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The newsletter contains information concerning meetings and conferences, publications of interest to echinoderm biologists, titles of theses on echinoderms, and research interests and addreses of echinoderm biologists. Individuals who desire to receive the newsletter should send their name, addresss, and research interests to the editor.

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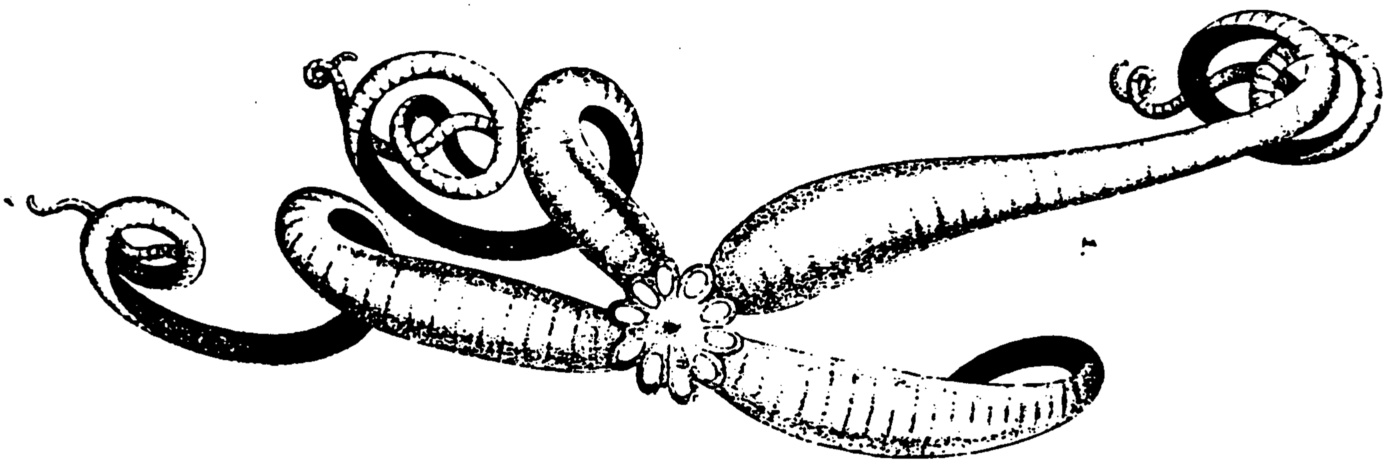

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Individuals who desire to be listed in the next newsletter are requested to send their numbers to the editor.

Addresses of other echinoderm workers will be most welcome.

A network for individuals with e-mail addresses has been set up by

Win Hide
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The Echinoderm Newsletter is distributed through the network.

Hide edits STARNET, an e-mail newsletter for echinoderm biologists.
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REQUESTS AND INFORMATION

Contents of GBRMPA. Crown-of-thorns starfish research update 1991/92. (U. Engelhardt, B. Lassig, eds.). Published by the Great Barrier Reef Marine Park Authority, PO Box 1379, Townsville, Q 4810, Australia.

Lassig, B. The research continues.
Moran, P. Current status of outbreaks.
Babcock, R. Spawning.
Black, K. Computer models show us where starfish larvae disperse.
Keesing, J., Recruitment.
Johnson, C. Deep water recruitment hypothesis and the riddle of juveniles.
Stump, R., J. Lucas. Ageing of crown-of-thorns starfish.
Keesing, J. Feeding.
Done, T. How long will it take for the Great Barrier Reef to recover?
DeVantier, L. Impact of the crown-of-thorns starfish on massive coral reefs.
Lassig, B. So, what causes outbreaks?

Port Erin Marine Laboratory - Centenary 1992

Symposium, 16-18 September 1992. The marine resources of the Irish Sea; experimental ecology; ecophysiology and behaviour; evolution and genetics.
Museum exhibit, 20 July - 6 January 1993. The surrounded Sea - 100 years of Manx Marine Biology. Liverpool City Museum.

Library Database. The Library, Marine Biological Association of the United Kingdom, Plymouth. The Library has catalogued papers of interest to the MBA and PML scientists as well as all papers on British waters, and all papers on marine pollution world-wide. References back to 1985 are being added to the Library Database, and this can be searched for all aspects of research on British waters and marine pollution.

Ophiuroid taxonomy. Seiichi Irimura is seeking students to assist in work on the taxonomy of Japanese ophiuroids.

Jack Cohen, B.D. Massey (Univ. Birmingham), A. Frettsome (Plymouth Marine Laboratory) are studying the effectiveness of sperm fertilization of *Psammechinus miliaris*. About 1/1000 sperm fertilze under experimental conditions regardless of the number of eggs.

V.G. Klikushin (St. Petersburg Paleontological Laboratory) is studying pentacrinids and has recently published a monograph on them.

Chantal Conand is now at: Laboratoire de Biologie Marine, Universite de La Reunion, 15 Avenue Rene Cassin, 97489 Saint-Denis cedex, France. La Reunion is a volcanic island in the Indian Ocean.

S. Johnsen (Univ. of North Carolina, Chapel Hill) is studying the responses of echinoderms to polarized light.

Botsford, L.W., J.F. Quinn (Bodega Marine Laboratory, University of California at Davis) at studying the spatial management of the northern California red sea urchin fishery. The population of S. franciscanus in northern California has declined nearly one-third. This study is designed to describe the variability in population dynamics over space and time to assist agencies regulating the fishery.

D.J. McKenzie and M.S. Kelly (Scottish Marine Biological Association, Dunstaffnage Marine Laboratory) have been studying the sub-cuticular bacteria of echinoderms from the British Isles. Twenty-five of fifty-one species examined have SCB. The distribution of SCB among species and taxa is very curious.

Maeve Kelly was awarded the Bank of Scotland Waitangi Fellowship to do research at the Portobello Marine Laboratory, University of Otago, Dunedin, New Zealand in the fall of 1992. She collaborated with Michael Barker in studies on the potential vertical transmission of sub-cuticular bacteria in ophiuroids.

John Himmelman (Universite Laval) is spending a sabbatical year (1992-1993) at the Instituto Oceanografico de Venezuela, Universidad del Oriente and the Gatty Marine Laboratory, University of St. Andrews.

Disease in Strongylocentrotus purpuratus and Strongylocentrotus franciscanus: Mortality from disease for these species was reported by Dayton et al in 1992 (P.K. Dayton, M.J. Tegner, P.B. Edwards. 1992. Temporal and spatial patterns of disturbance and recovery in a kelp forest community. Ecological Monographs. 62, 421-445). Dayton reports he has noted the disease since he started studying in the southern California area in 1970, and that Wheeler North and John Pearse saw it before that. He has observed it to cover areas ranging from hectares to ca. 1 square kilometer. He is willing to collect specimens for anyone interested in identifying the pathogen.

J.D. Gage (Scottish Marine Biological Association, Dunstaffnage Marine Laboratory) is comparing growth rates of shallow-water and deep-water echinoids. He and Paul Tyler (Oceanography, Southampton) are collaborating in a dietary study of starfish species from the Rockall Trough. Both of them and Craig Young

(Harbor Branch Institution) have been studying the reproductive biology of deep-sea echinoids.

Mark Wilcox (Dunstaffnage Marine Laboratory) is studying the genetic basis of salinity tolerance in Asterias rubens.

Aykio Agatsuma (Hokkaido Central Fisheries) is interested in the population dynamics and reproductive biology of sea urchins. He is studying Strongylocentrotus nudus, S. intermedius, and Hemicentrotus pulcherrimus.

K. Emily Knott (University of Alabama) is interested in the use of molecular techniques in studying the phylogenetic systematics of echinoderms.

Nina L. Leibson (Institute of Marine Biology, Vladivostok) is studying the regeneration of holothuroid tissue, emphasizing the digestive tract.

Echinoderms at the Australian Museum (Sydney)
(communicated by Dr. Penny Barents, Collection Manager)
Many of you are no doubt aware that Dr. Frank Rowe has left research and the Australian Museum, Sydney, to return to less sunny climes. Our large, well maintained collection bears testiment to Frank's diligent labours. Comprehensive in the eastern Australian fauna, the collection also represents shallow and deep-water species of the wider Indo-Pacific, Antarctic regions and beyond. And of course, the Austrlaian Museum is host Xyloplax spp. (Concentricycloidea) - fondly known as "Daisy". The collection continues to grow with the collection manager and four technical offiers. The dry collections are in controlled environment storage and the records are being put in computers. The Lizard Island Research Station, far North Queensland, is a facility of the Australian Museum. The directors there, Dr. Anne Hoggett and Dr. Lyle Vail, are both echinoderm researchers. So although Frank is no longer with us, our collections and interest in echinoderms continues. We invite any workers to make use of our collections and facilities. Enquiries may be directed to the Collection Manager, Marine Invertebrates.

SCHEDULED MEETINGS

LARVAL ECOLOGY MEETINGS
Marine Sciences Research Center
State University of New York
Stony Brook, New York, 11764-5000
20-22 August 1993 (tentative)
S.G. Morgan (516-632-8668), R.K. Cowen (516-632-8711), W. Wise (516-632-8656)
FAX (516-632-8820)

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1259 Trumansburg Road

Ithaca, NY 14850-1398 USA

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non-related organisms. Much of his interpretation is based on the larvae of echinoderms, particularly ophiuroids and echinoids.

Williamson, D.I. 1992. Larvae and evolution. Chapman & Hall. Williamson suggests the anomalies between adults and larvae of many groups, including echinoderms, resulted from the capture by organisms of genes from other organisms. These genes were incorporated into the genome of the host organisms and expressed in larval or juvenile stages. The book considers echinoderms and their lavrvae, the affinitie of echinoderms, the metamorphosis of echinoderms, the relationship between sea-urchins and brittle-stars.

NEWSLETTERS

Beche-de-mer Information Bulletin. No. 4. July 1992.
Fisheries Information Project
PO Box D5, New Caledonia

Group coordinator: Chantal Conand, Laboratoire Oceanographie Biologique, Universite de Bretagne Occidentale, 29287 Brest, France.

Contents:

Tuwo, A., C. Conand. Developments in beche-de-mer production in Indonesia during the last decade.

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Arakawa, K.Y.A handbook on the Japanese sea cucumber--its biology, propagation, and utilization.

Lokani, P. First results of an internal tag retention experiment on sea cucumber.

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Sea Urchin, Kelp, Abalone News. No. 1. March 1993.

Available from the editor:
Dr. Leon T. Davies
Sea Grant Extension Program
University of California
Department of Wildlife and Fisheries Biology
Davis, CA 95616-8751

COTS COMMS

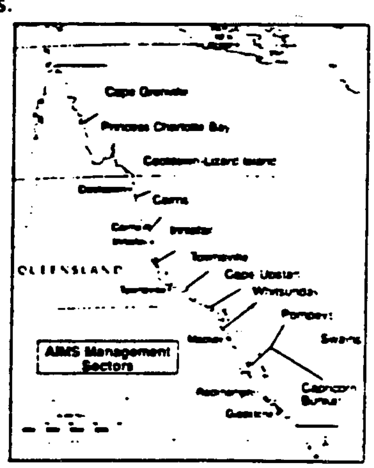
Dr Brian Lassig and Udo Engelhardt

Current COTS

Since the last issue of COTS COMMS the AIMS survey team has been to the two extremes of the Marine Park - the Swain and Capricorn/Bunker Sectors in the south and the Far Northern Section (I'll resist the tautology!). Active crown-of-thorns starfish (COTS) outbreaks were observed on two reefs in the Swains (Gannet Cay and Snake Reef) and, with coral cover on these reefs exceeding 50% away from the localised aggregations, the outbreaks seem likely to be around for some time to come.

The Capricorn/Bunker reefs maintained their consistency of having no COTS visible to manta towers, but they too have problems. The cover of hard corals was less than 30% on all of the four reefs in this sector surveyed. The coral cover at One Tree Island and Lady Musgrave Island had decreased significantly since last year's survey, probably as a result of cyclone Fran which visited the area in March last year. Lady Musgrave in particular seems to be suffering, going from a hard coral cover of >75% in 1986/87 to a level of <10% this year. A bid by the Authority for additional funds from the Federal Government to more closely investigate this dramatic decline was unsuccessful.

Sixteen reefs were surveyed in the Far Northern Section which includes three of AIMS' Sectors - Cape Grenville, Princess Charlotte Bay and Cooktown/Lizard Island. No outbreaks were observed although several of the surveyed reefs are recovering from previous outbreaks.



Swan ~~Song~~ Poem

As the last issue of COTS COMMS announced, Professor John Swan has retired from the chair of the Crown-of-thorns Starfish Research Committee (COTSREC) and been succeeded by Professor Graham Mitchell. John commemorated the occasion of his retirement by bequeathing the following literary legacy:

***The Age of Reason and* Acanthaster planci**

Under the December moon, more often under sun,
Chance encounters during spawning, there are almost none.
The female egg, as ever was the case,
Attracts the male sperm to her embrace.
And chemotaxis, as the name implies,
Makes no distinction 'twixt the foolish and the wise.
And what is more, the oft-observed communal aggregation,
Ensures for all a most successful starfish propagation.

Gastrula! Bipinnaria! Brachiolaria!
Fourteen days of buoyant freedom, sometimes twenty-eight,
A pea-soup diet, *Dunaliella*, presently their fate.
Then down they go! To bed with crustose algae and *Lithothamnium pseudosorum*.
Now watch each starfish grow from its remarkable primordium.

Then come the fish, the crabs, the worms
Their brothers, sisters, cousins,
That finally reduce our *Acanthaster* population
From the millions to the dozens.

A few more months and then, the promised land!
Where milk and honey flow from coral strand.
White scars appear on branching staghorn corals,
And far away - the muted roar of academic quarrels.

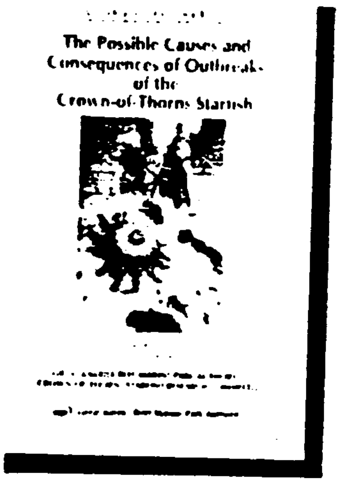
"It's predator removal"; "Heavy rainfall after drought";
"It's the farmers"; "It's El Nino"; "Larval transport without doubt".
It seems the reef is "under threat",
And who to blame? - the Managers, I'll bet.

But Johnson points to H. McCallum's optimistic simulations:
"The patterns of the starfish plagues in reef sub-populations,
Are cyclical, or quite chaotic, numbers high or low,
Depending on the larval pulses, water movement, ebb and flow."

The oceans are resilient, their systems are robust,
Life forms adapt, evolve and flourish; corals will adjust.
So shoot the foxes, feral cats, the pigs, the goats and rabbits,
But learn to love the crown-of-thorns;
accept its natural habits.

Causes and Consequences

The proceedings of a COTS workshop ('The Possible Causes and Consequences of Outbreaks of the Crown-of-Thorns Starfish') held in Townsville in June last year has finally been printed. The publication contains 17 contributions covering a variety of research and management aspects of the Authority's COTS program. Abstracts of the papers were included in Issue #10 of COTS COMMS. The real thing (168 pages) can be obtained by contacting either Brian Lassig or Udo Engelhardt of the Authority.



COTSREC Confabulates

COTSREC met in Townsville on 19 January 1993 for its first meeting with Professor Graham Mitchell as Chair. The meeting was primarily concerned with the research program's progress with some discussion of directions in the 1993/94 financial year.

The Committee made a number of recommendations that will be put to the Marine Park Authority for approval. These included support for a project by Dr Kerry Black of the Victorian Institute of Marine Sciences to investigate field testing of hydrodynamic models (contingent upon substantial Australian Research Council funding); maintenance of the Australian Institute of Marine Science crown-of-thorns starfish rearing program for a further 3 years (subject to the availability of funds and specimens), and collaboration with the Cooperative Research Centre (a consortium of agencies comprised of AIMS, GBRMPA, James Cook University, Queensland Department of Primary Industries and the Association of Marine Park Tourist Operators) in hydrodynamic and water quality programs to achieve mutual goals.

Local Controls

Can and should outbreaking populations of COTS be controlled? This rather emotive question has split public and scientific opinion for many years. The long standing policy of the Great Barrier Reef Marine Park Authority (GBRMPA) on this issue is not to interfere on a large scale unless it can be shown that outbreaks are initially caused or exacerbated by human activity (Kelleher 1993). However, local control efforts may be initiated in an attempt to protect sites of particular value to tourism or science. Scientific reviews of this matter have supported the Authority's policy.

Historically (ie. in the past 10-15 years), local-scale attempts to control starfish populations have relied largely on the use of a toxic agent such as copper sulphate ($CuSO_4$). Preliminary field experiments into methods suitable for controlling the starfish were conducted at Green Island in the early 1980s. The researchers concluded that of the variety of chemical agents tested, $CuSO_4$ had some outstanding properties, making it the most effective and efficient agent available (Hicks and Blackford 1981). Their work suggested that approximately 7 - 9.5 ml of $CuSO_4$ may be sufficient to kill individual starfish. However, their report did not provide any information on possible seasonal or size dependent variability in the actual amount of toxic compound required to kill starfish. Copper sulphate injections have since been the preferred means for controlling local scale populations of starfish.

Although the latest *wave* of COTS outbreaks appears to be coming to an end, some relatively large populations remain on reefs in the Whitsunday Region and further south in the Swains complex. A relatively large, *outbreaking* (?) population of COTS can still be found at Bait Reef off the Whitsunday Islands. This *typical* mid-shelf reef is located some 35 nautical miles off the coast in the Central Section of the Great Barrier Reef Marine Park.

Bait Reef is the main focus for the local diving

FOSSIL ECHINODERM COLLECTIONS -- MUSEUM FÜR NATURKINDE ZU BERLIN

During April 1992, I had the opportunity to examine the fossil echinoderm collections at the Museum für Naturkinde, der Humbolt-Universität zu Berlin (the Natural History Museum in the former East Berlin) during the Berlin Week, sponsored by the German Fulbright Commission. With this brief report, I wish to inform echinoderm paleontologists of the availability, magnitude, general content, and crinoid holdings of this important collection.

The Museum für Naturkinde is best know for its specimens of Archaeoptryx (the oldest bird; holdings include the best single individual, arguably the most significant fossil specimen, and an isolated feather) and for the largest mounted dinosaur, a splendid specimen of Brachiosaurus. In addition the Museum für Naturkinde houses a quite significant fossil echinoderm collection, including many type specimens and other referred collections. The Echinoderm collection fills approximately 35 ranges (13 drawers per range). Material is arranged systematically and is divided among Paleozoic crinoids (seven ranges), Mesozoic and Cenozoic crinoids (five ranges), blastozoans and homalozoans (two and one-half ranges together), Paleozoic echinoids (less than one range), Mesozoic and Cenozoic echinoids (17 ranges), asteroids (two ranges), and ophiuroids (one and one-half ranges).

Time permitted only a careful examination of the crinoids. This material is curated very well and includes more that 70 primary types, principally from localities in Germany. Primary types are from the work of H.E. von Beyrich, O. Jaekel, C.F. Roemer, and W.E. Schmidt. The collection was apparently amassed largely degree during the beginning of this century under the curatorships of Beyrich and Jaekel. Strengths of the crinoid collection are materials from Germany. Excellent collections include the pyritized crinoids from the Lower Devonian Hunsrückschiefer, Budenbach and vicinity, Germany; the Lower Devonian Coblentzian, Germany; the Middle Devonian Eifelian fauna; the fauna from the Lower Triassic Muschelkalk; and crinoids from the Jurassic Solenhofn Limestone.

Collections from outside Germany were presumably part of trades or purchases, perhaps from Frank Springer, U.S. National Museum of Natural History, and F.A. Bather, British Museum (Natural History). These presumed acquisitions include representative collections from the Lower Mississippian of Crawfordsville, Indiana, USA; the Silurian of Gotland, Sweden; and the Lower Carboniferous (Tournaisian) of Yorkshire, England. Smaller collections from outside Germany include Late Ordovician of Cincinnati, Ohio, USA; Silurian of western Tennessee, USA; southern Indiana, USA; northeastern Illinois, USA; and Dudley, England; Lower Mississippian of central Tennessee, USA and eastern Iowa, USA; Jurassic of England; and the Cretaceous of England. The only type and figured specimens from the United States are specimens from Roemer (1960), from the Late Silurian of Decatur County, Tennessee. A few other non-German type specimens include material from Bohemia, Columbia, and Russia.

During this visit I also learned of the existence of the

Roemer-Pelizaeus-Museum in Hildesheim, Germany[1]. Work at this museum includes a determination of the deposition of fossil collections which formed the basis of C.F. Roemer's scientific papers. Roemer was one of the earlier European scientists to make fossil collections in the New World and to name new species. Fossil echinoderms were named in at least (9) publications from 1844 to 1881, and many type and figured specimens were deposited in European museums.

Dr. Hermann Jaeger, Director of the Paleontological Institute, and Dr. Erika Pietrzeniuk were gracious hosts during my visit to the Museum für Naturkinde. Please feel free to contact me if you would like any additional information, including further data on Paleozoic crinoid primary types.

Roemer, C.F. 1860. Die silurishce Fauna des westlichen Tennessee. E. Trewendt; Breslau, Poland; 100 p.

[1]Dr. Helga Stein
Roemer-Pelizaeus-Museum
Am Steine 1-2
W-3200 Hildesheim
GERMANY

William I. Ausich
Department of Geological Sciences
155 South Oval Mall
The Ohio State University
Columbus, OH 43210 USA

Crown-of-thorns Starfish on the Great Barrier Reef:

Reproduction, Recruitment and Hydrodynamics

Editor: Craig Johnson

Crown-of-thorns Starfish

Crown-of-thorns Starfish on the Great Barrier Reef:
Reproduction, Recruitment and Hydrodynamics

Edited by Craig Johnson
Department of Zoology, University of Queensland

(Reprinted from *Australian Journal of Marine and Freshwater Research*, Volume 43, Number 3, 1992)

Contents

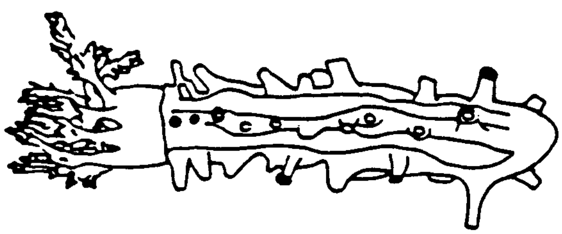
THE FAUNA OF

THE CLYDE SEA AREA

ECHINODERMATA

by

I.C. WILKIE, B.Sc., Ph.D.



OCCASIONAL PUBLICATION
No. 6

UNIVERSITY MARINE BIOLOGICAL STATION
MILLPORT
ISLE OF CUMBRAE

1989

The Kyles of Bute, from Forbes (1841).

ECHINODERM STUDIES

Edited by
MICHEL JANGOUX
Université Libre de Bruxelles, Belgium

JOHN M. LAWRENCE
University of South Florida, Tampa, USA

VOLUME 4

A.A. BALKEMA / ROTTERDAM / BROOKFIELD/ 1993

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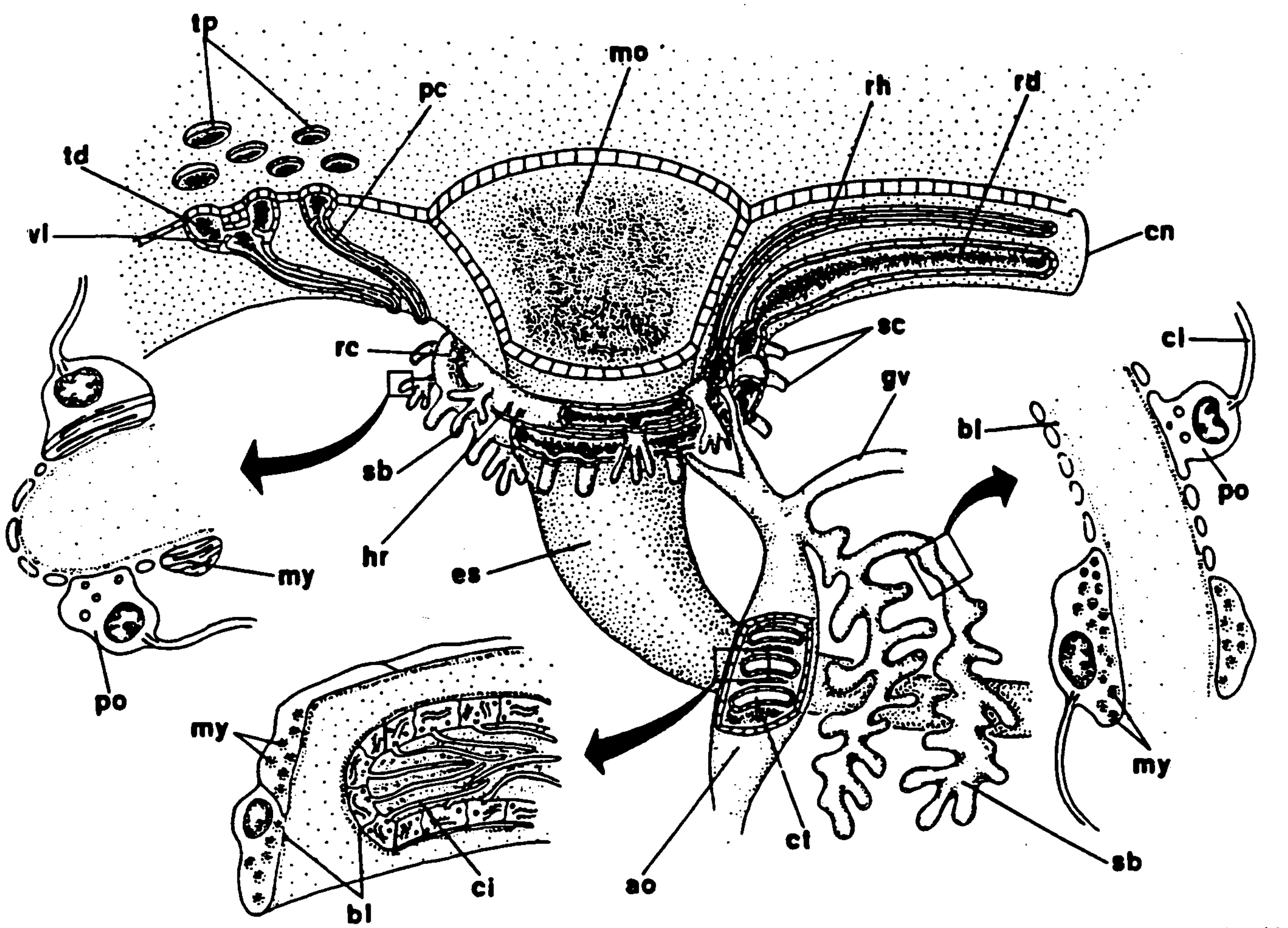

Fig. 1. Reconstruction of the oral axial organs of a comasterid crinoid based on serial thick sections for light microscopy and representative thin sections for electron microscopy. *ao* Axial organ; *bl* basal lamina; *ci* cilium; *cn* connective tissue; *ct* cellular tube; *es* esophagus; *gv* genital blood vessel; *hr* hemal ring; *mo* mouth; *my* myocyte, myofilaments; *pc* parietal canal; *po* podocyte; *rc* ring canal; *rd* radial canal; *rh* radial haemal canal; *sb* oral and axial parts of spongy body; *sc* stone canal; *td* tegmenal duct; *tp* tegmenal pore; *vl* valve. BALSER & RUPPERT 1993

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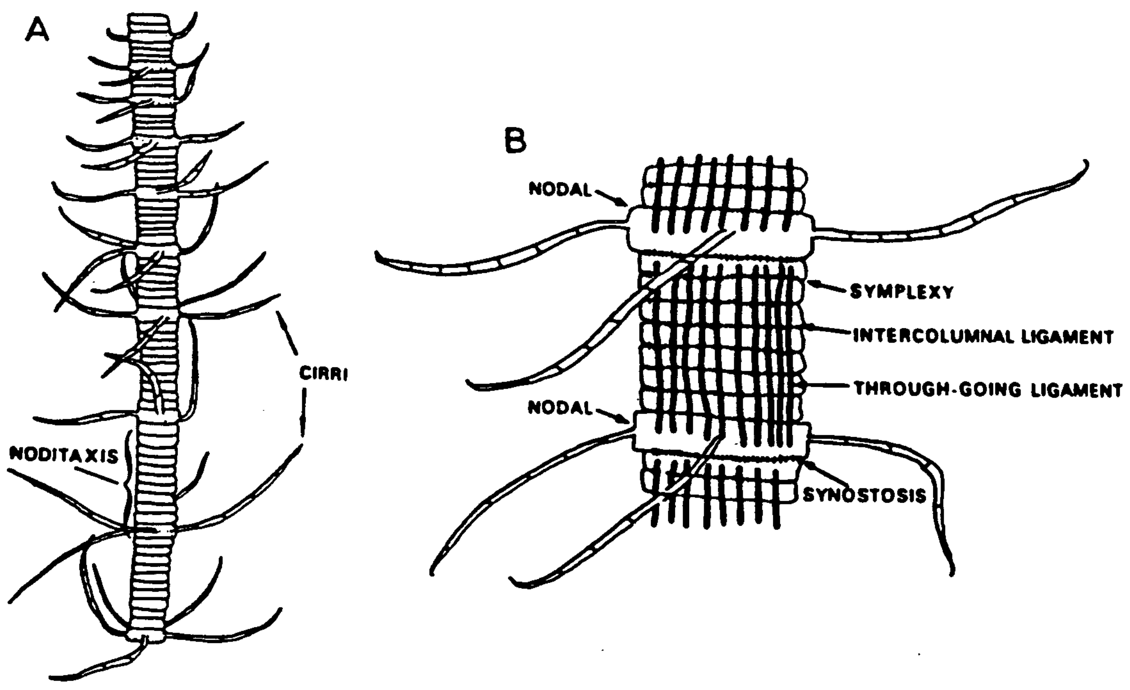

FIGURE 3. A schematic diagram of an isocrinid stalk. A, The proximal (top) and medial parts of the stalk are represented. Nodals are stippled. Note that the number of columnals/noditaxis increases distally in the proximal portion; it reaches a more or less constant value in the medial and distal portions. B, Partial segment of the medial or distal portion of the stalk. The through-going ligament connects a single noditaxis. Note that only intercolumnal ligament is present at synostoses whereas both types of ligament are present at symplectial articulations.

Baumiller + Ausich 1992

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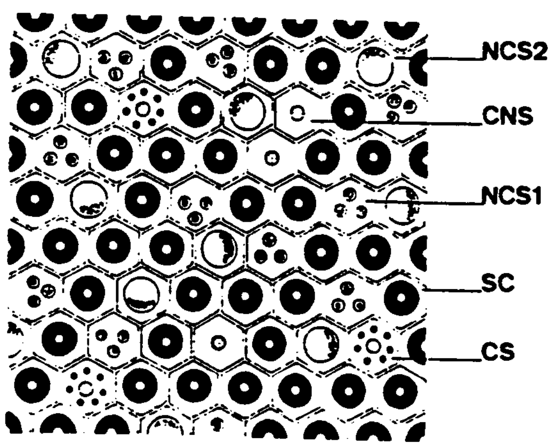

Fig. 14. Diagrammatic representation of a transverse section through the apex of the disc epidermis (not to scale). *CNS*, ciliated non-secretory cell; *CS*, ciliated secretory cell; *NCS1*, type 1 non-ciliated secretory cell; *NCS2*, type 2 non-ciliated secretory cell; *SC*, support cell

C.A. Freire et al.: Growth and spatial distribution of *Cassidulus mitis*

Table 1. *Cassidulus mitis*. Total numbers of females, males and individuals of indeterminate sex collected from February 1986 to January 1987, and sex ratio (female:male) as a function of arbitrary size class (gonopores were not detectable at < 10 mm length)

Sex	Test length (mm)					Total
	≤10.00	10.05–20.00	20.05–30.00	30.05–40.00	≥40.05	
Female	0	58	91	95	36	280
Male	0	16	83	67	27	193
Indeterminate	88	76	8	0	0	172
Total	88	150	182	162	63	645
Sex ratio	-	3.6	1.1	1.4	1.3	1.5

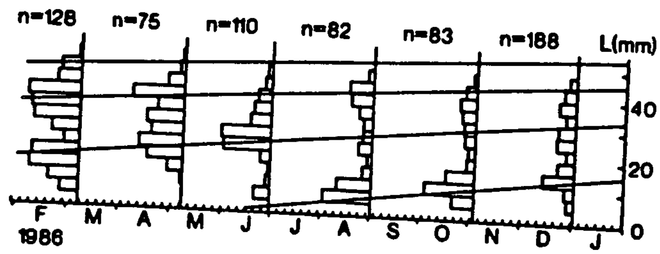

Fig. 4. *Cassidulus mitis*. Size-frequency (length, *L*) distribution over investigation period. Data are grouped bi-monthly, and growth curves of four size-cohorts are superimposed on histograms

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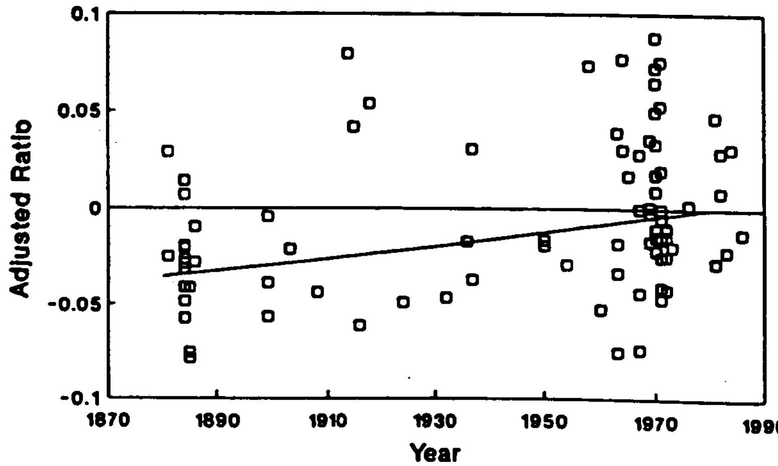

Fig. 2. *Diadema antillarum* demipyramid/test length ratio as a function of time. Ratios are allometrically adjusted (see Table 1). Regression equation: ln adjusted ratio = 0.00435time − 10.923, $R^2 = 0.114$, $P < .002$. (Time is in years and 0.1 is added to the ratio to remove negative numbers and allow for a natural logarithmic transformation.)

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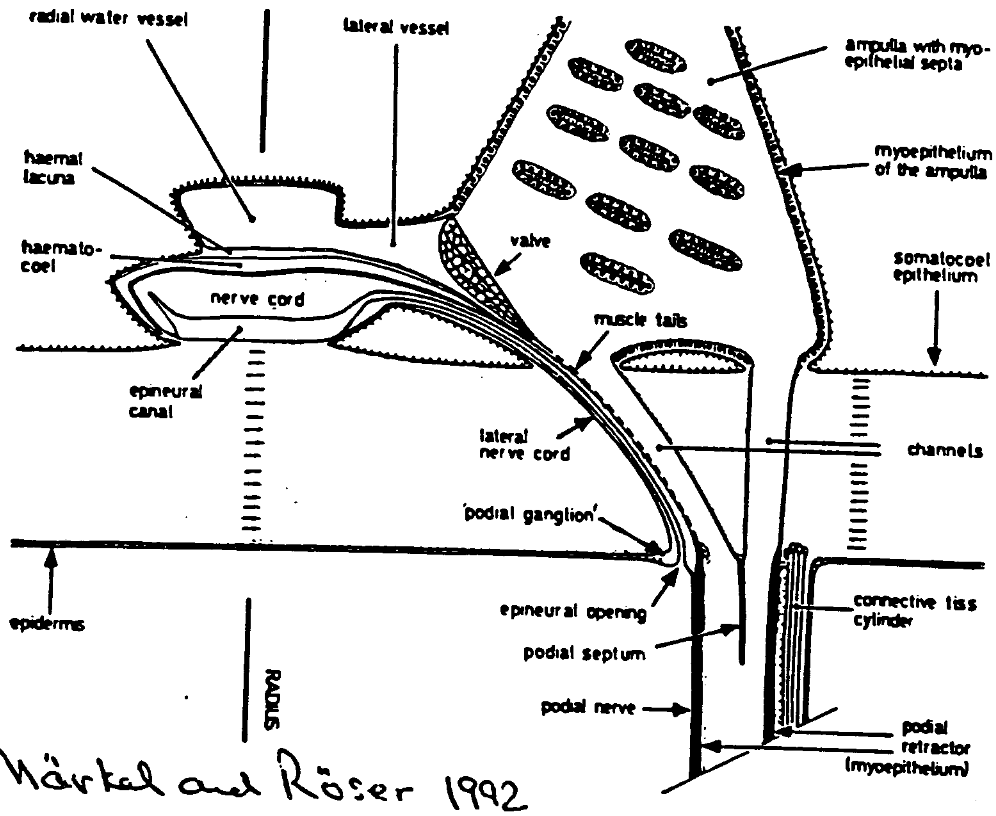

Märkel and Röser 1992

Fig. 11. Schematic representation of the radial organ complex with lateral branches to the right. The pore slit lies in the drawing plane and is not shown. The fact that the lateral nerve cord turns for about 90° around the perradial channel is ignored. Take note of the connection between the podial retractor muscle and the muscle tails (*broken line*) opposite to the 'podial ganglion'. *Hatched* the test plates. Not to scale

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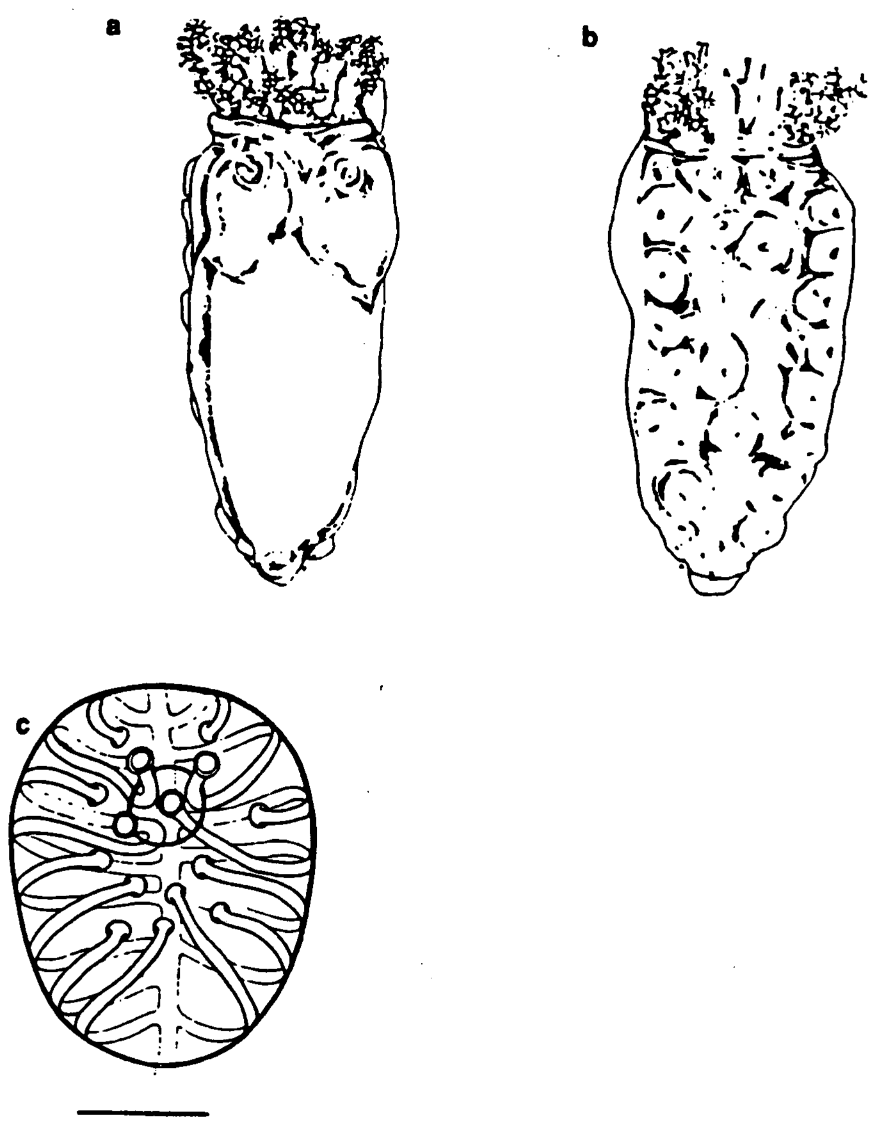

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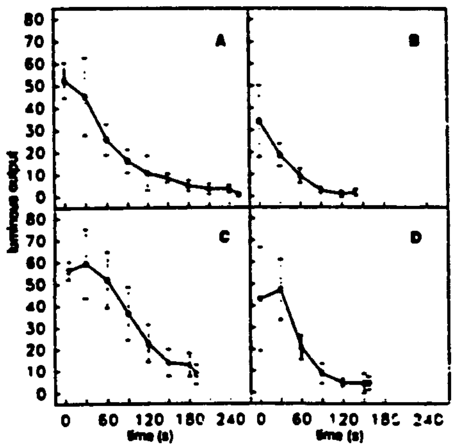

Robison 1992

Figure 3. Video image-analysis plots of the decay rate of luminescent output over time. Luminescent output is measured as the mean number of individual light sources within four 100 cm² areas on the face of the experimental vessel. The error bars are standard deviations for the four areas. (A) is the result of the initial stimulation of specimen #1; (B) is the re-stimulation of specimen #1, after all the light particles from the initial stimulation had gone dark. (C) & (D) are the initial and re-stimulation decay plots of a second specimen.

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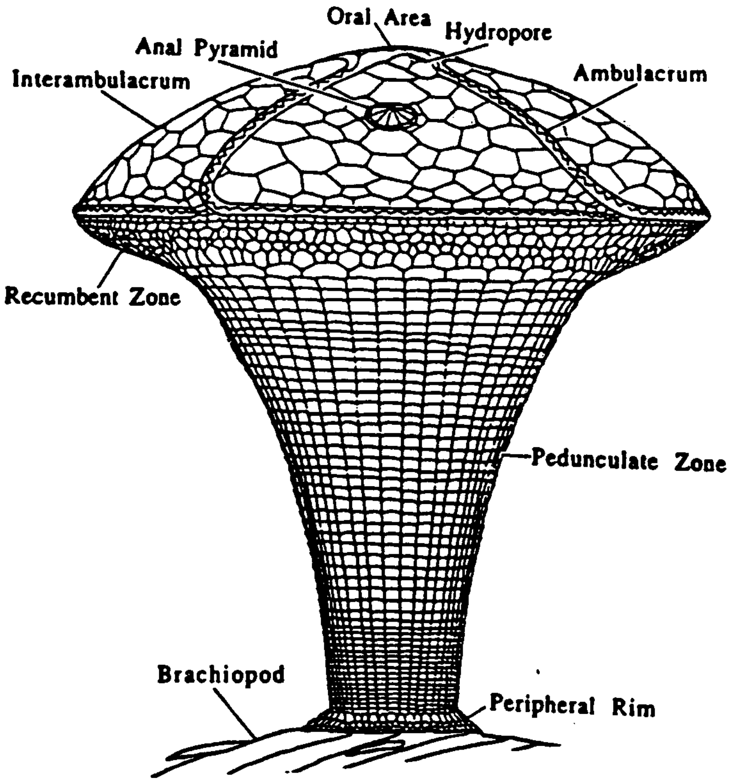
TABLE 6. Summary statistics on genetic structure in five species of sea stars in Alaska

	Species				
	Le	Lh	Lp	Et	Po
No. of locations collected	4	1	1	2	3
Total no. of animals collected	344	69	60	193	322
No. of loci examined*	16 (7)	16 (9)	25 (7)	25 (11)	24 (8)
Observed heterozygosity (H_o)	0.132	0.145	0.084	0.038	0.084
Expected heterozygosity (H_e)	0.135	0.151	0.083	0.050	0.092
Mean fixation index (F_{IS})	0.008	0.045	−0.030	0.247	0.088
Population heterogeneity (F_{ST})†	0.156	—	—	0.023	0.006



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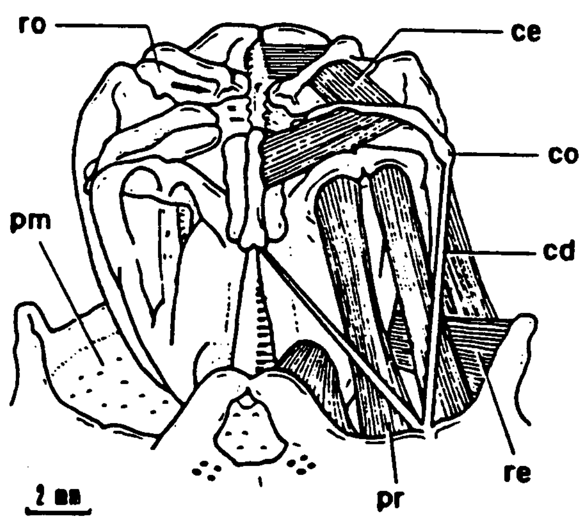

Fig. 1. Diagrammatic representation of the lantern of *Paracentrotus lividus*. The peripharyngeal coelomic membranes are omitted. Only the soft tissue components of the right side have been included: on the left side the insertion facets of the muscles are indicated by *stippling*. *cd* compass depressor; *ce* compass elevator; *co* compass; *pm* peristomial membrane; *pr* protractor muscle; *re* retractor muscle; *ro* rotula. *Arrow* indicates one of the pair of ligaments that link the compass to the rotula

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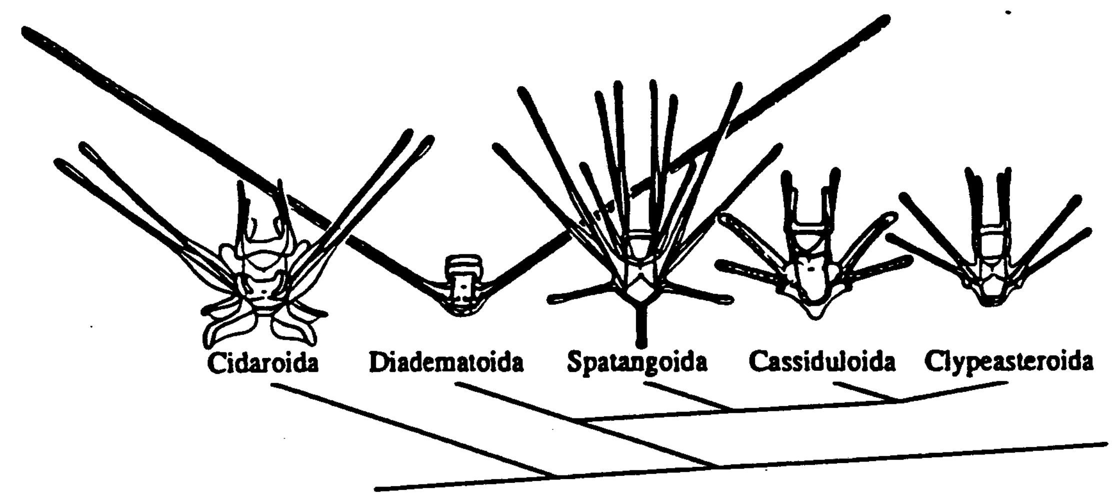

FIGURE 1. Diversity in echinopluteus larvae with planktotrophic development. The overall form of echinoplutei varies considerably between orders and within some orders. Illustrated are representative echinoplutei from several orders and families. Most of these clades themselves contain a significant diversity in echinoplutei. Species shown,

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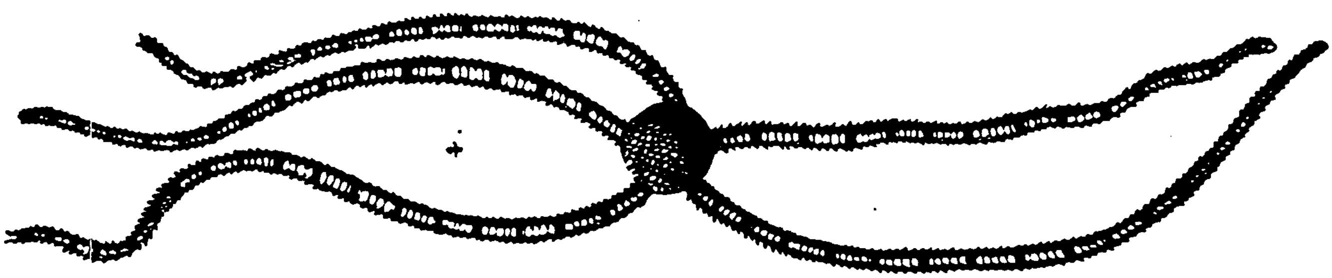

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Shick, J.M., W.C. Dunlap, R.M. Larsen. Accumulation of UV photoprotectants in coral reef holothuroids (Echinodermata). 43A.
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Oppenheimer, S.B., and 23 co-authors. Mapping developmental changes in sea urchin sugar receptors using lectin beads. 85A.
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Hart, M.W. Larval feeding performance and egg size evolution in echinoids. 114A.
Hendler, G. 150 million years of swimming brittlestars in brief114A.
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Shinner, G.O., J.B. McClintock. Structural characteristics of marsupial brood pouches of the Antarctic spatangoids Abatus nimrodi and Abatus shackletoni. 128A.
Smith, S.M., J.H. Dearborn. Ophiuroid tube feet: comparative

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Lacalli 1993

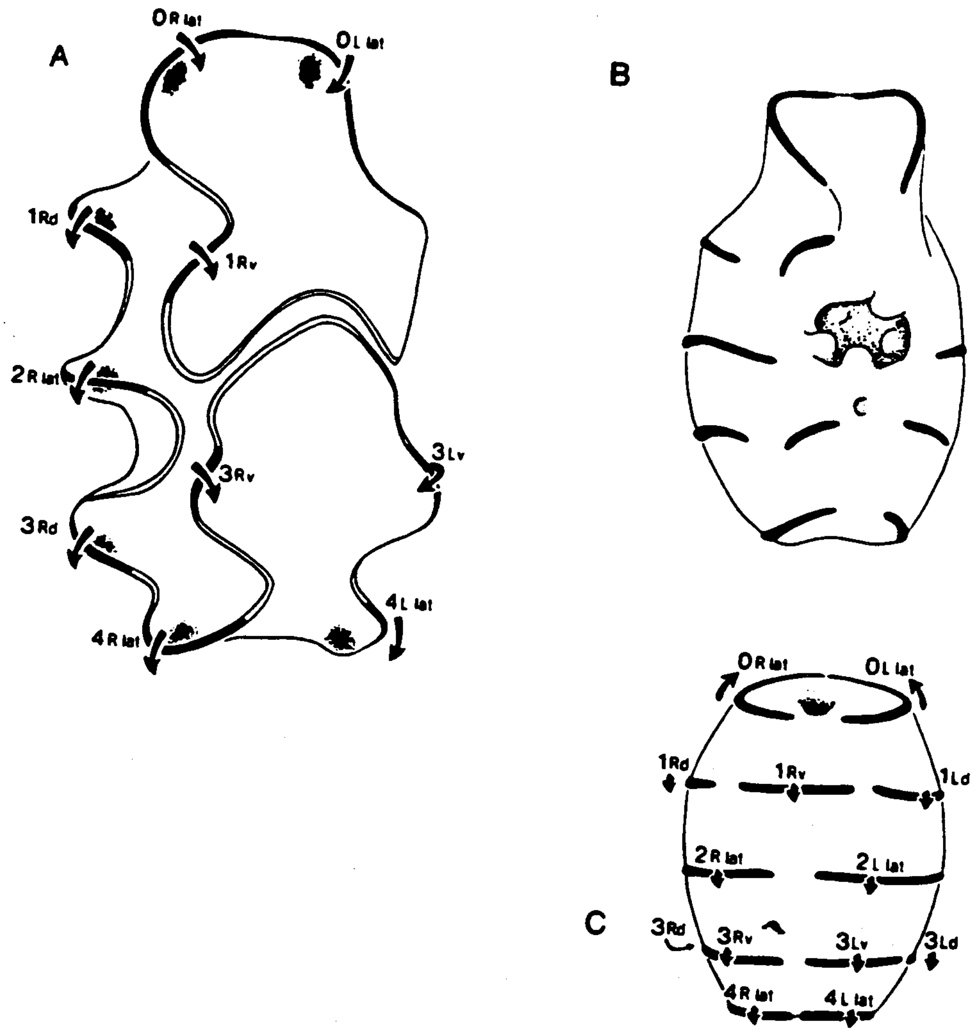

Fig. 2. Summary diagrams of the auricularia-to-doliolaria transition in *S. californicus* showing the origin and positional shifts of the band segments retained bv the doliolaria

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JOHN LAWRENCE

FRIENDS OF ECHINODERMS

1992

HARBOR BRANCH OCEANOGRAPHIC INSTITUTION, INC.

10, 11 July 1992

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McClintock, J.B., S.A. Watts, K.Marion and T.S. Hopkins. Reproductive biology of two deep water sea stars from the northern Gulf of Mexico.

Slattery, M. and I. Bosch. Possible costs of brooding and embryonic development in an antarctic sea star.

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Norris, D.R. Distribution, growth and sediment interactions of an infaunal deposit feeder (*Maretia planulata* Lamarck) in a tropical soft bottom community.

Stancyk, S.E., W.E. Dobson, and R.B. Aronson. Sublethal tissue loss by *Ophiura sarsi* on the North Carolina Continental Slope.

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<u>1991 ANNUAL MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA -- SAN DIEGO, CALIFORNIA</u>, October 21 to October 24, 1991. Geological Society of America Abstracts with Program 23(7). (communicated by W.I. Ausich).

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Beadle, S.C. Heterochrony and eccentricity: A new model for the oral surface morphology of dendrasterid sand dollars.

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Llewellyn, G., and C.G. Messing. Local variations in modern crinoid-rich carbonate bank-margin sediments.

Messing, C.G. Variations inposture, morphology & distribution relative to current flow and topograpy in an assemblage of living stalked crinoids.

Sprinkle, J. Origin of echinoderms in the Paleozoic evolutionary fauna: New data from the Early Ordovician of Utah and Nevada.

Sumrall, C.D. Plate morphology in stalker edrioasteroids.

Taylor, W.L., and C.E. Brett. Silurian crinoid Lagerstätten: Taphonomic and ecologic windows.

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Brower, J.C. Growth and functional morphology of <u>Euptychocrinus skopaios</u>, a dwarf camerate crinoid from the Ordovoician.

Greenstein, B.J. A temporal gradient of taphonomic overprint and the diversity history of the family Cidaridae (Echinodermata: Echinoidea).

<u>1992 NORTH-CENTRAL SECTION MEETING OF THE GEOLOGICAL SOCIETY OF AMERICA</u> IOWA CITY, IOWA, April 30 to May 1, Geological Society of America Abstracts with Program 24(4). (communicated by William I. Ausich)

Blake, D.B., and T.E. Guensburg. Caught in the act: A Late rdovician asteroid and its pelecypod prey.

Meyer, D.L., and T. Oji. Experimental taphonomy of a recent stalked crinoid: implications for the crinoid fossil record.

Schumacher, G.A., and M.R. Caudill. Combined flow storm-generated crinoid taphonomy: an example from the Upper Ordovician, Cincinnatian Series in northeastern Kentucky.

Terry, R.E. Echinoderm taphofacies within the Banff Formation (Lower Carboniferous; Alberta): Western versus eastern facies belts.

<u>FIFTH NORTH AMERICAN PALEONTOLOGICAL CONVENTION</u> CHICAGO, ILLINOIS, June 28 to July 1, 1992, Fifth North American Paleontologial Convention Abstracts and Program, The Paleontological Society Special Publication 6. (communicated by William I. Ausich)

The Cretaceaus crinoid <u>Uintacrinus</u> was part of the logo for the meeting, appearing on advertisements, the abstracts volume, and tee shirts.

Baumiller, T.K. The energetics of passive suspension feeding: ecological and evolutionary consequences for crinoids.

Brower, J.C. Ontogeny and functional morphology of <u>Eoparisocrinus crossmani</u>, a cladid crinoid from the Middle Ordovician

Donovan, S.K., and C.J. Veltkamp. A Rhuddanian (Silurian: Lower Llandovery) echinoderm fauna from Haverfordwest, southwest Wales

Foote, M. Early morphological diversity in blastozoan echinoderms.

Guensburg, T.E., and J. Sprinkle. Environmental controls of rapidily diversifying echinoderms during the Early Paleozoic.

Holterhoff, P.F. Ecophenotypic variation and phylogeny within the Erisocrinaceae (Crinoidea): linkage of morphology, ecology, and sea-level in the Late Paleozoic.

Kammer, T.W., and W.I. Ausich. Demise of the middle Paleozoic crinoid fauna: gradual or mass extinction?

Maples, C.G., J.A. Waters, N.G. Lane, and H.-f. Hou. Paleobiogeographic significance of Famennian echinoderm faunas from northwestern China.

Nebelsick, J.H. Actuopaleontological investigations of shallow water Red Sea echinoids.

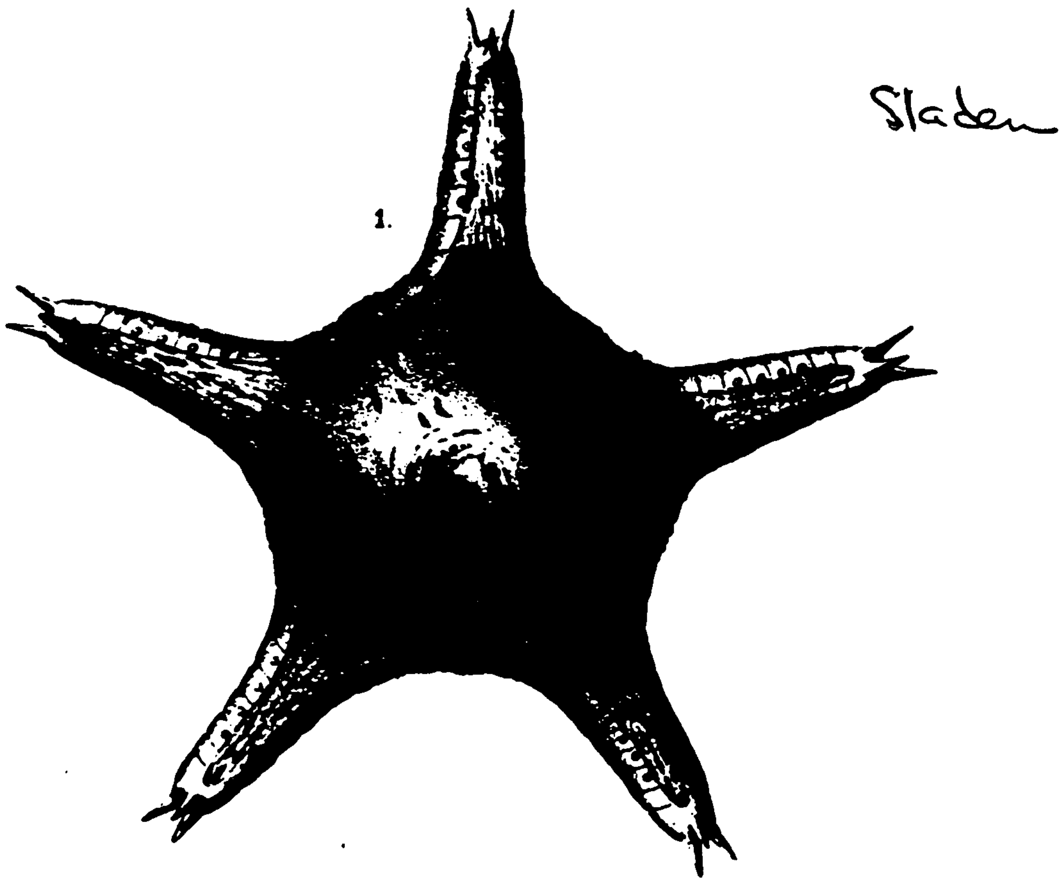
Oji, T., and S. Amemiya. Long survival of stalk pieces of Metacrinus rotundus Carpenter, a modern stalked crinoid, in an aquarium.

Polson, E.S., J. Lawrence, and L.L. Robbins. Shell matrix proteins -- a potential tool for investigating the phylogenetic relationships of Echinodermata.

Smith, A.B., and R. Christen. Morphological and molecular rates of evolution in post-Paleozoic echinoids.

Sumrall, C.D., and J. Sprinkle. Could edrioasteroids move?

Terry, R.E., and D.L. Meyer. A unique taphonomic profile for Lower Carboniferous crinoids of western Canada and possible Recent analogs.



AILSA'S SECTION

Echinoderms in culture

Reinhard, J. 1992. Sacred peaks of the Andes. National Geographic. 181 (3). p. 93: "The Cuzco market sells plenty of the small sacrificial bundles called **despachos**, like the ones the yatiris had taken to Illimani. These may contain items such as **starfish**, cookies, minerals, miniature metal figurines, seashells, incense, llama fat, and cocoa leaves and are remarkably like the offerings I have dug up from centuries-old Inca ceremonial platforms on the peaks."

Echinoderms in literature

Durrell, L. 1990. Caesar's vast ghost. Arcade Publishing, N.Y. "The virtue of such a beginning will become obvious when one wants to extend one's travels, for Arles is like a **starfish** in a central position, extending its arms in all directions."

Echinoderms in art

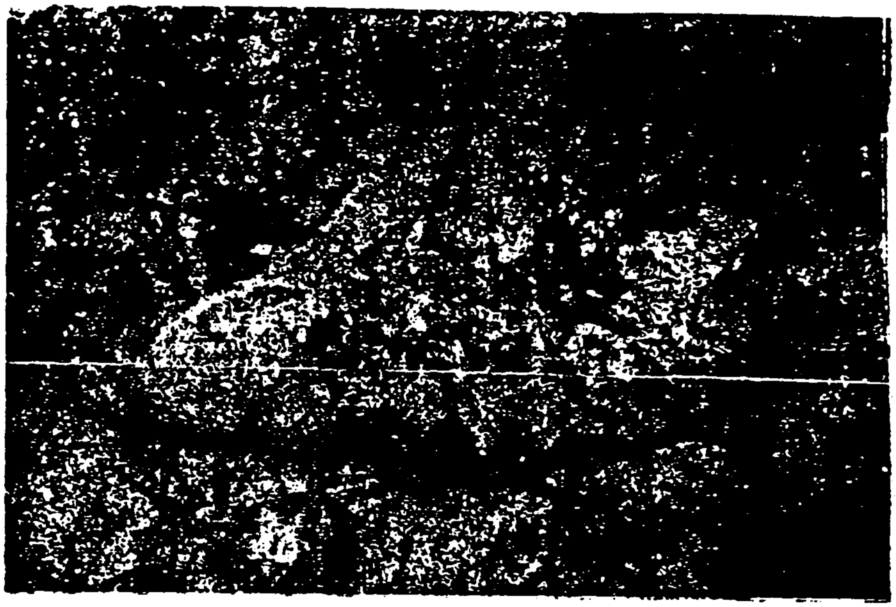
William Hogarth (British, 1697-1764): "The Mackinnen Children, 1747" Elizabeth is holding a fold in her skirt that contains various shells and, prominantly, the clean test of a sea urchin. As the sea urchin has an oblong shape, it is almost certainly Echninometra. (contributed by Fred Hotchkiss)

Echinoderms in poetry (?)

(communicated by Penny Barents)
SONG/ODE TO A SEA-DAISY
Daisy, Daisy, give me your answer, do.
I'm half crazy over the Phylogeny of you.
You won't make a stylish Cladogram.
With your shape why should you give a damn.
But we might have known,
With that sperm of your own,
You'd out-class your relatives too.

4) TAHITI

DEUX RECETTES POUR PREPARER LE RORI



RORI A LA CHINOISE

Recette du Jade Palace.

Les «Rori U» sont achetés dé- sséchés. C'est l'opération que nous avons montré hier. Ils sont dans un premier temps cuits à l'eau pendant trois heures, puis trempés dans l'eau froide pendant 18 heures.

Ensuite on remet à bouillir 3 heures et de nouveau tremper 18 heures dans l'eau froide, puis rebouillir jusqu'à trois ou quatre res.

On laisse sécher et l'on découpe en morceaux les «Rori U».

Les morceaux sont ensuite sautés à la poêle, puis l'on mélange les morceaux avec de la sauce huître, du soja, de l'huile de sésame du jus de gingembre et du rhum.

On mélange le tout que l'on fait cuire 3 à 5 minutes à l'étouffée. C'est à ce moment que l'on peut ajouter des champignons ou des abalones ; dernière cuisson de 3 mn à l'étouffée - Servez c'est prêt à manger.

RORI A LA TAHITIENNE

C'est le plat «Rori Taioro», que l'on peut trouver le dimanche matin tout préparé au marché.

Les espèces d'holothuries utilisées ne sont pas les «Rori U» mais celles plus faciles d'accès qui peuplent nos lagons à faible profondeur.

Laver le «rori», enlever les viscères et les gonades, oter la peau, découper le rori en morceaux.

Faire bouillir à feu tahitien (jusqu'à 4 heures) de manière à ce que les morceaux soient bien tendres.

Le taioro est du coco râpé très fin, auquel on mélange le jus exprimé de 2 à 3 têtes de chevrettes écrasées dans un linge. Laisser fermenter une nuit dans un récipient couvert de feuilles de burau.

On mange les morceaux de «rori» accompagnés de cette sauce.

Consumer usage

The cook's preparation for beche-de-mer takes on some of the aspects of persuading a sponge to take up a lot of liquid. After all the care that the processor takes to dry it for storage, the cook must take equal care to reconstitute the product to obtain a high quality dish.

There are thousands of cookbooks but few present information on such an exotic collection of foodstuffs as "Unmentionable Cuisine" by Calvin W Schwabe. (published by the University Press of Virginia, Charlottesville, Virginia, 22903). Even if you have no intention of cooking, you would enjoy this book. Dr Schwabe gives the following directions for the preparation of sea cucumbers: 14

Recipe

Basic preparation

Dried sea cucumbers, if not purchased pre-soaked, must be treated by a fairly involved process. First, soak them for four hours in cold water and then scrub them with a brush. Place them again in cold water, bring to boil, cook for five minutes, and allow to cool in the water again. Repeat this process ten times. The meat then is swollen and soft and ready to use in the following recipe:

Stewed sea cucumbers (Dun hoi sun)/China

Place eight prepared sea cucumbers in cold water. Bring to boil, simmer five minutes and drain. Then simmer them for about 20 minutes in about three cups chicken stock and cut the drained meat into large pieces. Discard the stick. Stir-fry the meat for about two minutes with a little light soy sauce in some hot oil in a wok. Remove the meat. To another wok add some fresh oil, heat it, add two green onions cut into 1½ inch length, about six thin slices of ginger, two tablespoons sherry, and the sea cucumbers. Stir-fry a bit and add three tablespoons light soy sauce, dashes of pepper and Ajinomoto, ½ teaspoon sugar, ½ tablespoon dark soy sauce and ½ cup fresh chicken stock. Cook on high heat for two minutes. Add one tablespoon cornstarch dissolved in two tablespoons cold water and ½ tablespoon sesame oil. Stir well and serve.

Mrs Bruce, a freelance writer, researched and wrote several articles on fish species and seafood for INFOFISH during a recent prolonged stay in South East Asia. N° 6/83

communicated by
Chantal Conand

From a chinese cook book

coeficiente de 0.65; es decir, presenta casi los dos tercios de su valor alimenticio.

El producto de la región indopacífica contiene 15 a 30% de cenizas, 35 a 52% de proteínas y de 21 a 23% de agua; los carbohidratos faltan, pero existe una pequeña cantidad de grasa (Greshoff y Sack, 1900; Greshoff y van Eck, 1901).

El producto del Mediterráneo parece ser aún más nutritivo, contiene de 56 a 65% de proteínas; 13 a 24% de cenizas, cerca de 0.7% de grasas y 10 a 11% de agua (Sella, 1940). Según Frankel y Jellinek (1927), la proteína, que existe en el *trepang*, es completamente soluble en pepsina, por lo que este producto parece ser muy fácilmente digerible. En algunos lugares de la región indopacífica, los holoturoideos son irritados hasta provocar la evisceración y los tubos de Cuvier y las gónadas, son entonces comidas en crudo.

El material ya seco es cortado en pequeñas piezas las que son usadas para condimentar las sopas o estofados y se dice que imparten un delicioso aroma. Cuando el *trepang* es cocinado, cada pedazo se hincha y adquiere un aspecto gelatinoso.

Receta de una Sopa Hecha con Trepang

Esta receta ha sido tomada del libro de Cherbonnier G., 1954, págs. 111, 112. "Se remojan a las holoturias en agua fría durante 4 horas y se les quita la delgada piel que las cubre, la cual se separa de ellas con relativa facilidad. Para 500 gramos de holoturias, se requeman 3 centilitros de aceite, en el que se freirán hasta dorarse, 20 gramos de ajos y 200 gramos de carne de cerdo, la cual se habrá cocido con anterioridad y rebanado en rodajas delgadas. Cuando está todo junto, se añaden las holoturias y se les deja cocer a fuego lento por espacio de 5 minutos. A todo lo anterior, se añade un cuarto de litro de consomé de pollo, una cucharada de sopa de soya y se deja cocer todo ello, a fuego lento, durante unos 15 minutos.

Lo expuesto anteriormente, no pretende dar una explicación detallada, de lo que hasta ahora se conoce con el nombre de *trepang*, ni mucho menos. Tan sólo se ha tratado de reunir algunas de las referencias más interesantes, que tuvieran algún interés, desde un punto de vista de divulgación general, con el fin de dar a conocer este interesante y peculiar producto marino.

Verdura cinese o cavolo di Tientsin, con trepang.

In un po' d'olio si frigge la verdura (cruda). Salare. Un momento prima di servire si aggiungerà il trepang.

Costole di maiale (ossa lievemente ricoperte di carne) *con trepang.*

Si friggono ben bene le ossa di maiale, spruzzandole con un po' di salsa di soya, dopo di che s'aggiungerà un pizzico di farina ed un po' di brodo. Sale, pepe. Si lascia cuocere per molto tempo. Un momento prima di servire si aggiungerà il trepang.

Per secoli e secoli, fatto curioso, il trepang è rimasto un cibo esclusivamente cinese, quasi un ghiotto attributo di quella razza e le altre popolazioni marinare, pur avendo a portata di mano oloturie a dovizia, non ne hanno imitato l'esempio. Chi di essi ha ragione ? Probabilmente hanno ragione i cinesi e il loro segreto deve consistere in una certa delicatezza, non facilmente imitabile, nel modo di preparare la vivanda, se è vero questo aforisma di una graziosa giapponesina : « Gli europei cucinano per il cervello, i giapponesi per gli occhi ed i cinesi per il palato ». Ma nei tempi odierni, molti cambiamenti che non si sono prodotti durante secoli possono verificarsi in pochi anni.

Le oloturie seccate e indurite, scrive Seale, sembrano immangiabili e solo quando siano state trasformate in una zuppa deliziosa dalle abili mani di un cuoco cinese, si comprende il reale pregio di questi frutti del mare. I quali vivono nei giardini di alghe sulla bianca sabbia e fra i coralli, nutrendosi di animaletti marini e di vegetali, e non v'è perciò ragione che non debbano appartenere alla classe dei cibi squisiti e non entrino nell'uso comune degli europei e degli americani ».

Fig. 7.

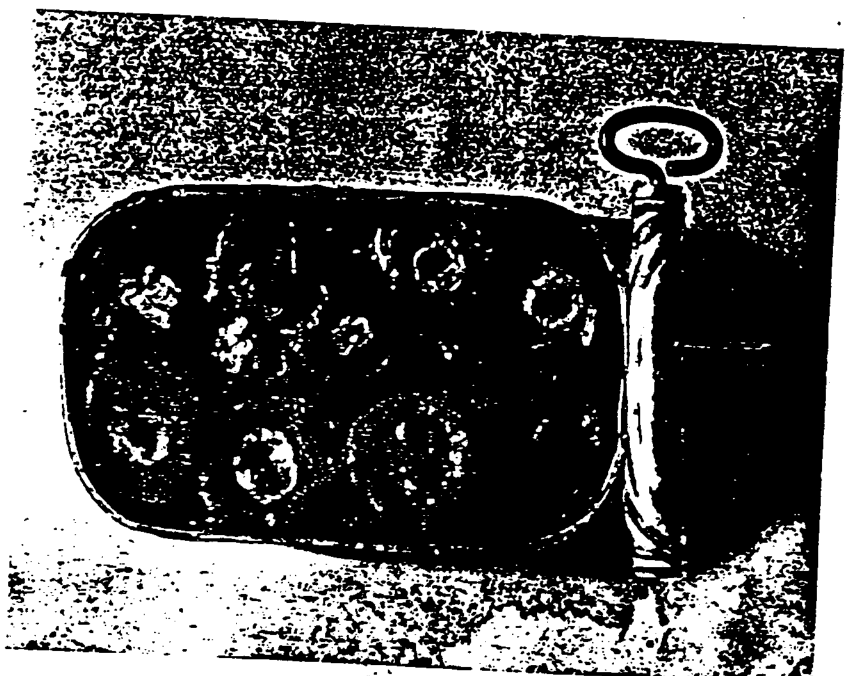


Fig. 8 - Anelli di *H. tubulosa* fresca spellata, in salsa di pomodoro piccante.

Carbajal. 1900. Zoological Record. Fuegians eat sea-urchins and starfish in fabulous quantities, til their stomachs are tight as drums, not withstanding cointinued indigestion due to economical methods of cooking.

in: Sella & Sella 1940
L'industria del Trepang
communicated by Chand de Conand

14

Lo « Hai-shen » (trepang) viene immerso nell'acqua per qualche giorno prima di usarlo, quindi viene bollito fino a che sia diventato morbido. Solamente dopo questo processo le oloturie vengono tagliate traversalmente in tanti pezzi della lunghezza di un pollice (non risulta che venga mai grattugiato) ed aggiunto alle pietanze sempre un momento prima di servirle. Lo « Hai-shen » per se stesso non ha nessun sapore e può essere aggiunto a qualsiasi pietanza, sia carne (di pollo o di maiale) o siano verdure. Non ha la proprietà di rendere le pietanze gelatinose. Sul mercato può essere acquistato già rammollito. I ristoratori cinesi lo cucinano soltanto quando viene ordinato appositamente.

Ricette

Brodo di trepang.

Nel brodo di pollo aggiungere il trepang tagliato a pezzi. Salare se vi è bisogno e servire caldo.

Trepang in salsa bianca.

A una certa quantità di brodo di pollo, aggiungere un po' di salsa di soya, un po' di farina, un pizzico di pepe ed unirvi il trepang tagliato a pezzi; lasciar cuocere fino a che quest'ultimo abbia preso bene la salsa. Servire caldo.

Trepang in salsa di pomodoro.

Nel brodo di pollo sciogliere la salsa di pomodoro. Sale e pepe ed un pizzico di farina. Mentre il tutto bolle aggiungervi il trepang tagliato a pezzi e lasciar cuocere. Servire.

Trepang con polpette di carne di maiale.

Si tritura la carne di maiale alla quale si aggiungerà sale, pepe ed un pochettino di zenzero, un po' di cipolline novelle tritate, alcune castagne d'acqua pure tritate finemente ed un giallo d'uovo. Farne delle polpette e friggerle. Allorchè saranno ben fritte, si ritireranno dalla padella e si terranno al forno ad una temperatura mediocre. Nel sugo che sarà rimasto nella padella mettere mezzo cucchiaio di farina, alcuni funghi di bambù (rammolliti), un po' di brodo ed un poco di salsa di soya. Dopo un momento di cottura, vi si rimetteranno le polpette ed il trepang. Si lascierà cuocere il tutto un momento ancora e si servirà.

Pollo e castagne con trepang.

Si frigge il pollo tagliato a pezzetti. Si aggiungono le castagne crude, alcuni funghi di bambù (rammolliti), mezzo cucchiaio di farina, un po' di salsa di soya, brodo, sale e pepe. Si lascia cuocere il tutto ed in ultimo, un momento prima di servire, vi si getterà il trepang.

Rognoni di maiale con trepang.

Dopo aver preparato i rognoni di maiale per la cottura, si taglieranno per metà. Fare alcuni intagli sulla superficie, friggere un momento, aggiungervi un bicchierino di cognac, un poco di salsa di soya, ed in ultimo il trepang. Servire caldo.

1) Make a thick sauce with white sauce, cream, and smashed urchins. Add salt, nut meg or the spices you like.

2) Cut recently made pancakes into thin ribbons like spaghettis. Mix with sauce. Serve hot with very cold chilean wine.

Have luck!

Laura Prat

(Alberto Lamain's mother)

CONCEPCION, CHILE 20 March 1993

13 JUNE 1992

PUESTO DE MARISCOS Y PESCADOS "APA"S

Centollas - Ostras - Erizos
Jaibas - Picorocos - Almejas
Cholgas - Potache - Curanto
Cancato - Sopa Marina
Pescado Frito - Machas - Camarones

ATENDIDO POR SUS DUEÑOS
Daniel Adonay Pino Hernández
y Sra.

LOCAL 57 — ANGELMO — PUERTO MONTT - CHILE


Paté de
Erizos
yadran
PRODUCTO DE CHILE
ERIZO
NATURAL
yadran
yadran
ERIZO
NATURAL
ERIZO
NATURAL

CHILE

Contributed by Rüdiger Birenheide
Tokyo Institute of Technology

Recipes for sea cucumbers - a little bit different

(from K.Y. Arakawa: A Handbook on the Japanese sea cucumber: Its Biology. Propagation and Utilization (In Japanese). Midorishogo, Tokyo)

1) Kodatami

......one of the eldest sea cucumber recipes in Japan

- cut a raw sea cucumber in pieces or slices and put for some time in sake (jap. rice wine)
- drain the sea cucumber pieces and season with a mixture of dashi (jap. soup stock), mirin (sweet sake) and salt
- serve with grated wasabi (jap. hot green radish)

2) Kaki-kodatami

like above recipe but add also some oysters to the sea cucumber pieces and season in the same way

3) Koubashira and konawata

- wash koubashira (adductor muscle of small scallops) in lightly salted water and drain
- mix 100 g of konowata (salted entrails of sea cucumbers) with two egg white, put into a vessel and steam. Drain.
- heat the konowata in a pot until water is evaporated
- mix with koubashira

4) Koubashira, iriko and cucumber in vinegar dressing

- wash iriko (dried sea cucumber, also known as trepang) in water
- put into water with charcoal ash added and simmer on low heat for 3 days (!)
- cut the now soft iriko into halves, wahs the inside thoroughly and cut into samll pieces
- fry with some salad oil and salt lightly
- wash koubashira and drain
- cut cucumber into small pieces
- mix iriko, koubashira and cucumber and season with white vinegar

5) **sea cucumber and vinegar**

......one of the traditional recipes from the Hiroshima region

- cut sea cucumber in pieces or slices, mix with cucumber and fried anago (conger) and season with sambaizu (mixture of soy sauce, vinegar and sugar).
- serve with grated daikon (jap. white reddish)

(the fried conger can be replaced with other fried fish)

6) **Namako-tempura** (deep-fried sea cucmber)

......another highlight from the Hiroshima region

- cut big sea cucumber in rather thick pieces
- put in boiling water, boil quickly and drain
- cover pieces with flour and deep-fry
- eat while still hot

7) **Yaki-namako** (fried sea cucumber)

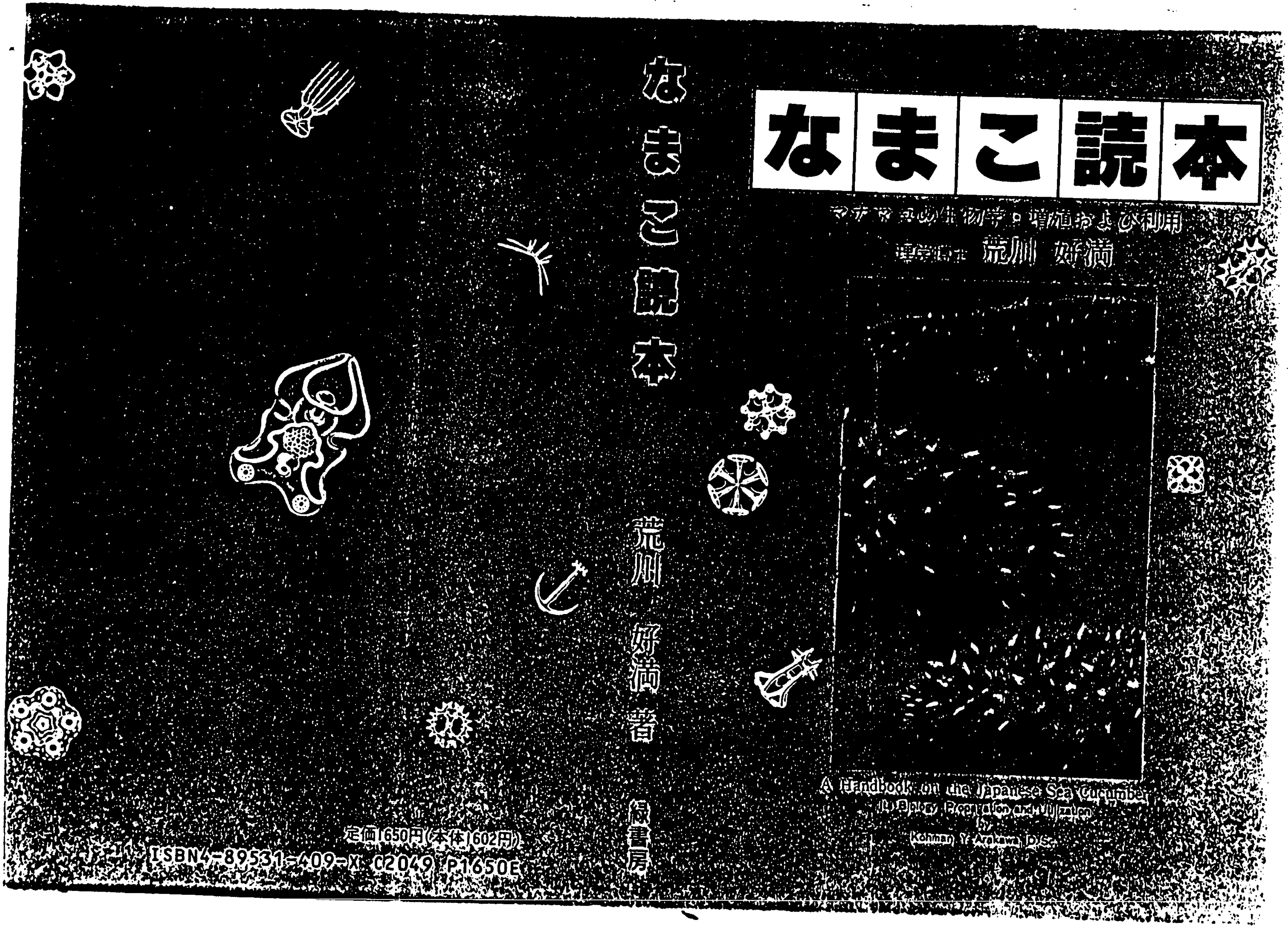
......surprises you with the simple beauty of the countryside

- wash a clean sea cucumber in salt water and put it as a whole onto a charcoal grill
- when done eat without any seasoning

8) **Shaburi-namako** (shaked sea cucumber)

......soft and good to keep

- put sea cucumber in a sieve and add 10 round pebbles and some salt
- shake for 20 - 30 minutes
- remove entrails, put sea cucumber into warm bancha (green tea) and let get cool.
- cut the considerably softened sea cucumber into pieces and season with sambaizu (see recipe 5); keep in refridgerator
- serve with fried conger and cucumber on a small plate and season with ponzu (mixture of bitter orange juice, soy sauce and vinegar); also add some grated daikon (white reddish) and chili pepper

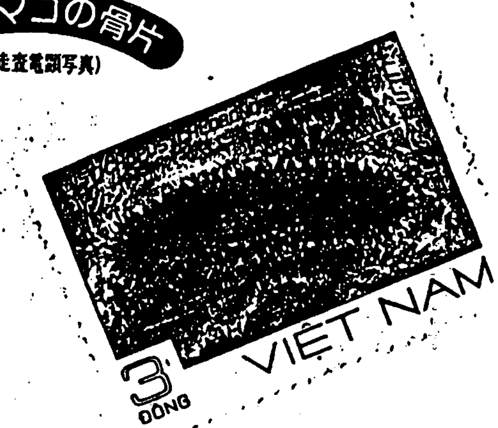

なまこ読本
マナマコの生物学・増殖および利用
理学博士 荒川好満
A Handbook on the Japanese Sea Cucumber
なまこ読本
荒川好満著
緑書房
定価1650円(本体1602円)
ISBN4-89531-409-X C2049 P1650E

ナマコ切手チェックリスト
(1989年11月現在)

バーブダ1987年発行
棘皮動物3種セットの1
ナマコの1種
Holothuria sp.

ヴェトナム1985年発行
棘皮動物7種セットの2種
ナマコの1種
Holothuria monocaria

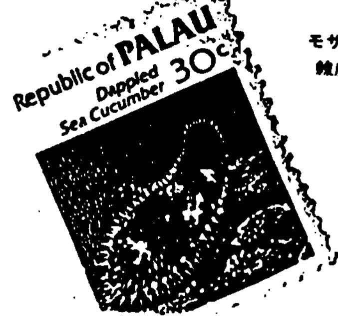
ナマコの1種
(An Aspadochirotid Sea Cucumber)
Stichopus chloronotus



マナマコの骨片
(走査電顕写真)

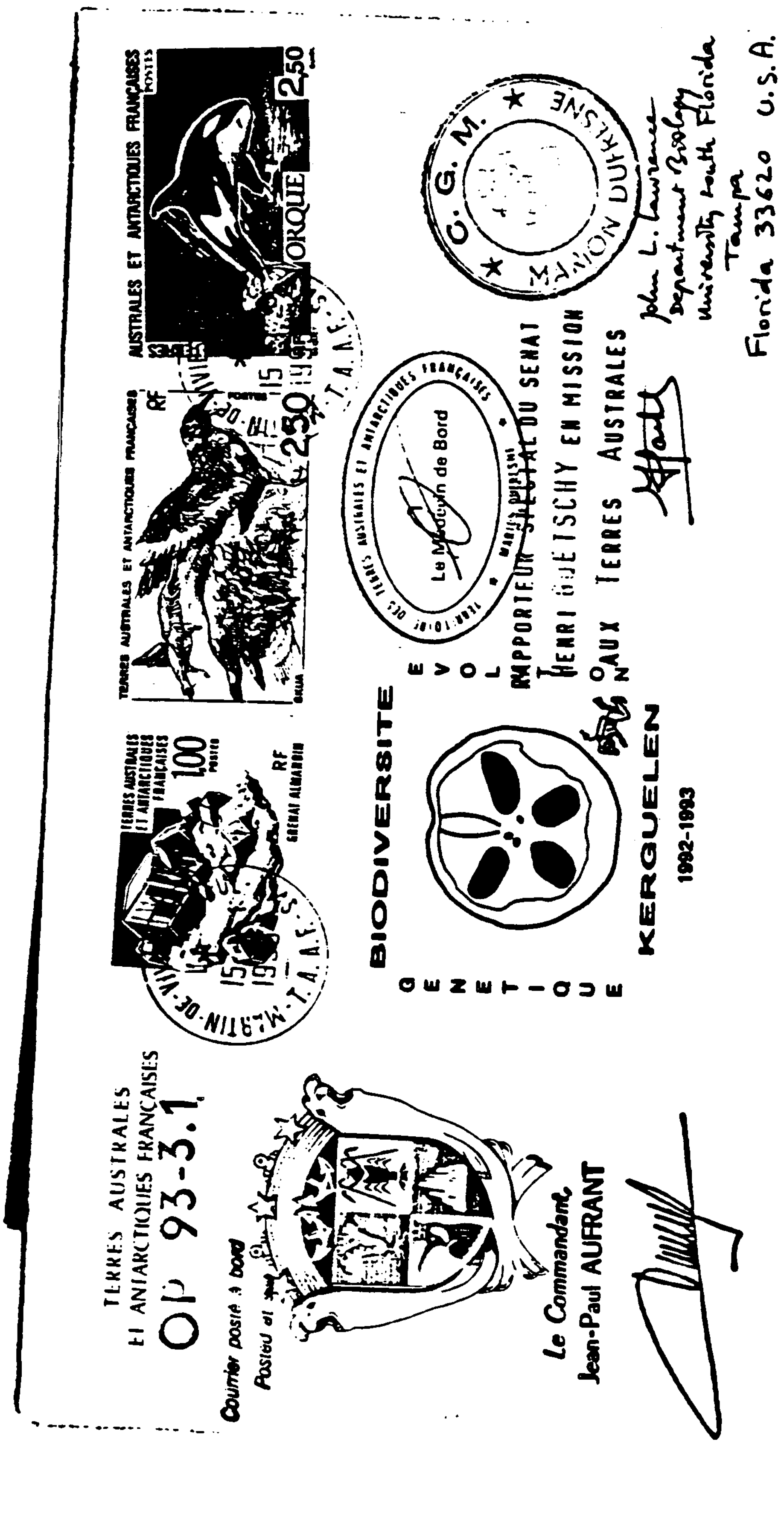
マナマコの産卵

アルバニア1966年発行
ナマコの1種
Holothuria tuberosa



モザンビーク1983年発行
棘皮動物6種セットの1
ナマコの1種
Holothuria scabra

パラオ1983年発行
ナマコの1種
(Dappled Sea Cucumber)
Holothuria pervicax


TERRES AUSTRALES
ET ANTARCTIQUES FRANÇAISES
OP 93-3.1
Courrier posté à bord
Posted at sea
Le Commandant,
Jean-Paul AUFRANT
TERRES AUSTRALES ET ANTARCTIQUES FRANÇAISES
1,00
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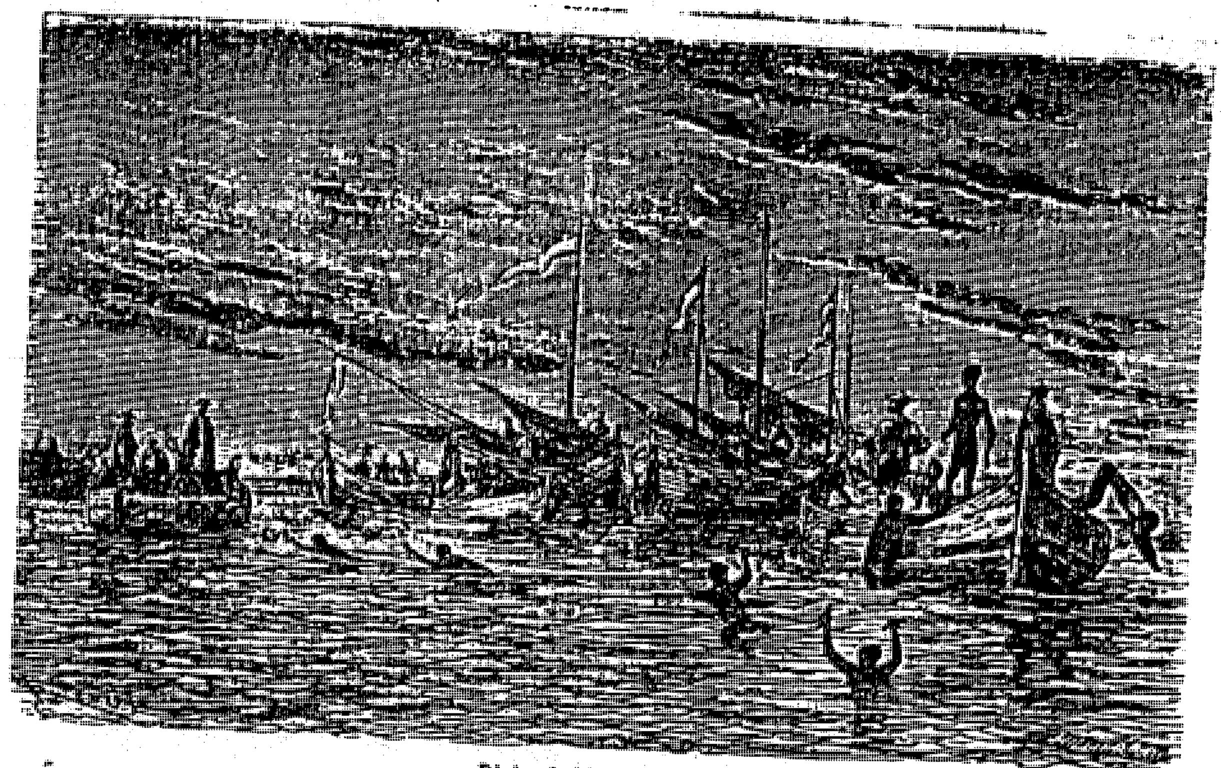
AUSTRALES ET ANTARCTIQUES FRANÇAISES
ORQUE
2,50
T.A.A.F.
BIODIVERSITE
GENETIQUE
EVOLUTION
KERGUELEN
1992-1993
Le Médecin de Bord
MARION DUFRESNE
HENRI GOETSCHY EN MISSION
AUX TERRES AUSTRALES
C.G.M.
MARION DUFRESNE
John L. Lawrence
Department Biology
University South Florida
Tampa
Florida 33620 U.S.A.

3



Pêche de l'holothurie.

Bibliothèque des Merveilles - les grandes pêches - Meunier - Hachette 1871

Chantal Conand

in : MULVANEY - the prehistory of Australia.

(3

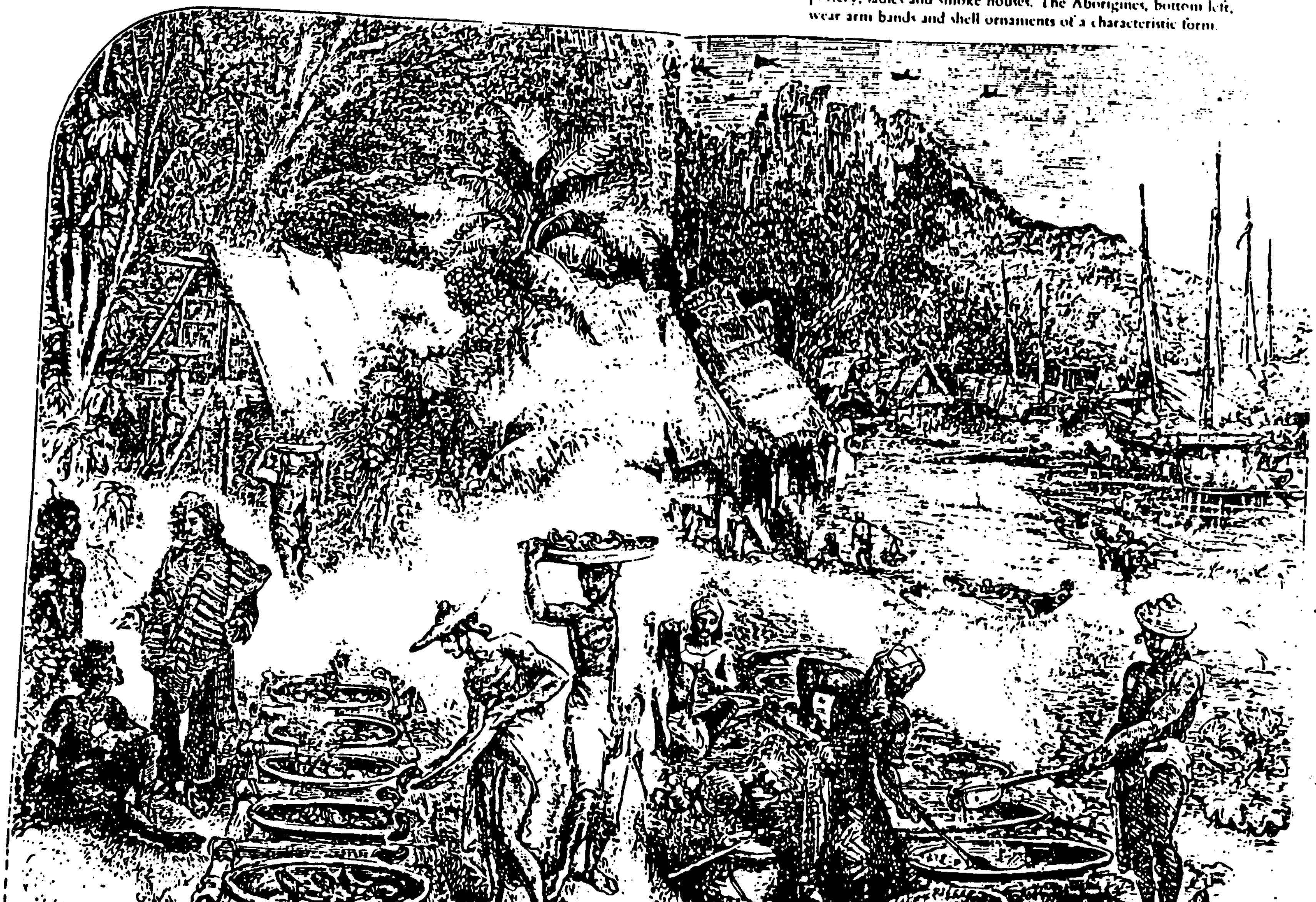


Plate 7 A scene purporting to be Port Essington, but with an East Indies terrain, around 1843-5, by Harden S. Melville, draftsman on the surveying voyages of H.M.S. *Fly*. Despite the unreal background and the brace of wildfowl (who fly across several of Melville's drawings), the scene contributes details of the trepanging industry. Note the lines of flat iron cauldrons, pottery, ladles and smoke houses. The Aborigines, bottom left, wear arm bands and shell ornaments of a characteristic form.

communicated by Chantal Conand

Pacific Daily Ne

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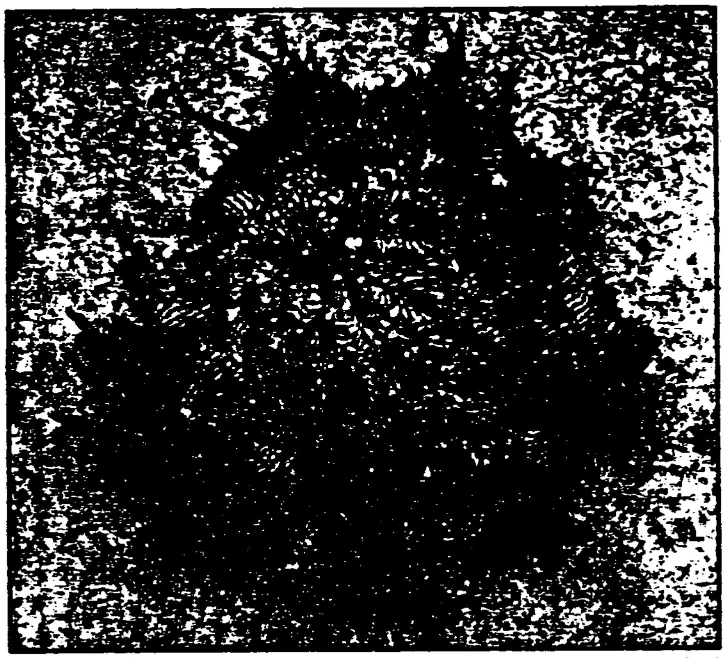
VOL. 23 NO. 135 AGANA, GUAM, AUGUST 4, 1992

Hafa Adai, it's Tuesday

Biba balaté

Rare find: Colorful sea cucumber found near Guam thrills UOG scientists

By LINDA AUSTIN
Daily News Staff



Cheryl Mitchell/Daily News Staff

A diver discovered this conspicuous candy-striped sea cucumber last weekend at Glass Breakwater in about 200 feet of water. ***See related photo/Page 4.***

A brilliant red and white candy-striped sea cucumber discovered last weekend at Glass Breakwater is wowing marine scientists who have never seen its kind in Guam waters.

"It's a beautiful animal ... just spectacular," University of Guam's sea-cucumber expert, Gustav Pauley, said about the two-foot-long creature, scientifically called *Thelenota rubralineata*.

"That means the red-striped spiny backed one in Latin," quipped graduate student Alex Kerr.

Kerr's diving partner, Peter Schupp, discovered the harmless animal in about 200 feet of water while the pair were searching for deep-water fish, they said.

The species is a new face on the international scene, discovered less than a year ago in the shallow waters near Papua New Guinea and Indonesia. The discovery of a Guam version snuggled in deep waters suggests the critters are more common and more widely dispersed than anticipated, Kerr said.

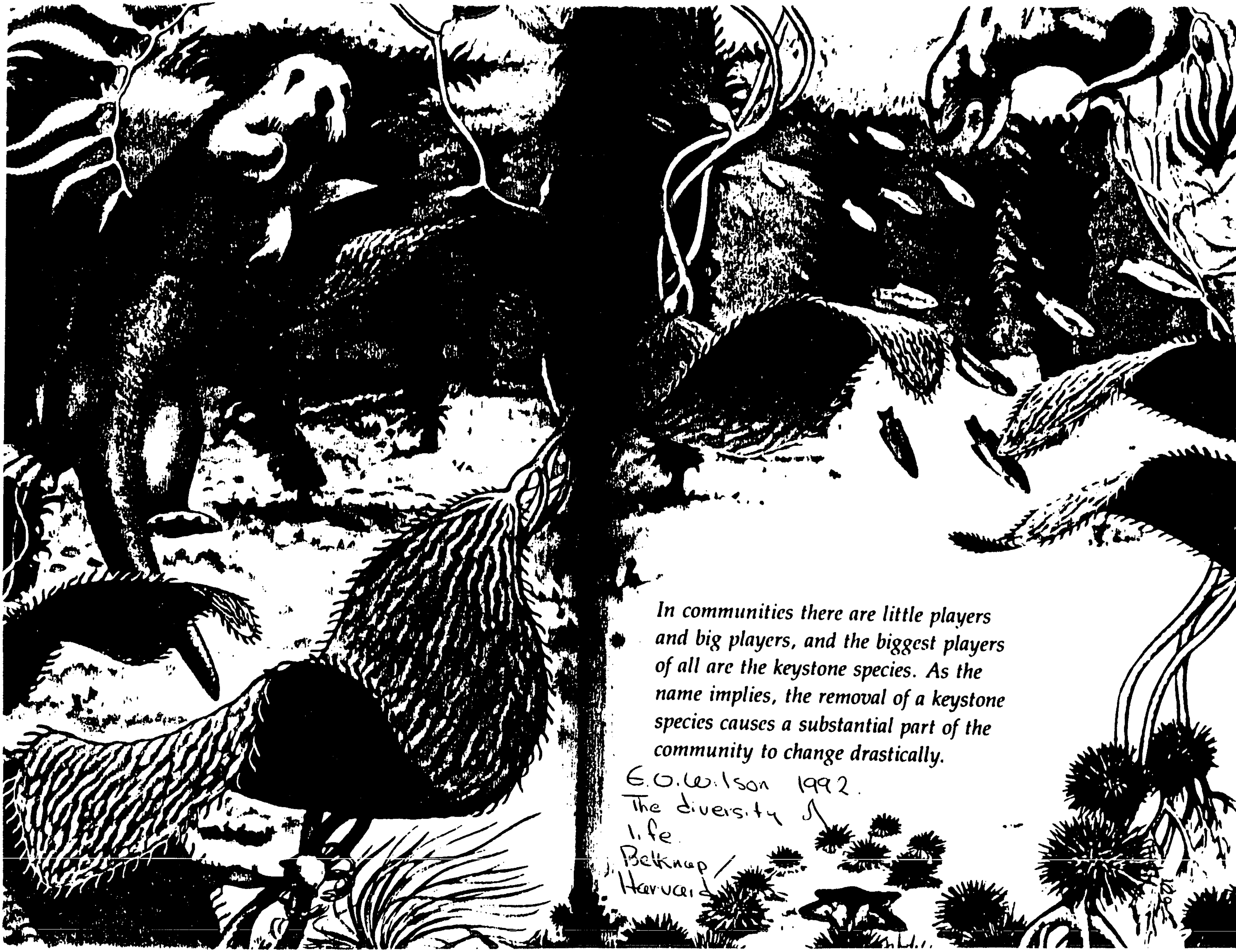
Sea cucumbers, known as balaté in Chamorro, are humble simple creatures with "not a whole lot of gray matter (brain) accumulation," Kerr said. "They pretty much just process sediment" and keep the reef face clean.

