

American Malacological Union



PROGRAM and ABSTRACTS

61st. ANNUAL MEETING

University of Hawai'i at Hilo

Hilo, Hawai'i

June 7 - 13, 1995

The Legend of the Logo 1995

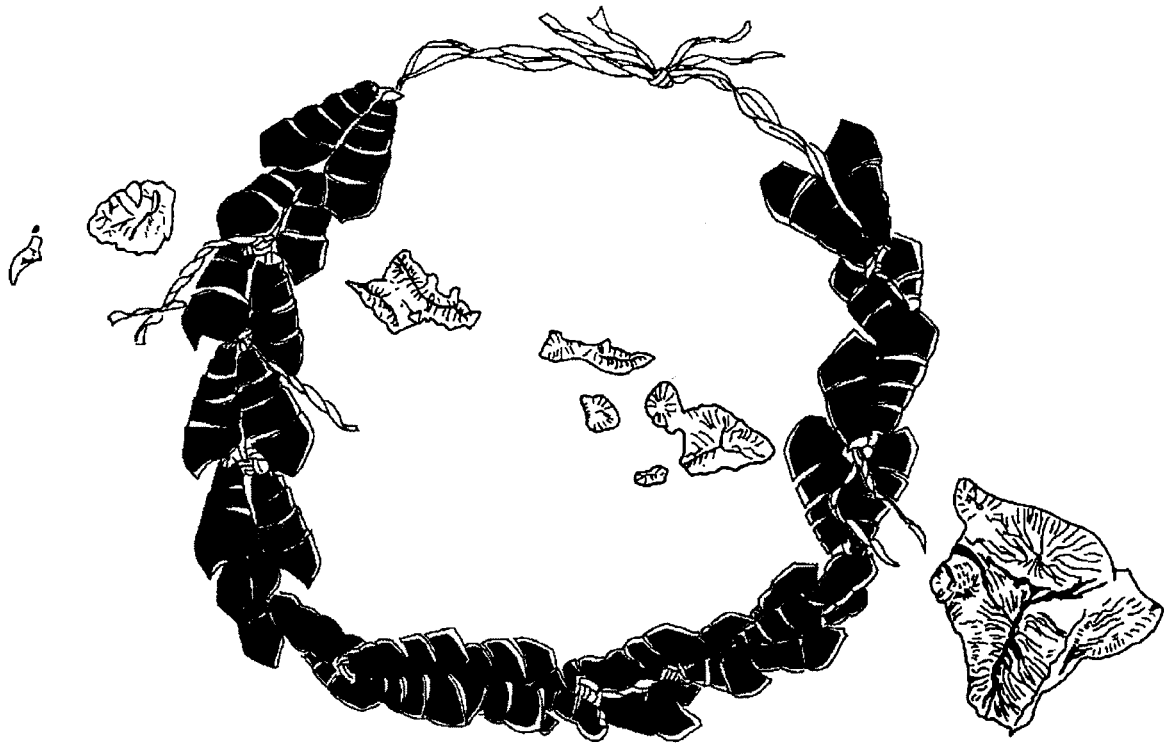
The shell lei which surrounds the Hawaiian islands in the logo is made up of shells of the ground-living land snail *Carelia*, the largest of the Hawaiian land snails and which is endemic to the island of Kauai. As Reg Gage (HMS member) tells the story, the lei was apparently taken from Kauai to England on one of Captain Cook's ships in 1779, and subsequently ended up in a museum in Berne, Switzerland. In the literature it was attributed to Tonga! Reg, seeing the shell lei illustrated, recognized it for what it was, a lei of shells from Kauai, and he not only identified two species in the lei, *Carelia cochlea* and *C. dolei*, but also the place from which they came, flats in the Kalihi-Kai area of the island (Gage, R. in *Archaeology on Kauai*, May 1988). Unfortunately, not only is *Carelia* apparently now extinct on Kauai, but the lei has disappeared. Only the picture remains.

The logo was designed and executed by Regina Kawamoto, who is also from Kauai, and was computer-executed by Fabio Moretzsohn for our use.

PROGRAM SUMMARY

	MORNING	AFTERNOON	EVENING
Wed Jun 7 10:00 a.m.	Arrival Campus CTR Lanai: Registration	Registration Dormitory Check-in: 3:00 p.m.	Council Meeting CIFA
Thu Jun 8	Registration Council CIFA; System	Keynote Address Biogeography I Ceph. Contr. papers	President's Welcome
Fri Jun 9	Biogeography II Ceph. Contr. Papers	Biogeography III Contr. Papers General	Sunset Reception
Sat Jun 10	Field Trips	Field Trips	Ice Cream Social
Sun Jun 11	Ceph. I Contr. Papers General	Ceph. II Contr. Papers General	Bar-B-Q Auction/ Wine Cooler
Mon Jun 12	Ceph. III Conservation I	Ceph. IV Conservation II 4:30 AMU Annual Meeting: Theatre	Pau Hana Banquet
Tue Jun 13	Departure		

Program and Abstracts
American Malacological Union
61st. ANNUAL MEETING



University of Hawai'i at Hilo
Hilo, Hawai'i June 7 - 13, 1995

Co-sponsored by the: Department of Biology
University of Hawai'i at Hilo
Department of Zoology
University of Hawai'i at Manoa

Guest of Honor: Jacqueline De Roy of the Galápagos Islands

American Malacological Union, Inc.
Executive Council 1994-1995

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AMERICAN MALACOLOGICAL UNION
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Calvin Goodrich	1936	Joseph Rosewater	1969
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A. Byron Leonard	1953	Alan J. Kohn	1983
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AMU 1994-1995 COMMITTEE CHAIRS

Nominating	Constance E. Boone
Auditing and Budget	Rüdiger Bieler
Finance and Endowment	George M. Davis
Conservation	Arthur Bogan
Membership	Paul Scott
Archives	George Davis
Student Award	Laura Adamkiewicz
Publications	Ronald B. Toll
Constitution, By-laws	Harold D. Murray
Newsletter Editor	Bowie Kotrla

Annual Meeting Assistance

Registration	Regina Kawamoto, Catherine Unabia, Tricia Lee
Symposia:	Gustav Paulay (Island Biogeography); Richard Young (Cephalopods); Elaine Hoagland (Conservation)
Field Trips	Don Hemmes, Brian Tissot
Field Trip Leaders	Grant Gerrish, Frank Howarth, Bill Mull, Don Hemmes, Brian Tissot
Book Sales	Bunnie and George Cook
Organization	Regina Kawamoto, Tricia Lee, Dwayne Minton, Fabio Moretzsohn
Transportation	Wayne Estabrooks, Dwayne Minton
Audio-Visuals	Tom Duda
Logo Design	Regina Kawamoto
Program and Printing	Fabio Moretzsohn
Auctioneer	Don Hemmes

We thank to all donors of auction materials. Mahalo. Funds resulting from the Friday night auction augment the AMU Symposium Endowment. Please join us!

Host: the University of Hawaii at Hilo. We are grateful not only for the welcome of the Chancellor but for the extraordinary organization and help of The Conference Center: Director Judith Fox-Goldstein and Assistant Mary Ann Tsuchiyama have gone far beyond the call of duty in making all of this possible.

EVENTS, HINTS AND COURTESIES

REGISTRATION: The AMU Registration table will be open from 3:00-6:00 p.m. Wednesday June 7 on the Campus Center Lanai (2nd floor of the Campus Center), then in the Hale Kehau Dining Room during the evening, and again on the Campus Center Lanai on Thursday morning from 8:00 a.m.

CHECK-IN/CHECK-OUT: For registrants who have purchased the Conference Housing package, check-in is from 3 p.m. on Wednesday June 7, and again anytime on Thursday. Check-out is by noon Tuesday June, 13.

MEAL PLAN (Hale Kehau Dining Room):

Breakfast (Hale Kehau): 7:30-8:30 a.m.

Lunch (Hale Kehau): 12:00 Noon

Dinner (Hale Kehau): 6:00-7:00 p.m.

MORNING AND AFTERNOON BREAKS: Beverages and pastries will be available for morning and afternoon breaks; **they are included in the conference meal package.** If you did not purchase a meal package, and you would like to partake of these goodies, please pay the small fee which we must charge for them at the registration desk.

PRESIDENT'S RECEPTION: This one is free -- all AMU registrants and their families are cordially invited to attend the reception -- in the Theatre, for a short, illustrated talk on Hawaiian malacologists, and then on the lanai for cheese and wine. Please come.

POSTERS AND BOOK SALES: Posters will be mounted in Campus Center 301 which serves as a gallery, and Bunnie and George Cook will also have Hawaiian shells books for sale in there -- at odd hours, during quiet periods, etc.

SYMPOSIA AND CONTRIBUTED PAPERS: We tried hard, but there was no way to do it without concurrent sessions. Sorry about that -- but the trek from the Theatre to Campus Center 306 is not far -- and it'll keep you healthy (there is an elevator should you need one). Unfortunately, although the sessions are concurrent, there was no way to keep them all to the same time lines: symposium speakers get 30 minutes, contributed papers 20 minutes, so you will have to juggle things as best you can.

Session Chairs: As well as introducing the speakers and controlling the discussion, it is essential that you keep speakers within their time allowance. Familiarize yourself with the controls for lights, projectors, microphones, pointers, etc. Help the speaker. Before your session, identify yourself to the speakers and make sure that their slides are with the projectionist.

Speakers: Make sure your slides are clearly labeled and with the projectionist before the start of your session. It is your responsibility to load the slides in the correct orientation. **Use the preview room: Campus Center 313** to sort out your slides. Before your session, introduce yourself to the session chair, familiarize yourself with the equipment on the platform and make sure you know where the controls are located. It is important that you do not exceed your time allowance: if you do, it upsets the whole program and is unfair to the subsequent speakers.

STUDENT PAPER COMPETITION: As in the past, there will be an award for the student who delivers the "best paper" as judged by a team of judges who evaluate scientific content, adequacy of research approach, organization of the presentation, the quality of the visual aids, and the manner in which the presenter handles questions and answers. The six presentations entered in this year's competition are designated by one asterisk in the session schedules that follow. Please make a special effort to attend student papers and offer our young malacologists your feedback and encouragement.

SUNSET RECEPTION: This reception is at the original mission home of the Lymans, now a museum. It is a very special place with lots of history -- and some exquisite shells. Buses will leave from the Campus Center at 5:30 on Thursday evening, and again at 6:00 p.m.; the first bus will leave Lyman House at 9:00, the second about 9:30. Parking is at a premium in the area, so car-renters may want to use the bus. We are promised interesting pupus and slack key guitar.

FIELD TRIPS: We think we have accommodated everyone, if not with the first choice, then with the second. Vans will leave from the Campus Center -- we will announce times and special requirements the day before. Box lunches will be in the vans, and those remaining behind can pick up their box lunches in the Hale Kehau dining room.

ICE CREAM SOCIAL: For relaxation after the field trips we will meet on campus for an old-fashioned, ice cream gathering. Just to give us all a breather. But please come!

BAR B-Q: This is one of the dinners in the **meal package** -- and will be on the Campus Center Lanai. Barbecues are an AMU tradition: a California style barbecue in Berkeley and a real Texas event in Houston. Ours is Hawaiian style.

AMU AUCTION: This event follows the Bar B-Q in Campus Center 306 about 8:00 p.m. Reprints and books will be for sale, and there are many great items on which to bid. Don Hemmes will preside. Refreshments will be served. And remember: proceeds go to our student endowment fund!

AMU ANNUAL MEETING: AMU will hold its annual business meeting at 4:30 on Sunday June 11, following the last paper in the Contributed Papers sessions in Campus Center 306. Plan to attend to hear about next year's meeting and other plans. It's your organization - be there!

PAU HANA BANQUET: The closing banquet will be held in the Marriott Dining Room on the evening of June 12th. Guaranteed very special -- only as we in Hawaii can do it.

No smoking in the Campus Center or Theatre

Please wear your badges to facilitate attending sessions, boarding buses and vans, and generally letting people know who you are.

MAKE IT A HABIT: CHECK THE MESSAGE BOARD ON THE CAMPUS CENTER LANAI FOR MESSAGES, PROGRAM CHANGES, INFORMATION.

UNIVERSITY OF HAWAII AT HILO and HAWAII COMMUNITY COLLEGE

MAIN CAMPUS

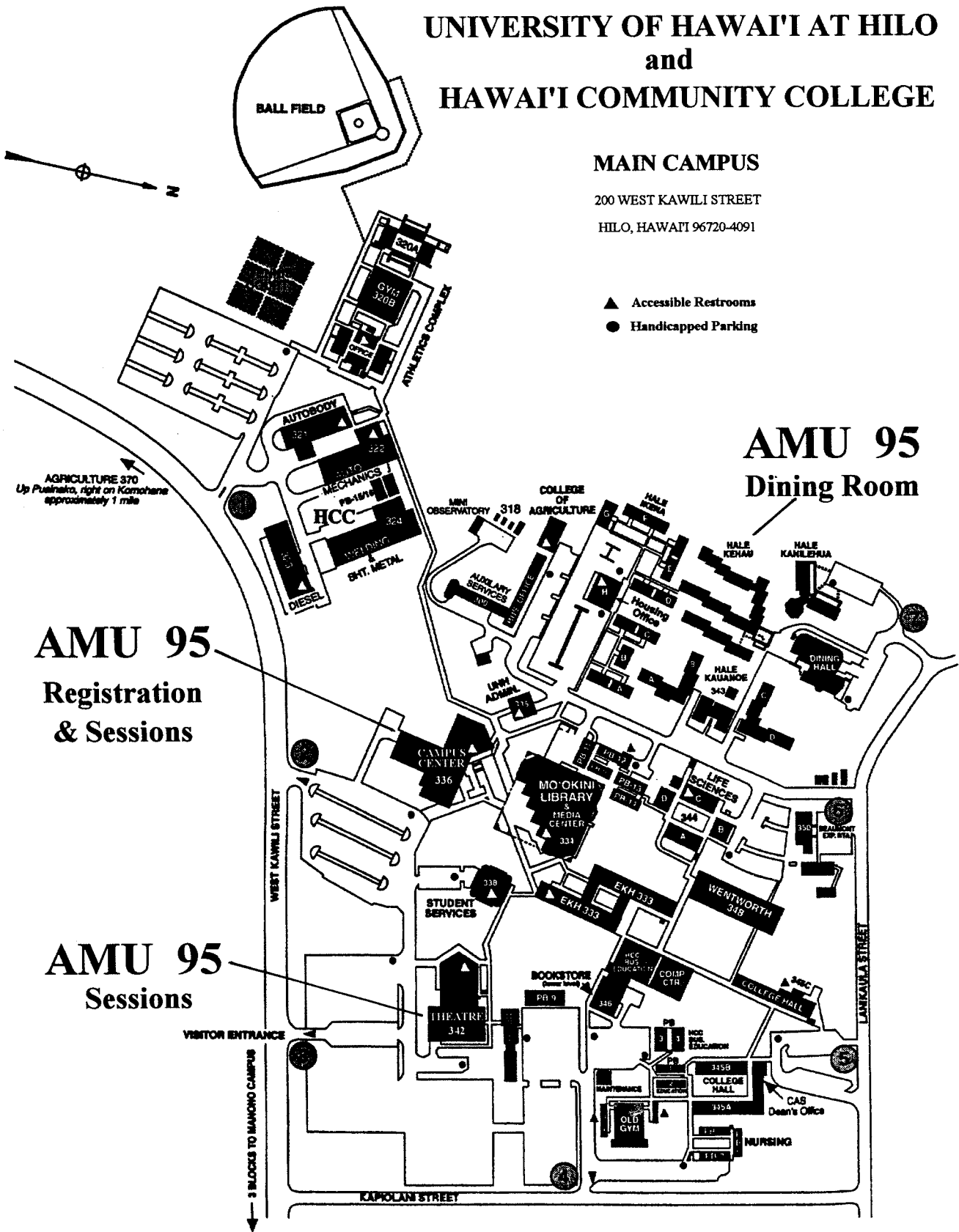
200 WEST KAWILI STREET
HILO, HAWAII 96720-4091

- ▲ Accessible Restrooms
- Handicapped Parking

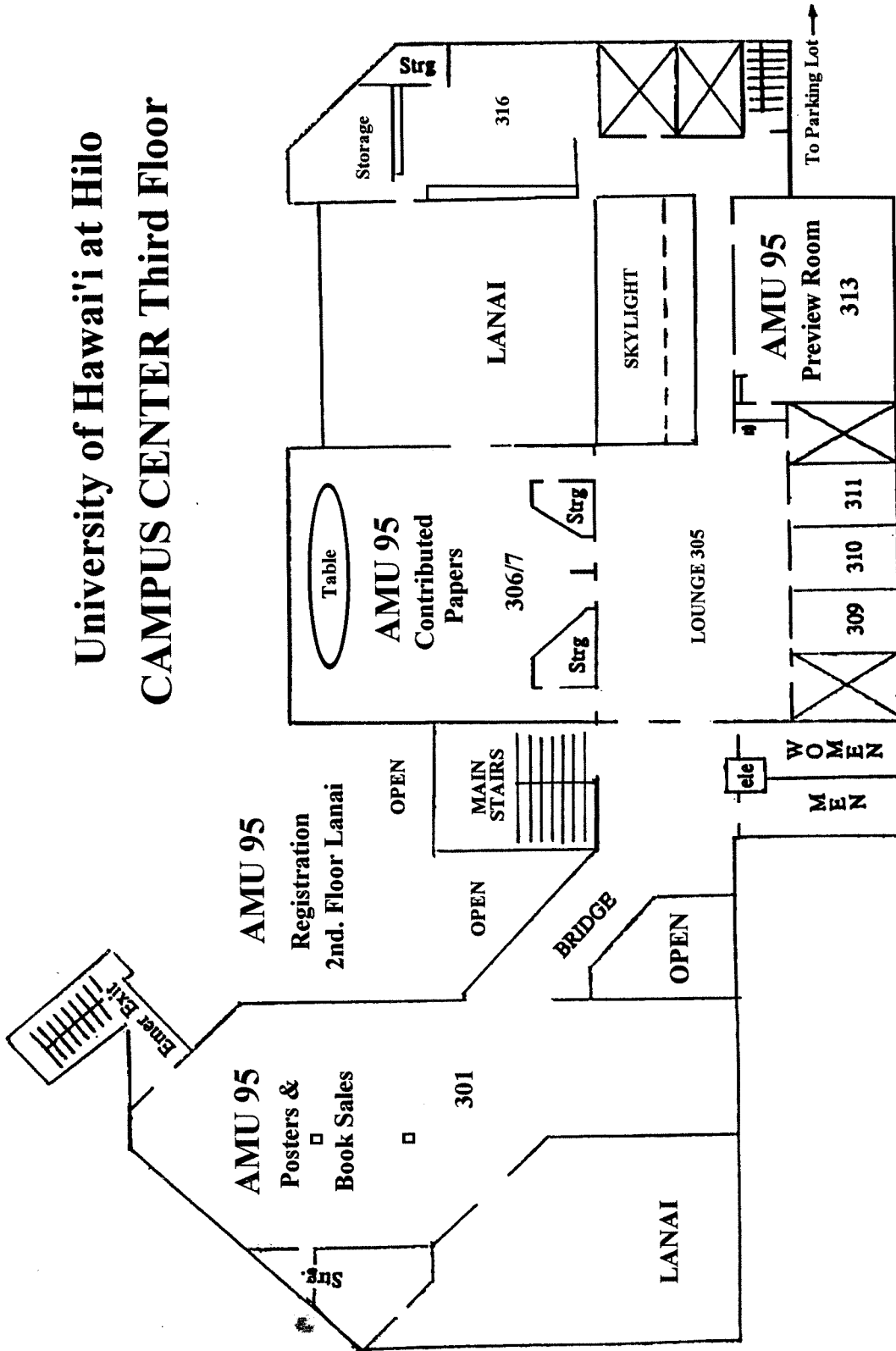
AMU 95 Dining Room

AMU 95 Registration & Sessions

AMU 95 Sessions



University of Hawai'i at Hilo CAMPUS CENTER Third Floor



WEDNESDAY, JUNE 7**ARRIVAL**

3:00 p.m. **REGISTRATION CAMPUS CENTER (CC) LANAI**
 6:30 Dinner: Hale Kehau -- Registration continues

