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The Annual Report of the Western Society of Malacologists is based on its yearly meeting. Distribution of the Annual Report is free to regular and student members who are, at the time of issue, in good standing. Membership dues are $15.00 for regular members, $17.00 family, and $6.00 student.

The Western Society of Malacologists has issued three **Occasional Papers** - No. 1, "'Sea Shells of Tropical West America': Additions and Corrections to 1975" by A. Myra Keen & Eugene Coan; No. 2, "A Catalogue of Collations of Works of Malacological Importance," by George E. Radwin & Eugene Coan: and No. 3, "Twenty-five Year Index to Publications of The Western Society of Malacologists: Author, Taxonomic, Geographic and Subject Indices," by Hans Bertsch.

Correspondence regarding membership and orders for additional or back issues of the **Annual Report** or the **Occasional Papers** should be addressed to the current W.S.M. Treasurer, Dr. George Metz, 121 Wild Horse Valley Drive, Novato, CA 94947 USA.

In Memoriam

Richard Saul (1922-1996)

Dick was born in Illinois in 1922 and moved to southern California with his family as a boy. After a stint in the Army Air Corps during WWII he attended Pasadena City College and eventually transferred to UCLA where he earned his bachelor's degree in Geology. In 1949 he married LouElla Rankin (Saul) and they successfully raised two sons. In 1959 he completed a master's degree also at UCLA. In 1987 he retired from the California Division of Mines and Geology after a 30+ year career but continued to do geologic consulting.

We fondly recall his cheerful demeanor and boundless delight in all forms of humor, including atrocious puns, snappy limericks, and bizarre jokes. We are indeed fortunate to have known him.

– Lindsay T. Groves

INSTRUCTIONS FOR AUTHORS: Contributions for the **Annual Report** are normally based on papers presented at the Annual Meeting. Submissions may be made in the form of: Abstract, Extended Abstract, or Full Length Paper. Each is reviewed by the Editorial Board: outside reviewers may also be asked to evaluate manuscripts. Although there are no page charges, authors must provide funds for publishing photographs; voluntary contributions for page costs will be especially welcomed from authors of multi-paged contributions. Manuscripts must be typed on white paper, 8½" by 11", double-spaced throughout, with author's full address in proper style; generic and specific level taxa must include author and year; if there are references in the text, include the literature citations. The work in the volume will serve as a style guide for submissions (address format, etc.)

To be published in the corresponding year's **Annual Report** all submissions must be in the hands of the editor one month after the end of the Annual Meeting. Send all material (for either the **Annual Report** or **Occasional Papers**) to the Editor: Dr. Hans Bertsch, Chair, Department of Mathematics & Natural Sciences, National University, 4125 Camino del Rio South, San Diego, CA 92018 USA.

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CONTRIBUTED PAPERS

FRESHWATER MALACOFAUNA OF THE KURIL ARCHIPELAGO

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In 1995-1996 non-marine malacofauna of the southern and middle islands of the Kuril Archipelago was investigated. On the generic and familial levels, island mollusk fauna is a depauperate version of Sino-Indian continental fauna. There are a few Palearctic genera (*Lacustrina*) and Japanese subgenera [*Musculium* (*Morimusculium*)]. Continental and island freshwater malacofauna have no species in common. However, the specific content of Kuril malacofauna has much in common with that of the Northern Hokkaido. Some species inhabit the Southern Kuril Islands, Southern Sakhalin and Hokkaido, and may extend to Northern Honshu as well. There are freshwater species occurring in several Southern Kuril Islands (Kunashir, Iturup, Zelyonyi, Shikotan, Urup) some species are restricted to one or all of these first three. The middle Kuril Islands are characterized by scanty and poor diversity of freshwater mollusks because of a lack of suitable biotopes.

A complete list of fresh- and brackish water malacofauna of the southern Kuril Islands counts 75 species, in 15 genera and 9 families. Ten species, 2 genera and 2 subgenera are new to this region. Twenty-five species are new to science. Seven freshwater species, in 5 genera and 3 families were found in the Middle Kuril Islands. All species are new distribution records for the region.

GENETIC DIVERGENCE AND SHELL MORPHOLOGY IN *NAUTILUS*

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Wray et al. (1995) reported on the DNA analysis of five proposed species of *Nautilus* and concluded that one species was phylogenetically distinct (*N. scrobiculatus*) while the other four were indistinguishable (*N. pompilius*, *N. macromphalus*, *N. stenomphalus*, *N. belauensis*). Wray et al. suggested shell morphology and species determination in *Nautilus* should be reconsidered; however, it is argued here that shell morophology in *Nautilus* correlates with the results of their study.

The two distinct species of *Nautilus* are *N. pompilius* and *N. scrobiculatus*. The shell morphology is clearly different between these two species with *N. pompilius* having a callus over its umbilical region and *N. scrobiculatus* having a large open umbilical region with deep vertical walls. The proposed species *N. macromphalus*, *N. stenomphalus*, and *N. belauensis* all have morphological characters identical to or differing slightly from variations of *N. pompilius*. The proposed species which are variations of *N. pompilius* do not have the degree of morphological variation found between *N. pompilius* and *N. scrobiculatus*.

THE SHELL GAME: THE HISTORY OF BYNE'S "DISEASE"

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The characteristic breakdown of malacological specimens in collections storage has been documented for nearly 100 years. Unfortunately, much of the literature hinges on a series of papers by Loftus St. George Byne which are based on speculation rather than science. Many useless, damaging, or even lethal recommendations have been published as a result. A review of the historical literature on this subject and conservationally sound recommendations for dealing with the problem will be presented.

MORPHOLOGICAL CHARACTERS IN A TOTAL EVIDENCE CLADISTIC ANALYSIS OF THE FAMILY HALIOTIDAE (PROSOBRANCHIA: VETIGASTROPODA)

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The phylogeny of abalone has been studied so far only using molecular data: DNA- and protein-sequences of the acrosomal sperm protein lysin, and allozyme frequencies. The combination of the above data-sets is advantageous in counteracting the bias of a particular data-set, making the resulting phylogenetic hypothesis more robust. However, the number of equally parsimonious trees also increases due to two factors: 1) the synergy of biases in the individual data-sets; 2) missing data for a number of taxa. An analysis restricted to 22 morphological characters for 29 species results - not surprisingly - in 1463 equally parsimonious trees, producing a barely resolved consensus tree. However, the addition of these morphological characters to the suit of biochemical characters always reduces the number of equally parsimonious trees, irrespective of the combination of data-sets chosen. Most striking is the analysis of all biochemical data, including gap-coding, which produces 14 equally parsimonious trees; adding the above morphological data results in only 1-3 equally parsimonious trees. The importance of morphological characters and the power of the total evidence approach is clearly demonstrated in this study.

ISOLATING AND PROTEIC IDENTIFICATION IN THE MOLLUSK *POMACEA FLAGELLATA* FROM VERA CRUZ, MEXICO

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Through electrophoretic analysis in total proteins of gastropod mollusk *Pomacea flagellata*, the genetic variability was analyzed for tropical populations in the state of Veracruz, inside the provinces of Misantla, Tlacotalpan, Alvarado, and Catemaco, all of them in the Gulf of Mexico, finding a proteic polymorphism and a well-defined heterozygosis. The analyzed populations presented heterozygotic variability according to the expected proportion. The results seem to be related to selective pressure from the environmental characteristics; genic manes were detected providing evidence of environment selective action according to the genetic variation. The genetic variation in one of the analyzed loci seems to be maintained by overdominance. It is proposed to use the basic genetic information obtained from this study to develop programs for aquaculture.

EVOLUTIONARY SIGNIFICANCE OF MOLLUSCAN ZOOGEOGRAPHIC PROVINCES IN THE EASTERN PACIFIC

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High species diversity and conspicuous morphological variability of molluscs have played significant roles in our understanding of the existence of biogeographic provinces. Differences in species composition between adjacent provinces can be remarkable, suggesting that oceanographic discontinuities associated with zoogeographic boundaries determine the modern distributions of species. However, without the knowledge of both the phylogenetic relationships among species, and an understanding of the historical relationships among populations within species, it is difficult to determine if the process of speciation is associated with geographic isolation of populations in different provinces. Molecular techniques provide potentially powerful tools for studies of both phylogeny and population structure, particularly in cases where convergence and morphological plasticity are suspected to commonly occur.

I have recently started to investigate whether or not sister-species tend to inhabit adjacent biogeographic provinces in the Eastern Pacific by constructing a phylogeny of the muricid subfamily Ocenebrinae based on mitochondrial DNA sequences. I have also used a molecular approach to investigate the population structure of the sister-species *Nucella emarginata* 'northern' and *N. emarginata* 'southern'. These species primarily inhabit adjacent biogeographic provinces, but with a significant region of geographic overlap. A combination of mitochondrial sequence and protein electrophoresis data suggest that the overlap is the result of recent colonization, and that speciation is likely to have occurred between populations isolated in adjacent biogeographic provinces. This approach has limitations, and the use of molecules should be carefully considered as well as supplemented with other traditional sources of information available to malacologists.

MOLECULAR COMPARISONS UNRAVEL MOLLUSCAN MYSTERIES

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This symposium features outstanding examples of comparative molecular methods applied to illuminate new levels of understanding of the phylogeny, morphology, reproduction, ecology, and biogeography of molluscs. Sequence comparisons can provide informative markers of shared history that can help resolve phylogenetic branching patterns, especially when combined with morphological evidence. A well-supported cladogram allows "reciprocal illumination" of competing hypotheses of character evolution. The criterion of parsimony can be utilized to explain observations of shared similarity in a manner that is maximally congruent with other character evidence. Examples from this symposium will be discussed as they relate to a general approach to hypothesis testing. In a further example from my own research, I have used molecular sequence and gene order comparisons, combined with morphological analysis, to examine the question of what extant taxa are the sister taxa of molluscs, which is also fundamental to determining character polarities within molluscs.

FROM TENTACLES TO TREES: THE NUTS AND BOLTS OF FINDING AND GRINDING CALAMARI

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Many exciting problems in molluscan biology can be addressed with molecular techniques, but the seeming complexity and/or high cost of molecular research may dissuade classical malacologists from adopting these tools. In this presentation, the potential triumphs and tragedies of molluscan DNA research will be reviewed from the perspective of a cash-strapped malacology graduate student/neophyte molecular phylogeneticist. I will provide an overview of the techniques used in DNA sequencing research (DNA extraction, PCR, purification, sequencing and basic sequence analysis) using loliginid squids as an example.

ENGRAILED EXPRESSION AND THE PHYLOGENETIC STATUS OF THE MOLLUSCA: USING DEVELOPMENTAL GENETIC DATA FOR PHYLUM LEVEL PHYLOGENETICS

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The ancestry of the molluscs remains controversial. One school of thought derives the molluscs from a non-coelomate, flatworm-like organism. A second school argues that the serial organization of the chitons and monoplacophorans suggest that molluscs are derived from metameric (serially organized) organisms such as annelids or arthropods. Molecular data can be used in two ways to investigate the problem of molluscan origins. First, gene expression data can be used to demonstrate potential homology of serial features in the molluscs, annelids and arthropods. To this end, the expression of *engrailed*, a highly conserved segment-polarity gene, is described for the chitons and bivalves. Second, DNA sequences can be used to derive hypotheses of evolutionary relationships amongst the molluscs and their potential ancestors. DNA sequence for two genes and a large morphologic data matrix are used to outline phylogenetic relationships of the molluscan classes as well as other pertinent metazoan taxa.

EVOLUTIONARY HISTORY AND ORIGINS OF FEEDING SPECIALIZATIONS IN THE MARINE GASTROPOD GENUS *CONUS*

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The predatory, marine gastropod genus *Conus* has undergone two dramatic radiations since the Miocene and has evolved a tremendous diversity of prey specializations. Three feeding strategies have been described: molluscivory, piscivory, and vermivory. This study investigated the origin of the feeding modes, the patterns of feeding specializations within the vermivorous cones, and the evolutionary history of the genus. Mitochondrial DNA and nuclear intron sequences were collected from 48 species. The two datasets produce concordant phylogenies, with greater support and resolution coming from the nuclear intron data. Both datasets suggest a single origin of molluscivorous species. However, both datasets identify two ancient clades of fish-eaters. The nuclear intron dataset also identifies a deep clade containing all molluscivorous and piscivorous as well as several vermivorous species, suggesting an origin of the molluscivorous and piscivorous species from the same ancestral lineage. The distribution of vermivorous diet types on the phylogenies and a comparison of genetic distance and diet similarity indices indicate that feeding specializations among the vermivores are not haphazard; closely related species share similar diets. Through an analysis of the fossil record using the estimated phylogenies, it appears that much of the diversity found in *Conus*, including the diversity of diets, is deeply rooted in the evolutionary history of this genus and can be attributed to the radiation of this genus during the Miocene.

COEVOLUTION IN A SQUID-LUMINOUS BACTERIUM SYMBIOSIS: DIFFERENTIATION OF SEPIOLID SPECIES BY MOLECULAR SYSTEMATICS AND SYMBIONT COLONIZATION

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The associations between shallow-water sepiolid squids and the luminous bacterium *Vibrio fischeri* offer several unique advantages as a model system for the study of the coordinated influence of bacteria on the evolution and speciation of its cephalopod host. We have used PCR generated markers of the internal transcribed spacer region (ITS) and the cytochrome oxidase c subunit I (COI) to analyze inter- and intra-species differences among various species and populations of Sepiolidae. The results of a phylogenetic comparison among host sequences can be compared with intraspecies groupings among their bacterial symbionts to provide evidence for the coevolution of specific symbiotic relationships.

The ease of obtaining and culturing both the host animals and their *V. fischeri* strains under laboratory conditions has allowed the determination of levels of symbiont specificity via bacterial cross-colonization studies. Symbiotic competence of various strains of *V. fischeri* was ascertained by measuring the efficiency of colonization, dose response, colonization extent, and interstrain competitive dominance during colonization of juvenile hosts. The combination of both molecular systematics and symbiont colonization are powerful techniques for resolving questions of coevolution among host/symbiont associations, and specifically the evolutionary events that are the origin of divergence for this group of sepiolids.

PHYLOGENETIC RELATIONSHIPS AND THE DIVERGENCE OF GAMETE RECOGNITION PROTEINS IN *TEGULA:* EVOLUTION AT NO SNAIL'S PACE

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Free spawning marine invertebrates offer a special opportunity to understand the evolution of reproductive isolation because the proteins determining species-specific mate recognition lie exposed on the surface of gametes. I have taken a molecular approach to address two questions relating the formation of biological species in the ocean. First, do new species form only in broad allopatry (for example, when separated by vast oceanic barriers), or can they form along single coastlines? A molecular phylogeny of over 25 species of *Tegula* based on >1100 bp of two mitochondrial genes suggests the latter. Second, what role, if any, does natural selection play in the evolution of reproductive isolation? As a step toward answering this question, I have isolated a 15K protein that is abundant in the acrosome of *Tegula* sperm. cDNA sequences encoding this protein vary tremendously (>50% divergence in amino acid sequence) between closely related species. This striking interspecific divergence in a protein involved in sperm-egg recognition may implicate a role for natural selection acting directly on mate recognition systems in the formation of new species.

A CURIOUS NEW GENUS AND SPECIES OF GASTROPOD FROM THE TURONIAN OF THE SANTA ANA MOUNTAINS, ORANGE COUNTY, CALIFORNIA

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Cerithiform gastropods from the Late Cretaceous that have strong, aligned axial ribs giving the spire a high pyramidal shape are regularly assigned to the genus *Pyrazus*. Apertures are almost universally broken. A specimen of *?Pyrazus* from the Santa Ana Mountains has a virtually complete aperture, but the aperture does not resemble that of *Pyrazus ebenius* (Bruguière, 1792) or any other known cerithacean. It is instead similar to that of some muricids in having an enclosed anterior canal and a round, rimmed apertural opening, bordered by an expanded varix. This specimen suggests that at least some of the Cretaceous species previously assigned to *Pyrazus* should be reclassified. This new genus was probably widely distributed in shallow, warm water faunas.

OVERVIEW OF PLEISTOCENE PALEONTOLOGY AND STRATIGRAPHY OF COASTAL SAN DIEGO COUNTY

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A general overview of the molluscan paleontology of the San Diego Jurassic, Cretaceous, Eocene, Pliocene, and Pleistocene record, including descriptions of the stratigraphic context, fossil preservation, faunal content, and biostratigraphy of the fossil assemlages.

PALEOGENE RECORD OF THE GASTROPOD GENUS *HIPPONIX* FROM THE PACIFIC COAST OF NORTH AMERICA

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The earliest known species of genus *Hipponix* from the Pacific coast of North America is *H. pristinus* Zinsmeister, 1983. It is from upper Paleocene rocks ("Martinez Stage") just above the Las Virgenes Sandstone in the lowermost part of the Santa Susana Formation, Simi Hills, southern California. This species and all other Paleocene hipponicids from the Pacific coast of North America lived in warm, shallow-marine waters. Specimens are both usually scarce and poorly preserved. *Hipponix pristinus?* is present in the lower Eocene ("Capay Stage") Juncal? Formation, Lockwood Valley, southern California.

Hipponix arnoldi (Dickerson, 1917) [=*H. ornata* Dickerson, 1917], from the Eocene of southwestern Washington, shows the diagnostic very prominent, anteriorly projecting, anteriorly opening horseshoe-shaped muscle-scar. Its protoconch is naticoid, smooth, and projected. The species ranges in age from early to late Eocene and is present in; 1) interbedded volcanic and sedimentary rocks in the upper Crescent Formation ("Capay Stage") near Olympia in the Black Hills; 2) in transitional beds (middle Eocene) of interbedded volcanic and sedimentary rocks in the upper Crescent Formation and the overlying McIntosh Formation, Doty Hills; and 3) in the volcanic-influenced "Gries Ranch beds" in the lower part of the Lincoln Creek Formation (upper Eocene Galvinian Stage) near Vader. At this latter locality, specimens are common.

Hipponix? carpenteri Arnold, 1908, is known only from a sedimentary interbed? in a late Oligocene-age pillow basalt within the Vaqueros Sandstone, Santa Cruz Mountains, San Mateo County, northern California.

MIRACLE AT SIXTH AND FLOWER, CONTINUED: MARINE INVERTEBRATES FROM THE UPPER PLIOCENE FERNANDO FORMATION IN DOWNTOWN LOS ANGELES

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History of discovery and paleontological overview of a spectacularly rich molluscan (and other invertebrate) fauna from the upper Pliocene Fernando Formation uncovered in 1969 during a building excavation for the Arco Towers Plaza in the heart of downtown Los Angeles.

FIELD OBSERVATIONS OF EOCENE BIVALVES AND GASTROPODS AT TORREY PINES STATE BEACH AND SEA CLIFFS, SAN DIEGO AND DEL MAR, CALIFORNIA

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There is information that can be gleaned about the nature of mollusks in rocks either before or after they have fallen to the beach from the sea cliffs. Illustrations include the oyster *Ostrea idriaensis*, its shell occupied by acorn or related barnacles and burrowing sponges.

The prolific Eocene *Teredo* lived in drift wood. The carbonized wood and *Teredo* galleries filled with silt demonstrate the abundance of them in Tertiary seas. Some wood still has shells attached. The molds of the bivalves and gastropods show excellent detail. Some are even geodes of anhydrite crystals.

LATE PLEISTOCENE INVERTEBRATE RECORD OF SAN DIEGO BAY, SOUTHERN CALIFORNIA

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The California Environmental Quality Act (CEQA) mandates that all governmental agencies implement monitoring and mitigation procedures for the preservation of archaeological and paleontological resources if they are likely to be adversely impacted by construction-related activities. In the City of San Diego, California, environmental requirements for its Monitoring, Mitigation, and Reporting program must be included on Applicant's project proposal before a building or construction permit is issued.

Paleontological monitoring and salvage collection during excavation for, and construction of, a new sewer pump station to replace the existing Sewer Pump Station no. 5, located on the western corner of Harbor Drive and Beardsley Street south of downtown San Diego, resulted in important collections of late Pleistocene invertebrate fossils from the Bay Point Formation. The Bay Point Formation dates to the peak of the last interglacial epoch (125,000 yrs BP), and to substage 5e of the marine oxygen isotope ($\delta^{18}O$) record. The formation is also correlative with marine sediments on the Nestor Terrace, which has been dated by uranium-series techniques using the solitary coral *Balanophyllia elegans* Verrill, 1864.

Fossiliferous sediments were present from 2.4 to 4.9 m (8-16 ft) below the ground surface, and consisted of an upper, silty fine sand, and lower, coarser shelly sands. The lowermost 0.3 m (1 ft) is a transgressive lag deposit dominated by shells of *Anomia* and *Ostrea*, and by heavily bioeroded and reworked shells along with scattered pebbles and cobbles. The only erosional unconformity in the section is below the *Anomia-Ostrea* bed. This lower unit correlates with the *Anomia* bed identified by early workers at Indian Point, 1.1 km (0.7 mi) km to the southeast.

The composite fauna from trench C3 (SDSU loc. 3850, LACMIP loc. 16881) and from the main pump station excavation (SDSU loc. 3851, LACMIP loc. 16884), representing nearly one hundred species and several thousand specimens, is dominated by bivalve and gastropod mollusks (39 and 43+ species, respectively). The fauna also contains one scaphopod, unidentified foraminifera, sponge borings, encrusting bryozoans, polychaete worm tubes, unidentified crab claws, three species of barnacles, a sand dollar and indeterminate echinoid spines, and miscellaneous rare vertebrate remains, mostly fish.

The most common species are the gastropods *Nassarius tegula, Crucibulum spinosum, Eupleura muriciformis*, and *Caecum californicum*, and the bivalves *Chione undatella, Ostrea conchaphila, Tellina meropsis, Mactrotoma californica, Psammotreta viridotincta, Laevicardium substriatum, Semele pulchra, Tagelus californianus*, and *Dosinia ponderosa*. *Chione californiensis* is relatively common and *Anomia peruviana* is relatively abundant in the basal portion of the fossiliferous section. Most of these species live in intertidal to shallow subtidal depths in or on sandy or muddy bottoms in protected bays and estuaries, a paleogeographic setting similar to that proposed for this part of San Diego Bay in the late Pleistocene.

Late Pleistocene estuarine faunas in California that date to the peak of the last interglacial period typically contain a distinct warm-water element, suggestive of paleoclimatic conditions warmer than those present at their current latitude. The fauna from the pump station site contains at least ten extralimital southern (tropical) species that are suggestive of water temperatures equivalent to those found today on the outer coast of central Baja California 560-640 km (350-400 mi) south of San Diego. The most common of these southern species are the bivalves *Dosinia ponderosa, Psammotreta viridotincta,*and *Trachycardium procerum*, and the gastropod *Eupleura muriciformis*.

PALEOCLIMATIC RECONSTRUCTION OF THE SOUTHERN OREGON COAST 80,000 YEARS BP: CAN INFERENCES BASED ON BIVALVE SHELL MINERALOGY AND MOLLUSCAN PALEOZOOGEOGRAPHY BE RESOLVED?

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Paleoclimatic inferences based on modern zoogeographic ranges of fossil mollusks have previously been at odds with results based on oxygen isotope studies. Early work in the 1960's was hampered by the lack of adequate dating methods that could discriminate the several sea-level high stands that make up the last interglacial complex (equivalent to oxygen isotope stage 5, or 75,000 to 130,000 yrs BP) of the late Pleistocene. More recent isotopic studies in southern California have suggested that the peak of the last interglacial period was cooler than at present, although the faunal (zoogeographic) evidence would suggest just the opposite — marine temperatures were warmer, at least seasonally, than they are today, especially in protected estuarine settings. A new approach to paleoclimatic reconstruction utilizing $^{18}O/^{16}O$, Mg/Ca, and Sr/Ca ratios in marine bivalve mollusks may help resolve some of these past differences. As a test case, we have examined the late Pleistocene marine fauna from the Whisky Run Terrace at Coquille Point in Bandon, Oregon (LACMIP loc. 2636). This fauna dates to the period about 80,000-85,000 yrs BP (based on amino acid and uranium-series dating techniques) and the later, cool-water phase (substage 5a) of the last interglacial complex (stage 5).

The marine invertebrate fauna from Coquille Point is comprised of approximately 65 species, most of which are gastropods, bivalves, and barnacles. Sixteen of these are extralimital northern species, indicative of cooler-water conditions in the late Pleistocene than presently exist along the southern Oregon coast. Although there is not a perfect concordance in the overlap of geographic ranges, most of the species ranges suggest temperature conditions equivalent to those of the modern Columbian subprovince of the Oregonian [zoogeographic] province, which extends from Dixon Entrance, north of the Queen Charlotte Islands, British Columbia, southward to Puget Sound, Washington. Published sea-surface temperatures (SST) for this region range from about 6.1° - 7.8° C. in January to March, and about 10.5° - 15.5° C. in July and August. However, the presence at Coqulle Point of the extralimital gastropod *Puncturella noachina*(Linne), which ranges today only as far south as the Gulf of Alaska, or possibly to Juneau, suggests even colder-water conditions.

Isotopic ($\delta^{18}O$) and minor element (Mg/Ca, Sr/Ca) compositional analyses of the mussel *Mytilus trossulus* (Gould) from the Whisky Run Terrace also allow another approach to paleoclimatic reconstruction of the southern Oregon coast during substage 5a. The oxygen isotopic composition of marine shells depends on both the temperature and the $\delta^{18}O$ of the surrounding seawater, and can be further affected by changes in salinity. Because such elemental ratios as Mg/Ca of the calcitic shell fraction of *Mytilus trossulus* vary linearly with seawater temperature, with little or no salinity effect, paired element and isotopic analyses of calcareous skeletons can be used to estimate the $\delta^{18}O$ of the original seawater. Skeletal oxygen isotopic values and Mg/Ca compositions show cyclic variations, the lowest $\delta^{18}O$ values coming from those parts of the shell deposited during the summer months (or times of decreased salinity), and the lowest Mg/Ca ratios coming from those parts of the shell deposited during the relatively colder months. The cyclic variation of the test *Mytilus* shell from Bandon spanned approximately three years of growth. The skeletal Mg/Ca ratios, which are relatively insensitive to salinity variation, yielded a mean annual SST estimate of 5.8° C., with an overall range of 4.7° to 7.8° C. The mean annual SST estimate is lower than that predicted using the zoogeographic aspect of the Bandon fauna, and is about 5.8° C. less than the published present mean annual SST (11.6° C.) at Bandon.

Additional calibration studies of modern and fossil *Mytilus* shells are currently being proposed for grant support, with the hope that further study will yield unambiguous paleoclimatic reconstructions for the late Pleistocene marine record.

A NEW UPPER OLIGOCENE CYPRAEOID FAUNA FROM THE ADOUR BASIN (SOUTHWESTERN FRANCE): AN EVOLUTIONARY PERSPECTIVE

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A very rich, beautifully preserved and largely undescribed fauna has been recovered from the Upper Oligocene (Chattian) deposits of the Adour Basin, SW France, containing over 1,100 marine gastropod species (66,000 specimens) belonging to 440 genera in 130 families and subfamilies. It includes 53 Cypraeoid species (34 Cypraeidae, 8 Ovulidae, 11 Triviidae), which are particularly common in outcrops where coral reef assemblages occur. Lower Oligocene faunas from the same region contain only 7

Cypraeidae, 3 Ovulidae, and 4 Triviidae. This discovery sheds new light on the diversification of Cypraeoidea during the European Oligocene, until now known based on species-poor deposits in the North Sea basin (Belgium, Germany) or badly preserved remains in Italy. The newly discovered assemblages are equivalent in richness to the Lower Miocene of southern Europe (France and Italy), where a total of 25 Cypraeidae, 6 Ovulidae, and 11 Triviidae has been recorded. Thus the recently exposed view that an important radiation of Cypraeoidea took place in the Lower Miocene, is a sampling artifact of the fossil record, results from the scarcity of adequate Oligocene deposits rather than from an actual diversification after the Oligocene. Incidentally, our results show that commonly held views on the Conid radiation equally need to be readdressed.

FOSSIL AND RECENT SPECIES OF EASTERN PACIFIC CYPRAEACEA (CYPRAEIDAE AND EOCYPRAEINAE [OVULIDAE]): AN UPDATE.

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Groves (1993) reported 72 species of fossil and Recent cypraeaceans from the eastern Pacific. Based upon a reassessment of that fauna, additions of species unknown to the eastern Pacific in 1993, and a new definition of the study area that count now stands at least 86 but does not include the ten species of ovulids of the subfamily Ovulinae as only the ovulid subfamily Eocypraeinae is now included. New species described since 1993 are *Zonaria (Zonaria) emmakingae* Groves, 1994 from the Miocene Topanga Canyon Formation of Los Angeles County, California, *Nucleolaria cowlitziana* Groves, 1994 from the Eocene Cowlitz Formation of Lewis County, Washington, and *Proadusta goedertorum* Groves & Squires, 1995 from the Eocene Crescent Formation of Thurston County, Washington. New species of *Bernaya* to be described include a species of *Bernaya s.s.* from the Cretaceous of Vancouver Island, British Columbia, a *Bernaya (Protocypraea)* from the Cretaceous of the Santa Ana Mountains of Orange County, California, and a *Bernaya s.s.* from the Eocene of Jefferson County, Washington. Four new species of *Eocypraea s.s.* will be described including one from the Paleocene of Lake County, California, one from the Eocene Cowlitz Formation of Thurston County, Washington, one from the Bateque Formation of Baja California Sur, Mexico, and one from the Gatuncillo Formation of Panamá. Two new species of *Zonaria* will be described from the Pliocene Esmeraldas beds of the Angostura Formation of Ecuador. An additional species not listed by Groves (1993) is now reported from the eastern Pacific, that being *Eocypraea (Eocypraea) moumeti* Dolin & Dolin, 1983 from the Eocene Domengine Formation of Fresno County, California.

Species of Fossil and Recent Cypraeacea of the Eastern Pacific

[IP] = Indo-Pacific species. [Mio-Rec], [Plio-Rec], or [Pleis-Rec] = Californian/ Panamic/Caribbean species with fossil record in the eastern Pacific. * = doubtful Recent records.

Cretaceous

Family Cypraeidae

Bernaya (Bernaya) crawfordcatei Groves, 1990
B. (B.) n.sp. [Haslam Fm., Vancouver Id., British Columbia]
B. (Protocypraea) argonautica (Anderson, 1958)
B. (P.) berryessae (Anderson, 1958)
B. (P.) gualalaensis (Anderson, 1958)
B. (P.) rineyi Groves, 1990
B. (P.) n.sp. [Ladd Fm., Santa Ana Mountains, Orange Co., CA]
Palaeocypraea (Palaeocypraea) fontana (Anderson, 1958)
P. (P.) suciensis (Whiteaves, 1895)

Family Ovulidae, Subfamily Eocypraeinae

Eocypraea (Eocypraea) louellae Groves, 1990

Paleocene

Family Cypraeidae

Propustularia kemperae (Nelson, 1925)
P. simiensis (Nelson, 1925)

Family Ovulidae, Subfamily Eocypraeinae

Eocypraea (Eocypraea) novasuma (Nelson, 1925)
E. (E.) n.sp. [Lake Co., CA]
Sphaerocypraea martini (Dickerson, 1914)

Eocene

Family Cypraeidae

Bernaya (Bernaya) fresnoensis (Anderson, 1905)
B. (B.) saltoensis (Clark *in* Clark & Durham, 1946)
B. (B.) n.sp. [Discovery Bay, Jefferson Co., WA]
B. (Protocypraea) grovesi Squires & Demetrion, 1992
Cypraeorbis colombiana (Clark *in* Clark & Durham, 1946)
Gisortia (Megalocypraea) clarki Ingram, 1940b
G. (M.) thomasi Olsson, 1930
Nucleolaria cowlitziana Groves, 1994
Proadusta goedertorum Groves & Squires, 1995

Family Ovulidae, Subfamily Eocypraeinae

Cypraedia (Cypraedia) cf. *C. fenestralis* Conrad *in* Wailes, 1854
C. (Eucypraedia) multicarinata (Dall, 1890)
= *C. (E.) multicarinata chira* Olsson, 1931
= *C. (E.) carmenensis* Clark *in* Clark & Durham, 1946
Cypraeogemmula warnerae Effinger, 1938
Cyproglobina (Luponovula) boggsi (Olsson, 1928)
Cypropterina (Cypropterina) ludoviciana (Johnson, 1899)

= *C. (C.) pijiguayensis* (Clark *in* Clark & Durham, 1946)
Eocypraea (Eocypraea) castacensis (Stewart, 1926 [1927])
E. (E.) maniobraensis Squires & Advocate, 1986
E. (E.) moumeti Dolin & Dolin, 1983
E. (E.) n.sp. 1 [Bateque Fm., Baja Calif. Sur, Mexico]
E. (E.) n.sp. 2 [Crescent Fm., Thurston Co., WA]
E. (E.) n.sp. 3 [Gatuncillo Fm., Panamá]
Sphaerocypraea negritensis (Olsson, 1928)
Sulcocypraea bullennewtoni (Olsson, 1930)
S. mathewsoni (Gabb, 1869)

Eocene\Oligocene
Family Ovulidae, Subfamily Eocypraeinae
Sulcocypraea oakvillensis (van Winkle, 1918)

Miocene
Family Cypraeidae
Muracypraea almirantensis (Olsson, 1922)
= *M. merriami* (Ingram, 1939b)
M. amandusi (Hertlein & Jordan, 1927)
M. angustirima (Speiker, 1922)
M. henekeni (Sowerby, 1850)
= *M. andersoni* (Ingram, 1947a)
= *M. projecta* (Ingram, 1947b)
= *M. tuberae* (Ingram, 1947a)
M. mus isthmica (Schilder, 1927)
Propustularia parisimina (Olsson, 1922)
Zonaria (Zonaria) emmakingae Groves, 1994
Z. (Pseudozonaria) telembiensis (Olsson, 1964)
Family Ovulidae, Subfamily Eocypraeinae
Cypropterina (Jenneria) gabbiana (Guppy, 1876)
Sphaerocypraea wegeneri Schilder, 1939
= *S. keenae* (Woodring, 1959)

Pliocene
Family Cypraeidae
Luria chilensis (Philippi, 1887)
Luria cinerea (Gmelin, 1791) [Carib/Mio?, Plio-Rec]
= *L. limonensis* (Ingram, 1940a)
= *L. morinis* (Ingram, 1939a)
L. costaricaensis (Ingram, 1940a)
Muracypraea cayapa (Pilsbry & Olsson, 1941)
Propustularia bartschi (Ingram, 1939a)
Zonaria (Zonaria) n.sp. [Angostura Fm., Esmeraldas Prov., Ecuador]
Z. (Pseudozonaria) n.sp. [Angostura Fm., Esmeraldas Prov., Ecuador]
Family Ovulidae, Subfamily Eocypraeinae
Cypropterina (Jenneria) panamensis (Olsson, 1967)

Pleistocene/Recent
Family Cypraeidae
Blasicrura alisonae (Burgess, 1983) [IP]
B. teres (Gmelin, 1791) [IP]
Erosaria (Erosaria) acicularis (Gmelin, 1791) [Carib]*
E. (E.) albuginosa (Gray, 1825) [Pleis-Rec]
E. (E.) cernica (Sowerby, 1870) [IP/Pleis]
E. (E.) helvova (Linné, 1758) [IP]
E. (Ravitrona) caputserpentis (Linné, 1758) [IP]
Errones (Errones) caurica (Linné, 1758) [IP]*
Luria isabellamexicana (Stearns, 1893)
Lyncina lynx (Linné, 1758) [IP]*
L. schilderiana (Iredale, 1939) [IP]
L. vitellus (Linné, 1758)
Macrocypraea cervinetta (Kiener, 1843) [Plio-Rec]
Mauritia (Mauritia) depressa (Gray, 1824) [IP]
M. (M.) maculifera Schilder, 1932 [IP]
M. (M.) scurra (Gmelin, 1791) [IP]
Monetaria (Monetaria) moneta (Linné, 1758) [IP]
M. (Ornamentaria) annulus (Linné, 1758) [IP]
Staphylaea staphylaea (Linné, 1758) [IP]*
Talparia talpa (Linné, 1758) [IP]
Zonaria (Zonaria) aequinoctialis Schilder, 1933 [Pleis?-Rec]
Z. (Z.) annettae (Dall, 1909) [Plio-Rec]
Z. (Neobernaya) spadicea (Swainson, 1823) [Plio-Rec]
Z. (Pseudozonaria) arabicula (Lamarck, 1810) [Pleis-Rec]
Z. (P.) nigropunctata (Gray, 1825) [Plioc-Rec]
= *Z. (P.) darwini* (Ingram, 1948)
Z. (P.) robertsi (Hidalgo, 1906)
Family Ovulidae, Subfamily Eocypraeinae
Cypropterina (Jenneria) pustulata [Solander, 1786] [Pleis-Rec]
Pseudocypraea adamsoni (Sowerby, 1832) [IP]
Family Pediculariidae
Pediculariella californica (Newcomb, 1854) [Pleis-Rec]

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MURACYPRAEA HENEKENI (SOWERBY, 1850) IN THE CARIBBEAN AND PANAMA: ONE SPECIES OR TWO?

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An examination of specimens of *Muracypraea henekeni* (Sowerby, 1850) in the Vokes collection at Tulane University revealed that the six specimens from Panama were clearly distinguishable from the Dominican Republic specimens of the same age. This leads to the hypothesis that the synonymy of *M. henekeni* published by Woodring may have been overly conservative. It appears that there were at least two distinct species present in the Caribbean and Panama during the late Miocene and early Pliocene. Resolution of this question will involve a review of the genus in order to determine a more appropriate taxonomic organization.

MURACYPRAEA IN THE PROTO-GULF OF CALIFORNIA: A REVIEW OF PRIOR REPORTS AND A REPORT OF NEW DISCOVERIES

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The cypraeid genus *Muracypraea* first appears in the early Miocene of Trinidad (Schilder, 1939). It occurs throughout the southern Caribbean region from the Miocene to the Recent. On the Pacific coast of the Americas, documented occurrences have previously been reported only from the Pliocene of Ecuador (Pilsbry & Olsson, 1941) and the middle Miocene of Baja California Sur, Mexico (Hertlein & Jordan, 1927). The only other published Pacific Coast occurrence was its appearance in a faunal list for the Lower Pliocene Imperial Formation of Imperial County, California (Powell, 1988). This report was derived from unpublished work of Stump (Powell, 1993, Stump, 1972). Efforts to confirm this report have resulted in locating several specimens that are clearly referable to *Muracypraea*. The discovery of these specimens confirms the occurrence of *Muracypraea* in the Imperial Formation and the Salda Formation of the cape region of Baja California. This confirms its survival into the late Pliocene of the proto-Sea of Cortez. These specimens are distinct from all previously described species and represent 2-3 undescribed species. An additional result of this investigation is the confirmation of the occurrence of *Macrocypraea* in the Imperial Formation. This is a significant extension of the stratigraphic range of *Macrocypraea* into the earliest Pliocene/latest Miocene.

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In the spirit of this symposium and as a part of a larger project on the phylogeny of Recent Cypraeidae, we translated the classic paper "Die Genera der Cypraeacea" by F. A. Schilder (1939) into English. Its style epitomizes classic late nineteenth and early twentieth century systematic biology: largely based on relative rather than absolute observations, being authoritative, and rooted in experience. This led to fruitful discussions on the presentation of data, influencing our own approach to science, and also a deeper appreciation of the social and philosophical contexts of science.

We decided to complete the translation and make it available to the malacological community, accompanied by our notes on cypraeid characters. This talk will be a brief presentation of the translation and some of our editorial choices, followed by a discussion of the differences between traditional systematic biology and contemporary approaches, cladistics in particular.

MOLECULAR PHYLOGENY OF LIVING CYPRAEA

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Cypraeid gastropods are an ideal taxon with which to test various ecological, evolutionary or biogeographical questions. However, a robust phylogeny is prerequisite in order to falsify historical hypotheses and to avoid the use of paraphyletic groups. Unfortunately as of yet, a phylogeny has not been developed. To this end, 620 base pairs of the cytochrome oxidase subunit I mitochondrial DNA were sequenced from over 35 species of Cypraea, three Ovulids, one Triviid, and three other putative outgroups. Sequenced taxa represent a broad phylogenetic sampling of extant cypraeid diversity. In order to generate a hypothesis of relationships, various phylogenetic analyses were performed on the data set including parsimony under several weighting schemes and maximum likelihood. These results will be compared.

In addition to the COI data set, preliminary sequence data from a non-coding region (16S) and a morphological data set are compared to reveal taxonomic congruence. Decay indices are derived from the molecular phylogenies to assess the robustness of the tree topology. The evolutionary implications of these results will be discussed and compared to previous works by other authors.

A NEW EXAMINATION OF CYPRAEA GENERA CLASSIFICATION

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A recently completed study presents illustrations of the radulae of more than 200 species of cowries. (Bradner and Kay, The Festivus, submitted). The radulae are arranged in 13 patterns based primarily on the form of the central tooth. The patterns, originally intended merely as a convenient way of grouping species with similar radular characteristics, are remarkably consistent with M. Schilder & F. Schilder's (1971) generic arrangement of the cowries. Significant pattern features will be illustrated, and scanning electron microscope photographs of representative radulae will be shown.

EVOLUTION OF GASTROPOD FEEDING: MULTIPLE PHYLOGENETIC PATHWAYS THROUGH A STRUCTURAL AND FUNCTIONAL DESIGN SPACE

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Evolutionary novelties in gastropod feeding include repeated parallel structural and functional modifications of the radula and ctenidium as well and unique innovations affecting structures not normally involved in feeding. Understanding the feeding biology of gastropods is thwarted by classifications that conflate various structures used to obtain food (e.g. ctenidial filter feeder, ciliary feeder) with the nature of food ingested (e.g. carnivore, herbivore, detritivore) or the location of food in the environment (suspension feeder, deposit feeder). The diversity of gastropod diets, feeding structures, and feeding mechanisms define a three-dimensional feeding design space through which I trace both unique and repeated, parallel phylogenetic trajectories. Suspension feeders provide an especially instructive example of parallel as well as unique solutions to the problem of removing nutritionally valuable particles from the water column and concentrating and transporting them to the site of ingestion.

Feeding structures, feeding mechanisms, and diets commonly change during ontogeny. The most dramatic ontogenetic shifts are correlated with the dramatic habitat shifts at settlement and metamorphosis in taxa with planktotrophic development. Post-metamorphic ontogenetic shifts in feeding may be under morphological, biomechanical, or physiological constraints related to size.

ADAPTIVE RADIATION OF THE OVULIDAE: FEEDING AND BODY COLOR

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Ovulid caenogastropods are specialized predators on anthozoan coelenterates. Some species exhibit color patterns that contrast markedly with their preferred habitat while others are well camouflaged. Other taxa have taken camouflage to remarkable extremes by developing specialized color patterns and elaboration of mantle papillae to mimic polyps of their prey. The distribution of these different adaptations throughout the Ovulidae is discussed. More information on phylogenetic relationships of ovulids is required to document evolutionary patterns of feeding specialization and color patterns.

LOW TIDE AND THE BURYING BEHAVIOR OF *EUPRYMNA SCOLOPES* (CEPHALOPODA: SEPIOLIDAE)

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Abstract

Euprymna scolopes is a small sepiolid endemic to the Hawaiian Islands that buries in the sand during the day. At night it has been seen sitting on or swimming over intertidal sand in water as shallow as 2-4 cm deep. If buried in intertidal sand during the day when the tide goes out, it must flee or hide, or die of predation or dessication. Several experilments were performed at Coconut Island (Oahu, Hawaii) to determine if it gets caught by low tides, what it does if caught, and what it does to avoid low tides. It appears to have several behaviors capable of keeping it from getting beached. Why it might enter intertidal areas and the mechanisms for avoiding low tides are discussed.

Introduction

One of the most common cephalopods in the Hawaiian Archipelago is *Euprymna scolopes* Berry 1913. This small endemic sepiolid typically lives in shallow water on mud and sand flats but may also occur in deeper water to at least 180 m deep (Berry, 1914). Species of the genus *Euprymna* are nocturnal and bury themselves in the substrate during the day (Singley, 1983).

Knowledge about *Euprymna scolopes* is increasing in recent years. Originally described by Berry (1913), Arnold et al (1972) documented development and laboratory maintenance, Moynihan (1983) elucidated aspects of its behavior, color changes and body patterning, and Singley (1983) delineated the life cycle. Shears (1986, 1988) characterized its use of a sand coat and determined diel activity. The light organ and the bacteria contributing to its light production have been studied by Montgomery and McFall-Ngai (1993) and Gillis (1993). Aspects of its escape behaviors in the field have been determined (Anderson and Mather, in press) and it has been successfully cultured in the laboratory (Anon., 1996; Rummel, 1996). Despite this literature and others, numerous questions remain about this sepiolid.

Kaneohe Bay (Oahu, Hawaii) has long been known as a place to find large numbers of *Euprymna scolopes* (Berry, 1914; Arnold, et al., 1972; Anderson and Mather, in press). The sepiolid is found there in water as shallow as 2-4 cm deep at night on low tides (Kurt Fiedler, Univ. of Hawaii, pers. comm.) and has been seen perched on the bottom or swimming over intertidal sand at night during high tide (Anderson and Mather, in press). The question investigated in this paper concerns what *E. scolopes* does when it buries in sand exposed by daytime low tides. Several laboratory and field experiments were conducted to answer this question.

Materials and Methods

A transect 15 m long was laid out in the intertidal zone on the sand flats from the seawall to the water's edge at low tide on the west side of Coconut Island. For a description of the habitats on Coconut Island see Anderson and Mather (in press). Low tides were 3.0 cm below mean lower low water and the mean tidal range in Kaneohe Bay was 42.6 cm (Tides and Currents 2.0^{R}, Nautical Software, 1995). Wind speed, water currents, water temperature, and wave height were measured at the Lilipuna Pier and at the sand flats on the west side of Coconut Island. Water temperatures ranged from 23.9^{0} C (Lilipuna Pier) to 27.8^{0} C (study site). Water currents ranged from none detectable at the site on Coconut Island to 0.2 kph at the Lilipuna Pier. Wind speed ranged from 0-32 kph. Maximum wave heights during high wind periods at the Lilipuna Pier were judged to be 30 cm high.

Live *Euprymna scolopes* were collected by snorkeling at night (2000-2200 hr) next to the Lilipuna Pier in Kaneohe Bay in May 1996. As many as eight (mantle length [ML] greater than or equal to 1.0 cm) were seen per hour of snorkeling effort by one person, in addition to numerous juveniles (ML < 1.0 cm). Captured sepiolids were measured for ML and placed in a perforated bucket partially filled with sand and hung under the pier over-night. Animals were transferred by bucket to Coconut Island the next morning, where the experiments took place. All procedures were performed in the mid-morning during low tides.

Laboratory Experiments:

1. To determine whether *Euprymna scolopes* dig deeper in the sand at low tide, *E. scolopes* (N = 4) were placed individually in a thin, laterally compressed acrylic aquarium (30 X 30 X 2 cm) 2/3 full of sand with water added to the top. The sepiolids were allowed to bury completely. Burying was considered to be complete after the arms stopped throwing sand over the body (see Boletzky and Boletzky [1970]). The time from the start of burying activities to its completion was noted and the duration calculated. After burying was completed, the water was gradually drained out over approximately 5 min, and the behavior of the sepiolids was noted.

2. *Euprymna scolopes* (N = 4, different animals) were placed individually in a large shallow plastic container (40 X 30 X 15 cm) 2/3 full of sand sloping at a 5^{0} angle with sea water over it. The sepiolids were again allowed to bury and 5 min later the sea water was gradually drained out from the lower end of the sand and the behavior observed.

Field Experiments:

3. Six *Euprymna scolopes* were placed individually in a "corral" (a perforated white bucket with the bottom cut out) in water 2 cm deep and allowed to bury in the sand. The slope of the sand on the beach was not measured but was judged to be somewhat less than 5^{0}. The sepiolids were observed as the tide went out, approximately 30 min each. The observer's shadow was not allowed to fall on the sepiolids and he remained as still as possible to avoid thigmotaxic disturbance of the sand.

4. The sepiolids (N = 6, different animals) were allowed to bury within the corral in shallow water on an outgoing tide. The corral was then gently removed, and the sepiolids observed as the tide went out, approximately 30 min.

5. At the study site the hummocks typical of callianassid ghost shrimp burrows were present. Ghost shrimp produce U-shaped burrows with an inlet and an outlet hole on the surface of the substrate for water circulation. At low tide, the inlet and outlet holes could be differentiated by the water being pumped by the shrimp one way in or out. A corral was placed over the shrimp inlet or outlet holes in the sand and a single *E. scolopes* (N = 6, different animals) was placed within as the tide went out and reactions were noted.

Results

In both the laboratory and field studies the sepiolids (mean 1.1 cm ML) took an average of 66 sec to begin burying in the sand in the small acrylic tank, the shallow pan and in the corrals. Burying was completed in an average of 44 sec. There was no significant difference in burying times between different aspects of the experiments. Color of the sepiolids was dark red-brown until burying was completed. In all cases the last part of the burying behavior (throwing sand over the top of the head and mantle using the arms) appeared to cover the animal completely. The eyes were often visible in small openings in the coarse sand (approximately 1 mm diameter). These openings were approximately the same size as the grains of black sand present in the substrate.

In all cases the sepiolids appeared to be alert when buried. Several times when I rapidly approached the small aquarium or shallow pan, the sepiolids would squirt a jet of sandy water in the direction of my disturbance. One individual inked from a buried position without uncovering itself. Thereafter, the sepiolids were observed while making as little movement as possible so as not to disturb the animals.

1. When the water was gradually drained from the thin acrylic tank the sepiolids did nothing until the water depth was less than 10 mm deep. As the water depth decreased, the sepiolids partially emerged from the sand to the extent that the mantle openings could be seen. When the water level dropped to just below the top of the mantle openings (water depth about 5 mm), all individuals ejected 1-3 jets of sandy water, emerged totally from the sand and crawled about haphazardly. At this point they were placed back in the water after approximately 2 min.

2. After the *E. scolopes* had buried in the sloping sand in the shallow pan, water was gradually drained out to simulate a tide going out over a sloping sand beach. The *E. scolopes* behaved just as they did in the thin aquarium experiment, emerging partially from the sand as the water depth got less than 5 mm deep, squirting several jets of sandy water, and emerging completely from the sand as the water got below the mantle openings. Three of the four animals in this experiment crawled into deeper water and re-buried themselves; the fourth crawled onto dry sand and was eventually removed to water after 2 min.

3. The sepiolids corralled at the water's edge in 2 cm deep water on an outgoing tide also emerged from the sand when the water depth dropped below 5 mm, and crawled about haphazardly on the sand. There being no water for them to crawl to, they were then removed to water after 2 min.

4. *Euprymna* corralled in shallow water and allowed to bury prior to the corral being removed also emerged from the sand as the tide dropped and crawled haphazardly about. None of the six individuals tested made it to the water's edge before weakening and being removed to water.

5. Of 6 individuals corralled over inlet and outlet holes of callianassid shrimp burrows, two went down inlet holes, following the water level down the hole. None of the other six went down outlet holes of the shrimp. Due to time constraints the sepiolids down a shrimp hole were not watched until the tide came back up.

Discussion

Why do *Euprymna scolopes* move into depths exposed at low tides? They may be carried there by water currents or incoming tidal currents. Although the currents measured at the study sites were minimal, at times trade winds and squalls contributed to considerable wave action (at least 30 cm wave height) which could carry a drifting sepiolid into shallow water.

They may be following their food source or prey into intertidal areas. *Euprymna scolopes* are known to eat worms (polychaetes) and small shrimps (Moynihan, 1983; Singley, 1983; Shears, 1986; Shears, 1988). Although the worms were not identified to species, the shrimp (*Palaemon* spp) are known to live near shore (Edmondson, 1946). Shrimps also come out of the sand and into the water as the tide moves in and it is possible the sepiolids pursue prey into intertidal areas.

Sepiolids buried in or caught over intertidal sand on an outgoing tide can either move into deeper water or hide in the sand. Most *Euprymna scolopes* probably follow the tide out if there is a suitable declination to the exposed beach, as three of the four animals in the laboratory study exposed to an outgoing tide were able to crawl into deeper water down-slope. However, if caught on the sand flats that are relatively level (less than 5^0 declination), the sepiolids may die of desiccation or be exposed to predators. Predatory birds such as golden plovers, mynah birds and cattle egrets were observed patrolling the water's edge at the site on Coconut Island.

Based on the results of experiments corralling sepiolids on an outgoing tide, allowing them to bury and then removing the corral, it does not appear that *E. scolopes* follow the water out as the tide goes out over the sand flats during the day. When the water level got restrictively low, they emerged from the sand and crawled about haphazardly. It is possible they may be able to crawl to standing pools of water between the low hummocks of sand piled up by the ghost shrimp. Alternatively, they may be able to survive by going down a ghost shrimp burrow and following the water level down as the tide goes out. Ghost shrimp, although much larger than *E. scolopes*, up to 7.5 cm long (Edmondson, 1946), are detritivores and are not likely to harm the sepiolids. Further study is indicated to determine if there is a relationship between *E. scolopes* and callianassid ghost shrimp.

The sepiolids may avoid burying in intertidal sand by determining if the substrate is intertidal or not before the tide goes out. There may be differences in the composition of the sand and mud which the sepiolids can detect. Sepiids are known to choose appropriate sand to bury in (Mather, 1986) and sepiolids may also. If so, as it gets close to dawn and they need to bury themselves for the day, they may be able to swim until they find the appropriate sand to bury in, sand that they have learned or innately know to be subtidal. This is also a topic for further research.

Although there was no such indication as determined by this study, *E. scolopes* may have a rheotactic sense to water currents or waves. There was frequently a brisk trade wind blowing across the study site up to 32 kph, producing waves up to 30 cm high. These sepiolids may be able to sense when waves are approaching shore and swim against the waves or tidal currents out to deeper water.

Whatever factor or combination of factors that *E. scolopes* uses to avoid being stranded at low tide, it must be effective. During varying periods over three years, none were spotted during the day at low tide on the shores of Coconut Island. *Euprymna scolopes* possesses a complicated and multiple set of behaviors (Anderson and Mather, in press) and it is likely that those governing its avoidance of stranding are also complex and varied.

Acknowledgements

A warm "mahalo!" to Ernst Reese and other faculty and staff of the Hawaiian Institute of Marine Biology on Coconut Island for allowing me to perform this research there. F.G. Hochberg and Jennifer and Lynn Mather provided thoughtful and constructive comments on my initial research proposal and the preliminary draft of the manuscript.

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A BLOOD-SUCKING SNAIL: COOPER'S NUTMEG (*CANCELLARIA COOPERI*) PARASITIZES THE CALIFORNIA ELECTRIC RAY, (*TORPEDO CALIFORNICA*)

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Feeding behavior of the Cancellariid snail *Cancellaria cooperi* on a cartilaginous ray is described, with illustrations of the radula and behavioral interactions.

ALGAE IN SHELLS OF *PODODESMUS MACROCHISMA*: CUI BONO?

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The inner surface of the upper (left) valve of the jingle shell *Pododesmus macrochisma* is a pearly green due to the color of the nacre and also due in part to an alga incorporated in the shell matrix. These jingle shells live down to 90 m deep, deeper than the photic zone in the N. E. Pacific, particularly in Puget Sound (Washington State). If the green color is due to chlorophyll, do shells from deeper water still have alga in them? Chlorophyll content of these shells was determined comparatively between deep shells, shallow shells and jingles living in the dark (from the filters of the Seattle Aquarium). Results will be discussed along with ecological implications to both alga and the jingle.

CYMATIUM MURICINUM AND OTHER RANELLID GASTROPODS: MAJOR PREDATORS OF CULTURED TRIDACNID CLAMS

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The recent development of technology for the ocean culture of juvenile giant clams (family Tridacnidae) in the South Pacific has brought attention to the predatory activities of a hitherto little studied mesogastropod genus: *Cymatium* (family Ranellidae). After comprehensively reviewing existing knowledge of this family, this work presents estimates of the impact of four species of *Cymatium* on ocean-nursery

culture of *Tridacna gigas* and the results of research into relevant aspects of their biology: feeding behavior, growth and food consumption rates, reproduction and recruitment, environmental factors affecting recruitment, impact on tridacnid culture and prospects for predator control. Implications of these results are analyzed for giant clam farmers.

FEEDING ECOLOGY OF ASCOGLOSSAN OPISTHOBRANCHS: *PLACIDA DENDRITCA* ON PACIFIC ROCKY INTERTIDAL SHORES

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Ecological theory suggests that herbivores exhibit two major strategies of attack of their food plants ("stealthy" and "opportunistic") and that certain life-history attributes are associated with each of these strategies. Ascoglossan opisthobranchs, particularly tropical species, have been traditionally considered stealthy herbivores, exhibiting low population densities and conservative host use. The widely distributed, temperate ascoglossan *Placida dendritica* contrasts with this strategy by exhibiting many opportunistic attributes. (1) This slug species seasonally attacks ~70% of the *Codium fragile* hosts and ~20% of *C. setchellii* hosts on Oregon rocky intertidal shores. (2) *P. dendritica* forms feeding aggregations on *Codium* spp., and members of these aggregations survive better and grow faster than do solitary conspecifics. (3) Herbivory by *P. dendiritica* often results in "profligate" mass loss to algal hosts. For example, slug feeding severely damages *C. fragile*, and the resulting branch loss far exceeds the biomass actually consumed. (4) The temporal and spatial pattern of slug occurrence suggests that slugs are selectively attacking desiccation-stressed hosts. (5) On many temperate shores, *P. dendritica* has expanded its host-range to include the introduced and highly invasive *C. fragile* subsp. *tomentosoides. P. dendritica* is the only known ascoglossan that exhibits multiple attributes of the opportunistic strategy and, consequently, can often be an ecologically important grazer of its green algal hosts.

STUDIES ON DEVELOPMENT AND FEEDING HABITS OF THE CHESTNUT COWRIE (*CYPRAEA SPADICEA*)

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Although Cypraeidae are much appreciated and well-known for their beautiful shell form, relatively little is known about the animals that inhabit these shells. This is especially true for the only species living in California, the chestnut cowrie (*Cypraea spadicea*), whose development and feeding habits are almost completely unknown.