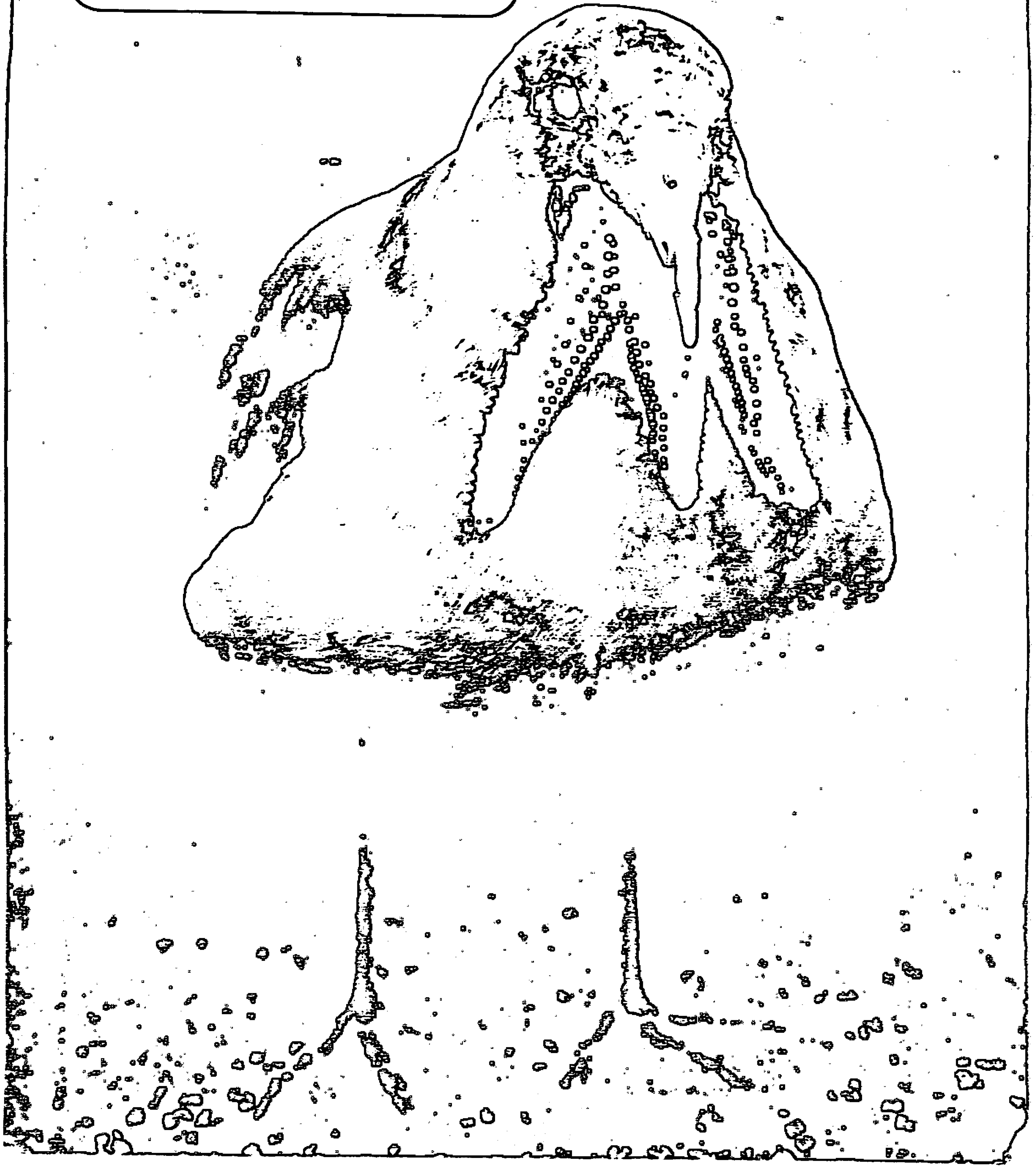
Still, they can perform amazing feats, especially when fleeing their main predator, sea snails. In the art of escape, balatés have been known to leap-frog to freedom or break off pieces of skin and spines to distract the gastropods while the main body flees, Kerr said.

balatés also come in male and female varieties, but because their reproductive organs are located on their heads, sometimes determining who's what can be tricky, Kerr admitted yesterday while tipping the striped one end over end looking for a clue.

For a while, Guam's latest celebrity will enjoy carefree days lounging at UOG's marine lab while Kerr incorporates this new discovery in his research papers.

Then, he or she will be "pickled — but not to eat," Schupp said. Such specimens are needed as scientific evidence and for future research, the pair said. Interest in the soon-to-be specimen has come as far away as the Smithsonian Institute but the balaté probably will remain in UOG's marine archives, they added.


In communities there are little players and big players, and the biggest players of all are the keystone species. As the name implies, the removal of a keystone species causes a substantial part of the community to change drastically.
E.O. Wilson 1992.
The diversity of life.
Belknap / Harvard



DIVISION OF INVERTEBRATE ZOOLOGY
AMERICAN SOCIETY OF ZOOLOGISTS

NEWSLETTER

FALL 1992

GREAT INVERTEBRATE ZOOLOGISTS: ALEXANDER EMMANUEL RODOLPHE AGASSIZ (1835-1910)

(by John P. Wourms)

Although a legend in his own time, Alexander Agassiz now is only vaguely remembered as a pioneer oceanographer. Yet, the enigmatic figure of the "less celebrated Agassiz" is worth closer study for he greatly influenced the conduct and infrastructure of zoology in 19th century America. Not only was he a prime mover in oceanography, but he played a pivotal role in the emergence of embryological research in America, and was deeply involved in the systematics of echinoderms, especially the echinoids. The latter stages of his career were devoted to the study of coral reefs. He brought the nascent Museum of Comparative Zoology (MCZ) at Harvard to fruition and established the Newport Marine Zoological Laboratory. The latter was the first permanent marine research laboratory in the US. Here, I can do little more than highlight some aspects of Agassiz's life and career.

Alexander Agassiz, the only son of Louis Agassiz, was born in Neuchatel, Switzerland, on December 17, 1835. His mother, Cecile Braun, was an artist of exceptional ability from whom he acquired his own skill as an illustrator. By 1846, the elder Agassiz's finances had collapsed. Cecile, ill and exasperated by the conduct of some of Agassiz's collaborators, separated from him. She returned to Freiburg to be near her brother, Alexander Braun, the distinguished German botanist. Louis Agassiz also left Neuchatel and eventually made his way to the United States. In Freiburg, Alexander cared for his invalid mother and two sisters. He was introduced to botany by his uncle and to zoology by von Siebold. His mother died in 1848 after which he joined his father in the United States. Louis' marriage to Elizabeth Cary in 1850 restored stability to the Agassiz family.

Alexander was introduced to the family business of natural history and zoology as a boy. He accompanied his father on a cruise of the *Bibb* and aided in a survey of the Florida reefs. Graduated from Harvard in 1855, he took a degree in engineering from the Lawrence Scientific School. A position with the US Coast Survey enabled him to travel to the coast of North America by way of Panama. Research that he carried out on jellyfish and viviparous surfperches apparently settled him on a career in zoology. Returning home, he took a second degree in natural history from the Lawrence School. Although he received many honorary degrees, he did not have an earned doctorate.

In 1860, he joined the newly established MCZ as an "agent", supervising the Radiate Collection (cnidarians, echinoderms, etc.) and assuming charge of the business affairs of the MCZ. In the same year, Alexander married Anna Russell, a member of a prominent Boston family. Summers were spent at Nahant where a marine lab had been fitted out in the Agassiz cottage. His first major scientific paper, on viviparous surfperches, appeared in 1861 and was followed by over 250 more. Most of the early papers dealt with marine organisms, especially their development. Among the highlights of this period were the *Embryology of the Starfish* (1864 and 1877), a handsomely illustrated monograph that provided a definitive account of development from fertilization through post-metamorphic juveniles, and the *North American Acalephae* (1865), a study of the medusoid jellyfishes of the Atlantic and Pacific coasts illustrated with 360 figures that Agassiz drew from life. In 1866, he was elected to the National Academy of Sciences.

His own impecunious state, the financial debacles of his father, and the recurrent fiscal problems of the MCZ caused Alexander to seek his fortune in mining. During 1866-68 he became supervisor of the Calumet and Hecla copper mine in northern Michigan. Agassiz transformed a failing enterprise into a fabulously prosperous mine and secured his own fortune. He labored under incredible conditions on what was then a rough and tumble frontier. To recoup his health, impaired by the Calumet ordeal, he spent 1869 and 1870 in Europe. There he visited museums and made "the acquaintance of nearly every working naturalist in Great Britain, Scandinavia, Italy, Germany, and France", among them Wyville-Thomson, with whom he discussed the emerging field of deep sea research. Alexander's primary objective was to examine collections of echinoids. On his return, he published his massive (770 page) *Revision of Echini* (1872-1874).

The first session of the Penikese school was held in the summer of 1873. Alexander taught embryology. The following year, he organized the second and last session, but did not participate in it. Late in 1873, Louis Agassiz died, followed shortly thereafter by Alexander's wife, Anna, who had been nursing the elder Agassiz. Their deaths dealt him a shattering blow from which he never fully recovered. Although still capable of warm friendship and great enthusiasm, he became a very private person, projecting an austere public image. It is interesting to speculate on the extent to which Alexander blamed his deceased father for the death of his wife and, earlier, for his mother's death. Following this tragedy, Alexander sought refuge in his work. In 1875, he became curator of the MCZ and launched his first major expedition, traveling to Lake Titicaca and coastal Peru.

To digress briefly, the first marine "lab" in the United States was part of the Agassiz cottage at Nahant, Massachusetts. Here from about 1850-1870, the elder Agassiz, his collaborators, and Alexander studied invertebrate biology and development. Alexander's research and field observations led to the publication in 1865 of *Seaside Studies in Natural History* which he co-authored with his stepmother, Elizabeth Cary Agassiz. This book contains a wealth of information on the ecology, biology, and development of the intertidal and inshore fauna of northeastern North America. It is the first such American guide to coastal marine life. The history of marine labs moves from Nahant to Newport by way of Penikese. The Penikese school was a glorious experiment in instruction carried out under quite primitive conditions. Attempts to move the Penikese operation to Woods Hole failed. Because his memories of Nahant were too distressing, Alexander built a home at Newport, Rhode Island. He had a room fitted out as a laboratory in which W.K. Brooks carried out his study on *Salpa*. In 1877, Agassiz constructed a separate building which became the Newport Marine Laboratory. He did not intend to replace Penikese but rather to move in a different direction, providing facilities for research. The original research emphasis was on the development of fishes and marine invertebrates. After its enlargement in 1891, the emphasis shifted to deep sea and coral reef biology. The laboratory was superbly designed and appointed. Illustrated accounts appear in *Nature* 19: 371-319; *The Century Magazine* 26(5): 728-734; and *Annual Reports of the Museum of Comparative Zoology* for 1877-78 and 1891-92. In architecture and design, the Newport Lab was distinctly American and differed from European labs such as the Stazione Zoologica at Naples. It served as a physical and intellectual model for other American marine labs. It incorporated many features that are now common, such as: (1) a well-designed flowing sea water system with aeration; (2) access to a rich local fauna; (3) facilities and boats for both in-shore and off-shore collecting; (4) custom glassware and aquaria; (5) reference library; (6) experienced assistants; (7) facilities for photography; (8) good research microscopes; and (9) knowledge of the local fauna and practical experience in its study using techniques such as artificial fertilization and experimental hybridization. The Newport Lab was the premier American research lab from the time of its inception until the US Fish Commission Laboratory and the MBL attained maturity in the 1890's. Among those who did research at Newport were A. Agassiz, W.K. Brooks, C.B. Davenport, W. A. Faxon, J.W. Fewkes, E.L. Mark, A.G. Mayer, E.A. Nunn (Mrs.

C.O. Whitman), G.H. Parker, W.E. Ritter, C.O. Whitman, E.B. Wilson. Detailed information about the lab seems to be fragmentary and scattered, but it might prove interesting to try to draw it together.

Alexander Agassiz was considered one of the leading American embryologists in the period 1860-1885. In 1879, he was awarded the Prix Serres for his research on the development of cnidarians, ctenophores, annelids, echinoderms, enteropneusts, and fishes. He was the first non-Frenchman so honored. Alexander was part of what should be considered the Boston-Cambridge school of embryology. This group was established by the elder Agassiz, a student of Döllinger. Initially, it was comprised of students and associates, such as Alexander Agassiz, Clark, Morse, Packard, Wyman and, subsequently, their students and associates such as Brooks and Minot. They operated within the framework of the MCZ, Boston Society of Natural History, and local colleges and institutes. Alexander espoused an integrative, organismal approach to development within the conceptual framework of what is now known as the life history model. He helped establish a tradition of painstakingly detailed observation of living embryos, larvae, and post-metamorphic juveniles combined with state-of-the-art microscopy. This approach later was to become associated with Brooks, Whitman and their students and culminated in the Hopkins-MBL school.

Under Agassiz's direction and with his financial assistance, the MCZ became the first American center for embryological research and the hub of the Boston-Cambridge school. He established an embryological research agenda and was aided in this by E.L. Mark who joined the Harvard faculty in 1877. Mark, the first American student to obtain a doctorate from Rudolf Leuckart (1876), brought to bear a cytological and histological approach. Mark, together with Minot and Whitman, was responsible for the introduction of advanced European microscopic technique. Whitman, while working as Agassiz's research associate on teleost development, wrote his *Methods in Microscopical Anatomy and Embryology*, the first American work. To further embryological research, Agassiz (1) insured access to research material via the Newport lab; (2) acquired microscopes and appartus needed for advanced microscopy; (3) assembled a research library; and (4) fostered an in-house publication series for well illustrated embryological monographs. To provide easy access to the scarce European literature, Agassiz, Mark, Faxon, and Fewkes published a series of selected illustrations from embryological monographs, i.e., "normal stages of development" with accompanying bibliographies. In addition, E.L. Mark translated several German reference works, notably, Korschelt and Heider's four-volume *Textbook of Embryology*. Unfortunately, Agassiz's vision of a center of excellence was thwarted by President Eliot's refusal to hire additional faculty, such as C.O. Whitman. Harvard's loss was Chicago's gain!

Agassiz's period of embryological research activities extended from about 1860 through 1890 during which he explored a number of topics, among which are the following:

(1) Cnidarians: alternation of generations, embryonic and larval development, tentacle differentiation, morphological variation, and growth rate of corals.

(2) Ctenophores: elegant comparative studies that accurately depicted unilateral (heart-shaped) cleavage and the segregation of the comb-forming cortical cytoplasm in micromeres by unequal cell division. He advocated splitting the ctenophores off from the cnidarians.

(3) Annelids: Alternation of generations, embryonic development, and metamorphosis.

(4) Echinoderms: an enormous body of work on echinoderm development that involved artificial fertilization and experimental hybridization. Description of starfish development from fertilization through post-metamorphic juveniles with elegant illustrations from living material. Viviparity and brooding. Homology of pedicellariae and simple spines. Post-metamorphic studies of growth and development carried out on a comparative basis.

(5) Enteropneusts: He described the metamorphosis of the tornaria larva and identified it as a stage in the development of *Balanoglossus*.

(6) Fishes: Cellular analysis of early teleost development (with C.O. Whitman), comparative studies of the development and metamorphosis of pelagic and demersal fish larvae, metamorphosis of flounder larvae and

different modes of eye migration to the dorsal surface, first observations on the development of the garpike, *Lepisosteus*, a primitive bony fish.

(7) Theoretical Studies: Agassiz criticized Haeckle's theories both in terms of factual evidence and its interpretation. Unlike his father, Alexander Agassiz accepted the evolutionary paradigm. In 1880, he presented a remarkable address to the annual AAAS meeting, entitled, "Paleontological and Embryological Development" in which he presaged the role of developmental constraints in evolution, questioned the constancy of evolutionary rates, and took the first steps toward a cladistic approach to taxonomy.

Having accomplished many of his goals in embryology, Agassiz moved on to deep sea biology and coral reef studies. Between 1877 and 1880, Agassiz directed the three cruises of the *Blake* in the Gulf Stream and West Indies. On these expeditions, he drew on his experience as a mining engineer to introduce wire cable as a replacement for rope, thus significantly improving sampling capabilities. Assessing the expedition, A.G. Mayer stated that, "due to the explorations of the *Blake* under Alexander Agassiz, we know more of the topography and the animals of the Gulf Stream and West Indian region than of any submarine area of equal extent in the world". In 1888, Agassiz published a unique two volume work entitled *Three Cruises of the Blake*. Not only did he provide an account of the scientific work of the expedition, but he also provided an overview of physical and biological oceanography, an analysis of the West Indian marine fauna, and a lengthy account of deep sea organisms. In actuality, it was the first oceanography textbook. In 1891, Agassiz undertook the first of three expeditions in the US Fish Commission's research vessel, *Albatross*. He explored vast areas of the Pacific. The first voyage traversed portions of the eastern Pacific. Many new deep-sea organisms were collected. Agassiz ascertained that the deep-sea fauna on the west coast of Central America had a close affinity to the Caribbean fauna confirming their continuity prior to the uplifting of the Isthmus of Panama. In 1899-1900, he took the *Albatross* from San Francisco to the Marquesas and across the tropical Pacific and its fabled islands and, thence, north to Japan. He found that the pelagic and bottom fauna in many areas was impoverished. On the third voyage in 1904, the *Albatross* returned to the eastern Pacific and conducted extensive studies on the rich pelagic fauna of the Humboldt Current and the correspondingly rich bottom fauna. Agassiz also explored the coral reefs of the Hawaiian Islands, Fiji, the Great Barrier Reef of Australia, the Maldives, Florida, and the Bahamas. He believed that Darwin's theory of coral reef formation was an oversimplification and that reefs could be formed in a variety of ways. Although he was working on a fourth version of a book to synthesize his years of coral reef research, he did not complete it before his death.

Agassiz resigned his curatorship at the MCZ in 1898 but retained control of its activities. His last years were interspersed with the *Albatross* and coral reef expeditions, the publication of expedition reports, and the study of echinoderms that were collected, e.g. "Panamic Deep Sea Echini" (1904). He died at sea while returning from Europe in 1910. With the deaths of W.K Brooks and C.O. Whitman that same year, the era of 19th century American zoology was brought to a close. If you seek his monument, look not only to the men but also to the institutions. Singular tributes were paid to this "Prince of Oceanographers" by Henry Adams, A.G. Mayer, John Murray, and George Parker. As unofficial mentor and role model, Alexander Agassiz influenced many about him, amongst whom I would single out W.K Brooks, H.P. Bigelow, A.G. Mayer, W. Ritter, T.W. Vaughn, and C.O. Whitman. Brooks founded the Chesapeake Lab and was mentor to Conklin, Harrison, Morgan and Wilson. Whitman nurtured the MBL through its early perilous years, created Chicago's center of excellence, and was mentor to the Lillies. Ritter founded Scripps and was succeeded by Vaughn. Mayer founded Carnegie's Tortugas Lab. Bigelow founded WHOI.

I acknowledge with thanks the comments and suggestions of Michael Ghiselin and Edward Ruppert.

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How I began to study echinoderms... Part 3.

The section of the Echinoderm Newsletter containing personal accounts of how individuals began their studies on echinoderms has proved to be extremely interesting and popular. I have found them fascinating.

Anderson, John M. (Cornell University). The year was 1948. Returning to Academia from four and a half years' service as a naval office in WWII, I had finished my graduate training in insect physiology under Prof. Daniel Ludwig at New York University and managed to produce an acceptable dissertation. Settling into an assistant professorship at Brown University as a fresh-caught PhD (by now with a wife and two small sons), I found myself for the next couple of years casting about for a stimulating field of research for the long haul. Histological and histochemical studies on the male reproductive system of the Japanese Beetle (the animal whose metamorphic biochemistry I had worked on as a graduate student, some intriguing problems in the reproduction of fresh-water planarians, and even an investigation of the biological effects of ultrasonic radiation (on years, of all things!) occupied my questing attention. At one point my newly assigned research assistant at Brown (and I as well) needed training and experience in histological and histochemical techniques (the latter coming increasingly into vogue at the time), and in seeking not-too-difficult invertebrate practice materials we began to play around with such things as crayfish hepatopancreas and the pyloric caeca of sea-stars (then commonly referred to as starfish). Brown University is located in Providence, RI, not far from Narragansett Bay, and sufficient numbers of starfish could be had be special request from dragger operating out of nearby Bristol. Seeking to understand what we were seeing in our practice slides of the starfish material, it was natural to check into the existing literature - which revealed interesting gaps, inconsistencies, and obvious inaccuracies in previous descriptions. This, plus the fascinatingly <u>different</u> nature of the asteroid digestive system in general, led us to focus on the starfish sections to the exclusion of other materials - and thus began my career-long obsession with gross and microscopic details of digestive systems in various species of sea-stars.

In 1952 the offer of a tenured appointment in the Department of Zoology at Cornell University lured me away from the seashore, but summertime association with the Marine Biological Laboratory at Woods Hole, beginning in 1953, made it possible to continue studies on <u>Asterias</u> <u>forbesi</u> for the next several years. The shallow-water asteroid fauna of the region south of Cape Cod is relative depauperate, however, and it was not until 1958 that a sabbatic leave from Cornell, together with a Guggenheim fellowship, enabled me to spend several months at the Hopkins Marine Station at Pacific Grove, California, studying species of sea-stars I'd never seen before. This experience opened my eyes to the variety of ways in which different asteroid families had adapted, in a functional-anatomical sense, to different food habits and feeding methods.

Following up aspects o these diverse adaptations occupied my research interest during the remainder of my active professional career.

