PICES XIII S3-1824 Oral
Predation on pelagic coelenterates

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Coelenterates (cnidaria and ctenophores) are well recognized as predators in food webs of marine ecosystems but are less often considered as prey. This is partly because they are digested very rapidly. In studies based on predator stomach contents the measured masses of different organisms are rarely scaled by their relative rates of digestion. Predators that are frozen and thawed, or for which whole stomachs are placed in preservatives, may have already lost much of their coelenterate content when they are examined. There is also a tendency to assume that gelatinous organisms, with their high water and salt content relative to organic content, are poor food. However, given the high rates of digestion (and presumably of assimilation) coelenterates may provide sources of energy comparable to better recognized prey such as arthropods. It is already becoming well documented that a number of cnidaria and ctenophores as well as fish utilize gelatinous organisms as prey. Data is more slowly accumulating on predation by a wide range of other carnivores such as annelids, chaetognaths, molluscs, arthropods, reptiles and birds.

PICES XIII S3-1979 Oral
Trophic roles of larvaceans in the coastal regions of the Gulf of Alaska

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During July/August 2003, larvaceans and juvenile salmon were collected from different vessels but from similar locations along the GLOBEC-Seward line in coastal shelf waters of the Gulf of Alaska. Concentration of all larvacean species was 95 - 1328 individuals m^{-3} and was highest above the thermocline, between 24-0 m and 10-0 m depending on location. The feeding rate of the most abundant species in the inner shelf, *Oikopleura dioica*, was measured on shipboard. Clearance rate averaged 308 ml $individual^{-1}$ d^{-1} (sd = 283) and the *O. dioica* population cleared up to 7.7% of the water column d^{-1}. Measurements were combined with additional laboratory data on *O. dioica* and other species to calculate the grazing impact of the total larvacean community on phytoplankton. Larvaceans consumed much more phytoplankton than the entire crustacean community. Juvenile pink salmon, *Oncorhynchus gorbuscha*, are abundant on the inner shelf during July-October. Preliminary analysis of stomach contents of juvenile salmon collected in July/August 2003 indicated larvaceans were important prey items at many stations. In July, they comprised 95% (by volume) of the stomach content of pink salmon at one inner shelf station but < 1% at another. In August, values at three inner shelf stations were 22%, 8% and 35% but < 1% at three stations farther offshore. Larvaceans in coastal Gulf of Alaska are a direct and efficient trophic link between small phytoplankton and juvenile pink salmon.

PICES XIII S3-2095 Invited
Gelatinous animals at sea: Convergent evolution and sampling problems

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There is no cover in the open ocean, no place to hide from visual predators during the day. In epipelagic communities, convergent evolution has selected for a limited number of anti-predatory adaptations for survivorship, with surprisingly similar strategies dominating guilds of remarkably dissimilar taxa. Animals in the open sea are 1) large, fast nekton, 2) schooling fish, squid and krill, 3) transparent, gelatinous invertebrates, 4) neuston, 5) small mesozooplankton below visual resolution, 6) micronekton and/or vertical diurnal migrators, 7) protists and members of microbial loops, and/or 8) cheaters. When apex predators in pelagic food webs are eliminated or reduced in number by over-fishing or environmental change, carnivores from other predatory guilds compensate with increased

population sizes. Populations of gelatinous predators have increased in some pelagic ecosystems and one suspects that micronekton have increased in others. Neither of these guilds have been well investigated, partly because fisheries biologists do not sample appropriately for species in these assemblages. Evaluating the biology of many of these species may require use of non-traditional sampling techniques, such as *in situ* direct observation by divers or remote vehicles, traps, species-specific acoustics and tracking of individual animals. Selected aspects of the history of pelagic ecosystems are reviewed, and examples of how gelatinous animals can impact fisheries food chains in unsuspected ways are presented.

PICES XIII S3-1961 Oral

Appendicularians around Kuroshio in winter-spring

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Appendicularians are one of dominant mesozooplankton groups in the planktonic food web around Kuroshio, which supports growth of larva/juveniles of many pelagic fishes. To evaluate their importance, we have examined samples collected from upper 150 m of the region in winter-spring during the main spawning period of pelagic fish. Samples were collected by vertical hawls of a conical plankton net, specimens were identified to species and body sizes were measured. The appendicularian biomass was about 10% of copepod biomass, but their production amounts to 30% or more, since their biological productivity is much higher than copepods. Appendicularians are famous for their "house", a mucous bag generally with duplex filters to collect food particles of appropriate size. The appendicularian community around Kuroshio was strongly dominated by *Oikopleura longicauda*. The "house" of *O. longicauda* is equipped with only one filter and has ability to collect large particles like diatoms and thus can utilize the diatom bloom in winter-spring. The body and "house" of appendicularians have appeared in the gut contents of larvae of sardine and anchovy, which verifies the existence of trophic mediation by appendicularians from primary producers to pelagic fish in Kuroshio region.

