

PROGRAM AND ABSTRACTS

56th ANNUAL MEETING
3-8 June 1990

Marine Biological Laboratory
Woods Hole, Massachusetts

AMERICAN MALACOLOGICAL UNION, INC.

Executive Council, 1989 - 1990

President	Roger T. Hanlon
President-Elect	Carole S. Hickman
Vice-President	Robert C. Bullock
Secretary/Treasurer	Clement L. Counts, III
Editor	Robert S. Prezant
Councilors-at-large	Terrence M. Gosliner Rudiger Bieler Robert Hershler
Immediate Past Presidents	James H. McLean Richard E. Petit William G. Lyons
Past President (4 to 10 years)	Melbourne R. Carriker
Past President (more than 10 years)	Harold D. Murray

Committee Chairpersons, 1989 - 1990

Nominating	James H. McLean
Auditing	Robert C. Bullock
Finance	Carole S. Hickman
Endowment Review	George M. Davis
Membership	Richard E. Petit
Auction	Richard E. Petit
History and Archives	George M. Davis
Constitution and By Laws	Harold D. Murray
Conservation	Raymond W. Neck
Dealers and Sales	Edward C. Nieburger
Publications	Robert S. Prezant
Student Award Judging	William M. Kier

Additional Meeting Organizers, 1990

Assistants to President	Joanne M. Hollyfield, Laura A. Koppe
Registrar	Joanne M. Hollyfield, Lou Ann King
Local Committee at MBL	Alan Kuzirian, Lou Ann King
Motel Accomodations	E. Joel Peterson
Worshop on Home Aquaria	John Forsythe, Steven Spotte, John Valois
Field Trips	Alan Kuzirian, Robert C. Bullock, Eileen Jokinen, Doug Smith, Amelie & Rudy Scheltema, John Valois
T-shirts	Anne Joffe
Logo	Alan Kuzirian, John Arnold, Bob Golder
Bourse	Edward C. Nieburger, Donald H.Y. Dan
Council of Systematic Malacologists	William K. Emerson
Institute of Malacology	George M. Davis

PAST PRESIDENTS

Henry A. Pilsbry	1931-32	Joseph C. Bequaert	1954	Dolores S. Dundee	1973
Paul Bartsch	1933	Morris K. Jacobson	1955	Harold D. Murray	1974
Junius Henderson	1934	Allyn G. Smith	1956	Donald R. Moore	1975
William J. Clench	1935	Ruth D. Turner	1957	Dorothea S. Franzen	1976
Calvin Goodrich	1936	Aurele LaRocque	1958	George M. Davis	1977
Joshua L. Baily, Jr.	1937	R. Tucker Abbott	1959	Carol B. Stein	1978
Carlos de la Torre	1938	Katherine V.W. Palmer	1960	William E. Old, Jr.	1979
Maxwell Smith	1939	Thomas E. Pulley	1961	Clyde F.E. Roper	1980
Horace B. Baker	1940	William K. Emerson	1962	Richard S. Houbbrick	1981
Harald A. Rehder	1941	Albert R. Mead	1963	Louise Russert-Kraemer	1982
Frank C. Baker	1942	John Q. Burch	1964	Alan J. Kohn	1983
Louise M. Perry	1943-45	Juan Jose Parodiz	1965	Robert Robertson	1984
Henry van der Schalie	1946-47	Ralph W. Dexter	1966	Melbourne R. Carriker	1985
A. Myra Keen	1948	Leo G. Hertlein	1967	James Nybakken	1986
Elmer G. Berry	1949	Arthur H. Clarke	1968	William G. Lyons	1987
Fritz Haas	1950	Joseph Rosewater	1969	Richard E. Petit	1988
Joseph P.E. Morrison	1951	G. Alan Solem	1970	James H. McLean	1989
Jeanne S. Schwengel	1952	David H. Stansbury	1971		
A. Byron Leonard	1953	Arthur S. Merrill	1972		

HONORARY LIFE MEMBERS

R. Tucker Abbott	William K. Emerson
Harald A. Rehder	Margaret C. Teskey
Ruth D. Turner	

HONORARY LIFE PRESIDENT

Harald A. Rehder

PROGRAM SUMMARY

Marine Biological Laboratory, Woods Hole, Mass., 3-8 June 1990

Date	Morning	Afternoon	Evening
SUN June 3	9:00 - 12:00 AMU Executive Council Meeting (private Dining Room, Swope Center)	12:00 - 8:00 12:00 - 7:30 2:00 - 4:00 4:00 - 6:00 Registration (Swope Center) Bourse - books, shells, art sales (Meigs Room in Swope) Council of Systematic Malacologists (private Dining Room, Swope Center) Conservation Committee (open) (private Dining Room, Swope)	8:00 - 10:00 President's Reception Everyone Invited (Meigs Room in Swope Center)
MON June 4	8:30 - 12:00 8:30 - 9:00 9:00 - 12:00 9:00 - 12:00 Registration (Swope Center) Welcome and opening address (Lillie Auditorium) Behavior of Molluscs (Candlehouse 104/105) Integrative Neurobiology (Whitman Auditorium)	11:00 - 2:30 1:00 - 5:00 1:00 - 5:00 Bourse (Meigs Room, Swope) Behavior of Molluscs (Candlehouse 104/105) Integrative Neurobiology (Whitman Auditorium)	4:30 - 7:30 7:00 - 8:30 8:30 - 10:00 Bourse (Meigs Room, Swope) Poster session with Reception honoring Symposia participants (Swope Center) Film Festival (Swope Dining Room)
TUE June 5	8:30 - 12:00 8:30 - 12:00 8:30 - 12:00 12:00 - 12:20 Behavior of Molluscs (Candlehouse 104/105) Integrative Neurobiology (Whitman Auditorium) Systematics, Biology & Fisheries of Cephalopods (Lillie Auditorium) Group Photo (Lillie Bldg. steps)	11:00 - 2:30 1:20 - 3:20 3:20 - 5:30 1:20 - 5:00 Bourse (Meigs Room, Swope) Integrative Neurobiology (Whitman Auditorium) Round-table discussion - Evolution, Neurobiology and Behavior (Whitman Audit.) Systematics, Biology & Fisheries of Cephalopods (Lillie Auditorium)	6:00 - 8:00 8:00 - 10:00 New England Clam & Lobster Boil (Swope Center) Auction (Meigs Room, Swope Center)
WED June 6	8:30 - 12:00 8:30 - 12:00 Systematics, Biology & Fisheries of Cephalopods (Lillie Auditorium) Contributed Papers - Marine (Candlehouse 105)	1:00 - 5:00 1:00 - 5:00 Systematics, Biology & Fisheries of Cephalopods (Lillie Auditorium) Contributed Papers - Marine, Cephalopod & Terrestrial (Candlehouse 105)	7:00 - 8:00 8:00 - 9:30 9:30 - 10:30 Workshop on Home Aquaria (MRC Building) Film Festival (Swope Dining Room) AMB Board of Editors Meeting (private Dining Room in Swope)
THU June 7	8:30 - 12:00 8:30 - 10:20 10:40 - 12:00 Systematics, Biology & Fisheries of Cephalopods (Lillie Auditorium) Contributed Papers - Freshwater (Candlehouse 105) Roundtable Discussion on Shells in Environmental Studies (Candlehouse 105)	1:00 - 4:00 3:00 - 4:00 4:00 - 5:00 5:00 - 5:15 Systematics, Biology & Fisheries of Cephalopods (Lillie Auditorium) Institute of Malacology Meeting (Lillie 103) AMU Business Meeting (open) (Lillie Auditorium) Field Trip Previews (Lillie Auditorium)	7:00 - 10:00 Social hour & banquet (Swope Dining Room)
FRI June 8	Field Trips: 1. Marine dredging &/or squid trawling on R/V GEMMA 2. Marine shore collecting in various Cape Cod ecosystems 3. Freshwater/terrestrial collecting on Cape Cod 4. Hiking in Cape Cod National Seashore 5. Visit lobster hatchery and shellfish culture on Martha's Vineyard		John Valois Robert C. Bullock Eileen Jokinen Amelie Scheltema Alan Kuzirian

NOTE: MBL library is open to all registrants throughout the week

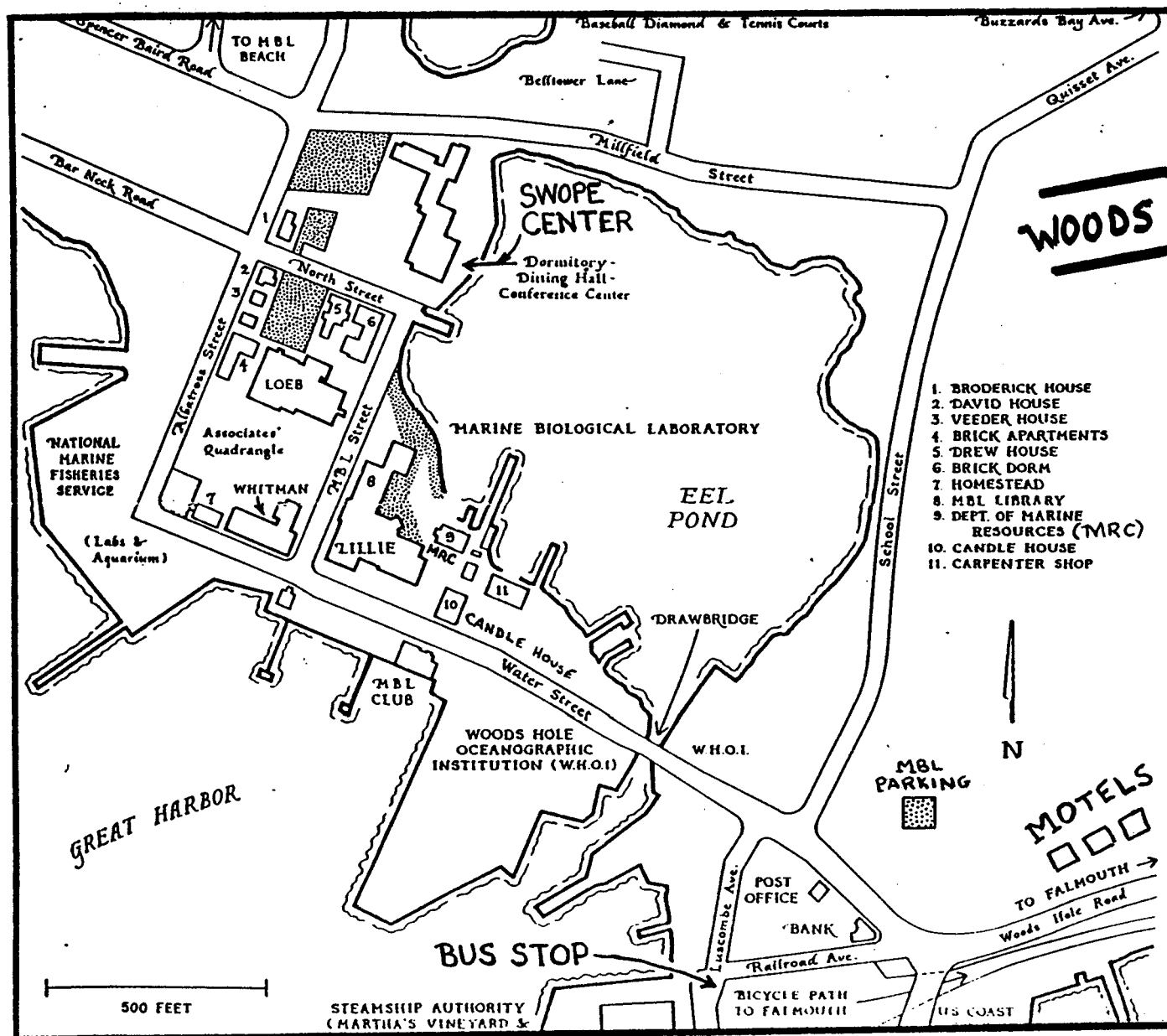
Swope Dining Room Hours

Breakfast: 7:00 - 8:30 Lunch: 12:00 - 1:00 Supper: 5:00 - 7:00

(NOTE: Meal Plan begins Sunday 3 June at Supper and ends Saturday 9 June after Lunch)

To receive Emergency Messages

Marine Biological Laboratory - telephone (508) 348-3705 or FAX (508) 540-6902 and specify AMU Meeting



REGISTRATION

The registration table will be open for those wishing to register or arrange tickets for the field trips or banquet. Tables for sales of AMU publications and T-shirts will be adjacent to registration. The tables will be located near the entrance door of Swope Center.

ACTIVITIES

President's Reception (Sunday)

All registrants and their families are invited to this informal reception in the Meigs Room of Swope Center. Mixed drinks, soft drinks and snacks will be provided. Come and renew old acquaintances or make new ones.

Dealers' Bourse (Sunday through Tuesday)

Bourse Chairman Edward Nieburger has arranged a sales area in Meigs Room in Swope Center for shells, books and art work. Features include: Donald Dan's Selected Specimen Shells (West Friendship, Maryland); Mathilda Duffy's shell drawings (Watertown, Massachusetts); Paul Monfills' specimen shells from Northeast Natural History Imports (Providence, Rhode Island); and Penelope Hart's pencilled shell drawings (Lexington, Massachusetts).

Poster Session and Reception for Symposia Participants (Monday)

AMU's largest poster session (32 posters) will be coupled with a reception (cash bar) for participants in both symposia to enhance information exchange and encourage everyone to meet more of the participants. Don't miss this enjoyable evening in the foyer of Swope Center.

Film Festival (Monday and Wednesday)

This activity will range from the sublime to the ridiculous. We have entries from highly professional films made for TV to scientific video spoofs orchestrated by bored graduate students! Join everyone Monday and Wednesday evenings for a memorable affair.

Round-Table Discussions (Tuesday and Thursday)

This new twist is being added to stimulate participation by a wider audience than standard paper presentations can provide. This is a chance for anyone to express their views and foster discussion among scientists and amateurs of different disciplines. Everyone is invited.

New England Clam and Lobster Boil (Tuesday)

This is the real thing. Get a good taste of traditional New England fare. The event will be held outdoors behind Swope Center along Eel Pond unless it rains. You must purchase ticket by Sunday evening.

Auction (Tuesday)

The annual auction of books and malacological paraphernalia is one of the highlights of every AMU meeting. Many interesting and valuable items will be one block this year according to auctioneer extraordinaire Dick Petit. All auction proceeds go to the symposium endowment fund that provides support for speakers at symposia of the annual meeting. Don't miss this opportunity to improve your library while supporting a vital function of AMU.

Workshop on Home Aquaria (Wednesday)

Three gentlemen have agreed to share their extensive knowledge on aquarium construction and maintenance and aquatic animal care. John Valois (Manager of Marine Resources Center of MBL), John Forsythe (Laboratory Manager at Marine Biomedical Institute) and Dr. Steven Spotte (author of several books on marine and freshwater aquaria) will provide a brief demonstration of materials and design and will discuss any problems or inquiries from workshop attendees. Those of you working with research aquaria may also find this workshop useful.

Student Paper Competition (throughout meeting)

An award is given annually for the best paper delivered by a student at the AMU meeting. The recipient of the award is selected by a team of judges who evaluate scientific content, adequacy of research approach, organization of the presentation, quality of visual aids, and the manner in which the presenter handles questions and answers. The twelve presentations entered in this year's competition are indicated by asterisks on the session schedules.

MBL/WHOI Library (open 24 hrs)

This extraordinary facility is never closed and features 3,000 scientific journals, printed in 40 languages and bound in some 160,000 volumes. There are over 26,000 monographs and 250,000 reprints representing literature over the past 300 years. The catalog and reading room are located on the second floor of the Lillie Building. Check it out.

Business Meeting (Thursday)

The annual business meeting will commence following the close of contributed and symposia papers on Thursday afternoon. This is where the dollars and sense of the AMU are established. Members are encouraged to come and participate in deciding the future of your organization.

Social Hour and Banquet (Thursday)

The social hour (cash bar) will precede the prime beef and prime seafood dinner, replete with wine and beer, wit and good cheer. We will have a talk and a band for dancing to satisfy all of you with happy feet. You must purchase ticket by Tuesday at noon.

Sightseeing

Locally there are tours of the Marine Resources Center of MBL, the aquarium at National Marine Fisheries Service and the Woods Hole Oceanographic Institution. The Falmouth Chamber of Commerce will provide brochures of local activities, shops, etc. for \$2. The Steamship Authority in Woods Hole provides access to Martha's Vineyard and Nantucket Islands. Check the registration desk for this and other information.

Parking

Always a problem in Woods Hole. On-campus parking stickers are available only to meeting registrants and instructions are available in Swope Center. Illegally parked cars will be towed quickly. There is an MBL parking lot near the Steamship Authority (see map) and a free shuttle service.

Shuttle service from motels

MBL vans can shuttle some registrants between the motels and Swope Center during the meal hours each day and later at night. There will be no set schedule and we encourage most guests to walk the short distance through the village of Woods Hole.

Field Trips (Friday)

Previews will be held Thursday afternoon at 5 pm in Lillie Auditorium. Please attend this, meet your trip leader and find out details of your outing. Box lunches are included (free to Meal Plan participants and \$5 to others).

Day Care

Inquire at the desk in Swope.

NOTES

Monday Morning, June 4

8:30 - 12:00 Registration - Swope Center

8:30 **WELCOME AND OPENING REMARKS**

Roger T. Hanlon, President of AMU; Harlyn O. Halvorson, President and Director, Marine Biological Laboratory; Professor J.Z. Young, F.R.S., Oxford University.

Location: Lillie Building Auditorium.

M
O
N
D
A
Y

SYMPOSIUM: INTEGRATIVE NEUROBIOLOGY AND BEHAVIOR OF MOLLUSCS

Conveners: Roger T. Hanlon, Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX and Alan M. Kuzirian, Marine Biological Laboratory, Woods Hole, MA.

Chairperson: Bernd U. Budelmann Location: Whitman Auditorium

9:00 NEURAL ORGANIZATION OF PREDATORY BEHAVIOR IN *PLEUROBRANCHAEA CALIFORNICA*.
GILLETTE, R. Department of Physiology and Biophysics, University of Illinois, Urbana, IL 61801.

9:20 OPTICAL RECORDINGS FROM THE *APLYSIA* ABDOMINAL GANGLION DURING THE GILL WITHDRAWAL REFLEX.
COHEN, Larry, Jian-young WU, Xiao Chun FALK and Hans-Peter HOPP. Department of Physiology, Yale University School of Medicine, New Haven, CT 06510.

9:40 THE *APLYSIA* GILL-WITHDRAWAL REFLEX REVISITED: ASSESSING THE ROLE OF IDENTIFIED MOTOR NEURONS.
LEONARD¹, Janet L., Manuel MARTINEZ-PADRON², John P. EDSTROM² and Ken LUKOWIAK². ¹Department of Zoology, University of Oklahoma, Norman, OK and Hatfield Marine Science Center, Newport, OR 97365; ²Department of Medical Physiology, University of Calgary, Calgary, Alberta, Canada.

10:00 NEURAL MECHANISMS UNDERLYING SENSITIZATION OF A DEFENSIVE REFLEX IN *APLYSIA*.
CLEARY, Leonard J., Douglas A. BAXTER, Fidelma NAZIF and John H. BYRNE. Department of Neurobiology and Anatomy, University of Texas Medical School, Houston, TX 77225.

10:20 **BREAK**

10:40 MAGNETIC FIELDS, OPIOID SYSTEMS AND DAY-NIGHT RHYTHMS OF NOCICEPTION IN THE LAND SNAIL, *CEPAEA NEMORALIS*.
KAVALIERS, M., K.-P. OSSENKOPP, D. TYSDALE and S. LIPA. Division of Oral Biology, University of Western Ontario, London, Canada.

11:00 MULTIPLE SITES OF SYNAPTIC MODULATION MEDIATE BEHAVIORAL PLASTICITY IN *APLYSIA*.
WRIGHT, W.G., E.M. MARCUS and T.J. CAREW. Department of Psychology, Yale University, New Haven, CT 06520.

11:20 PATTERNS OF BEHAVIORAL AND NEURONAL PLASTICITY IN *APLYSIA* MAY REFLECT FUNDAMENTAL DEFENSIVE PRINCIPLES.
WALTERS, E.T., A.L. CLATWORTHY and C.P. HICKIE. University of Texas Medical School, Houston, TX 77225.

11:40 IMMUNOHISTOCHEMISTRY OF DIVERGING AND CONVERGING NEUROTRANSMITTER SYSTEMS IN MOLLUSCS.
SOINILA, Seppo and George J. MPITSOS. Hatfield Marine Science Center, Newport, OR 97365.

12:00 **LUNCH**

Monday Morning, June 4

8:30 - 12:00 Registration - Swope Center

8:30 **WELCOME AND OPENING REMARKS**

Roger T. Hanlon, President of AMU; Harlyn O. Halvorson, President and Director, Marine Biological Laboratory; Professor J.Z. Young, F.R.S., Oxford University.
Location: Lillie Building Auditorium.

SYMPOSIUM: **BEHAVIOR OF MOLLUSCS**

Convener: Roger T. Hanlon, Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX.

Chairperson: Martin J. Wells Location: Candlehouse 104/105

9:00 **CEPHALOPODS BEAR ARMS: ON "CIRCUMORAL APPENDAGES" AND THEIR ROLE AS BEHAVIORAL INSTRUMENTS.**

BOLETZKY, Sigurd v. Laboratoire Arago, URA 117 C.N.R.S., F-66650 Banyuls-sur-Mer, France.

9:20* **COMPLEX COGNITION IN *OCTOPUS BIMACULOIDES*: DISCRIMINATION OF ODDITY.**

BOAL, Jean. University of North Carolina, Chapel Hill, NC 27599-3275.

9:40 **CHEMOTAXIS BY *OCTOPUS MAYA* IN A Y-MAZE.**

LEE, Phillip G., Keith A. **JOHNSON** and Roger T. **HANLON**. Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77550.

10:00 **ETHOLOGY, ECOLOGY AND EVOLUTIONARY CONSTRAINT IN THE OCTOPUS: AN INTEGRATED APPROACH.**

ARONSON, Richard B. Department of Paleobiology, Smithsonian Institution, Washington, DC 20560.

10:20 **BREAK**

10:40 **VISUAL MEMORY AND NAVIGATION IN JUVENILE *OCTOPUS VULGARIS*.**

MATHER, Jennifer A. Psychology Department, University of Lethbridge, Lethbridge, Alberta T1K 3M4, Canada.

11:00 **BEHAVIOURAL STUDIES ON VISION IN *NAUTILUS* AND *OCTOPUS*.**

MUNTZ, W.R.A. Department of Botany and Zoology, Monash University, Clayton, Victoria 3168, Australia.

11:20 ***NAUTILUS*; THE PHYSIOLOGY AND BEHAVIOUR OF A DEEP SEA ANIMAL.**

WELLS¹, M.J. and R.K. **O'DOR**². ¹Department of Zoology, Downing Street, Cambridge CB2 3EJ, United Kingdom and ²Department of Biology, Dalhousie University, Halifax, N.S. B3H 4J1, Canada.

11:40 **A MODEL FOR RADULAR FEEDING IN *HELISOMA*.**

SMITH, David A. and Robert S. **WEISS**. Department of Biology, Wabash College, Crawfordsville, IN 47933.

12:00 **LUNCH**

M
O
N
D
A
Y

Monday Afternoon, June 4

11:00 - 2:30 Bourse (Meigs Room in Swope)
4:30 - 7:30 " " "

SYMPOSIUM: INTEGRATIVE NEUROBIOLOGY AND BEHAVIOR OF MOLLUSCS

Conveners: Roger T. Hanlon, Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX and Alan M. Kuzirian, Marine Biological Laboratory, Woods Hole, MA.

Chairperson: Jon W. Jacklet Location: Whitman Auditorium

M
O
N
D
A
Y

- 1:00 TEMPORAL ORGANIZATION IN *APLYSIA*: THE CIRCADIAN OSCILLATOR IN THE EYE.
STRUMWASSER, Felix. Laboratory of Neuroendocrinology, Marine Biological Laboratory, Woods Hole, MA 02543.
- 1:20 PARTIAL CHARACTERIZATION OF A UNIQUE PROTEIN IN THE EYE, A CIRCADIAN ORGAN, OF *APLYSIA*.
COX, Rachel L., David L. GLICK, Richard J. RIDGE and Felix STRUMWASSER. Laboratory of Neuroendocrinology, Marine Biological Laboratory, Woods Hole, MA 02543.
- 1:40 MODULATION OF THE ELECTRORETINOGRAM BY THE CIRCADIAN PACEMAKER IN THE EYE OF *APLYSIA* (GASTROPODA: TECTIBRANCHIA).
JACKLET, Jon W. Department of Biology, SUNY-Albany, Albany, NY 12222.
- 2:00 BREAK
- 2:20 DIVALENT-CATION INDUCED VESICULATION AND VESICULAR FUSIONS AND MIGRATIONS AFTER TRANSECTION OF SQUID GIANT AXONS.
FISHMAN, Harvey M. and Kirti P. TEWARI. Department of Physiology and Biophysics, University of Texas Medical Branch, Galveston, TX 77550.
- 2:40 TRANSMISSION AT THE SQUID GIANT SYNAPSE.
DE SANTIS¹, A. and J.B. MESSENGER². ¹Stazione Zoologica, Naples, Italy and ²Department of Animal and Plant Sciences University of Sheffield, England.
- 3:00 GIANT AXON UTILIZATION IN ESCAPE RESPONSES.
GILLY, Wm. F. Hopkins Marine Station, Stanford University, Pacific Grove, CA.
- 3:20 BREAK
- 3:40 NEUROPHARMACOLOGY OF COLOUR CHANGE IN CEPHALOPODS.
MESSENGER, John B. Department of Animal and Plant Sciences, University of Sheffield, England.
- 4:00 THE INTERPRETATION OF CHROMATOPHORE SYSTEMS IN CEPHALOPOD MOLLUSCS.
PACKARD, Andrew. Department of Zoology, Naples, University and Stazione Zoologica, Napoli 80121, Italy.
- 4:20 NEW PREPARATIONS FOR BRAIN NEUROPHYSIOLOGY IN CEPHALOPODS.
BUDELMANN¹, Bernd U., Theodore H. BULLOCK² and Roddy WILLIAMSON³. ¹Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77550, ²Department of Neurosciences, A-001, University of California at San Diego, La Jolla, CA 92093 and ³Marine Biological Association of the United Kingdom, Plymouth PL1 2PB, England.
- 4:40 HOW THE LEARNING SYSTEMS OF CEPHALOPODS COMPUTE ADAPTIVE BEHAVIOUR.
YOUNG, John Z. Department of Experimental Psychology, Oxford University, Oxford OX1 3UD, England.

MONDAY EVENING

- 7:00 - 8:30 POSTER SESSION with Reception Honoring Symposia Participants (cash bar)
Location: Meigs Room plus Swope Center foyer
- 8:30 - 10:00 FILM FESTIVAL
Location: Dining Room, Swope Center

Monday Afternoon, June 4

11:00 - 2:30 Bourse (Meigs Room in Swope)
4:30 - 7:30 " " "

SYMPOSIUM: BEHAVIOR OF MOLLUSCS

Convener: Roger T. Hanlon, Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX.

Chairperson: Michael Mazurkiewicz Location: Candlehouse 104/105

- 1:00 THE ROLE OF CHEMICAL CUES IN ANTIPREDATION STRATEGIES IN FRESHWATER SNAILS.
CROWL¹, Todd A., Alan P. COVICH² and James A. ALEXANDER JR.² ¹Department of Fisheries and Wildlife and Ecology Center, Utah State University, Logan, UT 84322 and ²Department of Zoology, University of Oklahoma, Norman, OK 73019.
- 1:20 STUDY ON THE PRESENCE OF ALARM PHEROMONES IN SOME MEDITERRANEAN CEPHALASPIDEAN MOLLUSCS.
CIMINO¹, Guido, Antonio CRISPINO¹, Aldo SPINELLA¹, Guido VILLANI¹ and Guido SODANO². ¹Instituto per la Chimica di Molecole di Interesse Biologico (CNR), Via Toiano, 6 Arco Felice (NA), Italy and ²Dipartimento di Fisica, Università di Salerno, Baronissi (SA), Italy.
- 1:40 SOME EXAMPLES OF DEFENSIVE STRATEGIES IN OPISTHBRANCH MOLLUSCS: A CHEMICAL APPROACH.
AVILA, C., G. CIMINO, A. CRISPINO, V. DI MARZO, A. FONTANA, M. GAVAGNIN and R.R. VARDARO. Istituto per la Chimica di Molecole d'Interesse Biologico del C.N.R., Via Toiano 6, 80072 Arco Felice (NA), Italy.
- 2:00 BREAK
- 2:20 SEXUAL CONFLICT AND THE MATING SYSTEM OF *NAVANAX INERMIS* (CEPHALASPIDEA).
LEONARD, Janet L. Department of Zoology, University of Oklahoma, Norman, OK and Hatfield Marine Science Center, Newport, OR 97365.
- 2:40 MATING BEHAVIOR IN THE NUDIBRANCH *HERMISSENDA CRASSICORNIS* (ESCHSCHOLTZ).
LONGLEY, R.D. and A.J. LONGLEY. Pacific Sciences Institute, P.O. Box 835, Friday Harbor, WA 98250 and Friday Harbor Laboratories, 620 University Road, Friday Harbor, WA 98250.
- 3:00 SEASONAL REPRODUCTIVE BEHAVIOR OF THE SEA HARE *APLYSIA BRASILIANA* RANG (GASTROPODA, OPISTHBRANCHIA) AT SOUTH PADRE ISLAND, TEXAS.
STRENGTH, Ned E. Department of Biology, Angelo State University, San Angelo, TX 76909.
- 3:20 BREAK
- 3:40 SPERM STORAGE AND MULTIPLE INSEMINATION IN A NATURAL POPULATION OF THE FRESHWATER SNAIL, *PHYSA HETEROSTROPHA*.
DILLON JR., Robert T. and Amy R. WETHINGTON. Department of Biology, College of Charleston, Charleston, SC 29424.
- 4:00* SIZE ASSORTATIVE MATING IN TADPOLE SNAILS, *PHYSA GYRINA*: MATE CHOICE, PROTANDRY OR FACULTATIVE SEX SWITCHING?
DeWITT, Thomas J. Department of Biology, Boston University, Boston, MA.
- 4:20 OBSERVATIONS ON THE MATING BEHAVIOR, SPAWN MASS AND LARVAL DEVELOPMENT OF *HYDATINA PHYSIS* (LINNE', 1758) FROM PAKISTAN.
ZEHRRA, Itrat and Rukhsana PERVEEN. Centre of Excellence in Marine Biology, University of Karachi, Karachi 75270, Pakistan.

MONDAY EVENING

- 7:00 - 8:30 POSTER SESSION with Reception Honoring Symposia Participants (cash bar)
Location: Meigs Room plus Swope Center foyer
- 8:30 - 10:00 FILM FESTIVAL
Location: Dining Room, Swope Center

M
O
N
D
A
Y

Monday Evening, June 4

POSTER SESSION AND RECEPTION (cash bar)

7:00 - 8:30 PM Location: Swope Center foyer and Meigs Room

M I - NEUROBIOLOGY

- O**
- N**
- D**
- A**
- Y**
- 1.* A CALCIUM ANTAGONIST BLOCKS EXCITATION OF THE HEART OF A BIVALVE, *MERCENARIA MERCENARIA*.
DEVLIN, C.L. Department of Zoology, University of Rhode Island, RI 02882.
 2. MODIFICATION OF *HERMISSENDA* FEEDING BEHAVIOR BY ASSOCIATIVE LEARNING (GASTROPODA: *HERMISSENDA CRASSICORNIS*, PHIDIANA).
FARLEY, Joseph, Carla GIROLAMI and Tracy SCHERER. Program in Neural Science, Indiana University, Bloomington, IN 47405.
 3. EGG-SPECIFIC PROTEIN IN *APLYSIA*: PRIMARY STRUCTURE OF AN NADase.
GLICK¹, David L., Mark R. HELLMICH¹, Paul TEMPST² and Felix STRUMWASSER¹. ¹Marine Biological Laboratory, Woods Hole, MA 02543 and ²Department of Genetics, Harvard University School of Medicine, 25 Shattuck Street, Boston, MA 02115.
 4. CNS NEURONAL SOMATA OF OCTOPUS ARE INEXCITABLE AND LABEL RETROGRADELY WITH CARBOCYANINE DYES.
ROBERTSON, J.D., R. GILLETTE, P. LEE, S. MEADOWS, J. ZITZ and Owen SCHWARTZ. Duke University Marine Laboratory, Beaufort, NC and Department of Physiology and Biophysics, University of Illinois, Urbana, IL.
 5. INNERVATION OF THE ANTERIOR ARTERIAL SYSTEM OF *APLYSIA CALIFORNICA*.
SKELTON, Martin E. Center for Neurobiology and Behavior, College of Physicians and Surgeons, Columbia University, 722 W 168th Street, New York, NY 10032.
 6. HAIR CELL SENSITIVITY IN THE SQUID STATOCYST.
WILLIAMSON, R. The Marine Laboratory, Citadel Hill, Plymouth PL1 2PB, England.
 7. NEUROBIOLOGY OF OCTOPUS CAMOUFLAGE.
PACKARD, Andrew. Department of Zoology, Naples, University and Stazione Zoologica, Napoli 80121, Italy.

II - CEPHALOPODS

8. RESOURCE ALLOCATION IN THE MUD FLAT OCTOPUS.
CIGLIANO, John A. Department of Biology, Boston University, Boston, MA 02215.
9. THE WHITE BODY OF THE BAY SQUID *LOLLIGUNCULA BREVIS*: PRELIMINARY LIGHTMICROSCOPICAL AND ULTRASTRUCTURAL OBSERVATIONS.
CLAES¹, Michael, R.T. HANLON² and M. Patricia MORSE¹. ¹Marine Science Center, Northeastern University, Nahant, MA 01908 and ²Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77550.
10. AGONISTIC BEHAVIOR AMONG MALE SQUIDS, *LOLIGO (DORYTEUTHIS) PLEI BLAINVILLE*, 1823: AN INVERTEBRATE ASSESSMENT STRATEGY.
DIMARCO, F. Paul and Roger T. HANLON. Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77550.
11. ON THE REPRODUCTIVE EFFORT IN SEPIOLIDS (MOLLUSCA: CEPHALOPODA).
GABEL-DEICKERT, Adrienne. Institut für Allgemeine Zoologie, Freie Universität Berlin, Konigin-Luise-Strasse 1-3, 1000 Berlin 41, Germany.
12. THE COASTAL CEPHALOPOD FAUNA OF SOUTHERN BRAZIL.
HAIMOVICI, Manuel and Jose A. PEREZ. Fundacao Universidade do Rio Grande, Cx 474 Rio Grande RS, 96200 Brazil.
13. MULTIPLE ECOLOGICAL FUNCTIONS OF BURROWING AND BURYING BEHAVIOR IN BENTHIC CEPHALOPODS.
HANLON¹, Roger T., John CIGLIANO² and John FORSYTHE¹. ¹Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77550 and ²Department of Biology, Boston University, Boston, MA 02215.
14. INTERTIDAL HARVEST OF THE SMALL PATAGONIAN OCTOPUS, *OCTOPUS TEHUELCHUS D'ORBIGNY*.
IRIBARNE, Oscar O. School of Fisheries, WH-10, University of Washington, Seattle, WA 98195.
15. ON THE ASSOCIATION OF THE SQUID *ILLEX COINDETII* (MOLLUSCA, CEPHALOPODA) WITH TARGET SPECIES TRAWLED IN THE SICILIAN CHANNEL.
JEREB, P. and S. RAGONESE. Istituto de Tecnologia della Pesca e del Pescato, Via Luigi Vaccara 61, Mazara del Vallo 91026, Italy.
16. PERFORMANCE LIMITS OF "ANTIQUE" AND "STATE-OF-THE-ART" CEPHALOPODS.
O'DOR¹, R.K. and M.J. WELLS². ¹Biology Department, Dalhousie University, Halifax, N.S. B3H 4J1, Canada and ²Zoology Department, Cambridge University, Cambridge CB2 3EJ, United Kingdom.

17. SEXUAL MATURATION AND REPRODUCTIVE CYCLE OF *ELEDONE MASSYAE* VOSS, 1964 (CEPHALOPODA: OCTOPODIDAE) IN SOUTHERN BRAZIL.
PEREZ, Jose A. and Manuel HAIMOVICI. Fundacao Universidade do Rio Grande, Cx 474, Rio Grande RS, 96200 Brazil.
18. A CHECKLIST OF CEPHALOPODS FROM THE MEXICAN WATERS OF THE GULF OF MEXICO.
SALCEDO-VARGAS, M. Alejandro. Invertebrate Laboratory, Tokyo University of Fisheries, 4-5-7 Konan, Minatoku, Tokyo 108, Japan.
19. DISTRIBUTION OF PELAGIC CEPHALOPODS IN THE ROCKALL TROUGH.
YAU¹, Cynthia and John MAUCLINE. ¹Department of Zoology, University of Aberdeen, Tillydrone Avenue, Aberdeen AB9 2TN, Scotland and Scottish Marine Biological Assoc., Dunstaffnage Marine Laboratory, Box 3, Oban, Argyll PA34 4AD, Scotland.