Development studies to date have shown that eggs are laid in a mass of about 4 cm in diameter and are brooded by the female for about 3 weeks. Veligers emerge that appear to be lecithotrophic, possess a distinct propodium, and are relatively slow swimmers with many settling to the bottom.

Preliminary studies of feeding preferences have shown that certain ascidians are highly favored foods and are chosen above all else. These include the colonial ascidian *Distaplia* and the solitary ascidian *Ascidia ceratodes*. Bryozoans (*Membranipora*) and the brown algae *Macrocystis*, *Egregia*, and *Laminaria,* red algae *Porphyra* and *Iridaea*, and green algae *Ulva* and *Enteromorpha*, as well as several sponges (*Halichondria* and *Haliclona*) are also favored foods.

EVOLUTIONARY IMPLICATIONS OF *DE NOVO* BIOSYNTHESIS OF DEFENCE COMPOUNDS IN OPISTHOBRANCHS

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Nudibranchs lack the mechanical protection of a shell yet are often brightly colored and conspicuous. Investigations into their chemical defences have been undertaken with increasing sophistication, since acid secretion was discoverd in the early 1960's. It is now known that many nudibranchs utilise borrowed chemistry to concentrate or modify the secondary metabolites of their prey. Recently a few species have been shown, by radioisotope labelling, to synthesise their own defensive compounds. A new method, using stable isotopes, has unambiguously confirmed *de novo* biosynthesis in additional species of sponge feeding cryptobranchs and in bryozoan feeding phanerobranch dorids for the first time. The geographical range theory of Falkner *et al.* 1990 is upheld. The possible evolutionary significance of these compounds is explored. A new theory is proposed which predicts that cryptobranch dorids with *de novo* biosynthesis will be large, non-cryptic annuals living in temperate environments.

MESOHERBIVORES DOMINATE GRAZER FAUNA IN INTERTIDAL RED ALGAL BEDS ON OREGON ROCKY SHORES

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The relative importance of grazing by small (meso-) and large (macro-) invertebrate herbivores in red algal beds on Oregon rocky intertidal shores was evaluated by measuring densities in the field and feeding rates in the laboratory. Mesograzers included small snails (*Littorina scutulata* and

Lacuna marmorata) and small crustaceans (amphipods and isopods); mesograzer densities were collectively several orders of magnitude greater than those of macrograzers, with amphipods being numerically dominant. Macrograzers (turban snails, chitons, large limpets, kelp crabs, urchins) collectively averaged <7 per 0.25 m^2 at high, mid, and low intertidal levels. Seasonal peak densities differed among common taxa: the turban snail *Tegula funebralis* peaked in January, the snail *Littorina marmorata* in May/June, and amphipods in September. Feeding rates were determined from experiments where grazers were offered the choice of 10 algal species. Population-level estimates of mesoherbivory were substantially greater than those of macroherbivory, suggesting that small gastropod and crustacean grazers on cold-temperate shores may be more important than previously recognized.

PRELIMINARY REPORT OF THE FEEDING OF THE NUDIBRANCH *ROBOASTRA EUROPAEA* GARCÍA-GÓMEZ, 1985 FROM THE STRAIT OF GIBRALTAR

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To date, nothing about the feeding habits of the polyceratid nudibranch *Roboastra europaea* García-Gómez, 1985 was known. The study of the digestive contents of several specimens of this species indicates it preys preferentially upon one or more species of the genus *Polycera*. Nevertheless, some radulae of other polyceratids, *Polycerella emertoni* and *Limacia clavigera*, are also found among the digestive contents. The feeding of *R. europaea* is compared with that of *R. tigris*, as well as future experiments to be developed to complete our results are proposed.

PHYLOGENY OF HYPSELODORIS (NUDIBRANCHIA: CHROMODORIDIDAE)

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The genus Hypselodoris contains approximately fifty described species and at least a dozen undescribed ones. Detailed studies of the anatomy of members of the genus reveal far more variability than previously described. Details of reproductive anatomy and distribution of mantle glands provide valuable new characters for systematic and phylogenetic study. Analysis of phylogenetic relationships indicates that there are two major clades. One clade is found in the eastern Pacific and Atlantic while the other contains inhabitants of the Indo-Pacific tropics. Other evolutionary trends in development of color patterns and anatomical specializations are discussed.

PHYLOGENY OF FISSURELLID GENERA HAVING THE *FISSURISEPTA* SHELL FORM

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Eleven fissurellid genera (four are to be described as new) are discussed. Nine genera have a septum that separates the mantle cavity from the visceral mass and five of the genera (the *Fissurisepta* group) obliterate the protoconch and early whorl by the expansion of the foramen as the shell matures. Established genera in the *Fissurisepta* group are *Fissurisepta* Seguenza, 1862, and *Altrix* Palmer, 1941.

Species occur at continental slope to abyssal depths. Genera are defined by three differing gill morphologies (the plesiomorphic bipectinate state, and two apomorphic monopectinate states are known) and three radular plans (the plesiomorphic plan and two derived plans are known), in addition to other characters of the immature and mature shell and the epipodium.

Although there are gaps in the data, a cladistic analysis is performed. The outgroup genus is *Emarginula* Lamarck, 1801, with no septum and an open slit. Also included in the analysis are the separate genera *Puncturella* Lowe, 1827, and *Cranopsis* A. Adams, 1860, and *Diodora* Gray, 1821, which has a reduced septum and the apical whorls obliterated by the foramen.

The analysis yielded 16 equally parsimonious trees treating all characters as unordered. The traditional sequence of *Emarginula*, *Cranopsis*, *Puncturella*, and *Diodora* is confirmed. Of seven more highly derived genera, two pairs form sister groups and the remaining genera form an unresolved polytomy with these two pairs of genera. Better resolution can be expected when missing information on anatomy, radula, and protoconchs is added to the matrix.

[Editor's Note: The following paper is based on work presented at the 1995 Annual Meeting in Fairbanks, Alaska. Maps and figures referred to in the text were not included with this submission.]

THE HOLOCENE MOLLUSCAN FAUNA FROM SHELL MIDDENS ON THE COAST OF PETER THE GREAT BAY (SEA OF JAPAN): PALEOENVIRONMENTAL AND BIOGEOGRAPHICAL SIGNIFICANCE

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Introduction

The study of Holocene molluscan fauna on the continental coast of the Sea of Japan began in 1970 (Evseev, 1971) and continues to the present time. The results and conclusions are based on the materials from cores of bottom deposits, coastal terraces and lowlands (natural and anthropogenic outcrops) within the region between the Tumangan River mouth (Russian - Korean border) and Zerkalnaya Bay (mid-Primoriye) (Evseev, 1975, 1976, 1979, 1981; Lutaenko, 1988, 1993a, b). Peter the Great Bay, situated in this region, is of great biogeographical interest as its molluscan fauna is very rich and diverse, and contains a large number of warm-water (tropical-subtropical and subtropical) species which are absent in the fauna of the mid-Promoriye region. A wide variety of biotopes and environmental conditions - from lagoonal and estuarine to open marine are found here, due to considerable indentation of the coast.

It is well known that the study of archaeological sites, and especially, shell middens - concentrations and heaps of marine and freshwater shells, can give valuable paleogeographic and faunal information. Although selective harvesting of mollusks by ancient people strongly biases faunal lists from archaeological sites, these lists may be much richer than data from boreholes and natural outcrops. This situation has been observed in studies of shell middens of the Late Holocene in Peter the Great Bay. This has led us to undertake a study in collaboration with the Institute of History, Archaeology and Ethnography of Peoples of the Far East of the Russian Academy of Sciences (Vladivostok) and Laboratory and Museum of Archaeology of the Far East State University (Vladivostok).

This paper is a review of data on the systematic composition of the largest shell middens of the region and an attempt to develop and analyze a faunal list in paleogeographic and biogeographical aspects.

Previous Studies

Shell middens on the coast of Peter the Great Bay (Figs. 1, 2) have been known since 1860 and were first investigated in 1880 by the Russian Far Eastern naturalist M. I. Yankovsky (Rakov, Brodiansky, 1985; Andreeva et al., 1986). Yankovsky compared these shell concentrations with Danish Kokkenmoddinger (Danish term for "shell middens" - Petersen, 1986). Some of the first systematic determinations of mollusks (to genus level) were made by naturalist V. K. Arseniev in 1921 (Okladnikov, 1963). In 1920 archaeological sites with molluscan shells were studied by the hydrobiologist A. I. Razin (1925, 1926) on the coasts of Amur and Ussuri Bays. Complex archaeological and faunal investigations were organized by A. P. Okladnikov (1963) in 1956 and 1960 on the coast of Pestchany Peninsula, Amur Bay. From the ancient settlement on the Pestchany Peninsula ten species of bivalves and two species of gastropods were preliminarily identified by I. M. Meshcheryakova (1963). In the early 1970's it became clear that shell middens on the coast of Peter the Great Bay belonged to a separate archaeological culture which was called "Yankovskaya" (Andreeva et al., 1986). It dates from the eight to the third centuries B.C. (Early Iron Age) (Brodianski, Rakov, 1992) or from the eight to the fifth centuries B.C. (Andreeva et al., 1986). Radiocarbon dates for Yankovskaya culture are from 2900 to 2300 years B.P. (Kuzmin, 1992). Russian archaeologists have published a number of works dealing with this culture (Andreeva et al., 1986; Kluev, 1993).

V. A. Rakov and D. L. Brodyansky continued studies of faunistic composition from sites on the coast of Peter the Great Bay during the 1970's. A brief review of mollusk species composition from Neolithic - Middle Ages sites (based on random materials) from Primoriye and Sakhalin Island was given by E. V. Krasnov et al. (1977). This list contains 15 species of Bivalvia and five species of Gastropoda. The most complete species list of mollusks from southern Primoriye sites was compiled by Rakov and Brodyansky (1985) and includes 19 species of Bivalvia and seven species of Gastropoda.

Two large sites with shell middens of Early Neolithic were discovered in 1987 on the coast of Boysman Bay, western part of Peter the Great Bay (Brodyansky et al., 1995). These sites are related to the newly recognized Boysmanovskaya culture. Radiocarbon dates for this culture lie between 4400 and 6300 years B.P. (Jull et al., 1994), which places it in the mid-Holocene age.

Another Neolithic culture - Zaysanovskaya, has radiocarbon dates from 3000 to 5000 years B.P. (Kuzmin, 1994), and also contains molluscan remains.

Species Composition of Molluscan Assemblages from Shell Middens

This paper deals with species composition of mollusks from seven most completely studied (from faunistic viewpoint) shell middens, two of them refer to Boysmanovskaya culture of Early Neolithic (Sites 1, 2 - see Tables 1, 2), 1 - to transitional Zaysanovskaya culture (Site 3), and 4 - Yankovskaya culture of the Early Iron Age (Sites 4-7). Also, data from species found in "Recent" shell middens are given in Tables 1 and 2 (column 8). These modern shell concentrations appeared at the end of 19th century and early 20th century due in Tables 1 and 2 (column 8). These modern shell concentrations appeared at the end of 19th century and early 20th century due to activity of Korean population and shows that harvesting of mollusks in the coastal zone of Peter the Great Bay has a long beginning during second part of the Holocene (since 5000-6000 years B.P.). Archaeological sites mentioned in Tables 1 and 2 and in the text are shown in Fig. 2.

Species composition of molluscan fauna from archaeological sites reflects faunal changes in shallow waters of southern Primoriye which were closely related to paleoenvironmental changes during Middle and Late Holocene, mainly climatic changes. We considered peculiarities of molluscan assemblages from sites of different cultures.

Boysmanovskaya culture

Twenty-one species of Bivalvia and 18 species of Gastropoda are know from two shell middens on the western coast of Peter the Great Bay. Small terrestrial snails found in some shell layers are not included to the list. The primary feature of these two sites is presence of two mid-Holocene indicators of warming (*Anadara subcrenata* and *Meretrix lusoria*); they do not live in Peter the Great Bay now. Recent northern boundaries of their distribution probably lie in the region of East Korean Bay (700-800 km southward). These two species are represented well from natural mid-Holocene deposits of Peter the Great Bay (Evseev, 1981; Lutaenko, 1993a) - on the coast of Ussuri Bay (*A. subcrenata*) and Vostok Bay (*M. lusoria*) (see Fig. 2). However, predominant species in the both shell middens is the oyster *Crassostrea gigas* (Jull et al., 1994). Analysis of species composition from molluscan assemblages of the Boysmanovskaya culture shows that these assemblages are impoverished upper subtidal mid-Holocene fauna of Peter the Great Bay. Zonal-geographical composition of the assemblages is characterized by presence of warm-water mollusks (subtropical-lowboreal and subtropical) as well as boreal (lowboreal and widely distributed boreal). The only tropical-subtropical mollusk - bivalve *Trapezium liratum*, does not live in this bay at present, and its nearest settlements are situated of 80-100 km distant, at the head of Amur and Ussuri Bays. This fact illustrates some changes in molluscan fauna of the Boysman Bay since Middle Holocene.

The data permit a general reconstruction of the environment of Boysman Bay during deposition of the shell middens. The archaeological sites were located on the coast of a semi-enclosed bay or lagoon with dense settlements of oysters (oyster beds). Some subfossil oysters have been washed out by Ryazanovka River about 100-150 meters from Boysman 2 site. Near mouth of the paleo-Ryazanovka River an estuarine zone was situated with suitable conditions for the brackish-water bivalve *Corbicula japonica*. *A. subcrenata*, *M. lusoria*, *Ruditapes philippinarum* and other representatives of warm-water fauna inhabited the subtidal zone of the paleo-bay. *Ruditapes philippinarum* and other representatives of warm-water fauna inhabited the subtidal zone of the paleo-bay. The average salinity in the bay probably was 20-25 o/oo. However, some mollusks from shell middens belong to inhabitants of open coast (e.g., *Spisula sachalinensis, Dosinia japonica, Mya japonica, Saxidomus purpuratus, Callista brevisiphonata)*. They occur on sandy and mixed (sand, gravel, pebble, etc.) substrates and live in Boysman Bay at present. Ancient people collected these mollusks on beaches after strong storms as mass stranding of live specimens is a common occurrence in Peter the Great Bay (Lutaenko, 1994).

Zaysanovskaya culture

The only completely studied shell midden of Zaysanovskaya culture is located on the coast of Expeditzii Bay (Possjet Bay). This site contains 14 species of bivalves and seven species of gastropods. Among them, *M. lusoria* represents a subtropical element of extinct fauna from Peter the Great Bay. Some bivalve mollusks from the Possjet 1 site do not live in the adjacent area of the Expeditzii Bay but occur on the relatively open coasts of Possjet Bay (*Glycymeris yessoensis, Megangulus zyonoensis, D. japonica). T. liratum* also found in this shell midden, does not live in Possjet Bay, but inhabit other areas of Peter the Great Bay. All gastropods, except for *Umbonium costatum*, are common species in Expeditzii Bay.

These data show that Zaysanovskaya culture's mollusks existed during relatively warm conditions. Unfortunately, limited sample size precludes further paleoecological treatment.

Yankovskaya culture

Indicators from the Yankovskaya culture are especially important for biogeography and paleogeography of the Primoriye Holocene, because we have little data from this period. A significant number of bivalve species have been discovered from four well-studied shell middens of the culture - 44 (Shelekha Cape - 32, Gladkaya 1 - 18, Pestchany 1 - 43, Chapaevo 1 -18). It should be noted that these data are most complete for the Late Holocene of southern Primoriye.

Among the bivalves of Yankovskaya culture both cold-water and warm-water elements have been recognized. Some cold-water species (e.g., *Panomya arctica*) are rare in shallow areas of Peter the Great Bay and occupy mainly the lower subtidal zone (below 20-30 meters). On the other hand, *A. subcrenata*, the extinct subtropical species in this region, is identified for the first time from the Late Holocene (Pestchany 1). We stressed before (Lutaenko, 1991) that *A. subcrenata* is a very characteristic species of the Atlantic molluscan fauna and is a reliable marker of the mid-Holocene deposits. The finding of this species in the Early Iron Age shows that some warm-water mollusks probably existed in Peter the Great Bay during Middle-Late Holocene and disappeared in the Latest Holocene (? 800-1000 years B.P.). The same faunal changes have been recognized recently by Japanese researches. According to Matsushima (1984), *T. liratum* is an extinct species at present along the northern coast of Hokkaido and was found only in the time span 6800 and 4000 years B.P. However, this mollusk is recognized as having lived around the Moyoro shell midden dates 1000 years B.P. (Sakaguchi et al., 1985). According to Nakagawa et al. (1993), Late Holocene (4000 - 2000 years B.P.) the molluscan fauna of the Wakasa Bay (Sea of Japan side of Japan) contains many subtropical species (e.g., *Anadara granosa*) which can not be found living here. This suggests that remnants of the mid-Holocene fauna of the climatic optimum existed in the Late Holocene time in different bays of the Sea of Japan and adjacent areas and disappeared only last 1000 years.

Biogeographical analysis of Pestchany 1 fauna shows that tropical-subtropical (5.9%) and subtropical and subtropical-lowboreal (45.1%) bivalve mollusks are predominant; the proportion of other groups, lowboreal, boreal/amphiboreal, and boreal-arctic, is 31.4%, 11.7%, and 5.9%, respectively (Rakov, Tolstonogova, 1991). This seems to point to a warm-water character of Late Holocene molluscan assemblages in southern Primorye.

The oyster *C. gigas* is a predominant species in many shell middens of the Yankovskaya culture.

Conclusions

The number of bivalve and gastropod species from sites of different archaeological cultures varies. Maximum number of bivalve species is found at Pestchany 1 site (43), minimum number - 14 (Possjet 1 site). Species number depends on the methods used during excavation of shell middens and selective harvesting of mollusks by people in the past. Ancient people collected mostly large and/or abundant mollusks in the coastal zone and from beaches after storms, and many small shells rarely found from archaeological sites are incidental species which live within oyster beds or collected occasionally for decorations. We can not consider "archaeological" molluscan assemblages as a full set of nearshore fauna. However, based on the species identified, some conclusions may be drawn.

The number of bivalve species commonly obtained from shell middens in Primoriye is limited to 30-40 species. Similar species numbers were found also in shell middens from Hokkaido (Akamatsu, 1969). This estimation should be treated as maximum species diversity for "archaeological deposits" in the coastal area of the Sea of Japan.

Ancient people exploited not only natural settlements of upper subtidal mollusks but they also collected shells and living animals on the beaches. This is based on the presence in shell middens of mollusks which inhabit open areas of Peter the Great Bay while many archaeological sites were located in semi-enclosed bays. Some warm-water bivalves mollusks which appeared in southern Primoriye during the climatic optimum of the Holocene time (Atlantic stage), do not live here at present, but can be found in Late Holocene deposits. Before they were only known from mid-Holocene time. *Meretrix lusoria* is probably the only reliable indicator of Atlantic warming in southern Primoriye.

Oyster settlements of mid- and late-Holocene ages were distributed more widely in Peter the Great Bay as compared to their present distribution. It is traced by the location of shell middens on the coast. Species composition of bivalve mollusks from shell middens of southern Primoriye and Hokkaido (Akamatsu, 1969) is similar except for *Amusium japonica, Meretrix lamarckii, Cyclina sinensis, Gomphina melanaegis*and *Tresus keenae*, which have never been lived in Peter the Great Bay. That are very warm-water species found chiefly from Early to Late Jomon shell middens (6000-3000 years B.P.). Characteristic species from Hokkaido's archaeological sites are belonging to "oyster complex", "estuarine complex", "marine epifaunal complex " and "marine complex of burrowing invertebrates" (terminology introduced by Brodianski and Rakov, 1992). This is related to similar ways of harvesting of mollusks by ancient people in both Peter the Great Bay and Hokkaido.

The total number of bivalves decreased in Late and Latest Jomon (13-14 species) comparing to Earliest to Middle Jomon (20-26 species) (see Table 3), while in southern Primoriye it reaches up to 43 species in the Late Holocene (Pestchany 1 site).

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Table 1

Species composition of gastropod mollusks from shell middens on the coast of Peter the Great Bay (Sea of Japan)

	species	1	2	3	4	5	6	7	8
1.	*Notoacmea concinna* (Lischke)	-	-	-	-	-	+	-	-
2.	*Lottia heroldi* (Dunker)	-	-	-	-	-	+	-	-
3.	*Lottia dorsuosa* (Gould)	-	-	-	-	-	+	-	-
4.	*Lottia radiata* (Rathke)	-	-	-	-	-	+	-	-
5.	*Acmaea pallida* (Gould)	+	+	-	+	-	+	+	+
6.	*Puncturella nobilis* (Adams)	-	-	-	-	-	+	-	-
7	*Tegula rustica* (Gmelin)	+	+	+	+	+	+	+	+
8.	*Umbonium costatum* (Kiener)	+	+	+	+	+	+	+	+
9.	*Homalopoma sangarense* (Schrenck)	+	+	+	+	+	+	+	+
10.	*Turritella fortilirata* Sowerby	+	-	-	-	-	-	-	-
11.	*Epheria turrita* (Adams)	+	+	-	-	-	+	-	-
12.	*Littorina sitchana* Philippi	-	-	-	-	-	+	-	-
13.	*Littorina mandshurica* Schrenck	+	+	+	+	+	+	+	+
14.	*Littorina brevicula* Philippi	-	-	-	-	-	+	-	+
15.	*Littorina squalida* Broderip et Sowerby	-	-	-	+	+	+	+	+
16.	*Fluviocingula nipponica* Kuroda et Habe	+	+	-	-	-	+	-	-
17.	*Assiminea lutea* Adams	+	+	-	-	-	+	-	-
18.	*Lunatia pila* (Pilsbry)	-	-	-	-	-	+	-	+
19.	*Cryptonatica janthostoma* (Deshayes)	+	+	-	+	+	+	-	+
20.	*Batillaria cumingii* (Grosse)	+	+	+	+	+	+	+	+
21.	*Cerithiopsis* sp.	+	+	-	-	-	-	-	-
22.	*Tritia acutidentata* (Smith)	+	+	+	+	+	+		+
23.	*Mitrella burchardi* (Dunker)	-	-	-	-	-	+	-	-
24.	*Neptunea lyrata* (Gmelin)	-	-	-	-	-	+	-	-
25.	*Neptunea bulbacea* (Bernardi)	+	+	-	-	-	+	-	+
26.	*Neptunea polycostata* Scarlato	-	-	-	-	-	+	-	+
27.	*Plicifusus plicatus* (Adams)	-	-	-	-	-	-	+	-
28.	*Buccinum middendorfi* Verkruzen	-	-	-	-	-	+	-	-
29.	*Tritonalia japonica* (Dunker)	-	-	-	+	+	+	+	+
30.	*Boreotrophon candelabrum* (Adams et Reeve)	+	+	-	+	+	+	-	+
31.	*Nucella heyseana* (Dunker)	+	+	-	+	+	+	-	+
32.	*Nucella cf. freycinettii* (Deshayes)	+	+	-	+	-	+	-	-
33.	*Rapana venosa* Valenciennes	+	+	+	+	+	+	+	+
34.	*Bela erosa* (Schrenck)	-	-	-	-	-	+	-	-

Table 2

Species composition of bivalve mollusks from shell middens on the coast of Peter the Great Bay (Sea of Japan)

	species	1	2	3	4	5	6	7	8
1.	*Acila insignis* (Gould)	-	-	-	-	-	+	-	-
2.	*Crenomytilus grayanus* (Dunker)	+	+	+	+	+	+	+	+
3.	*Mytilus trossulus* Gould	-	-	-	-	-	-	-	+
4.	*Mytilus coruscus* Gould	-	-	-	-	+	-	-	-
5.	*Musculista senhousia* (Benson)	-	-	-	-	-	+	-	-
6.	*Modiolus kurilensis* Bernard	-	-	-	-	-	-	-	+
7.	*Septifer keenae* Nomura	-	-	-	-	-	+	-	-
8.	*Grassostrea gigas* (Thunberg)	+	+	+	+	+	+	+	+
9.	*Glycymeris yessoensis* (Sowerby)	+	+	+	+	+	+	+	+
10.	*Glycymeris* sp.	+	-	-	-	-	-	-	-
11.	*Arca boucardi* Jousseaume	-	-	+	+	+	+	+	+
12.	*Anadara subcrenata* (Lischke)	+	-	-	-	-	+	+	-
13.	*Anadara broughtoni* (Schrenck)	+	+	-	+	+	+	+	+
14.	*Swiftopecten swifti* (Bernardi)	-	-	-	+	-	+	-	+
15.	*Chlamys farreri* (Jones et Preston)	-	+	+	+	+	+	+	+
16.	*Mizunopecten yessoensis* (Jay)	+	+	+	+	+	+	+	+
17.	*Laternula limicola* (Reeve)	-	-	-	-	-	+	-	-
18.	*Hiatella arctica* (L.)	-	+	-	-	-	+	-	+
19.	*Panomya arctica* (Lamarck)	-	-	-	-	-	+	-	-
20.	*Panomya* sp.	-	-	-	-	-	+	-	-
21.	*Panope abrupta* (Conrad)	-	-	-	-	-	+	-	-
22.	*Keenocardium californiense* (Deshayes)	+	+	-	+	+	+	+	+
23.	*Kellia japonica* Pilsbry	-	-	-	-	-	+	-	-
24.	*Diplodonta semiasperoides* Nomura	-	-	-	-	-	+	-	-
25.	*Felaniella usta* (Gould)	-	-	-	-	-	+	-	-
26.	*Pillucina pisidium* (Dunker)	-	-	-	-	-	+	-	-
27.	*Nipponomysella obesa* Habe	-	-	-	-	-	+	-	-
28.	*Megangulus venulosus* (Schrenck)	-	-	-	+	+	+	-	+
29.	*Megangulus zyonoensis* (Hatai et Nisiyama)	+	+	+	+	-	+	-	+
30.	*Cadella lubrica* (Gould)	-	-	-	-	-	+	-	-
31.	*Macoma tokyoensis* Makiyama	-	-	-	-	-	+	-	-
32.	*Gari kazusensis* (Yokoyama)	-	-	-	-	-	-	-	+
33.	*Corbicula japonica* Prime	+	+	+	+	+	+	+	+
34.	*Trapezium liratum* (Reeve)	+	+	+	+	+	+	+	+
35.	*Callista brevisiphonata* (Carpenter)	+	+	-	+	-	+	-	+
36.	*Saxidomus purpuratus* (Sowerby)	-	+	-	+	-	+	-	+
37.	*Dosinia angulosa* (Philippi)	-	-	-	-	-	+	-	-
38.	*Dosinia japonica* (Reeve)	+	+	+	+	+	+	+	+
39.	*Meretrix lusoria* (Roding)	+	+	+	-	-	-	-	-
40.	*Ruditapes philippinarum* (Adams et Reeve)	+	+	+	+	+	+	+	+
41.	*Mercenaria stimpsoni* (Gould)	-	-	-	-	-	-	-	+
42.	*Protothaca euglypta* (Sowerby)	-	-	-	-	-	+	-	+
43.	*Protothaca jedoensis* (Lischke)	-	-	-	+	-	+	+	+
44.	*Callithaca adamsi* (Reeve)	-	-	-	-	-	+	-	-
45.	*Anisocorbula venusta* (Gould)	+	+	-	+	+	+	-	+
46.	*Potamocorbula amurensis* (Schrenck)	-	-	-	-	-	+	-	-
47.	*Siliqua alta* (Broderip et Sowerby)	-	-	-	-	-	-	-	+
48.	*Solen krusensierni* Schrenck	-	-	-	-	-	-	-	+
49.	*Mactra chinensis* Philippi	-	-	-	+	+	+	+	+
50.	*Mactra veneriformis* Deshayes	-	-	-	+	-	+	+	-
51.	*Spisula sachalinensis* (Schrenck)	+	+	+	+	+	+	+	+
52.	*Mya japonica* Jay	+	+	+	+	+	+	+	+

Sites: 1, 2 - Boysman 1 and Boysman 2; 3 - Possjet 1; 4 - Shelekha Cape; 5 - Gladkaya 1; 6 - Pestchany 1; 7 - Chapaevo; 8 - "Recent" shell middens on the coast of Peter the Great Bay.

Table 3

Species number of bivalve mollusks from shell middens of Middle and Late Holocene in Hokkaido (calculated based on data of Akamatsu, 1969)

Regions Jomon	Earliest Jomon	Early Jomon	Middle Jomon	Late Jomon	Latest Jomon
1	0	2	18	0	0
2	0	0	4	8	2
1	0	2	18	0	0
2	0	0	4	8	2
3	6	7	8	0	0
4	14	22	18	8	13
5	9	7	0	0	0
In Total	20	23	26	13	14

Earliest Jomon - up to 6000 years B.P.
Early Jomon - between 5000 and 6000 years B.P.
Middle Jomon - between 4000 and 5000 years B.P.
Late Jomon - between 3000 and 4000 years B.P.
Latest Jomon - between 2000 and 3000 years B.P.

Regions:
1 - southern part of Hokkaido (Oshima Peninsula)
2 - western part of Hokkaido
3 - northern part of Hokkaido (Okhotsk Sea coast)
4 - eastern part of Hokkaido (Pacific coast)
5 - Utiura Bay and adjacent areas (southern part of Hokkaido)

Explanation to Test Figures

Fig. 1. Map of the Sea of Japan area. Arrow points to the Peter the Great Bay

Fig. 2. Map of Peter the Great Bay with archaeological sites where shell middens were studied.
1,2 - Boysman 1 and Boysman 2 sites
3 - Possjet 1 site
4 - Shelekha Cape site
5 - Gladkaya 1 site
6 - Pestchany 1 site
7 - Chapaevo site

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Minutes
Executive Board Meeting
Western Society of Malacologists
Handlery Hotel, San Diego, California
23 June1996

Called to order by President Hugh Bradner at 4:10 p.m.

Present: Board members Hugh Bradner, Terry Arnold, George Metz, Kirstie Kaiser, Don Shasky, Sandra Millen, Doug Eernisse, Henry Chaney. Observer Kim Hutsell.

Secretary Report: Minutes accepted as read. Published minutes will be amended to 'as read' version to correct error in adjournment time.

Treasurer Report: See attached. In the future sources of Student Grant funds will be shown in the Annual Report.

Student Grant Committee:
28 proposals
Winners to be announced 31 July.

Action item for Treasurer. Review bylaws to clarify funding of student grant.

Nominations for 1997:

President	Henry Chaney
First Vice President	Sandra Millen
Second Vice President	Roger Seapy
Secretary	Terry Arnold
Treasurer	George Metz
Members at Large	Saxon Sharpe
	Paula Mikkelsen

Voted to present proposed slate to membership at general meeting.

Publications: Kim Hutsell will edit 1996 Annual Report.

1997 Meeting: 22-26 June in Santa Barbara at Radisson Hotel. Joint meeting with AMU.
Symposia:
Deep Sea Mollusca (1 ½ days Mon & Tues.) Jerry Harasewych
Phylogenetic Systematics (Wed) Gary Rosenberg
Cephalopods of Northern Pacific (Thurs.) Eric Hochberg
Evenings:

Sunday	Reception
Monday	Open
Tuesday	Wine Tour
Wednesday	Auction
Thursday	Banquet

Related Meetings: COA 13-18 July, Captiva FL.

1998 Meeting: Vancouver 21-25 June at University of BC. Campus housing available as follows:

private rooms 54 single & 75 double; semi-private 30 CDN funds. Food is available on campus.

Possible overlap with Society for Study of Evolution meeting.

New Business:

Motion made, seconded, and passed to present to the membership a proposal to join the Malacological Society of Australasia as an affiliate member.

Issue of mailing cost for overseas members was raised. An airmail option will be added for overseas members.

Adjourned at 5:51 PM.

Respectively submitted by Terry S. Arnold, Secretary.

Minutes
Annual Business Meeting
Western Society of Malacologists
Handlery Hotel, San Diego, California
26 June1996

Called to order by President Hugh Bradner at 3:39 PM.

Secretary Report: minutes accepted as read.

Treasurer Report: Presented as attached. Accepted as read.

Student Paper Award: (Doug Eernisse) Thomas Duda is recipient of best student paper award.

Audit Committee: Preliminary review is acceptable. Final report will appear in Annual Report.

Student Grant:
28 proposals.
Recommendation due at end of July.

Motion to allocate $1000 to Student Grant fund moved, seconded, and passed unanimously.

Nomination Committee: Slate for 1997

President	Henry Chaney
First Vice President	Sandra Millen
Second Vice President	Roger Seapy
Secretary	Terry Arnold
Treasurer	George Metz
Members at Large	Saxon Sharpe
	Paula Mikkelsen

No nominations from floor.
Motion to accept nominations made, seconded and passed. Show of hands to elect proposed slate. All aye votes. Proposed slated elected for 1997.

New Business:

Motion by Terry Gosliner. Vote of appreciation for outgoing officers and Symposium organizers. Moved, seconded, and passed.

Motion by Hans Bertsch to provide available copies of past and future WSM publications to three Baja California Universities. Moved, seconded, and passed.

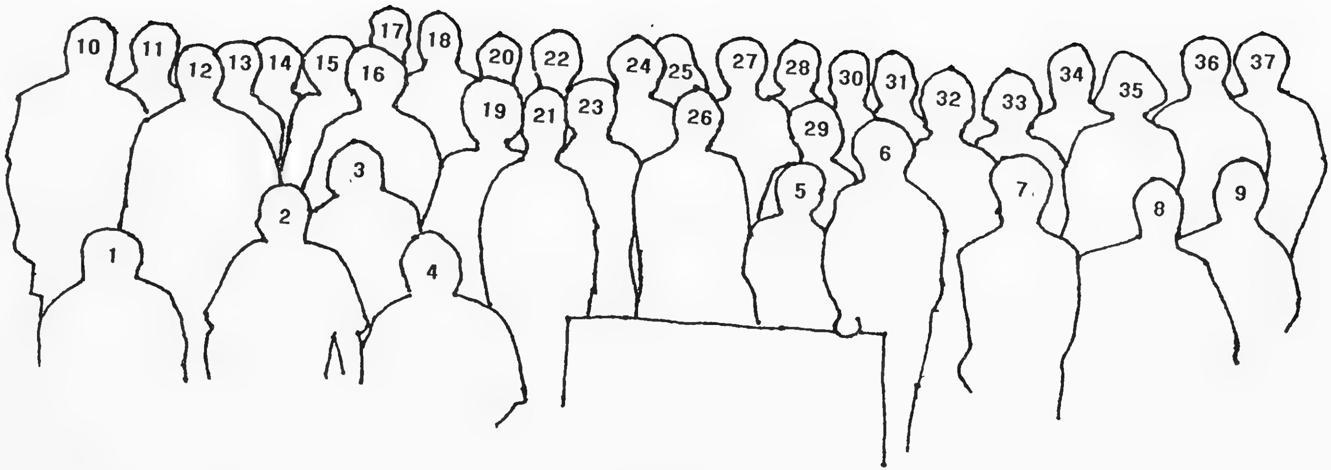
Auction and reprint sale:

Auction grossed	$3598.15
Reprints net	$139

Motion by Terry Arnold for WSM to join Malacological Society of Australasia. Moved Seconded and passed.

Adjourned 4:40 PM. Moved seconded and passed.

Respectively submitted by Terry S. Arnold, Secretary



The Western Society of Malacologists
Annual Meeting
San Diego, California - 1996

1. George E. Davis
2. Hugh Bradner
3. Marge Bradner
4. Ken Lindahl
5. Omar Diupotex
6. Maria E. Diupotex
7. Kirstie L. Kaiser
8. Carole S. Hickman
9. Kim C. Hutsell
10. Henry W. Chaney
11. Paul Skoglund
12. Jose Carlos Garcia Gomez
13. Donald R. Shasky
14. Wendy Koch
15. Walter D. Schroeder
16. Carol C. Skoglund
17. Kent D. Trego
18. Juan Lucas Cervera
19. Marge Lindahl
20. Christopher P. Meyer
21. Cesar Megina
22. Daniel Geiger
23. Wesley M. Farmer
24. Terry S. Arnold
25. Frank (Andy) Anderson
26. LouElla Saul
27. Richard L. Squires
28. Lindsey T. Groves
29. Yvonne Albi
30. Roland C. Anderson
31. George Metz
32. Cynthia D. Trowbridge
33. Barbara Chaney
34. Doug J. Eernisse
35. Carole M. Hertz
36. Jules Hertz
37. George L. Kennedy


Western Society of Malacologists
1996

WESTERN SOCIETY OF MALACOLOGISTS
TREASURER'S REPORT

1 October 1995 - 30 September 1996

INCOME

Membership dues	$2338.00	
Student Grant donations	275.00	
Symposium fund donations	213.00	
Interest from savings	479.52	
Royalties	210.11	
1996 Conference fees	4635.62	
Auction/Reprint sales	3491.60	
TOTAL INCOME during period		**$11642.85**

EXPENSES

Administrative (Fees, Dues, Officer Expense, Office Expense)	492.28	
1996 Student Grant	1000.00	
Publication of the 1994 & 1995 Annual Reports	1567.75	
1997 Meeting Advance Deposit	1500.00	
1996 Conference Expenses	3920.33	
TOTAL EXPENSES during period		**$8480.36**

Net Gain	$3162.49
Balance brought forward	3673.61
Current Balance	6836.10

Savings (Does not include Interest) **$10,007.21**

STUDENT GRANT AWARD RECIPIENT

Thomas F. Duda
University of Hawaii
Kewalo Marine Laboratory, 41 Ahui Street
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NETHERLANDS MALACOLOGICAL SOCIETY, c/o Zoological Museum, P.O. 4766, 100G AT Amsterdam, The Netherlands
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THE WESTERN SOCIETY OF MALACOLOGISTS

ANNUAL REPORT, FOR 1997/1998

VOLUMES 30/31

THE WESTERN SOCIETY OF MALACOLOGISTS

ANNUAL REPORT, FOR 1997/1998

VOLUMES 30/31

December 1998

PUBLICATIONS OF THE SOCIETY

Annual Report

The *Annual Report* of The Western Society of Malacologists is based on its yearly meeting. Distribution of the *Annual Report* is free to Members who are at the time of issue in good standing. Membership dues are $15.00 for Individuals, $17.00 for Families, $17.00 for Organizations, and $6.00 for Student Memberships.

Occasional Papers

No. 1. A. Myra Keen & Eugene V. Coan. 1975. "Sea Shells of Tropical West America": Additions and corrections to 1975. 66 pp. .... $ 5.00
No. 2. George E. Radwin & Eugene V. Coan. 1976. A catalogue of collations of works of malacological importance. 34 pp. .... $ 5.00
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Corrections to Volume 29

Page 6. The order of authorship for the following paper should read:

Klein, R. T., Kennedy, G. L., and Lohman, K. C. 1997. Paleoclimatic reconstruction of the southern Oregon coast 80,000 years BP: Can inferences based on bivalve shell mineralogy and molluscan paleozoogeography be resolved?

WESTERN SOCIETY OF MALACOLOGISTS, ANNUAL REPORT
TABLE OF CONTENTS, Volumes 30 / 31

VOLUME 30

Abstracts and Papers from the 30th Annual Meeting of the Western Society of Malacologists
and the 63rd Annual Meeting of the American Malacological Union
held jointly in Santa Barbara, California, 21-27 June 1997

VOLUME 31

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Do octopuses play?

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Play behavior is likely a sign of intelligence, and is an important activity of vertebrates, including mammals, birds, and perhaps reptiles. As cephalopods are known for their intelligence, it seems appropriate to look for play in this group. Small *Octopus dofleini* were held separately at The Seattle Aquarium and presented with a novel floating "toy." Presentations were made twice a day for five days, during which texture and brightness of the toy varied. Each octopus was observed during each presentation until it made no contact with the object for 30 minutes. We then compared the sequences of actions in the first and last days' observations, looking for different, prolonged or truncated sequences of behavior between them. Some actions and sequences were different, a necessary condition for the designation of "play." In addition, several octopuses showed a repeated behavior of "blowing" the toy away with a jet of water from the funnel only to have the toy circle the tank and return to the animal; this behavior continued for an extended period of time. The blowing behavior will be discussed as possible "play."

Statolith shape and microstructure in studies of systematics, age, and growth in planktonic paralarvae of gonatid squids (Cephalopoda: Oegopsida) from the western Bering Sea

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Microstructure, morphology and ontogenetic development of statoliths, and age and growth of 405 planktonic paralarvae and 117 juveniles belonging to ten species of gonatid squids (Cephalopoda, Oegopsida) were studied over and off the continental slope in the western part of the Bering Sea (57°00' to 61°30' N, 163°00' E to 179°20' W). Statolith microstructure of all species was characterized by the presence of a large droplet-shaped nucleus and bipartite post-nuclear zone divided in two by the first stress check, excluding *Berryteuthis magister*, which had only one stress check and the post-nuclear zone was not subdivided. In *Gonatus* spp., completion of development of the post-nuclear zone coincided with full development of the central hook on the tentacular club. Daily nature of statlith growth increments was validated by maintenance of 13 paralarvae belonging to the four most abundant species captured. Based on statolith microstructure, all species can be subdivided into two groups: (1) species with the nucleus in a central position in the first-check statolith (*Gonatopsis* spp., *Eugonatus tinro* and *B. magister);* and (2) species with the nucleus shifted to the inner side of the first-check statolith (*Gonatus* spp.). Comparative analysis of statolith morphology showed that paralarval statoliths have species-specific characters that allowed us to construct keys to species identification of gonatid paralarvae using their statoliths. Study of paralarval growth using statoliths revealed that cold-water planktonic gonatid paralarvae have rather fast growth rates in length, attaining 7-10 mm ML at early ages (15-20 days). Early juvenile sizes (20-25 mm ML) are attained at ages of 35-70 days.

A review of the family Simrothiellidae: The systematic status of the genera and their importance as a model for biogeography

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The family Simrothiellidae (Aplacophora: Neomeniomorpha) has a world-wide distribution at ocean depths between 75-4,300 meters. Six genera are placed in this family based on radula morphology, specifically possession of distichous bars with many denticles at some point during ontogeny and paired anteroventral radular pockets. The placement of *Uncimenia* in this family is somewhat dubious. This family may have important implications for understanding pre-Pangean biogeography. The genus *Helicoradomenia*, a vent species, is important because it possesses many of the plesiomorphic characters that are useful for defining and describing the primitive type Neomeniomorpha. The overview of this family will include a new genus and species collected from off the coast of Ireland and Scotland. (Supported by NSF DEB-PEET 95-21930.)

Problems and pitfalls in phylogeny inference as illustrated by molluscs

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Phylogeny inference is a field of biological researrh in which the results and conclusions of particular studies may depend heavily on the performance, accuracy and applicability of the methods and computer software used to analyze the data. In the present contribution we illustrate and discuss some controversial problems in phylogenetic data treatment. We particularly focus on (1) the differential performance of distance matrix programs applied to molecular data, (2) the use of bootstrapping, and (3) the effects of character choice and interpretation in parsimony analyses. These issues will be explored at different phylogenetic levels (from intraspecific taxa to phyla) using mainly, although not exclusively, molluscan examples based on both molecular (DNA sequences, RFL, RAPD, allozymes) and morphological data.

Squid (*Lolliguncula brevis*) distribution within Chesapeake Bay: Locomotive reasons for its ecological success

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The suggestion that squids evolved in environments where competitive intentions with fishes are minimized presumes that squid are inferior to fish with respect to swimming efficiency, endocrine functioning, and oxygen carrying capacity. However, one unique cephalopod, the brief squid *Lolliguncula brevis,* is frequently captured in the euryhaline waters of Chesapeake Bay where it is often in direct competition with hundreds of species of fishes. The extent to which *L. brevis* utilizes the bay and reasons for its successful invasion are not entirely known. To determine the number, size gradient, and spatial

distribution of squid found within the bay throughout the year, monthly trawl surveys were conducted. Furthermore, to provide insight into how this organism has managed to coexist with mobile communities of nekton, one aspect of its lifestyle, locomotion, was examined by videotaping squid of various sizes in a flume and analyzing the footage using a Peak Motion Measurement System. Results suggest that *L. brevis* utilizes the bay both as juveniles and adults and is capable of making extensive excursions into the bay where it can withstand a predictable range of environmental conditions. The success of *L. brevis* in estuaries may in part be a result of locomotive adaptations that make it more competitive with fishes in highly variable environments.

Preliminary results on fecundity of the common squid, *Todarodes pacificus* (Cephalopoda: Ommastrephidae), in the Japan Sea

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The reproductive systems of 30 mature female *Todarodes pacificus* Steenstrup, 1880, with mantle lengths of 179-285 mm from different regions of the Japan Sea were investigated to determine fecundity and egg diameter. Individual absolute fecundity (AF) was calculated as the sum of total oocyte number in the gonad plus egg number in the oviducts. For the more particular characteristic of reproductive system condition an index of spawning readiness (ISR) reflecting the weight ratio between oviducts and ovary was used. IAF (calculated from 30 mature females) varied from 116,000 to 1,069,000 with an average of 506,000 $\pm$37,000 oocytes. IAF does not depend on seasons and regions. The number of eggs in paired oviducts (OF) varied from 140 to 79,000. This value is 0.12 (11%) of IAF. The diameters of eggs ranged from 0.69-0.88 mm with a mean value of 0.82$\pm$0.0l mm. In view of the high correlation between egg diameter and mantle length, these parameters were compared by seasons and by regions.

The gonatid squid *Benyteuthis magister* in the western Bering Sea: Distribution, stock structure, recruitment, and ontogenetic migrations

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A 4-year series of observations (1993-1996) on distribution, abundance and length-at-age structure of *Berryteuthis magister* in the western Bering Sea revealed high fluctuations of the squid stock both in seasonal and inter-annual aspects. Two seasonal groups of squids were distinguished in the region using statolith- ageing techniques: spring-summer-hatched and autumn-winter-hatched squids. Squids of both groups showed similar patterns of ontogenetic migrations through the region, with minor differences from year to year. Juveniles of mantle length (ML) 14-19 cm entered the region from the southeast with the Eastem Bering Slope Current (EBSC) in May-June (autunm-hatched) and November-December (spring-hatched). They accumulated on the feeding grounds over the continental slope off eastern Siberia where they grew and matured during the next 4-5 months. Squids of both groups became mature at age 10-11 months at ML 24-26 cm (females) and 20-21 cm (males). Maturing squids gathered in dense concentrations in near-bottom layers above the slope, in locations with the highest near-bottom temperatures (between

350 and 450 m). As it was shown on the autumn-hatched group, functionally mature squids (males and mated females) in October started to migrate to the south-west until they left the region of study, with the Kamchatka Current. Only 5-10% of autumn-hatched squids spawned on the Siberian slope.

Our data indicated that *B. magister* migrated counterclockwise between the western and eastern parts of the Bering Sea following the general scheme of water circulation. Abundance of mature squids in pre-spawning concentrations in the western part depends largely on abundance of juveniles brought to the region by the EBSC from supposed spawning grounds located in the south-eastern part. Thus, the general scheme of the life cycle and population structure of *B. magister* can not be understood without data from both the western and eastern parts of the Bering Sea.

Size structured competitive interactions between a native and introduced estuarine mud snail: Implications for a species invasion

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Populations of the native mud snail, *Cerithidea californica*, have been decreasing over past decades in several northern California salt marshes. The presence of the introduced mud snail, *Batillaria attramentaria*, is often cited as a potential cause for *Cerithidea*'s decline. The goals of the present study are to document whether or not *Cerithidea*'s displacement is in fact due to replacement by *Batillaria*, whether the replacement is occurring through the suspected mechanism of exploitative competition for the snails' shared food resource (epibenthic diatoms), and to what degree competitive strengths vary with the sizes and densities of the snails. I conducted experiments to generate consumer resource interaction curves for two size classes of each snail species and their diatom food source. I then used these relationships to make predictions of the interspecific effects of each snail species on the other. The predictions were tested in the field and proved to describe accurately the outcomes of interspecific interactions between the snails. The predictions and tests indicate that *Batillaria* is the more efficient competitor and strongly suggest that *Cerithidea*'s decline in these marshes could be due to replacement by *Batillaria*.

Latitudinal variation in radular morphology in the Atlantic plate limpet, *Tectura testudinalis*

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Tectura testudinalis is a limpet (Archaeogastropoda: Lottiidae) that inhabits the rocky shores of the nortwestem Atlantic. I examined differences in radula morphology that could be due to a direct correlation between shell height and radula length. Limpets were collected from six latitudinaly separated populations in the New England area. *Tectura testudinalis* has a docoglossan radula that is long and stout with four blunt teeth per row, two central and two lateral. This limpet feeds on various red coralline algae in the genus *Clathromorphum*. Radulae were removed from the soft body tissue using sodium hypochlorite and examined with light and scanning electron microscopy. The radulae were measured from tooth row seven through row thirty-seven. Preliminary results indicate that this methodology could be effective in determining latitudinal variation in *T. testudinalis*.

The Eastern Pacific members of the bivalve family Sportellidae

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The taxonomy of the eastern Pacific species that have been allocated to the bivalve family Sportellidae are reviewed. All taxa are members of the tropical fauna. The genus *Basterotia* is represented by five species: *B. californica* Durham, 1950, here reported from the Recent fauna for the first time; *B.* #1 and *B.* #2, two new species, the latter the most common species in the genus and here reported to brood its young; *B. peninsularis* (Jordan, 1936) [of which *B. hertleini* Durham, 1950, and *B. ecuadoriana* Olsson, 1961, are synonyms]; and *B. quadrata* (Hanley, 1834) [of which *Poromya granatina* Dall, 1881, is a synonym]. A new genus is described, with a new species as its type. *Anisodonta americana* Dall, 1900 from the Plio-Pleistocene of Florida is also a member of this genus. *Ensitellops* is represented by *E. hertleini* Emerson and Puffer, 1957 [of which *E. pacifica* Olsson, 1961, is a synonym]. *Fabella* is represented by *F. stearnsii* (Dall, 1899) [of which *Sportella duhemi* Jordan, 1936, is a synonym]. *Sportella californica* Dall, 1899, proves to be an *Orobitella* (Galeommatoidea: Lasaeidae), and *Anisodonta pellucida* Dall, 1916, is based on a juvenile mactrid, probably *Simomactra falcata* (Gould, 1850).

In situ observations of nesting *Octopus dofleini*, the giant Pacific octopus

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Much of our information regarding the nesting behavior of *Octopus dofleini* has come from aquarium observations. This paper reports on the "*in situ*" observations of seven nesting *O. dofleini* females from discovery until their deaths or disappearance. All nesting dens were in 17 to 24 meters of water and were walled off. No midden heap was observed. Early in nesting the females were a pale gray color over the body with typical reddish arms. Later, the arms became a pale gray also. As death approached, the skin on the suckers and arms turned a pale yellow color and began to slough off. Three of six dead females were found outside their dens, one was partially out of the den and two died in their dens. At death the females had lost an estimated 50% - 93% of their body weight. An average of 330 strings with an average of 172 eggs in each string resulted in an average nest size of 56,760 eggs. Hatching occurred at night and finished in less than a week. Juveniles averaged 0.029 grams at hatching.

Patterns of introduction of non-indigenous non-marine snails and slugs in the Hawaiian Islands

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The native snails of the Hawaiian Islands are disappearing. One cause is predation by introduced carnivorous snails. Habitat destruction/modification is also important, facilitating the spread of other non-indigenous snails and slugs. Eighty-one species of snails and slugs are recorded as having been introduced. Thirty-three are established: 12 freshwater, 21 terrestrial. Two or three species arrived before western discovery of the islands (1778). During the 19th century about one species per decade, on average, was introduced. The rate rose to about four per decade during the 20th century, with the exception of an especially large number introduced in the 1950s as putative biocontrol agents against the giant African snail, *Achatina fulica*. The geographical origins of these introductions reflect changing patterns of commerce and travel. Early arrivals were generally Pacific or Pacific Rim species. Increasing trade and tourism with the USA, following its annexation of Hawaii, led to an increasing proportion of American species. More general facilitation of travel and commerce later in the 20th century led to a significant number of European species being introduced. African species dominated the 1950s biological control introductions. The process continues and is just part of the homogenization of the unique faunas of tropical Pacific islands.

Introduction of a new molluscan shell pest: Not just another "boring" organism

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In 1993, a new polychaete pest was found inhabiting the shell of California cultured abalone. The worm is being described as a new genus in the family Sabellidae. It is a non-indigenous species; apparently introduced through importation of South African abalone for commercial research purposes. Although the sabellid infestations do not impact abalone tissues, shell growth can become greatly altered. Interestingly, boring by these worms in the shell is not the mechanism responsible for the abnormal growth. Instead, this parasite is apparently able to interfere with the antifouling mechanisms of the mantle and then guide shell deposition of the host. Direct impacts include a decrease or virtual cessation in shell growth and a weakening of the shell structure. We have determined that host specificity of this sabellid is rather broad and many native California gastropod species may be at risk of infestation. It is possible that the altered shell structure may have indirect impacts (e.g., increased susceptibility to predation). With the recent finding of an established sabellid population in an intertidal habitat in California, further examination is needed to determine the potential environmental risks associated with the sabellids and which native species are most at risk. Without this information, management efforts to minimize the spread of the sabellid and protect native gastropod species is now, and will continue to be, seriously hindered.

Phylogenies of the *Columbella* and *Conella* groups (Neogastropoda: Columbellidae), and implications for the evolution of Neogene tropical American marine faunas

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The closure of the Isthmus of Panama in the mid-Pliocene is one of the most accessible model systems for assessing evolutionary responses to a vicariant event followed by large scale environmental change. The patterns of evolution of tropical American marine faunas have been the subject of many studies, but preservational and sampling biases have hampered their identification. This paper documents the patterns of diversification and extinction in two groups of shallow marine molluscs of the Neogene American tropics. The members of the *Columbella* and *Conella* groups of the neogastropod taxon Columbellidae were assessed through the corroboration of cladistic phylogenies and the fossil record.

The three major clades of the *Columbella* and *Conella* groups show different patterns of evolution through the Neogene in the American tropics, but also share some common trends. All three clades experienced increased extinction in the Caribbean after Isthmian closure, which was not balanced by increased origination; however no major clade went entirely extinct in the Caribbean. One eastern Pacific group underwent an episode of diversification, but the timing of this diversification is uncertain.

How to build an herbivore: The evolution of herbivory in columbellid gastropods (Neogastropoda: Columbellidae)

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The phylogeny of the neogastropod family Columbellidae, based on anatomical and morphological data, is used to address the evolutionary relationship between alimentary anatomy and feeding habits. Columbellids are opportunistic feeders and generally carnivorous; some species, however, include plant matter in their diets. Several studies have suggested a correlation between columbellid diet and alimentary anatomy, but the evolutionary basis of these observations has not been explored.

Comparison of a phylogenetic hypothesis with anatomy and diet suggests that facultative herbivory has evolved more than once in columbellids, and the transition from carnivory to herbivory is accompanied by changes in several features of alimentary anatomy. Most columbellids have gastric shields, but those of herbivores tend to be larger than those of carnivores. In addition, herbivores tend to have wider radular surfaces, with flat, blade-like cusps that may be more efficient for scraping, and odontophores with more cell layers in thickness than those of carnivores.

Lack of significant esterase and myoglobin differentiation in the planktonic developing periwinkle, *Littoiina striata* (Gastropoda: Prosobranchia)

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The relationship between gene flow and the maintenance of geographic or morphology-related variation in the polymorphic Macronesian periwinkle, *Littorina striata,* was investigated by means of isoelectric focusing of esterases (EST) and myoglobin (Mb). This revealed that: (1) individual EST variation is very high, (2) there is no EST differentiation between sexes, shell morphotypes or wave-exposure regimes, (3) there is no clear macrogeographic patterning of EST variability, although there is a (non-significant) trend of decreasing EST variability with increasing latitude (i.e., from the Cape Verde Islands in the south to the Azores in the north), and (4) there is no Mb variation, even not between islands separated by more than 2,000 km. These results indicate that *L. striata* shows a high degree of genetic homogeneity among geographic populations and that the morphological patterning in this species persists in the presence of intense gene flow.

Seasonal distribution of the gonatid squid *Berryteuthis magister* (Berry, 1913) in the Okhotsk Sea

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Estimations of cephalopod biomass in the Okhotsk Sea during 1989-1991 showed that *Berryteuthis magister* is a dominant species. Juvenile and immature squids forage and grow in the epi-, meso-, and upper bathypelagic zone. Young squid are concentrated in the pelagic zone over the continental slope of the northern Okhotsk Sea and the slope off eastern Sakhalin in the central deep sector of the sea. In this region concentrations of squid during summer and autumn-winter periods are low, whereas during the winter-spring season they significantly increased. In the southern deep sector of the sea, concentrations of squid in summer are somewhat lower than near the northern slope. During the winter-spring season young squids occur only in the bathypelagic zone.

On the whole throughout the Okhotsk Sea the biomass of *B. magister* is low during the winter-spring season, considerably increased in summer, and reduced to a minimum during the autumn-winter period. Horizontal and vertical distributions of juvenile and young squids are correlated with the hydrologic regime and cooling down of the upper layers that causes them to migrate to warm areas where water temperatures are greater than 2.0°C and the depths greater than 500 m.

Feeding behavior and chemoreception in cephalopods

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The feeding behavior of animals follows the sequence of perception, orientation, locomotion and finally ingestion of the food. Thus, the success or failure of test diets can be attributed to (1) the visual and/or chemical stimuli from the diet, (2) the texture and palatability of the diet, (3) the diet's nutritional quality, and (4) the post-ingestive feedback from the diet. Experiments that focused on chemical perception (using a Y-maze to test solutions such as extracts, nucleotides, amino acids) and acceptance of test diets (such as supplemented pellets and surimi; various shapes; whole animal diets; behavioral conditioning) indicated differences in the feeding responses among different groups of cephalopods. Data from *Nautilus,* octopus, cuttlefish and squid chemoattraction and feeding experiments suggest both a hierarchy of feeding responses within each group as well as a continuum along which each group displays a dominant mode of hunting. We present results in support of these models and then comment on the physiological and behavioral adaptations that also lend them support. Preliminary results indicate that *Nautilus* appears more sensitive to chemical stimuli, octopus to contact chemical and tactile stimuli, and squids to visual stimuli. Cuttlefish may utilize vision as well as contact chemical and tactile stimuli. Our ultimate goal is to understand more about the nutritional physiology and feeding behavior of cephalopods through the development of prepared diets.