PICES XIII S3-1883 Oral

Community composition and production of larvaceans in the Northern Bering Sea

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The larvacean community from north of St. Lawrence Island through Bering Strait was surveyed during early July 2002. The community was composed of *Oikopleura vanhoeffeni*, *O. labradoriensis*, and *Fritillaria borealis*, with relative related to water mass origin. Biomass was typically ~10% that of the copepod community. Populations were reproductively mature: Fecundity by *O. vanhoeffeni* ranged from 1700-4900 eggs per females, with egg hatching time of several days. House production ranged from 3-5 houses per day. Preliminary growth rates for just hatched individuals were successfully determined by the artificial cohort method for *Oikopleura* spp. and *F. borealis*: they ranged from 25-50% increases in body weight per day. These numbers suggest they have the ability to both outgrow and out-reproduce copepod populations, explaining their ability to bloom under favourable conditions.

PICES XIII S3-1908 Poster

Seasonal distribution of siphonophores in relation to water masses in the East China Sea, north of Taiwan

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The species composition and seasonal distribution of siphonophores associated with water masses in the East China Sea, north of Taiwan, were studied during four seasonal cruises from April 1996 to February 1997. A total of 47 zooplankton samples were taken along a transect from 26.5°N, 120.5° E to 25.0°N, 123.0° E across the East China Sea. In all, 47 species belonging to eight families and 22 genera were identified. The mean numerical abundance of siphonophores was 285 ± 257 ind./100m^3. *Muggiaea atlantica*, *Lensia subtiloides*, *Chelophyes appendiculata*, *Bassia bassensis* and *Diphyes chamissonis*, were the five most dominant species and together they comprised 77% of the total count of siphonophores. The abundance and number of species of siphonophores showed apparent seasonal changes, with higher abundances but fewer species in spring compared to the summer. Siphonophore assemblages exhibited clear spatial and seasonal succession: *Muggiaea atlantica* dominated most sampling sites during winter and spring seasons, *Bassia bassensis* were common in summer and in the Kuroshio Current, while *Lensia subtiloides* was abundant in autumn and in both the Taiwan Strait Warm Water and Kuroshio Current. From the results of MDS analysis, two seasonal groups were distinguished: summer-autumn and winter-spring.

PICES XIII S3-1916 Poster

Relationships between short-term increases of gelatinous zooplankton and physical environments in the near shore area of Iyo-Nada, Japan

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In several recent studies, the occurrences of dense aggregation of the scyphomedusa, *Aurelia aurita*, have been frequently reported in the coastal area of the Seto Inland Sea, Japan. However, physical factors that cause the aggregation of gelatinous zooplankton have not been resolved sufficiently in the area. Hence, based on results of data analyses, we discuss the mechanisms leading to aggregations of gelatinous zooplankton near shore region of Iyo-Nada located in the western part of the Seto Inland Sea. In this study, jellyfish data, which were sampled at a power plant located at the shore of the Iyo-Nada, were analyzed. In the power plant, large volumes of seawater are pumped as cooling-water for a turbine. Jellyfish existing within the seawater are carried into the water gate of the power plant and the daily amount of jellyfish (mainly *Aurelia aurita*) caught at the water gate has been recorded since 1998. Time series data of the gelatinous zooplankton showed that jellyfish near the shore repeatedly showed a sudden increase and was classified mainly into the following three cases. One is the periodic increase during the spring tidal period. We deduced that the size of a tide-induced topographic eddy which develops nearshore relates to the periodic increase. The second is the rapid increase caused by strengthening of the shoreward wind by a typhoon. The third is based on a change of direction of a monsoon. The overall quantity of jellyfish increased with the occurrence of the northwestern wind (shoreward wind) in autumn.

