Intergovernmental Oceanographic Commission

Workshop Report No. 64

Second IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP)

Phuket, Thailand, 25-31 September 1989

Unesco

IOC Workshop Reports

The Scientific Workshops of the Intergovernmental Oceanographic Commission are usually jointly sponsored with other intergovernmental or non-governmental bodies. In each case, by mutual agreement, one of the sponsoring bodies assumes responsibility for publication of the final report. Copies may be requested from the publishing bodies as listed below.

No.	Title	Publishing Body	Languages
1	CCOP-IOC, 1974, Metallogenesis, Hydrocarbons and Tectonic Patterns in Eastern Asia (Report of the IDOE Workshop on); Bangkok, Thailand 24-29 September 1973 UNDP (CCOP), 138 pp.	Office of the Project Manager UNDP/CCOP c/o ESCAP Sala Santitham Bangkok 2, Thailand	English
2	CICAR Ichthyoplankton Workshop, Mexico City, 16-27 July 1974 (Unesco Technical Paper in Marine Sciences, No. 20).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish (out of stock)
3	Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean, Monte Carlo, 9-14 September 1974.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock)
4	Report of the Workshop on the Phenomenon known as "El Niño", Guayaquil, Ecuador, 4-12 December 1974.	FAO Via delle Terme di Caracalla 00100 Rome, Italy	English (out of stock) Spanish (out of stock)
5	IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources, Kingston, Jamaica, 17-22 February 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish
6	Report of the CCOP/SOPAC-IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Suva, Fiji, 1-6 September 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
7	Report of the Scientific Workshop to Initiate Planning for a Co-operative Investigation in the North and Central Western Indian Ocean, organized within the IDOE under the sponsorship of IOC/FAO (IOFC)/Unesco/EAC, Nairobi, Kenya, 25 March-2 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
8	Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters, Penang, 7-13 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
9	IOC/CMG/SCOR Second International Workshop on Marine Geoscience, Mauritius, 9-13 August 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
10	IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring, Monaco, 14-18 June 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock) Russian
11	Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish (out of stock)
11 Suppl.	Collected contributions of invited lecturers and authors to the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain, Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
12	Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects, Fort-de-France, Martinique 28 November-2 December 1977.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
13	Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area, Port of Spain, Trinidad, 16-18 January 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
14	IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas, Abidjan, Ivory Coast, 2-9 May 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French
15	CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific, Santiago de Chile, 6-10 November 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
16	Workshop on the Western Pacific, Tokyo, 19-20 February 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Russian
17	Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS), Moscow, 9-11 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
17 Suppl.	Papers submitted to the Joint IOC/WMO Seminar on Oceanographic Products and the IGOSS Data Processing and Services System, Moscow, 2-6 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
18	IOC/Unesco Workshop on Syllabus for Training Marine Technicians, Miami, 22-26 May 1978 (Unesco reports in marine sciences, No. 4)	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) French Spanish (out of stock) Russian
19	IOC Workshop on Marine Science Syllabus for Secondary Schools, Llantwit Major, Wales, U.K., 5-9 June 1978 (Unesco reports in marine sciences, No. 5).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian Arabic
20	Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources, Bandung, Indonesia, 17-21 October 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
21	Second IDOE Symposium on Turbulence in the Ocean, Liège, Belgium, 7-18 May 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
22	Third IOC/WMO Workshop on Marine Pollution Monitoring, New Delhi, 11-15 February 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
23	WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Russian
24	WESTPAC Workshop on Coastal Transport of Pollutants, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
25	Workshop on the Intercalibration of Sampling Procedures of the IOC/WMO UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters, Bermuda, 11-26 January 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (superseded by IOC Technical Series No. 22)
26	IOC Workshop on Coastal Area Management in the Caribbean Region, Mexico City, 24 September-5 October 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
27	CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Nouméa, New Caledonia, 9-15 October 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
28	FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes Lima, 20 April-5 May 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
29	WESTPAC Workshop on Marine biological methodology Tokyo, 9-14 February 1981.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
30	International Workshop on Marine Pollution in the South-West Atlantic Montevideo, 10-14 November 1980.	IOC, Unesco Place de Fontenoy, 75700 Paris, France	English (out of stock) Spanish
31	Third International Workshop on Marine Geoscience Heidelberg, 19-24 July 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
32	UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the context of the New Ocean Regime Paris, 27 September - 1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
32 Suppl.	Papers submitted to the UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime Paris, 27 September-1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English

CONT'D ON INSIDE OF BACK COVER

Intergovernmental Oceanographic Commission

Workshop Report No. 64

Second IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP)

Phuket, Thailand, 25-31 September 1989

Edited by D.J. Staples,
Bureau of Rural Resources,
GPO Box 858, Canberra, ACT 2601
Australia

SC-90/WS-25

Unesco

TABLE OF CONTENTS

ANNEXES

1. INTRODUCTION

Mr. Rattakorn Nimwattana, on behalf of the Governor of the Province of Phuket, welcomed the participants of the Workshop and wished them a successful meeting.

Dr. Jurgen Alheit, Senior Assistant Secretary of IOC for OSLR, thanked all the persons and institutions that had contributed to the preparation and funding of the Workshop, particularly the Intergovernmental Oceanographic Commission (IOC), the Food and Agriculture Organization (FAO) and the Department of Industry, Technology and Science of Australia (DITAC). He mentioned particularly the generous support granted by the Government of Thailand, the host country, and the efforts made by Dr. Boonlert Phasuk, the Director of the Marine Fisheries Division of the Department of Fisheries of Thailand, to host the workshop. He also expressed his appreciation of the efforts made by Drs Derek Staples and Peter Rothlisberg in preparing and organizing the meeting.

Dr. Alheit introduced the Ocean Science in relation to Living Resources Programme which is co-operatively sponsored by IOC and FAO and explained its structure (Fig. 1, Annex II). He briefly presented the two pilot projects of OSLR, the Sardine-Anchovy Recruitment Project (SARP) and the Tropical Demersal Recruitment Project (TRODERP) which includes the Penaeid Prawn Recruitment Project (PREP) in the WESTPAC region and described on-going OSLR activities in other regions. Finally he stressed the interest of IOC in promoting interregional exchange of scientists and data and expressed his satisfaction that prawn researchers from Mexico and Spain were invited to the PREP Workshop in the WESTPAC region. A report on the relationship between penaeid prawn recruitment and environmental factors of the estuarine and offshore penaeid fishery on the central Mexican Pacific coast is included in Annex III. Annex IV contains the description of a new international project on the prawn fishery in the Pacific Mexican coast to be run co-operatively by Mexico, Spain and France which is funded by the Commission of the European Communities.

The Director General of the Department of Fisheries of Thailand, Dr. Plodprasop Suraswadi, welcomed the participants to the Workshop. He pointed out the importance of marine fisheries for Thailand which comprise 90% of the total fishery yield of the country. From the early sixties on, Thailand has increased its catches by a factor of 10 and now belongs to the top ten nations with reference to fish catches. The prawn catch of Thailand, both from wild populations and from mariculture, yielded in 1988 ca 20,0000t. Approximately 5,0000 t of prawns were exported which provides important overseas's revenue for the country.

2. RATIONALE AND OBJECTIVES OF WORKSHOP

The IOC-FAO collaborative research project on penaeid prawn recruitment (PREP) is aimed at promoting better management-orientated research on penaeid prawn resources throughout the Indo-west Pacific region. The project is attempting to enhance our understanding of the effects of fishing and environmental impacts on penaeid resources through the use of a geographic comparative approach to the factors affecting recruitment of prawns throughout the region.

2.1 MOTIVATION AND RATIONALE

There is a growing concern that many prawn fisheries throughout the region are overexploited (ie. number of fishing units exceeds that which can catch the long-term sustainable yield). However, penaeid prawn stocks are characterized by large inter-annual variability and the effects of fishing is often masked by the effects of environmental change. Many years data are usually required before these effects can be defined and predictive models can be formulated. PREP will attempt to shorten these time frames by a geographic comparison of the recruitment dynamics of prawns both within years and between years in several study sites spanning the Indo-west Pacific region. Factors affecting recruitment (i.e. the number of prawns entering into a given life history stage/habitat) are being studied at several levels within the life history to determine how these factors interact to control the number of prawns available to the fishery in any given year.

2.2 OBJECTIVES

The scientific objectives of PREP are:

(i) Collect data on the seasonal patterns of abundance of all life-history stages of selected species (i.e. Penaeus merguiensis, P. semisulcatus and Metapenaeus ensis)

(ii) Define the links between the timing of the different life-history stages to establish critical time/space windows for quantifying recruitment indices for the main generations.

(iii) Establish relationships between selected environmental and appropriate recruitment indices, both between generations within years and among years.

(iv) Identify causal mechanisms underlying any significant correlations, including effects of fishing, climate, ocean and estuarine processes,habitat changes and predation.

(v) Develop environment/stock:recruitment models for predicting changes in recruitment brought about by changes in both fishing pressure and other environmental/biological factors.

(vi) Provide relevant management advice at the national level.

2.2.1. Project Status 1988

Objective 1 and 2

Based on preliminary data presented during the first PREP Workshop held in Cleveland in July 1988 the following hypothesis to explain the patterns in the seasonal recruitment dynamics of P. merguiensis across the region was formulated (Staples and Rothlisberg, 1990).

(i) Spawning of P. merguiensis continues throughout much of the year in the Indo-west Pacific region but spawning activity (measured from population fecundity indices) peaks twice a year: (September - November) and (March - May).

(ii) One or both of these cohorts can survive to recruit into the coastal offshore region approximately 6 months later, the relative strength of these recruitment pulses depending on the timing of rainfall. In areas where only one wet season occurs each year (e.g. Philippines, Australia) only one main pulse of recruitment occurs and offshore fishing of this species is restricted to one period of the year. In areas where two distinct wet seasons occur, both generations contribute and fishing is effectively all year round. In other areas intermediate situations occur with one or the other generation being dominant and giving rise to seasonal peaks in prawn number and catches in periods during the main rainy season.

Objective 3

No firm relationships have been established yet. Most data sets are to short for analyses.

Objective 4 and 5

The following processes have been identified as possibly having a major effect on recruitment of prawns into the offshore area:

(i) Variable larval survival and loss due to variability in currents/tides and food supply.

(ii) Variable juvenile prawn survival due to variability in environmental factors, especially rainfall.

(iii) variable juvenile prawn loss due to changes in nursery ground habitat (e.g. mangroves and seagrass).

(iv) Overfishing of parental stock.

2.2.2. Objectives of 1989 Workshop

(i) Review recent data on seasonal dynamics of PREP study species. Establish appropriate spawning and recruitment indices for each study site where possible.

(ii) Examine inter-annual trends in recruitment and spawning indices.

(iii) Compare methods used by different countries for sampling, data collection and storage.

(iv) Identify problems with comparing results based on different methodologies.

(v) Standardize methods, where necessary, and describe these methods so that any new results are comparable with existing data.

3. REVIEW OF SEASONAL RECRUITMENT DYNAMICS AND INTERANNUAL VARIABILITY

3.1 SEASONAL RECRUITMENT DYNAMICS (PENAEUS MERGUIENSIS)

3.1.1 Australia

Spawning during 1988/89 (measured both from population fecundity index and larval abundance), peaked in September to November and again in January to May (Fig. 1a). Peaks in postlarval abundance followed approximately one month later giving rise to juveniles in the estuary throughout most of the year with a peak in November/December(Fig. 1b). Emigration of juvenile prawns from the estuary was restricted to the summer wet season period (December to March) (Fig. 1c) and resulted in a clear unimodal peak of recruitment into the offshore fishery (Fig. 1d). By following these modes in the relative abundance back through the different life history stages, it is apparent that the main commercial stock (taken within one or two weeks in April) originates from the minor spawning peak in

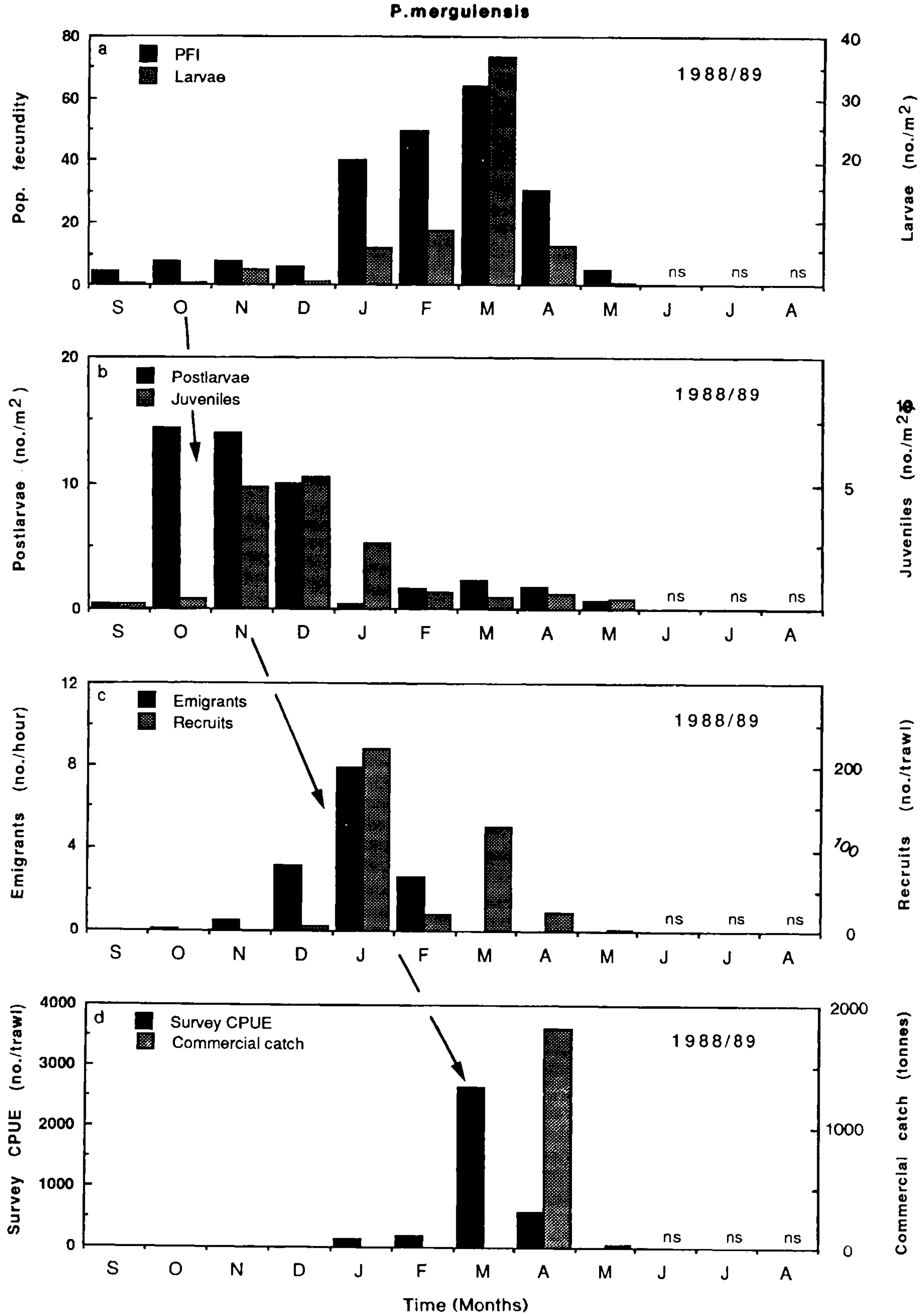


Fig. 1: Seasonal dynamics of Penaeus merguiensis (1988/89) in the Australian study site, Albatross Bay (a) Population Fecundity Index and larave (b) postlarvae and juveniles (c) emigrants and recruits and (d) Adults (commercial CPUE and survey). Arrow links stages of the main generation from spawning to commercial fishery.

September to November. Because of the filtering effect of an extremely seasonal wet season, the major spawning in February to April contributes little to the offshore population of adults.

3.1.2 Indonesia

The data on recruitment dynamics of P. merguiensis cover the period from May 1987 until December 1988 and the seasonal dynamics of this species is described using monthly averages for this period in the Cilacap region. The prawns spawned about 25 km offshore, usually in a depth between 20-30 m. The time of peak spawning as indicated by the percentage of mature prawns in the commercial catches showed that the prawns spawned throughout the whole year with peaks in March/April, August and November (Fig. 2a). Very reduced spawning was observed between May to July.

Postlarvae were immigrating into both the eastern and western inlets of the Segara Anakan Lagoon throughout the whole year with a minor peak in February/March and a large peak in June (Fig. 2b). The immigration rate at the eastern inlet was considerably higher than at the western inlet, probably due to the higher prawn abundance on the eastern fishing grounds at Penya Bay.

Many juveniles left the mangrove areas during the ebb tide through small rivers, channels and creeks. Juveniles were emigrating from the lagoon throughout the whole year with apparent peaks in February/March, August and November (Fig. 2c). Again, the emigration rate was higher at the eastern inlet. In 1988, three peaks of emigrating juveniles were observed, whereas only two were recorded in 1987. The adult prawns are fished in the coastal zone throughout the whole year with a peak in catches from September to January (Fig. 2d).

The main period of increased catches and recruitment, therefore, appears to originate from the peak of spawning which occurred in March/April. This was followed by a peak of emigrating juveniles and subadults in August and, finally, a peak in the fishing season in September/December. The time lapse between peak spawning and peak fishing was 6-7 months. Prawns spawned in September to November recruited offshore in February/March which allowed relatively high catches of adult prawns throughout March to July.

3.1.3 Malaysia

Postlarval prawns are not being sampled because of lack of expertise in sampling methods and larval identification.

Juveniles and emigrants have been sampled using commercial push nets and bag nets since February 1989. Catch and effort data were obtained from research surveys, fishermen's records and the statistics of the Fisheries Department. Two peaks occurred in the abundance of juveniles and subadults, one in February/March and the other in June/July (Fig. 3a), indicating two peaks of recruitment of postlarvae into the estuaries and two peaks of emigration back offshore.

Data on sub-adults/adult prawns were obtained from trawl catches and trammel nets which are operated off the coastal mangrove swamps. Seasonal peaks of abundance in sub-adults/adults were recorded in March/April and July/August (Fig. 3b) which correspond to the two peaks of emigration from the estuary one or two months earlier.

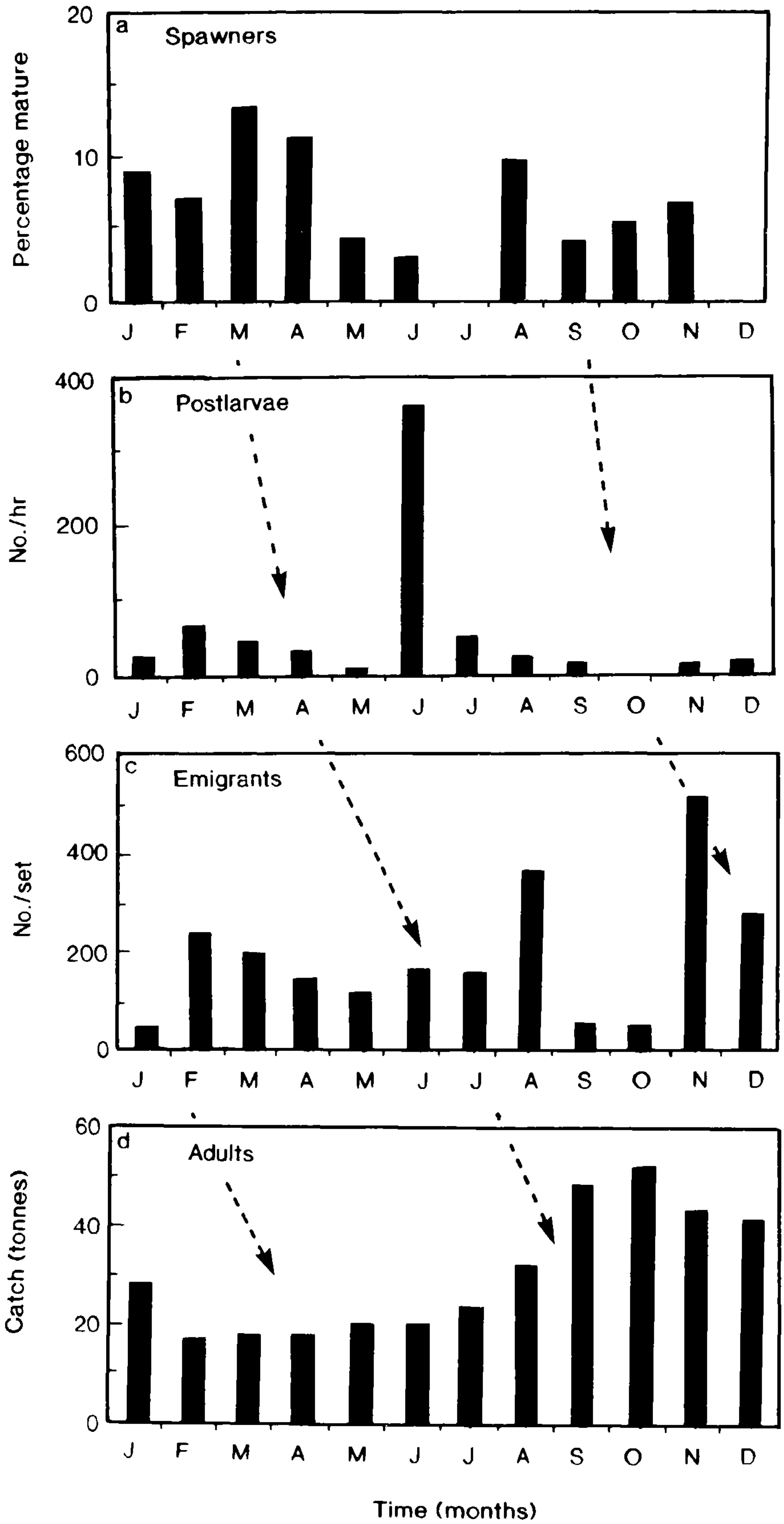


Fig. 2: Seasonal dynamics of Penaeus merguiensis (average over 5 years) in the Indonesian study site, Cilacap (a) Spawners (b) postlarvae (c) emigrants and (d) Adults (commercial CPUE). Arrow links stages of the main generations from spawning to commercial fishery.

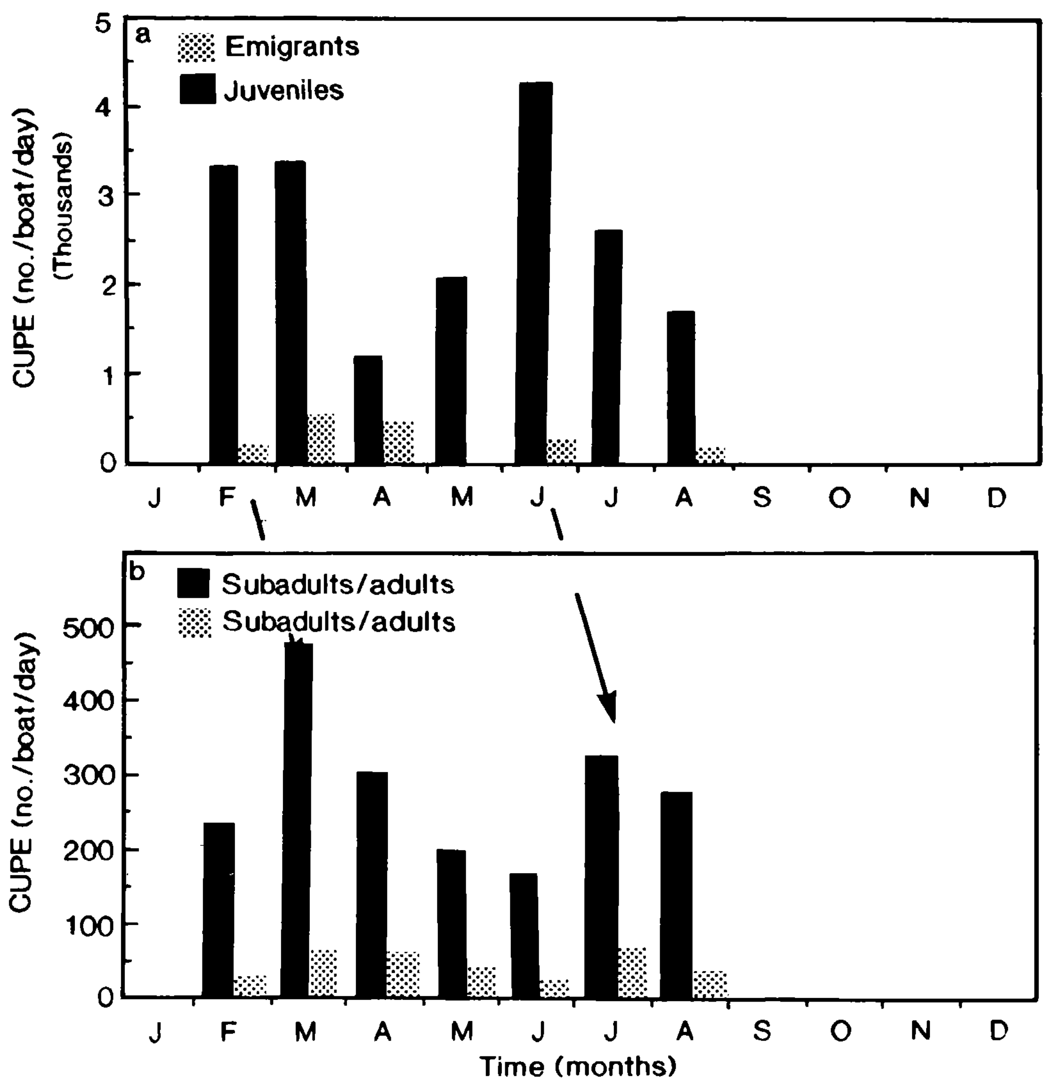


Fig. 3: Seasonal dynamics of <u>Penaeus merguiensis</u> (1989) in the Malaysian study site, Larut-Matang (a) Juveniles and emigrants and (b) subadults/adults (trammel nets and trawl). Arrow links stages of the main generations from juveniles to commercial fishery.

3.1.4 Papua New Guinea

Data on spawning indices (percentage of ripe females gonad stage 4) have been collected since November 1988. The highest percentages were recorded from December to February and July/August (Fig. 4a). A low percentage in November occurred at the time of low catches in the fishery and may indicate a movement of prawns out of the fishery into deeper waters for spawning. However, there are no larval or postlarval studies presently being carried out to refute or confirm this theory.

Juveniles were present in the estuaries in all months sampled so far with a peak in August (Fig. 4b). Adult catches peaked from April to July in 1988. A link with the spawning in November/December is hypothesized but further data are required.

3.1.5 Philippines

Earlier studies have suggested that the prawns spawn from March to May and in August. However, recent data on fecundity and the early life history stages are not available. Intensive short-term sampling only commenced in February 1989 and estimates of both emigrants and recruits are quite variable from month-to-month with no clear trends apparent. A large peak of recruits into the offshore fishery occurred in June but could not be linked to a high peak in emigration (Fig. 5a). Monthly catches were also variable with possible peaks occurring in June and September (Fig. 5b). However, earlier reports on catches given in the First PREP workshop indicated that peak CPUE of adults occurred from October to February, a period not yet sampled in the present study. Further sampling is required before definite links can be described and spawning/recruitment windows can be identified.

3.1.6 Thailand

Ban Don Bay

Data for earlier life history stages are quite variable from month-to-month and distinct peaks of spawning and recruitment are difficult to establish. However, two (possibly three) peaks in the adult CPUE can be seen, one in May to August and the other (possibly two) from October to January (Fig. 6e). Assuming a 6 to 7 month period from spawning to adult, these generations would have originated from the apparent peaks in spawning in September to November and May-July, respectively (Fig 6a). Some of the links between these peaks are difficult to see in the intermediate life-history stages and additional sampling is required before they can be more firmly established.

Phang-nga Bay

Postlarvae and juveniles were sampled from 13 stations along the coast of Phang-nga Bay from January to December 1987. Postlarval P. merguiensis were present during all months of the year, with maximum numbers recorded in May and again in September (Fig. 7a). Sub-adults/adults were also present all year round (Fig. 7b). Maximum numbers occurred in June and December, respectively. Two periods of recruitment into the coastal region each year is suggested by the increase in the percentage of smaller prawns in May and again in October (Fig. 8). These pulses of recruitment, however, do not show up clearly in the sub-adult/adult catches which showed a wide variability in both space and time making accurate assessment of the seasonal recruitment patterns difficult.