7:30 Council: CC 306/7; CIFA: CC301

THURSDAY, JUNE 8

7:30-8:30 a.m. Breakfast: Hale Kehau
 9:00 **REGISTRATION: CAMPUS CENTER LANAI**
 Council: CC 306/7
 CIFA: CC 301
 Council of Systematics Malacologists: CC 313
 10:00 Coffee: Campus Center Lanai
 12:00 n Lunch: Hale Kehau

1:00 p.m. **WELCOME: CHANCELLOR KENNETH PERRIN - THEATRE**
INTRODUCTIONS
 Keynote Address: **JEWELS OF THE RAINFOREST**
William A. Mull

CONCURRENT SESSIONS (see facing page)
BIOGEOGRAPHY SYMPOSIUM I: THEATRE
 Convener: Gustav Paulay
 Session Chair: Terry Gosliner

2:30 **RETENTION AROUND AND LONG-DISTANCE DISPERSAL BETWEEN OCEANIC ISLANDS BY PLANKTONIC LARVAE OF MARINE BENTHIC MOLLUSCA**
Rudolf Scheltema

3:00 **EGG SIZE, LIFE HISTORY AND BIOGEOGRAPHY OF MARINE GASTROPODS**
Alan J. Kohn

3:30 Break: CC Lanai

3:50 **STABILITY AND TURNOVER IN INSULAR MARINE MOLLUSK FAUNAS THROUGH THE LATE CENOZOIC**
Gustav Paulay

4:20 **PATTERNS OF DISTRIBUTION IN A GASTROPOD GROUP WITH TELEPLANIC LARVAE: ARCHITECTONICIDAE IN THE INDO-PACIFIC**
Rüdiger Bieler

4:50 **BIOGEOGRAPHY OF THE NATICIDAE IN THE INDO-WEST PACIFIC**
Alan Kabat

6:00-7:00 Dinner: Hale Kehau

CONCURRENT SESSIONS (see facing page)
CEPHALOPOD CONTRIBUTED PAPERS: CC 306/7
Session Chair: CC. Lu

- 2:30 THE MALAYSIAN SQUID FISHERY: A BRIEF OVERVIEW
Z. Ashirin, M. Ibrahim, and G. Kawamura
- 2:50 A COMPARATIVE STUDY OF THE DIET OF *LOLIGO VULGARIS* (LAMARCK 1799)
(MOLLUSCA: CEPHALOPODA) IN THE SOUTH COAST OF PORTUGAL AND THE
SAHARAN BANK (CENTRAL SOUTH AFRICA)
M. Coelho, P. Domingues, E. Balguerías-Guerra and P. Andrade
- 3:10 FEEDING CHRONOLOGY OF A SQUID, *L. EDULIS* UNDER SURFACE-FISHING LAMPS
Z. Ashirin, G. Kawamura and M. Ibrahim
- 3:30 Break: CC Lanai
- 3:50 LABORATORY OBSERVATIONS OF EGG MASSES OF THE JAPANESE COMMON SQUID,
TODARODES PACIFICA (CEPHALOPODA: OMMASTREPHIDAE)
J.R. Bower and Y. Sakurai
- 4:10 DEVELOPMENT OF AN OMMASTREPHID SQUID *TODARODES PACIFICUS*, FROM
FERTILIZED EGG TO THE RHYNCHOTEUTHION PARALARVA
K. Watanabe, Y. Sakurai, S. Segawa, and T. Okutani
- 4:30 EFFECTS OF TEMPERATURE ON SURVIVAL OF *TODARODES PACIFICA*
(CEPHALOPODA: OMMASTREPHIDAE) EMBRYOS AND HATCHLINGS: DOES
TEMPERATURE DETERMINE SPAWNING SITES?
Y. Sakurai and J.R. Bower
- 6:00-7:00 Dinner: Hale Kehau

7:00 President's Reception: Theatre/Lanai :
A President's Musings: Hawaii's Shells Didn't Come from Noah's Ark

FRIDAY, JUNE 9

7:30-8:30 a.m. Breakfast: Hale Kehau

CONCURRENT SESSIONS (see facing page)
BIOGEOGRAPHY SYMPOSIUM II: THEATRE

Session Chair: Rudolf Scheltema

- 9:00 INDO-PACIFIC OPISTHOBRANCH BIODIVERSITY AND BIOGEOGRAPHY: HOW DO WE KNOW WHAT WE DON'T KNOW
Terrence Gosliner and Robyn Draheim
- 9:30 CHARACTERISTICS OF SUBMARINE CAVE BIVALVES FROM THE NORTHWEST PACIFIC
Itaru Hayami
- 10:00 Coffee: CC Lanai
- 10:20 THE BIOGEOGRAPHY AND EVOLUTIONARY LINES OF ISLAND FRESHWATER *NERITINA*
Alison Haynes
- 10:50 EVOLUTION IN ANCIENT LAKES
A. Elinor Michel
- 11:20 INDEPENDENT EVOLUTION OF TERRESTRIALITY IN ATLANTIC TRUNCATELLID GASTROPODS
Gary Rosenberg

12:00 n Lunch: Hale Kehau

FRIDAY, JUNE 9

BIOGEOGRAPHY SYMPOSIUM III: THEATRE

Session Chair: Alan Kohn

- 1:00 p.m. DETERMINANTS OF DIVERSITY IN PACIFIC LAND SNAILS: BEYOND THE SPECIES-AREA RELATIONSHIP *3400 spp. unknown undiscovered - Endemic, How calc. only found one place & no where else 43% by one collection*
Robert Cowie *Opisthobranchia*
- 1:30 * EVOLUTION, DIVERSITY AND DECLINE OF LAND SNAILS IN THE MARIANA ISLANDS
Scott Bauman
- 2:00 THE EVOLUTION AND EXTINCTION OF *PARTULA*
Bryan Clarke

- 7:00 President's Reception: Theatre/Lanai
A President's Musings: Hawaii's Shells Didn't Come from Noah's Ark

FRIDAY, JUNE 9

7:30-8:30 a.m. Breakfast: Hale Kehau

CONCURRENT SESSIONS (see facing page)
CEPHALOPOD CONTRIBUTED PAPERS: CC 306/7

Session Chair: Michael Vecchione

- 9:00 REPRODUCTION OF *OCTOPUS RUBESCENS* BERRY, 1953
S. Osborn
- 9:20 FECUNDITY OF *OCTOPUS RUBESCENS* BERRY, 1953
S. Osborn
- 9:40 THE ST. AUGUSTINE "SEA MONSTER" AND THE "BERMUDA BLOB": *OCTOPUS GIGANTEUS* OR NOT?
S. Pierce, G. Smith, T. Maigel and M. Clarke
- 10:00 Coffee: CC Lanai
- 10:20 A NEW SMALL, LITTORAL, ARM-AUTOTOMIZING OCTOPUS FROM GUAM
L. Ward
- 10:40 IN-SITU OBSERVATIONS ON *BRACHIOTEUTHIS*: PAIRED BEHAVIOR, POSSIBLE MATING
C. Roper and M. Vecchione
- 11:20 THE REABSORPTION OF AMINO ACIDS AND GLUCOSE FROM COELOMIC FLUID AND RENAL SAC OF THE SQUID *ILLEX ILLECEBROSUS*
A.W. Martin and C.C. Lu
- 10:40 CEPHALOPOD COMMUNITY ASSOCIATED WITH MESOSCALE OCEANOGRAPHIC FEATURES AT THE ANTARCTIC POLAR FRONTAL ZONE EXPLOITED BY SATELLITE TAGGED PREDATORS
P.G. Rodhouse, P.A. Prince, P.N. Trathan, E.M.C. Hatfield, J.L. Watkins, D.G. Bone, E.J. Murphy, M.G. White
- 12:00 n Lunch: Hale Kehau

FRIDAY, JUNE 9**CONTRIBUTED PAPERS: CC 306/7**

Session Chair: Joseph Heller

- 1:00 A MOLECULAR PHYLOGENY OF THE BIVALVIA
L. Adamkewicz, M.G. Harasewych, and C. Bult
- 1:20 ALLOZYME ANALYSIS OF LUCINID BIVALVES FROM THE CARIBBEAN COAST OF PANAMA SUPPORTS SPECIES BOUNDARIES USING SHELL MORPHOLOGY
Penelope A.G. Barnes and L.A. Weigt
- 1:40 MITOCHONDRIAL DNA SEQUENCE VARIATION AND RELATIONSHIPS AMONG UNIONACEANS
Margaret Mulvey, C. Lydeard, D.L. Pyer, G.M. Davis
- 2:00 THE EVOLUTION OF *LOTTIA GIGANTEA*: EVIDENCE FROM MORPHOLOGICAL AND STRATIGRAPHIC DATA SETS
David R. Lindberg

- 2:30 BIOGEOGRAPHIC PATTERNS IN AEGEAN NON-MARINE GASTROPODS
Edmund Gittenberger
- 3:00 Break: Theatre Lanai
- 3:20 DIVERSITY AND DURABILITY: RESPONSES OF THE MADEIRAN AND PORTO-SANTAN
SNAIL FAUNAS TO NATURAL AND HUMAN-INDUCED ENVIRONMENTAL CHANGE
R.A.D. Cameron and L.M. Cook

- 5:30 **SUNSET RECEPTION:** Lyman House
Bus transport 5:30-6:00 from Campus Center

SATURDAY, JUNE 10

- 7:30-8:30 a.m. Breakfast: Hale Kehau
- 9:00 Field Trips: Vans leave from Campus Center
Lunches packed in vans
- 6:00-7:00 p.m. Dinner: Hale Kehau
- 8:00 Ice Cream Social: Marriott Dining Room

SUNDAY, JUNE 11

- 7:30 Breakfast: Hale Kehau

CONCURRENT SESSIONS (see facing page) CEPHALOPOD SYMPOSIUM I: THEATRE

Convener: Richard Young
Session Chair: Katharina M. Mangold

- 9:00 BIOCHEMICAL AND MOLECULAR APPROACH TO CEPHALOPOD PHYLOGENY
R. Boucher-Rodoni and L. Bonnaud
- 9:30 COEVOLUTION IN A SQUID-LUMINOUS BACTERIUM SYMBIOSIS: DIFFERENTIATION
OF *EUYPRYMNA* SPECIES BY MOLECULAR SYSTEMATICS AND SYMBIONT
COLONIZATION
M. Nishiguchi, E. Ruby and M. McFall-Ngai
- 10:00 Coffee Break: Theatre Lanai
- 10:20 RELATIONSHIP OF SOME COLEOID CEPHALOPODS ESTABLISHED BY CYTOCHROME
OXYDASE iii GENE SEQUENCE COMPARISON
L. Bonnaud and R. Boucher-Rodoni
- 10:40 THE VALIDITY OF THE GENUS *PHOTOLOLIGO*: A GENETIC PERSPECTIVE
A. Brierley, A. Allcock, J. Thorpe and M. Clarke

- 2:20 * EVOLUTIONARY RELATIONSHIPS AMONG AQUATIC NERITOPSINES
Bern V. Holthuis
- 2:40 * NERITACEAN RADULAE: CAN CLUES TO THE HISTORY OF THIS GASTROPOD GROUP BE READ IN THEIR TOOTH STRUCTURE?
Catherine R.C. Unabia
- 3:00 Break: CC Lanai
- 3:20 * CHARACTER COMPLEXES AND PHYLOGENETIC ANALYSES OF *CYPRAEA*
Christopher P. Meyer
- 3:40 * PHYLOGENY OF THE COLUMBELLA AND PYRENE GROUPS (NEOGASTROPODA: COLUMBELLIDAE) IN THE NEOGENE AMERICAN TROPICS: UNANSWERED QUESTIONS AND UNQUESTIONED ANSWERS
Marta deMaintenon
- 4:00 * BREAK A SHELL AND LEARN - SHELL STRUCTURES REVISITED
Claus Hedegaard
- 5:30 **SUNSET RECEPTION:** Lyman House
Bus transport 5:30-6:00 from Campus Center

SATURDAY, JUNE 10

- 7:30-8:30 am Breakfast: Hale Kehau
- 9:00 Field Trips: Vans leave from Campus Center
Lunches packed in vans
- 6:00-7:00 p.m. Dinner: Hale Kehau
- 8:00 Ice Cream Social: Marriott Dining Room

SUNDAY, JUNE 11

- 7:30 Breakfast: Hale Kehau

CONCURRENT SESSIONS (see facing page)
CONTRIBUTED PAPERS: GENERAL
Session Chair: Laura Adamkiewicz

- 9:00 A HANDFUL OF SAND
Donald R. Moore
- 9:20 MOLLUSCS AND OTHER CREATURES WITHIN THE PERMANENT OXYGEN MINIMUM ZONE, NORTHERN ARABIAN SEA
Amelie H. Scheltema and Graham, Oliver
- 9:40 INTERACTIONS BETWEEN BENTHIC MALACOFUNA AND ICTHYOFAUNA IN A VENEZUELAN SANDY BEACH
Abelardo Riera, E. Klein, P. Penchaszadeh, and R. Molinet
- 10:00 Coffee: CC Lanai
- 10:20 ADAPTATIONS OF MOLLUSCAN LARVAE: DISTINGUISHING FUNCTIONAL ADVANTAGE FROM BIOGEOGRAPHIC CONSEQUENCE
Carole S. Hickman

- 10:40 OBSERVATIONS ON THE REPRODUCTION OF *BIFURCIUM BICANALIFERUM* (SOWERBY, 1832) FROM THE PACIFIC COAST OF PANAMA (GASTROPODA, COLLUMBELLIDAE, STROMBINA GROUP)
Helena Fortunato, P. Penchaszadeh, P. Miloslavich, M. Alvarez
- 11:00 ARE NURSE EGGS REALLY ENOUGH TO ACCOUNT FOR THE HATCHLINGS OF NURSE EGG FEEDING PROSOBRANCHS?
Patricia Miloslavich
- 11:20 METAMORPHIC INDUCTION IN *HERMISSENDA CRASSICORNIS* LARVAE
Conxita Avila, A.M. Kuzirian, and C.T. Tamse
- 11:40 * DEVELOPMENT OF THE GASTROPOD RADULA IN A PHYLOGENETIC CONTEXT
Robert P. Guralnick and D.R. Lindberg

SUNDAY, JUNE 11

12:00 Lunch: Hale Kehau

CONCURRENT SESSIONS (see facing page)
CONTRIBUTED PAPERS: GENERAL: CC 307/307
 Session Chair: Edmund Gittenberger

- 1:00 OBSERVATIONS ON FOSSIL HAWAIIAN LAND SNAILS
Reginald P. Gage III
- 1:20 A REVIEW OF THE GENUS PARTULINA FROM THE WEST MAUI MOUNTAINS, HAWAII
Mike Severns
- 1:40 LAND MOLLUSK COMMUNITIES REFLECTED IN 9,000 YEARS OF FOSSIL DEPOSITS IN A LAVA TUBE ON MAUI, HAWAII
Mike Severns
- 2:00 HITCHHIKING CLAMS: LONG-DISTANCE DISPERSAL OF A SUBANTARCTIC BROODING BIVALVE BY KELP RAFTING
Brian S. Helmuth, R.R. Veit, and R. Holberton
- 2:20 MASS MORTALITY OF BLACK ABALONES IN SOUTHERN CALIFORNIA
Brian N. Tissot
- 2:40 DISTRIBUTION OF DIET-DERIVED METABOLITES AND CHEMICAL DEFENSE IN THE NUDIBRANCH *GLOSSODORIS PALLIDA*
Conxita Avila and Valerie J. Paul
- 3:00 Break: Theatre Lanai

4:30 **AMU 95. ANNUAL MEETING**

6:30 **Bar B-Q: CC Lanai**

8:00 **Auction: CC306/7**

MONDAY, JUNE 12

7:30-8:30 a.m. Breakfast: Hale Kehau

**CONCURRENT SESSIONS (see facing page)
CEPHALOPOD SYMPOSIUM III: THEATRE**

Session Chair: Richard Young

- 9:00 CLADISTIC ANALYSIS TODAY
Keynote Speaker: Mary Mickevich
- 9:40 CLADISTIC ANALYSIS OF MORPHOLOGY IN THE INCIRRATE OCTOPUSES
(OCTOPODA: INCIRRATA)
M. Norman, F. Hochberg, T. Stranks and C.C. Lu
- 10:00 Break: Theatre Lanai
- 10:20 PHYLOGENETIC RECONSTRUCTION OF INCIRRATE OCTOPODS WITH
MORPHOLOGICAL CHARACTERS
J. Voight
- 10:40 ANALYSIS OF MORPHOLOGICAL CHARACTERS TO DETERMINE ORDINAL
RELATIONSHIPS OF EXTANT CEPHALOPODS
M. Vecchione and R. Young
- 11:00 SYSTEMATICS AND EVOLUTION OF *TODARODES* AND *MARTIALIA* (CEPHALOPODA:
OMMASTREPHIDAE) REVISITED
M. Roeleveld
- 11:20 THE PHYLOGENY OF THE SEPIIDS; INSIGHT FROM THE FOSSIL RECORD
Peter Ward
- 11:40 PHYLOGENETIC AND HIERARCHICAL CLASSIFICATION OF THE FOSSIL COLEOIDEA
(CEPHALOPODA)
T. Engeser and C. Spaeth
- 12:00 Lunch: Hale Kehau

MONDAY, JUNE 12**CONCURRENT SESSIONS (see facing page)
CEPHALOPOD SYMPOSIUM IV: THEATRE**

Session Chair: Michael Vecchione

- 1:20 HETEROCHRONY IN THE FAMILY ONYCHOTEUTHIDAE
K. Tsuchiya
- 1:40 PHYLOGENETIC ANALYSIS OF RELATIONSHIPS AMONG THE LOLIGINID SQUIDS
(MYOPSIDA: LOLIGINIDAE) BASED ON MORPHOLOGICAL DATA
F. Anderson
- 2:00 ADAPTIVE ALLOMETRY OF THE BRACHIAL CROWN: SELECTION PRESSURES IN THE
PELAGIC BIOMASS SPECTRUM?
P. Rodhouse and U. Piatkowski
- 2:20 SHELL DRILLING LOCATION IN OCTOPUSES: LEARNED SPECIALIZATION OR PRESET
EVOLVED BEHAVIOR?
R. Anderson and J. Mather

MONDAY, JUNE 12

7:30-8:30 a.m. Breakfast: Hale Kehau

**CONCURRENT SESSIONS (see facing page)
CONSERVATION SYMPOSIUM: CLASSROOM**

Convener: Elaine Hoagland
Session Chair: Elaine Hoagland

9:00 KEYNOTE ADDRESS

Elliot Norse, Center for Marine Conservation

9:40 CONSERVATION AND MARINE MOLLUSKS: IS IT POSSIBLE?

