Penaeid prawns in the St Lucia Lake System: Post-larval recruitment and the bait fishery

A.T. Forbes and M.C. Benfield
Department of Biological Sciences, University of Natal, Durban

Recruitment of post-larval penaeid prawns and the bait prawn fishery in the St Lucia Lake System were monitored for two years before and one year after Cyclone Domoina. Post-larval *Penaeus indicus* Milne-Edwards, *P. monodon* Fabricius, *P. japonicus* Bate, *P. semisulcatus* de Haan and *Metapenaeus monoceros* (Fabricius) were found. Recruitment was dominated by *P. japonicus* but *P. indicus* was the major species taken in the bait fishery. *M. monoceros* catches in the fishery increased during the low salinity conditions following the cyclone. Differences in species ratios between the post-larvae and the bait fishery, factors affecting recruitment, the size of the bait catch and the relationship between recruitment and catch are discussed.
S. Afr. J. Zool. 1986, 21: 224 – 228

Werwing van post-larwale garnale van die familie Penaeidae en die aasgarnaalvissery in die St Lucia-meersisteem is oor 'n tydperk van twee jaar voor en een jaar na Sikloon Domoina bestudeer. *Penaeus indicus* Milne-Edwards, *P. monodon* Fabricius, *P. japonicus* Bate, *P. semisulcatus* de Haan en *Metapenaeus monoceros* (Fabricius) is in post-larwale stadia aangeteken. Werwing is deur *P. japonicus* oorheers maar *P. indicus* was die vernaamste spesie wat deur die vissery versamel is. *M. monoceros*-vangste in die vissery het toegeneem tydens die toestande van verlaagde soutgehalte wat na die sikloon geheers het. Verskille in spesies-verhoudings tussen die post-larwale stadia en die aasvissery, faktore wat werwing beïnvloed, die grootte van die aasvangs en die verhouding tussen werwing en vangs word bespreek.
S.-Afr. Tydskr. Dierk. 1986, 21: 224 – 228

A.T. Forbes*
Department of Biological Sciences, University of Natal,
King George V Avenue, Durban, 4001 Republic of South Africa

M.C. Benfield
Present address: Department of Marine Biology,
Texas A & M University at Galveston, P.O. Box 1675, Galveston, Texas 77550, U.S.A.

*To whom correspondence should be addressed

Received 11 November 1985; accepted 14 February 1986

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

The life cycle of many inshore penaeid species involves marine larval development followed by migration to lagoons or estuaries and a final return to the marine breeding grounds. The major prawn fisheries of the world exploit adult marine stocks but there are many areas where juvenile prawns support estuarine artisanal fisheries. These fisheries use a variety of gear and may operate at a subsistence level, cater to local requirements or supply bait demands. They tend to be less well documented than the large industrial fisheries (Garcia & Le Reste 1981; Gulland & Rothschild 1984).

In the Natal province of South Africa the St Lucia Lake system (Figure 1) supports a bait prawn fishery and has provided an annual catch of about 16 t for nearly 30 years (Forbes & Benfield 1985). It is now an integral part of the