PICES XIII S3-2127 Poster

New findings on young *Nemopilema nomurai* (Scyphozoa: Rhizostomeae) in the western coastal area of Korea

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Young *Nemopilema nomurai* (1.5 ~ 4 cm bell size) were first found on 29 May 2004 at Gunsan located in the western coastal area of Korea. Their umbrellas were slightly reddish- brown in color. The complex branches on the mouth arm were a deep reddish brown. There were several reddish spots and eight rhopalia on the umbrella edge. A sensory pit was located on exumbrella just above each rhopalium. The radial canals consisted of 8 rhopalar and 8 inter-rhopalar canals. The mouth-arms were divided into eight arms with two wings. The young *N. nomurai* had no long whip-shaped terminal appendages. As compared to adults, there are differences in number of wings of mouth-arm and the lack of a long whip-shaped terminal appendages. Adults had three wings and long whip-shaped terminal appendages.

PICES XIII S3-2129 Poster

Predation pressure by some fishes on *Aurelia aurita* (Scyphozoa; Semaeostomeae)

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An experiment in predation pressure of two species of fishes, *Navodon modestus* (black scraper, Tetraodontiforms; Monacanthidae) and *Stephanolepis cirrhifer* (thread-sail filefish, Tetraodontiforms; Monacanthidae), on *Aurelia aurita* was carried out to determine whether there are species-specific differences in feeding on jellyfish and how much jellyfish are consumed if they are eaten. One individual fish was kept in a small aquarium (volume = 34 L) with *A. aurita* for one day. This experiment was performed three times. The weight of *A. aurita* was estimated before and after each experiment. The weights of *N. modestus* and *S. cirrhifer* were 80~120 g and 60 g, respectively. *S. cirrhifer* ate 40~160 g of *A. aurita* per day, whereas *N. modestus* did not eat any. There was no difference in feeding rate relative to the weight of *S. cirrhifer*. The habitat of *S. cirrhifer* is in the coastal area, while *N. modestus* inhabits the offshore area. Considering these habitat differences, it is possible that *S. cirrhifer* overlaps more with and thus is more familiar with eating *A. aurita* than *N. modestus*.

PICES XIII S3-1921 Poster

Estimation of ecological role and trophic level of jellyfish *Aurelia aurita* using stable isotope ratios in the Uwa Sea, Japan

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In recent years, there has been a spate of publications noting unprecedented explosions of jellyfish populations which have been increasing in frequency and expanding in geographic coverage. Some publications have also reported that these jellyfish cause direct damage to fish populations. The Uwa Sea located at the east coast of the Bungo Channel in the southern part of Japan, is well known as an important fishery ground. The moon jellyfish, *Aurelia aurita,* is one of the most common scyphomedusae in the world's coastal waters and frequently forms large blooms in this area. This megagelatinous carnivorous zooplankton has recently received a great deal of interest from the scientific community since it may play a significant role in the food chain dynamics in the pelagic marine ecosystem. In this study, we attempt to estimate its ecological role and trophic level in the marine ecosystem using

stable-isotope ratios of carbon and nitrogen, which reflect the material flow through the food web. We found that the trophic level of *Aurelia aurita* was lower than or equal to copepods or fish larvae, which have been previously shown to be a main food of jellyfish. It should be expected that *Aurelia aurita* is not strong grazer but instead is a strong competitor of copepods or fish larvae. The main food of *Aurelia aurita* might be lower trophic level and smaller size plankton such as mesozooplankton.

PICES XIII S3-1923 Poster

A study on jellyfish patch formation using aerial photography

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Populations of jellyfish are increasing globally in recent years. Jellyfish blooms have a large impact on marine ecosystems. They form aggregations called patches which are often associated with negative effects such as lost of fish freshness in set nets or blockage of cooling water intakes in power plants. Two dominant factors are hypothesized for the patch formation: Reproductive strategy or avoidance of predation (active cause) and convergence of water (passive cause). In this study, we took aerial photographs of floats and jellyfish patches on the sea surface from various angles for about an hour. The distribution of horizontal divergence at the sea surface is calculated from the time rate-of-change of areas of triangles composed of floats. Consequently, the patchiness of jellyfish was highest in the region of convergence (minus divergence). This result suggests that passive aggregation is the dominant factor of the patch formation in the horizontal direction.