E. Alison Kay

10:00 Break: Campus Center Lanai

10:20 SETTING PRIORITIES FOR THE CONSERVATION OF LAND SNAIL FAUNAS

J. Heller and U. Safriel

10:40 CAPTIVE BREEDING AND THE POTENTIAL TO ESTABLISH NEW FIELD POPULATIONS OF HAWAIIAN TREE SNAILS

M.G. Hadfield, L. Hadway and D. Hopper

11:00 TREE SNAILS, TROPICAL STORMS AND DROUGHT IN THE MARIANA ISLANDS

Barry Smith

11:20 THE SAMOAN LAND, FRESH- AND BRACKISH WATER SNAIL FAUNA: DIVERSITY, STATUS AND PROSPECTS

Robert H. Cowie, S.E. Miller, A.C. Robinson, and B.D. Smith

11:40 MOLLUSK CONSERVATION AND ECOSYSTEM MANAGEMENT IN THE WESTERN UNITED STATES

Terrence Frest and Barry Roth

12:00 Lunch: Hale Kehau

MONDAY, JUNE 12

**CONCURRENT SESSIONS (see facing page)
CONSERVATION SYMPOSIUM II: CLASSROOM**

Session Chair: Terrence Frest

1:20 THE CONSERVATION OF FRESHWATER MOLLUSKS: AN ESSENTIAL INITIAL PROCEDURE USING UNIONID CLAMS AS AN EXAMPLE

George M. Davis

1:40 CONSERVATION AND STATUS OF FRESHWATER MUSSELS (UNIONACEA): THE SILENCE OF THE CLAMS

Kevin S. Cummings

2:00 CONSERVATION OF SPRINGSNAILS IN THE GREAT BASIN: SIMPLE SOLUTIONS COMPLICATED BY POLITICAL REALITIES

Robert Hershler

2:20 FEDERAL EFFORTS TOWARDS THE CONSERVATION OF MOLLUSKS

Donna D. Turgeon

(continues on page 18, bottom)

(continuation from page 16)

CONCURRENT SESSIONS (see below)
CEPHALOPOD SYMPOSIUM III: THEATRE

2:40 DISTRIBUTION AND ASSEMBLAGE PATTERNS OF PELAGIC CEPHALOPODS AT
FRONTAL ZONES IN THE CENTRAL AND NORTH PACIFIC OCEAN

M. Seki

3:00 Break: Theatre Lanai

3:20 BIOLOGICAL AND OCEANOGRAPHIC FACTORS AFFECTING THE DISTRIBUTION OF
OCTOPUSES IN SOUTHERN AUSTRALIA AND NEW ZEALAND

T. Stranks

3:40 THE BENTHIC OCTOPUS FAUNA OF THE HAWAIIAN ISLANDS ARCHIPELAGO

F. Hochberg and M. Norman

6:00-7:00 **Pau Hana Dinner:** Marriott Dining Room

TUESDAY, JUNE 12

7:00-8:00 a.m. Breakfast: Hale Kehau

ALOHA !

(continuation from page 17)

CONCURRENT SESSIONS (see above)
CONSERVATION SYMPOSIUM: CLASSROOM

2:40 THE ROLE OF THE AMATEUR IN CONSERVATION

Gary Rosenberg

3:00 Break: Campus Center Lanai

3:20 INTERNATIONAL ASPECTS OF MOLLUSCAN CONSERVATION

Mary Seddon

3:40 **CONSERVATION COMMITTEE MEETING**

6:00-7:00 **Pau Hana Dinner:** Marriott Dining Room

TUESDAY, JUNE 12

7:00-8:00 a.m. Breakfast: Hale Kehau

ALOHA !

POSTERS

The posters will be displayed in the Room 301, Campus Center, Third Floor.

HAWAII'S NATURAL AREA RESERVES SYSTEM

Betsy Harrison Gagné

PARAPHYLY IN MOLLUSCA

Claus Hedegaard

ULTRASTRUCTURAL ASPECTS OF THE MANTLE OF COWRIES AS SEEN BY TRANSMISSION ELECTRON MICROSCOPY: THE MANTLE EDGE

Don E. Hemmes and Brian N. Tissot

ILLEX AFC-BASED SPECIATION MODEL: CONSEQUENCES FOR SYSTEMATICS

Marek R. Lipinski

A VIEW OF THE BOTTOM FROM THE TOP: MARINE MICROMOLLUSKS AS TOOLS IN BENTHIC MONITORING

Regina Kawamoto, Dwayne Minton, Fabio Moretzsohn and E. Alison Kay

MINERALOGY OF GASTROPOD SHELLS: A RAPID TECHNIQUE FOR SYSTEMATICS AND PHYLOGENY

Paula M. Mikkelsen

COMPARATIVE ZOOGEOGRAPHY OF THE OPISTOBRANCH FAUNA OF ALASKA AND THE MAGELLANIC FAUNAL PROVINCE

Sandra Millen

HELIX ASPERSA LEAD EXPOSURE HISTORY AND POSSIBLE ADAPTATION: SHELL COMPOSITION, CONCHOLOGY, AND GENETICS

Michael C. Newman, Margaret Mulvey, and Alan Beeby

Additionally, there will be a computer demonstration:

DEMONSTRATION OF ONLINE ACCESS TO THE CEPHALOPOD COMPUTERIZED BIBLIOGRAPHIC SYSTEM

Michael Sweeney, Clyde Roper, and Michael Vecchione

ADAMKEWICZ, Laura, George Mason University, Fairfax, VA 22030, **HARASEWYCH, M.G.**, National Museum of Natural History, Smithsonian Institution, Washington, DC 20560, and **BULT, Carol**, The Institute for Genomic Research, 932 Clopper Road, Gaithersburg, MD 20878.

A MOLECULAR PHYLOGENY OF THE BIVALVIA.

We have sequenced the gene for 18s ribosomal RNA, and in many cases also the gene for elongation factor 1-alpha, in 15 bivalves and in representatives of three other molluscan classes as well as three other phyla. Such an extensive data set permits comparisons among phylogenies from several sources: *a*) those based on each gene individually *b*) phylogenies from *a* with those based on combined sequence and *c*) phylogenies from *a* and *b* with previously published ones derived from morphological data. These comparisons make the evolutionary positions of the conchifera and the bivalvia much clearer than phylogenies derived from single sources of information.

ANDERSON, Frank E., Department of Biology, The University of California, Santa Cruz, CA, 95064.

A PHYLOGENETIC ANALYSIS OF RELATIONSHIPS AMONG LOLIGINID SQUIDS (MYOPSIDA: LOLIGINIDAE) BASED ON MORPHOLOGICAL DATA.

This study is the first cladistic analysis of relationships among species of the cephalopod taxon Loliginidae - a speciose group of commercially important neritic squids. More than seventy morphological characters were gathered from literature searches and direct study of museum lots and coded into a data matrix for cladistic analysis. Forty-eight described loliginid species were included in the analysis. To test the hypothesis of loliginid monophyly, the analysis also included *Pickfordiateuthis pulchella*, *Ctenopteryx*, and *Bathyteuthis* (all putative close relatives of Loliginidae), and a diversity of other cephalopod groups such as *Rossia*, *Octopus*, *Todarodes*, *Moroteuthis*, *Berryteuthis*, *Sepia* and *Nautilus*. Characters examined include aspects of photophore, hectocotylus and fin morphology, sucker ring dentition, and gladius and neural characteristics. These data were analyzed with a maximum-parsimony algorithm (PAUP 3.0).

The results of this analysis will highlight potential problems in loliginid taxonomy and phylogeny. This study also sets the basis for a broader examination of relationships among loliginid squids, which will include molecular sequence data and behavioral characteristics for selected taxa.

ALLCOCK, A. Louise and **THORPE, John P.**, Department of Environmental and Evolutionary Biology, The University of Liverpool, Port Erin Marine Laboratory, Port Erin, Isle of Man; **RODHOUSE, Paul G.** and **BRIERLEY, Andrew S.**, British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge CB3 0ET, United Kingdom.

RESTRICTED GENEFLOW AND RECENT EVOLUTIONARY DIVERGENCE BETWEEN GEOGRAPHICALLY SEPARATED POPULATIONS OF THE ANTARCTIC OCTOPUS *Pareledone turqueti*.

The shelf dwelling Southern Ocean octopus *Pareledone turqueti* is pandemic amongst the islands of the Scotia Ridge. Three demes, two from opposing ends of South Georgia Island and one from the adjacent island, Shag Rocks, were subjected to standard allozyme electrophoretic techniques to test the null hypothesis of panmixia. Pairwise F-statistic analyses indicated extensive gene flow around South Georgia but restricted geneflow between South Georgia and Shag Rocks. These results are consistent with predictions of larval dispersal based on knowledge of local current patterns. Further analyses using measures of genetic distance and migration rates lead us to infer that effective population sizes are high. This conclusion supports data from net hauls and seal stomach content analyses that suggest a *P. turqueti* fishery would be commercially sustainable

ANDERSON, Roland C., The Seattle Aquarium, 1483 Alaskan Way, Seattle, WA 98101 and **MATHER, Jennifer A.**, University of Lethbridge, Lethbridge, Alberta, Canada T1K 3M4

SHELL DRILLING LOCATION IN OCTOPUSES: LEARNED SPECIALIZATION OR PRESET EVOLVED BEHAVIOR?

When faced with hard-shelled prey octopuses often drill a hole with the assistance of the salivary papilla and inject a neurotoxin, presumably weakening the prey for easy access. Studies have demonstrated that octopuses select particular locations on *Nautilus*, gastropods, and bivalves in which to drill holes, presumably based on access to vulnerable areas. Paradoxically, our recent study suggests that drill hole location may also be species-typical. Drill holes of *Octopus dofleini* in clams are central, those of *O. rubescens* are anterior or posterior over muscle attachments inside the shell. These contrast with other data from Mediterranean *O. vulgaris* showing drill holes on the dorsal margin. Possible reasons for the evolution of location-specific drilling will be discussed, as well as the combination of preprogramming and learning which sets limits on a behavior.

ASHIRIN, Z. S., IBRAHIM, M. and KAWAMURA, G. Fisheries and Marine Science Center, 21030, Mengabang Telipot, Kuala Terengganu, Malaysia.

THE MALAYSIAN SQUID FISHERY: A BRIEF OVERVIEW.

The recognition of the growing importance of cephalopod fishery in Malaysia in the past ten years have resulted in a substantial production. This paper highlights and reviews the exploitation of squid in Malaysian waters using available statistical data, review papers, past and current researches that deal directly or indirectly with squids. Also discussed is the capture techniques. At present the major gears used to harvest squids are bottom trawls for demersal fishing, purse seines, squid cast nets and jigs aided with lights for night pelagic fishing. Necessary studies for rational squid fishery management which include regulation for traditional fisheries and non-traditional fishing methods are also proposed. It is expected that modification in harvest and handling technology will occur in the coming decade. Increase in landing may be anticipated due to improvements in capture strategy.

AVILA, Conxita, KUZIRIAN, Alan M., and TAMSE, Catherine T. Marine Biological Laboratory, Woods Hole, MA 02543.

METAMORPHIC INDUCTION IN *Hermisenda crassicornis* LARVAE

In the last two decades *Hermisenda crassicornis* (Mollusca, Nudibranchia) has been used as a model system for biomedical and neurobiological research. However, many aspects of larval competence and metamorphosis are still unknown. Metamorphic yields in laboratory culture have been increased from the previous 2-5% to about 12% in our experiments using several artificial inducers. Metamorphic habituation in *Hermisenda* to the natural inducer, *Tubularia crocea* (its laboratory prey) was also observed.

Some of the metamorphic inducers, when used together, significantly increased the metamorphic success up to 37.5%. Among the best combinations were the natural inducer (*Tubularia*) with (\pm)-epinephrine (10^{-5} M), or with glutamate (10^{-4} M), or with magnesium chloride (20 mM).

Positive results for the induction of metamorphosis in *Hermisenda crassicornis* larvae with several neurochemicals indicate that the larval nervous system is implicated in detecting the natural inducer and in the internal mediation of metamorphosis.

(Supported by NIH-RR03820 grant to A.M.K. and Spanish Government Postdoctoral fellowship to C.A.).

ASHIRIN, Z.S., KAWAMURA, G. and IBRAHIM, M., Fisheries and Marine Science Center, 21030, Mengabang Telipot, Kuala Terengganu, Malaysia.

FEEDING CHRONOLOGY OF A SQUID, *Loligo edulis* UNDER SURFACE FISHING LAMPS

A feeding chronology of a commercially important squid, *Loligo edulis* was studied in the coastal waters off Kuala Terengganu, Terengganu, Malaysia. The study was conducted from April to July 1994 during a full, quarter and new moon phases on squid caught by traditional jiggers and commercial purse seiners. Fishing operations were carried out from sunset until the twilight of the following morning. The time of catch was divided into four periods for the jigging operations and three periods for the purse seine operations. Measurements on size (DML), identification of fullness and digestion condition of the stomach of individual squid were done immediately it was taken on board. Fullness recency of feeding was resolved from stomach fullness and digestion indices. The percentage of fullness recency histograms were compiled for full, quarter and new moon periods. The feeding state A, not recently eaten and empty was significantly higher during the early part of the nights (1900hrs to 2100hrs) as compared to feeding state B, recent but not full, C, recent and full and D, full but not recently eaten. The percentage of all feeding states were about equal during mid-night (0001hrs to 0300hrs). Detailed feeding chronology and the relationship between feeding states and moon phases are emphasized in the results.

AVILA, Conxita, PAUL, Valerie J. University of Guam Marine Laboratory, Mangilao, Guam 96923

DISTRIBUTION OF DIET-DERIVED METABOLITES AND CHEMICAL DEFENSE IN THE NUDIBRANCH *Glossodoris pallida*

Glossodoris pallida (Mollusca, Nudibranchia) possesses chemical compounds obtained from the diet and transformed (Rogers and Paul, 1991). It was our aim in this study to find out if the compounds were strategically located in the nudibranch body, as well as if they were present in their mucous secretion. The analysis of the distribution of the metabolites in the different body parts indicated an accumulation of compounds in the border of the mantle, as well as the presence of the metabolites in the secretion. Several experiments were conducted in order to establish a relationship between the location of the compounds and the nudibranch chemical defense, using artificial diets as well as animals with and without the border of the mantle.

The chemical compounds from the border of the mantle were deterrent when tested at their natural concentration. We present evidence that the accumulation of the compounds in the border of the mantle (where the mantle dermal formations (MDFs) are located) plays an essential role in the defense of the nudibranch, both in the field against several species of predatory reef fish and in the laboratory against *Leptodius* spp. crabs.

(Supported by NIH/MBRS GM44796 grant to V.J.P. and a Spanish Government Postdoctoral fellowship to C.A. at the M.B.L., Woods Hole, MA 02543)

BARNES, Penelope A.G. and WEIGT, L.A., Smithsonian Tropical Research Institute, P.O. Box 2072, Balboa, Republic of Panama.

ALLOZYME ANALYSIS OF LUCINID BIVALVES FROM THE CARIBBEAN COAST OF PANAMA SUPPORTS SPECIES BOUNDARIES DEFINED USING SHELL MORPHOLOGY

All members of the bivalve family Lucinidae examined, to date, form obligate symbioses with chemoautotrophic, sulphide-oxidizing bacteria. As part of an investigation into host/symbiont specificity, 9 sympatric species of lucinid bivalve were collected from shallow-water, seagrass bed sediments along the Caribbean coast of Panama. Specific identification was based on shell morphology but proved difficult for some juvenile specimens. Specimens were analyzed using allozyme electrophoresis; 24 enzymes were tested, resulting in 9 reliable loci. Diagnostic alleles were found for all species, enabling accurate identification of juveniles. Results of the allozyme analysis supported the species boundaries established using shell morphology but were not informative in regard to generic boundaries. It is clear that the systematics of the family would benefit from a phylogenetic analysis using DNA sequence data, morphometric analysis following re-examination of shell characters and the incorporation of data on soft morphology.

BIELER, Rüdiger, Field Museum of Natural History, Chicago, IL 60605

PATTERNS OF DISTRIBUTION IN A GASTROPOD GROUP WITH TELEPLANIC LARVAE: ARCHITECTONICOIDEA IN THE INDO-PACIFIC

Most members of the Architectonicoidea (Architectonicidae and Mathildidae), a small clade of marine "lower heterobranchs," are known or suspected to have long-distance larval dispersal capabilities. There are species- and genus-specific differences in protoconch (larval) size and morphology. Using species-level data from their worldwide distribution, their fossil record, and from the distribution of their prey organisms, several questions are addressed:

Do species with larger larval shells (reflecting longer feeding periods in the plankton) have larger ranges? What are the reasons for "centers of diversity" in this group? Can there be "endemic species" among long-distance dispersers?

Current species-level patterns of architectonicoidean distribution are explained as resulting from a combination of vicariance, dispersal ability, and extinction.

BAUMAN, Scott, Marine Laboratory, University of Guam, Mangilao GU 96923

EVOLUTION, DIVERSITY AND DECLINE OF LAND SNAILS IN THE MARIANA ISLANDS

The land snails of the Southern Mariana Islands, with emphasis on Guam and Rota, are reviewed on the basis of recent collections of living and subfossil material, and literature records. New collections, especially of subfossil specimens, add numerous new records, and allow for the evaluation of the validity of taxa recorded from the Marianas in the literature.

Among taxa that have been critically reviewed in the past (e.g. Partulidae, Helixarionidae), a large fraction of species have ranges spanning more than one island, a situation that is atypical among Pacific land snail faunas where single-island endemics predominate. Nevertheless there is evidence for intra-island speciation in some groups. Broad species distributions could be the result of wind transport due to the archipelago's location in the western Pacific typhoon trough. The hypothesis that Mariana land snails tend to have greater ranges than land snails on Pacific plate high islands is evaluated with the entire known fauna.

Numerous species are known only from subfossil or historical records and were not collected alive in this survey, indicating that the land snail fauna of the Southern Marianas has been recently devastated. Operculate species appear to have undergone lesser declines than non-operculate land snails.

BONNAUD, Laure, and BOUCHER-RODONI, Renata, Biologie des Invertébrés marins et Malacologie, URA 699 CNRS, MNHN, 55 rue Buffon, 75005 Paris, and **MONNEROT, Monique**, Centre de Génétique moléculaire, CNRS, 91198 Gif-sur-Yvette, France.

RELATIONSHIP OF SOME COLEOID CEPHALOPODS ESTABLISHED BY CYTOCHROME OXIDASE III GENE SEQUENCE COMPARISON.

