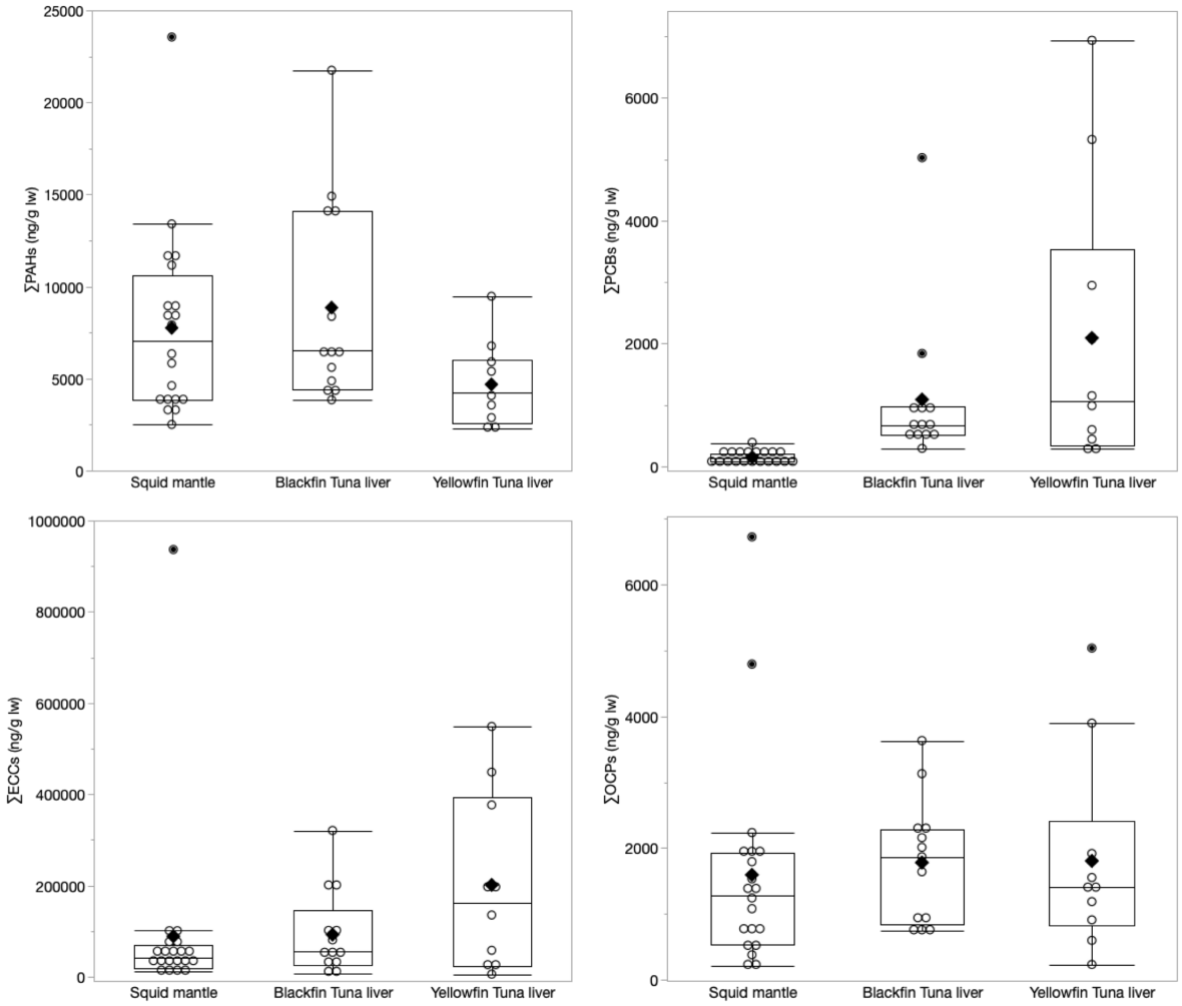

Figure 3.18: Concentration of organic contaminants (ng/g lw) in squid mantle tissue and tuna liver tissue. Open circles represent individual samples, solid black dot represents the mean total concentration.

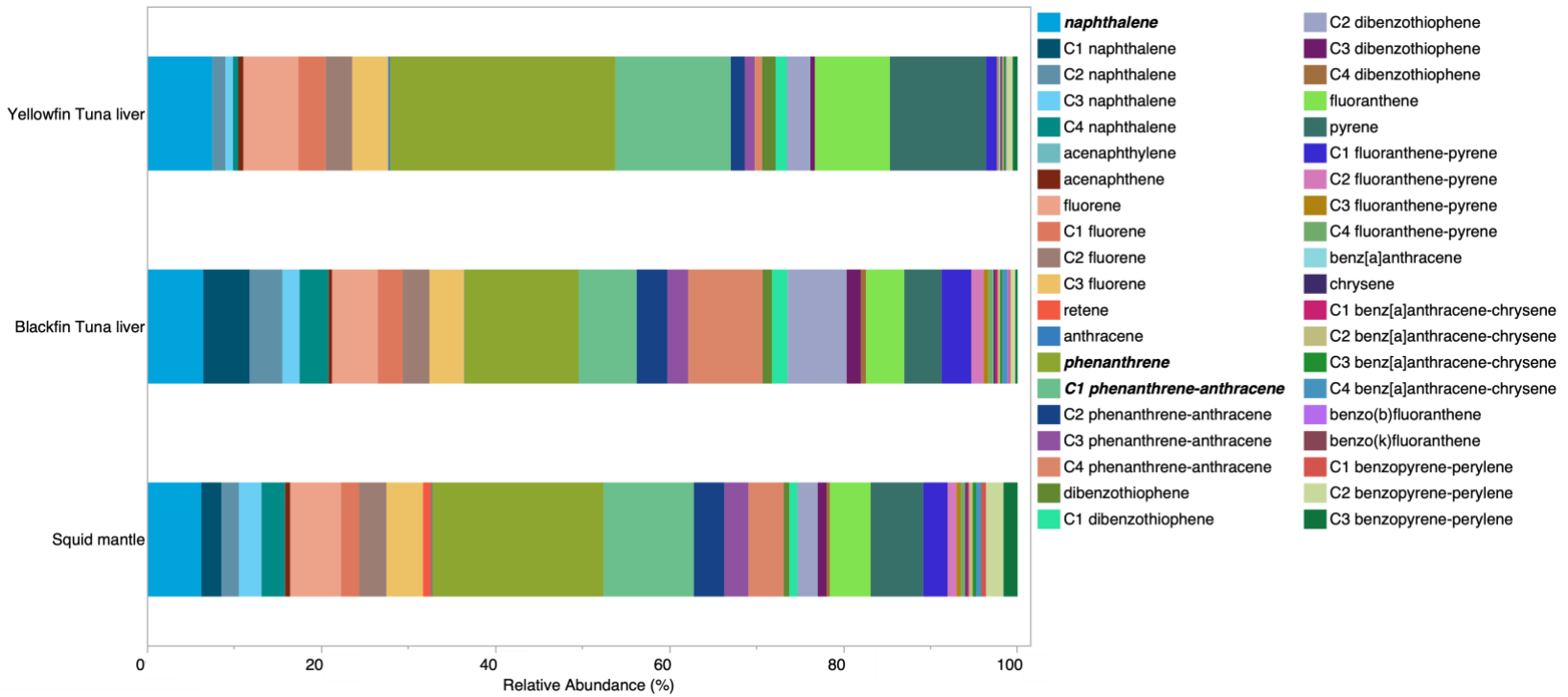

Figure 3.19: Composition of PAHs (calculated based on concentrations in ng/g lw) in tuna liver and squid mantle tissue. The most abundant analytes in squid mantle tissue are noted in bold in legend.

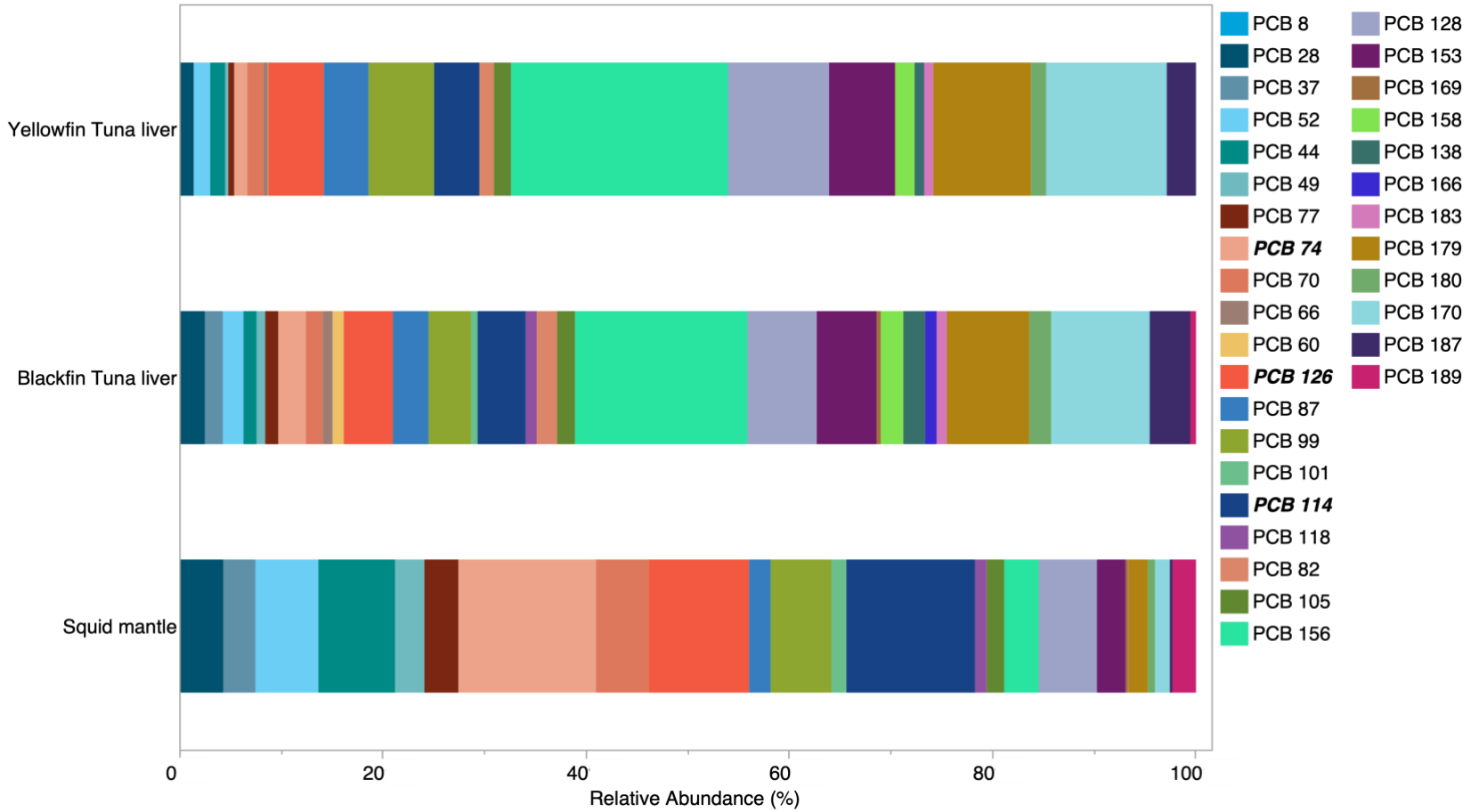

Figure 3.20: Composition of PCBs (calculated based on concentrations in ng/g lw) in tuna liver and squid mantle tissue. The most abundant analytes in squid mantle tissue are noted in bold in legend.