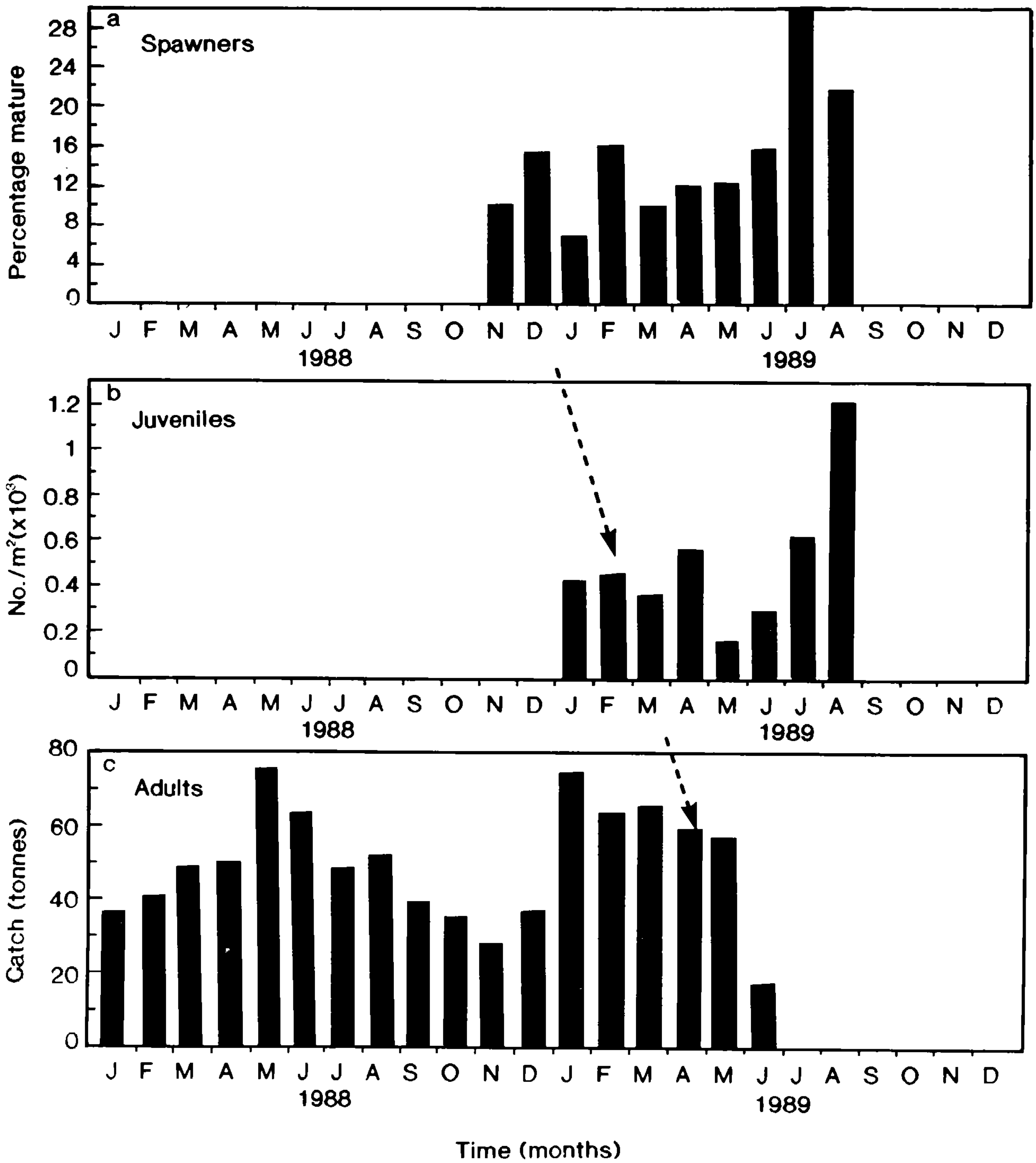


Fig. 4: Seasonal dynamics of <u>Penaeus merguiensis</u> (1988/89) in the Papua New Guinea study site, Gulf of Papua (a) Spawners (b) juveniles and (c) adults (commercial catch). Arrow links stages of the main generations from spawning to commercial fishery.

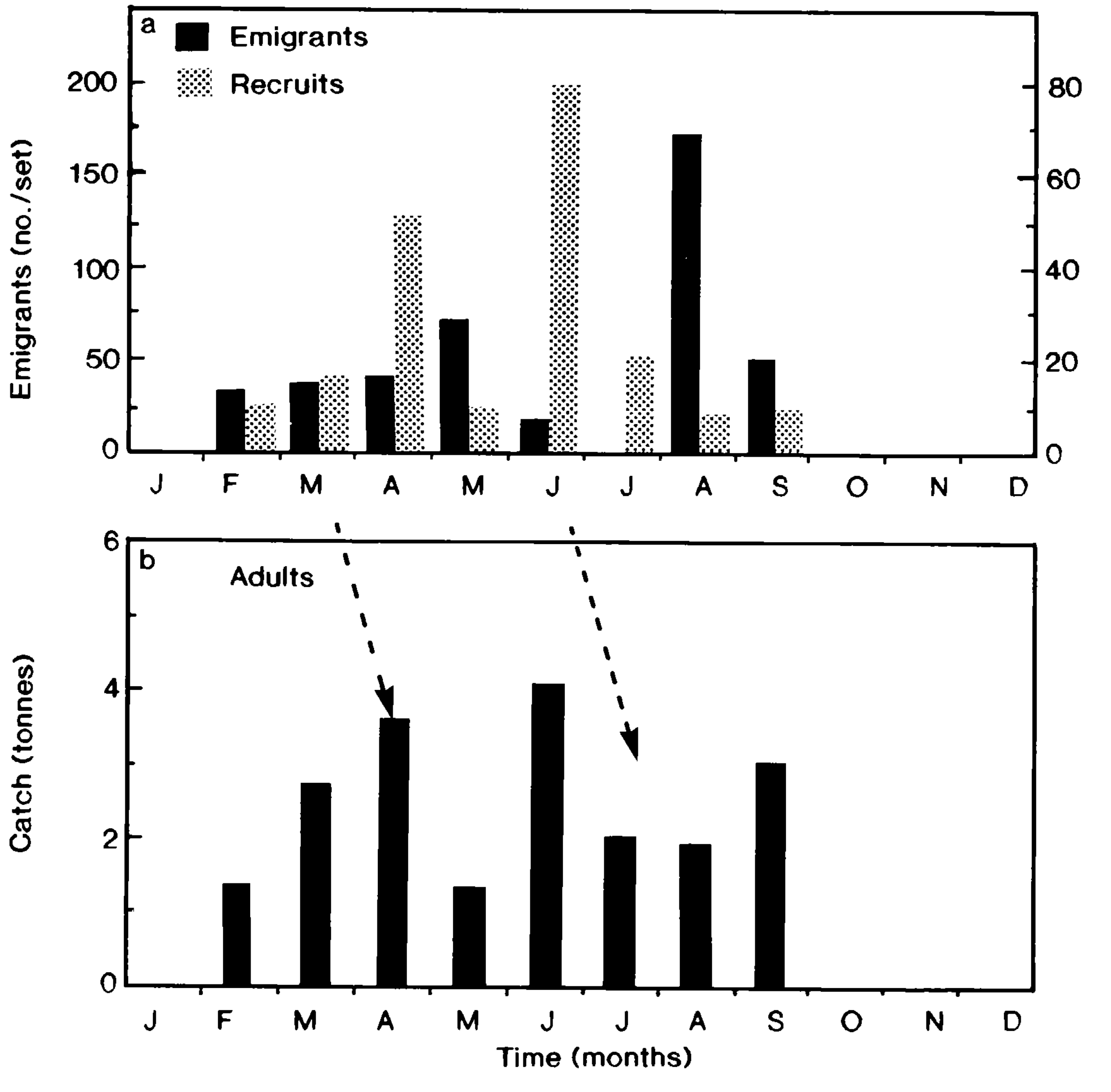


Fig. 5: Seasonal dynamics of <u>Penaeus merguiensis</u> (1989) in the Philippine study site, Sorsogan Bay (a) emigrants and recruits and (b) adults (commercial catch). Arrow links stages of the main generations from spawning to commercial fishery.

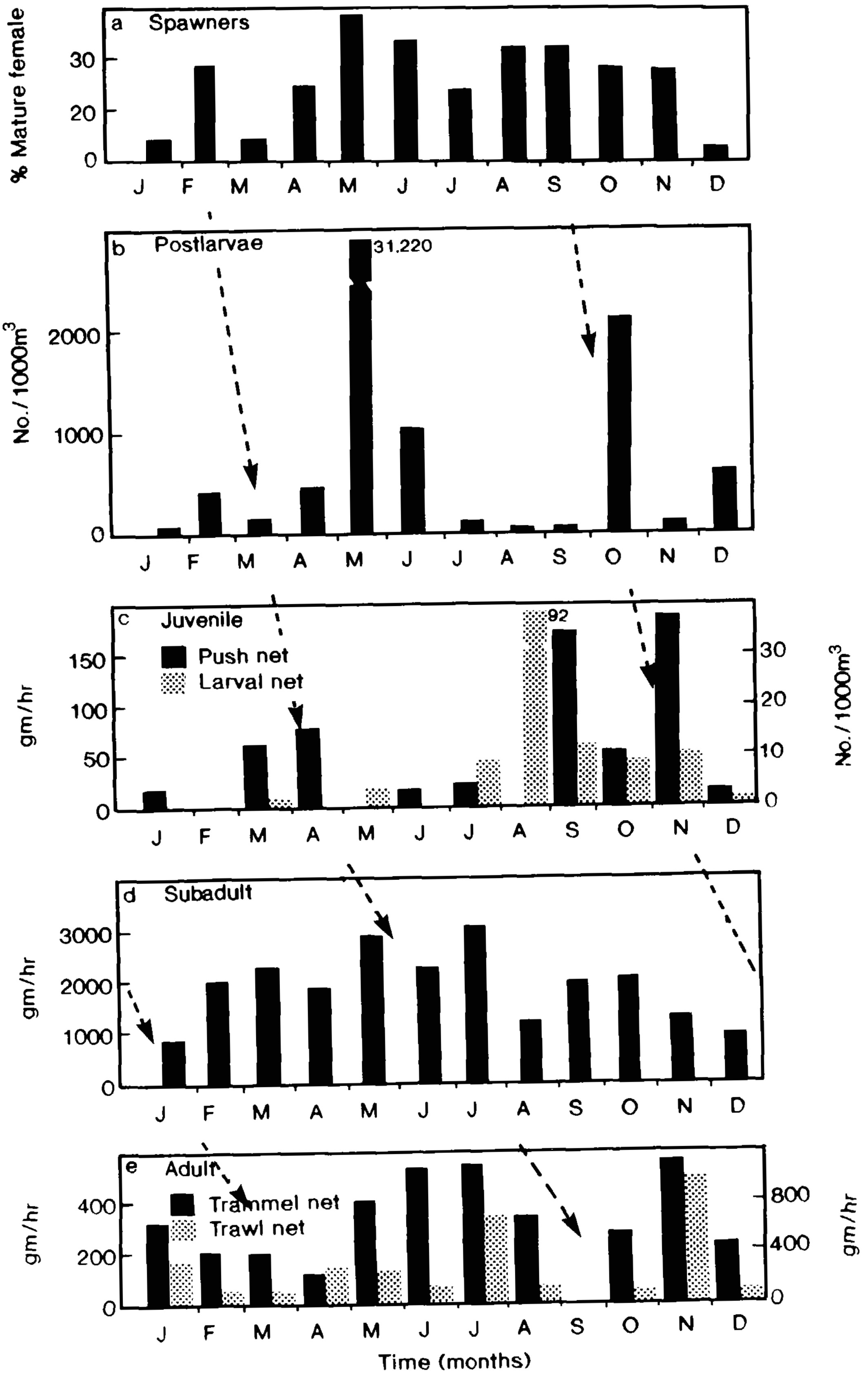


Fig. 6: Seasonal dynamics of <u>Penaeus merguiensis</u> (1988/89) in the Thailand study site, Ban Don Bay (a) Spawners (b) postlarvae (c) emigrants (d) subadults and (e) adults. Arrow links stages of the main generations from spawning to commercial fishery.

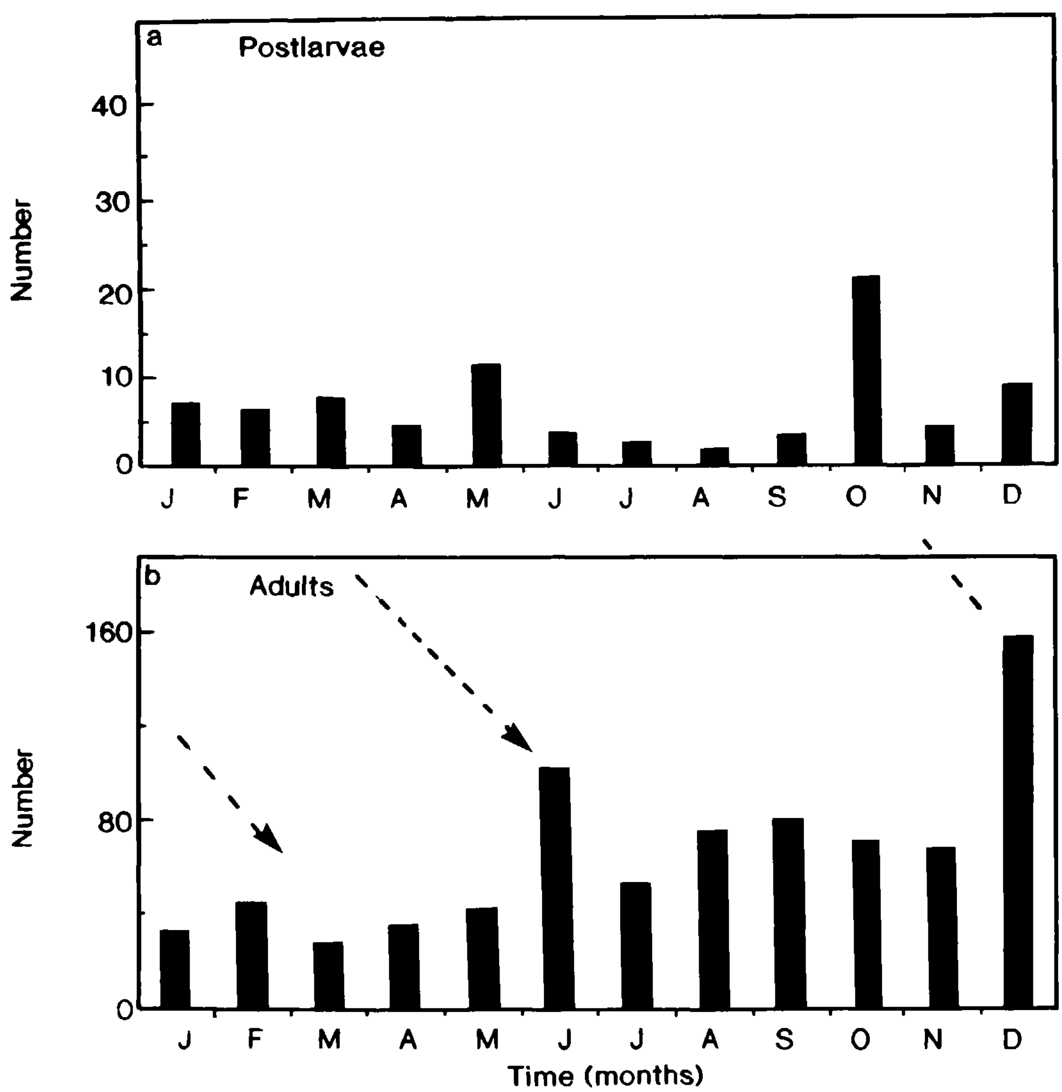


Fig. 7: Seasonal dynamics of Penaeus merguiensis (1988) in the Thailand study site, Phang Nga Bay (a) postlarvae and (b) adults. Arrow links stages of the main generations from spawning to commercial fishery.

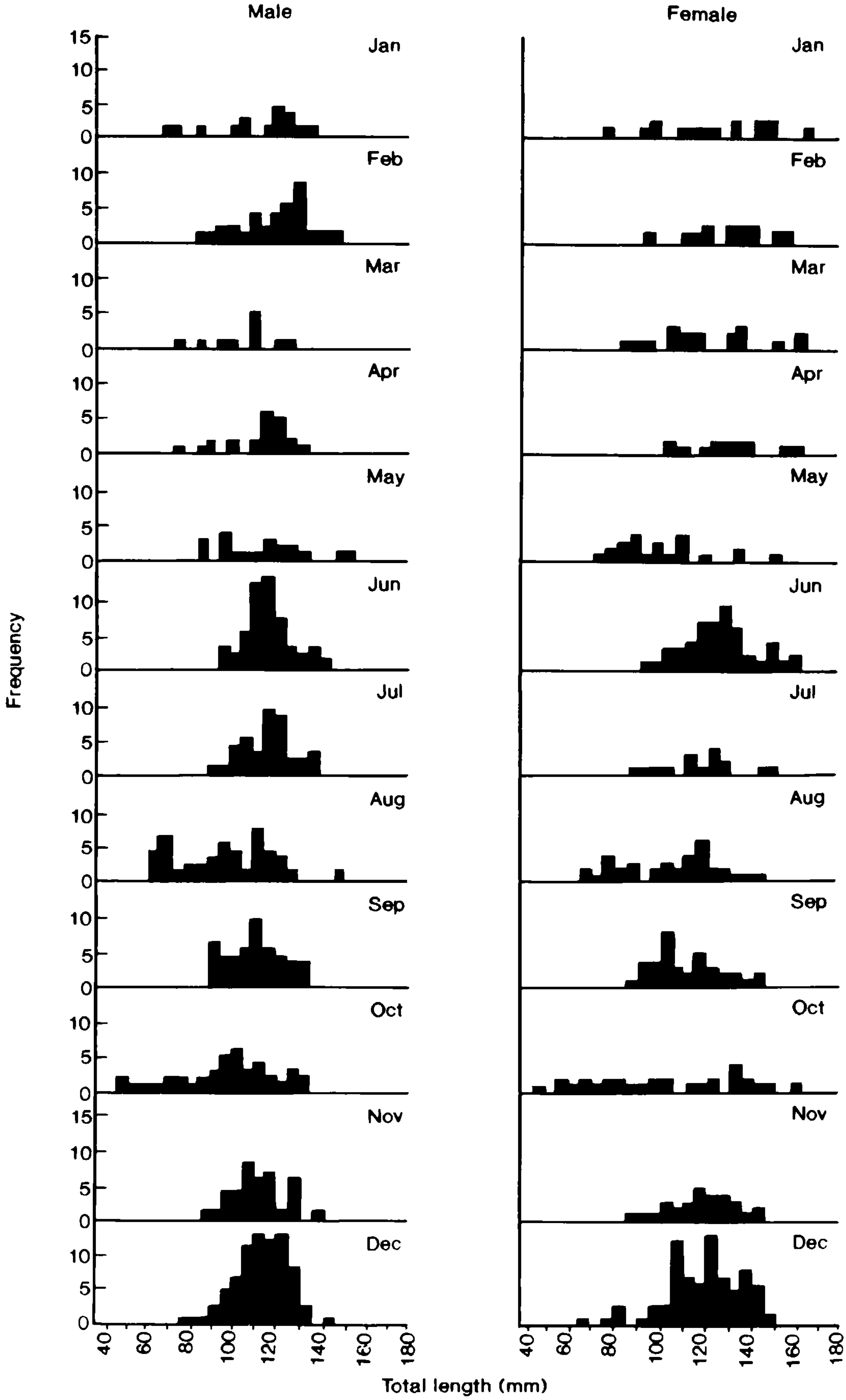


Fig. 8: Length frequency of <u>Penaeus merguiensis</u> in Phang Nga Bay, Jan 1988 to Dec 1988.

3.1.7 China (People's Republic of)

The northern part the species range is in the South China Sea which is adjacent to the mainland of China. Water temperatures in this region are very seasonal, dropping as low as 18° in winter. There are also many rivers which act as nursery grounds for a large range of fish and prawns as well as provide high nutrient input into the coastal waters. In the northern part of South China Sea there are more than 350 species of prawns and 100 species of penaeids; Penaeus merguiensis is one of the dominant species.

Adult P. merguiensis usually live between 10-15 m, and are rare in water deeper than 20m. Tagging studies have shown only local movements of prawns, most recaptures coming from less than 20 nm from release sites. The fishing season is all year round but recruitment into the offshore fishery is extremely seasonal with a pulse occurring in June/July (Fig. 9). These young prawns are caught from August to January, while from February to June the catch is mainly composed of spawners. Females with stage IV ovaries can be found from February to September with the major peak of mature females occurring in April and May (Fig. 10a). After spawning, most prawns die but a few will survive to spawn again in the next spring early in the spawning season.

The sex ratio of P. merguiensis is 1:1 from January to June. From July to December females outnumber males. (The yearly average is 57% female) (Fig. 10b). Mating occurs throughout the year, the peak period being November/December.

3.2 SEASONAL RECRUITMENT DYNAMICS (P. SEMISULCATUS, METAPENAEUS ENSIS)

3.2.1 Australia

Penaeus semisulcatus.

For the biological year August 1988 to August 1989, egg production reached a peak in October during a prolonged period of egg production from September to January. Offshore larval abundance peaked in October and November, with a lesser peak in February-March not predicted by the spawning data (Fig. 11a). Adult P. semisulcatus are known to migrate offshore during these months and population fecundity estimates are therefore biased. These larval peaks then result in peaks of postlarvae and juvenile abundance in the sea grass beds of the estuary in October-November and again in March-April (Fig. 11b).

Abundance of recruits (15-25 mm CL) in the offshore fishery peaked in December and January as a result of emigration of the October-November peak in juveniles. As seen with P. merguiensis, recruitment offshore is unimodal with the March-April peak of juveniles not reflected in the peak of recruits offshore (Fig. 11c). Adults (>30 mm CL) appear in the study area after January, and migrate offshore over the period February to May, by which time the population is widely dispersed offshore (Fig. 11d). The commercial fishery commences on this stock from August to November after the formation of a thermocline offshore and a concomitant migration of the stock to shallower water.

3.2.2 Indonesia

Metapenaeus ensis

M. ensis comprise 31% of the total catch of prawns in the Cilacap

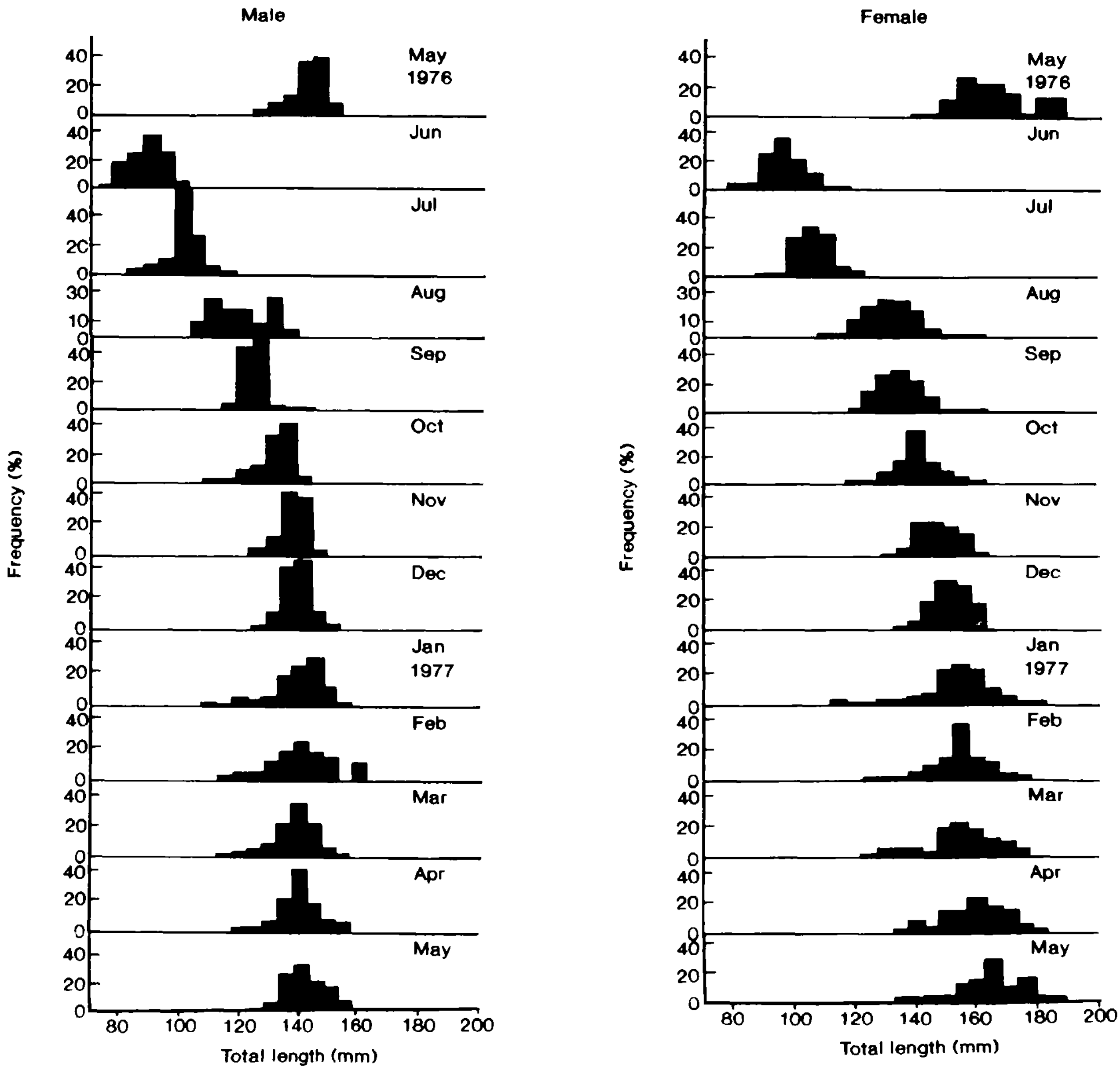


Fig. 9: Length frequency of <u>Penaeus merguiensis</u> in South China Sea, May 1976 to May 1977.

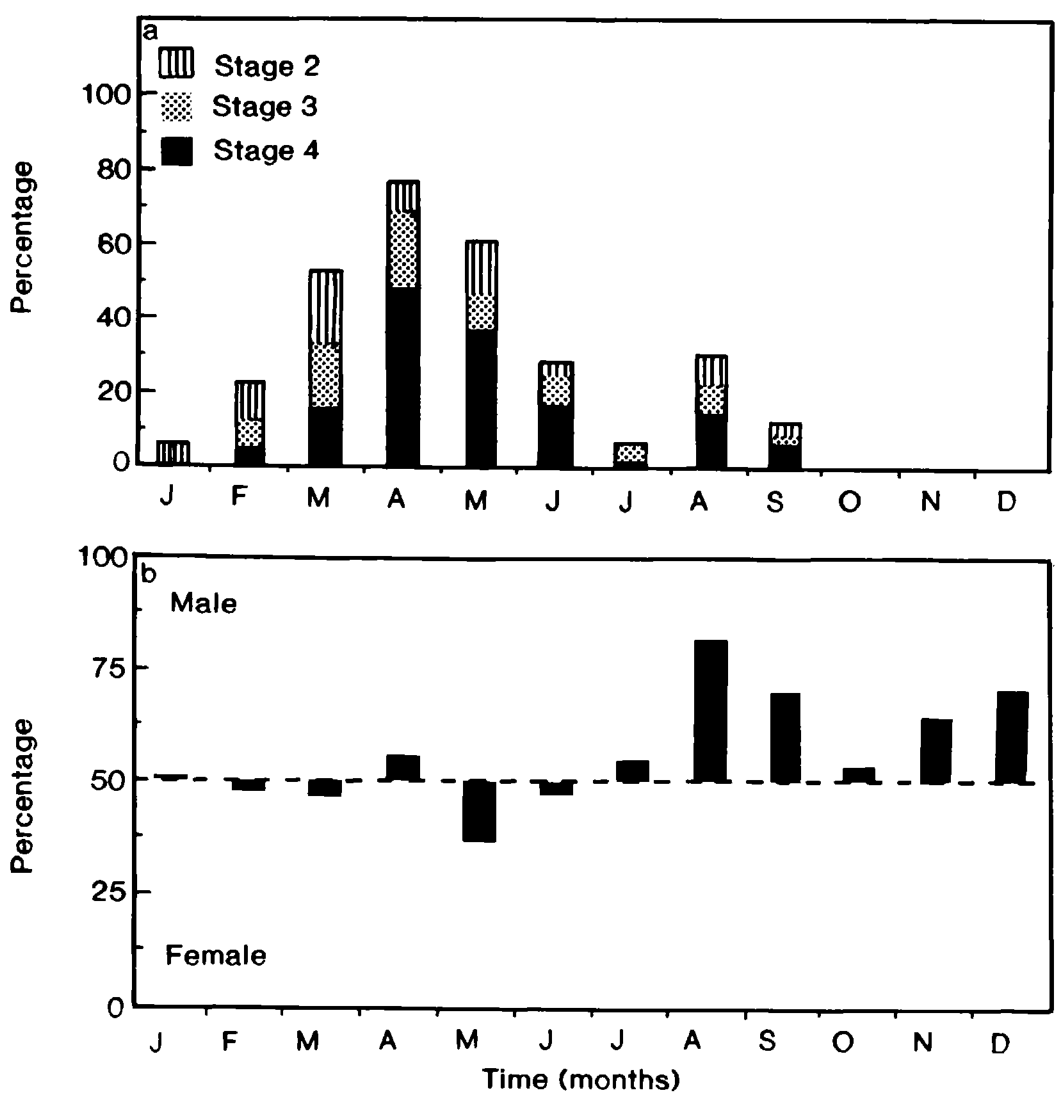


Fig. 10: Spawning periodicity and sex ratio of <u>Peaneaus merguiensis</u> in the South China Sea.

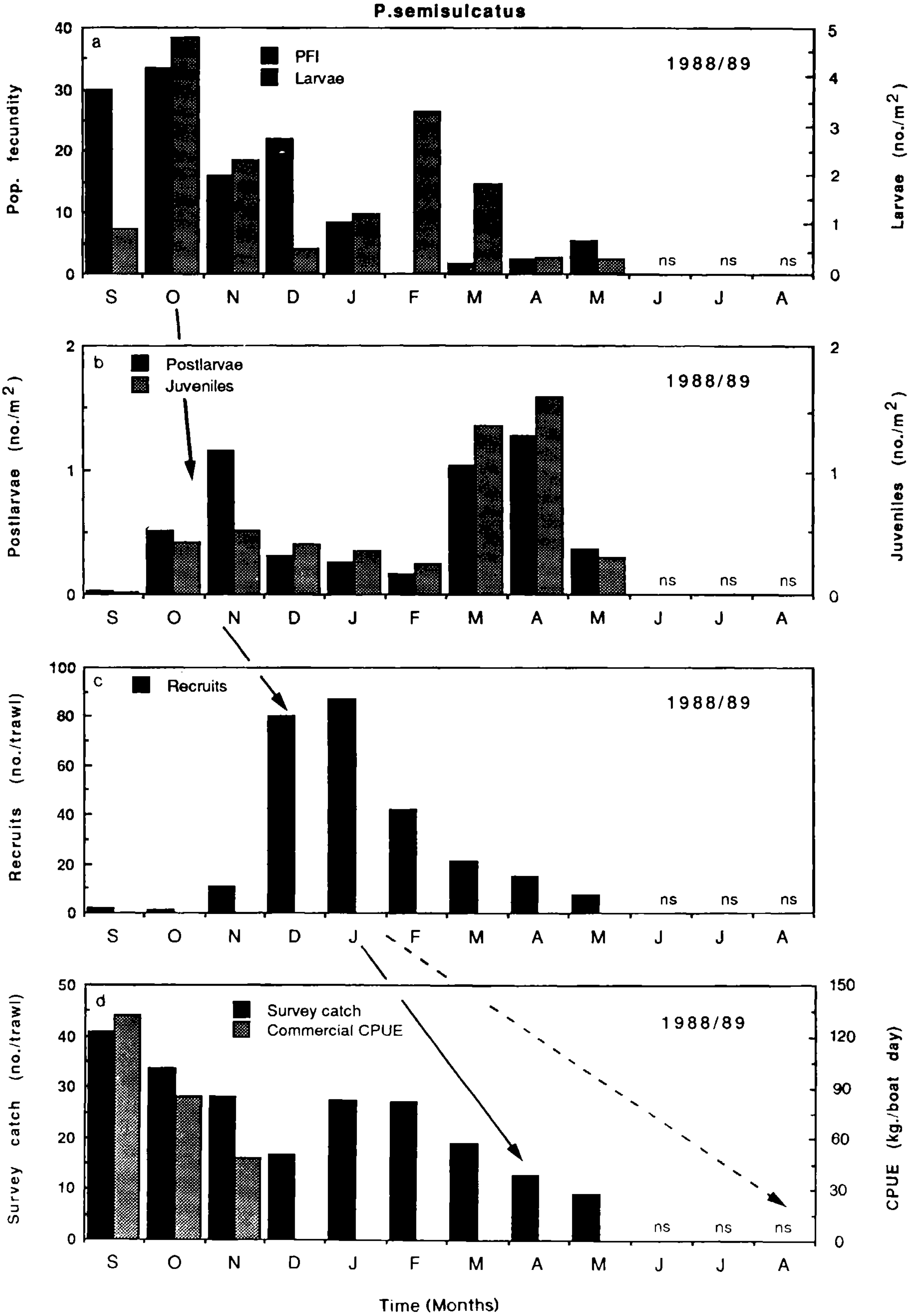


Fig. 11: Seasonal dynamics of Penaeus semisulcatus (1988/89) in the Australian study site, Albatross Bay (a) Population Fecundity Index and larave (b) postlarvae and juveniles (c) emigrants and recruits and (d) Adults (commercial CPUE and survey). Arrow links stages of the main generation from spawning to spawning to commercial fishery.

area, and come mainly from the western fishing ground, Panaujung and Pangaudarah. Based on the data on recruitment dynamics of M. ensis collected in the Cilacap and Segara Anakan areas from May 1987 to December 1988, an annual average of seasonality is summarized as follows.

The spawners of M. ensis are more abundant in the western part of the fishing ground. Spawning occurs all year round with two peaks in activity; a major peak in January to March and a minor peak in July/August (Fig. 12a). Immigrating postlarvae to Segara Anakan lagoon peaked from March to May, with a minor peak in December/January. (Fig. 12b). In contrast with P. merguiensis, more immigrating postlarvae came from Panaujung area through the west entrance. Emigrating juveniles and subadults were caught throughout the year with the highest rate recorded in November (Fig. 12c). More juveniles were recorded in the east entrance. Data on the adult M. ensis caught in the offshore area by commercial fishing boats show that fishing activities also occurs throughout the year with a significant peak in catches during the months of September through November (Fig. 12d).

By comparing peaks of each life-history phase (Fig. 12) to the subsequent phase the major peak in spawning which occurred in the offshore area in January to March can be linked to the peak of postlarvae at the lagoon entrances in the months of March through May. This then provides the prawns for the peak of juveniles and subadults which leave the lagoon around August and contribute to the increased catches in the offshore area in October.

The second peak of spawning occurred in July-August which seems to become a peak of juveniles and subadult in the lagoon in November/December which then provides recruits for the minor peak in catches in April/May.

The general life cycle of M. ensis in the Cilacap region, therefore, is similar to that of P. merguiensis with an essentially bimodal pattern of spawning and recruitment into the offshore region but with a dominant generation arising from the January to March spawning. There appears to be a strong link between the lagoon nursery area and the adjacent offshore fishing area and on the basis of the above analysis it follows that the majority of the prawns taken were six to seven months old.

3.2.3 Malaysia

No data available.

3.2.4 Papua New Guinea

No data available.

3.2.5 Philippines

Metapenaeus ensis.

Juveniles emigrating out into coastal areas were recorded from February to September with a peak in March (Fig. 13a). Abundance of recruits showed a peak in March and September (Fig. 13a). Adults were taken during all months of sampling with increased catches in July and September (Fig. 13b). More sampling is required before the life history of this species can be described but the existing data suggests that a major spawning in March/April may result in increased recruitment 6 months later in July/August. Length frequency analyses will help testing this hypothesis.

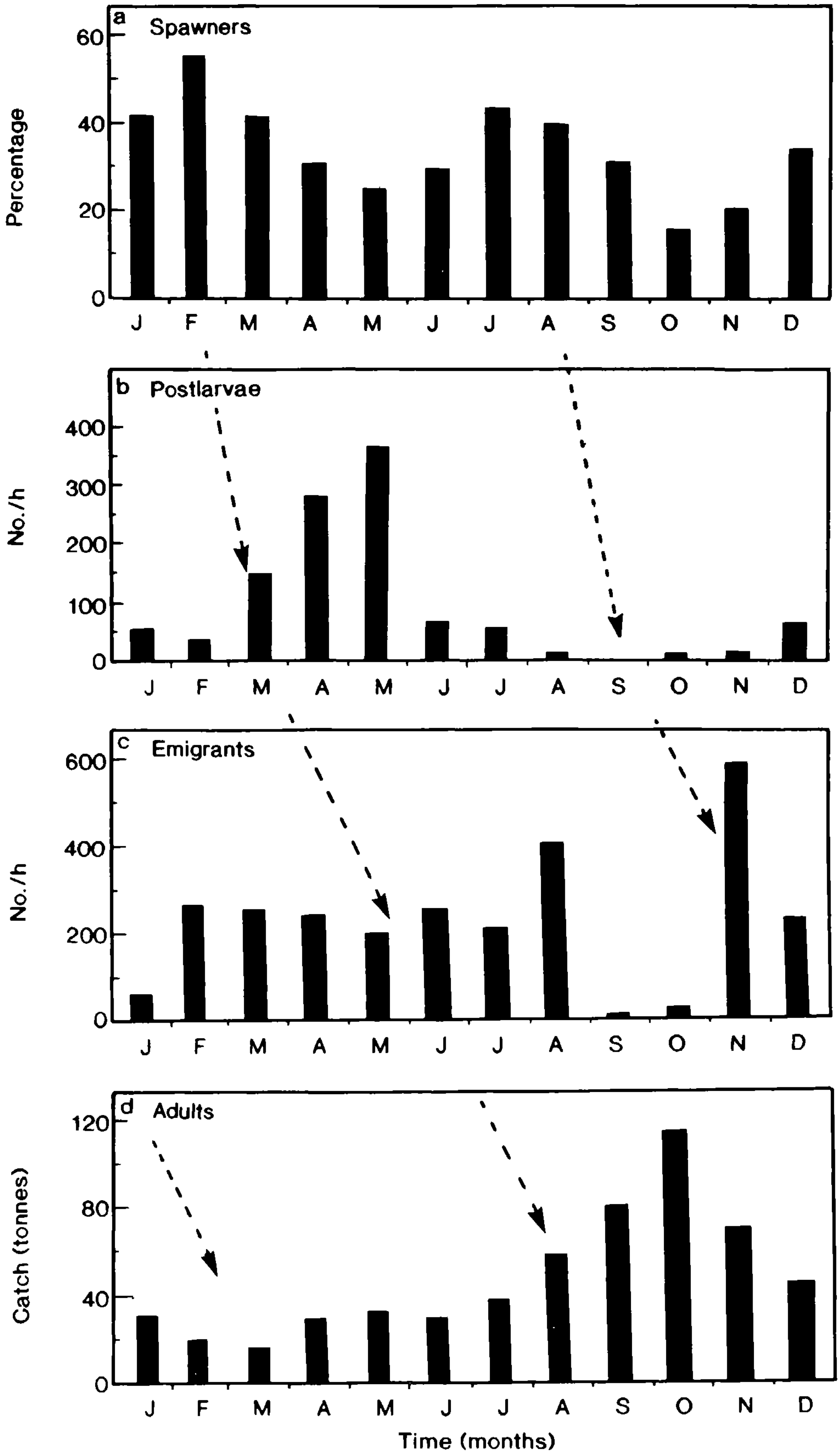


Fig. 12: Seasonal dynamics of <u>Metapenaeus ensis</u> (average over 5 years) in the Indonesian study site, Cilacap (a) Spawners (b) postlarvae (c) emigrants and (d) Adults (commercial CPUE). Arrow links stages of the main generations from spawning to commercial fishery.

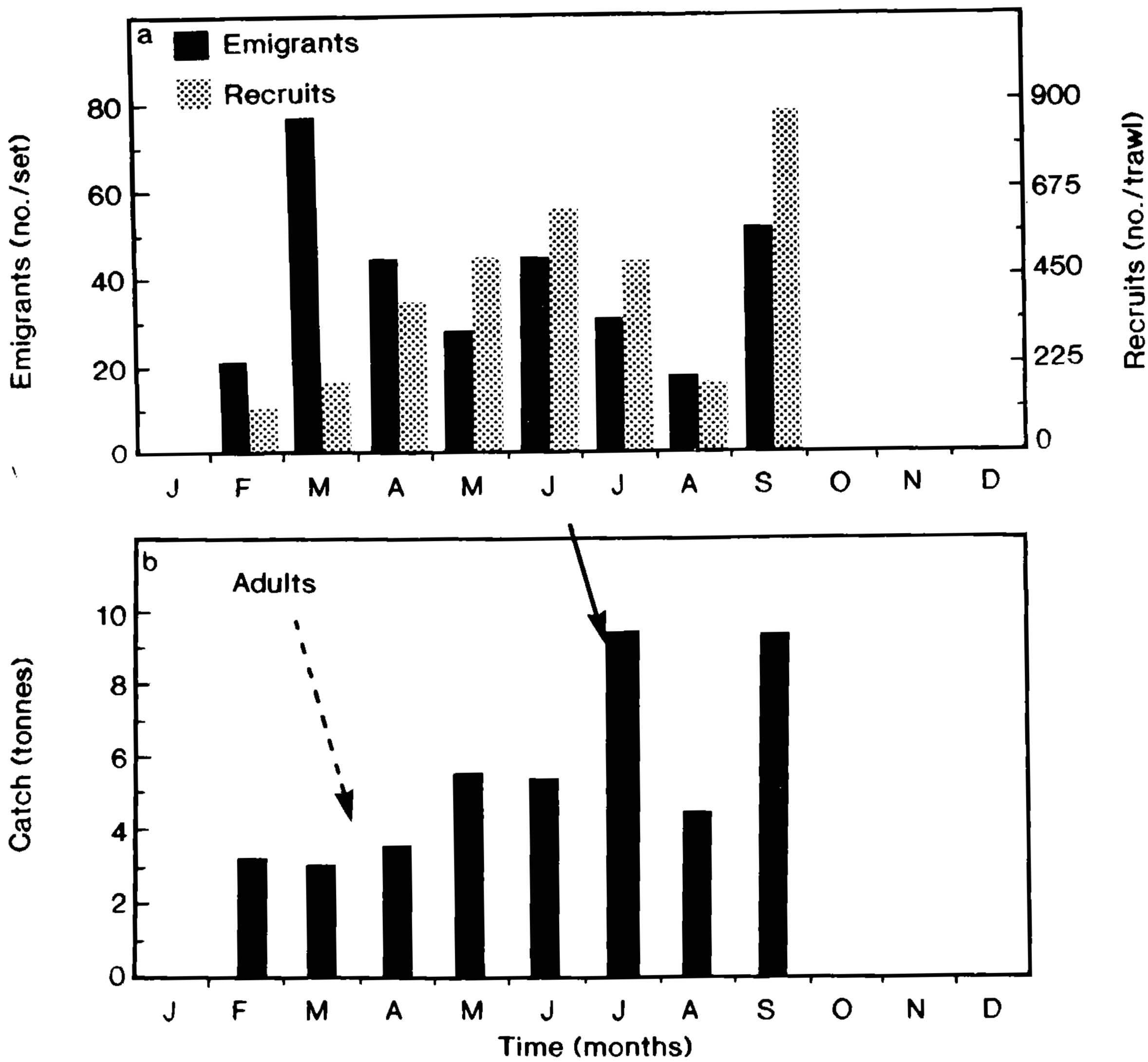


Fig. 13: Seasonal dynamics of <u>Penaeus merguiensis</u> (1989) in the Philippine study site, Sorsogan Bay (a) emigrants and recruits and (b) adults (commercial catch). Arrow links stages of the main generations from spawning to commercial fishery.

3.2.6 Thailand

Phang-nga Bay

Penaeus semisulcatus

Postlarval *Penaeus semisulcatus* were recorded at stations associated with sea-grass at the outer part of Phang-nga Bay. As with *P. merguiensis*, postlarvae were present all year, maximum number occurring in May and October (Fig. 14). Juvenile/subadults were also recorded all year with maximum abundances in June and December. Length frequency data show a preponderance of smaller juveniles from May to July and October to November. Abundances peaked in June 1987 suggesting a main recruitment period into the study sites around May to June with a possible second recruitment in October to January. As with *Penaeus merguiensis*, however, abundance estimate were variable in space and time making clear cut recruitment patterns hard to interpret.

3.3 INTERANNUAL VARIABILITY

3.3.1 Australia

Penaeus merguiensis

In general, the seasonal patterns for each life stage are similar for the 3 years 1986/87, 1987/88 and 1988/89 (Figure 15). Population fecundity, larval numbers, postlarvae and juveniles have broadly bimodal patterns of abundance and there is some variation from year to year in the relative strengths of each peak. In 1986/87 the September to January peak of postlarvae and juveniles was lower than in other years.

We have calculated an index of abundance for each life-history stage by taking the mean catch over the following time windows:

Population fecundity	August to November
Larvae	August to November
Postlarvae	September to November
Juveniles	November to February
Emigrants	November to February
Subadults	January to March
Adults (survey)	January to April
Adults (commercial catch)	April

There is no clearcut linear relationship between the relative abundances of the different life stages over the 3 years (Fig. 16). Population fecundity and offshore larval numbers as well as estuarine postlarvae and juveniles were low in 1986/87. In 1987/88, however, although offshore numbers were also low, postlarval and juvenile abundance increased substantially. In contrast, large population fecundity and larval numbers in 1988/89 led to slightly reduced numbers of postlarvae and juveniles.

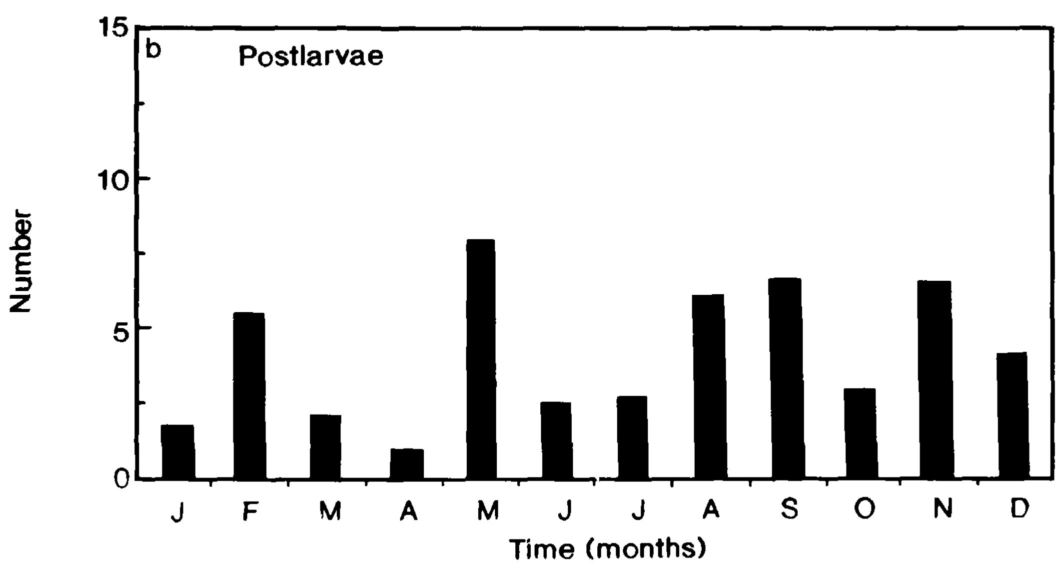


Fig. 14: Seasonal dynamics of <u>Penaeus semisulcatus</u> (1988) in the Thailand study site, Phang Nga Bay (a) postlarvae and (b) adults.

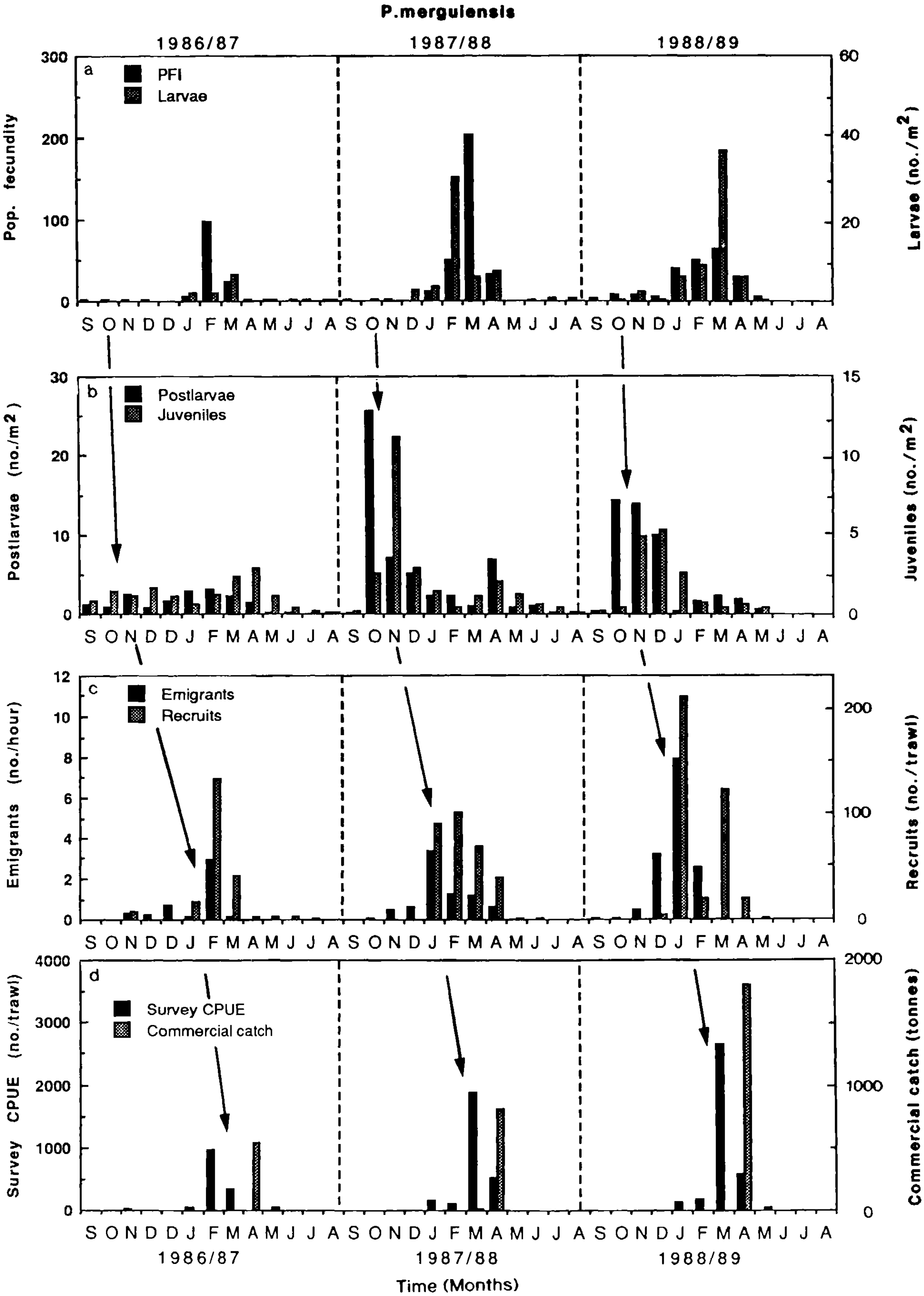


Fig. 15: Changes in the seasonal dynamics of Penaeus merguiensis in Albatross Bay over three years of study (1986 - 1989).

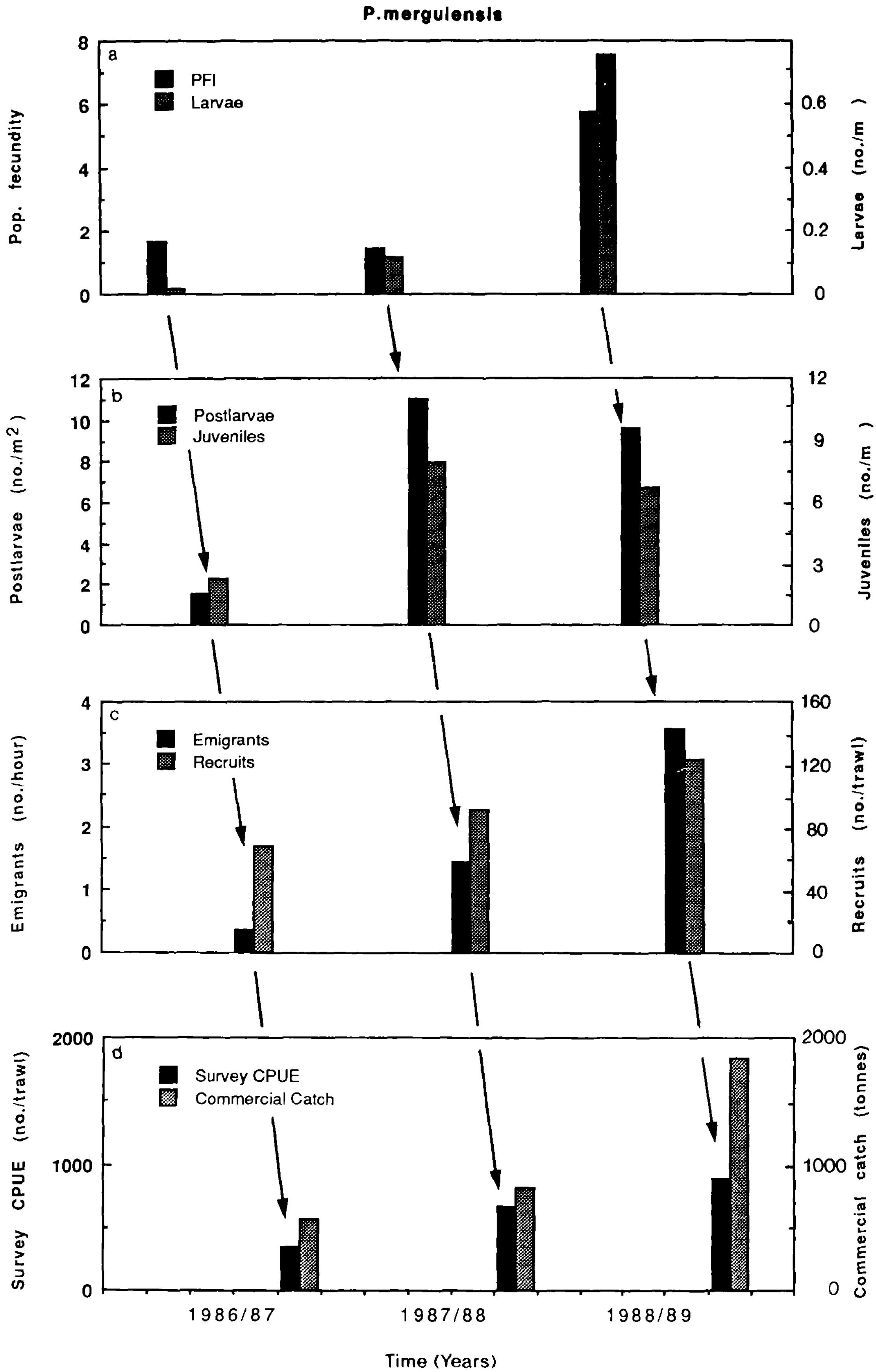


Fig. 16: Inter-annual variability in the relative abundance of the main life-history stages of Penaeus merguiensis in Albatross Bay over three years (1986 - 1989). Relative abundance indices for critical time windows only (see text).