Phylogenetic relationships for extant Cephalopods have been based, so far, mainly on morphology and paleontology. Nucleotide sequence data are still rare. Sequence analyses from the 3' end of the 16S rDNA gene of Cephalopods showed that this portion of gene can bring valuable information on taxonomic relationships at the infrafamilial level (Bonnaud et al., 1994). Another mitochondrial gene, the cytochrome oxidase III, is investigated to analyse higher taxonomic levels (i.e. order). Amino acids, as well as nucleotide sequences are considered in 18 species, belonging to 13 genera. The phylogenetic analysis takes thus into account 1 vampyromorph, 2 octopods (1 octopodid, 1 eledonid) and 15 decapods (3 sepiids, 2 sepiolids, 1 idiosepiid, 1 spirulid, 4 loliginids, 2 enoploteuthids, 2 ommastrephids).

The structure of Cephalopods CoIII sequence is compared with that of other Invertebrates.

BOUCHER-RODONI, Renata, and BONNAUD, Laure, Biologie des Invertébrés marins et Malacologie, URA 699 CNRS, MNHN, 55 rue Buffon, 75005 Paris.

BIOCHEMICAL AND MOLECULAR APPROACH TO CEPHALOPOD PHYLOGENY

According to the hierarchical level considered, various biochemical and molecular approaches can be used to try to establish reliable phylogenetic relationships among Cephalopods. Protein electrophoresis and immunology studies provide distances matrices, not always easy to interpret in phylogenetic terms. Nucleic acid sequencing is a very promising approach. But a series of prerequisite must be kept in mind: the variability of the primary sequence of the selected gene portion must be congruent with the taxonomic problem (the same gene does not provide the same information according to the taxonomic level, and the supposed divergence date), possibly more than one gene should be analyzed, the choice of specimen number and taxonomic group is crucial.

A series of examples of biochemical and molecular results bringing new information on taxonomic and phylogenetic relationships among some Cephalopod groups (Sepioids, Vampyromorphs, Spirulids) are presented.

BRIERLEY *, Andrew S., ALLCOCK, A. Louise, THORPE, John P. and CLARKE, Malcolm R., Port Erin Marine Laboratory, Department of Environmental and Evolutionary Biology, University of Liverpool, Isle of Man, IM9 6JA, British Isles. (* Current address: British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, U.K.)

THE VALIDITY OF THE GENUS *Photololigo*: A GENETIC PERSPECTIVE.

Confusion abounds regarding the relative generic status of many member species of the family Loliginidae. In 1984 a taxonomic reorganization within the family was proposed in which loliginids possessing photophores on the ink sac, including the then named *Loligo chinensis* and *Loligo edulis*, were removed to a newly created genus *Photololigo*. This system of classification has not however gained universal acceptance, and papers published as recently as 1993 continue to refer to these species as *Loligo*. Here biochemical genetic data are presented supporting the assertion that *Loligo edulis* and *Loligo chinensis* should indeed be positioned in a genus distinct to that typified by the type *Loligo vulgaris*. These species are shown to be as genetically distant from *Loligo vulgaris* as are members of the genera *Alloteuthis*, *Uroteuthis* and *Sepioteuthis*.

BOWER, John R., and SAKURAI, Yasunori, Faculty of Fisheries, Hokkaido University, Hakodate, Hokkaido, 041, Japan.

LABORATORY OBSERVATIONS OF EGG MASSES OF THE JAPANESE COMMON SQUID, *Todarodes pacificus* (CEPHALOPODA: OMMASTREPHIDAE).

The Japanese common squid, *Todarodes pacificus*, is a commercially important fishery resource in Japan, occurring throughout Japanese coastal waters, yet little is known about its reproductive characteristics. To date, there have been no observations of egg masses of *T. pacificus* in the natural habitat. This is the first description of a spherical egg mass spawned by *T. pacificus* under laboratory conditions.

Adult specimens of *T. pacificus* were collected by jigging from the inshore waters of southern Hokkaido and transferred to a raceway tank where they matured and mated. Two egg masses were discovered on day 24 of captivity. After hatching, daily observations were made of the behavior of the paralarvae.

Visual observation of the larger egg mass spawned by a captive female of 27 cm in DML indicate that *T. pacificus* can produce nearly spherical gelatinous egg masses up to 80 cm in diameter with approximately 200,000 eggs. Egg masses were nearly neutrally buoyant. Examination of the egg mass surface layer revealed that the outer nidamental gland gel was effective in preventing crustaceans, protozoans, and bacteria from entering the egg mass. Hatching occurred after 6-7 days at 18-19°C. Paralarvae actively swam immediately after hatching, with many individuals seen swimming at the surface layer. The egg masses disintegrated soon after hatching. All paralarvae died after approximately six days, presumably due to starvation.

BRIERLEY *, Andrew S., CLARKE, Malcolm R. and THORPE, John P., Port Erin Marine Laboratory, Department of Environmental and Evolutionary Biology, University of Liverpool, Isle of Man, IM9 6JA, British Isles. (* Current address: British Antarctic Survey, Natural Environment Research Council, High Cross, Madingley Road, Cambridge, CB3 0ET, U.K.)

Ctenopteryx sicula, A BATHYPELAGIC LOLIGINID?

Ctenopteryx sicula is an open-eyed, deep water inhabitant and as such has traditionally been classified in the suborder Oegopsida (family Ctenopterygidae) along with other families of squid exhibiting these characteristics. *Ctenopteryx sicula* however displays numerous morphological features, including fused axons in the giant nerve fibre system and accessory nidamental glands, found otherwise only within members of the myopsid families Loliginidae and Pickfordioteuthidae. This has lead previous authors to suggest that *Ctenopteryx* species would be more appropriately placed in the sub-order Myopsida. Here biochemical genetic evidence is presented which shows *Ctenopteryx sicula* to be more closely related to several loliginid species than to member species of the Oegopsid families Histiototeuthidae, Ommastrephidae and Enoploteuthidae. This data, in conjunction with new data on comparative beak morphology, also suggests that *Ctenopteryx sicula* should in fact be considered an oceanic myopsid species.

CAMERON, Robert A. D., Division of Adult Continuing Education, University of Sheffield, 196-198 West Street, Sheffield, S1 4ET, UK and **COOK, Laurence M.**, The Manchester Museum, Manchester, UK.

DIVERSITY AND DURABILITY: RESPONSES OF THE MADEIRAN AND PORTO-SANTAN SNAIL FAUNAS TO NATURAL AND HUMAN-INDUCED ENVIRONMENTAL CHANGE.

The snail fauna of the Madeiran Archipelago shows all the characteristics of oceanic island faunas: taxonomic imbalance at higher levels, high regional diversity and endemism, and high species and genus differentiation between islands. It is unusual in two respects: the existence of good Pleistocene/Holocene fossil records, and the apparent durability of the endemic fauna in the face of massive human disturbance and the introduction of non-indigenous species.

We use the fossil record, the present microdistribution of species and the environmental records available to track the generation of diversity and the response to human disturbance. The nature of the environment available and life-habits of endemic species appear to account for the relative resilience of endemic species.

COELHO, Maria L. (1), DOMINGUES, Pedro (1), BALGUERÍAS-GUERRA, Eduardo (2), ANDRADE, Pedro (1). (1) Universidade do Algarve, U.C.T.R.A., Campus de Gambelas, 8000 Faro, Portugal (2) I.E.O. Centro Oceanográfico de Canarias. Carretera de San Andrés, s/n, 38120 Santa Cruz de Tenerife, Islas Canarias, España.

A COMPARATIVE STUDY OF THE DIET OF *Loligo vulgaris* (LAMARCK, 1799) (MOLLUSCA: CEPHALOPODA) IN THE SOUTH COAST OF PORTUGAL AND THE SAHARAN BANK (CENTRAL-EAST ATLANTIC).

This work presents data on the diet of the squid *L. vulgaris* (Lamarck, 1799) in the Algarve (South Coast of Portugal) and in the Saharan Bank.

A total of 964 squid were captured in the Algarve coast, between March 1993 and October 1994 with bottom trawling. An additional sample of 70 stomach contents was obtained from the hand jigging fishery during 1991 and 1992. In the Saharan Bank, 848 squid were obtained, between June 1993 and January 1994. The composition of the diet was determined by stomach content analysis, preys being identified to the lowest taxon, as accurately as possible.

Stomachs with contents were 28.1% in the Algarve (bottom trawling) and 40.8% in the Saharan Bank. Fish were always the main component of the diet for both regions, representing 88.6% of the total weight of the preys found in the stomachs, for the Algarve (bottom trawling), and 70.9% for the Saharan Bank. *Trachurus trachurus* (occurring in 7.7% of the stomachs with content) and fish belonging to the Family Gobiidae (4.4%) were the most frequent fish found in the Algarve samples, while flat fish (9.9%) were the most common fish in the Saharan Bank samples. *L. vulgaris* (cannibalism) was the dominant cephalopod found in the stomachs for both regions, being present in 2.6% of the stomachs in the Algarve and 9.2% for the Saharan Bank. No differences in the diet were found between males and females. The comparison of the diet between immature and mature squid indicated that the importance of fish increases with growth, for both regions. The squid captured in the Algarve coast with bottom trawling fed mainly on fish, and those captured with hand jigging included an important percentage of crustaceans in their diet.

CLARKE, Bryan, Department of Genetics, University of Nottingham, Queens Medical Centre, Nottingham NG7 2UH, U.K.

THE EVOLUTION AND EXTINCTION OF *Partula*

Land snails of the genus *Partula* have been exceptionally productive of information about evolution in general, and speciation in particular. I will briefly review the work on species from the island of Moorea, French Polynesia, and pay particular attention to a very puzzling cline in the genetic distance between two sympatric species (*P. taeniata* and *P. suturalis*). The pattern of differentiation leads to the suggestion that where there is sympatry, neutral genes may be inappropriate material for revealing phylogeny. I will also discuss the recent extinctions of Moorean and other Partulae, telling the story of their captive breeding and re-introduction to Moorea.

COWIE, Robert H., Bishop Museum, P.O. Box 19000, Honolulu, HI 96817-0916.

DETERMINANTS OF DIVERSITY IN PACIFIC LAND SNAILS: BEYOND THE SPECIES-AREA RELATIONSHIP

In general, within archipelagos in the Pacific, the number of recorded land snail species on individual islands is related to island area, and in some cases also to island altitude, island age, habitat diversity, and to the amount of scientific study of each island. Differences between archipelagos may relate to the geographic isolation of an archipelago and the extent of evolutionary radiation in situ within that archipelago. The latter factor especially has confounded previous attempts to detect Pacific-wide patterns. Nevertheless, there does seem to be an underlying pattern relating numbers of species to island area Pacific-wide. The challenge is to develop models that incorporate all the variables and reflect their relative importance.

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THE SAMOAN LAND, FRESH- AND BRACKISH WATER SNAIL FAUNA: DIVERSITY, STATUS AND PROSPECTS

The native Samoan land snail fauna is composed of just over 100 nomenclaturally valid species. About two thirds of these are pulmonates, one third are operculate snails. About 15 non-native land snail species have also been recorded. The fresh- and brackish-water fauna of about 40 nomenclaturally valid species is dominated by Neritidae and Thiariidae, but the status of many of these as native or introduced is not clear. Habitat destruction, extensive collecting, and the introduction of alien predators have all contributed to the decline of the fauna, especially the land snails. Recent surveys in both American and Western Samoa have been undertaken to ascertain their current status and identify possible conservation measures. The alien carnivorous snails, especially *Euglandina rosea*, that have been introduced to the islands of Tutuila and Tau in misguided attempts to control *Achatina fulica* have as yet not been introduced more widely. A captive breeding program has been started for the highly endangered partulids on Tutuila.

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THE CONSERVATION OF FRESHWATER MOLLUSKS: AN ESSENTIAL INITIAL PROCEDURE USING UNIONID CLAMS AS EXAMPLE.

It is essential to know the distribution, numbers of populations, and patterns over time to understand the present situation for a state or a region. A rational first step is to computerize museum records from all relevant museums so that distributions can be plotted on drainage systems for different lenses of time. When this is done, a number of realities become evident: 1) A river was ecologically destroyed 50 years ago and can no longer support life; 2) a species once widely distributed is apparently now found in one or two streams; 3) another species was never common in a state; 4) one species is only found in a stream with a restricted set of chemical parameters; 5) all species ranges have become reduced with x-number extinct in some states, or totally extinct.

With these data in hand one can rationally plan where a survey is needed to assess current status and then plan short term and long term conservation and recovery measures.

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CONSERVATION AND STATUS OF FRESHWATER MUSSELS (UNIONACEA): THE SILENCE OF THE CLAMS

Freshwater mussels may be the most endangered group of organisms on earth. In North America there are 297 species and subspecies of freshwater mussels of which 213 (72%) are imperiled. Of those 297 taxa, 21 (7%) are considered extinct, 77 (26%) are endangered, 43 (15%) threatened, 72 (24%) of special concern, 14 (5%) are listed as undetermined, and only 70 (23%) are considered to be currently stable. The factors responsible for the decline in aquatic species include loss of habitat, siltation, creation of impoundments, channelization, commercial harvest, chemical pollution, and competition from nonindigenous species, especially the zebra mussel, *Dreissena polymorpha*.

Most habitat preservation efforts since the turn of the century have focused on terrestrial ecosystems, with almost no attention given to aquatic systems, particularly streams. Streams are being degraded or destroyed at an alarming rate, resulting in a decline in aquatic biodiversity far greater than that documented for terrestrial species. In Illinois, over 30% of all threatened or endangered species (plants and animals) are associated with aquatic habitats, including more than 61% of all state listed animal species. Over 100 streams or stream segments have been designated as Illinois Natural Areas, based on distributional data of state listed mussels, crayfishes, and fishes. The Natural Areas designation provides some legal protection against modification or destruction and may prove to be a useful tool in freshwater mussel conservation.

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PHYLOGENY OF THE *Columbella* AND *Pyrene* GROUPS (NEOGASTROPODA: COLUMBELLIDAE) IN THE NEOGENE AMERICAN TROPICS: UNANSWERED QUESTIONS AND UNQUESTIONED ANSWERS.

One of the most significant events in the history of the American tropics was the gradual closure of the Panamanian Isthmus, approximately 3.5 million years ago. Many studies have addressed the patterns of change in Neogene transisthmian marine faunas during this event, primarily through biostratigraphic censuses. However, the evolutionary histories of the included taxa have generally not been evaluated from within a phylogenetic framework, and remain poorly understood.

Preliminary cladistic phylogenies are presented for a portion of the neogastropod family Columbelloidae, including the extant tropical American species of the *Columbella* and *Pyrene* groups. Characters have been drawn from soft anatomy and shell microstructure, as well as conchological and radular morphology. Both of these groups appear to have diverged early in the history of the family, and have existed independently in the American tropics throughout the Neogene.

The preliminary cladograms have several implications for the evolution of tropical American taxa. First, the trees suggest close evolutionary relationships between columbellid taxa in the American tropics and the Indo-west Pacific, contrary to traditional classifications. The trees also suggest patterns of divergence within the tropical American crown groups through the closure of the Panamanian Isthmus, including the number of clades contributing to diversity on both sides of the Isthmus, and the morphological and ecological changes that have occurred within these lineages.

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PHYLOGENETIC AND HIERARCHICAL CLASSIFICATION OF THE FOSSIL COLEOIDEA (CEPHALOPODA)

The Coleoidea (Early Devonian to Recent) are a monophyletic grouping within the Cephalopoda whose monophyly can be demonstrated with several autapomorphies (inner shell, thin rostrum, ink sac, lens eyes, fins etc.) (Berthold & Engeser, 1987, Engeser, 1990). They can be subdivided into two sister-groups, the Belemnoida and the Dibranchiata. The Belemnoida are characterized by the presence of a closing membrane which seals off the first chamber, and the presence of typical belemnoid hooks arranged in 10 to 40 pairs arranged in double rows on all ten subequal arms. The belemnoid hooks are a convergency to the hooks of Recent oegopsids.

The Dibranchiata alternatively developed suckers for grasping prey. Two major clades can be recognized: the Octobranchia modified the 2. arm pair and reduced the phragmocone to a gladius, the Decabranchia modified the 4. arm pair into tentacles and developed suckers with horny rings. Within the Octobranchia two groups may be distinguished: the Vampyromorpha and the Octopoda. The Decabranchia split into the Uniductia (Spirulida + Myopsida) and the Oegopsida. The main focus of the report, however, is on fossil groups.

This phylogenetic scheme is adapted to a hierarchical classification and compared with more recent ideas about the phylogeny and hierarchical classifications of the Coleoidea (Khromov, 1990, Doyle et al., 1994).

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MOLLUSK CONSERVATION AND ECOSYSTEM MANAGEMENT IN THE WESTERN UNITED STATES

Recent strong efforts to apply the principles of ecosystem management to federal forest and range lands in northern California, Idaho, Oregon, and Washington have included evaluation of the region's freshwater and terrestrial mollusk fauna, and some provision for its conservation. Within the range of the Northern Spotted Owl we suggested designation of some 108 mollusk taxa as sensitive species. Forest Service and BLM planners have subsequently slated 43 taxa for special protection. A similar effort has been made within the limits of the Interior Columbia Basin. Some 187 taxa in this region are regarded as sensitive species, almost equally divided between freshwater and land forms.

Our analysis was not limited to described species. We estimate that about 50% of existing taxa have been formally described. Perhaps 35% should be considered sensitive and in some danger of extinction. Many are concentrated into relatively small areas of endemism. There is considerable geographic overlap of land and freshwater endemic clusters. Frequent endemism is a feature of a relatively small number of genera, notably *Vespericola* and *Oreohelix* among the shelled forms; the slugs *Hemphillia* and *Prophyaon*; and the hydrobiids *Fluminicola* and *Pyrgulopsis*.

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OBSERVATIONS ON THE REPRODUCTION OF *Bifurcium bicanaliferum* (SOWERBY, 1832) FROM THE PACIFIC COAST OF PANAMA (GASTROPODA, COLUMBELLIDAE, STROMBINA GROUP).

Bifurcium bicanaliferum is the only living species of the genus and it is a Pacific restricted species. The egg capsules are deposited attached to the adult shell. In each egg capsule a mean of 25 eggs measuring 150 microns in diameter are deposited. There are no nurse eggs; nevertheless there is evidence of late intracapsular cannibalism. Hatching takes as a free veliger which survives as a swimming larva for at least 10 days in the aquarium. The shell length at hatching is 232 microns and presents 1 ½ volutions. Given that the protoconch of the adult consists of 2 ½ volutions, it seems that an important planktonic period of time must be completed. The mode of development of this species was previously inferred by Jackson et al. (in press) by using the relationship between the maximum diameter of the adult's protoconch and its maximum number of volutions. Our results with live material corroborate the planktonic mode of development. A comparison of the reproductive pattern of *Bifurcium* with two Caribbean *Strombina* which have a lower number of bigger eggs per egg capsule and direct development (Cipriani and Penschaszadeh, 1993, The Veliger, 36: 178-184) show striking differences in their reproductive patterns.

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OBSERVATIONS ON FOSSIL HAWAIIAN LAND SNAILS

The land snails of the Hawaiian Islands comprise an ecologically diverse assortment of mollusks with a high number of endemic species. Many of them are extinct. Field study and published data show that the shells of prehistorically extinct fossil land snails are preserved throughout the islands. Fossil land snails are an outstanding vehicle for biometric and systematic study. The environments in which fossil land snails are found are described and fossil deposits are listed for the islands of Hawaii, Maui, Molokai, Oahu, Kauai, and Niihau.