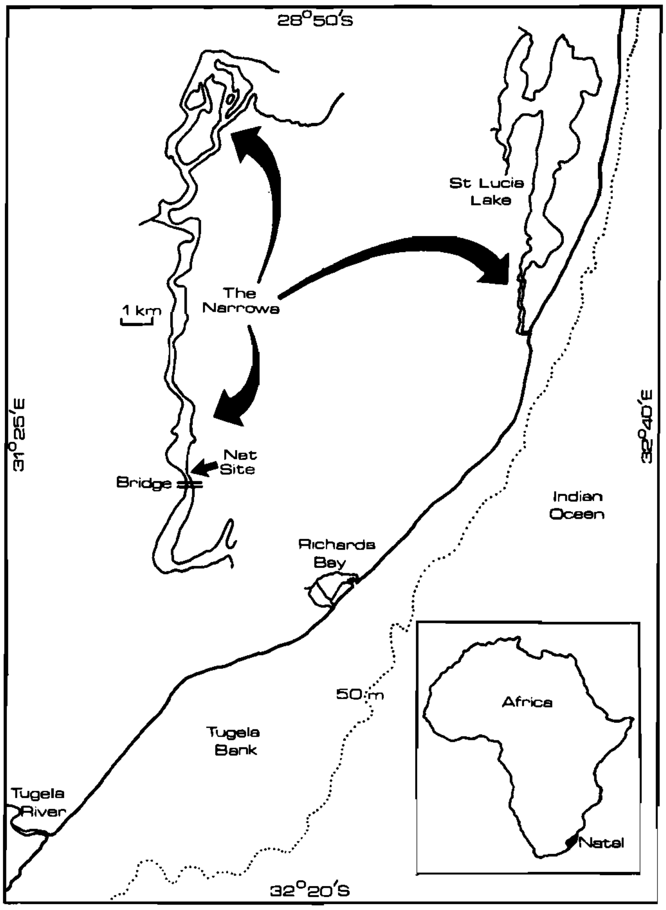

Figure 1 The study area: St Lucia Lake, the Narrows, post-larval sampling site 'Net Site', Richards Bay and the Tugela Bank.

recreational infrastructure of the area which revolves very much around sport fishing. Bait demand is seasonal and highly dependent on local fishing conditions. Prawn catches are also seasonal and do not always coincide with peak angling periods. Freezer storage is thus necessary and has at times resulted in quality deterioration and consumer resistance.

Catch prediction has been investigated in several ways. Christmas & van Devender (1981) found a degree of correlation between the abundance of post-larval and later stages in the life cycle in *Penaeus aztecus* in the northern Gulf of Mexico. Garcia & Le Reste (1981) consider that the question of the practical usefulness of post-larval abundances for predicting juvenile or adult abundance remains unresolved although the answer might well depend on the ecosystem considered. To date no studies of this nature have been done on the east coast of Africa.

A programme to monitor recruitment of post-larvae into the St Lucia system was begun in 1982. This was designed to provide information on the seasonality of recruitment of the different penaeid species, annual variation in the extent of recruitment, the relative species ratios of recruiting post-larvae in comparison with species ratios in the bait fishery and finally the relationship between recruitment and subsequent size of the bait fishery catch.

Methods

Net site

Sampling was carried out in the Narrows 4,8 km from the mouth (Figure 1). This was beyond the limit of wave action and at the first point where there was a narrowing of the channel down to *ca.* 185 m. Sampling was carried out in mid-stream between two fixed points on opposite banks.

Sampling techniques

Post-larvae were sampled at approximately six-weekly intervals from March 1982 until November 1984. Nocturnal sampling was done as it has been shown that maximal post-larval activity is associated with night flood tides (Garcia & Le Reste 1981). Samples were taken on two nights over spring flood tides which usually began to rise at the sample site at about 01h00.

A circular 0,25-m^2 net, 2,5 m long with a 1-mm mesh was streamed in the tidal current *ca.* 7 m behind the anchored boat. The net was mounted on a gimbal so that it remained at right angles to the current. A combination of a weight and either one or two floats allowed the net to be set at the surface or on the bottom. A current meter mounted in front of the net was used to measure the total volume of water passing through the net.

Sampling was done at hourly intervals for 4 h. Each sampling consisted of a 10 min surface set followed immediately by a 5 or 10 min bottom set. Mean surface sample volume was 78,5 m^3 (*sd* 21,5; $n = 251$). Mean bottom sample volume was smaller at 51,4 m^3 (*sd* 20,5; $n = 244$) owing to slower current speeds and reduction of sampling time when large amounts of detritus were present. All samples were fixed in the field using a formalin/phloxine mixture which selectively coloured animal tissue. Post-larval prawns were identified following the keys of Mohamed, Rao & George (1968) and Motoh & Buri (1980).

Samples were obtained from the bait fishery. This largely daytime fishery operates almost entirely in the Narrows (Figure 1) and involves a maximum of three open 5-m dinghies powered by 19,5 or 22,5 kw outboard engines. The nets consist of simple beam trawls 4,9 m wide by 1,1 m high with a 25,4 mm stretch mesh bag. These are towed about 3 m behind the boat in depths seldom exceeding 1 m and appear to be assisted by the wash from the engines pushing prawns into the net. Samples from the fishery were collected at approximately fortnightly intervals. About 1 kg of prawns was taken from the first haul of the day or from the second if the first haul was insufficient. Natal Parks Board records of boat numbers, days fished and total catch size were used to calculate catch per unit effort.