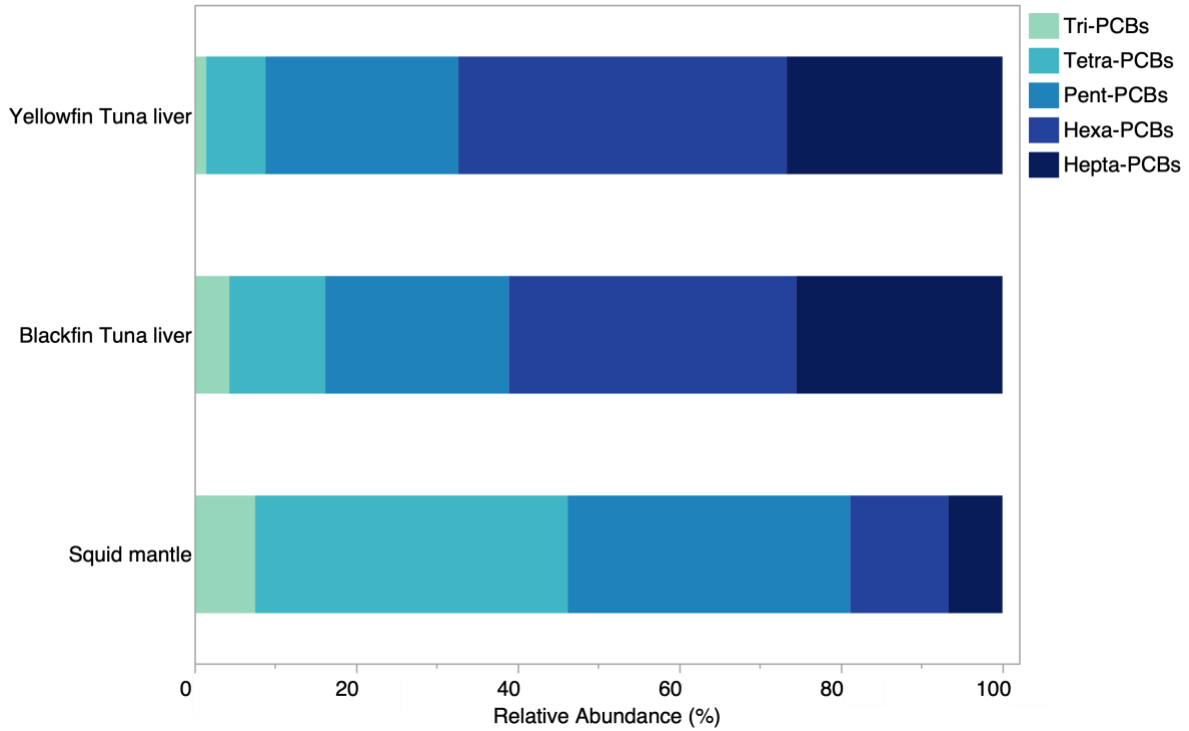

Figure 3.21: Composition of PCBs (calculated based on concentrations in ng/g lw) by chlorination (tri, tetra, penta, hexa, and hepta) for tuna liver and squid muscle tissues.

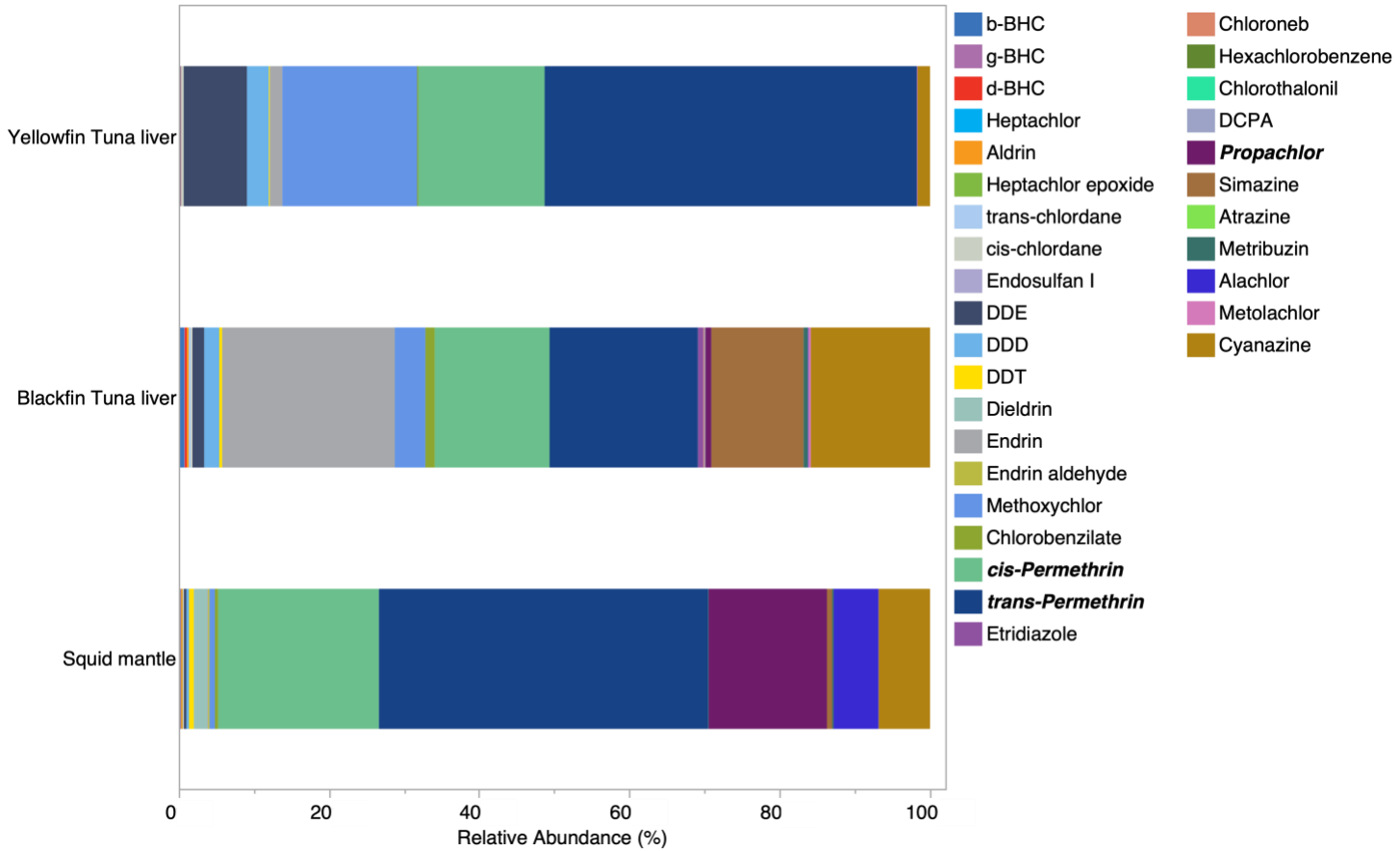

Figure 3.22: Composition of OCPs (calculated based on concentrations in ng/g lw) in tuna liver and mantle tissue. The most abundant analytes in squid mantle tissue are noted in bold in the legend.

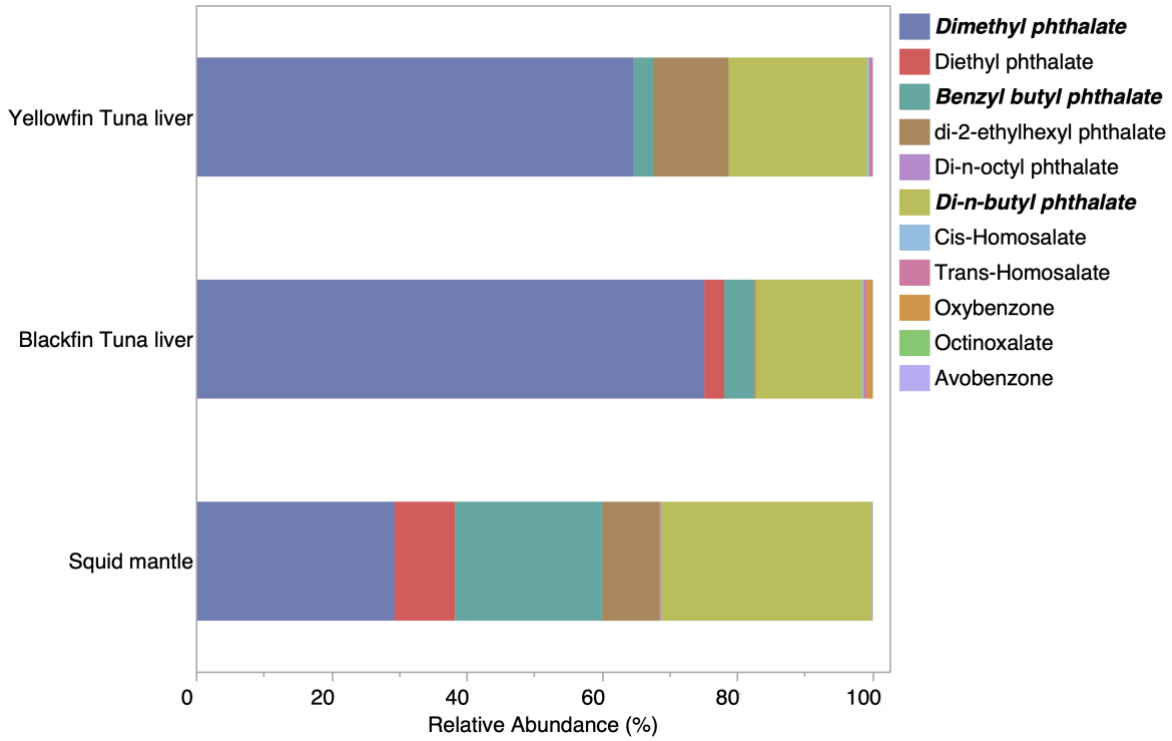

Figure 3.23: Composition of ECCs (calculated based on concentrations in ng/g lw) in tuna liver and mantle tissue. The most abundant analytes in squid mantle tissue are noted in bold in the legend.

CHAPTER 4: DISCUSSION AND CONCLUSION

Two pelagic fish, Blackfin Tuna and Yellowfin Tuna, were studied to quantify the concentrations and composition of five organic compound groups (PAHs, OPAHs, PCBs, OCPs, and ECCs). Additionally, the diet as an exposure pathway to these tunas was assessed by analyzing the Common Clubhook Squid, one of the most abundant prey items found in their stomach. Overlapping habitats of squid and fish species may expose tuna to organic contaminants through predator-prey interactions (Almeda et al., 2013; Fenton et al., 2015; Daniela M. Pampanin and Sydnes, 2017; Sambolino et al., 2023). Tuna undergo diel vertical migration, spending nights at the surface and migrating to deeper water during the day. Specifically, Yellowfin Tuna have a range of 100 – 1000 m while Blackfin Tuna range from the surface to 200 m (Hoolihan et al., 2014; Fenton, et al., 2015). The Common Clubhook Squid. has been found throughout the water column, from the surface to 1500 m in the GoM, and is a weak vertical migrator, with a higher abundance of squid near the surface during the day (Judkins and Vecchoine, 2020).

Results from this study indicated that lipid normalized (lw) concentrations of PAHs and PCBs were higher in muscle tissue than liver tissue for both tuna species, suggesting long-term accumulation or chronic exposure to these compounds. Organisms can bio-transform and excrete contaminants through urine and feces, potentially decreasing accumulation in the liver and muscle tissue (Beyer et al., 2010; Abdel-Shafy and Mansour, 2016). Cephalopods have a digestive gland that is less efficient in metabolizing xenobiotics than their predators (Gomes et al., 2013; Lobo-Da-Cunha, 2019). Hydrophobic compounds, such as lipid based organic compounds, are more difficult to eliminate and can bioaccumulate and magnify up the food chain (Torres et al., 2009).

The tuna showed contrasting lipid storage trends in their liver and muscle tissue. The tuna in this study showed similar diets based on stomach contents (Figure A.5, Figure A.6). Metabolic differences due to behavioral variations linked to their ranges (vertically and spatially across the GoM) may influence lipid utilization. Yellowfin Tuna, which have a broader range both vertically and throughout the GoM and may utilize more of their stored lipids from muscle tissue (Le-Alvarado et al., 2021). In contrast, Blackfin Tuna, have a smaller range vertically and may spend more time in residence around oil platforms and may not draw on their muscular lipid reserves as extensively. Lower liver lipid content, as seen in Blackfin Tuna from this study, could also be associated with reproductive activities, as oocyte development is sourced from feeding and liver based lipids (Zudaire et al., 2014).

Organic Contaminants

∑PAH mean total concentrations in squid, and tuna liver and muscle tissues were compared with other studies (Table 4.1). This study revealed that the ∑PAHs in both species of tuna were higher than those found in previous research conducted in the GoM and other areas (Murawski et al., 2014; Novakov et al., 2017; Wickrama-Arachchige et al., 2020), with the exception of a study by Schwaab, M. (2020) (Table 4.1). Results in this study indicated higher ∑PAHs compared to those reported by Schwaab for the Northwest GoM, but lower than those reported for the North Central GoM due to differences in potential exposure via produced waters and proximity to more active oil operations in the North Central region (Schwaab, 2020).