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BIOGEOGRAPHIC PATTERNS IN AEGEAN NON-MARINE GASTROPODS.

The insular (sub)species of land snails of the Aegean, SE. Europe, show various biogeographic patterns. It is obvious that the actual distribution of water and land in the area cannot explain the observations. To understand for example Boettger's molluscan border-line, between the islands of Antikithira and Kithira, we have to go back to the Miocene configuration.

Continuing tectonical movements and glacially induced sea level changes have influenced the shape of the archipelago again and again. This has resulted in migration, isolation, speciation events, etc. Though the geological data are still far from unequivocal, and much remains to be done in molluscan systematics and phylogeny reconstruction, enough is known to enable comparisons between the supposed geological history of the area and the various biogeographic patterns shown by the land snails.

Some of the most evident repetitive patterns will be shown and discussed, in particular concerning the so-called South Aegean Island Arc, connecting Asia Minor and the Peloponnese. We may conclude a.o. that the actual island of Crete is of a composite nature, and that the connections between the series of islands were broken at different times.

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DEVELOPMENT OF THE GASTROPOD RADULA IN A PHYLOGENETIC CONTEXT

The gastropod radula is a continuously secreted membranous strap of chitin that bears projecting mineralized "teeth." The odontoblasts, a particular group of apocrine cells in the radular sac, secrete the organic matrix that determines tooth shape and size. The odontoblasts are organized as discrete fields. Each field produces organic matrix making up one tooth on the radular membrane.

The adult radula has been used to group different taxa and to understand patterns of relationships between taxa. Traditional terminology has differentiated between three types of teeth based on tooth position and shape: the rachidian, lateral and marginal fields. Despite voluminous literature describing the form and character of the radula, little has been done describing the development of the odontoblastic fields that determine tooth shape and position. The odontoblastic fields, not the "teeth," are the homologous element of the radula.

We present two growth models for three different clades, one for pulmonates and one for caenogastropods and patellogastropods. In the pulmonates, the odontoblasts are large and non-mitotic and tooth addition is by recruitment of totipotent cells. In caenogastropods and patellogastropods, the odontoblasts are small and mitotically active and new tooth fields form through splitting of existing fields. Recognition of homologous odontoblast fields in the radula provides accurate representation of ontogenetic and evolutionary change in the radula complex.

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INDO-PACIFIC OPISTHOBRANCH GASTROPOD BIOGEOGRAPHY: HOW DO WE KNOW WHAT WE DON'T KNOW.

Indo-Pacific opisthobranch gastropod biodiversity is much higher than previously believed. More than 3400 species are known to inhabit the region, including more than 1000 known undescribed species. Distribution patterns remain poorly known. The Hawaiian Islands probably represent the best studied Indo-Pacific Island opisthobranch fauna. Kay's compilation of Hawaiian marine mollusks included 131 opisthobranchs. Presently, more than 430 species are known to occur in Hawaiian waters. More than 40% of the known Hawaiian opisthobranchs appear to be undescribed. A similar percentage of undescribed species is known from other Indo-Pacific islands that have been studied.

Estimates of island, archipelago or plate endemism vary widely. Hawaiian opisthobranch endemism ranges from 5-42%, depending on method of calculation. These ranges are typical of most regions examined. This variation attests to lack of fundamental knowledge of Indo-Pacific distributions.

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CAPTIVE BREEDING AND THE POTENTIAL TO ESTABLISH NEW FIELD POPULATIONS OF HAWAIIAN TREE SNAILS.

Species in imminent danger of extinction from threats which cannot be controlled in nature often must be removed for captive propagation. The goal is the eventual release into the wild of laboratory born individuals to create new populations in areas deemed safe enough for the populations to expand. Captive breeding of endemic Hawai'ian tree snails was initiated with the achatinelline *Partulina redfieldii* in 1986. In 1990 species of the federally listed genus *Achatinella* were added to the captive-breeding effort. By 1995, six *Achatinella* species have been brought to our facility, but for only two species were numbers sufficient to test the effectiveness of the effort: *A. mustelina* and *A. fuscobasis*. After 4-5 years, laboratory numbers of both species have increased more than four fold. Success with a small reintroduction of *P. redfieldii* on Molokai has been encouraging: 10, 6-12 month old, lab-born snails were placed in the field in June 1989; the number declined to three by July 1993, but these snails had become mature and new-born snails were present. In February 1995, there were 17 snails in the release tree, including the three surviving adults and field-born snails in most size classes. An experimental release of *A. mustelina* is now one-year old and results are thus far consistent with those from the *P. redfieldii* release. Captive propagation and field release are useful strategies for conserving endangered Hawai'ian tree snails.

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EVOLUTION OF THE CHROMATOPHORE SYSTEM: A KEY TO UNDERSTANDING THE BEHAVIOR OF COLEOID CEPHALOPODS

The complexity, speed of change, and diversity of appearance of the skin of cephalopods is unmatched in the animal kingdom. The chromatophore system includes: (i) chromatophore organs, iridophores, leucophores, reflector cells, and peripheral nerves in the skin; and (ii) the major brain areas controlling chromatic expression, i.e., the optic, lateral basal, and chromatophore lobes. Direct neural control of chromatophore organs by the brain enables patterning in the skin for many facets of behavior. The photophore system of many cephalopods functions in the same manner. The evolution of the capability to show such rapid "transient polymorphism" sets coleoids apart from ancient cephalopods. Benthic cephalopods in nearshore waters are masters of cryptic coloration, and the mechanisms of crypsis are highly conserved across cephalopod genera and are tuned to the excellent visual capabilities of teleost fishes and mammals that appeared at the same time as coleoids. Furthermore, some secondary defenses such as Deimatic Displays and Flamboyant Displays are also highly conserved. Some of these cryptic body patterns and signalling displays must be very ancient, since the major orders of cephalopods probably diverged some 200 million years ago. A radiograph from a fossil coleoid suggests that the skin was already well developed by the Devonian.

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THE BIOGEOGRAPHY AND EVOLUTIONARY LINES OF ISLAND FRESHWATER *Neritina*.

Neritina is the most widely distributed freshwater genus of the family Neritidae. Ten-eleven species are present in the Java-N.Guinea-Solomon Is.-Fiji region but fewer species are found on islands in the North and East Pacific, the Indian Ocean and the Caribbean. Endemic *Neritina* species have evolved at the extremes of their distribution.

The characters shell-shape, operculum thickness and shape, type of spermatophore and male head with penis were compared in widespread and endemic *Neritina* species.

A genealogical table was drawn to show the proposed lines along which evolution had proceeded. Two separate lines gave rise to endemic species. The widespread brackish water species *Neritina auriculata* with a winged shell had many features in common with the four endemic Hawaiian species, with *N. latissima*, endemic to the Pacific coast of Central America and with one species endemic to the South Pacific. Another widespread, brackish water species, *N. turrita*, without a winged shell was at the base of another line which gave rise to the endemic Indian Ocean species *N. gagates* and the Caribbean species *N. virginea* and *N. punctulata*.

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CHARACTERISTICS OF SUBMARINE CAVE BIVALVES FROM THE NORTHWEST PACIFIC.

[no abstract available]

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BREAK A SHELL AND LEARN - SHELL STRUCTURES REVISITED.

Shell structures, the three dimensional organization of lime and organic material in shells, provide important phylogenetic information, which so far has been largely ignored. Fractured sections of shells from adult mollusks, examined by scanning electron microscopy, reveal one or several layers, each with one of 15-20 different shell structures. Shell structures are invariant within clades and different between clades, and excellently suited for phylogenetic analysis. Some clades are characterized by a homologous sequence of layers, which may be analyzed as other sequential information (DNA, proteins). Aragonitic crossed lamellar structure is probably an apomorphy for the clade Mollusca; intersected crossed platy structure is a vetigastropod apomorphy, whereas columnar nacre is confined to a subclade of the Vetigastropoda; prismatic complex crossed lamellar structure is found in Acmaeidae and Lottidae, foliated structure in Acmaeidae, Nacellidae and Patellidae, calcitic crossed lamellar in Lepetidae and Patellidae. One of the interesting results is that nacre (mother-of-pearl) does not characterize "primitive" gastropods - nacreous gastropods do not occur close to the base of most parsimonious trees, depicting gastropods' inferred descent, nor is there any indication that those actually on early branches (Patellogastropoda) have nacreous ancestors.

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PARAPHYLY IN MOLLUSCA. [poster]

A brief review of the concept of paraphyly will demonstrate its detrimental impact on phylogeny and taxonomy. This will be illustrated by examples of paraphyletic molluscan taxa still in common usage. Paraphyletic taxa, e.g. "Archaeogastropoda," are prominent features of our classic training. This poster is intended as a stimulus to discussion about paraphyly, the alternatives and about the way we do (should do) science, rather than a presentation of elaborate data.

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HITCHHIKING CLAMS: LONG-DISTANCE DISPERSAL OF A SUBANTARCTIC BROODING BIVALVE BY KELP RAFTING

The probability of successful dispersal by sessile benthic invertebrates is thought to strongly influence their geographic distribution and population genetics. Generally, species with long-lived planktonic larvae are expected to exhibit wider distribution patterns than those species which brood their young, due to their presumably greater potential for dispersal. In some cases, however, brooding species exhibit broad distributions and show evidence of genetic exchange with geographically distant populations. One factor that has been invoked as a potential explanation is the dispersal of adults by rafting. Several studies have shown that it is possible for sessile adults to disperse several to many thousand kilometers by rafting on debris in ocean currents. With few exceptions, however, direct evidence of rafting in the open ocean has been lacking. We present evidence of long-distance (1300 to 2000 km) dispersal of a brooding pelecypod, *Gaimardia trapesina*, in the Southern Ocean in the vicinity of Cape Horn, the Falkland Islands, and the antarctic island South Georgia. Data on the abundance and fecundity of *G. trapesina* and the prevalence of kelp rafts suggest that dispersal by rafting can occur over ecologically relevant time scales and could potentially serve as a significant means of genetic exchange between populations.

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SETTING PRIORITIES FOR THE CONSERVATION OF LAND SNAIL FAUNAS.

With 30,000 species of land snail throughout the world and limited resources for conservation, it is necessary to set conservation priorities. We suggest a priority scale for land snail conservation that is based on three groups of criteria:

1. Range-related vulnerability. a). Species with narrow global distribution get higher priority. b). Within a country, species with very narrow ranges get higher priority
2. The genus. a). Higher priority goes to species of a genus with fewer species. b) Within a country, priority goes to species of a local genus.
3. Pragmatic considerations. Some species possess unusual features, that should raise their priority .

For each species, conservation priority within each criterion is expressed in numerical values. The higher the total score, the higher the conservation priority of a given species. We propose application of a universal scoring protocol in which maximum numerical value of the total score is 21.

Our priority scale is simple, can easily be adjusted to fit needs of any country and any change in environmental deterioration.

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ULTRASTRUCTURAL ASPECTS OF THE MANTLE OF COWRIES AS SEEN BY TRANSMISSION ELECTRON MICROSCOPY: THE MANTLE EDGE. [poster]

Pieces of the outer one-two millimeters of the right and left hand mantle edges of *Cypraea isabella* were fixed and sectioned for transmission electron microscopy. Outer and inner epithelia cover a middle layer of muscle and nervous tissue. The outer epithelium consists of mucous and acid secreting cells interspersed with ciliated epithelial cells. This epithelium increases its surface area with numerous deep invaginations and a dense layer of microvilli up to 5 μ m long. The inner epithelium consists of a layer of elongated cells with shallow folds and a lining of short microvilli directed toward the extrapallial space. These inner epithelial cells contain pigment granules in addition to the normal complement of cellular organelles. A Golgi apparatus is frequently seen. A specialized secretory zone is located in the lower epithelium where the upper epithelium extends around the mantle edge and meets the lower epithelium. This secretory zone is 6-10 cells thick and appears to extend the entire length of both mantle edges.

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CONSERVATION OF SPRINGSNAILS IN THE GREAT BASIN: SIMPLE SOLUTIONS COMPLICATED BY POLITICAL REALITIES.

A field survey of springsnails (Gastropoda: Hydrobiidae) throughout the 500,000 km² Great Basin of the western United States was recently conducted in order to document the diversity and conservation status of this poorly known fauna, and generate materials and data for taxonomic and biogeographic analysis. As expected, given the paucity of previous work and insular drainage of this generally remote region, a large, highly endemic and mostly undescribed fauna was revealed, much of which is at risk due to various human-related activities. Although relatively simple and inexpensive measures would adequately conserve most of this fauna, implementation of these is complicated by frequent occurrence of populations on private land and by pertinent land management agencies traditionally focusing instead on vertebrate biota and larger aquatic habitats. A recently initiated, multi-agency effort to provide protection for this rich, fragile fauna seeks to overcome these hurdles.

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THE BENTHIC OCTOPUS FAUNA OF THE HAWAIIAN ISLANDS ARCHIPELAGO.

This paper reviews the species of benthic octopuses which have been collected at depths ranging from 0-2500m within the Hawaiian Islands Archipelago. Specimens in collections, literature and photographic records were surveyed. Young, Harman & Hochberg (1989) documented the presence of 13 species of octopus paralarvae in the plankton off the Hawaiian Islands. At that time only 7 species of adult octopuses had been described or reported from the islands. Currently, 15 species of adults are recognized as occurring in the Hawaiian Islands. Of these 6 are named: *Berrya hoylei* (Berry, 1909); *Octopus bocki* Adam, 1941; *O. cyanea* (Gray, 1849); *O. hawaiiensis* Eydoux & Souleyet, 1852; *O. ornatus* Gould, 1852; and *Scaergus patagiatus* Berry, 1913; A further 9 species are either unnamed, undescribed or can not be assigned to currently existing taxa from the tropical Pacific. At present none are considered to be endemic to the Hawaiian Islands.

The type of *Octopus hawaiiensis*, long thought to be not extant, has been discovered in the collections of the Museum National d'Histoire Naturelle in Paris. It will be related to material recently collected as part of the present study. Details also will be presented on the "rock tako" which is recognized as an undescribed species. This species is widely distributed throughout the tropical Pacific Ocean yet appears to be narrowly restricted to lava substrates and tidepools.

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ADAPTATIONS OF MOLLUSCAN LARVAE: DISTINGUISHING FUNCTIONAL ADVANTAGE FROM BIOGEOGRAPHIC CONSEQUENCE.

Because larval dispersal is so clearly affected by variables that include morphology, behavior, developmental mode, and length of larval period, there is a tendency to view these variables as targets of selection for dispersal. However, dispersal and geographic distributions of taxa are the *consequences* of larval morphology, behavior, and life history. It is therefore more appropriate to analyze the features of molluscan larvae as evolutionary solutions of complex functioning organisms to the immediate demands of larval existence and the requirements of their successful terminal transformation.

This paper examines some morphological traits of planktotrophic veliger larvae that demonstrably affect their ability to swim, feed, and resist predation as well as developmental traits that affect their ability to settle and metamorphose. Examples are provided in each of three categories: (1) features that confer mechanical resistance to predation by zooplankton predators, (2) changes in the properties of larval shells that assist larvae in settlement, and (3) secretory modifications of the larval shell aperture that are prerequisite to metamorphosis.

Biogeographic consequences of larval morphology are expressed over a range of spatial and temporal scale. One of the most interesting consequences for distributions of molluscan taxa in the Pacific basin is tied to tectonic style and resulting distribution of tectono-sedimentary settings.

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EVOLUTIONARY RELATIONSHIPS AMONG AQUATIC NERITOPSINES.

A phylogenetic hypothesis for 19 genera and subgenera of aquatic neritopsines is presented; this hypothesis represents the single shortest tree generated by a cladistic analysis of soft-part morphological characters of generotype species. The anatomies of many of the genera included herein have been unknown or very poorly known until now; most notable among these genera is *Neritopsis*, a "living fossil" dating back to the Triassic. The analysis indicates that the freshwater *Neritilia* branched off very early in the history of the suborder; that the shallow marine *Phenacolepas* and the hydrothermal vent-inhabiting *Bathyneryta* are sister groups; and that the latter two genera form a clade which is sister to the Neritinae. The phylogeny suggests that the Neritinae was originally a brackish-water group: *Nerita*, the first to branch off, expanded into "marine" habitats - primarily supratidal; the remaining genera entered truly freshwater habitats at least four times independently; *Puperita*, which occupies supratidal splash pools, likely represents a secondary invasion of marine habitats from brackish waters. Most aquatic neritopsines for which development is known have planktotrophic veliger larvae; according to the phylogenetic hypothesis presented here, direct development has evolved at least four times independently within the Neritinae, twice in conjunction with the evolution of nurse eggs. The anatomies of generotype species in Neritidae indicate that the currently recognized supraspecific classification of the family is in need of radical revision.

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CRYPTIC SPECIATION IN *Sepioteuthis lessoniana* COMPLEX IN SOUTHWESTERN JAPAN.

The oval squid, *Sepioteuthis lessoniana* Lesson, 1830, is a loliginid squid widely distributed throughout the Indian Ocean to the western to central Pacific. It has long been believed that *S. lessoniana* is the only species of the genus occurring in Japanese inshore waters. This study suggests that *S. lessoniana* in southwestern Japan is composed of the sympatric three types differentiated into specific level from the view point of genetics, morphology and reproductive biology.

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GENETIC DIFFERENTIATION AND EVOLUTIONARY DIVERGENCE BETWEEN SPECIES OF THE FAMILY GONATIDAE (TEUTHOIDEA: OEGOPSIDA)

Protein electrophoresis is a basic technique in molecular systematic research. Starch, and polyacrylamide gel electrophoresis with subsequent enzyme staining were used to assess taxonomic relationships and possible evolutionary divergence in North Pacific gonatid squids. Eight species from three genera were investigated. A total 17 to 21 allozyme loci per pair of species were used to evaluate between-species genetic identity (I), and genetic distance (D). From two to 16 diagnostic loci were revealed for each pair of comparable species.

These data suggest that: (1) four species of the genus *Gonatus* and *G. octopedatus* form a group of the most genetically similar taxa; (2) *G. borealis* and both species of *Berryteuthis* are genetically distinct from each other and from the *Gonatus* group. The tree topology of genetic distances indicates that the *B. magister* lineage diverged from the main family stem over 50 million years ago (D=1.5), *B. anonychus* and *G. borealis* ancestors appeared about 15 million years ago (D=1.0), and four *Gonatus* species together with *G. octopedatus* lineages radiated about 2 million years ago (D=0.3). Genetic differentiation of gonatid species is basically concordant with the traditional morphological classification of this family.

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BIOGEOGRAPHY OF THE GENERA OF NATICIDAE IN THE INDO-PACIFIC.

The biogeographic distribution of the tropical genera of Naticidae (Gastropoda) is reconsidered using the cladistic classification of these genera. Approaches towards cladistic biogeography are demonstrated with the Naticidae; the problems of extrapolating from models based upon nonmarine organisms to the marine fauna are discussed. The presence of multiple modes of larval dispersal in some genera is a confounding variable that may affect such analyses.

A briefer consideration of naticid species distribution and abundance in the Indo-Pacific is also included; island type and distance from the Southeast Asian / Indonesian biodiversity hotspots are analyzed as major factors in species diversity.