Results

Conditions at the study site

Water depth and tidal regime were modified by Cyclone Domoina which struck at the end of January 1984. Scouring effects resulted in the maximum depth increasing from 3,1 to 3,7 m and the tidal amplitude (over spring tides) increasing from 0,6 to 0,8 m.

Marine salinities (34 – 35‰) prevailed at the study site from March 1982 to November 1983. After local rain in December 1983 and January 1984 minimum salinities of 22 – 23‰ were recorded on ebb tides. After the initial effects of the cyclone at the end of January 1984 had passed, salinities during the rest of the year dropped to 5 – 6‰ on ebb tides rising to 27 – 33‰ on peak floods.

The water at the site was generally turbid (> 20 n.t.u.) owing to a combination of the muddy nature of the local substrata and the tidal currents which attained flow rates up to 0,75 m s^{-1}. Oxygen saturation levels were always in excess of 70% and annual temperatures ranged from 17,0 to 28,4°C. Differences between surface and bottom temperatures and salinities were negligible.

Post-larvae

Early post-larval stages of *Penaeus indicus* Milne Edwards, *P. monodon* Fabricius, *P. japonicus* Bate, *P. semisulcatus* de Haan and *Metapenaeus monoceros* (Fabricius) were all recorded in the plankton. These are the same five species recorded as juveniles in the system by Joubert & Davies (1966). Post-larvae of *P. japonicus, P. latisulcatus* and *P. canaliculatus* cannot presently by separated in the post-larval stages (Motoh & Buri 1980) but as the latter two species are very rare in Natal waters (de Freitas 1980) post-larvae in this group were treated as *P. japonicus*.

Recruitment was dominated by *P. japonicus* (Figure 2) which occurred in numbers up to an order of magnitude greater than those of any other species (Figures 3 and 4). *P. japonicus* was also the most consistent species during the three-year period, generally showing peaks in autumn (May – June) and spring (September – October) and lower numbers during summer (November – February). *P. indicus* (Figure 3) also appeared to decrease during November – January but there were marked inter-annual variations.

P. monodon and *P. semisulcatus* did not show any clear trends while *M. monoceros* declined steadily (Figure 4) and post-larvae of this species were consistently uncommon during 1984. Sampling was not possible in the period immediately following the cyclone at the end of January 1984 but all species were recorded in April.

Bait fishery

The bait fishery was seasonal with greatest catch per unit effort (CPUE) in the second half of summer (January – March) (Figure 5). Total catches per season (June – May) during the study period and the percentage numerical contribution of each species are shown in Table 1. Despite the dominance

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

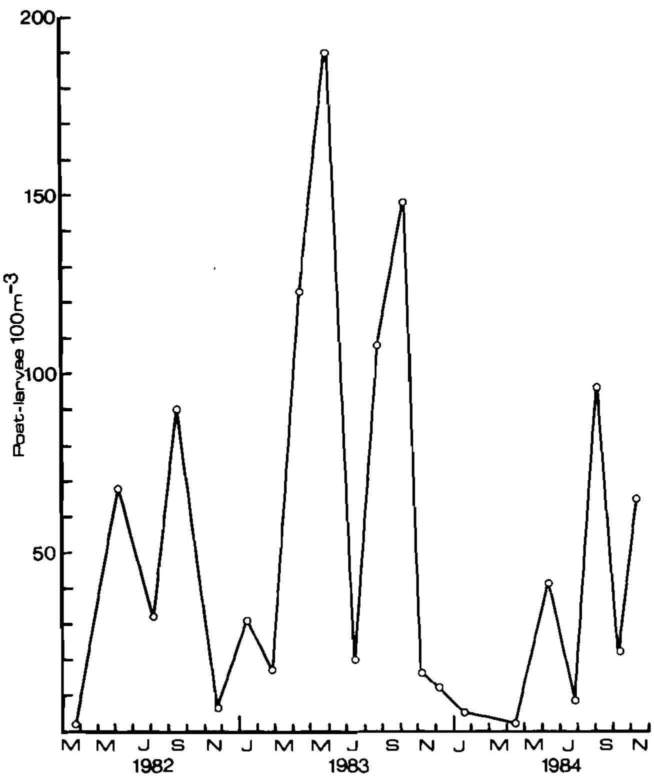

Figure 2 *Penaeus japonicus.* Mean abundance of post-larvae over two night spring flood tides during the months shown.

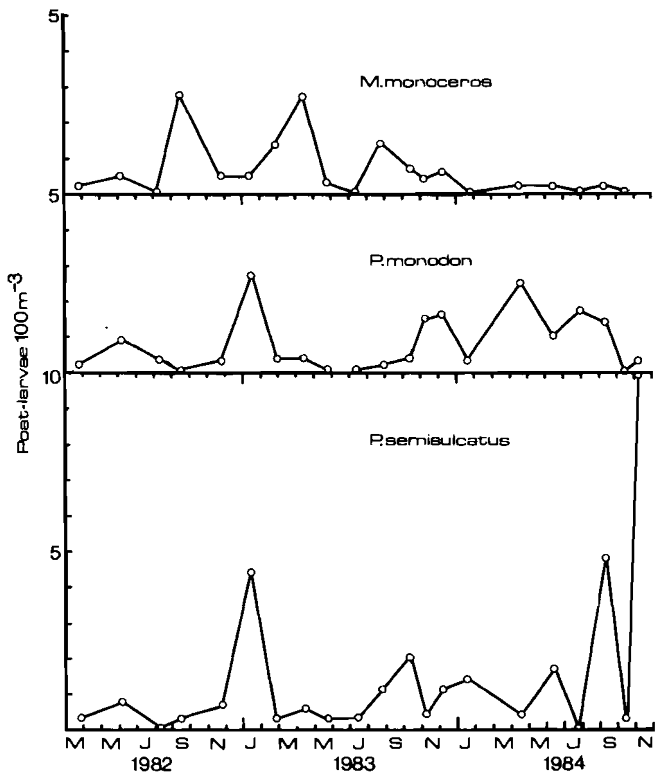

Figure 4 Mean abundance of post larvae of the species indicated over two night spring flood tides during the months shown.

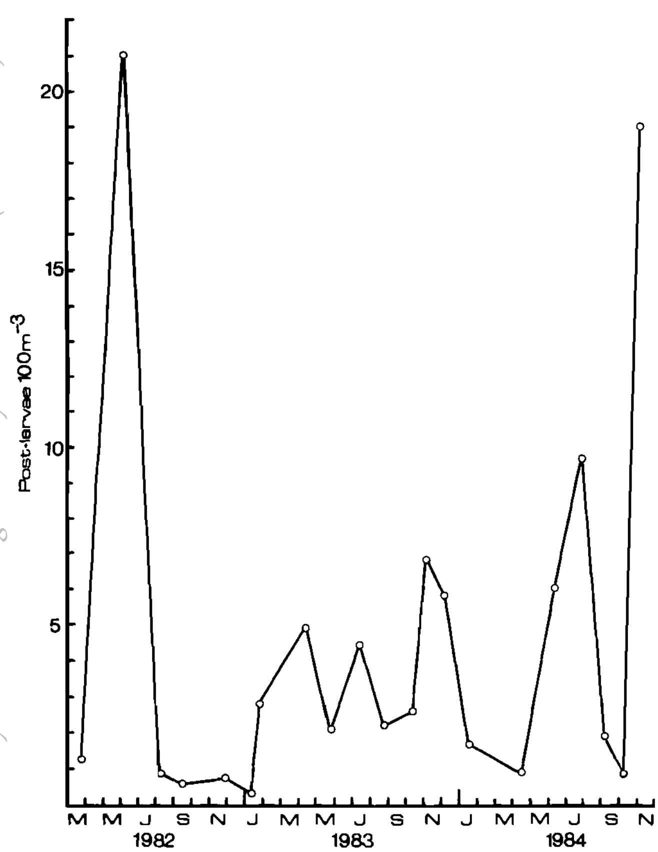

Figure 3 *Penaeus indicus.* Mean abundance of post-larvae over two night spring flood tides during the months shown.

Table 1 Bait fishery catches and percentage numerical contribution of each species during the study period. Season runs from June to end May. No netting took place between Feb – June 1984 following the cyclone

	1982 – 1983	1983 – 1984	1984 – 1985
Total catch (kg)	14 885	6 355	16 728
P. indicus	87,3	93,9	50,7
P. monodon	1,9	0,6	2,7
M. monoceros	10,7	5,5	41,3
Other penaeid	0,1	–	–
Macrobrachium sp.	0,1	–	4,7
Other carid	–	–	0,6
	n = 8551	*n* = 1182	*n* = 2390

of *P. japonicus* in the post-larval stages (*cf.* Figures 2 – 4), it made a negligible contribution to the bait fishery which was dominated by *P. indicus* in the 1982 – 1983 and 1983 – 1984 seasons and partially replaced by *M. monoceros* in 1984 – 1985.

Peaks of prawn abundance as shown by CPUE (Figure 5) to some extent followed post-larval recruitment peaks. Recruitment of *P. indicus* post-larvae from March to early December 1983 was consistently high in comparison with the levels recorded in the latter half of 1982 (Figure 3). CPUE during December and January in the 1983 – 1984 season (preceding the cyclone) were double those during the corresponding months of the 1982 – 1983 season (Figure 5). The single high post-larval peak in March 1982 was not detectable in subsequent bait fishery catches and generally the bait fishery data were inadequate to determine the period between post-larval recruitment and appearance of the later stages in the fishery catches. In 1984 recruitment of *P. indicus* post-larvae began in June as opposed to February in 1983 and was more variable although generally higher than in 1982. Subsequent CPUE data indicated similar total juvenile prawn densities in the

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

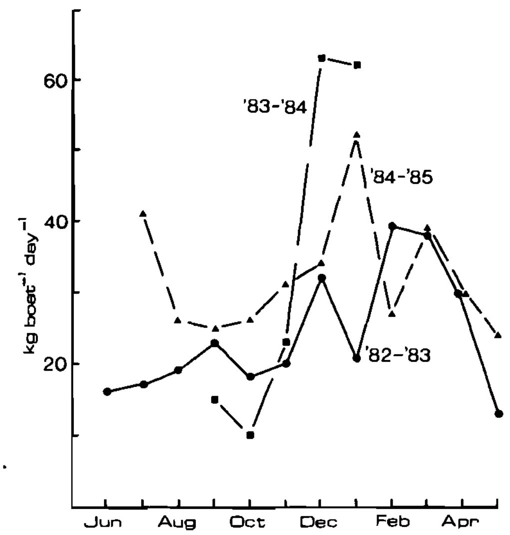

Figure 5 Mean daily bait catch per boat for each month during the study period — all species combined.

1982 – 1983 and 1984 – 1985 seasons (Figure 5) but very different species proportions (Table 1).

Discussion

Post-larval abundance did not follow the same seasonal patterns in all species and individual species showed marked annual variations. Little is known of the source of these variations (George 1962; Edwards 1978) but in the present case they could be attributed to the prawns being tropical species at the limit of their zoogeographic ranges, possible variations in breeding effort and larval survival, and the vagaries of currents in the adjacent nearshore waters.

Species ratios in the post-larval samples (Figures 2, 3, 4) were not reflected in the bait fishery catches which were generally dominated by *P. indicus* (Table 1). *P. indicus* contributed more than 70% in 1964 – 1965 (Joubert & Davies 1966) and 76,8% of the total catch in 1966 – 1968 (Champion 1976). The proportional decline of *P. indicus* and increase of *M. monoceros* and *Macrobrachium* sp. during 1984 – 1985 may be due to the lower salinities following the cyclone. *Macrobrachium* sp. previously appeared at St Lucia during low salinity periods in 1976 – 1978 (unpublished data) and *M. monoceros* is known to be more tolerant of low salinities than *P. indicus* (de Freitas 1980).