Increased juvenile numbers in 1987/88 were followed by increased emigrants and recruits to the offshore area but lower juvenile numbers in 1988/89 also resulted in increased emigrants and recruits. There is some consistency between emigrants, recruits and offshore commercial catch; each of these stages has increased throughout the 3 year period.

Although we have not yet done any detailed environment/stock: recruitment analysis a simple graph of rainfall,juveniles, emigrants, offshore recruits and commercial catch suggests that there may be an interaction between rainfall and juvenile numbers (Fig. 17). In 1986/87 rainfall was high but juvenile numbers and emigrants were low. In 1987/88 juvenile numbers increased considerably, rainfall although decreasing a little was still substantial, and emigrants increased. In 1988/89 rainfall was high, juvenile numbers decreased but were still higher than 1986/87 and emigrants and subsequent commercial catch were the highest for the 3 years.

Penaeus semisulcatus

To date, insufficient data is available to examine stock/recruitment relationships for P. semisulcatus, however 3 years comparative data on life history stages is available. An index of abundance for each life history stage was calculated using the "critical window" periods established from the 3 year data, and outlined above. Comparison of mean catches for representative "windows" for each life history stage reveals that the spawning index for the critical August to November period has shown an upward trend over the 3 years 1986/87, 87/88, 88/89 (Fig. 18a). The index of offshore larval abundance for the same "window" also has the highest value in the third year (1988/89), but the 87/88 value is lower than for 1986/87.

Abundance of postlarvae and juveniles appeared lower in the second year (1987/88), even though numbers of recruits increased this year (Fig. 18b,c). This may be explained by a suspected sampling problem for postlarvae and juveniles in the second year when weed clogging of nets was a problem, and possibly influenced catches. Catches from larger nets, not affected by the weed problem, showed higher abundances commensurate with the higher abundance of recruits. Survey catch and commercial catch CPUE (Fig. 18d) also showed an upward trend over these first two years. In the third year, 1988/89, where egg production and larvae were highest, juvenile abundance was similar to the first year, but recruits were more abundant for the third year, while the highest abundance of recruits was in the second year. Data is not yet available for survey catch or commercial CPUE for the third year, but early indications are that abundances may be higher than for the second year.

3.3.2 Indonesia

Penaeus merguiensis

There is no strong interannual variability of P. merguiensis catch over the 4 years 1984-1987 (Fig. 19), although higher catches were recorded over the period from September 1985 to March 1986. The high catches did not correspond to a peak in rainfall; in fact the highest catch (September, 1985) followed a 3 month period of reduced rainfall in July to September 1985.

Metapenaeus ensis

Based on the monthly catch data of M. ensis for the years of 1984 through 1987, it seems that there is strong interannual variability from

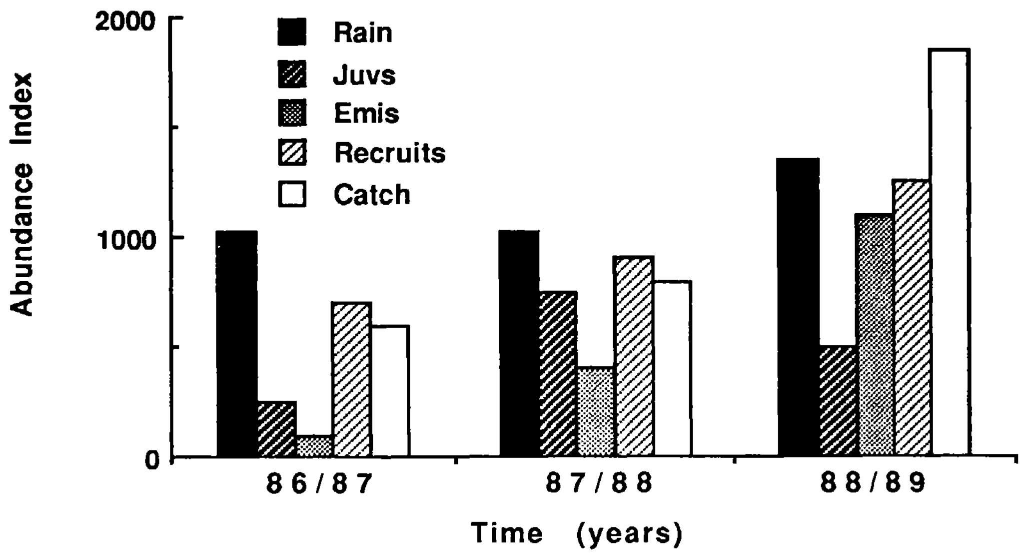


Fig. 17: Changes in rainfall, juvenile numbers, emigrants, recruits and commercial catch of Penaeus merguiensis over three years (1986 - 1989).

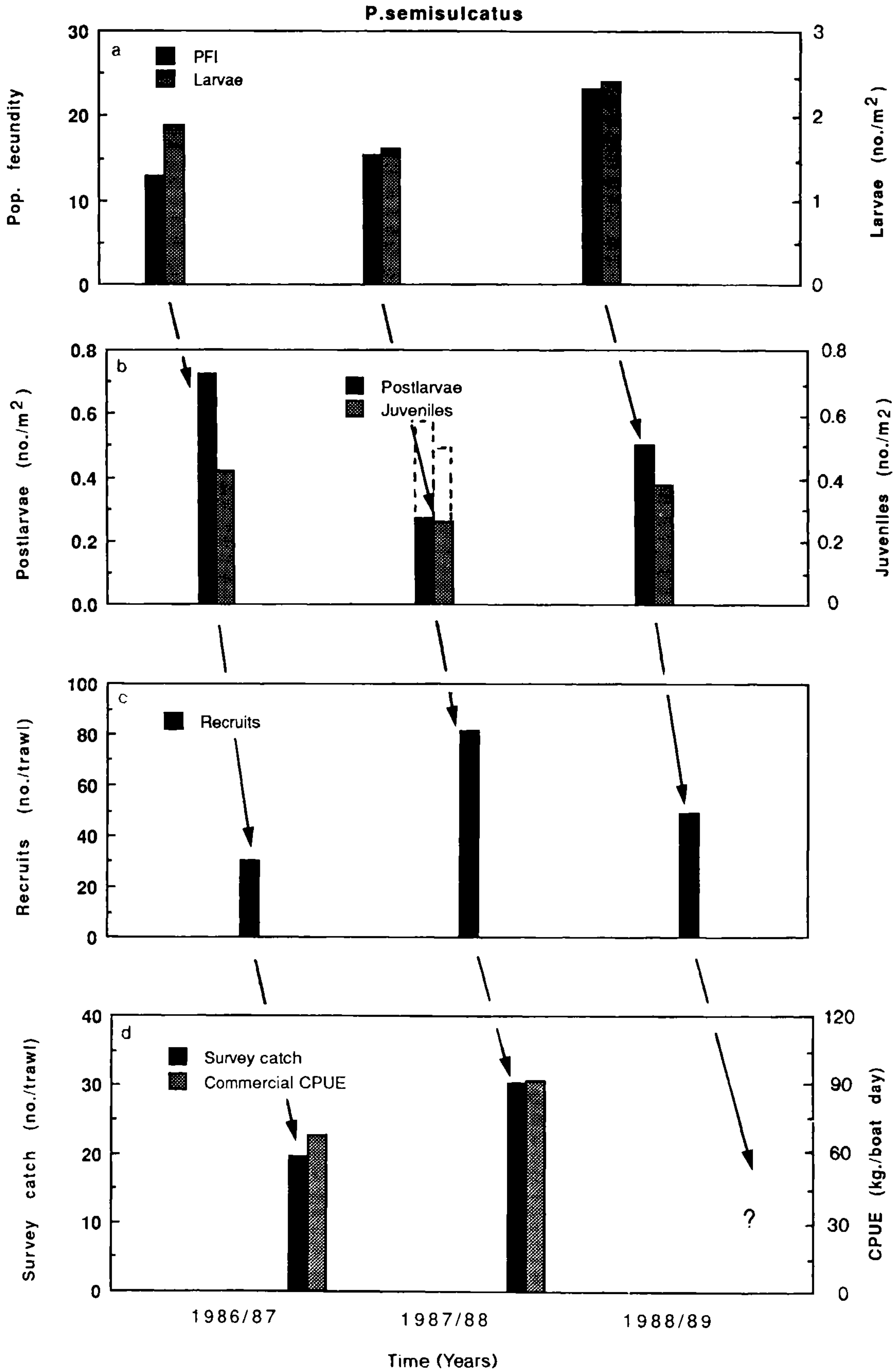


Fig. 18: Inter-annual variability in the relative abundance of the main life-history stages of <u>Penaeus semisulcatus</u> in Albatross Bay over three years (1986 - 1989).

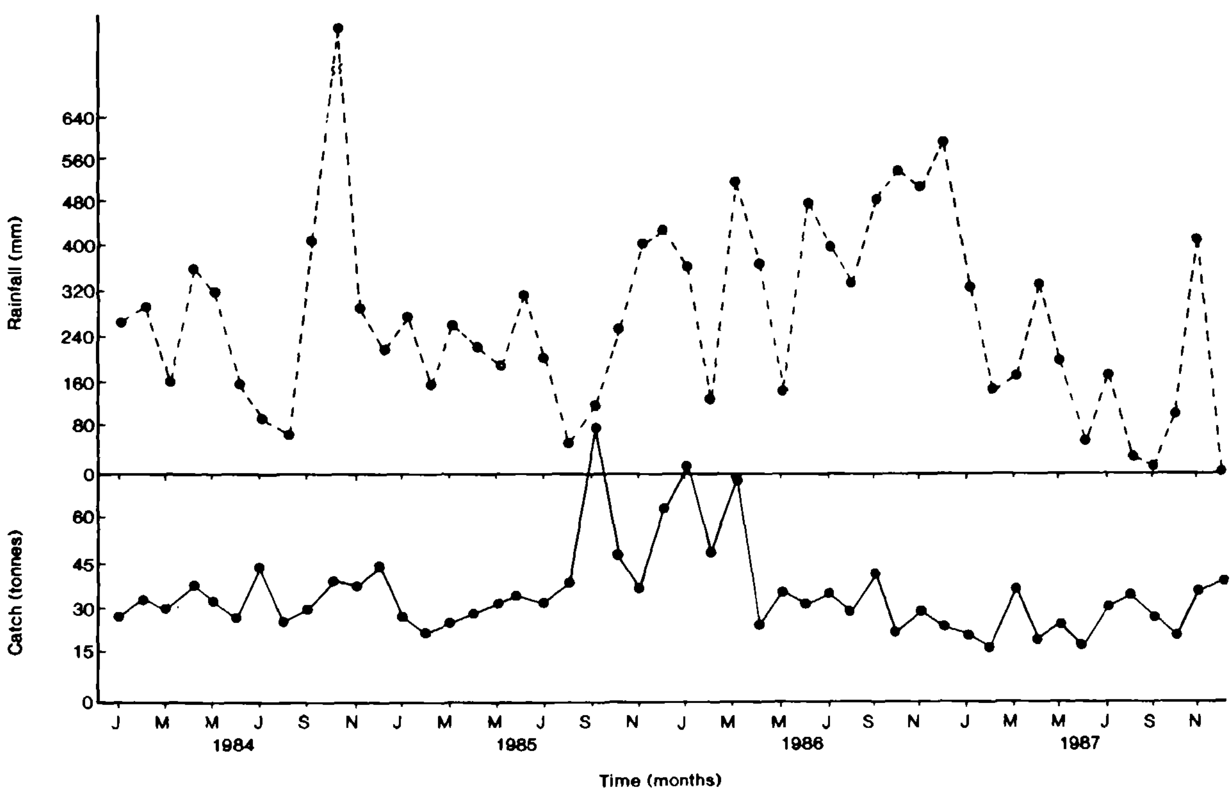


Fig. 19: Inter-annual variability in rainfall and commercial catch Penaeus merguiensis in Cilacap (1984 - 1987).

year to year, (Fig. 20). As with P. merguiensis, the high catch in September - October, 1985 followed a period of low rainfall.

3.3.3 Malaysia

No data available.

3.3.4 Papua New Guinea

Inter-annual variability in the fishery showed that rainfall was negatively correlated with catch (Fig. 21); when there is period of high rainfall, catches offshore decrease.

3.3.5 Philippines

No data available.

3.3.6 Thailand

The southern regions of Thailand are under the influence of the southwest and northeast monsoons which prevail for at least eight months of the year. The annual rainfall (October to September) in Chumporn, Surat-thani and Nakorn-srithamarat provinces was positively correlated with prawn catches from 1976 to 1984 (Fig 22). After this time, annual prawn catches have declined although rainfall has remained high. A possible cause for this may be the loss of mangrove habitat and the collection of postlarvae associated with the increase in prawn farming in the district. The area of prawn culture has increased by at least 6 times since 1986 and some of this expansion has encroached on mangrove nursery areas. The prawn culture production increased from 298 tons in 1984 to 1612 tons in 1985.

3.4 REVIEW OF PROGRESS

CONCLUSIONS AND PROJECT STATUS 1989

Objectives 1 and 2

To assess the progress of the project over the past year, participants were asked to critically assess the hypothesis which was formulated from the preliminary data given in the first workshop in Cleveland, 1988. (see project status 1988 and Staples and Rothlisberg, 1990). The hypothesis referred to the seasonal pattern of spawning of P. merguiensis across the region. A pattern of two periods of increased spawning activity within the year (August to November and March to May) was accepted as being common to all study sites with the exception of southern China; only one major period of spawning occurred at this higher latitude (Fig. 10a). It was generally agreed that these spawning peaks could be linked to peaks in the recruitment of subadults into the offshore area approximately six months later. The timing and relative strengths of these peaks appears to be related to the timing and strengths of the seasonal rainfall. All countries observed an increase in the relative abundance of subadults/adults during the seasons of higher rainfall resulting in a strong unimodal pulse of recruitment offshore at sites experiencing one main rainy season each year and a bimodal recruitment pattern in areas experiencing two rainy seasons. In several cases, sampling has only recently commenced and more testing of this hypothesis is needed.

The suggested mechanism for this process is the stimulating effect of rainfall on the emigration of juvenile prawns from their nursery habitats. It has been demonstrated in Australia that decreasing salinity and

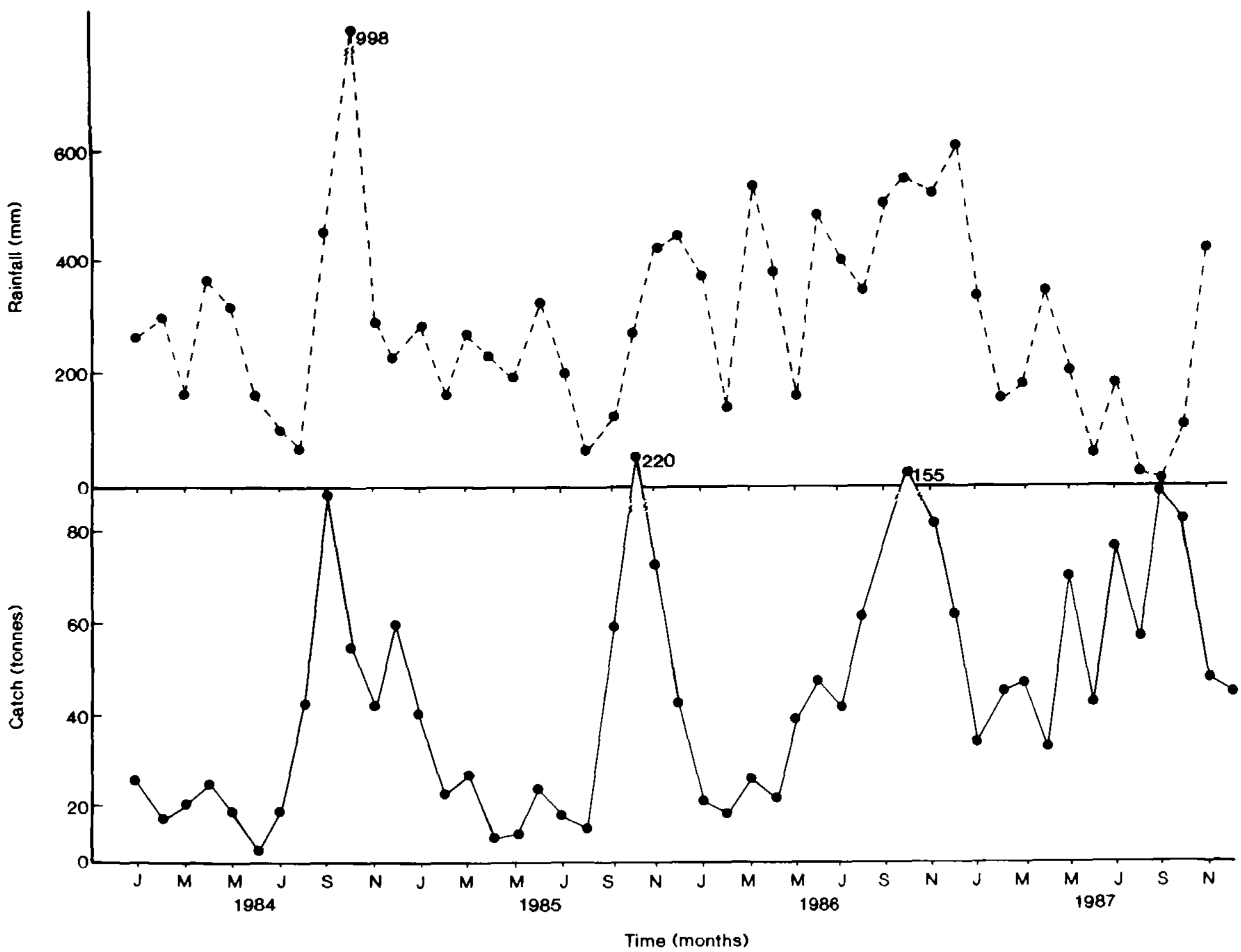


Fig. 20: Inter-annual variability in rainfall and commercial catch Metapenaeus ensis in Cilacap (1984 - 1987).

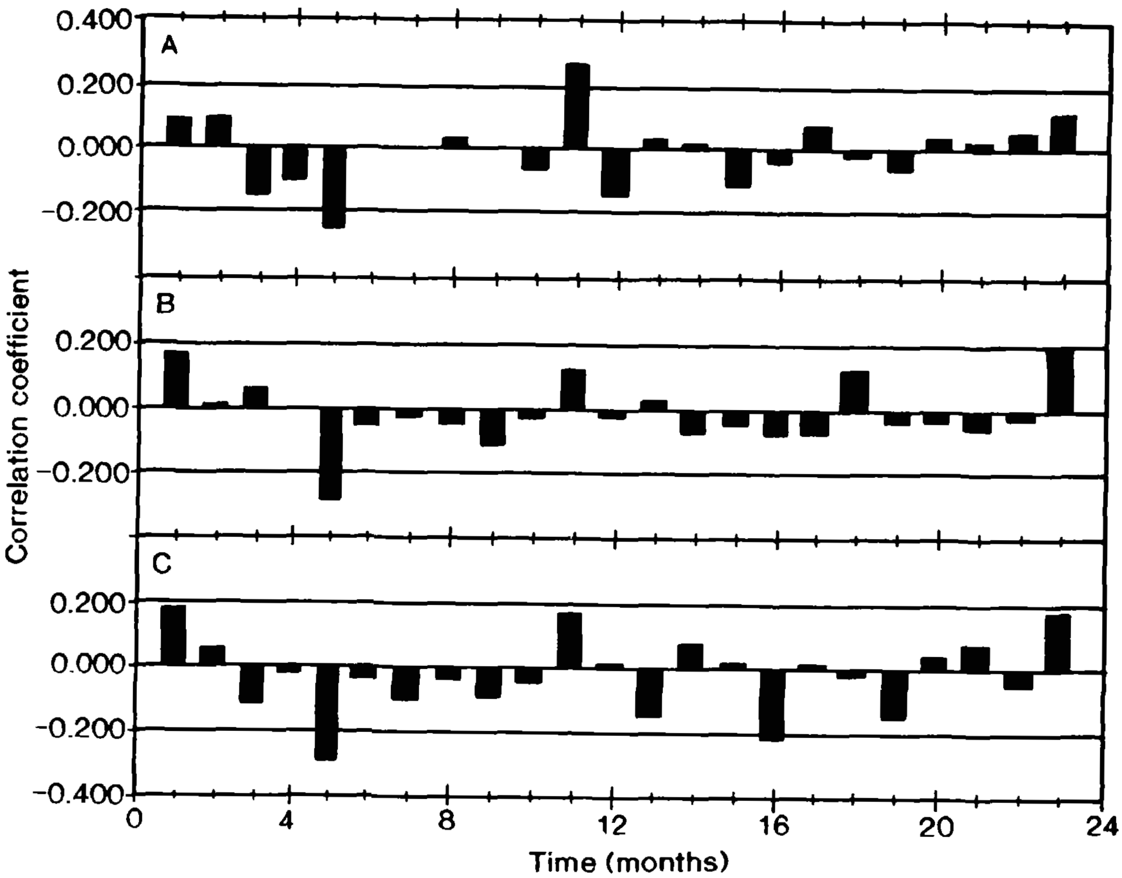


Fig. 21: Correlation coefficients between monthly rainfall and commercial catch of <u>Penaeus merguiensis</u> in the Gulf of Papua.

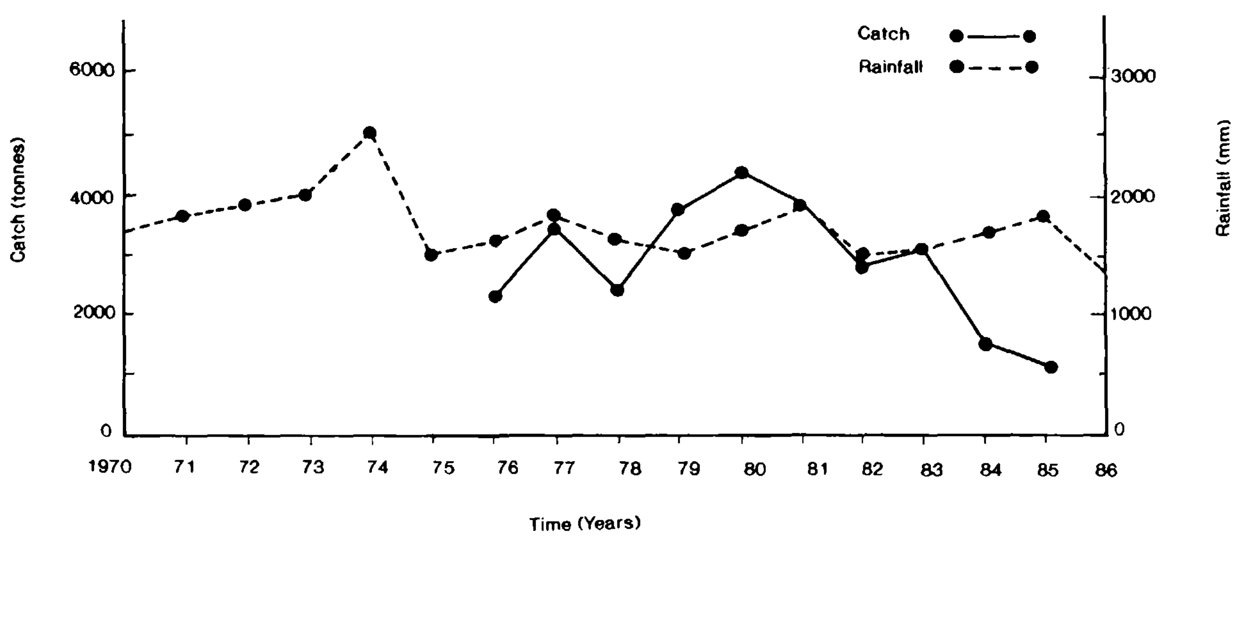


Fig. 22: Inter-annual variability in rainfall and commercial catch <u>Penaeus merguiensis</u> in three provinces of Thailand (1971 - 1986).

increased estuarine current speeds, following periods of rain, stimulate the offshore migration. The larger the juvenile prawn, the more sensitive the individual is to the stimulus, resulting in only the largest prawns migrating during periods of low intensity rainfall, with smaller individuals migrating during periods of heavier rainfall. This results in a large recruitment pulse during rainy seasons.

More research on this important process is planned, as outlined in the description of the Rainfall Recruitment Experiment (REX) (see Annnex VI).

Objectives 3 and 4

Most countries soon will be in a position to be able to define the critical time windows which will allow the estimation of the appropriate indices of spawning and recruitment into the successive life-history phases. It should then be possible to examine the effects of fishing pressure and the environment on recruitment. At this stage of the project, this has not been attempted at any study sites but will soon be attempted by those countries having sufficiently long time series of data. Techniques for these types of analysis will be the subject of the next Workshop.

Results from Mexico and China (see Annexes III and V) provide excellent examples of how spawning and recruitment indices can be monitored to provide management information. In Penaeus orientalis, recruitment into the offshore area is highly correlated with the spawning stock and recruitment into the fishery and, therefore, it is dependent on the number of prawns remaining after the fishing season. On the other hand, prawn catches in lagoons in Mexico are highly correlated with temperature during the spawning season, river discharge and the period between the timing of the offshore closure and the damming of the lagoon entrance. Commercial catch fluctuations, therefore, are largely driven by environmental variability.

4. SHORT-TERM SAMPLING

4.1 SAMPLING THEORY

Derek Staples introduced the subject of short-term sampling by giving a brief lecture on sampling theory. The main topic considered were the advantages and disadvantages of using random, stratified or systematic sampling designs. Simple definitions for these three designs are:

Random sampling: Selection of n sampling units out of N available units such that each unit has an equal chance of being chosen.

Stratified random sampling: Selection of n sampling units from a subpopulation of N units e.g. stratifying the coastal area into depth zones so that more samples can be taken from the inshore area where the density and diversity of prawns is greatest.

Systematic sampling: Selection of every K^{th} unit from the population e.g. transect or grid sampling.

Three different population types were considered (i) a population exhibiting a linear trend, (ii) a population with cyclic trends and (iii) a highly aggregated or auto-correlated population. In all these cases, stratified or systematic sampling is superior to simple random sampling. In most cases systematic sampling gives a more precise estimate of the population mean (less variation). In cases where the population distribution is cyclic in space or time, the frequency of systematic sampling becomes very important. The most accurate estimate will be obtained when the frequency is an odd multiple of the half period.

A computer simulation for comparing random and systematic sampling was used to demonstrate changes in the precision of estimate of abundance. Both the distribution of the population and the number of samples were changed to determine how these parameters affected the sampling design.

4.2 SHORT-TERM SAMPLING - COUNTRY REPORTS

4.2.1 Australia

Sampling design

For the current Albatross Bay study, the bounds of the study area have been established with reference to commercial log book data on distribution of the species under study, and by preliminary survey work. It is critical that the spatial distribution of the population is covered by the study area.

Stations are located on a 6 x 6 n mile grid pattern, with 20 standard stations ranging in depth from 6 to 45 m. Sampling is carried out over 3 or 4 nights each lunar month, during hours of darkness only, to standardized for day/night catchability changes. Each cruise is centered around new moon to standardize the catchability differences associated with moon phase. Sampling over the full year in 1986/87 and 1987/88 has enabled identification of critical "windows" for both the spawning (Aug-Nov) and sub-adult recruitment (Jan-Apr) phases. Sampling effort directed at estimating the spawning index and subadult recruitment index can thus be restricted to these periods for the continuing study from 1989 to 1992.

Sampling is carried out from a chartered commercial trawler, using four 5 fathom headrope otter trawls. A standard trawl is of 15 minutes duration (bottom time), and the standard effort measure thus becomes 4 nets x 15 minutes = 60 net-minutes. Catches are sorted to species and sex on board, and individuals measured to obtain length frequency data. Replication of selected standard stations is carried out each month.

Reproductive activity: Spawning Index

An index of potential egg release by the population is obtained by estimating the abundance of females which are ready to spawn, and then estimating the number of eggs released by each spawning female relative to their size (carapace length). The method requires an estimate of the abundance of females, obtained from survey data, and an estimate of the proportion of these females in spawning condition, obtained from histological assessment of ovary stages of samples of females from each survey trawl. The fecundity/size relationship is established for each species by egg counts over a full size range of spawning females.