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A VIEW OF THE BOTTOM FROM THE TOP: MARINE MICROMOLLUSKS AS TOOLS IN BENTHIC MONITORING [poster]

Our laboratory has been involved with benthic monitoring of wastewater outfall sites around Oahu since 1974. We sort micromollusks from standard volumes of sediments of from 15 to 25 cm³, count and identify the micromollusks present, and analyze those counts for abundance, species diversity, trophic structure and spatial habits. The impact signals on benthic communities provided by micromollusks include the occurrence of eulimids, pyramidellids, and suspension feeding forms. Eulimids mean particulate-feeding invertebrates such as holothurians and sea urchins are nearby; pyramidellids tell us of the occurrence of sponges and other sessile invertebrates, and suspension feeding micromollusks signal high nutrient content in the water column.

On Oahu, on the south shore in Mamala Bay, we have recorded abundance records of 10-27 shells per cm³ and species numbers of 45-115 per 100 cm³. Some of the more interesting patterns of occurrence of dominant species are shown. The patterns do not appear to reflect impact by proximity to the wastewater outfalls. In Pearl Harbor itself, however, we recorded enormous numbers of pyramidellids and suspension feeders, signalling the presence of both fouling organisms and high nutrient content in the water.

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CONSERVATION AND MARINE MOLLUSKS: IS IT POSSIBLE?

Despite the fact only one marine mollusk species is thought to have gone extinct in recent time, numbers of marine species are undergoing changes in population size and distribution: coral reef mollusks and mollusks fished commercially are especially vulnerable to local extinction and to extreme population fluctuations. Nor does demand decrease: mariculture helps to avert some pressure but the more Pacific islanders entertain visitors, the more coral reef mollusks appear in shops from Rhodes to Hawaii.

Conventional regulatory methods have not been effective because there is little capability of enforcement. More attention must be focused on the isolation and preservation of islands and large areas of ocean bottom to maintain reservoirs of impacted marine mollusk species.

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EVOLUTION AND SYSTEMATICS OF CEPHALOPODS: A BIOCHEMICAL APPROACH.

Controversy in systematics and evolution of cephalopods led to the development of alternative biochemical methods useful for taxonomic revision of typological species.

These methods could be decisive in evaluating evolutionary pathways of certain taxa due to the molecular base of evolution. Method of substrate-inhibitor analysis of enzymes was used in solving controversial points of cephalopod systematics. 12 species of 4 families (Ommastrephidae, Gonatidae, Onychoteuthidae, Thysanoteuthidae) were investigated.

Three isolated populations of *Ommastrephes bartramii* were shown to exist in three geographically separated parts of the species range: the north Atlantic, the north Pacific, and the south Atlantic (the Great Australian Bay). This conclusion correlates with presumptive evolutionary history, and with morphological analysis of the species.

Application of enzymological methods for intraspecific structure investigation in *Berryteuthis magister* from the three parts of the species range (the Olytoro-Navarinskyi, the Prybilov-Alaska region of the Bering sea, and the central Kurils) showed 7-10 fold between-region differences in several inhibitor properties of enzymes. This fact together with biological data suggest that intraspecific groups exist in *B. magister* in the northern Pacific. At the same time, investigation of enzyme substrate properties of several species of Gonatidae revealed 2-5 fold between-species differences.

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EGG SIZE, LIFE HISTORY AND BIOGEOGRAPHY OF INDO-PACIFIC MARINE GASTROPODS

Egg size is postulated to be a key variable that controls other early life history attributes and that provides a window to help understand how dispersal ability importantly affects biogeography in the sea. We have taken advantage of the remarkably broad variation in egg size and developmental and biogeographic patterns among species of the immense genus *Conus* to examine how development relates to dispersal ability and, in turn, to geographic distribution. Knowledge of egg size of a *Conus* species permits accurate predictions of reproductive energetics, length of embryonic period, size and stage at hatching, and minimum duration and growth rate during the planktonic, feeding larval period. Egg size also explains 40% of the variance in absolute extent of the geographic range of Indo-Pacific *Conus* species. The role of dispersal in determining the geographic distribution of species is a controversial issue in biogeography. Analyses of several biogeographic patterns in Indo-Pacific *Conus*, summarized and updated from the results of Kohn and Perron's 1994 book, "Life history and biogeography: Patterns in *Conus*," support the importance of dispersal ability as a determinant of geographic range of Indo-Pacific island marine gastropods.

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THE EVOLUTION OF *Lottia gigantea*: EVIDENCE FROM MOLECULAR, MORPHOLOGICAL AND STRATIGRAPHIC DATA SETS.

Lottia gigantea is a large (> 100 mm in length) patellogastropod from the temperate northeastern Pacific Ocean. The phylogeny of *L. gigantea* was investigated using three data sets: (1) morphological characters, (2) molecular characters, and (3) stratigraphic occurrences in the Pleistocene of California and Baja California. Morphological characters included in the analysis were obtained from internal and external anatomy. Molecular characters included 192 alleles for 30 loci. Stratigraphic occurrences were studied on Pleistocene terraces (ranging from > 1.0 Mya to 80 Kya in age) between Pt. Conception, CA and Baja California, Mexico. The five taxa included: (1) *L. gigantea*, (2) *L. limatula*, (3) *L. strigatella*, and as outgroups, (4) *L. pelta* and "*Collisella*" *scabra*. Cladistic analyses were done using PAUP, and shape capture and analyses were conducted with MorphSys and GRF-ND. Results of the morphometric analyses were plotted onto the resultant cladograms. Total evidence analysis suggests that *L. limatula* and *L. strigatella* are sister taxa and *L. gigantea* is the sister taxon of that subclade. Stratigraphic analysis indicates that "*L. limatula*-like" ancestors were present 1.0 Mya, whereas *L. strigatella* and *L. limatula* appear suddenly in the lower terraces about 200 Kya. Analysis of the morphological trajectories overlain on the phylogeny of these limpets indicates that a path from the common ancestor to *L. gigantea* requires less morphological modification than one leading to living *L. limatula* and *L. strigatella*. This finding is masked by current taxonomy.

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***Illex* AFC-BASED SPECIATION MODEL: CONSEQUENCES FOR SYSTEMATICS** [poster]

The main result of the Correspondence Analysis of shape of all *Illex* species is, that balance between locomotion-related variables and attack-related variables may be regarded as a vehicle of speciation in this genus. Therefore, morphological changes to attack-related structures are likely to carry much of the systematic weight. Systematic significance of shape of fins, mantles and heads is difficult to analyze, determine and use in practice.

The general morphological pattern leads obviously from least balanced *I. coindetii* (heavy arms (especially in males), complicated hectocotylus) to more balanced *I. illecebrosus* and *I. argentinus*. Also, sexual dimorphism and ecology play obvious role: from *I. coindetii* (largest sexual dimorphism, close association with the bottom, migrations limited) to both higher latitudes species. And the simplification of structures is perhaps a main cue. The best morphological sign of speciation in the genus in this light is hectocotylization and associated changes in armature of arms IV. Hectocotylus of *I. oxygonius* can not be distinguished from the one of *I. illecebrosus*, however.

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SYSTEMATICS OF THE AUSTRALIAN CUTTLEFISH (SEPIIDA : SEPIIDAE).

The Australian cuttlefish fauna is among the world's richest in endemic species, with 26 of approximately 124 nominal species present in Australian waters. Each of the three genera, *Sepia*, *Metasepia* and *Sepiella* are represented. The Australian taxa are, therefore, a useful starting point for a revision of the family. To date, there is no existing hypothesis of phylogenetic relationships between genera or species within the Sepiidae based on cladistic methods. Within *Sepia*, 6 species complexes have been identified by several workers. The complexes recognized are, however, not entirely congruent between studies.

In the present study, morphological characters are used to test the validity of these groupings, and evolutionary relationships within the Australian Sepiidae using cladistic techniques. A revised classification within *Sepia* is suggested, based on the recognition of monophyletic groups identified in the analysis. This proposal will be tested later in a broader study including Sepiidae from other parts of the world.

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SPECIATION IN SQUID ** DOODLES AND NOTES

Reproductive isolation, seen as a result of molecular changes, is most probable when these changes occur in the part of the genome which regulates development. Molecular biology does not have too much data about this; the only insight possible now is through the mathematical analysis of whole organism properties, e.g. shape.

Squid adults (*Illex* species) shapes were analyzed using Correspondence Analysis (AFC, Benzecri version TABET-1). *I. oxygonius* was between *I. illecebrosus* and *I. coindetii* on Q graph, but rather weakly differentiated. Generally, Q analysis adequately separated at least 3 species, both males and females. This is proof that R analysis must have clear biological interpretation. Indeed, factor I of R (35-77% of variance) can be interpreted as a balance (or lack thereof) between attack-associated variables (arms, tentacles, suckers) and locomotion-assoc. variables (fins, mantles, heads). This balance (or lack thereof) was similarly defined in intra- and inter-specific variation and was highly discontinuous between individuals. Therefore, factor I can be seen as a vehicle of speciation.

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THE REABSORPTION OF AMINO ACIDS AND GLUCOSE FROM COELOMIC FLUID AND RENAL SAC OF THE SQUID *Illex illecebrosus*.

The branchial hearts and their appendages lie free in the large pericardial coelom of squids. Martin and Aldrich (1970) have shown that the branchial heart appendages of *Illex* produce a filtrate from the blood, probably of the same composition with respect to glucose and amino acids as the blood. The changes from blood concentrations to urinary concentrations were measured by standard techniques. Glucose was reabsorbed almost to completion, and there was effective absorption of most amino acids during the passage through the coelomic space and urinary sac.

The morphology of the urinary tract differs from that of octopuses, hence an effort was made to locate the principal organs of absorption. Perfusion methods were not adequate, so pieces of tissue were immersed in isotonic media and measurement- of rates of uptake were made *in vitro*. Some organs, both in the coelomic cavity and in the urinary sac, were shown to take up glucose and tyrosine actively.

Work done at the Marine Biological Laboratory of the Memorial University of Newfoundland.

Reference: 1970, Canadian Journal of Zoology 48: 751-756.

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INTER- & INTRA-SPECIES VARIATION IN BEHAVIOUR OF OCTOPUS: MATERIAL FOR SELECTION

Evolution must be the result of the twin influences of the variation amongst individuals (which may be structure, physiology or behaviour) and selection but this is difficult to trace and rarely studied, particularly in Cephalopods. This paper will discuss some aspects of the first part, variations in behaviour, in individuals of the genus *Octopus*. One species typical behaviour is activity pattern; both *Octopus cyanea* in Hawai'i and *Octopus vulgaris* in Bermuda are crepuscular. Nevertheless, individuals vary widely in time of activity and such variation will be demonstrated. A second species typical behaviour is prey choice -- some species choose a narrow range of prey species and some a wide one. Again, the pattern of prey choice in species and variation amongst individuals will be demonstrated. The results of evaluation of these two behaviours will give some idea of the variability within and across species which is the material on which natural selection acts to produce evolution.

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ENDEMIC RADIATION OF GASTROPODS IN FOSSIL & RECENT ANCIENT LAKES

Gastropod clades that have undergone evolutionary radiation in ancient lakes have figured prominently in debates over the rates and patterns of evolution. Particular clades (the hydrobioid and cerithioidean prosobranchs and planorbis pulmonates) show repeated patterns of endemic diversification in both extant and fossil lakes. These groups share a number of characters that may be the basis of their evolutionary lability. Radiative clades share reproductive and dispersal strategies (brooders and poor dispersers), genetic structures (tightly constrained genetic systems), morphology (often relatively thick and ornamented shells), substrate specificity (hard bottom stenotopy) and physiology (tolerance of deep water). Trophic differentiability and complex mating behavior may also accelerate speciation, but have been poorly investigated in gastropods. Fossil gastropod radiations illuminate differences in pattern and rate of intralacustrine diversification that are not discernible in extant faunas. The most notable examples of these evolutionary theaters are extant lakes Tanganyika, Baikal, Ohrid, Biwa, Titicaca, Malawi, Victoria, and fossil lakes Steinheim, Pannon, Idaho, Biwa and Idaho.

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CHARACTER COMPLEXES AND PHYLOGENETIC ANALYSES OF *Cypraea*

Cypraeids are one of the most abundant and diverse groups of reef associated gastropods. Their long geologic history, ecological prominence and worldwide distribution make them an excellent taxonomic group with which to explore ecological, biogeographical and evolutionary questions. Their systematic history is rich in proposed relationships, but no authors have applied modern phylogenetic approaches based on parsimony.

The morphological diversity within the group provides a number of character sets that can be used in a phylogenetic analysis. In the past, researchers have chosen a primary character set to determine groupings. The phylogeny presented is based on total information; it includes characters from the radula, mantle, reproductive system, and shell microstructure. Conchological features are limited because of gap coding problems associated with continuous characters. Representatives of all species complexes are included in an attempt to limit taxon sampling biases. The phylogeny based on total information is compared to other hypotheses of relationships. Such comparisons reveal the problems associated with restricted data sets.

A phylogenetic hypothesis of relationships is an essential first step in order to establish monophyly of traditional species complexes and to avoid paraphyly when testing evolutionary questions.

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CLADISTIC ANALYSIS TODAY

Cladistic analysis of systematic data is now unquestioned by the once skeptic scientific community. Yet, the paradigm, as accepted, is not uniform. A situation apparent upon a review of some typical modern studies. Today practices follow two different schools of systematic analysis, synapomorphic and approximate cladists. Their underlying assumptions can be deduced from their procedures. The synapomorphists look for defining characters seeking to find transformations that uniquely define taxa. The approximists take simple observations on taxa and use parsimony on these variables to filter out noise.

The procedures of each school are outlined. The advantages and disadvantages of each are discussed.

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MINERALOGY OF GASTROPOD SHELLS: A RAPID TECHNIQUE FOR SYSTEMATICS AND PHYLOGENY. [poster]

Two qualitative mineralogical tests (Feigl's Solution, Alizarin Red) can rapidly determine the form of calcium carbonate present in molluscan shells and other calcified structures. Feigl's Solution forms a silver-black precipitate on aragonite; Alizarin Red stains either calcite or aragonite bright red. These tests are proposed as straightforward, inexpensive, qualitative methods for determining a potentially useful taxonomic character.

In the present study on selected gastropods, 59 samples from 55 species were tested and characterized as fully aragonitic (31 shells), fully calcitic (4 gizzard plates), or mixed (23 shells); mixed samples were further described as layered or patchy in distribution of the calcite/aragonite. Layered shells (14) were in most cases aragonitic internally, overlain by calcite; 6 of these were largely aragonitic, while 3 were largely calcitic. Two samples showed the opposite layering (aragonite over calcite). Only two samples reacted negatively in part to both tests, suggesting the presence of some other mineralized substance: (a) the shell of *Hydatina physis* (Linné, 1758) (Cephalaspidea: Aplustridae), and (b) the capped, calcified gizzard plates of *Scaphander watsoni* Dall, 1881 (Cephalaspidea: Scaphandridae).

From statements in the literature and these results, fully aragonitic mineralogy is assumed to be most plesiomorphic in gastropods, and the presence of calcite appears derived. The results of one cladistic analysis (involving shelled opisthobranchs) supports this hypothesis.

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ARE NURSE EGGS REALLY ENOUGH TO ACCOUNT FOR THE HATCHLINGS OF NURSE EGG FEEDING PROSOBRANCHS?

A biochemical study of the eggs and hatchlings of temperate (*Buccinum undatum* and *Buccinum cyaneum*) and tropical (*Fasciolaria tulipa hollisteri*, *Fusinus closter* and *Eualetes tulipa*) nurse egg feeding gastropods was carried out. The objective was to determine if the total protein, glycogen and lipid contained in eggs and nurse eggs are enough to account for the same totals in the hatchlings. The biochemical analysis of eggs and hatchlings indicated that buccinids and the vermetid have enough material in eggs and nurse eggs to account for the total in the hatchlings. Fasciolarids do not have sufficient material in eggs and nurse eggs to account for the hatchlings, so some of the material must come from another source within the egg capsule. This study indicates that there are taxonomic differences at the family level in the biochemical construction of the hatchlings.

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COMPARATIVE ZOOGEOGRAPHY OF THE OPISTHOBRANCH FAUNA OF ALASKA AND THE MAGELLANIC FAUNAL PROVINCE [poster]

Many opisthobranch molluscs of the eastern Pacific show a pattern of bipolar speciation characterized by a number of sibling or disjunct species found in north and south cold temperate waters. Both areas exhibit similar species proportions from each opisthobranch order, and both are relatively depauperate compared to warmer waters. Alaska has 88 species of benthic opisthobranchs; 24% Cephalaspidea, 2% Notaspidea, 3% Sacoglossa and 71% Nudibranchia. In the Magellanic province there are 60 species; 22% Cephalaspidea, 5% Notaspidea, 5% Sacoglossa and 68% Nudibranchia. Compared worldwide, these proportions are high in the order Cephalaspidea, low for the herbivorous Anaspidea (0%) and Sacoglossa, and average for Notaspidea and Nudibranchia.

The geographical affinities of the Alaskan opisthobranchs is strongly endemic in the northeastern Pacific (47%), less so in the subarctic (25%). The Pacific species have large ranges with southern limits usually at San Diego or the Gulf of California. Three species share disjunct distributions with the Magellanic province. There is a strong Atlantic component to the Alaskan opisthobranchs (24%) and a weaker circum-Pacific influence (19%). The Magellanic province opisthobranchs are also strongly endemic. Thirty percent have Pacific affinities, 20% have Atlantic affinities and 20% inhabit both the Pacific and Atlantic waters. The remaining 30% occur only in the subantarctic waters of the Magellan Strait or Tierra del Fuego.

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A HANDFUL OF SAND

A handful of sand collected 10 meters from shore on the west side of Hawaii was full of micromolluscs. Close to 2000 specimens were picked out of the sand, most of them adult or subadult. Gastropods far exceeded bivalves, and there were no scaphopods or chitons.

This fauna is typical of shallow water carbonate regimes in the tropics. The vast majority of individuals are gastropod browsers belonging to the Trochidae, Phasianellidae, Cerithidae and Rissoidae. A malacologist working in the Bahamas would see a familiar world when looking at material from Hawaii.

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MITOCHONDRIAL DNA SEQUENCE VARIATION AND RELATIONSHIPS AMONG UNIONACEANS.

DNA sequence variation was assessed for more than thirty species of Unionacean mussels. A portion (> 400 bp) of the 16s mitochondrial ribosomal gene was used. A phylogenetic analysis included the three recognized families and representative species from eight of the nine recognized subfamilies of North American Unionaceans. The resulting phylogenetic trees were largely consistent with relationships determined from morphological or allozyme data. Exceptions will be discussed. The 16s RNA sequence data clarify relationships for some of the morphologically convergent taxa.

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Helix aspersa LEAD EXPOSURE HISTORY AND POSSIBLE ADAPTATION: SHELL COMPOSITION, CONCHOLOGY, AND GENETICS [poster]

Shell composition, shell morphology and allozyme genetics were examined in English and Welsh populations of the common garden snail, *H. aspersa* with different lead (Pb) exposure histories. Isotopic Pb ratios and total Pb concentration were used to imply exposure duration (decades to millennia) and intensity, respectively.