III - CONTRIBUTED

20. MOVEMENTS OF A FRESHWATER GASTROPOD IN AN ARTIFICIAL STREAM.
BADGEROW, John P. Department of Biology, Eastern Michigan University, Ypsilanti, MI 48197.
21. SHELLWATCH: A BASELINE MONITORING PROGRAM FOR CONSPICUOUS MOLLUSKS AT SANIBEL ISLAND.
COOK¹, Susan B. and Alice D. ANDERS². ¹Bermuda Biological Station for Research, Inc., ²Sanibel, FL.
22. MATING BEHAVIOR OF TADPOLE SNAILS, *PHYSA GYRINA*.
DEWITT, Thomas J. Department of Biology, Boston University, Boston, MA.
23. DIEL PERIODICITY OF DEPTH PREFERENCE BY *ELIMIA LAQUEATA* (GASTROPODA: PLEUROCERIDAE).
GORDON¹, Mark E. and Tina M. THEYEL². ¹Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville, TN 38505 and ²Honolulu, HI.
24. HYPERCALCEMIA, PROTEINEMIA AND THE TRANSUTERINE TRANSPORT OF CALCIUM IN A LAND SNAIL.
KUNIGELIS, Stan C. Department of Zoology, Duke University, Durham, NC 27713.
25. OVERABUNDANCE OF FOOD STUNTS LARVAL GROWTH.
KUZIRIAN, Kara L., Alan M. KUZIRIAN and Catherine T. TAMSE. Marine Biological Laboratory, Woods Hole, MA 02543.
26. DIET VERSUS FEEDING MORPHOLOGY IN CEPHALASPIDEA (GASTROPODA, OPISTHOBRANCHIA).
MIKKELSEN, Paula M. Harbor Branch Oceanographic Institute, 5600 Old Dixie Hwy, Ft. Pierce, FL 34946.
27. SWIMMING BEHAVIOUR OF SEA SCALLOP LARVAE (*PLACOPECTEN MAGELLANICUS*).
SILVA, M. Angelica and R.K. O'DOR. Biology Department, Dalhousie University, Halifax, N.S. B3H 2Z9, Canada.
28. INTRA-RANGE DIFFERENCES IN FEEDING RATES AND SCHEDULES OF THE LIMPET *TECTURA PERSONA*.
STRASZYNSKI, Elizabeth B. Watershed Ecosystems Graduate Program, Trent University, Peterborough, ON K9J 7B8, Canada.
29. ROLLER CULTURE SYSTEM: THE FITNESS MACHINE FOR *HERMISSENDA CRASSICORNIS* LARVAE?
TAMSE¹, Catherine T., Alan M. KUZIRIAN¹ and Thomas R. CAPO². ¹Marine Biological Laboratory, Woods Hole, MA 02543 and ²BLR/RSMAS, University of Miami, Miami, FL 33149.
30. QUANTITATIVE MORPHOLOGICAL ANALYSIS OF THE MARSUPIAL GILLS OF *ANODONTA CATARACTA* USING LIGHT AND SCANNING ELECTRON MICROSCOPY.
TANKERSLEY, Richard A. and Ronald V. DIMOCK JR. Department of Biology, Wake Forest University, Winston-Salem, NC 27109.
31. HEART ULTRASTRUCTURE IN CAUDOFOVEATA (MOLLUSCA, APLACOPHORA) AND REMARKS ON ULTRAFILTRATION.
TSCHERKASSKY, Martin. University of Vienna, A-1090, Vienna, Austria.
32. HIGH POLYSACCHARIDE LEVELS IN *APLYSIA PENIS*.
YOUNG¹, Erwin S., Jeffrey L. RAM¹ and Thomas R. CAPO². ¹Department of Physiology, Wayne State University, Detroit, MI 48201 and ²Biological Living Resources, RSMAS, University of Miami, Miami, FL 33149.

NOTES

Tuesday Morning, June 5

SYMPOSIUM: SYSTEMATICS, BIOLOGY AND FISHERIES OF RECENT CEPHALOPODS

Conveners: Clyde F.E. Roper, Michael Vecchione and Michael J. Sweeney. National Museum of Natural History, E-512, Smithsonian Institution, Washington, D.C. 20560

Chairperson: Clyde F.E. Roper Location: Lillie Auditorium

8:30 OPENING REMARKS

8:40 GILBERT L. VOSS: A COMMEMERATION, BIBLIOGRAPHY AND DESCRIBED TAXA.

SWEENEY, Michael J. and Clyde F.E. ROPER. National Museum of Natural History, E-512, Smithsonian Institution, Washington, D.C. 20560.

9:00 TWO AND A HALF DECADES OF DECAPODAN DENIZENS: THE SYSTEMATICS AND BIOLOGY OF SQUID OF THE GENUS *ARCHITEUTHIS*, BASED ON A STUDY OF FIFTEEN SPECIMENS FROM NEWFOUNDLAND WATERS.

ALDRICH, Frederick A. Memorial University of Newfoundland, St. John's, Nfld. A1C 5S7, Canada.

9:20 BIOCHEMICAL COMPARISON OF FAST-CONTRACTING TENTACLE AND SLOW-CONTRACTING ARM MUSCLE OF SQUID.

KIER¹, William M. and Frederick H. SCHACHAT². ¹Department of Biology, University of North Carolina, Chapel Hill, NC 27599 and ²Department of Cell Biology, Duke University Medical Center, Durham, NC 27710.

9:40 THE *SEPIOLA PARVA* AND *S. BIROSTRATA* PROBLEM.

OKUTANI, Takashi and Koichi TAKAYAMA. Department of Invertebrate Zoology, Tokyo University of Fisheries, Minato-ku, Tokyo 108, Japan.

10:00 STATOCYST FLUID COMPOSITION AND ITS EFFECTS ON CALCIUM CARBONATE PRECIPITATION IN THE SQUID *ALLOTEUTHIS SUBULATA*: TOWARDS A MODEL FOR BIOMINERALIZATION.

MORRIS, Claude C. Department of Biology, Memorial University of Newfoundland, St. John's, Nfld. A1C 5S7, Canada.

10:20 BREAK

10:40 TAXONOMIC REVIEW OF THE AUSTRALIAN ROSSIINAE (CEPHALOPODA: SEPIOLIDAE).

REID, Amanda L. Department of Invertebrate Zoology, Australian Museum, Sydney South 2000, Australia.

11:00 POPULATION STRUCTURE OF THE OMMASTREPHID SQUID *MARTIALIA HYADESI* AT THE ANTARCTIC POLAR FRONTAL ZONE IN THE VICINITY OF SOUTH GEORGIA.

RODHOUSE, P.G. British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, U.K.

11:20 ON THE DISTRIBUTION OF PELAGIC CEPHALOPODS IN THE ARABIAN SEA DURING MAY/JUNE 1987.

PIATKOWSKI, Uwe and Wolfgang SCHÖFER. Institut für Meereskunde, Universität Kiel, Düsternbrooker Weg 20, D-2300 Kiel 1, F.R. Germany.

11:40 WILL THE REAL *OCTOPUS JOUBINI* (OCTOPODIDAE; CEPHALOPODA) PLEASE RAISE YOUR ARM(S)!

FORSYTHE¹, John W. and Ronald B. TOLL². ¹Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77550 and ²The University of the South, Sewanee, TN 37375.

12:00 GROUP PHOTO Location: Steps of Lillie Building on MBL Street

12:20 LUNCH

T
U
E
S
D
A
Y

Tuesday Morning, June 5

SYMPOSIUM: INTEGRATIVE NEUROBIOLOGY AND BEHAVIOR OF MOLLUSCS

Conveners: Roger T. Hanlon, Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX and Alan M. Kuzirian, Marine Biological Laboratory, Woods Hole, MA.

Chairperson: David J. Prior Location: Whitman Auditorium

8:30 CONTINUING REMARKS

8:40 CONTRACTION AND SEROTONIN-ELICITED MODULATION OF DISSOCIATED FIBERS OF *APLYSIA* BUCCAL MUSCLE.

RAM, Jeffrey L. and Feng ZHANG. Department of Physiology, Wayne State University, Detroit, MI 48201.

9:00 STUDIES OF THE APPETITIVE PHASE OF FEEDING BEHAVIOR OF *APLYSIA*.

KUPFERMANN, Irving, Thomas TEYKE, Steven C. ROSEN, Scott HOOPER and Klaudiusz WEISS. Center for Neurobiology and Behavior, Columbia University, New York, NY 10032 and Department of Physiology and Biophysics, Fischberg Research Center in Neurobiology, Mount Sinai School of Medicine, New York, NY 10029.

9:20 SEROTONIN ANALOG SELECTIVELY ABATES *HERMISSENDA* FEEDING BEHAVIOR.

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

9:40 NEUROMODULATION OF THE CONSUMATORY PHASE OF FEEDING BEHAVIOUR OF *APLYSIA*.

WEISS, Klaudiusz R., Elizabeth C. CROPPER, Mark MILLER, Ferdinand S. VILIM and Irving KUPFERMANN. Department of Physiology and Biophysics, Fischberg Research Center in Neurobiology, Mount Sinai School of Medicine, New York, NY 10029 and Center for Neurobiology and Behavior, Columbia University, 722 W. 168th Street, New York, NY 10032.

10:00 CODING OF EXCITATORY AND INHIBITORY ACTIONS OF A MULTIFUNCTION INTERNEURON IN THE SLUG, *LIMAX MAXIMUS*.

PRIOR, David J. Physiology and Functional Morphology Group, Department of Biological Sciences, Northern Arizona University, Flagstaff, AZ 86011.

10:20 BREAK

10:40 NEURAL CONTROL OF ESCAPE SWIMMING IN THE PTEROPOD MOLLUSC *CLIONE LIMACINA*.

SATTERLIE, Richard A. Department of Zoology, Arizona State University, Tempe, AZ 85287-1501.

11:00 THE BURSTING NEUROSECRETORY CELL R15 OF *APLYSIA* CONTRIBUTES TO THE CONTROL OF EGG LAYING.

ALEVIZOS, A., K.R. WEISS and J. KOESTER. Center for Neurobiology and Behavior, Columbia University, 722 W. 168th Street, New York, NY 10032.

11:20 PHEROMONAL ATTRACTION AND INDUCTION OF COPULATORY BEHAVIOR IN *APLYSIA*: RELATIVE CONTRIBUTIONS OF FACTORS DERIVED FROM EGG CORDONS AND EGG LAYERS.

PAINTER, Sherry D. Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77550.

11:40 PEPTIDES THAT MEDIATE REPRODUCTIVE BEHAVIOR IN *APLYSIA*: PRECURSOR STRUCTURE, PRODUCTS, AND PROCESSING ENZYMES.

NAGLE, Gregg T. Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77550.

12:00 GROUP PHOTO Location: Steps of Lillie Building on MBL Street

12:20 LUNCH

T
U
E
S
D
A
Y

Tuesday Morning, June 5

SYMPOSIUM: BEHAVIOR OF MOLLUSCS

Convener: Roger T. Hanlon, Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX.

Chairperson: Thomas Carefoot Location: Candlehouse 104/105

8:30 CONTINUING REMARKS

8:40 A CONCEPTUAL ROLE FOR STRONTIUM IN LARVAL RETENTION AND ADVECTION FROM ESTUARIES. GALLAGER¹, Scott M., Alan M. KUZIRIAN², Joseph P. BIDWELL³, Judith M. McDOWELL CAPUZZO¹. ¹Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543; ²Marine Biological Laboratory, Woods Hole, MA 02543 and ³Mayo Clinic, Rochester, MN.

9:00 HOW WELL DOES GROWTH RATE PREDICT THE RATE AT WHICH MOLLUSC LARVAE (*CREPIDULA PLANA*) BECOME COMPETENT TO METAMORPHOSE? PECHENIK, Jan A. and Kerry M. ZIMMERMAN. Department of Biology, Tufts University, Medford, MA 02155.

9:20 RECRUITMENT DYNAMICS OF THE HARD CLAM (*MERCENARIA MERCENARIA*): AN ALTERNATIVE MODEL. ROLLINS¹, Harold B., Robert S. PREZANT² and Ron TOLL³. ¹Department of Geology, University of Pittsburgh, Pittsburgh, PA 15260; ²Department of Biology, Indiana University of Pennsylvania, Indiana, PA 15705 and ³Department of Biology, University of the South, Sewanee, TN 37375.

9:40* LAND SNAIL MOVEMENT PATTERNS IN NORTHERN MICHIGAN. PEARCE, Timothy A. Museum of Zoology, University of Michigan, Ann Arbor, MI 48109.

10:00 SUBSTRATE PREFERENCE OF NATURAL POPULATIONS OF ICELAND SCALLOPS (*CHLAMYS ISLANDICA* MÜLLER, 1776) ON THE NORTHEASTERN GRAND BANK OF NEWFOUNDLAND. GILKINSON¹, Kent D. and Jean-Marc GAGNON². ¹LeDrew, Fudge and Associates Limited, P.O. Box 9370 Stn. B, St. John's, Nfld., Canada and ²Department of Biology, Memorial University of Newfoundland, St. John's, Nfld. A1B 3X9, Canada.

10:20 BREAK

10:40 RELATIONSHIP OF BLOOD-GLUCOSE LEVELS TO ACTIVITY PATTERNS IN SEA HARES (*APLYSIA*). CAREFOOT, Thomas. Department of Zoology, University of British Columbia, Vancouver, B.C. V6T 2A9, Canada.

11:00 THE ENIGMA OF *APLYSIA* RESPIRATORY PUMPING. KANZ, James E., William D. QUAST, Doreen M. GRECH, Natalie BANNEEL and Susan J. TIGERT. Department of Marine Biology, Texas A&M University at Galveston, Galveston, TX 77553.

11:20* THE BURROWING MECHANISM OF *CADULUS ABERRANS* (SCAPHOPODA: GADILIDA). LEVITT, Jenifer L. Moss Landing Marine Labs, Moss Landing, CA 95039.

11:40* FEEDING AND INTERSPECIFIC BEHAVIORAL INTERACTIONS OF NUDIBRANCHS INHABITING COLONIES OF *OBELIA GENICULATA*. LAMBERT, Walter J. Department of Zoology, University of New Hampshire, Durham, NH 03824.

12:00 GROUP PHOTO Location: Steps of Lillie Building on MBL Street

12:20 LUNCH

T
U
E
S
D
A
Y

Tuesday Afternoon, June 5

11:00 - 2:30 Bourse (Meigs Room in Swope)

SYMPOSIUM: INTEGRATIVE NEUROBIOLOGY AND BEHAVIOR OF MOLLUSCS

Conveners: Roger T. Hanlon, Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX and Alan M. Kuzirian, Marine Biological Laboratory, Woods Hole, MA.

Chairperson: E. Terry Walters Location: Whitman Auditorium

1:20 CONSTITUTIVE PKC ACTIVITY IS RESPONSIBLE FOR LEARNING-PRODUCED REDUCTIONS IN K CURRENTS OF HERMISSENDA TYPE B PHOTORECEPTORS (GASTROPODA: HERMISSENDA CRASSI-CORNIS).

FARLEY, Joseph and Erin SCHUMAN. Program in Neural Science, Indiana University, Bloomington, IN 47405.

1:40 VARIATION IN SENSE ORGAN DESIGN AND RELATED SENSORY CAPABILITIES AMONG CLOSELY RELATED MOLLUSCS.

HAMILTON, Paul V. Department of Biology, University of West Florida, Pensacola, FL 32514.

2:00 ONTOGENY OF SENSORY RECEPTORS AND LARVAL BEHAVIOR IN OPISTHOBRANCH VELIGERS.

CHIA, Fu-Shiang and Ron KOSS. Department of Zoology, University of Alberta, Edmonton, Alberta T6B 2E9, Canada.

2:20 BREAK

2:40 CATECHOLAMINE BREAKDOWN PRODUCTS INDUCE PARTIAL METAMORPHOSIS IN THE NUDIBRANCH *PHESTILLA SIBOGAE*:

PIRES, Anthony and Michael G. HADFIELD. Kewalo Marine Laboratory, P.B.R.C., University of Hawaii, 41 Ahui Street, Honolulu, HI 96813.

3:00 CHEMOSENSORY AND INTEGRATIVE MECHANISMS CONTROLLING SETTLEMENT AND METAMORPHOSIS OF ABALONE LARVAE: MOLECULAR DISSECTION OF THE AMPLIFIER PATHWAY.

MORSE, Daniel E. Department of Biological Sciences, University of California, Santa Barbara, CA 93106.

ROUND-TABLE DISCUSSION

3:20 - 5:30 **EVOLUTIONARY ASPECTS OF MOLLUSCAN BEHAVIOR AND NEUROBIOLOGY**

Chairpersons - Sigurd v. Boletzky Location: Whitman Auditorium
- Michael J. Greenberg

T
U
E
S
D
A
Y

TUESDAY EVENING

6:00 - 8:00 **NEW ENGLAND CLAM & LOBSTER BOIL**

Location: Meigs Room and patio behind Swope Center

8:00 - 10:00 **AUCTION**

Location: Meigs Room, Swope Center

Tuesday Afternoon, June 5

11:00 - 2:30 Bourse (Meigs Room in Swope)

SYMPOSIUM: SYSTEMATICS, BIOLOGY AND FISHERIES OF RECENT CEPHALOPODS

Conveners: Clyde F.E. Roper, Michael Vecchione and Michael J. Sweeney. National Museum of Natural History, E-512, Smithsonian Institution, Washington, D.C. 20560

Chairperson: Richard E. Young

Location: Lillie Auditorium

- 1:20 CHIROTEUTHID AND RELATED PARALARVAE FROM HAWAIIAN WATERS: SYSTEMATIC IMPLICATIONS.
YOUNG, Richard E. Department of Oceanography, University of Hawaii, 1000 Pope Road, Honolulu, HI 96822.
- 1:40 CEPHALOPODS AS INDIVIDUALS.
PACKARD, Andrew. Department of Zoology, University of Naples, Stazione Zoologica, Naples 80121, Italy.
- 2:00* THE GROWTH OF *SEPIA OFFICINALIS* LINNE, 1758 IN SOUTHERN BRITTANY AND THE NORTHERN BAY OF BISCAY (FRANCE).
LE GOFF, Ronan. Station de Biologie Marine, Ile Bailleron, 56 860 Sene, France.
- 2:20* GROWTH OF THE PATAGONIAN SQUID, *LOLIGO GAHI* (D'ORBIGNY, 1835).
HATFIELD, Emma M.C. British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, U.K.
- 2:40 THE NAMING OF THE NORTH AMERICAN COMMON SQUID.
GILBERT, Daniel L. Laboratory of Biophysics, NINDS, National Institutes of Health, Bethesda, MD 20892.
- 3:00 BREAK
- 3:20 THE ROLE OF CEPHALOPODS IN THE DIET OF SWORDFISH FROM THE MEDITERRANEAN SEA.
BELLO, Giambattista. Laboratorio di Biologia Marina, 70123 Bari, Italy.
- 3:40 THE OCTOPUS FISHERIES IN THE MEXICAN WATERS OF THE GULF OF MEXICO AND THE CARIBBEAN SEA.
SOLIS-RAMIREZ, Manuel. Centro Regional de Investigacion Pesquera de Yucalpeten, Apdo Postal 73, Progreso, Yucatan 97320, Mexico.
- 4:00 DISTRIBUTION AND REPRODUCTIVE BIOLOGY OF THE SQUID *ILLEX COINDETHI* (MOLLUSCA, CEPHALOPODA) IN THE SICILIAN CHANNEL.
JEREB, P. and S. RAGONESE. Istituto di Tecnologia della Pesca e del Pescato, Via Luigi Vaccara 61, Mazara del Vallo 91026, Italy.
- 4:20 THE BIOLOGY OF THE SQUID *LOLIGO VULGARIS* IN RELATION TO THE ARTISANAL FISHING SITE OF TIFNIT, MOROCCO.
BADDYR, Mohammed. Institut Agronomique and Veterinary Hassan II, Agadir, Morocco.
- 4:40 FEEDING DYNAMICS OF TWO DEEP-SEA CEPHALOPODS *OPISTHOTEUTHIS AGASSIZI* AND *OPISTHOTEUTHIS VOSSI* FROM THE SOUTHEASTERN ATLANTIC (OCTOPODA: CIRRATA).
VILLANUEVA¹, Roger and Angel GUERRA². ¹Instituto de Ciencias del Mar (CSIC), Paseo Nacional, 08003 Barcelona, Spain and ²Instituto de Investigaciones Marinas (CSIC), Eduardo Cabello 6, 36208 Vigo, Spain.

TUESDAY EVENING

6:00 - 8:00 NEW ENGLAND CLAM & LOBSTER BOIL
Location: Meigs Room and patio behind Swope Center

8:00 - 10:00 AUCTION
Location: Meigs Room, Swope Center

T
U
E
S
D
A
Y

Wednesday Morning, June 6

CONTRIBUTED PAPERS - MARINE

Chairperson: Melbourne R. Carriker

Location: Candlehouse 105

W
E
D
N
E
S
D
A
Y

8:30 OPENING REMARKS

8:40 MALACOLOGICAL JOURNALS AND NEWLETTERS, 1773 - 1990.
KABAT¹, Alan R. and Rüdiger BIELER². ¹Museum of Comparative Zoology, Harvard University, Cambridge, MA 02138 and ²Delaware Museum of Natural History, P.O. Box 3937, Wilmington, DE 19807.

9:00 THE APLACOPHORA POSSESS A TRUE RADULAR MEMBRANE.
SCHELTEMA¹, Amélie H. and Alan M. KUZIRIAN². ¹Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543 and ²Marine Biological Laboratory, Woods Hole, MA 02543.

9:20 THE EASTERN PACIFIC SPECIES OF THE BIVALVE FAMILY SPHENIOPSISIDAE.
COAN, Eugene V. Department of Invertebrate Zoology, California Academy of Sciences, Golden Gate Park, San Francisco, CA 94108.

9:40 COMPARISON OF DEPTH DISTRIBUTIONS OF EASTERN PACIFIC AND WESTERN ATLANTIC MOLLUSCAN FAUNAS.
ROSENBERG, Gary. Academy of Natural Sciences, Philadelphia, PA 19103.

10:00 DIAGNOSTIC EGG HULL SCULPTURING OF AN EPIZOIC CHITON.
EERNISSE, Douglas J. Museum of Zoology and Department of Biology, University of Michigan, Ann Arbor, MI 48109.

10:20 BREAK

10:40 DECIPHERING HISTORICAL CONTAMINATION EVENTS WITH BIVALVE SHELLS.
BOURGOIN¹, B.P., E.D. EVANS¹ and R.J. CORNETT². ¹Environmental and Resource Studies Program, Trent University, Peterborough, Ontario K9J 7B8, Canada and ²Atomic Energy of Canada Ltd., Chalk River, Ontario K0J 1J0, Canada.

11:00 NATIONAL STATUS AND TRENDS PROGRAM: CONTAMINANTS IN BLUE MUSSEL TISSUES FROM NORTHEASTERN UNITED STATES COASTAL WATERS.
TURGEON, Donna D. and Gunnar G. LAUENSTEIN. Ocean Assessment Division, National Ocean Service, NOAA, Rockville, MD 20852.

11:20 SOME ASPECTS OF THE DISTRIBUTION AND MIGRATION OF GASTROPOD AND BIVALVE MOLLUSCS IN THE SUEZ CANAL.
SOLIMAN, Gamil N. Department of Zoology, Faculty of Science, University of Cairo, Egypt.

11:40 A HIGHLY MODIFIED COPEPOD PARASITE OF TROPICAL WESTERN ATLANTIC CHITONS (POLYPLACOPHORA: ISCHNOCHITONIDAE).
FRANZ¹, Craig J. and Robert C. BULLOCK². ¹Department of Biology, La Salle University, 20th Street at Olney Avenue, Philadelphia, PA 19141 and ²Department of Zoology, University of Rhode Island, Kingston, RI 02881.

12:00 LUNCH

Wednesday Morning, June 6

SYMPOSIUM: SYSTEMATICS, BIOLOGY AND FISHERIES OF RECENT CEPHALOPODS

Conveners: Clyde F.E. Roper, Michael Vecchione and Michael J. Sweeney. National Museum of Natural History, E-512, Smithsonian Institution, Washington, D.C. 20560

Chairperson: Ronald B. Toll Location: Lillie Auditorium

- 8:30 CONTINUING REMARKS
- 8:40 CHARACTER VARIABILITY AND ITS BEARING ON THE SUPRA-SPECIFIC CLASSIFICATION OF THE OCTOPODINAE.
TOLL, Ronald B. Department of Biology, The University of the South, Sewanee, TN 37375.
- 9:00 JET PROPULSION AND THE EVOLUTION OF CEPHALOPODS.
WELLS¹, M.J. and Ron K. O'DOR². ¹Zoology Department, Cambridge University, Cambridge CB2 3EJ, United Kingdom. and ²Biology Department, Dalhousie University, Halifax, N.S. B3H 4J1, Canada.
- 9:20* AGE, GROWTH AND POPULATION DYNAMICS OF TROPICAL SQUIDS AND SEPIOLIDS, AS DETERMINED BY STATOLITH GROWTH RING ANALYSIS.
JACKSON, George D. Department of Marine Biology, James Cook University of North Queensland, Townsville 4811, Australia.
- 9:40* ENERGY CONSUMPTION OF THE CUTTLEFISH *SEPIA OFFICINALIS* LINNE, 1758 (MOLLUSCA: CEPHALOPODA) DURING EMBRYONIC DEVELOPMENT: FIRST RESULTS.
BOUCHAUD, Olivier F. Station de Biologie Marine, Ile Bailleron, 56 860 Sene, France.
- 10:00 *OCTOPUS MAGNIFICUS* (CEPHALOPODA: OCTOPODIDAE) A NEW SPECIES OF LARGE OCTOPOD FROM THE SOUTH-EASTERN ATLANTIC.
VILLANUEVA¹, Roger, Pilar SANCHEZ¹ and Martina ROELEVELD². ¹Instituto de Ciencias del Mar (CSIC), Paseo Nacional, 08003 Barcelona, Spain and ²South African Museum, Box 61, Capetown 8000, South Africa.
- 10:20 BREAK
- 10:40 *CTENOPTERYX*, THE COMB-FIN SQUID IS RELATED TO *LOLIGO*.
YOUNG, John Z. Department of Experimental Psychology, University of Oxford, Oxford OX1 3UD, U.K.
- 11:00 THE RELATIONSHIP BETWEEN CUTTLEBONE MORPHOLOGY AND HABITAT DEPTH IN THE SEPIIDAE.
WARD, Peter D. Department of Geological Sciences, University of Washington, Seattle, WA 98195.
- 11:20 ULTRASTRUCTURE OF THE OLFATORY ORGAN AT THE HATCHING STAGE OF *LOLIGO VULGARIS* LAMARCK, 1798 (CEPHALOPODA).
WILDENBURG, Gaby. Lehrstuhl für Spezielle Zoologie, Zoolog. Inst., Huffer str. 1, D-4400, Munster, West Germany.
- 11:40 POPULATION DYNAMICS AND LIFE HISTORY OF *OCTOPUS BIMACULOIDES*.
LANG, Michael A. Office of the Assistant Secretary for Research, Smithsonian Institution, Washington, D.C. 20560.
- 12:00 LUNCH

W
E
D
N
E
S
D
A
Y

Wednesday Afternoon, June 6

CONTRIBUTED PAPERS - MARINE AND CEPHALOPOD

Chairperson: Robert C. Bullock Location: Candlehouse 105

W
E
D
N
E
S
D
A
Y

- 1:00 ON THE SYSTEMATIC POSITION OF THE GENUS *NUCELLA* (PROSOBRANCHIA: MURICIDAE: TROPHONINAE).
KOOL, Silvard P. Mollusk Department, Museum of Comparative Zoology, Harvard University, Cambridge, MA 02138.
- 1:20 CULTIVATION OF SYMBIOTIC PIGMENT-PRODUCING BACTERIA FROM THE ACCESSORY NIDAMENTAL GLANDS OF THE SQUID *LOLIGO PEALEI*.
DUNLAP, Paul V. Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543.
- 1:40 ASPECTS OF THE REPRODUCTION AND DEVELOPMENT OF *OCTOPUS RUBESCENS* BERRY, 1953 (MOLLUSCA: CEPHALOPODA).
OSBORN, Steven A. Moss Landing Marine Laboratories, Moss Landing, CA 95039.
- 2:00 NOTES ON THE SUPPOSED FAILURE OF CEPHALOPODS.
MOYNIHAN, Martin H. Smithsonian Tropical Research Institute, APO Miami 34002.
- 2:20 MARICULTURE OF SQUIDS.
LEE, Phillip G., Roger T. HANLON, Philip E. TURK, John W. FORSYTHE and William S. FISHER. Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77550.
- 2:40 open
- 3:00 BREAK

CONTRIBUTED PAPERS - TERRESTRIAL

- 3:20 MADAGASCAR'S ACAVOID LAND SNAILS.
EMBERTON, Kenneth C. Department of Malacology, Academy of Natural Sciences, 19th & Parkway, Philadelphia, PA 19103.
- 3:40* ANATOMICAL VARIATION IN A POPULATION OF *OMALONYX* SP. AND ITS IMPLICATIONS FOR THE SYSTEMATICS OF SUCCINEID LAND SNAILS.
DUTRA-CLARKE, Ana. Department of Malacology, Academy of Natural Sciences, 19th & Parkway, Philadelphia, PA 19103.
- 4:00 PRELIMINARY LIFE HISTORY STUDIES OF SLUGS IN THE FAMILY PHILOMYCIDAE (GASTROPODA: PULMONATA).
FAIRBANKS, Lee. Department of Biology, Penn State Beaver, Monaca, PA 15061.
- 4:20 CONTRIBUTIONS TO AMERICAN MALACOLOGY BY PIONEER NATURALISTS OF EASTERN OHIO.
DEXTER, Ralph W. Department of Biological Sciences, Kent State University, Kent OH 44242.
- 4:40 FEDERAL FUNDING FOR BIODIVERSITY: PRESENT AND FUTURE OPPORTUNITIES FOR MALACOLOGISTS.
HOAGLAND, K. Elaine. Association of Systematics Collections, Washington, D.C. 20001.

WEDNESDAY EVENING

- 7:00 - 8:00 WORKSHOP ON HOME AQUARIA (FRESH AND SALT WATER)
Location: Marine Resources Center (MRC Building)
- 8:00 - 9:30 FILM FESTIVAL
Location: Dining Room, Swope Center
- 9:30 - 10:30 BOARD OF EDITORS MEETING, AMERICAN MALACOLOGICAL BULLETIN
Location: private Dining Room, Swope Center

Wednesday Afternoon, June 6

SYMPOSIUM: SYSTEMATICS, BIOLOGY AND FISHERIES OF RECENT CEPHALOPODS

Conveners: Clyde F.E. Roper, Michael Vecchione and Michael J. Sweeney. National Museum of Natural History, E-512, Smithsonian Institution, Washington, D.C. 20560.

Chairperson: Michael Vecchione Location: Lillie Auditorium

- 1:00 A METHOD FOR EXAMINING THE CONTENTS OF THE DIGESTIVE TRACT OF PARALARVAL SQUIDS.
VECCHIONE, M. NMFS Systematics Laboratory, NMNH, Smithsonian Institution, Washington, D.C. 20560.
- 1:20 CEPHALOPOD CAPTURE METHODS: AN OVERVIEW.
RATHJEN, Warren F. Center for Fisheries Engineering Studies, Florida Institute of Technology, Melbourne, FL 32901-6988.
- 1:40 THE FOOD OF *LOLIGO GAHI* (MOLLUSCA: CEPHALOPODA).
GUERRA¹, A., B.G. CASTRO¹ and M. NIXON². ¹Instituto de Investigaciones Marinas, Eduardo Cabello 6, Vigo 36208, Spain and ²60 Norfolk Road, New Barnet, Hertfordshire EN5 5LT, England.
- 2:00 PRELIMINARY STOCK ASSESSMENT OF THE SQUID *ILLEX COINDETHI* (MOLLUSCA, CEPHALOPODA) IN THE SICILIAN CHANNEL.
RAGONESE, S. and P. JEREB. Instituto di Tecnologia della Pesca e del Pescato, Via Luigi Vaccara 61, Mazara del Vallo 91026, Italy.
- 2:20* *OCTOPUS CYANEA* GRAY, 1849 (MOLLUSCA: CEPHALOPODA) IN AUSTRALIAN WATERS: DESCRIPTION, DISTRIBUTION AND TAXONOMY.
NORMAN, Mark D. Zoology Department, University of Melbourne, Parkville, Victoria 3052, Australia.
- 2:40 ASPECTS OF THE BIOLOGY OF *OCTOPUS FITCHI* IN THE GULF OF CALIFORNIA.
JACKINTELL¹, Lori A. and Michael A. LANG². ¹Department of Biology, San Diego State University, San Diego, CA 92182 and ²Office of the Assistant Secretary for Research, Smithsonian Institution, Washington, D.C. 20560.
- 3:00 BREAK
- 3:20 A NEW SPECIES OF *ELEDONE* (MOLLUSCA: CEPHALOPODA) FROM AUSTRALIA.
LU, C.C. and T.N. STRANKS. Department of Invertebrate Zoology, Museum of Victoria, 285-321 Russell Street, Melbourne, Victoria 3000, Australia.
- 3:40 THE CEPHALOPODA OF THE IONIAN SEA (MEDITERRANEAN SEA): FIVE YEARS OF RESEARCH.
TURSI, A., G. D'ONGHIA, A. MATARRESE and P. PANETTA. Institute of Zoology and Comparative Anatomy, University of Bari, Via Amendola 165/A, 70100 Bari, Italy.
- 4:00 CELLULAR CHANGES AT THE ONSET OF VITELLOGENESIS.
BOYLE, P.R. Department of Zoology, University of Aberdeen, Tillydrone Avenue, Aberdeen AB9 2TN, Scotland, U.K.
- 4:20 RIBOSOMAL RNA SEQUENCE ANALYSIS OF SELECTED CEPHALOPODS.
KUNCIO¹, Gerald S. and Roger T. HANLON². ¹University of Pennsylvania, Philadelphia, PA 19104 and ²Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77550.
- 4:40 *IN OVO* MOVEMENTS OF THE LIVING *NAUTILUS* EMBRYO: A VIDEO PRESENTATION.
ARNOLD¹, John M., Bruce A. CARLSON² and Neil H. LANDMAN³. ¹Pacific Biomedical Research Center, University of Hawaii, Honolulu, HI 96822; ²Waikiki Aquarium, University of Hawaii, Honolulu, HI 96815 and ³Department of Invertebrates, American Museum of Natural History, New York, N.Y. 10024.

WEDNESDAY EVENING

7:00 - 8:00 WORKSHOP ON HOME AQUARIA (FRESH AND SALT WATER)
Location: Marine Resources Center (MRC Building)

8:00 - 9:30 FILM FESTIVAL
Location: Dining Room, Swope Center

9:30 - 10:30 BOARD OF EDITORS MEETING, AMERICAN MALACOLOGICAL BULLETIN
Location: private Dining Room, Swope Center

W
E
D
N
E
S
D
A
Y

Thursday Morning, June 7

CONTRIBUTED PAPERS - FRESHWATER

Chairperson: Marian E. Havlik Location: Candlehouse 105

- 8:30 OPENING REMARKS
- 8:40 EFFECTS OF A LOW-HEAD DAM REPLACEMENT ON A NAIAD MOLLUSK POPULATION (UNIONIDAE), STEEL DAM, ROCK RIVER, MILAN, IL, MAY 1988.
HAVLIK, Marian E. Malacological Consultants, La Crosse, WI 54601.
- 9:00 LENGTH/AGE/SEX OF FRESH-DEAD *LAMPSILIS HIGGINSI* (LEA, 1857) (UNIONIDAE), PRAIRIE DU CHIEN, WI, MISSISSIPPI RIVER, 1987.
HAVLIK, Marian E. Malacological Consultants, La Crosse, WI 54601.
- 9:20 EARLY PLEISTOCENE UNIONIDAE FROM SOUTHERN FLORIDA (BIVALVIA).
BOGAN¹, Arthur E. and Roger W. PORTELL². ¹Department of Malacology, Academy of Natural Sciences, Philadelphia, PA 19103 and ²Paleontology, Florida State Museum of Natural History, Gainesville, FL 32611.
- 9:40 *WUCONCHONA* (GASTROPODA: TRICULINAE) OF CHINA: ANATOMY, PHYLOGENETIC RELATIONSHIPS, NEW GENUS AND TRIBE DESCRIBED, TRANSMISSION OF SCHISTOSOMA.
DAVIS, George M. Academy of Natural Sciences, Philadelphia, PA 19103.
- 10:00 THE SUCCESSFUL REINTRODUCTION OF THE SPINY RIVER SNAIL, *IO FLUVIALIS* (SAY, 1825) (GASTROPODA: PLEUROCERIDAE) INTO THE NORTH FORK HOLSTON RIVER IN SOUTHWEST VIRGINIA AND EAST TENNESSEE.
AHLSTEDT, Steven A. Water Resources, Aquatic Biology Department, Tennessee Valley Authority, Norris, TN 37828.
- 10:20 BREAK

ROUND-TABLE DISCUSSION
SHELLS IN ENVIRONMENTAL STUDIES

Chairperson: B.P. Bourgoïn Location: Candlehouse 105

10:40 - 12:00

Bivalve shells are gaining utility in various environmentally related programs. The use of the shells themselves within these programs is multifaceted, ranging from trace metal analyses (e.g., Cd, Pb) to defining the extent of growth seasons via "annual layers" deposited within the shells.

Researchers from various disciplines involved in shell work are continuously developing methods but they are not used by others due to lack of information exchange. This will be the topic of this discussion.

12:00 LUNCH

T
H
U
R
S
D
A
Y

Thursday Morning, June 7

SYMPOSIUM: SYSTEMATICS, BIOLOGY AND FISHERIES OF RECENT CEPHALOPODS

Conveners: Clyde F.E. Roper, Michael Vecchione and Michael J. Sweeney. National Museum of Natural History, E-512, Smithsonian Institution, Washington, D.C. 20560

Chairperson: Katharina M. Mangold Location: Lillie Auditorium

- 8:30 CONTINUING REMARKS
- 8:40 *OCTOPUS SCHULTZEI* HOYLE, 1910; A REDESCRIPTION AND SYSTEMATIC STATUS.
MANGOLD¹, Katharina M. and Clyde F.E. ROPER². ¹CNRS, Laboratoire Arago, Universite Pierre and Marie Curie, 66650 Banyuls-sur-Mer, France and ²Department of Invertebrate Zoology (Mollusks), Smithsonian Institution, Washington, D.C. 20560.
- 9:00 THE INFLUENCE OF AN ELECTRIC LIGHT ON THE CAPTURE OF DEEP-SEA CEPHALOPODS.
CLARKE¹, Malcolm R. and Philip PASCOE². ¹Ridge Court, Court Road, Newton Ferrers, Plymouth, U.K. and ²Plymouth Marine Laboratory, Citadel Hill, Plymouth, U.K.
- 9:20 FORAGING STRATEGIES AND ENERGETICS OF *OCTOPUS VULGARIS* IN BERMUDA: TIME-MINIMIZING?
MATHER¹, Jennifer A. and Ron K. O'DOR². ¹Psychology Department, University of Lethbridge, Alberta, Canada and ²Biology Department, Dalhousie University, Halifax, N.S. B3H 4J1, Canada.
- 9:40 RE-EVALUATION OF THE CEPHALOPOD GENUS *ONYKIA*.
TSUCHIYA, Kotaro and Takashi OKUTANI. Department of Invertebrate Zoology, Tokyo University of Fisheries, Minato-ku, Tokyo 108, Japan.
- 10:00 THE 'TERMINAL SPINE' OF SEPIOLID HATCHLINGS: ITS DEVELOPMENT AND FUNCTIONAL MORPHOLOGY (MOLLUSCA, CEPHALOPODA).
BOLETZKY, Sigurd v. CNRS, Laboratoire Arago, 66650 Banyuls-sur-Mer, France.
- 10:20 BREAK
- 10:40 *OCTOPUS* PREDATION ON *NAUTILUS*: EVIDENCE FROM PAPUA, NEW GUINEA.
SAUNDERS¹, W.B., Paul N. BOND¹ and R.L. KNIGHT². ¹Department of Geology, Bryn Mawr College, Bryn Mawr, PA 19010 and ²P.O. Box 108, Lorengau, Manus, Papua, New Guinea.
- 11:00 THE MIGRATION CYCLE OF THE CHOKKER SQUID *LOLIGO VULGARIS REYNAUDII*.
AUGUSTYN, C. Johann. Sea Fisheries Research Institute, Private Bag X2, Rogge Bay 8012, South Africa.
- 11:20 DISSOLVED OXYGEN AND THE DISTRIBUTION OF THE EURYHALINE SQUID *LOLLIGUNCULA BREVIS*.
VECCHIONE, M. NMFS, Systematics Laboratory, National Museum of Natural History, Washington, D.C. 20560.
- 11:40 *IN VITRO* ARTIFICIAL FERTILIZATION AND EMBRYONIC DEVELOPMENT OF OCEANIC SQUID FOR DEVELOPMENTAL STUDIES, PARALARVAL IDENTIFICATION AND CULTURE.
ARNOLD¹, John M. and Ron K. O'DOR². ¹Pacific Biomedical Research Center, University of Hawaii, Honolulu, HI 96822 and ²Department of Biology, Dalhousie University, Halifax, N.S. B3H 4J1, Canada.
- 12:00 LUNCH

T
H
U
R
S
D
A
Y

Thursday Afternoon, June 7

SYMPOSIUM: SYSTEMATICS, BIOLOGY AND FISHERIES OF RECENT CEPHALOPODS

Conveners: Clyde F.E. Roper, Michael Vecchione and Michael J. Sweeney. National Museum of Natural History, E-512, Smithsonian Institution, Washington, D.C. 20560

Chairperson: Michael J. Sweeney Location: Lillie Auditorium

- 1:00** **DEFINING THE GENUS *OCTOPUS*: REDESCRIPTION OF *OCTOPUS VULGARIS*.**
MANGOLD¹, Katharina and F.G. HOCHBERG². ¹CNRS, Laboratoire Arago, Universite Pierre and Marie Curie, 66650 Banyuls-sur-Mer, France and ²Department of Invertebrate Zoology, Santa Barbara Museum of Natural History, Santa Barbara, CA 93105.
- 1:20** **POTENTIAL IMPACT OF A SEASONAL MIGRATORY JUMBO SQUID (*DOSIDICUS GIGAS*) POPULATION ON A GULF OF CALIFORNIA SARDINE (*SARDINOPS SAGAX CAERULEA*) STOCK.**
EHRHARDT, Nelson A. Marine Biology & Fisheries, Rosenstiel School of Marine & Atmospheric Science, University of Miami, Miami, FL 33149.
- 1:40** **ABUNDANCE AND RECRUITMENT OF CEPHALOPODS.**
COELHO, M.L. Universidade do Algarve, Campus de Gambelas, Apartado 322, 8004 Faro, Portugal.
- 2:00** **OBSERVATIONS ON WESTERN NORTH ATLANTIC CEPHALOPODS USING SUBMERSIBLES.**
VECCHIONE¹, M. and Clyde F.E. ROPER². ¹NMFS Systematics Laboratory, National Museum of Natural History, Washington, D.C. 20560 and ²Department of Invertebrate Zoology (Mollusks), Smithsonian Institution, Washington, D.C. 20560.
- 2:20** **BEHAVIOR OF THE LARGER PACIFIC STRIPED OCTOPUS.**
RODANICHE, Arcadio F. Smithsonian Tropical Research Institute, Box 2072, Balboa, Panama.
- 2:40** **ENLARGED SUCKERS AS AN INDICATOR OF A MATURE AGE CLASS IN *OCTOPUS*.**
VOIGHT, Janet. Department of Ecology & Evolutionary Biology, University of Arizona, Tucson, AZ 85721.
- 3:00 - 4:00** **CONCLUDING REMARKS ON CEPHALOPOD SYMPOSIUM**
- 3:00 - 4:00** **INSTITUTE OF MALACOLOGY MEETING**
Location: Lillie 103
- 4:00 - 5:00** **ANNUAL BUSINESS MEETING, AMERICAN MALACOLOGICAL UNION**
Location: Lillie Auditorium
- 5:00 - 5:15** **FIELD TRIP PREVIEWS**
Location: Lillie Auditorium

THURSDAY EVENING

- 7:00 - 10:00** **SOCIAL HOUR, ANNUAL BANQUET AND DANCE**
Location: Dining Room, Swope Center

**T
H
U
R
S
D
A
Y**

NOTES

THE SUCCESSFUL REINTRODUCTION OF THE SPINY RIVER SNAIL, *IO FLUVIALIS* (SAY, 1825) (GASTROPODA: PLEURO CERIDAE) INTO THE NORTH FORK HOLSTON RIVER IN SOUTHWEST VIRGINIA AND EAST TENNESSEE

AHLSTEDT, Steven A., Water Resources, Aquatic Biology Department, Tennessee Valley Authority, Norris, TN 37828

Following pollution abatement in the North Fork Holston River, southwest Virginia, in 1972, routine monitoring of the river indicated fish and benthic macroinvertebrates were recovering rapidly in the river. In 1978, the spiny river snail, *Io fluvialis*, was reintroduced into the river at two sites in the lower North Fork Holston, along the Virginia and Tennessee State borders, and subsequently at one additional site in the upper river above Saltville, Virginia, in 1979. Successful reproduction of transplanted specimens was first observed in 1986, downstream from the two lower transplant sites at Cloud Ford. Quantitative sampling in 1987 and 1988 reported population densities comparable to the best remaining native populations in the Clinch and Powell Rivers. Recent sampling in 1990, at the upper transplant site above Saltville, Virginia, also confirmed successful reproduction of spiny river snails. This demonstrates that transplants should be considered a viable technique (long-term) for re-establishing aquatic faunas in river systems that have suffered similar pollution problems.

THE BURSTING NEUROSECRETORY CELL R15 OF *APLYSIA* CONTRIBUTES TO THE CONTROL OF EGG LAYING.

ALEVIZOS, A., K.R. WEISS and J. KOESTER.

Center for Neurobiology & Behavior, Columbia University, 722 W. 168 St., New York, NY 10032

R15 is an endogenously bursting neurosecretory cell in the abdominal ganglion of the opisthobranch *Aplysia californica*. It synthesizes the R15 α 1 neuropeptide which others have shown to cause water uptake. Previous attempts to demonstrate specific, reliable synaptic actions of R15 have been unsuccessful for 2 reasons: R15 bursts spontaneously in the isolated ganglion and the synaptic actions of the R15 α 1 peptide desensitize profoundly. We found that blocking R15 spontaneous activity for 2 hrs by hyperpolarization allows the desensitization to decay, unmasking R15's synaptic actions. Using this protocol, we found that R15: (1) increases the frequency of respiratory pumping, by exciting the R25/L25 network; (2) causes contraction of the pleuroabdominal connectives, by exciting motoneuron L7, and (3) directly excites the large hermaphroditic duct, generating anterograde peristaltic movements such as occur during egg laying. Others have shown that R15 is excited by the bag cells, which trigger egg laying, so we propose that R15's synaptic actions may integrate various components of egg laying behavior. The water uptake presumed to be triggered by R15 activity may contribute to the replacement of the water loss that occurs during egg laying. Our *in vivo* recordings showed that R15 is silent in the intact animal, so the desensitizing actions of the R15 α 1 peptide are not chronically expressed.

We hypothesize that R15 is a conditional burster that is allowed to burst during egg laying. The rapid desensitization of its synaptic actions may contribute to the timing of egg laying behavior.

TWO AND A HALF DECADES OF DECAPODAN DENIZENS: THE SYSTEMATICS AND BIOLOGY OF SQUID OF THE GENUS ARCHITEUTHIS, BASED ON A STUDY OF FIFTEEN SPECIMENS FROM NEWFOUNDLAND WATERS

ALDRICH, Frederick A., Professor of Biology, Memorial University of Newfoundland, St. John's, NF, Canada, A1C 5S7

Professor Gilbert L. Voss had a long interest in squid of the Family Architeuthidae. On two occasions he visited the author in Newfoundland to examine two specimens of these giant cephalopods which were secured through strandings.

This paper presents data on fifteen specimens of architeuthids which became available for study from 1964 to date. The individual animals - fourteen females and a single male - are presented through morphometric and anatomical study, with reference to their zoogeography and an attempt is made to work toward a resolution of the systematics of the genus. On the basis of existing information and understanding all are assigned to the species Architeuthis dux Streenstrup.

IN OVO MOVEMENTS OF THE LIVING NAUTILUS EMBRYO: A VIDEO PRESENTATION.

ARNOLD, John M., Pacific Biomedical Research Center, Univ. of Hawaii, Honolulu, HI 96822, CARLSON, Bruce A., Waikiki Aquarium, Univ. of Hawaii, Honolulu, HI 96815 and LANDMAN, Neil H., Dept. Invertebrates, American Museum of Natural History, New York, NY 10024

Four types of movement are obvious in the Nautilus embryo at the time of major organogenesis and formation of the first chamber. 1) When disturbed, the embryo sharply contracts, pulls down and the edge of the shell comes in contact with the yolk mass. This movement is comparable to the retraction of the adult animal into the shell. 2) A rhythmic respiratory contraction lifts and retracts the shell to facilitate the circulation of the intrachorionic fluid through the mantle chamber in an approximate four second cycle. 3) Sudden irregularly timed circumferential constrictions of the extra-embryonic musculature occur below the embryonic area which causes the embryo to extend upward, away from the yolk mass. 4) A slow rotation of the entire embryo takes place in the egg capsule which causes it to make one complete revolution in about 21 minutes. This may be cilia mediated movement. These four movements probably are related to: 1) protection, 2) respiration, 3) rearrangement of the yolk and promotion of the extra-embryonic circulation, and 4) extra-embryonic yolk sac respiration.

IN VITRO ARTIFICIAL FERTILIZATION AND EMBRYONIC DEVELOPMENT OF OCEANIC SQUID FOR DEVELOPMENTAL STUDIES, PARALARVAL IDENTIFICATION AND CULTURE.

ARNOLD, John M., Pacific Biomedical Research Center, Univ. of Hawaii, Honolulu, HI 96822 and O'DOR, Ron, Dept. of Biology, Dalhousie Univ., Halifax, Nova Scotia B3H4J1, Canada

This paper gives a description of a technique for in vitro artificial fertilization of oceanic squid and methods for the study of the subsequent embryonic development through hatching. It has been used with varying success with Stenoteuthis, Abralia, Abraliopsis and to a lesser extent with Thysanoteuthis rhombus. Basically, the nidamental glands of Loligo were obtained fresh-frozen, lyophilized and crushed into a fine powder. Sperm were obtained from the seminal receptacles of females of oceanic species, opened in filter-sterilized sea water and checked for activation. Ova were obtained by opening the oviducts in sea water and washing out all follicular syncytium and cellular debris. Sperm reservoirs or spermatophores, depending on the species and availability of males, were added and the lyophilized, powered, nidamental gland preparation was added and dissolved. The subsequent zygotes were monitored and polar bodies and cleavage percentage were recorded. After a few hours those zygotes with cleavage furrows were transferred to a clean solution of nidamental jelly and subsequent development was observed. A description of the developmental sequence is given.

THE MIGRATION CYCLE OF THE CHOKKER SQUID LOLIGO VULGARIS REYNAUDII.

AUGUSTYN, C. Johann, Sea Fisheries Research Institute, Private Bag X2, Rogge Bay 8012, South Africa

The chokker squid Loligo vulgaris reynaudii spawns in shallow waters off the southeast coast of South Africa. Analysis of biomass, length frequency, maturity stage and feeding data from various areas on the south and west coasts indicate that; a) juveniles move offshore and westward after hatching; b) subadults are found in the southeast, west and southwest of the continental shelf where feeding activity is highest; and c) maturing and mature adults migrate back to the southeast coast to complete the cycle. The duration of the life cycle calculated from mean growth rates of dominant cohorts appears to be about 18 months in females and probably a year longer in males.

ETHOLOGY, ECOLOGY AND EVOLUTIONARY CONSTRAINT IN THE OCTOPUS: AN INTEGRATED APPROACH.

ARONSON, Richard B., Department of Paleobiology, Smithsonian Institution, Washington DC 20560

In 1972 Andrew Packard theorized that the unique morphology, physiology and behavior of coleoid cephalopods arose as adaptations to competition and predation from teleostean fishes in the Mesozoic. While recent paleontological discoveries necessitate modifying this scenario, it remains true that a streamlined body form, visual acuity, a closed circulatory system, and denning, body patterning and other complex behaviors help octopods avoid their teleostean predators. There is currently no evidence that teleost-octopod competition is important in shallow marine communities. However, field studies suggest an inverse relationship between predatory fish and octopus population densities. Where predatory fish are absent, in an isolated Bahamian marine lake, octopuses are two orders of magnitude more abundant than in Caribbean coastal communities. Octopuses are the top carnivores in the lake, where a constraint of behavioral evolution becomes important: dens are the limiting resource. Denning is also an evolutionary imperative in Caribbean coastal communities, but dens are plentiful because predation is limiting. Thus predation in the geologic past molded behaviors that are well-suited to current high-predation environments. These behaviors become ecological constraints when the usual limitation of heavy predation pressure is lifted.

SOME EXAMPLES OF DEFENSIVE STRATEGIES IN OPISTHOBRANCH MOLLUSCS: A CHEMICAL APPROACH.

AVILA, C., CIMINO, G., CRISPINO, A., DI MARZO, V., FONTANA, A., GAVAGNIN, M. and VARDARO, R.R.. Istituto per la Chimica di Molecole d'Interesse Biologico del C.N.R., Via Toiano 6, 80072 Arco Felice (NA), ITALY.

Opisthobranch molluscs have developed a variety of defensive strategies to avoid predation. Among these we have recently decided to study, under a chemical and biochemical point of view: a) toxic mucous secretions; b) autotomy and c) accumulation of toxins into the mantle.

Chromodorididae mantle defensive metabolites are generally derived from dietary sponge sources. Strategical localization of these toxic substances in mantle dermal formations (MDFs) of both Hypselodoris and Chromodoris species will be discussed, as well as their origin and defensive role.

Species of the ascoglossan Oxynoe secrete toxic mucus and also use autotomy as last resource to deter predation. We have isolated the molecules most likely responsible for the mucus toxicity in Oxynoe olivacea. Their chemical structures suggest a dietary origin.

Finally, from the mantle, cerata and mucus of the dendronotacean Tethys fimbria we have isolated some novel prostaglandin (PG) derivatives, PG-1,15-lactones. These exhibit ichthyotoxic activity, and biosynthetic experiments showed their origin from endogenous PG's and their accumulation into the cerata. Here, upon the defensive detachment, the lactones are converted back into PG's which might intervene in cerata smooth muscle contractions, thus facilitating the secretion of mucus.

THE BIOLOGY OF THE SQUID LOLIGO VULGARIS IN
RELATION TO THE ARTISANAL FISHING SITE OF TIFNIT,
MOROCCO.

BADDYR, Mohammed, Institut Agronomique and
Veterinary Hassan II, Agadir, Morocco

The fishery and biology of the inshore squid Loligo vulgaris were studied at the artisanal fishery of Tifnit from May 1985 to April 1986. The total landing in the area was 96 tons, with a local value of 2,113,000 dirhams. Dories using trammel nets landed 67% of the catch (55% of the total sale value) and the remaining catch was landed by dories using jigs and hooks.

Growth was studied using length-frequency data for 21,409 squid taken randomly three times per week during the fishing season. Comparisons of growth rates showed that males grew in length faster than females (t-test; $P < 0.05$). However, females were heavier above 100 mm ML ($P < 0.05$). Life span was estimated as 2.5 years for females and nearly 4 years for males. Females outnumbered males throughout the year.

Fresh eggs were collected throughout the year on sand and silt bottoms at depths from 6 to 120 m. Size at first maturity was estimated as 155 mm for males and 180 mm ML for females. Maximum fecundity was estimated as 42,000 eggs (both ovary and internal oviduct eggs).

Food habit studies showed that L. vulgaris fed mainly on fishes, crustaceans and its own species.

The monthly maximum sustained yield was estimated to be 5 times greater than the present rate.

THE ROLE OF CEPHALOPODS IN THE DIET OF SWORDFISH
FROM THE MEDITERRANEAN SEA.

BELLO, Giambattista, Laboratorio di Biologia
Marina, 70123 Bari, Italy

The swordfish, Xiphias gladius, is a fast growing pelagic teleost that preys upon animals living in the water column, among which it seems to prefer cephalopods. The stomach contents of 30 specimens of adult and sub-adult swordfish caught in the northern Ionian and southern Adriatic Seas were examined, with prey items extracted from the stomachs identified to the lowest possible taxon. The identification of cephalopods was done on both fleshy remains and loose mandibles.

The bulk of swordfish prey is made up of pelagic cephalopods (>80%), while the remainder is pelagic teleosts and crustaceans. Cephalopodan prey comprise both very small species, such as the sepiolid Heteroteuthis dispar, and rather large ones, such as the ommastrephid Todarodes sagittatus. The latter species is also the most important food item of the examined swordfish. The other cephalopods found in the survey are Illex coindetii, Onychoteuthis banksi, Ancistroteuthis lichtensteinii, Argonauta argo and Ocythoe tuberculata. Because most of these species are rarely observed in the zone of swordfish capture, these results contribute to the knowledge of the teuthofauna of the zone.

MOVEMENTS OF A FRESHWATER GASTROPOD IN AN ARTIFICIAL
STREAM

BADGEROW, John P., Department of Biology, Eastern
Michigan University, Ypsilanti, MI 48197

An artificial stream was used to investigate the effects of controlled variation in three environmental factors on movements of the prosobranch gastropod, Campeloma decisum (Say). The experiments were of a 3x3x2 factorial design using floor, sand (0.5-2 mm), and gravel (8-16 mm) as levels of substrate type, 0 cm/sec, 8 cm/sec, and 14 cm/sec as current velocities, and light (approximating daylight intensity) and darkness as levels of light condition. Snails in groups of eight were placed facing alternately left and right across the width of the stream at the midline and tested daily for 30 min under each combination of conditions.

Movements in sand and gravel were negligible due to a burrowing/sheltering habit. Movement on the exposed floor was extensive, allowing comparisons among the effects of current and light. Standing water tests resulted in virtually no net directional movement in light and darkness. Moving water elicited positive rheotaxis in most individuals. Rates of movement were similar at current velocities of 8 and 14 cm/sec and about 50% greater than in standing water. Light condition had no significant effect at 14 cm/sec but at 8 cm/sec, most snails moved far upstream in the light and moderately downstream in the dark. The results suggest that although the movement may have a single, known purpose, the pattern reflects a complex response to interacting factors.

COMPLEX COGNITION IN OCTOPUS BIMACULOIDES:
DISCRIMINATION OF ODDITY

BOAL, Jean, University of North Carolina,
Chapel Hill NC 27599-3275

The demonstration of complex learning in cephalopods would provide critical insight into the evolution of cognition. Most research on complex cognition has focused on higher vertebrates. Since octopuses have no obvious means of self defense and live in a highly competitive environment, these cephalopods might be expected to show complex cognition as well (Wells, 1962).

In order to assess learning abilities, octopuses were tested with a series of combinations of three stimuli: (A+ B- B-), (C+ D- D-),.... Shells were suspended into home tanks and animals were rewarded with food for correctly grabbing the odd shell. Although response rates were variable and sample sizes small, success rates reached 70-100%.

Associative learning was demonstrated by the eventual mastery of each combination. By presenting new combinations of the same stimuli, (A+ D- D-), (C+ B- B-),...., transfer of inference was also demonstrated. Preliminary data suggest that learning improved across the series. Also, presentations of combinations of completely novel stimuli suggest that the octopuses may be able to form the relative class concept of oddity.

EARLY PLEISTOCENE UNIONIDAE FROM SOUTHERN FLORIDA (BIVALVIA)

BOGAN, Arthur E. Department of Malacology, Academy of Natural Sciences, Philadelphia, Pa. 19103 and PORTELL, Roger W. Paleontology, Florida State Museum of Natural History, Gainesville, Fl 32611

Unionid valves are reported from the base of the Bermont Formation (Early Pleistocene) from Leisey Shell Pit 1 and numerous valves of *Anodonta* are identified from the basal Bermont Formation from Leisey Shell Pit 3, Hillsborough County, Florida. A matched pair of valves of *Megalonaias* were collected from the Leisey Shell Pit 1 spoil, probably also from the Bermont Formation. The two samples collected in situ from Leisey Shell Pit 1 and Pit 3 are stratigraphically from below a series of strontium ratio dates. The unionid valves from Leisey Shell Pit 1 are from below the lowest strontium sample with a reported date of 2.3 MYA and the *Anodonta* are from below the lowest strontium sample taken in Leisey Shell Pit 3 with a reported date of 1.7 MYA. These unionid remains from south Florida are the oldest Cenozoic freshwater bivalves from the Eastern United States. This occurrence of *Megalonaias* is 200 miles south of its modern range limit in the panhandle of Florida. These valves point to a major range contraction of some species of unionids in penninsular Florida during the Pleistocene.

THE TERMINAL SPINE OF SEPIOLID HATCHLINGS: ITS DEVELOPMENT AND FUNCTIONAL MORPHOLOGY (MOLLUSCA, CEPHALOPODA).

BOLETZKY, Sigurd v., CNRS - Laboratoire Arago, F-66650 Banyuls-sur-Mer, France

As far as is known all sepiolid embryos form a spine-like integumental structure at the rear of the mantle, just below the hatching gland. The muscular base of this so-called terminal spine can contract independently to stretch out the tough apex of the spine. This stretching movement is normally superimposed on the contraction of the underlying mantle muscle when the mantle end is thrust against the inner wall of the egg case during hatching. The primary function of the terminal spine can be considered in relation to the presence of a hard surface layer of the egg capsule. This "shell" resists the dissolving action of the hatching enzyme and must be forced open by the mechanical action of the terminal spine which is pressed against it (pressure being generated by muscular action of the mantle and the arms which are propped against the capsule wall opposite to the hatch opening). Although this condition is observable only in the genus *Rossia* (and probably exists in other *Rossiinae*), it can be considered as the ancestral condition from which the phenotype of the *Sepiolineae* and the *Heteroteuthinae* (leathery outer coat of egg capsule instead of a hard shell) can be derived. The important fact in systematics is the generalized presence of the terminal spine.

CEPHALOPODS BEAR ARMS : ON "CIRCUMORAL APPENDAGES" AND THEIR ROLE AS BEHAVIORAL INSTRUMENTS

BOLETZKY, Sigurd v., Laboratoire Arago, URA 117 C.N.R.S., F-66650 Banyuls-sur-Mer

The collective name "appendage" used in glossaries to denote the arms and tentacles of cephalopods almost perfectly conceals their biological significance, while the adjective "circumoral" at least hints at a function relative to the mouth. Although the capture and manipulation of prey is the foremost function of these organs, they also take on various other prehensile functions as well as propulsive ones, and in many instances they act as signal effectors, especially in conjunction with body postures and skin patterns.

The entire arm crown may be involved in concerted actions, or individual arms or pairs of arms may act in a discrete manner. The morphogenetic pathways leading from a uniform embryonic anlage, through subdivision into distinct arm rudiments, to the differentiation of arms reveal a highly conservative pattern underlying the early ontogenetic stages.

This paper addresses the question of how far the behavioral "achievements" of arms in juvenile and adult cephalopods are constrained by the respective morphological commitment of the individual "appendages".

ENERGY CONSUMPTION OF THE CUTTLEFISH *SEPIA OFFICINALIS* LINNE, 1758 (MOLLUSCA: CEPHALOPODA) DURING EMBRYONIC DEVELOPMENT: FIRST RESULTS.

BOUCHAUD, Olivier F., Station de Biologie Marine, Ile Bailleron, 56 860 Sene, France. Embryonic development in the telolecithal egg of the cuttlefish *Sepia officinalis* was influenced by water temperature. Higher water temperature resulted in shorter development time and smaller hatchlings. Contrarily, at lower temperatures, development was longer and cuttlefishes hatched at a larger size.

In order to investigate the energetics of egg-yolk utilization, eggs laid by a whelk-pot captured female, were reared in controlled conditions of 15°, 18°, 21°, and 24°C. Eggs were maintained under a light-cycle of LD 8:16, the dissolved oxygen content at maximum, and a salinity of 35‰.

Calorific values were made by burning egg-yolk and hatchlings after drying them by lyophilisation, using a Parr 1241 bomb calorimeter. Hatching size, development rates and energy consumption for the hatchlings in the four temperature groups were compared.

This report gives preliminary data for estimating some of the energetic mechanisms taking place during telolecithal egg embryogenesis with direct development.

DECIPHERING HISTORICAL CONTAMINATION EVENTS WITH BIVALVE SHELLS.

B.P. BOURGOIN, R.D. EVANS¹ & R.J. CORNETT²

¹Environmental and Resource Studies Program,
Trent University, Peterborough, Ontario, Canada K9J 7B8

²Atomic Energy of Canada Ltd.,
Chalk River, Ontario, Canada K0J 1J0

The three main structural shell components (i.e., periostracum, outer calcite layer and inner nacreous layer) and the soft tissues of the common blue mussel, *Mytilus edulis*, were analyzed for Pb to test the hypothesis that Pb bioavailability could be estimated from shell analyses. Mussel samples were collected near a Pb smelter on New Brunswick's north shore (Canada). A technique was developed to separate the calcite and nacreous layers. Nacre provided the best relationship ($r: 0.946$) when Pb levels in the different shell components were regressed with tissue Pb levels. Nacre also provided a better resolution of environmental quality as the statistical variability associated with the Pb levels in this material was less than half of the variability related to the tissue Pb levels (c.v.: 22 & 45 %, respectively). Historical tissue Pb levels were successfully estimated by analyzing discrete "annual layers" within the nacreous shell component. This study demonstrated that bivalve shells not only provide a better resolution of environmental quality as compared to tissue analyses, but also record significant temporal changes in environmental Pb levels.

NEW PREPARATIONS FOR BRAIN NEUROPHYSIOLOGY IN CEPHALOPODS.

¹BUDELMANN, Bernd U., ²BULLOCK, Theodore H. and ³WILLIAMSON, Roddy, ¹Marine Biomedical Institute, University of Texas Medical Branch, Galveston TX 77550, ²Department of Neurosciences A-001, University of California San Diego, La Jolla CA 92093, ³Marine Biological Association of the U.K., Plymouth PL1 2PB, England

Although the anatomy of the cephalopod brain is well described and many recordings have been made from their peripheral nervous systems, only a few recordings have been made from the brains. This has been mainly due to the difficulties in adequately immobilizing the animals during recordings and to the poor survival of the brains when anesthetized or perfused. Two new cephalopod preparations for brain neurophysiology will be described: (i) a brain slice preparation that allows analysis of the properties and connections of identified brain neurons, and (ii) an intact animal preparation that, for the first time ever, permits recording of brain activity (spikes and compound field potentials) in unanesthetized and unrestrained cuttlefish that are capable of behaving. These preparations allow a variety of brain neurophysiological experiments to be done. With further improvements and together with the wealth of morphological information that exists on the pathways of the brain, these new cephalopod preparations, in general, may become an interesting alternative model for brain neurophysiology.

Supported by grant DHHS 1 R01 EY 08312-01 to B.U.B.

CELLULAR CHANGES AT THE ONSET OF VITELLOGENESIS.

BOYLE, P.R., Department of Zoology, University of Aberdeen, Tillydrone Ave., Aberdeen AB9 2TN Scotland, U.K.

The process of reproductive maturation has been studied in females of the octopus *Eledone cirrhosa*. Development and differentiation of the follicle cell layer surrounding the oocytes is described from light and electron microscopy. The DNA content of follicle cells, selectively stained and scanned by microdensitometry, has been estimated for a range of oocyte and ovary maturity states. In pre-vitellogenic eggs the DNA content of follicle cells is distributed closely about the diploid cell quantity, twice that of the sperm nucleus. At the onset of vitellogenesis the follicle cells become increasingly polyploid, their nuclear DNA quantities increasing up to 5x normal. The relationship between these cellular changes and yolk secretion is discussed.

RELATIONSHIP OF BLOOD-GLUCOSE LEVELS TO ACTIVITY PATTERNS IN SEA HARES (*Aplysia*)

CAREFOOT, Thomas, Department of Zoology, University of British Columbia, Vancouver, B.C. Canada V6T 2A9

Daily behaviour of sea hares includes, in general order: feeding, resting while food is digested, mate selection and copulation, followed again by feeding. In nocturnal species, such as *Aplysia dactylomela*, the resting period is during daylight; in diurnal species, such as *A. parvula*, resting is mainly at night. Blood-sugar levels peak in early evening in *A. dactylomela*, coincidental with brisk mate selection and intensive copulation. Force-feeding experiments, using intubated *A. juliana*, showed that blood-glucose levels began to rise 1-2 h post-prandial and reached a peak about 5 h after the meal. Current investigations focus on the relationship between preference for seaweed as a food and its digestibility (reflected in increase in blood-glucose level), on the kinetics of glucose mobilization, and on the controlling influence of glucose on various behaviours, such as feeding and copulation.

ONTOGENY OF SENSORY RECEPTORS AND LARVAL BEHAVIOR IN OPISTHOBRANCH VELIGERS.

CHIA, Fu-Shiang and KOSS, Ron, Department of Zoology, University of Alberta, Edmonton, Alberta, Canada T6B 2E9

The purpose of this paper is to point out the ontogenetic relationship between larval behavior and sensory receptors in opisthobranch molluscs. Changes in behavior are often associated with the sequential development of larval sensory structures. For example, larval swimming behavior involves the statocysts, while selection of food particles during feeding may involve the cephalic sensory organ. Therefore these structures are present at hatching. The appearance of eyes precedes the onset of negative phototaxis toward the latter part of the larval phase, enabling downward migration of larvae toward an appropriate substratum for settlement. Advanced veligers of certain species settle and metamorphose in response to chemical(s) within the adult habitat. This capacity may require specialized settlement organs. For example, competent larvae of the nudibranchs, Rostanga pulchra and Onchidoris bilamellata, respond to chemical cues related to the adult prey species. In Rostanga, rhinophores develop prior to metamorphosis, and are probably utilized in substratum selection since larvae are incapable of metamorphosis before this event. The propodium in both species develops as a structural marker, indicating metamorphic competence. The propodium of Onchidoris veligers contains ganglia which are suspected to be involved in settlement by perceiving environmental cues, and then triggering the behavioral responses of settlement. Information in this report is drawn from published data and studies presently in progress.

STUDY ON THE PRESENCE OF ALARM PHEROMONES IN SOME MEDITERRANEAN CEPHALASPIDEAN MOLLUSCS.

CIMINO Guido, CRISPINO Antonio, SPINELLA Aldo, VILLANI Guido, Istituto per la Chimica di Molecole di Interesse Biologico (CNR), Via Toiano, 6 Arco Felice (NA) ITALY and SODANO Guido, Dipartimento di Fisica, Università di Salerno, Baronissi (SA) ITALY.

Several studies have shown that chemical communication is often implied in the behavior of many opisthobranch molluscs. For example, some molluscs are able to use ichthyotoxins or antifeedants as defense allomones or molecules acting as alarm pheromones. Chemoreceptive communication plays an important role in the Pacific cephalaspidean mollusc Aglaja (Navanax) inermis. In fact, A. inermis is a carnivorous opisthobranch which is able to locate its preys by chemoreception¹ and also, when molested, to secrete some chemical compounds which induce an alarm response in a trail following Aglaja².

The consideration that parallel behaviors could be found in similar species stimulated our research on the presence of alarm pheromones in Mediterranean cephalaspidean molluscs. This study allowed us to determine that the Mediterranean Aglaja depicta does not contain any alarm pheromones while one of its preys, Haminoea navicula, does. The alarm response in H. navicula was first observed in the field and after confirmed in the laboratory using the active metabolites isolated from the mollusc. Also other molluscs of Haminoea sp. show a similar behavior while it was not possible to perform bioassays on some others cephalaspidean molluscs. In these cases the presence of alarm pheromones has been only suspected on the basis of the chemical similarity of the isolated metabolites with those of the pheromones identified in Aglaja inermis and Haminoea navicula.

1. Paine, R.T., 1963, Veliger, 6, 1-9.

2. Sleeper, H.L., Paul, V.J., Fenical, W., 1980, J. Chem. Ecol., 6, 57-70.

RESOURCE ALLOCATION IN THE MUD FLAT OCTOPUS

CIGLIANO, John A., Department of Biology, Boston University, Boston MA 02215.

Octopuses are reported to be solitary in nature. Past laboratory studies, however, have indicated that octopuses are capable of setting up linear size based hierarchies. Previous field studies have shown that (1) octopuses prefer dens that offer a high degree of protection, (2) dens may be spatially clumped and (3) individuals compete for and defend dens from other octopuses. This suggests that when dens are clumped and vary in quality (degree of protection) octopuses may allocate den use based on dominance.

An experiment was conducted to test if Octopus bimaculoides sets up size based hierarchies when faced with a clumped distribution of dens that vary in quality. To determine which dens were preferred, each octopus (n=17) was initially allowed to choose among four dens that differed in volume and size of opening. A choice consisted of a particular den being inhabited over night. The most and least preferred den were then placed into a circular tank (2m x .5m) and three octopuses were simultaneously introduced into the tank (n=5). A dominance relationship among the three octopuses was computed. A positive correlation was found between the degree of dominance of an individual and the den it inhabited. The data support the hypothesis that octopuses have the ability to allocate dens through dominance when they are spatially clumped and vary in quality.

THE WHITE BODY OF THE BAY SQUID LOLLIGUNCULA BREVIS: PRELIMINARY LIGHTMICROSCOPICAL AND ULTRASTRUCTURAL OBSERVATIONS.

CLAES, Michael, Marine Science Center, Northeastern University, Nahant MA 01908,
HANLON, Roger T., Marine Biomedical Institute, University of Texas Medical Branch, Galveston Texas 77550-2772,
MORSE, M. Patricia, Marine Science Center, Northeastern University, Nahant MA 01908

It is believed that the circulating hemocytes in cephalopods are formed in the white bodies, a pair of multilobed organs, one attached to the medial surface of each eye.

In Lolliguncula brevis the white bodies are bilobed and as in other cephalopod species, they are covered by a capsule of connective tissue. Extensions of this capsule project into the organ and divide it into irregularly organized cords of cells.

The white bodies seem to consist of three different cell types which resemble developmental stages of typical leucopoietic tissues. Preliminary observations indicate that cells of a specific type form separate and distinct aggregations which suggests that different parts of the white body perform different functions in the formation of the hemocytes.

THE INFLUENCE OF AN ELECTRIC LIGHT ON THE CAPTURE OF DEEP-SEA CEPHALOPODS.

CLARKE, Malcolm R., Ridge Court, Court Rd., Newton Ferrers, Plymouth, UK and PASCOE, Philip, Plymouth Marine Laboratory, Citadel Hill, Plymouth, UK

The influence of light of various wattages on the cephalopods caught by rectangular midwater trawls with mouth areas of 8m², 10m², and 50m², as well as on bottom otter trawls, was determined by a comparative series of hauls made at several selected depths in three regions of the Northeast Atlantic. The overall catches of cephalopods were increased in numbers and by volume by the light. Some individual species, which were caught in sufficient numbers for statistical comparisons, were also shown to be caught in larger numbers and their mean and maximum volumes also increased with the lights. The influence of the lights varied with depth, while the optimum wattage showing a positive influence on the catch was about 70 watts.

THE EASTERN PACIFIC SPECIES OF THE BIVALVE FAMILY SPHENIOPSISIDAE

COAN, Eugene V., Department of Invertebrate Zoology, California Academy of Sciences, Golden Gate Park, San Francisco, CA 94108

The Spheniopsidae contains only a few fossil and three uncommon living species. The type species of *Spheniopsis*, *S. scalaris*, from the middle Oligocene of Germany, is discussed and figured. A new species of *Spheniopsis* is being described from the Panamic province and compared to *S. mississippiensis* from the lower Oligocene and *S. americana* from the upper Miocene, both of the eastern United States. *Grippina californica* occurs from California to Costa Rica; *G. berryana* is a synonym. *Grippina aupaoria* (Powell, 1937) occurs in New Zealand. Recent spheniopsids have a laterally elongate lithodesma, and probably all brood their young.

NEURAL MECHANISMS UNDERLYING SENSITIZATION OF A DEFENSIVE REFLEX IN *APLYSIA*

CLEARY, Leonard J., Baxter, Douglas A., Nazif, Fidelma and Byrne, John. H., Dept. of Neurobiol. & Anat., Univ. Texas Med. School, Houston, TX 77225

The tail-siphon withdrawal reflex in *Aplysia* is a useful model system to study simple forms of learning such as sensitization. The two components of the reflex are mediated by monosynaptic and polysynaptic circuits. Interneurons in the pleural ganglion form a parallel pathway to tail motor neurons and conduct sensory input to siphon motor neurons. The excitatory interneurons may contribute to sensitization of the reflex by producing slow excitatory potentials in tail motor neurons. In addition, they activate facilitatory L29 neurons in the abdominal ganglion.

An important population of modulatory interneurons contains the neurotransmitter serotonin. The pleural sensory neurons are encapsulated by varicose serotonergic fibers that make direct contacts with somata of the sensory neurons. When a sensitizing stimulus is delivered, serotonin is presumably released and elevates the concentration of intracellular cAMP in the sensory neurons. The electrophysiological and morphological correlates of sensitization produced by the cAMP pathway include increased excitability, increased action potential duration, enhanced transmitter release, and an increased number of varicosities in the axonal arbor. Elevation of cAMP in the soma may be necessary to regulate cellular processes that are restricted to the soma, such as gene transcription and protein synthesis.

ABUNDANCE AND RECRUITMENT OF CEPHALOPODS.

COELHO, M.L., Universidade do Algarve, Campus de Gambelas, Apartado 322, 8004 Faro, Portugal

The economic importance of cephalopods as food and their key role in marine ecosystems justify efficient approaches to management. While management of traditional fisheries has been supported by a long history of fish population studies, management of cephalopod stocks has been discouraged owing to the inadequacy of corresponding age-based methods. As a consequence, questions such as stock and recruitment in cephalopods have been ignored. Alternative solutions may result from cooperative long-term studies based on long time series of length at maturity and environment data. A case study (*Illex illecebrosus*) is introduced to illustrate that population complexity/ geographical range are key factors in defining abundance and recruitment variability.

OPTICAL RECORDINGS FROM THE Aplysia ABDOMINAL GANGLION DURING THE GILL WITHDRAWAL REFLEX.

COHEN, Larry; WU, Jian-young; FALK, Xiao Chun; HOPP, Hans-Peter; Department of Physiology, Yale University School of Medicine, New Haven, CT 06510

Multisite optical recordings using voltage-sensitive dyes were made from the Aplysia abdominal ganglion during the gill-withdrawal reflex. These recordings indicated that between 300-400 of the approximately 1000 neurons present in the ganglion were activated by the light touch to the siphon skin that elicited the gill-withdrawal. This result suggests that determining the detailed cellular basis of the withdrawal reflex and its plasticity will be extremely difficult.

We have begun preliminary experiments to study more general properties of the neuronal response elicited by the siphon touch. We compared the neuronal response during a normal withdrawal with the response obtained with the gill and siphon movements blocked. Blocking the peripheral movement had little effect on the neuronal response. We also examined the trial-to-trial variability in the neuronal response under constant stimulus conditions. The responses were neither stereotyped nor totally different.

Supported by NIH grant # NS08437.

PARTIAL CHARACTERIZATION OF A UNIQUE PROTEIN IN THE EYE, A CIRCADIAN ORGAN, OF Aplysia.

COX Rachel L., GLICK, David L., RIDGE, Richard J., and STRUMWASSER, Felix, Lab. of

Neuroendocrinology, MBL, Woods Hole, MA 02543

The isolated eye of Aplysia contains a neuronal circadian oscillator. This circadian oscillator modulates the frequency of action potentials emitted in constant darkness as measured in the optic nerve. Our studies have focused on determining proteins that are unique to the neurosecretory cells of the eye, since these cells are presumed to contain the circadian oscillator. One protein of interest was determined by the use of monoclonal antibodies, which identified the neurosecretory cells uniquely, and on western blots identified a single band (m.w.=62-64 kD) on one-dimensional PAGE. On 2-dimensional gels this protein has a pI of 5 and runs as a large inverted triangular spot.

The N-terminal sequence of the 62-64k eye protein was determined, from an immobilized blot of the 2-D gel, by automatic Edman degradation on an ABI 477A protein sequencer. The sequence of the first 24 residues is:

lys-THR-LYS-GLN-x-PHE-VAL-ALA-ALA-ISO-LEU-arg-GLN-his-arg-MET-GLN-glu-GLN-ALA-GLN-GLN-ALA-ASP

where lower case symbols represent residues for which the confidence level is not high and "x" means unknown residue.

Supported by MH41223 to F.S.

SHELLWATCH: A BASELINE MONITORING PROGRAM FOR CONSPICUOUS MOLLUSKS AT SANIBEL ISLAND.

COOK, Susan B., Bermuda Biological Station for Research, Inc. and ANDERS, Alice D., Sanibel, FL.

Shellwatch is a pilot project to collect ecological data on populations of large collectible gastropods on the sandflats and grassbeds behind Sanibel Island, Florida. The goal of the project is to provide a baseline against which to detect future changes in the abundance of the lightning whelk, Busycon contrarium, the pear whelk Busycon spiratum, the banded tulip Fasciolaria hunteria, and the true tulip Fasciolaria tulipa. The project is currently supported by the Non-Game Wildlife Program of the State of Florida, the Sanibel Captiva Shell Club, and the Sanibel Captiva Conservation Foundation.

Teams of trained volunteers from SCCF and the Sanibel community census 12 permanent plots every 2-3 months. Both visual and tactile search methods are used to detect visible snails and individuals buried in the bottom or hidden amongst the grasses.

Preliminary data indicate the presence of significant differences in the densities of B. contrarium at different sites and from one plot to the next at each site. Seasonal differences also appear to occur.

THE ROLE OF CHEMICAL CUES IN ANTIPREDATION STRATEGIES IN FRESHWATER SNAILS.

CROWL¹, Todd A., COVICH², Alan P. and ALEXANDER², James A., Jr. ¹Department of Fisheries and Wildlife and Ecology Center, Utah State University, Logan, UT 84322 and ²Department of Zoology, University of Oklahoma, Norman, OK 73019

The freshwater physid snail Physella virgata virgata exhibits a "crawl-out" response as well as a life-history shift in the presence of actively feeding crayfish predators. Both antipredation strategies are shown to only occur in the presence of actively foraging crayfish and suggest that some constituent chemical of the snail is being modified by the digestive process of the crayfish. Other freshwater snails (e.g., Helisoma sp. and Biomphalaria sp.) also show a crawl-out response. As with the physid, active predation is a necessary cue. The question arises as to whether these responses are a function of tight coevolutionary linkages or if they simply reflect a response to a general class of chemical cues. We report the results of laboratory predation trials in which snails were exposed to predation by decapods that the snails are known to co-occur with as well as decapods that have allopatric distributions. In most cases, only naturally co-occurring combinations of decapods and snails resulted in significant behavioral avoidance. Finally, we show that within these interactions, the antipredation response is graded and is directly correlated with both predation intensity and snail vulnerability.

WUCONCHONA (GASTROPODA: TRICULINAE) OF CHINA: ANATOMY, PHYLOGENETIC RELATIONSHIPS, NEW GENUS AND TRIBE DESCRIBED, TRANSMISSION OF SCHISTOSOMA.

DAVIS, George M. Academy of Natural Sciences, Philadelphia, PA 19103

The detailed comparative anatomy of *Wuconchona nizhuangensis* Kang 1983 from Hubei Province is presented. Novel innovations are found in the female reproductive system, most notably, the loss of the normal seminal receptacle and the replacement for this function found within the oviduct. Phylogenetic analyses were done with and without computer aid, involving 10 genera, one of them new. The computer program used was Hennig-86 yielding 5 equally most parsimonious trees of 21 steps with a consistency index of 0.80. Genera grouped into two tribes, the Triculini and a new tribe "x". A new genus is described by necessity for a species previously placed in *Neotricula*. *Wuconchona* is the most derived genus if one considers the direction of evolution to be from a state of having a normal seminal receptacle to a state of loss of the normal seminal receptacle and evolving a novel replacement. The genetic potential to transmit *Schistosoma* is mapped on the cladogram. Genetic continuity for transmission is unbroken in the cladogram. Supported by NIH AI 11373

A CALCIUM ANTAGONIST BLOCKS EXCITATION OF THE HEART OF A BIVALVE, *MERCENARIA MERCENARIA*
DEVLIN, C. L., Department of Zoology,
University of Rhode Island, RI 02882

The myogenic heart characteristic of the phylum Mollusca is modulated by excitatory and inhibitory neurohumors. A sucrose gap method was used to record action potentials (APs) and accompanying force (F) from the ventricle of *M. mercenaria* while excited by 5-hydroxytryptamine (5HT). 5HT had a biphasic effect on systolic activity of the heart. Rate of rise, amplitude and frequency of APs and F increased progressively with 5HT concentration from 10^{-10} M to 10^{-6} M. Doses of 5HT greater than 10^{-6} M caused systolic arrest. The action of 5HT is dependent upon maintaining physiological levels of calcium in the extracellular medium. Perfusion of the ventricle with lanthanum or calcium-free sea water greatly reduced 5HT's excitatory action on rhythmicity. Treatment of the ventricle with verapamil had no significant effect on spontaneous activity. However, verapamil had a profound inhibitory effect on excitation induced by 5HT, suggesting that a "use-dependent" mechanism may be involved. A concentration of 5HT (10^{-6} M) which stimulated maximal beating was blocked by simultaneous treatment with 10^{-6} M verapamil.

TRANSMISSION AT THE SQUID GIANT SYNAPSE.

DE SANTIS, A., Stazione Zoologica, Naples, Italy and MESSENGER, J.B., Dept. of Animal and Plant Sciences University of Sheffield, England

The nature of the transmitter at the giant synapse between the second- and third-order fibers has never been established. We describe four kinds of experiment that suggest it may be the amino acid, L-glutamate. The stellate ganglia of *Alloteuthis subulata* and *Loligo vulgaris* were examined. The second-order giant fiber was stimulated and both action and synaptic potentials were recorded in the largest third-order fiber. Drugs were applied by bath perfusion or iontophoretically. Bath application of L-glutamate and its agonists, kainate, quisqualate and AMPA reversibly blocks transmission at the synapse and abolishes the synaptic potential, presumably because of desensitization. The first three of these substances depolarise the postsynaptic membrane when applied iontophoretically. Broad-band antagonists for L-glutamate also block transmission, as do specific blockers of the mammalian "kainate/quisqualate" receptor such as the new quinoxalinedione drugs. Argiotoxin 636, a potent blocker of glutamate activated channels in insects, irreversibly abolishes the synaptic potential at very low concentrations and at rates correlated with stimulus frequency. After repetitive stimulation of the preganglionic axon, L-glutamate can be recovered from the saline bathing the ganglion.

MATING BEHAVIOR OF TADPOLE SNAILS, *PHYSA GYRINA*

DeWitt, Thomas J., Department of Biology
Boston University, Boston, MA

Laboratory observations were made of *Physa gyrina* from the Fenway in Boston, Massachusetts. The mating sequence for male copulants encompassed mounting (mate selection), positioning (clockwise circling), eversion of preputium, intromission and dismounting. The sequence was sometimes interrupted if the female copulant rejected mates at any point. I have observed four stereotyped ways in which mates are rejected. A female may swing her shell back and forth, jerk it about, position it so male copulants cannot reach her gonopore, or she may make head to preputium contact ("biting").

It is interesting to compare these results with a recent study on mating in the pond snail, *Lymnaea stagnalis*, a closely related taxon (van Duivenboden and ter Maat 1988). The limnaeid study describes sham copulation by males and the absence of female mating behaviors. Although it is possible these differences are a true taxonomic distinction, I argue they may be methodological artifact. The limnaeid study used laboratory raised snails which were reunited after a period of isolation. Also, 20-25 copulating pairs were observed at a time. I propose the best method of observing general gastropod reproduction involves animals taken from the wild (suitably acclimated to laboratory conditions) and observed using focal pair sampling.

SIZE ASSORTATIVE MATING IN TADPOLE SNAILS,
Physa gyrina: MATE CHOICE, PROTANDRY OR
FACULTATIVE SEX SWITCHING?

DeWITT, Thomas J., Department of Biology
Boston University, Boston, MA

Physa gyrina were collected from the Fenway in Boston, Massachusetts for laboratory investigation of size related mate pairing. Populations (n=300-500) composed of individuals of varied shell length were established on six independent occasions. Twenty to 24 hours after collection, shell lengths of the first 12 copulating pairs were measured. Each female copulant was removed to a holding vessel for five days, after which I recorded the number of eggs oviposited. Data on failed copulations were also collected.

Male copulants were found coupled with mates significantly larger than themselves. Female copulants occasionally rejected mates that were significantly larger than themselves. The relationship between size of female copulants and their fecundity was positive and significant.

I conclude size assortative mating in the Fenway population occurs because of one or more of the following conditions: 1) Male mate choice for larger (more fecund) individuals, coupled with female mate rejection of large mates. 2) Facultative switching of sexual function based on the size of mates encountered. 3) There may be a higher probability that smaller snails have not developed female function. I argue for a preliminary synthesis of these alternatives based on the size-fecundity relationship.

SPERM STORAGE AND MULTIPLE INSEMINATION IN A
NATURAL POPULATION OF THE FRESHWATER SNAIL,
Physa heterostropha.

DILLON, Robert T., Jr. and WETHINGTON, Amy R.,
Department of Biology, College of Charleston,
Charleston, SC, 29424

Although some figures are available regarding the capacity of freshwater pulmonates to store sperm after laboratory mating, no such data are available for wild-collected snails, where the recency of mating is necessarily unknown. We collected 35 *Physa heterostropha pomilia* from a local population and held each in isolation for 60 days, rearing all egg masses. We then used protein electrophoresis to determine the LAP genotype of each parent and a sample of its offspring. Five of the parental snails (total 60-day fecundities from 300 - 600 progeny) were found to be homozygous at the LAP locus yet producing approximately 50% heterozygous offspring. In 4 of these 5 cases, no significant difference was detected in offspring genotype frequencies over 60 days, suggesting both that mating has generally been recent and that reservoirs of stored sperm are generally large. In the fifth case, the frequency of heterozygous offspring significantly increased, suggesting multiple insemination. Multiple insemination and sperm storage have obvious adaptive significance to colonizing species such as freshwater pulmonates.

CONTRIBUTIONS TO AMERICAN MALACOLOGY BY
PIONEER NATURALISTS OF EASTERN OHIO.

DEXTER, Ralph W., Department of Biological
Sciences, Kent State University,
Kent, OH 44242.

A brief sketch is presented with portraits of the following pioneer naturalists in eastern Ohio who contributed to the development of the science of malacology -- Sen. Benjamin Tappan, Jr. (1773-1857), Ravenna; Dr. Samuel P. Hildreth (1783-1863), Marietta; Dr. Jared P. Kirtland (1793-1877), Lakewood; George W. Dean (1820-1901), Kent; and George J. Streator (1846-1925), Garrettsville.

AGONISTIC BEHAVIOR AMONG MALE SQUIDS, *LOLIGO*
(*DORYTEUTHIS*) *PLEI* BLAINVILLE, 1823: AN INVERTE-
BRATE ASSESSMENT STRATEGY.

DIMARCO, F. Paul and HANLON, Roger T., Marine
Biomedical Institute, Univ. Texas Medical Branch., Galveston,
TX 77550.

In squid schools, males interact through aggressive bouts to determine dominance relationships. Iterations among six different combinations of squids ($\sigma^{\circ}; \sigma^{\circ} + \sigma^{\circ}; \sigma^{\circ} + \sigma^{\circ}; \sigma^{\circ} + \sigma^{\circ}; \sigma^{\circ} + \sigma^{\circ}; \sigma^{\circ} + \sigma^{\circ}$) were tested and analyzed. Activity records indicated that male squids can employ about 24 behaviors during agonistic bouts, usually in complex and rapidly changing combinations. A distinctive feature of these bouts was a stereotyped Lateral Display, which in its fullest expression was characterized by variable persistence and variable intensity. Overall, there were no differences in total duration or frequency of components shown by the dominant versus the subordinate males. However, significant differences did occur at the end of the bouts when dominant males physically displaced subordinate males during rapid fin-beating tournaments, and then did all the chasing. A probability density function and hazard function generated from contest durations closely resembled those found in game theory models. Asymmetries in resource holding power and resource value affected the nature of the contests. Given these observations, it is reasonable to suggest that these data may underscore an assessment strategy used by male squids in establishing social dominance.

CULTIVATION OF SYMBIOTIC PIGMENT-PRODUCING BACTERIA FROM THE ACCESSORY NIDAMENTAL GLANDS OF THE SQUID *LOLIGO PEALEI*.

DUNLAP, Paul V., Biology Department, WHOI, Woods Hole, MA 02543

Females of the squid *Loligo pealei*, like many other teuthoid and sepoid cephalopods, bear a pair of accessory nidamental glands that are colonized by bacteria. The gland changes from colorless in immature animals to mottled red-orange in reproductively mature animals, and the color has been attributed to the symbiotic bacteria. To begin addressing the role pigment-producing bacteria may play in reproduction of the squid, bacteria from the accessory glands of mature female *L. pealei* were cultured and examined. The glands were found to contain a mixed assemblage of six or more different types of bacteria. In culture, one type produced transparent red-orange pigmented colonies similar in appearance to the color of the gland. To determine if this bacterial type was responsible for the red-orange color of the gland, pigments were extracted from one of these isolates and compared by HPLC analysis with pigments extracted directly from the gland of a mature female. The gland was found to contain a major pigment structurally similar to sepiaxanthin (absorption maxima of 490 and 525 nm) and a small amount of an astaxanthin-like 4-keto carotenoid. The pigment produced by the red-orange bacterial isolate was very similar. Thus, the red-orange isolate may be the bacterial type responsible for the color of the *L. pealei* gland. Similar red-orange pigment-producing bacteria were isolated also from the accessory nidamental glands of *Sepia officinalis*, *Loliguncula brevis*, and *Sepioteuthis lessoniana*. The red-orange isolates were found to be gram-negative, motile by polar flagella, non-luminous, asporogenous rods that require salt for growth and do not ferment glucose. In combination with the distinctive pigmentation, these characteristics apparently distinguish these isolates from previously described bacterial groups. Consequently, the red-orange isolates may be a new bacterial species. Future work will focus on changes in the bacterial assemblage during maturation of the squid, the mode by which symbiotic bacteria are transferred to the new squid generation, and the effect of the red-orange pigment-producing bacteria on survival and development of the squid.

DIAGNOSTIC EGG HULL SCULPTURING OF AN EPIZOIC CHITON.

EERNISSE, Douglas J., Museum of Zoology and Dept. of Biology, University of Michigan, Ann Arbor, MI 48109.

A chiton described from Bird Rock, San Diego County, California as *Cyanoplax dentiens* (Gould, 1846) *cryptica* Kues, 1974 [= *Lepidochitona cryptica* (Kues, 1974)] has only been found living on the shallow subtidal brown alga, *Eisenia arborea* Areschoug, 1876, on which it apparently feeds. In January, 1990, three chitons were taken from *Eisenia* at the type-locality for *L. cryptica* and were identified as such by comparisons to the original diagnosis and the holotype specimen. One of the collected *L. cryptica* was a female with a mature gonad, permitting examination of egg hull sculpturing with SEM. The sculpturing proved to be distinct from the already investigated egg hull sculpturing of other members of *Lepidochitona* Gray, 1821 that are morphologically similar to *L. cryptica*, including *L. dentiens* (Gould, 1846) and especially *L. berryana* Eernisse, 1986. Other morphological attributes, besides egg hulls, are suggested to be equally diagnostic, confirming the elevation of *L. cryptica* to specific status.

ANATOMICAL VARIATION IN A POPULATION OF *OMALONYX* SP. AND ITS IMPLICATIONS FOR THE SYSTEMATICS OF SUCCINEID LAND SNAILS.

DUTRA-CLARKE, Ana, Academy of Natural Sciences, 19th & Parkway, Philadelphia, PA 19103

Six preserved adults from a population of *Omalonyx* sp. collected along 0.5 km of the banks of a canal in Caruaru, Northeast Brazil, were dissected in detail. The reproductive, nervous, digestive and muscular systems were studied following the methods of Hoagland & Davis (1987).

Large-scale variation in the general body organization and pattern of its development has been observed. The penial organ is variously lies on left, right or mid-line of the body. The penial retractor insertion (a character important to species definition in the literature) is on the vas deferens, either a short distance from epiphalic head or very close to it. The internal penial sculpture (another weighted character) varies significantly in pattern and extent. The hermaphroditic duct varies from almost straight to contorted. The body retractor muscles may pass either inside or outside the glandular oviduct. From external view, one or two receptacula seminis can be visualized. In the radula, the transverse rows are slightly V-shaped and the significance of the modification of endocones into small cusps into a serated appearance is here reported for the first time.

These results indicate that the standard characters, particularly of the reproductive system, used for systematics of the Succineidae may not be fixed within all species.

POTENTIAL IMPACT OF A SEASONAL MIGRATORY JUMBO SQUID (*DOSIDICUS GIGAS*) POPULATION ON A GULF OF CALIFORNIA SARDINE (*SARDINOPS SAGAX CAERULEA*) STOCK.

EHRHARDT, Nelson M., Marine Biology & Fisheries Rosenstiel School of Marine & Atmospheric Science, University of Miami, Miami, FL 33149

Dosidicus gigas inhabits the Central Eastern Pacific. Annually, the species migrates with different intensities in and out of the Gulf of California. In 1979-1980 an unusually large squid population was observed in the Gulf. Extensive research on that migratory population resulted in new insights about the biology and population dynamics of *D. gigas*. Further analyses are presented in this paper which indicate that *S. sagax caerulea* was a significant component in the jumbo squid diet. A quantitative assessment of the potential sardine biomass consumption by *D. gigas* was determined by integrating biological components into a population simulator. The results indicate that up to 50,000 metric tons of *S. sagax caerulea* may have been consumed by *D. gigas* during its nine months residence in the Gulf of California. Drop in total sardine landings during the 1980/1981 fishing season may be attributed at least in part to an unusually high sardine mortality which may have been induced by squid predation.

MADAGASCAR'S ACAVOID LAND SNAILS.

EMBERTON, Kenneth C., Department of Malacology, Academy of Natural Sciences, 19th & Parkway, Philadelphia, PA 19103

The distribution of the acavoid-strophocheiloid clade is apparently restricted to South America, southwestern Africa, Madagascar, the Seychelles, Sri Lanka, and eastern Australia. These snails are important biogeographic indicators of Gondwanian tectonic and geomorphologic events because of their low vagility and the unlikelihood of passive transport due to large size. They are valuable for understanding the adaptive significance of shell morphology, because, unlike most higher taxonomic groups of land snails, which have either a high-spired or a low-spired shell within any given geographic region, acavoid-strophocheiloids occupy the full morphological range in many regions where they occur.

As the first step in a long-term goal of phylogenetic reconstruction of the entire acavoid-strophocheiloid clade, analysis of the Madagascan taxa is clearly most urgent, because of disappearing habitat (only 2% of native forest remains), possible ecological competition by introduced *Achatina*, and probable predation by *Euglandina* (deliberately introduced in 1962).

Madagascan acavoids account for about one-fourth of the island's known land-snail fauna. They consist of five genera, all endemic, comprising 99 known species. Descriptions of species began in the 1790s, peaked in 1870, then declined to total cessation in the 1930s and 40s, when the number of recognised species stood at 65. The extensive revisionary work of Fischer-Piette and colleagues in the 1950s, 60s, and 70s produced a bloom of new species. There are doubtless many more undiscovered taxa.

Soft-part anatomy is very poorly known for Madagascan acavoids. Line drawings of the proximal reproductive systems exist for 11 of the 62 species of *Ampelita*, 2 of the 12 species of *Clavator*, 1 of the 3 species of *Eurystyla*, 6 of the 15 species of *Helicophanta*, and 1 of the 7 species of *Leucotaenius*; genitalia have never been compared for delimiting species, and are only sketchily known for three species from three different genera. No Madagascan acavoids have been investigated ecologically, biochemically, or phylogenetically.

MODIFICATION OF HERMISSENDA FEEDING BEHAVIOR BY ASSOCIATIVE LEARNING (GASTROPODA: HERMISSENDA CRASSICORNIS, PHIDIANA).

FARLEY, Joseph, GIROLAMI, Carla, & SCHERER, Tracy, Program in Neural Science, Indiana University, Bloomington, IN 47405

Bite-strike behavior of *Hermisenda* directed towards a food is modified if an extract of that food is repeatedly paired with rotation-produced stimulation of the statocyst. Animals exposed to a single training session (in which 15-50 pairings of food-extract exposure and rotation are administered) exhibit 3-4 fold increases in bite-strike latencies to the trained food for up to 48 hrs following the last conditioning trial. These changes are relatively pairing- and stimulus-specific. Rotational stimulation of the statocyst has also previously been used to condition suppression of *Hermisenda's* phototactic behavior. We have therefore asked: If both light and a food extract are paired at the same time with rotation, is learning about either stimulus influenced by the presence of the other? The presence of light during a food extract - rotation pairing greatly reduces the learned suppression of feeding that would otherwise occur to the food. Our results indicate that *Hermisenda* can learn to avoid foods which reliably signal an aversive event, that the aversive event need not necessarily entail untoward nutritional consequences, and further that this learning can be prevented by the presence of another stimulus during pairings.

PRELIMINARY LIFE HISTORY STUDIES OF SLUGS IN THE FAMILY PHILOMYCIDAE (GASTROPODA: PULMONATA)

FAIRBANKS, Lee, Department of Biology, Penn State Beaver, Monaca, PA 15061

Eggs of three species from two genera were incubated in petrie dishes, the hatchlings were raised in terraria. Food was provided ad libitum from 16 June 1989 through 12 December 1989. Weight and crawling length measurements were taken at approximately seven day intervals. Average clutch size was 30.7 eggs. Incubation time averaged 20.1 days. Fecundity averaged 92%. The average weight of two-day old hatchlings was 0.021g, the average crawling length was 8.75mm. Data was collected for 186 days (10 June through 12 December 1989). The average weight gain for the average slug was 0.013g per day, the average increase in crawling length was 0.273mm per day. Observations indicate that, at the end of the test period, these slugs were mature and would reproduce during their second year.

CONSTITUTIVE PKC ACTIVITY IS RESPONSIBLE FOR LEARNING-PRODUCED REDUCTIONS IN K CURRENTS OF HERMISSENDA TYPE B PHOTORECEPTORS (GASTROPODA: HERMISSENDA CRASSICORNIS).

FARLEY, Joseph & SCHUMAN, Erin, Program in Neural Science, Indiana University, Bloomington, IN 47405

Exposure of Type B photoreceptors to phorbol esters induces many of the memory-related changes produced by pairings of light and statocyst hair cell stimulation. To determine whether PKC activation is necessary for the induction and/or continued maintenance of cellular memory, we have exposed Type B cells--before as well as after conditioning has occurred--to a battery of kinase inhibitors. Bath-application, prior to conditioning, of the PKC-inhibitors staurosporine, sphingosine, or the general kinase inhibitor H-7 prevented the B cell depolarization and input resistance increases that are a consequence of pairings. In contrast, inhibitors of Ca/CAM- (TFP, W-7) or cyclic nucleotide-dependent PKs (H-8) failed to block these changes. Voltage-clamp measurements of B cell I_A and I_{K-Ca} from preparations conditioned in vitro revealed that the presence of H-7 in the bath prevented the training-produced reduction of K currents. Measurements from B cells of behaviorally-conditioned animals several days following training revealed that the presence of H-7 at the time of recording reversed the training-produced reductions of K currents. These results suggest that associative learning results in a shift of PKC from an initially inactive form to one which is endogenously active in B cells.

DIVALENT-CATION INDUCED VESICULATION AND VESICULAR FUSIONS AND MIGRATIONS AFTER TRANSECTION OF SQUID GIANT AXONS.

FISHMAN, Harvey M. and TEWARI, Kirti P., Department of Physiology and Biophysics, University of Texas Medical Branch, Galveston, TX 77550

Images of squid (*loligo pealei*) giant axon obtained by phase contrast and video differential-interference-contrast microscopy after transection of axons in Ca^{2+} - and Mg^{2+} -containing artificial sea water (ASW) show rapid (min) development of vesicles in the subaxolemmal region of axons extending several mm away from a cut end. Vesicles grow in size by fusions, reaching 50 μm (diam.) or more (called "axosomes"), while migrating toward the injured site where they accumulate. Axosomal formation does not occur without divalent cations (10 mM Ca^{2+} or 50 mM Mg^{2+}) in the ASW. Ultrastructural evidence and the presence of specific ion channels (patch clamp measurements) suggest that axosomes consist of membrane from different sources (e.g., axolemma, organelles and Schwann cells); however, localization of axosomal formation to the inner region of the axolemma and the formation dependence on divalent cations imply principal involvement of cisternae of endoplasmic reticulum. Axosomal formation was induced in axons from many different animals (4 species of cephalopods, and in cockroach, crayfish and earthworm). Divalent-cation induced vesiculation and subsequent phenomena seem to be short-term (min to hrs) fundamental processes that precede axonal degeneration or repair and regeneration.

A HIGHLY MODIFIED COPEPOD PARASITE OF TROPICAL WESTERN ATLANTIC CHITONS (POLYPLACOPHORA: ISCHNOCHITONIDAE).

FRANZ, Craig J., Department of Biology, La Salle University, 20th Street at Olney Avenue, Philadelphia, PA 19141, and BULLOCK, Robert C., Department of Zoology, University of Rhode Island, Kingston, RI 02881.

A new genus and new species of a highly modified copepod parasite are described from the polyplacophoran mollusks *Ischnochiton striolatus* (Gray, 1828) from Isla de Margarita, Venezuela, and *Stenoplax boogi* (Haddon, 1886) from southeast of Pensacola, Florida, in the northern Gulf of Mexico. The female, which resides in the chiton's branchial cavity, is characterized by a swollen, laterally elongate ectosoma and a bifurcated tubular endosoma that extends through the host's visceral cavity. Egg masses are attached to the lateral aspects of the ectosoma and are composed of grape-like clusters of variable size and egg number. The much smaller sexually dimorphic males exhibit two pair of anterior processes. Multiple males are found with each female.

The parasite occurs infrequently. On Isla de Margarita the percentage of *I. striolatus* parasitized was 0.4-9.7% at five sites (n=836). None was found at 11 other localities (n=676).

Copepods have not been reported previously as parasites of chitons. Due to the lack of external morphological characters typical of many parasitic copepods, the phylogenetic position of the new species is uncertain.

WILL THE REAL OCTOPUS JOUBINI (OCTOPODIDAE; CEPHALOPODA) PLEASE RAISE YOUR ARM(S)!

FORSYTHE, John W., Marine Biomedical Institute, Galveston, TX 77550 and TOLL, Ronald B., The University of the South, Sewanee, TN 37375

Over the past ten years, evidence suggests that at least two distinct species have been referred to as *Octopus joubini*. Since Robson's (1929) description of the holotype (from St. Thomas, Virgin Islands), virtually the entire literature on *O. joubini* has reported on specimens collected from Biscayne Bay (south Florida) and St. Joseph Bay (northwest Florida). These two populations produce large eggs and benthic hatchlings. However, a second pygmy species in the Gulf of Mexico produces very small eggs and planktonic hatchlings. The holotype of *Octopus joubini* Robson, 1929 was re-examined and based on the ovarian eggs, we have determined that the small egg form, not the large egg form, supports the name *Octopus joubini*. It cannot be determined at present if *Octopus mercatoris* Adam, 1937 is a junior synonym of the true *O. joubini* or if the former is the "large egg" form.

Information was obtained from live animals collected south of Galveston, Texas during 1981-1986, on the distribution, reproductive biology, development and growth from egg-laying through the planktonic phase to settlement of the true *Octopus joubini*.

ON THE REPRODUCTIVE EFFORT IN SEPIOLIDS (MOLLUSCA: CEPHALOPODA).

GABEL-DEICKERT, Adrienne, Institut für Allgemeine Zoologie, Freie Universität Berlin, Königin-Luise-Strasse 1-3, 1000 Berlin 41, Germany.

Abstract of poster presentation unavailable at this time.

A CONCEPTUAL ROLE FOR STRONTIUM IN LARVAL RETENTION AND ADVECTION FROM ESTUARIES.

GALLAGER, Scott M., Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543, KUZIRIAN, Alan M., Marine Biological Laboratory, Woods Hole, MA 02543, BIDWELL, Joseph P., Mayo Clinic, Rochester, MN and MCDOWELL CAPUZZO, Judith M., Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543

We present the hypothesis that embryos of some planktotrophic bivalves are rapidly advected from estuaries to maximize exposure to oceanic levels of strontium during first shell formation; shelled larvae may be imported after the window for the strontium requirement has passed. Our previous studies have demonstrated that strontium is required during embryonic development for normal shell mineralization in a number of bivalves and gastropods. When the strontium concentration in the ambient medium is less than 6 ppm during development of the trochophore, the embryonic shells of bivalve larvae are abnormal or completely absent. The concentration of strontium in the world oceans is about 8 ppm and varies only with salinity. Therefore, the minimum level of strontium required for normal shell development corresponds to a salinity of about 25.5 ‰. Experiments demonstrate that abnormal larval development of *Mercenaria mercenaria* and *Mytilus edulis* at low salinity can be reversed by addition of strontium at 8 ppm. Data from intense plankton sampling programs in two local estuaries show a net efflux of early bivalve embryos in the surface waters on ebb tides followed by a net influx of shelled veligers on flood tides. In general, shells of larvae imported on flood tides are normal while many of the shells of those larvae remaining in the estuaries and exposed to salinities as low as 20 ‰ are wrinkled, crenulated and improperly formed. Net advection of early embryos on surface ebb flows suggests vertical migration plays a role in maximizing exposure to strontium.

SUBSTRATE PREFERENCE OF NATURAL POPULATIONS OF ICELAND SCALLOPS (*CHLAMYS ISLANDICA* MÜLLER, 1776) ON THE NORTHEASTERN GRAND BANK OF NEWFOUNDLAND.

GILKINSON, Kent D., LeDrew, Fudge and Associates Limited, P.O. Box 9370 Stn. B, St. John's, Nfld., Canada.

GAGNON, Jean-Marc, Department of Biology, Memorial University of Newfoundland, St. John's, A1B 3X9, Canada

Live, adult Iceland scallops (*Chlamys islandica*) were quantified and their occurrences assigned to substrate coarseness grades along five photographic transects (7-10 km in length) covering areas of the northeastern Grand Bank of Newfoundland. Scallops were disproportionately (53-94% occurrence) associated with the coarsest grade of substrate representing 80-100% (area of coverage) gravel and cobble. Overall, occurrences of scallops were rare on predominantly sand substrates. Average densities of scallops per photograph (5.44 m²) ranged from 0.5 to 13.8 on cobble fields and from 0.02 to 1.7 on open sand substrates.

The observed patterns are discussed in terms of aspects of the behavioural ecology of the species, the extent of Grand Bank bedforms and the occurrence of mobile predators.

THE NAMING OF THE NORTH AMERICAN COMMON SQUID.

GILBERT, Daniel L., Laboratory of Biophysics, NINDS, National Institutes of Health, Bethesda, MD 20892

Loligo pealei was named by a famous naturalist, Charles Alexandre Lesueur (1778-1846) in a paper read on March 21, 1821 before the Academy of Natural Sciences in Philadelphia (Summers, 1990; Aldrich, 1990). Lesueur resided in Philadelphia for nine years, from 1816 to 1825. In this paper, he mentioned a Mr. R[ubens] Peale, the manager of the Philadelphia Museum in 1821. However, he was also a friend of Titian Ramsay II Peale, a younger half-brother of Rubens and a noted naturalist (Poesch, 1979). Both Titian II and Lesueur were members of the Academy of Natural Sciences of Philadelphia in 1821. Their father, Charles Willson Peale, was founder of this first popular museum of natural science and art; in addition, he was a noted artist and painted a portrait of Lesueur. Perhaps Lesueur named this species after these three members of the Peale family, collectively.

NEURAL ORGANIZATION OF PREDATORY BEHAVIOR IN *Pleurobranchaea californica*.

GILLETTE, R., Department of Physiology & Biophysics, University of Illinois, Urbana, IL 61801

Predatory feeding and avoidance behaviors are integrated by motivational state and learned recognition of dangerous prey in the opisthobranch *Pleurobranchaea californica*. Locomotion, orienting, and sensory avoidance are regulated by the functional state of the neural network of feeding behavior. Skin secretion of sulfuric acid in response to noxious stimuli both repels other predators and potentiates *Pleurobranchaea's* own avoidance behavior via nociceptive paths. The mechanisms of food-avoidance learning, and feeding and avoidance behaviors indicate a simplest connectionist scheme for integration of complex behavior. Briefly, weaker food stimuli simultaneously stimulate systems driving locomotion, orienting, and aversive turns. Stronger stimuli excite feeding. The feeding network has essentially two excited states: (I) oscillatory, driving feeding or rejection movements, and (II) non-oscillatory, in which it is locked in a phase of proboscis retraction. State I suppresses locomotion and aversive sensory paths, while state II inhibits orienting pathways and releases locomotion. State transitions are coregulated by motivation and learning.

GIANT AXON UTILIZATION IN ESCAPE RESPONSES.

GILLY, Wm. F., Hopkins Marine Station, Stanford University, Pacific Grove CA.

Behavioral and neurophysiological studies of escape responses were carried out in free-swimming and restrained *Loligo opalescens*, respectively. A sudden visual stimulus (light flash) triggers an all-or-none, high pressure jet. This has a short latency (50-75 ms), is driven by a single spike in the giant axons, and resists habituation in schooling animals. Electrical, chemical, and vibrational stimuli produce a more readily habituating, delayed-escape response (>200 ms latency) with variable-amplitude jets, each mediated by a burst of small axon activity lasting 50-60 ms. Mantle pressures attained by non-giant axons acting alone can be as large as those generated in flash-stimulated responses. During a cycle of delayed-escape jetting, the giant axons may also fire, always at the end of the small axon discharge, and thereby boost the escape response. Interplay between giant and non-giant motor pathways thus enhances behavioral flexibility.

Escape responses develop in embryonic squid before giant axons can be identified morphologically. As the giants grow, escape performance improves markedly and peaks before hatching. Electrical stimuli elicit short latency responses (<50 ms) throughout development, but these show a pattern in which giant axon firing precedes non-giant activity. Flash stimuli elicit responses with delays from as high as 80 ms in late stage embryos (driven only by small axons) to as low as 10 ms in hatchlings (driven by giant axons). Hatchlings, unlike adults, thus employ the giant axons strictly in the production of fast-start responses.

DIEL PERIODICITY OF DEPTH PREFERENCE BY *ELIMIA LAQUEATA* (GASTROPODA: PLEUROCERIDAE).

GORDON, Mark E., Tennessee Cooperative Fishery Research Unit, Tennessee Technological University, Cookeville TN 38505, and THEYEL, Tina M., Honolulu HI.

Depth preference was determined for a pleurocerid snail (*Elimia laqueata*) within a 113 cm vertical gradient over a 24 hr period. In replicate trials, an initial negative geotactic response was observed but snail movements tended to be highly vagile. An overall mean preferred depth of 88.1 cm was recorded, but hourly means followed an oscillating pattern indicative of circadian rhythm. Minimum mean depths were observed near noon with maximum mean depth occurring 12 hrs later. Oscillating amplitude equaled approximately half of the depth gradient. Diel migratory patterns are hypothesized to be a mechanism to optimize trophic/energy relationships. Previous assertions pertaining to the ecological importance of depth in pleurocerid dispersal appear to have been misinterpreted.

EGG-SPECIFIC PROTEIN IN *APLYSIA*: PRIMARY STRUCTURE OF AN NADASE.

GLICK, David L.¹, HELLMICH, Mark R.¹, TEMPST, Paul² and STRUMWASSER, Felix¹. 1) Marine Biological Laboratory, Woods Hole, MA 02543. 2) Dept. of Genetics, Harvard University School of Medicine, 25 Shattuck street, Boston, MA 02115.

The gene coding for an egg-specific NADase has been cloned and sequenced from an *Aplysia ovotestis* cDNA library, produced by standard methods. The library was screened using mixed oligonucleotide probes constructed from internal amino acid (a.a.) sequence of the purified NADase. The mixed oligonucleotide probe identified 3 inserts. The largest insert (1225 b.p.) was prepared for sequencing by either subcloning into bacteriophage M13 or a plasmid vector. Nested deletions of the DNA insert were produced using Exonuclease III/mung bean nuclease deletion kit (Stratagene). Sequence was determined in both the 3'-5' and 5'-3' direction using the Sanger dideoxy-mediated chain-termination reaction. The gene codes for a protein 282 a.a. residues long. Currently, 61% of the derived a.a. structure has been verified by direct sequencing of the purified NADase. The N-terminus contains a hydrophobic signal sequence of 24 residues, the first residue of the native protein is an isoleucine and the carboxy-residue is alanine. The native protein also contains 10 cysteines and hydropathicity analysis indicates that it is predominantly hydrophilic. Searches of protein sequence data bases have not revealed significant similarity to other proteins.

THE FOOD OF *LOLIGO GAHI* (MOLLUSCA: CEPHALOPODA).

GUERRA, A., CASTRO, B.G., Instituto de Investigaciones Marinas, Eduardo Cabello 6, Vigo 36208 Spain and NIXON, M., 60 Norfolk Road, New Barnet, Hertfordshire EN5 5LT, England

The stomach contents of 13 specimens (7 males and 6 females) of the squid *Loligo gahi* Orbigny, 1835 from the Falkland Islands, randomly taken from a total sample of 128, were examined. The size of animals in the whole sample ranged from 190 to 125 mm dorsal mantle length; the sample was composed of males and females near spawning condition, with similar stomach fullness and stages of digestion. The food material belonged to a single euphausiid species, which was not identified. The remains in the stomachs were in fragments and showed some maceration. The weight of the stomach contents was 3.07-7.78g (4.5-8.0% of the total body weight). Several stomachs contained many euphausiid eyes, the number ranging from 192 to a maximum of 488.

The results show that this species has a prey and a food intake similar to other loliginids and ommastrephids from temperate and boreal waters, that is, able to capture euphausiids in considerable numbers in 5 to 15 minutes. This feeding method must exert a considerable influence on krill populations, playing an important role in the trophic web of the ecosystem.

THE COASTAL CEPHALOPOD FAUNA OF SOUTHERN BRAZIL.
HAIMOVICI, Manuel and PEREZ, Jose A., Fundacao
Universidade do Rio Grande, Cx 474 Rio Grande
RS, 96200 Brazil

In the coastal waters between Rio de Janeiro (22°S) and Rio Grande do Sul (34°S) more than 30 species of cephalopods occur in different environments. Temperate benthic octopuses of low fecundity, bearing large eggs, are restricted to the cold bottom waters of the outer shelf and the slope. In contrast, species of tropical origin occupy the more diverse shallow water habitats, principally along the Rio de Janeiro coast. Tropical cosmopolitan octopuses with high fecundity, such as Scaeurus unicirrus and Octopus vulgaris, are found along the entire study area because the transport of pelagic juveniles is favored by the warm southward flowing superficial Brazil Current. All three families of epipelagic octopuses are found.

The neritic squid fauna includes only five myopsid species, four of them of tropical origin. At the upper slope Illex argentinus is dominant and several mesopelagic and bathypelagic oegopsids, widely distributed in tropical and temperate Atlantic waters, can also be found. The absence of endemic species indicates the transitional character of the fauna between the Caribbean and the Patagonian regions.

MULTIPLE ECOLOGICAL FUNCTIONS OF BURROWING AND BURYING BEHAVIOR IN BENTHIC CEPHALOPODS.

HANLON¹, Roger T., CIGLIANO², John and FORSYTHE¹, John W., ¹Marine Biomedical Institute, Univ. Texas Medical Branch, Galveston, TX 77550 and ²Department of Biology, Boston University, Boston, MA 02215.

Octopuses and cuttlefishes actually dig into the substrate either temporarily or for protracted periods. Burrowing involves careful excavation and longer residence, while burying is defined as immediate disappearance into the substrate for shorter but varying lengths of time. Burrowing behavior is performed only by octopuses and is used to construct homes, presumably when other natural lairs are not available; octopuses may also use this behavioral tactic to ambush prey. Burying behavior has different functions in octopuses versus sepioids (cuttlefishes, sepiolids, etc.). Some octopuses bury quickly into sand or mud for immediate predator avoidance. Sepioids will partially or completely bury (for hours) to conceal themselves from predators, but they will also prey upon suitable prey organisms that wander nearby. We review the literature to explain these ideas and we also present new field and laboratory observations on burrowing behavior in octopuses.

VARIATION IN SENSE ORGAN DESIGN AND RELATED SENSORY CAPABILITIES AMONG CLOSELY RELATED MOLLUSCS

HAMILTON, Paul V., Department of Biology, University of West Florida, Pensacola, FL 32514

Knowledge of the variation in structural and functional properties of an organ among representatives of a group is prerequisite to establishing accurate generalizations about the organ's role for the entire group. However, for many molluscan sense organs, generalizations have developed with minimal knowledge of variability across species. Comparison of the gross structure, optical properties and visual responses of benthic gastropods will be used as the major example of this situation. In these animals lens structures range from hard to soft, with concomitant differences in refractive index, and both structural and optical homogeneity. The degree of spherical aberration ranges from being uncorrected, to almost perfectly corrected. Key photoreceptor dimensions range through an order of magnitude and photoreceptor abundances range over three orders of magnitude. Behavioral responses range from simple taxis, to the ability to detect an object's orientation. Thus, the commonly used, yet basically undefined names for gastropod eyes, such as eyespot or ocellus, fail to recognize either the range of ocular variation or complexity present in the group. Minor emphasis will be given to other examples of inadequate data on sense organ variation, including comparison of the structure, functional properties and behaviors mediated by the rhinophores of opisthobranchs.

GROWTH OF THE PATAGONIAN SQUID, LOLIGO GAHI (D'ORBIGNY, 1835).

HATFIELD, Emma M.C., British Antarctic Survey, High Cross, Madingley Rd., Cambridge, CB3 0ET U.K.

Age and growth were estimated for the two spawning groups of the myopsid squid Loligo gahi (d'Orbigny, 1835) by examining the growth increments within the statoliths. Two sets of samples were used for the analysis. The first sample was collected from commercial fishing vessels around the Falkland Islands as part of the Falkland Island Fishery Observer Program, from March to October 1987, and the second set was taken from squid caught on the R/V WIECZNO as part of a commissioned survey around the Falkland Islands in August 1988. Length at age data were examined for males and females separately assuming that increments are formed daily. Growth rates were calculated for both sexes from both spawning groups. The maximum life-span of the males exceeds 1 year and is \leq 1 year in females.

FEDERAL FUNDING FOR BIODIVERSITY: PRESENT AND FUTURE OPPORTUNITIES FOR MALACOLOGISTS.

HOAGLAND, K. Elaine, Association of Systematics Collections, Washington, DC 20001

The importance of the study and protection of biodiversity has made an impression on federal policy-makers. Opportunities for malacologists to become involved in research to meet this national need are expanding. Legislation to create a national institute for biotic resources has been drafted as a part of an effort to create a national institutes of the environment. An effort to create an endowment program for faculty positions in systematics is underway. The National Science Foundation has released a report on biodiversity and is mapping a strategy to increase funding for systematics and museum collections as well as conservation biology. The Environmental Protection Agency and several conservation organizations and the World Bank are all interested in development of infrastructure in developing countries to deal with the biodiversity crisis --- museum resources and systematics research are important pieces of these programs. In the light of this national environment, opportunities for malacologists will be reviewed. In particular, we can expect greater attention to invertebrates and the marine environment from conservation groups and federal agencies than in the past.

EFFECTS OF A LOW-HEAD DAM REPLACEMENT ON A NAIAD MOLLUSK POPULATION (UNIONIDAE), STEEL DAM, ROCK RIVER, MILAN, IL, MAY 1988.

HAVLIK, Marian E., Malacological Consultants, La Crosse, WI, 54601.

L. higginsii salvage survey done for ILDOT, before/after cofferdam construction, prior to finish of replacement dam. Construction effects drastic & must be considered with future dams. Only 6 living naiades found in 968 m² cofferdam site, compared to 6 - 21/m² in the N channel, Sept. 1987. We determined how far population affected with 4 - 1/4 m² samples every 3 m, on 35 mm transects. None alive at 64, 96, 128 m W of Dam. At 160 m W live naiades found; at 224 m W transect densities 22/1/4 m². Divers recovered 38 sp.: 21 living (1141 specimens), 3 sp. fresh-dead, & 14 sp. sub-fossil shells (5349 specimens). O. olivaria resembled L. higginsii (9 sub-fossil valves). River record is 40 sp.; new records for sub-fossil P. capax, C. monodonta, E. crassidens; recent records for live T. verrucosa and A. l. carinata. Species diversity down 33%; no evidence of die-off. Reproduction in only a few sp., may be more apparent than real due to cobble substrata. Shallow, 1 km river area between Steel Dam/bridge needs sanctuary status. 3 large L. higginsii found during July 1988 low water (1 killed for bait, 1 stranded on gravel bar, 1 ret. to river).

INTERTIDAL HARVEST OF THE SMALL PATAGONIAN OCTOPUS, Octopus tehuelchus d'Orbigny.

IRIBARNE, Oscar O., School of Fisheries, WH-10 University of Washington, Seattle, WA 98195 USA

The "tehueche octopus", Octopus tehuelchus d'Orb., is a small benthic species distributed from Southern Brazil (38 S) to Northern Patagonia (43 -44 S), Argentina. This species reaches its highest densities in the intertidal and shallow subtidal areas of the San Matias Gulf, Argentina (41 and 42 S), where it supports a seasonal fishery. Catch and effort statistics together with biological data were collected over four fishing seasons (1982-1987). The results shows that fishermen operate in the intertidal zone principally during the summer, using either their hands or a 30-40 cm long hand-gaff. The seasonality of the fishery is determined by the octopus' life cycle; a single cohort is the target. Catch per fisherman oscillated in phase with the tidal cycle over the fishing season. Annual catch declined from 300 tons during the period 1965-1974, to less than 50 tons at present. Likely explanations are: (1) a decrease of fishing areas, and (2) a decrease of fishing efficiency. The alternation of years of good and bad catches is hypothesized to be a result of density-dependent interactions.

LENGTH/AGE/SEX OF FRESH-DEAD LAMPSILIS HIGGINSII (LEA, 1857) (UNIONIDAE), PRAIRIE DU CHIEN, WI, MISSISSIPPI RIVER, 1987.

HAVLIK, Marian E., Malacological Consultants, La Crosse, WI 54601.

Due to low water 316 203/2 L. higginsii were salvaged, 1987, Mississippi River, Prairie du Chien, WI. Specimens gave opportunity for age/length study. 137 cleaned paired fresh-dead, plus 8 live, were measured and aged. A few single valves increased the sample size. Results graphed for age/length: 2 - 21 yrs., with most 4 - 13 yrs, 3 specimens were > 17 years, 63% females (F), 32% males (M), 5% juveniles (J), sexual dimorphism at 4 years. Preliminary analyses of all for age/length = R² 0.66. Sorting by sex, including data on 7 J with both sex groups, increased the R² to 0.67 (F) and 0.75 (M). Back-measuring done to give 10 for each age/sex group, 1 thru 11 years: R² was 0.70 on 256 data sets. Regression analyses on 137 F and 119 M increased R² to 0.72 (F), and decreased R² to 0.74 (M). Maximum age 25 years (Prairie du Chien) to 30 years (Rock River, IL). Demography of live populations not known. Previous sex ratio data were reversed, based on living/empty specimens collected from 1972 - 1986. This may suggest that F are stressed during low water. L. higginsii collected in 1988 are being analyzed separately, and combined with 1987 data.

ASPECTS OF THE BIOLOGY OF OCTOPUS FITCHI
IN THE GULF OF CALIFORNIA.

JACKINTELL, Lori A., Department of Biology, San Diego State University, San Diego, CA 92182 and LANG, Michael A., Office of the Assistant Secretary for Research, Smithsonian Institution, Washington DC 20560

A diagnosis of living characters in O. fitchi clearly reveals a golden ocellus and mantle white spots. The eyes are large and prominent, with several interocular cirri. There are 1-2 suckers conspicuously enlarged on each arm in both sexes. The general color of live specimens ranges from brick red to wood brown dorsally, with paler ventral and oral surfaces. O. fitchi is endemic to the upper Gulf of California to at least Bahia de Los Angeles. Water temperatures average 30-32°C in the summer and 10-12°C in winter. Mixed semidiurnal tides range through a maximum of 24 feet of vertical displacement. The low tides typically occur early in the morning and late in the evening throughout the year. San Felipe is characterized by an extensive sand/mud intertidal flat with interspersed rocky patches serving as suitable shelter. Berry (1953) correctly noted that O. fitchi characteristically affixed its eggs to the underside of intertidal rocks rather than in empty shells as does O. digueti. Recent observations have shown a marked increase in tidal flat gill netting that effectively removes all potential shelters for O. digueti, O. alecto and O. bimaculatus. The strong segregation of habitat that once existed now is less distinct. Conversely, O. fitchi never has been found in shells at this site, but, rather, always underneath rocks in the rocky patches or in the intertidal boulderfields. Two major factors influencing the densities of O. fitchi are rock size and the presence of other Octopus species.

AGE, GROWTH AND POPULATION DYNAMICS OF TROPICAL SQUIDS AND SEPIOLIDS, AS DETERMINED BY STATOLITH GROWTH RING ANALYSIS.

JACKSON, George D., Department of Marine Biology, James Cook University of North Queensland, Townsville 4811, Australia

Statolith growth ring validation involving tetracycline staining techniques has been used to demonstrate daily ring periodicity in the tropical squids Loliolus noctiluca, Loligo chinensis, Sepioteuthis lessoniana and the sepioid Idiosepius pygmaeus. Maximum ages encountered ranged from I. pygmaeus which completes its life cycle in less than 80 days to S. lessoniana in which the oldest individual aged was a female 184 mm DML, which was 188 days old. All individuals of L. noctiluca and L. chinensis (including sexually mature individuals) were less than 120 days old.

These data suggest that growth in tropical squids is much faster than what has been suggested from previous work, and that growth models based on other sources of information (such as length frequency data) probably are inappropriate for tropical squids. Further work into statolith growth ring validation and squid aging techniques is needed for both tropical and temperate species to ascertain the important biological parameters associated with squid growth.

MODULATION OF THE ELECTRORETINOGRAM BY THE CIRCADIAN PACEMAKER IN THE EYE OF APLYSIA. (GASTROPODA: TECTIBRANCHIA).

JACKLET, Jon W., Department Biology, SUNY-Albany, Albany, NY 12222.

An eye of Aplysia contains thousands of large specialized photoreceptor cells and a small population of pacemaker neurons whose activity appears in the optic nerve (ON) as a synchronized compound action potential (CAP). The CAP frequency exhibits a circadian rhythm, and is required for the circadian locomotor rhythm. Highest CAP frequency occurs during projected day. Simultaneous recordings of the electroretinogram (ERG) and ON CAP activity from an isolated eye in darkness in this study show that the ERG is depressed by CAP activity when the CAP frequency increases dramatically at projected dawn. This results in an antiphase relationship between the CAP frequency rhythm and the ERG amplitude. The effect diminishes with repeated circadian cycles suggesting that the causative agent is depleted in vitro. From other studies the putative efferent transmitter 5-HT and ON stimulation are known to increase the ERG, the opposite effect of CAP activity. These results suggest that CAP activity generated by the pacemakers neurons releases a factor at the eye level that modulates the ERG produced by the photoreceptors.

DISTRIBUTION AND REPRODUCTIVE BIOLOGY OF THE SQUID ILLEX COINDETII (MOLLUSCA, CEPHALOPODA) IN THE SICILIAN CHANNEL.

JEREB, P. and RAGONESE, S., Istituto di Tecnologia della Pesca e del Pescato, Via Luigi Vaccara 61, Mazara del Vallo 91026, Italy

Geographical distribution and biological characteristics of the broadtail squid, Illex coindetii (Verany, 1839), population in the Sicilian Channel are determined from eight seasonal trawl surveys. Illex coindetii is the most abundant cephalopod species and is found year-round throughout the area, mostly between 50 and 600 meters. Analysis of gonad/body weight ratio and information obtained using an "ad hoc elaborated" macroscopic, maturity scale are used to identify spawning time and areas.

ON THE ASSOCIATION OF THE SQUID ILLEX COINDETII
(MOLLUSCA, CEPHALOPODA) WITH TARGET SPECIES
TRAWLED IN THE SICILIAN CHANNEL.

JEREB, P. and RAGONESE, S., Istituto de
Tecnologia della Pesca e del Pescato, Via Luigi
Vaccara 61, Mazara del Vallo 91026, Italy
Illex coindetii (Verany, 1839) was the most abundant cephalopod species captured during two years of seasonal trawl surveys carried out in the Sicilian Channel. Relative abundances (calculated as number captured per hour) were derived for each species in the catch. Data collected were analyzed by cluster analysis to determine the association of Illex coindetii (considered a by-catch species along the southern Sicilian coast) with other commercially important target species, such as Merluccius merluccius, Mullus surmuletus, Mullus barbatus, Aristaeomorpha foliacea, Nephrops norvegicus and Parapenaeus longirostris. Associations also were calculated for I. coindetii with other species of cephalopods (a commercial category generally considered of "secondary importance"), such as Eledone cirrhosa, Eledone moschata and Todaropsis eblanae.

THE ENIGMA OF APLYSIA RESPIRATORY PUMPING

KANZ, James E, QUAST, William D., GRECH, Doreen M., BANNEEL, Natalie, TIGERT, Susan J., Dept. of Marine Biology, Texas A&M University-Galveston, Galveston, Tx 77553. The stereotyped behavioral response in Aplysia known as respiratory pumping (RP) consists of a 5-10 sec coordinated contraction of the parapodia and mantle organs and originates from two cellular networks in the abdominal ganglion. Each RP contraction turns over seawater bathing the gill; and ambient hypoxia/anoxia increase RP, accounting for its ascribed respiratory function.

However, recent studies question the simple ventilatory role assigned to RP and suggest that RP is a complex multi-functional behavioral-physiological response. For example, Susswein and coworkers found no positive correlation between O₂ consumption and RP rate. And, Kanz and Quast reported the discovery of forms of spontaneous RP other than the single, randomly-occurring contractions previously known, including a stereotyped, patterned sequence of RP responses termed an "RP seizure". Seizures occurred under ambient normoxia, less frequently in hypoxic seawater, but more frequently than normoxic rates upon reoxygenation of the medium.

Here we show that the cannulated introduction of such anerobic end-products as succinate and lactate into whole, unrestrained Aplysia can trigger RP, but that in vivo, circulating concentrations of lactate are not significantly correlated with RP activity. We also show the in vivo modulatory influence on RP of neuronal vs. hemolymph-derived input to the abdominal ganglion, including results suggesting that hemolymph-borne factor(s) generate RP seizures.

Thus, it seems inappropriate to categorize RP as "merely" a ventilatory mechanism.

MALACOLOGICAL JOURNALS AND NEWSLETTERS,
1773 - 1990.

KABAT, Alan R., Museum of Comparative Zoology, Harvard Univ., Cambridge MA 02138; and BIELER, Rüdiger, Delaware Museum of Natural History, P.O. Box 3937, Wilmington, DE 19807.

We have compiled full bibliographic references to over 250 malacological journals and newsletters. Of these serials, about 130 are still published. 25 percent of current malacological publications appear in these journals devoted solely to the study of mollusks. The geographical distribution (31 countries) and the usage of molluscan journals are analyzed in terms of the broader context of scientific serials.

Several other interesting historical and statistical issues are covered. Problems of taxonomic statements (including the description of new taxa) in newsletters and of access to rarer serials (as well as the fragile paper of older publications) are addressed; the future implications will be discussed.

MAGNETIC FIELDS, OPIOID SYSTEMS AND DAY-NIGHT RHYTHMS OF NOCICEPTION IN THE LAND SNAIL, CEPAEA NEMORALIS.

KAVALIERS, M., OSSENKOPP, K.-P., TYSDALE, D. and LIPA, S., Div. Oral Biology, Univ. Western Ontario, London, Canada.

There is accumulating evidence that magnetic stimuli can affect fundamental endogenous opioid mediated behavioral and physiological processes. The ability to detect and respond to aversive environmental stimuli is a basic characteristic of animals that is embodied in the term nociception. There is substantial evidence that opioid peptides are involved in the modulation of nociception and behavioral responses to aversive and stressful (danger-associated) stimuli in molluscs. Endogenous opioid systems and exogenous opiates have been implicated in the modulation of the thermal avoidance behaviors ('nociceptive' responses) and thermal behaviors of the land snail, Cepaea nemoralis. The latency of response of Cepaea to an aversive thermal surface is enhanced by morphine and various opioid peptides in a manner analogous to the expression of analgesia in mammals. Brief (15 min) exposure to low intensity 60-Hz magnetic stimuli have been observed to have inhibitory effects on these opioid-mediated analgesic responses of Cepaea. Further, there are day-night rhythms in opioid modulation of the thermal nociceptive and analgesic behaviors of Cepaea, as well as in the inhibitory effects of exposure to 60-Hz magnetic fields, with the behavioral responses during the twilight transitions being particularly sensitive to the magnetic stimuli.

These observations with Cepaea indicate that endogenous opioid systems are: (i) important modulators of day-night rhythms of nociception and analgesia and (ii) are sensitive to low intensity 60-Hz magnetic fields.

BIOCHEMICAL COMPARISON OF FAST-CONTRACTING TENTACLE AND SLOW-CONTRACTING ARM MUSCLE OF SQUID.

KIER, William M., Dept. of Biology, Univ. of North Carolina, Chapel Hill, NC 27599 and SCHACHAT, Frederick H., Dept. of Cell Biology, Duke Univ. Medical Center, Durham, NC 27710

The protein composition of myofilament extracts of transverse muscles of tentacles and arms of *Sepioteuthis lessoniana* was compared using sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) and immunochemistry. Previous research showed that transverse muscle of tentacles causes extremely rapid (15-30 msec) tentacular extension during prey capture, whereas transverse muscle mass of the arms creates the slower bending movements. The ultrastructure of transverse muscle of tentacles reflects its specialization for rapid contraction; the muscle fibers are cross-striated with unusually short thick filaments (0.5-0.8 μm) and sarcomeres (0.9-1.4 μm) and thus differ from the obliquely striated muscle fibers of the arms with long thick filaments and sarcomeres. The protein composition of myofilament extracts of the two muscle types is nevertheless remarkably similar and suggests that specialization for fast contraction occurred through a change in organization, rather than composition, of the myofilaments. We have concentrated our analysis, therefore, on proteins that organize the myofilament lattice such as paramyosin and α -actinin. Our results suggest that paramyosin is less abundant in the cross-striated muscle cells.

RIBOSOMAL RNA SEQUENCE ANALYSIS OF SELECTED CEPHALOPODS.

KUNCIO, Gerald S., and HANLON*, Roger T., University of Pennsylvania, Philadelphia, PA 19104, and *University of Texas, Galveston, TX 77550

A rapid and sensitive direct RNA sequencing protocol was applied to investigate the sequence divergence among several cephalopod taxa. Total RNA isolated from frozen specimens was sequenced using primers complementary to regions near the 5'-terminus and flanking three sequence divergent domains of the large ribosomal RNA (LrRNA): D1, D6, and D7. Nearly 500 nucleotide sites were analyzed for specimens of *Nautilus pompilius*, *Sepia officinalis*, *Loligo opalescens*, and *Octopus maya*.

Results from the comparative sequence analysis do not differ from phylogenetic results obtained from more traditional morphological characters and demonstrate the utility of this approach for distinguishing cephalopods at the ordinal level.

In addition, data were obtained for the D6 variable domain of *Loligo forbesi*, *Loligo pealei*, *Loligo plei*, *Lolliguncula*, *Loliolus uyii*, *Todarodes pacificus*, and *Uroteuthis edulis* LrRNAs. While few nucleotide differences were noted, data indicate that it is possible to distinguish these organisms at the generic level as well. Specific and subspecific discrimination, although not shown here, should be feasible as more regions are sequenced. The rapidity with which RNAs from a large number of samples can be comparatively analyzed should prove valuable in the establishment of critical cephalopod phylogenies.

ON THE SYSTEMATIC POSITION OF THE GENUS *NUCELLA* (PROSOBRANCHIA: MURICIDAE: TROPHONINAE).

KOOL, Silvard P., Mollusk Department, Museum of Comparative Zoology, Harvard University, Cambridge, MA, 02138
The muricid genus *Nucella* has been traditionally placed in the Thaidinae. Comparative anatomical investigations of the type species of *Nucella* (*N. lapillus*) and of members of the Thaidinae have revealed that this placement is incorrect.

This study tests for phylogenetic affinities among *Nucella* and the type species of two other subfamilies in the Muricidae: *Ocenebra erinacea* (Ocenebriinae) and *Trophon geversianus* (Trophoninae). Results indicate that *Nucella* is closely related to *Trophon*, although it also shares many characters with *Ocenebra*. Based on detailed studies of the soft anatomy, radula, protoconch, shell ultrastructure and operculum, the genus *Nucella* is placed in Trophoninae.

HYPERCALCEMIA, PROTEINEMIA AND THE TRANSUTERINE TRANSPORT OF CALCIUM IN A LAND SNAIL

KUNIGELIS, Stan C., Department of Zoology, Duke University, Durham NC 27713

Specimens of *Helix aspersa* were reared under constant environmental conditions. Experimental animals were selected for developmental maturity by the presence of a reflected shell lip. Hemolymph was collected by severing an optic tentacle of animals anesthetized by the injection of succinylcholine chloride into the mantle collar. Measurements were made of ionic and total calcium, as well as total hemolymph protein. Ovipositing animals were found to exhibit both hypercalcemia and proteinemia relative to non-egg-laying snails.

Calcium movement across the wall of the ovotestis *in vitro* was measured using radiolabelled calcium. Unidirectional flux studies indicate a greater influx of calcium for egg-laying animals than for non-egg-laying animals. In non-egg-laying animals, the rate of calcium movement towards the lumen of the ovotestis increased with increasing diffusion gradients, but remained constant in an opposing calcium concentration gradient. Calcium influx was reduced in the presence of quinidine, suggesting that an active transport mechanism(s) may be involved in the movement of calcium across the uterine wall.

STUDIES OF THE APPETITIVE PHASE OF FEEDING BEHAVIOR OF APLYSIA.

KUPFERMANN, Irving, TEYKE, Thomas, ROSEN, Steven C., HOOPER, Scott, and WEISS, Klaudiusz R. Cntr for Neurobiol. and Behav., Columbia Univ., New York, N.Y. 10032, and Dept. of Physiol. & Biophysics, Fischberg Research Cntr in Neurobiol., Mount Sinai School of Medicine, New York, N.Y. 10029

The appetitive phase of feeding behavior in Aplysia is elicited by chemical stimuli, and consists of 1) initial locomotion, followed by head lifting and assumption of a "feeding" posture; 2) movement of the head toward a contact chemical stimulus. In addition, the animals show characteristic changes of cardiovascular responses, and suppression of withdrawal behaviors. The appetitive behaviors are inhibited by afferent information from the gut. Many aspects of the appetitive behaviors may be controlled by the activity of a cerebral neuron termed CPR (Cerebral-Pedal Regulator). Firing of CPR affects the activity of numerous neurons involved in different aspects of appetitive behaviors. It inhibits neurons involved in withdrawal; it excites neurons that appear to lift the head, as well as neurons controlling the cardiovascular system, and command elements (e.g., CBI-2) that drive consummatory biting responses. It also excites the MCC, which modulates biting. The evidence indicates that modulatory systems for feeding are hierarchically organized, i.e., specific neurons modulate progressively more inclusive aspects of the totality of feeding behavior.

SEROTONIN ANALOG SELECTIVELY ABATES HERMISSENDA FEEDING BEHAVIOR.

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

As a corollary to a histochemical study to identify and visualize several neurotransmitter substances in the central nervous system of Hermisenda, the serotonergic analog, 5,7-dihydroxytryptamine (5,7-DHT) was found to inhibit feeding. Animals exposed to ascorbate buffered artificial seawater (ASC/ASW) and 6-hydroxydopamine (6-OHDA) retained their normal feeding intake. The effects of a single exposure to the toxic analog lasted 2-3 days, after which the animals slowly resumed feeding.

The experimental protocol involved injecting either toxin (50 μ L at 10mM) in 1% ASC/ASW or ASC/ASW alone into the animal's foot, placing them in beakers to allow the injection site to close and remove any exuded chemical, and then placing each animal in running seawater in separate sieve cages with a piece of Ciona intestinalis (digestive system) as food. Cages were checked daily for amount of food eaten and fresh food was resupplied; the amount small enough to be consumed within 24 hours.

Serotonin and its regulation of feeding behavior is well documented for the leech and also via the metacerebral giant cell (MCG), for several other subclasses of gastropod molluscs. Selective abatement of a specific behavior from an animal's repertoire is an important neurobiological tool for assisting in dissecting out the various integrated neural systems governing that animal's overall behavioral pattern.

OVERABUNDANCE OF FOOD STUNTS LARVAL GROWTH.

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

Hermisenda crassicornis has been used as a biomedical research model for neurobiological studies of associative learning for many years and recently, with other molluscan species, to study strontium's role in the initiation of embryonic calcification. To provide a constant supply of healthy research animals with known developmental backgrounds and behavioral experiences, an effort has been undertaken to establish Hermisenda in laboratory culture. One parameter that needed to be established was the optimal larval food concentration of microalgae.

Newly hatched larvae were put into culture using roller culture methods with the following microalgal food concentrations: 5, 10, 15, 20, 30 $\times 10^6$ cells/L. At intervals, the larval cultures were changed, fresh microalgae added and representative larvae sampled and shells measured. The data indicated an optimal food concentration of 15 $\times 10^6$ cells/L. Cultures with lesser concentrations of algae had smaller shells and showed signs of starvation. The highest concentration of 30 $\times 10^6$ cells/L, although initially yielding good growth, eventually produce cultures with smaller larvae. This is due to a decreased feeding efficiency from ineffective particle capture coupled with fouling of the particle sorting mechanism of the oral cilia.

FEEDING AND INTERSPECIFIC BEHAVIORAL INTERACTIONS OF NUDIBRANCHS INHABITING COLONIES OF OBELIA GENICULATA.

LAMBERT, Walter J., Department of Zoology, University of New Hampshire, Durham, NH 03824

Feeding mechanisms and behavioral interactions between 4 species of nudibranchs (Dendronotus frondosus, Doto coronata, Eubranchus exiguus, Tergipes tergipes) were studied to determine if interference governs the feeding locations within a hydroid colony. Two feeding mechanisms are utilized by D. frondosus: small individuals (<5 mm) are suctorial feeders while larger animals (>5 mm) are polyp biters. Doto and Eubranchus are suctorial feeders. Doto feeds by penetrating stolons while Eubranchus pierces hydrothecae and removes polyps. Tergipes rasps naked tissue from exposed polyps.

The initial behaviors displayed by individuals of each species were similar when approaching another nudibranch. Nudibranchs initiated contact by touching with rhinophores or tasting. These encounters were brief and the response of any nudibranch to contact varied but both aggressor and recipient generally reacted non-aggressively. Encounters occurred most frequently while one nudibranch was crawling across the kelp surface; meetings between any two nudibranchs on a hydrocaulus were infrequent. It appears that interspecific interactions between nudibranchs do not dictate where a nudibranch feeds within a hydroid colony.

POPULATION DYNAMICS AND LIFE HISTORY OF OCTOPUS BIMACULOIDES.

LANG, Michael A., Office of the Assistant Secretary for Research, Smithsonian Institution, Washington, DC 20560.

Agua Hedionda lagoon in Carlsbad, California, is a shallow water coastal lagoon, supporting an unusually high density of Octopus bimaculoides. The sampling design consisted of a total of 600 octopus traps in two replicate grids, each covering an area of 550m² and placed 100m apart. O. bimaculoides were sampled monthly, and marked and released with a numbered fingerling tag affixed to the inside of the mantle cavity. On average, 35 octopuses were trapped per monthly sample. Movement within and through the grids was considerable, resulting in a steady immigration and emigration of octopuses, indicative of a fairly mobile population. The sex ratio of octopuses was equal. O. bimaculoides is a large-egged species with benthonic hatchlings of approximately 70mg and a dorsal mantle length of 7mm. Reproduction and brooding of octopuses were observed on a year-round basis. Maturation and spawning events in O. bimaculoides suggested a life span of less than one year. The major prey item of juveniles and adults was the speckled bay scallop Argopecten circularis, occurring in maximum densities up to 600/m². O. bimaculatus, a sibling species, has a planktonic early life history trait, providing the mechanism by which they can be flushed into or out of the lagoon, making it highly unlikely that they could remain in the lagoon from hatching until settlement. The exploitation of an optimum habitat and prey resource is favored by O. bimaculoides, with a narrow dispersal range and benthonic hatchlings.

CHEMOTAXIS BY OCTOPUS MAYA IN A Y-MAZE.

LEE, Phillip G., JOHNSON, Keith A. and HANLON, Roger T., Marine Biomedical Institute, UTMB, Galveston, TX 77550
The behavioral responses of O. maya (N=20) to chemicals introduced at a distance (teloreception) were measured in a y-maze. The trials (254) were conducted in a 46 L y-maze system with the chemicals entering only one arm of the y-maze. The octopuses (starved 24 hr) were placed initially in the base near the convergence of the arms and allowed to acclimate to the y-maze (10 min). The chemical was added and octopus movements (15 min) were recorded on videotape. The video records provided information on the arm first penetrated, the sequence of the penetrations, the number of penetrations into each arm, the duration of time spent in each arm and the mean time spent in each arm per penetration. Eight chemicals (ATP, AMP, alanine, betaine, glutamic acid, glycine, proline and taurine), two crude extracts (crab and shrimp) and the control (no chemical) were introduced at random to only one arm of the y-maze. The final concentration of the chemicals was 10⁻⁴ M except for ATP 10⁻⁵ M and AMP 10⁻⁵ M, while the crude extracts were prepared by homogenizing crab or shrimp tissue to a final concentration of 5 X 10⁻⁵ g/L. The results confirmed that there was a significant difference between the octopuses' response to different chemicals. When presented with proline and ATP, the octopuses most often penetrated the arm with the chemical first. Both the chemical and individual differences between octopuses each accounted for a significant amount of the difference in the number of penetrations per arm and the total duration spent in each arm. No significant relationship was demonstrated between chemical and the sequence of penetrations. Both the control (no chemical) and chemically exposed octopuses were very active while in the y-maze, penetrating each arm multiple times. It is apparent that the most significant effect of the chemical was in the first exposure (first penetration) and that the octopuses probably habituated to the presence of the chemical.

MARICULTURE OF SQUIDS.

LEE, Phillip G., HANLON, Roger T., TURK, Philip E., FORSYTHE, John W. and FISHER, William S., Marine Biomedical Institute, Univ. Texas Medical Branch, Galveston, TX 77550 USA.

Sepioteuthis lessoniana and Sepia officinalis have been cultured in the laboratory in closed recirculating systems repeatedly over the past 2 years. The squids grew exponentially during the first 60 days with a maximal instantaneous growth rate of 13.4% of body weight/d for S. lessoniana and 7.6% of body weight/d for S. officinalis. The mean instantaneous growth rates from hatching to full adult size were 7.2% (200 d) and 3-4% of body weight/d (300 d), respectively. Hatchling mortality has been improved to <40% for S. lessoniana and <10% for S. officinalis but the rate of hatching continues to be variable for S. lessoniana, 0-76%. Laboratory reproduction has been successful and F₃ and F₅ generations have been produced for S. lessoniana and S. officinalis, respectively. Both squids have been resistant to disease at high densities (>5 squid/m³). Water quality was maintained at high standards: <0.1 mg/L NH₄-N, <0.07 mg/L NO₂-N and >8.0 pH. NO₃-N levels above 80 mg/L were correlated with increased irritability and inking in both species and high mortality in S. lessoniana. The squids were cultured in systems ranging from 3,500 L to 55,000 L and at bioloads exceeding 2.5 kg/m³.

THE GROWTH OF SEPIA OFFICINALIS LINNE, 1758 IN SOUTHERN BRITTANY AND THE NORTHERN BAY OF BISCAY (FRANCE).

LE GOFF, Ronan, Station de Biologie Marine, Ile Bailleron, 56 860 Sene, France

In order to define the growth of the cuttlefish Sepia officinalis in southern Brittany and in the northern Bay of Biscay, three different surveys were carried out: the sizes of individuals caught by professional fishermen were examined during the whole migratory cycle, and breeding adults and juveniles belonging to the zero age group were collected in the main spawning places of the study area. A study of the effects of different factors was conducted by rearing cuttlefishes in the laboratory of the marine biology station of the island of Bailleron.

This enables us to define the annual migration cycle of Sepia officinalis and especially the different growth stages of the individuals belonging to the zero, first and second age groups. Furthermore, the size distribution of the catches during the breeding period seems to show that their maturation varies from one year to the next, affecting the population dynamics of the species.

SEXUAL CONFLICT AND THE MATING SYSTEM OF NAVANAX INERMIS (CEPHALASPIDEA).

LEONARD, Janet L., Dept. of Zoology, University of Oklahoma, Norman, and Hatfield Marine Science Center, Newport, Oregon 97365.

Navanax is a simultaneous hermaphrodite with unilateral copulation. In Navanax normal mating behavior involves the active alternation of sexual roles over a bout of copulations. Sexual conflict theory predicts that hermaphrodites should have a species-specific preferred sexual role. Traditional models based on Bateman's principle predict that the male role will be preferred. Observational data suggest that in Navanax the female role is preferred and the mating system is based on sperm-trading, which serves to enforce reciprocation, preventing individuals from specializing in the female sexual role. The hypothesis that the female role is preferred in Navanax, was tested using interactions between three individuals to identify cases in which an individual had a choice of sexual role. Experimental and observational evidence indicate that the female role is preferred, contrary to predictions from Bateman's principle.

Comparison of Navanax to other hermaphrodites suggests that the preferred sexual role is that which offers control of fertilization. If this is true, then the gamete-trading model predicts that all hermaphroditic gastropods with sperm storage and a gametolytic gland should demonstrate a preference for the female role and a mating system based on sperm-trading. This model and the Hermaphrodite's Dilemma model of strategies in a situation of sexual conflict make specific predictions about the behavior of hermaphroditic gastropods. Comparative studies are needed to test these predictions.

THE BURROWING MECHANISM OF CADULUS ABERRANS (SCAPHOPODA: GADILIDA)

LEVITT, Jenifer L., Moss Landing Marine Labs, Moss Landing, CA 95039

Scaphopod burrowing, described only for species of Dentalium, is characterized as slow and shallow. These species have large, heavy shells which they drag obliquely into the sediment with a small foot. In contrast, scaphopods in the order Gadilida have small, smooth shells and a large flexible foot. Recent observations of deep burrowing, up to 46 cm into the substrate, by the gadilid Cadulus aberrans, *in situ* and *in vitro*, suggest a different burrowing mechanism. This was investigated by watching foot movement in a fingerdish and burrowing in an ant farm. The foot emerges through the ventral aperture then elongates by eversion, analogous to the proboscis of nemerteans or priapulids. The foot is twisted as it inserts into the sediment. Hemocoelic fluid pumped into the foot causes it to straighten when fully everted. This pulls the shell into an erect position, perpendicular to the sediment surface. Often, the shell spins around in order to straighten out the foot. This cork screw motion allows deeper penetration of the foot and initial penetration of the shell. Complete foot extension is also accompanied by flaring of the terminal disc; this disc acts as an umbrella anchor. As the foot is longer than the shell, contraction of four longitudinal foot muscles results in complete burial in one burrowing cycle, with a duration of one second. Penetration is nearly perpendicular to the sediment surface. Rapid, complete burrowing appears to be an effective escape response to epibenthic predators.

THE APLYSIA GILL-WITHDRAWAL REFLEX REVISITED: ASSESSING THE ROLE OF IDENTIFIED MOTOR NEURONS

LEONARD, Janet L., Dept. of Zoology, University of Oklahoma, Norman, and Hatfield Marine Science Center, Newport, Oregon 97365; MARTINEZ-PADRON, Manuel; EDSTROM, John P. and LUKOWIAK, Ken, Dept. of Medical Physiology, University of Calgary, Calgary, Alberta Canada.

The response of the gill of Aplysia to tactile stimuli delivered to the siphon, the "gill-withdrawal reflex" (GWR), has been an important model system for studies of the cellular mechanisms of learning. Recently, we have learned that a number of qualitatively distinct movements occur in this context. Since all of these movements can occur in the absence of the abdominal ganglion (PVG), the identified neural pathways which have their somata in the PVG, are clearly not necessary for the GWR.

In an effort to identify a more adequate description of the role of the 6 identified PVG gill motor neurons (L7, LDG1, LDG2, 2 L9s, and RDG) in gill responses we performed experiments involving hyper- and depolarization of these motor neurons individually and in pairs during evoked gill movements. The initial results of these tests demonstrate that these neurons are not part of the circuit involved in evoked gill behaviors in the suppressed behavioral state. Except in cases of suppressed preparations where gill motor neuron activity is unrelated to the GWR, the effect of altering activity is highly unpredictable. Our observations demonstrate that for example, the effect on the amplitude of the GWR due to hyperpolarization of a single motor neuron, LDG1, varies from 0-100%. Therefore, activity in motor neurons is not a good predictor of gill behavior.

MATING BEHAVIOR IN THE NUDIBRANCH Hermisenda crassicornis (ESCHSCHOLTZ).

LONGLEY, R. D. and LONGLEY, A. J., Pacific Sciences Institute, P. O. Box 835, Friday Harbor, WA 98250 and Friday Harbor Labs, 620 University Road, Friday Harbor, WA 98250

Mating behavior in nudibranchs is remarkably similar except for duration. In some species copulation time is measured in hours, while in others such as Aeolidia papillosa, copulation lasts for only a few minutes. In Hermisenda crassicornis, whose behavior is described here, copulation lasts for about five seconds.

We found in A. papillosa that mating frequency is greatly increased by handling, although the exact time of occurrence of the behavior cannot be predicted. The ability to increase the probability of this otherwise infrequent behavior with non-specific stimuli allows us to study the rapid copulatory behavior in H. crassicornis cinematographically at 40 frames/sec. Rapid body movements in H. crassicornis are possible because the anterior part of the animals is reared above the substratum. Penis eversion is synchronized in a mating pair within about 25 msec. Initiation of movement of the penial sac to extend the penis is coordinated with right turning of the animals. Body movements were examined for 0.5 sec prior to movement in the penial sac but cues that might signal the beginning of copulation were not found.

A NEW SPECIES OF ELEDONE (MOLLUSCA: CEPHALOPODA) FROM AUSTRALIA.

LU, C.C. and STRANKS, T.N., Dept. Invertebrate Zoology, Museum of Victoria, 285-321 Russell St., Melbourne, Victoria 3000, Australia

A new species of Eledone (Cephalopoda: Octopodidae) is described and illustrated from Australian waters. It is the first record of the genus outside the Atlantic Ocean. The species can be easily distinguished from other members of the genus by characters that include: a broadly ovoid, dorso-ventrally compressed mantle, with a distinctive pattern of papillae on the dorsum, and a prominent ventro-lateral integumentary ridge; short arms, with unusual arm tip modifications on males; a medium-sized ligula (5-9% of third right arm length) and a large differentiated calamus; very large eggs (14-16 mm long); and 5 gill lamellae. The species lives on sand or mud bottom in offshore waters in depths from 110-120 m. The animal is medium-sized: males mature at approximately 30 mm mantle length and females attain ovarian maturity at a mantle length of about 60 mm. The development of the calamus on the hectocotylus, and the implication for definition of the genus Eledone, are discussed.

OCTOPUS SCHULTZEI HOYLE, 1910; A REDESCRIPTION AND SYSTEMATIC STATUS.

MANGOLD, Katharina M., CNRS, Laboratoire Arago, Université Pierre & Marie Curie, 66650 Banyuls-sur-mer, France and ROPER, Clyde F.E., Department of Invertebrate Zoology (Mollusks), Smithsonian Institution, Washington, DC 20560

We examined the holotype of Octopus schultzei Hoyle, 1910, borrowed from the Humboldt University Museum, Berlin in order to verify its taxonomic status. We discovered that the holotype, a male and the only specimen known, possessed unusual characters not referred to in the original description nor in subsequent reports. Most striking are the armtips, all of which, except the hectocotylus (right third arm), have a mass of long, closely packed papillae instead of suckers. The hectocotylus is very small and unusual in that it lacks a calamus, longitudinal depression, and cross-striations but instead possesses a spongy structure. These and other characters confirm the specific validity of O. schultzei and readily distinguish it from all other known species of Octopus sensu stricto. The systematic significance of these unusual characters is discussed in relation to possible generic placement.

DEFINING THE GENUS OCTOPUS: REDESCRIPTION OF OCTOPUS VULGARIS.

MANGOLD, Katharina, CNRS, Laboratoire Arago, Université Pierre & Marie Curie, 66650 Banyuls-sur-mer, France and HOCHBERG, F.G., Department of Invertebrate Zoology, Santa Barbara Museum of Natural History, Santa Barbara, CA 93105
Octopus vulgaris Cuvier, 1797, the type species of the genus, is redescribed based on adult males, females and hatchlings. Type specimens were not designated by Cuvier nor was a type locality indicated in the original description. Material identified by Cuvier or other early cephalopod workers such as Lamarck is not extant. A neotype of an adult male from the western Mediterranean (Banyuls-sur-mer, France) has been designated. Although Octopus vulgaris has been reported to be a cosmopolitan species in the literature, its distribution is redefined to conform to modern biogeographical boundaries.

Definition of the genus Octopus s.s. is amended based on characters observed in living animals. Characters observed in the skin of living O. vulgaris are briefly compared with those seen in non-Octopus species.

VISUAL MEMORY AND NAVIGATION IN JUVENILE OCTOPUS VULGARIS.

MATHER, Jennifer A., Psychology Department, University of Lethbridge, Lethbridge, Alberta T1K 3M4 Canada.

Observations from laboratory and field suggest that the octopus navigates its way around its home range using memorized visual landmarks. Juvenile Octopus vulgaris foraged across relatively small home ranges (14 m in diameter), and did not return home by retracing their paths across the rocky landscape. Since they both initiated a foraging trip and returned the last 2 m to home by jet-propelled backwards movement and were more likely to jet out ($r=0.684$) and back ($r=0.54$) if they had gone further away, they likely stored home locations in memory. When displaced from their foraging path by attacks of territorial damselfish, octopuses returned home by the most direct route. When "deciding" whether or not to return to home to consume prey, octopuses were most strongly affected by distance to the home ($r=0.34$). They remembered "where they were" in the home range. In the laboratory, Octopus rubescens were trained to go to visual landmarks for food reward. They continued to orient to the landmark when it was moved relative to their position 90° at each daily trial. This combination of information suggests that the octopus learns the location of features of its home range, memorizes them, and uses them to guide its movement.

FORAGING STRATEGIES AND ENERGETICS OF OCTOPUS VULGARIS IN BERMUDA: TIME-MINIMIZING?

MATHER, Jennifer A., Psychology Department, University of Lethbridge, Alberta, Canada and O'DOR, Ron K., Biology Department, Dalhousie University, Halifax, Canada B3H 4J1

Observations of spacing, foraging behavior, time budgeting, and weight gain of juvenile Octopus vulgaris in Bermuda led us to suspect that they are time-minimizing their foraging effort in this situation. Octopuses did not restrict each other from their small (177 m sq) foraging areas, since half of the home ranges overlapped and no territorial behavior was seen. They foraged by using chemotactile exploration of areas likely to contain prey, using a win-switch pattern and moving to a new area after a week on average. They were probably attracted by the presence of the fragile-shelled bivalve Lima pellucida which lives in areas of high current flow; is the most common item in their diet and can be opened and eaten by an octopus in 5 minutes. Nevertheless, octopuses did not spend much time away from home, but limited their foraging (10%) and eating (11%) during the daytime. These octopuses gained weight comparable to those from other populations. This strategy appeared to produce an energy budget adequate for normal weight gain, suggesting that the animals foraged only until they attained a specific input, then rested at home for the remainder of the day, a time-minimizing strategy.

DIET VERSUS FEEDING MORPHOLOGY IN CEPHALASPIDEA (GASTROPODA, OPISTHOBANCHIA).

MIKKELSEN, Paula M., Harbor Branch Oceanographic Inst., 5600 Old Dixie Hwy, Ft. Pierce, FL 34946.

Phylogenetic relationships of the widely variant Cephalaspidea are unresolved because of the high probability of convergence or loss of traditional taxonomic characters. Non-shell "hard parts" (i.e., radula, gizzard plates) have played a dominant role in classification, but may have been modified by diet, masking phylogenetic information. This analysis reviews available data on diet versus feeding morphology in an attempt to identify characters for use in phylogenetic reconstruction.

Diet is known for only about 100 species.

Carnivores (e.g., Scaphander, Philine) usually have a bilobed rachidian and large hook-like laterals. However, polychaete specialists (e.g., Hydatina, Acteon) have radulae composed of minute, numerous, pulmonate-like teeth. Herbivores (e.g., Haminoea, Cylindrobulla) have taenioglossate-like radulae, with a rhomboidal rachidian and varying numbers of "laterals." Resemblance to other gastropods (e.g., Anaspidea, many Prosobranchia) suggests that this radular type is the more primitive. Omnivorous Bulla, the "typical" cephalaspidean, has a unique radular structure which must be treated separately.

Gizzard plates, when present, show two tendencies: (1) calcification (e.g., Scaphander, Philine), or (2) elaboration by sculpture (e.g., Haminoea, Runcina, Retusa). The latter may have evolved more than once in the Cephalaspidea.

Determination of correlation with diet must await analysis in combination with other characters, however, loss of features has probably occurred more than once. Absence of features should therefore be used with caution in cephalaspidean classification.

NEUROPHARMACOLOGY OF COLOUR CHANGE IN CEPHALOPODS.

MESSENGER, John B., Dept. of Animal & Plant Sciences, University of Sheffield, England.

Much is now known about the occurrence and distribution of putative neurotransmitters in the cephalopod brain. We have exploited this to test the effect of such substances on colour change by administering them in physiological doses to the blood supplying the brain of Octopus. Three classes of response can be elicited. Darkening, with dopamine, noradrenaline, octopamine or their agonists; and with L-glutamate or its (non-NMDA) agonists. Paling, with ACh or its (nicotinic) agonists; and with phentolamine or other mammalian alpha-blockers. Patterning (a bold mottle) with 5-HT. A model for the central action of chromatophore neurons is discussed.

New evidence is presented that in squids the excitatory transmitter at the nerve-muscle junction on the radial muscles of the chromatophores is L-glutamate. Topically applied glutamate or its non-NMDA agonists causes expansion of all colour classes of chromatophores, even in the presence of TTX or after denervation. Specific glutamate antagonists immobilise or retract previously expanded chromatophores. Antibodies raised to L-glutamate stain the nerves along the radial muscles in the same way as silver or methylene blue. Immunostaining with an antibody to 5-HT gives a similar picture suggesting that these two transmitters may be co-localised in the same nerves. The possible function of 5-HT is discussed in view of its undoubted physiological effect of causing the chromatophores to retract.

STATOCYST FLUID COMPOSITION AND ITS EFFECTS ON CALCIUM CARBONATE PRECIPITATION IN THE SQUID ALLOTEUTHIS SUBULATA: TOWARDS A MODEL FOR BIOMINERALIZATION.

MORRIS, Claude C., Dep't. Biology, Memorial University of Newfoundland, St. John's, Newfoundland A1C 5S7 Canada

Biom mineralization in cephalopod statocysts differs from that of other organisms in that ions are secreted into a comparatively large volume of fluid before deposition, rather than being secreted by a membrane applied to the mineralized structure. Ionic composition of statocyst fluid in the squid Alloteuthis subulata is similar to that of blood with the exception of magnesium which has a concentration about 1% of that found in its blood and in seawater. Magnesium concentrations above 1.0 millimolar, strontium concentrations above 10 micromolar, and natural statocyst fluid in dilutions up to 1:1000 inhibit precipitation of calcium carbonate in an artificial statocyst fluid by increasing the time required for nucleation and slowing the precipitation rate. Preliminary indications of an organic component that reversibly polymerizes with varying pH, as well as data based on ionic composition, suggest possible mechanisms by which "diurnal" growth increments are formed in molluscs.

CHEMOSENSORY AND INTEGRATIVE MECHANISMS CONTROLLING SETTLEMENT AND METAMORPHOSIS OF ABALONE LARVAE: MOLECULAR DISSECTION OF THE AMPLIFIER PATHWAY

MORSE, Daniel E., Department of Biological Sciences, University of California, Santa Barbara, CA 93106

Larvae of the marine gastropod, *Haliotis rufescens* (red abalone) are induced to settle from the plankton and metamorphose by contact-dependent chemosensory recognition of a GABA-mimetic inducer on the surfaces of crustose red algae. This response is controlled by two convergent chemosensory pathways: a morphogenetic pathway activated by the GABA-mimetic inducer, and a regulatory "amplifier" pathway stimulated by lysine in seawater. The system displays both habituation, acting at the level of the morphogenetic pathway receptors, and facilitation, mediated by the amplifier pathway. Receptors for the exogenous morphogen control a cAMP-dependent opening of chloride channels; the resulting efflux of chloride and excitatory depolarization of the chemosensory cell trigger settlement and metamorphosis. Output and sensitivity of the morphogenetic pathway are enhanced as much as 100-fold by stimulation of the amplifier pathway. We now have resolved *in vitro* the majority of the receptor-dependent and signal transduction reactions involved in this control, in cilia highly purified from the larval epithelium. These results confirm conclusions drawn from experiments *in vivo*. The cilia contain specialized chemosensory receptors for lysine. These regulate a signal transducing G protein, that controls a diacylglycerol- and calcium-stimulated protein kinase (PK) C; this activated PKC in turn phosphorylates a 130 kD target protein. The receptors, G protein, and phosphorylated target protein have been labeled, and the latter two have been purified. The G protein cDNA has been synthesized from mRNA purified from the cilia, amplified, cloned and sequenced. This is, to our knowledge, the first eukaryotic chemosensory pathway in which the receptors, G protein, PKC and target phosphoprotein, and their sequential control, all have been functionally demonstrated and resolved *in vivo*.

BEHAVIOURAL STUDIES ON VISION IN NAUTILUS AND OCTOPUS.

MUNTZ, W.R.A., Department of Botany & Zoology, Monash University, Clayton, Vic.3168, Australia.

Nautilus, a cephalopod that has changed little over 150 million years, shows many primitive features. These include the eye, which lacks any dioptic apparatus and acts as a pin-hole camera. Visual behaviour, in the form of the optomotor response and positive phototaxis, is however well developed, and can be used to assess the animals' visual capabilities.

In Octopus, visual capacity can be gauged from training experiments. The lens is well developed and of high quality, and as we should expect visual performance is very much better than in Nautilus.

The visual performance of these two cephalopods is considered in the light of the physical constraints of their environments. Some vision should be possible for Nautilus even at the great depths (up to 750m) at which it lives, and may in particular be useful in responding to bioluminescence. In Octopus vision is very well developed, and it is possible that physical limitations in the ability of water to transmit light determine a ceiling to the animals' visual capabilities.

NOTES ON THE SUPPOSED FAILURE OF CEPHALOPODS. MOYNIHAN, Martin H., Smithsonian Tropical Research Institute, APO Miami 34002.

It has been claimed (Wells, 1962) that cephalopods have somehow "failed". It is true that they are less speciose than existing vertebrates or, a fortiori, of arthropods. Yet the biomasses of existing coleoid cephalopods in the sea are enormous. What needs to be explained is why these animals do not usually occur in fresh waters or on land. Something is, or has been, blocking them. I would like to suggest that it is time rather than structure or physiology. The coleoids that would seem to be preadapted to life on land, the octopuses, apparently did not develop before the Cretaceous. By which time, the terrestrial niches were already occupied by other organisms. It is not that octopuses are unavailable or incompetent. It is just that they arrived too late. This is about as accidental as evolutionary history can get.

PEPTIDES THAT MEDIATE REPRODUCTIVE BEHAVIOR IN APLYSIA: PRECURSOR STRUCTURE, PRODUCTS, AND PROCESSING ENZYMES.

NAGLE, Gregg T., Marine Biomedical Institute and Department of Anatomy and Neurosciences, University of Texas Medical Branch, Galveston TX 77550

Peptides that mediate behavior in mollusks are synthesized as part of larger precursor proteins which are enzymically cleaved at specific processing sites, typically mono- and dibasic residues, to generate the peptides. Although much attention has focused on the chemistry and biological activity of molluscan peptides, little is known about the processing enzymes that convert prohormones to their final peptide products. The Aplysia bag cell neurons and atrial gland, which synthesize and process large amounts of egg-laying hormone (ELH) or ELH-related precursors, are potentially useful model systems for studying these processing steps. Our lab is attempting to characterize the Aplysia dibasic endoprotease from the atrial gland and subsequently from the neuroendocrine bag cells.

OCTOPUS CYANEA GRAY, 1849 (MOLLUSCA: CEPHALOPODA)
IN AUSTRALIAN WATERS: DESCRIPTION, DISTRIBUTION
AND TAXONOMY.

NORMAN, Mark D., Zoology Dept., University of Melbourne, Parkville, Victoria 3052, Australia
Octopus cyanea Gray, 1849 was originally described from an unspecified locality in Australian waters (as "Coast of New Holland"). This species is widely distributed throughout tropical waters of the Indian and Pacific Oceans. The distributional range of the species in Australian waters never has been examined, with confusion arising from the name being regularly and inaccurately assigned to a temperate east coast Australian octopus species. No records of the genuine O. cyanea had been made in tropical Australian waters prior to the works of Roper & Hochberg (1987, 1988) on Lizard Island, northern Great Barrier Reef. The current paper reviews the synonymy of O. cyanea, provides original data on Australian and wider distributions of this species, and provides a detailed description of specimens from Australian waters. Octopus cyanea is now confirmed for northern Australian tropical waters from the southern end of the Great Barrier Reef, north to Torres Strait and west to North West Cape, Western Australia. Geographic variation in the morphology of this species over its wider range is examined. The misuse of the name Octopus cyanea (and cyaneus) for warm temperate Australian waters is also resolved.

THE SEPIOLA PARVA AND S. BIROSTRATA PROBLEM.

OKUTANI, Takashi and TAKAYAMA, Koichi, Department of Invertebrate Zoology, Tokyo University of Fisheries, Minatoku, Tokyo 108, Japan
In the genus Sepiola, two species have been thought to exist in Japanese waters, namely, S. parva Sasaki, 1914 and S. birostrata Sasaki, 1918. To determine their identity, close morphological observations were made on 167 specimens (89 males, 78 females) from four localities, viz. Seto Inland Sea, Tokyo Bay, the Pacific coast of northern Honshu and the western part of the Japan Sea. Conventional measurements following the modern guidelines were carried out, but no significant differences were detected among specimens examined.

The most important character that separates S. parva and S. birostrata is the number and shape of the fleshy projections on the hectocotylized arm. Among 89 males, 3 specimens have a single nipple-like projection, 81 have a double projection and 5 have trirostrate projections. Occurrences of each form are related neither to locality nor to maturity. Among them, trirostrate projections are unlike those in S. birostrata Voss, 1963 from the Philippines. Such consistency in biometrical characters and the transitional condition of the hectocotylus projections suggest that the number of projections do not signify a species difference but, instead, represent variability within a single species. Further confirmation is needed in respect to the differences or uniformity of the life cycle.

PERFORMANCE LIMITS OF "ANTIQUÉ" AND "STATE-OF-THE-ART" CEPHALOPODS, NAUTILUS AND SQUID.

O'DOR, R.K. & M.J. WELLS, Biology Dept., Dalhousie U., Halifax, N.S., B3H 4J1 & Zoology Dept., Cambridge U., Cambridge, U.K., CB2 3EJ

The performance of this representative of shelled cephalopods which dominated the Paleozoic and Mesozoic seas suggests these seas were less energy demanding than modern seas. Maximum power output of Nautilus swimming in a flume at 0.3m/s, is 0.16W/kg BW (pressure-volume work), near squid power at this speed. Maximum speed is 1/5th and power 1/50th of the modern squid. Sustainable output is 0.04W/kg and input 0.53W/kg (95 ml oxygen/kg-h), for cruising at 0.15m/s. Higher muscle efficiencies at equivalent speeds and neutral buoyancy make slow jet swimming cheaper than undulation. Squid, however, are only competitive at maximum power, since fish dominate the intermediate power spectrum.

ASPECTS OF THE REPRODUCTION AND DEVELOPMENT OF OCTOPUS RUBESCENS BERRY, 1953 (MOLLUSCA : CEPHALOPODA)

OSBORN, Steven A., Moss Landing Marine Laboratories, Moss Landing, CA 95039
Mating behavior, embryonic development and chromatophore development were documented in the laboratory for Octopus rubescens. No conspicuous courtship behavior was observed. Five females laid fertile broods of eggs over two separate breeding seasons, with annual peaks occurring in April and May. Approximately 89 days at 13-15 °C were required for complete embryonic development. The course of embryogenesis closely resembles that published for O. tetricus and O. bimaculatus. Unique characteristics of this species were noted and chromatophore development was documented for each brood. Attempts to rear the planktonic hatchlings were unsuccessful, with a maximum survival time of 18 days. Six environmental parameters were tested in the laboratory, with results showing no significant difference in survival time. Four juvenile O. rubescens were collected in Monterey Bay on 5 October, 1989 and maintained in the laboratory for 117 days. Both males developed hectocotyli at two months post-capture. Two basic chromatophore patterns occurred in all broods at nearly a 1:1 ratio. As all field-collected, juvenile males revealed one of the observed patterns and all juvenile females revealed the other, such chromatophore patterns may be sex-dependent, possibly allowing the first pre-hatching evaluation of sex ratios within broods of cephalopods. An unknown ectoparasite found on eggs of O. rubescens is also described.

CEPHALOPODS AS INDIVIDUALS.

PACKARD, Andrew, Department of Zoology,
University of Naples, Stazione Zoologica,
Naples 80121, Italy

Teuthologists have under-exploited the resources offered by studying individuals. The word individual is used in two ways: individuals as separate entities in time and space, available for the study of individual differences; individuals as single entities continuing in time and space, available for studies of ontogeny and of changing relations within entities. The two combine in studies of the development of relations between individuals (social studies). This presentation illustrates the kinds of unique understanding to be gained from simple observations of single captive *Loligo vulgaris* in feeding, signalling and hierarchical relations in captivity, and of the variability and processes of generation and regeneration of chromatophore patterns in the octopus.

THE INTERPRETATION OF CHROMATOPHORE SYSTEMS IN CEPHALOPOD MOLLUSCS.

PACKARD, Andrew, Department of Zoology, Naples University and Stazione Zoologica, Napoli 80121, Italy.

Chromatophores do not act singly but together. They are linked a) by their nerves, b) through their muscles, the particular pattern of connections in any one animal and at any one stage being determined by developmental rules which produce separate sub-systems of chromatophores within the skin. Chromatophores of younger sub-systems have chromatophores which are smaller, paler, and usually more numerous than the chromatophores of older sub-systems, and the sub-systems act independently; but it is not known how much of an expressed colour component is due to nerve and how much to muscle connections.

Denervation dramatically alters the behaviour of chromatophore muscles which become supersensitive to pharmacological agents, conduct waves, and respond to electronic flash. However they do not normally die or dedifferentiate, even with long-term denervation.

The talk will illustrate some of the properties of the separate subsystems, by reference to specific components in the colour repertoires of octopuses and squids - such as streaks, paling, counter-shading, white spots and their screens - and discuss some of the methodological advantages which photographs of the living cephalopod skin have to offer for the study of nerve/muscle interactions in smooth muscle generally.

NEUROBIOLOGY OF OCTOPUS CAMOUFLAGE

PACKARD, Andrew, Department of Zoology, Naples University and Stazione Zoologica, Napoli 80121, Italy.

The poster shows three 'visual units' in the skin of *Octopus vulgaris* evoked through surface stimulating electrode. Each is characterized by contrast and by center-surround organization, and contributes to cryptic mottle. Each is part of a motor unit consisting of different, but overlapping, size classes of melanophores (dark chromatophores).

PHEROMONAL ATTRACTION AND INDUCTION OF COPULATORY BEHAVIOR IN *APLYSIA*: RELATIVE CONTRIBUTIONS OF FACTORS DERIVED FROM EGG CORDONS AND EGG LAYERS.

PAINTER, Sherry D., Marine Biomedical Institute, University of Texas Medical Branch, Galveston, TX 77550.

During the reproductive season, many species of *Aplysia* form breeding aggregations which contain both mating and egg-laying individuals and are associated with recently deposited egg cordons. The pheromonal factors initiating and maintaining these aggregations have not been examined in detail, but behavioral studies have demonstrated that egg-laying animals are more attractive than nonlaying animals and have shorter latencies to mating. We have now examined the relative importance of the egg cordon and the egg layer to these phenomena. T-maze experiments were used to examine pheromonal attraction. The studies showed that animals are attracted to egg-laying animals with or without cordons and to cordons with or without animals. Cordons were more attractive than egg layers without cordons and as attractive as egg layers with cordons, suggesting that cordon-derived factors may play the more significant role in attraction. Mating experiments showed that, although there are animal-derived factors that can induce the activity, animals do not distinguish between egg layers and nonlayers either in the presence or absence of an egg cordon. These results suggest that cordon-derived factors are also primarily responsible for the induction of mating behavior by egg-laying animals.

LAND SNAIL MOVEMENT PATTERNS IN NORTHERN MICHIGAN

PEARCE, Timothy A., Museum of Zoology, University of Michigan, Ann Arbor, MI 48109

Land snails move to find food, find mates, avoid predators, and adjust their micro-environment (such as remaining moist). Mucous trails may play a role in communication and navigation. All snails are predicted to move when the need arises and conditions are favorable, but when the need arises and conditions are unfavorable, snails willing to take greater risks may better exploit resources, although they may face greater mortality. Differences in risk acceptance are expected among coexisting species of land snails that share similar diet and habitat.

I used spool and line to trace movement patterns of three species of large (>13 mm diameter) land snails coexisting in northern Michigan, *Anguispira alternata*, *Mesodon thyroideus*, and *Triodopsis albolabris*. Snails moved more at night and during moist weather, and different species showed variability in these tendencies. Snails did not return to a home refuge, but they occasionally followed mucous trails. Size of activity range and degree of association with fallen logs differed among species. Differences in spatial and temporal movement patterns may help to explain how species with similar niches can coexist.

SEXUAL MATURATION AND REPRODUCTIVE CYCLE OF *ELEDONE MASSYAE* VOSS, 1964 (CEPHALOPODA: OCTOPODIDAE) IN SOUTHERN BRAZIL.

PEREZ, Jose A. and HAIMOVICI, Manuel, Fundacao Universidade do Rio Grande, Cx 474, Rio Grande RS, 96200 Brazil

Eledone massyae is a small benthic octopus distributed in warm temperate waters of the continental shelf between Argentina and Rio de Janeiro. The reproductive cycle was studied in 228 females and 98 males captured on the shelf and the upper slope between 30°S and 34°S. Maturation in females was characterized by an enlargement of the ovary and expressed by using a morphological scale, maturity indices, and mean oocyte and oviducal gland sizes. Females started to mature in November showing a wide range of sizes and attained the most advanced stages in January (summer). Neither fully mature nor spent females were found, thus spawning is likely to take place during late summer over rough bottoms, outside of trawling areas. Spermatophores were found within the ovary of maturing females predominantly in the spring, approximately three months before the spawning season. Mean fecundity was 79 eggs and variation with female size was not significant. Male maturation started earlier at smaller sizes (20 mm) and was linearly correlated with body size. Spermatophores were found in the spermatophoric sac from the end of autumn and the most advanced gonadal stages occurred in January. Mating seemed to occur principally in the spring.

HOW WELL DOES GROWTH RATE PREDICT THE RATE AT WHICH MOLLUSC LARVAE (*CREPIDULA PLANA*) BECOME COMPETENT TO METAMORPHOSE?

PECHENIK, Jan A. and ZIMMERMAN, Kerry M., Department of Biology, Tufts University, Medford, MA 02155

The larvae of marine bivalves and gastropods must typically develop for days or weeks before they can end their dispersal phase by metamorphosing to the benthos. In this study we explored the relative effects of environmental factors on the rates at which gastropod larvae (*Crepidula plana*) become competent to metamorphose and the rates at which they grow. Larvae were reared at 20 °C, 25 °C, or 29 °C, and at salinities between about 20 and 30 ppt. Under these conditions, growth rates were poor predictors of the amount of time required for larvae to acquire metamorphic competence.

ON THE DISTRIBUTION OF PELAGIC CEPHALOPODS IN THE ARABIAN SEA DURING MAY/JUNE 1987.

PIATKOWSKI, Uwe and SCHÖFER, Wolfgang, Institut für Meereskunde, Universität Kiel, Düsternbrooker Weg 20, D-2300 Kiel 1, F.R. Germany
During spring of 1987 RV "Meteor" collected zooplankton and micronekton samples in the north-eastern part of the Arabian Sea. From the micronekton samples of that cruise carried out with an IKMT (0-1000m depth) 156 cephalopod specimens were identified to the lowest possible taxon. Twelve species of 8 families were recorded. Most of the specimens were early life stages of epipelagic oceanic species. The cranchiid squid *Liocranchia reinhardtii* (n=108 specimens) was most abundant followed by the enoploteuthid squids *Abraliopsis lineata* (n=21) and *Abralia marisarabica* (n=9). Distribution maps and size frequency compositions are compiled for the abundant species.

The data reveal a typical tropical cephalopod fauna and may extend our poor knowledge on the distribution pattern of pelagic cephalopods in the Indian Ocean.

CATECHOLAMINE BREAKDOWN PRODUCTS INDUCE
PARTIAL METAMORPHOSIS IN THE NUDIBRANCH
PHESTILLA SIBOGAE

PIRES, Anthony, and HADFIELD, Michael G., Kewalo Marine
Laboratory, P.B.R.C., University of Hawaii, 41 Ahui St., Honolulu,
HI 96813

Veliger larvae of the aeolid nudibranch Phestilla sibogae
metamorphose in response to a soluble factor from their prey coral,
Porites compressa. Metamorphosis begins with destruction of the
velum, a ciliated structure used for swimming and feeding. Previous
investigation had shown that larvae exposed to certain catecholamine
neurotransmitters lost the velum, but failed to complete any
subsequent steps of metamorphosis.

Since catecholamines oxidize rapidly in seawater, we have
re-examined morphogenic effects of catecholamines using superfusion
chambers that allow periodic replacement of test solutions. We
report that L-DOPA, dopamine, epinephrine, norepinephrine, and
isoproterenol have no morphogenic potency. Aged, oxidized 2×10^{-4}
M solutions of all of these compounds induce velar loss in most
larvae within 7 h of exposure. Oxidized solutions of the
catecholamine metabolites dihydroxyphenylacetic acid and
dihydroxymandelic acid, and of catechol, are similarly effective.
Structurally similar but more stable compounds that do not have two
ring hydroxyl groups have no morphogenic effects in fresh or aged
solutions. Preliminary pharmacological experiments indicate that
velar loss induced by catecholamine breakdown products cannot be
blocked by chlorpromazine (a dopamine and α_1 -adrenergic
antagonist), yohimbine or propranolol (α_1 - and β -adrenergic
antagonists respectively). Current efforts focus on structural
identification of morphogenically active catecholamine derivatives,
and a search for their expression *in vivo*, to test the hypothesis that
catecholamine breakdown products mediate velar disintegration in
natural metamorphosis.

PRELIMINARY STOCK ASSESSEMENT OF THE SQUID ILLEX
COINDETII (MOLLUSCA, CEPHALOPODA) IN THE SICILIAN
CHANNEL.

RAGONESE, S. and JEREB, P., Istituto de
Tecnologia della Pesca e del Pescato, Via Luigi
Vaccara 61, Mazara de Vallo 91026, Italy

Length-frequency data for more than 12000 specimens
of Illex coindetii (Verany, 1839) from eight
randomly stratified trawl surveys carried out with
seasonal periodicity (May 1985 - February 1987)
were used in order to make an initial estimate of
the population structure of this species in the
Sicilian Channel. Length-frequency distribution
was analyzed, for both survey and sex, with
different methods to estimate growth parameters and
mortality. These estimates were then used to form-
ulate preliminary management recommendations for
I. coindetii in this area, taking into account the
lack of information on the actual potential of this
resource.

CODING OF EXCITATORY AND INHIBITORY
ACTIONS OF A MULTIFUNCTION INTERNEURON
IN THE SLUG, LIMAX MAXIMUS

PRIOR, David J., Physiology and
Functional Morphology Group,
Department of Biological Sciences,
Northern Arizona University,
Flagstaff, AZ 86011

In the terrestrial slug, Limax maximus,
feeding activity and cardiovascular
function have been shown to be
correlated. For example, in intact
animals, both feeding responsiveness and
heart activity are suppressed during
dehydration (Grega and Prior, 1986).
The paired peptidergic buccal ganglion
neurons RB1 and LB1 have dramatic
modulatory effects on both the feeding
motor program (FMP) and force of heart
contraction (Welsford and Prior, 1990).
The B1 neurons appear to contain both
FMRamide and the SCPs. Preliminary
observations suggest that in addition to
a frequency dependent excitation of the
FMP and heart, B1 may also be capable of
a frequency dependent inhibition of
these targets. Thus interneuron B1 may
serve to mediate the coincident
modulation of multiple responses to
physiological stresses.

CONTRACTION AND SEROTONIN-ELICITED MODULATION OF
DISSOCIATED FIBERS OF APLYSIA BUCCAL MUSCLE.

RAM, Jeffrey L. and ZHANG, Feng, Dept. of Phy-
siology, Wayne State Univ., Detroit, MI 48201
Buccal mass muscles of Aplysia are innervated by
both cholinergic and serotonergic neurons.
Serotonergic input is thought to underlie, in
part, increased contractility during feeding
arousal. With isolated muscles, acetylcholine
(ACh) causes contraction, whereas serotonin (5-HT)
potentiates contraction. In order to study the
mechanisms underlying these responses at the
single cell level, dissociated muscle fibers were
prepared by treating muscles for 2 - 4 hrs with
collagenase. Resultant fibers typically average
 $270 \pm 10 \mu\text{m}$ in length ($n=37$) and $10.8 \pm .7 \mu\text{m}$ in
diameter ($n=19$; max. diameter averages $13.6 \pm .9$
 μm). High K (100 mM superfusion for 2 s) causes
contraction, e.g. shortening a typical field of 7
fibers from $285 \pm 20 \mu\text{m}$ to $245 \pm 20 \mu\text{m}$ ($p < .05$,
paired t). $5\text{-HT}^- (10^{-6} \text{ M}, 1 \text{ min})$ potentiates con-
traction (resting length, $285 \pm 35 \mu\text{m}$; 3 s high K,
 $190 \pm 30 \mu\text{m}$; 3 s high K after 5-HT , $140 \pm 20 \mu\text{m}$;
 $n=5$, $p < .05$, paired t). Similarly, ACh also
elicits contractions which are potentiated by 5-
HT. Patch clamp recording: In whole cell con-
figuration, ACh and depolarization elicit inward
and outward currents, respectively. With Cs in
the electrode and TEA/4-AP outside, calcium-
dependent inward current can be elicited by
depolarization. On-cell patches (540 mM KCl in
electrode) contain stretch-activated channels.
Supported by MDA and NIH RR 08167).

CEPHALOPOD CAPTURE METHODS: AN OVERVIEW.

RATHJEN, Warren F., Center for Fisheries Engineering Studies, Florida Institute of Technology, Melbourne, FL 32901-6988

Cephalopods, including octopus, cuttlefish, and squid, are a major component in the marine biomass. Due to high behavioral diversity among species, uncertainty exists concerning the general applicability of sampling and capture techniques. This factor impacts on understanding the overall abundance and status of stocks.

In addition to the acceleration of exploitation of cephalopods by international fisheries, cephalopods represent a major forage component in the diets of other marine species. In the Antarctic alone, it is estimated that the consumption of cephalopods by seabirds, whales and seals may reach 34 million tons annually. On a worldwide basis, the total predation on cephalopods probably exceeds 100 million tons, the total annual harvest of all marine species by humans.

Scientists and fisheries managers have not attained accuracy in measuring stocks under direct exploitation. These few species comprise only a fraction of available worldwide resources.

Some of the traditional capture techniques are discussed with an indication of their effectiveness; possible options and access to new or latent methods are also noted.

CNS NEURONAL SOMATA OF OCTOPUS ARE INEXCITABLE AND LABEL RETROGRADELY WITH CARBOCYANINE DYES. Robertson, J.D., R. Gillette, P. Lee*, S. Meadows, J. Zitz* and Owen Schwartz. Duke Univ. Marine Lab., Beaufort, NC, & Dept of Physiol. and Biophysics, Univ. of Ill., Urbana, IL.

Intracellular recordings were made from neuronal somata of brain slices of supra- and subsophageal lobes of Octopus. Recordings were also made in isolated buccal and stellate ganglia. Action potentials and PSPs were frequently seen. However, in over 200 recordings from cells with membrane potentials of -35 to -70 mV, action potential amplitudes never exceeded 20 mV, and in most cases were <10 mV. The most likely interpretation of these results is that the octopus neuron somata are inexcitable. This resembles the situation for arthropods, and contrasts with that for generally excitable somata of other molluscs. We discuss inexcitable somata as an evolutionary adaptation of the molluscan CNS plan to the large and complex brain of the octopus.

In related experiments we injected DiI or DiO into one cerebrobrachial commissure. After 8 days, many large (~50-60 μ m) cell bodies, were labeled with numerous brightly fluorescent, sharply demarcated 2-5 μ m diameter perinuclear organelles in the posterior buccal, subfrontal and subvertical lobes. Clusters of 50-75 labeled cells were also found on one side in the caudal cell wall of the basal lobe. The latter may represent a new motor nucleus. Numerous interspersed small unlabeled cells ~5 μ m in diameter were also seen. Controls for autofluorescence showed granules visible only at high magnification (40x obj.) that were somewhat larger, more irregular in outline much more sparse in number and relatively very weakly fluorescent. Supp. by NSF Grants BNS-88-20409 and BNS-86-03816.

TAXONOMIC REVIEW OF THE AUSTRALIAN ROSSIINAE (CEPHALOPODA: SEPIOLIDAE).

REID, Amanda L., Dept. of Invertebrate Zoology, Australian Museum, Sydney South 2000, Australia
Geographic variation in the morphological characters of Australian Rossiinae was examined using principal components analysis (PCA), multivariate analysis of variance (MANOVA), discriminant function analysis (DFA), analysis of variance (ANOVA) and latitudinal and longitudinal regression analyses. The results show genetically distinct, morphological differences occur between populations of *Rossia* from the North West Shelf (Western Australia), identified as an undescribed species, and populations from eastern and southern Australia, identified as *R. australis* Berry, 1918. That all the latter specimens belong to a single species is further supported by electrophoretic evidence.

Although individual qualitative and quantitative characters could not be found to distinguish the North West Shelf specimens from the African species *R. mastigophora*, multivariate statistical analyses consistently grouped specimens into two clusters corresponding to these disjunct populations. However, it cannot be determined whether the observed variation is ecophenotypic or a reflection of genotypic differences warranting new species distinction for the North West Shelf specimens.

In addition, a new species of *Neorossia* is identified and described.

BEHAVIOR OF THE LARGER PACIFIC STRIPED OCTOPUS.

RODANICHE, Arcadio F., Smithsonian Tropical Research Institute, Box 2072, Balboa, Panama
The behavior of the Larger Pacific Striped Octopus (*Octopus* n.sp.; sibling species of *O. chierchiae*) was observed, briefly *in situ* and extensively in the laboratory. Food preference and different hunting strategies were observed. This octopus has a body pattern repertoire of considerable complexity. The male is distinguished from the female by an external permanent narrow white line along the edge of the hectocotylus (right third arm). No other octopus has been described with a permanent stripe. This species copulates in a method previously not described for octopods, mainly beak to beak for a period of two to three minutes. The species may be iteroparous. In captivity, females spawned small clutches of infertile eggs every six weeks for several months, then produced a large clutch of fertile eggs. Once the eggs hatched, the female resumed spawning small clutches of infertile eggs for several months. No captive female ever spawned more than one fertile clutch, but none died after the fertile eggs hatched. When brooding, the female "cleans" the eggs, continues to feed and occasionally leaves the nest to hunt. Infertile eggs are either eaten or abandoned two or three weeks after being laid. Each egg (capsule 4.65 x 1.60 mm) is attached individually to the substrate by a stalk (2.2 mm). Hatching occurs after 37-38 days, mostly at night; hatchlings are pelagic.

POPULATION STRUCTURE OF THE OMMASTREPHID SQUID
MARTIALIA HYADESI AT THE ANTARCTIC POLAR FRONTAL
ZONE IN THE VICINITY OF SOUTH GEORGIA.

RODHOUSE, P.G., British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, U.K. In February 1989 three scientists from the British Antarctic Survey joined two Japanese squid jigging vessels for exploratory fishing in the vicinity of South Georgia, Shag Rocks and the Antarctic Polar Frontal Zone (APFZ). Commercial quantities of the ommastrephid squid, Martialia hyadesi, were caught some 185 nautical miles west of Shag Rocks. This was on the northern edge of the North Scotia Ridge in the vicinity of the APFZ, where the water depth was some 3000 m. The frequency structure of the Martialia catch from the two vessels showed that there was a marked increase in the mean size of squid taken after dark. Data on the demography of the catch of a Japanese jigging vessel on the Patagonian shelf in 1986, when unusually large numbers of this species were caught in that fishery, showed that the catch from the Patagonian shelf consisted of squid with a larger mean size than from the APF. The hypothesis is proposed that the life cycle of Martialia is associated with the West Wind Drift in the vicinity of the APFZ. By analogy with other ommastrephids this implies that the spawning ground of the population sampled during the present exercise is to the west of the area where they were caught.

COMPARISON OF DEPTH DISTRIBUTIONS OF EASTERN
PACIFIC AND WESTERN ATLANTIC MOLLUSCAN FAUNAS

ROSENBERG, Gary, Academy of Natural Sciences, Philadelphia, PA, 19103
Minimum and maximum depths were recorded for 2953 species treated by Abbott (1974), Keen (1971) and Bernard (1983). Western Atlantic species occurring south of Cape Hatteras and north of Uruguay, and Eastern Pacific species from the Gulf of California to Peru were included. These data were used to produce graphs showing species diversity by depth. Western Atlantic bivalves and Eastern Pacific bivalves and gastropods show highest diversity around 20 meters depth, whereas Western Atlantic gastropod diversity peaks about 60 meters. Depth curves for Eastern Pacific bivalves from Keen (1971) and Bernard (1983) are virtually identical, although Bernard gave data for almost twice as many species. Bernard based his data on live collected material only, and it is apparent that Keen did this as well. Abbott's data came from dredging records that did not distinguish live and dead collected records.

Gastropods, being mainly epifaunal, are more subject to postmortem transport, and the deeper modal depth of Western Atlantic than Eastern Pacific gastropods is probably a taphonomic artifact, not a biological phenomenon. Bivalves, being primarily infaunal, are less subject to transport, so the equivalence of the modal depths of Western Atlantic and Eastern Pacific bivalves is real.

RECRUITMENT DYNAMICS OF THE HARD CLAM (MERCENARIA
MERCENARIA): AN ALTERNATIVE MODEL

ROLLINS, Harold B., Department of Geology, University of Pittsburgh, Pittsburgh, PA 15260
PREZANT, Robert S., Department of Biology, Indiana University of Pennsylvania, Indiana, PA 15705

TOLL, Ron, Department of Biology, University of the South, Sewanee, TN 37375

At St. Catherines Island, Georgia, the hard clam (M. mercenaria) exhibits a dual strategy for population recruitment. In higher energy habitats dispersal of this sedentary bivalve often involves passive hydrodynamic entrainment of adults. This complements dispersal by larvae, a strategy dominant in more offshore waters and instrumental in long-range colonization by this species. Recruitment by adult hard clams was demonstrated by a capture/release program at three intertidal sites. This strategy is consistent with the previously noted heterozygotic deficiencies in this species along coastal Georgia and the common absence of younger age classes. This model of hard clam recruitment occasions a re-evaluation of traditional views regarding recovery of harvested clam populations. Missing younger age classes may be a predictable response to specific hydrodynamic conditions and not a failure of spawning or larval set. This indicates more rapid re-occupation of stressed (including harvested) sites by reproductively viable individuals but decreased predictability of hard clam harvesting, a result of greater spatial heterogeneity of distribution, abundance, and age class structure.

A CHECKLIST OF CEPHALOPODS FROM THE MEXICAN
WATERS OF THE GULF OF MEXICO.

SALCEDO-VARGAS, M. Alejandro, Invertebrate Laboratory, Tokyo University of Fisheries, 4-5-7 Konan, Minato-ku, Tokyo 108, Japan
The Instituto de la Pesca, Fisheries Institute, Ministry of Fisheries in Mexico conducted planktonic surveys covering the continental slope and the 200 mile fishery zone in the Gulf of Mexico. Cephalopods were included for the first time in a survey to up-date and search for non-utilized fisheries resources. Very few cephalopod papers have been published on the Mexican waters of the Gulf of Mexico. In order to make an up-dated checklist of the identified species, it was necessary to visit scientific collections, museums and universities in national and foreign laboratories.

This report is based on 545 specimens, including all of those from the Mexican research vessel surveys during April-May and August of 1986. The list includes adult, juvenile and paralarval forms of 71 species. For the species with systematic problems, diagnostic and distributional data are discussed. Zoogeographical relationships and species with potential as fisheries resources in the Gulf of Mexico are also discussed.

NEURAL CONTROL OF ESCAPE SWIMMING IN THE PTEROPOD MOLLUSC *CLIONE LIMACINA*.

SATTERLIE, Richard A., Department of Zoology
Arizona State University, Tempe, AZ 85287-1501
Three forms of forward locomotion have been described in *Clione*, including slow, fast and escape swimming. The neuromuscular organization of the swimming system suggests that a two-gear system operates for slow and fast swimming, while the escape response is superimposed on fast swimming. Two peripheral inputs appear to be involved in the initiation and maintenance of escape swimming. A pair of recently-identified motor neurons appear to induce a "startle" response, and may be involved in initiation of the escape. These neurons have very high firing thresholds, and do not receive input from the swim pattern generator (the cells are electrically silent during normal slow and fast swimming activity). In addition, a pair of serotonin-immunoreactive neurons modulate muscle activity with a time course that corresponds to the period of enhanced fast swimming which follows the "startle" phase of escape swimming. These latter neurons are not involved in initiation of escape, but may be involved in maintenance of escape swimming.

THE APLACOPHORA POSSESS A TRUE RADULAR MEMBRANE

SCHELTEMA, Amélie H., Biology Department, Woods Hole Oceanographic Institution, Woods Hole, MA 02543 and KUZIRIAN, Alan M., Marine Biological Laboratory, Woods Hole, MA 02543

The radulae of the Aplacophora consist of 6 to more than 40 rows of teeth attached to a membrane. They fall into three categories: distichous, monostichous, and polystichous (two, one, and several teeth per row). Monostichous and polystichous radulae are considered apomorphic based primarily on the fused ducts of their paired salivary glands.

Light and scanning electron microscopic examination of isolated radulae of all three types show the presence of a continuous membranous ribbon to which the teeth are attached. The ribbon and teeth are formed at the blind end of a ventral, pharyngeal radular sac. Thin sections of two species with plesiomorphic distichous radulae reveal actively secreting odontoblasts, membranoblasts, and superior epithelium at the blind end of the sac. The continuous membrane beneath the teeth stains differentially from the attached teeth.

Cellular and hard structures of the aplacophoran radula and radular sac are considered homologous to those in other mollusks because of their similarity in presumed function and topographic positions relative to each other and to the pharynx. The membrane to which the teeth are attached in Aplacophora is thus a true radular membrane and not a part of the pharyngeal cuticle.

OCTOPUS PREDATION ON NAUTILUS: EVIDENCE FROM PAPUA NEW GUINEA.

SAUNDERS, W.B. and BOND, Paul N., Department of Geology, Bryn Mawr College, Bryn Mawr, PA 19010 and KNIGHT, R.L., P.O. Box 108, Lorengau, Manus, Papua New Guinea

It has recently been shown that many live-caught specimens of *Nautilus* have survived attacks by *Octopus*, as indicated by incomplete or repaired borings in the shell. Frequencies of these sub-lethal attacks vary from 1.1% (Philippines) to 7.8% (Palau) of individuals examined. To date, however, there have been no figures on the proportion of successful (lethal) attacks on *Nautilus*, because insufficient shells are available whose source (live-caught versus drifted) are known.

In the Admiralty Islands, Papua New Guinea, drifted shells of *Nautilus pompilius* and the sympatric form *Nautilus scrobiculatus* are fairly common and there is no evidence that they have ever been systematically trapped or marketed. In 1984, a reward was offered for perfect shells, and 1,532 were accumulated over a period of several years. Fifty-seven percent of the shells have been bored by *Octopus*. Analysis of shell morphometric data and details of the shell borings provides a basis for evaluating predator preferences in terms of *Nautilus* size, sex and species, as well as drilling locations.

SWIMMING BEHAVIOUR OF SEA SCALLOP LARVAE (*Placopecten magellanicus*).

SILVA, M. Angelica, O'DOR, R.K.
Biology Department, Dalhousie University,
Halifax, N.S. B3H 2Z9 Canada.

Veliger larvae of *Placopecten magellanicus* present a ciliated velum that allows for continuous swimming, alternating between periods of rising and sinking in vertically oriented helices or in a straight line. Larvae are capable of regulating these behaviours by slowing downward movements and/or increasing downward speed.

Components of the swimming activity were measured under experimental conditions for scallop larvae in the range of $108\mu\text{m}$ to $239\mu\text{m}$ (from 4 to 30 days old), to determine swimming capabilities through development. The diameter of the helix is consistently larger during downward movement, when fed larvae swim in filtered seawater. When food is added to previously fed or starved larvae, there is also an increase in the helix diameter during the upward movement.

Swimming velocities were in the range of 0.45 to $1.51\text{ mm} \cdot \text{s}^{-1}$ for veligers between 4 to 22 days old during upward swimming and between 0.55 to $1.09\text{ mm} \cdot \text{s}^{-1}$ during downward swimming. When swimming in "straight lines" upward speeds are in the range of 0.97 to $1.98\text{ mm} \cdot \text{s}^{-1}$ and between 0.95 to $1.77\text{ mm} \cdot \text{s}^{-1}$ during downward movement.

The ability of a pelagic invertebrate larvae, such as sea scallop larvae, to move independently through the water column is discussed in the context of a feeding strategy.

INNERVATION OF THE ANTERIOR ARTERIAL SYSTEM OF APLYSIA CALIFORNICA.

SKELTON, Martin E. Center for Neurobiology & Behavior, College of Physicians & Surgeons, Columbia University, 722 W 168 Street, New York, N.Y. 10032

Neurons have previously been identified which innervate the cardiovascular system of the opisthobranch Aplysia californica. All of these neurons are situated in the abdominal ganglion and either innervate the heart and/or the proximal portions of the arterial vessels.

This study has shown that one of these neurons, R15, not only innervates the anterior aorta close to the pericardium, but also sends processes to the anterior branches of the vessel via a route through the head ganglia. R15 and its putative transmitter R15a1 peptide cause selected branches of the anterior aorta to constrict. The effect of R15 on the anterior aorta may redirect blood flow during egg laying.

This study also reports that the anterior aorta is innervated by a bilaterally symmetrical pair of previously unidentified neurons in the pedal ganglion. These cells, named P_{AC}, cause a longitudinal contraction of the anterior aorta close to the head ganglia but do not cause constriction. *In vivo* recordings of P_{AC} have indicated that they are active during behaviors involving withdrawal of the head, such as defensive withdrawal, respiratory pumping and escape stepping.

IMMUNOHISTOCHEMISTRY OF DIVERGING AND CONVERGING NEUROTRANSMITTER SYSTEMS IN MOLLUSCS.

SOINILA, Seppo., and MPITSOS, George J. Hatfield Marine Science Center, Newport, OR 97365.

Computer simulation models of neural networks and experiments on simple biological systems have demonstrated that a set of neurons can produce more than one activity pattern. These observations call for reevaluation of the interpretation that different forms of behavior are purely a result of fixed, response-specific neural circuits. To account for the extensive, electrophysiologically observed divergence and convergence in generation of multiple behaviors, we have previously proposed a dynamic model in which the functions of the components of the system are temporally variable, and the output of the system depends on the context of firing of the individual components, all of which may be coactive for the different behaviors.

In the present immunohistochemical study, we examined complete histological sections of all central ganglia in Pleurobranchaea and Aplysia. The findings on the buccal ganglia are representative: For over a dozen transmitters, small numbers of neurons project over the entire neuropil, apparently synapsing profusely with many neurons. Broad overlap of the projection areas of the different transmitters suggests convergence of inputs on similar targets. We also examined convergence on the somata of identified neurons. Additionally, convergence of many functionally active transmitter substances was found in the esophagus which is not expected to generate as complicated nor as many behaviors as the buccal ganglion.

The findings suggest that the effects of transmitter-specific innervations are diffuse rather than specific for particular motor systems. Given electrophysiological evidence that the buccal ganglion is multifunctional, the findings support our view that different behaviors emerge variably from the matrix of diverging and converging connections rather than through rigid behavior-specific neurocircuits. A line we are following is that the multifunctional capabilities arise in part through converging transmitter control of bifurcation dynamics of the network. Supported by AFOSR 89-0262.

A MODEL FOR RADULAR FEEDING IN HELISOMA.
SMITH, David A., and WEISS, Robert S.,
Department of Biology, Wabash College,
Crawfordsville IN 47933

Radular grazing in gastropods can create elaborate patterns on appropriate substrate. This action involves three component behaviors, (1) forward locomotion, (2) pendulum motion of the head, and (3) rasping movements of the radula. These activities are highly coordinated and co-occur at different rates. When crawling rapidly adult Helisoma may take 2-4 feeding strokes per total excursion of the head (which departs approximately 10° to either side of the body midline at maximum amplitude). Locomotion slows during intense feeding and individuals may take as many as 14-20 feeding strokes per total excursion of the head (which departs more than 45° to either side of center at maximum amplitude). Here we describe a computer model which simulates patterns produced by radular feeding. Earlier work concerning radular mechanics had demonstrated that the serial elements of radular action are highly ordered and are controlled by distinct neural arrays. Our model simulates other elements of radular feeding (forward locomotion, pendulum motion of the head, and rasping) which manifest as somewhat more flexible patterns of motor output.

SOME ASPECTS OF THE DISTRIBUTION AND MIGRATION OF GASTROPOD AND BIVALVE MOLLUSCS IN THE SUEZ CANAL.

SOLIMAN, Gamil N., Department of Zoology,
Faculty of Science, University of Cairo, Egypt.

The Suez Canal is an artificial passageway (173 km long, 100-200 m wide and 42 m deep) connecting the Gulf of Suez with the eastern Mediterranean, and passing through a number of hypersaline lakes. The prevailing temperature is 15.7-28.8°C and the average salinity is 4-4.3%, but rises to 5-5.5% or more in the Great Bitter Lake. The corresponding figures in the Gulf of Suez are 18-28°C and 4-4.4%, and are 17-27°C and 3.9% in the eastern Mediterranean.

The results of a 3-year survey in the Canal, eastern Mediterranean (from Damietta to Port Said) and western Gulf of Suez have provided helpful data about the distribution and migration of molluscs within that area. The prevailing northward tidal and bottom currents in the Canal, beside other factors, are in favour of the Suezian (lessepsian) migration of erythraean molluscs into the Mediterranean, as is true for other Red Sea animals. Thus, while 9 Red Sea bivalves and 3 gastropods established themselves in the eastern Mediterranean, only 5 Mediterranean bivalves (but not a single gastropod) were collected from the Gulf of Suez. Again, 18 erythraean bivalves and 6 gastropods were able to traverse the whole Canal, whereas 10 Mediterranean bivalves and 6 gastropods reached the Lakes but failed to cross this barrier. The current heavy transport in the Canal (mainly of oil tankers) undoubtedly adds to the difficulties against Suezian migration.

THE OCTOPUS FISHERIES IN THE MEXICAN WATERS OF THE GULF OF MEXICO AND THE CARIBBEAN SEA.

SOLIS-RAMIREZ, Manuel, Centro Regional de Investigacion Pesquera de Yucalpeten, Apdo Postal 73, Progreso, Yucatan, 97320 Mexico.

Octopus resources are commercially exploited in only two areas of the Mexican shelf of the Gulf of Mexico and Caribbean Sea: the waters adjacent to the port of Veracruz and the Yucatan Peninsula. At Veracruz the artisanal fishing method is very simple and consists of a mirror visor and a rod with a hook at its end. The mean annual catch is 20 metric tons (m.t.). The second area extends from Isla Aguada, Campeche up to the Yucatan Channel with two types of fishing (artisanal and mechanized). Both fleets use a drift method with 7-15 crab-baited lines operated at one side of the boat. Each small artisanal boat carries 1-3 canoes which are launched at the fishing grounds. Mechanized vessels carry an average of 7 canoes. Both fleets catch two species: Octopus maya and O. vulgaris. The former is caught only off the Yucatan Peninsula and the latter is harvested off Veracruz and on the Campeche Bank. Campeche reported 50 m.t. in 1949, but the catch has varied between 1000 and 2500 m.t. in the last 20 years. Yucatan started to harvest octopuses in 1970 (304 m.t.) and catches from 1970 to 1989 show an increasing trend. The 1989 season reported 15,000 m.t. for both species. Several fishery studies are being conducted to aid management of this resource on the Yucatan shelf.

SEASONAL REPRODUCTIVE BEHAVIOR OF THE SEA HARE APLYSIA BRASILIANA RANG (GASTROPODA, OPISTHOBRANCHIA) AT SOUTH PADRE ISLAND, TEXAS.

STRENGTH, Ned E., Department of Biology

Angelo State University, San Angelo, Texas 76909

Collections of Aplysia brasiliana were made on a monthly basis at South Padre Island, Texas for a four year period. Seasonal changes in distributions of various weight classes strongly support the existence of a maximum life cycle of approximately one year in duration. Large numbers of juveniles in spring collections are produced by reproductive activities of overwintering adults or possible recruitment of larvae from tropical areas, or a combination of the two. Large adults (350 to 550 gm.) are absent from the population by late spring or early summer. Spring juveniles increase in size and range from 75 to 150 gm. in average weight by late summer. Winter collections, when successful, yielded small numbers of large adults.

INTRA-RANGE DIFFERENCES IN FEEDING RATES AND SCHEDULES OF THE LIMPET TECTURA PERSONA

STRASZYNSKI, Elizabeth B., Watershed Ecosystems Graduate Program, Trent University, Peterborough, ON, K9J 7B8, CANADA.

Radula fraction within species of intertidal limpet has been shown to vary with intertidal height. At the lower end of a species' intertidal range, radulae are shorter for a given shell length. This variation may be due to plasticity of shell morphology, radula replacement rates, number and duration of feeding bouts. In this study, feeding data were collected with an attached listening device to evaluate the role of feeding rates and schedules.

Both upper- and lower-range T. persona fed primarily at night, especially when rock surfaces were wet. Diurnally, animals fed mainly when free water was available (eg. if splashed or submerged); nocturnally, these states were not used as much. Lower animals fed for longer periods, although their feeding rates do not differ. When animals were transferred from their original location to the other end of the species' range, they appear to adjust to the shift in wet/dry cycle, which dictates potential feeding time.

Overall, the times that predation and drying risk are lowest are those exploited for longer periods of feeding. Since lower animals have greater potential feeding times, it is hypothesized that higher radula use (via longer feeding bouts) accounts for their lower radula fraction.

TEMPORAL ORGANIZATION IN APLYSIA: THE CIRCADIAN OSCILLATOR IN THE EYE.

STRUMWASSER, Felix, Lab. of Neuro-endocrinology, MBL, Woods Hole, MA 02543

Locomotor behavior in Aplysia, under constant conditions (dim red light, constant temperature) is circadian. The eyes play a major role in circadian locomotor behavior since there is a large reduction in the circadian component, but no change in total distance travelled each day, when they are removed. In vitro electrical recordings from the optic nerve of isolated eyes, in darkness and constant temperature, show that there is a large amplitude circadian oscillation of the frequency of the spontaneous impulses (compound action potentials, CAPs) each day. Thus, these CAPs inform the cerebral ganglion about the phase of the "internal" day and must be the source of the circadian locomotor behavior of the intact Aplysia. There are further properties of the circadian clock in the eye that allow it to keep accurate time. The oscillator is temperature-compensated and is entrainable by light pulses (and other agents) in vitro. This talk will review what we do and do not know about the biochemical mechanisms generating the circadian oscillation. The overall problem of the circadian oscillator can be divided into three parts, presumably all within a single cell: 1. Input (entrainment); 2. the oscillator itself; 3. output. We understand the most about entrainment, primarily as a result of work by Eskin, Block and their colleagues. Some biochemical approaches and data relevant to understanding the oscillator and its output will be reviewed.

GILBERT L. VOSS: A COMMEMORATION, BIBLIOGRAPHY AND DESCRIBED TAXA.

SWEENEY, Michael J. and ROPER, Clyde F.E., National Museum of Natural History, Smithsonian Institution, Washington, DC 20560

Prof. Gilbert L. Voss served in the leading role in American cephalopod research for the past 40 years. He drew attention to the importance of cephalopods in marine ecosystems and as fisheries resources. Through his research and that of his students he markedly advanced the knowledge of cephalopod systematics, distribution and biology. Some of Gil Voss' ideas and attitudes concerning cephalopod research are discussed, as well as those on teaching, biological oceanography, hobbies, etc.

Gil's broad interests are indicated in his bibliography of over 210 diverse items, including 73 book reviews, 16 editorials, and 124 research papers on cephalopods, botany, zoogeography, history of oceanography, anthropology, and marine and deepsea biology. He authored or coauthored descriptions of two new families or subfamilies, 6 new genera and more than 65 new species or subspecies.

QUANTITATIVE MORPHOLOGICAL ANALYSIS OF THE MARSUPIAL GILLS OF ANODONTA CATARACTA USING LIGHT AND SCANNING ELECTRON MICROSCOPY

TANKERSLEY, Richard A. and DIMOCK, Ronald V. Jr., Department of Biology, Wake Forest University, Winston-Salem, NC 27109

During reproduction, female *Anodonta cataracta*, like other freshwater unionid mussels, incubate their larvae (glochidia) in the water tubes of their outer demibranchs which serve as marsupia. During the brooding season, the gills swell to up to 30 times their original size and undergo drastic morphological and architectural changes. The morphological changes that occur within the outer brooding gills of *Anodonta cataracta* were compared to the non-marsupial gills of brooding females (inner demibranchs) and the inner and outer demibranchs of males using both scanning electron and video enhanced light microscopy. Marsupial gills typically possessed a tripartite system of water tubes that were not present in non-marsupial gills and included two secondary water canals and one primary water tube which contained developing glochidia. Marsupial gills were characterized as having thinner primary septa and shorter water canals between filaments. Marsupial gills also differed significantly from non-marsupial gills in shape and the cross-sectional area of the primary and secondary water tubes. Similar differences were observed in the spacing and distribution of the gill filaments.

ROLLER CULTURE SYSTEM: THE FITNESS MACHINE FOR *Hermisenda crassicornis* LARVAE?

TAMSE, Catherine T., KUZIRIAN, Alan M., Marine Biological Laboratory, Woods Hole, MA 02543, and CAPO, Thomas R., BLR/RSMAS, University of Miami, Miami, FL 33149

The interest in *H. crassicornis* as a research model for biomedical studies has markedly increased over the years. This increased research use also highlighted the seasonal limitations of and dependence on field-collected animals. This study investigates the reliability of the roller bottle and flask methods for larval culture in the laboratory, with growth rates as the measure for larval fitness.

H. crassicornis egg layers from Monterey, CA, were held in a Dayno aquarium with recirculating 12°C seawater. Egg masses were incubated in 1 L flasks with 0.22µ-filtered seawater and 0.25 mg/L EDTA, and set up for larval culture after 7 days. For the culture phase, 10 mg/L Chloramphenicol, 0.25 mg/L EDTA, and microalgal food (3C and Iso, total concentration 1.5 x 10⁷ cells/L) were added to the prefiltered seawater. Larvae (1/ml density) were then added to the roller bottles and flasks, sealed with 3 layers of Parafilm, and kept in a 12°C incubator. Seawater was changed, food was replenished, and shell length measurements (10 larvae per treatment) were recorded weekly.

Larvae from roller cultures had higher, more uniform growth rates, reached maximum shell length (313 µ) and underwent metamorphosis. Larvae from flask cultures did not reach 300 µ nor get to the metamorphic stage. Thus, larval fitness and subsequent metamorphosis was enhanced in the roller culture system compared to the stationary flask culture system.

CHARACTER VARIABILITY AND ITS BEARING ON THE SUPRA-SPECIFIC CLASSIFICATION OF THE OCTOPODINAE.

TOLL, Ronald B., Department of Biology, The University of the South, Seawee, TN 37375

Intra- and inter-specific variability of selected octopodine characters, including morphology of the penis, penis diverticulum, ink sac, ink duct, radula, crop diverticulum, web, and number and placement of suckers, are discussed. The traditional supra-specific classification of the Octopodinae is reviewed and partially revised based on recent findings related to these and other characters. Suggestions for future areas of systematic investigations also are presented.

HEART ULTRASTRUCTURE IN CAUDOFOVEATA (MOLLUSCA, APLACOPHORA) AND REMARKS ON ULTRAFILTRATION

TSCHERKASSKY, Martin, University of Vienna, A-1090 Vienna, Austria

The hearts of *Scutopus ventrolineatus*, *Falcidens crossotus* and *Chaetoderma nitidulum* have been examined in relation to the function as ultrafilters. Unlike in other molluscan groups the heart ultrastructure in caudofoveates shows no direct evidence of the formation of urine through the heart wall by pressure filtration. The epicardial cells are only in loose contact to each other and underlain by a relatively thin musculature. The heart cells show a very complex membrane labyrinth with long cytopodia and a large number of mitochondria indicating high metabolic activity. Coarse filtration into the pericardial cavity may take place, but the arrangement of the epicardial cells appears to be unsuitable for an ion filter.