Size composition data is available from the survey data. The calculated spawning index on a per station basis provides a spatial distribution of spawning activity (spawning areas), while means of station values for each month indicate seasonal patterns. A mean of monthly index values for a selected critical spawning "window" (eg. August-November) provides an annual value for the spawning index for use in interannual comparisons.

Larval sampling

Larval sampling is carried out over a 15 station subset of the 20 standard stations sampled for adult abundance. Stations are spaced at 6 nm intervals in the inshore region of the study area, and 12 nm intervals offshore. Plankton tows are taken using a single cylinder-cone net with a square 0.5 x 0.5 m mouth opening. A mesh size of either 142 or 250 microns is used to quantitatively sample early stage penaeid larvae. The net has a filtering to mouth-area ratio in excess of 10:1. To estimate volume of water filtered, a flow meter is fitted to the mouth opening and calibrated before each sampling cruise.

Sampling involves a stepped-oblique tow at 2 knots, from surface to bottom to standardize for vertical distribution of the larvae. Depending on water depth and clarity, towing time is 5 to 8 minutes. Plankton samples are removed from the net with intensive washing with a salt water hose, and fixed with 4% buffered formaldehyde.

In the laboratory, samples are first split in two using a Folsom plankton sample splitter. One half of the sample is subjected to destructive biomass analysis (dry weight) and the other half is further subdivided until a sample of a suitable size for larval counting (usually 1/8 or 1/16 of original) is obtained. The first phase of sample analysis involves sorting all penaeid larvae from the subsample, and identifying these to genus level. In the second phase, all Penaeus and Metapenaeus larvae are sorted to stage and species level using the discriminant analysis method (see 6.1 Larval Identification). Larval abundance is expressed as no/m^2 (ie. no/m^3 X depth of sample), using the three protozoal sub stages as an indicator of larval abundance.

Postlarval abundance

Both P. merguiensis and P. semisulcatus are sampled using 0.5 by 0.5m plankton nets with 1 mm mesh net. Nets are set at the surface, middle and bottom of the water column in the main river channel at its mouth, for 10 to 15 minutes approximately halfway through the flood tide. Sampling is carried out fortnightly on spring tides. The volume of water filtered is calculated using flowmeter readings from each net. Samples are frozen, sorted using a microscope to species groups, and identified to species using gel electrophoresis (see 6.2 Postlarval Identification).

Juvenile Abundance

The short-term sampling regime at Weipa is based on the results of previous intensive sampling done in the Embley River to assess the variations in catchability which might affect abundance estimates. Over 12-months, 24- hour sampling was carried out at 3-weekly intervals, on alternate spring and neap tides, with trawls being made every 2 hours during the 24-hour period. Sampling was carried out at different locations and habitat types. Location/habitat type, tidal cycle, day/night cycle, tide and moon phase all affected the variability in catch, the relative importance of these factors depending on the species involved.

Penaeus merguiensis was mainly caught on a mangrove-lined sloping mudbank habitat whereas P. semisulcatus was predominantly caught on sea-grass flats and algal beds. Therefore, all our current sampling directed towards these two species is carried out on these habitats. For P. merguiensis sampling is conducted in a small creek as well as the main river as we have found that size composition of catches in these two locations is often different.

Short-term catchability of P. merguiensis is strongly influenced by the stage of the tide cycle; the day/night cycle is of secondary importance. At Weipa, the semi-diurnal tides results in maximum catches of P. merguiensis near the lower of the two low tides. Catchability of P. semisulcatus is less influenced by tide and more by the day/night cycle; catches are greater at night. Sampling for P. semisulcatus occurs just before high tide at night.

All sampling is done with beam trawls; in the main river a 1 by 0.5m beam with 2 mm mesh net with a 1 mm codend for small prawns and a 2 m beam with 28 mm mesh net and 12 mm cod end for larger prawns are used. In small creeks only the 2 mm/1 mm net is used. Sampling is carried out fortnightly on spring tides so as not to miss peaks of postlarval settlement.

For P. merguiensis the orientation of the trawl with respect to the shoreline is critical. The greatest concentrations and the smallest size prawns are in the shallow water close to the edge; larger prawns tend to be in slightly deeper water. To sample the whole population adequately, the whole population is covered by trawling perpendicular to the bank. Four perpendicular trawls and a trawl parallel to the bank are carried out at each location. For P. semisulcatus trawls are taken perpendicular to the waters edge, across the sea-grass flat.

Samples are sorted first by eye to extract large prawns (greater than 3 mm carapace length). Postlarvae are then sorted using a binocular microscope. If the sample is very large (because of large volumes of trash or large numbers of prawns) all the large prawns are extracted by eye and then a subsample is sorted under the microscope to get an estimate of the abundance of postlarvae. P. merguiensis and larger P. semisulcatus are identified using morphological characters (Gre et. al, 1983). Postlarval P. semisulcatus are identified to species using gel electrophoresis.

Emigrants

Emigrating Penaeus merguiensis are sampled with a 1.0 by 0.5 m set net fitted with a with 2 mm mesh and a 2 m beam fitted with a 28 mm mesh and 12 mm codend. The nets are set at the surface in the middle of the river channel near the juvenile trawl station for the duration of the ebb tide. Sampling is carried out fortnightly on spring tides.

Environmental sampling

The main environmental data collected offshore are water temperature and salinity involving a depth profile at each trawl station. In the estuary, temperature and salinity are measured at each trawl location, as well as turbidity and light penetration (Secchi disc). Once a month temperature and salinity are determined at 10 locations along the length of the river to determine the extent to which fresh water limits the available nursery habitat.

4.2.2 Indonesia

Selection of species

Three species have been selected for this research because of their high catch in both the lagoon and in the offshore areas.i.e. Penaeus merguiensis, Metapenaeus ensis, and M. elegans. The main study site is the Segara Anakan Lagoon and adjacent are as in Cilicap.

Selection of stations

The lagoon has two connections to the sea (east entrance and west entrance) and sampling stations were set up in both entrances to sample larvae and postlarvae immigrating to the lagoon.

Four stations have been selected to sample juveniles emigrating from the lagoon. Two stations are located close to the east and the west entrance, respectively while the other two stations are located in the middle of the lagoon. The selection is based on the availability of the tidal trap fishing gear fixed by the fishermen in those areas assuming that the existence of those traps are an indication of the abundance of juvenile prawns and fish.

Sampling methods

Immigrating larval and postlarval prawns and fish were sampled by setting a plankton net from a buoy moored near the east and west entrances channels of Segara Anakan Lagoon. A plankton net, 113 cm in diameter and 350 cm in length fitted with NS nylon netting (170 um mesh) was used. The net was set near the surface (0.5 m deep) fortnightly during both flood and ebb tides to monitor lunar periodicity and seasonal changes in the number of immigrants. Additional nets moored near the bottom (0.5 m from the bottom) and in the middle of the river provide information on the depth distribution of migrating prawns and fish. In the laboratory the samples were identified and the number of all penaeid prawns, fish and other crustacean species were recorded. Postlarvae of each species were identified from the description of Hall (1962) and Young (1977).

Emigrating juvenile prawns, fish and other crustaceans were sampled by a "Jaring Apong" set from a buoy moored near the river mouth (east and west entrances of the Segara Anakan Lagoon) at the tidal creeks in the mangrove area and in the lagoon during the ebb tide. A trawl type set net, measuring 18 m headrope and with 20 mm cod-end mesh size was set near the bottom during the ebb tide once a fortnight. In the laboratory or in the field, the number of all penaeid prawns, fish and other aquatic animal species were identified and recorded. Juvenile prawns were identified from the descriptions of Kubo (1949); Dall (1957); Racek and Dall (1965); and Kirkegard <u>et al.</u> (1969).

4.2.3 Malaysia

Sampling for the abundance of larvae and postlarvae in the offshore waters has not been conducted to date.

Sampling for the abundance of postlarvae and juveniles in the estuary is conducted by direct observation of the catches of commercial push net and bag set gear operating in the estuary. This sampling is carried out every month during full moon for a period of 5 days.

Sampling for the abundance of subadults and adults is conducted by direct observation of the catches of commercial fishing gears operating in slightly deeper waters of the coastal mangrove swamps using trammel nets and trawl gear. Sampling is carried out every month during full moon.

All samples are sorted into species and sex, and total length is determined. Data on commercial catch and effort are also taken. Gonad stage of adult female prawns is determined by visual observation.

4.2.4 Papua New Guinea

Abundance of larvae and postlarvae (offshore)

There is no current study carried out on these life history stages offshore, but postlarvae that reach the river mouths and estuaries are being sampled together with juveniles.

Abundance of postlarvae and juveniles

These are being sampled monthly using a 100 m beach seine net with a stretch mesh of 6 mm. Suitable sampling sites were chosen and two hauls, each of approximately 15 minutes duration, covering a total area of 200 m^2 are taken. The catch is sorted into species and their carapace lengths taken by using dial calipers, measuring to the nearest 0.01 mm.

All adult animals are sexed, the reproductive activity or stage of maturation of females is determined, recording also size, texture and colour of ovaries. Stage 1 is when the ovary is invisible; stage 2 is when the ovary appears milky without the extension of texture up to 2/3 of the distance to the posterior of the prawn and the ovary bears a yellowish colour; stage 3 ovaries extend to posterior section of the prawn and a fission is seen in the ovary dorsally in the posterior section of the carapace. The ovary appears light green in colour. The ripe stage (stage 4) appears globular in appearance in the posterior section of the thorax. Normally two lumps spread on either side of the ovary in the first abdominal segment. The ovary appears dark green (often black) in colour. Those animals that have released the eggs are said to have spent and are classified as in stage 5.

Environmental Parameters

Details of fringing vegetation and substratum are described for each of the six sampling stations. Prior to the actual sampling, relevant physico-chemical data (temperature, salinity, conductivity and pH) are recorded as well as the subsequent disturbance of suspended particulate matter which would significantly affect the reading.

		Equipment used
(a) Physico-chemical parameters	- Salinity - Water Temperature - Conductivity - pH	Field Analyser (T.P.S. Model FL 80)
(b) Meteorological Data	- Rainfall - Relative humidity - Cloud cover	Rain gauges and hygrometers

4.2.5 Philippines

Regular monthly sampling started in February 1989. No data on larval, postlarval, juvenile are available.

For subadult/adult prawns, data on seasonal abundance, and length frequency, are collected from a fish corral with a mesh size of 1 mm. This is installed at a depth of 4 m at the mouth of Cadacang River. The sampling is carried out during low tide usually early in the morning and late in the afternoon over a period of two days. The total catch is recorded, numbers of individuals per species counted and the carapace length measured.

For adults, gill nets with a mesh size of 2.0 mm and mini trawl (2 mm mesh size) are used. The gill nets are used during daytime, while the mini trawl is operated at night. Sampling is carried out at the deeper parts of the bay, from 5 to 7 fathoms. The total catch of both types of gear is recorded and length measurements taken. Tow duration, area swept, depth, species composition and weight are recorded. Additional data are obtained from the log books of the fishing companies based in the area. Carapace length (CL) of all penaeids is measured using calipers. When the sample size is small all individuals are measured, but in large samples, as many measurements as possible are taken, making sure that all sizes are represented.

Maturity stages are determined macroscopically. Stage I is immature stage II-early maturing, stage III-late maturing, stage IV-mature, and stage V-spent.

Environmental sampling

During the regular monthly sampling, surface water temperature, water visibility and salinity are determined at 0.5 m depths.

4.2.6 Thailand

Larval and postlarval abundance (offshore)

In 1988, the study on larval and postlarval abundance was only carried out in the coastal zone and not attempted in the offshore region.

Postlarval/juvenile abundance (estuary)

Fortnightly samples are obtained with both a larval net and a beam trawl, during spring tides, from 4 designated stations. One station is in the middle of the river mouth, the other 3 stations are in the river, 3 km apart. The larval net (3 m long with 1mm mesh) is used to take surface samples. Bottom samples are collected by the rectangular beam trawl (mouth opening of 0.5 x 1.0 m fitted with a 1 mm mesh net). The period of towing is 5 minutes for both gears.

A 30 minute push net trawl (mouth opening 14 m wide and mesh size of 7 mm at the cod end with a cover net of 1.5 mm) is used for collecting juveniles. Sampling is carried out bi-monthly in the river, 3 km from the river mouth during spring tides at night.

Subadult-Adult prawn abundance and length frequency

Subadult sampling is conducted monthly along the estuary at four designated stations up to a depth of 5 m (about 3 km from shore line). Samples are obtained at night using a push net with a mouth opening 14 m wide and a mesh size of 7 mm at cod end, operated for one hour per haul.

Adults are collected by commercial trammel nets in coastal areas during spring tides. Sample collection is carried out monthly, when the total length, weight, sex, catch and effort are recorded.

Reproductive Activity

Samples are obtained monthly from commercial trawlers, push nets and trammel nets. The stage of maturity is determined for females larger then 13 cm.

Environmental sampling (Temperature/Salinity)

While collecting samples of postlarvae, juveniles and subadults, the surface water temperature and salinity are also determined before towing the nets at each station.

4.3 STANDARDIZATION

A discussion on the problems of sampling the different life-history stages of penaeid prawns followed the country reports. These included both sampling strategies and gear. The following recommendations were formulated.

(i) Clearly define objectives. This involves writing down exactly why the sampling is being conducted.

(ii) Define the population to be studied. The will often involve a pilot study or survey to define the limits and distribution of the population to be studied. Gradients in size or sex of the prawns must be considered.

(iii) Select an appropriate sampling unit. The should be at least as large as the distance between aggregation in the population, if possible. Where the sampling device selectively samples only part of the population to be studied, extreme care in gear selection is required. Mesh size, net opening size, and filtering area of the net must be considered and comparative trials of different gear must be conducted at the same place and time to describe the selectivity of each gear type used.

(iv) Select the data to be collected. Carefully consider what variables are relevant to the objective of the study and ensure that all of these variables are collected.

(v) Consider how the data is to be analyzed, including the statistical methods to be used (see Table 1). Establish how many samples are required to obtain an estimate of the population mean to within the required precision. This is often achieved through a pilot study to gain an estimate of the population mean and variance.

It must be noted that replication is needed to provide an estimate of the variance for use in calculating the standard error and 95% confidence limits of the mean.

Several sampling problems were recognized. The main problems were incorrect selection of sample sites, lack of replication, incorrect selection of gear mesh size, net opening size and filtering area and incorrect use of the fishing gear. After discussion, we attempted to standardize sampling gear, frequency of sampling, unit of measure, definition of life history stage and the distribution of the population (Table 1).

Table 1. Standardized sampling methods for short-term sampling of Penaeus merguiensis

	LARVAE	PLANKTONIC POSTLARVAE	BENTHIC POSTLARVAE JUVENILES	EMIGRANTS	SUB-ADULTS	ADULTS
SAMPLING GEAR (mesh size)	Plankton net 250 um (Penaeus) 140 um (other Penaeids)	Plankton net 1 mm	Beam trawl Beach seine Push net Fish corral 1) 1-2 mm 2) 12 mm 3) 28 mm	Set net Bag net Fish corral 1) 1-2 mm 2) 12 mm 3) 28 mm	Beam trawl Otter trawl Mini trawl Push net Gill net Trammel net 30-50 mm mesh (20-60 mm trammel)	Otter trawl Mini trawl Trammel net
FREQUENCY OF SAMPLING (CATCHABILITY FACTORS)	Lunar monthly	14 days Spring tide Flood tide	14 days Spring tide Low tide (beam trawl)	14 days Spring tide Night New moon	Tidal-monthly Neap tide	Tidal-monthly
UNITS OF MEASURE	no/sq.m.	no/cu.m.	no/sq.m.	no/cu.m. no/hr	no/hr	no/hr
LIFE HISTORY STAGE DEFINITION	Protozoeal Stages	Early planktonic postlarvae	3-25 mm CL benthic postlarvae and juvenile	3-25 mm CL	18-25 mm CL	> 25 mm CL
POPULATION DEFINITION (DISTRIBUTION)	Adult distribution over entire water column	Cross-section of estuary mouth	Whole of estuary	Surface or estuary mouth (also bottom?)	Inshore and coastal to about 10 m but include to the limits of the adult population	To the offshore limits of the population

5. LONG-TERM MONITORING OF RECRUITMENT AND SPAWNING INDICES

5.1 DATA REQUIREMENTS

Ideally, to determine the effects of climate and fishing on prawn recruitment, we need long time series on the monthly and annual changes in the relative abundance of the major life history stages as well as a range of environmental variables. In many cases, however, these data sets are not available but we can often use relevant data from other sources (proxy data) to gain the same information. Commercial catch and effort data can provide recruitment indices while meteorological and hydrological data sets can often be used to describe changes in the marine environment. Two sources of long- term data for prawns were investigated viz. survey data from research vessels and commercial catch data.

5.2 LONG-TERM SAMPLING - COUNTRY REPORTS

5.2.1 Australia

Survey data

No long-term survey data is currently available but hopefully the current sampling will be continued to produce a long-term data set. The 3 years sampling to date has provided enough information to allow sampling to be restricted to the times of year which are critical for each life history stage. The sampling windows are as follows:

Population fecundity (Offshore)	August to November
Larvae (Offshore)	August to November
Postlarvae (Estuary)	September to December
Juveniles (Estuary)	November to February
Emigrants (Estuary)	November to March
Adults (Offshore)	January to May

The sampling methods used will be the same as those described for the current short-term sampling.

Commercial Catch and Effort Statistics

Approximately 240 vessels operate in the Declared Management Zone of the Northern Prawn Fishery. The zone stretches across northern Australia from approx. 120°E to 142°E. A compulsory log book programme is managed by the Australian Fisheries Service. The fishermen record in a daily log: catch by species group, area fished, and effort in terms of boat days. This provides an estimation of CPUE by species group by region. In addition, landing statistics are collected from processors, thus providing an independent measure of total catch. Total effort in the fishery can be estimated from the relationship between total catch from landings statistics, total effort, and catch per unit effort from the log book data. Effort can also be apportioned by region or by time using this relationship.

Environmental sampling

The Weipa climate has marked seasonal variation. Water temperature and salinity are directly affected by the ambient air temperature and the amount of rainfall. An overall picture of yearly variation in salinity or water temperature can be gained by measuring monthly totals of rainfall and mean air temperatures. Daily rainfall patterns will also be examined to determine the effect of intensity of rainfall and the duration of rainfall events. Daily and monthly rainfall and temperature data are readily available from the Australian Meteorological Bureau. Some river discharge data is available for the rivers in the Weipa region and although the recording stations are well upriver the data does give an indication of the year-to-year variation in fresh water outflow from the rivers. These data are available from the Queensland Water Resources Commission.

5.2.2 Indonesia

Commercial catch sampling

Spawning season, spawning ground and other population parameters such as recruitment patterns of offshore prawns and fish are identified by taking samples regularly (fortnightly) at the landing places from the commercial trammel net catches. Spawning seasons are identified by observing the gonadal maturity stage. The abundance of the stock is estimated from catch per unit of effort (CPUE) and the stock size is estimated by using Surplus Production Models (Schaefer, 1954, 1957; Fox, 1970). Population parameters data (growth, mortality, recruitment pattern) are derived from length frequency data by using ELEFAN (Pauly and David 1981, Pauly, 1982). The yield per recruit is estimated from population parameters derived from a modified version of Beverton and Holt models (1957). The data are collected monthly to assess the seasonality of the prawns' life history. Time series data which are available for several years are treated as monthly averages by using REFLEX micro computer package programme.

Irregular Oceanographic Surveys

The following data also collected from irregular oceanographic surveys: temperature, salinity, primary productivity, phosphate, nitrate and plankton.

Rainfall data

Rainfall and other meteorological data can be obtained from local (Cilacap) Meteorological Station.

5.2.3 Malaysia

No long-term surveys have been conducted in the study site to monitor the various life history stage of P. merguiensis. However, long-term commercial catch and effort data are available through an ongoing national fisheries statistics programme of the Department of Fisheries, Malaysia. Annual and monthly landing of various categories of fishing gears are available. The statistical data are collected by sampling the catches of the various fishing gears at selected fish landing centres through direct recording of their catches as they are being landed. The numbers of fishing units are estimated through frame surveys conducted by the staff of the Statistics Unit and total landings are computed from the estimated catch per unit effort and total effort of the individual fishing gears in operation.

In the case of environmental data, long-term rainfall data is available from the records of the Department of Meteorology which monitors the rainfall at specific stations throughout the country. One such station is located near the study site. Rainfall records from this meteorological station are available and the data has been utilized in the previous PREP workshop.

5.2.4 Papua New Guinea

Scientific surveys

There are no long-term scientific surveys in Papua New Guinea at the present time, but now that the seasonality of spawning and recruitment has been identified for the fishery in the Gulf of Papua, scientific cruises can be made each year during these time windows.

Catch and effort statistics

Papua New Guinea has a system of monitoring commercial catch similar to that of Australia, where commercial catch and effort data are monitored through the distribution of log books to fishermen.

Daily catch, effort and other relevant data required are entered and returned to the Department of Fisheries. These records are then entered into the main national data base.

Environmental monitoring

All meteorological data were previously obtained from the National Weather Bureau, however, information for specific areas of interest, especially Kikori, Baimuru, Ihu and the southern parts of the highlands, were sometimes not available.

The department has now installed equipment in almost all the surrounding districts draining the Gulf of Papua. With the identification of recruitment spawning time windows, it will now be much easier to extract or collect these data.

5.2.5 Philippines

Long-term monitoring of catch of effort data in Sorsagon Bay is available since 1982. Total catch is obtained from exporting firms; catch and effort by gear type is obtained from the statistics of the local fisheries office. The Philippines Coast Guard provides effort data (number of boats), but this is not broken down by gear type. Interviews of fishermen are conducted to provide missing data.

The National Weather Bureau has compiled air temperature and rainfall data of the area since 1975.

5.2.6 Thailand

Survey data are available in Ban Don Bay since 1984 including monthly postlarval samples from pushnets and beam trawls samples taken in the estuary, bi-monthly emigrants data from setnets in the estuary sampled at low tides and monthly subadult samples from pushnets in the estuary at night as described in Section 4.7

Commercial catch and effort statistics - Gulf of Thailand

Samples are collected from both trammel net and otter-board trawl on a monthly basis. Effort by the otter-board trawlers is measured by the number of fishing boats and the numbers of hours of operation per day. Trammel net effort is measured by the number of fishing boats and the number of hours operation per day, including the number of the nets in each boat.

Environmental sampling

Salinity and water temperature are recorded while collecting samples of postlarvae, juveniles and subadults. Long-term data on climate are available from selected stations.

5.2.7 China (People's Republic of)

Meteorological data

Rainfall, wind and temperature data can be obtained from the state weather bureau or local weather stations.

Environmental data

The State Oceanic Administration conducts quarterly oceanographic surveys in the coastal areas of the China Sea in February, May, August and November (monthly surveys from 1965 to 1980). The parameters being measured are: water temperature, salinity depth, Secchi disc depth, water color, wind direction and speed, DO, pH, nitrate, nitrite, ammonia, phosphate and silicon oxide.

Pre-season survey

In early August in Liaodong Bay, Bohai Bay and Laizhou Bay, 100 stations are occupied to assess of the abundance of P. orientalis. At each station, two beam trawls are made and the data used for catch forecasting.

5.3 PROBLEMS OF LONG-TERM MONITORING

Several problems in the long-term monitoring of both biological and environmental parameters, especially in the use of catch and effort data to estimate spawning and recruitment indices were identified.

These problems included:

(i) Accuracy of data. In many cases, data are collected by personnel who do not understand the data requirements of research scientists. Improved communication between scientists and the field staff involved in data collection is essential if the data quality is to be improved. Positive feedback to these people must be encouraged. Problems in recording accurate data from fishermen must also be addressed. Data collection must be separated from enforcement of regulations if accurate reporting of information is to occur.

(ii) Units of measure. Use of appropriate units of measure is especially important in estimating effort. Standard units of effort such as boat-days and trips change over time with changes in boat design, engine power, instrumentation and gear design. These data must also be collected to standardize effort for making long-term comparisons.

(iii) Relevance of data. Commercial catch and effort data are usually collected for several purposes, and more often than not end up as broad summaries of catches over large areas and species groups, and lack the resolution required for recruitment studies. Data must be collected at least monthly on spatial scales which are relevant for a particular study site. When data are lumped for several species, species resolution is often possible from an analysis of the species composition in time and space in the study site and related back to the catch statistics.

Although environmental data are often more accurate and are usually collected at a scale of resolution required for recruitment studies, some care is needed in their use. For example, rainfall and river discharge are not always directly related because of catchment topography and other geographic features. Variables which control the general climate, such as barometric pressure, are often useful in reducing local variability of other parameters.

(iv) Sampling strategies. Researchers must also make more effort to assist in the design and implementation of sampling strategies. Many of the recommendations presented for improving the quality of short-term biological sampling are also relevant to long-term monitoring. Objectives must be clearly stated, the population to be sampled (e.g. the fishermen) must be clearly defined and the precision of the data estimated by standard statistical results. All estimates of catch and effort are samples of the true catch and effort, and their variance and 95% confidence limits should be calculated.

6. LARVAL, POSTLARVAL, JUVENILE AND ADULT IDENTIFICATION

6.1 LARVAL IDENTIFICATION

Mr. Jackson discussed the generic identification of penaeid larvae, paying particular attention to the protozoal stage. He referred to a paper to be published in Fishery Bulletin (Jackson, Rothlisberg, Pendrey and Beamish 1989; document no 7). This paper contains a key to genera of penaeid larvae, and part of the key was discussed in detail. It was pointed out that the genus Penaeus is quite distinctive and relatively easy to identify. However, Metapenaeus, the second genus which is commonly studied in the PREP region, is more difficult to identify, being very similar to Metapenaeopsis, Atypopenaeus and Parapenaeus. Some skill and experience is needed to separate these genera.

The species identification of penaeid larvae was then discussed. Until recently, workers had been unable to reliably identify these early larval stages. Mr. Jackson described a new technique, based on discriminant analysis, which now allows researchers to identify early larvae. The method uses a reference collection assembled by rearing larvae from adult prawns of known identity. Many morphological measurements are made on each larva in the reference collection and these data are analyzed by discriminant analysis. The analysis is used to choose about 4-8 characters which in combination, best highlight the morphological differences between the species. Using the reference collection's data for these characters, the discriminant analysis produces a set of classification functions, which are then read in to a separate computer programme. This programme can then be used to identify unknown larvae. The programme operates by prompting the user to measure the appropriate characters on each unknown animal, and then these data and the classification functions are used to calculate the most likely identification. The probability associated with the identification is tested against a threshold value and, if high enough, the identification is accepted. If the identification probability is below the threshold value, the unknown larva is reported as "unidentified". The programme also records the identification, and all morphological measurements, in a computer file. The programme was demonstrated and workshop participants had an opportunity identify larval specimens.

It was explained that, unfortunately, the technique was not easily transferable to other workers for the following reasons: (i) Different species occur in different regions; (ii) There may be subtle morphological differences in the same species from different regions; (iii) It is very difficult to define the measurement used to identify larvae sufficiently accurately, and different operators may measure the same character differently. For these reasons it is necessary that each country develop its own reference collection.

Details of how to set up the identification scheme were handed out to all participants, with a figure illustrating the types of characters to be measured in the reference collection larvae.

6.2 POSTLARVAL, JUVENILE AND ADULT IDENTIFICATION

Dr. Staples lectured on the techniques of identification used and problems encountered, along with a new method of identifying postlarval prawns. Keys available for adults of all commercial penaeid species are adequate and there is no apparent problem in any of the countries. Juveniles in the genus Penaeus can be identified using morphological characters. However, juveniles of other genera, including Metapenaeus, which rely on mature genitalia for identification, are not readily identified to species. Postlarvae can be identified to genera or species groups by morphological characters, but identification to species levels is a problem in many countries.

Electrophoresis is a technique which has been used to solve these identification problems for some species in Australia. Currently in Australia the technique is being used to identify approximately 300 specimens per day to separate morphologically similar species of Penaeus and Metapenaeus. It is a simple technique although there is some initial development time required for each species identification. In addition, samples will have to be handled differently, promptly freezing them in the field and keeping them chilled during sorting and processing in the laboratory.