Snails from populations with long histories of exposure (millennia) to high Pb levels had proportionally more Pb in their shell than soft tissue compared snails from other surveyed populations. These observations suggest that Pb sequestration in shell has been enhanced in populations with long and intense exposure to Pb. Shells of snails from areas with long histories of Pb contamination were also significantly more robust (shell width/shell height) than snails from other areas. Genetic variation, measured using allozymes, was not related to Pb history nor geographic distance between populations. *H. aspersa* adaptation to Pb contamination may involve significant changes in shell characteristics but these do not correlate with genetic traits assessed with allozymes.

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NORTH PACIFIC GONATIDS: NICHE DIVISION AND EVOLUTION

Fourteen species of gonatid squids inhabit the North Pacific, 10 present in the NW Pacific and Far Eastern seas, 6 may be caught in one trawl. They all live in the epipelagic layer as paralarvae and juveniles and then descent to greater depths in adulthood. Are they ecologically alike or different? Results of many cruises into Russian Far Eastern seas and NW Pacific using large commercial subsurface, midwater and bottom trawls show a degree of niche division. Ten cold-water gonatids differ: in the size (from small, ML 15-20 cm, to very large, up to 62 cm); in the presence/absence in the Okhotsk and Japan seas; in the adult (spawning) habitat (midwater or bottom); in the time and maturity stage at the beginning of gelatinous degeneration; in the presence/absence of diel vertical migration in juvenile phase; in the size and maturity stage at the beginning of descent from epipelagic layer to great depths; in the presence of early and lately maturing groupings etc. The North Pacific gonatids arose not earlier than in Late Miocene and radiate during Plio-Pleistocene, their evolution was rather rapid. But they are well different both in morphology and in ecology and occupied enough different niches in the same adaptive zone.

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COEVOLUTION IN A SQUID-LUMINOUS BACTERIUM SYMBIOSIS; DIFFERENTIATION OF *Euprymna* SPECIES BY MOLECULAR SYSTEMATICS AND SYMBIONT COLONIZATION.

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) to analyze inter- and intra-species differences among various species and populations of *Euprymna*. The results of a phylogenetic comparison among host sequences can be compared with intraspecies groupings among their bacterial symbionts to provide evidence for the evolution 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 contribute to the divergence of this group of sepiolids.

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CLADISTIC ANALYSIS OF MORPHOLOGY IN THE INCIRRATE OCTOPUSES (OCTOPODA: INCIRRATA).

Considerable confusion surrounds the systematics of the incirrate octopuses. Problems range from poor species delineation to ill-defined and inconsistent generic and higher level classifications. The majority of these problems directly result from incomplete or inaccurate morphological descriptions.

In order to investigate the phylogenetic relationships amongst the extant fauna, internal and external morphology was examined in 36 species of incirrate octopod, representing eight families and 27 genera.

A cladistic analysis of more than 50 morphological characters was undertaken. The resulting trees support the need for a major revision of octopod classification and may provide clues to evolutionary events and the geography of evolution in these octopuses. A parallel molecular study has been commenced.

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FECUNDITY OF *Octopus rubescens* BERRY, 1953 (MOLLUSCA: CEPHALOPODA)

Fecundities ascertained from twenty female *O. rubescens* (26-137 g) maintained in the laboratory have helped elucidate the effects of female body size on various brood characteristics (e.g. egg density, festoon length, etc.), gravimetric vs. volumetric analytical techniques, and the effects sample size and replication have on fecundity estimates. Females laid between 2,000-19,000 eggs or 41-140 egg/g of female body weight. Number of festoons increased with increasing female wet weight. Mean festoon length remained constant (approx. 60% female ML) for all females regardless of body size. Egg densities remained constant within broods but differed between females with higher egg densities found for larger females. Gravimetric techniques provided significantly lower average percent errors and lower indices of precision when estimating fecundity. Results indicate 4 festoons per subsample and 5 subsamples per brood provide the most accurate and precise data for estimating fecundities.

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REPRODUCTION OF *Octopus rubescens* BERRY, 1953 (MOLLUSCA: CEPHALOPODA)

As part of a study on the life history of *Octopus rubescens* an analysis of this species' reproductive processes was conducted. Such information may provide additional insight into the complex reproductive processes of octopuses. Thirty-one females and eighteen males were collected in Monterey Bay, CA over four consecutive breeding seasons and reared in the laboratory. Based on observed reproductive behaviors, laboratory experiments, and functional morphology ascertained through histological and electron microscopic techniques, information on the mating behavior, spermatophore transfer, spermatophore reaction, sperm deposition, sperm storage, oogenesis, egg fertilization, and egg deposition has been obtained and is discussed.

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QUESTIONS OF CHROMATOPHORE SYSTEMATICS AND OF BEHAVIORAL HOMOLOGIES

What are cephalopod chromatophores and where do they come from? There are no obvious homologues in other molluscs. *Nautilus* does not have them. No fossil traces have been reported by paleontologists (have they been sought?) and there is at present no genetics of cephalopods. The existing diversity of one of the few diagnostic characters of coleoids has for most of this century been ignored by zoologists. Although a classification of color pattern repertoires exists there is no proper systematics of chromatophore organs or their parts, or of their arrangement in the skin that would enable students to put flesh on putative behavioral homologies. Here I illustrate, partly from the old literature on tegumental chromatophores, what kinds of systematic evidence are required.

Morphological (presence or absence and types of chromatophores in the main orders - vampyromorphs and cirrotopods lack dynamic ones - and of muscle fibres, innervation and chromatophore lobes; group-specific similarities and differences in the arrangement of chromatophores in paralarva, juveniles and adults). **Biochemical, developmental and morphogenetic** (nature of the pigment(s) - are they all ommochromes?; classification of developmental types of chromatophore and of their distribution in relation to other structures; different expressions of the same algorithms and evidence of different algorithms for pattern generation). **Molecular biological** (identification and comparison of genes/proteins for chromatophore-genesis). **Physiological and pharmacological** (characteristics of chromatophore populations and their central control within and between groups). **Behavioral** (evidence for homologies in the classification of chromatic patterns).

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STABILITY AND TURNOVER IN INSULAR MARINE MOLLUSK FAUNAS THROUGH THE LATE CENOZOIC

The high amplitude and -frequency sea level fluctuations that characterize the late Cenozoic have led to major changes in the physiography of reef systems and in the availability and distribution of nearshore habitats on Pacific islands. Protected nearshore habitats, such as lagoons, mangals, moats, and reef flats, are greatly varied within and among islands during high sea stands. These, however, are stranded during regressions, leaving only exposed reef slopes, which are more uniform among islands. Previous work on the habitat requirements of Recent insular bivalves indicated that numerous species would be vulnerable to local extinction on oceanic islands during regressions, when habitats to which they are restricted to disappear.

I present evidence for such regression-caused local extinction from the uplifted atoll of Niue, where a high sea stand fossil lagoonal biota is compared with the low sea stand biota surviving on the island today. Pliocene through Holocene fossils from the Mariana, Niue, Cook, Pitcairn and Hawaiian Islands provide evidence for localized (single island) to basin-wide range contractions, mostly affecting species with inshore habitat specificities. Species with large body size, such as tridacnids, have especially unstable ranges. In contrast, species inhabiting fore reef habitats show little turnover. Several of the latter exhibit morphological differentiation among islands, indicating potential genetic divergence and speciation.

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INTERACTIONS BETWEEN BENTHIC MALACOFAUNA AND ICTHYOFAUNA IN A VENEZUELAN SANDY BEACH.

The trophic contribution of the benthic malacofauna to the ichthyofauna was evaluated in a sandy beach of North-western Venezuela (Playa Tucacas, 68°19'26" LW, 10°45'55" LN). Over one year of bi-monthly sampling, the fish community is dominated, in number and weight, by seven resident species, all of them juveniles of commercially important adults. Five of them were found to feed on mollusks. The bivalve *Pinctada radiata*, very abundant during the rainy season, represents up to 44.5% of the diet of *Conodon nobilis*. Whole *Donax denticulatus* and *D. striatus* individuals contribute partially to the diet of *Trachinotus carolinus*, *T. goodei*, and *C. nobilis*, with a pooled 31.7% of all food items. *Menticirrhus littoralis* feeds on *Tivela mactroides* and *Donax* spp siphons, a "grazing" strategy that does not kill the bivalves. The benthic malacofauna represents 27.3% of all food items and contributes in 22.3% in number and weight to the diet of the dominant fish species.

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THE ST. AUGUSTINE "SEA MONSTER" AND THE BERMUDA "BLOB": *Octopus giganteus* OR NOT?

Two similar carcasses washed onto beaches in Florida (1896) and Bermuda (1988). The former weighed tons and was originally hailed as a gigantic octopus [*O. giganteus* (Verrill)]. Although Verrill later disavowed his species description, it has persisted for almost a century. Except for a much smaller mass, the Bermuda carcass was very similar in gross morphology to the older specimen and suggested by some to be the same species. We have done biochemical, light and electron microscopic analyses on pieces of both remains. Both carcasses are huge masses of pure collagen fibers, no other cellular structure remains. The collagen fiber arrangement indicates that both are likely from vertebrate skin. Neither relic has any microscopic morphological similarity with cephalopod mantle. The amino acid compositions of the collagens indicate that the carcasses are the remains of different species. The "Blob" is likely from a poikilotherm, while the "sea monster" is probably from a homiotherm, most likely a whale. Neither is from an octopus, supporting Verrill's disclaimer.

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ADAPTIVE ALLOMETRY OF THE BRACHIAL CROWN: SELECTION PRESSURES IN THE PELAGIC BIOMASS SPECTRUM?

Pelagic squid were sampled in the Scotia Sea south of the Antarctic Polar Front (Station 1) and on the South Georgia slope (Station 2). The most abundant species at each station were *Brachioteuthis ?picta*, *Galiteuthis glacialis* and *Alluroteuthis antarcticus*. In these species brachial crown growth is positively allometric with respect to mantle length. Biomass spectra in high latitude pelagic systems have peaks of biomass separated by biomass minima. Individual body mass at these peaks are separated by one to several orders of magnitude. We propose the causal hypothesis that positive allometric growth in the brachial crown of these Antarctic oceanic squid has evolved as an adaptation to the peaked, structure of the pelagic biomass spectrum which must be spanned by these predators as their optimum prey size increases with growth. The short life cycles of pelagic squid, coupled with high levels of interspecific variability in characters such as arm and tentacle length, might give rise within populations to rapid and reversible microevolutionary change in the brachial crown, driven by interannual variability in the shape of the pelagic biomass spectrum.

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CEPHALOPOD COMMUNITY ASSOCIATED WITH MESOSCALE OCEANOGRAPHIC FEATURES AT THE ANTARCTIC POLAR FRONTAL ZONE EXPLOITED BY SATELLITE TAGGED PREDATORS

Satellite tags attached to nine grey-headed albatrosses indicated that foraging activity was concentrated at the Antarctic Polar Frontal Zone (PFZ), north of South Georgia. Acoustic and net surveys and CTD transects were taken in this area and remote sensed sea-surface temperature images from NOAA polar orbiting satellites were analyzed. Cephalopods were simultaneously recovered from food samples of the grey-headed albatross at Bird Island. The cephalopod community sampled by nets closely resembled that exploited by grey-headed albatrosses. The largest and most conspicuous species was the ommastrephid squid *Martialia hyadesi* which is the most important cephalopod prey species. Stomach contents of *M. hyadesi* consisted of crustacea and mesopelagic fish. The cephalopod community was sampled in a meander or eddy, interpreted as a warm core ring, in an area characterized by mesoscale features associated with the bathymetry of the northern end of the Northeast Georgia Rise and near a gap in the Falklands Ridge. At the PFZ epipelagic fish are absent and the dominant top predators are cephalopods.

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IN-SITU OBSERVATIONS ON *Brachioteuthis*: PAIRED BEHAVIOR, POSSIBLY MATING

A behavior that we have never seen in cephalopods was observed three times in a large aggregation of *Brachioteuthis*. During a series of submersible dives off Cape Hatteras, NC, pairs of *Brachioteuthis* were seen and videotaped with one squid grasping the other by the posterior mantle in its arm crown. This paired behavior involved brief periods in which the grasped squid bent its body and showed considerable movements of its arms around the head and mantle opening of the grasping squid. Although we were unable to capture any of the three coupling pairs to determine their stage of maturity, we feel this unusual behavior may represent mating.

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SYSTEMATICS AND EVOLUTION OF *Todarodes* AND *Martialia* (CEPHALOPODA: OMMASTREPHIDAE) REVISITED.

The association of *Todarodes filippovae* and *Martialia hyadesi* with circum-Antarctic water masses was a previous starting point to address the question: "What can palaeoceanography of the Southern Ocean tell us about ommastrephid evolution?" In that study a phylogenetic analysis of all described species of *Todarodes* and *Martialia*, using *Loligo vulgaris* as the outgroup, indicated that the genus *Todarodes* is not monophyletic. *T. pacificus* was found to be the least specialized species and dispersal from the Pacific via the Tethys was suggested for the *T. angolensis/sagittatus/filippovae* ancestor. The similarity between *M. hyadesi* and *T. filippovae* is apparently due to convergence; the relationship between *T. pacificus* and *T. pusillus* was unresolved.

New data on supposed *T. angolensis* from the Tasman Sea and *T. filippovae* off Chile, and additional data for previously described species of *Todarodes* and *Martialia*, radically altered *Todarodes*. Discriminant analysis showed that the Tasman "*T. angolensis*" and the Chilean "*T. filippovae*" are both new species and that *T. sagittatus* is a complex of three species. Furthermore, *T. pacificus* and *T. pusillus* are not only very different to this group but to each other as well, each warranting a separate genus.

Phylogenetic analysis using Hennig86 of 39 gap weighted characters for 10 taxa, specifying *M. hyadesi* as the outgroup, gave a single most parsimonious tree that supported the splitting of *Todarodes*. Alternate hypotheses for dispersal routes, explored in MacClade, increased the tree length considerably for both south polar and Tethyan routes. A combination hypothesis, polar dispersal for one clade and Tethyan dispersal for the other, produced a much shorter tree. This hypothesis puts evolution of the *T. sagittatus/T. angolensis* clade after closure of the Tethys and of the *T. filippovae* clade after formation of the subtropical convergence.

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INDEPENDENT EVOLUTION OF TERRESTRIALITY IN ATLANTIC TRUNCATELLID GASTROPODS

Phylogenetic analysis of truncatellid gastropods using comparative anatomy and ribosomal RNA sequences shows that terrestrial truncatellids likely evolved three times independently in the Caribbean. The terrestrial subfamily Geomelaniinae, characterized in part by pallial fertilization and uniquely derived features of radula and protoconch, occurs in the Greater Antilles and Cayman Islands. Truncatellinae, with renopericardial fertilization, has several widespread amphibious species and two terrestrial species restricted to Trinidad and Barbados. The species in Barbados may be the most recent animal species to evolve full terrestriality; Barbados emerged above sea-level only about one million years ago. By the mid-Cenozoic, truncatellids had traits enabling them to colonize land in appropriate tectonic settings. Parallel trends in character evolution occurred in the terrestrial lineages. In older terrestrial radiations, transitional character states would likely be lost, potentially allowing parallelism to confound phylogenetic analysis of morphological characters.

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THE ROLE OF THE AMATEUR IN MOLLUSCAN CONSERVATION

As environmental awareness in this country increases, shell collecting is often viewed as politically incorrect. But is shell collecting environmentally incorrect? I will argue that is not, for two reasons: 1) The impact of shell collecting on molluscan species is far less than the impact of habitat destruction or commercial fisheries; 2) Shell-collectors, because of their collecting activities, are in position to notice and document declines in molluscan populations.

Collecting live specimens in moderation is important for documenting local faunas. If the fauna of an area was poorly known before an oil spill, how can we assess recovery in its aftermath? Dead shells can give some idea of a fauna, but might be hundreds of years old and thus not give an accurate indication of the species currently living in an area. The shells of specimens collected alive on known dates can also be used for chemical analyses that might help reveal causes of environmental changes. Professional malacologists should cooperate with amateurs in studies of regional molluscan faunas.

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MOLLUSCS AND OTHER CREATURES WITHIN THE PERMANENT OXYGEN MINIMUM ZONE, NORTHERN ARABIAN SEA.

Shipboard observations on the RSS DISCOVERY during the expedition ARABESQUE II in the northwestern Arabian Sea revealed unusual downslope changes in the fauna. Owing to extremely high production in surface waters during monsoons, an oxygen minimum zone (OMZ) extends permanently from about 60 m to 900 m. Levels of greatest stress and concomitant reduction in faunal diversity, although not densities, occurred at depths between 400 and 500 m, with about 0.2 O₂ ml/l. The molluscan faunal diversity at these depths was dominated by a species of *Amygdalum*. At depths of 670 m there were no molluscs, and aplacophorans were not found anywhere within the oxygen minimum zone. From 900 to 1,400 m species diversity increased but densities within species were lower. Samples from >3,000 m had molluscan faunal elements normal for the lower Continental Slope. However, densities of Aplacophora were higher at these depths than in many other areas of the deep sea.

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EFFECT OF TEMPERATURE ON SURVIVAL OF *Todarodes pacificus* (CEPHALOPODA: OMMASTREPHIDAE) EMBRYOS AND HATCHLINGS: DOES TEMPERATURE DETERMINE SPAWNING SITES?

The main spawning grounds of *Todarodes pacificus* gradually shift from the southwestern part of the Japan Sea to the northern part of the East China Sea during autumn to winter. This shift in the spawning areas may be dependent on seasonal changes of the warm currents and water masses in the region.

To date, there is little information of the optimum temperature range for the embryonic development and survival of ommastrephid hatchlings. A serial technique of rearing hatchlings via artificial fertilization was used to examine the effect of temperature on the embryonic development and survival of *T. pacificus* hatchlings at 15 different temperatures, from 3°C to 29°C.

Normal hatching occurred at temperatures of 12.1 to 26.0°C, with highest survival rates occurring between 15.0 and 22.20°C. The relationship between temperature and embryonic development time can be expressed by an exponential regression formula: $\log(T) = 1.644 - 0.051(x)$ (T: days, x: temperature). The development time of eggs within a naturally spawned egg mass was approximately 1.5 days longer than that of artificially fertilized embryos at 18-19°C. From this observation, the formula was modified to $\log(T) = 1.734 - 0.0051(x)$, for naturally spawned egg masses.

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RETENTION AROUND AND LONG-DISTANCE DISPERSAL BETWEEN OCEANIC ISLANDS BY PLANKTONIC LARVAE OF MARINE BENTHIC MOLLUSCA

It is proposed that populations of marine molluscan species on oceanic islands are largely self-sustained by indigenous populations. Accordingly larvae of species with planktonic larvae (including most sublittoral forms) must remain within proximity of their natal island in order to be recruited into their parent population. Initial evidence from plankton samples, drift-bottles data, and knowledge of mesoscale circulation allows a tentative explanation of how larvae may be retained around the Hawaiian Islands.

In order to maintain genetic continuity between oceanic islands it is necessary that gene-flow occur between such widely separate populations. One way this may be accomplished is by dispersal of veliger larvae. It is proposed that a small fraction of larvae can escape the local circulation around islands and be advected by ocean currents to remote island populations. Evidence from plankton samples suggests that this occurs and drift bottle data from the tropical Pacific give some evidence of the likelihood that a larva carried by ocean currents will actually encounter another island population.