Some chromosomic and electrophoretic characteristics of the genus *Pomacea* (Gastropoda: Pilidae) from southeastern Mexico

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Karyotypic and electrophoretic characterisitcs of freshwater snails of the genus *Pomacea* were compared. Organisms from provinces of the states of Veracruz, Tabasco and Campeche, southeast Mexico, were used. The polymorphism found in the organisms originating in different provinces showed great similarity to that shown by organisms originating in Lake Catemaco, where this endemic species is classified as *Pomacea patula catamacensis.* Karyotypes of the two species *P. p. catamacensis* and *P. flagellata* showed similar numbers $2n = 26$ and $n = 13$ and morphology, and lacked a differentiated sexual chromosome. There were slight differences between metacentric and mediocentric chromosomes. Electrophoretic studies also showed a marked similarity between the organisms collected in the different provinces and those of Lake Catemaco. However, there are variations in the magnitude of the band pattern and a differential band in the Catemaco samples, revealed both in the isolectric running and in molecular weight. This band was only detected in the organisms with their origin in Catemaco. Results of this study determened both the variations in the populations analyzed, and a method for determining the source and diversity of clones.

Remains of the prey: Recognizing the midden piles of *Octopus dofleini*

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Octopuses use dens for shelter, and discard meal remains outside the den in midden piles. Contents of middens are important data for describing octopus diets, yet field signs for distinguishing octopus midden piles from remains left by other processes can be subtle. We describe contents and field signs of 50 midden piles of *Octopus dofleini* from Prince William Sound, Alaska. Midden piles were recognized as discards from octopuses based on one of two criteria: either midden piles were found at the mouth of a den containing an octopus (N = 36) or midden piles contained at least one remain drilled by an octopus (N = 35; 21 samples met both criteria). The crabs *Telmessus cheiragonus, Cancer oregonensis, Pugettia gracilis*, and *Lophopanopeus bellus* together comprised 68% of the remains. Drills were found on the carapace and chelipeds of 8 (35%) of 23 species found in middens. The drill mark is distinguishable from those of other molluscs by its shape: drills of *O. dofleini* on crabs were oblong (2-6 by 1-2.5 mm), and came to a point at one or both ends. Drill marks tapered toward the inside of the shell; the final perforation of the inner surface was no more than a pinpoint.

The effects of laboratory prepared diets on survival, growth and condition of the cuttlefish, *Sepia officinalis*

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Laboratory prepared, supplemented surimi diets (fish myofibrillar protein concentrate) were fed during four separate 30-day experiments. Four essential amino acids (methionine, lysine, leucine and proline) were tested for their effects on the feeding rate, food conversion, survival, growth and condition of the cuttlefish, *Sepia officinalis.* The first experiment tested methionine. Two of the four test diets had no added methionine but different amounts of protein (62.1% and 93.5%). The remaining two diets had 93.5% protein with increasing concentrations of methionine, so that one diet was fully supplemented with amino acids. During the remaining experiments, similar diets were fed to test the effects of lysine, leucine and proline. Only diets with full supplementation produced significant growth ($p < 0.05$) while none of the remaining three diets in each experiment produced significant growth ($p > 0.05$). After the lysine experiment, cuttlefish fed the fully supplemented diet laid viable eggs, whereas cuttlefish fed the other diets did not lay eggs. This work was supported by a Ph.D. scholarship grant (BD 3210/95) from the J.N.I.C.T., Program PRAXIS XII from the Portuguese government and by NIH National Center for Research Resources (Grant # RR01024 and RR04226), the Texas Institute of Oceanography, and the Marine Biomedical Institute, University of Texas Medical Branch at Galveston.

The challenge of resolving high-level molluscan phylogeny with separate or combined data sets

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Major questions of higher-level molluscan phylogeny remain unsettled despite recent efforts to test hypotheses with explicit cladistic methodology. Even if "morphologists" generally agree that molluscs are, indeed, a monophyletic group, they disagree about the basal divergence within molluscs and are even more divided about which other phyla are closest relatives to the Mollusca. The aplacophoran molluscs are especially problematic. Are they monophyletic or paraphyletic? Are they sister taxa to a clade, Testaria, comprised of polyplacophorans plus conchiferans, i.e., all other molluscs, or are they sister taxa to polyplacophorans, together comprising Aculifera, the sister taxon of Conchifera? Some have even suggested that one or both aplacophoran lineages are conchiferans whose shell-less non-metameric body reflects secondary reductions, not plesiomorphic simplicities. With little consensus concerning the closest sister taxa, and with no surviving outgroup that is morphologically similar to molluscs, it is exceedingly difficult to polarize morphological character variation within molluscs. An example is metamerism. Was the ancestral mollusc metameric like a chiton, or not, like an aplacophoran? Molecular sequence comparisons could provide such a resolution, but the most extensive ones published to date, a 1996 study based on 18S ribosomal RNA by B. Winnepenninickx and coauthors, were discouraging because they did not even support molluscan monophyly. My own parsimony analysis of these molluscan sequences include additional outgroup sequences and was based on my own sequence alignment. The minimum-length trees found differed from those previously reported by supporting molluscan monophyly and by including a caudofoveate aplacophoran within a clade of conchiferan molluscs as sister taxa to polyplacophorans. The nearest outgroup to molluscs was resolved as not a single taxon but as clade of several eutrochozoan phyla. Addition of morphological data to the analyses did not substantially alter the topology.

Evolution in deep-sea molluscs: A molecular genetic approach

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The origin of the extraordinarily diverse deep-sea benthic fauna is poorly understood and represents an enormous gap in our understanding of basic evolutionary phenomena. The main obstacle to studying evolutionary patterns in the deep sea has been the technical difficulty of measuring genetic variation in species that are typically minute, must be recovered from extreme depths, and are fixed in formalin. We developed molecular genetic techniques to work with a formalin-fixed macrofauna. Population genetic structure of several species of bivalves and gastropods revealed strong differentiation along a depth gradient from 500 to 4,800 m despite the lack of any obvious topographic or oceanographic features that would impede gene flow. Our findings indicate that the deep-sea macrofauna can have strong population structure over small spatial scales, similar to that observed in shallow-water and terrestrial organisms, with important implications for evolution in the deep sea. Our new genetic methods make it possible for the first time to use extensive available collections of deep-sea species to explore the evolutionary historical basis of deep-sea biodiversity on global scales, and add a new dimension to the use of museum collections in general for spatial and temporal analyses of population structure.

Population structure and life history of the gonatid squid *Berryteuthis magister* (Berry, 1913) in the North Pacific

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Population structure of the Commander squid in the North Pacific is proposed based on an analysis of data on spatial, temporal, and size-sexual structure of this squid in most areas of its wide range. Four spatially distinct populations are distinguished with their own spawning and foraging areas, as well as probably with exchanges of individuals to varying degrees: (1) Bering Sea population with the main spawning area along the Commander and Aleutian Islands, Bowers Ridge and a minor spawning area (based on biomass and abundance) on the slope of the western Bering Sea. A joint, overlapping foraging area occurs in the Bering Sea and partially near the northern Kurile Islands; (2) Okhotsk Sea population with the main spawning area near the Kurile Islands and a minor spawning area in the southwestern Okhotsk Sea. The foraging area occurs almost throughout the Okhotsk Sea and insignificantly in the subarctic zone of the western North Pacific; (3) Japan Sea population, the most isolated, with weakly divided seasonal spawnings in the northeastern Japan Sea. The foraging area occurs almost throughout the Japan Sea; (4) American population (presumed) with a spawning area in the Pacific off the west coast of North America. The foraging area extends to the eastern Aleutian Islands and partially in the boreal zone of the North Pacific.

We distinguish temporal seasonal spawning groups of squids isolated in a varying degree within the Bering Sea and Okhotsk Sea populations and we consider the groups to be seasonal subpopulations (spring-summer and autumn-winter). Each subpopulation consists of early and late spawning individuals that differ slightly in size, but are significantly different in sexual maturity. We propose probable tracks of transportation of larvae and juvenile squids of every subpopulation of the Bering Sea and Okhotsk Sea populations with currents depending on flow in the epi-, meso-, and upper bathypelagic zones of the Bering and Okhotsk Seas, and the North Pacific. A hypothetical scheme for the life history of *B. magister* in the North Pacific is proposed.

Calibrating phylogenies with the fossil record

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Cladistic analyses of well sampled groups with a good fossil record commonly yield phylogenies of species that conflict strongly with stratigraphic data, even to the extent of hypothesizing phylogenies that turn the stratigraphy upside down. This is almost certainly due to the convergent evolution of similar morphologies (i.e., homoplasy), rather than the inadequacy of the fossil record. This problem can be dealt with either through the use of stratigraphic information as a character (i.e., stratocladistics), or by constructing separate phylogenies for different stratigraphic intervals that can then be assembled into a composite phylogeny. Snails of the genus *Strombina* were used to test the second approach. Strombinids originated and diversified in the Caribbean during the Miocene and Pliocene, when they became nearly extinct in the Caribbean, but diversified greatly in the Eastern Pacific. Phylogenies of 42 species based only on morphology (49 shell characters, 186 states) yield trees with high stratigraphic inconsistency and ghost lineages that postulate the presence of descendants 10 million years or more before the first appearance of their ancestors. Removal of species that originated after the Pliocene resolved all these stratigraphic inconsistencies although some ghost lineages remained. This Miocene/Pliocene tree was then used to root the Pleistocene and Recent species. This final composite tree is highly consistent with the known fossil record for this group.

Land snails of the lower Salmon River drainage, Idaho

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The rich Lower Salmon River area, Idaho, endemic land snail fauna has been known since the 1860s. Six taxa have been federal listing candidates since the inception of the Endangered Species Act. We conducted a comprehensive terrestrial mollusk survey of the lower 100 km in 1992-1994, visiting over 210 sites. Sixty-plus land snail taxa were encountered, of which 18+ are new. Site diversity is comparatively low (3); but over 50% of the taxa are Lower Salmon/regional endemics. Endemism is most noted in *Oreohelix* and *Cryptomastix*. Many taxa are limited to single drainages or accreted terrain blocks with regionally unusual lithologies, such as limestone or marble. Endemics can occur at any elevation or in any moisture regime, but are most frequent in semi-arid settings at lower elevations. This small area has at least five discrete species assemblages, only one of which extends beyond the region. Adjacent Hells Canyon seems to show similar patterns of speciation, endemism, and substrate localism. At least 36 Lower Salmon taxa are in some danger of extinction. Grazing, recreation, and human settlement are the main threats to lower elevation sites; logging also at higher elevations. Many taxa are limited to one or a few sites. Site numbers and population reductions have been noted for such listing candidates as *Oreohelix idahoensis idahoensis* and *O. waltoni* since 1988.

Host specificity patterns of dicyemid mesozoans found in eight species of cephalopods from Japan

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Dicyemid mesozoans are parasites that live in the renal sacs of benthic cephalopods. Eight species of cephalopods caught off the coast of Japan were examined for the presence of dicyemids. To date we have recovered a total of 21 dicyemid species from these cephalopods: *Octopus dofleini* (2 species); *O. fangsiao* (5); *O. hongkongensis* (3); *O. minor* (3); *O. vulgaris* (3); *Sepia esculenta* (6); *S. lycidas* (2); and *Sepioteuthis lessoniana* (1). Four genera of dicyemids were encountered: *Dicyema* (12 species); *Pseudicyema* (1); *Dicyemennea* (7); and *Dicyemodeca* (1). The largest cephalopod host species, namely, *O. dofleini, O. hongkongensis,* and *Sepioteuthis lessoniana,* harbored the largest dicyemid species. Typically two to three species of dicyemids occur in each host species. However, in *O. fangsiao* and *S. esculenta*, five or six species of dicyemids were detected. In both cases all species of dicyemids were never observed together in a single host. In contrast, only one species of dicyemid has ever been found in *Sepioteuthis lessoniana.*

Most species of dicyemids examined are host specific. In a few instances, the same species of dicyemid was detected in two different cephalopod hosts that belonged to the same genus. Three dicyemids, namely, *Dicyema acuticephalum, D. japonicum,* and *D. misakiense,* each infects two host species in the genus *Octopus. Pseudicyema truncatum* infects two cuttlefishes in the genus *Sepia.* In summary, a high degree of host specificity appears to be characteristic of dicyemid-cephalopod relationships.

Taxonomic problems with tropical members of the family Haliotidae (Gastropoda: Prosobranchia)

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Most commercial species in the family Haliotidae are well known and present no taxonomic problems. However, many of the small, tropical species are little known and their taxonomy has been confusing. Here three recent cases are presented. (1) From Geiger (1996): The purported but replaced "type" specimen of *Haliotis unilateralis* Lamarck, 1822, is identified as *H. varia* Linné, 1758. This species does not occur in the East African faunal province from which *H. unilateralis* is exclusively known. A neotype has been designated, and the radula and epipodium have been described for the fust time. In the Red Sea, only *H. pustulata* Reeve, 1846, occurs sympatically with *H. unilateralis.* (2) From Geiger and Stewart (submitted) and Stewart and Geiger (submitted): *H. crebisculpta* Sowerby, 1914, is represented by three syntype specimens belonging to two species. The identity of both species is discussed, including their soft part characters and their geographic distributions. (3) From Geiger and Coleman (in prep.): a still unnamed species from the tropical western Pacific is discussed.

Abalone in the fossil record: A review (Gastropoda: Prosobranchia: Haliotidae)

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Fossil abalone are rare and poorly known, in contrast to their Recent counterparts. The taxonomy is problematic, because most of the 35 fossil species have been described from single specimens, and because the shell of Recent species is extremely plastic. The use of fossil species in phylogeny is questionable. Abalone first appear in the Upper Cretaceous with two species, are unknown in the lower Paleocene, appear again in the upper Eocene and Oligocene of New Zealand and Europe, and are regularly found from the Miocene onwards worldwide. Most records are from intensively studied areas: West America, Caribbean, Europe, South Africa, Japan and Australia. The scarcity of Indo-Pacific records is remarkable, because their highest present-day diversity is found there. Three hypotheses for the origin of the family are discussed: Central Indo-Pacific, Pacific Rim, and Tethys. Fossil and Recent abalone both seem to have lived in rocky, shallow sublittoral depths in tropical and temperate climate. No onshore-offshore pattern could be detected.

The coccidian parasite *Aggregata* (Apicomplexa: Aggregatidae) in cephalopods from European waters

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Coccidians of the genus *Aggregata* are host-specific intracellular parasites found in the digestive tracts of a large number of cephalopod hosts. Transmited via the host diet, the infection is initiated when cephalopods feed on crabs, shrimps and other crustaceans. Most studies on this group of protozoan parasites in European waters date from the beginning of this century. Based on this early work several species of *Aggregata* are recognized, namely: (1) *A. eberthi*, found in *Sepia officinalis* (Linnaeus 1758), is widely distributed throughout the Mediterranean (Italy, Monaco, France, Spain, Tunisia), English Channel (France, England), and North Sea (Germany); (2) *A. octopiana*, found in *Octopus vulgaris* (Cuvier, 1797), has been reported from the Mediten-anean (Italy, Monaco and France), and English Channel (France); and (3) *A. spinosa*, also found in *O. vulgaris*, previously has been recorded only from the English Channel (France). In order to review host range, geographic distribution, and incidence of the coccidians in European populations of cephalopods, we initiated a large sampling program to survey a diversity of host species from the Mediterranean and the northwestern Iberian Peninsula. *Aggregata octopiana* in *O. vulgaris* and *A. eberthi* in *S. officinalis* were the most abundant coccidians encountered. An undescribed species of *Aggregata* was found in the oceanic ommastrephid squid *Todarodes sagitattus* (Lamarck, 1798) off the northwest coast of Spain. Sample localities, levels of infections, and comparative data on morphology and morphometry of sporocysts and sporozoites are reported in this work.

Light-polarization and color sensitivity in the common octopus and firefly squid of Japan

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Color vision (hue discrimination) is a contrast-enhancing mechanism involving complex interactions among several different types of cells, such as the blue, green and red cones and various interneurons in the primate retina. It is, however, based on a relatively simple principle: lateral inhibition. Here, the same principle is demonstrated in the contrast-deriving properties of the octopus retina: a color-blind but polarization-sensitive system greatly simplified by the presence of only two types of visual cells. This model system demonstrates a digital enhancement principle applicable to any parameter of visual contrast. In the eye of most color-blind animals, the only possible parameter of contrast is brightness; whereas in vertebrates with color vision, the contrast parameters used (in photopic conditions) are differences in both brightness and hue. The ventral retina of the firefly squid appears to use three different parameters: brightness, hue, and polarization. However, to say that Japanese firefly squids have color vision is probably a misconception. The purpose of the second half of this talk will be to explain how the firefly squids probably use their system, and why they have color sensitivity but not "color vision."

Species composition and distribution of octopuses of the genus *Octopus* on the northwestern Japan Sea Shelf

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Bottom octopuses were collected in the northwestern Japan Sea shelf over the past 10 years by different types of sampling gear. Species composition of octopuses is relatively poor. Three highly abundant species are present, and two of them are of commercial value: *Octopus dofleini* and *O. conispadiceus.* The third species, which is smaller in size and less numerous, could not be identified with any known species, probably due to the lack of reliable taxonomic guides. *Octopus dofleini* is found between 42°-46° N, although commercial concentrations were present only in the southern part of the surveyed area. Vertical distribution is susceptible to seasonal fluctuations, and is highly influenced by hydrological conditions. Octopuses of this species are extremely rare in the depth range of 20 to150 m in the winter-spring period. Commercial stocks are found at depths of 20 to50 m in the summer-autumn period when temperatures range from 8°-18°C. *Octopus conispadiceus* is found between 42°-48° N, and commercial stocks are located mainly in the northern part of the region. Unlike *O. dofleini,* the distribution of *O. conispadiceus* is restricted to waters with low temperatures that range between 0° and 5°C. The species lives at depths from 30 to 400 m in the winter-spring period, and moves towards the shelf edge in summer and fall. *Octopus* sp. (description will be presented; identification may correspond to *O. fujitai* or *O. yendoi*). The species occurs between 42°-48° N in depths that range from 50 to 260 m. Its distribution is restricted to cold waters.

Species composition of cephalopods found in the diet of the Hawaiian monk seal, *Monachus schauinslandi*

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The diet of the Hawaiian monk seal, *Monachus schauinslandi,* was determined through examination of fecal material collected from seals in the northwestern Hawaiian Islands during the years 1991-1994. Cephalopods were found in the feces as undigested beaks and comprised approximately 25% of the diet. Of the 940 fecal samples examined, 228 contained a total of 630 octopus beaks and 43 contained a total of 338 squid beaks. Cephalopod species were identified using both upper and lower beaks obtained from known specimens of octopus and squid. Five benthic species and two pelagic species of octopus were identified, representing a mix of diurnally and nocturnally active species. In addition, 19 species of squid were found in the samples, representing a mix of coastal, pelagic and mesopelagic species. Length and weight of squid species were determined using length/weight regressions of lower rostral lengths. These findings indicate that cephalopods are an important component in the diet of Hawaiian monk seals, which forage both inshore and offshore, and both diurnally and nocturnally.

Phylogenetics and classification of the *Philine aperta* clade: Traditional versus cladistic approaches

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The Philinidae are a group of highly derived cephalaspidean opisthobranchs, in which the shell is reduced and internal. A preliminary phylogeny of the Philinidae is presented. Many traditional characters, such as shell sculpture and shape, have been modified within several lineages and are therfore less informative in characterizing major clades. Species phylogenetically closely related to *Philine aperta* Linnaeus, 1758, the type species of the genus, have been the subject of considerable systematic discord and instability. Re-examination of the anatomy of members of this clade suggests that several taxa that have been united under the name *P. aperta*, are in fact distinct. *Philine aperta* from southern Africa is distinct from the European *P. quadripartita* Ascanius, 1777, on the basis of consistent differences in gizzard plate and penial morphology. The anatomy of *P. elegans* Bergh, 1905, and *P. orientalis* A. Adams, 1854, is described together with that of three undescribed species. Cladistic analysis indicates that penial morphology, gizzard plate shape and microstructure, and ornamentation provide valuable new characters for ellucidating relationships among members of the *Philine aperta* clade and to other closely allied outgroups. Members of the *Philine aperta* clade are among the most highly derived members of the Philinidae.

Gill filament differentiation and experimental colonization by symbiotic bacteria in the tropical lucinid clam *Codakia orbicularis*

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A previous study, using PCR analysis, has demonstrated that the transmission mode of sulfur-oxidizing bacteria located in gill-bacteriocytes of *Codakia orbicularis* is environmental. Aposymbiotic juveniles differentiate gill filaments, as usual in most bivalves, when sterile sand is added. Mucocytes, granule cells, and intercalary cells differentiate progressively, whereas bacteriocytes are lacking. Therefore, the differentiation of these three cell types does not appear as a consequence of symbiosis, but may be a prerequisite.

Experimental colonization of aposymbiotic juveniles has been obtained by addition of crude sand collected in the natural habitat of *C. orbicularis.* A free-living form of the bacterial endosymbionts associated with sea-grass-bed sand appears to be endocytosed at the apical pole of undifferentiated cells that become bacteriocytes. The association between the symbiont and its bivalve host is not necessary for metamorphosis. However, it must occur at some postmetamorphic stage. Undifferentiated cells of the gill filaments remain receptive to bacteria several months after metamorphosis, and become bacteriocytes when aposymbiotic juveniles are put in contact with the symbiont free-living form. In *C. orbicularis,* the environmental transmission of symbionts does not appear to be restricted to a definite period of the post-larval development.

Traditional versus phylogenetic characters: The art of the state in molluscan systematics

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Correct assessment of morphological similarity and difference is essential for either traditional or phylogenetic frameworks. However, in traditional frameworks, assessments of putative homology are not rigorously tested by congruence. By contrast, in phylogenetic methodologies initial assessment of homology must pass the test of congruence before we can adequately assess true homologies from homoplasies. Our assumptions of homology based on similarity may prove to be false.

Not only has homology assessment of characters undergone theoretical remodelling within a phylogenetic framework, but the notion of the character itself has changed. Characters have often been thought of as the endpoints of develeopmental processes. However, systematists have rightly pointed out that the character is the ontogeny instead. I will show that by focusing on morphological endpoints of developmental processes as opposed to the full ontogeny of characters, a tremendous amount of phylogenetic information is misinterpreted and therefore miscoded or missing in datasets. I use case studies from the gastropod radula to show the importance of ontogenetic information in character definition.

From the bottom up or the intertidal down? Patterns of movement based on phylogenetic inferences in the Patellogastropoda

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Morphological and molecular work supports the position of the Patellogastropoda, the true limpets, as the most basal gastropod clade. Although the clade is composed mostly of species that live intertidally, some members live in the deep sea and can be associated with hot vents and cold seeps. We ask whether these deep sea-taxa have originated onshore and migrated offshore or vice versa. Previous workers have shown that the prevailing trend based on the fossil record is onshore origination and offshore migration over the course of evolution of a monophyletic lineage. We take a different approach using a phylogenetic hypothesis among living forms to determine the polarity of movement.

I have gathered a dataset of morphological characters and taxa in order to assess the phylogeny of the patellogastropods. This analysis includes eighteen taxa, seven of which are from the deep sea, and four outgroups. I have scored eighty five characters for each of these taxa based on histological sections, dissection, shell microstructure, and external anatomy. The phylogenetic hypothesis I generated does not support the onshore-offshore model, but instead the pattern of speciation suggests that taxa have migrated from the offshore to the onshore. Stratigraphic distribution of the patellogastropod lineages indicated that anoxic events may be correlated with recolonization of on-shore habitats during the Cretaceous.

Shells, anatomy, and the phylogeny of the Nassariinae (Prosobranchia: Nassariidae)

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How does the inclusion of shell characters affect phylogenetic analyses? Shell characters are often ignored or granted a relatively minor role due to perceived high levels of homoplasy. I report on preliminary phylogenetic analyses of the bucciniform gastropod subfamily Nassariinae using shell and anatomical characters. Our current understanding of nassariine phylogeny is extremely poor. Shell characters could provide valuable information for the following reasons: subfamilial taxonomy among nassariids is based largely on shell characters; some nonshell characters (e.g., radular dentition) could exhibit higher levels of homoplasy than has been acknowledged; and there are a number of fossil taxa that could represent sister taxa or plesiomorphic representatives to the extant forms.

A data matrix of 42 taxa and 44 characters was constructed. Because relationships between nassariines and possible outgroups are unknown, 14 taxa were used as outgroups. Of the 44 characters, 13 were anatomical and 31 were shell characters. Characters were experimentally weighted to examine their relative effect on tree topologies. The combined analysis supported the monophyly of the Nassariinae plus a few additional taxa. With few exceptions, the anatomical characters exhibited less homoplasy than shell characters. Weighting each character by 1,000 times their rescaled C.I. produced similar results. In these analyses, anatomical characters seem to be structuring basal clades, whereas shell characters structure relationships among derived clades.

A molecular survey of eogastropod phylogeny

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A preliminary survey of partial 18S sequences of representatives of all living families of Eogastropoda revealed that all shallow-water (shelf) patellogastropods comprise a highly robust clade with high bootstrap support and characterized by the presence of several unique inserts. Bathyal and abyssal limpets (Neolepetopsidae and Pectinodontinae), from vents, seeps, and submerged wood, emerge as a separate clade that could not be confidently joined to the shelf patellogastropods, and lack the inserts characteristic of the shelf limpets. These profound differences suggest that the deep-sea limpets comprise an ancient divergence within the Eogastropoda.

Phylogeny and zoogeography of the bathyal family Pleurotomariidae (Mollusca: Gastropoda: Orthogastropoda)

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The relationships of the family Pleurotomariidae, and ten of its 24 known Recent species were investigated using an iterative, three gene [18S rDNA, cytochrome c oxidase I (CO I), 16S rDNA] approach to phylogeny reconstruction. A broad survey of the Gastropoda using partial 18S rDNA sequences (450 bp) was used to orient the Pleurotomariidae within the class and to determine suitable outgroups. The 18S data strongly support the monophyly of Pleurotomariidae, which is the sister group to a clade comprising the remaining superfamilies assigned to Vetigastropoda (Lepetodrilloidea + Scissurelloidea + Fissurelloidea + Haliotoidea + Trochoidea). Sequences from the CO I gene (579 bp) confirm the sister group relationship between the Pleurotomariidae and the remaining Vetigastropoda. Data from the 18S, CO I, and 16S genes (475), analyzed separately and together, clearly distinguish *Entemnotrochus* from *Perotrochus* s.l. Resolution of taxa within *Perotrochus* s.l. is less robust, with species generally assigned to *Mikadotrochus* invariably the most basal, the large, thin-shelled *Perotrochus* referred to "*Perotrochus* Group B" intermediate, and *Perotrochus* s.s. the most derived. The data suggest that the western Atlantic *Perotrochus* s.l. are derived from western Pacific *Perotrochus* s.l., a contention that is supported by newly discovered Antarctic Cretaceous and Paleocene fossils, and that *Perotrochus* s.s. represents a monophyletic, western Atlantic radiation.

Homology analysis and parsimony algorithms: Enemies or friend?

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"Pattern Cladism" regards homology as a deductive concept after applying a parsimony analysis of character distributions. Contrary to various statements, "non-weighting" of characters is not possible. If characters are equally weighted (as usually done), character selection is the most powerful way of relative weighting (0 versus 1). However, as in molecular analysis, selection of "good" characters is always done on a basis of an (often subconscious) *a priori* homology analysis. Modifying Orwell's law, "all characters are equal, but some are more equal than others." Moreover, the classic distribution criterion of homology, i.e., "homologous characters have identical or hierarchical distribution," is the theoretical basis of parsimony analysis. Accordingly, application of the parsimony principle is a kind of homology analysis based on inductive character selection.

A synthetic way of "Hennigian patterning" is proposed for phenotypic (and in principle also for molecular) analysis with application of *a priori* criteria of homology. The resulting, preliminary a *priori* probabilities of homology serve as criteria for selection and weighting (very low = not selected / low / medium/ high /Dollo characters) of characters. After application of a parsimony algorithm, the final cladogram decides homology estimations.

News on monoplacophoran anatomy and phylogeny

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The interpretation of the monoplacophoran bauplan has been controversially debated in the past. The anatomy and fine structure of recently discovered species (*Laevipilina antarctica, Micropilina minuta, M. arntzi*) was examined to clear up this matter. *Laevipilina antarctica* (shell length: 3 mm) resembles the previously described larger species: it lacks any connection between the pericardium and nephridia and is also devoid of connections between nephridia themselves. The tiny (about 1 mm shell length) *Micropilina minuta* and *M. arntzi* lack a heart and are partly paedomorphic in showing only four and three ctenidial and nephridial pairs, respectively. The latter species is a simultaneous hermaphrodite and a brooder. Comparative analysis reveals a differentiation of ctenidia and possibly also gonads from posterior to anterior. Nephridial conditions clearly contradict all ideas of annelid affinities. It is shown that the extant monoplacophorans cannot be regarded as "living fossils," but form a considerably modified early offshoot of conchiferan mollusks. The autapomorphic serial repetition of various organ systems is one aspect of their modification.

Nacre is homoplastic: Then what ?

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When molluscan shell structures are mapped on a composite phylogeny, it is most parsimonious to interpret nacre as homoplastic and crossed lamellar structures as plesiomorphic. This refutes the traditional assumption that the "ancestral mollusc" had a nacreous (mother-of-pearl) shell. The interpretations are invariant under different assumptions of accelerated or delayed character transformation, and whether crossed lamellar structure is an unordered or a Dollo character (evolved once, reduced several times). The properties of nacre from gastropods, bivalves, cephalopods, and monoplacophorans differ between the groups, but not within. Consequently, nacre should not be considered homoplastic, but rather as four different characters of mistaken identity. The distribution of nacre in mollusks is not an evolutionary oddity, but the result of an inadequate character analysis. The take-home message is not "nacre is apomorphic, crossed lamellar plesiomorphic." The point is, classic assumptions should be tested repeatedly, and also that putative homoplasies should be re-investigated. Inferred homoplasy may be due to a flawed character analysis.

Form, function and diversity of epithelial sensory structures in trochoidean gastropods

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Among the major branches of the gastropod evolutionary tree, elaboration of epithelial sensory structures is the hallmark of trochoidean vetigastropods. The epithelium of the head and foot is a richly microvillar surface containing an extraordinary density and diversity of putative sensory structures. Previous knowledge of these structures resides primarily in verbal descriptions and scanning electron micrographs of inadequately fixed and poorly preserved material. The minute cantharidine trochid *Alcyna ocellata* A. Adams, 1861, provides new data from a combination of scanning and transmission electron microscopy of carefully relaxed and fixed material.

Seven different kinds of cilia project from the epithelium: (1) single short cilia, (2) clusters of 5 to 7 short cilia emerging from a shallow pit, (3) clusters of multiple cilia at the tip of a short stalk, (4) single cilia at the tip of a short stalk, (5) clusters or tufts of longer cilia, (6) tracts of longer cilia, and (7) regions of longer cilia associated with discrete epithelial structures. The most complex structural arrangements occur on the cephalic and epipodial tentacles, where a single cell with microvillae wraps around six to eight flattened and concentrically packed columnar sensory cells, each with a basal nucleus and as many as 12 distal cilia projecting into the environment. Trochoideans appear to have specialized in epithelial detection of a diversity of close range stimuli, both mechanical and chemical, in contrast to caenogastropod osphradial specialization in discriminating more distant cues.

Peculiarities of giant protists infecting the gills of some squids from the Bering Sea

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Hochbergia, a genus of giant protist of unknown affinities, is found on the gills of a diversity of oceanic cephalopods in the North Pacific Ocean. Squid examined for this parasite were collected in August to December, 1995-1996, on the slope of the northwest Bering Sea. A total of 14 specimens of *Moroteuthis robusta* (970-1,350 mm ML) were 100% infected with *H. moroteuthensis.* Intensities of infection varied from 12-750 specimens per host (average 220). The minimum intensity was observed in a mature male of 970 mm ML. The remainder of the *M. robusta* examined were immature females with minimum intensities of 53-60 specimens per host. Two distinct morphs or stages of protists were present: (1) small white protists, 0.4-1.2 mm in length, with a smooth cyst wall; (2) larger yellow protists, 1.1-1.9 mm in length, with a complexly sculptured cyst wall. The ratio between white and yellow forms ranged from 0 to 100% of the total number in any given host (average 65% white and 35% yellow).

Several undescribed species of *Hochbergia* were present in squids of the genus *Gonatus.* In *G. onyx* (12 specimens; 70-180 mm ML), the incidence of infection was 80% with intensities ranging from 4-100 specimens per host. Only yellow fomis were present. A single specimen of *G. middendorffi* (425 mm ML) had hundreds of the large yellow morphs. In contrast, both *Gonatopsis borealis* (15 specimens; 85-140 mm ML) and *Berryteuthis magister* (20,300 specimens; 30-380 mm ML) were not infested with *Hochbergia.* Several possible reasons for the observed differences in parasite distribution will be discussed.

A phylogeny of pleurocerid snails (Caenogastropoda: Cerithioidea) based on molecular and morphological data

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Phylogenetic hypotheses for North American pleurocerid snails remain in their infancy. I was interested in estimating relationships of pleurocerid snails using both morphological and molecular data. For the molecular data set, a portion of the mitochondrial 16S rRNA gene was sequenced for representative species of the family. For the morphological data set, I constructed a data matrix based on variation observed in the radula from the same representative taxa that were sequenced. Phylogenies were constructed for the morpholgical and molecular data sets both separately and combined. Taxonomic and character congruence is discussed.

First record of the "*Octopus aegina* genus group" in the Hawaiian Islands Archipelago

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A new species of the "*Octopus aegina* group" *sensu* Robson (1929) has been discovered in shallow, coastal, subtropical waters of the Hawaiian Islands Archipelago. This species is characterized as medium sized (ML to 100 mm) with moderate sucker counts (160-210 on normal arms of males and females; about 100 on hectocotylized arms of males). Gill counts range from 9-11 per demibranch; copulatory organs are small, 2.5-3.5% of the length of the hectocotylized arm; eggs are small and hatchlings planktonic. This species shares several characteristics with the non-ocellate members of the "*aegina* group," namely: *O. aegina* Gray, 1849; *O. marginatus* Taki, 1964; and O. sp. 3 (Norman, 1992). It differs primarily in its geographic distribution, body size, sucker counts, and spermatophore size and number. The species occupies sandy substrates in depths ranging from 1 to 80 m and appears to be crepuscular. Distribution, morphology (including illustrations), and delineation from other members of the "*O. aegina* group" are presented.

Preliminary data on the distribution of the faniily Prochaetodermatidae (Mollusca: Caudofoveata)

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At present the family Prochaetodermatidae includes 13 species in five genera. Based on literature and collection data, it is possible to make the following preliminary conclusions: (1) Presently we probably know no more than half of species diversity of the family world-wide. (2) Representatives of the family live in all oceans, excluding the Arctic, subarctic, and continental seas (except for the Mediterranean and the Sea of Marmara). (3) The distribution has a near-continental amphioceanic pattern. (4) All known species inhabit the continental slope, except two species of *Chevroderma* that also occur on the East Pacific and Atlantic abyssal plains. (5) Generally, the family is bathyal-hadal in its vertical distribution. Species

have been recorded on slopes of the following trenches: Aleutian, Kurile-Kamchatka, Japan, Izu-Bonin, Philippine, Sunda, and Peruvian. The depth range is 539 to 7,500 m in the Pacific, 1,050 to 7,060 m in the Indian Ocean, and 457 to 5,208 m in the Atlantic (except *Prochaetoderma raduliferum*, occurring at 54-2,415 m). (6) The distribution pattern and the levels of monotypy and endemism suggest a Pangean-tropical origin of the group. (Partial support from NSF DEB-PEET grant 95-21930.)

Allozyme homozygosity and phally polymorphism in the land snail *Zonitoides nitidus* (Gastropoda: Pulmonata)

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Genetic variation in the pulmonate land snail *Zonitoides nitidus* was examined by means of vertical polyacrylamide gel electrophoresis in 17 European populations (4 Swedish, 4 German, 7 Belgian, 1 British, and 1 Spanish). No heterozygotes were observed. Hence, Z. *nitidus* consists of a number of fixed homozygous multilocus genotypes (strains). Nine strains were detected and in most populations >2 strains co-occurred. Strains were unevenly distributed between the localities. One strain was remarkably differentiated from the others, which is suggestive of a taxonomic differentiation. Anatomically, two phally types were distinguished: euphallics, with well developed male reproductive organs, and hemiphallics, in which the male reproductive organs are weakly developed. Both phally types occurred together, but euphally ratios were very low (0-19%). This, together with the absence of heterozygotes suggests that selfing may be the prevailing breeding system in this species. There was no relation between phally type and alleles or genotypes, but euphally ratios differed between geographical regions. On average, hemiphallic individuals were smaller, but no intermediate phally types were found. Yet, it remains to be decided whether hemiphally is a juvenile character or not.

The Ptychatractinae: An endemic deep-sea clade of the Turbinellidae?

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Due to the scarcity of its representatives, the composition and relationships of the subfamily Ptychatractinae remain little known. Based on new, rich material from recent expeditions, mainly in the Indo-Pacific, it has been possible to study the anatomy of a number of ptychatractine taxa and the generic composition of the subfamily, hitherto much confused and debated, is being revised. As understood here, the subfamily is essentially a deep-water one, inhabiting shallower waters only in the boreal and Arctic zones, and includes five genera [*Ptychatractus* Stimpson, 1865, 45-900 m; *Ceratoxancus* Kuroda, 1952, 360-1000 m; *Latiromitra* Locard, 1897 (=*Cyomesus* Quinn, 1981), 200-1900 m; *Benthovoluta* Kuroda and Habe, 1950 (= *Chatamidia* Dell, 1956, and probably *Surculina* Dall, 1908), 50-1,750 m; and *Metzgeria* Norman, 1879, 110-900 m] and 39 species (17 new). The fossil record of the subfamily is extremely scanty, but the family Graphidulidae, from the Cretaceous of Texas, may be closely related. Ptychatractinae are widely distributed in the World Ocean, with the greatest diversity in the tropics, essentially the Indo-Pacific.

Some of the species of *Benthovoluta* and *Latiromitra* have very broad distributions. Their biology remains unknown, but species of *Ceratoxancus* may have spectacular labral teeth, the function of which is speculative. The Ptychatractinae do not appear to be closely related to the rest of the turbinellids, with which they do not share apomorphic characters. The group should probably be elevated to full family rank.

A new subspecies of the schoolmaster gonate squid *Berryteuthis magister* (Berry, 1913): Genetic and morphologic evidence

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The gonatid squid *Berryteuthis magister* is considered to be a polytypic species with two subspecies: *B. m. magister* (Berry, 1913); and *B. m. nipponensis* Okutani and Kubodera, 1988. The nominal subspecies ranges in distribution over a vast area of the North Pacific, including marginal basins, such as the geographically and hydrologically semi-isolated Japan Sea.

Morphologic and genetic variation of *B. m. magister* from the Japan Sea and northwestern Pacific were analyzed. Two sources of information unequivocally suggested that specimens from the Japan Sea constitute a third taxon of subspecific rank. When compared to the nominal subspecies, specimens of the new subspecies are considerably smaller, have relatively larger fins, and less pronounced size differences of club suckers. The radula of the new subspecies has dicuspid lateral (L(2)) teeth, whereas specimens of *B. m. magister* usually have three cusps on L(2).

Based on information from 26 putative genetic loci, revealed by protein electrophoresis, standard genetic distance D(N) between the new and the nominal subspecies of *B. magister* was 0.044. Intersubspecific distance estimate is almost forty times higher than D(N) between geographically separated populations of *B. m. magister* from the northwestern Pacific. D(N) values between the two subspecies suggests that the Japan Sea population was separated from the ancestral population almost 220 thousand years ago. Seven out of 12 polymorpnc genetic loci showed significant differences between the two subspecies. Genetic differentiation F(ST) between taxa was 0.12, which corresponds to a negligibly small theoretical migration rate of two animals per generation.

Two unusual *Gonatopsis* species (Gonatidae: Cephalopoda) from the bathyal waters off Sanriku, northeastern Japan

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Five specimens of unusual *Gonatopsis* squid were collected from the bathyal waters off Sanriku, northeastern Japan, during an investigation of the cephalopod fauna. They were classified into two species, both of which are different from hitherto known *Gonatopsis* species. One species resembles *G. borealis*, but has a much more muscular, tightened and proportionally longer mantle than *G. borealis.* Four specimens, including a mature male and a female, of this species were collected by an oblique tow of a mid-water trawl from 1,200-1,300 m depth and by a bottom trawl at about 1,500m depth. The other species also resembles *G. borealis,* but is easily distinguished from known *Gonatopsis* species by having a large photogenic tissue on the ventral surface of the eyes. Only one specimen of this species was collected by a bottom trawl at about 1,500 m depth. Detailed systematic comparison of the present two species and the other *Gonatopsis* species is given.

Young cephalopods collected by a mid-water trawl in the Bering Sea in summer

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Cephalopods collected with a large mid-water trawl during August to October in 1988 and 1989 in the eastern Bering Sea were examined. Samples were provided by the U. S.-Japan joint research project on Resources of Walleye Pollack in the Bering Sea conducted by the National Research Institute of Far Seas Fisheries. The trawl used for the research had a mouth opening of about 43 m by 34 m and had two otter boards. Tows sampled near 25-70 m depth at about 4.0 knots for 30 minutes within several hours after sunset. In total, 79 tows were conducted and more than 4,400 young cephalopods, mostly 10-100 mm DML, were collected. A total of 15 species was identified; 12 species were from the family Gonatidae. The most abundant species was *Gonatopsis borealis,* followed by *Berryteuthis anonychus* and *Gonatus middendorffi.* These three species comprised 66% of the total catch. Annual fluctuations were recognized in the abundance, horizontal distribution, and size-frequency distribution of the dominant species.

Molecular phylogeny of hydrobiid gastropods

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Hydrobiids are the largest group of freshwater mollusks, comprising more than 400 Recent and fossil genera and several thousand extant species. These snails are ideal subjects for studies of evolution and vicariance biogeography because of their diversity, antiquity, and linkage with drainage systems. Despite the unique and compelling features of the group, absence of a rigorously proposed phylogenetic hypothesis has prevented use of these animals in evolutionary and biogeographic studies. Many of the morphological and anatomical characters exhibit homoplasy. Thus, the resulting trees are poorly resolved. The purpose of our study was to generate a cladistically based phylogenetic hypothesis of hydrobiid gastropods using DNA sequences. We selected 50+ taxa that represent most of the currently recognized subfamilies of hydrobiids, provide a broad spectrum of areas of endemisim around the world, and include brackish--coastal and freshwaer inland snails fiom three continents. We sequenced portions of three genes; mitochondrial 16S rRNA and cytochrome c subunit I and nuclear 18S rRNA. The phylogenetic hypothesis inferred from DNA data was used to address the following questions: (1) are hydrobiid snails monophyletic? (2) has invasion of the freshwater environment occurred more than once during hydrobiid adaptive radiation? and (3) does the phylogenetic topology fit a biogeographic model? We also seek to determine whether the molecular phylogenies are congruent among themselves, and with the existing morphology-based classification.

The diel vertical migration of Norris' top snail, *Norrisia norrisi* , on giant kelp, *Macrocystis pyrifera*

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Norris' top snail, *Norrisia norrisi,* has been reported to undergo a diel vertical migration on giant kelp, *Macrocystis pyrifera,* at Santa Catalina Island, climbing up the kelp at dusk and descending at dawn. The influence of irradiance and snail size on the diel behavior and vertical distribution of *Norrisia* on *Macrocystis* has not been studied previously. On Santa Catalina Island at Pumpernickel Reef, I made 1,602 observations of snail height and irradiance over a 10 month period.

Mean height above the holdfast was always highest at night for all snail sizes. However, only snails 17 mm showed a consistent and significant negative response to irradiance, decreasing their height above the holdfast with increasing irradiance. Snails > 17 mm were distributed throughout the kelp during the day (high irradiance). A 25% increase in the mean number of snails observed at night was due to snails 17 mm emerging from the holdfast. During the day, snails of all sizes were relatively inactive, either hiding in or on the holdfast or clinging to stipes and the base of blades. At night, snails were more active, moving onto distal portions of the blades and feeding more frequently. The diel vertical migration of snails 17 mm may be an adaptive behavior to avoid diurnal predators and diminishes as snails grow.

A review and critique of the single-organ system approach: Lessons from freshwater mollusks

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The use of a single-character or single-organ system for systematic studies of molluscs has a very long history. Nearly every organ system has been studied by one investigator or another over the years. One interesting byproduct of the single-organ system approach has been the tendency for some investigators to claim that the organ system they studied provides the most accurate reflection of phylogeny. Most investigators today recognize the value of single-organ system approaches particularly for the wealth of comparative material obtained, but realize that the data need to be examined in a phylogenetic context with other characters (a holistic or total evidence approach). Freshwater molluscs have been studied using both single-organ system and holistic approaches. I compare the single-organ approach and holistic approach in case studies of unionid mussels and pleurocerid snails. The study strongly supports an integrative approach using all available data to infer accurate phylogenies.

In search of *Rossia pacifica diegensis*

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In 1912 S. S. Berry presented a full description of his species *Rossia pacifica* and noted that some specimens from off southern California differed somewhat. To the latter he gave the subspecific name *R. p. diegensis.*

Since that time, this subspecies has been virtually ignored. We present evidence based on the retreival of *Rossia* eggs from a depth of 1,000 m off southern California that *R. p. diegensis* is a valid taxon and discuss the zoogeographical implications.

Cephalopods eaten by swordfish, *Xiphias gladius* Linnaeus, caught off the western Baja California Peninsula

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Lower beaks of 994 cephalopods from the stomach contents of 138 swordfish, *Xiphias gladius*, caught off the western coast of peninsular Baja California were analyzed. They belonged to 15 species of teuthoids, four octopods and one vampyromorph. Weight and mantle length of cephalopods were estimated from the beak rostral lengths. The ommastrephid squids *Sthenoteuthis oualaniensis* and *Dosidicus gigas* comprised 62 % by number and 79 % by estimated weight. Three species of Gonatidae represented 19 % by number, and *Argonauta* sp. was the most abundant octopod, comprising 7.5 % by number. *Ancistrocheirus lesueurii* is recorded for the first time in the California Current. Discussion on the distribution of most important cephalopods is done. Swordfish showed a preference for powerful, medium to large sized squid that probably feed at the surface at night.

Evolutionary origins of endemic hydrothermal vent neomphalinid gastropods: 28S rRNA investigations

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A molecular systematic investigation of gastropod phylogeny was performed to examine the antiquity of the hydrothermal vent endemic *Neomphalina* (Neomphaloidea + Peltospiroidea). Twenty-three new D1 domain and thirty new D6 domain DNA sequences of the 28S ribosomal RNA gene were obtained from fresh-frozen and formalin-ethanol preserved gastropod specimens. These were combined with previously published molluscan 28S ribosomal RNA sequences for a total of 159 sequences. Alone, either domain exhibited poor resolution of gastropod phylogeny but together (32 genera only) monophyly of the Neritamorpha, *Neomphalina* (Peltospiridae + Cyathermiidae), Vetigastropoda, Patellogastropoda, Caenogastropoda (including *Viviparus, Ampullaria,* and *Campanile*), and Heterobranchia (Euthyneura plus Valvata) was supported by bootstrap values. Relationships among these groups could not be resolved, possibly due to rapid early-Paleozoic radiations. Elevated evolutionary rates in the Patellogastropoda conformed to previous studies and confounded analyses. Exclusion of overly distant taxa yielded bootstrap support of the sister relationship between Caenogastropoda and Heterobranchia. The hydrothermal vent *Neomphalina* exhibited divergence values and phylogenetic novelty equivalent to the other early Paleozoic radiations, supporting its consideration as a vent refugial phylogenetic relic. Sequences of 28S ribosomal RNA are best used to examine within-order gastropod relationships due to saturation of substitutions at higher levels and among-order evolutionary rate variation.

Taxonomic status of deep-sea gastropods of the northeastern Pacific

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Deep-sea gastropods of the northeastern Pacific have been poorly sampled compared to those of Japan and the northeastern Atlantic. Few new taxa from the northeastern Pacific have been described in the last six decades except for those associated with hydrothermal vents and seeps. Based on my compilation of taxa for inclusion in an illustrated manual on the northeastern Pacific gastropods ranging from the Bering Sea to central Baja California, I have assembled a list of 140 species of shelled gastropods with depth records of 800 m and deeper. Of these, 45 species are undescribed and intended for description in the book, if not described in advance of the book. Taxonomic composition is similar to that known from the lower continental slope and abyssal plains worldwide, with 36 families represented, of which there are 16 archaeogastropod, 10 mesogastropod, 8 neogastropod and 2 opisthobranch families. Highest species diversity is known for the families Buccinidae (28), Turridae (18) and the turriform Conidae (13). There are four main sources of material: (1) Material from the RV *Albatross* surveys, of which 55 species were described by Dall between 1889 and 1919. (2) Material from Andrew Carey's University of Oregon surveys in the 1970s, containing many new species from the lower slope and the Cascadia and Tufts abyssal plains off Oregon. (3) Material from Scripps cruises to the deep slope of the San Diego Trough and other southern California basins, containing a number of new species. (4) Recently described limpets, other archaeogastropods and provannids from hydrothermal vents of the Juan de Fuca and Gorda Ridges.

On the vertical distribution of morpho-functional types of Conoidea

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The superfamily Conoidea is one of most characteristic components of the deep-sea gastropod fauna. Its evolution was strongly associated with alterations in the foregut anatomy and specialization of feeding mechanisms. The following analysis has been based on numerous published data on the anatomy and radulae, as well as the original data. Six main types of morpho-functional organization and respective feeding mechanisms are presently known for the Conoidea (Taylor et al., 1993, Kantor and Sysoev, 1996). They are primarily determined by the function of the radula and the presence of a venom gland. The most typical situation is the use of individual teeth of the membrane-less radula at the proboscis tip for envenomation of prey. The evolution of feeding mechanisms leads finally to a complete reduction and loss of the radula. The most primitive feeding mechanisms, in which the radula functions only as a whole, is found only in shallow-water species (Pseudomelatominae and some Clavatulinae). The use of marginal teeth at the proboscis tip, and the presence of a radular membrane, are characteristic of shelf, many bathyal, and a few abyssal species (Driliinae, Cochlesspirinae, Crassispirinae, Turrinae, some Terebridae). The majority of abyssal species belong to the feeding type in which the radula does not function as a whole, and individual hollow teeth are used at the proboscis tip (Turridae, Terebridae, all Conidae). Two feeding mechanisms include species without a venom gland: some shallow-water species do not use teeth at the proboscis tip and possess a well developed radular membrane (Strictispirinae), and some are highly specialized radula-less forms, mostly inhabiting deep waters (Daphnellinae, Taraninae, some Terebridae). One more type of foregut organization also included radula-less deep-sea species with a venom gland (some

Conidae). All morpho-functional types are recorded in the shelf faunas, although the most specialized radula-less forms are rare. The bathyal fauna is characterized by an almost complete spectrum of feeding mechanisms, except for most primitive ones. It includes many primitive forms with a radular membrane. Basically, the abyssal is inhabited by representatives of four feeding mechanisms, but the vast majority of species belong to advanced groups (membrane-less forms with hollow teeth, or the radula is absent). The share of advanced species increases with increases in depth. The tendency to reduction of radula, up to the complete loss, is also characteristic of abyssal species. Thus, the deep waters were colonized by evolutionarily young taxa with advanced feeding mechanisms, and only the most specialized species are able to live at the greatest depths of the ocean.

Coding what we can't see: The negative gain and parallelism of shell loss in cladistics

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The use of traditional characters in phylogenetic analysis helps us directly contrast taxonomic value in a conventional classification with that suggested by a cladogram. Whereas most cladistic characters are structurally complex, highly derived groups such as opisthobranchs offer numerous cases of character loss in shell, operculum, streptoneury, etc. — some as presumed synapomorphies for higher-level taxa. These can be complete (absence) or partial (reduction), and have been called "negative gains." To describe and code such characters, we are forced to assess morphology that is no longer present. How we do so determines the shape of the tree, and thus the relationships it infers. These points are illustrated by a real dataset of 37 sacoglossan opisthobranchs (shelled and unshelled) coded for 52 characters. By manipulating only two shell characters through different *a priori* assumptions and coding options (binary, multistate, ordered, unordered), substantial changes in the final cladogram(s) ensue. If the cladogram is translated into a hierarchical classification, these choices mean the difference between two or eight equal-rank clades, and confirmation or rejection of traditional taxa. Modern phylogenetic methods are improving our basis for molluscan systematics and our understanding of evolutionary processes. Including negative gain characters, even if initially presumed homoplastic, can document the extent of parallelism or presumed trends. Still, subjective decisions play a strong role and have profound effects. Garbage in, garbage out.

Early development of *Crucibulum auricula* and *Crepidula convexa* (Gastropoda: Prosobranchia: Calyptraeidae) from the Venezuelan Caribbean

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A population of *Crucibulum auricula* was found in Chacopata, living attached to rocky substrates at about 1 m depth. Each female broods between 4 and 20 egg capsules in the mantle cavity, and these are attached to the substate by a short stalk. The capsules contain between 55 and 305 eggs, each measuring around 200 μm. Between 3 and 15 embryos develop and ingest the nurse eggs; cannibalism among siblings was also observed. Only 1 to 11 hatch as crawling juveniles measuring between 600 and 840 μm.

The population of *Crepidula convexa* was found in Morrocoy, living attached to live *Modulus modulus* gastropods at about 10 to 50 cm depth. Each female broods between 5 and 15 egg capsules that are also attached to the substrate by a stalk. The egg capsules contain between 1 and 6 eggs measuring around 350 μm. All eggs develop and hatch as nonswimming pediveligers measuring between 550 and 1,170 μm. No adelophophagy or cannibalism was observed.

Terrestrial gastropods from tropical rain forest leaf litter, southern Veracruz, México

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Abstract

Tropical rain forest leaf litter samples were collected monthly from April 1990 to June 1991 from two contrasting types of ground leaf litter: one where *Ficus yoponensis* was present had a rapid rate of decay, and another where *Nectandra ambigens* was present had a slow rate of decay. These sites were situated in a secondary growth forest with *Ficus* only, and in a tropical rain forest with both *Ficus* and *Nectandra*. Additional samples were taken from canopy leaf litter from October 1991 to April 1992 to determine which species lived in the canopy. Accumulated leaf litter was sampled from the tops of all shrubs and small trees between 50 cm and about 2 m in height in a 5 m^2area. Fifty species from 14 families were recovered from the ground leaf litter; two species were found only in the canopy; and 25 species were found in both. Shells were more common in the secondary growth forest (*Ficus*), perhaps because of the denser understory. In the tropical rain forest, shells were especially common for a short period of time under *Ficus*; whereas under *Nectandra,* shell numbers were less, but present over a longer period of time during the 15 month study period. Live snails seemed to prefer canopy leaf litter (47 alive/6 months) rather than ground leaf litter. Weather and vegetative cover both seem to have great influence on the molluscan distributions.

Introduction

Several studies on the molluscan fauna from areas that surround the tropical rain forests of Veracruz have been published: Cordoba, Pacho, Mirador (Fischer & Crosse, 1870 1894; von Martens 1890 - 1901); Hacienda Cuatotolapam, Catemaco, etc. (Baker, 1922 a & b, 1923a & b, 1926, 1927, 1928a & b, 1930, 1939a & b, 1940a & b, 1941, 1943, 1945). Recently, Naranjo-García and Polaco (1997) compiled information on the nonmarine molluks of the Los Tuxtlas region. Our own studies on terrestrial mollusks from tropical rain forest leaf litter in Mexico were initiated in 1990 (Naranjo-García, 1992).

The invertebrate fauna of leaf litter is of tremendous importance because of the biological processes that take place there. Several groups of arthropods along with earthworms and terrestrial gastropods, have been studied in relation to ground leaf litter and soil formation (e.g., Madge, 1966, Zusevics, 1982; Curry et al., 1985). Land snails perform various functions in soil and leaf litter, including recycling organic matter (Runham 1978) and breaking down fresh or dead leaves or other organic matter into smaller pieces (Graham, 1955; Mason, 1970 *in* Chatfield, 1976; Vitousek & Sanford, 1986). In addition, land snails feed on soil (Szlavecz, 1986), and make organic matter available to bacteria and fungi (Chatfield, 1976).

The objective of this study was to analyse the distribution of the terrestrial snail fauna in two types of leaf litter from tropical rain forests in the Nature Reserve of the Estación de Biología de Los Tuxtlas, Veracruz, operated by the Universidad Nacional Autónoma de México.

Materials and Methods

Los Tuxtlas Biological Station is located at 18°34' to 18°36' N latitude and 95°04' to 95°09" W longitude, in the southeast part of the State of Veracruz, Mexico. The station encompasses about 640 hectares of tropical rain forest; elevations range from 150 to 530 m (Alvarez, 1988).

Samples were collected monthly from April 1990 to June 1991 from four sites (Fha, NV, Nha, and FJ) and from two contrasting types of ground leaf litter: one where *Ficus yoponensis* was present had a rapid rate of decay, and a second where *Nectandra ambigens* was present had a slow rate of decay. These sites are situated in a secondary growth forest developed on 55 year old abandoned crop land with *Ficus* only, and in a tropical rain forest with both *Ficus* and *Nectandra.* Samples were all from leaf litter from 30 cm square plots (collected to bare ground) taken at the bases (sites FHAB, NVB, NhaB and FJB) and from 5 m distance from the tree trunks (sites FHa5, NV5, Nha5 and FJ5). Observations in the tropical rain forest revealed snails crawing on vegetation (leaves, stems, and trunks). Additional samples were taken from canopy leaf litter from October 1991 to April 1992 to determine which species lived in the canopy itself. Accumulated leaf litter was sampled from the tops of all shrubs and small trees between 50 cm and about 2m in height. Samples were taken at random every month.