∑PAH concentrations were higher in the Common Clubhook Squid mantle tissue than in a previous study by Romero et al. (2020) in the GoM. Higher concentrations may be related to further weathering of petrogenic inputs, changes related to diet, or ML as squid from this study had a smaller size range than those from Romero et al. (2020) (Table 4.1). Concentrations in squid can be affected by environmental availability of contaminants and their diet, as low trophic level prey

provides a route for exposure to lipophilic organic contaminants in predator-prey interactions (Llobet et al., 2006; Perugini et al., 2007; Gomes, et al., 2013; Romero et al., 2020). Regarding ML, negative correlations between ML and ∑PAHs might stem from maternal transfer during spawning or the growth-dilution effect, where concentrations decrease as mantle length increases, as shown in this study. (Xie et al., 2023).

Both tuna species in this study were caught near oil platforms, and while Yellowfin Tuna is a highly migratory species (vertical and intercontinental) having a broader range than Blackfin Tuna, they both may spend time in residency and migrate between these structures. Point and non-point sources such as those related to oil rigs, run-off, and atmospheric deposition may be identified by analyzing the composition of the PAHs (Neff et al., 2011; Stogiannidis and Laane, 2015; Abdel-Shafy and Mansour, 2016). LMW PAHs such as naphthalene, fluorene, and phenanthrene are most abundant in crude oil while heavier four to six ring PAHs appear in lower abundance. However, LMW PAHs are more susceptible to degradation than HMW PAHs which can result in a higher abundance of HMW PAHs as crude oil becomes weathered and degraded (Daniela M Pampanin and Sydnes, 2013; Stogiannidis and Laane, 2015; Daniela M. Pampanin and Sydnes, 2017). Pyrogenic activities such as coal burning can produce emissions that escape stacks and enter the ocean through atmospheric deposition which show relative abundance profiles of FL, PY, P and An (Rotatori et al., 2003; Stogiannidis and Laane, 2015). PAH ratios of P/An, An/P+An, Fl/Fl+Py, and PI showed mostly petrogenic sources for species in this study (Romero et al., 2015; Stogiannidis and Laane, 2015) (Table 3.8). Blackfin Tuna exhibited higher ∑PAHs levels compared to Yellowfin Tuna, potentially due to variations in metabolism, behavior, or prolonged exposure. PAHs can be reabsorbed in tuna liver tissues when exposure surpasses their capacity to metabolize or eliminate these compounds, especially under chronic exposure conditions. (Abdel-Shafy and Mansour, 2016; Pulster et al., 2020).

The oxidized products of PAHs, OPAHs (hydroxy, oxy, and nitro PAHs), can result from metabolic activities or dietary intake. In this study, hydroxy PAHs constituted the majority of OPAHs and showed a correlation with PAHs, as well as LMW, HMW, and Nitro-PAHs. This indicates they are a result of metabolic activities in both tuna. Hydroxyphenanthrenes and Hydroxynaphthalenes can form during biotransformation, often representing the initial step in metabolic processes, when parental PAHs undergo hydroxylation. This modification increases their water solubility, facilitating excretion (Abdel-Shafy and Mansour, 2016; Daniela M. Pampanin and Sydnes, 2017; Clergé et al., 2019). These compounds exhibit increased bioavailability due to their polar nature and water solubility, creating a greater risk for genotoxic, mutagenic, and carcinogenic effects than their parent PAHs (Bandowe and Meusel, 2017; Daniela M. Pampanin and Sydnes, 2017; Clergé, et al., 2019). Nitro-PAHs were very low across tissue types in this study and were lower than those found in other studies in fish from Sweden and Lake Michigan (Bandowe and Meusel, 2017).

The ∑PCB concentrations observed in this study closely resembled those previously reported for the GoM in a global study by Nicklisch et al. (2017) (Table 4.1). Nicklisch, et al., (2017) suggest that the Mississippi River and atmospheric inputs may contribute to the higher concentrations in the GoM. PCBs do not degrade easily and persist in runoff, riverine inputs, resuspended sediments, and contaminated prey items, perpetuating exposure in marine ecosystems (Faroon and Olsen, 2000; Nicklisch et al., 2017). In this study, ∑PCB concentrations were lower than those found in an Australian study that collected samples through inshore fisheries (Table 4.1).Ta Factors such as proximity to land, urban runoff, and benthic influences may have increased exposure to PCBs (Endo et al., 2016).

This study found ∑PCB (lw) concentrations 7 – 20 times higher in tuna liver and muscle tissue than the Common Clubhook Squid mantle tissue. ∑PCB concentrations in the mantle tissue

of the Common Clubhook Squid were compared to those in other muscular squids, and similar concentrations were found (Won et al., 2009, 2010; Wu et al., 2019) (Table 4.1). Alongside the differing compositions of PCB analytes between squid and tuna, variations in backbone chlorination are also observed, with tuna exhibiting a higher prevalence of PCBs with a greater degree of chlorination (Figure 3.11). This difference might be linked to dietary exposure in tuna, as PCBs build up through the food chain and in fatty tissues, increasing over time, and may be acquired from prey other than squid. (Ross, 2004; Ramos and Gonzalez-Solis, 2012).

The concentrations of ∑OCPs in tuna muscle observed in this study were similar to or exceeded those found in other studies, except at a few locations where the historical or ongoing DDT use resulted in higher levels (Torres, et al., 2009; Nicklisch, et al., 2017) (Table 4.1). Factors such as ocean circulation, atmospheric deposition, runoff, and how close an area is to land can affect the bioavailability of contaminants in different locations. Additionally, the migration patterns of fish can influence their exposure to these contaminants (Van Der Oost et al., 2003). DDT and metabolites adsorb to particulates that persist in the environment and may continue entering the GoM through its expansive watershed and resuspension of sediments, reintroducing legacy contaminants, like DDT, into marine ecosystems (Kennicutt, 2017).

For squid, comparable research has primarily focused on DDT, and the DDT concentrations found in the Common Clubhook Squid were lower than those reported in the mantle tissue of similarly muscular squid in other studies. (Table 4.1). Squid and tuna differed in OCP composition, with squid containing more currently in use OCPs, while tuna predominantly contained legacy OCPs. Legacy OCPs were primarily found in tuna liver, while their concentrations were notably lower in muscle tissue, highlighting the fish's capability to eliminate these contaminants. Similar to PAHs, squid had a negative correlation of ML and OCPs suggesting

growth-dilution effect or reduction due to spawning and tuna may be acquiring OCPs from other prey items.

Results from this study showed that concentrations of the phthalates DBP and DEHP in tuna muscle were higher than those in other studies involving canned tuna in oil and water. Additionally, the DEP concentrations found in this study were lower than those of canned tuna. (Table 4.1). The Common Clubhook Squid mantle tissues showed that phthalate (DMP, DEP, DBP, BBP, DEHP, DnOP) concentrations in this study were higher than those reported for other muscular squids (Table 4.1). Differences related to size, location, bioavailability, feeding habits and metabolism could all be factors of variability between cephalopods (Sambolino, et al., 2023).

UV Filters have been shown to be endocrine disruptors which could have generational effects on populations (Yen et al., 2011). Avobenzone is the strongest UVA1 filter allowed in sunscreens in the US and Oxybenzone and other UV Filters provide UVA2 and UVB protection from skin cancer (Pintado-Herrera and Lara Martín, 2020; Fivenson et al., 2021; National Academies of Sciences et al., 2023). AVO and other UV filters are FDA-approved as "Marketed Unapproved Drugs" but are not a generally recognized as safe and effective (GRASE) in the USA (Fivenson, et al., 2021). The UV Filters in this study are oil-soluble and toxicity can include possible endocrine disruption, photo-allergen, and carcinogen effects (Fivenson, et al., 2021). In addition to personal care products UV filters are also added to plastics and paints for UV protection (De Miranda et al., 2021). UV filters and plastics may travel long distances and reach aquatic environments through run off and wastewater treatment and tend to increase in more densely populated areas (Auta et al., 2017; De Miranda, et al., 2021; Fivenson, et al., 2021).

In this study, ∑ECCs showed the highest concentrations among all compound groups across all species. The only significant relationship found for ECCs was a negative correlation with SL in Yellowfin Tuna liver. Additionally, there was no significant difference in concentrations between

species based on tissue type. Questions remain about the sources (runoff, ocean currents, atmospheric depositions, etc.) of ECCs for all species (Hidalgo-Serrano et al., 2022).

Trophic Connectivity

The trophic position, as calculated in this study, revealed that six tuna were at a lower trophic position than the squid, despite both being top predators. The mean trophic position (TP) of tuna (Blackfin Tuna: 3.95; Yellowfin Tuna: 4.03) in this study was similar to the TP of 4.1 for Yellowfin Tuna from other research in the GoM (Le-Alvarado, et al., 2021). Regardless of the BMF method used, the results revealed all compound groups had analytes with biomagnification factors > 1 for both tuna species. Other studies of polybrominated diphenyl ethers (PBDEs) and DDT in Yellowfin Tuna and their diet of Flying squid (*Sthenoteuthis oualaniensis*) and Kite squid (*Sthenoteuthis oualaniensis*) documented biomagnification for most compounds in the study (Moisey et al., 2001; Houde et al., 2006; Alava and Gobas, 2012; Sun et al., 2020; Sun et al., 2024). Similarly, PCBs and OCPs, including DDT and derivatives, were the highest BMFs in this study. These results indicate that Blackfin Tuna and Yellowfin Tuna are acquiring organic contaminants from the Common Clubhook Squid in this food chain.

Public Health Guidelines

In a global market, where concentrations of organic contaminants in tunas from around the world can vary from ocean to ocean, sourcing seafood origins may be of importance to human health (Endo, et al., 2016; Nicklisch, et al., 2017). Concentrations of organic contaminants found in this study (Table 3.4) were compared with published safety levels through various governmental regulations. The European Union established PAH guidelines for smoked fishery products: BAPY are 2.0 ng/g, ww and the sum of BAPY, BAA, BBFL, and CHR are 12.0 ng/g, ww (Agency for Toxic Substances and Disease Registry, 2023; European Union, 2024). BAPY was below detectable

limits and the mean sum concentrations of BBA, BBFL, and CHR were below guidelines for all tissue types studied.

PCB guidelines set forth by The Federal Drug Administration (FDA)are 2000 ng/g, ww for fish and in the European Union for fishery products levels are 75 ng/g, ww (muscle) and 200 ng/g, ww (liver) (Agency for Toxic Substances and Disease Registry, 2023; European Union, 2024). Results indicate that ∑PCB concentrations (liver: Blackfin Tuna: 30.33 ± 13.72; Yellowfin Tuna: 28.38 ± 17.82; muscle: Blackfin Tuna: 7.03 ± 10.04; Yellowfin Tuna: 8.17 ± 6.80; mantle: 6.85 ± 1.98) were 57 - 285 times lower than FDA guidelines for all tissue types. Tuna liver tissue was ~ 6 times lower and muscle and mantle tissue ~ 10 times lower than the EU guidelines. The FDA published OCP guidelines for individual compounds for fish: Aldrin & Dieldrin: 300 ng/g, ww, CHL: 300 ng/g, ww, DDT, DDE & TDE: 5000 ng/g, ww, HEP & HEP-epox: 300 ng/g, ww (U.S. Food & Drug Admistration, 2000). Mean concentrations measured in the tuna species and squid were far lower (ranging from 0.02 – 2.3 ng/g, ww) than guidelines for all tissue types for these OCP compounds. However, the concentrations of currently in use compounds such as Simazine in Blackfin Tuna liver 192 ± 200 ng/g, ww, and Propachlor in squid mantle tissue 124 ± 67 ng/g, ww, do suggest the need to monitor and investigate the effects of new compounds on biota. Toxic reference levels of phthalates are based on human consumption, and values listed for chronic oral exposure are BBP: 200 ng/g/day, DBP –100 ng/g/day, DEHP – 0.02 ng/g/day, DEP – (800 ng/g/day), and DMP – no information available (U.S. Environmental Protection Agency, 2007; Yen, et al., 2011).

Conclusion

In this study, I quantified and compared the concentrations and compositions of organic contaminants in two pelagic predators, Blackfin Tuna and Yellowfin Tuna, as well as the mantle tissue of a prey item, which is also a predator, sourced from their stomach contents. Location plays a

vital role in the exposure to organic contaminants and exposure risk from activities related to oil platforms, runoff from land, atmospheric deposition, and resuspension of contaminated sources in GoM waters. These species continue to be exposed to compounds that have genotoxic, carcinogenic, and endocrine-disrupting effects, although concentrations found in this study are generally well below safety guidelines.

Accumulation was observed for all tissue types and compound groups with varying concentrations, which could be attributed to metabolic abilities or behavior of each species. The BMFs between tuna and their prey (squid) showed biomagnification of specific analytes in each compound group with the highest in PCBs. Overall, tunas can metabolize or excrete most of these, but are still accumulating contaminants in more long-term storage tissues such as the liver and muscle (Van Der Oost, et al., 2003; Abdel-Shafy and Mansour, 2016).

Future research could include the analysis and comparison of males from both Blackfin Tuna and Yellowfin Tuna to observe any differences between the sexes and other prey items from the stomach contents (e.g., fish, crustaceans, etc.) to show the full extent of organic contaminant exposure from their diet. Squid analysis may include individual assessments of the mantle or edible parts, digestive glands, and gills of the prey item, as well as homogenized samples of the whole animal to observe this species' ability to eliminate organic contaminants. Future sampling efforts during spawning season would be beneficial to collect gravid females to test maternal transfer. Sampling and analysis of basal resources and water samples throughout the water column where predators are captured could provide a bottom-up view of the trophic transfer of contaminants.

Blackfin Tuna are an important recreational fishery with landings higher than Yellowfin Tuna in some years, yet contamination information was unavailable. This study found some significant differences between tuna species for PAHs and OCPs. Blackfin Tuna may either have a higher exposure risk to these contaminants through their environment or diet, or a lesser ability to

process contaminants than Yellowfin Tuna. This study is an important addition to existing data for Yellowfin Tuna and the Common Clubhook Squid in the GoM and may also provide baseline data for Blackfin Tuna.

Tables

Table 4.1: Comparable study concentrations of Yellowfin Tuna and similar squid from around the world. Reported concentration units were standardized to ng/g, weights (ww, dw, lw) were left as is and compared directly to this study.

Species	Sample/ Publish Date	Location	Compounds	Sample Type	Mean Concentration	Units	Reference
PAHs							
Tuna							
Blackfin Tuna	2020	Northwest GoM	46 PAHs	muscle liver	42.32 ± 9.60 291.11 ± 135.12	ng/g, ww ng/g, ww	This study
Yellowfin Tuna	2020	Northwest GoM	46 PAHs	muscle liver	49.98 ± 22.34 73.69 ± 20.17	ng/g, ww ng/g, ww	This study
Yellowfin Tuna	2020	Northwest GoM	43 PAHs	liver	56.1	ng/g, ww	(Schwaab, 2020)
		North Central GoM	43 PAHs	liver	108	ng/g, ww	
Yellowfin Tuna	Pub. 2019	Indian Ocean	24 PAHs	muscle	784.1	ng/g, lw	(Wickrama-Arachchige, et al., 2020)
Canned tuna	Pub. 2017	Serbia	16 PAHs	muscle	17.67	ng/g, ww	(Novakov, et al., 2017)
Combined mixed species fish sample	2011-2012	Gulf of Mexico	18 PAHs	liver & muscle	< 35	ng/g, ww	(Murawski, et al., 2014)
Squid							
O. banksii	2020	Northwest GoM tuna stomach contents	46 PAHs	mantle	331.60 ± 70.74	ng/g, ww	This study
O. banksii	2015-2016	N-GoM	Total PAHs	mantle	700 ± 400	ng/g, lw	(Romero, et al., 2020)
Loligo duvaucelii, Loligo vulgaris	2010-2011	Indic Ocean markets in NW region of Portugal	18 PAHs	edible parts	9.16 (0.28-18.6), 45.4 (3.05-49.7)	ng/g, ww	(Gomes, et al., 2013)
Loligo reynaudii, Loligo gahi	2010-2011	Atlantic Ocean markets in NW region of Portugal	18 PAHs	edible parts	58.6 (0.24-60.9), 26.9 (0.22-3.11)	ng/g, ww	(Gomes, et al., 2013)
Loligo opalescens	2010-2011	Pacific Ocean markets in NW region of Portugal	18 PAHs	edible parts	15.1 (2.81-43.5)	ng/g, ww	(Gomes, et al., 2013)
O. banksii	2010	N-GoM	Total PAHs	mantle	1,800 ± 600	ng/g, lw	(Romero, et al., 2020)
Todarodes pacificus	2005-2007	South Korea Fish Market	16 PAHs	muscle (skinless)	51.7 ± 27.5	ng/g, dw	(Moon et al., 2010)
Loligo vulgaris	2005	Supermarket - Spain	16 PAHs	mantle	3.0	ng/g, dw	(Llobet, et al., 2006)
Todarodes sagittatus	2004	Summer in the Gulf of Naples	ΣPAHs	mantle	16.39 ± 0.71	ng/g, ww	(Perugini, et al., 2007)
Todarodes sagittatus	2004	Winter in the Gulf of Naples	ΣPAHs	mantle	71.23 ± 10.30	ng/g, ww	(Perugini, et al., 2007)

Table 4.1: (Continued)

PCBs							
Tuna							
Blackfin Tuna	2020	Northwest GoM	32 PCBs	muscle	7.03 ± 10.04	ng/g, ww	This study
				liver	30.33 ± 13.72	ng/g, ww	
Yellowfin Tuna	2020	Northwest GoM	32 PCBs	muscle	8.17 ± 6.80	ng/g, ww	This study
				liver	28.38 ± 17.82	ng/g, ww	
Yellowfin Tuna	Pub. 2017	N Pacific Ocean	209 PCBs	Muscle	3.40 ± 2.98	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	NE Pacific Ocean	209 PCBs	muscle	3.38 ± 2.65	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	GoM	209 PCBs	muscle	8.08 ± 5.08	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	SE Pacific Ocean	209 PCBs	muscle	0.55 ± 0.33	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	NW Atlantic	209 PCBs	muscle	3.82 ± 1.28	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	NE Atlantic	209 PCBs	muscle	6.52 ± 2.47	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	Indian Ocean	209 PCBs	muscle	0.23 ± 0.10	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	S China Sea	209 PCBs	muscle	0.69 ± 0.41	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	N China Sea	209 PCBs	muscle	1.25 ± 0.90	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	NW Pacific Ocean	209 PCBs	muscle	0.12 ± 0.04	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	SW Pacific Ocean	209 PCBs	muscle	0.22 ± 0.11	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	2013-2014	W Indian Ocean	34 PCBs	muscle	0.035 ± 0.029 (0.0058-0.119)	ng/g, ww	(Munschy et al., 2020)
Yellowfin Tuna	2010	Western Indian Ocean	7 PCBs	muscle	63.4 x 29.9	ng/g, lw	(Bodin et al., 2014)
Yellowfin Tuna	2009	Atlantic Ocean St. Peter and St. Paul archipelago	27 PCBs	muscle	518.23 (116.14-2556.1)	ng/g, lw	(Pizzochero et al., 2011)
Yellowfin Tuna	2007	W Indian Ocean	28 PCBs, 7 PCBs	muscle	43.8-381.7, 21.6-226.7	ng/g, lw	(Torres, et al., 2009)
Yellowfin Tuna	2007	W Indian Ocean	28 PCBs, 7 PCBs	liver	51.6-621.2, 32.3-440.6	ng/g, lw	(Torres, et al., 2009)
Yellowfin Tuna	2005-2007	Japan (Shizuoka)	13 PCBs	muscle	280 ± 160	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	Japan (Wakayama)	13 PCBs	muscle	230 ± 140	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	Japan (Ogasawara Islands)	13 PCBs	muscle	550 ± 260	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	Japan (Okinawa)	13 PCBs	muscle	210 ± 60	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	Sri Lanka & Maldives	13 PCBs	muscle	330 ± 420	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	Australia	13 PCBs	muscle	2890 ± 3620	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	New Zealand	13 PCBs	muscle	5250 ± 3380	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	USA (Honolulu)	13 PCBs	muscle	80 ± 70	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	USA (San Francisco)	13 PCBs	muscle	N.D	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	Sum (n = 117)	13 PCBs	muscle	850 ± 1980	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2003-2007	Japan	13 PCBs	muscle	0.31 ± 0.43 (0.03-7.29)	ng/g, ww	(Hisamichi et al., 2010)

Table 4.1: (Continued)

Squid							
O. banksii	2020	Northwest GoM tuna stomach contents	32 PCBs	mantle	6.85 ± 1.99	ng/g, ww	This study
Loligo reynaudii Chokka squid	2017	South Africa (3 locations)	4 PCBs	mantle	9.2, 8.6, 4.8	ng/g, lw	(Wu, et al., 2019)
Todarodes pacificus Japanese common squid	2006	Korea. East Sea, Yellow Sea	21 PCBs	mantle	76 (59–91), 131 (70–275)	ng/g, lw	(Won, et al., 2009)
Loligo pealei long-finned squid	2006	Narragansett Bay, RI	29 PCBs	whole animal	26 (0.08 - 15)	ng/g, dw	(Morgan and Lohmann, 2010)
Illex coindetii broadtail squid	2005	Adriatic Sea, Italy	17 PCBs	hepatopancreas	721.4 (338.0–1,287.0)	ng/g, lw	(Storelli et al., 2006)
Todarodes pacificus Japanese common squid	2005	Southeast Korea small July, large M July, large F July, large M October, large F October	22 PCBs	mantle	8.85, 11.0, 6.79, 4.83, 5.41	ng/g, dw	(Won, et al., 2010)
Todarodes sagittatus European flying squid	2003-2004	Tyrrhenian Sea, Italy	7 PCBs	edible parts	15.45 ± 8.36 (1.54 –29.79)	ng/g, ww	(Ferrante et al., 2007)
Loligo opalescens California market squid	2003-2004	Southern California coast (4 stations)	41 PCB s	whole animal	40, 100, 10	ng/g, ww	(Jarvis et al., 2007)
Todarodes sagittatus European flying squid	2002	Giulianova (Giu) and Pescara (Pe) - Central Adriatic Sea, Italy	7 PCBs (28, 52, 101, 118, 138, 153 and 180)	edible parts	3.08, 1.69	ng/g, ww	(Perugini M. et al., 2004)
Long-finned squid	1995	Menemsha, MA and Nantucket Sound USA	25 PCBs	whole animal	24.5, 22.5	ng/g, ww	(Weisbrod et al., 2001)
Gonatopsis borealis eight-armed squid	Pub. 1986	N Pacific and Bering Sea	PCBs	whole animal	200 (110-270)	ng/g, lw	(Kawano et al., 1986)
Todarodes pacificus	1979	Taiji, Japan	Sum PCBs	whole animal	68 (35-95)	ng/g, ww	(Tanabe et al., 1984)
OPCs							
Tuna							
Blackfin Tuna	2020	Northwest GoM	36 OCPs	muscle liver	3.54 ± 2.09 197.39 ± 152.57	ng/g, ww ng/g, ww	This study
Yellowfin Tuna	2020	Northwest GoM	36 OCPs	muscle liver	3.13 ± 1.44 32.97 ± 13.90	ng/g, ww ng/g, ww	This study
Yellowfin Tuna	Pub. 2017	N Pacific Ocean	29 OCPs	muscle	3.40 ± 3.65	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	NE Pacific Ocean	29 OCPs	muscle	7.86 ± 3.50	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	GoM	29 OCPs	muscle	1.62 ± 1.17	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	SE Pacific Ocean	29 OCPs	muscle	0.49 ± 0.47	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	NW Atlantic	29 OCPs	muscle	1.06 ± 0.28	ng/g, ww	(Nicklisch, et al., 2017)

Table 4.1: (Continued)

Yellowfin Tuna	Pub. 2017	NE Atlantic	29 OCPs	muscle	8.23 ± 3.35	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	SE Atlantic	29 OCPs	muscle	3.22 ± 1.35	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	Indian Ocean	29 OCPs	muscle	0.43 ± 0.18	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	S China Sea	29 OCPs	muscle	0.93 ± 0.58	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	N China Sea	29 OCPs	muscle	1.42 ± 1.38	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	NW Pacific Ocean	29 OCPs	muscle	0.20 ± 0.11	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	Pub. 2017	SW Pacific Ocean	29 OCPs	muscle	0.27 ± 0.12	ng/g, ww	(Nicklisch, et al., 2017)
Yellowfin Tuna	2017	South China Sea	7 DDTs	muscle	0.46 (0.43–0.51)	ng/g, ww	(Sun, et al., 2020)
Yellowfin Tuna	2013-2014	W Indian Ocean	5 DDTs (p,p'-DDT, o,p'-DDT, o,p'-DDD, p,p'-DDD, p,p'-DDE	muscle	0.120 ± 0.099 (0.020-0.445)	ng/g, ww	(Munschy, et al., 2020)
Yellowfin Tuna	2010	Western Indian Ocean	4 DDTs	muscle	24.8 ± 10.9	ng/g, lw	(Bodin, et al., 2014)
Yellowfin Tuna	2009	Atlantic Ocean St. Peter and St. Paul archipelago	DDT (p, p'–DDT, o, p'–DDT, p,p'–DDD, o, p'–DDD p, p'–DDE e o, p'–DDE	muscle	77.52 (15.77-178.7)	ng/g, lw	(Pizzochero, et al., 2011)
Yellowfin Tuna	2007	W Indian Ocean	pp'-DDE, *pp′*-DDD, *pp′*-DDT, *op′*-DDD	muscle	4.4-28.0	ng/g, lw	(Torres, et al., 2009)
Yellowfin Tuna	2007	W Indian Ocean	pp'-DDE, *pp′*-DDD, *pp′*-DDT, *op′*-DDD	liver	6.6-62.7	ng/g, lw	(Torres, et al., 2009)
Yellowfin Tuna	2007	W Indian Ocean	28 OCPs (including DDTs)	muscle	82.3-601.5	ng/g, lw	(Torres, et al., 2009)
Yellowfin Tuna	2007	W Indian Ocean	28 OCPs (including DDTs)	liver	17.6-82.3	ng/g, lw	(Torres, et al., 2009)
Yellowfin Tuna	2005-2007	Japan (Shizuoka)	p,p' -DDE	muscle	200 ± 110	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	Japan (Wakayama)	p,p' -DDE	muscle	170 ± 110	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	Japan (Ogasawara Islands)	p,p' -DDE	muscle	360 ± 190	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	Japan (Okinawa)	p,p' -DDE	muscle	220 ± 80	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	Sri Lanka & Maldives	p,p' -DDE	muscle	60 ± 100	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	Australia	p,p' -DDE	muscle	180 ± 210	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	New Zealand	p,p' -DDE	muscle	540 ± 540	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	USA (Honolulu)	p,p' -DDE	muscle	30 ± 70	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	USA (San Francisco)	p,p' -DDE	muscle	ND	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2005-2007	Total (n = 117)	p,p' -DDE	muscle	200 ± 200	ng/g, lw	(Endo, et al., 2016)
Yellowfin Tuna	2003-2007	Japan	p,p' -DDE	muscle	0.24 ± 0.26	ng/g, ww	(Hisamichi, et al., 2010)
Squid							
O. banksii	2020	Northwest GoM tuna stomach contents	36 OCPs	Mantle	213.18 ± 68.17	ng/g, ww	This study
Sthenoteuthis oualaniensis	2017	South China Sea	7 DDTs	mantle	0.84 (0.75-0.92)	ng/g, ww	(Sun, et al., 2020)

Table 4.1: (Continued)

Todarodes sagittatus European flying squid	2003-2004	S Tyrrhenian Sea, Italy	p,p-DDT, p,p-DDE, and p,p-DDD	edible parts	1.29 ± 1.41 (ND– 4.65)	ng/g, ww	(Ferrante, et al., 2007)
Todarodes pacificus Japanese common squid	2006	East Sea, Yellow Sea	DDTs: sum of o,p'-DDT, o,p'-DDD, o,p'-DDE, p,p'-DDT, p,p'-DDD, and p,p'-DDE	mantle	61 (52-86), 326 (118-698)	ng/g, lw	(Won, et al., 2009)
Illex coindetii (broadtail squid)	2005	Adriatic Sea, Italy	DDTs = p,p 0 -DDT, p,p0-DDE, o,p0-DDT, p,p0-DDD, o,p0-DDD	liver	573.1 (305.0–1017.0)	ng/g, lw	(Storelli, et al., 2006)
Todarodes pacificus Japanese common squid	2005	Southeast Korea small July, large M July, large F July, large M October, large F October	DDTs: sum of o,p0-DDT, o,p0-DDD, o,p0-DDE, p,p0-DDT, p,p0-DDD, and p,p0-DDE	mantle	8.86, 10.7, 7.20, 5.40, 6.37	ng/g, dw	(Won, et al., 2010)
Todarodes pacificus Japanese common squid	2005	Southeast Korea small July, large M July, large F July, large M October, large F October	CHLs: sum of a-chlordane, c-chlordane, cis-nonachlor, trans-nonachlor, oxychlordane	mantle	0.64, 0.96, 1.12, 1.14, 0.92	ng/g, dw	(Won, et al., 2010)
Long-finned squid	1995	Menemsha, MA and Nantucket Sound USA	18 OCPs including DDT	whole animal	0.63, 0.62	ng/g, ww	(Weisbrod, et al., 2001)
Todarodes sagittatus European flying squid	2003-2004	Tyrrhenian Sea, Italy	p,p-DDT, *p,p*-DDE, and *p,p*-DDD	edible parts	1.29 ± 1.41 (ND– 4.65)	ng/g, ww	(Ferrante, et al., 2007)
Totarodes sagitattus European flying squid	2002	Giulianova (Giu) and Pescara (Pe) - Central Adriatic Sea, Italy	p,p0 -DDE, p,p0 -DDD, p,p0 -DDT and o,p0 -DDT	edible parts	1.41, 0.78	ng/g, ww	(Perugini M., et al., 2004)
Loligo opalescens California market squid	2003-2004	Southern California coast	Total DDT *ortho-* and *para-*isomers of DDT, DDE, DDD	whole animal	0.7, 1.7, 0.3	ng/g, ww	(Jarvis, et al., 2007)
Todarodes pacificus	1979	Taiji, Japan	DDT (p,p'-DDT, p,p'-DDD, and *p,p'-DDE)*	whole animal	22 (16-28)	ng/g, ww	(Tanabe, et al., 1984)
Gonatopsis borealis Eight-armed squid	Pub. 1986	N Pacific & Bering Sea	DDTs (p,p'DDE, *p,p'*- DDD and *p,p'-DDT)*	whole animal	89 (77-97)	ng/g, lw	(Kawano, et al., 1986)
Emerging Contaminants of Concern							
Tuna							
Blackfin Tuna	2020	Northwest GoM	DMP, DEP, BBP, DEHP, DnOP, DBP, CH, TH, OB, OC, AVO	muscle liver	124.64 ± 82.68 2,593.00 ± 1,425.70	ng/g, ww ng/g, ww	This study
Yellowfin Tuna	2020	Northwest GoM	DMP, DEP, BBP, DEHP, DnOP, DBP, CH, TH, OB, OC, AVO	muscle liver	59.12 ± 36.17 2,894.13 ± 1,945.45	ng/g, ww ng/g, ww	This study

Table 4.1: (Continued)

Tuna	2017-2019	Montreal Canada	DBP, DEP, DEHP, DINP, DINCH	canned tuna in oil	3.76 ±4.55, 19.8 ± 39.5, 10.3 ± 11.8, 29.8 ± 13.5, 8.45 ± 9.74	ng/g, ww	(Tian et al., 2022)
Tuna	2017-2019	Montreal Canada	DBP, DEP, DEHA, DEHP, DINP, DIDA	canned tuna in water	3.62 ± 2.72, 6.82 ± 13.5, 2.49 ± 3.49, 4.57 ± 3.31, 10.6 ± 2.61, 0.55 ± 0.93	ng/g, ww	(Tian, et al., 2022)
Tuna	2017-2019	South Africa	BPA, DEP, DINP, DIDA	canned tuna in oil	14.8 ± 20.6, 63.5 ± 89.8, 13.2 ± 0.60, 0.79 ±1.01	ng/g, ww	(Tian, et al., 2022)
Tuna	2017-2019	South Africa	BPA, DBP, DEP DEHP, DINP	canned tuna in water	11.7 ± 2.7, 1.16 ± 1.56, 28.0 ± 39.4, 2.14 ± 1.59, 10.6 ± 3.05	ng/g, ww	(Tian, et al., 2022)
Squid							
O. banksii	2020	Northwest GoM tuna stomach contents	DMP, DEP, BBP, DEHP, DnOP, DBP, CH, TH, OB, OC, AVO	mantle	3,216.83 ± 2,596.50	ng/g, ww	This study
Loligo vulgaris, Ommastrephes caroli, Sthenoteuthis pteropus	2019-2020	NE Atlantic local market in Funchal, Madeira Island	7 PAEs: DMP, DEP, DiBP, DBP, BBP, DEHP, DNOP	mantle	20.69 ± 19.35, 30.86 ± 8.95, 16.61 ±12.2	ng/g, ww	(Sambolino, et al., 2023)

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APPENDIX A: SUPPLEMENTARY TABLES AND FIGURES

Table A.1: Biometrics of Blackfin Tuna. Data includes sex, standard length (SL), fork length (FL), and total length (TL) in cm, total body weight, liver weight, gastrointestinal tract (GI) weight, and gonad weight in kg (next to Fish ID denotes tunas used in this study). Missing data: Fish ID Nansen 4 missing tail, Nansen 22 head only, Nansen 25 no samples taken, Perdido 23& 24 length not recorded.*

Station	Fish ID	Species	Sex	SL	FL	TL	Total Body Wt. (kg)	Liver Wt. (kg)	GI Wt. (kg)	Gonad Wt. (kg)
Hoover	1	Blackfin Tuna	F	52.4	57	65	3.000	0.034	0.124	0.006
Hoover	2	Blackfin Tuna	M	51	56	64	3.000	0.028	0.132	0.008
Nansen	3*	Blackfin Tuna	F	65	71	78	6.300	0.040	0.234	0.054
Nansen	4	Blackfin Tuna	F	-	-	-	4.000	0.060	0.350	0.034
Nansen	5	Blackfin Tuna	F	54	59	67	6.500	0.032	0.160	0.030
Nansen	6	Blackfin Tuna	F	45	48	53	3.900	0.012	0.068	0.004
Nansen	7*	Blackfin Tuna	F	62	66	71	5.800	0.052	0.344	0.034
Nansen	8*	Blackfin Tuna	F	59	62	67	3.500	0.030	0.186	0.028
Nansen	9*	Blackfin Tuna	F	56	58	61	5.200	0.034	0.174	0.006
Nansen	10*	Blackfin Tuna	F	55	59	66.5	9.000	0.022	0.162	0.004
Nansen	11	Blackfin Tuna	M	53	57	62	3.600	0.030	0.132	0.004
Nansen	12*	Blackfin Tuna	F	55.5	58.5	65	3.800	0.026	0.134	0.020
Nansen	13*	Blackfin Tuna	F	56	58.5	61	5.200	0.032	0.130	0.004
Nansen	14*	Blackfin Tuna	F	55	58	63	5.500	0.020	0.146	0.006
Nansen	15	Blackfin Tuna	M	57	60	65	6.000	0.042	0.154	0.008
Nansen	16*	Blackfin Tuna	F	59	62	69	5.000	0.030	0.138	0.004
Nansen	17	Blackfin Tuna	F	59	62	67	5.200	0.050	0.144	0.028
Nansen	18	Blackfin Tuna	F	55	59	65	7.200	0.032	0.148	0.022
Nansen	19*	Blackfin Tuna	F	55	57.5	63	7.000	0.040	0.136	0.006
Nansen	20	Blackfin Tuna	M	56	59	63	3.500	0.036	0.126	0.004
Nansen	21	Blackfin Tuna	M	53	56	62	7.500	0.026	0.132	0.006
Nansen	22	Blackfin Tuna	-	-	-	-	-	-	-	-
Nansen	23*	Blackfin Tuna	F	54	57	62	3.000	0.016	0.124	0.004
Nansen	24*	Blackfin Tuna	F	50	53	58	6.500	0.032	0.108	0.016
Nansen	25	Blackfin Tuna	-	54	55.5	60	3.000	-	-	-
Perdido	23	Blackfin Tuna	F	-	-	-	3.750	0.030	0.142	0.020
Perdido	24	Blackfin Tuna	M	-	-	-	4.250	0.048	0.182	0.008
Perdido	26	Blackfin Tuna	M	53	56	61	3.000	0.034	0.146	0.006
Perdido	27*	Blackfin Tuna	F	59	61	64	3.750	0.038	0.202	0.028
Perdido	28*	Blackfin Tuna	F	83	90	106	12.800	0.082	0.372	0.024
Perdido	43*	Blackfin Tuna	F	55	58	64	7.500	0.028	0.198	0.022
Perdido	46	Blackfin Tuna	M	54	55.5	61	7.700	0.032	0.154	0.004

Table A.2: Biometrics of Yellowfin Tuna. Data includes sex, standard length (SL), fork length (FL), and total length (TL) in cm, total body weight, liver weight, gastrointestinal tract (GI) weight, and gonad weight in kg (denotes tuna used in this study). Missing data: Perdido 18 & 19 head only.*

Station	Fish ID	Species	Sex	SL	FL	TL	Total Body Wt. (kg)	Liver Wt. (kg)	GI Wt. (kg)	Gonad Wt. (kg)
Nansen	1	Yellowfin Tuna	M	83	85.5	96	9.250	0.071	0.280	0.004
Nansen	2	Yellowfin Tuna	M	116	123	136	28.900	0.093	0.738	0.016
Perdido	1	Yellowfin Tuna	M	78	81	91	9.300	0.073	0.314	0.020
Perdido	2	Yellowfin Tuna	M	79	86.5	102	11.600	0.078	0.336	0.004
Perdido	3	Yellowfin Tuna	M	88	95	114	14.800	0.103	0.476	0.006
Perdido	4*	Yellowfin Tuna	I	79	86	101	11.200	0.074	0.396	0.004
Perdido	5	Yellowfin Tuna	M	109	118	142	29.400	0.161	0.826	0.014
Perdido	6	Yellowfin Tuna	M	84	91	107	12.000	0.078	0.394	0.004
Perdido	7	Yellowfin Tuna	F	80	87	103	11.500	0.078	0.356	0.032
Perdido	8	Yellowfin Tuna	M	79	86.5	101.5	10.800	0.070	0.340	0.004
Perdido	9	Yellowfin Tuna	M	79	86	100	10.600	0.067	0.320	0.004
Perdido	10	Yellowfin Tuna	M	80	87	102	10.900	0.074	0.320	0.004
Perdido	11	Yellowfin Tuna	M	79	86	101	10.800	0.071	0.304	0.002
Perdido	12	Yellowfin Tuna	M	77	84	100	10.300	0.065	0.340	0.004
Perdido	13*	Yellowfin Tuna	F	73.5	80	95.5	8.600	0.059	0.298	0.016
Perdido	14	Yellowfin Tuna	F	78	85	101	10.500	0.064	0.292	0.016
Perdido	15	Yellowfin Tuna	M	78	85	100	10.900	0.079	0.336	0.002
Perdido	16	Yellowfin Tuna	M	80	86	95	10.200	0.062	0.274	0.002
Perdido	18	Yellowfin Tuna	-	-	-	-	-	-	-	-
Perdido	19	Yellowfin Tuna	-	-	-	-	-	-	-	-
Perdido	20*	Yellowfin Tuna	F	75	81	98	9.300	0.067	0.280	0.018
Perdido	21	Yellowfin Tuna	M	110	118	129	29.000	0.199	0.832	0.024
Perdido	22	Yellowfin Tuna	F	112	116.5	131	25.600	0.181	0.800	0.080
Perdido	25	Yellowfin Tuna	F	80	87	101	11.100	0.068	0.362	0.018
Perdido	29*	Yellowfin Tuna	F	77.5	83.5	98	9.800	0.057	0.338	0.012
Perdido	30*	Yellowfin Tuna	F	105	115	135	26.800	0.153	0.850	0.080
Perdido	31	Yellowfin Tuna	M	77	83	98.5	10.000	0.078	0.366	0.004
Perdido	32	Yellowfin Tuna	M	82	88.5	104.5	11.600	0.079	0.397	0.002
Perdido	33*	Yellowfin Tuna	F	86	93	104	13.400	0.089	0.418	0.026
Perdido	34	Yellowfin Tuna	M	79	84	100	11.100	0.080	0.396	0.014
Perdido	35	Yellowfin Tuna	F	80	86	104	11.200	0.096	0.352	0.012
Perdido	36	Yellowfin Tuna	M	85	92	108	13.100	0.074	0.446	0.006
Perdido	37	Yellowfin Tuna	M	77	84	97	8.900	0.063	0.344	0.002
Perdido	38	Yellowfin Tuna	M	79	86	100	11.700	0.073	0.406	0.002
Perdido	39*	Yellowfin Tuna	F	76.5	83.5	94.5	11.500	0.079	0.432	0.032
Perdido	40	Yellowfin Tuna	F	109	118	144	27.000	0.150	0.780	0.100
Perdido	41*	Yellowfin Tuna	F	75.2	83	99	9.800	0.065	0.492	0.014
Perdido	42*	Yellowfin Tuna	F	78	81.5	91	8.200	0.056	0.320	0.006
Perdido	44	Yellowfin Tuna	M	93	97	109	16.300	0.075	0.546	0.006
Perdido	45*	Yellowfin Tuna	F	87	92	104	13.200	0.054	0.430	0.022
Perdido	48	Yellowfin Tuna	M	87	90	102	11.700	0.066	0.426	0.004

Table A.3: Total cephalopods from the stomach contents of Blackfin Tuna and Yellowfin Tuna. Data are listed by species (squid beak = individual upper and lower beaks were totaled and divided by two).*

Species	Totals
Ommastrephes bartramii	1
Ommastrephidae	1
Onychoteuthis banksii	52
Onychoteuthis spp.	1
Ornithoteuthis antillarum	7
squid beak*	110
unidentified squid	43

*Table A.4: Individual cephalopod prey items from stomach contents of Blackfin Tuna and Yellowfin Tuna. Squid used in this study are noted with * next to Prey Item Number.*

Station	Predator ID	Predator Name	Prey Item Number	Prey Name	Mantle Length (ML)	Prey Weight (g)
Nansen	1	Yellowfin Tuna	2	unidentified squid	39	0.7
Nansen	2	Yellowfin Tuna	4	squid beak		
Nansen	2	Yellowfin Tuna	5	squid beak		
Nansen	2	Yellowfin Tuna	6	squid beak		
Nansen	2	Yellowfin Tuna	7	squid beak		
Nansen	2	Yellowfin Tuna	8	squid beak		
Nansen	2	Yellowfin Tuna	9	squid beak		
Nansen	2	Yellowfin Tuna	10	squid beak		
Nansen	2	Yellowfin Tuna	11	squid beak		
Nansen	2	Yellowfin Tuna	12	squid beak		
Nansen	3	Blackfin Tuna	3	unidentified squid	40	0.98
Nansen	4	Blackfin Tuna	11	*Onychoteuthis banksii*	40	1.7
Nansen	5	Blackfin Tuna	7	squid beak		
Nansen	5	Blackfin Tuna	8	squid beak		
Nansen	5	Blackfin Tuna	9	squid beak		
Nansen	5	Blackfin Tuna	10	squid beak		
Nansen	5	Blackfin Tuna	11	squid beak		
Nansen	5	Blackfin Tuna	12	squid beak		
Nansen	7	Blackfin Tuna	15*	*Onychoteuthis banksii*	36.5	1.8
Nansen	7	Blackfin Tuna	16*	*Onychoteuthis banksii*	43	1.5
Nansen	9	Blackfin Tuna	5*	*Onychoteuthis banksii*	32	1.4
Nansen	9	Blackfin Tuna	6	unidentified squid	19	0.1
Nansen	9	Blackfin Tuna	7	unidentified squid		0.5
Nansen	9	Blackfin Tuna	8	squid beak		
Nansen	11	Blackfin Tuna	1	squid beak	0	
Nansen	14	Blackfin Tuna	2	squid beak		
Nansen	14	Blackfin Tuna	3	squid beak		
Nansen	14	Blackfin Tuna	4	squid beak		
Nansen	14	Blackfin Tuna	5	squid beak		
Nansen	14	Blackfin Tuna	6	squid beak		
Nansen	14	Blackfin Tuna	7	squid beak		
Nansen	14	Blackfin Tuna	8	squid beak		
Nansen	14	Blackfin Tuna	9	squid beak		
Nansen	15	Blackfin Tuna	1	unidentified squid		
Nansen	15	Blackfin Tuna	4	squid beak		
Nansen	15	Blackfin Tuna	5	squid beak		
Nansen	16	Blackfin Tuna	8	unidentified squid	23	0.3
Nansen	16	Blackfin Tuna	9	squid beak		
Nansen	16	Blackfin Tuna	10	squid beak		
Nansen	16	Blackfin Tuna	11	squid beak		
Nansen	16	Blackfin Tuna	12	squid beak		
Nansen	16	Blackfin Tuna	13	squid beak		
Nansen	16	Blackfin Tuna	14	squid beak		
Nansen	16	Blackfin Tuna	15	squid beak		
Nansen	16	Blackfin Tuna	16	squid beak		
Nansen	16	Blackfin Tuna	17	squid beak		
Nansen	16	Blackfin Tuna	18	squid beak		
Nansen	16	Blackfin Tuna	19	squid beak		
Nansen	16	Blackfin Tuna	20	squid beak		
Nansen	16	Blackfin Tuna	21	squid beak		
Nansen	17	Blackfin Tuna	1	squid beak		
Nansen	18	Blackfin Tuna	1	squid beak		
Nansen	19	Blackfin Tuna	2	*Onychoteuthis banksii*	25	0.01
Nansen	19	Blackfin Tuna	3	squid beak		
Nansen	19	Blackfin Tuna	4	squid beak		
Nansen	19	Blackfin Tuna	5	squid beak		
Nansen	19	Blackfin Tuna	6	squid beak		
Nansen	19	Blackfin Tuna	7	squid beak		
Nansen	19	Blackfin Tuna	8	squid beak		
Nansen	19	Blackfin Tuna	9	squid beak		
Nansen	19	Blackfin Tuna	10	squid beak		
Nansen	19	Blackfin Tuna	11	squid beak		
Nansen	19	Blackfin Tuna	12	squid beak		
Nansen	19	Blackfin Tuna	13	squid beak		
Nansen	19	Blackfin Tuna	14	squid beak		

Table A.4: (Continued)

Nansen	19	Blackfin Tuna	15	squid beak		
Nansen	19	Blackfin Tuna	16	squid beak		
Nansen	19	Blackfin Tuna	17	squid beak		
Nansen	19	Blackfin Tuna	18	squid beak		
Nansen	19	Blackfin Tuna	19	squid beak		
Perdido	2	Yellowfin Tuna	1	squid beak		
Perdido	2	Yellowfin Tuna	2	squid beak		
Perdido	2	Yellowfin Tuna	3	squid beak		
Perdido	2	Yellowfin Tuna	4	squid beak		
Perdido	2	Yellowfin Tuna	5	squid beak		
Perdido	2	Yellowfin Tuna	6	squid beak		
Perdido	3	Yellowfin Tuna	1	squid beak		0
Perdido	3	Yellowfin Tuna	2	squid beak		
Perdido	3	Yellowfin Tuna	3	squid beak		
Perdido	3	Yellowfin Tuna	4	squid beak		
Perdido	3	Yellowfin Tuna	5	squid beak		
Perdido	3	Yellowfin Tuna	6	squid beak		
Perdido	3	Yellowfin Tuna	7	squid beak		
Perdido	3	Yellowfin Tuna	8	squid beak		
Perdido	3	Yellowfin Tuna	9	squid beak		
Perdido	3	Yellowfin Tuna	10	squid beak		
Perdido	3	Yellowfin Tuna	11	squid beak		
Perdido	4	Yellowfin Tuna	2	unidentified squid		0.16
Perdido	5	Yellowfin Tuna	3	squid beak		
Perdido	5	Yellowfin Tuna	4	squid beak		
Perdido	5	Yellowfin Tuna	5	squid beak		
Perdido	5	Yellowfin Tuna	6	squid beak		
Perdido	5	Yellowfin Tuna	7	squid beak		
Perdido	5	Yellowfin Tuna	8	squid beak		
Perdido	5	Yellowfin Tuna	9	squid beak		
Perdido	5	Yellowfin Tuna	10	squid beak		
Perdido	5	Yellowfin Tuna	11	squid beak		
Perdido	5	Yellowfin Tuna	12	squid beak		
Perdido	5	Yellowfin Tuna	13	squid beak		
Perdido	5	Yellowfin Tuna	14	squid beak		
Perdido	5	Yellowfin Tuna	15	squid beak		
Perdido	5	Yellowfin Tuna	16	squid beak		
Perdido	5	Yellowfin Tuna	17	squid beak		
Perdido	5	Yellowfin Tuna	18	squid beak		
Perdido	5	Yellowfin Tuna	19	squid beak		
Perdido	5	Yellowfin Tuna	20	squid beak		
Perdido	5	Yellowfin Tuna	21	squid beak		
Perdido	5	Yellowfin Tuna	22	squid beak		
Perdido	5	Yellowfin Tuna	23	squid beak		
Perdido	5	Yellowfin Tuna	24	squid beak		
Perdido	5	Yellowfin Tuna	25	squid beak		
Perdido	5	Yellowfin Tuna	26	squid beak		
Perdido	5	Yellowfin Tuna	27	squid beak		
Perdido	5	Yellowfin Tuna	28	squid beak		
Perdido	5	Yellowfin Tuna	29	squid beak		
Perdido	5	Yellowfin Tuna	30	squid beak		
Perdido	5	Yellowfin Tuna	31	squid beak		
Perdido	5	Yellowfin Tuna	32	squid beak		
Perdido	5	Yellowfin Tuna	33	squid beak		
Perdido	5	Yellowfin Tuna	34	squid beak		
Perdido	5	Yellowfin Tuna	35	squid beak		
Perdido	5	Yellowfin Tuna	36	squid beak		
Perdido	5	Yellowfin Tuna	37	squid beak		
Perdido	5	Yellowfin Tuna	38	squid beak		
Perdido	5	Yellowfin Tuna	39	squid beak		
Perdido	5	Yellowfin Tuna	40	squid beak		
Perdido	5	Yellowfin Tuna	41	squid beak		
Perdido	5	Yellowfin Tuna	42	squid beak		
Perdido	6	Yellowfin Tuna	3	*Ornithoteuthis antillarum*	56	3.4
Perdido	7	Yellowfin Tuna	6	*Ornithoteuthis antillarum*	18	0.8
Perdido	7	Yellowfin Tuna	7	*Ornithoteuthis antillarum*	17	0.7
Perdido	7	Yellowfin Tuna	8	squid beak		
Perdido	7	Yellowfin Tuna	9	squid beak		

Table A.4: (Continued)

Perdido	7	Yellowfin Tuna	10	squid beak		
Perdido	13	Yellowfin Tuna	1	unidentified squid	9	0.1
Perdido	13	Yellowfin Tuna	2	squid beak		
Perdido	13	Yellowfin Tuna	3	squid beak		
Perdido	15	Yellowfin Tuna	1	squid beak		0
Perdido	20	Yellowfin Tuna	1	*Onychoteuthis banksii*	38	9.6
Perdido	20	Yellowfin Tuna	2	*Onychoteuthis banksii*		4.8
Perdido	20	Yellowfin Tuna	3	*Ommastrephidae*	32	5.6
Perdido	21	Yellowfin Tuna	2	unidentified squid		0.9
Perdido	21	Yellowfin Tuna	3	squid beak		
Perdido	21	Yellowfin Tuna	4	squid beak		
Perdido	21	Yellowfin Tuna	5	squid beak		
Perdido	22	Yellowfin Tuna	1	*Ornithoteuthis antillarum*	24	0.95
Perdido	22	Yellowfin Tuna	2	unidentified squid		0.59
Perdido	24	Blackfin Tuna	2	squid beak		0.12
Perdido	25	Yellowfin Tuna	6	unidentified squid	31	0.3
Perdido	25	Yellowfin Tuna	7	unidentified squid		0.4
Perdido	25	Yellowfin Tuna	8	unidentified squid		0.24
Perdido	25	Yellowfin Tuna	9	unidentified squid		0.41
Perdido	25	Yellowfin Tuna	10	unidentified squid		0.14
Perdido	25	Yellowfin Tuna	11	squid beak		
Perdido	25	Yellowfin Tuna	12	squid beak		
Perdido	25	Yellowfin Tuna	13	squid beak		
Perdido	25	Yellowfin Tuna	14	squid beak		
Perdido	25	Yellowfin Tuna	15	squid beak		
Perdido	26	Blackfin Tuna	1	squid beak		
Perdido	26	Blackfin Tuna	2	unidentified squid		
Perdido	26	Blackfin Tuna	3	*Onychoteuthis banksii*	32.8	0.68
Perdido	26	Blackfin Tuna	4	*Onychoteuthis banksii*	34	0.82
Perdido	26	Blackfin Tuna	5	*Onychoteuthis banksii*	46.5	0.3.63
Perdido	26	Blackfin Tuna	6	*Onychoteuthis banksii*	34	0.97
Perdido	26	Blackfin Tuna	7	*Onychoteuthis banksii*	31.5	0.69
Perdido	26	Blackfin Tuna	8	*Onychoteuthis banksii*	36.5	1.0
Perdido	27	Blackfin Tuna	11*	*Onychoteuthis banksii*	38.5	4.21
Perdido	27	Blackfin Tuna	12*	*Onychoteuthis banksii*	26.5	0.77
Perdido	27	Blackfin Tuna	13*	*Onychoteuthis banksii*	29.2	1.31
Perdido	27	Blackfin Tuna	14	*Onychoteuthis banksii*	35.5	2.15
Perdido	27	Blackfin Tuna	15*	*Onychoteuthis banksii*	34	1.1
Perdido	27	Blackfin Tuna	16	unidentified squid	28.5	1.24
Perdido	28	Blackfin Tuna	10	squid beak		
Perdido	28	Blackfin Tuna	11	squid beak		
Perdido	28	Blackfin Tuna	12	squid beak		
Perdido	28	Blackfin Tuna	13	squid beak		
Perdido	28	Blackfin Tuna	14	squid beak		
Perdido	28	Blackfin Tuna	15	squid beak		
Perdido	28	Blackfin Tuna	16	squid beak		
Perdido	28	Blackfin Tuna	17	squid beak		
Perdido	29	Yellowfin Tuna	1*	*Onychoteuthis banksii*	105	-
Perdido	29	Yellowfin Tuna	2*	*Onychoteuthis banksii*	46	4.11
Perdido	30	Yellowfin Tuna	18	*Onychoteuthis banksii*	67	8.78
Perdido	30	Yellowfin Tuna	19	*Onychoteuthis banksii*	40	8.44
Perdido	30	Yellowfin Tuna	20	*Onychoteuthis banksii*	61	6.1
Perdido	30	Yellowfin Tuna	21	*Onychoteuthis banksii*	68	2.0
Perdido	30	Yellowfin Tuna	22	unidentified squid	32	1.09
Perdido	30	Yellowfin Tuna	23	unidentified squid		1.02
Perdido	30	Yellowfin Tuna	24	squid beak		
Perdido	30	Yellowfin Tuna	25	squid beak		
Perdido	30	Yellowfin Tuna	26	squid beak		
Perdido	30	Yellowfin Tuna	27	squid beak		
Perdido	30	Yellowfin Tuna	28	squid beak		
Perdido	30	Yellowfin Tuna	29	squid beak		
Perdido	30	Yellowfin Tuna	30	squid beak		
Perdido	30	Yellowfin Tuna	31	squid beak		
Perdido	30	Yellowfin Tuna	32	squid beak		
Perdido	30	Yellowfin Tuna	33	squid beak		
Perdido	30	Yellowfin Tuna	34	squid beak		
Perdido	30	Yellowfin Tuna	35	squid beak		
Perdido	30	Yellowfin Tuna	36	squid beak		

Table A.4: (Continued)

Perdido	30	Yellowfin Tuna	37	squid beak		
Perdido	30	Yellowfin Tuna	38	squid beak		
Perdido	30	Yellowfin Tuna	39	squid beak		
Perdido	30	Yellowfin Tuna	40	squid beak		
Perdido	30	Yellowfin Tuna	41	squid beak		
Perdido	30	Yellowfin Tuna	42	squid beak		
Perdido	30	Yellowfin Tuna	43	squid beak		
Perdido	30	Yellowfin Tuna	44	squid beak		
Perdido	30	Yellowfin Tuna	45	squid beak		
Perdido	30	Yellowfin Tuna	46	squid beak		
Perdido	30	Yellowfin Tuna	47	squid beak		
Perdido	30	Yellowfin Tuna	48	squid beak		
Perdido	30	Yellowfin Tuna	49	squid beak		
Perdido	30	Yellowfin Tuna	50	squid beak		
Perdido	30	Yellowfin Tuna	51	squid beak		
Perdido	30	Yellowfin Tuna	52	squid beak		
Perdido	30	Yellowfin Tuna	53	squid beak		
Perdido	30	Yellowfin Tuna	54	squid beak		
Perdido	30	Yellowfin Tuna	55	squid beak		
Perdido	31	Yellowfin Tuna	10	*Ornithoteuthis antillarum*	44	3.79
Perdido	31	Yellowfin Tuna	11	unidentified squid	24	0.89
Perdido	31	Yellowfin Tuna	12	unidentified squid		1.05
Perdido	31	Yellowfin Tuna	13	squid beak		
Perdido	31	Yellowfin Tuna	14	squid beak		
Perdido	32	Yellowfin Tuna	7	*Onychoteuthis banksii*	68	12.1
Perdido	32	Yellowfin Tuna	8	unidentified squid		0.8
Perdido	32	Yellowfin Tuna	9	unidentified squid		1.23
Perdido	32	Yellowfin Tuna	10	squid beak		
Perdido	32	Yellowfin Tuna	11	squid beak		
Perdido	32	Yellowfin Tuna	13	squid beak		
Perdido	32	Yellowfin Tuna	14	squid beak		
Perdido	33	Yellowfin Tuna	1	*Ornithoteuthis antillarum*	58	3.15
Perdido	33	Yellowfin Tuna	2	unidentified squid		0.7
Perdido	33	Yellowfin Tuna	3	unidentified squid		0.59
Perdido	33	Yellowfin Tuna	4	squid beak		
Perdido	33	Yellowfin Tuna	5	squid beak		
Perdido	33	Yellowfin Tuna	6	squid beak		
Perdido	33	Yellowfin Tuna	7	squid beak		
Perdido	33	Yellowfin Tuna	8	squid beak		
Perdido	33	Yellowfin Tuna	9	squid beak		
Perdido	33	Yellowfin Tuna	10	squid beak		
Perdido	33	Yellowfin Tuna	11	squid beak		
Perdido	33	Yellowfin Tuna	12	squid beak		
Perdido	33	Yellowfin Tuna	13	squid beak		
Perdido	34	Yellowfin Tuna	2	*Onychoteuthis banksii*	69	8.6
Perdido	34	Yellowfin Tuna	3	*Onychoteuthis banksii*	66	9.5
Perdido	34	Yellowfin Tuna	4	*Onychoteuthis banksii*	66	10.3
Perdido	34	Yellowfin Tuna	5	*Onychoteuthis banksii*	48	2.1
Perdido	34	Yellowfin Tuna	6	*Onychoteuthis banksii*	29	0.6
Perdido	34	Yellowfin Tuna	7	unidentified squid	24	0.2
Perdido	34	Yellowfin Tuna	8	squid beak		
Perdido	34	Yellowfin Tuna	9	squid beak		
Perdido	34	Yellowfin Tuna	10	squid beak		
Perdido	36	Yellowfin Tuna	2	*Onychoteuthis banksii*	70	9.2
Perdido	37	Yellowfin Tuna	4	unidentified squid	19	0.25
Perdido	37	Yellowfin Tuna	5	unidentified squid		0.28
Perdido	38	Yellowfin Tuna	11	unidentified squid	42	2.2
Perdido	38	Yellowfin Tuna	12	squid beak		
Perdido	39	Yellowfin Tuna	4	unidentified squid		7.1
Perdido	39	Yellowfin Tuna	11*	*Onychoteuthis banksii*	48	3.98
Perdido	39	Yellowfin Tuna	12*	*Onychoteuthis banksii*	52	3.06
Perdido	40	Yellowfin Tuna	25	*Onychoteuthis banksii*	66	10.14
Perdido	40	Yellowfin Tuna	26	*Onychoteuthis banksii*	66	8.59
Perdido	40	Yellowfin Tuna	27	*Onychoteuthis banksii*	54	1.73
Perdido	40	Yellowfin Tuna	28	unidentified squid		1.18
Perdido	40	Yellowfin Tuna	29	unidentified squid		0.23
Perdido	40	Yellowfin Tuna	30	unidentified squid		0.38
Perdido	40	Yellowfin Tuna	31	unidentified squid		0.32

Table A.4: (Continued)