PICES XIII S3-1898 Oral

Long-term changes in salp distribution in a polar ecosystem: Some like it hot

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The pelagic tunicate *Salpa thompsoni* is one of the most important large filter feeders of the Southern Ocean channelling biogenic carbon from surface waters into the ocean's interior and seafloor. *S. thompsoni* has the ability to undergo an explosive population development outcompeting other zooplankton species and dramatically altering the Antarctic pelagic food web economy. This tunicate is well adapted to oceanic, low Antarctic (45-60°S) latitudes and generally not found in coastal seas surrounding the continent. Recently, it has been hypothesized that the salp distribution might have changed over the past half a century by shifting southward. Since *S. thompsoni* is a cold-temperate species, the above may indicate a large-scale environmental shift in Antarctic regions. The salp expansion to the areas previously considered as the Antarctic krill domain may, however, be damaging to their populations. There is evidence indicating that salps might experience deformations in their reproduction at high latitudes. Furthermore, elevated particle concentrations, which are relatively normal at the marginal ice zone, may lead salp populations to collapse. In the light of possible climate change, it is critical to understand patterns in salp life cycle changes in the Southern Ocean if modellers want to better understand their contribution to the high Antarctic biological pump. This presentation will discuss latitudinal distribution patterns in *S. thompsoni* biological and some demographic parameters in the Southern Ocean based on historical and most recent data sets spanning between 1989 and 2004.

PICES XIII S3-1899 Oral
Climate effects on jellyfish populations: A review

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Jellyfish often occur in large numbers worldwide and are important predators of zooplankton and ichthyoplankton. Jellyfish populations are known for great inter-annual variations in abundance, but the causes of "blooms" are generally unknown. Long-term records have shown that increases in jellyfish populations are correlated with environmental indices and warm ocean conditions. I review correlative and experimental data on climate factors that may increase jellyfish populations: Ctenophore *Mnemiopsis leidyi* (Narragansett Bay, warm temperature), hydromedusa *Moerisia lyonsi* (Chesapeake Bay, warm temperature, mid-salinity), and scyphomedusae *Pelagia noctiluca* (Mediterranean Sea, warm temperature, low rainfall, high atmospheric pressure), *Chrysaora quinquecirrha* (Chesapeake Bay, mid-salinity, warm temperature, negative North Atlantic Oscillation Index (NAOI)), *C. melanaster* (Bering Sea, warm stable water column), *Cyanea lamarkii* and *Aurelia aurita* (North Sea, negative NAOI), and *A. labiata* (NE Pacific, warm temperature, mid-salinity). Temperature and salinity both are significant; they may act directly on the physiology of the jellyfish and on feeding success, and indirectly on prey availability. In warming ocean conditions, jellyfish could increase in numbers, have longer seasons, and change geographic distributions. Jellyfish populations also may be enhanced by other human-induced changes in marine ecosystems, such as eutrophication, over-fishing, species introductions, and augmentation of substrates, such as marinas, for the benthic stages. Large jellyfish populations are generally considered detrimental to fish populations through competition for zooplankton prey, predation on fish eggs and larvae. Abundant jellyfish also clog fishing gear, disrupt power plant operations, and reduce tourism. Therefore, increases in jellyfish populations probably are undesirable for human interests.

PICES XIII S3-1865 Oral
Predation by the Scyphomedusa *Chrysaora fuscescens* in the northern California Current

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The scyphomedusa *Chrysaora fuscescens* is abundant inshore of the upwelling front off the coasts of Oregon and Washington (USA) each summer and fall, yet no quantitative data have yet been published on their trophic impact. Our goal was to assess predation by *C. fuscescens* on co-occurring zooplankton in the northern California Current. During August 2002, we quantified medusae and mesozooplankton in shelf and slope waters from central Oregon to northern California. During summer 2002 and 2003, medusae were dip-netted from surface waters or collected by divers at 8 locations off the central Oregon coast for gut evacuation experiments or analysis of gastric contents; concurrently, we estimated zooplankton availability using vertical hauls of a 0.5-m, 202 μm-mesh net. In 2002, early stages of euphausiids dominated the diet, with medusae exhibiting exceptionally strong selection for euphausiid eggs. In 2003, when early-stage euphausiids were less abundant, copepods and bivalve larvae comprised the largest proportion of medusan diet. During both years, relatively rare yet large or non-evasive prey such as fish eggs, larvaceans, ctenophores, polychaete larvae, and cladocerans were also ingested. Although *C. fuscescens* do ingest copepods, predation impact on these populations was minimal. However, *Chrysaora fuscescens* could cause significant mortality to early-life stages of euphausiids during years of high ecosystem productivity. Along with physical factors such as climatic regime, strength of summer upwelling, and onshore retention, we suggest that predation may play a role in mediating euphausiid population dynamics in nearshore regions of the northern California Current.