Birkeland, Charles (University of Guam). I have always been interested in animals, but as a boy I found terrestrial animals difficult to work with. They were either speedy, cryptic, at the tops of the trees, or hidden in the shrubbery. I enjoyed searching and getting glimpses, and frequently even good views. But they were frustrating for getting serious work accomplished. I thought birds, fishes, mammals and insects make good hobbies, but I would rather do serious work with large, slow animals.

In high school I had a summer job with the Illinois Natural History Survey, sampling forage-crop insects. We would take sweep samples in the open alfalfa fields, then dump several sweep-net loads into the cab of the pickup truck, hop in, close the door, and sample the galaxy of insects for particular species of economic interest as they spread themselves out on the windshield, attracted to the sunlight. In the Illinois summer, the temperature and humidity were usually about 100 (degrees F and %, respectively). As I worked in the hot, stuffy cab, searching and collecting selected species with an aspirator, the many insects would stick to me and drift into my eyes while they crawled in the sweat that poured down my face and neck. During those times, I thought that I would like to be a marine biologist, feel clean and never be hot and sticky.

Like many other marine biologists, I got imprinted on my first field trip in graduate school. On my first dive in Puget Sound, I encountered several species of starfish eating Ptilosarcus in a vast bed of sea pens. It was a spectacular and interesting sight. The starfish were large, surreal, bizarre, and beautiful, as were their prey. These echinoderms preying on anthozoans became the subject of my thesis right then, and for the last 22 years, it has been a major focus of my experiences on coral reefs. They have never become routine or boring.

Conand, Chantal (Universite de Britannia Occidentale). When I arrived from France and Senegal in New Caledonia in 1979, I wanted to continue studying fish biology. As in other tropical islands, the fishery in New Caledonia was considered at that time as not important enough to require scientific management. The New Caledonia economy was based on nickel and due to the nickel crisis the authorities wanted to diversify the sources of income and the artisanal fisheries. One of them, the beche-de-mer, was said to have been prosperous once but there was no information! I was asked by ORSTOM (Institut Francais de Recherches pour le Developpement en Cooperation) to undertake studies to determine which holothurian species are valuable, where they live, how they grow, reproduce, die, how much could be fished... I started sampling on reef flats and diving in the lagoons with admiration. It has been the start of my association with these wonderful creatures, although mostly depreciated by "non connaisseurs"! I soon met my new echinoderm colleagues at the Seminaire organized in Paris by Alain Guille and they became friends. (John, my English is too poor to make a joke with nickel - "mining" - and nickel - "money" - with beche-de-mer!)

Farmanfarmaian, Allahverdi Abdul-Hossieh (Rutgers University). Toward the end of WW II, my guardian put me on a train in Teheran and, along with several of my brothers, sent me off to the American University of Beirut (AUB) Prep School (IC) "...so that I might become civilized and educated and leave my saintly mother to have some peace", his words. I was 13 and had never seen an echinoderm though I had collected shells on the beautiful shores of the Caspian Sea. Zenkevitch does not report any echinoderms in the Caspian (average salinity 12-13 ppt). To save fuel, the IC boarding masters dictated cold showers from April to October, and to make sure we "savages" took our showers, they herded us off to the beautiful AUB plage to swim in the Mediterranean. Mr. Damous, our athletics director, kept order with his piercing police whistle and giant torso. In spite of his severe injunctions and my bad right ear drum, I could not wait to explore the sea bottom. I had no diving implements other than my brief Bikini - the recyclable standard issue of the IC athletic department. It was there on an algae-covered rock, about 14 feet below, that I saw a purplish greenish spiny fuzz-ball - larger than a golfball - moving on that rock. I took a breath and returned to the same rock, and the creature was there and moving. I looked and found no head, no eyes, no antennae, no legs, arms, fins or claws. A little afraid, but mostly curious, I went to my brothers who were attending Mr. Damous' high diving lessons near the diving board. They would not believe my story and laughed at the idea of the moving creature without a head, eyes, legs, and we almost came to blows when my brother Tari said, "Oh, yeh, we have several of those in our class and one is named Verdi". Mr. Damous broke up the fight and ordered us to the showers. He told us to get dressed and report to him just outside the University gates where the vendor Hatab sold different kinds of foods and sandwiches to students. We dutifully turned up at the appointed time and place. Mr. Damous said something in Lebanese Arabic to Hatab. We Persians did not understand. Hatab went behind his cart and came back with a bucket of chilled sea-water, a plate, a loaf of French bread, a couple of fresh lemons and a peculiar knife. He then reached into the bucket and pulled out my creature - the Mediterranean Echinus of Aristotelian fame. I started to scream with laughter at my brothers who were looking for cracks to crawl into. Hatab deftly cut the creature at the ambitus into clean halves and placed it on the plate. Mr. Damous showed us how to pick the yellowish gonads with a small fork, place it on a piece of bread, squeeze a few drops of lemon juice and eat it. Tari did not like it but the rest of us enjoyed several of these sea urchins. Mr. Damous paid Hatab 80 Lebanese piasters and dismissed us in his usual military manner.

For years thereafter I looked for these creatures without heads, tails, right or left, front or back on shores, in museums, and in exhibitions with great curiosity. As a sophomore in my first invertebrate course, and later as a graduate student in D.P. Abbott's Marine Invertebrates Course and A.C. Giese's Comparative and Ecological Physiology Course at Stanford's Hopkins Marine

Station, I studied a variety of echinoderms. Scuba diving around Monterey, Catalina, Florida, Cayman, Woods Hole and Palau, I observed and collected many echinoderms and never ceased to marvel at their beauty and behavior. I did research on more than 30 species, representing all five living classes and ranging from the depth of the Monterey Canyon to the shores of Cape Cod, the sea tables of Naples, and the rocky beaches of Hormuz in the Persian Gulf. I read Cuenot and Hyman cover to cover twice and in part several times and consulted tons of other literature in several languages including German and Japanese. I published and presented many papers on the respiratory, circulatory, digestive, absorptive temperature tolerance, osmoregulatory, and reproductive physiology of echinoderms. For several years I taught a highly specialized course in echinoderm biology at Woods Hole. Finally, though I have worked on other animals, I have never stopped puzzling about echinoderms for the last 50 years (13-63). The puzzle never ends. I admire all who continue the struggle to unravel these great secrets.

Fenaux, Lucienne (Station Zoologique, Villefranche-sur-mer). After having obtained my Licence en Sciences Naturelles (Academie de Paris, 1958), I had two possibilities: commencing a third cycle of biological oceanography with the obligation of returning to my country Haiti after finishing my studies, or having a post as technician in a laboratory of plant physiology at the University of Paris. I liked the second possibility better as my future advisor, Dr. Camus, gave me the opportunity of beginning a doctoral program under his direction. Then I went to Villefranche to see Robert Fenaux, my future husband, who introduced me to Mr. Roger Lallier, a scientist with CNRS. Mr. Lallier spoke to me of his studies on embryonic determination and showed me the effects of lithium and zinc on the embryonic development of urchins. This was a blow to the heart! The material was fantastic: it was easy to observe under the stereomicroscope and the changes induced by lithium and zinc were spectacular. Now I knew that I wanted to work on echinoderm larvae but how to choose in a field so vast? Professeur Paul Bougis, director of the Station Zoologique of Villefranche-sur-mer, received me and spoke to me about larval nutrition that was still poorly known, of the experiments that could be done on larval growth raised with particles encountered naturally in the marine environment. This time my research project took form. But it was first necessary to know well larval ecology <u>in situ</u>, the gametogenic cycle of adults, the different changes in form the larvae took during the course of gametogenesis. The adults I could collect at Villefranche still had an unknown larval development. The literature of Muller, Mortensen, Giese and his collaborators, and those of other authors revealed by reading the book edited by Boolootian "Physiology of Echinodermata" became familiar to me... And this is how I presented a thesis titled "Aspects ecologiques de la reproduction des Echinides et Ophiurides de Villefranche-sur-Mer". Later I discovered that Richard Strathmann had the same passion...

Ferguson, John Caruthers (Eckerd College). Before deciding to be an echinoderm biologist, I had to elect not to follow my parents into medicine and biomedical research. This departure occurred as an undergraduate at Duke, after reading N.J. Berrill's The Living Tide, with its description of marine life in the Dry Tortugas. A life studying sea animals pictured as much more rewarding than one emersed in human blood and guts. Knut Schmidt-Nielsen and his Comparative Physiology course further fascinated me with the beautiful diversity of animal functions. While enquiring into graduate schools to pursue this new interest, John Anderson intercepted my letter and invited me to focus my attention on invertebrates with him at Cornell. It as a big step to give up animals with backbones, but there was a lot to discover in these "other" animals, and they could be a good excuse to spend a lot of time at marine labs. Arriving at Cornell, I was surprised to find John Anderson off on sabbatical, leaving a note telling me, in effect, to choose an animal and get to work on something - anything! Thus, I had complete freedom on choose any animal group for my career. After considering all the alternatives, the answer was clear: starfish (and echinoderms were weird, puzzling, casually fascinating, and definitely marine - what else could be more interesting! Further, since Anderson also worked on them, he could provide me unique support and guidance. When Anderson finally did return, I found in him a true mentor who never farmed his work out on me, but provided a free, intellectual environment that fully encouraged my own creativity, subject only to the rigors of his constructive criticism. Being fortunate to find employment on a sea-front campus in Florida, I have been able to investigate through the years a number of basic properties of echinoderm biology. Each January I lead a sailing and study expedition with students to the Dry Tortugas, and try to pass on to them some of the spirit I inherited from Berrill (whom I have never met), Schmidt-Nielsen, and John Anderson.

Fischelson, Lev (Tel Aviv University). It was just at the beginning of my studies in the Gulf of Aqaba in 1951 when I became fascinated by the changeover from day-active to nocturnal animals. The most impressive was the appearance of the crinoids Lamprometra klunzingeri and Capillaster multiradiata that at this time covered all the coral forereef like a long-haired carpet. To observe this we used a normal flashlight inside a glass jar. This was before underwater lights became common.

The obstacle to overcome in observing crinoids was that one had to "fight" one's way through and between the most frightening long spines of the common Diadema setosum. Getting stung here and there on the stomach was worth it, however, and so one night I went out without a wetsuit, manoevering between the hostile spines. And there it was, on one site, that I lost my balance and fell over on my behind, landing of course on dozens of spines. It was very painful and I got angry and decided to crush this Diadema. Turning around, I pulled it out of me and discovered that it was not a Diadema, despite its black appearance. This was my first encounter with Echnothrix calarmaris, then a rare animal indeed on the Eilat reefs. From this time on I decided to study echinoderms and the rest is written history.

Holland, Nicholas Drew (Biological Oceanography, Scripps Institution of Oceanography, La Jolla). Growing up in southern Florida, I spent much of my time combing beaches for sea shells. I even took my specimens to the public library to match them up with the pictures in shell books to learn the scientific names. Although I was not adverse to including dried remains of starfishes and sea urchins in my collection, I was definitely not an echinoderm biologist in those years. Even so, whenever a grown-up would inquire as to my plans for a future career, I would always tell them I would be a marine biologist. Neither they nor I really knew what marine biologists really did for a living, but my answer never failed to satisfy everyone concerned. After leaving all oceans far behind, I majored in biology at a very small college in Minnesota. There, I stayed interested in the invertebrates in spite of a lean offering of living material (hydras, planarians, earthworms, and crayfishes). My differentiation into an echinoderm biologist took place at the MBL at Woods Hole in the summer of 1960 between my undergraduate and graduate school. I took the MBL invertebrate course (which long ago vanished beneath the rising tide of reductionism), which was taught by a series of instructors, each entrusted with a phylum or two. As a result, the quality of the teaching fluctuated wildly from the ridiculous to the sublime. Certainly, the best lecture series was given by Verdi Farmanfarmaian, who covered the echinoderms. That lecture series played a big part in bringing me into the echinoderm fold-- but it was not quite the whole story. The critical moment occurred in the middle of Verdi's performance, when the student next to me blurted out: "This sure is interesting, it's too bad you can't make a living doing it." I looked her in the eye (she's a college administrator now, and a very good one and I said: "We'll see about that!) The rest is history.

Jangoux, Michel (Universite Libre de Bruxelles). Until the age of 18 I was not particularly interested in biology, nor anything else except reading novels of all kinds, walks in the woods, and going out with friends. I registered in the school of medicine at the University of Brussels....as that pleased my parents, especially my mother. One of the required courses was zoology. The course was remarkably taught by a true zoologist (a specialist in fresh-water sponges) and with such enthusiasm that I decided to abandon the medical direction and registered in the section of biology of the faculty of science. In reality, all aspects of fundamental biology interested me and when after three years it was necessary to choose between botany, zoology, and molecular biology, it was a true rending. If I finally chose zoology, it was because it was the only department where research could be done in the marine environment. It was thus quite natural that, a year later, I went to the director of the laboratory of marine biology, Prof. Jean Bouillon, a specialist of hydrozoans, to ask him to accept me as a master's student. He very cordially welcomed me and asked me which group of animals I wished to study. I was not at all prepared for this question, being convinced that he was going to propose a study on hydropolyps or hydromedusae to me! He explained to me that he found it much more rewarding to have a student work on subjects of which he was not a specialist. He then gave me two books (one of Monton on molluscs, and the other edited by Boolootian on echinoderms), and asked me to read them and return to see him two months later...this was in August 1968. The echinoderms pleased me more than the molluscs, both for aesthetic reasons and as I found them very mysterious. I was especially interested in reading the chapter by J.M. Anderson ("Aspects of nutritional physiology") and very intrigued by a small paragraph reporting the existence, in starfish, of small digestive organs of unknown function: the rectal caeca. I thus proposed to Prof. Bouillon to make this the subject of my master's thesis....and it was thus my researches on echinoderms began.

Johnson, Craig (University of Queensland, Brisbane). My story is simple. I had good lecturers as an undergraduate at the Univerity of Tasmania so from the beginning found echinoderms both interesting and aesthetic creatures. I was further motivated by Ken Mann when he visited the University on a lecture tour as a Senior Queens Fellow in my third year as an undergraduate. Ken gave a tremendous talk about the Nova Scotia "urchin situation". I was fascinated to hear of the outbreaks and destruction of kelp, and of the best pieces of Breen's, Fong's, Guerinot's and others of his students' work. Some good slides certainly helped stimulate my interest. Subsequently I wrote to Ken about the possibility of pursuing a PhD under his supervision in Halifax, and the rest, as they say, is history.

Levitan, Donald (University of California, Davis). In the summer of 1983 I went to the U.S. Virgin Islands to teach a course, and start my dissertation research on overgrowth interactions between encrusting taxa. When I got to the shore, I quickly realized that entering the water was impossible; from the intertidal down to the sand halo, the entire reef was covered spine tip to spine tip with the poisonous sea urchin Diadema antillarum. In fact, from a distance, the reef had a black hue caused by the hugh numbers of Diadema. When I finally managed to get into the water (by jumping off a dock), I noticed that the surface the sea urchins were feeding on were grazed clean. I began to wonder how individuals could survive and how populations could persist under these apparently food-limited conditions. This changed the direction of my research and started my interest in echinoderm biology.

Manchenko, Gennady (Institute of Marine Biology, Vladivostock). I am not an echinoderm biologist in the strict sense of the term. However my entering biological science was tightly connected with echinoderms. When I was still a school boy I, as many children in the former Soviet Union, dreamt to become a military pilot. In 1964 my dream almost became true after my entering the military aviation high school. However after only one year of studies at the school I drastically changed my mind and left the school. This mistake in my life-strategy cost me four years of life which I had to spend surviving in the Soviet Army. Nevertheless, I am very thankful to this period of my life as it stimulated me to think much more deeply about my being. As a result, I firmly decided to enter the Division of Natural Sciences of the State University of Novosibirsk. I entered Novosibirsk University in 1968 and was graduated in 1973, majoring in "cytology and genetics". About one month before graduation from the University, I met Dr. Alexey V. Zirmunsky, the Director of the Institute of Marine Biology at Vladivostok. He invited me to work at the Genetics Laboratory headed by Alexander Pudovkin. The Institute was very young (it was founded in 1971) and no zoologists were very familiar with the great variety of invertebrate species inhabiting the Sea of Japan. Echinoderms and molluscs were perhaps the only invertebrate groups represented by species with large, attractive, and well-diagnosed individuals inhabiting the sublittoral zone and thus easily available for collection and identification. Fortunately, the most beautiful sea animals, the sea stars, were almost completely unstudied at that time in respect to the level of intraspecific genetic variability. So I began to study allozymic variation in sea stars using the enzyme electrophoresis technique. Since that time I studied isozymes in sea stars, sea urchins, sea cucumbers, and sea lilies. In 1981 I was invited by John Lawrence to take part in the International Echinoderm Conference at Tampa Bay and to prepare a report on genetic variation in echinoderms. However, my attempts to visit Tampa failed because of the well-known difficulties concerning travel from the U.S.S.R. at that time. My report was also not submitted to the Conference because of some unexplained delay of Soviet authorities in supplying me with the necessary permission to send the manuscript abroad. Although I am rather an isozymologist than an echinoderm biologist, I love echinoderms as they are beautiful and studying them is associated with a substantial part of my scientific life. I believe my love is not yet finished.

McNamara, K.J. (Palaeontology, Western Australian Museum, Perth): The lure of fossil echinoids has been a pervasive influence on my palaeontological career, even from the earliest days when I first started collecting fossils. Having been brought up on the chalk downland in Sussex in England, it is not surprising that when I first got bitten by the fossil bug when I was 9 years old that echinoids should have been one of my sought after treasures. While many Museum fossil collections in England would seem to indicate that the English Chalk is riddled with echinoids, this was certainly not the case in Sussex, and I spent many hours searching for those elusive urchins. My university training took me away from fossil echinoids, and following 4 years in the Precambrian at Aberdeen University my PhD at Cambridge was on Ordovician trilobites.

My first employment after completing my doctorate was at the University of Queensland in Australia. There I dabbled in trilobites and ammonites. After two years the job folded, and it was a case of returning to the UK or finding another in Australia. Scanning the local newspapers I found a 3 or 4 line advert that was to affect my future career quite dramatically. Graeme Philip, then Edgeworth David Professor at the University of Sydney, wanted a research assistant to work on Tertiary irregular echinoids with him. Not being able to resist the lure of echinoids, I applied and got the job. As my research background had precluded any studies of echinoids I asked and got the job. As my research background had precluded any studies of echinoids, I asked Graeme what papers I should read. "Don't you dare read anything", he threatened. "I don't want you to be influenced by what other people have said. Work it all out for yourself!" This, curiously, turned out to be really quite good advice and perhaps was one of the reasons why I was able to combine my interest in heterochrony with the echinoid studies. Southern Australia has a magnificent Tertiary echinoid fauna, much of which had been hardly worked on. Not only did I have access to magnificent collections made by Bob Foster and his mother, but I was able to draw on many of the untouched collections in the Museums of Victoria and South Australia.

Not longer after starting in Sydney the job as Curator at the Western Australian Museum was advertised. With some reluctance I applied, having just got into the echinoid studies with Graeme, but when offered the job I could hardly refuse. But this opened up the even more untapped echinoid treasures of Western Australia and a lifetime's work.

Mooi, Rich (California Academy of Sciences). I was fortunate in being born to two extraordinary parents who fostered my interest in the natural world from a very early age. This was reinforced by a synergy with my younger brother. I remember sitting in the forests of local conservation areas around Toronto, Canada, drawing plants and animals from life, and spending hours with identification guides, learning the rudiments of evolutionary biology and systematics. I also recall watching every nature program that we could get on TV, and through this window on the planet, I discovered an inner drive to work in the ocean. At the age of 10, I decided that marine biology would be my calling, and almost every move I made in subsequent years was aimed at fulfilling this goal, in spite of my landlocked situation in the middle of Ontario. Camping trips to both coasts of Canada enhanced my desire to study marine organisms, and I practically lived in the pages of Rachel Carson's books.

In my first year at the University of Toronto, I had the audacity to think that I could just march into the office of the campus' resident marine biologist, and demand information and ideas for how to pursue my calling. Luckily, the man occupying the office was Malcolm Telford, and he indulged my brash enthusiasm to the point where my energies could be focused on a library project that searched databases for papers on deep-sea ecology. Little did I know that Malcolm was to become not only the most important academic influence on my career, but one of my closest friends as well. Naturally I took his marine biology field course, and the invertebrate zoology course, too. I really enjoyed all the stuff about worms, molluscs, and crustaceans, but it wasn't until he introduced the echinoderms as a weird bunch of mutated space garbage left over from an extraterrestrial's picnic that I had my niche. By this time, my early experience with drawing had developed into a real interest in wildlife painting and technical illustration, and it seemed as though the Echinodermata were the perfect blend of artistic, aesthetic, and scientific wonder. I became a graduate student of Malcolm's who insisted that I was not working for him, but with him, an important distinction that emphasized to me the value of collaboration.