Both the epithelia of gills and pallial wall show well developed features for ion transport (brush border with associated fibrous layers, basal membrane infoldings).

It is likely that in caudofoveates the sites of excretion are found in several regions: (1) Defecation via the digestive tract, (2) Coarse blood purification across the heart wall, and (3) Filtration via gills and pallial wall.

RE-EVALUATION OF THE CEPHALOPOD GENUS ONYKIA.

Tsuchiya, Kotaro and Okutani, Takashi, Department of Invertebrate Zoology, Tokyo University of Fisheries, Minatoku, Tokyo 108, Japan
The genus Onykia Lesueur, 1821 is characterized by the possession of round fins, marginal suckers on the tentacular club, a short endocone on the gladius, distinct iridescence of the body surface, and the absence of a visceral photophore. Gravid or mature specimens of Onykia species never have been found except in O. rancureli.

In the family Onychoteuthidae, the genus Onykia shares in common with the genus Moroteuthis the absence of the visceral photophore. Young Moroteuthis specimens have a small number of marginal suckers on the tentacular club and possess an indistinct cartilaginous cap on the gladius endocone. Large Onykia specimens develop features similar to Moroteuthis, such as rhomboidal fins, a Y-shaped ridge in the funnel groove, and a reduced number of marginal suckers on the club. It is thus suggested that the genus Onykia represents the juvenile stages of the genus Moroteuthis. In addition, close examination of a series of specimens of O. "carribaea" revealed that it is not monospecific, but contains more than one species. This may cause the creation of many "species" based on subtle characters.

NATIONAL STATUS AND TRENDS PROGRAM: CONTAMINANTS IN BLUE MUSSEL TISSUES FROM NORTHEASTERN UNITED STATES COASTAL WATERS

TURGEON, Donna D. and Gunnar G. LAUENSTEIN, Ocean Assessment Division, National Ocean Service, NOAA, Rockville, MD 20852

Since 1986, NOAA's National Status and Trends (NS&T) Program has monitored, through its Mussel Watch Project, the levels of more than 70 contaminants in surface sediments and in tissues from oyster and mussel species at more than 220 sites nationwide. Results are presented from 1986 through 1989 collections.

From Penobscot, ME, to Absecon Inlet, NJ, contaminant levels in surface sediments and in tissues of Mytilus edulis from 31 sites have been used as indicators of the status of coastal environmental quality in the Northeast. Generally, highest accumulations of organic contaminants are found in mussel tissues from the following urban areas: (1) PAHs in samples from the Hudson-Raritan Estuary, the New York Bight, Long Island Sound, and Boston Harbor; (2) PCBs at sites in Buzzards Bay (Angelica Rock and Round Hill), followed by moderately high concentrations in the Hudson-Raritan Estuary and Long Island Sound; and (3) DDT from sites in the Hudson-Raritan Estuary. Concentrations of metal contaminants were variable in mussel tissue: (1) Ag, Hg, Pb, Cd, and Cr are highest in the Hudson-Raritan Estuary; while (2) Pb and Cr are also high in Salem Harbor. Results from a study on the variations between oyster and mussel contaminant uptake at a site in the Housatonic River indicated that certain metals (Zn, Ag, Cu, and Cd) are markedly more concentrated in oysters than mussels, irrespective of proximity to contaminant sources. Results from a preliminary assessment of the NS&T data for possible trends indicate that at least some contaminants may be consistently increasing at certain sites and decreasing at others. Comparisons between NS&T data (1986-88) and EPA's Mussel Watch data (1975-78) indicate significant decadal differences: lead and cadmium are lower in both mussels and oysters, but copper concentrations are higher in mussels (but not oysters).

THE CEPHALOPODA OF THE IONIAN SEA (MEDITERRANEAN SEA): FIVE YEARS OF RESEARCH.

TURSI, A., D'ONGHIA, G., MATARRESE, A., and PANETTA, P., Institute of Zoology and Comparative Anatomy, University of Bari, Via Amendola 165/A, 70100 Bari, Italy

This work presents data on the distribution, biology and fishery of the Cephalopoda in the Ionian Sea (Mediterranean Sea), collected during five years of research carried out from 1985 to 1989. The sampling has been done with commercial fishing gear between 10 and 650 meters of depth. Twenty-four species of Cephalopoda have been found and about ten of these are very important (approximately 18% of the commercial catch) as demersal resources. The most important commercially exploited cephalopod species living in the Ionian Sea are: Illex coindetii, Sepia officinalis, Eledone cirrhosa, Eledone moschata and Octopus vulgaris.

A METHOD FOR EXAMINING THE CONTENTS OF THE DIGESTIVE TRACT OF PARALARVAL SQUIDS.

VECCHIONE, M., NMFS Systematics Laboratory, National Museum of Natural History, Washington, DC 20560.

Starvation resulting from failure to feed successfully after absorption of the yolk reserves has been proposed to be a major source of pre-recruitment mortality in squids. In order to test this hypothesis, methods must be developed to determine the success of first feeding in the field. In paralarvae that have been stained with Alcian Blue and then cleared with trypsin, the entire digestive tract can be examined intact for the presence of food. This method was used for Abralia trigonura and Sthenoteuthis oualaniensis paralarvae from Hawaiian waters. Approximately 9% of the former and 16% of the latter contained recognizable food material, mostly crustacean fragments. Food was found in the stomach, caecum, and intestine. The smallest specimen of A. trigonura with recognizable food in its digestive tract was 2.2 mm DML, while for S. oualaniensis the smallest was 5.2 mm DML.

OBSERVATIONS ON WESTERN NORTH ATLANTIC CEPHALOPODS USING SUBMERSIBLES.

VECCHIONE, M., NMFS Systematics Laboratory, National Museum of Natural History, Washington, DC 20560, and ROPER, C.F.E., Department of Invertebrate Zoology (Mollusks), Smithsonian Institution, Washington, DC 20560.

We have compiled, with the cooperation of several investigators, a collection of 110 observations made from submersibles, primarily the Johnson Sea-Link. These observations include 75 videotape sequences; 55 cephalopods were collected, and many were photographed alive aboard ship. At least 28 species have been observed to date in this continuing study. A few species have been observed repeatedly and could be good subjects for directed studies. The methods developed for in-situ observation and collection of specimens with little or no damage allow for the first time descriptions of behavior, morphology, physiology, and distribution that are impossible with other methods.

DISSOLVED OXYGEN AND THE DISTRIBUTION OF THE EURYHALINE SQUID LOLLIGUNCULA BREVIS.

VECCHIONE, M., NMFS Systematics Laboratory, National Museum of Natural History, Washington, DC 20560

The coastal waters off Louisiana become hypoxic seasonally because of salinity stratification resulting from runoff from the Mississippi/Atchafalaya River system. During the summer, one of the few abundant nektonic species in benthic samples is the squid Lolliguncula brevis (Blainville, 1823). This is also the only eurytopic species of cephalopod commonly captured in low-salinity estuaries.

L. brevis is known to adapt to conditions of acute hypoxia, and paralarvae are often collected in discrete-depth samples from hypoxic bottom waters. Two years of monthly trawling data are presented from estuarine and coastal waters of southwestern Louisiana to indicate that older squids are commonly found in hypoxic waters.

Lolliguncula brevis ranked 8th in abundance in the coastal study but 23rd in the estuarine study. Although taken at stations with hypoxic bottom waters, L. brevis was more abundant during the same cruises at stations with higher dissolved oxygen concentrations. While their apparent capture in hypoxic water could be explained as a sampling artifact, recent observations from submersibles confirm their occurrence on the bottom in hypoxic water.

FEEDING DYNAMICS OF TWO DEEP-SEA CEPHALOPODS OPISTHOTEUTHIS AGASSIZI AND OPISTHOTEUTHIS VOSSI FROM THE SOUTHEASTERN ATLANTIC (OCTOPODA: CIRRATA).

VILLANUEVA, Roger, Instituto de Ciencias del Mar (CSIC), Paseo Nacional, 08003 Barcelona, Spain and GUERRA, Angel, Instituto de Investigaciones Marinas (CSIC), Eduardo Cabello 6, 36208 Vigo, Spain

The diet of Opisthoteuthis agassizi Verrill, 1883 and O. vossi Sanchez and Guerra, 1989 was studied from 171 and 121 stomachs, respectively. Small crustaceans and polychaetes were the most frequent prey in both species collected in the southeastern Atlantic (23°S to 27°57'S). The feeding pattern of both species was studied over two 24-hour sampling periods.

The ultrastructure of the cirra is described and the characteristic pigmentation of the digestive tract is examined. The possible trophic function of both characteristics is discussed.

OCTOPUS MAGNIFICUS (CEPHALOPODA: OCTOPODIDAE) A NEW SPECIES OF LARGE OCTOPOD FROM THE SOUTH-EASTERN ATLANTIC.

VILLANUEVA, Roger, and SANCHEZ, Pilar, Instituto de Ciencias del Mar (CSIC), Paseo Nacional, 08003 Barcelona, Spain and ROELEVELD, Martina, South African Museum, Box 61, Capetown 8000, South Africa

A new species of octopod, Octopus magnificus, is described from the southeastern Atlantic Ocean. The species is characterized by the large size of the entire animal, the relative length of the hectocotylized arm and the shape of the funnel organ. Basic life history information is presented for 131 specimens. The species is reported from 26°03'S 13°43'E to 34°29'S 25°36'E in depths of 2 to 560 meters. In Namibian waters, 85% of the specimens are from a fine sandy bottom between 400 and 550 meters depth.

ENLARGED SUCKERS AS AN INDICATOR OF A MATURE AGE CLASS IN OCTOPUS.

VOIGHT, Janet, Department of Ecology & Evolutionary Biology, University of Arizona, Tucson, AZ 85721

Inadequate separation of age classes in octopods has severely limited field studies of octopod biology. Maturation encompasses three aspects: the cessation of growth; the attainment of full sexual maturity; and the approach of senescence. Each of these aspects is predicted to be displayed by a cohort as follows. In continuously reproducing populations, mature age classes should show overall large body sizes which are relatively constant through the year. Mature males should show increased mobility, since their reproductive fitness depends on the number of receptive females they encounter. Mature animals should also show aggressiveness or decreased regeneration capacity.

An intertidal population of Octopus digueti, sampled for one year, provided data to test the hypothesis that males with enlarged suckers represent a mature age class as characterized with the above predictions about a mature age class. In O. digueti males, the presence of enlarged suckers appears to accurately indicate full male maturity.

PATTERNS OF BEHAVIORAL AND NEURONAL PLASTICITY IN APLYSIA MAY REFLECT FUNDAMENTAL DEFENSIVE PRINCIPLES.

WALTERS, E.T., Clatworthy, A.L., & Hickie, C.P. University of Texas Med. School, Houston 77225

Several laboratories have described a large number of behavioral, cellular, and molecular alterations in the opisthobranch, A. californica following noxious stimulation. To what extent do these alterations represent primitive defensive adaptations that may be phylogenetically widespread? Although a firm answer to this question will require broad comparative studies, similarities in the organization and plasticity of nociceptive systems in Aplysia and a very distantly related species, the laboratory rat, suggest that mechanisms found in Aplysia reflect common adaptations to a ubiquitous biological problem - coping with injury. On the basis of these similarities we tentatively propose a fundamental pattern of reflex and circuit modulation following trauma: 1) active escape behavior followed by prolonged quiescence, 2) biphasic modulation (transient inhibition and persistent facilitation) of defensive reflexes, 3) biphasic modulation of peripheral and central sensory representations of the traumatized region, and 4) selective facilitation of motor systems mediating defensive responses that protect the traumatized region. The actual generality of this pattern, and of underlying mechanisms that have been found in Aplysia (e.g. activity-dependent enhancement of inhibition and facilitation in nociceptive neurons representing the traumatized region) can begin to be tested in a variety of analytically advantageous molluscs.

THE RELATIONSHIP BETWEEN CUTTLEBONE MORPHOLOGY AND HABITAT DEPTH IN THE SEPIIDAE.

WARD, Peter D., Dep't. Geological Sciences, University of Washington, Seattle, WA 98195

The cuttlebones of the cephalopod genera Sepia and Sepiella are used as buoyancy devices, and thus contain gas-filled spaces susceptible to implosion at depths dictated by cuttlebone structure. Analyses of 29 species of Sepia shows that cuttlebone length, width, septal spacing, and sutural morphology are all correlated to maximum habitat depth. The deepest living species known, including S. australis, S. elegans, S. orbignyana, and S. hieronis, are all capable of descending to depths in excess of 400m; all share the characteristics of small, narrow cuttlebones with closely packed septa and modified sutures. Large species such as Sepia latimanus, S. officinalis, and S. pharaonis are restricted to much shallower depths, usually less than 200m, and show very different septal spacing and sutures than the deeper water species. These two groups serve as end members of the wide spectrum of sepiid species currently extant. Water depth may have been one of the major contributors in determining the course of sepiid evolution during the Tertiary Period.

NEUROMODULATION OF THE CONSUMATORY PHASE OF FEEDING BEHAVIOUR OF APLYSIA.

WEISS, Klaudiusz R., CROPPER, Elizabeth C., MILLER, Mark, VILIM, Ferdinand S. and KUPFERMANN, Irving. Dept. Physiol. & Biophysics, Fishberg Res. Cntr in Neurobiol. Mt. Sinai School of Medicine, NY, NY 10029; Cntr. for Neurobiol and Behav., Columbia Univ., NY, NY 10032

Two types of neuromodulation affect the consumatory feeding behavior of Aplysia. The first type is termed "extrinsic", since it is exerted by cells (the MCCs) that are not a part of mediating motor circuitry. The serotonergic MCCs exert global modulation of the system by enhancing the output of the central pattern generator, the firing of many motor neurons and the contractility of muscles. The second type of modulation, termed "intrinsic", is effected by peptide cotransmitters of cholinergic motor neurons. This type of modulation is limited to the muscle innervated by a specific motor neuron. The two types of modulation may play different behavioral roles. On the one hand, the extrinsic modulation, which exerts widespread actions, may be responsible for implementing behavioral changes associated with different behavioral states, e.g. satiation and arousal. On the other hand, the intrinsic modulation, which is limited to the target of the motoneuron, may be responsible for maintaining a smooth functioning of the system in the face of changing behavioral demands that are put on individual muscles.

NAUTILUS ; THE PHYSIOLOGY AND BEHAVIOUR OF A DEEP SEA ANIMAL.

WELLS, M.J., Department of Zoology, Downing St. Cambridge U.K. and O'DOR, R.K., Department of Biology, Dalhousie, Canada. Nautilus can be trapped at 300-400m and brought rapidly to the surface without apparent damage. It will feed, mate and survive well in aquaria, so that, for once, we can readily study the physiology of a deepwater animal in the laboratory. The confines of an aquarium mean that we can only infer the likely behavior of the animal in the open sea. A study of the respiratory and circulatory physiology of Nautilus can partially overcome this limitation by showing what the animal could do and, from the peculiar adaptations that it shows, what it probably does do, down there in the cold near-darkness. Thus we find that it tends to intermittent activity, even in the absence of food, that the smell of carrion excites it to a period of activity during which it will swim up-current, that its sustainable speed is in the region of 15 cm s⁻¹, above which it speedily runs into oxygen debt. More surprisingly that enjoys a remarkable capacity to endure hypoxic and even anoxic conditions. The heart continues to beat, very slowly, even under near-zero oxygen conditions, with the Nautilus waking up to brief periods of jetting every forty minutes or so, a behaviour that might get it out of a potentially lethal physiological trap. With its very low metabolic rate, slow growth and low fecundity, Nautilus is physiologically and behaviourally quite unlike any of the other cephalopods we have studied, but it may give us clues to the long-sustained success of extinct shelled forms.

JET PROPULSION AND THE EVOLUTION OF CEPHALOPODS.

WELLS, Martin J., Zoology Dept., Downing St., Cambridge University, Cambridge, U.K. and O'DOR, Ron K., Dep't. of Biology, Dalhousie University, Halifax Nova Scotia, B3H 4J1 Canada Cephalopods rose to dominate the mid-Paleozoic because they combined neutral buoyancy with jet propulsion. The subsequent evolution of fishes, with an inherently more economical and potentially faster locomotor system, put pressure on the cephalopods. Locomotion by ectocochleates was limited by the volume of the mantle cavity; a range of modifications exploited by the ammonites could do nothing to overcome the central problem that Thrust = mass(m) x volume(v) while the energy required rises as mv². Extension of the body outside the shell allowed a large increase in m but necessitated a switch from the shell muscles to the mantle as the means of producing the jet. Shell reduction in aid of streamlining sacrificed neutral buoyancy, again adding to transport costs. Many coleoids use fins or crawl, using expensive jet propulsion for emergencies only, and some have redeveloped neutral buoyancy by alternative means.

ULTRASTRUCTURE OF THE OLFATORY ORGAN AT THE HATCHING STAGE OF LOLIGO VULGARIS LAMARCK, 1798 (CEPHALOPODA).

WILDENBURG, Gaby, Lehrstuhl für Spezielle Zoologie, Zoolog. Inst., Huffer str. 1, D-4400, Münster, West Germany

The so-called olfactory organ of the dibranchiate cephalopod Loligo vulgaris Lamarck, 1798, covered by a brushborder of microvilli and cilia, is situated behind the eyes. It can be recognized in stage XI-XII (Naef, 1921/28) and is already accompanied by a nerve.

At the hatching point (stage XX) the pseudo-stratified epithelium consists of two types of epithelial (supporting cells) and four types of sensory cells (receptors). Epithelial cells fill the space between the sensory cells. Their nuclei are always situated in the basal part of the cell where the cytoplasm is extensive. It is sparse in the apical parts with the exception of the slightly enlarged distal ending. One type of the epithelial cells bears cilia at the top.

The sensory epithelium contains four morphological types of neurons differing in size and position of the ciliated cell-part. It varies from a small distal pocket to a spacious cave. As there are intermediate forms, the different morphological features of the sensory cells can either be interpreted as separate, distinct cell types or as forms of a morphological continuum.

An alternative hypothesis is discussed that the organ plays a part in mechanoreception.

HAIR CELL SENSITIVITY IN THE SQUID STATOCYST
WILLIAMSON, R., The Marine Laboratory, Citadel Hill,
Plymouth PL1 2PB, England.

The statocyst of the squid is thought to detect linear and angular accelerations in a way analogous to the detection systems found in the vertebrate vestibular system. Experiments were undertaken to establish whether the actual sensory structures in the squid, the statocyst hair cells, have response characteristics similar to those found for vertebrate hair cells.

Intracellular recordings were made from statocyst hair cells in the anterior transverse crista segment of the squid, *Alloteuthis subulata*. Hair cells on the dorsal side of the crista ridge are primary hair cells, having a centripetal axon. These cells were depolarised by displacing the overlying cupula in the dorsal direction. The hair cells on the ventral side of the crista ridge are secondary hair cells, having no centripetal axon, but contacting an afferent neurone. These cells were depolarised by a ventral displacement of the cupula and had a sigmoidal displacement/response curve similar to that found for vertebrate hair cells. The sensitivity of the squid hair cells was measured at 0.5 mV depolarisation per degree angle of cupula displacement. This compares with figures of 3mV per degree cilia displacement for frog saccular hair cells and 10mV per degree for turtle basilar papillar hair cells.

These results show that the secondary hair cells in the squid statocyst have sensory response characteristics and sensitivities similar to those of vertebrate hair cells.

R.W. is a Wellcome Trust Senior Research Fellow.

DISTRIBUTION OF PELAGIC CEPHALOPODS IN THE
ROCKALL TROUGH.

YAU, Cynthia, Dept. of Zoology, University of Aberdeen, Tillydrone Ave., Aberdeen, AB9 2TN Scotland, and MAUCLINE, John, Scottish Marine Biological Assoc., Dunstaffnage Marine Laboratory, Box 3, Oban, Argyll, PA34 4AD Scotland. Between the years 1973-1978, 348 cephalopod individuals were collected from the Rockall Trough area of the north-east Atlantic with the use of open combination rectangular midwater trawls (RMT), Isaacs-Kidd midwater trawls (IKMT), and 2m ring nets deployed to maximum fishing depths of over 2000m.

The most common species found, in decreasing order of abundance, consisted of *Brachioteuthis riisei*, *Teuthowenia megalops*, *Gonatus fabricii* (*G. steenstrupi*) and *Eledone cirrhosa*. Together, these four species comprised approximately 88% of all the cephalopods caught. Interpretations are offered regarding the distribution and abundance of these specimens in relation to their biology and to the hydrological features of the Trough.

MULTIPLE SITES OF SYNAPTIC MODULATION MEDIATE
BEHAVIORAL PLASTICITY IN *APLYSIA*

WRIGHT, W.G., MARCUS, E.M. and CAREW, T.J. Department of Psychology, Yale University, New Haven, CT 06520

During the last two decades, significant progress has been made in our understanding of the cellular and molecular basis of learning through the use of "simple systems". One such system is the siphon withdrawal reflex in *Aplysia*. Previous work suggested that this reflex is facilitated by application of a strong stimulus, such as electric shock to the tail. However, recent work has shown that such strong stimuli can have inhibitory as well as facilitatory effects, depending on three parameters: the state of the reflex (habituated or non-habituated), the strength of the modulating tail shock, and the time after the tail shock. The diverse nature of this behavioral plasticity suggests the possibility of multiple interacting neuromodulatory pathways, and raises the question of how such pathways are integrated to give rise to the various forms of reflex modulation produced by tail shock.

To examine this question, we monitored the siphon withdrawal reflex and net synaptic activity in identified siphon motor neurons in response to siphon stimulation. We also monitored the monosynaptic connection between identified siphon sensory neurons and the same motor neurons. Using stimulus protocols known to produce the behavioral plasticity described above, we found that tail-shock induced modulation of the monosynaptic connection paralleled some (but not all) of the diverse patterns of reflex modulation caused by tail shock. In contrast, modulation of the net synaptic activity in motor neurons elicited by siphon stimuli closely paralleled all of the changes in the reflex. These results indicate that, in addition to the direct monosynaptic connection, other neural elements make important contributions to behavioral plasticity. We are presently identifying these elements and analysing how they interact with the monosynaptic connection to modulate behaviorally relevant net synaptic activity in motor neurons.

HIGH POLYSACCHARIDE LEVELS IN *APLYSIA* PENIS.

YOUNG, Erwin S., RAM, Jeffrey L., and CAPO, Thomas R., Dept. of Physiology, Wayne State Univ., Detroit, MI 48201 & Biological Living Res., RSMAS, Univ. of Miami, Miami, FL 33149

An unexpected finding in experiments on stress effects on carbohydrate metabolism in *Aplysia* was that the highest concentrations of glycogen (or a related glucose polysaccharide) is present in the penis. In newly received field-collected 200 - 400 g animals, glycogen concentrations (μg glycogen/mg wet wt., mean \pm S.E., n=4) were: penis (P), 22.3 ± 2.7 ; hepatopancreas (HP), $1.9 \pm .9$; and ovotestis, $1.8 \pm .4$. P glycogen levels were affected relatively little by nutritional state, compared to HP. In animals fed ad lib 17-25 days (n=7), HP glycogen increased 13.5-fold; whereas, P glycogen was unchanged. In contrast P glycogen underwent developmental changes while HP glycogen stayed relatively constant: In maricultured *Aplysia*, P glycogen increased from $3.2 \pm .5$ (n=3) in 10 g animals to 10.0 ± 1.3 (n=5) in 50 g animals ($p < .05$); whereas in the same size animals HP glycogen was $2.4 \pm .5$ (n=5) and $2.0 \pm .3$ (n=5), respectively. Expts. on effects of mating: At the end of one hour of intense mating (a ring of 3 animals mating simultaneously as male & female), P glycogen was 8.5, 20.9 & 18.8; three non-mating controls had 19.1, 4.2, & 21.1. P glycogen appears to be related to reproductive maturity and not nutritional state. Possible functions may be secretory, energy storage, or structural. (supported by NIH RR 08167)

CTENOPTERYX, THE COMB-FIN SQUID IS RELATED TO LOLIGO.

YOUNG, John Z., Department of Experimental Psychology, University of Oxford, OX1 3UD, U.K.

Ctenopteryx shows a combination of unique features with others that are found only in loliginids and Pickfordiateuthis. These characters include: complete fusion of the two first order giant nerve fibers; origin of the third order fibers in a distinct giant fiber lobe; one giant fiber in each stellar nerve; suckers on the buccal lappets (also in Bathyteuthis); accessory nidamental gland; and tentacles retracted into pockets. So many similarities in various parts of the body can hardly be accidental, especially since fusion of nerve axons is very unusual. However, Ctenopteryx also shows features not present in any other squids: fins have hydromuscular rays (which will be described); statocyst has a unique partition, related to turning in the rolling plane; photosensitive vesicles unite ventrally under a shield; and there is a large photophore on the posterior end of the mantle in mature males.

Ctenopteryx should be classified nearer to loliginids than to other teuthoids, perhaps in the Myopsida (although the eye chamber is open). It is cosmopolitan but it is not clear what niche its fins and other special features enable it to occupy in the mesopelagic to bathypelagic zones. Perhaps it may be considered as a loliginid that has become adapted to deep waters.

CHIROTEUTHID AND RELATED PARALARVAE FROM HAWAIIAN WATERS: SYSTEMATIC IMPLICATIONS.

YOUNG, Richard Edward, Department of Oceanography, University of Hawaii, 1000 Pope Road, Honolulu, HI 96822

Paralarvae of the Chiroteuthidae, Mastigoteuthidae, and Joubiniteuthidae from Hawaiian waters are described along with several related paralarvae. The presence of a "doratopsis" paralarva is shown to be unique to the Chiroteuthidae and is characteristic of all genera. Relationships of non-doratopsid paralarvae, previously thought to be chiroteuthids are discussed.

HOW THE LEARNING SYSTEMS OF CEPHALOPODS COMPUTE ADAPTIVE BEHAVIOUR.

YOUNG, John Z., Dept. Experimental Psychology, Oxford University, Oxford OX1 3UD.

The success of cephalopods no doubt depends partly on their learning and adaptability. Signals from the optic lobes pass through four learning centres, with recurrent collaterals. In *Octopus* the tactile system also has four such centres. Recent work on the hippocampus and neocortex of mammals shows how such a series produces adaptive behaviour. I suggest that the centres in an octopus provide competitive matrices in which fibres that are active together become linked by strengthened synapses. Returning collaterals reinforce connections already made. Thus by a series of selections the original large number of channels is replaced by fewer cells, which constitute representations of particular patterns of input. Signals of food, trauma, etc. switch each learned pattern into appropriate behaviour.

Such a multichannel system allows for completion, that is recognition of objects seen or touched even if they are only glimpsed or are not exactly the same as those met previously.

The anatomy and connections make it likely that these lobes function as such a series of matrices. Evidence supporting the theory is that after removal of parts of the systems, learning is slowed and recognition is less accurate. The defect is proportional to the amount removed. It now becomes necessary to study the transmission through the lobes and to find the modifiable synapses responsible for the learning. A clue may be that in both visual and tactile systems one of the lobes contains numerous amacrine cells.

OBSERVATIONS ON THE MATING BEHAVIOR, SPAWN MASS AND LARVAL DEVELOPMENT OF HYDATINA PHYISIS (LINNE',1758) FROM PAKISTAN

ZEHRA, Itrat and Rukhsana PERVEEN

Centre of Excellence in Marine Biology,

University of Karachi, Karachi-75270, Pakistan

Studies on breeding season, mating behavior, egg laying, spawn mass, egg capsule structure and prehatching development of *Hydatina physis* (Linne') were undertaken. The individuals start appearing in masses from October and stay until March. Spawning season extends from mid of November till mid-February with a peak in December. During this period the individuals are seen aggregated.

Pairing in captivity is recorded for two pairs and details of mating process are given. The pairing process lasts for 25-30 minutes. Two days later these individuals copulated again for 20-30 minutes. At the time of egg laying the mother turns "up-side down", the egg ribbon (20.2mmx-10.0mm) is intensely folded with an adhesive disc. The eggs (4-6, each measuring 70 μ m) are enclosed in single layer of hyaline capsules. The development is indirect and free swimming veligers hatch after 14 days of incubation.

AUTHOR INDEX

AHLSTEDT, Steven A.	22	EDSTROM, John P.	6
ALDRICH, Frederick A.	13	EERNISSE, Douglas J.	18
ALEVIZOS, A.	14	EHRHARDT, Nelson A.	24
ALEXANDER JR., James A.	9	EMBERTON, Kenneth C.	20
ANDERS, Alice D.	11	EVANS, E.D.	18
ARNOLD, John M.	21, 23	FAIRBANKS, Lee	20
ARONSON, Richard B.	7	FALK, Xiao Chun	6
AUGUSTYN, C. Johann	23	FARLEY, Joseph	10, 16
AVILA, C.	9	FISHER, William S.	2p
BADDYR, Mohammed	17	FISHMAN, Harvey M.	8
BADGEROW, John P.	11	FONTANA, A.	9
BANNEEL, Natalie	15	FORSYTHE, John W.	10, 13, 20
BAXTER, Douglas A.	6	FRANZ, Craig J.	18
BELLO, Giambattista	17	GABEL-DEICKERT, Adrianne	10
BIDWELL, Joseph P.	15	GAGNON, Jean-Marc	15
BIELER, Rüdiger	18	GALLAGER, Scott M.	15
BOAL, Jean	7	GAVAGNIN, M.	9
BOGAN, Arthur E.	22	GILBERT, Daniel L.	17
BOLETZKY, Sigurd v.	6, 23	GILKINSON, Kent D.	15
BOND, Paul N.	23	GILLETTE, R.	6, 10
BOUCHAUD, Olivier F.	19	GILLY, Wm. F.	8
BOURGOIN, B.P.	18	GIROLAMI, Carla	10
BOYLE, P.R.	21	GLICK, David L.	8, 10
BUDELMANN, Bernd U.	8	GORDON, Mark E.	11
BULLOCK, Robert C.	18	GRECH, Doreen M.	15
BULLOCK, Theodore H.	8	GUERRA, Angel	17, 21
BYRNE, John H.	6	HADFIELD, Michael G.	16
CAPO, Thomas R.	11	HAIMOVICI, Manuel	10, 11
CAREFOOT, Thomas	15	HAMILTON, Paul V.	16
CAREW, T.J.	6	HANLON, Roger T.	7, 10, 20, 21
CARLSON, Bruce A.	21	HATFIELD, Emma M.C.	17
CASTRO, B.G.	21	HAVLIK, Marian E.	22
CHIA, Fu-Shiang	16	HELLMICH, Mark R.	10
CIGLIANO, John A.	10	HICKIE, C.P.	6
CIMINO, Guido	9	HOAGLAND, K. Elaine	20
CLAES, Michael	10	HOCHBERG, F.G.	24
CLARKE, Malcolm R.	23	HOOPER, Scott	14
CLATWORTHY, A.L.	6	HOPP, Hans-Peter	6
CLEARY, Leonard J.	6	IRIBARNE, Oscar O.	10
COAN, Eugene V.	18	JACKINTELL, Lori A.	21
COELHO, M.L.	24	JACKLET, Jon W.	8
COHEN, Larry	6	JACKSON, George D.	19
COOK, Susan B.	11	JEREB, P.	10, 17, 21
CORNETT, R.J.	18	JOHNSON, Keith A.	7
COVICH, Alan P.	9	KABAT, Alan R.	18
COX, Rachel L.	8	KANZ, James E.	15
CRISPINO, Antonio	9	KAVALIERS, M.	6
CROPPER, Elizabeth C.	14	KIER, William M.	13
CROWL, Todd A.	9	KNIGHT, R.L.	23
DAVIS, George M.	22	KOESTER, J.	14
DE SANTIS, A.	8	KOOL, Silvard P.	20
DEVLIN, C.L.	10	KOSS, Ron	16
DeWITT, Thomas J.	9, 11	KUNCIO, Gerald S.	21
DEXTER, Ralph W.	20	KUNIGELIS, Stan C.	11
DILLON JR., Robert T.	9	KUPFERMANN, Irving	14
DIMARCO, F. Paul	10	KUZIRIAN, Alan M.	11, 14, 15, 18
DI MARZO, V.	9	KUZIRIAN, Kara L.	11
DIMOCK JR., Ronald V.	11	LAMBERT, Walter J.	15
D'ONGHIA, G.	21	LANDMAN, Neil H.	21
DUNLAP, Paul V.	20	LANG, Michael A.	19, 21
DUTRA-CLARKE, Ana	20	LAUENSTEIN, Gunnar G.	18

LEE, P.	10	SATTERLIE, Richard A.	14
LEE, Phillip G.	7, 20	SAUNDERS, W.B.	23
LE GOFF, Ronan	17	SCHACHAT, Frederick H.	13
LEONARD, Janet L.	6, 9	SCHELTEMA, Amélie H.	18
LEVITT, Jenifer L.	15	SCHERER, Tracy	10
LIPA, S.	6	SCHÖFER, Wolfgang	13
LONGLEY, A.J.	9	SCHUMAN, Erin	16
LONGLEY, R.D.	9	SCHWARTZ, Owen	10
LU, C.C.	21	SILVA, M.	11
LUKOWIAK, Ken	6	SKELTON, Martin E.	10
MANGOLD, Katharina M.	23, 24	SMITH, David A.	7
MARCUS, E.M.	6	SODANO, Guido	9
MARTINEZ-PADRON, Manuel	6	SOINILA, Seppo	6
MATARRESE, A.	21	SOLIMAN, Gamil N.	18
MATHER, Jennifer A.	7, 23	SOLIS-RAMIREZ, Manuel	17
MAUCHLINE, John	11	SPINELLA, Aldo	9
McDOWELL CAPUZZO, Judith M.	15	STRANKS, T.N.	21
MEADOWS, S.	10	STRASZYNSKI, Elizabeth B.	11
MESSENGER, John B.	8	STRENGTH, Ned E.	9
MIKKELSEN, Paula M.	11	STRUMWASSER, Felix	8, 10
MILLER, Mark	14	SWEENEY, Michael J.	13
MORRIS, Claude C.	13	TAKAYAMA, Koichi	13
MORSE, Daniel E.	16	TAMSE, Catherine T.	11, 14
MORSE, Patricia M.	10	TANKERSLEY, Richard A.	11
MOYNIHAN, Martin H.	20	TEMPST, Paul	10
MPITSOS, George J.	6	TEWARI, Kirti P.	8
MUNTZ, W.R.A.	7	TEYKE, Thomas	14
NAGLE, Gregg T.	14	THEYEL, Tina M.	11
NAZIF, Fidelma	6	TIGERT, Susan J.	15
NIXON, M.	21	TOLL, Ronald B.	13, 15, 19
NORMAN, Mark D.	21	TSCHERKASSKY, Martin	11
O'DOR, R.K.	7, 10, 19, 23	TSUCHIYA, Kotaro	23
OKUTANI, Takashi	13, 23	TURGEON, Donna D.	18
OSBORN, Steven A.	20	TURK, Philip E.	20
OSSENKOPP, K.-P.	6	TURSI, A.	21
PACKARD, Andrew	8, 10, 17	TYSDALE, D.	6
PAINTER, Sherry D.	14	VARDARO, R.R.	9
PANETTA, P.	21	VECCHIONE, M.	21, 23, 24
PASCOE, Philip	23	VILIM, Ferdinand S.	14
PEARCE, Timothy A.	15	VILLANI, Guido	9
PECHENIK, Jan A.	15	VILLANUEVA, Roger	17, 19
PEREZ, Jose A.	10, 11	VOIGHT, Janet	24
PERVEEN, Rukhsana	9	WALTERS, E.T.	6
PIATKOWSKI, Uwe	13	WARD, Peter D.	19
PIRES, Anthony	16	WEISS, Klaudiusz R.	14
PORTELL, Roger W.	22	WEISS, Robert S.	7
PREZANT, Robert S.	15	WELLS, M.J.	7, 10, 19
PRIOR, David J.	14	WETHINGTON, Amy R.	9
QUAST, William D.	15	WILDENBURG, Gaby	19
RAGONESE, S.	10, 17, 21	WILLIAMSON, R.	8, 10
RAM, Jeffrey L.	11, 14	WRIGHT, W.G.	6
RATHJEN, Warren F.	21	WU, Jian-young	6
REID, Amanda L.	13	YAU, Cynthia	11
RIDGE, Richard J.	8	YOUNG, Erwin S.	11
ROBERTSON, J.D.	10	YOUNG, John Z.	8, 19
RODANICHE, Arcadio F.	24	YOUNG, Richard E.	17
RODHOUSE, P.G.	13	ZEHRA, Itrat	9
ROLEVELD, Martina	19	ZHANG, Feng	14
ROLLINS, Harold B.	15	ZIMMERMAN, Kerry M.	15
ROPER, Clyde F.E.	13, 23, 24	ZITZ, J.	10
ROSEN, Steven C.	14		
ROSENBERG, Gary	18		
SALCEDO-VARGAS, M. Alejandro	11		
SANCHEZ, Pilar	19		

NOTES

NOTES

NOTES