SEDDON, Mary

INTERNATIONAL ASPECTS OF MOLLUSCAN
CONSERVATION.

[no abstract available]

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METABOLIC AND LOCOMOTORY ADAPTATIONS OF
PELAGIC CEPHALOPODS TO HABITAT DEPTH AND
OXYGEN CONCENTRATION

The metabolic rates of 24 species of pelagic cephalopods from Hawaiian and Californian waters were measured and regressed against minimum depth of occurrence. Metabolic rates ranged from 0.05 $\mu\text{moles O}_2 / \text{g wet weight} \cdot \text{h}$ for the bathypelagic *Vampyroteuthis infernalis*, to 8.79 $\mu\text{moles O}_2 / \text{g wet weight} \cdot \text{h}$ for the epipelagic squid, *Gonatus onyx*. A significant decline in metabolic rate with increasing minimum depth of occurrence was observed in both Hawaiian ($p=0.006$) and Californian ($p=0.0004$) animals.

V. infernalis and *Japetella heathi* were shown to be capable of aerobic living within the well-developed oxygen minimum layer off California. Both species regulated oxygen consumption down to 6 torr. *Japetella diaphana*, living within the oxygen minimum layer off Hawaii, regulated its oxygen consumption to 21 torr corresponding to the minimum oxygen concentration found in that region.

The enzymatic activities in mantle, fin, and arm muscle of 28 species of pelagic cephalopods were also measured. Citrate synthase was used to estimate sustained aerobic swimming potential within each tissue. Octopine dehydrogenase was used to estimate burst swimming potential. The adaptive significance of metabolic and locomotory changes with depth are discussed.

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DISTRIBUTION AND ASSEMBLAGE PATTERNS OF PELAGIC
CEPHALOPODS AT FRONTAL ZONES IN THE CENTRAL NORTH
PACIFIC OCEAN.

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 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 along the 174.5° and 179.5° W meridians straddling the Subarctic Boundary between the 37° and 46° N parallels. 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 Enoploteuthidae, Gonatidae, Onychoteuthidae, 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.

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A REVIEW OF THE GENUS *Partulina* FROM THE WEST
MAUI MOUNTAINS, HAWAII

West Maui is a heavily eroded shield volcano with narrow, steep ridges and deep broad valleys radiating from a central peak. Tree snail populations of the genus *Partulina* isolated on these ridges showed enough variation that early collectors described fourteen species a *Partulina* from West Maui. Most early collectors had poor geographical information for the localities of the populations, and in some cases, collecting data indicated locations that were miles from the actual populations.

Beginning in 1979 until the present a thorough survey of *Partulina* populations of West Maui was undertaken and populations of all but two of the original fourteen species were located and accurately mapped. When these populations were placed in the context of their geographic distribution, continuous gradations between the fourteen species became evident and the number of species of West Maui *Partulina* was reduced to five. A search of several lowland Pleistocene fossil deposit on West Maui added no new species of *Partulina*.

No West Maui *Partulina* species are immediately threatened, but some populations are vulnerable because they are small and isolated. Current threats include habitat loss, rat predation, and the introduced predatory snail *Euglandina rosea*.

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LAND MOLLUSK COMMUNITIES REFLECTED IN 9,000 YEARS OF FOSSIL DEPOSITS IN A LAVA TUBE ON MAUI, HAWAII

Snail shells washing into the pitfall entrance to Pu'u Naio cave on Maui have provided a paleontological history of the molluscan fauna around the cave. Preserved in thinly stratified layers of alluvium deposited by sheetwash during floods is a record of dynamic change in local snail communities beginning about 9,000 years ago and continuing through the collapse of the native fauna coinciding with the arrival of humans. Radiocarbon dates indicate that sediment deposition continued at a uniform rate over the history of the site.

Several major fluctuations in numbers of snails and community structure occurred over this 9,000 year period, reflecting changes in climate and habitat. Observations of species with known habitats familiar to us from fieldwork suggested conditions existing during specific periods. Lowland dryland species and arboreal species were particularly useful as indicators of the type of habitat existing in the area of the cave entrance.

The snail community collapse shortly after the arrival of humans was indicated by the presence of introduced taxa and charcoal in the sample. Of the approximately forty species of land snails found at the site, only one survived into the period of European contact in the area of the cave.

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TREE SNAILS, TROPICAL STORMS, AND DROUGHT IN THE MARIANA ISLANDS

A two-year field study of the tree snails *Partula gibba* and *Partula radiolata* on Guam and Rota, Mariana Islands, revealed that partulids exhibit sensitivity to environmental disruptions caused by tropical storms and drought. Population densities of tree snails in each of five 5 m x 5 m quadrats declined after forest canopy was damaged by tropical storms in 1992. Recovery of snail populations was rapid where damage to forest canopy was limited to defoliation, but slower where canopy trees were toppled.

Drought exerted a greater negative effect on snail populations than tropical storms. In the southern Mariana Islands, the record drought associated with the 1993 El Niño caused partulid populations to decline by up to 90% of their pre-drought densities. In areas where forest canopy had recovered, snail populations rebounded within 1 yr after the drought ended. Where canopy trees were lost to storms, snail populations have not recovered 2 yr after the drought ended.

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MICROSATELLITE DNA AND POPULATION GENETICS OF THE SQUID *Loligo forbesi*.

Detailed examination of population structure in cephalopods using molecular genetic techniques has been hindered by the lack of suitable variation at allozyme loci, and suitable mtDNA markers due to the unusual organization of the mitochondrial genome in molluscs. The analysis of nuclear DNA microsatellite regions in a number of organisms has recently indicated its propensity for providing highly polymorphic genetic marker loci suitable for intra-specific studies ranging from paternity testing to large scale geographic population structuring.

We are developing microsatellite DNA markers for the NE Atlantic squid of partial genomic libraries with a range of tetra-, tri- and di-nucleotide probes has uncovered the presence of repeat motifs in up to 10% of clones. A selection of 20 pure and chimeric microsatellite sequences are currently being screened for their usefulness in population structure analysis: results will be presented. This is the first report of the use of microsatellite markers in cephalopods as far as we are aware.

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THE BEHAVIOR AND ECOLOGY OF *Vampyroteuthis infernalis* CHUN.

Observations from a remotely operated vehicle and from captive specimens caught by this ROV have allowed detailed study of the behaviors of *Vampyroteuthis infernalis* Chun. Behaviors were recorded, catalogued, and further analyzed to extract the patterns which are seen in the field and in the laboratory. These behavioral patterns include typical body postures, use of the filaments, feeding behaviors, and bioluminescent displays, including a new bioluminescent display novel to all cephalopods thus far described. A review of all behaviors and their potential significance to the ecology and evolution of coleoids will be given. A videotape illustrating many of these behaviors will be shown.

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BIOLOGICAL AND OCEANOGRAPHIC FACTORS AFFECTING THE DISTRIBUTION OF OCTOPUSES IN SOUTHERN AUSTRALIA AND NEW ZEALAND

Systematics of the inshore, benthic octopuses (Octopodidae) from southern Australia and New Zealand are the subject of current research. As part of these studies, aspects of reproductive biology and zoogeography were examined among the nine species of octopodids recorded from temperate waters of the south-eastern Australian region.

Seven species produce large eggs (7-15 mm long) in low numbers (10s or 100s), and have juveniles that hatch out immediately to a benthic existence (e.g. *Octopus berrima* and *O. pallidus*). Another two species produce small eggs (2-7 mm long) in high numbers (1000s), with juveniles that are temporarily planktonic before settling to the benthos (e.g. *O. maorum* and *O. warringa*). The distribution of these species is also influenced by regional oceanographic factors such as the Leeuwin Current, West Wind Drift and East Australian Current.

The seven species with direct development have limited means for dispersal, and are restricted in distribution to waters off southeastern Australia; the other two species with indirect development have the potential for long-range dispersal, and have an extended distribution through the waters of south-eastern Australia, the Tasman Sea and New Zealand.

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MASS MORTALITY OF BLACK ABALONE IN SOUTHERN CALIFORNIA.

Between 1986 and 1994 black abalone (*Haliotis cracherodii*) throughout southern California have declined in abundance by over 95%. The cause of the decline is unclear but appears to be related to the spread of a pathogen in combination with ecological stress associated with El Niño. I conducted surveys between 1986-1995 in both southern (Santa Cruz Island) and central (Año Nuevo Island) California and focused on the growth, survivorship, and recruitment of individuals in permanent transects. Abalone on Santa Cruz Island have declined over 99.5% in abundance. Growth rates and survivorship have been low when compared to other studies. Although recruitment of juvenile abalone has been occurring, mortality is high apparently due to the effects of the pathogen which was involved in the original mass mortality. In contrast, abalone on Año Nuevo island have experienced no significant mortality in the last eight years. The difference between the two populations may be related to the distribution of the pathogen or, more likely, to the lower seasonal temperatures present at Año Nuevo.

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DEMONSTRATION OF ONLINE ACCESS TO THE CEPHALOPOD COMPUTERIZED BIBLIOGRAPHIC SYSTEM.

A cross-referenced, bibliographic card file on cephalopod literature generated by Clyde Roper and Mike Sweeney was "computerized" in 1984 to form a searchable, reference bibliography with associated keywords. Through funding provided by the Smithsonian Institution and National Marine Fisheries Service, the database software was upgraded in 1989 and an early version was included on a CD-ROM produced by the National Museum of Natural History in 1990. We decided in 1994 to convert the standalone database to an Online Public Access Catalog (OPAC) on the Smithsonian Institution Research Information System (SIRIS). Access to this research database by cephalopod colleagues around the world has been established as a high priority by the Cephalopod International Advisory Council (CIAC). Currently, 4,500 predominantly English language, annotated, bibliographic entries reside in the system. Each reference lists taxa discussed, along with numerous other subject headings and associated data. Access to the bibliography is available on the Internet as a Telnet connection to allow remote log-on. The system will be demonstrated during the poster sessions.

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HETEROCHRONY IN THE FAMILY ONYCHOTEUTHIDAE

The Onychoteuthidae is one of poorly characterized families among the Oegopsida, in not only species level taxonomy but also the generic relationship. The characters conventionally used for defining the genera are, 1) intestinal photophores, 2) dorsal nuchal folds, 3) dermal structure, 4) tentacular armatures, and 5) gladius. Among them, the features of the dermal structure and tentacular armatures ontogenetically change. In some species, e.g. *Onychoteuthis raptor* Owen, 1881, appears to have mosaic characters among above mentioned generic definition. Also, the systematic position of "*Onykia*" *rancureli* Okutani, 1981 is problematic.

In the present study, the character evolution is analyzed using the cladistic methods. Characters evaluated are twelve including the spermatophore and club hook. Twelve nominal species and some unnamed species of five genera are analyzed.

The character evolution from the assessed cladogram suggests the presence of heterochrony in some characters, and the previous generic classification is needed the revision. The generic status of *Ancistroteuthis*, *Moroteuthis* (= *Onykia*), and "*Onykia*" *rancureli* will be discussed.

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FEDERAL EFFORTS TOWARDS THE CONSERVATION OF MOLLUSKS

The awareness of scientists, society, and state and federal governments regarding crucial issues in biodiversity has been elevated through various grass-roots appeals such as the Sustainable Biosphere Initiative and the Global Marine Biological Diversity Strategy. For the past two years numerous agency and federal partnership planning efforts have been underway that involve inventorying U.S. natural resources boding well for the conservation of mollusks. Biodiversity, ecosystem health, sustainable development, wise stewardship of resources, and "yes" even the status of invertebrate taxonomy have received considerable attention in current federal strategic plans and budgets. I will share some of the exciting efforts that NOAA has underway and also discuss a few political realities that could have implication for implementing all this strategic planning.

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ANALYSIS OF CHARACTERS TO DETERMINE ORDINAL RELATIONSHIPS OF EXTANT CEPHALOPODS.

Although most families of living coleoid cephalopods are well defined, phylogenetic relationships among them are controversial. A necessary first-step toward analyzing the phylogeny of decapod families is the determination of proper outgroups to polarize characters. The clastic position of the Vampyromorpha is of particular interest. Toward this goal, we have examined 51 morphological characters in 22 species from 17 families. The material examined included representatives from the oegopsids, myopsids, sepioids and sepiolids, cirrate and incirrate octopods, and *Vampyroteuthis*. At this level, the characters were polarized either by comparison with *Nautilus*, by ontogenetic sequence, or, for a few, by the fossil record. We found that of these 51 characters, 18 were informative as defining synapomorphies at the ordinal level.

The resulting consensus of most-parsimonious trees is: (((oegopsid+myopsid+sepioid+sepiolid)(((cirrate)(incirrate)) vampire))(nautilus)).

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NERITACEAN RADULAE: CAN CLUES TO THE HISTORY OF THIS GASTROPOD GROUP BE READ IN THEIR TOOTH STRUCTURE?

Radular structure in the six families of the Neritacea is analyzed, seeking clues to relationships between families and between this and other gastropod groups. Their proper position in the scheme of prosobranch classification has been the subject of debate which can only be settled by a knowledge of their phylogenetic history. Using radular morphology including individual tooth shapes, their relative numbers, proportions and alignments, and also the many complex interactions between teeth, the range of radular structure in each family is defined. The degree of homogeneity is assessed, looking also for overall neritacean characteristics. In the large families, the Neritidae and Helicinidae, radular form is consistent throughout except for a few genera whose taxonomic status then becomes open to discussion.

A phylogenetic hypothesis for the history of the group is developed from similarities between taxa suggesting possible shared descent. Despite an ancient fossil history, the unique neritacean blend of primitive and advanced anatomical and life history traits sets them apart from other gastropods. Since the rhipidoglossan radula is shared with most traditional archaeogastropod families, radular structure from a number of representative taxa is compared. Docoglossan, polyplacophoran and taenioglossan radulae are also examined in order to explore whether the tooth patterns seen in the Neritacea support the suggestion that they are one of the earliest branches from the gastropod stem.

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PHYLOGENETIC RECONSTRUCTION OF INCIRRATE OCTOPODS WITH MORPHOLOGICAL CHARACTERS

Chief among problems confronting octopod systematists are few apparent characters informative in reconstructing relationships among the soft-bodied, ecologically diverse octopods. Characters have been heavily used to classify of the group, sucker rows, the presence or absence of a crop and ink sac are too few to resolve relationships among the 9 recognized, but generally little-known incirrate families. Detailed anatomical and morphological study of these recognized families have discovered characters helpful in resolving relationships. The tradition of excising the digestive and reproductive systems from the animal, other organs and each other, destroy data which these studies find to define the Octopodidae, Bolitaenidae, Argonautoidae, and Amphitretidae (s.l.) as monophyletic groups and define relationships among the taxa. Establishing higher-order relationships is critical to defining relationships within each group. Although octopodids had been considered to be unique in their high species diversity, mid-water groups contain many previously undiscovered species.

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A NEW SMALL, LITTORAL, ARM-AUTOTOMIZING OCTOPUS FROM GUAM.

A new member of the *Octopus horridus* species group, a shallow-water octopus from Guam is presented. Arm autotomy is readily employed by this octopus; arms characteristically detach 5-6 suckers from the mouth, slightly proximal of the web margin. The consistent location of the autotomy zone suggests the existence of a preformed breakage plane. Histological examination of the breakage zone has shown no morphological specialization in muscle or connective tissue to facilitate breakage in this region, however.

Loss of the hectocotylied arm used for sperm transfer by males would reduce male fitness. I tested whether this arm (R3) would be autotomized by males as readily as other arms, and whether the corresponding arm in females was as readily autotomized as other arms. In tests, males never autotomized arm R3, while females autotomized this arm at least as readily as other arms.

Notes on the life history (egg production, brooding, hatchling morphology and coloration, etc.) are also presented.

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***Allonautilus*: A NEW GENUS OF LIVING NAUTILOID CEPHALOPOD**

For centuries it has been believed that a single genus of nautiloid cephalopod survives: *Nautilus* Linnaeus, 1758. Five or six extant species are commonly accepted as valid, and four these are quite similar in shell- and soft-part morphology. The shells of the two species, however, are quite distinct, but until recently no soft parts were known. In 1984, the most atypical species currently assigned to *Nautilus*, *N. scrobiculatus* Lightfoot, 1786 was seen alive for the first time. In order to better understand relationships between the various species of *Nautilus*, we have undertaken comparisons of shell morphology, shell ultrastructure, and (where available) salient anatomical features of all five extant species of *Nautilus* along with two closely related fossil species, Tertiary *N. praepompilius* Shimansky and Cretaceous *Eutrephoceras dekayi* (Conrad) to serve as an outgroup. The anatomical comparisons show that *N. scrobiculatus* differs fundamentally from other *Nautilus* species, and our cladistic analysis indicates that *N. scrobiculatus* and the morphologically similar species *N. perforatus* (known only from drift shells) share few characters with the other *Nautilus* species. The results lead us to conclude that *N. scrobiculatus* and *N. perforatus* represent a new genus, *Allonautilus*, with *A. scrobiculatus* as its type species. Its most distinctive differences are its shell form, shell ultrastructure, gill morphology, and details of the male reproductive system. We hypothesize that *Allonautilus* is a Late Tertiary derivative of *Nautilus*.

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THE PHYLOGENY OF THE SEPIIDS; INSIGHT FROM THE FOSSIL RECORD?

Most post-Cretaceous coleoid cephalopods have a very poor fossil record, and the controversy over systematic position of many groups is in no small way the result of this sad fact. Among extant coleoids, the sepiids are one of the better represented groups. Their fossil record, however, is still far from adequate. Nevertheless, the presence of isolated specimens from Tertiary deposits in many parts of the world has given us important insights into character development and polarity when constructing cladistic analyses of this group. The cuttlebone, especially, provides important information into evolutionary pathways. One of the most pressing questions is whether the various subgenera as described (but not formalized) by Khromov (1987) represent true clades, or are polyphyletic groups evolved through convergent evolution. In this study I present a biogeographic test as well as a preliminary morphological analysis suggesting that Khromov's hypothesis (that *Sepiella*, *Hemisepius*, *Sepia* ss, *Acanthosepia*, *Rhombosepia*, *Metasepia* and *Doratosepia*) may be valid taxa representing clades that perhaps should be formalized) may be correct. Important characters include the nature of the cone, spine, cuttlebone shape, pillar morphology, and septal contacts.

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DEVELOPMENT OF AN OMMASTREPHID SQUID *Todarodes pacificus*, FROM FERTILIZED EGG TO THE RHYNCHOTEUTHION PARALARVA.

The present study established the atlas of the normal development of *Todarodes pacificus* from fertilized egg to the rhyngoteuthion paralarva for the first time. In the course of the present study, the observations on embryogenesis and histological differentiations in *T. pacificus* were made for consideration on developmental mode of Oegopsida, which is a specialized group with the degenerated external yolk sac. It is considered that the differentiations of the respiratory organs and the digestive organs are delayed in Oegopsida, with a reduction of the yolk sac and the egg size as well. This may be related to strategy of oceanic squids against the environment in which their floating eggs and paralarvae are exposed.

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Pres. Reception - Fri 7:00 - Don Hemmes - Librarian.

Bill Mull.

NOTES:

300 cucumbers → 1000 → 1400 full sp

8000 insects ←

crickets & wolf spiders

NOTES:

NOTES: