Mar. Freshwater Res., 1996, **47**, 323–9

Aspects of the Life History and Management of Tailor (*Pomatomus saltatrix*) in Queensland

B. M. Zeller, B. R. Pollock and L. E. Williams

Marine Fisheries Division, Queensland Department of Primary Industries, GPO Box 2454, Brisbane, Qld 4001, Australia.

Abstract. Tailor (*Pomatomus saltatrix*) is an important commercial and recreational species. Published and unpublished information on the reproductive biology and seasonal migrations of *P. saltatrix* in southern Queensland are summarized for 1978–93. Gonad index (GI) data from commercial ocean beach catches gave mean monthly values for fish ≥ 250 LCF (length to caudal fork; $n = 389$), decreasing from January to April before increasing to a peak in November. *P. saltatrix* taken on Fraser Island in September and on South Stradbroke Island in November had high GI values. Adult fish in spawning condition were captured, tagged and released ($n = 7090$) on Fraser Island beaches in 1978–80 and 1987–89. Most tagged fish dispersed southward, being recaptured within 400 km of the tagging point. Gonad maturity at tag release and recapture locations and egg concentrations in plankton tows identified a major spawning area for *P. saltatrix* as the inshore waters between Indian Head and Waddy Point, Fraser Island. Although it is generally accepted that the eggs and/or larvae move southward with the East Australian Current (EAC), distribution and movement of larval *P. saltatrix* in Queensland waters are not known. Juveniles inhabit and move extensively throughout estuaries to the south of Fraser Island until recruitment as adults on ocean beaches. Recent stock management strategies in Queensland include a minimum legal size of 300 mm (total length), an annual one-month (September) closure to all forms of fishing in the spawning area identified on Fraser Island and input controls on fishing effort of commercial ocean-beach net fishers. Bag limits for recreational anglers may be introduced.

Introduction

Pomatomus saltatrix has a south-to-north distribution on the east coast of Australia from Wilson's Promontory, Victoria, to Fraser Island, Queensland. Adults migrate northward to spawning areas in southern Queensland (Fig. 1) from June to October. Information on the reproductive activity and early life history of *P. saltatrix* in eastern Australian waters is fragmentary. Unpublished data provide details on stock abundance and condition during the spawning season and on trends in commercial and recreational harvesting levels. This paper summarizes published and unpublished data on the stocks in Queensland and identifies areas of further research.

Materials and Methods

Study Area

The south Queensland coastline is characterized by open surf beaches interrupted by rocky headlands, tidal estuaries and large sheltered embayments. Large sand islands (Fraser, Bribie, Moreton and North and South Stradbroke Islands) provide protection from ocean wave action and allow the formation of extensive littoral wetland habitats in, for example, Moreton Bay and the Great Sandy Strait (Fig. 1) which are important as nursery areas for juveniles (Morton *et al.* 1993). Tidal lands supporting important mangrove and seagrass habitats used by *P. saltatrix* during growth and maturation have been recognized by gazettal as declared Fish Habitat Areas. Sexually mature adults form schools that move into the surf zone of ocean beaches and around rocky headlands between Byron Bay, New South Wales (NSW) (about 28·8°S), and Sandy Cape, Fraser Island (about 24·7°S).

Reproductive State

Monthly samples of adult *P. saltatrix* (consisting of 152 males and 237 females) were taken from commercial catches in southern Queensland in 1980. Gonad weight to the nearest 0·1 gram, body length (LCF) to the nearest 5 mm and sex were recorded for each fish. A gonad index (GI) was determined for individual *P. saltatrix* from

$$\mathrm{GI} = \frac{\text{gonad weight (g)} \times 10^9}{\mathrm{LCF\ (mm)}^3}.$$

The gonad maturity stages described by van der Elst (1976) and Bade (1977) were assessed for similarity. A revised system incorporating shared attributes of similar stages was developed to compare the gonad maturity stages of sampled fish, focussed on the maturity stages at or very near actual spawning. Nominal categories identified the shared attributes from each classification (Table 1) and indicated the maturity stages (A to E) of fish from Fraser Island and South Stradbroke Island (this study) and Byron Bay and Fraser Island by Bade (1977) (Table 2).

Catch Levels

Commercial catch summaries for 1946–81 and for 1988–94 were collated from Queensland Fish Board data and Queensland commercial fishing logbook records respectively.