Results

Fifty species of terrestrial mollusks in 14 families were recovered from the ground leaf litter. Interesting patterns are seen from the graphs for four collecting sites: In general snails were more numerous at the bases of the trees (PHAB, NVB, NhaB) than at a 5 m distance, except under *Ficus yoponensis* in secondary growth vegetation (FJB), where they were more numerous away from the trunk of the tree (FJ5). This sample site also yielded the greatest number of specimens compared to all of the remaining (Fig. 1).

On the other hand, snails were more evenly distributed, as was expected, under *Nectandra ambigens* leaf litter (NHaB and NHa5), where the decay rate was less and the layer of leaves thicker than under *Ficus* (FHaB and FHa5). Nevertheless, under *Nectandra* (NV5) the number of snails was less. Shell numbers were greater for a short period of time under *Ficus* (FHaB); while under *Nectandra* numbers were less, but snails were found over a longer period during the 15 month study period.

In all sites the "nortes" season – when north winds that originate in the northern part of United States due to the Manitoba anticyclone – brings heavy rains to the eastern states of Mexico from about October to February and sometimes as late asl May, and have an influence as shown by the lesser number of shells.

Live snails were more numerous in the canopy leaf litter (47 alive/6 months) than in ground leaf litter during the months surveyed. The greatest number of live snails was found during October. In ground leaf litter 50 species of land snails were found, 26 of which were different from those found in the canopy leaf litter.Twenty four species were found in the canopy, of which 22 were in common with those from the ground leaf litter; two species were found only in the canopy. A total of 52 species was found during this survey of both types of leaf litter from the Mexican tropical rain forest.

Discussion

In the secondary growth forest the understory is denser than that found in the tropical rain forest and may explain the great number of shells found in this type of habitat. Nevertheless, under *Nectandra* from the tropical rain forest (NV5), the number of snails was slightly less. This site has a 9° slope, however, and the leaf litter layer might be thiner or the slope might have influenced their presence.

Live snails seemed to prefer canopy leaf litter (47 alive/6 months) rather than ground leaf litter. During the months surveyed the highest numbers of live snails were found during October – at the end of the rainy season – and in January, the "nortes" season (the rainy season extends from about May to October and continues during the "nortes" season; annual rainfall reaches almost 5,000 mm). These seasonal rains may cause snails to migrate vertically to avoid flooding or from being washed away, and could help explain why live animals are not found as often in ground leaf litter.

On the other hand, our results are similar to those of Nadkarni and Longino (1990), who observed that the abundance of invertebrates was higher on the ground than in the canopy. The mean density of ground leaf litter snails in Los Tuxtlas was 1.5 times greater than for those of the canopy. In comparison, Nadkarni and Longino (1990) found the abundance of snails "2.6 times greater on the ground than in the canopy" in a similar study in Costa Rica. In our study the fauna present in the ground was more diverse than that in the canopy, which also corresponds with the results of Nadkarni and Longino (1990).

Snails certainly move from the ground to the canopy, or vice versa, because at least half of the species are using both types of habitats. During this study more live snails were found in the canopy than in ground leaf litter (Fig. 2). Unfortunately, canopy leaf litter was sampled mainly during the "nortes" season. It will be adviseable to continue this type of research to see how the climatic conditions, type of leaf litter, cover, etc., influence the distribution of land snails in this type of forest.

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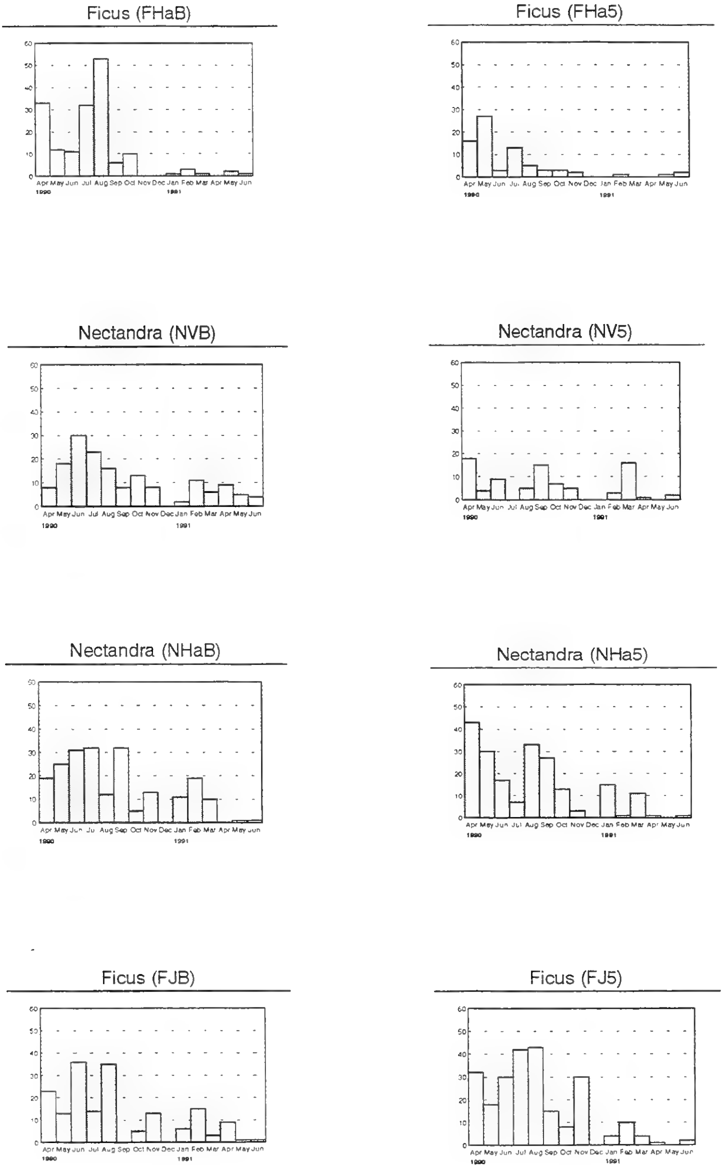
Fig. 1



Ground leaf litter land snails from four sites in a Tropical Rain Forest

Fig. 2

Canopy leaf litter snails from four sites of the tropical rain forest

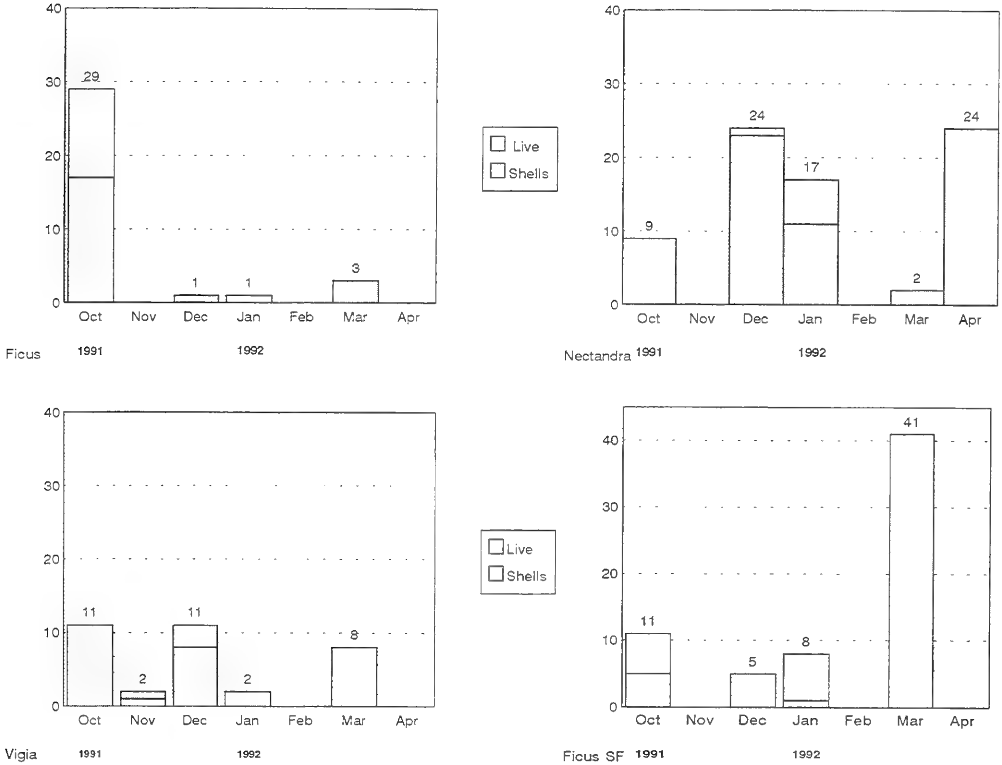


TABLE 1. Ground and canopy leaf litter land snails from a tropical rain forest of Mexico

Helicinidae
*Helicina cf. cinctella**
Helicina lirata (Pfeiffer, 1847)*
Helicina tenuis Pfeiffer, 1848*
*Helicina cf. vernalis**
Schasichila minuscula (Pfeiffer, 1859)

Megalomastomidae
Tomocyclus lunae Bartsch, 1945

Pupillidae
*Pupisoma sp.**

Pupillidae

Table 1 (cont.)

Strobilopsidae	
Strobilops cf. *veracruzensis**	*Strobilops* B
Ferrussaciidae	
Cecilioides consobrinus primus (De Folin, 1870)	Ferrussaciidae
Cecilioides jod Pilsbry, 1907*	
Subulinidae	
Diaopeas beckianum (Pfeiffer, 1846)	*Opeas goodalli* Miller
Lamellaxis (?) gracilis (Hutton, 1834)	*Opeas* A
Lamellaxis martensi (Pfeiffer, 1857) *	*Opeas* B
Lamellaxis (Allopeas) micra (d'Orbigny, 1835)	*cf. Opeas*
Leptinaria cf. interstriata	
Spiraxidae	
Euglandina sp.*	*Spiraxis cf. sulciferus*
Pseudosubulina cf. berendti (L. Pfeiffer)	*Streptostyla cf. bocourti* Crosse y Fischer
Pseudosubulina A	*Streptostyla cf. lurida*
Pseudosubulina B	*Streptostyla mitraeformis* (Shuttleworth, 1852)
Salasiella (Perpusilla) perpusilla (Pfeiffer, 1866)	*Streptostyla* B
Spiraxis cf. scalella	*Streptostyla* C
Systrophidae	
Miradiscops A**	*Systrophia* A*
Miradiscops B*	*Systrophia* B**.
cf. Scolodonta	
Punctidae	
cf. *Punctum*	
Helicodiscidae	
Chanomphalus pilsbry (Baker, 1922)	
Sagdidae	
Xenodiscula sp.	
Euconulidae	
Guppya biolleyi Martens, 1892	*Guppya* sp.*
Guppya miamensis Pilsbry, 1903	*Habroconus trochulinus* (Morelet, 1851)*
Vitrinidae	
Hawaiia minuscule (Binney, 1840)*	Vitrinidae sp.*
Omphalina cf. zonites	
Thysanophoridae	
Thysanophora (Lyroconus) plagioptycha (Shuttleworth, 1854)	*Thysanophora* B*
Thysanophora A *	

* species common to ground and canopy leaf litter
** species only found in canopy leaf litter

Shell paedomorphosis in *Prunum* (Neogastropoda: Marginellidae): A multilineage microstructural analysis

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Living and fossil gastropods have figured prominently in research on the evolution of development through phylogeny (e.g., heterochrony). Here we examine: (1) spatial, temporal, and microstructural patterns of shell deposition through ontogeny; (2) changes in these depositional patterns through phylogeny; and (3) the relationship between microstructure depositional patterns and the assembly and evolution of shell features in three clades of paedomorphic *Prunum* (Neogastropoda: Marginellidae) from the western Atlantic. Ontogenetic patterns of microstructure deposition are mapped on phylogenies for each *Prunum* clade to determine if paedomorphic shells exhibit global or dissociated heterochrony and if paedomorphic shells in different clades are a product of similar microstructure deposition patterns.

Our microstructural analyses focus on shell layering, the external varix, the inner lip, dorsal lip callus, the anterior aperture margin callus, and the posterior aperture margin callus. Ontogenetic studies of these shell characters in all three clades indicate that paedomorphic shells are formed by similar microstructure deposition patterns. However, paedomorphic shell characters do not evolve in concert: the direction and magnitude of character evolution is different among characters. In addition, the evolution of paedomorphs is not due to a simple truncation of ancestral adult ontogeny; the loss or reduction of shell features and microstructural layers in paedomorphs is not the reverse order of character appearances in the outgroup.

Molecular phylogeny of marginelliform gastropods: A progress report

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Maximum-parsimony phylogenetic analyses of marginelliform gastropods (Neogastropoda: families Marginellidae and Cystiscidae), using multiple character sets (shell, radula, and soft-part morphology) have produced robust estimates of the relationships of marginelliforms to other neogastropod families (Olividae, Volutidae, Volutomitridae) and the interrelationships among marginellid tribes (Nehm, 1996). However, resolution of within-tribe phylogeny is currently poor, and the results of morphological analyses have yet to be corroborated with molecular data.

DNA sequences from 16S RNA are used to: (1) test the Coovert hypothesis of marginellid polyphyly (that cystiscids are most closely related to olives rather than marginellids); (2) determine the phylogenetic position of *Hyalina* within the Marginellidae, thus establishing if radular loss was a single or multiple event; and (3) test the monophyly of *Prunum* and *Volvarina*.

Fifteen species from nine marginelliform genera (*Prunum, Dentimargo, Marginella, Hyalina, Volvarina, Rivomarginella, Bullata, Persicula*, and *Gibberula*) and one outgroup (*Olivella*) are available for molecular analyses. Successful DNA extraction has been completed for *Prunwn, Dentimargo, Persicula, Gibberula*, and *Olivella,* and is currently in progress for the remaining taxa. PCR and DNA sequencing have been completed for *Dentimargo*, and are in progress for the other genera.

Finned octopuses (Cirrata) in the seas of Russia

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Finned octopuses, long considered rare exotic animals, have, in the last few decades, been found to be common and usual inhabitants of the near-bottom layer on continental slopes and abyssal plains throughout the World Ocean. Three species, representing a peculiar reproductive strategy and belonging to two differrnt life forms, are recorded in the Russian seas. *Cirroteuthis muelleri* Eschricht (family Cirroteuthidae) belongs to the campanula-like forms and inhabits the northern seas, *Opisthoteuthis californiana* Berry and *O.* "*albatrossi*" (Sasaki) (family Opisthoteuthidae) belong to the flapjack-like forms and inhabit the Far Eastern seas. All three feed on small epibenthic and suprabenthic animals, mostly crustaceans, have large (length 10-11 mm) eggs, produced continuously during the whole adult life and laid individually on the bottom. The individual period of maturity is extended, and feeding and growth continue during spawning. Fecundity is rather low (according to Ch. M. Nigmatullin and V. V. Laptikhovsky, some 1,000-4,000), development is direct, juveniles are less connected with the bottom than are adults. *Cirroteuthis muelleri* may reach 35 cm in total length and is distributed through the whole Arctic Basin, Scandic Basin and Baffin Sea. It is benthopelagic, recorded in the near-bottom layer at approximately 500-3,800 m, but was repeatedly caught in midwater and once even at the surface. It is a common and characteristic animal of the lower slope under the Atlantic Water Mass and on the abyssal plains.

Opisthoteuthis are predominantly benthic animals, occurring mainly on the upper slope and very common locally. *Opisthoteuthis californiana* is widely distributed from the northern Bering Sea to off eastern Honshu and California at depths ranging from 125 to approximately 1,100 m. In the Okhotsk Sea it is common at 400-900 m, in the western Bering Sea at 300-650 m. Maximal arm ring diameter in males is 72 cm, in females 64 cm. *Opisthoteuthis "albatrossi"* is a larger (females to 80 cm) and deeper-water species (780-3,400 m), known from the Aleutian Islands to eastern Honshu, including the Okhotsk Sea. Males of both species of *Opisthoteuthis* are larger than females. The sex ratio is equal or females predominate.

Gonatid squids in the subarctic North Pacific: Ecology, biogeography, niche diversity, and role in the ecosystem

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All available ecological and biogeographical data are gathered on the northern North Pacific gonatid squids: *Berryteuthis* (2 species), *Gonatopsis* (3 sp.) and *Gonatus* (7 sp.). The species are compared according to their size, horizontal and vertical distribution, spawning habitats, diurnal vertical migrations, and gelatinous degeneration associated with maturation. "Ecological individuality" of each species is evaluated. Each species occupies its own ecological niche but these niches overlap to varying degrees. The history of niche divergence in North Pacific gonatids during the Neogene-Pleistocene is characterized. Common features are described of horizontal and vertical distribution of relative abundance and biomass of North Pacific gonatids. Their roles in the ecosystem are analyzed as predators, prey, competitors, and hosts of parasites. In addition, the biomass, production, and food consumption of gonatids are evaluated.

Total biomass of gonatids in the subarctic North Pacific and Russian Far Eastern seas is roughly estimated in 1520 mln tons, their yearly production in 50-80 mln tons (some 10-15% of the world total production of mesopelagic cephalopods) and yearly food consumption in 100-200 mln tons. The life cycle of gonatids is much shorter and their P/B-coefficient much higher than in subarctic mesopelagic fishes. Squid biomass in the Okhotsk Sea is less than 10% of that of fish, but their production is assessed at 58-67% of the total fish production. This emphasizes the very important role of gonatid squids in subarctic oceanic ecosystems.

Deep-water octopods (Opisthoteuthidae: Bathypolypodinae, Graneledoninae) from the Okhotsk and western Bering Seas

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Based on data collected in the Okhotsk Sea (OS) in 1984 at depths of 55-2,000 m, eight deep-water benthic octopuses inhabit this region, namely: *Opisthoteuthis californiana* (400-900 m); *O.* "*albatrossi*" (780-1,500 m); *Benthoctopus* sp. 1 (145-800, ?850 m); *Benthoctopus* sp. 2 (280-1375, ?2000 m); *Benthoctopus* sp. 3 (750-1,375, ?2,000 m); *Benthoctopus* sp. 4 (n. sp., 1,800- 1,840 m); *Bathypolypus salebrosus* (300-750 m); and *Graneledone boreopacifica* (1,040-2,000 m). *Opisthoteuthis californiana, B. salebrosus, G. boreopacifica* and at least three *Benthoctopus* spp. were present off NE Japan and oceanward from the Kurile Islands; three more species of *Benthoctopus* are known off NE Japan. In the western Bering Sea (WBS), in 1993-1995, at depths of 100-750 m, three species were recorded: *O. califomiana* (328-578 m), *B. salebrosus* (350-578 m), *Benthoctopus* n. sp. aff. *B. abruptus* (260-750 m). All species have large eggs, 10-11 mm in *Opisthoteuthis* spp., 16-20 mm in *B. salebrosus,* 22-27 mm in *B.* sp. aff. *B. abruptus,* 20-28 to 35-37 mm in *Benthoctopus* spp. Fecundity in Bathypolypodinae is some dozen of eggs.

Benthoctopus sp. aff. *B. abruptus* is known to occur off NE Japan but not in the OS and none of the four OS *Benthoctopus* are found in the WBS. Morphologically and biogeographically *B.* sp. aff. *B. abruptus* is an intermediate link between rather deep- and warm-water *B. abruptus* (southern and eastern Japan, 300-1,000 m) and *B. sibiricus* from the eastern Arctic, the most cold- and shallow-water (38-220 m) species of *Benthoctopus.* The migration of *Benthoctopus* spp. into the High Arctic is thought to have proceeded in two ways: (1) from the North Atlantic in post-glacial time (*B. piscatorum*)*;* and (2), from the North Pacific through the Bering Strait probably in the middle Pliocene (*B.* sp. aff. *B. abruptus* - *B. sibiricus*).

Egg size, fecundity, vitelline oocyte resorption, and spawning in the gonatid squid, *Berryteuthis magister* (Gonatidae)

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This is the first study of reproduction in a species of "large egg" squid. The reproductive systems of a total of 165 females (160-345 mm ML) were investigated. Specimens examined in this study were collected in the western part of the Bering Sea during 1994-1996. All stages of maturity were represented. Fresh ripe

eggs ranged in size from 3.5-4.1 by 3.4-3.7 mm. During the process of spawning the size of the eggs decreased significantly. Potential fecundity (PF) in pre-spawning females varied between 30,000 and115,000 and increased as ML's increased: PF = exp (2.629 + 0.00432 ML). Relative fecundity ranged between 50 and 102 oocytes per gram (average 75). Large-scale resorption of vitelline oocytes began in pre-spawning females and intensified during the course of spawning. The spawning type is defined as intermittent and descending with a gradual decrease in the number of eggs per egg mass coupled with a gradual degeneration of liver and mantle tissue. The reproductive balance (evolution PF in ontogeny) is as follows: values for average actual (realized) fecundity were 42% PF and for residual fecundity they were 58% PF. The residual stock of oocytes, on average, consisted of 10 % PF protoplasmatic, 2.5 % PF normal vitelline, and 45.5% vitelline resorbed oocytes. The process of vitellogenesis during ontogenesis involved an average of 90% PF (=VF). From this figure 46% VF is realized, 51 % VF is involved in the process of resorption, and 3% VF remained as residual normal oocytes. The energy of resorbed vitelline oocytes probably is one of the main sources for metabolism in non-feeding, spawning females.

Fecundity of the ommastrephid squid, *Dosidicus gigas*, in the Eastern Pacific

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The female reproductive systems of a total of 76 *Dosidicus gigas*, collected in 1980-1989 from off southern Peru to Nicaragua (150-720 mm ML), were investigated. The average diameter of ripe eggs was 0.78-1.07 mm and the egg weight was 0.22-0.47 mg. These features are significantly higher (t=8.129 and t=6.321) in female squid caught off Nicaragua compared to squid caught off Peru. Potential fecundity (PF=total oocyte stock in pre-spawning females) varied between 300,000 and 13,000,000 and increased in direct proportion to increases in mantle length (ML) and body weight (BW): PF=exp (5.110 + 0.00589 ML) r=0.89 and PF=exp (6.775 + 0.000215 BW) r=0.82. Relative fecundity of mature females (588-3,768 oocyte/g; mean 1,632) did not differ in different parts of the species' range (Peruvian waters, equatorial zone, and Nicaragua region). Intra-specific variations in PF were extremely high even among animals of the same size and in the same physiological condition. Thus in maturing females (380-395 mm ML) the PF varied from 2.5 to 6.0 million oocytes. Variations presumably are caused by different individual growth rates during the foraging period, when PF levels are already established. The Index of Potential Reproductive Investment is 0.19-1.32 (0.56). Mature females accumulate from 10,000 (ML 150 mm) to 1,000,000 (ML > 500 mm) oocytes in the oviducts. During a single spawning event each female spawns more than 30% of the initial oocyte stock. Spawning is intermittent, as is typical in other ommastrephids.

Rendezvous in the dark: Coevolution between sepiolids and their luminous bacterial symbionts

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It has long been noted that the partners of an animal-bacterial symbiosis express phenotypic traits that reflect adaptation to their relationship. We have studied the coevolutionary patterns of the independently culturable partners in the sepiolid squid-luminous bacteria symbioses. Molecular phylogenies for the host

squid were derived from sequences of the nuclear internal transcribed spacer region and the mitochondrial cytochrome oxidase subunit I; the glyceraldehyde phosphate dehydrogenase gene was used for phylogenetic determinations of the bacterial symbionts. A combined tree for all three loci indicated a parallel phylogeny between the sepiolids and their respective symbionts. These phylogenetic analyses were coupled with experiments examining the ability of the different symbiont strains to compete and colonize a particular sepiolid host. Our results indicated an enhanced specificity for native strains of symbionts over non-native strains, and provided a hierarchy of symbiont competency that completely complemented the phylogenetic relationships. This combination of molecular systematics and symbiont colonization provides both molecular and biological evidence for mechanisms of coevolution among animal-bacterial associations, and specifically the evolutionary events that may provide insights for the origin and divergence of this group of sepiolids.

Phylogenetic relationships of flabellinid nudibranchs based on mitrochondrial DNA sequences

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Opisthobranch mollusks in general show a high incidence of convergent evolution in anatomical structures that are used in their classificaiton. This might have serious implications for establishing phylogenetic relationships based on morphology within these groups as homoplasy would hinder the recovery of correct phylogenies.

The large and morphologically diverse nudibranch family Flabellinidae has recently received much attention, and phylogenetic relationships within this family based on morphological characters have been published (Gosliner and Kuzirian, 1990; Gosliner and Willan, 1991). Both studies, however, show large amounts of homoplasy in their datasets. To investigate the extent of convergent evolution of anatomical structures within this family, I have established a preliminary phylogeny of flabellinid nudibranchs based on DNA sequences of the mitochondrial genes 16S and cytochrome oxidase I. This molecular phylogeny provides an independent phylogenetic framework for this family on which the evolution of anatomical structures and be traced.

Invertebrate megafauna, community structure, and molluscan associates at three deep-sea sites off central California

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Invertebrate megafaunal community structure at three sites at the base of the continental slope at 3,000 m was investigated by beam trawls and camera sleds. The sedimentary environment was dominated by holothurians, ophiurans, pennatulids and one species of sea star and one species of corallomorpharian. There was considerable variation in rank order of abundance of the dominant invertebrates among the

sites and between years at one of the sites. Comparisons between camera sleds and trawls indicated no differences in rank order of abundance, but the densities estimated from the camera sleds were about four times those of the trawls. The molluscan fauna was sparse in relation to the other invertebrates, only 15 species were found, and the two most abundant species were the large scaphopod, *Fissidentalium megathyris,* and the turrid, *Steiraxis aulaca.*

Molecular phylogenetic relationships of brooding oysters

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Molluscan systematists have traditionally regarded the Ostreacea as a notoriously difficult taxon, due in large part to their xenomorphic growth patterns. In some cases, systematic relationships have been further obscured by undocumented anthropogenic transfers. Molecular characterization of oyster taxa, however, promises to significantly increase our understanding of phylogenetic relationships among these intriguing organisms. We are focusing on the brooding oysters: the Lophinae and the Ostreinae. Their phylogenetic relationships to other members of the Ostreacea are being delineated using 28S nuclear ribosomal gene sequences. A fragment of the mitochondrial 16S ribosomal gene is being used to investigate relationships among the brooders. Preliminary results indicate that: (1) parental care may have been secondarily lost in ancestral lineages of cupped oysters; (2) the Lophinae and the Ostreinae may both be paraphyletic; (3) Harry's (1985) interpretation of systematic relationships among Southern Hemisphere Ostreinae is not supported; (4) the "non-ostreid" larval development of *Tiostrea chilensis* is secondarily derived.

Molecular systematics of Aplacophora based on EF1a nuclear gene sequences

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Aplacophora are shell-less, vermiform, deep-sea mollusks in which the external cuticle is covered by numerous aragonite spicules. Little is known about aplacophoran phylogeny, and its analysis has been based mostly on morphological characters. The only published molecular data, which utilized 18S rRNA sequences, did not resolve the phylogeny of the Aplacophora. The phylogenetic questions are whether the two aplacophoran taxa, Neomeniomorpha and Chaetodermomorpha, are monophyletic and whether they are basal to all extant mollusks. To resolve conflicting hypotheses, the highly conserved nuclear coding gene elongation factor-1 alpha (EF1 a) was analyzed for *Epimenia australis* and *Chaetoderma canadense.* The analysis of a 1200 bp fragment of the EF1a gene from the two aplacophoran species and from species representing the Polyplacophora, Bivalvia, Gastropoda, and Cephalopoda represents the first aplacophoran phylogeny based on EF1 a molecular data. (Supported in part by NSF DEB-PEET 95-21930.)

Land snail ecology on the northern Kuril Islands, Far Eastern Russia: Habitat versus isolation

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Boreal islands in the northern Kuril Island Archipelago in Far Eastern Russia have relatively few vegetation assemblages, and represent an excellent situation in which to examine the influences of habitat and isolation on the composition of terrestrial gastropod assemblages. In 1996, I collected 6,250 gastropods of 13 species from 61 leaf litter samples taken from meadow, alder (*Alnus maximawiczii*), and pine (*Pinus pumila*) habitats on eight of the northern Kuril Islands. In contrast to temperate North American gastropod faunas, meadow samples averaged more species than alder forest samples, although abundances were slightly lower in meadows. Pine forests had very few species and extremely low abundances of individuals. Consistent with island biogeography theory, larger islands tended to have a greater total number of species, however, gastropod abundances tended to be lower on larger islands. Five species occurred on all or all but one island suggesting that isolation does not limit their distribution, but five other species occurred on four or fewer of the islands, consistent with the hypothesis that isolation influences the distribution of some species. All or all but one of the 13 species occurred in the meadow and alder habitats, respectively, but only four species occurred in pine forest litter, indicating that habitats are not equally suitable. Thus, both habitat and isolation appear to influence gastropod species assemblages on the northern Kuril Islands.

The spawn in the genus *Adelomelon* (Prosobranchia: Volutidae) from the Atlantic coast of South America

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Since the early descriptions of egg capsules of South American volutes in the past century, very few additions have been made, many of them unfortunately proved to be wrong. We describe here the egg capsule of the largest South American volute, *Adelomelon becki* (Broderip, 1836), and redescribe the often confused spawn of *A. ancilla* (Lightfoot, 1786). The spawn of *A. becki* is a single, conspicuous, large, globose and hemispheric egg capsule attached to pectinid shells, measuring 50 mm in basal diameter and 35 mm in height. The base is round and has a narrow (3 mm) margin. The number of embryos ranges from 7 to 10. The size at hatching was 16.0 to 18.6 mm in shell length. The internal volume of the egg capsule was 30 to 35 ml. No nurse eggs were observed. All the studied material was at a pre-hatching crawling stage.

The egg capsule of *A. ancilla* is oval and flat, with a diameter ranging from 37 to 45 mm, never covered by a calcareous layer. They are generally attached to pectinid shells. The number of eggs per capsule is 5 to 8, and so is the number of developing embryos; nurse eggs are not present. The eggs are 150 microns in diameter and are surrounded by a very dense liquid. The internal volume of the egg capsule ranged from 2.5 to 4.0 ml. Hatching takes place as crawling juveniles, the shell measuring between 11.7 and 12.7 mm.

We discuss the affinities within the volutids, including *Adelomelon brasiliana* free egg capsules.

Dynamics of adult and juvenile bivalve dispersal: A shifting paradigm

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There has been a growing literature base that has attempted to, at least in part, refocus our attention on recruitment and dispersal mechanisms, away from planktonic and larval propagules, towards small and juvenile forms. In bivalve molluscs, it is now well known that short to medium range dispersal in juvenile (post-larval) tellinids, mytilids, venerids, solenids, myids, and arcids is possible via byssal or stochastic drift. We believe we must add to this list dispersal of some adult bivalves as well. Evidence of dispersal in some adult venerid, mactrid, and corbiculid bivalves is substantial. Brooding *Corbicula fluminea* can disperse as adults using mucoid drogue lines. Large, sexually mature *Mercenaria mercenaria* can be entrained from sandy sediments and are thus capable of passively migrating to new sites.

The relative importance of adult bivalve dispersal in founding new demes or patch dynamics is unknown. We suggest that repetitive findings of small populations of adult bivalves in sites where larval recruitment is not evident could represent viable founding populations that have their origins in adult phases. Discrepancies in fisheries surveys as well as anomalies in predicted trends of population heterozygosities, could reflect dispersal by adult bivalves.

Effect of diet and temperature on growth and biogeographic distribution of the herbivorous kelp snail *Norrisia norrisi*

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Norrisia norrisi (family Trochidae), a hervbivorous snail that commonly lives and feeds on kelps, is largely confined to the warmer waters of the Southern California Bight from Point Conception to Isla Asunción, Baja California Sur, Mexico. Previous experimental research has shown that *N. norrisi* prefers kelps over all other algal foods. Here, we test the hypothesis that *N. norrisi* not only shows strong preferences for kelps but also grows best on its preferred seaweed food. In addition, we test the hypotheses that colder seawater temperatures result in reduced consumption and assimilation of algal foods and reduced growth (shell and body mass). To test these hypotheses, individual snails were held in feeding arenas in the laboratory and fed algal diets ad-libitum for a minimum of six weeks. Diets consisted of fresh thalli of either the green alga *Ulva lobata* or the kelp *Eisenia arborea*, which were provided every four days. Snail shell size and biomass were measured bimonthly to determine growth. Additionally, the amount of seaweed food consumed and the quantity of fecal matter produced were determined for both algal diets. Our results suggest that when fed a unialgal diet, *N. norrisi* grows best on kelp and that its feeding biology is strongly influenced by seawater temperature. (Sponsored by CSU Fullerton Biology Department and CSU Fullerton DAC.)

New data on the anatomy and taxonomy of *Lacustrina* Sterki (Bivalvia: Pisidioidea)

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Small freshwater clams placed by Russian taxonomists in the superfamily Pisidioidea and by other specialists in the family Sphaeriidae are difficult to identify because their shells have few diagnostic features. Consequently, interest in anatomical study of these small bivalves has increased, especially since the 1990s (Meier-Brook, 1992; Korniushin, 1989, 1990, 1992, 1996; Kuiper et al., 1989; Prozorova et al., 1996 and others).

We studied specimens of the genus *Lacustrina* conchologically and anatomically. Anatomical study included examination of the structure of the mantle edge, gills, and brood sac. Anatomically, this genus is characterized by a short presiphonal suture, presence of the upper siphon only, and of descending lamellae in an outer demibranch (Korniushin, 1990, 1996).

American and Canadian malacologists consider the only representative of the genus in North America to be *Pisidium idahoense* Roper (Clark, 1973, 1981; Burch, 1975). Both Russian and European specialists regard this species to be a Nearctic counterpart of the Palaearctic species *P. subtilestrianum* (Lindholm) (Kuiper et al., 1989) or *Lacustrina dilatata* (Westerlund) (Starobogatov, 1970; Korniushin, 1990, 1996). In 1985, a second species with less curved valves, *L. chukchensis* (Prozorova), was described from Chukotka. Later, both species of *Lacustrina* were found in Alaska in the same location (Prozorova and Foster, in press). When found together, they are morphologically discrete conchologically and are thus recognized as valid species. Both anatomical and conchological characteristics of studied Alaskan specimens of *L.dilatata* were revealed to coincide with those of Palaearctic individuals of this species (see Korniushin, 1996). This evidence provides a good argument for the conspecificity of *L. dilatata* and *P. idahoense*. Thus, *L. dilatata* is wide-spread through the Holarctic in large lakes. Distribution of the closely related *L. chukchensis* is restricted to the Beringian region from the Kolhyma River to the west and Yukon River to the east.

Of great interest is the finding of a species of *Lacustrina* on Iturup Island in the Southern Kuril Islands, Russia. In 1994-1996 we collected and studied clams that had been described by Mori (1935) as *Pisidium amnicum etorohuense* and inhabiting only two lakes on the Iturup. Well visible descending lamellae were found in the outer demibranch of all examined specimens, indicating that they differed from *Pisidium*. Furthermore, we discovered the brood sac developed from the thickening of the middle part of an inner demibranch only (Korniushin, 1996). This species, *Lacustrina etorohuense*, is the most southward ranging species in the genus. The structure of its gills differs from that of two other species by having a less reduced descending lamella of the outer demibranch. The height of the descending lamella of *L. etorohuense* is more than twice that of the ascending one, whereas the difference between the height of these lamella in *L. dilatata* and *L. chukchensis* does not exceed 1.5. According to Korniushin (1996), the reduction of the outer demibranch is defined by a decrease of its height and displacement back relative to the inner demibranch. A second index of the outer demibranch reduction, counting the inner demibranch filaments corresponding to the anterior edge of the outer demibranch, revealed the same number for all species of *Lacustrina*, 6-7 filaments.

Age determination of the gonatid squid *Berryteuthis magister* (Berry, 1913) based on morphometric characters

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There are two, three, or four different age groups present in harvested populations of *Berryteuthis magister.* Size distributions of these groups overlap considerably, which makes it difficult to determine precisely the modal size classes. We worked out a method of discrimination between groups of the squid based on cluster analysis of morphometric traits. We obtained data on number, maturity, and size-weight character of each age group. Modal size classes of these groups were time approximated on the multiplicative model ($Y = aX^b$). Theoretical growth curves for *B. magister* from the western Bering Sea and from the Kurile Islands region also were obtained. These curves were based on data for each sex for a several year period.

A preliminary assessment of the generic relationships of the Lampsilini (Bivalvia: Unionidae) based on a portion of the 16S rRNA gene

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The Lampsilini contains approximately one third of all North American unionid taxa. Members of this tribe display an astonishing variety of conchological and reproductive adaptations not found in other freshwater bivalves in North America.

A phylogenetic analysis of Lampsilini relationships constructed upon a preliminary molecular data set of mitochondrial 16S rRNA sequences provides an opportunity to test the monophyly of the Lampsilini as well as explore relationships among the genera in that tribe. In addition, the classification allows examination of the evolution of reproductive structures found in the various informally recognized groups within the Lampsilini. The data set generated will also provide the basis for future research aimed at generating much needed classifications within the various generic groups, and research into the evolution of reproductive strategies in the Lampsilini.

Reproducibility and explicit hypotheses in molluscan phylogeny

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One of the advantages of phylogenetic systematics over traditional methods of expressing relationships among taxa is that methods and data used to reach conclusions can be explicitly stated, allowing other workers to verify the results and test the effects of various methodological assumptions. Some workers however, continue to proceed in a narrative mode, loosely guided by phylogenetic principles. They present neither explicit methods nor explicit data. Others present data matrices, but their stated methods

do not reproduce their results. In some cases it is possible to reconstruct the methodological efforts that lead to the erroneous results. Malacologists have generally shied away from debates about phylogenetic methods, but such debates can have salutory effects for the field if conducted in a collegial fashion. In the hopes of stimulating debate, I draw examples from phylogenies recently published by Taylor, Kantor & Sysoev (1993), Bandel & Reidel (1994), and Coovert & Coovert (1995).

Highest known land snail diversity: Sixty-six species from one site in Jamaica

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Four person hours of collecting at a small (circa 4 hectare) karstic, partially disturbed site near Auchtembeddie, Jamaica in September 1996 yielded 57 species of land snails and two species of slugs. A subsequent visit in February 1997 yielded 50 snail species in six person hours, including seven species not collected earlier. Of the total, 21 species were found alive, nine freshly dead, and 30 with sufficient gloss, color or periostracum remaining to indicate that they probably still exist at the site. Six species were represented only by long dead shells. Of 21 species collected alive, 20 are Jamaican endemics. At least 43 genera are represented. Family distribution is as follows: Helicinidae, 13 species; Poteriidae, 2; Annulariidae, 3; Truncatellidae, 2; Succineidae, 1; Pupillidae, 1; Valloniidae, 1; Euconulidae, 1; Subulinidae, 2; Oleacinidae, 9; Orthalicidae, 1; Bulimulidae, 2; Urocoptidae, 6; Systrophiidae, 1; Sagdidae, 13; Camaenidae, 5; Helminthoglyptidae, 1; Veronicellidae, 2.

Highest diversities previously reported are 60 species at Waipipi Reserve, New Zealand (56 native snails, one native slug and three introduced snails) and 52 native snails at Manombo, Madagascar. Of the 66 Jamaican species, 58 are native, including two slugs, four are introduced, and four, all micromollusks, are of uncertain status. The sites in New Zealand and Madagascar have been searched more intensively than the Jamaican site, where no arboreal, leaf litter, or soil sampling has been done. Only 11 (17%) of the Jamaican species sampled reach maturity at under 5 mm. Thus, further work at the site should push known diversity considerably higher than 66 species.

Popular delusions, phantom taxa, and the weirdness of ranks

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Biological classifications shape the way we think about the organisms of interest to us. Aspects of traditional ("canonical") systematics are examined for some less-than-salutary effects on scientific thinking. Rank-free classification, incorporating phylogeny-based taxonomy, while not free of problems of its own, can help us avoid some of the pitfalls of canonical classification.

Early Paleozoic stem group chitons from Utah and Missouri: No Problematica!

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Conical sclerites from the North American Cambrian were placed in an extinct molluscan class Mattheva by Yochelson (1966). In 1979, Runnegar and others suggested that *Matthevia* Walcott is the oldest known chiton and a close relative of early Paleozoic chiton genera such as *Chelodes* Davidson and King and *Hemithecella* Ulrich and Bridge. However, a counter proposal by Stinchcomb & Darrough (1995) moved *Matthevia* and *Hemithecella* back to the "molluscan Problematica."

Large numbers of silicified fossils from uppermost Cambrian (Sunwaptan) strata in Utah show that *Matthevia* had at least two types of sclerites (valves) that are repeatably found in ratios of 4 or 5:1. These ratios are not those expected from undisturbed chiton graveyards (6:1) but they do falsify the notion that *Matthevia* had only two valves (Yochelson) or as many as 15 (Stinchomb & Darrough). As one of the median faces of the more numerous kind of valve is distinctively concave, apparently to receive the leading face of an adjacent valve, this new species of *Matthevia* helps bridge the morphological gap between *M. variabilis* and *Hemithecella.* Their relationship to unequivocal stem group chitons is now supported by additional characters and partially articulated specimens. With regard to the broader picture, it is likely that all Paleozoic chitons are stem group polyplacophorans and that early disparity was reduced by a series of mass extinction events.

Dreissena polymorpha: Macrocosm, microcosm and the organism interface

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Ernst Mayr reminded biologists years ago that there is never a time in the life of a sexually reproduced organism when it does not have both a genome and an environment, and that it is the dynamic relation between the two that eludes understanding, and yet that demands it. The anxious call went out in 1989 as one of the first symposia was being organized to confront the sudden and massive appearance of *Dreissena polymorpha* in the Great Lakes: "Let's not reinvent the wheel!" The accompanying plea to participants was an exhortation to use what we knew, in order to proceed in a more more deliberate and creative way than in the past, with other introduced organisms.

In this paper, I carefully review what has been done, what has been found, where research seems to be going, and where research ought to be going on *D. polymorpha.* My particular concern will be for the organism, and for Mayr's prophetic injunction.

Intertidal ecology of *Octopus dofleini*

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The ecology of the giant octopus, *Octopus dofleini,* is largely known from SCUBA diving studies around Vancouver Island, British Columbia. Here, we present new data on the habitat use of this species from Prince William Sound, Alaska. We searched for octopuses on foot in the intertidal during minus tides, and to depths of 30 m (100 ft) by SCUBA diving. Octopuses were found in habitats characterized by low slope, cobble or rock outcrops, and dense vegetation cover; and typically were not found on steep slopes, bedrock, gravel, or mud, areas of low vegetation, nor on boulder piles. Intertidal prey middens were composed primarily of crab remains; as depth increased, scallops became common in middens and largely replaced crabs below -10 m. Seventy-five percent of octopuses were found in the intertidal zone between +2 and -1.3 m MLLW. During SCUBA surveys, octopuses were more abundant on shallow dives (to -5 m) than on deep dives. Three octopuses from the intertidal, tracked using sonic transponders, remained in or returned to shallow water. This pattern of intertidal habitat use contrasts with studies by others in British Columbia that reported on subtidal octopuses between -5 and -20 m. Sea otters are regular predators on octopuses; and we suspect that intertidal habitats provide a refuge from otter predation for juvenile octopuses. Otters were prevalent in Prince William Sound, but absent at the British Columbia study sites.

The Aplacophora as a deep-sea taxon

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The ocean depths are not such an unvarying, constant envirornment as they once were thought to be. Differences among aplacophoran faunas reflect the physical, chemical, and biological environments at hydrothermal vents, on the bottom beneath regions of high and low organic flux from the surface, in trenches, on continental slopes and abyssal plains, on sea mounts, in oxygen rich and poor areas, and in polar and tropical regions. Prochaetodermatidae numerically dominate upper continental slopes and neomenioids are dominant on sea mounts. (Supported by NSF DEB-PEET 9521930.)

Reproduction among protobranch bivalves from sublittoral, bathyal, and abyssal depths off the New England coast (USA)

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An examination of seven species of protobranch bivalves reveals that the "apparent fecundity" (i.e., the number of ova produced by a single female at the time of reproduction) is consistently greater among sublittoral than among bathyal and abyssal species. Such a relationship exists both among forms with lecithotrophic planktonic larvae and those lacking a planktonic stage. The apparent fecundity of a species increases with increasing size (i.e., shell length) in both shoal-water and deep-sea species. Accordingly, the apparent fecundity of older individuals exceeds that of smaller, younger ones. From examination of gonads at different seasons, spawning in sublittoral species is inferred to be periodic and occurs only during the summer months. Contrariwise among deep-sea species, evidence suggests continuous gametogenesis in those species examined. It is therefore not possible to estimate the rate that ova are produced nor the lifetime fecundity of such deep-sea forms. Populations of sublittoral species are dominated by juvenile individuals, whereas in deep-sea species at their optimum depth (i.e., the depth at which they occur in greatest numbers), populations consist largely of sexually mature individuals, suggesting relative stability in such populations. Deep-sea species near the limits of their depth distributions are composed of

populations that more nearly resemble those of sublittoral forms and are made up mostly of juvenile individuals. Species with a development lacking a planktonic stage have larger and fewer ova and, among those populations examined, were dominated at both sublittoral and abyssal depths by juvenile individuals.

Molecular phylogeny of giant clams (Cardiidae: Tridacninae)

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Giant clams have been shown to be a morphologically highly derived clade of cardiid bivalves. A phylogenetic hypothesis of giant clams is constructed with the mitochondrial ribosomal 16S gene. As the sister taxon to the Tridacninae is the Lymnocardiinae, a basal lymnocardiinae, the edible cockle *Cerastoderma.* is used as the outgroup. This molecular phylogenetic hypothesis is compared to results previously obtained from morphological analysis and the fossil record. Giant clams, like cardiids in general, have numerous morphological characters and an excellent fossil record. This situation, unusual among bivalves, allows assessment of the 16S gene as a tool for phylogenetic reconstruction of clades that have diverged during the Cenozoic.

Flight of the Vampire: Scaling of metabolism and aquatic "flight" in *Vampyroteuthis infernalis* (Cephalopoda: Vampyromorpha)

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Vampyroteuthis infernalis is a cosmopolitan cephalopod that lives in the heart of the oxygen minimum layer below 600 m depth. Morphometric and physiological studies have indicated that *V. infernalis* has little capacity for jet propulsion and has the lowest metabolic rate ever measured for a cephalopod. Because fin swimming is inherently more efficient than jet propulsion, some of the reduction in energy usage relative to other cephalopods may result from the use of fins as the primary means of propulsion. *Vampyroteuthis infernalis* undergoes a rapid metamorphosis that consists of changes in the position, size, and shape of the fins. This suggests that there are changes in the selective factors affecting locomotion through ontogeny. The present study describes these changes in *V. infernalis* in relation to models for underwater "flight." Citrate synthase (CS) and Octopine dehydrogenase (ODH) activities, indicative of aerobic and anaerobic metabolism, respectively, were measured across four orders of magnitude size range. Results indicate that fin swimming is the primary means of propulsion at all post-metamorphic sizes. Negative allometry of CS activity in mantle and arm muscle is consistent with scaling of aerobic metabolism observed in most animals. The unusual positive allometry of fin muscle suggests that fin swimming is more costly at larger sizes. Positive scaling of ODH activity in fin, mantle, and arm tissue suggests that fin propulsion, jet propulsion, and medusoid "bell-swimming" are all important for burst escape responses. The observed scaling patterns and morphological changes at metamorphosis appear to function as an ontogenetic "gait-transition."

Post-spawning egg care in *Gonatus* (Cephalopoda: Teuthoidea): Life history and energetics

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A novel reproductive strategy of deep-water spawning and egg-care was observed for the mesopelagic squid, *Gonatus onyx*. Brooding females and associated eggs and hatchlings, captured between 1,250 and 1,750 m off southern California are described. Brooding females appear to be senescent and are lacking tentacles. The loss of tentacles in gonatid species is discussed in relation to this unusual life-history characteristic previously unreported for squids. Metabolic estimators and chemical composition of *G. onyx* and *G. pyros* also are reported and discussed in relation to bouyancy and energy reserves that may support a non-feeding, post-spawning brood period of up to nine months.

Distribution and assemblage patterns of micronektonic squids at large-scale fronts in the central North Pacific Ocean

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Large-scale oceanic fronts associated with water masses form the primary biogeographic boundaries in the open ocean. In the North Pacific, the Subarctic and Subtropical Fronts form boundaries that divide some of the large, core pelagic biogeographic provinces. Historically, biogeographic ranges of many micronektonic species, including euphausiids, pteropods, heteropods, and chaetognaths as well as some commercial fish species, have been shown to correspond with regions delimited by these large scale features. Recent trawl surveys that sampled across these fronts and frontal zones support previous suppositions that the distribution, abundance, and assemblage patterns of pelagic cephalopods are also strongly influenced by these physical features.

During August 1991, >3,000 cephalopods representing 25 species were collected at sites across the Subarctic Boundary along the 174.5° and 179.5° W meridians between the 37° and 46° N latitudes. Another 637 individuals representing 34 species were taken in the Subtropical Frontal region (between 21° and 31° N latitudes) during March-April 1992. The oegopsid squid families Onychoteuthidae, Enoploteuthidae, Gonatidae, Pyroteuthidae, Cranchiidae, and Chiroteuthidae were the most extensively sampled and provided the best insight into how cephalopods respond to variations in oceanographic conditions. Patterns of distribution, abundance, and interspecific associations of the cephalopod fauna are described with respect to the local frontal environment and discussed within the context of large scale northern transitional and central biogeographic provinces. Taxonomic advances and concerns are highlighted.

Distribution and abundance of pelagic cephalopods in the central North Pacific: Information from large-scale high-seas driftnet fisheries

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During the late 1970s through to 1992, high-seas drift gillnet fisheries targeting flying squid, *Ommastrephes bartramii,* and tuna and billfishes operated in waters of the North Pacific transition zone (NPTZ) and its associated subtropical and subarctic boundaries. These large-scale fishing operations generally involved deploying numerous panels of rectangular nets 30-50 m long by about 10 m deep strung together to form a curtain of webbing stretching several kilometers across the oceans' surface and capturing animals by entanglement. At the height of the fisheries in the late 1980s, more than 700 vessels operated in the multinational fisheries, each fishing about 30-60 km of nets per day. During the 1990-91 fishing seasons, observer programs were administered over the fisheries, monitoring catch and effort in up to 10% of the fishing fleets. Information collected by the observers have provided an unprecedented near-basinwide characterization of pelagic nekton species composition, distribution, abundance, and interspecific relationships on a relatively short time scale.

Overall, more than 25 million cephalopods were observed captured during the 22-month monitoring program, of which >99% were *O. bartramii.* Regions of high catch rates and observed size frequency distributions are consistent with life history and ecological movement patterns reported for the species. For other commonly taken species, *Onychoteuthis borealijaponica* were most abundant in the subarctic western Pacific east of Hokkaido, Japan where catch rates exceeded 2,000 squid/50 km of net in several 1° latitude by 1° longitude statistical areas. The highest catch rates of *Gonatopsis borealis* (>200 squid/50 km net) were all found in areas west of the dateline in the vicinity of the Subarctic Boundary, whereas the pelagic octopus, *Ocythoe tuberculata,* was taken in limited numbers throughout the NPTZ during all seasons but was nowhere abundant. Capture of *Thysanoteuthis rhombus* was basically restricted to subtropical waters fished during the winter months with large mesh (ca. 170-180 mm stretched measure) nets.

How aqueous geochemistry affects lacustrine mollusks

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Changes in climate and hydrology through time affect the solute composition and the stable isotopic content of lake water. These changes may be reflected in both the presence (occurrence patterns) and the isotopic composition of shell aragonite of lacustrine mollusks. Interpretation of preliminary data suggests that modern molluscan occurrences are restricted by solute composition, rather than just pH or salinity as is commonly believed. All mollusks are found in waters with (bi)carbonate and calcium ($CaCO_3$) forming the dominant-to-important components of the solute composition. Additionally, the bicarbonate-to-calcium ratio within this solute type appears to limit certain genera. Linkage of species occurrences to solute chemistry provides a new way of viewing biogeographical ecology and, from that, a new

methodology for econstructing past hydrology and climate. A related study compares the stable oxygen isotopic content of modem gastropod shells with that of the water at the time of shell growth. Results show that the $\delta\ ^{18}O$ content of lacustrine gastropod shells covaries with that of the host water, although the variability and offset from the value of the water differ among genera. Understanding the relationship between water and shell isotope values provides a basis for interpreting shell stable isotope geochemistry and the isotopic values of the waters in which the mollusks lived. Both studies will contribute to our understanding of mollusk ecology and biology, and paleoenvironments.

Multiple paternity within broods of a squid, *Loligo forbesi*, demonstrated with microsatellite DNA markers

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For some time, observations on spawning aggregations of squid have suggested the possibility that females may mate with more than one male before spawning. Due to the difficulties of catching, then maintaining these animals under controlled conditions, confirmation of multiple paternity within broods has been impossible. The adoption of multiple matings, whether solicited or not (i.e., "sneaker males"), and their effectiveness in producing multiple sired broods, has many important implications for the study of behavior, genetic population structure, and evolution in these species.

Here we confirm, using sensitive microsatellite DNA markers specifically developed for this species, that multiple males do contribute to the fertilization of single broods of a loliginid squid, *Loligo forbesi*. To achieve this result pre-hatching embryos from single egg strings collected from the wild were genotyped using six independent microsatellite loci, and prospective maternal and paternal genotypes reconstructed from the allelic combinations observed. We also genetically confirm that females may lay their egg strings within existing bunches laid by other females. The wider applications of microsatellite DNA markers to behavioral and evolutionary studies in cephalopods are discussed.

Evidence for four species of *Brachioteuthis* (Oegopsida: Brachioteuthidae) in the eastern North Atlantic

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As currently recognized, the family Brachioteuthidae contains one genus (*Brachioteuthis*) and five species (*B. beanii, B. riisei, B. behnii, B. bowmanii,* and *B. picta*), but is greatly in need of revision. Taxonomic confusion within the family can be attributed in part to poor original descriptions, and in part to the paucity of available mature specimens in good condition. Traditionally, the eastern Atlantic has been thought to have only one species, *B. riisei* (Steenstrup, 1882); however, a detailed examination of newly hatched and juvenile specimens collected during the Amsterdam Mid North Atlantic Plankton Expeditions of 1980-1983 (n = 259) revealed that four morphotypes were consistently distinguishable based on the shape of the head, the mantle chromatophore patterns, and the shape of the tentacle. Only two of these four morphotypes can be tentatively assigned to currently recognized species. *Brachioteuthis* sp. 3 is described similarly to *B. picta*, and *Brachioteuthis* sp. 4 has many of the same characters as *B. bowmanii.* Confident identifications are hampered by the lack of original descriptions of hard parts, such as beak morphology, as well as the potential allometric differences between adults and juvenile or newly hatched cephalopods.

Distribution and biology of *Rossia pacifica* (Cephalopoda: Sepiolidae) in the Russian Exclusive Zone of the Japan Sea

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Rossia pacifica Berry, 1911, is a common species in coastal waters of the Japan Sea. In the Russian Exclusive Zone it is found south to 51° N in the summer-autumn period. It occurs both near the bottom (15-310 m) and in the pelagic layers (0-490 m). The sepiolid ranges in size from 12-82 mm ML; female mantle lengths are 41-82 mm (mean 51 mm) and male mantle lengths are 27-42 mm (mean 32 mm). Egg masses of *R. pacifica* have been found in Peter the Great Bay (42°33' N, 131°13' E) from October-November in depths ranging from 100-300 m; in the region 42°40' N, 133°02' E to 42°50' N, 133°37' E from July-November in depths of 30-50 m; and in the region 43°02' N, 134°10' E from July-September in depths of 15-20 m. Egg masses typically are attached to rocks and to the underside of various objects (trap boxes, etc.).

In the winter-spring period *R. pacifica* is distributed south to 49° N. Of the total population 94% occurred in epipelagic depths, 5.3% in mesopelagic, and 0.7% in the bathypelagic zone. Maximum abundance of the species (200 specimens per hour trawling) was observed on the South Sakhalin shelf. Small specimens (less than 20 mm) dominate in pelagic catches, whereas large specimens (greater than 50 mm) dominate in bottom catches. Sizes in winter-spring range from 9 to 85 mm ML; female mantle lengths are 43-85 mm (mean 65 mm) and male mantle lengths are 33-56 mm (mean 45 mm). Females mature at 62 mm and males at 38 mm.

In summary, juveniles of *R. pacifica* live mainly in epipelagic layers (10-200 m), whereas adults are demersal. The species spawns throughout the year with a peak in autumn.

Discovery of an egg mass with embryos of *Rossia pacifica* (Cephalopoda: Sepiolidae) in the Okhotsk Sea

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A total of 27 tows were conducted at depths ranging from 100-300 m during the Okhotsk Sea bottom trawl survey off southwestern Kamchatka between 51° and 54° N in July 1996. In 14 samples (52%), 144 specimens of *Rossia pacifica* and an egg mass fragment were collected. The frequency of occurrence of *R. pacifica* increased from 17% at the 100 m isobath to 80% at the 250 and 300 m isobaths. Mean catch was 8.1 specimens per half-hour tow. Maximum abundance was observed at 250 m depth: mean catch was 15 specimens, or 1,615 g. Mature female mantle lengths ranged from 84-100 mm (mean 88.3 mm); lengths of nidamental glands, 45-55 mm (mean 50.8 mm); body weights, 165-235 g (mean 192.5 g). Male mantle lengths varied from 54 to 58 mm (mean 56.0 mm); body weights, 60-95 g (mean 75 g).

An egg mass fragment with 36 eggs was collected in 250 m on a sand bottom. The water temperature near bottom at this location was 1.58°C. Each egg (12 mm in diameter) contained three capsules. The external capsule is oval in shape, white in color, and ranges in size from 13.8 to17.8 mm. The egg is filled with a yolk mass and an embryo lies on it with its mouth plunged deeply into the yolk. The dorsal mantle length of the embryo is 1.6 mm. All arms and tentacles are well developed with suckers in 2-3 unarranged rows. The embryo body form, head, fins, and armature of the arms correspond to those of *R. pacifica.*

The presence of mature males and females, ready to spawn, plus an egg mass fragment caught at a depth of 250 m indicates the presence of a *R. pacifica* spawning ground.

Molluscan paleontology of middle Eocene brackish-marine rocks near Ojai, Ventura County, southern California

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Within-habitat, brackish-marine mollusks are rare in lower Tertiary rocks of California. Lagoonal mudstones in a localized, 50 m-thick section in the lower middle Eocene ("Transition Stage") upper part of the Matilija Sandstone at Matilija Hot Springs near Ojai, contain low-diversity assemblages of gastropods and bivalves. Although the number of specimens is highly variable, the gastropods *Potamides* and *Loxotrema*, and the bivalves *Acutostrea, Cuneocorbula*, *Pelecyora*, *Tellina*, and *Trapezium* are in the majority of the assemblages. Less widely distributed are the gastropods *Crepidula, Tympanotonus, Melanatria?, Pygrulifera, Crommium*, and *Neverita,* and the bivalves *Barbatia* and *Corbicula.* This is the first confirmed record of *Tympanotonus* in North America and the first record of *Trapezium* on the Pacific coast of North America. The assemblages are of two types: those that are nearly *in situ* and those that have undergone only short-distance post-mortem transport. The former consists of up to 12 species of mollusks, all of which are unabraded and many of which are complete. The latter consists of coquinas of either *Pelecyora* or *Cuneocorbula,* both of which are made up of tightly packed, unabraded single valves.

Through time, the quiet-water lagoonal environment fluctuated repeatedly with coastal-sabkha evaporates, as well as with barrier-bar/sandy beaches. The latter contains only fragments of the oyster *Acutostrea.*

The morphospatial "whorled" of strombid snails

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Phylogenetic systematic analyses provide more objective, reproducible, and falsifiable means of classifying taxa than do traditional systematic techniques. In addition, branching patterns (cladograms) obtained from phylogenetic systematic analyses may be interpreted as reconstructions of evolutionary processes.

Mollusk shells are ideally suited for mathematical modeling and analyses using morphological space (morphospace). Records of ontogenic history are recoverable from specimens, and this developmental information (in the form of mathematical parameters) can be used as complementary data in cladogram construction.

By combining mathematical models, morphospatial analyses, and cladograms, therefore, falsifiable scenarios of morphological evolution of mollusks can be hypothesized. This type of synthetic approach is exemplified with species of Strombidae. A cladogram is mapped into a three-dimensional morphospace, using a geometric algorithm to position nodes (interpretable as ancestors). During evolution of members within a clade containing all species traditionally classified in *Lambis* and some in *Strombus*, morphological change consisted predominantly of an increase in vertical dimensions of whorls. The change was greatest early in the history of the group and diminished thereafter. In the development of the synthesis, ancestral forms are reconstructed and traditional subgeneric classification within *Lambis* is shown to be untenable.

A review of the sea hare *Aplysia donca* (Gastropoda: Opisthobranchia) from Mustang Island, Texas

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Aplysia donca was described from a single specimen collected in March of 1947 from a tide pool along the coast of Mustang Island, Texas. This species is known only from this one small and probably immature specimen. Despite extensive field work conducted on sea hares along the Texas coast, this species has never again been reported nor collected. Taxonomic characters that constituted the basis of the original description of *A. donca* were examined in a juvenile series of *A. morio* from South Padre Island, Texas. Similarities of these characters in combination with the lack of a single non-variable character support the premise that the original description of *A. donca* was based upon an immature specimen of *A. morio.*

The utility of the gastric chamber of Caenogastropod stomachs in higher and lower level systematic studies

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Features of the caenogastropod midgut, indeed of gastropods in general, have been regarded as potentially misleading in phylogeny reconstruction due to functional constraints. Thus, these characters have been assumed to be homoplasious and have remained underexplored as a potential source of characters in phylogeny reconstruction at lower and higher systematic levels. Revealed here are previously undescribed features of the midgut that are useful at a variety of taxonomic levels.

At higher systematic levels, one such character is the direction of ciliary currents on the left gastric chamber wall. Commonly associated with a sorting area in this region, the direction of ciliary action has been shown to reverse at the base of the neogastropod radiation. This suggests a fundamental shift in the

circulation and digestion of food within the neogastropod stomach. In addition, comparative studies within families have been undertaken to assess the conservatism of features within the gastric chamber, revealing a number of features that may be useful at lower systematic levels. For example, several species of freshwater cerithiaceans have been shown to possess a similar modification of the glandular pad on the gastric chamber floor. Finally, the presence of a ciliated ridge associated with the sorting area within the gastric chamber of some littorinids, has potential significance at both higher and lower systematic levels.

The anatomy of a new hadal, cocculinid limpet (Gastropoda: Cocculinoidea), with a preliminary phylogenetic analysis of the family Cocculinidae

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Ever since their discovery and first description by Dall in 1882, cocculinid species have intrigued their investigators with unique combinations of features. The anatomy of a new species of cocculinid limpet is no exception. The only cocculinid, apart from *Fedikovella caymanensis,* known to inhabit hadal depths, this species possesses a number of features characteristic of cocculinids, including the presence of broad oral tappets, epipodial tentacles, a hemal gland with associated aortic arch, and vestigial eyes modified into the so-called basitentacular gland. The hermaphroditic reproductive system includes a modified right cephalic tentacle inferred to function as a copulatory organ and a single receptaculum seminis. No evidence of a seminal groove could be found. However, this species is unique within the family in several aspects of both external and internal anatomy. These unique features include a prominent internal transverse septum within the shell, a closed receptaculum duct, and the presence of several small statocones in some individuals. In addition, the species displays a unique combination of features heretofore undocumented among coccutinids, the most significant being the configuration of the nervous system. Preliminary phylogenetic analysis of the Cocculinidae includes fourteen taxa and twenty nine characters. Results indicate a basal placement of the species within the family and support monophyly of the genera *Cocculina* and *Coccopigya.*

Origin and distribution of the deep-sea fauna of conoidean gastropods

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Conoidean gastropods, and especially the part formerly known as the family Turridae, are among the dominant molluscan groups in deep-sea faunas. These gastropods are very diverse, particularly as concerns their anatomy and feeding mechanisms. The evolution of the group was probably targeted at improvement of feeding, and advanced taxa possess highly specialized and efficient feeding mechanisms. Conoidean origin and initial stages of evolution were associated with shallow waters of tropical areas. The most primitive taxa (families and subfamilies) are still either restricted to, or most diverse in, warm, shallow-water habitats. Bathyal and, especially, abyssal faunas consist mainly of advanced representatives, and the share of higher taxa increases with depth. However, there are no taxa of the family group that are characteristic only for the deep-water fauna. This may indicate that the deep-water faunas are evolutionarily rather young and, at the same time, that colonization of deep waters reflected the adaptive

radiation of conoideans rather than a major step in their evolution. A specific bathyal fauna of conoideans is known from as early as Oligocene deposits, and whereas Mio-Pliocene faunas were very similar to Recent ones from respective regions. The bathyal zone is characterized by an increased percentage of primitive taxa as compared to the shelf. Abyssal and hadal conoideans are represented by relatively few genera and families and subfamilies. An increase in diversity is recorded in near-continental regions, often inhabited by endemic genera, whereas the fauna of oligotrophic oceanic areas mostly consists of representatives of a few widely spread genera belonging to advanced groups. The distribution pattern of deep-sea conoideans is characterized by the presence of a number of species with very limited ranges. At the same time, there are species with very wide ranges (e.g., amphioceanic). The mode of larval development seems not to strictly correlate with the area of species range.

Occurrence of the adult form of *Neoteuthis* sp. from the Hawaiian Islands

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During the surveys on the diet of *Alepisaurus ferox*, two adult form specimens of *Neoteuthis* sp. were discovered in the Hawaiian waters. The predator fish werr collected in 1982 from 11°23.0' N, 177°58.5' E, 180 m in fishing depth, and 11°24.0' N, 169°4.5' E, 230 m, by longline. The squid specimens are both females, 62.5 mm and 61.5 mm in DML, respectively. The body is weakly muscular and its surface bears distinct iridescence.

Two species of the genus *Neoteuthis* are hitherto known (Nesis, 1982), being *N. thielei* Naef, 1921, the type species of the genus, from the Atlantic, and an unnamed species (from Hawaiian waters by Young, 1972). *Neoteuthis thielei* reaches 17 cm DML in adult (Nesis, 1982), whereas adult male specimens of the unnamed Pacific species (Young, 1972) reach 83 mm DML. The present specimens are almost conspecific, but yet differ from Young's (1972) specimen in several indices and features. In the present study, the taxonomic status of this species, and some ecological information are discussed.

Shell polymorphism in the neogastropod *Alia carinata* (Hinds)

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I analyzed *Alia carinata* from four different habitats to investigate the presence of literature-alleged shell pattern and shell form polymorphism. Using univariate and multivariate statistics, I demonstrated that *Alia* from *Gastroclonium subarticulatum* (Rhodophyta), *Zostera marina,* and benthic hard bottom habitats displayed measurably and identifiably distinct forms. Individuals from *Macrocystis pyrifera* (Phaeophyta) canopies showed considerable form overlap with benthic specimens. Inter-habitat polymorphism was related to differences in both size and shape, whereas observed sexual dimorphism was strictly size-related, with males larger than females. *Alia* from *Zostera* were mostly non-patterned and dark in color, whereas those from the other three habitats were generally patterned and variably colored. Planktonic dispersal of juveniles suggests that intraspecific polymorphism is a result of phenotypic plasticity, and not natural selection. Allometric growth, wave exposure, and predation differences among sampled habitats may be important controlling factors in observed intraspecific polymorphism.

Distribution and transport of *Illex argentinus* paralarvae (Cephalopoda: Ommastrephidae) across the western boundary of the Brazil/Malvinas Confluence Front off southern Brazil

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This study discusses the transport and the influence of different water masses, phytoplankton and zooplankton biomass on the distribution and abundance of *Illex argentinus* paralarvae off southern Brazil (28°09' - 34°20' S). During four surveys carried out from 1987 to 1991, a total of 428 paralarvae were collected with a bongo net (0.33 mm mesh size) in 203 tows. Paralarvae were found from autumn to spring, but were absent in summer and in regions of major influence of coastal and subantarctic waters. The greatest relative abundance (41 paralarvae/100 m^3) was found in spring of 1987. Paralarvae were mainly distributed along a shelf-break front formed between tropical waters of the Brazil Current and subantarctic waters of the Malvinas/Falklands Current where partial upwelling processes and planktonic enrichment were found. From the slope to the coast, there was a clear progression of paralarval sizes. Hatchlings occurred at the outer shelf and slope in tropical and/or subtropical waters. The largest paralarvae and small juveniles were found at the inner shelf under the influence of subantarctic waters, where high concentrations of chlorophyll-a and zooplankton biomass were measured.

Studies of hydrothermal vent faunas, especially gastropods

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Extreme and highly variable temperatures, exposure to chemically reducing fluids, such as hydrogen sulfide, and heavy metals and temporally unstable habitats, limit the number of animals that dwell at hydrothermal vents. Studies of diversity have virtually ignored vent habitats due to the limited number of species they support and the difficulties in adequately sampling abyssal habitats. Animal diversity at volcano-hosted vents on Juan de Fuca and Explorer Ridges in the northeast Pacific is significantly lower than at the East Pacific Rise (EPR) at 9°-21° N. Although individually, EPR vents are smaller and shorter-lived than are northeast Pacific vents, EPR vents appear to occur in greater diversity; they thus may offer more total area than do the larger, comparatively long-lived, but well spaced North Pacific vents. The increased proximity of individual EPR vents may also allow large, apparently endemic predators to forage at multiple vents and therefore to survive, despite the ephemeral nature of the individual habitats. Such predators are virtually absent from northeast Pacific vents. The proximity of EPR vents may directly enhance the effective dispersal of the large larvae of vent-dwelling gastropods, which are likely to have limited individual dispersal capacity.

The California market squid fishery

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Market squid (*Loligo opalescens*) is presumed to be one of the most abundant marine resources in California waters. Squid range from southeastern Alaska to Bahía Asuncion, Baja California Sur, Mexico. Catches have traditionally come from two fishing areas within California: Monterey Bay and the islands off southern California. Squid become vulnerable to commercial fishing gear when they concentrate near shore to spawn and are typically taken at night. Harvest and demand are primarily controlled by international market conditions. The demand for squid has increased dramatically in recent years. Prior to 1987, California landings averaged 10,000 tons. Beginning in 1988, commercial landings began to increase and have grown from approximately 40,000 tons to over 83,000 tons in 1996.

Little is known about the present size, structure, or status of the population, but historical evidence from research cruises, as well as catch data, indicates the biomass is large. It is believed that squid can be more intensively harvested than other marine animals because they are short lived. They also appear to be heavily influenced by environmental conditions.

The role of stratigraphic data in phylogenetic analyses of extinct molluscs

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Both biotic factors (rates and models of morphologic change, rates of extinction, numbers of applicable characters, and speciation models) and abiotic factors (rates of sampling) affect the accuracy of parsimony. The molluscan fossil record provides workers with a high proportion of the widely distributed species, which increases the accuracy of parsimony in simulations. However, high rates of morphologic change (well within the ranges inferred by cladistic analyses of molluscs) seriously undermine the accuracy of parsimony in the same simulations, even with no patterned homoplasy present. Stratigraphic data offer tests of whether congruent characters represent a phylogenetic signal or convergence. Existing phylogenetic methods utilize stratigraphic data based on congruence and total evidence logic and on probability theory. These methods provide more exact estimates of phylogeny than does parsimony by making explicit ancestor-descendant estimates and implying particular patterns of speciation and routes of morphologic change. Evaluation of these methods is very important when contrasting the evolutionary scenarios implied by alternate estimates of phylogeny. Simulations using preservation and evolutionary rates typical of molluscs find that all methods incorporating stratigraphy perform better than does parsimony. Methods currently in development evaluate the likelihood of a phylogeny implying both particular amounts of stratigraphic gaps and particular amounts of morphologic change. Ultimately, likelihood approaches probably will provide workers with the most robust phylogenetic estimates of phylogeny for extinct molluscs.

The phylogenetic relationships of some littorinid species assessed by small subunit ribosomal DNA sequences and morphology

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Small subunit ribosomal DNA (18S rDNA) is usually considered to be a slowly evolving molecule with very limited, if any, phylogenetic resolving power for divergences that took place in less than 40 MY. We evaluated this issue by a congruence and total evidence analysis of morphological data and complete 18S rDNA sequences of nine littorinid species from the genera *Melarhaphe, Littoraria, Nodilittorina* and *Littorina.* We particularly focused on the still somewhat controversial position of the Macaronesian periwinkle *Littorina* (*Liralittorina*) *striata*, a species that has been variously assigned to *Melarhaphe, Nodilittorina,* and currently *Littorina.* These analyses suggested (1) that 18S rDNA provided a much stronger phylogenetic signal to recover the well known, young *Littorina-Neritrema* radiations (divergence time < 10 MY), whereas the topology of the older, *LittorariaNodilittorina-Liralittorina* branches was much less supported, and (2) that the current morphological and molecular data are insufficient to unambiguously resolve the relationships of *L. striata.* Anyway, although current practice suggests the contrary, 18S rDNA may not be so unsuitable to reconstruct relatively young radiations.

Unordered versus ordered multistate characters: Explication and implication

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Characters with three or more states are typically treated as ordered or unordered in multistate character coding methods. Although both treatments hypothesize which character states directly evolve into which other states (= character transformation series or character state trees), the proposed suppositions are very different. What are these differences? Does unordered really provide a logical approach based on similarity, the first criterion of testing homology? These questions are addressed in an effort to establish how these issues affect the reconstruction of the evolutionary history of the Phylum Mollusca, or for that matter any attempt at phylogenetic systematics.

Life history and population structure of the neon flying squid, *Ommastrephes bartrami,* in the North Pacific Ocean

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The neon flying squid consists of an autumn cohort (formally known as LL group) and a winter-spring cohort (L, S, SS groups combined) as based on age estimation with statolith microstructure, mantle length compositions, distribution of both mature individuals and paralarvae. Both cohorts are estimated to have a one-year life span. They undergo seasonal north-south migrations between the spawning grounds in the subtropical waters and feeding grounds in the Subarctic waters. The winter-spring cohort can be further

separated into a western stock and a central-eastern stock on the basis of intensity of infection with larval nematode and cestode parasites. The autumn cohort was abundant in the central and eastern North Pacific but rare west of 170° E, which coincides with the location of the Emperor Seamount Chain north of 35° N. The autumn cohort also is separable into central and eastern stocks on the basis of parasite infection intensity.

REPORTS OF SOCIETY BUSINESS

MINUTES OF THE 1997 WSM EXECUTIVE BOARD MEETING

[Minutes for Executive Board Meeting not available; summary of meeting provided by Treasurer George Metz.]

[Santa Barbara, California.] Members present: Hank Chaney, George Metz, Sandra Millen, Paula Mikkelsen, possibly Nora Foster and Hugh Bradner.

Secretary's Report. Minutes for 1996 meeting read and approved.

Treasurer's Report. Report for Fiscal 1996 and Fiscal 1997 up to point of Santa Barbara meeting read and approved. [See attached Treasurer's Report.]

Sandra Millen presented plans for the 1998 meeting which was to be a joint meeting with the AMU to sponsor the III Congress of Malacology, to be held in Washington, DC, 25-30 July 1998. Upon presentation at the business meeting and ample discussion the concept and plans were voted upon and approved. Millen also announced plans for a brochure outlining the qualifications, areas of interest and research of all members of WSM. This motion was voted and approved.

The Nomination Committee (Kirstie Kaiser, Chair) presented the recommended slate of officers for the 1998 year. Nominations were:

President:	Sandra Millen
Vice President	Roger Seapy
2nd Vice President	Carole Hickman
Secretary	Terry Arnold
Treasurer	George Metz
Members-at-Large	Kirstie Kaiser and Paula Mikkelsen

Upon recommendation of the Treasurer it was recommended that the WSM increase the annual contribution to the Student Grant from $1,000 to $1,500 for the 1998 year and consider a further increase the following year. After adequate discussion the motion was approved.

MINUTES OF THE 1997 WSM ANNUAL BUSINESS MEETING

26 June 1997, Santa Barbara, California. Meeting commenced at 4:05 PM. Henry Chaney, presiding.

Secretary Report from 1996 meeting: Accepted as read from the Annual Report.

Treasurer's Report: [Submitted separately by George Metz], accepted as read.

1998 Meeting.

Sandra Millen reported that the WSM Board unanimously approved a recommendation to hold the 1998 meeting as a joint meeting with the AMU and UNITAS, to be held in Washington, DC, in July 1998. This recommendation was accepted by the majority of members present, with one negative vote.

1999 Meeting.

Roger Seapy reported that the 1999 gathering would be help on the campus of California State University, Fullerton and that several symposia are planned.

Nominations for 1998.

The nominating committee proposed the following slate of candidates for 1998:

President:	Sandra Millen
Vice-President:	Roger Seapy
2nd Vice-President	Carole Hickman
Secretary	Terry Arnold
Treasurer	George Metz
Members-at-Large	Kirstie Kaiser and Paula Mikkelsen

There were no nominations from the floor. Slate was accepted.

STUDENT GRANTS

In 1997 there were 25 proposals received of which five were approved for funding. The grant recipients were Renee Avery (University of Massachusetts), James Byers (University of California, Santa Barbara), Roberto Cipriani (University of Chicago), Daniel Geiger (University of Southern California), and Nancy Smith (Smithsonian Marine Station, Florida).

Moved, seconded, passed that the grant allocation be increased in 1998 from $1,000 to $1,500.

NEW BUSINESS

Membership survey.

The mail survey on meeting frequency had a 60% response from the membership with no clear consensus reached. Opion was evenly divided between having a meeting every year, every other year or in a staggered schedule in combination with other societies. No action was taken.

Change in Editorship

The Chair announced that George Kennedy would assume responsibilities for Editorship of the Annual Report, with plans to publish the proceedings during the second half of the year. It was MSP that a resolution of thanks and appreciation to outgoing Editor, Hans Bertsch, be extendeded for his efforts and contributions.

Meeting adjourned at 4:50 PM.

[Submitted by Henry Chaney]

WESTERN SOCIETY OF MALACOLOGISTS
TREASURER'S REPORT
1 October 1996 - 30 September 1997

INCOME

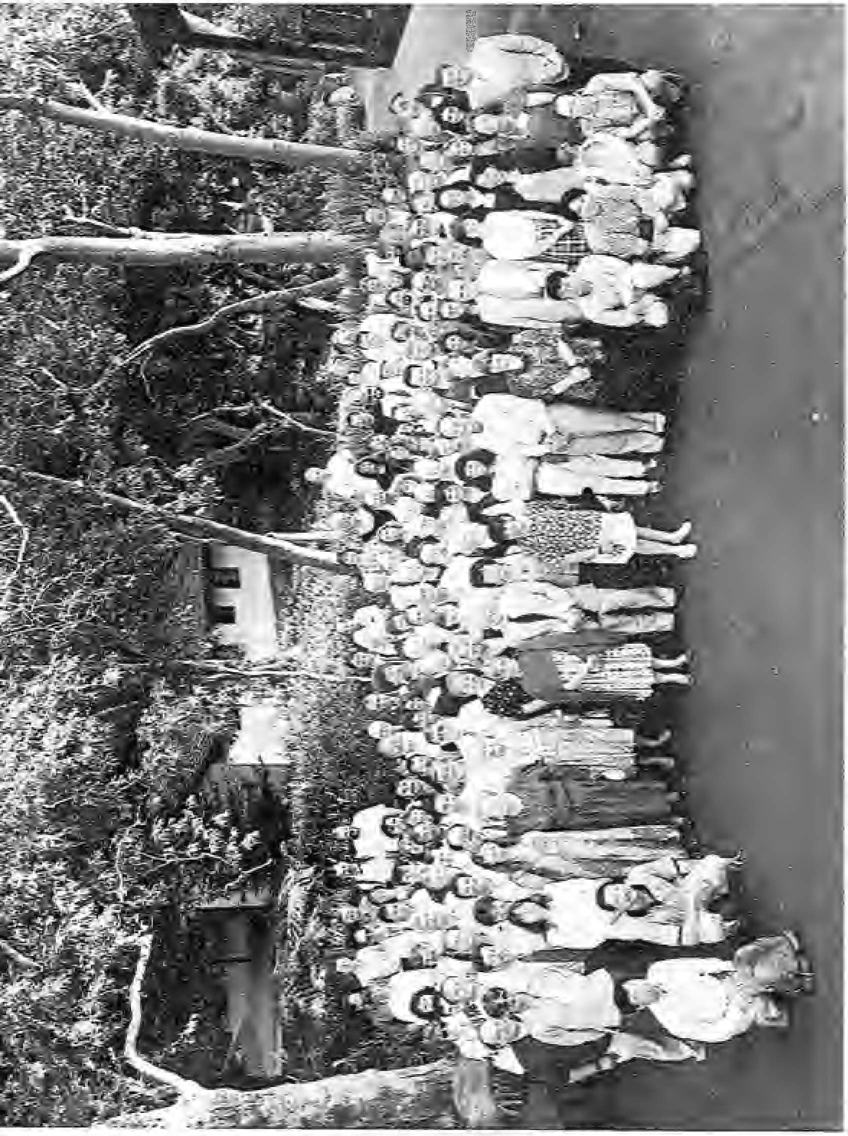
Membership dues	$1,734.00	
Student Grant donations	120.00	
Symposium fund donations	193.00	
Royalties	121.86	
1997 Auction/Reprints	1,116.70	
TOTAL INCOME during period	**$3,285.56**	

EXPENSES

Administrative (Fees, Dues, Officer Expense, Office Expense)	213.81	
1996 Student Grant	1,100.00	
Publication of the 1996 Annual Report	822.66	
Certificate of Deposit Purchase	4,000.00	
TOTAL EXPENSES during period		**6,136.47**
Net Gain/(Loss)		**(2,850.91)**
Balance brought forward (Corrected)		**6,996.06**
Current Balance		**4,145.15**
Savings (Does not include all of interest)		**15,617.80**
Net Worth as of 1 October, 1997		**$19,762.95**

STUDENT GRANT RECIPIENTS

Renee Avery, University of Massachusetts
James Byers, University of California, Santa Barbara
Roberto Cipriani, University of Chicago
Daniel Geiger, University of Southern California
Nancy Smith, Smithsonian Marine Station, Florida



Number key to 1997 AMU/WSM Meeting Group Photograph
Santa Barbara Museum of Natural History, 26 June 1997

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THE WESTERN SOCIETY OF MALACOLOGISTS

ANNUAL REPORT, FOR 1998

VOLUME 31

Abstracts of papers contributed by Members of the Western Society of Malacologists (31st Annual Meeting) at the World Congress of Malacology held in Washington, DC, 25-30 July 1998

December 1998

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Secretary	Terry S. Arnold
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at the III World Congress of Malacology, Washington, DC, 25-30 July 1998
Abstracts reprinted, with permission, from: Rüdiger Bieler and Paula M. Mikkelsen, editors, 1998,
Abstracts of the World Congress of Malacology, Washington DC 25-30 July 1998, *published on behalf of* UNITAS MALACOLOGICA *and the* 1998 World Congress of Malacology Organizing Committee *in cooperation with the* AMERICAN MUSEUM OF NATURAL HISTORY (New York) *by the* FIELD MUSEUM OF NATURAL HISTORY (Chicago), copyright ©Unitas Malacologica, 1998

ABSTRACTS

Beer bottles on the sea floor: Trash, dens and research opportunities

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Although den middens have been used to determine the diet of octopuses, middens have not been reported for the red octopus *Octopus rubescens* Berry, 1953, and its diet in the wild has been poorly studied. To determine its diet, *O. rubescens* were collected in beer-bottle dens determined to be aged by their coating of barnacles. The octopuses were evicted from the bottles for measurement, and released. The shell contents of the bottles were then sieved, identified, and compared to those from bottles not containing octopuses. In addition, new brown beer bottles painted black were placed on the bottom for 60 days, and the contents of occupied bottles were compared to those from unoccupied bottles. The contents of the bottles were significantly different. We determined what the population of *O. rubescens* was in a limited area and what the octopuses were eating. Beer bottle trash on the sea floor bottom can be a major non-polluting den resource for *O. rubescens* and a valuable tool for aiding diet analysis where not otherwise possible.

The eastern Pacific species of *Sphenia* (Bivalvia: Myidae)

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There are four eastern Pacific Ocean species of the genus *Sphenia:* (1), *S. fragilis* (H. Adams & A. Adams, 1854), occurs in a variety of nestling situations from the intertidal zone to shallow water, from Santa Barbara County, California, to Guayas Province, Ecuador, and has as synonyms *S. fragilis* Carpenter, 1857, *S. pacificensis* de Folin, 1867, and *S. trunculus* Dall, 1916. It is probably morphologically indistinguishable from the western Atlantic *S. antillensis* Dall & Stimpson, 1901. (2), *Sphenia* n. sp. A, is restricted to soft bottoms in the Golfo de California. (3), *Sphenia hatcheri* Pilsbry, 1899, occurs from Buenos Aires Province, Argentina, through the Estrecho de Magallanes, as far north as Isla Chiloé, Chile; *S. subequalis* Dall, 1908, is a synonym. It probably occurs in relatively soft substrata. (4), *Sphenia luticola* (Valenciennes, 1846), occurs offshore in rock cavities from Jefferson County, Washington, to San Diego County, California, and has as synonyms *S. pholadidea* Dall, 1916, *Cuspidaria nana* Oldroyd, 1918, and *S. globula* Dall, 1919. *Sphenia bilirata* Gabb, 1861, appears to have been based on Recent specimens of *Hiatella arctica* (Linné, 1758). *Sphenia ovoidea* Carpenter, 1864, is based on a juvenile *Mya*, most probably *M. arenaria* Linné, 1758.

Recent and fossil mollusk collections at the American Museum of Natural History

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The collection of Recent mollusks at AMNH comprises 323,000 lots (3 million specimens) and was largely founded in 1874 with the acquisition of the John C. Jay Collection. Regional strengths include the tropical Pacific and western Atlantic Oceans. Taxonomically, the families Conidae, Cypraeidae, and Epitoniidae are exceptionally well represented. The type collection includes 1,791 primary types (9,338 specimens) with extensive material from the Congo and *Vema* Expeditions as well as the Jay, Haines, Nowell-Usticke, and Whitney South Seas Collections. The fossil collection comprises 4 million specimens and was founded upon the purchase of the James Hall Collection in 1875. Regionally, North America is well represented as are Europe and South America. Taxonomically, the collection is rich in Paleozoic and Mesozoic bivalves, gastropods, and ammonites. The type collection includes 2,509 primary types including material from the Hall, Whitfield, Greene and McConathy, Haas, and Columbia University Collections. The invertebrates department currently staffs five full-time and three emeritus curators including one Recent mollusk curator who studies marine heterobranch gastropods and bivalves and one fossil curator with research interests in fossil cephalopods. In addition, a collections manager studies Recent freshwater bivalves and two scientific assistants are each responsible for the fossil and non-molluscan invertebrates, respectively. Access to the collection for studying invertebrates, obtaining type catalogs, depositing vouchers, visiting AMNH, or applying for collections study grants may be achieved by contacting collections staff.

Analysis of color pattern morph frequencies in Neogene neritid gastropods from the Dominican Republic

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Color patterns, although rarely preserved in the fossil record, provide a chart of physiological activity that is under a combination of intrinsic and extrinsic control. Accordingly, changes in pattern frequencies in populations may reflect changes in gene frequency, changes in the environment, or both. From large samples of the neritid gastropods *Smaragdia viridimaris* and *Neritina figulopicta* from the Neogene of the northern Dominican Republic, we classify intricate color patterns into seven distinctive types and analyze changes in morph frequencies in a tightly controlled stratigraphic, geographic, and paleobathymetric framework. Our analyses indicate an environmental control on the overall distribution of both species. Based on independent estimates of paleodepths, all samples containing *Smaragdia* and *Neritina* represent depths of > 50 m, and population sizes decline with increasing paleodepth. Living species of *Smaragdia* occur obligately on seagrasses, especially in the genus *Halophila,* which tolerates low light and turbid conditions and has been reported as deep as 85 m in very clear water. Living species of *Neritina* are restricted

to shallower depths. Within the two fossil species, changes in color morph frequencies follow separate spatial and temporal patterns. We document distributions that are geographically distinct and coherent within individual stratigraphic sections as well as distributions reflecting a predominance of paleoenvironmental control and change upsection. Differences between the two species support a conclusion that there is no single pattern of response intrinsic to neritids.

Chromosome and electrophoretic study of the freshwater snail *Pomacea* from Veracruz, Mexico

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The genus *Pomacea* is an organism appropiate as a model for investigation, principally within the field of genetics. In this work, karyotypic and electrophoretic comparisons were made to continue the organism characterization of the genus *Pomacea* originating in the state of Veracruz, and thus to determine its interspecific and intraspecific diversification. The polymorphism registered in individuals originating in different regions did not show significant differences, at least not in reference to the cytogenetic and electrophoretic studies made between *Pomacea flagellata* and *P. patula catemacensis*, the latter being a species exclusive to the region of Lake Catemaco in the State of Veracruz. However, variations are present within the different regions of collection; Lake Alvarado, Tlacotalpan, and Misantla River, in the magnitude of the band pattern both in the localization of the isoelectrofocus (IFE) point and molecular weight, which presents a band characterized principally in the region of Lake Catemaco perhaps as an endemic population. In this way, this technique is determining, on the one hand, the differentiation between the variations of the analyzed populations, and on the other, determination of the source and diversity of clones.

Purification and characterization of three glycosyl hydrolases from a fresh-water mollusk, *Pomacea flagellata*

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Three glycosyl hydrolases were purified from viscera of a freshwater mollusk, *Pomacea flagellata*, by ammonium sulfate precipitation, low pressure DEAE-Sepharose chromatography, and anion exchange HPLC. In this study we describe the purification and properties of *P. flagellata* enzymes with glycosyl hydrolase activity, including physicochemical characteristics of the enzymes (amino

acid analysis, molecular weight, isoelectric focusing, and effect of pH on temperature on glycosyl hydrolase activity), substrate specificities, effects of various compounds and metal ions, and secondary structure content of these enzymes.

Genetic confirmation of limpet sibling species and a test of possible character displacement

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We have found allozyme evidence confirming the existence of a sibling species pair, *Lottia digitalis* (Rathke, 1833) and *L. austrodigitalis* (Murphy, 1978). Despite the fact that *L. austrodigitalis* was described two decades ago, it has not been generally recognized as a valid species, probably due to a lack of perceived morphological distinction by specialists. The diagnosis of *L. austrodigitalis* was based mostly on allozyme frequency differences at two enzyme-coding loci, together with geographic differences. *Lottia digitalis* was claimed to extend south only to Monterey Peninsula, California, whereas *L. austrodigitalis* ranged north only to Monterey Peninsula. The evidence for their sympatry at Monterey Peninsula suggests an intriguing possibility that these species might be undergoing character displacement where their geographic range overlaps. For example, one species might be found more frequently in high "rock" habitats and the other more often in lower "barnacle" habitats. We employed starch gel electrophoresis to compare multiple enzyme systems, sampling limpets from southern and northern California locations and also from both "rock" and "barnacle" habitats at each location. We found new evidence from multiple loci that strongly support the existence of the two species as originally described, with only *L. digitalis* at the northern site and only *L. austrodigitalis* at the southern site. Ongoing studies are designed to test whether character displacement might be occurring where the two species' ranges overlap at Monterey Peninsula.

Description of a new species of *Halgerda* from the Indo-Pacific, with a preliminary phylogenetic analysis

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A new species of *Halgerda* (Gastropoda: Nudibranchia: Halgerdidae) is described based on several specimens all having morphological similarities with *H. elegans* Bergh, 1905. This new species is known from Okinawa, Papua New Guinea, and Indonesia. Comparison is made with the original description and newly collected material of *H. elegans* and with other described *Halgerda* species. The coloration, and reproductive and radular morphology of this new species differ significantly from those of *H. elegans* and other previously described *Halgerda* species. The presence of some anatomical consistencies and similar color patterns between *H. elegans* and the new species suggest that the two species may be more closely related to each other than to some other members of the genus. A preliminary phylogenetic analysis establishes the relationship between the species.

Endemics in an ancient western North American lake (Upper Klamath Lake, Oregon): Lake or stream origin?

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Ancient lakes have been touted either as reservoirs from which more recent stream faunas are derived (Russel-Hunter, 1978), or as independent centers of endemism that may show little relation even to tributary stream drainage (Boss, 1978; Davis, 1979; Taylor, 1988). Western North America during the late Cenozoic had a plethora of large pluvial lakes with large endemic molluscan faunas. The best remaining example is the hypertrophic Upper Klamath Lake (UKL), Oregon, remnant of a system dating to the Miocene. Survey of 300 UKL drainage sites yielded > 70 mollusk species: > 25 are narrow endemics, of which some 16 are undescribed. Very few taxa are endemic to the lake only; most are found in springs in limited portions of surrounding and tributary drainages. Most "lake" endemics are confined to small areas influenced by underwater springs. Endemics are mostly prosobranchs ("*Fluminicola,*" *Pyrgulopsis*, "*Lyogyrus*") and pulmonates (*Vorticifex, Carinifex*) derived from ancient but precinctive western North American stocks, thus partially corroborating the pattern reported by Boss and by Taylor. However, these genera are found mostly in springs and streams, not lakes. Thus, there are lakes and there are lakes, but stream origin and diversity are more important, as suggested by Davis and by Taylor.

The hydrobiid subfamily Amnicolinae in the northwestern United States

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Epigean and subterranean freshwater amnicolinins (Gastropoda: Hydrobiidae) are well deployed in the eastern U. S. and Europe but virtually unreported from the western U. S., with only one taxon described, "*Lyogyrus*" *greggi* (Pilsbry, 1935). Collecting in the northwestern states and in northern California in 1988-1998 proved them relatively widespread, if uncommon (present at 170 of 2,500 sites). Amnicolinins are largely absent from areas north of the Wisconsinan glacial border and the Great Basin. Apparent absences elsewhere may be due to undercollecting or to historic factors. *Amnicola s. s.* occurs in a few kettle lakes, a habitat like that preferred by some eastern taxa. Other western forms differ substantially in anatomy, habitat, or (typically) both. Currently known are: (1) a form resembling some eastern U. S. *Logyrus* in habitat (ponds and lakes) but substantially different anatomically; (2) *"Lyogyrus" greggi* and congeners, restricted to cold springs; (3) nearly pigmentless cold limnocrene taxa associated with pluvial lake basins; (4) a coastal lineage found in cold, muddy seeps, and small springs. Northwestern forms generally are restricted to very cold oligotrophic habitats; most are photophobic. Roughly half of the sites also have other precinctive hydrobiids. Northwestern subterranean forms have yet to be found. Taxonomic and habitat differentiation of eastern forms implies relatively long separation and separate evolution, both also true of other western hydrobiids and pleurocerids.

Biogeography of the Haliotidae (Gastropoda: Vetigastropoda)

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The Haliotidae are a family of gastropods with a worldwide distribution in tropical and temperate waters. Distributional data from approximately 4,000 lots of the 55 species were collected to address the question of the origin of the family. Three scenarios have been proposed in the literature: (1) Pacific Rim, (2) Indo-Pacific, and (3) Tethys. Area cladograms with an underlying vicariance assumption were constructed. Three alternative roots corresponding to the three proposed origins of the family were used, and tree length was employed as the discriminating factor. Comparison with a preliminary parsimony analysis of the taxa is made.

DNA data as elementary hypotheses: How to avoid impossible character state reconstructions

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The use of DNA sequence data has transformed systematic biology, including malacology. Despite a wealth of data having been acquired, the debate on the proper utilization of the data is unsettled. One of the most basic questions of how observation should be represented in a data matrix is here addressed with a special focus on the homology concept. DNA sequence alignment is discussed and the commonalities between morphological as well as molecular data are highlighted. As alignment is an observational process, gaps must be coded as an additional character state and not as missing data. The treatment of questionable aligned regions is explored through multiple coding strategies. Elision, case sensitive, missing data, and polymorphic coding all violate homology either through the test of conjunction or by contradiction with the original observations. Only character exclusion and contraction result in character state reconstructions in agreement with homology. Furthermore it is proposed to use additional character states to include highly divergent sequences. Some examples from ongoing work in the Haliotidae illustrate the effects of the various coding strategies.

Toxic deception: Mimicry complexes of nudibranchs and polyclad flatworms

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Recent studies of organisms inhabiting tropical reefs in the Indian and Pacific Oceans have brought to light numerous unpalatable organisms that have remarkably similar, elaborate color patterns. These represent some of the first documented cases of Batesian and Mullerian mimicry

involving phylogenetically distantly related groups of marine organisms. Mimicry circles have been described for complexes of nudibranch species, but have not been well documented for complexes involving nudibranchs and flatworms. Numerous examples of different mimetic complexes involving nudibranchs and flatworms are presented. Some members of these complexes represent intermediate conditions between Batesian and Mullerian mimicry, as there is differential unpalatability, depending on the predators involved. Mimetic complexes occur commonly in tropical reef ecosystems and represent a common adaptive strategy of nudibranchs and flatworms in these ecosystems.

A phylogenetic analysis of the Patellogastropoda based on morphological and molecular data sets

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The relationships among taxa and character transformation series within the Patellogastropoda have not been previously examined in a rigorous phylogenetic context. We scored 83 morphological characters based on gross anatomy, microstructure, ultrastructure, and histology in 18 ingroup taxa. Ingroup OTUs represent a range of "taxonomic" levels dependent on our confidence of OTU monophyly. Some OTUs represent species whereas others are at the "family" level. Four outgroup taxa were used based on recent phylogenetic hypotheses in the Gastropoda. Analyses with and without outgroups comprise hypotheses based on morphology only. We then used the most parsimonious trees from the morphological data as starting trees and optimized these against the less complete molecular data set to determine the best fit between morphology and molecules. The best supported phylogenetic hypothesis shows two major clades, with one branch leading to the Patellina and Nacellina and the other to the Acmaeoidea. The deep-sea taxon *Bathyacmaea*, whose anatomy has never before been described, is placed as a basal Acmaeoidea; mosaically sharing apomorphies with *Patellina* and *Nacella* and others with the Acmaeoidea. A major finding of the character analysis is that although patellogastropod muscle and radular systems appear plesiomorphic, cartilage morphology and the association of cartilage and radula have undergone major modifications likely related to the change from flexoglossate to stereoglossate feeding.

The gastropod larval shell as a model for integrative analysis of structure

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Larval shells have been used to infer life history and nutritional modes in ecological, paleoecological, and macroevolutionary studies. The larval shell encodes considerably more information. A program of research focusing on the total information content of larval shell morphology is based on the study of living veliger larvae from Hawaiian plankton. Using a comparative and integrative approach, I explore the interplay of features that are (1) purely

constructional and emerge from specific biomineralization processes and growth rules, (2) ecological, (3) phylogenetically shared as innovations in specific clades, and (4) adaptive in terms of close-fit to engineering paradigms for performance advantage. Some of the most surprising results emerge from experimental studies of veligers in culture in the absence and presence of predators. Repeated patterns of larval shell breakage and subsequent repair, documented with SEM, shed light not only on the nature of predation attempts but also on antipredator adaptations in shell construction. Use of the paradigm method provides equally powerful evidence of a set of features of larval shell microsculpture that serve to retard breakage at particularly vulnerable points on the larval shell. Finally, there are microarchitectural features that suggest fundamentally different mechanism of mineralization in larval and adult shells and a reorganization of shell formation at metamorphosis.

Phylogeny and evolution of color pattern in chromodorid nudibranchs

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The chromodorid nudibranchs are a diverse, brightly colored group of more than 600 species found primarily in tropical and subtropical waters. Although there has been recent interest in this group, due to their striking color patterns, much of their taxonomy remains in a rudimentary state. This project focuses on five relatively small genera within the family Chromodorididae: *Thorunna, Pectenodoris, Digidentis, Durvilledoris,* and *Ardeadoris.* There are currently 23 described species in these genera, as well as six or more undescribed species. Anatomy of all of the taxa included in these groups is examined. Monophyly for each of these genera has been hypothesized, but never tested. Phylogenetic analyses of the members of these genera and other taxa in the family are used to ascertain the evolutionary relationships among species and to test for monophyly. The resulting hypothesis of phylogeny is used to address questions regarding biogeography and evolution of color pattern in these nudibranchs.

The effects of forest practices on freshwater molluscan habitat: A case study from the Torpy River watershed in east-central British Columbia, Canada

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The impacts of forestry and other anthropogenic activity on freshwater mollusks is not well understood. Our approach has been to examine molluscan diversity in a watershed that has a 40-year history of forestry activity. Specifically we examined the ecology of the sphaeriid clam, *Pisidium casertanum,* in the Torpy River watershed in east-central British Columbia. This watershed is mountainous with an alluvial substrate of clay, sand, and gravel. Streams are mainly first order, either spring-fed or the result of snow-melt and ground-water inputs. The forest cover is primarily coniferous. Forestry related activities, such as the installation of culverts to allow access roads to cross streams, have affected stream hydraulics and resulted in the accumulation of fine organic-rich sediments that host populations of *P. casertanum.* A survey of 75 streams along 47 km of the watershed adjacent to the river revealed some strong associations among clam density in these newly created habitats, and certain environmental variables. Clam density was significantly correlated to water temperature ($r = 0.457$, $p = 0.016$) and organic content of the sediment ($r = 0.379$, $p = 0.050$) but not to dissolved oxygen, conductivity, or pH. Further research this summer will examine the relationship between upstream forest practices (*i.e.,* clearcuts, riparian conditions) and the downstream sampling sites. Ultimately we hope to examine these and other anthropogenic impacts on the ecology of freshwater mollusks throughout northern British Columbia.

An evaluation of the role of different hierarchical levels in the resolution of gastropod phylogeny

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Much discussion has focused on the utility of character subsets in phylogenetic reconstruction. One of the central issues of this debate is the value of morphological versus molecular characters. Within molecular characters there is a secondary but related debate concerning the appropriateness of certain genes in being informative relative to the depth of the divergence. Within morphological characters this debate is just as rigorous, but without much empirical justification. Here we evaluate the role of morphological character suites in the resolution of gastropod phylogeny. Our analysis uses as a baseline the Ponder & Lindberg data set consisting of 117 characters and 40 gastropod taxa. Five outgoup taxa were included, representing four conchiferan groups and Polyplacophora. We begin by examining the nature of morphological data at different hierarchical levels (*e.g.,* ultrastructure, gross anatomy, histological) and at the level of different anatomical systems (*e.g.,* digestive, nervous system) that encompass different hierarchical levels. Our methodology is to exclude certain data sets (*e.g.,* all histological or digestive system characters) and determine loss or gain in the optimization of characters and trees. Using parsimony as the optimality criterion, exclusion of gross anatomy, histological, or ultrastructural characters had no significant effects on the final topologies. Identical results were also found when we removed the more integrated (structurally and functionally) anatomical system data. There is no necessary panacea in any data set.

Feeding mode mediates success of invasive whelk

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The recent expansion of Kellet's whelk, *Kelletia kelletii* (Forbes, 1852), from Point Conception to Monterey Bay, California, introduced a novel feeding mode to the guild of invertebrate predators preying on trochid snails in Monterey Bay. Sea stars, the primary native predators of trochids in Monterey Bay, feed using an eversible stomach, whereas *Kelletia* feed with a prehensile proboscis. I used two sea stars (*Astrometis sertulifera, Pisaster giganteus*) and *Kelletia* from southern California as predators and two trochid congeners as prey, to (1) compare predator consumption rates; and (2) assess prey anti-predatory defenses. Prey were either *Tegula eiseni* (southern California) or *T. brunnea* (Monterey Bay). Single predators had a constant density (n = 6) of a single prey species for 70 days. Prey species were switched after 35 days. *Astrometis* ate both *Tegula* spp. at equal rates. *Pisaster* and *Kelletia* ate significantly more *T. brunnea* than *T. eiseni.* Escape frequency and consumption time were greater for *T. eiseni,* supporting previous suggestions that *T. eiseni* is better defended than its congeners. Among predators, *Kelletia* ate a significantly higher proportion of *T. brunnea* than did either *Pisaster* or *Astrometis.* Whereas deep withdrawal by *T. brunnea* was a partially effective defense against sea stars, it was ineffective against the novel feeding mode of *Kelletia.* Successful establishment of *Kelletia* in non-native habitats may be expedited by its novel feeding mode.

Growth measurements of *Norrisia norrisi* (Sowerby, 1838) in a kelp forest at Santa Catalina Island, California

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Growth rates for Norris' top snail *Norrisia norrisi* (Sowerby, 1838) in kelp forests have not been studied previously. Field measurements of individual snails at Pumpernickel Reef, Santa Catalina Island, California, were recorded over a 10-month period beginning in June 1992. I measured growth along the greatest dimension of the shell *in situ* using calipers precise to 1 mm. Individual snail sizes were scratched into the periostracum of the shell with a scriber, which lasted up to 5 months. It is not known when *Norrisia* reproduce but recruits (4 mm) displaying larval shell morphology were observed during early summer only. As expected, small snails (< 30 mm) increased at a significantly greater rate (1.8 mm/mo) than larger snails (30 mm, 1 mm/month). Using conservative but realistic growth rates, I propose snails 17 mm are 1 year old (young of the year), snails 18-29 mm are 1-2 years old, and snails 30 mm are 2 years old. Snails 42 mm were uncommon in the kelp forest and did not measurably increase from month to month.

Comparative anatomy establishes correlativity in distributional direction and phylogenetic progression in the Achatinidae

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A continuing program of dissecting the soft anatomies of giant African land snails (Achatinidae) has greatly strengthened the hypothesis that the earliest forms originated in the Lower Guinea of Cameroon and Gabon. Phylogenetically close to these plesiomorphic forms, the family broke into two major trunks. The anatomically more conservative trunk formed three branches: (1) a strong western branch that moved through the Upper Guinea and the small islands of the Guinea

Sea; (2) an evolutionarily vigorous branch of small, hardy forms that proded the Sahara all along the north and penetrated deeply into Central Africa; and (3) a direct eastern thrust into the Horn of Africa, and a strong side branch to the Cape. The second major trunk from the Lower Guinea, with its distinctive morphology, also formed three branches: (1) a weak branch that moved straight south through Angola and Namibia into western South Africa; (2) a strong southeastern branch that fanned out into the Congo Basin to form a rich group of very similar appearing species; and (3) a direct eastern branch that moved into the Lake country, with a weak side branch to the Horn of Africa and a stronger one going to southern Africa. The intermixing third branches of the two major trunks passed through similar environments to produce conchologically similar appearing species from anatomically distinct stocks.

Bivalve biodiversity in the Florida Keys

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Despite a century of shell collecting in the Florida Keys, the malacofauna has never been comprehensively assessed. The region encompasses nearly 10,000 km^2 of marine habitat, ranging from hypersaline ponds, to mangrove islands, seagrass meadows, and sand bars, to deep sand plains and the only living coral reef in the continental U. S. (newly protected by the Florida Keys National Marine Sanctuary). Influences on the fauna include the Gulf Stream flowing northward from the Caribbean, nutrient-heavy waters from the Everglades moving southward across Florida Bay, as well as millions of vacationing tourists per year. This survey, compiled from original collections, museum and literature records, comprises 1,293 species (9xx gastropods, 2xx bivalves, xxx other), surpassing the only other published list (1995) by xx%. This part of the ongoing assessment examines the Bivalvia. Approximately half of the recognized bivalve families and xxx of superfamilies are represented in the Keys. Analyses by habitat show about equal proportions of infauna and epifauna, with the latter including important coral reef borers and cementers. Within-Keys distributions include one-third ranging the full length of the island chain, one-third so far recorded from only one zone (Upper, Middle, Lower, Tortugas), and one-third overlapping two or more zones. Species ranges show 54% of Keys bivalves considered "wide ranging" both north and south, but xx% of the remainder decidedly tropical in distribution. Historical records indicate little species turnover, although habitat shifts from natural to artificial substrata are evident.

File clams and flame scallops in the western Atlantic (Bivalvia: Limidae)

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The western Atlantic representatives of *Lima* and *Ctenoides* are revised. Studies of live-collected

material from the Florida Keys, supplemented by museum collections and literature data, identified anatomical characters to corroborate genus- and species-level taxa formerly based on shells. *Lima* (file clams) includes *L. caribaea* Orbigny (Bermuda, Carolinas-Brazil), and *L. marioni* Fischer (deep-water Atlantic, including off Brazil). The former is *L. lima* auct. (in part), distinguished from eastern Atlantic *L. lima* Linné, Indo-Pacific *L. sowerbyi* Deshayes, and eastern Pacific *L. tetrica* Gould, by relative numbers of radial shell ribs. *Ctenoides* (flame scallops) includes two shallow-water species, *C. scabra* (Born) (Carolinas-Venezuela) and *C. floridana* (Olsson & Harbison) (Carolinas-Venezuela), and two deep-water species, *C. planulata* (Dall, 1886) (Florida, Barbados) and one new species. *Ctenoides floridana* (= *tenera* Sowerby, non Turton), previously considered a variety of *C. scabra,* is a sympatric congener based on consistent characters in shell and anatomy. The new species, from southern Florida to Caribbean South America, is distinguished by roundly ovate valves, flattened ribs with minute prickles and narrow interspaces. As presently understood from western Atlantic species, the genera are characterized by features (apomorphies?) of shell and anatomy: *Lima,* with ungaping, inequilateral valves, strong ribs with large erect scales, non-persistent periostracum, short (whitish) pallial tentacles, truncated visceral mass; and *Ctenoides,* with gaping, equilateral shells, scaly ribs divaricating centrally, brownish periostracum, long colorful (red-orange) pallial tentacles, expanded visceral mass with intestinal loop.

The genus *Cumanotus*: Aeolid nudibranchs with deviance, but how deviant?

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The genus *Cumanotus* consists of three species of soft-bottom-dwelling aeolid nudibranchs. They have short, wide bodies and long cerata used in swimming. The only species in which the reproductive system is known, *C. beaumonti* (Eliot, 1906), has bizarre sexual habits. A simultaneous hermaphrodite like other nudibranchs, the female region of *C. beaumonti* features a pair of prominent studded claspers that grasp the partner's long snaky penis. Other, less dramatic features also differentiate this genus. It has been treated as a monogeneric subfamily or given family status depending on the importance attached to the position of its anus. The recent discovery of a fourth species in the northeastern Pacific and a reexamination of the other poorly described Pacific species extends our knowledge of this little-known genus.

Schistosomiasis intermediate hosts in eastern Mexico: a new survey of the aquatic malacofauna

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Species of *Biomphalaria* (Gastropoda: Planorbidae) known to be susceptible to *Schistosoma mansoni* (intestinal schistosomiasis) have been reported from several parts of Mexico but little is known of their wider distribution within the country. Although the disease does not occur in Mexico, the

presence of susceptible *Biomphalaria* in the country has assumed significance with the recognition that *S. mansoni* could be introduced via migrants from endemic countries en route to the United States. A freshwater snail survey was therefore carried out in July 1997 in northeastern Mexico, the presumed route of these migrants, specifically to look for *Biomphalaria* and to provide baseline malacological data to help assess the likelihood of schistosomiasis becoming established. The species of *Biomphalaria* collected in the area and its rich freshwater molluscan community are discussed.

Mollusks associated with Mayan ruins on the Yucatan Peninsula, México

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The Mayan ruins in the state of Yucatan are a habitat for a variety of land and freshwater mollusks. Since the middle of last century, several workers have contributed to a gradually improving knowledge of the non-marine mollusks of the area (Morelet, 1949; Phillips, 1846; Pilsbry, 1891 Bequeart & Clench, 193 3, 1936, 1938). Since Harry (1950), however, the non-marine malacofauna of Yucatan has received little attention compared to the marine species. A revision of this nonmarine malacofauna has been undertaken, using both classical information based on shell morphology on the one hand and scanning electron microscopy, anatomical features, and radulae on the other. Field work was done in some of the "cenotes" (freshwater-filled sinkholes) typical of this karstic area, grottos in which the ceiling has partly collapsed, and ruins. Mollusks were also collected from shady areas. Families and genera reported in this survey are: Mesodontidae (*Praticolella* and *Polygyra*); Annulariidae (*Choanopoma*); Subulinidae (*Allopeas* and *Subulina*); Spiraxidae (*Streptostyla* and *Euglandina*) Hydrobiidae (*Pyrgophorus* and *Littoridinops*); Bulimulidae (*Bulimulus* and *Drymaeus*); Urocoptidae (*Macroceramus*); Succincidae (*Succinea*); and Planorbidae (*Biomphalaria*). These studies have not only resolved some long-standing taxonomic problems, but have updated distributional data and provided information on the conservation status of the non-marine Yucatan mollusks.

Distribution and abundance of the malacofauna of ground leaf litter in a tropical rain forest in southern Veracruz, México

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In 1991 Naranjo-García started the first study of the molluscan fauna of the ground leaf litter at Estación de Biología Los Tuxtlas, in southern Veracruz, Mexico. She found about 51 taxa from this type of habitat. Subsequent studies have focused on the distribution and abundance of these mollusks. Litter samples were collected monthly from November 1996 to October 1997 at three sites, one in old secondary growth forest and two, named "Hectare" and "Vigia 4," in the tropical

rain forest proper. During the study period, 34 species belonging to 13 families were recovered from the ground leaf litter. The most common species at all sites were: *Systrophia* sp. A, *Thysanophora plagioptycha, Miradiscops* sp. A, *Pseudosubulina berendti,* and *Pseudosubulina* sp. B. Species found only at particular sites were: *Omphalina* sp. (Vigia 4), *Xenodiscula* sp. (Hectare), and *Strobilops* sp. A (Secondary growth forest). More living snails were found during the rainy season (August-November) than in the dry season. The Shannon-Wiener and Sorensen diversity indices were similar for each site.

Radular loss in the evolution of dorid nudibranchs: A phylogenetic hypothesis of the Porostomata

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Porostomata is a controversial group created to unite the Dendrodorididae and Phyllidiidae, the two families of radula-less dorid nudibranchs. Several authors, based on the distinct gill morphology of phyllidiids, questioned the monophyly of the Porostomata. Different origins for phyllidiids have been suggested, all of them implying that radula has been lost twice independently in dorid evolution. The present paper attempts to test whether the Porostomata is a monophyletic group, using an array of characters and taxa. The external morphology and anatomy of the type species of all the genera involved and additional representatives have been carefully examined, using in many cases the critical-point technique for scanning electron microscopy. A database was generated, including 31 taxa of porostomids, and other five cryptobranch and phanerobranch genera for comparative proposes. Fifty-two informative characters were considered, polarized with *Bathydoris* as the outgroup. A single consensus tree was produced. It shows that Porostomata is a monophyletic group, supported by several apomorphies. An unnamed species from South Africa, provisionally assigned to *Doriopsilla,* is the sister group of the rest of the taxa involved, and therefore is regarded as a distinct new genus. *Dendrodoris, Doriopsilla,* and phyllidiids are three independent monophyletic clades. There is little resolution within phyllidiids. With this scenario a new classification should be proposed for these taxa. The families Dendrodorididae and Phyllidiidae are regarded as synonyms, with Phyllidiidae being the older valid name.

Give us time: Integrating the study of living mollusks with history

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Research on living mollusks has often proceeded independently of that on fossils. This is neither necessary nor desirable. With their excellent fossil record, mollusks provide unparalleled opportunities to add the dimension of time to the study of systematics, biogeography, and adaptation. I give examples of studies on muricid, buccinid, and pseudolivid gastropods in which knowledge of the living species alone would have led to serious misinterpretations of

biogeography, evolution, and adaptation. I discuss patterns of diversification, adaptation, and geographical restriction that could not have been inferred without fossils. Conversely, I cite molecular and anatomical results for muricids that significantly inform and enrich conclusions founded on fossils.