Ms. Rattana Poltanya, Thailand, Dept. of Fisheries demonstrated the equipment needed for starch gel electrophoresis. Use of the method for mollusc identification was discussed and compared with the method used to identify postlarval prawns in Australia. It was noted that most countries had expertise in this field which could be tapped to provide suitable methods for the routine identification of postlarvae and juvenile of species which are difficult to distinguish by standard morphological techniques.

7. FIELD TRIP

7.1 PUSH NET FISHERY

An early morning visit to a product landing site close to Phuket provided the opportunity to observe long-tail boats and push-net gear first hand. Several vessels which had been fishing the night before in the adjacent creeks and shallow bays were unloading baskets of catch. The prawn catch consisted of predominantly small size grades of several Metapenaeus species while some P. merguiensis and some large P. monodon were also present. The prawn catch represented approximately half the total catch; the other catch being predominantly small fishes, small swimming crabs, and some squid.

7.2 FISHERIES RESEARCH VESSEL

The Department of Fisheries, Thailand, made available the 25 metre, 90 ton, "Research Vessel Number 10" for a day-long field excursion in Phang-nga Bay. The opportunity to observe plankton sampling and stern trawling operations provided the basis for informative discussion and interchange of ideas on methods used in each country. The plankton trawl, a circular net of 1.5 m mouth diameter and 3 mm stretch-mesh net, was deployed on the surface for about 10 min. The activity prompted useful discussion on the merits of this type of gear and mesh size for postlarval sampling. It pointed to possible problems of measurement of mesh sizes (stretched-mesh versus square mesh etc), and provided for discussion on the importance in net washing techniques. Design of plankton nets in terms of mouth area to filtering area ratio was discussed and so provided for a more informed approach to and standardization of net design for participants contemplating plankton studies. Further north in Phang-nga Bay the stern trawl (otter trawl, "Mexican type", headrope approx. 10 m) was deployed for about 1 hour in a depth of 30 m. The catch consisted mainly of small fishes. The exercise stimulated useful discussion on comparative methods, gear types, sampling strategies and sampling sites between the country groups. The practical nature of the days activity tended to highlight differences and difficulties in approach and interpretation of methods, which may not have otherwise come under discussion.

8. DATA ENTRY, EDITING, STORAGE AND BACK-UP

8.1 DEFINITIONS

Mr. C. Jackson introduced the session using a flow diagram to illustrate the various steps involved in data entry and validation (Fig.23). A distinction was made between the two separate processes of backup (short-term protection against accidental data loss) and archive (long-term secure storage of data). It was emphasized that at least two archive copies of an important data-set should exist, and they should be kept in different places. Regarding data entry, the importance of the original paper record (field sheet, log book etc) being preserved was stressed. The flow diagram illustrated the two separate areas where data should be checked and validated - at the time of initial entry into the computer, and later, in a repetitive check/edit cycle. It was stressed that data validation is difficult and very time-consuming, but that it must be done.

8.2 COUNTRY REPORTS

8.2.1 Australia

Data from the Larval, Juvenile and Adult/Reproduction groups are collected and processed differently in terms of software and hardware but the principles involved in the data handling are the same for each group.

All groups record data onto field data sheets initially and these are of two basic types:

(i) Station identification and environmental data, e.g. station number, date, trawl time, net type, gear breaks, temperature, salinity.

(ii) Species data, either recorded in the field or in the lab.

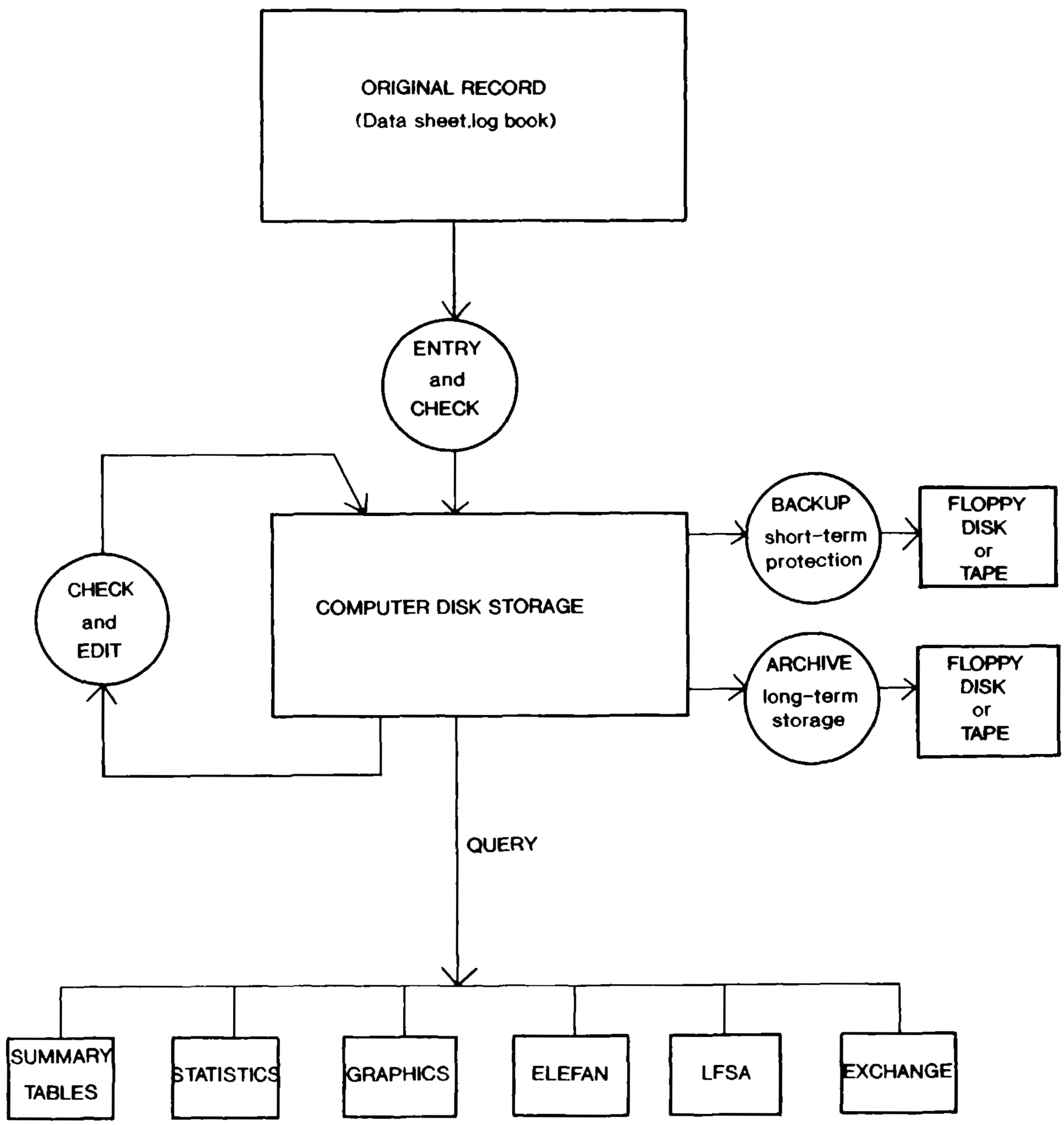


Fig. 23: Flow diagram for data base management including data entry, checking, editing, storage, backup and archive to use for subsequent data analyses (e.g. statistics, ELEFAN).

Juvenile and Adult prawn measurements are recorded on data sheets and then entered to a computer while the Penaeus measurements are entered directly to a computer by the measurer.

Data validation

In all groups, data is entered to a computer via a keyboard and screen by a group member or contractor. In some cases (larval station data) the field data sheets are hand checked before entry into the computer but in all groups the data is checked on entry to ensure that each variable falls within allowable ranges. In all cases, the computer package will not accept a value which is out of range and the operator has to make the correction before proceeding further.

The location of first data entry varies between groups. Juvenile data is initially entered to a DBASE database using a microcomputer at the Weipa Field Station. Some checking is done on the DBASE files before they are converted to ASCII, mailed to the Cleveland lab, and entered into Oracle on the VAX. Larval data is entered to the Oracle database on the VAX computer at Cleveland while Adult data is entered to the VAX computer via an interactive Fortran programme which range checks and stores the data in ASCII files.

Once data is entered to the VAX computer, either to the Oracle database (Larvae and Juveniles) or to ASCII files (Adults), this data is then regarded as the primary data; all corrections are made to this set only.

Data storage backup/archive

Storage of data occurs in several ways and at different levels.

(i) In all groups the original data sheets are stored indefinitely for reference.

(ii) In the Juvenile group a copy of the data as it was transferred from Weipa is held on diskettes at Cleveland.

(iii) At the moment, all data can be stored on the hard disc in the VAX computer at Cleveland.

(iv) Data is backed up onto magnetic tape either by each group or as part of the general Cleveland backup system. Every day the system is backed up onto tape and this copy is kept for a month. Once a month the system is archive and this copy is stored indefinitely.

Data retrieval, summaries and subsequent processing (statistics/graphics)

All groups utilize pre-written SQL procedures or Fortran programmes, either interactive or menu driven, which retrieve data from the Oracle database or ASCII files. These procedures produce summaries or listings in commonly used formats or groupings of data.

The output can be in printed report form, ASCII files or SAS files ready for further analysis using the SAS statistical package. Ad hoc retrievals can also be made from the database using SQL.

Grouping of data and calculation of means and other simple statistics are sometimes performed using SQL. Statistics and graphic are performed using SAS.

In some cases, ASCII summary files are produced which are then passed to a statistician for more complicated analyses, and ASCII summary files are produced and transferred to an Apple Macintosh computer for graphs for submission to scientific journals.

Data sharing and exchange

Each group's data is usually freely accessible to staff within each group but some contract workers only have Write access to particular tables. Read only access or Read/Write access is sometimes given to people in related groups. More commonly, data is shared at the summary level by graph or report and through publications.

8.2.2 Indonesia

Data collected from field sampling are recorded on field data sheets. Field data sheets for postlarvae, juveniles and subadults include information on station number, date, time of the day (hour, day or night) tide and current, temperature, salinity and turbidity. For the juveniles and subadults catch data on catch composition (prawn species and finfish species), gear and mesh size is also included.

For data entry, DBASE is used for catch data and ELEFAN for length frequency analysis. The data is checked through print out and then stored on hard disc. ELEFAN and SAS programmes are used for data processing.

8.2.3 Malaysia

Data collected from sampling of the catches from the various relevant fishing gear in the study site are recorded on data sheets in the field and then entered into IBM or IBM compatible microcomputer in the laboratory. The data is stored on floppy diskettes, and backups are updated every time new data is entered. Processing and analysis of the data is done with the data transferred into hard disc in the microcomputer to facilitate and speed up the processing.

Currently the catch and length frequency data obtained from the study site is entered, processed and analyzed with LOTUS 123 and COMPLEAT ELEFAN from ICLARM. However, it is envisaged that future data entry will be done with either an appropriate database management software (e.g. DBASE IV) or with the data entry protocol of SPSS. Archive storage will also be implemented in future on microcomputer magnetic tapes.

8.2.4 Papua New Guinea

Original data is recorded on data sheets, observer data sheets, juvenile data sheets and by books. Data sheets for the observer programme includes details of boat number, name, catch composition (fish, sharks, turtles, lobsters, rays or other), species composition of prawns as well as length frequency data. Data is entered into DBASE III^{+} (DBASE IV) and checked by browsing the files. To minimize errors, codes are used for companies, vessel, sex etc. Hard disc storage is available and data are checked by manual checking. Data is backed up on floppy discs and archiving is carried out with two floppies. Data is analyzed using LFSA, ELEFAN and SYSTAT while graphics are done using STATGRAPH, LOTUS and SYSTAT. Data exchange is through publication of reports and papers.

8.2.5 Philippines

Data from the different fishing gears are originally recorded by month in record books. Table and graphs are prepared and a report of the trip written. The data is entered into DBASE and stored on floppy discs. Record books and summaries are stored. Database fields include date, time, depth, fishing gear, number caught. Length frequency data has not yet been entered into a computer as the data set is still small (project started February 1989). Data is recorded on date, species, carapace length and frequency. Environmental data are stored as original data table and DBASE files including date, station number, depth, air and water temperature, salinity and rainfall.

8.2.6 Thailand

Data on catch, stage of maturity and environment are entered into IBM PC compatible computers. Length frequency data is stored and analyzed using ELEFAN and LFSA packages. The FSAS package is used for population dynamic analyses.

8.2.7 China (People's Republic of)

All information must be recorded on a national standard data sheet and a summary cruise report (including graphs) must be submitted after any research cruise. At the end of any project, all data is given to the National Data Centre. Computers are now used in China by individual scientists and there is no standard software for analyses. IBM compatible PCs are the most commonly used computers. There is usually no data exchange between research groups except on an individual basis.

8.3 SUMMARY OF COUNTRY REPORTS AND RECOMMENDATIONS

Data were entered using a number of software packages including DBASE, ELEFAN, LFSA, ORACLE, FORTRAN and LOTUS. Most countries did little data checking at this stage. Three countries stored their data on floppy disc, the rest on a hard disk. Only Australia followed comprehensive procedures involving range checks, cross checking between different parts of the database, and checks within records. Most other countries relied on visual comparison of data print outs against original record sheets. Most editing of data at this stage used DBASE (4 countries) with ORACLE and LOTUS also being used (1 country each). Most countries backed up their data onto floppy disk with only Australia using magnetic tape. The same media were reported being used for archiving.

Because most countries do not yet have large data sets, extensive use of computers for data storage and analysis is only just beginning. With small data-sets the problems of data validation and security are not too great. However as greater volumes of data are gathered, these aspects will assume greater importance. In general, it was felt that databases should be the main storage area for all data-sets, in preference to spread sheets, ASCII files, or special-purpose programmes such as ELEFAN. (ELEFAN should be able to input data from an ASCII or database file to facilitate this). It was also felt that SQL was rapidly becoming a standard database manipulation language which offered considerable advantages in terms of its ability to scan, subset and summarize data, allowing powerful procedures for data validation to be used. DBASE 4 has an SQL interface which was being used by PNG, while Australia was committed to the ORACLE SQL based package.

The chairman finished the session by discussing the various methods which could be used to detect errors in the data. Methods relying on checks within a record, such as checksums and range checks were described and some examples given. Cross-checking across several files should also be carried out.

The use of statistics and summaries to check data was introduced, with an example where one sample was taken every week. By summarizing the sample file to show the number of records present for each month, such problems as missing records, duplicated records, and mis-coded data would become apparent.

The use of simple graphics to find data errors was illustrated (Fig. 24). Drawing a frequency histogram for a variable such as temperature may highlight doubtful data values (Fig. 24a). However it would be more effective to plot temperature against time. This would reveal values which might be within the overall normal range but were abnormally high or low for the particular season (Fig. 24b). The final example given was of plotting one variable against another, even where the combination might not be of interest directly. For example, in the situation where every time a sample is taken, the next sample number in sequence is used, a plot of sample number against time would reveal mis-coding of date or sample number (Fig.24c).

Finally, some general principles and procedures were given:

(i) Data sheets and database structure should be designed with future validation requirements in mind.

(ii) As much data checking as possible should be done at the data entry stage, as it is preferable to stop bad data from ever getting into the computer.

(iii) The person entering the data should have some familiarity with data sets as this will lead to fewer mistakes.

(iv) Data validation is a time-consuming but vital step which must be taken, otherwise any analysis of the data will not be correct.

It was decided by all participants that each country was responsible for the entry, storage and analysis of their own data sets. No need was seen to standardize software, providing the correct procedures of validation and checking were followed. Data exchange when necessary will be carried out using ASCII files, summary tables, graphs and publications.

9. NATIONAL COORDINATORS' MEETING

The National Coordinators' Meeting was held at the Phuket Marine Biological Station on Saturday, September 30, at 9 am. Those present included national coordinators or their delegates from the Philippines, Thailand, Malaysia, Indonesia, PNG and Australia. A representative from China, Spain and Mexico also attended.

9.1 NATIONAL REPORTS. PRESENT STATUS OF PROJECT, CAPACITIES AND PROBLEMS

All co-ordinators reported that the PREP network formed an important part of their research efforts in their respective countries, supported mainly by national research funds. In two countries, data

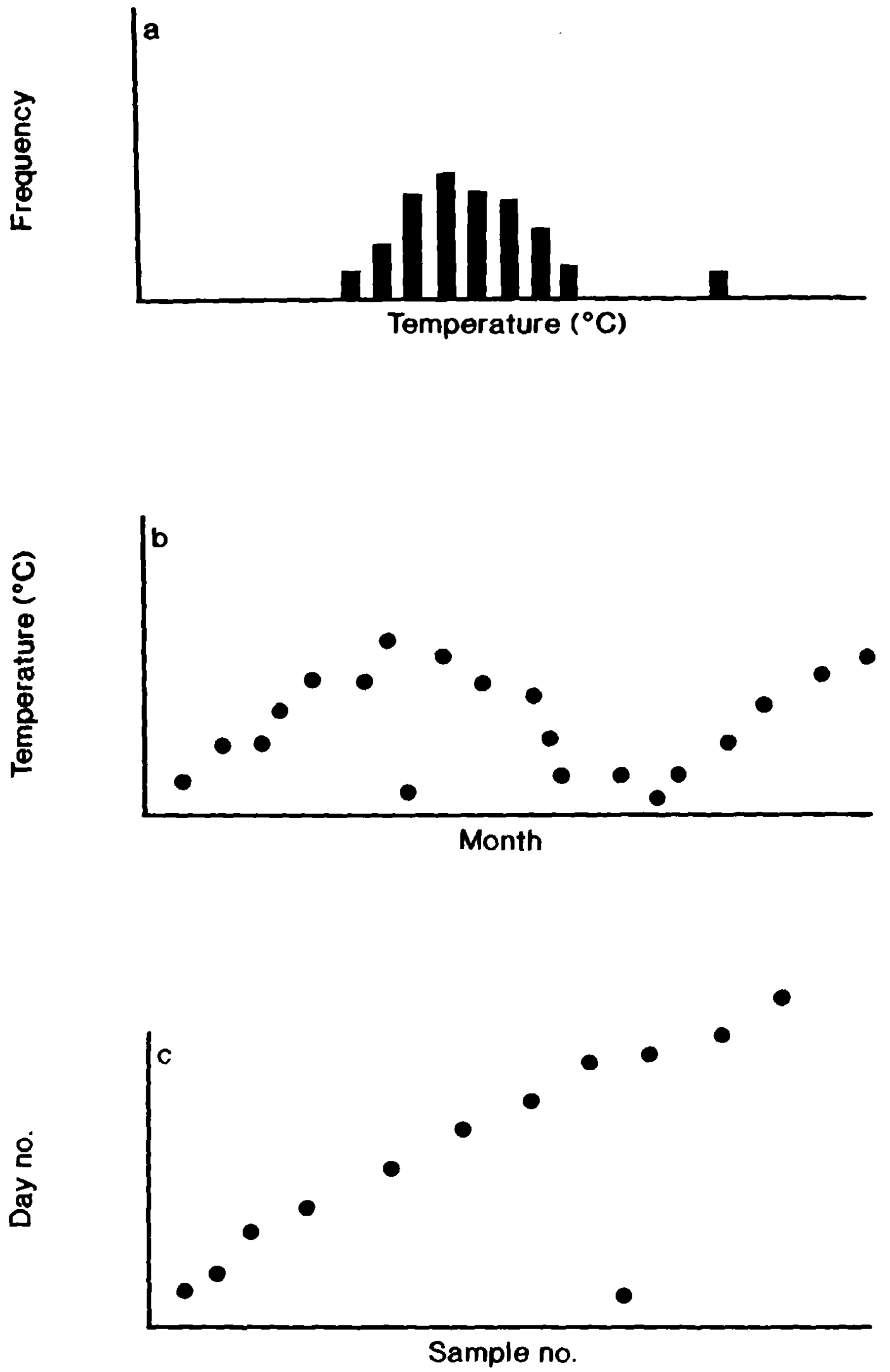


Fig. 24: Techniques for data checking (a) Simple bar graph (b) Time series checks and (c) Scatter plots of two variables.

collection was relatively new, starting only in February 1989. In other countries, data has been collected for several years and a considerable data set has been accumulated. Staffing ranged from a large team of scientists as in Thailand and Australia to one biologist and a technician in Malaysia. All countries are concentrating on the collection of seasonal data, although annual surveys are also conducted at some sites and a commitment to longer-term data collection has been made.

Budgets to support the research at the national level were considered adequate in three countries, while the others expressed problems with funding. All countries agreed that it would help if PREP was to have a more official status. Problems associated with carrying out the necessary research reflected the funding situation in the respective countries. In countries where adequate funding exists, problems ranged from difficulty in purchasing overseas equipment and materials, constraints on the utilization of funds and staff, lack of expertise in data collection and analyses, especially with reference to penaeid early life history stages. Countries with some serious budget constraints reported difficulty in purchasing adequate equipment, especially computers and laboratory facilities (e.g. electrophoresis equipment and chemicals). All countries recognized the need for training in specialist topics such as larval and postlarval identification.

9.2 FUNDING STRATEGIES

Problems with funding the project, especially in supporting activities at the network level were discussed. The forthcoming mission organized by the UNDP to look at funding a range of activities including red tide studies and penaeid recruitment was discussed at length. It was felt that a submission to UNDP to support network activities was probably the best hope for stability of core funding and successful continuation of the project. Other funding sources such as AIDAB, SEAFDEC, World Bank were discussed and more information will be sought about these possible alternatives. At the National level various bilateral funding agencies were suggested as possible sources of funds to enhance PREP activities at the national level.

All members agreed that funding would be easier to obtain, if PREP received more formal recognition and official status both nationally and internationally. The IOC representative agreed to investigate how this could be achieved within the IOC-FAO/OSLR framework. He also described the role of certain agencies within the EEC and encouraged participants to make further enquiries to other agencies as well as the traditional sources of funds within south-east Asia. Participating countries were urged to submit research proposals to funding agencies of their choice to fund research at the national level. The PREP Technical Coordinators would assist where appropriate.

9.3 FUTURE ACTIVITIES

There was general agreement that PREP should provide:

(i) coordination and focus of research efforts on penaeid prawn recruitment in the WESTPAC region;

(ii) a network for sharing of methodologies, data and interpretation of results on penaeid prawn recruitment;

(iii) training and consultancies for specialized topics along with assistance in purchasing critical equipment;

(iv) stimulus for long-term commitment for research and scientific management of prawn resources;

(v) stimulus for funding at the national level so that each country can conduct their own research relevant to their own national needs.

All countries recognized the importance of workshops in carrying out some of the above functions, although the desired frequency of workshops differed among countries. When asked to priorize immediate needs including the purchase of critical equipment, training and consultancies, four of the six countries listed training as their top priority, consultancy as the second priority and purchase of equipment such as computers rated third overall. It must be stressed, however, in the two countries where the purchase of equipment rated top priority it is critical to their successful participation in PREP that these items be purchased as soon as possible.

China expressed interest in becoming an active member of the PREP network, while Spain and Mexico offered continued interaction at the regional level, providing assistance with interpretation of research results and the exchange of information and ideas.

9.4 PROJECT IMPLEMENTATION

In discussing how PREP should be implemented over the next year or so, there was general consensus that the next workshop on data analysis should be held in 18 months' time, in order to make further geographic comparisons of data collected during the intervening period (see recommendations). It was also requested that the PREP Technical Co-ordinator arrange a visit to each study site early next year to evaluate the adequacy of data collection, especially with reference to the Rainfall Emigration Experiment (REX; ANNEX IV). It was also agreed that training, especially in the field of larval and postlarval identification, should proceed between laboratories where this expertise already exists and those that need it in the next 12 months.

Technical coordination for the project will still be provided by Dr. P. Rothlisberg in his capacity as IOC-FAO/OSLR Technical Co-ordinator and Dr. D. Staples, PREP Technical Coordinator. The need for further communication, outside of the present network of researchers and organizations was discussed. It was agreed that there was a need for better communication, both within countries, between Fishery Departments and Universities and among countries to inform others of PREP activities. The OSLR newsletter was seen as a potential means for this communication, although it was also felt that regular newsletters such as FISHBYTE should also be more fully utilized.

10. RECOMMENDATIONS

The specific recommendations arising from the Phuket Workshop were:

1. The network activities should be supported as a top priority for funding from international organizations.

2. The participants of the Workshop urge IOC and FAO to do everything possible so that the WESTPAC-PREP initiative gains more official recognition in the participating countries.

3. Funding needs to implement PREP studies should be pursued by the participating countries at a bi-lateral level.

4. Priority should be given to the following activities within the WESTPAC-PREP initiative:

   (i) the region should be visited by experts to evaluate data collection especially with reference to the Rainfall Emigration Experiment (REX);

   (ii) a workshop should be held in about 18 months to evaluate data sets and to make geographic comparisons on penaeid recruitment dynamics;

   (iii) the scientists involved in the PREP initiative should receive additional training using TEMA and other training programmes.

11. CLOSURE OF WORKSHOP

Dr. J. Alheit concluded the workshop by expressing his thanks to all involved in making the workshop such a successful meeting. In particular, he thanked the Thailand Department of Fisheries, Ministry of Agriculture and Cooperatives, The Royal Government of Thailand for providing such generous support and facilities. These included the organization of the workshop, the secretarial work, as well as the warm hospitality extended to everyone. Dr. Alheit also thanked participants for their contributions towards providing the valuable workshop report and the Technical Coordinators for their input into the workshop. The workshop closed with Dr. Staples thanking IOC and FAO and Dr. Alheit for their continued support and expressed the hope that PREP would continue to serve the need for management-oriented research in the WESTPAC region in the future.

REFERENCES

Dall, W. 1957. A revision of the Australian species of Penaeinae (Crustacea Decapoda: Penaeidae). Australian Journal of Marine and Freshwater Research 8: 136-230

Beverton, R.J.H. and Holt, S.J. 1957. On the dynamics of exploited fish populations. U.K. Ministry of Agriculture and Fisheries, Fishery Investigations (Series 2) 19: 73-90

Fox, W.W. 1970: An exponential yield model for optimizing exploited fish populations. Transactions of the American Fisheries Society 99: 80-88.

Grey, D.L., Dall, W. and Baker, A. 1983. A guide to the Australian penaeid prawns. N.T. Department of Primary Production, Darwin, 140pp.

Kirkegaard, I. 1969. The larvae of Trachypenaeus fulvus Dall (Crustacea: Decapoda: Penaeidae). Fisheries Notes, Queensland Department of Harbours and Marine 3: 15-25

Kubo, I. 1949. Studies on the penaeidae of Japanese and its adjacent waters. Journal of the Tokyo College of Fisheries 36:1-467

Jackson, C.J., Rothlisberg, P.C., Pendrey, R.C. and Beamish, M 1989. A key to genera of the penaeid larvae and early postlarvae of the Indo-west Pacific region with descriptions of the larval development of Atypopeneus formosus Dall and Metapenaeopsis palmensis Haswell (Decapoda Penaeoidea: Penaeidae) reared in the laboratory. Fishery Bulletin U.S. 3 (in press)

Pauly, D. 1982. Studying single-species dynamics in a multi-species context pp 33-70 In Pauly, D. and Murphy, G.I. (Eds) Theory and management of tropical fisheries. ICLARM Conference Proceedings 9, Manila, 360pp

Pauly, D. and David, N. 1981. A BASIC programme for the objective extraction of growth parameters from length-frequency data. Meerforsch. Report on Marine Research 28: 205-211

Racek, A.A. and Dall, W. 1965. Littoral Penaeinae (Crustacea:Decapoda) from northern Australia, New Guinea and adjacent waters. Verhandelingen der Koninkligke Nederlandse Akademie van Wertenschappen, Afd. Natuurkund, Tweede Reeds 56: 1-116

Schaeffer, M.B. 1954. Some aspects of the dynamics of populations important to the management of the commercial marine fisheries. Bulletin of the Inter-American Tropical Tuna Commission. 1(2): 27-56.