My master's degree dealt with tube-foot morphology of sand dollars, and I soon realized that as good as functional morphology was as a topic, it seemed to obtain much greater value as a comparative study. Which led me to phyogenetics, which in turn led me to Rick Winterbottom, a Royal Ontario Museum ichthyologist who introduced me to cladistics, and made me realize that phylogenetic analysis should be the basis of all comparative biology. My doctoral thesis put this idea to work, using sand dollars as a model for some of my wilder thoughts about miniaturization, and heterochrony within the Echinoidea. I obtained a post-doc with Dave Pawson at the National Museum in Washington, where I was fortunate in having access to the famous collections, as well as a conduit to collaborations with many international figures in echinology. My interests have consequently expanded to include deep-sea echinoids, and the evolution of the phylum as a whole - projects that I am fostering with Bruno David in Dijon, France. I have tried as best I can to maintain these contacts and am now pleased to have the opportunity to do so from a position at the California Academy. They seem happy to suffer my eccentricities for echinoderms, and take delight in pointing out to me that the value of the echinoid type of dollar is higher here than in Canada. Dendraster does seem to be larger in California.

Pentreath, Victor W. (University of Salford). A required component of my first degree in Zoology at St. Andrews University, Scotland, was the completion of a research project. My supervisor, Glen Conttrell in the Gatty Marine Laboratory, who was studying neurotransmittors in a range of invertebrate nervous systems, suggested I investigate the cholinergic system in starfish nerve. This proved an immediate fruitful source of the cholinergic triad, thus allowing me to extend the early observations of Bacq, and also to make some functional interpretations. However, the main growing awareness for me then was how little was known about the echinoderm nervous system and how few biologists had made a serious study of it.

Cold but happy hours spent on the windy Scottish shoreline, collecting various Asterias, Ophiothrix and Antedon with my friend and colleague Jim Cobb, also at the Gatty Marine Laboratory, led to a series of valuable collaborative investigations. Although it is now almost impossible to obtain funding for studies of echinoderm neurobiology, my deep interest remains.

Propp, Michael (Institute of Marine Biology, Vladivostock). I remember my first encounter with sea urchins perfectly well. From childhood I was fascinated by books of Jules Verne and about the sea, and dreamed myself as an explorer of the Ocean. So, when SCUBA appeared in the fifties, it as my chance. But Leningrad where I began to dive in 1957, is on the practically fresh Baltic and Black Seas and nearly devoid of echinoderms. But in August 1959 I stood on the rocky shore of the Barents Sea in very cumbersome, home-made SCUBA ready to become the first man to dive in the Russian part of this sea. I stepped into the water - and this was my first contact with the wonder of Strongylocentrotus droebachiensis - as all the needles pricked my heel followed by trickles of ice-cold water. I slipped and bumped by bottom on the rock and - O! O! O! -the urchins were everywhere. I grabbed stones to regain my balance -and they were all covered by these wonderful animals. So a little later, having obtained the proper skill to extract crushed needles from my own skin, I simply could not make them the main point of my Ph.D.

Later I chose to supervise the research of my disciples and many urchins were sacrificed to measure respiration rates, dry weights and many other things. So I had my vengeance, but in due turn the urchins had theirs when I advised my last disciple to begin work with Diadema - he fled to Sebastopol on the Black Sea where he was unable to find any living echinoderms. This, unfortunately, happened to be the end for me of researching these fascinating animals.

Scheibling, Robert (McGill University). I suppose I became interested in echinoderms in a rather round-about way. When I enrolled in graduate school at McGill University in 1973, I was undecided about whether I wanted to study marine biology or animal behaviour. My supervisor, Carol Lalli was a malacologist and I thought I could indulge both of my interests, as well as my desire to work in some exotic place by undertaking a field study of predatory behaviour and territoriality in tropical octopuses. Somewhere in the Caribbean would be perfect, and the fact that McGill had a research station in Barbados fit well with my plan. So I diligently devoted myself to learning all I could about octopuses, and went to Barbados that first winter to begin some pilot studies. As it turned out, Barbados was no place to study octopuses (only because there were very few of them about), although I knew the Caribbean was right for me, maan! While on the rebound to find a new tropical animal to study, another student of Dr. Lalli's suggested I work on Oreaster reticulatus. He told me these sea stars occurred in large numbers in the Grenadines, where he had observed them feeding on urchins in seagrass beds. At the time, I was taken by Bob Paine's work on sea stars as keystone predators, and I thought I might be able to find a tropical analogue in Oreaster. In any event, I was interested in predator-prey interactions, and even if sea stars were brainless, it was still the Caribbean. When I searched the literature on Oreaster, I found that virtually nothing was known about its biology and ecology. It appeared that, while this species used to be widespread throughout the Caribbean, it had long been collected as a curio due to its handsome appearance and was now rare among the more populated islands like Barbados. I happened to see my first specimen in a shop window in downtown Montreal. It was part of a clothing display but I convinced the shop owner to sell it to me, and so the love affair began. The next thing I knew, I was on Carriacou, a remote desert island in the Grenadines, where I set out to learn what I could about this curious beast, armed only with a diving mask, snorkel and fins, and the companionship of a good woman. What more could one ask for? I suppose I learned more about life and about myself on that isolated and wondrous island than I did about Oreaster, but that experience paved the way to further adventures and discoveries, and ultimately decided my career. By the way, I soon found that the shallow lagoons off Carriacou were full of octopuses that no one had ever studied, but once I had stars in my eyes I never looked back. Those years in the Caribbean, studying the life of a sea star, were among the best years of my life.

Sibuet, Myriam (Institut francais de recherche pour l'exploitation de la mer, Brest). I was struck, during my first voyage in 1969 for three months aboard the ship Jean Charcot, by the abundance of echinoderms in the trawls and especially their unusual, nearly elegant forms. It was of course the genus Deima that attracted me! A long time the photo of this species was at my door and the figure of Herrouard in 1902 illustrated the first page of my state thesis! This typically marine group has seemed to me from the beginning of my research on the abyssal biology a group well adapted to the conditions of extreme life in the depths of the abyss. The morphological characters are very peculiar and curious in certain cases and answer to a form of adaptation. I have sought to interpret the mode of life and the adaptation to the great depths in considering the echinoderms and especially the holothuroids as a model zoological group. Later the studies made in collaboration on the nutrition of holothuroids have led me again to interpret the detritivore system in using the holothuroid species as a model.

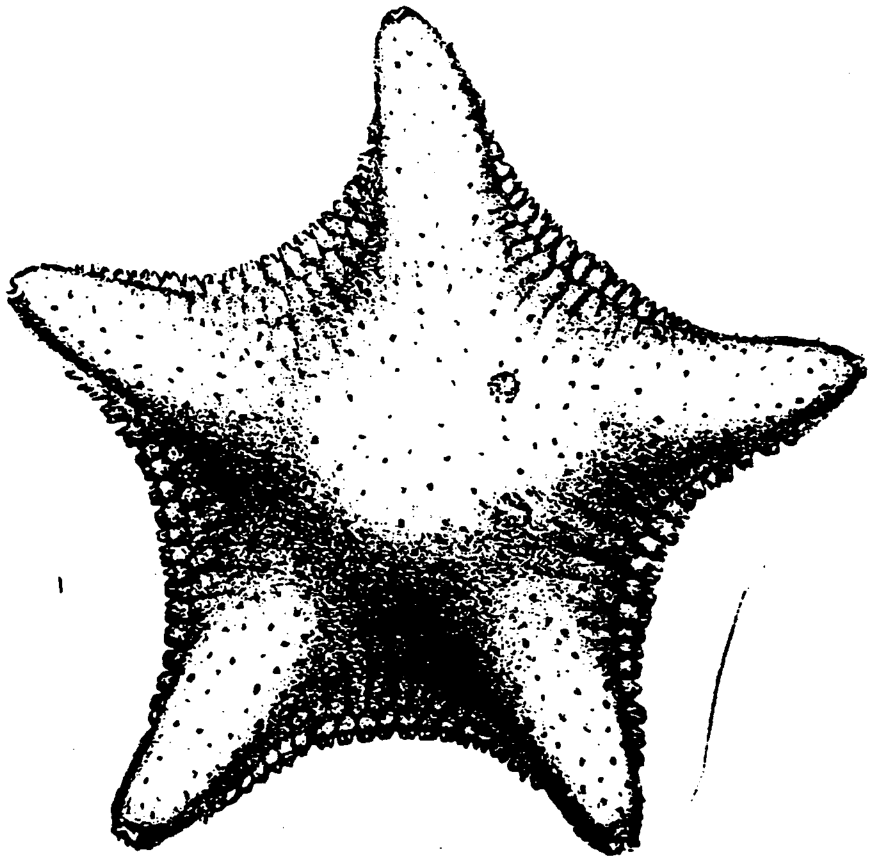
Woodley, Jeremy (Discovery Bay Marine Laboratory). When I was an undergraduate in the Zoology Department in Oxford, I attended a field course at the Millport marine Station. It was in the Easter vacation of, I think, 1959 and was attended by students from several other universities. We learned a lot and had a good time! Our visit overlapped with April Fool's Day when, I remember, the front gates of all the houses around Kames Bay were mysteriously interchanged. It was then that I learned how to bolt a door from the outside (on the inside) with a piece of string. One of my colleagues, excluded thus from his bedroom, borrowed. I regret to report that, when he took the ladder back, I wa secretly watching and slipped in and did it again!

Echinoderms? Oh, yes: we each had to choose a group of organisms to sort from communal collections, identify and display to the others. I chose brittle-stars because I thought they were pretty. Also something of a challenge because some of them looked rather similar. So it was that I first met those fascinating creatures, the burrowing amphiurids, dredged from the glutinous mud of the Firth of Clyde.

Later in my undergraduate career, I had a term of tutorials in vertebrate biology from David Nichols. Not surprisingly, we talked about echinoderms quite often, and he suggested that I stay on after graduation to work with him. I had been much influenced by Arthur Cain and the school of evolutionary ecology at Oxford, and my first thought was to find out more about the adaptive radiation of British brittle-stars. But that meant, not only finding out what they don, but how they do it, and one day David asked "How do brittle-star tube-feet work, anyway?@ We soon realized, not only that no-one knew the answer, but that the question had never really been asked. I resolved to try and answer it. Even before I graduated, I was back at Millport watching tube-feet and preserving brittle-stars for histology.

Even so, my career could have been in quite another field. I went on a University Expedition to British Guiana (as it then was), studying frogs and lizards in the rain fores of the Potaro River. I enjoyed working in the tropics, became fascinated by frogs, and actually secured a Brazilian Government Scholarship to continuye working with them, though it would have been for only one year. Had it been possible, in those distant days, to get support for a postgraduate project with fieldowrk overseas, I would now be a herpetologist! Funding was available to support projects at home, and I remember saying to myself that I would just knowck off this ittle project on brittle-star tube-feet, then go back to my real love, the study of tropical frogs. People do change, don't they?! Nonetheless, when I took my first real job, I moved to the

University of the West Indies in Jamaica because it offered research opportunities, not only on marine invertebrates, but on tropical frogs! As it turned out, they remained a hobby, and I moved deeper and deeper into the sea.



Bell

OBITUARIES

Smith, James Eric. (an obituary for Dr. Smith by David Nichols appeared in the 1992 Echinoderm Newsletter. An extensive one by Q. Bone and D. Nichols appeared in Biographical Memoires of the Royal Society. 38, 325-343, 1992. The section on his echinoderm work follows)

Honours

Eric was awarded a C.B.E. in 1972 and was knighted in 1977; among other honours, he received the gold medal of the Linnean Society in 1971, the Frink medal of the Zoological Society in 1982, and was elected a Fellow of King's College (1964) and Queen Mary College (1967). He received an honourary D.Sc. from Exeter (1968), and was one of the first Fellows of the then Plymouth Polytechnic (now theUniversity of Plymouth).

Scientific work

Smith began his scientific life as a Student Probationer at the Laboratory of the Marine Biological Association at Plymouth. His first paper (1)* in 1932 was the result of this two-year studentship, and described the physical nature and fauna of the Eddystone Shell-Gravels. He concluded that 'The distribution of species over the whole area is such as to suggest that any one of the three lamellibranchs, *Glycymeris glycymeris, Chione (=Venus) fasciata,* and *Astarte triangularis*, associated with *Spatangus purpureus* - which, although few in numbers, is characteristic of the ground - is sufficient to characterise the community'. Interestingly, he noted a significant decline in numbers of the small bivalve *Gouldia minima* since a previous survey ten years before, and Holme's later extensive surveys of the Channel benthos showed that this species has declined even more steeply since Smith's work (Holme, 1946). During his work on the shell-gravel, Smith started to collect embryonic stages of the nemertine worm *Cephalothrix rufifrons*. When he moved to an Assistant Lectureship at the University of Manchester, he filled in the missing developmental stages on return visits to Plymouth. His paper (2) describes the early development, of interest because the worm is a representative of the group of nemertines which exhibit direct development.

Smith's echinoderm work began with a short letter to *Nature* (5) on the occurrence of immature individuals within the genital bursae of *Ophiothrix fragilis* anticipating his 1940 paper (6) on the reproductive system of this brittle-star, a diversion from his principal work at that time. Smith notes the occurrence of young in the genital bursae of males as well as females. The habit is almost certainly a chance entering of the bursa by a young individual seeking a small crevice for safety during a vulnerable stage of the life-cycle: like spine-clinging, it does not denote vivipary. He was later to comment (6) that the term 'genital bursa' is unfortunate, as in so many ophiuroids, including *O. fragilis*, the oviducts do not open into these sacs, and their use as havens for the young is far from universal.

In this later paper (6) Smith describes for the first time, the gross stages in gametogenesis. As there is no evidence of proliferation of germ-cells from the gonadial epithelium itself, Smith concludes that the primary germ-cells present in the gonads have migrated there from the rachis: 'The gonad is not the place of origin of the gametocytes, but within it maturation and growth of germ-cells takes place.'

* Numbers in this form refer to entries in the bibliograpny at the end of the text.

The neurobiology of asteroids

While at Manchester, Smith embarked on the monumental work for which he became principally known: the neurobiology of the starfish. When he began, knowledge of the echinoderm nervous system was rudimentary. It was known that the neurons were very small, that spines, pedicellariae and tube feet could function autonomously, and that there was a motor system innervating effector organs. There was, however, still little unanimity of view regarding the subdivisions of the nervous system, and connections of neurons within it were largely unknown. It was in this historical context that Smith began the daunting task of investigating the nervous system of a group of animals that did not lend themselves readily to specific nerve stains, and whose nerves were difficult to identify (or even to see) by routine methods. He said later in life that his colleague at Cambridge, Carl Pantin, had tried in vain to warn him off the echinoderms, reminding him that their cells were far smaller than those of most other animals; that nobody could get very far with the neuroanatomy of animals so generously endowed with endoskeleton; and that these animals did not lend themselves to specific nerve stains. A later worker in echinoderm neurobiology has commented that 'There is less known about the organization of the echinoderm nervous system than that of any other phyla of metazoan animals. The reason for this is not that they are obscure or that they are not intriguing. It is simply that they are very difficult to work with technically (Cobb 1987). Electron microscopical techniques, which were later to enable great strides to be made in neural mapping, particularly at nerve-muscle junctions, were not yet available. Recently, too, new staining techniques, such as Lucifer yellow introduced iontophoretically into neurons, have enabled pathways to be traced with greater accuracy. But even without these later techniques Smith's work took the subject of echinoderm neurobiology forward with an impressive set of papers.

In the first of a series of three major papers in the *Philosophical Transactions* (3), Smith began to extend understanding of the nervous system by painstaking sectioning in several planes, followed by observations at the limits of optical microscopy. In this 1936 paper, in which his preparations were stained by conventional histological techniques, particularly Mallory's trichrome, Smith made enormous advances in understanding the neural basis for starfish activity. The paper has been extensively quoted subsequently, and no fewer than ten of Smith's figures from it were reproduced by Hyman in the echinoderm volume of her classic series *The Invertebrata*, a book that begins with the now-famous affirmation: 'I here salute the echinoderms as a noble group especially designed to puzzle the zoologist.'

The second paper (8) on the mechanics and innervation of the starfish tube-foot-ampulla system greatly advanced the study of the neural pathways involved in locomotion and other activities. As Smith remarked in his introduction, 'The tube feet of a starfish are concerned in almost every action which the animal as a whole is called upon to perform. It is, moreover, the *coordinated* movement of the podia which gives direction, purpose and rhythm to the action.'

To map neurons and their axons for this paper, Smith used for the first time the Unna-MacConnell methylene-blue leucobase technique for *intravitam* staining of nervous tissue in fairly large chunks of starfish arm, subsequently fixed in ammonium molybdate and thick-sectioned. This variant of Ehrlich's technique had been used successfully in demonstrating the nerve net of the coelenterate *Hydra* about ten years previously, and although it was to prove invaluable in tracing some nervous pathways in the starfish, it was also to be instrumental in misleading him in the structure of certain elements.

In his third paper on starfish neurobiology, published in 1950 (10), Smith describes in detail the innervation of the arm, ampullar and tube-foot musculature in *Astropecten*. He states that the axons innervating the tube-foot musculature 'may best be likened to ribbons many times broader than the thread-like fibres of the nerve chain. They are applied along the length of the muscles, many fibres of which are served by collateral branches of the ribbon axons.' A principal difficulty in this work was the accurate identification of the form of nerve-fibre terminals, as Smith recognized, and it later became clear that the 'ribbon axons' are in fact modified muscle cells. Dr J.L.S. Cobb writes: 'Smith produced many useful images (by his methylene-blue staining) but regrettably the advent of the electron microscope showed: (a) that muscle cells had also stained; and, (b) that long processes arise from muscles with a striking convergent similarity to axons.'

Coordination of movement in the starfish

Smith's first review (7) was written during the highly productive period of laboratory work he undertook at Cambridge. The principal theme was the way arm and tube-foot movements are coordinated. Movement in echinoderms, he suggests, is worthy of special study because these are animals in which radial symmetry extends in varying degrees to almost all organ systems of the body, and so the nature of their movement has no counterpart in the activities of bilaterally symmetrical animals. The nervous system exhibits different powers of integration in different parts of the body: spines and pedicellariae are virtually independent effectors, whereas tube feet and arms are subject to a rigid coordination in the interests of the whole animal.

The question whether there are special coordinating centres had much exercised echinoderm biologists, and in this review (7) Smith remarked that 'One might suggest that the nerve ring includes a nerve centre at the base of each arm, and that the neurones of these centres can heighten the general level of excitation within the radial nerve cord of their respective arms'. He reiterates the classic experiment in which starfish arms are autotomized or severed with or without a part of the adjacent nerve ring, experiments that had so influenced earlier thinking. With part of the nerve ring intact, the arm is said to act as a leading arm, with its tip foremost, whereas an arm severed distal to its junction with the ring will move off with its proximal (open) end leading. This experiment does not always produce cut-and-dried results, and after a time the arm with part of the nerve ring attached will often revert to behave like the arm lacking part of the ring. As Smith said, 'there are indications that the general level of activity of the neurons of these supposed centres is not always constant'.

In a synthesis of the relation between structure and function in echinoderms (11) he showed how his work on starfish sensory and motor systems and the distribution and fine anatomy of nerve tracts connecting them enabled a more meaningful examination of behavioral aspects of nervous control. He pointed out that it is not possible to study locomotory coordination of arms and tube feet by simply suspending a starfish in water: the arms of such a preparation will twist and bend incessantly and the tub- ... -mp. to regain contact with a hard surface. But an inverted starfish placed over a ... ly sized cylinder will permit observation of an actively stepping experimental animal.

When such an animal is gently touched on its dorsal surface by a probe, the spr... of excitation from the stimulated spot can be followed.

The sequence of responses evoked lead to the conclusion that there is a dual-control mechanism in place, the one peripheral and reflex, the other central and generalized, and this pattern is of significance in the integration of locomotory stepping.

Because the sequence of tube-foot movements is not dependent on a centrally determined rhythm, the integration of stepping activity must be by cycles of activity within the foot itself. Smith therefore advocated in this paper that there should be subsequent study of the effects of localized and graded stimuli applied to a tube foot at different phases of its stepping cycle, and a survey of the different kinds of step that may be associated with various stimuli. Such a study has yet to be done.

The current view on the neural basis of echinoderm behaviour is that coordination is effected by the series of segmental ganglia composing the radial nerve-cord along each arm, and that the circum-oral nerve ring serves mainly to connect the nerve cords one to another. The layout of the nervous system is thus radial rather than central, and 'the dominance that coordinates whole-animal behaviour can shift from one part of the radial nervous system to another' (Cobb 1990). Such an approach helps to explain not only the observed differences in tube-foot response down the length of an arm that Smith and others had observed, but also the progressive change in tube-foot response in severed arms. It is also becoming increasingly evident that responses and hierarchical interactions are dependent on the physiological state of the animal, such as its nutritional condition or the level of illumination in which it has been living before observation.

Smith's achievement was to provide, for the first time, considerable anatomical detail of sensory and motor pathways, giving to subsequent echinoderm workers a framework for further studies using more recent ultrastructural and recording techniques.

Some 15 years after completing experimental work on the echinoderm nervous system, and shortly before leaving Queen Mary College London, Smith published two further reviews on the current status of echinoderm neurobiology. In both (15, 16) he suggested the occurrence of a giant-fibre system in ophiuroids. More recent work by Brehm (1977) has indeed described giant fibres in the ophiuroid arm, from which single-unit action potentials could be recorded. Since then, these large neurons of brittle stars foreseen by Smith have enabled an appreciable increase in knowledge of the echinoderm nervous system at the cellular level.