Biological investigations of the genus *Graneledone* from abyssal and bathyal depths of the North Pacific Ocean

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Increasing our understanding of the diversity and distribution of benthic octopuses in the deep sea requires that we gain more information about the animals' biology and collect detailed morphological data to allow us to better distinguish cryptic taxa. Members of the octopodid genus *Graneledone* occur at abyssal and bathyal depths in many of the world's oceans. Members of the genus share conspicuously warty skin on the dorsal mantle, few gill lamellae, and a limited number of suckers that usually occupy a single row; they lack the ink sac and crop. The skin and sucker characters allow individuals of *Graneledone* to be identified to genus in videotapes filmed by submersibles. These observations increase our knowledge of the animals, their appearance *in situ,* and their reproductive biology. This study compares 46 specimens from between 1,100 and 2,450 m depths in the northeastern Pacific Ocean. Specimens from abyssal depths, referred here to *Graneledone pacfica* Voss & Pearcy, 1990, can be distinguished from those at bathyal depths by subtle differences in the numbers of suckers on each arm, of gill lamellae, and of tubercles on the dorsal mantle. The differences may reflect ecophenotypic variation, if a single species occurs over this 1,300-m depth range or, arguably more likely, these differences may signify the existence of a cryptic species isolated by depth.

Minutes of the 1998 WSM Executive Board Meeting

Held at Hirschhorn Museum, Washington DC, 27 July 1998. Meeting called to order by President Sandra Millen at 12:10 PM. Board members present: Sandra Millen, Terry Arnold, George Metz, Kirstie Kaiser, Henry Chaney, Paula Mikkelsen, Roger Seapy

Secretary's Report (Henry Chaney): Minutes accepted as read.

Treasurer's Report (George Metz): See attached Cash Flow Report.

Student Grant Committee (Henry Chaney):

27 proposals received.

Proposals are being matched up with COA grants to avoid duplication. Four awards are planned. Approximately $2,850 will be awarded.

Nominations for WSM Officers for 1999:

President	Roger Seapy
First Vice President	open
Second Vice President	open
Secretary	Terry Arnold
Treasurer	George Metz
Members at Large	Jules Hertz
	Kirstie Kaiser

Voted to present proposed slate to membership at general meeting.

Publications: There will be a combined 1997-1998 Annual Report. George Kennedy will edit the combined 1997-1998 Annual Report.

1999 Meeting: 16-20 June at Cal State Fullerton. See attachment for details.
2000 Meeting: Joint with AMU in San Francisco
2001 Meeting: Tentatively in San Diego

New Business: A draft of the new brochure was reviewed and approved in terms of form and basic content. A list of members will be included. A motion was made and approved to put the brochure on the WSM web page. A proposal will be made to the membership to post the memberships list to the web page.

Meeting adjourned at 1:10 PM.

Respectively Submitted,
Terry S. Arnold
Secretary

Minutes of the 1998 WSM Annual Business Meeting

Meeting commenced at 1:10 PM. Sandra Millen, presiding.

Henry Chaney read the minutes of the 1997 General Meeting from his notes, as the Secretary was unavoidably absent from the proceedings. Accepted.

Student Travel Awards.

The Chair reported that four students from the membership were awarded travel grants to attend the World Congress of Malacology. These were Shireen Fahy, Rebecca Johnson, Jacquie Lee, and Steve Lonhart.

Student Grants.

In 1998 there were 25 proposals received of which three were approved for funding. The grant recipients were Alicia Cordero (University of California, Berkeley), Rowan Lockwood (University of Chicago), and Brad Seibel (University of California, Santa Barbara).

1999 Meeting.

Roger Seapy reported that the 1999 meeting on the campus of California State University, Fullerton would offer several symposia, including "Recent Advances in Molluscan Research" and "Current Research on West Coast Molluscan Paleontology." Other plans were in progress and a mailing would be sent to membership early in 1999.

2000 Meeting.

There was no report on the meeting for 2000, however it was assumed that the WSM would be meeting jointly with the AMU [AMS] at San Francisco State University.

Nominations for 1999.

In a departure from standard practice the nominating committee reported that the slate of officers for 1999 was not yet complete, owing to a dearth of available (willing) candidates. The following candidates were proposed:

President:	Roger Seapy
Vice-President	[Vacant]
2nd Vice-President	[Vacant]
Secretary	Terry Arnold
Treasurer	George Metz
Members-at-Large	Jules Hertz and Kirstie Kaiser

There were no nominations from the floor. Slate was accepted with the hope that the vacancies would soon be filled.

NEW BUSINESS

Sandra Millen reported on the production of the WSM brochure containing membership information and addresses of active members/researchers. It was hoped that this information would be incorporated into the Society's website.

Annual Report issues. Due to the delay in publishing the Annual Report for 1997, it was proposed that a combined issue be produced containing the proceedings from 1998. This idea was met with agreement by members present.

Meeting adjourned at 1:42 PM.

Respectfully submitted,
Henry Chaney
Acting Secretary

WESTERN SOCIETY OF MALACOLOGISTS
TREASURER'S REPORT
1 October 1997 - 30 September 1998

INCOME

Membership dues	$ 1,745.00	
Student Grant donations	389.00	
Symposium fund donations	136.00	
Royalties	123.82	
TOTAL INCOME during period		**$ 2,393.82**

EXPENSES

Administrative (Fees, Dues, Officer Expense, Office Expense)	$ 260.81	
1998 Student Grant	1,850.00	
1998 Student Assistance to World Congress	1,000.00	
Publication of the 1997-98 Annual Reports	pending	
1998 World Congress Expenses	700.00	
TOTAL EXPENSES during period		**$ 3,810.81**

Net Gain/(Loss)		**(1,416.99)**
Balance brought forward (Corrected)		**4,145.15**
Current Balance		**2,728.16**
Savings (Does not include all of interest)		
CD 577-000847-5	$ 4,358.90	
CD 008-037930-8	9,971.58	
CD 577-016612-4	2,442.92	
Total		**16,773.40**
Total Assets		**$19,501.56**

STUDENT GRANT RECIPIENTS

Alicia Cordero (University of California, Berkeley)
Rowan Lockwood (University of Chicago)
Brad Seibel (University of California, Santa Barbara)

WSM
Student Support Activities
1998

During the past calendar year the WSM has been able to rpovide financial support to students through the following activities.

1998 World Congress of Malacology, 26-30 July, 1998, Washington, DC.

Shireen Fahy
Rebecca Johnson
Jacquie Lee
Steve Lonhart

These four students each received $250, from the WSM, for support of their presentations of papers or posters at this meeting.

1998 Student Grant Awards

$1000 Alicia M. Cordero, University of California, Berkeley, CA
$ 800 Rowan Lockwood, University of Chicago, IL
$1000 Brad A. Seibel, University of California, Santa Barbara, CA

The student grants were made possible by gifts from:

Individual donations by the members of the WSM
Santa Barbara Malacological Society
San Diego Shell Club
Northern California Malacozoological Club
Individual member donations in memory of Paul Skoglund
WSM

Tentative schedule and information for the 1999 Annual Meeting of the Western Society of Malacologists, to be held 16-20 June 1999 at California State University, Fullerton

June 13, Sunday

- Early evening: Executive Board Meeting
- Evening: Reception (tentatively planned to be held at the Marriott Hotel)

June 17, Monday

- Morning Symposium: "Recent Advances in Molluscan Research"; Douglas Eemisse, Organizer
- Afternoon: Contributed Papers
- Evening: open (but could include slide presentations, as at past meetings)

June 18, Tuesday

- Morning Symposium: " Invasive Molluscs: Environmental and Conservation impacts"; Jonathan Geller, Organizer
- Afternoon: Contributed Papers
- Late afternoon: Annual Meeting
- Evening: Reprint sale (to be run by George Kennedy) and Shell Auction (hopefully to be run by Hank Chaney); tentatively planned to be held at the Marriott Hotel.

June 19, Wednesday

- Morning Symposium: "Current research on West Coast Molluscan Paleontology"; Richard Squires and Lindsay Groves, Organizers
- Afternoon: Field Trip to Silverado Canyon (Santa Ana Mountains) to study Late Cretaceous shallow marine molluscs; Richard Squires and Lindsey Groves, Organizers. During the morning session, an introductory talk about the field trip will be presented by the organizers.
- Evening: Banquet at Angelo's and Vinci's Ristorante in downtown Fullerton.

June 20, Thursday

- Afternoon: Contributed Papers (if needed)

Meeting Location

The symposia, contributed paper sessions, and the Annual Meeting will be held in the cnetrally-located lecture theater and adjoining smaller rooms in the University Hall on the California State University, Fullerton campus.

Accommodations

- Fullerton Marriott Hotel - located immediately adjacent to the campus and within walking distance of University Hall. We will receive a group discount on the rooms. In addition, we have scheduled several meeting rooms for planned events, including the Sunday evening Recption and the Tuesday evening Reprint Sale and Shell Auction.

- On-campus housing - dormitory space will not be available during the month of June. Thus, we will not have access to on-campus housing during the meetings.

- Off-campus housing - a number of hotel and motel alternatives to the Marriott Hotel are available close to CSUF (an annotated list with approximate costs and map will be included with the meeting announcement and registration).

- Camping facilities (both hook-up and tent) are available at Featherly Park in the Santa Ana Canyon, which is a 10 minute drive from the CSUF campus and is located off the 91 Freeway at Gypsum Canyon Road.

Campus Facilities

- University Library - the library was recently enlarged and will be open during the meetings (although the hours are not known at present).

- University Center - the "UC" includes several lounges (open rooms, with comfortable seating), small conference rooms, a cafeteria, and even a bowling alley, pool and ping pong rooms.

- Titan Bookstore - the campus book store is large. In addition to housing text, reference and other books, it has a copy center and a fairly good computer and software section.

- Hours of the Library, University Center and Bookstore are not known at present, but hopefully will be known and included in the meeting announcement.

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Program and Abstracts

Combined Annual Meeting

21 - 27 June 1997

Radisson Hotel
Santa Barbara

Program and Abstracts

63rd Annual Meeting
American Malacological Union

and the

30th Annual Meeting
Western Society of Malacologists

21 - 27 June 1997

American Malacological Union

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[see membership list for contact information]

Western Society of Malacologists

Executive Board, 1996-1997

Committees for 1996-1997

STUDENT GRANT AWARD

The WSM student grant is given annually in competition open to graduate students working on Mollusca. The student grant fund is maintained through donations and the annual auction proceeds. Send requests for information to: Department of Invertebrate Zoology, Santa Barbara Museum of Natural History, 2559 Puesta del Sol, Santa Barbara, CA 93105, USA. Email: inverts@sbnature.org (Attention: Henry Chaney)

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GENERAL INFORMATION

MEETING VENUES

All meeting presentations will be given at the Radisson Hotel, either in the "El Cabrillo Room" on the second floor or the "La Cantina Room" on the ground floor. These rooms are in close proximity to each other by a stairway and elevator. All session breaks will be held in the El Cabrillo Room.

POSTERS

Posters will be displayed in the El Cabrillo Room and the adjoining Gazebo Room. Posters can be set-up from 3:00-4:00 PM on Sunday and during program breaks on Monday. They will be grouped as shown in the program schedule. The formal Poster Session will be on Tuesday at 4:10 PM. Posters can remain on display until Thursday.

GROUP PHOTOGRAPH

The group photograph will be taken at creek side on the grounds of the Santa Barbara Museum of Natural History just prior to the closing reception and banquet, approximately 6:45 PM on Thursday. The wine will be poured and the hor d'oeuvres served once you are photographed.

T-SHIRTS

T-shirt sales will be at the registration desk, located in the anteroom of the El Cabrillo Room. Shop early because supplies are limited.

STUDENT PAPER COMPETITION

The AMU will be presenting awards for the best paper delivered by a student at this joint meeting. This year there are 15 such productions to be considered. Judges will evaluate presentations based on scientific content, adequacy of research approach, organization and quality of visual aids and the manner in which the student handles questions and answers. An asterisk in the program after the presenter's name designates eligible papers for this competition.

BUSINESS MEETINGS

The business meetings for both Societies will be held Thursday afternoon in the El Cabrillo Room. Note the schedule for the correct time. All members are urged to attend.

EVENING EVENTS

SUNDAY: The Presidents' Reception will be held at the Cabrillo Pavilion Arts Center, directly across Cabrillo Blvd. from the Radisson Hotel, and situated on Santa Barbara's East Beach. Wines and beers from the local region will be featured with a variety of hor d'oeuvres. The festivities begin at 7:00 PM. Come and enjoy this traditional opening night event.

MONDAY: Gary Rosenberg will be conducting a workshop on cladistics. This session is intended to give those unfamiliar with cladistics an introduction to its terminology, methods and philosophy. The presentation will be low-tech, giving you the opportunity to work through some examples with pencil and paper. Those so inclined can then try running some phylogenetics

programs on lap-top computers. Scheduled to begin at 7:30 PM in the Gazebo Room, adjoining the El Cabrillo Room.
Meanwhile, the traditional WSM slide night will be held in the El Cabrillo Room. All interested persons are invited to bring their photographic slides for use in short, very informal presentations.

TUESDAY: At 5:45 PM buses will be departing from the Radisson for the Santa Ynez Valley and the Gainey Vineyard. Included in this trip will be a tour of the facilities, a tasting of the current varietals and a barbecue tri-tip steak dinner as the midsummer sun sets over the vineyard. Return should be by 11:00 PM. Late afternoons in the valley are usually warm, but a sweater is suggested as temperatures often cool abruptly in the evening.

WEDNESDAY: The annual WSM reprint sale, followed by the AMU/WSM auction will be held in the El Cabrillo Room. The reprint sale will begin at 7:00 PM as will the auction preview. The actual auction commences at 8:00 PM. A selection of mollusk books and other shell paraphernalia are featured with the redoubtable Dick Petit presiding. A cash bar with light snacks will be available.

THURSDAY: The final night of the meeting will include a reception and banquet at the Santa Barbara Museum of Natural History. Prior to dinner, participants can tour the public galleries of the museum including two special exhibitions: "Pacific Currents," underwater photographs of life along the coastline of western North America from Mexico to Canada, and "Delights for the Eye and Mind: Images of Mollusks during the Age of Enlightenment." There are also numerous shell exhibits that are supporting the Museum's summer programs. Transportation between the museum and the Radisson Hotel is available, buses depart at 6:15 PM.

FIELD TRIPS

Announcements will be made during the meeting about final arrangements for the field trips on Friday, 27 June. The boat for the Channel Island Cruise will be departing the Santa Barbara Harbor at about 8:00 AM. The Paleontology Trip will depart the Radisson Hotel at 9:00 AM.

VISIT TO SBMNH

On Friday, 27 June the Department of Invertebrate Zoology at the Museum will be holding an Open House for all those interested in visiting the mollusk collections. The open house will begin at 9:00 AM and will last until 4:00 PM. There will be no organized transportation from the Hotel so private arrangements should be made by those without cars.

AMU/WSM Meeting Schedule

	Morning	Afternoon	Evening
Saturday, June 21		- AMU Council meeting, 2:30 - 6:30 PM, El Monte Room	Free
Sunday, June 22	- AMU Council Meeting, committee, 8:30 - 1:00, El Monte Room	- Check-in, Registration, 2:00 - 5:30 PM, Lobby - WSM Board meeting, 3:00 - 4:00 PM, Pool-side - CSM meeting, 4:00-5:30 PM El Cabrillo Room	- Presidents' Reception, Cabrillo Pavilion, 7:00-9:30 PM
Monday, June 23	- **Plenary: Deep-Sea Symposium** 8:15-12:10, El Cabrillo Room - AMU Editorial Board, lunch, Restaurant	- **(1) Deep-Sea Symposium**, continued, 1:50-4:50 El Cabrillo Rm. - **(2) Contributed papers: Biology and Ecology** 1:30-4:30, La Cantina Room	- Cladististics Workshop, 7:30-8:30, Gazebo Room - Informal Slide Show, 7:30-8:30, El Cabrillo Room
Tuesday, June 24	- **Contributed Papers: Taxonomy and Evolution** 8:30–12:10, El Cabrillo Room - AMU Publ. Comm., lunch, Restaurant	- **Contributed Papers: Taxonomy and Evolution** 1:30–4:10, El Cabrillo Room - Poster Session 4:10-5:00, El Cabrillo Room	- Santa Ynez Valley Winery evening; meet buses in front of hotel at 5:30 PM

	Morning	**Afternoon**	**Evening**
Wednesday, June 25	- **(1) Phylogenetic Systematics Symposium** 8:30 - 12:00, El Cabrillo Room - **(2) Contributed Papers: Cephalopods**, 8:30 – 10:10 La Cantina Room	- **(1) Phylogenetics**, continued 1:30 - 5:10, El Cabrillo Room - **(2) Special Session: Cephalopods of the North Pacific** 1:30 - 5:20, La Cantina Room	- CMS [Veliger] Board Meeting 5:30-7:00 PM, Hotel Resturant - Reprint sale [WSM] and Auction Preview, 7:00 PM, El Cabrillo Room - Auction of literature, art [AMU-WSM] 8:00 - 10:00 PM El Cabrillo Room
Thursday, June 26	- **(1) Special Session: Cephalopods of the North Pacific**, continued 8:30 - 12:10, El Cabrillo Room - **(2) Contributed Paper: Biology and Ecology** 8:30 - 11:50, La Cantina Room	- **Special Session: Cephalopods of the North Pacific**, continued 1:30 - 2:50, El Cabrillo Room - AMU Membership Meeting, 3:00 - 4:00 PM, El Cabrillo Room - WSM Membership Meeting, 4:00 - 5:00 PM, El Cabrillo Room	- Banquet, SBMNH; meet buses in front of hotel at 6 PM - Group Photograph creekside at Museum 6:30 PM
Friday, June 27	- Field Trips: Meet buses in front of hotel at 8:00 AM: (1) Fossil Tour; (2) Channel Island Cruise; (3) Tour of SBMNH to 4:00 PM		

AMU/WSM Program

Monday Morning

8:15-8:30
Opening Remarks

Deep-Sea Symposium

El Cabrillo Room
Chair: M. G. Harasewych

8:30-8:40
Introduction: M. G. Harasewych

8:40-9:00
The Aplacophora as a deep-sea taxon
Amelie H. Scheltema

9:00-9:20
A review of the family Simrothiellidae: the systematic status of the genera and their importance as a model for biogeography
Pamela Arnofsky

9:20-9:40
Preliminary data on the distribution of the family Prochaetodermatidae (Mollusca: Caudofoveata)
Dmitry L. Ivanov

9:40-10:10
News on monoplacophoran anatomy and phylogeny
Gerhard Haszprunar

10:10-10:30 – Break

10:30-10:50
Studies of hydrothermal vent fauna, especially gastropods
Janet R. Voight

10:50-11:10
Evolutionary origins of endemic hydrothermal vent neomphalinid gastropods: 28S rRNA investigations
Andrew G. McArthur, Ben F. Koop and Verena Tunnicliffe

11:10-11:30
Evolution in deep-sea molluscs: a molecular genetic approach
R. J. Etter, M. R. Chase, Michael A. Rex and J. Quattro

11:30-11:50
The anatomy of a new hadal, cocculinid limpet (Gastropoda: Cocculinoidea), with a preliminary phylogenetic analysis of the family Cocculinidae
Ellen E. Strong, M. G. Harasewych and Gerhard Haszprunar

11:50-12:10
Phylogeny and zoogeography of the bathyal family Pleurotomariidae (Mollusca: Gastropoda: Orthogastropoda)
M. G. Harasewych, Andrew G. McArthur, Rei Ueshima, Atsushi Kurabayashi, S. Laura Adamkewicz, Matthew Plassmire and Patrick Gillevett

Monday Afternoon

1 - Deep-Sea Symposium

El Cabrillo Room
Chair: Andrew G. McArthur

1:50-2:10
Reproduction among protobranch bivalves from sublittoral, bathyal and abyssal depths off the New England coast (USA)
Rudolf S. Scheltema and Isabelle P. Williams

2:10-2:30
A molecular survey of eogastropod phylogeny
M. G. Harasewych and Andrew G. McArthur

2:30-2:50
The Ptychatractinae: an endemic deep-sea clade of the Turbinellidae?
Yuri I. Kantor and Philippe Bouchet

2:50-3:10
Origin and distribution of deep-sea fauna of conoidean gastropods
Alexander V. Sysoev

3:10-3:30 – Break

3:30-3:50
On the vertical distribution of morpho-functional types of Conoidea
Alexandra I. Medinskaya

3:50-4:10
Taxonomic status of deep-sea gastropods of the northeastern Pacific
James H. McLean

4:10-4:30
Invertebrate megafauna, community structure and molluscan associates at three deep-sea sites off central California
James Nybakken, Guillermo Moreno, Lisa Smith Beasley, Anne Summers and Lisa Weetman

4:30-4:50
Discussion: M. G. Harasewych

2 - Contributed Papers: Biology and Ecology

La Cantina Room
Chair: Tim Pearce

1:30-1:50
Dreissena polymorpha: macrocosm, microcosm and the organism interface
Louise Russert-Kraemer

1:50-2:10
Land snails of the lower Salmon River drainage, Idaho
Terrence J. Frest and E. J. Johannes

2:10-2:30
Leaf litter land gastropods from a tropical rain forest, southern Veracruz, Mexico
Edna Naranjo-García

2:30-2:50
Land snail ecology on northern Kuril Islands, Far Eastern Russia: habitat versus isolation
Timothy A. Pearce

2:50-3:10
Some chromosomic and electrophoretic characteristics of the genus *Pomacea* (Gastropoda: Pilidae) from the southeastern Mexico
Maria E. Diupotex, Nora Foster and Sofia A. Rubio

3:10-3:30 – Break

3:30-3:50
Patterns of introduction of non-indigenous non-marine snails and slugs in the Hawaiian Islands
Robert H. Cowie

3:50-4:10
A review of the sea hare *Aplysia donca* (Gastropoda: Opisthobranchia) from Mustang Island, Texas
Ned E. Strenth and John D. Beatty

4:10-4:30
Introduction of a new molluscan shell pest: not just another "boring" organism
Carolynn S. Culver and Armand M. Kuris

Tuesday Morning

Contributed Papers: Taxonomy and Evolution

El Cabrillo Room
Chair: Barry Roth

8:30-8:50
Early Paleozoic stem group chitons from Utah and Missouri: no Problematica!
Bruce Runnegar and Michael J. Vendrasco

8:50-9:10
Molluscan paleontology of middle Eocene brackish-marine rocks near Ojai, Ventura County, southern California
Richard L. Squires and Gian Carlo Shammas

9:10-9:30
Abalone in the fossil record: a review (Gastropoda: Prosobranchia: Haliotidae)
Daniel L. Geiger and Lindsey T. Groves

9:30-9:50

Molecular phylogeny of giant clams (Cardiidae:Tridacninae)

Jay A. Schneider and Diarmaid Ó Foighil

9:50-10:10

Form, function and diversity of epithelial sensory structures in trochoidean gastropods

Carole S. Hickman

10:10-10:30 – Break

10:30-10:50

The utility of the gastric chamber of Caenogastropod stomachs in higher and lower level systematic studies

Ellen E. Strong*

10:50-11:10

Nacre is homoplastic - then what?

Claus Hedegaard

11:10-11:30

Phylogenetics and classification of the *Philine aperta* clade: traditional versus cladistic approaches

Terrence M. Gosliner and Rebecca Price

11:30-11:50

From the bottom up or the intertidal down? Patterns of movement based on phylogenetic inferences in the Patellogastropoda

Robert P. Guralnick

11:50-12:10

The Eastern Pacific members of the bivalve family Sportellidae

Eugene V. Coan

Tuesday Afternoon

Contributed Papers: Taxonomy and Evolution

El Cabrillo Room
Chair: John Wise

1:30-1:50

A phylogeny of pleurocerid snails (Caenogastropoda: Cerithioidea) based on molecular and morphological data

Wallace E. Holznagel*

1:50-2:10

Phylogenies of the *Columbella* and *Conella* groups (Neogastropoda: Columbellidae), and implications for the evolution of Neogene tropical American marine faunas

Marta J. deMaintenon

2:10-2:30

Taxonomic problems with tropical members of the family Haliotidae (Gastropoda: Prosobranchia)

Daniel L. Geiger*

2:30-2:50

Shells, anatomy, and the phylogeny of the Nassariinae (Prosobranchia: Nassariidae)

David M. Haasl

2:50-3:10

Shell paedomorphosis in *Prunum* (Neogastropoda: Marginellidae): a multilineage microstructural analysis

Ross H. Nehm and Claus Hedegaard

3:10-3:30 – Break

3:30-3:50

Molecular phylogenetic relationships of brooding oysters

Diarmaid Ó Foighil, Derek Taylor and Christopher Jozefowicz

3:30-4:10

A preliminary assessment of the generic relationships of the Lampsilini (Bivalvia: Unionidae) based on a portion of the 16S rRNA gene

Kevin J. Roe

4:10-5:00

Poster Session

El Cabrillo Room
Chair: S. Laura Adamkewicz

1 - Deep-Sea Symposium

- Finned octopuses (Cirrata) in the seas of Russia

  K. N. Nesis

- Molecular systematics of Aplacophora based on EF1a nuclear gene sequences

  Akiko Okusu

2 - North Pacific Cephalopods

- Preliminary results on fecundity of the common squid, *Todarodes pacificus* (Cephalopoda, Ommastrephidae), in the Japan Sea

  Natalya B. Bessmertnaya and Yaroslav A. Reznik

- Seasonal distribution of the gonatid squid *Berryteuthis magister* (Berry, 1913) in the Okhotsk Sea

  Vasili D. Didenko, Yuri A. Fedorets and Petr P. Railko

- Remains of the prey — recognizing the midden piles of *Octopus dofleini*

  Rebecca Dodge and David Scheel

- Host specificity patterns of dicyemid mesozoans found in eight species of cephalopods of Japan

  Hidetaka Furuya

- Species composition and distribution of octopuses of the genus *Octopus* on the northwestern Japan Sea Shelf

  Alexi V. Golenkevich

- Peculiarities of giant protists infecting the gills of some squids in the Bering Sea

  F. G. Hochberg and Chingis M. Nigmatullin

- First record of the "*Octopus aegina* genus group" in the Hawaiian Islands Archipelago

  Christine L. Huffard and F. G. Hochberg

- Young cephalopods collected by a mid-water trawl in the Bering Sea in summer

  Tsunemi Kubodera and Keiichi Mito

- Age determination of the gonatid squid *Berryteuthis magister* (Berry, 1913) based on morphometric characters

  Petr P. Railko

- Distribution and abundance of pelagic cephalopods in the central North Pacific: information from large-scale high-seas driftnet fisheries

  Michael P. Seki

- Distribution and biology of *Rossia pacifica* (Cephalopoda, Sepiolidae) in the Russian Exclusive Zone of the Japan Sea

  Gennadi A. Shevtsov and Nikolai M. Mokrin

- Discovery of an egg mass with embryos of *Rossia pacifica* (Cephalopoda, Sepiolidae) in the Okhotsk Sea

  Gennadi A. Shevtsov and Vladimir I. Radchenko

2 - Contributed Papers

- How to build an herbivore: the evolution of herbivory in columbellid gastropods (Neogastropoda: Columbellidae)

  Marta J. deMaintenon

- Lack of significant esterase and myoglobin differentiation in the planktonic developing periwinkle, *Littorina striata* (Gastropoda, Prosobranchia)

  Hans De Wolf, Thierry Backeljau, Kurt Jordaens and Ron Verhagen

- The coccidian parasite *Aggregata* (Apicomplexa: Aggregatidae) in Cephalopods from European waters

  Camino Gestal, F. G. Hochberg, Paola Belcari, Christina Arias and Santiago Pascual

- Gill filament differentiation and experimental colonization by symbiotic bacteria in the tropical lucinid clam *Codakia orbicularis*

  Olivier Gros, Liliane Frenkiel and Marcel Mouëza

- Allozyme homozygosity and phally polymorphism in the land snail *Zonitoides nitidus* (Gastropoda, Pulmonata

  Kurt Jordaens, Thierry Backeljau, Hans De Wolf, Paz Ondina, Heike Reise and Ron Verhagen

- Molecular phylogeny of marginelliform gastropods: a progress report

  Ross H. Nehm and Chinh N. Tran

- Phylogenetic relationships of flabellinid nudibranchs based on mitrochondrial DNA sequences

  Katharina Noack*

- Highest known land snail diversity: 66 species from one site in Jamaica

  Gary Rosenberg and Igor V. Muratov

- Multiple paternity within broods of a squid, *Loligo forbesi*, demonstrated with microsatellite DNA markers

  Paul Shaw and Peter R. Boyle

- Evidence for four species of *Brachioteuthis* (Oegopsida: Brachioteuthidae) in the eastern North Atlantic

  Elizabeth K. Shea*

- Distribution and transport of *Illex argentinus* paralarvae (Cephalopoda: Ommastrephidae) across the western boundary of the Brazil/Malvinas Confluence Front off southern Brazil

  Erica A. G. Vidal and Manuel Haimovici

- The phylogenetic relationships of some littorinid species assessed by small subunit ribosomal DNA sequences and morphology

  Birgitta Winnepenninckx and Thierry Backeljau

Wednesday Morning

1 - Phylogenetic Systematics

El Cabrillo Room
Chair: Gary Rosenberg

8:30-8:40
Introduction: Gary Rosenberg

8:40-9:10
Homology analysis and parsimony algorithms — enemies or friend?

Gerhard Haszprunar

9:10-9:40
Problems and pitfalls in phylogeny inference as illustrated by molluscs

Thierry Backeljau, Hans De Wolf, Kurt Jordaens, Patrick Van Riel and Birgitta Winnepenninckx

9:40-10:10
A review and critique of the single-organ system approach: lessons from freshwater mollusks

Charles Lydeard

10:10-10:30 – Break

Chair: Paula Mikkelsen

10:30-11:00
Molecular phylogeny of hydrobiid gastropods

Hsiu-Ping Liu, Robert Hershler, M. Mulvey and Winston Ponder

11:00-11:30
The challenge of resolving high-level molluscan phylogeny with separate or combined data sets

Douglas J. Eernisse

11:30-12:00
Popular delusions, phantom taxa, and the weirdness of ranks

Barry Roth

2 - Contributed Papers: Cephalopods

La Cantina Room
Chair: Kir Nesis

8:30-8:50
Rendezvous in the dark: coevolution between sepiolids and their luminous bacterial symbionts

Michele Kiyoko Nishiguchi, E. G. Ruby and Margaret J. McFall-Ngai

8:50-9:10
Locomotory adaptations of pelagic cephalopods to habitat depth

Brad A. Seibel*

9:10-9:30
Squid (*Lolliguncula brevis*) distribution within the Chesapeake Bay: locomotive reasons for its ecological success

Ian K. Bartol*

9:30-9:50
Feeding behavior and chemoreception in cephalopods

F. Paul DiMarco and Phillip G. Lee

9:50-10:10

The effects of laboratory prepared diets on survival, growth and condition of the cuttlefish, *Sepia officinalis*

Pedro M. Domingues, F. Paul DiMarco, Jose P. Andrade and Phillip G. Lee

9:50-10:10 – Break

Wednesday Afternoon

1 - Phylogenetic Systematics

El Cabrillo Room
Chair: Gary Rosenberg

1:30-2:00

Coding what we can't see: the negative gain and parallelism of shell loss in cladistics

Paula M. Mikkelsen

2:00-2:30

Unordered vs. ordered multistate characters: explication and implication

John B. Wise and Ellen E. Strong

2:30-2:50

Traditional versus phylogenetic characters: the art of the state in molluscan systematics

Robert Guralnick*

2:50-3:10

The morphospatial "whorled" of strombid snails

Jon R. Stone*

3:10-3:30 – Break

Chair: John Wise

3:30-4:00

Calibrating phylogenies with the fossil record

Helena Fortunato

4:00-4:30

The role of stratigraphic data in phylogenetic analyses of extinct molluscs

Peter Wagner

4:30-4:50

Reproducibility and explicit hypotheses in molluscan phylogeny

Gary Rosenberg

4:50-5:10

Concluding Discussion and Remarks: Rosenberg

2 - Cephalopods of the North Pacific

La Cantina Room
Chair: F. G. Hochberg

1:30-1:40

Introduction: F. G. Hochberg

1:40-2:00

Post-spawning egg care in *Gonatus* (Cephalopoda: Teuthoidea): life history and energetics

Brad A. Seibel, F. G. Hochberg, James J. Childress and David B. Carlini

2:00-2:20

Gonatid squids in the subarctic North Pacific: ecology, biogeography, niche diversity, and role in the ecosystem

Kir N. Nesis

2:20-2:40

Two unusual *Gonatopsis* species (Gonatidae: Cephalopoda) from the bathyal waters off Sanriku, northeastern Japan

Tsunemi Kubodera

2:40-3:00

The California market squid fishery

Marija Vojkovich

3:00-3:20 – Break

3:20-3:40

In search of *Rossia pacifica diegensis*

Katharina M. Mangold, Richard E. Young and Craig R. Smith

3:40-4:00

In situ observations of nesting *Octopus dofleini*, the giant pacific octopus

James A. Cosgrove

4:00-4:20
Intertidal ecology of *Octopus dofleini*
David Scheel, Tania L. S. Vincent and Rebecca Dodge

4:20-4:40
Deep-water octopods (Opisthoteuthidae, Bathypolypodinae, Graneledoninae) from the Okhotsk and western Bering seas
Kir N. Nesis and Chingis M. Nigmatullin

4:40-5:00
Do octopuses play?
Roland C. Anderson and Jennifer A. Mather

Thursday Morning

1 - Cephalopods of the North Pacific

El Cabrillo Room
Chair: Takashi Okutani

8:30-8:50
Distribution and assemblage patterns of micronektonic squids at large-scale fronts in the central North Pacific Ocean
Michael P. Seki

8:50-9:10
Cephalopods eaten by swordfish, *Xiphias gladius* Linnaeus, caught off western Baja California Peninsula
Unai Markaida*

9:10-9:30
Species composition of cephalopods found in the diet of the Hawaiian monk seal, *Monachus schauinslandi*
Gwen Goodman-Lowe*

9:30-9:50
Life history and population structure of the neon flying squid, *Ommastrephes bartrami*, in the North Pacific Ocean
Akihiko Yatsu, Junta Mori, Hiroyuki Tanaka, Hiroshi Okamura and Kazuya Nagasawa

9:50-10:10
Statolith shape and microstructure in studies of systematics, age, and growth in planktonic paralarvae of gonatid squids (Cephalopod, Oegopsida) from the western Bering Sea
Alexander I. Arkhipkin and Vyacheslav A. Bizikov

10:10-10:30 – Break

10:30-10:50
The gonatid squid *Berryteuthis magister* in the western Bering Sea: distribution, stock structure, recruitment, and ontogenetic migrations
Vyacheslav A. Bizikov and Alexander I. Arkhipkin

10:50-11:10
A new subspecies of the schoolmaster gonate squid *Berryteuthis magister* (Berry, 1913): genetic and morphologic evidence
Oleg N. Katugin

11:10-11:30
Egg size, fecundity, vitelline oocyte resorption, and spawning in the gonatid squid, *Berryteuthis magister* (Gonatidae)
Chingis M. Nigmatullin

11:30-11:50
Population structure and life history of the gonatid squid *Berryteuthis magister* (Berry, 1913) in the North Pacific
Yuri A. Fedorets, Vladimir A. Luchin, Vasili D. Didenko and Petr P. Railko

2-Contributed Papers: Biology and Ecology

La Cantina Room
Chair: Doug Eernisse

8:30-8:50
Early development of *Crucibulum auricula* and *Crepidula convexa* (Gastropoda, Prosobranchia, Calyptraeidae) from the Venezuelan Caribbean
Patricia Miloslavich and Pablo Penchaszadeh

8:50-9:10
The spawn in the genus *Adelomelon* (Prosobranchia: Volutidae) from the Atlantic coast of South America

Pablo E. Penchaszadeh, P. M. S. Costa, M. Lasta and Patricia Miloslavich

9:10-9:30
Dynamics of adult and juvenile bivalve dispersal: a shifting paradigm

Robert S. Prezant, Harold B. Rollins and Ronald B. Toll

9:30-9:50
Shell polymorphism in the neogastropod *Alia carinata* (Hinds)

Jeff Tupen

9:50-10:10
The diel vertical migration of Norris' top snail (*Norrisia norrisi*) on giant kelp (*Macrocystis pyrifera*)

Steve I. Lonhart*

10:10-10:30 – Break

10:30-10:50
Diet and temperature on growth and biogeographic distribution of the herbivorous kelp snail *Norrisia norrisi*

Michelle Priest*

10:50-11:10
How aqueous geochemistry affects lacustrine mollusks

Saxon E. Sharpe*

11:10-11:30
Latitudinal variation in radular morphology in the Atlantic plate limpet, *Tectura testudinalis*

Eric J. Chapman*

11:30-11:50
Size structured competitive interactions between a native and introduced estuarine mud snail: implications for a species invasion

James E. Byers*

Thursday Afternoon

Cephalopods of the North Pacific

El Cabrillo Room
Chair: Tsunemi Kubodera

1:30-1:50
Fecundity of the ommastrephid squid *Dosidicus gigas* in the eastern Pacific

Chingis M. Nigmatullin, Vladimir Laptikhovsky and Nikolay Mokrin

1:50-2:10
Occurrence of the adult form of *Neoteuthis* sp. from the Hawaiian Islands

Kotaro Tsuchiya

2:10-2:30
Light-polarization and color sensitivity in the common octopus and firefly squid of Japan

Ian G. Gleadall, Yoshio Hayasaki and Yasuo Tsukahara

2:30-3:00 - Break

3:00-4:00

AMU Membership Meeting

4:00-5:00

WSM Membership Meeting

Abstracts of Papers and Posters

Do octopuses play? [NPC]

Roland C. Anderson and Jennifer A. Mather
The Seattle Aquarium, 1483 Alaskan Way, Seattle, Washington 98101-2059; roland.anderson@ci.seattle.wa.us

Play behavior is likely a sign of intelligence, and is an important activity of vertebrates, including mammals, birds and perhaps reptiles. As cephalopods are known for their intelligence, it seems appropriate to look for play in this group. Small *Octopus dofleini* were held separately at The Seattle Aquarium and presented with a novel floating "toy." Presentations were made twice a day for five days, during which texture and brightness of the toy varied. Each octopus was observed during each presentation until it made no contact with the object for 30 min. We then compared the sequences of actions in the first and last days' observations, looking for different, prolonged or truncated sequences of behavior between them. Some actions and sequences were different, a necessary condition for the designation of "play." In addition, several octopuses showed a repeated behavior, "blowing" the toy away with a jet of water from the funnel only to have the toy circle the tank and return to the animal; this behavior continued for an extended period of time. The blowing behavior will be discussed as possible "play."

Statolith shape and microstructure in studies of systematics, age, and growth in planktonic paralarvae of gonatid squids (Cephalopoda, Oegopsida) from the western Bering Sea [NPC]

Alexander I. Arkhipkin and Vyacheslav A. Bizikov
Atlantic Research Institute of Marine Fisheries and Oceanography (AtlantNIRO); 5 Dm. Donskoy Street, Kaliningrad 236000 Russia; janet@meitre.koenig.su

Microstructure, morphology and ontogenetic development of statoliths, and age and growth of 405 planktonic paralarvae and 117 juveniles belonging to ten species of gonatid squids (Cephalopoda, Oegopsida) were studied over and off the continental slope in the western part of the Bering Sea (57°00'-61°30'N, 163°00'E-179°20'W). Statolith microstructure of all species was characterized by the presence of a large droplet-shaped nucleus and bipartite post-nuclear zone divided in two by the first stress check, excluding *Berryteuthis magister*, which had only one stress check and the post-nuclear zone was not subdivided. In *Gonatus* spp., completion of development of the post-nuclear zone coincided with full development of the central hook on the tentacular club. Daily nature of statolith growth increments was validated by maintenance of 13 paralarvae belonging to the four most abundant species captured. Based on statolith microstructure, all species can be subdivided into two groups: (1) species with the nucleus in a central position in the first-check statolith (*Gonatopsis* spp., *Eugonatus tinro* and *B. magister*); and (2) species with the nucleus shifted to the inner side of the first-check statolith (*Gonatus* spp.). Comparative analysis of statolith morphology showed that paralarval statoliths have species-specific characters that allowed us to construct keys to species identification of gonatid paralarvae using their statoliths. Study of paralarval growth using statoliths revealed that cold-water planktonic gonatid paralarvae have rather fast growth rates in length, attaining 7-10 mm ML at early ages (15-20 days). Early juvenile sizes (20-25 mm ML) are attained at ages of 35-70 days.

NOTES

* = eligible for Best Student Paper/Poster Award
[PS] = Phylogenetics Symposium
[DS] = Deep-Sea Symposium
[NPC] = North Pacific Cephalopoda Special Sessions
[poster] = poster area; all other titles are oral presentations
Address listed is the primary address of the first author

A review of the family Simrothiellidae: the systematic status of the genera and their importance as a model for biogeography [DS]

Pamela Arnofsky
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The family Simrothiellidae (Aplacophora; Neomeniomorpha) has a world-wide distribution at ocean depths between 75-4300 meters. Six genera are placed in this family based on radula morphology, specifically possession of distichous bars with many denticles at some point during ontogeny and paired anteroventral radular pockets. The placement of *Uncimenia* in this family is somewhat dubious. This family may have important implications for understanding pre-Pangean biogeography. The genus *Helicoradomenia*, a vent species, is important because it possesses many of the plesiomorphic characters which are useful for defining and describing the primitive type Neomeniomorpha. The overview of this family will include a new genus and species collected from off the coast of Ireland and Scotland. (Supported by NSF DEB-PEET 95-21930)

Problems and pitfalls in phylogeny inference as illustrated by molluscs [PS]

Thierry Backeljau, Hans De Wolf, Kurt Jordaens, Patrick Van Riel and Birgitta Winnepenninckx
Royal Belgian Institute of Natural Sciences, Vautierstraat 29, B-1000 Brussels, Belgium; tbackeljau@kbinirsnb.be

Phylogeny inference is a field of biological research in which the results and conclusions of particular studies may heavily depend on the performance, accuracy and applicability of the methods and computer software used to analyze the data. In the present contribution we illustrate and discuss some controversial problems in phylogenetic data treatment. We particularly focus on (1) the differential performance of distance matrix programs applied to molecular data, (2) the use of bootstrapping, and (3) the effects of character choice and interpretation in parsimony analyses. These issues will be explored at different phylogenetic levels (from intraspecific taxa to phyla) using mainly, though not exclusively, molluscan examples based on both molecular (DNA sequences, RFLP, RAPD, allozymes) and morphological data.

Squid (*Lolliguncula brevis*) distribution within the Chesapeake Bay: locomotive reasons for its ecological success

Ian K. Bartol*
The College of William and Mary, Virginia Institute of Marine Science, School of Marine Science, Gloucester Point, Virginia 23062; ibartol@vims.edu

The suggestion that squids evolved in environments where competitive interactions with fishes are minimized presumes that squid are inferior to fish with respect to swimming efficiency, endocrine functioning, and oxygen carrying capacity. However, one unique cephalopod, the brief squid *Lolliguncula brevis*, is frequently captured in the euryhaline waters of the Chesapeake Bay where it is often in direct competition with hundreds of species of fishes. The extent to which *L. brevis* utilizes the bay and reasons for its successful invasion are not entirely known. To determine the number, size gradient, and spatial distribution of squid found within the bay throughout the year, monthly trawl surveys were conducted. Furthermore, to provide insight in to how this organism has managed to coexist with mobile communities of nekton, one aspect of its lifestyle, locomotion, was examined by videotaping squid of various sizes in a flume and analyzing the footage using a Peak Motion Measurement System. Results suggest that *L. brevis* utilizes the bay both as juveniles and adults and is capable of making extensive excursions into the bay where it can withstand a predictable range of environmental conditions. The success of *L. brevis* in estuaries may in part be a result of locomotive adaptations that make it more competitive with fishes in highly variable environments.

Preliminary results on fecundity of the common squid, *Todarodes pacificus* (Cephalopoda, Ommastrephidae), in the Japan Sea [NPC, poster]

Natalya B. Bessmertnaya and Yaroslav A. Reznik
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The reproductive systems of 30 mature female *Todarodes pacificus* Steenstrup, 1880, with mantle lengths of 179-285 mm from different regions of the Japan Sea were investigated to determine fecundity and egg diameter. Individual absolute fecundity (IAF) was calculated as the sum of total oocyte number in the gonad plus egg number in the oviducts. For the more particular characteristic of reproductive system condition an index of spawning readiness (ISR) reflecting the weight ratio between oviducts and ovary was used. IAF (calculated from 30 mature females) varied from 116,000 to 1,069,000 with an average of 506,000 ±37,000 oocytes. IAF does not depend on seasons and regions. The number of eggs in paired oviducts (OF) varied from 140-79,000. This value is 0.12-11% of IAF. The diameters of eggs ranged from 0.69-0.88 mm with a mean value of 0.82 ±0.01 mm. In view of the high correlation between egg diameter and mantle length, these parameters were compared by seasons and by regions.

The gonatid squid *Berryteuthis magister* in the western Bering Sea: distribution, stock structure, recruitment, and ontogenetic migrations [NPC]

Vyacheslav A. Bizikov and Alexander I. Arkhipkin
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A 4-year series of observations (1993-1996) on distribution, abundance and length-at-age structure of *Berryteuthis magister* in the western Bering Sea revealed high fluctuations of the squid stock both in seasonal and inter-annual aspects. Two seasonal groups of squids were distinguished in the region using statoliths ageing techniques: spring-summer-hatched and autumn-winter-hatched squids. Squids of both groups showed similar patterns of ontogenetic migrations through the region, with minor differences from year to year. Juveniles of mantle length (ML) 14-19 cm entered the region from the southeast with the Eastern Bering Slope Current (EBSC) in May-June (autumn-hatched) and November-December (spring-hatched). They accumulated on the feeding grounds over the continental slope off eastern Siberia where they grew and matured during the next 4-5 months. Squids of both groups became mature at age 10-11 months at ML 24-26 cm (females) and 20-21 cm (males). Maturing squids gathered in dense concentrations in near-bottom layers above the slope, in locations with the highest near-bottom temperatures (between 350 and 450 m). As it was shown on the autumn-hatched group, functionally mature squids (males and mated females) in October started to migrate to the south-west until they left the region of study, with the Kamchatka Current. Only 5-10% of autumn-hatched squids spawned on the Siberian slope.

Our data indicated that *B. magister* migrated counterclockwise between the western and eastern parts of the Bering Sea following the general scheme of water circulation. Abundance of mature squids in pre-spawning concentrations in the western part depends largely on abundance of juveniles brought to the region by the EBSC from supposed spawning grounds located in the south-eastern part. Thus, the general scheme of the life cycle and population structure of B. magister can not be understood without data from both the western and eastern parts of the Bering Sea.

Size structured competitive interactions between a native and introduced estuarine mud snail: implications for a species invasion

James E. Byers*

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Populations of the native mud snail, *Cerithidea californica*, have been decreasing over past decades in several northern California salt marshes. The presence of the introduced mud snail, *Batillaria attramentaria,* is often cited as a potential cause for *Cerithidea's* decline. The goals of the present study are to document whether or not *Cerithidea's* displacement is in fact due to replacement by *Batillaria*, whether the replacement is occurring through the suspected mechanism of exploitative competition for the snails' shared food resource — epibenthic diatoms, and to what degree competitive strengths vary with the sizes and densities of the snails. I conducted experiments to generate consumer-resource interaction curves for two size classes of each snail species and their diatom food source. I then used these relationships to make predictions of the interspecific effects of each snail species on the other. The predictions were tested in the field and proved to describe accurately the outcomes of interspecific interactions between the snails. The predictions and tests indicate that *Batillaria* is the more efficient competitor and strongly suggest that Cerithidea's decline in these marshes could be due to replacement by *Batillaria.*

Latitudinal variation in radular morphology in the Atlantic plate limpet, *Tectura testudinalis*

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Tectura tesudinalis is a limpet (Archeogastropoda: Lottiidae) that inhabits the rocky shores of the nortwestern Atlantic. I examined differences in radula morphology that could be due to a direct correlation between shell height and radula length. Limpets were collected from six latitudinaly separated populations in the New England area. *Tectura testudinalis* has a docoglossan radula that is long and stout with four blunt teeth per row, two central and two lateral. This limpet feeds on various red coralline algae in the genus *Clathromorphum.* Radulae were removed from the soft body tissue using sodium hypochlorite and examined with light and scanning electron microscopy. The radulae were measured from tooth row seven through thirty seven. Preliminary results indicate that this methodology could be effective in determining latitudinal variation in *T. testudinalis.*

The Eastern Pacific members of the bivalve family Sportellidae

Eugene V. Coan

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The taxonomy of the eastern Pacific species that have been allocated to the bivalve family Sportellidae are reviewed. All taxa are members of the tropical fauna. The genus *Basterotia* is represented by five species: *B. californica* Durham, 1950, here reported from the Recent fauna for the first time; *B.* #1 and *B.* #2, two new species, the latter the most common species in the genus and here reported to brood its young; *B. peninsularis* (Jordan, 1936) [of which *B. hertleini* Durham, 1950, and *B. ecuadoriana* Olsson, 1961, are synonyms]; and *B. quadrata* (Hanley, 1834) [of which *Poromya granatina* Dall, 1881, is a synonym]. A new genus is described, with a new species as its type. *Anisodonta americana* Dall, 1900 from the PlioPleistocene of Florida is also a member of this genus. *Ensitellops* is represented by *E. hertleini* Emerson and Puffer, 1957 [of which *E. pacifica* Olsson, 1961, is a synonym]. *Fabella* is represented by *F. stearnsii* (Dall, 1899) [of which *Sportella duhemi* Jordan, 1936, is a synonym]. *Sportella californica* Dall, 1899, proves to be an *Orobitella* (Galeommatoidea: Lasaeidae), and *Anisodonta pellucida* Dall, 1916, is based on a juvenile mactrid, probably *Simomactra falcata* (Gould, 1850).

In situ observations of nesting *Octopus dofleini*, the giant pacific octopus [NPC]

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Much of our information regarding the nesting behavior of *Octopus dofleini* has come from aquarium observations. This paper reports on the "in situ" observations of seven nesting *O. dofleini* females from discovery until their deaths or disappearance. All nesting dens were in 17 to 24 meters of water and were walled off. No midden heap was observed. Early in nesting the females were a pale gray color over the body with typical reddish arms. Later, the arms became a pale gray also. As death approached, the skin on the suckers and arms turned a pale yellow color and began to slough off. Three of six dead females were found outside their dens, one was partially out of the den and two died in their dens. At death the females had lost an estimated 50% - 93% of their body weight. An average of 330 strings with an average of 172 eggs in each string resulted in an average nest size of 56,760 eggs. Hatching occurred at night and finished in less than a week. Juveniles averaged 0.029 grams at hatching.

Patterns of introduction of non-indigenous non-marine snails and slugs in the Hawaiian Islands

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The native snails of the Hawaiian Islands are disappearing. One cause is predation by introduced carnivorous snails. Habitat destruction/modification is also important, facilitating the spread of other non-indigenous snails and slugs. Eighty-one species of snails and slugs are recorded as having been introduced. Thirty-three are established: 12 freshwater, 21 terrestrial. Two or three species arrived before western discovery of the islands (1778). During the 19th century about one species per decade, on average, was introduced. The rate rose to about four per decade during the 20th Century, with the exception of an especially large number introduced in the 1950s as putative biocontrol agents against the giant African snail, *Achatina fulica*. The geographical origins of these introductions reflect changing patterns of commerce and travel. Early arrivals were generally Pacific or Pacific Rim species. Increasing trade and tourism with the USA, following its annexation of Hawaii, led to an increasing proportion of American species. More general facilitation of travel and commerce later in the 20th Century led to a significant number of European species being introduced. African species dominated the 1950s biological control introductions. The process continues and is just part of the homogenization of the unique faunas of tropical Pacific islands.

Introduction of a new molluscan shell pest: not just another "boring" organism

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In 1993, a new polychaete pest was found inhabiting the shell of California cultured abalone. The worm is being described as a new genus in the family Sabellidae. It is a nonindigenous species; apparently introduced through importation of South African abalone for commercial research purposes. Although the sabellid infestations do not impact abalone tissues, shell growth can become greatly altered. Interestingly, boring by these worms in the shell is not the mechanism responsible for the abnormal growth. Instead, this parasite is apparently able to interfere with the anti-fouling mechanisms of the mantle and then guide shell deposition of the host. Direct impacts include a decrease or virtual cessation in shell growth and a weakening of the shell structure. We have determined that host specificity of this sabellid is rather broad and many native California gastropod species may be at risk of infestation. It is possible that the

altered shell structure may have indirect impacts (e.g., increased susceptibility to predation). With the recent finding of an established sabellid population in an intertidal habitat in California, further examination is needed to determine the potential environmental risks associated with the sabellids and which native species are most at risk. Without this information, management efforts to minimize the spread of the sabellid and protect native gastropod species is now, and will continue to be, seriously hindered.

Phylogenies of the *Columbella* and *Conella* groups (Neogastropoda: Columbellidae), and implications for the evolution of Neogene tropical American marine faunas

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The closure of the Isthmus of Panama in the mid-Pliocene is one of the most accessible model systems for assessing evolutionary responses to a vicariant event followed by large scale environmental change. The patterns of evolution of tropical American marine faunas have been the subject of many studies, but preservational and sampling biases have hampered their identification. This paper documents the patterns of diversification and extinction in two groups of shallow marine molluscs of the Neogene American tropics. The members of the *Columbella* and *Conella* groups of the neogastropod taxon Columbellidae were assessed through the corroboration of cladistic phylogenies and the fossil record.

The three major clades of the *Columbella* and *Conella* groups show different patterns of evolution through the Neogene in the American tropics, but also share some common trends. All three clades experienced increased extinction in the Caribbean after Isthmian closure, which was not balanced by increased origination; however no major clade went entirely extinct in the Caribbean. One eastern Pacific group underwent an episode of diversification, but the timing of this diversification is uncertain.

How to build an herbivore: the evolution of herbivory in columbellid gastropods (Neogastropoda: Columbellidae) [poster]

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The phylogeny of the neogastropod family Columbellidae, based on anatomical and morphological data, is used to address the evolutionary relationship between alimentary anatomy and feeding habits. Columbellids are opportunistic feeders and generally carnivorous; some species, however, include plant matter in their diets. Several studies have suggested a correlation between columbellid diet and alimentary anatomy, but the evolutionary basis of these observations has not been explored.

Comparison of a phylogenetic hypothesis with anatomy and diet suggests that facultative herbivory has evolved more than once in columbellids, and the transition from carnivory to herbivory is accompanied by changes in several features of alimentary anatomy. Most columbellids have gastric shields, but those of herbivores tend to be larger than those of carnivores. In addition, herbivores tend to have wider radular surfaces, with flat, blade-like cusps that may be more efficient for scraping, and odontophores with more cell layers in thickness than those of carnivores.

Lack of significant esterase and myoglobin differentiation in the planktonic developing periwinkle, *Littorina striata* (Gastropoda, Prosobranchia) [poster]

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The relationship between gene flow and the maintenance of geographic or morphology-related variation in the polymorphic Macaronesian periwinkle, *Littorina striata*, was investigated by means of isoelectric focusing of esterases (EST) and myoglobin (Mb). This revealed that: (1) individual EST variation is very high, (2) there is no EST differentiation between sexes, shell morphotypes or wave-exposure regimes, (3) there is no clear macrogeographic patterning of EST variability, although there is a (non-significant) trend of decreasing EST variability with increasing latitude (i.e., from the Cape Verde Islands in the south to the Azores in the north), and (4) there is no Mb variation, even not between islands separated by more than 2000 km. These results indicate that *L. striata* shows a high degree of genetic homogeneity among geographic populations and that the morphological patterning in this species persists in the presence of intense gene flow.

Seasonal distribution of the gonatid squid *Berryteuthis magister* (Berry, 1913) in the Okhotsk Sea [NPC, poster]

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Estimations of cephalopod biomass in the Okhotsk Sea during 1989-1991 showed that *Berryteuthis magister* is a dominant species. Juvenile and immature squids forage and grow in the epi-, meso-, and upper bathypelagic zone. Young squid are concentrated in the pelagic zone over the continental slope of the northern Okhotsk Sea and the slope off the eastern Sakhalin in the central deep sector of the sea. In this region concentrations of squid during summer and autumn-winter periods are low whereas during the winter-spring season they significantly increased. In the southern deep sector of the sea concentrations of squid in summer are somewhat lower than near the northern slope. During the winter-spring season young squids occur only in the bathypelagic zone.

On the whole throughout the Okhotsk Sea the biomass of *B. magister* is low during the winter-spring season, considerably increased in summer, and reduced to a minimum during the autumn-winter period. Horizontal and vertical distributions of juvenile and young squids are correlated with the hydrologic regime and cooling-down the upper layers that causes them to migrate to warm areas where water temperatures are greater than 2.0°C and the depths greater than 500 m.

Feeding behavior and chemoreception in cephalopods

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The feeding behavior of animals follows the sequence of perception, orientation, locomotion and finally ingestion of the food. Thus, the success or failure of test diets can be attributed to (1) the visual and/or chemical stimuli from the diet, (2) the texture and palatability of the diet, (3) the diet's nutritional quality, and (4) the post-ingestive feedback from the diet. Experiments that focused on chemical perception (using a Y-maze to test solutions such as extracts, nucleotides, amino acids) and acceptance of test diets (such as supplemented pellets and surimi; various shapes; whole animal diets; behavioral conditioning) indicated differences in the feeding responses among different groups of cephalopods. Data from *Nautilus*, octopus, cuttlefish and squid chemoattraction and feeding

experiments suggest both a hierarchy of feeding responses within each group as well as a continuum along which each group displays a dominant mode of hunting. We present results in support of these models and then comment on the physiological and behavioral adaptations that also lend them support. Preliminary results indicate that *Nautilus* appears more sensitive to chemical stimuli, octopus to contact chemical and tactile stimuli, and squids to visual stimuli. Cuttlefish may utilize vision as well as contact chemical and tactile stimuli. Our ultimate goal is to understand more about the nutritional physiology and feeding behavior of cephalopods through the development of prepared diets.