Staples, D.J. and Rothlisberg, P.C. 1990. Recruitment of penaeid prawns in the Indo-west Pacific. Proceedings of the second Asian Fisheries Forum, Tokyo, Japan, april 17-22, 1989 (in press)

Young, P.C. 1977. A working key to common species of juvenile penaeid prawns from Moreton Bay, Queensland, Australia. (Penaeidae:Natantia). Australian C.S.I.R.O. Division of Fisheries and Oceanography Report 72: 1-12

ANNEX I

TIMETABLE

Monday 25 September

Welcome speech	Mr. Rattakorn Nimwattana Phuket Governor's representative
Introductory speech	Dr. J. Alheit Technical Secretary for IOC-FAO OSLR Programme
Opening speech	Dr. Plodprasop Suraswadi Director General of Department of Fisheries
Introduction	Rationale of PREP and objectives of workshop Dr. D. Staples

Review of recruitment dynamics of <u>Penaeus</u> <u>merguiensis</u>

Dr. P. Rothlisberg (Chairman)

Seasonal dynamics and inter-annual variability
Country Reports
Discussion - Geographic comparisons

Recruitment dynamics of other species (<u>Semisulcatus</u>, <u>Metapenaeus</u> <u>ensis</u>)

Dr. J. Alheit (Chairman)

Seasonal dynamics and inter-annual variability
Country Reports
Discussion - Geographic comparisons

Tuesday 26 September

Short-term sampling methods

Dr. P. Rothlisberg (Chairman)

Sampling theory - Dr. D. Staples
Larval and postlarval abundance (offshore)
Postlarval/juvenile abundance and length frequency (estuary)
Subadult/adult prawn abundance and length frequency (offshore)
Reproductive activity (maturity and egg production)
Environmental sampling
Country Reports
Standization of techniques for PREP

Wednesday 27 September

Long-term monitoring (recruitment, spawning indices and environment)

Dr. J. Alheit (Chairman)

Survey data
Commercial catch and effort statistics
Environmental data (proxy data)
Country Reports
Standardization of techniques for PREP

Larval, postlarval and juvenile identification

Dr. P. Rothlisberg (Chairman)

Larval taxonomy and identification - C. Jackson
Postlarvae/juvenile identification - D. Staples

Thursday 28 September

Field sampling

Adult prawn taxonomy and identification

Friday 29 September

Data entry, storage and exchange

Mr. C. Jackson (Chairman)

Data entry/validation and editing
Data storage backup/archive
Data sharing exchange
Country Reports
Standardization of techniques for PREP

Saturday 30 September

National Coordinators Meeting

ANNEX II

INTRODUCTION OF THE PROGRAMME "OCEAN SCIENCE IN RELATION TO LIVING RESOURCES" (OSLR)

There is a need to bring about a much closer interaction between oceanographic research and marine biology. Several recent national and international initiatives show that the time is ripe for coupling these two branches of marine science. One initiative towards this goal is the "Ocean Science in Relation to Living Resources" (OSLR) programme which is jointly sponsored and formulated by the Intergovernmental Oceanographic Commission (IOC) of Unesco and by the Food and Agriculture Organization (FAO). This programme was under discussion for several years in the early eighties and was initiated officially in 1983 by an international workshop in Halifax, Canada. The formulation, development and implementation of the Programme is carried out and guided by the Guiding Group of Experts for OSLR the members of which come from the fields of marine biology and physical oceanography. SCOR, the Scientific Committee on Oceanic Research, and ICES, the International Council for the Exploration of the Sea, have permanent representatives on this group. The Group reports to the governing bodies of IOC and FAO. The purpose of OSLR is to promote improvements in scientific understanding which will lead to more effective development, management and conservation of the living marine resources of coastal nations. So far, OSLR has concentrated its efforts in the field of Fish Recruitment.

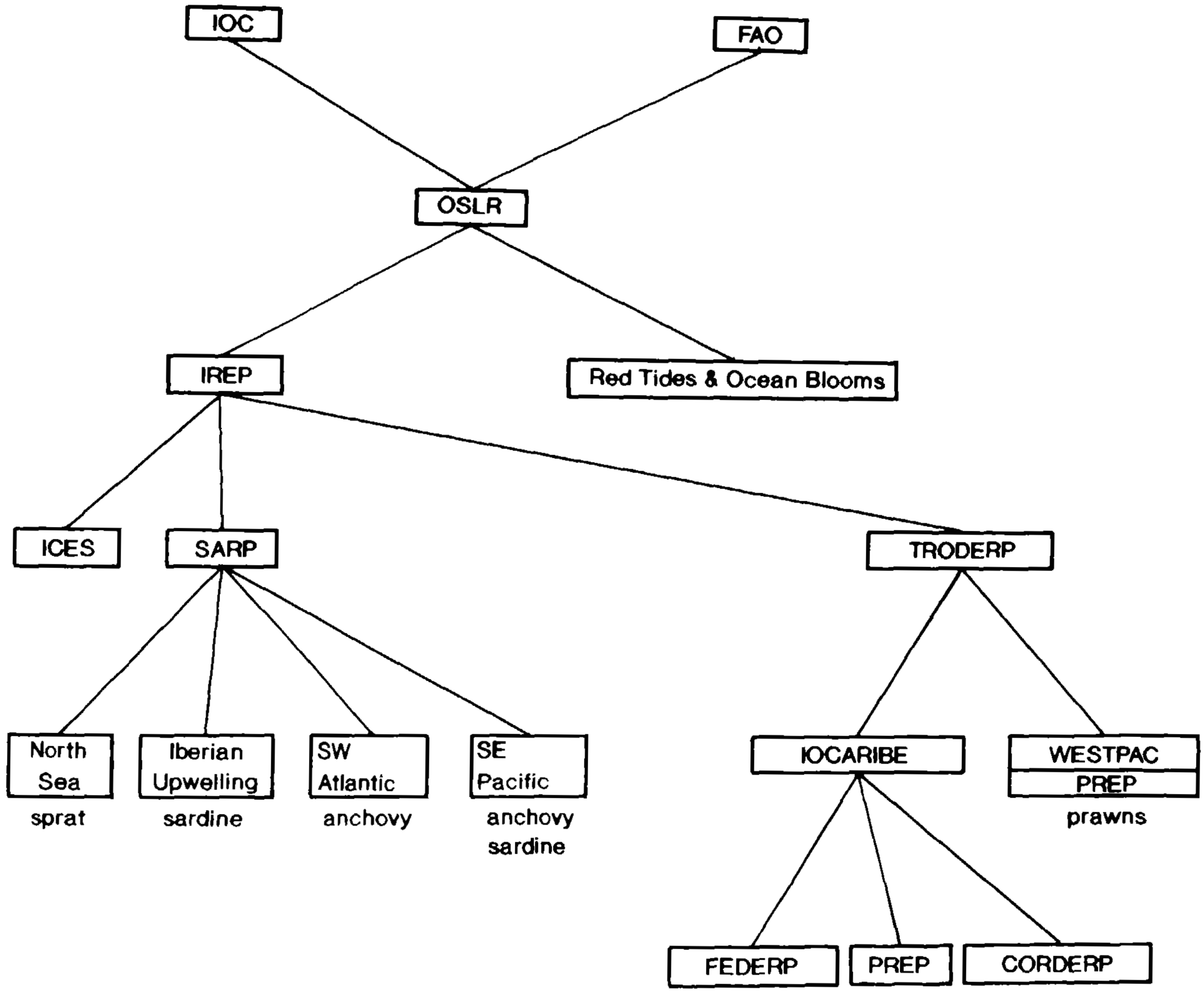
The varibility of fish recruitment is considered to be the most important unsolved problem in fishery population dynamics. The processes controlling the variability of fish recruitment are the subject of the "International Recruitment Project" (IREP) of OSLR. Fisheries management could be improved considerably if recruitment success or failure could be anticipated or if, at least, it be known if recruitment failure of a fish stock is due to natural or man-made causes, such as over-fishing or pollution. A variety of physical oceanographic phenomena on the macro-, meso- and micro-scale, such as currents, upwelling, turbulence, Langmuir circulations, surface slicks are known to affect fish at all life stages, particularly in the highly vulnerable larval or early juvenile phase. However, their net effects at the population level are poorly understood. The result is large unexplained inter-year variability in recruitment which, besides being a major source of uncertainty to those involved in fishing and associated industries, is typically so extreme as to largely obscure essential signals need to foresee and to manage the long-term effects of fishery exploitation, habitat alterations, global climate change and other vital concerns in a scientific manner. The need to develop the means to filter this interyear "noise" in order to resolve the crucial underlying signals is perhaps the most important argument for promoting research on the recruitment problem.

IREP has been initiated by two pilot projects, the "Sardine/Anchovy Recruitment Project" (SARP) and the "Tropical Demersal Recruitment Project" (TRODERP). Within the context of SARP, the principal biological and physical factors causing mortality of the early life stages, including the early juvenile phase, are intensely studied as it is commonly assumed that recruitment strength is determined at these stages.

Several regional SARP projects have been formed. Sprat recruitment in the North Sea is studied cooperatively by the United Kingdom, Denmark and Germany. Sardine recruitment in Iberian waters is investigated in a bilateral project by Portugal and Spain with some US support. A multinational project on the recruitment of the Southwest Atlantic anchovy with scientists from Argentina, Uruguay, Brazil, Germany and Sweden will begin in November of this year. Similar studies will be initiated next year on anchovies and sardines in the upwelling region off the Chilean coast. A major aspect of the SARP scientific rationale involves application of the comparative method of science whereby the multiple expression of the problem afforded by various species groups inhabiting different regional ecosystems may facilitate the sorting out of the complex interacting mechanisms involved in recruitment variability.

Another growing sphere of activity within IREP focuses on the demersal resources of the tropical band through the "Tropical Dermersal Recruitment Project (TRODERP)". TRODERP has been initiated in Southeast Asia in the form of a penaeid prawn recruitment project (PREP) involving Australia, Indonesia, Malaysia, Papua New Guinea, the Philippines and Thailand. In the western tropical Atlantic area, the IOCARIBE Subcommission of IOC has defined three focal research areas under TRODERP: (i) fish estuarine/deltaic recruitment (FEDERP); (ii) penaeid prawn recruitment (PREP); and, (iii) coral reef demersal recruitment (CORDERP). A schematic presentation of OSLR and its various regional components is given in Fig. 1.

A second sub-programme of OSLR to be launched in 1989 will focus on Red Tides and Ocean Blooms which are the cause of growing concern of many coastal nations.



Annex II - Fig.1: Structure of IOC-FAO Programme on Ocean Science for Living Resources (OSLR).

ANNEX III

DEPENDENCE OF POPULATION PARAMETERS UPON ENVIRONMENTAL FACTORS IN THE ESTUARINE AND OFFSHORE PENAEID FISHERY IN CENTRAL MEXICAN PACIFIC COAST

I. del Valle
Coordinación de Investigación y Postgrado, Mazatlán
Universidad Autonoma de Sinaloa, México

INTRODUCTION

This paper summarizes the main results obtained during the past four years of research on the estuarine and offshore shrimp fishery in the Central Mexican Pacific coast (Fig. 1).

THE OFFSHORE FISHERY

The fishery is almost entirely based on three species of the genus Penaeus: P. californiensis, P. vannamei and P. stylirostris. Landings of P. brevirostris are less important than the other 2 species. The fishery operates from mid-September to May or June, and has a closed season during the remaining months of the year. About 70% of the total catches of a given season are taken during the first three months of the fishing season. The industrial fishing fleet consists of vessels ranging from 19 to 25 meters LOA. Most of them are all-steel trawlers powered with 350 to 550 HP diesel engines. Fishing operations are carried out at depths between 2 and 50 fm.

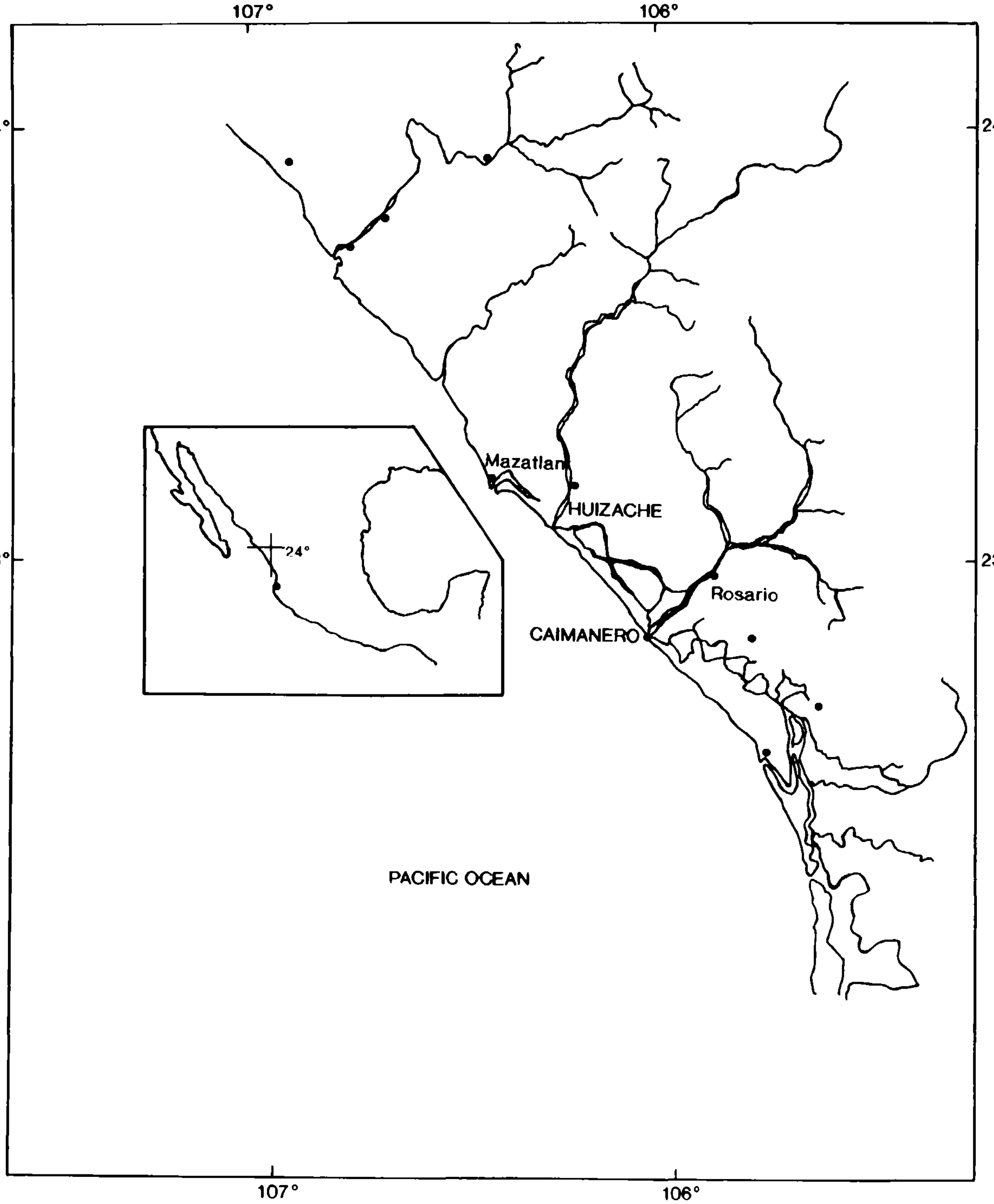
THE ESTUARINE FISHERY

The penaeid postlarvae recruited to the estuaries and coastal lagoons in the months of April to August (owing to ascending sea level and tidal waves) are fished using "tapos" from August to February. Juveniles are retained in these coastal systems with the help of "tapos" which are fences built across channels preventing juvenile shrimp from migrating to the sea. Tapos of different screen sizes, such as mangrove poles, packed brushwood between two rows of stakes etc., are used to drive shrimps into collecting chambers where they are fished with fine mesh scoops (between 1 and 2 cm mesh size).

INTERANNUAL ESTUARINE YIELD IN HUIZACHE-CAIMANERO (Coastal lagoon system in Southern Sinaloa, Mexico). LINEAR REGRESSION MODEL

The lagoon coastal system supports a highly productive penaeid fishery, characterized by large interannual variation. In the last 16 years (1972- 1987) the catches have oscillated between 294 tones in 1981 with a maximum of 1550 tones in 1983. The highest catches correspond with the El Nino/Southern Oscillation events. The seasonal interaction of the Equatorial Currents (Counter-current North Equatorial) and the California Current.

A multiple linear regression model is presented which estimates the contribution to variability in the estuarine penaeid yield of temperature during the reproductive period, river discharge (averaged during the wet period) and closed season of the offshore fishery (Table 1). High correlation coefficients and precision estimates (minimun standard error of estimation) were obtained (R^2 = 0.794). Temperature in June and July explained 63% of the variability and can be used as an index of postlarval recruitment success.



Annex III - Fig.1: Study site for the Mexico prawn recruitment study.

INTERANNUAL GROWTH VARIATIONS OF PENAEID SHRIMPS IN RELATION TO POPULATION DENSITY IN HUIZACHE-CAIMANERO LAGOON SYSTEM

The length distributions of commercial shrimp catches during the fishing seasons 1972 to 1987 were measured. The interannual variation of the modes are directly dependent on river discharge and inversely related to the temperature of the reproductive period. (Table 2). The difference between exported catches and total catches has decreased, starting from 1980 onwards. At the same time the number of fishermen in the lagoon system has increased, with a consequent decrease in the yield per recruit.

FACTORS INFLUENCING THE OFFSHORE PENAEID FISHERY

Initially, the linear regression model used dummy variables through the integration of two simple linear models each one corresponding to distinct periods, one from 1969-1976 and 1984-1986, and the other from 1977 to 1983. The independant variable was the sum of the temperature from May to September of each year. This variable explains 86.9% of the catch variability. The sea climate during the main reproductive period of the four species is a significant factor to the abundance of shrimp on offshore fishing grounds. The recovery of the shrimp population from 1977 to 1983 coincided with an annual temperature increase (hemispherc heating, McLain, 1985).

A second multiple regression model is presented which estimates the contribution to the offshore fishery yield by the following factors: accumulated temperature from May to September, closed season period and sun spot number. The two first factors explain 63% of the total variation of the annual catches. Including sun spot number to the model we obtained a $R^2 = 0.84$ (Table 3). The last factor is probably a good proxy of the heating period (1976-1983) of the Northeast Pacific.

TEMPORAL VARIATION OF SPECIFIC COMPOSITION OF PENAEID POSTLARVAE RECRUITED TO THE HUIZACHE-CAMANERO LAGOON SYSTEM

The Huizache-Caimanero lagoon system is connected to the sea through two narrow winding channels (Aguadulce and Ostiakl). These channels have been sampled biweekly from 1985 to 1987. Sampling was carried out during an entire tidal cycle with 2 hour frequency.

Each species has two peaks in abundance each year. This leads to the conclusion that the generation time of the four species is approximately six months (Table 4).

Table 1: Regression coefficients of multiple linear regression between the penaeid prawn catches from the Huizache-Caimanero system from 1972-1987 an environmental variables.

Variable	R^2 x 100	d.f.	Mean S. E.	% Response	F
Temp. June-July	63.1	14	233	14.2	24.00***
River discharge June-August	71.8	13	211	12.8	16.00***
Closed season	79.4	12	188	11.4	15.40***

*** P < 0.001

Table 2: Coefficients of linear correlation between annual values of specified parameters

	1	2	3	4	5	6
1. Modal length of total catch	1.0	0.97	-0.83	0.62	0.63	-0.59
2. Modal length of exported catch		1.0	-0.80	0.58	0.59	-0.63
3. Temperature in Jun-Jul			1.00	-0.58	-0.59	0.84
4. Mean river run-off in Jun-Aug				1.0	0.89	-0.21
5. Mean river run-off in Jun-Sep					1.0	-0.30
6. Total catch						1.0

Table 3: Estimated values of multiple linear regression between offshore catches of prawns and accumulated temperatures from May-September, the duration of the closed seasons and the number of sun spots.

Variable	R^2 x 100	d.f.	Mean S.E.	% Response	F
Temperature	57.16	16	985	15.9	21.0***
Closed Season	67.5	15	886	14.3	16.0***
Sun Spots	84.0	14	643	10.3	25.0***

*** P < 0.001

Table 4: Periods of maximum abundance of postlarvae of Penaeus spp. in entrance lagoon of Huizache-Caimanero.

Species	Period of high no.	Period of peak no.	Period of max. no.
P. vannamei	Jul - Oct Feb - Mar	Aug - Sep Feb	Aug
P. stylirostris	Apr - Jun Nov	May	May Nov
P. californiensis	Apr - Jun Nov - Jan	Apr - May Nov - Dec	Apr - May
P. brevirostris	May - Jul Jun	Jun Jun	Jun

ANNEX IV

**BASIS FOR THE RESTRUCTURING OF THE DEMERSAL FISHERIES
IN THE PACIFIC MEXICAN COAST**

Commission of the European Communities,
Directorate General for Science, Research and
Development 1989-1992

Associated Partners:

(i) Beatriz morales-Nin, C,S,I,C, Spain

(ii) Ignacio del Valle, Universidad Autónoma de Sinaloa, México

(iii) Henri Farrugio, Ifremer, France

Objectives of the Proposal

The penaeid shrimp fishery in Mexico is the third largest generator of employment and capital in the primary production sector. Current management policies have failed to prevent over-exploitation of the resource and to sustain optimal rents from the fisheries. This fishery activity also has a significant impact on the demersal populations and consequently over the mesopelagic comunities, both of which represent potential economic resources.

To improve the management policies it is necessary to know the biology, structure and temporal variations of the exploited populations as well as to know the fleet composition and the socioeconomic conditions of the fishery. This, integrated with the environmental properties, may allow us to formulate sound management policies.

The goal of the project is to improve the management of the Pacific Mexican fisheries by means of studying the following objectives:

(i) To study the penaeid shrimp biology and fishery in coastal lagoons, determine the temporal distribution of recruitment, and evaluate the impact of culture practices upon the natural population.

(ii) To determine reproductive patterns and population dynamics of the multi-species penaeid shrimp populations and their relation with environmental conditions at sea.

(iii) To study the temporal and spatial oceanographic variations ana their relationship with climatic conditions.

(iv) To evaluate the penaeid shrimp populations and productivity.

(v) To determine the composition and structure of the demersal and mesopelagic communities and their relation with the environment.

(vi) To improve the management of the demersal fisheries by means of exploring new areas and evaluate alternative fishing techniques.

(vii) To study in detail the fleet operating in the area and the fishing techniques.

1. ACTIVITIES TO BE UNDERTAKEN

The research area will be divided in two zones, Center (Sinaloa, Nayarit Coast) and South (Oaxaca, Chiapas Coast), characterized by differences in their penaeid shrimp fisheries, faunal composition, topography and oceanographic conditions. The project will be supported by Scientific of Technical Development (STD) and an International Cooperation (IC) contracts.

Estuarine research (STD funds)

Two representative estuaries in each zone will be selected to determine penaeid shrimp abundance, species composition, recruitment and biological cycles. Their relationships with environmental properties and dynamics will be modeled.

Penaeid shrimp fisheries and the finfish catch in the estuaries will be determined. Samples will be collected with monthly periodicity between November-February and biweekly during the shrimp reproduction period (March- October). During the sampling, hydrographic as well as climatological data will be determined. A total of 112 sampling collections are planned.

Coastal research (STD/IC funds)

Survey cruises will be carried out on research vessels to obtain fishing and biological data of the coastal resources. This will include catch composition by weight and length, sexual maturity, and other biological parameters as well as oceanographic data to study community structure and penaeid shrimp productivity.

Alternative fishing methods will be used to determine their potential in the study area. The mesopelagic and demersal resources (fishes, crustaceans and cephalopods) will be evaluated.

The cruises will determine the time scale variations in the catches and in the animal communities. Relationships with oceanographic properties will also be determined.

This study will also survey the catch of the commercial fleet. Skippers will be instructed to complete fishery log books of the trawling time, fishing sites and depth, shrimp catch by haul and approximate composition of the catch and weight of the bycatch. In the landing areas these questionnaires will be collected together with length frequency and sexual maturity data for each shrimp species.

Establishment of a fisheries network (IC funds)

An environmental monitoring routine will be established to expand existing long-term data bases necessary to model fisheries fluctuations in this dynamic environment. The cooperative fishing societies will provide socio-economic information to implement the fishery economic study.

Information dissemination (STD/IC funds)

Information bulletins will be produced to guarantee the diffusion of the results of the project to all the Mexican Universities and research institutes on the Pacific area.

Training seminars (IC funds)

Training courses and seminars will be held to guarantee the diffusion of knowledge of fishery methods and the results and conclusions obtained upon fishery management and biological systems in the Mexican Pacific coast.

TIMETABLE OF ACTIVITIES (I: INTERNATIONAL COOPERATION PROJECT, STD: Scientific and Technical Development)

1989**

	SEP	OCT	NOV	DEC
ESTUARINE SAMPLING (frequency)	2	2	2	2
OCEANOGRAPHIC CRUISES		STD		
FISHERY AND CLIMATIC DATA RECOLLECTION	STD	STD	STD	STD
SEMINARS		STD		

1990

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ESTUARINE SAMPLING (frequency)	2	2	2	2	2	2	2	2	2	2	2	2
OCEANOGRAPHIC CRUISES		STD			STD			I			I	
FISHERY AND CLIMATIC DATA RECOLLECTION	I	I	I	I	I	I	I	I	I	I	I	I
SEMINARS		I			I			I				

1991

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ESTUARINE SAMPLING (frequency)	2	2	2	2	2	2	2	2	2	2	2	2
OCEANOGRAPHIC CRUISES		I			STD			I			I	
FISHERY AND CLIMATIC DATA RECOLLECTION	I	I	I	I	I	I	I	I	I	I	I	I
SEMINARS		I			I						I	

1992

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ESTUARINE SAMPLING (frequency)	2	2										
OCEANOGRAPHIC CRUISES		I										
FISHERY AND CLIMATIC DATA RECOLLECTION	STD	STD	I	I	I	I	I	I	I	I		
SEMINARS		X				X						X

ANNEX V

THE RECRUITMENT DYNAMICS OF PENAEUS ORIENTALIS KISHINOUYE IN CHINA

Mingyuan Zhu, First Institute of Oceanography,
State Oceanic Administration, Qingdao, People's Rep. of China

The fleshy prawn Penaeus orientalis Kishinouye, is a species living in near shore shallow areas of the warm temperate zone. It is the most important commercial shrimp in China. The catch varies from 5,000 to 40,000 tons. The life cycle is characterized by extensive migrations (Fig.1).

During winter, from December-March, the average water temperature in the near bottom layer of the Bohai Sea is 6.0, 3.4, 0.7, 2.1°C for December, January, February, and March, respectively. There are very few prawns in the Bohai Sea, in December. The prawn overwinter in the deep water of the south Yellow Sea (33°00'-36°00' N latitude and 122°-125° E longitude). In early or mid March, the prawns leave the Yellow Sea to begin the spawning migrations. In late April, with water temperatures are 8-9°C, the prawns arrive at the nearshore spawning grounds. Some move to Rushan and Haizhou Bay, while most prawns continue to migrate to the north. After passing over the tip of Chenshandon, they divide again into two branchs. One moves to the East coast of Liaodong peninsula and the main branch enters the Bohai Sea. In early or mid May, the mature females begin spawning in nearshore water especially near estuaries.