PICES XIII S3-1930 Oral

A comparison of predatory habits of the physonect siphonophore *Nanomia cara* in coastal basins (Wilkinson and Georges, Gulf of Maine) and deep-water canyons (Oceanographer and Hydrographer)

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Regulation of prey populations results from the interplay of biological and physical processes that operate on various spatial and temporal scales. Unfortunately, reliable assessments of the distribution, abundance, and trophic transfer by midwater gelatinous predators are sparse, primarily because these fauna are extremely fragile. As a first step toward quantifying the role of predation by a prominent physonect siphonophore, *Nanomia cara*, we conducted *in situ* investigations (=observations, transects and collections) to depths of 1000 m with a JSL submersible and performed digestion and respiration experiments on freshly collected colonies within controlled (=temperature and light) environments of shipboard laboratories. Results from September periods (2001-2004) provided a strong foundation for predicting predator-prey dynamics. Two populations of *Nanomia* exist in Northwest Atlantic coastal waters, judging from differences in morphology, behavior and diet. Colonies in the basins (ca. 300 m depth) were smaller (mean =25 gastrozooids per colony), had simpler nematocyst batteries, performed extensive diel vertical (220 to 20 m) migrations, and fed (mean=20% gastrozooids with prey) exclusively on the copepod, *Calanus finmarchicus* (stage IV-V), at night. *Nanomia* (mean=35 gastrozooids per colony) from canyon habitats (1000 m depth) along the southern margin of Georges Bank resided in deeper water (500-600 m), migrated upward less frequently (50-200 m) each night, and fed (mean=28% gastrozooids with prey) day and night on *C. finmarchicus* most often (70%) but also consumed krill, *Meganyctiphanes novegica*, (25%) and myctophid and gonostomatid fishes (5%). Digestion varied (3-4.5 h) with the size of the prey. Respiration rates averaged 3.1 µl O_2/mgC/h.

PICES XIII S3-1909 Poster

Winter distribution of siphonophores (Cnidaria) in the waters surrounding Taiwan

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This study is a part of the TaiCOFI program conducted by the Taiwan Fisheries Research Institute. TaiCOFI is a newly established log-term and large-scale survey of the hydrography and plankton at 60 stations in the waters surrounding Taiwan to study and evaluate the relationship between the distribution of plankton (particularly ichthyoplankton) and water masses. This study presents preliminary results of siphonophores collected from the FRI cruise during 13-22 February 2003. Zooplankton samples were taken with an ORI plankton net (160 cm mouth opening with 333µm mesh), hauled obliquely from 200 m (or 10 m above the bottom at shallower stations) to the surface at 28 stations. In total, 64 species belonging to 28 genera and 8 families of siphonophores were identified, with the mean abundance of 478.9 ± 858.5 ind./100 m^3. The number of species of Calycophorae (48) was greater than that of Physonectae (16). *Muggiaea atlantica* was the most abundant species (28% of the total catch). Other common species included *Chelophyes appendiculata* (11%), *Lensia subtiloides* (8%), *Chelophyes contorta* (7%), and *Diphyes chamissonis* (7%). Siphonophores showed higher abundance in the waters of northwestern Taiwan than off eastern Taiwan, while the species diversity was higher in the waters of southern Taiwan than off northern Taiwan. Different dominant siphonophores showed different distribution patterns and were associated with different water masses.

PICES XIII   S3-1838 Poster
Abundance and distribution of jellyfishes in epipelagical of the Okhotsk Sea

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We analyzed the distribution, number and biomass of jellyfish based on data from five trawl surveys of the epipelagic zone of the Okhotsk Sea carried out in fall of 1998 – 2003. Scyphozoa dominated the jellyfish biomass (73 – 99% of the total). In this period the biomass varied dramatically among the different years from 0.7 to 3.0 mmt in the northern part of the Okhotsk Sea, and from 212 to 1912 kg per square km in the southern part. Biomass trends of different species of jellyfishes showed different patterns. In 1998 – 2003, two species, *Cyanea capillata* and *Chrysaora melanaster*, alternated as the dominant species by biomass. The size distribution of scyphomedusae also strongly differed interannually. Apparently, the growth and death rate of jellyfishes in the Okhotsk Sea showed considerable annual variations and the predation intensity of jellyfishes on zooplankton varied greatly. While large catches of medusae occurred in all areas of the sea, there are annual distinctions in distribution of jellyfishes, especially in the northern part of the Okhotsk Sea. There were also some constant features of the distribution of species. For example, large catches of *C. capillata* occur in shelf or nearby waters of a shelf, whereas *C. melanaster* is abundant in the central part and near western Kamchatka.