Some chromosomic and electrophoretic characteristics of the genus *Pomacea* (Gastropoda: Pilidae) from the southeastern Mexico

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Karyotypic and electrophoretic characterisitcs of freshwater sanils of the genus *Pomacea* were compared. Organisms from provinces of the states of Veracruz, Tabasco and Campeche, southeast Mexico, were used. The polymorphism found in the organisms originating in different provinces showed great similarity to that show by organisms originating in Lake Catemaco, where this endemic species is classified as *Pomacea patula catamacensis*. Karyotypes of the two species *P.p. catamacensis* and *P. flagellata* showed similar numbers 2n = 26 and n = 13 and morphology, and lacked a differentiated sexual chromosome. There were slight differences between metacentric and mediocentric chromosomes. Electrophoretic studies also showed a marked similarity between the organisms collected in the different provinces and those of Lake Catemaco. However, there are variations in the magnitude of the band pattern and a differential band in the Catemaco samples, revealed both in the isolectric running and in molecular weight. This band was only detected in the organisms with their origin in Catemaco. Results of this study determened both the variations in the populations analyzed, and a method for determining the source and diversity of clones.

Remains of the prey — recognizing the midden piles of *Octopus dofleini* [NPC, poster]

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Octopuses use dens for shelter, and discard meal remains outside the den in midden piles. Contents of middens are important data for describing octopus diets, yet field signs for distinguishing octopus midden piles from remains left by other processes can be subtle. We describe contents and field signs of 50 midden piles of *Octopus dofleini* from Prince William Sound, Alaska. Midden piles were recognized as discards from octopuses based on one of two criteria: either midden piles were found at the mouth of a den containing an octopus (N = 36) or midden piles contained at least one remain drilled by an octopus (N = 35; 21 samples met both criteria). The crabs *Telmessus cheiragonus*, *Cancer oregonensis*, *Pugettia gracilis*, and *Lophopanopeus bellus* together comprised 68% of the remains. Drills were found on the carapace and chelipeds of 8 (35%) of 23 species found in middens. The drill mark is distinguishable from other molluscs by its shape: drills of *O. dofleini* on crabs were oblong (2—6 by 1—2.5 mm), and came to a point at one or both ends. Drill marks tapered toward the inside of the shell; the final perforation of the inner surface was no more than a pinpoint.

The effects of laboratory prepared diets on survival, growth and condition of the cuttlefish, *Sepia officinalis*

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Laboratory prepared, supplemented surimi diets (fish myofibrillar protein concentrate) were fed during four separate 30-day experiments. Four essential amino acids (methionine, lysine, leucine and proline) were tested for their effects on the feeding rate, food conversion, survival, growth and condition of the cuttlefish, *Sepia officinalis*. The first experiment tested methionine. Two of the four test diets had no added methionine but different amounts of protein (62.1% and 93.5%). The remaining two diets had 93.5% protein with increasing concentrations of methionine, so that one diet was fully supplemented with amino acids. During the remaining experiments, similar diets were fed to test the effects of lysine, leucine and proline. Only diets with full supplementation produced significant growth ($p<0.05$) while none of the remaining three diets in each experiment produced significant growth ($p>0.05$). After the lysine experiment, cuttlefish fed the fully supplemented diet laid viable eggs while cuttlefish fed the other diets laid no eggs. This work was supported by a Ph.D. scholarship grant (BD 3210/95) from the J.N.I.C.T., Program PRAXIS XXI from the Portuguese government and by NIH National Center for Research Resources (Grant # RR01024 and RR04226), the Texas Institute of Oceanography and the Marine Biomedical Institute, University of Texas Medical Branch at Galveston.

The challenge of resolving high-level molluscan phylogeny with separate or combined data sets [PS]

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Major questions of higher-level molluscan phylogeny remain unsettled despite recent efforts to test hypotheses with explicit cladistic methodology. Even if "morphologists" generally agree that molluscs are, indeed, a monophyletic group, they disagree about the basal divergence within molluscs and are even more divided about which other phyla are closest relatives of molluscs. The aplacophoran molluscs are especially problematic. Are they mono- or paraphyletic? Are they sister taxon to a clade, Testaria, comprised of polyplacophorans plus conchiferans, i.e., all other molluscs, or are they sister taxon of polyplacophorans, together comprising Aculifera, the sister taxon of Conchifera? Some have even suggested that one or both aplacophoran lineages are conchiferans whose shell-less non-metameric body reflect secondary reductions, not plesiomorphic simplicities. With little consensus concerning the closest sister taxa, and with no surviving outgroup that is morphologically similar to molluscs, it is exceedingly difficult to polarize morphological character variation within molluscs. An example is metamerism. Was the ancestral mollusc metameric like a chiton or not like an aplacophoran? Molecular sequence comparisons could provide such a resolution , but the most extensive ones published to date, a 1996 study based on 18S ribosomal RNA by B. Winnepenninickx and coauthors, were discouraging because they did not even support molluscan monophyly. My own parsimony analysis of these molluscan sequences include additional outgroup sequences and was based on my own sequence alignment. The minimum-length trees found differed from those previously reported by supporting molluscan monophyly and by including a caudofoveate aplacophoran within a calde of conchiferan molluscs as sister taxon to polyplacophorans. The nearest outgroup to molluscs was resolved as not a single taxon but as clade of several eutrochozoan phyla. Addition of morphological data to the analyses did not substantially alter the topology.

Evolution in deep-sea molluscs: a molecular genetic approach [DS]

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The origin of the extraordinarily diverse deep-sea benthic fauna is poorly understood and represents an enormous gap in our understanding of basic evolutionary phenomena. The main obstacle to studying evolutionary patterns in the deep sea has been the technical difficulty of measuring genetic variation in species that are typically minute, must be recovered from extreme depths and are fixed in formalin. We developed molecular genetic techniques to work with formalin-fixed macrofauna. Population genetic structure of several species of bivalves and gastropods revealed strong differentiation along a depth gradient from 500 to 4800m despite the lack of any obvious topographic or oceanographic features that would impede gene flow. Our findings indicate that the deep-sea macrofauna can have strong population structure over small spatial scales, similar to that observed in shallow-water and terrestrial organisms, with important implications for evolution in the deep sea. Our new genetic methods make it possible for the first time to use extensive available collections of deep-sea species to explore the evolutionary-historical basis of deep-sea biodiversity on global scales, and add a new dimension to the use of museum collections in general for spatial and temporal analyses of population structure.

Population structure and life history of the gonatid squid *Berryteuthis magister* (Berry, 1913) in the North Pacific [NPC]

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Population structure of the Commander squid in the North Pacific is proposed based on an analysis of data on spatial, temporal, and size-sexual structure of this squid in the most areas of its wide range. Four spatially distinct populations are distinguished with their own spawning and foraging areas, as well as probably with exchanges of individuals to varying degrees: (1) Bering Sea population with the main spawning area along the Komandor-Aleutian islands, Bowers Ridge and a minor spawning area (based on biomass and abundance) on the slope of the western Bering Sea. A joint, overlapping foraging area occurs in the Bering Sea and partially near the northern Kurile Islands; (2) Okhotsk Sea population with the main spawning area near the Kurile Islands and a minor spawning area in the southwestern Okhotsk Sea. The foraging area occurs almost throughout the Okhotsk Sea and insignificantly in subarctic zone of the western North Pacific; (3) Japan Sea population, the most isolated, with weakly divided seasonal spawnings in the northeastern Japan Sea. The foraging area occurs almost throughout the Japan Sea; (4) American population (presumed) with a spawning area in the Pacific off the west coast of North America. The foraging area extends to the eastern Aleutian Islands and partially in the boreal zone of the Northern Pacific.

We distinguish temporal seasonal spawning groups of squids isolated in a varying degree within the Bering Sea and Okhotsk Sea populations and we consider the groups to be seasonal subpopulations (spring-summer and autumn-winter). Each subpopulation consists of early and late spawning individuals that differ slightly in size, but are significantly different in sexual maturity. We propose probable tracks of transportation of larvae and juvenile squids of every subpopulation of the Bering Sea and Okhotsk Sea populations with currents depending on flows in the epi-, meso-, and upper bathypelagic zones of the Bering and Okhotsk seas, and the North Pacific. A hypothetic scheme for the life history of *B. magister* in the North Pacific is proposed.

Calibrating phylogenies with the fossil record [PS]

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Cladistic analyses of well sampled groups with a good fossil record commonly yield phylogenies of species that conflict strongly with stratigraphic data, even to the extent of hypothesizing phylogenies that turn the stratigraphy upside down. This is almost certainly due to the convergent evolution of similar morphologies (i.e., homoplasy), rather than the inadequacy of the fossil record. This problem can be dealt with either through the use of stratigraphic information as a character (i.e., stratocladistics), or by constructing separate phylogenies for different stratigraphic intervals that can then be assembled into a composite phylogeny. Snails of the genus *Strombina* were used to test the second approach. Strombinids originated and diversified in the Caribbean during the Miocene and Pliocene, when they became nearly extinct in the Caribbean, but diversified greatly in the Eastern Pacific. Phylogenies of 42 species based only on morphology (49 shell characters,186 states) yield trees with high stratigraphic inconsistency and ghost lineages that postulate the presence of descendants 10 million years or more before the first appearance of their ancestors. Removal of species that originated after the Pliocene resolved all these stratigraphic inconsistencies although some ghost lineages remained. This Miocene/Pliocene tree was then used to root the Pleistocene and Recent species. This final composite tree is highly consistent with the known fossil record for this group.

Land snails of the lower Salmon River drainage, Idaho

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The rich Lower Salmon River area, Idaho, endemic land snail fauna has been known since the 1860s. Six taxa have been federal listing candidates since the inception of the Endangered Species Act. We conducted a comprehensive terrestrial mollusk survey of the lower 100 km in 1992-1994, visiting over 210 sites. 60+ land snail taxa were encountered, of which 18+ are new. Site diversity is comparatively low (3); but over 50% of the taxa are Lower Salmon/regional endemics. Endemism is most noted in *Oreohelix* and *Cryptomastix*. Many taxa are limited to single drainages or accreted terrain blocks with regionally unusual lithologies, such as limestone or marble. Endemics can occur at any elevation or in any moisture regime, but are most frequent in semi-arid settings at lower elevations. This small area has at least five discrete species assemblages, only one of which extends beyond the region. Adjacent Hells Canyon seems to show similar patterns of speciation, endemism, and substrate localism. At least 36 Lower Salmon taxa are in some danger of extinction. Grazing, recreation, and human settlement are the main threats to lower elevation sites; logging also at higher elevations. Many taxa are limited to one or a few sites. Site numbers and population reductions have been noted for such listing candidates as *Oreohelix idahoensis idahoensis* and *O. waltoni* since 1988.

Host specificity patterns of dicyemid mesozoans found in eight species of cephalopods of Japan [NPC, poster]

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Dicyemid mesozoans are parasites that live in the renal sacs of benthic cephalopods. Eight species of cephalopods caught off the coast of Japan were examined for the presence of dicyemids. To date we have recovered a total of 21 dicyemid species from these cephalopods: *Octopus dofleini* (2 species); *O. fangsiao* (5); *O. hongkongensis* (3); *O. minor* (3); *O. vulgaris* (3); *Sepia esculenta* (6); *S. lycidas* (2); and *Sepioteuthis lessoniana* (1). Four genera of dicyemids were encountered: *Dicyema* (12 species); *Pseudicyema* (1); *Dicyemennea* (7); and *Dicyemodeca* (1).

The largest cephalopod host species, namely , *O. dofleini*, *O. hongkongensis*, and *Sepioteuthis lessoniana*, harbored the largest dicyemid species. Typically 2-3 species of dicyemids occur in each host species. However, in *O. fangsiao* and *S. esculenta* 5 or 6 species of dicyemids were detected. In both cases all species of dicyemids were never observed together in a single host. In contrast, only one species of dicyemid has ever been found in *Sepioteuthis lessoniana*.

Most species of dicyemids examined are host specific. In a few instances, the same species of dicyemid was detected in two different cephalopod hosts, which belong to the same genus. Three dicyemids, namely, *Dicyema acuticephalum*, *D. japonicum*, and *D. misakiense*, each infects two host species in the genus Octopus. *Pseudicyema truncatum* infects two cuttlefishes in the genus *Sepia*. In summary, a high degree of host specificity appears to be characteristic of dicyemid-cephalopod relationships.

Taxonomic problems with tropical members of the family Haliotidae (Gastropoda: Prosobranchia)

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Most commercial species in the family Haliotidae are well known and present no taxonomic problems. However, many of the small, tropical species are little known and their taxonomy has been confusing. Here three recent cases are presented. (1) From Geiger (1996): The purported but replaced "type" specimen of *Haliotis unilateralis* Lamarck, 1822, is identified as a *H. varia* Linné, 1758. This species does not occur in the East African faunal province from which *H. unilateralis* is exclusively known. A neotype has been designated, and the radula and epipodium have been described for the first time. In the Red Sea, only *H. pustulata* Reeve, 1846, occurs sympatically with *H. unilateralis*. (2) From Geiger and Stewart (submitted) and Stewart and Geiger (submitted): *H. crebisculpta* Sowerby, 1914, is represented by three syntype specimens belonging to two species. The identity of both species is discussed, including their soft part characters and their geographic distributions. (3) From Geiger and Coleman (in prep.): a still unnamed species from the tropical western Pacific is discussed.

Abalone in the fossil record: a review (Gastropoda: Prosobranchia: Haliotidae)

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Fossil abalone are rare and poorly known, in contrast to their Recent counterparts. The taxonomy is problematic, because most of the 35 fossil species have been described from single specimens, and because the shell of Recent species is extremely plastic. The use of fossil species in phylogeny is questionable. Abalone first appear in the Upper Cretaceous with two species, are unknown in the Lower Paleocene, appear again the late Eocene and Oligocene of New Zealand and Europe, and are regularly found from the Miocene onwards worldwide. Most records are from intensively studies areas: West America, Caribbean, Europe, South Africa, Japan and Australia. The scarcity of Indo-Pacific records is remarkable, because their highest present-day diversity is found there. Three hypotheses for the origin of the family are discussed: Central Indo-Pacific, Pacific Rim and Tethys. Fossil and Recent abalone both seem to have lived in the shallow, rocky sublittoral in tropical and temperate climate. No onshore-offshore pattern could be detected.

The coccidian parasite *Aggregata* (Apicomplexa: Aggregatidae) in Cephalopods from European waters [poster]

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Coccidians of the genus *Aggregata* are host-specific intracellular parasites found in the digestive tracts of a large number of cephalopod hosts. Transmited via the host diet, the infection is initiated when cephalopods feed on crabs, shrimps and other crustaceans. Most studies on this group of protozoan parasites in European waters date from the beginning of this century. Based on this early work several species of *Aggregata* are recognized, namely: (1) *A. eberthi*, found in *Sepia officinalis* (Linnaeus, 1758), is widely distributed throughout the Mediterranean (Italy, Monaco, France, Spain, Tunisia), English Channel (France, England), and North Sea (Germany); (2) *A. octopiana*, found in *Octopus vulgaris* (Cuvier, 1797), has been reported from the Mediterranean (Italy, Monaco and France), and English Channel (France); and (3) *A. spinosa*, also found in *O. vulgaris*, previously has been recorded only from the English Channel (France).In order to review host range, geographic distribution, and incidence of the coccidians in European populations of cephalopods we initiated a large sampling program to survey a diversity of host species from the Mediterranean and the northwestern Iberian Peninsula. *Aggregata octopiana* in *O. vulgaris* and *A. eberthi* in *S. officinalis* were the most abundant coccidians encountered. An undescribed species of *Aggregata*, was found in the oceanic ommastrephid squid *Todarodes sagitattus* (Lamarck, 1798) off the NW coast of Spain. Sample localities, levels of infections, and comparative data on morphology and morphometry of sporocysts and sporozoites are reported in this work.

Light-polarization and color sensitivity in the common octopus and firefly squid of Japan [NPC]

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Color vision (hue discrimination) is a contrast-enhancing mechanism involving complex interactions among several different types of cell, such as the blue, green and red cones and various interneurons in the primate retina. It is, however, based on a relatively simple principle: lateral inhibition. Here, the same principle is demonstrated in the contrast-deriving properties of the octopus retina: a color-blind but polarization-sensitive system greatly simplified by the presence of only two types of visual cell. This model system demonstrates a digital enhancement principle applicable to any parameter of visual contrast. In the eye of most color-blind animals, the only possible parameter of contrast is brightness; while in vertebrates with color vision, the contrast parameters used (in photopic conditions) are differences in both brightness and hue.The ventral retina of the firefly squid appears to use three different parameters: brightness, hue and polarization. However, to say that Japanese firefly squids have color vision is probably a misconception. The purpose of the second half of this talk will be to explain how the firefly squids probably use their system and why they have color sensitivity but not "color vision."

Species composition and distribution of octopuses of the genus *Octopus* on the northwestern Japan Sea Shelf [NPC, poster]

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Bottom octopuses were collected in the north-western Japan Sea shelf overthe past 10 years by different types of sampling gear. Species composition of octopuses is relatively poor. Three highly abundant species are present, and two

of them are of commercial value: *Octopus dofleini* and *O. conispadiceus*. The third species, which is smaller in size and less numerous, could not be identified with any known species, probably due to the lack of reliable taxonomic guides. *Octopus dofleini* is found between 42°-46°N, though commercial concentrations were present only in the southern part of the surveyed area. Vertical distribution is susceptible to seasonal fluctuations, and is highly influenced by hydrological conditions. Octopuses of this species are extremely rare in the depth range 20-150 m in the winter-spring period. Commercial stocks are found at depths of 20-50 m in the summer-autumn period when temperatures range from 8-18°C. *Octopus conispadiceus* is found between 42°-48°N, and commercial stocks are located mainly in the northern part of the region. Unlike *O. dofleini*, the distribution of *O. conispadiceus* is restricted to waters with low temperatures that range between 0-5°C. The species lives at depths from 30-400 m in the winter-spring period, and moves towards the shelf edge in summer and fall. *Octopus* sp. (description will be presented; identification may correspond to *O. fujitai* or *O. yendoi*). The species occurs between 42°-48°N in the depths that range from 50-260 m. Its distribution is restricted to cold waters.

Species composition of cephalopods found in the diet of the Hawaiian monk seal, *Monachus schauinslandi* [NPC]

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The diet of the Hawaiian monk seal, *Monachus schauinslandi*, was determined through examination of fecal material collected from seals in the northwestern Hawaiian Islands during the years 1991-1994. Cephalopods were found in the feces as undigested beaks and comprised approximately 25% of the diet. Of the 940 fecal samples examined, 228 contained a total of 630 octopus beaks while 43 contained a total of 338 squid beaks. Cephalopod species were identified using both upper and lower beaks obtained from known specimens of octopus and squid. Five benthic species and two pelagic species of octopus were identified, representing a mix of diurnally and nocturnally active species. In addition, 19 species of squid were found in the samples, representing a mix of coastal, pelagic and mesopelagic species. Length and weight of squid species were determined using length/weight regressions of lower rostral lengths. These findings indicate that cephalopods are an important component in the diet of Hawaiian monk seals, which forage both inshore and offshore,and both diurnally and nocturnally.

Phylogenetics and classification of the *Philine aperta* clade: traditional versus cladistic approaches

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The Philinidae are a group of highly derived cephalaspidean opisthobranchs, in which the shell is reduced and internal. A preliminary phylogeny of the Philinidae is presented. Many traditional characters, such as shell sculpture and shape, have been modified within several lineages and are therfore less informative in characterizing major clades. Species phylogenetically closely related to *Philine aperta* Linnaeus, 1758, the type species of the genus, have been the subject of considerable systematic discord and instability. Re-examination of the anatomy of members of this clade suggests that several taxa that have been united under the name P. aperta, are in fact distinct. *Philine aperta* from southern Africa is distinct from the European *P. quadripartita* Ascanius, 1777, on the basis of consistent differences in gizzard plate and penial morphology. The anatomy of *P. elegans* Bergh, 1905, and *P. orientalis* A. Adams, 1854, is described together with that of three undescribed species. Cladistic analysis of indicates that penial morphology, gizzard plate shape and microstructure and ornamentation provide valuable new characters for ellucidating relationships amoung members of the *Philine aperta* clade and to other closely allied outgroups. Members of the *Philine aperta* clade are among the most highly derived members of the Philinidae.

Gill filament differentiation and experimental colonization by symbiotic bacteria in the tropical lucinid clam *Codakia orbicularis* [poster]

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A previous study, using PCR analysis, has demonstrated that the transmission mode of sulfur-oxidizing bacteria, located in gill-bacteriocytes of *Codakia orbicularis* is environmental. Aposymbiotic juveniles differentiate gill-filaments as usual in most bivalves, when sterile sand is added. Mucocytes, granule cells, and intercalary cells differentiate progressively, whereas bacteriocytes are lacking. Therefore, the differentiation of these three cell-types does not appear as a consequence of symbiosis, but may be a prerequisite.

Experimental colonization of aposymbiotic juveniles have been obtained by addition of crude sand collected in the natural habitat of *C. orbicularis*. A free-living form of the bacterial endosymbionts associated to sea-grass bed sand appears to be endocytosed at the apical pole of undifferentiated cells which become bacteriocytes. The association between the symbiont and its bivalve host is not necessary for metamorphosis. However, it must occur at some post-metamorphic stage. Undifferentiated cells of the gill-filaments remain receptive to bacteria, several months after metamorphosis, and become bacteriocytes when aposymbiotic juveniles are put in contact with the symbiont free-living form. In *C. orbicularis*, the environmental transmission of symbionts does not appear to be restrained to a definite period of the post-larval development.

Traditional versus phylogenetic characters: the art of the state in molluscan systematics [PS]

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Correct assessment of morphological similarity and difference is essential for either traditional or phylogenetic frameworks. However, in traditional frameworks, assessments of putative homology are not rigorously tested by congruence. By contrast, in phylogenetic methodologies initial assessment of homology must pass the test of congruence before we can adequately assess true homologies from homoplasies. Our assumptions of homology based on similarity may prove to be false.

Not only has homology assessment of characters undergone theoretical remodelling within a phylogenetic framework, but the notion of the character itself has changed. Characters have often been thought of as the endpoints of develeopmental processes. However, systematists have rightly pointed out that the character is the ontogeny instead. I will show that by focusing on morphological endpoints of developmental processes as opposed to the full ontogeny of characters, a tremendous amount of phylogenetic information is misinterpreted and therefore miscoded or missing in datasets. I use case studies from the gastropod radula to show the importance of ontogenetic information in character definition.

From the bottom up or the intertidal down? Patterns of movement based on phylogenetic inferences in the Patellogastropoda

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Morphological and molecular work supports the position of the Patellogastropoda, the true limpets, as the most basal gastropod clade. Although the clade is composed mostly of species that live intertidally, some members live in the deep sea and can be associated with hot vents and cold seeps. We ask whether these deep sea taxa have originated onshore and migrated offshore or vice versa. Previous workers have shown that the prevailing trend based on the fossil record is onshore origination and offshore migration over the course of evolution of a monophyletic lineage. We take a different approach using a phylogenetic hypothesis among living forms to determine the polarity of movement.

I have gathered a dataset of morphological characters and taxa in order to assess the phylogeny of the patellogastropods. This analysis includes eighteen taxa, seven of which are from the deep sea, and four outgroups. I have scored eighty five characters for each of these taxa based on histological sections, dissection, shell microstructure and external anatomy. The phylogenetic hypothesis I generated does not support the onshore-offshore model, but instead the pattern of speciation suggests that taxa have migrated from the offshore to the onshore. Stratigraphic distribution of the the patellogastropod lineages indicated that anoxic events may be correlated with recolonization of on-shore habitats during the Cretaceous.

Shells, anatomy, and the phylogeny of the Nassariinae (Prosobranchia: Nassariidae)

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How does the inclusion of shell characters affect phylogenetic analyses? Shell characters are often ignored or granted a relatively minor role due to perceived high levels of homoplasy. I report on preliminary phylogenetic analyses of the bucciniform gastropod subfamily Nassariinae using shell and anatomical characters. Our current understanding of nassariine phylogeny is extremely poor. Shell characters could provide valuable information for the following reasons: subfamilial taxonomy among nassariids is based largely on shell characters; some nonshell characters (e.g., radular dentition) could exhibit higher levels of homoplasy than has been acknowledged; and there are a number of fossil taxa that could represent sister taxa or plesiomorphic representatives to the extant forms.

A data matrix of 42 taxa and 44 characters was constructed. Because relationships between nassariines and possible outgroups are unknown, 14 taxa were used as outgroups. Of the 44 characters, 13 were anatomical and 31 were shell characters. Characters were experimentally weighted to examine their relative effect on tree topologies. The combined analysis supported the monophyly of the Nassariinae plus a few additional taxa. With few exceptions, the anatomical characters exhibited less homoplasy than shell characters. Weighting each character by 1000 times their rescaled C.I. produced similar results. In these analyses, anatomical characters seem to be structuring basal clades, while shell characters structure relationships among derived clades.

A molecular survey of eogastropod phylogeny

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A preliminary survey of partial 18S sequences of representatives of all living families of Eogastropoda revealed that all shallow-water (shelf) patellogastropods comprise a highly robust clade with high bootstrap support and characterized by the presence of several unique inserts. Bathyal and abyssal limpets (Neolepetopsidae and Pectinodontinae), from vents, seeps, and submerged wood, emerge as a separate clade that could not be confidently joined to the shelf patellogastropods, and lack the inserts characteristic of the shelf limpets. These profound differences suggest an that the deep-sea limpets comprise and ancient divergence within Eogastropoda.

Phylogeny and zoogeography of the bathyal family Pleurotomariidae (Mollusca: Gastropoda: Orthogastropoda) [DS]

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The relationships of the family Pleurotomariidae, and ten of its 24 known Recent species were investigated using an iterative, three gene [18S rDNA, cytochrome c oxidase I (CO I), 16S rDNA] approach to phylogeny reconstruction. A broad survey of the Gastropoda using partial 18S rDNA sequences (450 bp) was used to orient the Pleurotomariidae within the class and to determine suitable outgroups. The 18S data strongly support the monophyly of Pleurotomariidae, which are the sister group to a clade comprising the remaining superfamilies assigned to Vetigastropoda (Lepetodrilloidea + Scissurelloidea + Fissurelloidea + Haliotoidea + Trochoidea). Sequences from the CO I gene (579 bp) confirm the sister group relationship between the Pleurotomariidae and the remaining Vetigastropoda. Data from the 18S, COI, and 16S genes (475), analyzed separately and and together, clearly distinguish *Entemnotrochus* from *Perotrochus* s.l. Resolution of taxa within *Perotrochus* s.l. is less robust, with species generally assigned to *Mikadotrochus* invariably the most basal, the large, thin-shelled *Perotrochus* referred to "*Perotrochus* Group B" intermediate, and *Perotrochus* s.s. the most derived. The data suggest that the western Atlantic Perotrochus s.l. are derived from western Pacific *Perotrochus* s.l., a contention that is supported by newly discovered Antarctic Cretaceous and Paleocene fossils, and that *Perotrochus* s.s. represents a monophyletic, western Atlantic radiation.

Homology analysis and parsimony algorithms — enemies or friend? [PS]

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"Pattern Cladism" regards homology as a deductive concept after applying a parsimony analysis of character distributions. Contrary to various statements, "non-weighting" of characters is not possible. If characters are equally weighted (as usually done), character selection is the most powerful way of relative weighting (0 versus 1). However, as in molecular analysis, selection of "good" characters is always done on a basis of an (often subconscious) a priori homology analysis. Modifying Orwell's law, "all characters are equal, but some are more equal than others". Moreover, the classic distribution criterion of homology-"homologous characters have identical or hierarchical distribution"-is the theoretical basis of parsimony analysis. Accordingly, application of the parsimony principle is a kind of homology analysis based on inductive character selection.

A synthetic way of "Hennigian patterning" is proposed for phenotypic (and in principle also for molecular) analysis with application of a priori criteria of homology. The resulting, preliminary a priori probabilities of homology serve as criteria for selection and weighting (very low = not selected / low / medium / high / Dollo characters) of characters. After application of a parsimony algorithm, the final cladogram decides homology estimations.

News on monoplacophoran anatomy and phylogeny [DS]

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The interpretation of the monoplacophoran bauplan has been controversially debated in the past. The anatomy and fine structure of recently discovered species (*Laevipilina antarctica*, *Micropilina minuta*, *M. arntzi*) was examined to clear up this matter. *Laevipilina antarctica* (shell length: 3 mm) resembles the previously described larger species: it lacks any

connection between the pericardium and nephridia and is also devoid of connections between nephridia themselves. The tiny (about 1 mm shell length) *Micropilina minuta* and *M. arntzi* lack a heart and are partly paedomorphic in showing only four and three ctenidial and nephridial pairs, respectively. The latter species is a simultaneous hermaphrodite and a brooder. Comparative analysis reveals a differentiation of ctenidia and possibly also gonads from posterior to anterior. Nephridial conditions clearly contradict all ideas on annelid affinities. It is shown that the extant monoplacophorans cannot be regarded as "living fossils," but form a considerably modified early offshoot of conchiferan mollusks. The autapomorphic serial repetition of various organ systems is one aspect of their modification.

Nacre is homoplastic - then what ?

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When molluscan shell structures are mapped on a composite phylogeny, it is most parsimonious to interpret nacre as homoplastic and crossed lamellar structures as plesiomorphic. This refutes the traditional assumption that the "ancestral mollusc" had a nacreous (mother-of-pearl) shell. The interpretations are invariant under different assumptions of accelerated or delayed character transformation, and whether crossed lamellar structure is an unordered or a Dollo character (evolved once, reduced several times). The properties of nacre from gastropods, bivalves, cephalopods, and monoplacophorans differ between the groups, but not within. Consequently, nacre should not be considered homoplastic, but rather as four different characters of mistaken identity. The distribution of nacre in mollusks is not an evolutionary oddity, but the result of an inadequate character analysis. The take-home message is not "nacre is apomorphic, crossed lamellar plesiomorphic." The point is, classic assumptions should be tested repeatedly, and also that putative homoplasies should be re-investigated. Inferred homoplasy may be due to a flawed character analysis.

Form, function and diversity of epithelial sensory structures in trochoidean gastropods

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Among the major branches of the gastropod evolutionary tree, elaboration of epithelial sensory structures is the hallmark of trochoidean vetigastropods. The epithelium of the head and foot is a richly microvillar surface containing an extraordinary density and diversity of putative sensory structures. Previous knowledge of these structures resides primarily in verbal descriptions and scanning electron micrographs of inadequately fixed and poorly preserved material. The minute cantharidine trochid *Alcyna ocellata* A. Adams, 1861, provides new data from a combination of ccanning and transmission electron microscopy of carefully relaxed and fixed material.

Seven different kinds of cilia project from the epithelium: (1) single short cilia, (2) clusters of 5 to 7 short cilia emerging from a shallow pit, (3) clusters of multiple cilia at the tip of a short stalk, (4) single cilia at the tip of a short stalk, (5) clusters or tufts of longer cilia, (6) tracts of longer cilia, and (7) regions of longer cilia associated with discrete epithelial structures. The most complex structural arrangements occur on the cephalic and epipodial tentacles, where a single cell with microvillae wraps around six to eight flattened and concentrically packed columnar sensory cells, each with a basal nucleus and as many as 12 distal cilia projecting into the environment. Trochoideans appear to have specialized in epithelial detection of a diversity of close range stimuli, both mechanical and chemical, in contrast to caenogastropod osphradial specialization in discriminating more distant cues.

Peculiarities of giant protists infecting the gills of some squids from the Bering Sea

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Hochbergia, a genus of giant protist of unknown affinities, is found on the gills of a diversity of oceanic cephalopods in the North Pacific Ocean. Squid examined for this parasite were collected in August to December, 1995-1996, on the slope of the northwest Bering Sea. A total of 14 specimens of *Moroteuthis robusta* (970-1350 mm ML) were 100% infected with *H. moroteuthensis*. Intensities of infection varied from 12-750 specimens host-1 (average 220). The minimum intensity was observed in a mature male of 970 mm ML. The remainder of the *M. robusta* examined were immature females with minimum intensities of 53-60 specimens host-1. Two distinct morphs or stages of protists were present: (1) small white protists - 0.4-1.2 mm in length, with a smooth cyst wall; (2) larger yellow protists - 1.1-1.9 mm in length, with a complexly sculptured cyst wall. The ratio between white and yellow forms ranged from 0-100% of the total number in any given host (average 65% white and 35% yellow).

Several undescribed species of *Hochbergia* were present in squids of the genus *Gonatus*. In *G. onyx* (12 specimens; 70-180 mm ML), the incidence of infection was 80% with intensities ranging from 4-100 specimens host-1. Only yellow forms were present. A single specimen of *G. middendorffi* (425 mm ML) had hundreds of the large yellow morphs. In contrast, both *Gonatopsis borealis* (15 specimens; 85-140 mm ML) and *Berryteuthis magister* (20,300 specimens; 30-380 mm ML) were not infested with *Hochbergia*. Several possible reasons for the observed differences in parasite distribution will be discussed.

A phylogeny of pleurocerid snails (Caenogastropoda: Cerithioidea) based on molecular and morphological data

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Phylogenetic hypotheses for North American pleurocerid snails remain in their infancy. I was interested in estimating relationships of pleurocerid snails using both morphological and molecular data. For the molecular data set, a portion of the mitrochondrial 16S rRNA gene was sequenced for representative species of the family. For the morphological data set, I constructed a data matrix based on variation observed in the radula from the same representative taxa that were sequenced. Phylogenies were constructed for the morpholgical and molecular data sets both separately and combined. Taxonomic and character congruence is discussed.

First record of the "*Octopus aegina* genus group" in the Hawaiian Islands Archipelago [NPC, poster]

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A new species of the "*Octopus aegina* group" sensu Robson (1929) has been discovered in shallow, coastal, subtropical waters of the Hawaiian Islands Archipelago. This species is characterized as medium sized (ML to 100 mm) with moderate sucker counts (160-210 on normal arms of males and females; about 100 on hectocotylized arms of males). Gill counts range from 9-11 per demibranch; copulatory organs are small, 2.5-3.5% of the length of the hectocotylized arm; eggs are small and hatchlings planktonic. This species shares several characteristics with the non-ocellate members of the "aegina group," namely: *O. aegina* Gray, 1849; *O. marginatus* Taki, 1964;. and O. sp. 3 (Norman, 1992). It differs primarily in its geographic distribution, body size, sucker counts, and spermatophore size and number. The species occupies sandy substrates in depths ranging from 1-80 m and appears to be crepuscular. Distribution, morphology (including illustrations), and delineation from other members of the "*O. aegina* group" are presented.

Preliminary data on the distribution of the family Prochaetodermatidae (Mollusca Caudofoveata) [DS]

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At present the family Prochaetodermatidae includes 13 species in 5 genera. Based on literature and collection data, it is possible to make the following preliminary conclusions: (1) Presently we probably know no more than half of species diversity of the family world-wide. (2) Representatives of the family live in all oceans, excluding the Arctic, Subarctic, and continental seas (except for the Mediterranean and the Sea of Marmara). (3) The distribution has a near-continental amphioceanic pattern. (4) All known species inhabit the continental slope, except two species of *Chevroderma*, which also occur on the East Pacific and Atlantic abyssal plains. (5) Generally, the family is bathyal-hadal in its vertical distribution. Species have been recorded on slopes of the following trenches: Aleutian, Kurile-Kamchatka, Japan, Izu-Bonin, Philippine, Sunda, and Peruvian. The depth range is 539 to 7500 m in the Pacific, 1050 to 7060 m in the Indian Ocean, and 457 to 5208 m in the Atlantic (except *Prochaetoderma raduliferum*, occurring at 54-2415 m). (6) The distribution pattern and the levels of monotypy and endemism suggest a Pangean-tropical origin of the group. (Partial support from NSF DEB-PEET grant 95-21930).

Allozyme homozygosity and phally polymorphism in the land snail *Zonitoides nitidus* (Gastropoda, Pulmonata [poster]

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Genetic variation in the pulmonate land snail *Zonitoides nitidus* was examined by means of vertical polyacrylamide gel electrophoresis in 17 European populations (4 Swedish, 4 German, 7 Belgian, 1 British and 1 Spanish). No heterozygotes were observed. Hence, *Z. nitidus* consists of a number of fixed homozygous multilocus genotypes (strains). Nine strains were detected and in most populations >2 strains co-occurred. Strains were unevenly distributed between the localities. One strain was remarkably differentiated from the others, which is suggestive of a taxonomic differentiation. Anatomically, two phally types were distinguished: euphallics, with well-developed male reproductive organs, and hemiphallics, in which the male reproductive organs are weakly developed. Both phally types occurred together, but euphally ratios were very low (0-19%). This, together with the absence of heterozygotes suggests that selfing may be the prevailing breeding system in this species. There was no relation between phally type and alleles or genotypes, but euphally ratios differed between geographical regions. On verage, hemiphallic individuals were smaller, but no intermediate phally types were found. Yet, it remains to be decided whether hemiphally is a juvenile character.

The Ptychatractinae: an endemic deep-sea clade of the Turbinellidae? [DS]

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Due to the scarcity of its representatives, the composition and relationships of the subfamily Ptychatractinae remains little known. Based on new, rich material from recent expeditions, mainly in the Indo-Pacific, it has been possible to study the anatomy of a number of ptychatractine taxa and the generic composition of the subfamily, hitherto much confused

and debated, is being revised. As understood here, the subfamily is essentially a deep-water taxon, inhabiting shallower waters only in the boreal and Arctic zones, and includes five genera [*Ptychatractus* Stimpson, 1865, 45-900 m; *Ceratoxancus* Kuroda, 1952, 360-1000 m; *Latiromitra* Locard, 1897 (= *Cyomesus* Quinn, 1981), 200-1900 m; *Benthovoluta* Kuroda and Habe, 1950 (= *Chatamidia* Dell, 1956, and probably *Surculina* Dall, 1908), 50-1750 m; and *Metzgeria* Norman, 1879, 110-900 m] and 39 species (17 new). The fossil record of the subfamily is extremely scanty, but the family Graphidulidae, from the Cretaceous of Texas, may be closely related. Ptychatractinae are widely distributed in the World Ocean, with the greatest diversity in the tropics, essentially the Indo-Pacific. Some of the species of *Benthovoluta* and *Latiromitra* have very broad distributions. Their biology remains unknown, but species of *Ceratoxancus* may have spectacular labral teeth, the function of which is speculative. The Ptychatractinae do not appear to be closely related to the rest of the turbinellids, with which they do not share apomorphic characters. The group should probably be elevated to full family rank.

A new subspecies of the schoolmaster gonate squid *Berryteuthis magister* (Berry, 1913): genetic and morphologic evidence [NPC]

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The gonatid squid *Berryteuthis magister* is considered to be a polytypic species with two subspecies: *B. m. magister* (Berry, 1913); and *B. m. nipponensis* Okutani and Kubodera, 1988. The nominal subspecies ranges in distribution over a vast area of the North Pacific, including marginal basins, such as the geographically and hydrologically semi-isolated Japan Sea.

Morphologic and genetic variation of *B. m. magister* from the Japan Sea and northwestern Pacific were analyzed. Two sources of information unequivocally suggested, that specimens from the Japan Sea constitute a third taxon of the subspecific rank. When compared to the nominal subspecies, specimens of the new subspecies are considerably smaller, have relatively larger fins, and less pronounced size differences of club suckers. The radula of the new subspecies has dicuspid lateral (L(2)) teeth while specimens of *B. m. magister* usually have three cusps on L(2).

Based on information from 26 putative genetic loci, revealed by protein electrophoresis, standard genetic distance D(N) between the new and the nominal subspecies of *B. magister* was 0.044. Intersubspecific distance estimate is almost forty times higher, than D(N) between geographically separated populations of *B. m. magister* from the north-western Pacific. D(N) values between the two subspecies suggests that the Japan Sea population was separated from the ancestral population almost 220 thousand years ago. Seven out of 12 polymorphic genetic loci showed significant differences between the two subspecies. Genetic differentiation F(ST) between taxa was 0.12, which corresponds to a negligibly small theoretical migration rate of two animals per generation.

Two unusual *Gonatopsis* species (Gonatidae: Cephalopoda) from the bathyal waters off Sanriku, northeastern Japan [NPC]

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Five specimens of unusual *Gonatopsis* squid were collected from the bathyal waters off Sanriku, northeastern Japan, during an investigation of cephalopod fauna. They were classified into two species, both of which are different from hitherto known *Gonatopsis* species. One species resembles G. borealis, but has a much more muscular, tightened and proportionally longer mantle than *G. borealis*. Four specimens, including a mature male and a female, of this species were collected by an oblique tow of a mid-water trawl from 1200-1300m depth and by a bottom trawl at about 1500m depth. The other species also resembles *G. borealis*, but is easily distinguished from the known *Gonatopsis* species by having a large photogenic tissue on the ventral surface of the eyes. Only one specimen of this species was collected by a bottom trawl at about 1500m depth. Detailed systematic comparison of the present two species and the other *Gonatopsis* species is given.

Young cephalopods collected by a mid-water trawl in the Bering Sea in summer [NPC, poster]

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Cephalopods collected with a large mid-water trawl during August to October in 1988 and 1989 in the eastern Bering Sea were examined. Samples were provided by the U. S.-Japan joint research project on Resources of Walleye Pollack in the Bering Sea conducted by the National Research Institute of Far Seas Fisheries. The trawl used for the research had a mouth opening of about 43mx34m and had two otter boards. Tows sampled near 25-70 m depth at about 4.0 knots for 30 minutes within several hours after sunset. In total, 79 tows were conducted and more than 4400 young cephalopods, mostly 10-100 mm DML, were collected. A total of 15 species were identified; 12 species were from the family Gonatidae. The most abundant species was *Gonatopsis borealis*, followed by *Berryteuthis anonychus* and *Gonatus middendorffi*. These 3 species comprised 66% of the total catch. Annual fluctuations were recognized in the abundance, horizontal distribution and size-frequency distribution of the dominant species.

Molecular phylogeny of hydrobiid gastropods [PS]

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Hydrobiids are the largest group of freshwater mollusks, comprising more than 400 recent and fossil genera and several thousand extant species. These snails are ideal subjects for studies of evolution and vicariance biogeography because of their diversity, antiquity, and linkage with drainage system. Despite the unique and compelling features of the group, absence of a rigorously proposed phylogenetic hypothesis has prevented use of these animals in evolutionary and biogeographic studies. Many of morphological and anatomical characters exhibit homoplasy. Thus, the resulting trees are poorly resolved. The purpose of our study was to generate a cladistically based phylogenetic hypothesis of hydrobiid gastropods using DNA sequences. We selected 50+ taxa which represent most of the currently recognized subfamilies of hydrobiids, provide a broad spectrum of areas of endemisim around the world, and include brackish-coastal and freshwaer inland snails from three continents. We sequenced portions of three genes; mitochondrial 16S rRNA and cytochrome c subunit I and nuclear 18S rRNA. The phylogenetic hypothesis inferred from DNA data was used to address the following questions: (1) are hydrobiid snails monophyletic? (2) has invasion of the freshwater environment occurred more than once during hydrobiid adaptive radiation? and (3) does the phylogenetic topology fit a biogeographic model? We also seek to determine whether the molecular phylogenies are congruent among them-selves, and with the existing morphology-based classification.

The diel vertical migration of Norris' top snail (*Norrisia norrisi*) on giant kelp (*Macrocystis pyrifera*)

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Norris' top snail, *Norrisia norrisi*, has been reported to undergo a diel vertical migration on giant kelp, *Macrocystis pyrifera*, at Santa Catalina Island, climbing up the kelp at dusk and descending at dawn. The influence of irradiance and snail size on the diel behavior and vertical distribution of *Norrisia* on *Macrocystis* has not been studied previously. On Santa Catalina Island at Pumpernickel Reef, I made 1,602 observations of snail height and irradiance over a 10-mo. period.

Mean height above the holdfast was always highest at night for all snail sizes. However, only snails 17 mm showed a consistent and significant negative response to irradiance, decreasingtheir height above the holdfast with increasing irradiance. Snails >17 mm were distributed throughout the kelp during the day (high irradiance). A 25% increase in the mean number of snails observed at night was due to snails 17 mm emerging from the holdfast. During the day, snails of all sizes were relatively inactive, either hiding in or on the holdfast or clinging to stipes and the base of blades. At night, snails were more active, moving onto distal portions of the blades and feeding more frequently. The diel vertical migration of snails 17 mm may be an adaptive behavior to avoid diurnal predators and diminishes as snails grow.

A review and critique of the single-organ system approach: lessons from freshwater mollusks [PS]

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The use of a single-character or single-organ system for systematic studies of molluscs has a very long history. Nearly every organ system has been studied by one investigator or another over the years. One interesting by-product of the single-organ system approach has been the tendency for some investigators to claim that the organ-system they studied provides the most accurate reflection of phylogeny. Most investigators today recognize the value of single-organ system approaches particularly for the wealth of comparative material obtained, but realize that the data need to be examined in a phylogenetic context with other characters (a holistic or total evidence approach). Freshwater molluscs have been studied using both single-organ system and holistic approaches. I compare and contrast the single-organ approach and holistic approach in case studies of unionid mussels and pleurocerid snails. The study strongly supports an integrative approach using all available data to infer accurate phylogenies.

In search of *Rossia pacifica diegensis* [NPC]

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In 1912 S. S. Berry presented a full description of his species *Rossia pacifica* and noted that some specimens from off southern California differed somewhat. To the latter he gave the subspecific name *R. p. diegensis*. Since this time, this subspecies has been virtually ignored. We present evidence based on the retreival of Rossia eggs from a depth of 1000 m off southern California that *R. p. diegensis* is a valid taxon and discuss the zoogeographical implications.

Cephalopods eaten by swordfish, *Xiphias gladius* Linnaeus, caught off western Baja California Peninsula [NPC]

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Lower beaks of 994 cephalopods from the stomach contents of 138 swordfish, *Xiphias gladius*, caught off western Baja California Peninsula coast were analyzed. They belonged to 15 species of teuthoids, four octopods and one vampyromorph. Weight and mantle length of cephalopods were estimated from the beak rostral lengths. The ommastrephid squids *Sthenoteuthis oualaniensis* and *Dosidicus gigas* comprised 62 % by number and 79 % by estimated weight. Three species of Gonatidae represented 19 % by number, and *Argonauta* sp. was the most abundant octopod comprising 7.5 % by number. *Ancistrocheirus lesueurii* is recorded for the first time in the California Current. Discussion on the distribution of most important cephalopods is done. Swordfish showed a preference for powerful, medium to large sized squid that are probably feed at surface at night.

Evolutionary origins of endemic hydrothermal vent neomphalinid gastropods: 28S rRNA investigations [DS]

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A molecular systematic investigation of gastropod phylogeny was performed to examine the antiquity of the hydrothermal vent endemic *Neomphalina* (Neomphaloidea + Peltospiroidea). Twenty-three new D1 domain and thirty new D6 domain DNA sequences of the 28S ribosomal RNA gene were obtained from fresh-frozen and formalin-ethanol preserved gastropod specimens. These were combined with previously published molluscan 28S ribosomal RNA sequences for a total of 159 sequences. Alone, either domain exhibited poor resolution of gastropod phylogeny but together (32 genera only) monophyly of the Neritimorpha, *Neomphalina* (Peltospiridae + Cyathermiidae), Vetigastropoda, Patellogastropoda, Caenogastropoda (including *Viviparus*, *Ampullaria*, and *Campanile*), and Heterobranchia (Euthyneura plus Valvata) was supported by bootstrap values. Relationships among these groups could not be resolved, possibly due to rapid early-Paleozoic radiations. Elevated evolutionary rates in the Patellogastropoda conformed to previous studies and confounded analyses. Exclusion of overly-distant taxa yielded bootstrap support of the sister relationship between Caenogastropoda and Heterobranchia. The hydrothermal vent *Neomphalina* exhibited divergence values and phylogenetic novelty equivalent to the other early Paleozoic radiations, supporting its consideration as a vent refugial phylogenetic relic. Sequences of 28S ribosomal RNA are best used to examine within-order gastropod relationships due to saturation of substitutions at higher levels and among-order evolutionary rate variation.

Taxonomic status of deep-sea gastropods of the northeastern Pacific [DS]

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Deep-sea gastropods of the northeastern Pacific have been poorly sampled compared to Japan and the northeastern Atlantic. Few new taxa from the northeastern Pacific have been described in the last six decades except for those associated with hydrothermal vents and seeps. Based on my compilation of taxa for inclusion in an illustrated manual on the northeastern Pacific gastropods ranging from the Bering Sea to central Baja California, I have assembled a list of 140 species of shelled gastropods with depth records of 800 m and deeper. Of these, 45 species are undescribed and intended for description in the book, if not described in advance of the book. Taxonomic composition is similar to that known from the lower continental slope and abyssal plains worldwide, with 36 families represented, of which there are 16 archaeogastropod, 10 mesogastropod, 8 neogastropod and 2 opisthobranch families. Highest species diversity is known for the families Buccinidae (28), Turridae (18) and the turriform Conidae (13). There are four main sources of material: (1) Material from the R/V *Albatross* surveys, of which 55 species were described by Dall between 1889 and 1919. (2) Material from Andrew Carey's University of Oregon surveys in the 1970s, containing many new species from the lower slope and the Cascadia and Tufts abyssal plains off Oregon. (3) Material from Scripps cruises to the deep slope of the San Diego Trough and other southern California basins, containing a number of new species. (4) Recently described limpets, other archaeogastropods and provannids from hydrothermal vents of the Juan de Fuca and Gorda ridges.

On the vertical distribution of morpho-functional types of Conoidea [DS]

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The superfamily Conoidea is one of most characteristic components of deep-sea gastropod fauna. Its evolution was strongly associated with alterations in the foregut anatomy and specialization of feeding mechanisms. The following analysis has been based on numerous published data on the anatomy and radulae, as well as the original

data. Six main types of morpho-functional organization and respective feeding mechanisms are presently known for the Conoidea (Taylor et al., 1993, Kantor and Sysoev, 1996). They are primarily determined by the function of the radula and the presence of a venom gland. The most typical situation is the use of individual teeth of the membrane-less radula at the proboscis tip for envenomation of prey. The evolution of feeding mechanisms leads finally to a complete reduction and loss of the radula. The most primitive feeding mechanisms, in which the radula functions only as a whole, is found only in shallow-water species (Pseudomelatominae and some Clavatulinae). The use of marginal teeth at the proboscis tip, at the presence of radular membrane, is characteristic of shelf, many bathyal, and a few abyssal species (Driliinae, Cochlesspirinae, Crassispirinae, Turrinae, some Terebridae). The majority of abyssal species belong to the feeding type, in which the radula does not function as a whole, and individual hollow teeth are used at the proboscis tip (Turridae, Terebriedae, all Conidae). Two feeding mechanisms include species without a venom gland: some shallow-water species do not use teeth at the proboscis tip and possess a well-developed radular membrane (Strictispirinae), and some are highly specialized radula-less forms, mostly inhabiting deep waters (Daphnellinae, Taraninae, some Terebridae). One more type of foregut organization also included radula-less deep-sea species with a venom gland (some Conidae). All morpho-functional types are recorded in the shelf faunas, though the most specialized radula-less forms are rare. The bathyal fauna is characterized by almost complete spectrum of feeding mechanisms, except for most primitive ones. It includes many primitive forms with radular membrane. Basically, the abyssal is inhabited by representatives of four feeding mechanisms, but vast majority of species belong to advanced groups (membrane-less forms with hollow teeth, or the radula is absent). The share of advanced species increases with the depth increase. The tendency to reduction of radula, up to the complete loss, is also characteristic of abyssal species. Thus, the deep waters were colonized by evolutionarily young taxa with advanced feeding mechanisms, and only the most specialized species are able to live at greatest depths of the ocean.

Coding what we can't see: the negative gain and parallelism of shell loss in cladistics [PS]

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The use of traditional characters in phylogenetic analysis helps us directly contrast taxonomic value in a conventional classification with that suggested by a cladogram. While most cladistic characters are structurally complex, highly derived groups such as opisthobranchs offer numerous cases of character loss — in shell, operculum, streptoneury, etc. — some as presumed synapomorphies for higher-level taxa. These can be complete (absence) or partial (reduction), and have been called "negative gains." To describe and code such characters, we are forced to assess morphology which is no longer present. How we do so determines the shape of the tree, and thus the relationships it infers. These points are illustrated by a real dataset of 37 sacoglossan opisthobranchs (shelled and unshelled) coded for 52 characters. By manipulating only two shell characters through different a priori assumptions and coding options (binary, multistate, ordered, unordered), substantial changes in the final cladogram(s) ensue. If the cladogram is translated into a hierarchical classification, these choices mean the difference between two or eight equal-rank clades, and confirmation or rejection of traditional taxa. Modern phylogenetic methods are improving our basis for molluscan systematics and our understanding of evolutionary processes. Including negative gain characters, even if initially presumed homoplastic, can document the extent of parallelism or presumed trends. Still, subjective decisions play a strong role and have profound effects. Garbage in, garbage out.

Early development of *Crucibulum auricula* and *Crepidula convexa* (Gastropoda, Prosobranchia, Calyptraeidae) from the Venezuelan Caribbean

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A population of *Crucibulum auricula* was found in Chacopata, living attached to rocky substrates at about 1 m depth. Each female broods between 4 and 20 egg capsules in the mantle cavity, and these are attached to the substate by a short stalk. The capsules contain between 55 and 305 eggs measuring around 200 mm. Between 3 and 15 embryos develop and ingest the nurse eggs, and later cannibalism among siblings was observed. Only 1 to 11 hatch as crawling juveniles measuring between 600 and 840 mm.

The population of *Crepidula convexa was* found in Morrocoy, living attached to live *Modulus modulus* gastropods at about 10 to 50 cm depth. Each female broods between 5 and 15 egg capsules also attached to the substrate by a stalk. The egg capsules contain between 1 and 6 eggs measuring around 350 mm. All eggs develop and hatch as non-swimming pediveligers measuring between 550 and 1170 mm. No adelophophagy or cannibalism were observed.

Leaf litter land gastropods from a tropical rain forest, southern Veracruz, Mexico

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Studies on leaf litter land mollusks from a tropical rain forest are presented. Samples were collected monthly from April 1990 to June 1991 from two contrasting types of ground leaf litter: one where *Ficus yoponensis* was present and had a rapid rate of decay, and other where *Nectandra ambigens* had a slow rate. These sites were situated in a secondary forest with *Ficus* only and in a tropical rain forest with both *Ficus* and *Nectandra*. Live snails were uncommon (27 alive/ 15 months). Additional samples were taken from canopy leaf letter from October 1991 to April 1992 to determine which species, if any, lived there. Accumulated leaf litter was sampled from the tops of all shrubs and small trees between 50 cm to about 2 m in height in 5 m^2 area. Forty species of 17 families were recovered from ground leaf litter; nine species were found only in the canopy; 14 in both. Shells were more common in secondary forest (*Ficus*), perhaps because of a denser understory. In the topical rain forest, shells were especially common for a short period of time under *Ficus*; while under *Nectandra* shell numbers were lower, but found over a longer period during the 15 months. Live snails seem to prefer canopy leaf littler (47 alive/6 months) rather than ground leaf litter; high annual rainfall (ca. 5,000 mm) is a possible explanation.

Shell paedomorphosis in *Prunum* (Neogastropoda: Marginellidae): a multilineage microstructural analysis

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Living and fossil gastropods have figured prominently in research on the evolution of development through phylogeny (e.g., heterochrony). Here we examine: (1) spatial, temporal, and microstructural patterns of shell deposition through ontogeny; (2) changes in these depositional patterns through phylogeny; and (3) the relationship between microstructure depositional patterns and the assembly and evolution of shell features in three clades of paedomorphic *Prunum* (Neogastropoda: Marginellidae) from the western Atlantic. Ontogenetic patterns of microstructure deposition are mapped on phylogenies for each *Prunum* clade to determine if paedomorphic shells exhibit global or dissociated heterochrony and if paedomorphic shells in different clades are a product of similar microstructure deposition patterns.

Our microstructural analyses focus on shell layering, the external varix, the inner lip, dorsal lip callus, the anterior aperture margin callus, and the posterior aperture margin callus. Ontogenetic studies of these shell characters in all three clades indicate that paedomorphic shells are formed by similar microstructure deposition patterns. However, paedomorphic shell characters do not evolve in concert: the direction and magnitude of character evolution is different among characters. In addition, the evolution of paedomorphs is not due to a simple truncation of ancestral adult ontogeny: the loss or reduction of shell features and microstructural layers in paedomorphs is not the reverse order of character appearances in the outgroup.

Molecular phylogeny of marginelliform gastropods: a progress report [poster]

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Maximum-parsimony phylogenetic analyses of marginelliform gastropods (Neogastropoda: Families Marginellidae and Cystiscidae) using multiple character sets (shell, radula, and soft-part morphology) have produced robust estimates of the relationships of marginelliforms to other neogastropod families (Olividae, Volutidae, Volutomitridae) and the interrelationships among marginellid tribes (Nehm, 1996). However, resolution of within-tribe phylogeny is currently poor, and the results of morphological analyses have yet to be corroborated with molecular data.

DNA sequences from 16S RNA are used to: (1) test the Coovert hypothesis of marginellid polyphyly (that cystiscids are most closely related to olives rather than marginellids); (2) determine the phylogenetic position of Hyalina within the Marginellidae, thus establishing if radular loss was a single or multiple event; and (3) test the monophyly of Prunum and Volvarina.

Fifteen species from nine marginelliform genera (*Prunum*, *Dentimargo*, *Marginella*, *Hyalina*, *Volvarina*, *Rivomarginella*, *Bullata*, *Persicula*, and *Gibberula*) and one outgroup (*Olivella*) are available for molecular analyses. Successful DNA extraction has been completed for *Prunum*, *Dentimargo*, *Persicula*, *Gibberula*, and *Olivella*, and is currently in progress for the remaining taxa. PCR and DNA sequencing have been completed for *Dentimargo*, and are in progress for the other genera.