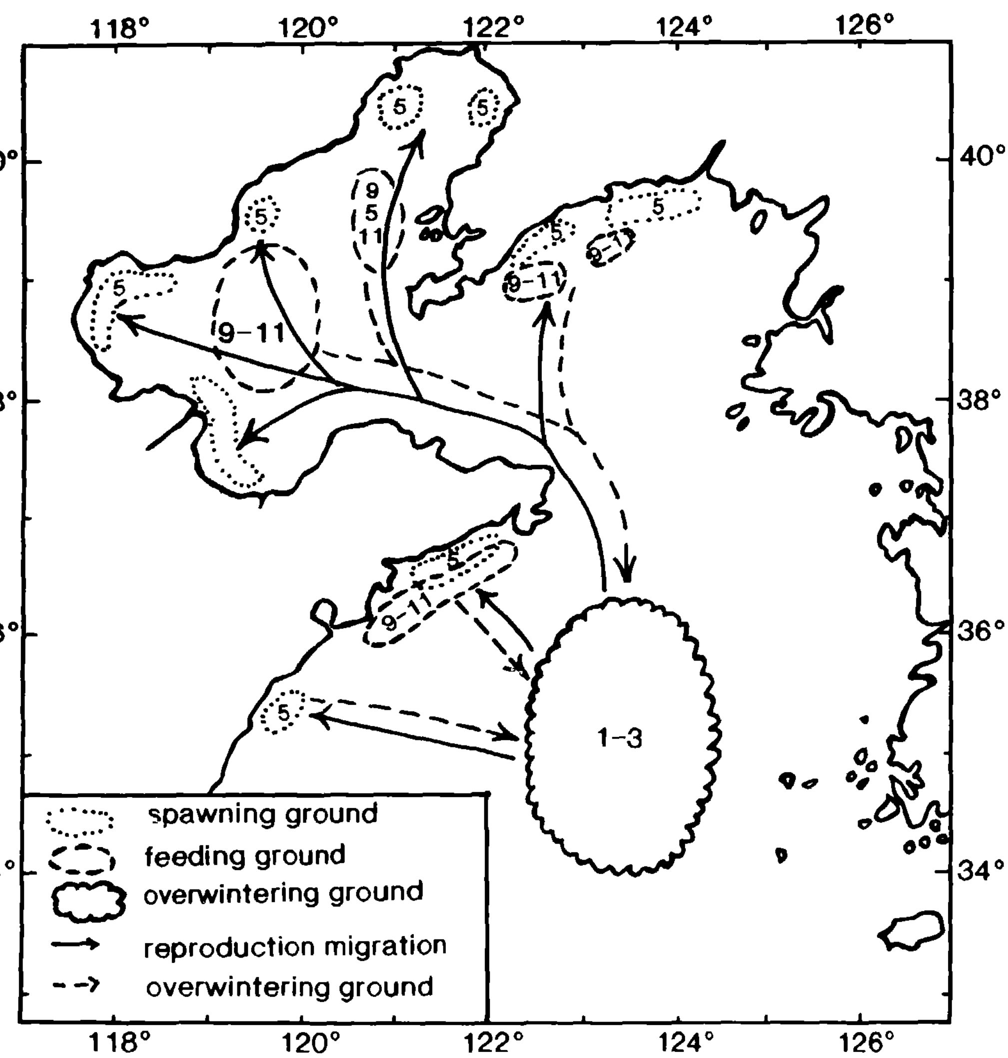
After spawning, almost all the adult prawns die. From late May to July, the relative density is 3.2, 1.9, and 0.9 ind./haul. hr, respectively. The larvae and juveniles enter the rivers during the flood tides. When they reach the length of 30 mm, they live in the tidal zone. In mid August the new recruits live in depths below 5 m. and become the subadults. The catches increase to 33 ind./haul. hr. and the prawns have an average length of 100 mm. Growth is rapid during August to September and the prawns move further offshore. September is the main fishing period. The average catch in Bohai Sea is 369 ind./haul. hr. and the highest catch recorded was 4067 ind./haul.hr. Under heavy fishing pressure the density decreases sharply. In October, the average catch is only 49 ind./haul.hr, one seventh of that September. In November, prawns move toward the center of Bohai Sea.

Spawning season is from late October to early November. After spawning about 40% of the males die. The sex ratio of females to males changes from 1:1 in September to 1.6:1 in November. When the air temperature decreases in November the prawn leave the Bohai Sea to their overwintering grounds. The average monthly catch of prawn during May 1982-December 1982 is shown in Fig. 2.

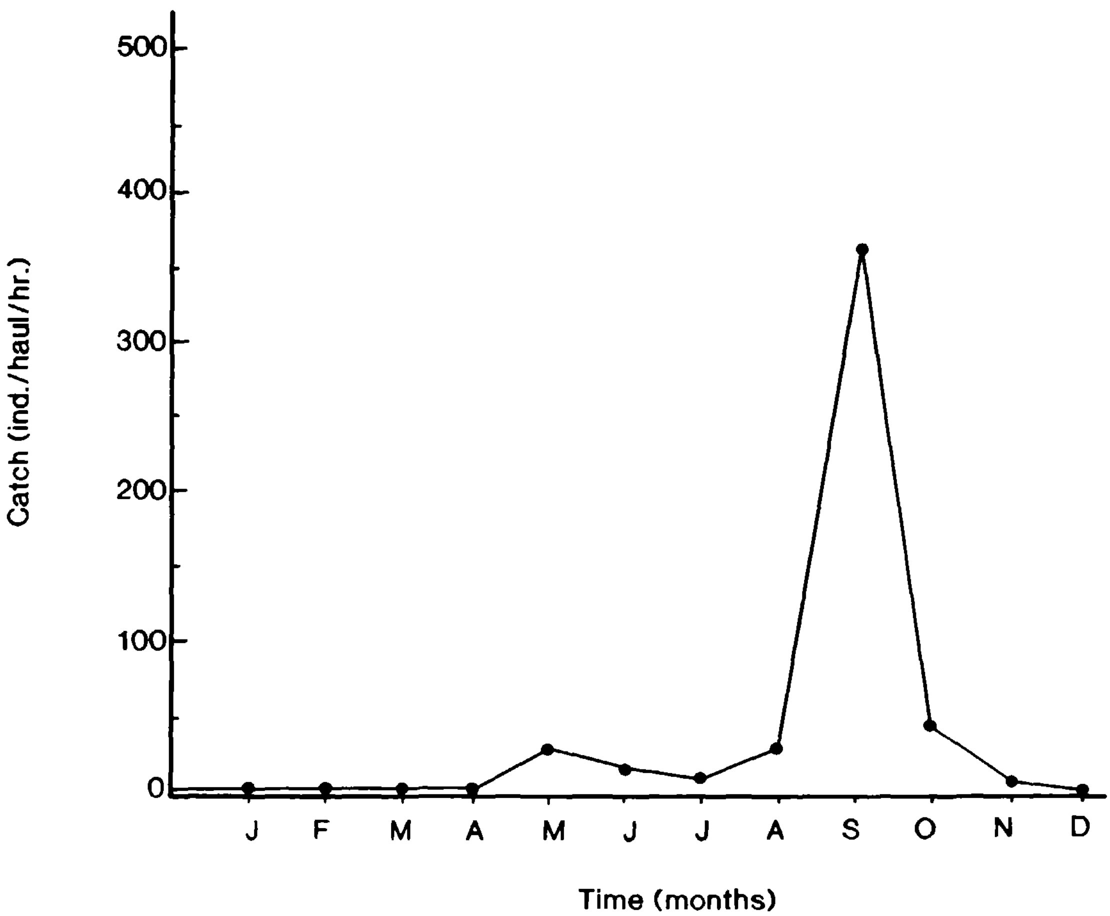
For females, the fastest growth is from August to September with a rate of 1.6 mm/day (Table 1, Fig. 3). Males grow slower than females and there is a close relation between the increase of length and that of weight. The equations are as follows:

$$W_F\ (g) = 7.8 \times 10^{-5}\ L^{2.639}\ (mm) \quad (r = 0.99)$$

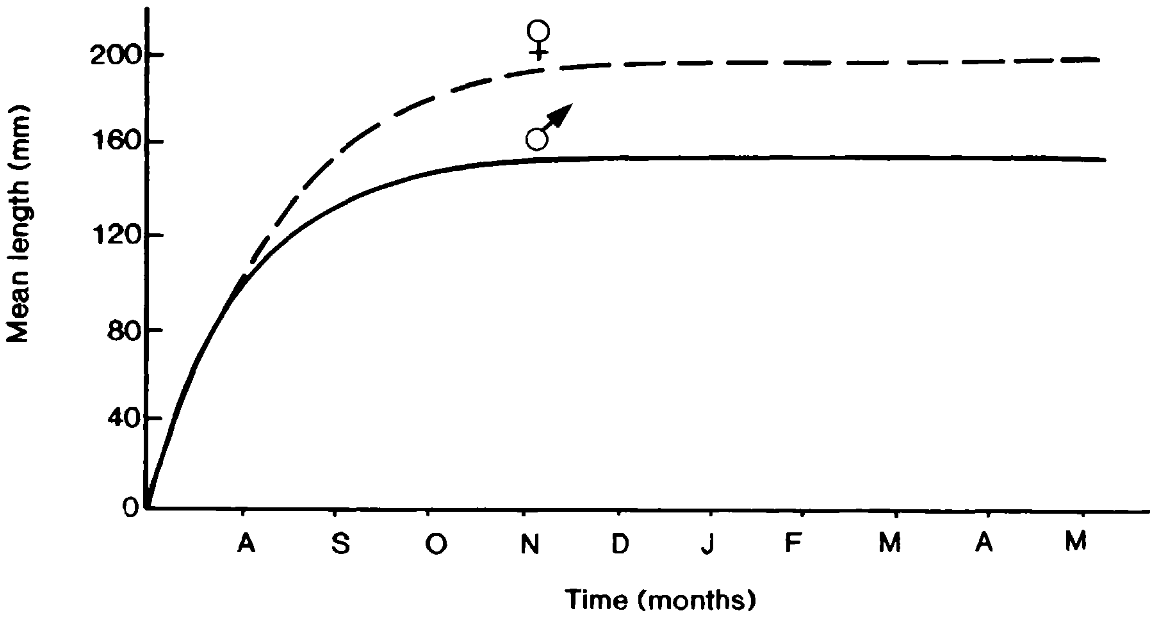
$$W_M\ (g) = 3.3 \times 10^{-5}\ L^{2.803}\ (mm) \quad (r = 0.98)$$



Annex V - Fig.1: Migration route of <u>Penaeus orientalis</u> between overwintering, spawning and feeding grounds.



Annex V - Fig.2: Monthly distribution of <u>Penaeus orientalis</u> catches in northern China.



Annex V - Fig.3: Growth curves for male and female Penaeus orientalis in northern China.

As the prawns have a life cycle of only one year, we can use the catch of spawners in spring as the relative abundance of the parent stock and the catch in autumn and winter as the relative recruitment. According to the statistical data from fisheries and biological surveys, we can transform the catch to the number of individuals caught. The relative abundance of the parent stock in 1961 was set as 100. The annual variation of the parent stock and the recruitment is shown in Fig. 4. Using the Ricker equation, the following stock:recruitment model was generated:

$$R = 24.48 \times A \times e^{-3.5710}$$

where R is recruitment

A is parent stock

Using the Beverton model, one gets the following equation:

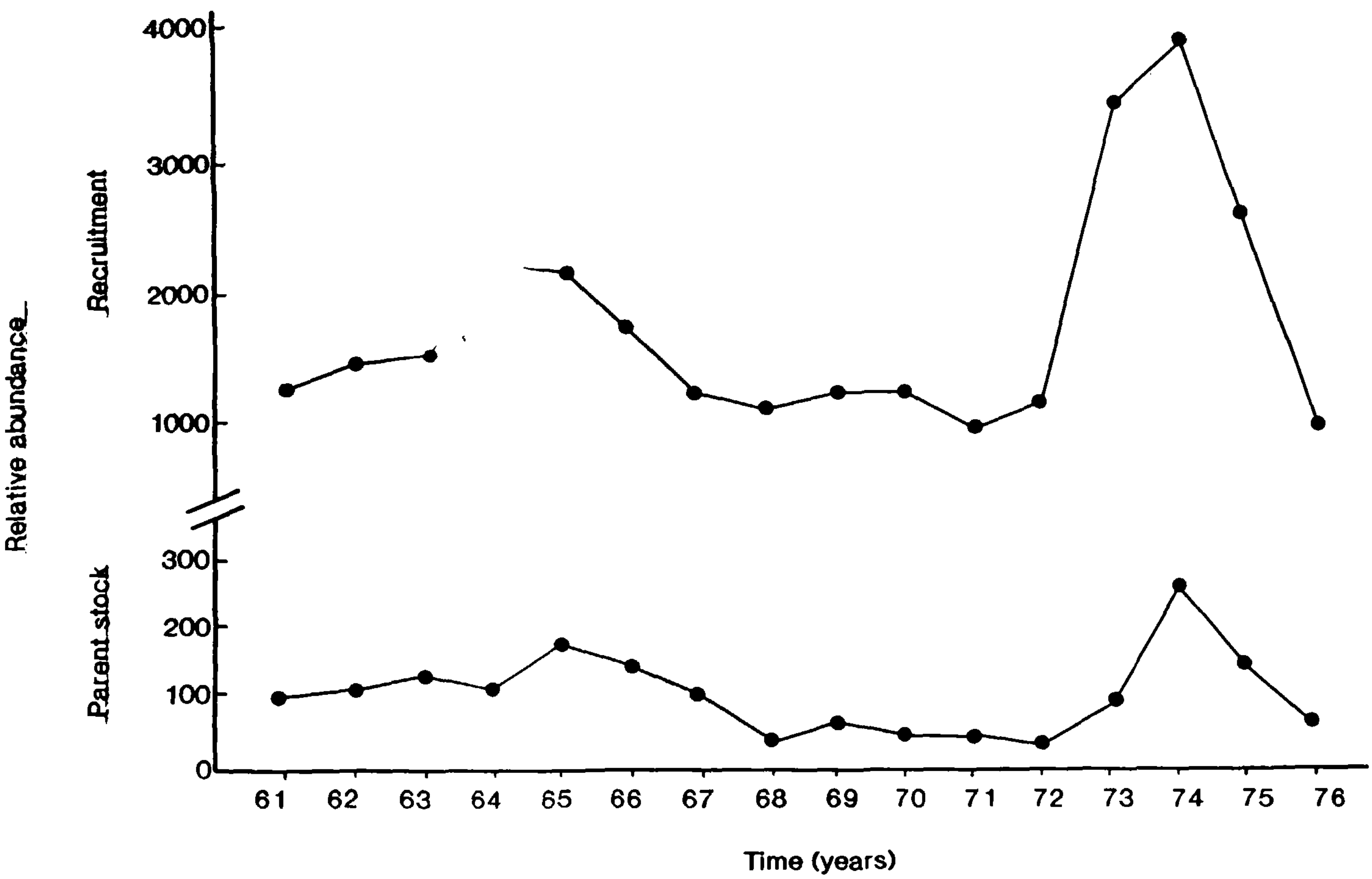
$$R = A\,(2.092 \times 10^{-4}A + 4.187 \times 10^{-2})^{-1}$$

It was calculated that the maximum sustainable yield of P. orientalis in the Bohai Sea is about 30,000 tons. This requires a spawning stock of 2,411 tons although only in 1974 and 1979, the annual yield reached 30,000 tons.

China enhances the resource by releasing artificially bred juveniles with a mean length of 3 mm. The results in 1985 and 1986 are shown in Table 2.

Year	Artificial releasing (million)	Total catch (T)	Catch from released prawns (T)
1985	280	16,000	612
1986	870	10,900	1,800

The yield from the culture of P. orientalis was 80,000 tons in 1986.



Annex V - Fig.4: Inter-annual changes in spawning stock and recruitment of Penaeus orientalis (1961-1976)

ANNEX VI

RAINFALL EMIGRATION EXPERIMENT (REX)

The hypothesis to explain the geographic variability in the seasonal recruitment dynamics of *Penaeus merguiensis* (see main text: Seasonal recruitment dynamics of *P. merguiensis*), relies heavily on observations of the effects of rainfall on the emigration of juvenile *P. merguiensis* in Australia. In a study conducted in the Gulf of Carpentaria, increased currents and decreased salinity following heavy rainfall stimulated juvenile prawns to leave the estuaries and emigrate into the offshore coastal zone. In periods of low rainfall only a small number of larger juveniles were stimulated to migrate, whereas during periods of heavy rainfall, a much larger number of smaller prawns left the estuary. This results in a seasonal recruitment pattern of sub-adult prawns into the coastal zone which reflects the seasonality of rainfall across the different PREP study sites.

Because of the apparent importance of rainfall to the recruitment dynamics of *P. merguiensis*, it was decided to test the rainfall/emigration hypothesis throughout the region.

Basic data to collect are:

(i) Estimates of the number and size of emigrating prawns collected at night (at least half of the ebb tide period) as near as possible to the time of spring tide. Use set nets, bagnets or fish corals over the entire ebb tide period. (In areas where semi-diurnal tides occur, catch for both ebb tides should be collected).

(ii) Fortnightly (spring tide) estimates of the number and size of juvenile prawns in the estuary.

(iii) Date, start time and finish time of the sampling period.

(iv) Times of dawn and dark for the day of sampling.

(v) Rainfall for the catchment area over the preceeding fortnight.

(vi) Tidal range for the ebb tide periods.

(vii) Lunar phase (full, first quarter, new, last quarter).

Extra useful data includes

(i) Salinity and temperature at high tide on the day of sampling.

(ii) Average current speed over the ebb tide period (flowmeter record).

(iii) Turbidity at the mid-point of the ebb tide period.

(iv) River discharge on the day of sampling.

ANNEX VII

LIST OF PARTICIPANTS

I. LECTURERS

Derek J. Staples
CSIRO Division of Fisheries
PO Box 120
CLEVELAND QLD 4163
Ph (07) 286 8222 Fax. 286 2582
Australia

Peter C. Rothlisberg
CSIRO Division of Fisheries
PO Box 120
CLEVELAND QLD 4163
Ph (07) 286 8222 Fax. 286 2582
Australia

Christopher J. Jackson
CSIRO Division of Fisheries
PO Box 120
CLEVELAND QLD 4163
Ph (07) 286 8222 Fax. 286 2582
Australia

II. PARTICIPANTS

Australia

David J. Vance
CSIRO Division of Fisheries
PO Box 120
CLEVELAND QLD 4163
Ph (07) 286 8222 Fax 286 2582

Peter J. Crocos
CSIRO Division of Fisheries
PO Box 120
CLEVELAND QLD 4163
Ph (07) 286 8222 Fax 286 2582

China (People's Republic of)

Mingyuan Zhu
Associate Research Prof.
Vice Chief Division of Marine Biology
First Institute of Oceanography
State Oceanic Administration
Hongdao Road 13
QINGDAO
Ph 286 810 Cable 1164
Telex 32135 BHFJ CN

Indonesia

Nurzali Naamin
Director, Research Institute for Marine Fisheries
Agency for Agricultural Research and Development
Jalan Krapu 12
Sunda Kelapa
Jakarta 14430
Ph 679 191, 679935 Fax 062 21 5482634 Telex 46432 AARDJK IA

A. Victor Toro
Centre for Oceanological Research and Development - LIPI
Jln. Pasir Putih 1, Ancoltimur
PO Box 580
DAK JAKARTA 11001 Cable LONAS
Ph 683 850 Telex 62 875 PDII-IA

Malaysia

Lui Yean Pong
Senior Fisheries Officer
Fisheries Research Institute
Department of Fisheries
Ministry of Agriculture
11700 GELUGOR
PENANG
Ph 04-881 777

Alias Bin Man
Fisheries Officer
Fisheries Research Institute
Department of Fisheries
Ministry of Agriculture
11700 GELUGOR
PENANG
Ph 04-881 777

Mexico

Ignacio del Valle L.
Escuela de Ciencias del Mar
Universidad Autonoma de Sinaloa
Morelos 132 Pte.
Mazatlan
SINALOA
Ph 25410

Papua New Guinea

Alois Conzaka Wafy
Fisheries Biologist
Department of Fisheries and Marine Resources
PO Box 165, KONEDOBU
PAPUA NEW GUINEA
Ph 21 4522 Telex 22391/22392 FISHREP

Philippines

Edna Vintero-Agasen
Aquatic Resources Development Specialist
Fisheries Resources Research Division
Bureau of Fisheries and Aquatic Resources
Arcadia Bldg 1184 Quezon Avenue
QUEZON CITY, METRO MANILA 3008
Ph 96-54-28, 99-12-49

Corazón M. del Mundo
Senior Aquatic Resources Development Specialist
Fisheries Resources Research Division
Bureau of Fisheries and Aquatic Resources
Arcadia Bldg 1184 Quezon Avenue
QUEZON CITY, METRO MANILA 3008
Ph 96-54-28, 99-12-49

Spain

Beatriz Morales-Nin
Fisheries Biologist
Institut estudis Avancats Illes
Balears, Crtd. Valldemossa Km 7.5
07071 PALMA MALLORCA
Ph 347120711 Fax 3471200741

Thailand

Matana Boonyubol
Marine Fisheries Biologist
Chief of Marine Life-history sub-division
Marine Fisheries Division
Department of Fisheries
89/1 Soi Charoenkrung 58
Yanawa
BANGKOK 10120
Ph (02) 2114981-2

Cherdohinda Chotiyaputta
Marine Fisheries Biologist
Marine Fisheries Division
Department of Fisheries
89/1 Soi Charoenkrung 58
Yanawa
BANGKOK 10120
Ph (02) 2114981-2

Chinda Nakrobruh
Marine Fisheries Biologist
Marine Fisheries Division
Department of Fisheries
89/1 Soi Charoenkrung 58
Yanawa, BANGKOK 10120
Ph (02) 2114981-2

III. OBSERVERS

Boonlert Phasuk
Director
Marine Fisheries Division
Department of Fisheries
89/1 Soi Sapan Pla, Charoenkrung 58,
Yanawa
BANGKOK 10120
Ph (02) 2114981-2, 2110461

Atchara Vibhasiri
Marine Fisheries Biologist
Marine Fisheries Division
Department of Fisheries
89/1 Soi Charoenkrung 58,
Yanawa
BANGKOK 10120
Ph (02) 2114981-2

Kittipong Klinrod
Marine Fisheries Biologist
Marine Fisheries Division
Department of Fisheries
89/1 Soi Charoenkrung 58,
Yanawa
BANGKOK 10120
Ph (02) 2114981-2

Supatr Sriphanpaiboon
Marine Fisheries Biologist
Marine Fisheries Division
Department of Fisheries
89/1 Soi Charoenkrung 58,
Yanawa
BANGKOK 10120
Ph (02) 2114981-2

Pongsak Rojanavipart
Chief, Marine Pollution Research Unit
Marine Fisheries Division
Department of Fisheries
89/1 Soi Charoenkrung 58,
Yanawa
BANGKOK 10120
Ph (02) 2114981-2

Sommai Yoo-sook-swat
Marine Fisheries Biologist
Eastern Marine Fisheries Development Center
Ban-Phe,
RAYONG 211060

Wannakiat Thubthimsaeng
Chief, Marine Resource Survey Sub-division
Eastern Marine Fisheries Development Center
Ban-Phe,
RAYONG 211060

Saramit Uraiwan
Chief of Marine Resource Servey Sub-division
Lower Southern Marine Fisheries Development Center
SONGKLA

Pairoh Sutthakorn
Chief of Marine Life History Sub-division
Andaman Sea Fisheries Development Center
PHUKET 83000
Ph (076) 391138

Boonsri Jaruthamsophon
Marine Fisheries Biologist
Andaman Sea Fisheries Development Center
PHUKET 83000
Ph (076) 391138

Pensri Boonruang
Chief of Marine Biological Productivity Sub-division
Phuket Marine Biological Center
PO Box 60
PHUKET 83000
Ph (076) 391127-8 Fax (076) 391127

Prajuab Lumubol
Department of Marine Sciences
Faculty of Fisheries
Kasetsart University
Bangkhen
BANGKOK 10903 Ph 57995575

IV. SECRETARIAT

Jurgen Alheit **(Technical Secretary)**
Senior Assistant Secretary,
Intergovernmental Oceanographic Commission
Unesco
7, Place de Fontenoy
75700 PARIS
FRANCE
Ph (1) 45684045 Fax. (1) 43061122 Telex 204461

ANNEX VIII

LIST OF ACRONYMS AND ABBREVIATIONS

CORDERP	Coral Reef Demersal Recruitment Project (TRODERP)
FAO	Food and Agricultural Organization of the United Nations
FEDERP	Fish Estuarine Deltaic Recruitment Project (TRODERP)
IOC	Intergovernmental Oceanographic Commission
IOCARIBE	IOC Sub-Commission for the Caribbean and Adjacent Regions
IPFC	Indo-Pacific Fisheries Commission (FAO)
IREP	International Recruitment Programme (OSIR)
OSLR	Ocean Science in Relation to Living Resources (IOC-FAO)
PREP	Penaeid Recruitment Project (WESTPAC, IOCARIBE)
RT	Red Tide Project (WESTPAC)
SARP	Sardine/Anchovy Recruitment Project (IREP/OSLR)
SCORRAD	Standing Committee on Resources Research and Development (FAO/IPEC)
TRODERP	Tropical Demersal Recruitment Project (IOCARIBE/OSLR)
WESTPAC	IOC Regional Committee for the Western Pacific

No.	Title	Publishing Body	Languages
32 Suppl.	Papers submitted to the UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime Paris, 27 September-1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
33	Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR) Halifax, 26-30 September 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
34	IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa) Tenerife 12-17 December 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
35	CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific Suva, Fiji, 3-7 October 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
36	IOC/FAO Workshop on the Improved Uses of Research Vessels Lisbon, 28 May - 2 June 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
36 Suppl.	Papers submitted to the IOC-FAO Workshop on Inproved Uses of Research Vessels Lisbon, 28 May-2 June 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
37	IOC/Unesco Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs Colombo, 8-13 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
37 Suppl.	Papers submitted to the IOC/Unesco Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs Colombo, 8-13 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
38	IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region Basrah, Iraq, 8-12 January 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
39	CCOP (SOPAC)-IOC-IFREMER-ORSTOM Workshop on the Uses of Submersibles and Remotely Operated Vehicles in the South Pacific Suva, Fiji, 24-29 September 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
40	IOC Workshop on the Technical Aspects of Tsunami Analyses, Prediction and Communications Sidney, B.C., Canada, 29-31 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
40 Suppl.	IOC Workshop on the Technical Aspects of Tsunami Analyses, Prediction and Communications *Submitted Papers* Sidney, B.C., Canada, 29-31 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
41	First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2) Dakar, Senegal, 28 October - 1 November 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
42	IOC/UNEP Intercalibration Workshop on Dissolved/Dispersed Hydrocarbons in Seawater Bermuda, USA, 3-14 December 1984 (in press)	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
43	IOC Workshop on the Results of MEDALPEX and Future Oceanographic Programmes in the Western Mediterranean Venice, Italy, 23-25 October 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
44	IOC/FAO Workshop on Recruitment in Tropical Coastal Demersal Communities Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish
44 Suppl.	IOC/FAO Workshop on Recruitment in Tropical Coastal Demersal Communities - *Submitted Papers* Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
45	IOCARIBE Workshop on Physical Oceanography and Climate Cartagena, Colombia, 19-22 August 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
46	Reunión de Trabajo para Desarrollo del Programa «Ciencia Oceanica en Relación a los Recursos No vivos en la Región del Atlantico Sudoccidental Porto Alegre, Brazil 7-11 de Abril de 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	Spanish
47	IOC Symposium on Marine Science in the Western Pacific: The Indo-Pacific Convergence Townsville, 1-6 December 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
48	IOCARIBE Mini-Symposium for the Regional Development of the IOC-UN (OETB) Programme on "Ocean Science in Relation to Non-Living Resources (OSNLR)"	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
49	AGU-IOC-WMO-CPPS Chapman Conference: An International Symposium on "El Niño" Guyaquil, Ecuador, 27-31 October 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
50	CCAMLR-IOC Scientific Seminar on Antarctic Ocean Variability and its Influence on Marine Living Resources, particularly Krill (organized in collaboration with SCAR and SCOR) Paris, France, 2-6 June 1987	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
51	CCOP/SOPAC-IOC Workshop on Coastal Processes in the South Pacific Island Nations, Lae, Papua-New Guinea, 1-8 October 1987	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
52	SCOR-IOC-Unesco Symposium on Vertical Motion in the Equatorial Upper Ocean and its Effects upon Living Resources and the Atmosphere Paris, 6-10 May 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
53	IOC Workshop on the Biological Effects of Pollutants Oslo, 11-29 August 1986	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
54	Workshop on Sea-level Measurements in Hostile Conditions Bidston, UK, 28-31 March 1988	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
55	IBCCA Workshop on Data Sources and Compilation Boulder, Colorado, 18-19 July 1988	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
56	IOC/FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP) Cleveland, Australia, 24-30 July 1988	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
57	IOC Workshop on International Co-operation in the Study of Red Tides and Ocean Blooms Takamatsu, Japan, 16-17 November 1987	IOC, Unesco Place de Fontenoy 75700 Paris, France	English