Bait fishery CPUE data (Figure 5) showed that greatest prawn abundance occurred in December 1983 and January 1984 prior to the cyclone. *P. indicus* was the major species (Table 2) and this followed the regular occurrence of post-larval *P. indicus* during much of 1983 (Figure 3). Poor bait catches during the 1982 – 1983 season followed the relatively small recruitment of post-larvae during the latter half of 1982. The difference in abundance of post-larval *P. indicus* during the two years despite the marine salinity conditions prevailing in the Narrows in both years presumably reflects changing conditions in the marine larval habitat and emphasizes the significance of marine effects on estuarine systems.

Numbers of post-larval *P. indicus* recorded during 1984 were variable and although high at times (Figure 3), catches in the 1984 – 1985 season were generally low and similar to the poor 1982 – 1983 season. Mean daily catch per boat in peak months during both seasons was 30 – 40 kg. Daily catches during peak season in 1980 – 1981, 1981 – 1982 (unpublished data) and 1983 – 1984 prior to the cyclone averaged 50 – 60 kg. Variable post-larval numbers during 1984 combined with high lake levels and low salinities following the cyclone complicate interpretations but Indian studies (George 1962; Mohamed & Rao 1971; Achuthankutty & Nair 1983) showed that *P. indicus* post-larvae recruited into estuaries outside of the monsoon season during periods of marine salinities. In St Lucia during 1984 low salinities and high lake levels resulting in a net outflow of water could have hindered migration of post-larvae into the system.

Of the other species recorded as post-larvae and subsequently in beam trawl samples only *M. monoceros* contributed significantly to the bait fishery. This species prefers muddy substrata and tolerates virtually fresh water (de Freitas 1980). Numbers in beam trawl samples increased in spring and summer during 1982 – 1983 and during spring 1983 – 1984 following periods of abundance of post-larvae (Figure 4) but the greatest proportional increase in the bait fishery occurred under the low salinity conditions of 1984 – 1985 (Table 1) despite this being a period of minimum abundance of the post-larvae. This suggests that the low salinities favoured *M. monoceros* at the expense of *P. indicus*. *P. monodon* is widespread in the Indo-Pacific and is a valuable but never abundant component of prawn fisheries seldom exceeding 10% of the catch (de Freitas 1980; Ulltang, Brinca & Silva 1980; Motoh 1981). St Lucia conformed to this general pattern. *P. semisulcatus* was not recorded in the bait fishery. This is understandable as this species is typically associated with sea-grasses (de Freitas 1980) which were absent from the trawling areas of St Lucia.

The most striking contrast between post-larval and juvenile abundance occurred in *P. japonicus*. This species is nocturnally active and is typically associated with sandy or muddy sand substrata (de Freitas 1980). Sandy substrata occur only at the northern limits of the Narrows and on the eastern shores of the lake which would require the post-larvae to be transported at least 20 km up the channel. *P. japonicus* was extremely rare during the present and past studies (Joubert & Davies 1966; Champion 1970). No specimens were obtained during night hauls over sandy bottoms in the lake. If the relatively high levels of recruitment of *P. japonicus* during 1982 – 1984 are typical even low levels of survival in the upper Narrows and Lake should permit this species to make some contribution to the bait fishery during emigration. Its virtual absence from both the fishery and our beam trawl samples suggests that the post-larvae do not survive in St Lucia.

The source of this sustained supply of post-larval *P. japonicus* is problematic. The other major prawn nursery area on the Natal north coast is at Richards Bay (Figure 1) which is also exploited for bait purposes. Unpublished data indicate that *P. japonicus* is equally rare although there is a similar potential bias in that fishing is only done during the day. Offshore commercial catch data show that on the Tugela Bank (Figure 1) this species made up less than 1% of the catch (Champion 1970). A single non-commercial sample in 1984 off Richards Bay contained 16% *P. japonicus* (n = 67). On the continental shelf off Mozambique it contributed about 3% of the catch (de Freitas 1980) although it apparently became more significant when the catches were small (Ivanov & Hassan 1976). The abundance of *P. japonicus* post-larvae thus does not correlate with the apparent general paucity of both juvenile and adult stages. Unless *P. japonicus* is markedly more fecund than the other species and has correspondingly high mortality rates this suggests that there might be unknown and unexploited stocks of this species.