Perdido	40	Yellowfin Tuna	32	unidentified squid		0.53
Perdido	40	Yellowfin Tuna	33	squid beak		
Perdido	41	Yellowfin Tuna	14*	*Onychoteuthis banksii*	78	16.9
Perdido	41	Yellowfin Tuna	15	*Onychoteuthis banksii*	66	1.4
Perdido	41	Yellowfin Tuna	16	*Onychoteuthis banksii*	22	0.6
Perdido	41	Yellowfin Tuna	17*	*Onychoteuthis banksii*	75	9.1
Perdido	41	Yellowfin Tuna	18*	*Onychoteuthis banksii*	66	6.1
Perdido	41	Yellowfin Tuna	19*	*Onychoteuthis banksii*	68	7.4
Perdido	41	Yellowfin Tuna	20	squid beak		
Perdido	41	Yellowfin Tuna	21	squid beak		
Perdido	41	Yellowfin Tuna	22	squid beak		
Perdido	41	Yellowfin Tuna	23	squid beak		
Perdido	41	Yellowfin Tuna	24	squid beak		
Perdido	41	Yellowfin Tuna	25	squid beak		
Perdido	41	Yellowfin Tuna	26	squid beak		
Perdido	41	Yellowfin Tuna	27	squid beak		
Perdido	42	Yellowfin Tuna	5	squid beak		
Perdido	42	Yellowfin Tuna	6	squid beak		
Perdido	42	Yellowfin Tuna	7	squid beak		
Perdido	42	Yellowfin Tuna	8	squid beak		
Perdido	43	Blackfin Tuna	17*	*Onychoteuthis banksii*	39.5	1.02
Perdido	43	Blackfin Tuna	18	*Onychoteuthis banksii*	20.5	0.39
Perdido	43	Blackfin Tuna	19*	*Onychoteuthis banksii*	23.5	0.4
Perdido	43	Blackfin Tuna	20*	*Onychoteuthis banksii*	57	1.2
Perdido	43	Blackfin Tuna	21	*Ornithoteuthis antillarum*	66.5	4.56
Perdido	43	Blackfin Tuna	22	*Onychoteuthis banksii*	39	4.06
Perdido	43	Blackfin Tuna	23	*Onychoteuthis banksii*	32	0.71
Perdido	43	Blackfin Tuna	24*	*Onychoteuthis banksii*	18	0.31
Perdido	43	Blackfin Tuna	25*	*Onychoteuthis banksii*	19	0.28
Perdido	43	Blackfin Tuna	26	*Onychoteuthis banksii*	25.5	0.19
Perdido	43	Blackfin Tuna	27	*Onychoteuthis banksii*	21.5	0.85
Perdido	43	Blackfin Tuna	28	unidentified squid		0.54
Perdido	43	Blackfin Tuna	29	unidentified squid		0.59
Perdido	43	Blackfin Tuna	30	unidentified squid		0.39
Perdido	43	Blackfin Tuna	31	unidentified squid		0.4
Perdido	43	Blackfin Tuna	32	unidentified squid		0.2
Perdido	43	Blackfin Tuna	33	unidentified squid		0.25
Perdido	43	Blackfin Tuna	34	unidentified squid		0.36
Perdido	43	Blackfin Tuna	35	squid beak		
Perdido	43	Blackfin Tuna	36	squid beak		
Perdido	44	Yellowfin Tuna	3	squid beak		
Perdido	44	Yellowfin Tuna	4	squid beak		
Perdido	44	Yellowfin Tuna	5	squid beak		
Perdido	44	Yellowfin Tuna	6	squid beak		
Perdido	44	Yellowfin Tuna	7	squid beak		
Perdido	44	Yellowfin Tuna	8	squid beak		
Perdido	44	Yellowfin Tuna	9	squid beak		
Perdido	46	Blackfin Tuna	6	*Onychoteuthis spp.*	46	03.04
Perdido	46	Blackfin Tuna	7	squid beak		
Perdido	46	Blackfin Tuna	8	squid beak		
Perdido	46	Blackfin Tuna	9	squid beak		
Perdido	46	Blackfin Tuna	10	squid beak		
Perdido	46	Blackfin Tuna	11	squid beak		
Perdido	48	Yellowfin Tuna	1	*Ommastrephes bartramii*	135	82.21

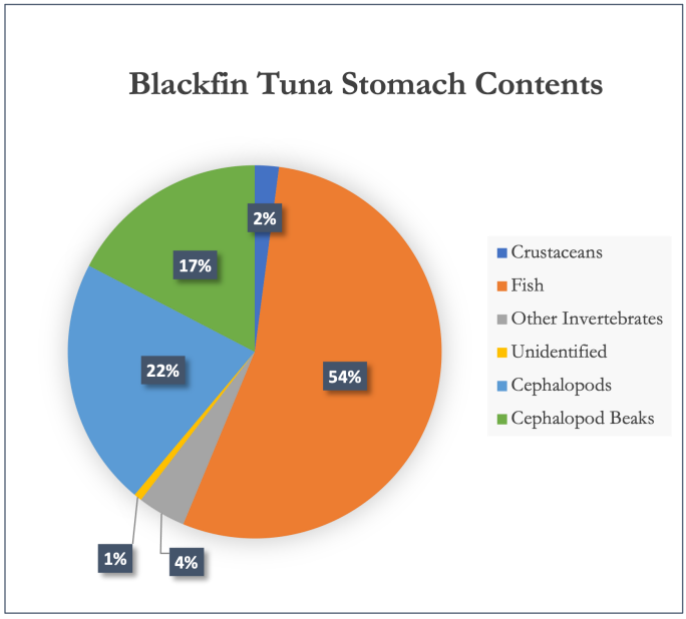

Figure A.5: Pie chart illustrating the distribution of the number of prey items (percentage of total) found in the stomach contents of Blackfin Tuna (n=15) analyzed in this study.

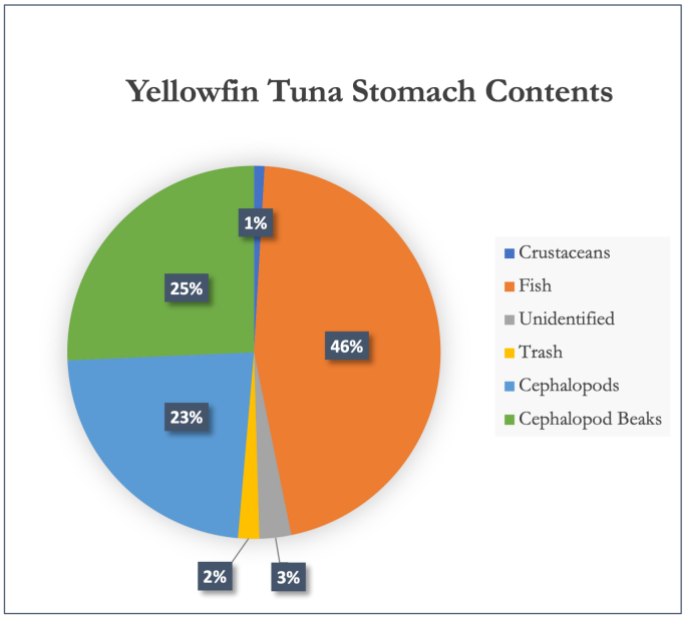

Figure A.6: Pie chart illustrating the distribution of the number of prey items (percentage of total) found in the stomach contents of Yellowfin Tuna (n=10) analyzed in this study.

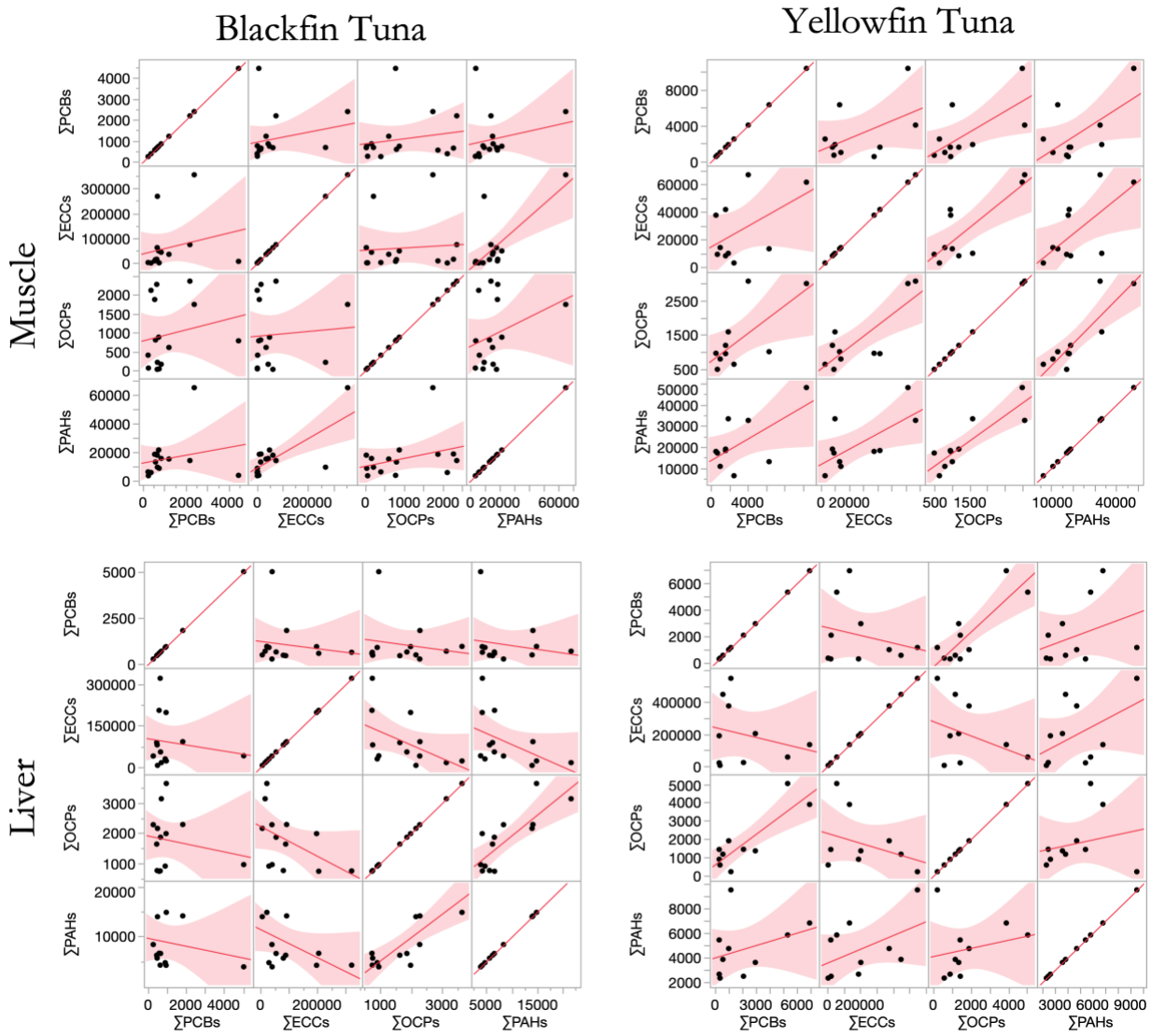

Figure A.7: Scatterplot matrix of ∑[compound group] (lw) by ∑[compound group] (lw) in liver and muscle tissue for Blackfin Tuna and Yellowfin Tuna. Black dots represent individual fish samples, the red line is the line of fit, and the shaded area is the 95% CI.

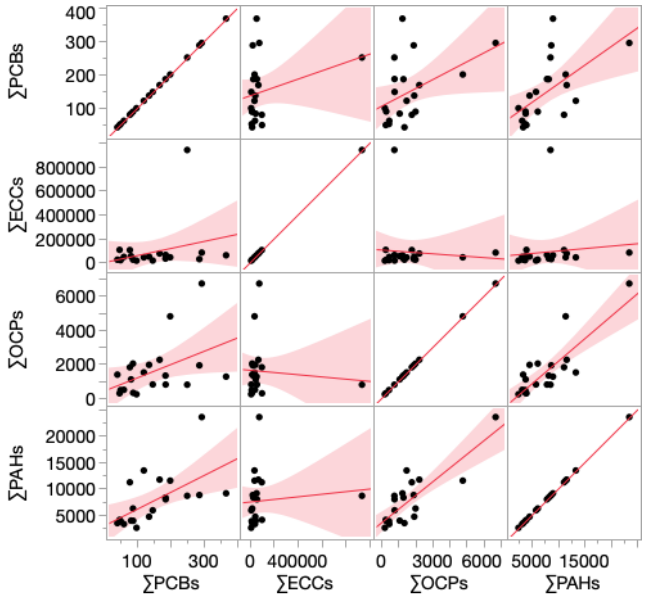

Figure A.8: Scatterplot matrix of ∑[compound group] (lw) by ∑[compound group] (lw) in mantle tissue of O. banksii. Black dots represent individual squid samples, the red line is the line of fit, and the shaded area is the 95% CI.