Finned octopuses (Cirrata) in the seas of Russia [DS, poster]

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Finned octopuses, long considered rare exotic animals, have, in the last few decades, been found to be common and usual inhabitants of the near-bottom layer on continental slopes and abyssal plains throughout the World Ocean. Three species, representing a peculiar reproductive strategy and belonging to two different life forms, are recorded in the Russian seas. *Cirroteuthis muelleri* Eschricht (fam. Cirroteuthidae) belongs to the campanula-like forms and inhabits the northern seas, *Opisthoteuthis californiana* Berry and *O.* "*albatrossi*" (Sasaki) (fam. Opisthoteuthidae) belong to the flapjack-like forms and inhabit the Far Eastern seas. All three feed on small epibenthic and suprabenthic animals, mostly crustaceans, have large (length 10-11 mm) eggs, produced continuously during the whole adult life and laid individually on the bottom. The individual period of maturity is extended, and feeding and growth continue during spawning. Fecundity is rather low (according to Ch. M. Nigmatullin and V. V. Laptikhovsky, some 1-4 thousand), development direct, juveniles are less connected with bottom than adults. *Cirroteuthis muelleri* may reach 35 cm in total length and is distributed through the whole Arctic Basin, Scandic Basin and Baffin Sea. It is benthopelagic, recorded in near-bottom layer at approx. 500-3,800 m, but was repeatedly caught in midwater and once even at the surface. It is a common and characteristic animal of the lower slope under the Atlantic Water Mass and on the abyssal plains.

Opisthoteuthis are predominantly benthic animals, occurring mainly on the upper slope and very common locally. *Opisthoteuthis californiana* is widely distributed from the northern Bering Sea to off eastern Honshu and California at depths ranging from 125 to approximately 1100 m. In the Okhotsk Sea it is common at 400-900 m, in the Western Bering Sea at 300-650 m. Maximal arm ring diameter in males is 72 cm, in females 64 cm. *O. "albatrossi"* is a larger (females to 80 cm) and deeper water species (780-3400 m), known from the Aleutian Islands to eastern Honshu, including the Okhotsk Sea. Males of both species of *Opisthoteuthis* are larger than females. The sex ratio is equal or females predominate.

Gonatid squids in the subarctic North Pacific: ecology, biogeography, niche diversity, and role in the ecosystem [NPC]

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All available ecological and biogeographical data are gathered on the northern North Pacific gonatid squids: *Berryteuthis* (2 species), *Gonatopsis* (3) and *Gonatus* (7). The species are compared according to their size, horizontal and vertical distribution, spawning habitats, diurnal vertical migrations, and gelatinous degeneration associated with maturation. "Ecological individuality" of each species is evaluated. Each species occupies its own ecological niche but these niches overlap to varying degrees. The history of niche divergence in North Pacific gonatids during Neogene-Pleistocene is characterized. Common features are described of horizontal and vertical distribution of relative abundance and biomass of North Pacific gonatids. Their roles in the ecosystem are analyzed as predators, prey, competitors, and hosts of parasites. In addition, the biomass, production, and food consumption of gonatids are evaluated.

Total biomass of gonatids in the subarctic North Pacific and Russia's Far Eastern seas is roughly estimated in 15-20 mln tons, their yearly production in 50-80 mln tons (some 10-15% of the world total production of mesopelagic cephalopods) and yearly food consumption in 100-200 mln tons. The life cycle of gonatids is much shorter and their P/B-coefficient much higher than in subarctic mesopelagic fishes. Squid biomass in the Okhotsk Sea is less than 10% that of fish but their production is assessed in 58-67% of total fish production. This emphasizes the very important role of gonatid squids in subarctic oceanic ecosystems.

Deep-water octopods (Opisthoteuthidae, Bathypolypodinae, Graneledoninae) from the Okhotsk and western Bering seas [NPC]

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Based on data collected in the Okhotsk Sea (OS), in 1984, at depths of 55-2000 m, eight deep-water benthic octopuses inhabit this region, namely: *Opisthoteuthis californiana* (400-900 m); *O. "albatrossi"*(780-1500 m); *Benthoctopus* sp. 1 (145-800, ?850 m); *Benthoctopus* sp. 2 (280-1375, ?2000 m); *Benthoctopus* sp. 3 (750-1375, ?2000 m); *Benthoctopus* sp. 4 (n. sp., 1800-1840 m); *Bathypolypus salebrosus* (300-750 m); and *Graneledone boreopacifica* (1040-2000 m). *Opisthoteuthis californiana*, *B. salebrosus*, *G. boreopacifica* and at least 3 *Benthoctopus* spp. were present off NE Japan and oceanward from Kurile Islands; three more species of *Benthoctopus* are known off NE Japan. In the western Bering Sea (WBS), in 1993-1995, at depths of 100-750 m, three species were recorded: *O. californiana* (328-578 m), *B. salebrosus* (350-578 m), *Benthoctopus* n. sp. aff. *abruptus* (260-750 m). All species have large eggs, 10-11 mm in Opisthoteuthis spp., 16-20 mm in *B. salebrosus*, 22-27 mm in *B.* aff. *abruptus*, 20-28 to 35-37 mm in *Benthoctopus* spp. Fecundity in Bathypolypodinae is some dozen of eggs.

Benthoctopus aff. *abruptus* is known to occur off NE Japan but not in the OS and none of the four OS *Benthoctopus* are found in the WBS. Morphologically and biogeographically *B.* aff. *abruptus* is an intermediate link between rather deep- and warm-water *B. abruptus* (southern and eastern Japan, 300-1000 m) and B. sibiricus from the eastern Arctic, the most cold- and shallow-water (38-220 m) species of *Benthoctopus*. The migration of *Benthoctopus* spp. into the High Arctic is thought to have proceeded in two ways: (1) from the North Atlantic in the post-glacial time (*B. piscatorum*); and (2) from the North Pacific through the Bering Strait probably in mid-Pliocene (*B.* aff. *abruptus* - *B. sibiricus*).

Egg Size, Fecundity, Vitelline Oocyte Resorption, and Spawning in the Gonatid Squid, *Berryteuthis magister* (Gonatidae)

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This is the first study of reproduction in a species of "large egg" squid. The reproductive systems of a total of 165 females (160-345 mm ML) were investigated. Specimens examined in this study were collected in the western part of Bering Sea during 1994-1996. All stages of maturity were represented. Fresh ripe eggs ranged in size from 3.5-4.1 x 3.4-3.7 mm. During the process of spawning the size of the eggs decreased significantly. Potential fecundity (PF) in pre-spawning females varied between 30,000-115,000 and increased as ML's increased: PF = exp (2.629+ 0.00432 ML). Relative fecundity ranged between 50-102 oocyte g –1 (average 75). Large-scale resorption of vitelline oocytes began in pre-spawning females and intensified during the course of spawning. The spawning type is defined as intermittent and descending with a gradual decrease in the number of eggs per egg mass coupled with a gradual degeneration of liver and mantle tissue. The reproductive balance (evolution PF in ontogeny) is as follows: values for average actual (realized) fecundity were 42% PF and for residual fecundity they were 58% PF. The residual stock of oocytes, on average, consisted of 10% PF protoplasmatic, 2.5% PF normal vitelline, and 45.5% vitelline resorpted oocytes. The process of vitellogenesis during ontogenesis involved an average of 90% PF (=VF). From this figure 46% VF is realized, 51% VF is involved in the process of resorption, and 3% VF remained as residual normal oocytes. The energy of resorpted vitelline oocytes probably is one of the main sources for metabolism in non-feeding, spawning females.

Fecundity of the Ommastrephid Squid, *Dosidicus gigas*, in the Eastern Pacific [NPC]

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The female reproductive systems of a total of 76 *Dosidicus gigas*, collected in 1980-1989 from off southern Peru to Nicaragua (150-720 mm ML), were investigated. The average diameter of ripe eggs was 0.78-1.07 mm and the egg weight was 0.22-0.47 mg. These features are significantly higher ($t = 8.129$ and $t = 6.321$) in female squid caught off Nicaragua compared to squid caught off Peru. Potential fecundity (PF = total oocyte stock in pre-spawning females) varied between 300,000 and 13,000,000 and increased in direct proportion to increases in mantle length (ML) and body weight (BW): $PF = \exp(5.110 + 0.00589\ ML)$ $r=0.89$ and $PF = \exp(6.775 + 0.000215\ BW)$ $r=0.82$. Relative fecundity of mature females (588-3768 oocyte/g; mean 1632) did not differ in different parts of the species' range (Peruvian waters, equatorial zone, and Nicaragua region). Intra-specific variations in PF was extremely high even among animals of the same size and in the same physiological condition. Thus in maturing females (380-395 mm ML) the PF varied from 2.5 to 6.0 million oocytes. Variations presumably are caused by different individual growth rates during the foraging period, when PF levels are already established. The Index of Potential Reproduc-

tive Investment is 0.19-1.32 (0.56). Mature females accumulate from 10,000 (ML 150 mm) to 1,000,000 (ML>500 mm) oocytes in the oviducts. During a single spawning event each female spawns more than 30% of the initial oocyte stock. Spawning is intermittent as is typical in other ommastrephids.

Rendezvous in the dark: coevolution between sepiolids and their luminous bacterial symbionts

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It has long been noted that the partners of an animal-bacterial symbiosis express phenotypic traits that reflect adaptation to their relationship. We have studied the coevolutionary patterns of the independently culturable partners in the sepiolid squid-luminous bacteria symbioses. Molecular phylogenies for the host squid were derived from sequences of the nuclear internal transcribed spacer region and the mitochondrial cytochrome oxidase subunit I; the glyceraldehyde phosphate dehydrogenase gene was used for phylogenetic determinations of the bacterial symbionts. A combined tree for all three loci indicated a parallel phylogeny between the sepiolids and their respective symbionts. These phylogenetic analyses were coupled with experiments examining the ability of the different symbiont strains to compete and colonize a particular sepiolid host. Our results indicated an enhanced specificity for native strains of symbionts over non-native strains, and provided a hierarchy of symbiont competency that completely complemented the phylogenetic relationships. This combination of molecular systematics and symbiont colonization provides both molecular and biological evidence for mechanisms of coevolution among animal-bacterial associations, and specifically the evolutionary events that may provide insights for the origin and divergence of this group of sepiolids.

Phylogenetic relationships of flabellinid nudibranchs based on mitrochondrial DNA sequences [poster]

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Opisthobranch mollusks in general show a high incidence of convergent evolution in anatomical structures that are used in their classificaiton. This might have serious implications for establishing phylogenetic relationships based on morphology within these groups as homoplasy would hinder the recovery of correct phylogenies.

The large and morphologically diverse nudibranch family Flabellinidae has recently recieved much attention, and phylogenetic relationships within this family based on morphological characters have been published (Gosliner and Kuzirian, 1990; Gosliner and Willan, 1991). Both studies, however, show large amounts of homoplasy in their datasets. To investigate the extent of convergent evolution of anatomical structures within this family, I have established a preliminary phylogeny of flabellinid nudibranchs based on DNA sequences of the mitochondrial genes 16S and cytochrome oxidase I. This molecular phylogeny provides an independent phylogenetic framework for this family on which the evolution of anatomical structures and be traced.

Invertebrate megafauna, community structure and molluscan associates at three deep-sea sites off central California [DS]

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Invertebrate megafaunal community structure at three sites at the base of the continental slope at 3,000 m was investigated by beam trawls and camera sleds. The sedimentary environment was dominated by holothurians, ophiurans, pennatulids and one species of sea star and one species of corallomorpharian. There was considerable variation in rank

order of abundance of the dominant invertebrates among the sites and between years at one of the sites. Comparisons between camera sleds and trawls indicated no differences in rank order of abundance, but the densities estimated from the camera sleds were about four times those of the trawls. The molluscan fauna was sparse in relation to the other invertebrates, only 15 species were found, and the two most abundant species were the large scaphopod, *Fissidentalium megathyris,* and the turrid, *Steiraxis aulaca.*

Molecular phylogenetic relationships of brooding oysters

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Molluscan systematists have traditionally regarded the Ostreacea as a notoriously difficult taxon, due in large part to their xenomorphic growth patterns. In some cases, systematic relationships have been further obscured by undocumented anthropogenic transfers. Molecular characterization of oyster taxa, however, promises to significantly increase our understanding of phylogenetic relationships among these intriguing organisms. We are focusing on the brooding oysters: the Lophinae and the Ostreinae. Their phylogenetic relationships to other members of the Ostreacea are being delineated using 28S nuclear ribosomal gene sequences. A fragment of the mitochondrial 16S ribosomal gene is being used to investigate relationships among the brooders. Preliminary results indicate that: (1) parental care may have been secondarily lost in ancestral lineages of cupped oysters; (2) the Lophinae and the Ostreinae may both be paraphyletic; (3) Harry's (1985) interpretation of systematic relationships among Southern Hemisphere Ostreinae is not supported; (4) the "non-ostreid" larval development of *Tiostrea chilensis* is secondarily derived.

Molecular systematics of Aplacophora based on EF1a nuclear gene sequences [DS, poster]

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Aplacophora are shell-less, vermiform, deep-sea mollusks in which the external cuticle is covered by numerous aragonite spicules. Little is known about aplacophoran phylogeny, and its analysis has been based mostly on morphological characters. The only published molecular data, which utilized 18S rRNA sequences, did not resolve the phylogeny of the Aplacophora. The phylogenetic questions are whether the two aplacophoran taxa, Neomeniomorpha and Chaetodermomorpha, are monophyletic and whether they are basal to all extant mollusks. To resolve conflicting hypotheses, the highly conserved nuclear coding gene elongation factor-1 alpha (EF1a) was analyzed for *Epimenia australis* and *Chaetoderma canadense*. The analysis of a 1200 bp fragment of the EF1a gene from the two aplacophoran species and from species representing Polyplacophora, Bivalvia, Gastropoda, and Cephalopoda represents the first aplacophoran phylogeny based on EF1a molecular data. (Supported in part by NSF DEB-PEET 95-21930)

Land snail ecology on northern Kuril Islands, Far Eastern Russia: habitat versus isolation

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Boreal islands in the northern Kuril Island Archipelago in Far Eastern Russia have relatively few vegetation assemblages, and represent an excellent situation in which to examine the influences of habitat and isolation on the composition of terrestrial gastropod assemblages. In 1996, I collected 6,250 gastropods of 13 species from 61 leaf litter samples taken from meadow, alder (*Alnus maximawiczii*), and pine (*Pinus pumila*) habitats on eight of the northern Kuril Islands. In contrast to temperate North American gastropod faunas, meadow samples averaged more species than alder forest samples, although abundances were slightly lower in meadows. Pine forests had very few species and extremely low abundances of individuals. Consistent with island biogeography theory, larger islands tended to have a greater total number of species, however, gastropod abundances tended to be lower on larger islands. Five species occurred on all or all but one island suggesting that isolation does not limit their distribution, but five other species occurred on four or fewer of the islands, consistent with the hypothesis that isolation influences the distribution of some species. All or all but one of the 13 species occurred in the meadow and alder habitats, respectively, but only four species occurred in pine forest litter, indicating that habitats are not equally suitable. Thus, both habitat and isolation appear to influence gastropod species assemblages on the northern Kuril Islands.

The spawn in the genus *Adelomelon* (Prosobranchia: Volutidae) from the Atlantic coast of South America

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Since the early descriptions of egg capsules of South American volutes in the past century, very few additions have been made, many of them unfortunately proved to be wrong. We describe here the egg capsule of the largest South American volute, *Adelomelon becki* (Broderip, 1836), and redescribe the often confused spawn of *A. ancilla* (Lightfoot, 1786). The spawn of *A. becki* is a single, conspicuous, large, globose and hemispheric egg capsule attached to pectinid shells, measuring 50 mm in basal diameter and 35 mm in height. The base is round and has a narrow (3 mm) margin. The number of embryos ranges from 7 to 10. The size at hatching was 16.0 to 18.6 mm in shell length. The internal volume of the egg capsule was 30 to 35 ml. No nurse eggs were observed. All the studied material was at a pre-hatching crawling stage.

The egg capsule of *A. ancilla* is oval and flat, with a diameter ranging from 37 to 45 mm, never covered by a calcareous layer. They are generally attached to pectinid shells. The number of eggs per capsule is 5-8, and so is the number of developing embryos; no nurse eggs are present. The eggs are 150 microns in diameter and are surrounded by a very dense liquid. The internal volume of the egg capsule ranged from 2.5 to 4.0 ml. Hatching takes place as crawling juveniles, the shell measuring between 11.7 and 12.7 mm.

We discuss the affinities within the volutids, including *Adelomelon brasiliana* free egg capsules

Dynamics of adult and juvenile bivalve dispersal: a shifting paradigm

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There has been a growing literature base that has attempted to, at least in part, refocus our attention on recruitment and dispersal mechanisms, away from planktonic and larval propagules, towards small and juvenile forms. In bivalve molluscs, it is now well known that short to medium range dispersal in juvenile (post-larval) tellinids, mytilids, venerids, solenids, myids, and arcids is possible via byssal or stochastic drift. We believe we must add to this list dispersal of some adult bivalves as well. Evidence of dispersal in some adult venerid, mactrid, and corbiculid bivalves is substantial. Brooding *Corbicula fluminea* can disperse as adults using mucoid drogue lines. Large, sexually mature *Mercenaria mercenaria* can be entrained from sandy sediments and are thus capable of passively migrating to new sites.

The relative importance of adult bivalve dispersal in founding new demes or patch dynamics is unknown. We suggest that repetitive findings of small populations of adult bivalves in sites where larval recruitment is not evident could represent viable founding populations that have their origins in adult phases. Discrepancies in fisheries surveys as well as anomalies in predicted trends of population heterozygosities, could reflect dispersal by adult bivalves.

Diet and temperature on growth and biogeographic distribution of the herbivorous kelp snail *Norrisia norrisi*

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Norrisia norrisi (Family Trochidae), a hervbivorous snail that commonly lives and feeds on kelps, is largely confined to the warmer waters of the Southern California Bight from Point Conception to Isla Asuncion, Baja California, Mexico. Previous experimental research has shown that *N. norrisi* prefers kelps over all other algal foods. Here, we test the hypothesis that *N. norrisi* not only shows strong preferences for kelps but also grows best on its preferred seaweed food. In addition, we test the hypotheses that colder seawater temperatures result in reduced consumption and assimilation of algal foods and reduced growth (shell and body mass). To test these hypotheses, individual snails were held in feeding arenas in the laboratory and fed algal diets ad-libitum for a minimum of 6 weeks. Diets consisted of fresh thalli of either the green alga *Ulva lobata* or the kelp *Eisenia arborea* which were provided every four days. Snail shell size and biomass were measured bimonthly to determine growth. Additionally, the amount of seaweed food consumed and the quantity of fecal matter produced were determined for both algal diets. Our results suggest that when fed a unialgal diet, *N. norris*i grows best on kelp and that its feeding biology is strongly influenced by seawater temperature (Sponsored by CSU Fullerton Biology Department and CSU Fullerton DAC)

Age determination of the gonatid squid Berryteuthis magister (Berry, 1913) based on morphometric characters [NPC, poster]

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There are 2, 3 or 4 different age groups present in harvested populations of *Berryteuthis magister*. Size distributions of these groups overlap considerably, which makes it difficult to determine precisely the modal size classes. We worked out a method of discrimination between groups of the squid based on cluster analyses of morphometric traits. We obtained data on number, maturity, and size-weight character of each age group. Modal size classes of these groups were time approximated on the multiplicative model (Y = aX^b). Theoretical growth curves for *B. magister* from the western Bering Sea and from the Kurile region also were obtained. These curves were based on data for each sex for a several-year period.

A preliminary assessment of the generic relationships of the Lampsilini (Bivalvia: Unionidae) based on a portion of the 16S rRNA gene

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The Lampsilini contains approximately 1/3 of all North American unionid taxa. Members of this tribe display an astonishing variety of conchological and reproductive adaptations not found in other freshwater bivalves in North America.

A phylogenetic analysis of Lampsilini relationships constructed upon a preliminary molecular data set of mitochondrial 16S rRNA sequences provides an opportunity to test the monophyly of the Lampsilini as well as explore relationships among the genera in that tribe. In addition, the classification allows examination of the evolution of reproductive structures found in the various informally recognized groups within the Lampsilini. The data set generated will also provide the basis for future research aimed at generating much needed classifications within the various generic groups, and research into the evolution of reproductive strategies in the Lampsilini.

Reproducibility and explicit hypotheses in molluscan phylogeny [PS]

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One of the advantages of phylogenetic systematics over traditional methods of expressing relationships among taxa is that methods and data used to reach conclusions can be explicitly stated, allowing other workers to verify the results and test the effects of various methodological assumptions. Some workers however, continue to proceed in a narrative mode, loosely guided by phylogenetic principles. They present neither explicit methods nor explicit data. Others present data matrices, but their stated methods do not reproduce their results. In some cases it is possible to reconstruct the methodological errors that lead to the erroneous results. Malacologists have generally shied away from debates about phylogenetic methods, but such debates can have salutory effects for the field if conducted in a colleagial fashion. In the hopes of stimulating debate, I draw examples from phylogenies recently published by Taylor, Kantor & Sysoev (1993), Bandel & Reidel (1994), and Coovert & Coovert (1995).

Highest known land snail diversity: 66 species from one site in Jamaica [poster]

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Four person hours of collecting at a small (circa 4 hectare) karstic, partially disturbed site near Auchtembeddie, Jamaica in September 1996 yielded 57 species of land snails and 2 species of slugs. A subsequent visit in February 1997 yielded 50 snail species in six person hours, including 7 species not collected earlier. Of the total, 21 species were found alive, 9 fresh dead, and 30 with sufficient gloss, color or periostracum remaining to indicate that they probably still exist at the site. Six species were represented only by long dead shells. Of 21 species collected alive, 20 are Jamaican endemics Jamaica. At least 43 genera are represented. Family distribution is as follows: Helicinidae, 13 species; Poteriidae, 2; Annulariidae, 3; Truncatellidae, 2; Succineidae, 1; Pupillidae, 1; Valloniidae, 1; Euconulidae, 1; Subulinidae, 2; Oleacinidae, 9; Orthalicidae, 1; Bulimulidae, 2; Urocoptidae, 6; Systrophiidae, 1; Sagdidae, 13; Camaenidae, 5; Helminthoglyptidae, 1; Veronicellidae, 2.

Highest diversities previously reported are 60 species at Waipipi Reserve, New Zealand (56 native snails, 1 native slug and 3 introduced snails) and 52 native snails at Manombo, Madagascar. Of the 66 Jamaican species, 58 are native, including two slugs, 4 are introduced, and 4, all micromollusks, are of uncertain status. The sites in New Zealand and Madagascar have been searched more intensively than the Jamaican site, where no arboreal, leaf litter, or soil sampling has been done. Only 11 (17%) of the Jamaican species sampled reach maturity at under 5 mm. Thus, further work at the site should push known diversity considerably higher than 66 species.

Popular delusions, phantom taxa, and the weirdness of ranks [PS]

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Biological classifications shape the way we think about the organisms of interest to us. Aspects of traditional ("canonical") systematics are examined for some less-than-salutary effects on scientific thinking. Rank-free classification, incorporating phylogeny-based taxonomy, while not free of problems of its own, can help us avoid some of the pitfalls of canonical classification.

Early Paleozoic stem group chitons from Utah and Missouri: no Problematica!

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Conical sclerites from the North American Cambrian were placed in an extinct molluscan class, Mattheva, by Yochelson (1966). In 1979, Runnegar and others suggested that *Matthevia* Walcott is the oldest known chiton and a close relative of Early Paleozoic chiton genera such as *Chelodes* Davidson and King and *Hemithecella* Ulrich and Bridge. However, a counter proposal by Stinchcomb & Darrough (1995) moved *Matthevia* and *Hemithecella* back to the "molluscan Problematica."

Large numbers of silicified fossils from latest Cambrian (Sunwaptan) strata in Utah show that *Matthevia* had at least two types of sclerites (valves) that are repeatably found in ratios of 4 or 5:1. These ratios are not those expected from undisturbed chiton graveyards (6:1) but they do falsify the notion that *Matthevia* had only two valves (Yochelson) or as many as 15 (Stinchomb & Darrough). As one of the median faces of the more numerous kind of valve is distinctively concave, apparently to receive the leading face of an adjacent valve, this new species of Matthevia helps bridge the morphological gap between *M. variabilis* and *Hemithecella*. Their relationship to unequivocal stem group chitons is now supported by additional characters and partially articulated specimens. With regard to the broader picture, it is likely that all Paleozoic chitons are stem group polyplacophorans and that early disparity was reduced by a series of mass extinction events.

Dreissena polymorpha: macrocosm, microcosm and the organism interface

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Ernst Mayer reminded biologists years ago that there is never a time in the life of a sexually reproduced organism when it does not have both a genome and an environment, and that it is the dynamic relation between the two that eludes understanding, and yet that demands it. The anxious call went out in 1989 as one of the first symposia was being organized to confront the sudden and massive appearance of *Dreissena polymorpha* in the Great Lakes: "Let's not reinvent the wheel!" The accompanying plea to participants was an exhortation to use what we knew, in order to proceed in a more more delibrate and creative way than in the past, with other introduced organisms.

In this paper, I carefully review what has been done, what has been found, where research seems to be going, and where research ought to be going on *D. polymorpha*. My particular concern will be for the organism, and for Mayr's prophetic injunction.

Intertidal ecology of *Octopus dofleini* [NPC]

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The ecology of the giant octopus, *Octopus dofleini*, is largely known from SCUBA diving studies around Vancouver Island, B.C. Here, we present new data on the habitat use of this species from Prince William Sound, Alaska. We searched for octopuses on foot in the intertidal during minus tides, and to depths of 30 m (100 ft) by SCUBA diving. Octopuses were found in habitat characterized by low slope, cobble or rock outcrops, and dense vegetation cover; and typically were not found on steep slopes, bedrock, gravel, or mud, areas of low vegetation, nor on boulder piles. Intertidal prey middens were composed primarily of crab remains; as depth increased, scallops became common in middens and largely replaced crabs below -10 m. Seventy-five percent of octopuses were found in the intertidal zone between +2 and -1.3 m MLLW. During SCUBA surveys, octopuses were more abundant on shallow dives (to -5 m) than on deep dives. Three octopuses from the intertidal, tracked using sonic transponders, remained in or returned to shallow water. This pattern of intertidal habitat use contrasts with studies by others in B.C. that reported on subtidal octopuses between -5 and -20 m. Sea otters are regular predators on octopuses; and we suspect that intertidal habitats provide a refuge from otter predation for juvenile octopuses. Otters were prevalent in the Sound and absent at the B.C. study sites.

The Aplacophora as a deep-sea taxon [DS]

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The ocean depths are not such an unvarying, constant environment as they once were thought to be. Differences among aplacophoran faunas reflect the physical, chemical, and biological environments at hydrothermal vents, on the bottom beneath regions of high and low organic flux from the surface, in trenches, on continental slopes and abyssal plains, on sea mounts, in oxygen rich and poor areas, and in polar and tropical regions. Prochaetodermatidae numerically dominate upper continental slopes and neomenioids are dominant on sea mounts. (Supported by NSF DEB-PEET 95-21930)

Reproduction among protobranch bivalves from sublittoral, bathyal and abyssal depths off the New England coast (USA) [DS]

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An examination of seven species of protobranch bivalves reveals that the "apparent fecundity" (i.e., the number of ova produced by a single female at the time of reproduction) is consistently greater among sublittoral than among bathyal and abyssal species. Such a relationship exists both among forms with lecithotrophic planktonic larvae and those lacking a planktonic stage. The apparent fecundity of a species increases with increasing size (i.e., shell length) in both shoal-water and deep-sea species. Accordingly, the apparent fecundity of older individuals exceeds that of smaller, younger ones. From examination of gonads at different seasons, spawning in sublittoral species is inferred to be periodic and occurs only during the summer months. Contrariwise among deep-sea species, evidence suggests continuous gametogenesis in those species examined. It is therefore not possible to estimate the rate that ova are produced nor the lifetime fecundity of such deep-sea forms. Populations of sublittoral species are dominated by juvenile individuals, whereas in deep-sea species at their optimum depth (i.e., the depth at which they occur in greatest numbers), populations consist largely of sexually mature individuals, suggesting relative stability in such populations. Deep-sea species near the limits of their depth distributions are composed of populations that more nearly resemble those of sublittoral forms and are made up mostly of juvenile individuals. Species with a development lacking a planktonic stage have larger and fewer ova and, among those populations examined, were dominated at both sublittoral and abyssal depths by juvenile individuals.

Molecular phylogeny of giant clams (Cardiidae:Tridacninae)

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Giant clams have been shown to be a morphologically highly derived clade of cardiid bivalves. A phylogenetic hypothesis of giant clams is constructed with the mitochondrial ribosomal 16S gene. As the sister taxon to the Tridacninae is the Lymnocardiinae, a basal lymnocardiinae, the edible cockle *Cerastoderma*, is used as the outgroup. This molecular phylogenetic hypothesis is compared to results previous obtained from morphological analysis and the fossil record. Giant clams, like cardiids in general, have numerous morphological characters and an

excellent fossil record. This situation, unusual among bivalves, allows assessment of the 16S gene as a tool for phylogenetic reconstruction of clades that have diverged during the Cenezoic.

Flight of the Vampire: Scaling of metabolism and aquatic "flight" in *Vampyroteuthis infernalis* (Vampyromorpha: Cephalopoda) [NPC]

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Vampyroteuthis infernalis is a cosmopolitan cephalopod that lives in the heart of the oxygen minimum layer below 600 m depth. Morphometric and physiological studies have indicated that *V. infernalis* has little capacity for jet propulsion and has the lowest metabolic rate ever measured for a cephalopod. Because fin swimming is inherently more efficient than jet propulsion, some of the reduction in energy usage relative to other cephalopods may result from the use of fins as the primary means of propulsion. *Vampyroteuthis infernalis* undergoes a rapid metamorphosis which consists of changes in the position, size, and shape of the fins. This suggests that there are changes in the selective factors affecting locomotion through ontogeny. The present study describes these changes in *V. infernalis* in relation to models for underwater "flight". Citrate synthase (CS) and Octopine dehydrogenase (ODH) activities, indicative of aerobic and anaerobic metabolism respectively, were measured across four orders of magnitude size range. Results indicate that fin swimming is the primary means of propulsion at all post-metamorphic sizes. Negative allometry of CS activity in mantle and arm muscle is consistent with scaling of aerobic metabolism observed in most animals. The unusual positive allometry of fin muscle suggests that fin swimming is more costly at larger sizes. Positive scaling of ODH activity in fin, mantle and arm tissue suggests that fin propulsion, jet propulsion and medusoid "bell-swimming" are all important for burst escape responses. The observed scaling patterns and morphological changes at metamorphosis appear to function as an ontogenetic "gait-transition".

Post-spawning egg care in *Gonatus* (Cephalopoda: Teuthoidea): life history and energetics [NPC]

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A novel reproductive strategy of deep-water spawning and egg-care was observed for the mesopelagic squid, *Gonatus onyx*. Brooding females and associated eggs and hatchlings, captured between 1250 and 1750 m off southern California are described. Brooding feemales appear to be senescent and are lacking tentacles. The loss of tentacles in gonatid species is discussed in relation to this unusual life-history characteristic previously unreported for squids. Metabolic estimators and chemical composition of *G. onyx* and *G. pyros* also are reported and discussed in relation to bouyancy and energy reserves which may support a non-feeding, post-spawning brood period of up to 9 months.

Distribution and assemblage patterns of micronektonic squids at large-scale fronts in the central North Pacific Ocean [NPC]

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Large-scale oceanic fronts associated with water masses form the primary biogeographic boundaries in the open ocean. In the North Pacific, the Subarctic and Subtropical Fronts form boundaries that divide some of the large, core pelagic biogeographic provinces. Historically, biogeographic ranges of many micronektonic species including euphausiids,

pteropods, heteropods, and chaetognaths as well as some commercial fish species have been shown to correspond with regions delimited by these-large scale features. Recent trawl surveys that sampled across these fronts and frontal zones support previous suppositions that the distribution, abundance and assemblage patterns of pelagic cephalopods are also strongly influenced by these physical features.

During August 1991, >3000 cephalopods representing 25 species were collected at sites across the Subarctic Boundary along the 174.5° and 179.5° W meridians between the 37° and 46° N latitudes. Another 637 individuals representing 34 species were taken in the Subtropical Frontal region (between 21° and 31° N latitudes) during March-April 1992. The oegopsid squid families Onychoteuthidae, Enoploteuthidae, Gonatidae, Pyroteuthidae, Cranchiidae, and Chiroteuthidae were the most extensively sampled and provided the best insight into how cephalopods respond to variations in oceanographic conditions. Patterns of distribution, abundance, and interspecific associations of the cephalopod fauna are described with respect to the local frontal environment and discussed within the context of large scale northern transitional and central biogeographic provinces. Taxonomic advances and concerns are highlighted.

Distribution and abundance of pelagic cephalopods in the central North Pacific: information from large-scale high-seas driftnet fisheries [NPC, poster]

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During the late 1970s through to 1992, high-seas drift gillnet fisheries targeting flying squid, *Ommastrephes bartramii*, and tuna and billfishes operated in waters of the North Pacific transition zone (NPTZ) and its associated subtropical and subarctic boundaries. These large-scale fishing operations generally involved deploying numerous panels of rectangular nets 30-50 m long by about 10 m deep strung together to form a curtain of webbing stretching several kilometers across the oceans' surface capturing animals by entanglement. At the height of the fisheries in the late 1980s, more than 700 vessels operated in the multinational fisheries, each fishing about 30-60 km of nets per day. During the 1990-91 fishing seasons, observer programs were administered over the fisheries, monitoring catch and effort in up to 10% of the fishing fleets. Information collected by the observers have provided an unprecedented near-basinwide characterization of pelagic nekton species composition, distribution, abundance, and interspecific relationships on a relatively short time scale.

Overall, more than 25 million cephalopods were observed captured during the 22-month monitoring program, of which >99% were *O. bartramii*. Regions of high catch rates and observed size frequency distributions are consistent with life history and ecological movement patterns reported for the species. For other commonly taken species, *Onychoteuthis borealijaponica* were most abundant in the subarctic western Pacific east of Hokkaido, Japan where catch rates exceeded 2,000 squid/50 km of net in several 1° latitude x 1° longitude statistical areas. The highest catch rates of *Gonatopsis borealis* (>200 squid/50 km net) were all found in areas west of the dateline in the vicinity of the Subarctic Boundary, while the pelagic octopus, *Ocythoe tuberculata*, were taken in limited numbers throughout the NPTZ during all seasons but was nowhere abundant. Capture of *Thysanoteuthis rhombus* was basically restricted to subtropical waters fished during the winter months with large mesh (ca. 170-180 mm stretched measure) nets.

How aqueous geochemistry affects lacustrine mollusks

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Changes in climate and hydrology through time affect the solute composition and the stable isotopic content of lake water. These changes may be reflected in both the presence (occurrence patterns) and the isotopic composition of shell

aragonite of lacustrine mollusks. Interpretation of preliminary data suggests that modern molluscan occurrences are restricted by solute composition, rather than just pH or salinity as is commonly believed. All mollusks are found in waters with (bi)carbonate and calcium ($CaCO^3$) forming the dominant-to-important components of the solute composition. Additionally, the bicarbonate-to-calcium ratio within this solute type appears to limit certain genera. Linkage of species occurrences to solute chemistry provides a new way of viewing biogeographical ecology and, from that, a new methodology for econstructing past hydrology and climate. A related study compares the stable oxygen isotopic content of modern gastropod shells with that of the water at the time of shell growth. Results show that the D ^{18}O content of lacustrine gastropod shells covaries with that of the host water, although the variability and offset from the value of the water differ among genera. Understanding the relationship between water and shell isotope values provides a basis for interpreting shell stable isotope geochemistry and the isotopic values of the waters in which the mollusks lived. Both studies will contribute to our understanding of mollusk ecology and biology, and paleoenvironments.

Multiple paternity within broods of a squid, *Loligo forbesi*, demonstrated with microsatellite DNA markers [poster]

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For some time, observations on spawning aggregations of squid have suggested the possibility that females may mate with more than one male before spawning. Due to the difficulties of catching, then maintaining these animals under controlled conditions, confirmation of multiple paternity within broods has been impossible. The adoption of multiple matings, whether solicited or not (i.e "sneaker males"), and their effectiveness in producing multiply sired broods, has many important implications for the study of behaviour, genetic population structure and evolution in these species.

Here we confirm, using sensitive microsatellite DNA markers specifically developed for this species, that multiple males do contribute to the fertilisation of single broods of a loliginid squid, *Loligo forbesi*. To achieve this result pre-hatching embryos from single egg strings collected from the wild were genotyped using 6 independent microsatellite loci, and prospective maternal and paternal genotypes reconstructed from the allelic combinations observed. We also genetically confirm that females may lay their egg strings within existing bunches laid by other females. The wider applications of microsatellite DNA markers to behavioural and evolutionary studies in cephalopods are discussed.

Evidence for four species of *Brachioteuthis* (Oegopsida: Brachioteuthidae) in the eastern North Atlantic [poster]

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As currently recognized, the family Brachioteuthidae contains one genus (*Brachioteuthis*) and five species (*beanii*, *riisei*, *behnii*, *bowmanii*, and *picta*), but is greatly in need of revision. Taxonomic confusion within the family can be attributed in part to poor original descriptions, and in part to the paucity of available mature specimens in good condition. Traditionally, the eastern Atlantic has been thought to have only one species, B. riisei (Steenstrup, 1882); however, a detailed examination of newly-hatched and juvenile specimens collected during the Amsterdam Mid North Atlantic Plankton Expeditions of 1980-1983 (n = 259) revealed that four morphotypes were consistently distinguishable based on the shape of the head, the mantle chromatophore patterns, and the shape of the tentacle. Only two of these four morphotypes can be tentatively assigned to currently recognized species. *Brachioteuthis* sp. 3 is described similarly to *B. picta*, and *Brachioteuthis* sp. 4 has many of the same characters as *B. bowmaniii*. Confident identifications are hampered by the lack of original descriptions of hard parts, such as beak morphology, as well as the potential allometric differences between adults and juvenile or newly-hatched cephalopods.

Distribution and biology of *Rossia pacifica* (Cephalopoda, Sepiolidae) in the Russian Exclusive Zone of the Japan Sea [NPC, poster]

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Rossia pacifica Berry, 1911, is a common species in coastal waters of Japan Sea. In the Russian Exclusive Zone it is found south to 51°N in the summer-autumn period. It occurs both near the bottom (15-310 m) and in the pelagic layers (0-490 m). The sepiolid ranges in size from 12-82 mm ML; female mantle lengths are 41-82 mm (mean 51 mm) and male mantle lengths are 27-42 mm (mean 32 mm). Egg masses of *R. pacifica* have been found in Peter the Great Bay (42°33'N, 131°13'E) from October-November in depths ranging from 100-300 m; in the region 42°40'N, 133°02'E to 42°51'N, 133°37'E - from July-November in depths of 30-50 m; and in the region 43°02'N, 13410'E - from July-September in depths of 15-20 m. Egg masses typically are attached to rocks and to the underside of various objects (trap boxes, etc.).

In the winter-spring period *R. pacifica* is distributed south to 49°N. Of the total population 94% occurred in epipelagic depths, 5.3% in mesopelagic, and 0.7% in the bathypelagic zone. Maximum abundance of the species (200 specimens per hour trawling) was observed on the South Sakhalin shelf. Small specimens (less than 20 mm) dominate in pelagic catches, while large specimens (more than 50 mm) dominate in bottom catches. Sizes in winter-spring range from 9-85 mm ML; female mantle lengths are 43-85 mm (mean 65 mm) and male mantle lengths are 33-56 mm (mean 45 mm). Females mature at 62 mm ML, and males at 38 mm.

In summary, juveniles of *R. pacifica* live mainly in epipelagic layers (0-200 m) whereas adults are demersal. The species spawns throughout the year with a peak in autumn.

Discovery of an egg mass with embryos of *Rossia pacifica* (Cephalopoda, Sepiolidae) in the Okhotsk Sea [NPC, poster]

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A total of 27 tows were conducted at depths ranging from 100-300 m during the Okhotsk Sea bottom trawl survey off southwestern Kamchatka between 51°- 54°N in July 1996. In 14 samples (52%), 144 specimens of *Rossia pacifica* and an egg mass fragment were collected. The frequency of occurrence of *R. pacifica* increased from 17% at the 100 m contour to 80% at the 250 and 300 m contours. Mean catch was 8.1 specimens per half-hour tow. Maximum abundance was observed at 250 m depth: mean catch was 15 specimens, or 1615 g. Mature female mantle lengths ranged from 84-100 mm (mean 88.3 mm); lengths of nidamental glands - 45-55 mm (mean 50.8 mm); body weights - 165-235 g (mean 192.5 g). Male mantle lengths varied from 54-58 mm (mean 56.0 mm); body weights - 60-95 g (mean 75 g).

An egg mass fragment with 36 eggs was collected in 250 m on a sand bottom. The water temperature near-bottom at this location was 1.58°C. Each egg (12 mm in diameter) contains 3 capsules. The external capsule is oval in shape, white in color, and ranges in size from 13.8-17.8 mm. The egg is filled with a yolk mass and embryo lies on it with its mouth plunged deeply into the yolk. The dorsal mantle length of the embryo is 1.6 mm. All arms and tentacles are well developed with suckers in 2-3 unarranged rows. The embryos body form, head, fins, and armature of the arms corresponds to those of *R. pacifica.*

The presence of mature males and females, ready to spawn, plus an egg mass fragment caught at a depth of 250 m indicates the presence of a *R. pacifica* spawning ground.

Molluscan paleontology of middle Eocene brackish-marine rocks near Ojai, Ventura County, southern California

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Within-habitat, brackish-marine mollusks are rare in lower Tertiary rocks of California. Lagoonal mudstones in a localized, 50 m-thick section in the lower middle Eocene ("Transition Stage") upper part of the Matilija Sandstone at Matilija Hot Springs near Ojai, contain low-diversity assemblages of gastropods and bivalves. Although the number of specimens is highly variable, the gastropods Potamides and Loxotrema, and the bivalves *Acutostrea*, *Cuneocorbula*, *Pelecyora*, *Tellina*, and *Trapezium* are in the majority of the assemblages. Less widely distributed are the gastropods *Crepidula*, *Tympanotonus*, *Melanatria?*, *Pygrulifera*, *Crommium*, and *Neverita*, and the bivalves *Barbatia* and *Corbicula*. This is the first confirmed record of *Tympanotonus* in North America and the first record of *Trapezium* on the Pacific coast of North America. The assemblages are of two types: those that are nearly in situ and those that have undergone only short-distance post-mortum transport. The former consists of up to 12 species of mollusks, all of which are unabraded and many are complete. The latter consists of coquinas of either *Pelecyora* or *Cuneocorbula*, both of which are made up of tightly packed, unabraded single valves.

Through time, the quiet-water lagoon environment fluctuated repeatedly with coastal-sabkha evaporites, as well as with barrier-bar/sandy beaches. The latter contains only fragments of the oyster *Acutostrea*.

The morphospatial "whorled" of strombid snails [PS]

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Phylogenetic systematic analyses provide more objective, reproducible, and falsifiable means of classifying taxa than do traditional systematic techniques. In addition, branching patterns (cladograms) obtained from phylogenetic systematic analyses may be interpreted as reconstructions of evolutionary processes.

Mollusk shells are ideally suited for mathematical modeling and analyses using morphological space (morphospace). Records of ontogenic history are recoverable from specimens, and this developmental information (in the form of mathematical parameters) can be used as complementary data in cladogram construction.

By combining mathematical models, morphospatial analyses, and cladograms, therefore, falsifiable scenarios of morphological evolution of mollusks can be hypothesized. This type of synthetic approach is exemplified with species of Strombidae. A cladogram is mapped into a three-dimensional morphospace, using a geometric algorithm to position nodes (interpretable as ancestors). During evolution of members within a clade containing all species traditionally classified in *Lambis* and some in *Strombus*, morphological change consisted predominantly of an increase in vertical dimensions of whorls. The change was greatest early in the history of the group and diminished thereafter. In the development of the synthesis, ancestral forms are reconstructed and traditional subgeneric classification within *Lambis* is shown to be untenable.

A review of the sea hare *Aplysia donca* (Gastropoda: Opisthobranchia) from Mustang Island, Texas

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Aplysia donca was described from a single specimen collected in March of 1947 from a tide pool along the coast of Mustang Island, Texas. This species is known only from this one small and probably immature specimen. Despite extensive field work conducted on sea hares along the Texas coast, this species has never again been reported nor collected. Taxonomic characters which constituted the basis of the original description of A. donca were examined in a juvenile series of A. morio from South Padre Island, Texas. Similarities of these characters in combination with the lack of a single non-variable character support the premise that the original description of A. donca was based upon an immature specimen of A. morio.

The utility of the gastric chamber of Caenogastropod stomachs in higher and lower level systematic studies

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Features of the caenogastropod midgut, indeed of gastropods in general, have been regarded as potentially misleading in phylogeny reconstruction due to functional constraints. Thus, these characters have been assumed to be homoplasious and have remained underexplored as a potential source of characters in phylogeny reconstruction at lower and higher systematic levels. Revealed here are previously undescribed features of the midgut that are useful at a variety of taxonomic levels.

At higher systematic levels, one such character is the direction of ciliary currents on the left gastric chamber wall. Commonly associated with a sorting area in this region, the direction of ciliary action has been shown to reverse at the base of the neogastropod radiation. This suggests a fundamental shift in the circulation and digestion of food within the neogastropod stomach. In addition, comparative studies within families have been undertaken to assess the conservatism of features within the gastric chamber, revealing a number of features that may be useful at lower systematic levels. For example, several species of freshwater cerithiaceans have been shown to possess a similar modification of the glandular pad on the gastric chamber floor. Finally, the presence of a ciliated ridge associated with the sorting area within the gastric chamber of some littorinids, has potential significance at both higher and lower systematic levels.

The anatomy of a new hadal, cocculinid limpet (Gastropoda: Cocculinoidea), with a preliminary phylogenetic analysis of the family Cocculinidae [DS]

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Ever since their discovery and first description by Dall in 1882, cocculinid species have intrigued their investigators with unique combinations of features. The anatomy of a new species of cocculinid limpet, is no exception. The only cocculinid, apart from *Fedikovella caymanensis*, known to inhabit hadal depths, this species possesses a number of features characteristic of cocculinids including the presence of broad oral lappets, epipodial tentacles, a hemal gland with associated aortic arch, and vestigial eyes modified into the so-called basitentacular gland. The hermaphroditic reproductive system includes a modified right cephalic tentacle inferred to function as a copulatory organ and a single receptaculum seminis. No evidence of a seminal groove could be found. However, this species is unique within the family in several aspects of both external and internal anatomy. These unique features include a prominent internal transverse septum within the shell, a closed receptaculum duct and the presence of several small statocones in some individuals. In addition, this species displays a unique combination of features heretofore undocumented among cocculinids, the most significant being the configuration of the nervous system. Preliminary phylogenetic analysis of the Cocculinidae includes fourteen taxa and twenty nine characters. Results indicate a basal placement of the species within the family and supports monophyly of the genera *Cocculina* and *Coccopigya*.

Origin and distribution of deep-sea fauna of conoidean gastropods [DS]

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Conoidean gastropods, and especially the part formerly known as the family Turridae, are among the dominant molluscan groups in deep-sea faunas. These gastropods are very diverse, particularly as concerns their anatomy and feeding mechanisms. The evolution of the group was probably targeted at improvement of feeding, and advanced taxa possess highly specialized and efficient feeding mechanisms. Conoidean origin and initial stages of evolution were associated with shallow waters of tropical areas. The most primitive taxa (families and subfamilies) are still either restricted to, or most diverse in, warm, shallow-water habitats. Bathyal and, especially, abyssal faunas consist mainly of advanced representatives, and the share of higher taxa increases with depth. However, there are no taxa of the family group, that are characteristic only for the deep water fauna. This may indicate that the deep-water faunas are evolutionarily rather young and, at the same time, that colonization of deep waters reflected the adaptive radiation of conoideans rather than a major step in their evolution. A specific bathyal fauna of conoideans is known from as early as Oligocene deposits, and while Mio-Pliocene faunas were very similar to Recent ones from respective regions. The bathyal zone is characterized by an increased percentage of primitive taxa as compared to the shelf. Abyssal and hadal conoideans are represented by relatively few genera and families and subfamilies. An increase in diversity is recorded in near-continental regions, often inhabited by endemic genera, whereas the fauna of oligotrophic oceanic areas mostly consists of representatives of few widely spread genera belonging to advanced groups. The distribution pattern of deep-sea conoideans is characterized by the presence of a number of species with very limited ranges. At the same time, there are species with very wide ranges (e.g., amphioceanic). The mode of larval development seems not to strictly correlate with the area of species range.

Occurrence of the adult form of *Neoteuthis* sp. from the Hawaiian Islands [NPC]

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During the surveys on the diet of *Alepisaurus ferox*, two adult form specimens of *Neoteuthis* sp. were discovered in the Hawaiian waters. The predator fish were collected in 1982 from 11°23.0'N, 177°58.5'E, 180m in fishing depth, and 11°24.0'N, 169°4.5'E, 230m, by longline. The squid specimens are both females, 62.5 mm and 61.5 mm in DML, respectively. The body is weakly muscular and its surface bears distinct iridescence.

Two species of the genus *Neoteuthis* has hitherto been known (Nesis, 1982), such as, *N. thielei* Naef, 1921, the type species of the genus, from the Atlantic, and unnamed species (from Hawaiian waters by Young, 1972). *Neoteuthis thielei* attains to 17 cm DML in adult (Nesis,1982), while the adult male specimens of the Pacific unnamed species (Young, 1972) does 83 mm DML. The present specimens is almost conspecific, but yet different from Young's (1972) specimen in several indices and features. In the present study, the taxonomic status of this species, and some ecological information are discussed.

Shell polymorphism in the neogastropod *Alia carinata* (Hinds)

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I analyzed *Alia carinata* from four different habitats to investigate the presence of literature-alleged shell pattern and shell form polymorphism. Using univariate and multivariate statistics, I demonstrated that *Alia* from *Gastroclonium subarticulatum* (Rhodophyta), *Zostera marina*, and benthic hard bottom habitats displayed measurably and identifi-

ably distinct forms. Individuals from *Macrocystis pyrifera* (Phaeophyta) canopies showed considerable form overlap with benthic specimens. Interhabitat polymorphism was related to differences in both size and shape, while observed sexual dimorphism was strictly size-related, with males larger than females. *Alia* from *Zostera* were mostly non-patterned and dark in color, while those from the other three habitats were generally patterned and variably colored. Planktonic dispersal of juveniles suggests that intraspecific polymorphism is a result of phenotypic plasticity, and not natural selection. Allometric growth, wave exposure, and predation differences among sampled habitats may be important controlling factors in observed intraspecific polymorphism.

Distribution and transport of *Illex argentinus* paralarvae (Cephalopoda: Ommastrephidae) across the western boundary of the Brazil/Malvinas Confluence Front off southern Brazil [poster]

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This study discusses the transport and the influence of different water masses, phytoplankton and zooplankton biomass on the distribution and abundance of *Illex argentinus* paralarvae off southern Brazil (28°09' S-34°20' S). During four surveys carried out from 1987 to 1991, a total of 428 paralarvae were collected with a bongo net (0.33 mm mesh size) in 203 tows. Paralarvae were found from autumn to spring, but were absent in summer and in regions of major influence of coastal and subantarctic waters. The greatest relative abundance (41 paralarvae 100 m^3) was found in spring of 1987. Paralarvae were mainly distributed along a shelf-break front formed between tropical waters of the Brazil Current and subantarctic waters of the Malvinas/Falklands Current were partial upwelling processes and planktonic enrichment were found. From the slope to the coast, there was a clear progression of paralarval sizes. Hatchling occurred at the outer shelf and slope in tropical and/or subtropical waters. The largest paralarvae and small juveniles were found at the inner shelf under the influence of subantarctic waters, where high concentrations of chlorophyll-a and zooplankton biomass were measured.

Studies of hydrothermal vent fauna, especially gastropods [DS]

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Extreme and highly variable temperatures, exposure to chemically reducing fluids, such as hydrogen sulfide, and heavy metals and temporally unstable habitats, limit the number of animals that dwell at hydrothermal vents. Studies of diversity have virtually ignored vent habitats due to the limited number of species they support and the difficulties in adequately sampling abyssal habitats. Animal diversity at volcano-hosted vents on Juan de Fuca and Explorer ridges in the northeast Pacific is significantly lower than the East Pacific Rise (EPR) at 9°-21°N. Although individually, EPR vents are smaller and shorter-lived than are North Pacific vents, EPR vents appear to occur in greater diversity; they thus may offer more total area than do the larger, comparatively long-lived, but well-spaced North Pacific vents. The increased proximity of individual EPR vents may also allow large, apparently endemic predators to forage at multiple vents and therefore to survive, despite the ephemeral nature of the individual habitats. Such predators are virtually absent from northeast Pacific vents. The proximity of EPR vents may directly enhance the effective dispersal of the large larvae of vent-dwelling gastropods, which are likely to have limited individual dispersal capacity.

The California market squid fishery [NPC]

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Market squid (*Loligo opalescens*) is presumed to be one of the most abundant marine resources in California waters. Squid range from southeastern Alaska to Bahia Asuncion, Baja California, Mexico. Catches have traditionally come from two fishing areas within California: Monterey Bay and the islands off southern California. Squid become vulnerable to commercial fishing gear when they concentrate near shore to spawn and are typically taken at night. Harvest and demand are primarily controlled by international market conditions. The demand for squid has increased dramatically in recent years. Prior to 1987, California landings averaged 10,000 tons. Beginning in 1988, commercial landings began to increase and have grown from approximately 40,000 tons to over 83,000 tons in 1996.

Little is known about the present size, structure or status of the population, but historical evidence from research cruises, as well as catch data, indicates the biomass is large. It is believed that squid can be more intensively harvested than other marine animals because they are short lived. They also appear to be heavily influenced by environmental conditions.

The role of stratigraphic data in phylogenetic analyses of extinct molluscs [PS]

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Both biotic factors (rates and models of morphologic change, rates of extinction, numbers of applicable characters and speciation models) and abiotic factors (rates of sampling) affect the accuracy of parsimony. The molluscan fossil record provides workers with a high proportion of the widely distributed species, which increases the accuracy of parsimony in simulations. However, high rates of morphologic change (well within the ranges inferred by cladistic analyses of molluscs) seriously undermine the accuracy of parsimony in the same simulations, even with no patterned homoplasy present. Stratigraphic data offer tests of whether congruent characters represent phylogenetic signal or convergence. Existing phylogenetic methods utilize stratigraphic data based on congruence and total evidence logic and on probability theory. These methods provide more exact estimates of phylogeny than does parsimony by making explicit ancestor-descendant estimates and implying particular patterns of speciation and routes of morphologic change. Evaluation of these methods is very important when contrasting the evolutionary scenarios implied by alternate estimates of phylogeny. Simulations using preservation and evolutionary rates typical of molluscs find that all methods incorporating stratigraphy perform better than does parsimony. Methods currently in development evaluate the likelihood of a phylogeny implying both particular amounts of stratigraphic gaps and particular amounts of morphologic change. Ultimately, likelihood approaches probably will provide workers with the most robust phylogenetic estimates of phylogeny for extinct molluscs.

The phylogenetic relationships of some littorinid species assessed by small subunit ribosomal DNA sequences and morphology [poster]

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Small subunit ribosomal DNA (18S rDNA) is usually considered to be a slowly evolving molecule with very limited, if any, phylogenetic resolving power for divergences that took place in less than 40 MY. We evaluated this issue by a congruence and total evidence analysis of morphological data and complete 18S rDNA sequences of nine littorinid species from the genera *Melarhaphe*, *Littoraria*, *Nodilittorina* and *Littorina*. We particularly focused on the still somewhat controversial position of the Macaronesian periwinkle *Littorina (Liralittorina) striata*, a species that has been variously assigned to *Melarhaphe*, *Nodilittorina*, and currently *Littorina*. These analyses suggested (1) that 18S rDNA provided a much stronger phylogenetic signal to recover the well-known, young *Littorina-Neritrema* radiations (divergence time < 10 MY), whereas the topology of the older, *Littoraria-Nodilittorina-Liralittorina* branches was much less supported, and (2) that the current morphological and molecular data are insufficient to unambiguously resolve the relationships of *L. striata*. Anyway, although current practice suggests the contrary, 18S rDNA may be not so unsuitable to reconstruct relatively young radiations.

Unordered vs. ordered multistate characters: explication and implication [PS]

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Characters with three or more states are typically treated as ordered or unordered in multistate character coding methods. Although both treatments hypothesize which character states directly evolve into which other states (= character transformation series or character state trees), the proposed suppositions are very different. What are these differences? Does unordered really provide a logical approach based on similarity, the first criterion of testing homology? These questions are addressed in an effort to establish how these issues affect the reconstruction of the evolutionary history of the Phylum Mollusca, or for that matter any attempt at phylogenetic systematics.

Life history and population structure of the neon flying squid, *Ommastrephes bartrami*, in the North Pacific Ocean [NPC]

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The neon flying squid consists of an autumn cohort (formally known as LL group) and a winter-spring cohort (L, S, SS groups combined) as based on age estimation with statolith microstructure, mantle length compositions, distribution of both mature individuals and paralarvae. Both cohorts are estimated to have one-year life span. They undergo seasonal north-south migrations between the spawning grounds in the subtropical waters and feeding grounds in the Subarctic waters. The winter-spring cohort can be further separated into a western stock and a central-eastern stock on the basis of intensity of infection with larval nematode and cestode parasites. The autumn cohort was abundant in the central and eastern North Pacific but rare west of 170°E which coincides with the location of the Emperor Sea Mount Chain north of 35°N. The autumn cohort also is separable into central and eastern stocks on the basis of parasite infection intensity.