At this stage it is not possible to establish a quantitative

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).

relationship between recruitment intensity and subsequent catch size partly because of the availability of only three years' data and also because of the disruptive effects of the cyclone.

There are very few catch data from habitats comparable to St Lucia to permit comparisons of productivity. One such area is the Huizache-Caimanero lagoon system on the western coast of Mexico. Although at a lower latitude (23°N vs 28°S) it is otherwise very similar in terms of temperatures, salinities, substrata, shallow, fluctuating water levels and tenuous connections with the sea (Edwards 1977). Prawn catches in this system in the years 1976 – 1980 varied between 1100 and 1400 t (Blake, Bowers & Naylor 1981) in comparison with the St Lucia annual average of about 16 t. This tremendous difference is made more significant by the fact that the Mexican lagoons are about 1/3 the size of the St Lucia system. The full reasons for this difference are uncertain. Unfortunately no comparable CPUE data are available. The fishing effort at St Lucia has traditionally been limited to a maximum of three boats operating only in the Narrows as the system is a nature reserve. The possible effects of increased effort on the catch are unknown. A second point relates to the carrying capacity and significance of the lake as prawn habitat. During surveys of the whole system (Joubert & Davies 1966; Champion 1976) it appeared that the more sandy eastern shores of the lake did not support any prawns. If the Narrows which make up less than 5% of the system provide the only major prawn habitat the difference in productivity between the two areas would not be as marked.

As there appears to be a relation between intensity of recruitment of *P. indicus* and the fishery catch it is worthwhile to compare post-larval abundances in different areas. In the Mexican lagoons Edwards (1978) obtained figures of up to 10 post-larvae of all species per cubic metre and quotes results showing up to 100 m^{-3}. Post-larval *P. duorarum* occurred in densities up to 30 m^{-3} in channels in south Florida (Roessler & Rehrer 1971). Peak densities of *P. indicus* post-larvae in St Lucia only exceeded 0,3 m^{-3} three times in three years while *P. japonicus* rarely exceeded 3 m^{-3}. Mean densities for all post-larvae in St Lucia over a night flood tide rarely approached 2 m^{-3} and densities of *P. indicus* during 1983, which was a relatively good recruitment year, generally ranged between 0,02 and 0,07 m^{-3}. Irrespective of other considerations these differences could be expected to lead to large differences in catch. It is interesting that the St Lucia figures compare closely with results obtained by Staples (1980) for *P. merguiensis* in the Gulf of Carpentaria where he recorded between 0,05 and 0,2 post-larvae m^{-3} in the Norman River. The significance of these differences is not clear and they pose a number of possible questions. Do they reflect differences in fecundity of different species with possible associated differences in mortality rates? Are current systems in some areas more suitable for transport of post-larvae to the estuarine and inshore nursery grounds or are the differences simply a reflection of different carrying capacities in different areas?

Acknowledgements

The authors gratefully acknowledge the financial assistance of the South African National Committee for Oceanographic Research and the co-operation of the Natal Parks, Game and Fish Preservation Board.

References

ACHUTHANKUTTY, C.T. & SREEKUMARAN NAIR, S.R. 1983. Larval migration and growth of marine prawns in the estuarine habitat. *Mahasagar* 16(2): 243 – 250.

BLAKE, B.F., BOWERS, A.B. & NAYLOR, E. 1981. Ecology and *Penaeus* fishery of a coastal lagoon system in W. Mexico: Report on the University of Liverpool/National Autonomous University of Mexico Lagoon Research Project 1973 – 1979. Overseas Developmental Administration, London. 58 pp.

CHAMPION, H.F.B. 1970. Aspects of the biology of *Penaeus indicus* (Milne Edwards) with notes on associated penaeidae occurring off Natal on the east coast of South Africa. Oceanography in South Africa – 1970, Durban 4 – 6 Aug. 1970, (GI): 1 – 17.

CHAMPION, H.F.B. 1976. Recent prawn research at St Lucia with notes on the bait fishery. Natal Parks, Game and Fish Preservation Board. St Lucia Scientific Advisory Council Workshop Meeting at Charters Creek 15 – 17 February 1976.

CHRISTMAS, J.Y. & VAN DEVENDER, T.N. 1981. Prediction of shrimp landings from investigations on the abundance of post-larval shrimp. *Kuwait Bull. Mar. Sci.* 2: 307 – 310.

DE FREITAS, A.J.O. 1980. The Penaeoidea of Southeast Africa. Ph.D. thesis, University of the Witwatersrand. 480 pp.

EDWARDS, R.R.C. 1977. Field experiments on growth and mortality of *Penaeus vannamei* in a Mexican coastal lagoon complex. *Estuarine Coastal Mar. Sci.* 5: 107 – 121.

EDWARDS, R.R.C. 1978. The fishery and fisheries biology of penaeid shrimp on the Pacific coast of Mexico. *Oceanogr. Mar. Biol. Annu. Rev.* 16: 145 – 180.

FORBES, A.T. & BENFIELD, M.C. 1985. Aspects of the penaeid prawn fisheries in Natal. *S. Afr. J. Sci.* 81(8): 430 – 431.

GARCIA, S. & LE RESTE, L. 1981. Life cycles, dynamics, exploitation and management of coastal penaeid shrimp stocks. *FAO Fish. Tech. Pap.* (203): 215 pp.

GEORGE, M.J. 1962. On the breeding of penaeids and the recruitment of their post-larvae into the backwaters of Cochin. *Indian J. Fish.* 9: 110 – 116.

GULLAND, J.A. & ROTHSCHILD, B.J. (Eds) 1984. Penaeid shrimps — their biology and management. Fishing News Books Ltd. Farnham, U.K. 308 pp.

IVANOV, B.G. & HASSAN, A.M. 1976. Penaeid shrimps (Decapoda, Penaeidae) collected off East Africa by the fishing vessel 'Van Gogh', 1. *Solenocera ramadani* sp. nov., and commercial species of the genera *Penaeus* and *Metapenaeus*. *Crustaceana* 30(3): 241 – 251.

JOUBERT, L.S. & DAVIES, D.H. 1966. The penaeid prawns of the St Lucia lake system. *Investl Rep. Oceanogr. Res. Inst.* 13: 1 – 40.

MOHAMED, K.H. & VEDAVYASA RAO, P. 1971. Estuarine phase in the life-history of the commercial prawns of the west coast of India. *J. Mar. Biol. Assoc. India* 13(2): 149 – 161.

MOHAMED, K.H., VEDAVYASA RAO, P. & GEORGE, M.J. 1968. Post-larvae of penaeid prawns of south-west coast of India with a key to their identification. *FAO Fish. Rep.* 57(2): 487 – 503.

MOTOH, H. 1981. Studies on the fisheries biology of the giant tiger prawn *Penaeus monodon* in the Philippines. *Tech. Rep. Aquacult. Dep. Southeast Asian Fish. Dev. Cent.* 7: 1 – 128.

MOTOH, H. & BURI, P. 1980. Identification of the postlarval *Penaeus* (Crustacea, Decapoda, Penaeidae) appearing along shore waters. *Q. Res. Rep. Aquacult. Dep. Southeast Asian Fish. Dev. Cent.* 4(2): 15 – 19.

ROESSLER, M.A. & REHRER, R.G. 1971. Relation of catches of post-larval pink shrimp in Everglades National Park to the commercial catches on the Tortugas grounds. *Bull. Mar. Sci.* 21(4): 790 – 805.

STAPLES, D.J. 1980. Ecology of juvenile banana prawns, *Penaeus merquiensis*, in a mangrove estuary and adjacent off-shore area of the Gulf of Carpentaria. 1. Immigration and settlement of postlarvae. *Aust. J. Mar. Freshwater Res.* 31: 635 – 652.

ULLTANG, O., BRINCA, L. & SILVA, C. 1980. A preliminary assessment of the shallow water prawn stocks off Mocambique, north of Beira. Revista de Investigacao Pesqueira. Servico de Investigacoes Pesqueiras Maputo. 1: 1 – 69.

Reproduced by Sabinet Gateway under licence granted by the Publisher (dated 2010).