1323-1650/96/020323$05.00

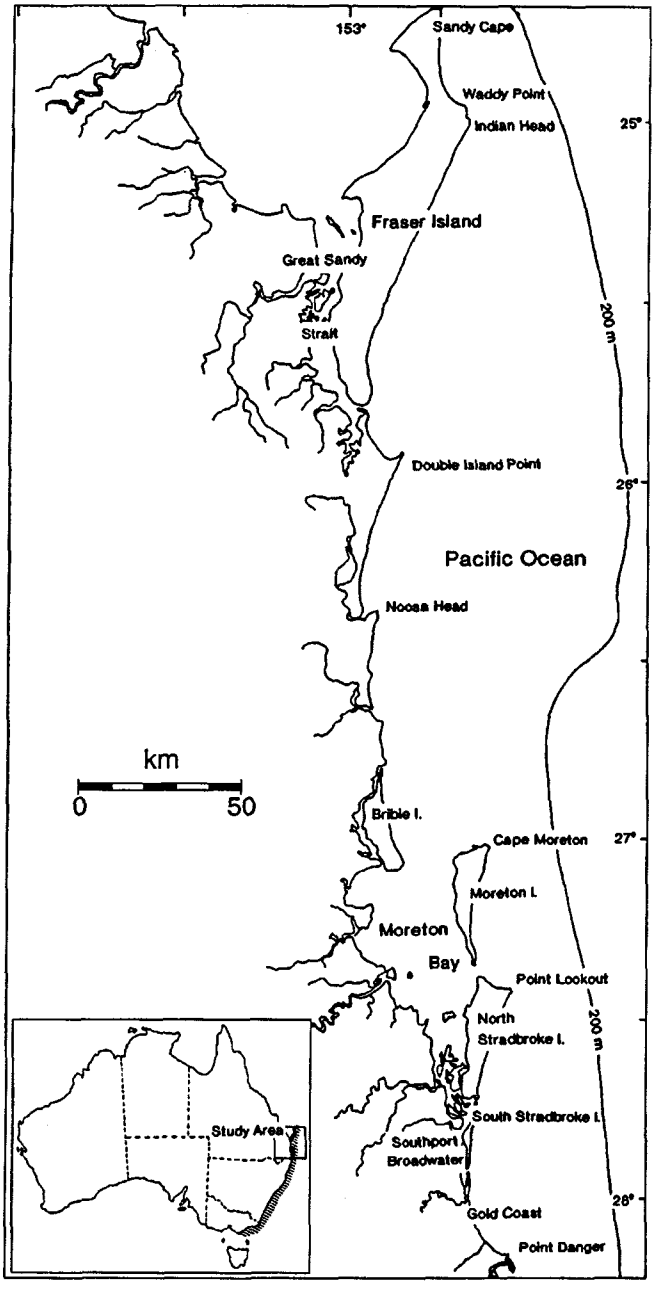

Fig. 1. Study area for tailor (*Pomatomus saltatrix*) in southern Queensland. The inset shows the distribution of tailor in eastern Australia (shaded area).

Results and Discussion

P. saltatrix Schools

Analysis of Queensland commercial fishing logbook data and supporting anecdotal evidence indicated major aggregations of adults in waters close inshore, east of North and South Stradbroke, Moreton and Fraser Islands (Fig. 1). In September, numerous schools occur in shallow water along ocean beaches and in the vicinity of rocky headlands between the Gold Coast and Fraser Island. Large schools, some estimated in excess of 100 t, have been observed between Noosa Head and Sandy Cape, Fraser Island, at this time (Mann, unpublished data). During the peak of the spawning season in 1991–93, commercial fishers aboard a light aircraft at low altitude (160 m) close to the shoreline between Noosa Head and Sandy Cape spotted schools; estimates of school size obtained by this technique agreed closely with the catches of commercial beach seine netters targetting the same school (Mann, personal communication).

Spawning

Bade (1977) reported a long spawning period from late winter through spring between Byron Bay and Fraser Island and concluded that a peak in spawning activity occurs in September and October and slightly earlier in the south. Bade (1977) found that a June sample from Byron Bay had gonads of most fish (80%) developing (Stage B) (Table 2) with 10% mature (Stage C). Most (85%) sampled in southern Queensland at this time were still immature (Stage A). By July, fish with mature and spawning (Stage D) gonads could also be found on South Stradbroke Island beaches, and a month later most fish (89%) were mature at Fraser Island with a small proportion (3%) spawning.

A monthly mean GI index for each sex calculated from new data obtained in the present study (Fig. 2) indicates that gonads are inactive between February and June, followed by rapid enlargement as fish mature for spawning between August and November. Female tailor had consistently higher mean monthly GI values than those of males. The lowest and highest mean monthly GI values for both sexes occurred in April (females 73·5 ± 15·4; males 25·1 ± 18·5) and November (females 667 ± 161; males 566 ± 177) respectively.

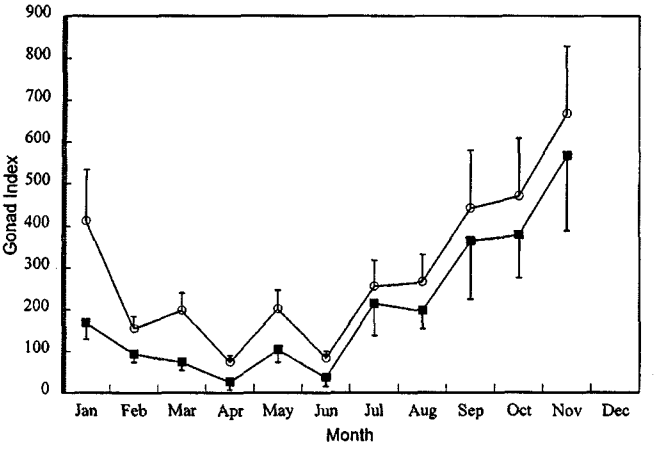

Fig. 2. Mean gonad index for tailor (*Pomatomus saltatrix*) sampled from commercial landings in southern Queensland, 1980: (○) females, n = 237; (■) males, n = 152. Vertical bars indicate one standard deviation from the mean. No samples taken in December.

Table 1. Gonad maturity stages of *P. saltatrix* [adapted from van der Elst 1976 (South Africa) and Bade 1977 (Australia)]

Gonad maturity stages	Attributes	
	Male	Female
A - Immature	testes bilaterally flattened and off-white in colour; no milt extrusable	ovary red in colour; ovary< half length of the body cavity
B - Developing	testes off-white in colour; small amount of 'creamy milt' in vas deferens	ovary orange-yellow to yellow in colour and >half the length of dorsal body cavity; increased vascularity of ovarian blood vessels; ova visible to the naked eye
C - Mature	testes larger; as for stage 'B'	as for stage 'B'; ova are tightly packed
D - Spawning	testes large and white; white milt released with slight pressure	ovaries large and > three quarters the length of the body cavity; ova large and transparent or nearly so; ova loosely suspended; slight pressure causes ova to flow from the vent
E - Spent	testes thinner and pink as a result of haemorrhage	ovaries flaccid and red owing to haemorrhage

Table 2. Reproductive condition of tailor between February and November on southern Queensland and northern New South Wales beaches

Month	Location	*n*	A. Immature (%)	B. Developing (%)	C. Mature (%)	D. Spawning (%)	E. Spent (%)
February[A]	S. Stradbroke I.	–	–	–	present (females)	present (males)	–
June[A]	Byron Bay, NSW	50	–	80	10	–	–
June[A]	S. Queensland	40	85	–	–	–	–
July[A]	S. Stradbroke I.	–	–	–	present (females)	present (males)	–
August[A]	Fraser I.	180	–	–	89	3	–
September[B]	Fraser I.	66	–	–	79	21	–
November[C]	S. Stradbroke I.	99	–	–	35	61	4

[A]Bade (1977); [B]Pollock (1984*a*); [C]This study.

High GI values calculated for samples from commercial catches taken on Fraser Island in September 1980 and on South Stradbroke Island in November 1980 were similar; 713 ± 208 and 718 ± 330 respectively. Almost all fish from both localities had gonads either mature or in spawning condition (Table 2), indicating that spawning activity was imminent or under way. Logbook data also indicate that in some years adults form schools and perhaps spawn off beaches of the Moreton region through summer. This is supported by the presence of most fish (96%) in mature or spawning condition and only a small proportion (4%) that were spent (Stage E) in November, and mature and spawning fish in February at South Stradbroke Island.

Inshore waters of north-east Fraser Island are the major known spawning area for tailor in eastern Australia. Halliday (1990) noted that spawning aggregations at Fraser Island are much larger than those encountered further south during the northward winter migration. Mann (1992) observed the largest schools at Indian Head and on the adjacent sand banks north of Sandy Cape, Fraser Island. Tagged adults were at or near spawning condition (Pollock 1984*a*; Anon. 1987), suggesting that spawning activity is concentrated between Indian Head and Waddy Point, Fraser Island. This was confirmed by the collection of eggs from adjacent inshore waters (Halliday 1990).

Other evidence suggests that there may be other spawning areas. Experienced commercial and recreational fishers believe that Sandy Cape is the main spawning site for the early spring aggregation of fish (Halliday 1990). Mann (1992) frequently observed schools at Double Island Point, and Cape Moreton and Point Lookout are close to beaches where large commercial catches of adults are taken (see Fig. 3). *P. saltatrix* also spawns at South Stradbroke Island. Plankton sampling for eggs and larvae at these locations may confirm their importance for spawning.

Tagging Studies

Tagging studies have been undertaken at Fraser Island in 1978–80 on spawning adults (Pollock 1984*a*) and in 1987–89 on spawning and non-spawning adults (Anon. 1987; Halliday 1990) and on juveniles (Morton *et al.* 1993). Several tag types were used including polyethylene 'T-bar' anchor tags, lock-on spaghetti tags and large and small monel metal strap opercular tags. Pollock (1984*b*) found that yellow spaghetti tags locked into the dorsal musculature had a significantly higher rate of recovery than that for strap opercular tags because strap tags were less prominent. Strap tags were not used for tagging after 1980. With greater refinement of tagging technology, lock-on spaghetti tags were replaced by 'T-bar' anchor tags for 1987–89. From

1987 a toll-free telephone number was included on the tag and rewards offered for recapture information.

Tagging of adults in northern NSW and in southern Queensland between July and October when gonad activity was increasing (Fig. 2) provided limited evidence that *P. saltatrix* undertakes extensive northward movements (Bade 1977). Further tagging studies at Fraser Island between August and October (Bade 1977; Pollock 1984*a*; Anon. 1987; Halliday 1990) indicate spawning at Fraser Island before a return southward. Most tag recaptures were within 400 km of the tagging point. Juveniles (< 270 mm LCF) were tagged at several locations within Moreton Bay (about 150 km south of Fraser Island) in 1987 (Morton *et al.* 1993). Almost all recaptures occurred within Moreton Bay and the Southport Broadwater, indicating the importance of these sheltered waters as nursery habitats for juveniles.

Tag recapture rates for juveniles and adults for 1987–89 (Table 3) were high compared with similar tagging studies (of other species) conducted in Australia and elsewhere (Halliday 1990) and were also higher than those calculated from the data of Pollock (1984*a*). While measures were taken to improve the reported recapture incidence of tagged fish for 1987–89, the high rate of recaptures and supporting anecdotal evidence of strong fishing pressure from recreational anglers suggested that management measures be implemented to protect both juvenile and spawning *P. saltatrix*. Consequently a 300 mm (total length) minimum legal size was introduced in 1987 (Morton *et al.* 1993). A total fishing closure was declared in 1989 between the high water mark and 400 m to seaward from a point 400 m west of Waddy Point to a point 400 m south of Indian Head, Fraser Island, from midday 1 September to midday 30 September each year.

Plankton

Surface tows for eggs and larvae were undertaken on the full moon in nearshore waters of Indian Head and Waddy Point, Fraser Island, in September and October 1988 and in June and July 1989 (Halliday 1990). A single plankton net (500 μm mesh, 50 cm diameter) was towed behind a 6·4-m vessel at an approximate speed of 2·5 knots. Tows sampled waters less than 3 m from the surface and up to 1·6 km offshore in water between 20 and 30 m in depth. Sampling times were 0500–0800 hours. Twelve out of 13 tows in 1988 were 15 min in duration with all subsequent tows 10 min long. Hydrological data of inshore conditions near Indian Head are unavailable. However, satellite imagery indicated thatsea surface temperatures around the northern tip of Fraser Island ranged from 19°C in July to 25°C in October (Halliday 1990). The presence of several genera of holoplanktonic invertebrates collected during egg sampling suggests that these inshore waters are influenced by advective processes of the East Australian Current (EAC). Calanoid copepods (including Undinula, Euchaeta and Candacia) normally confined to more tropical waters formed part of the plankton recovered from net tows within 1.6 km of the Indian Head–Waddy Point area. Semi-quantitative sampling of *P. saltatrix* eggs in near-shore waters around Indian Head and Waddy Point, Fraser Island, allowed assessment of spawning intensity (egg abundance) and spawning location (egg distribution). No *P. saltatrix* larvae were sampled although other fish larvae were present. In 1988, tailor eggs were in peak abundance late in September with reduced abundance in late October. Sampling for eggs in June and July 1989 was unsuccessful (Halliday 1990). These findings support a pattern of spawning at Fraser Island beginning some time after mid winter, reaching a peak in September or early October before declining by late October. The exact time spawning ends at Fraser Island is unknown.

The presence of eggs off Fraser Island (Halliday 1990) is evidence that spawning had occurred within about 48 h (Deuel *et al.* 1966). However, the absence of larvae suggests that spawning had only just begun, that larvae had been transported out of the spawning area, or that larvae occurred at depths other than those sampled. Kendall and Naplin (1981) reported about 80% of *P. saltatrix* larvae at or below a depth of 4 m for the same sampling times (0500–0800 hours) undertaken at Fraser Island. Alternatively, larvae may have evaded capture by the method employed.

Table 3. Recapture rates for tagged adults and juveniles in southern Queensland, 1978–89

Year	Release Location	Life stage	No. tagged	No. recaptured	Recaptured (%)
1978[A]	Fraser Island	Adult	521	28	5·4
1979[A]	Fraser Island	Adult	684	34	5·0
1980[A]	Fraser Island	Adult	526	40	7·6
1987[B]	Fraser and Moreton Islands	Adult	805	70	8·6
1987[C]	Moreton Bay	Juvenile	2173	237	11
1988[D]	Fraser Island	Adult	1323	292	22
1989[D]	Fraser Island	Adult	3254	256	7·9

[A]Pollock (1984*a*); [B]Anon. (1987); [C]Morton *et al.* 1993; [D]Halliday (1990).

P. saltatrix eggs are highly buoyant (Wilk 1977) and larvae inhabit surface waters above the thermocline (Kendall and Walford 1979). Consequently, both life stages may be subject to movement by surface currents. Middleton *et al.* (1994) suggested that tidal movements periodically exchange waters between the outer continental slope and the continental shelf as the EAC flows southward. This may be significant in terms of a mechanism for larval dispersal.

At its closest point the continental slope (200-m isobath) lies about 20 km ENE of Sandy Cape and about 25 km ENE of Waddy Point. Hamon and Tranter (1971) reported a southward current past Fraser Island along the edge of the continental shelf. If eggs and larvae are transported southward by the EAC and spawning is confined to inshore waters close to Indian Head and Waddy Point, such dispersal away from inshore waters would depend on a transport mechanism that overcomes the effects of the variable (September) and predominantly onshore (October) winds (Bureau of Meteorology data) during spawning.

Satellite images of sea surface temperature indicate that the EAC moves along the continental slope east of Fraser Island, flowing southward past Indian Head and over the continental shelf near Double Island Point. Middleton *et al.* (1994) found evidence that this current flowed strongly southward from here and that upwelling and mixing of EAC and shelf waters occurred. Inner shelf waters also tend to flow southward under the influence of the EAC (Middleton and Cunningham 1984).

Under these conditions it might be expected that eggs and larvae are transported in shelf waters driven southward by the EAC. This would obviate the need for an offshore spawning area closer to the continental slope. Seaward spawning of the prominent headlands at Indian Head and Waddy Point may also isolate the eggs and possibly the larvae in the shelf waters, thereby minimizing the risk of being carried into the surf zone with tidal movements or wind-driven currents. This is supported by the presence of eggs at Waddy Point in contrast to their absence in waters adjacent to nearby surf beaches to the north-west of this location (Halliday 1990).

Juveniles

Larvae entrained by waters influenced by the EAC may be carried passively until able to actively swim shoreward. Juveniles are fully developed at 40–50 mm in length in the USA (Wilk 1977) and are reported to enter inshore waters in their first year (Norcross *et al.* 1974). No data are available on the size of *P. saltatrix* juveniles recruited to inshore waters in Queensland. However, Bell *et al.* (1984) reported an early juvenile (27 mm LCF) in a tidal mangrove creek in southern NSW. Blaber and Blaber (1980) reported that juvenile *P. saltatrix* recruited to Moreton Bay only in March; this suggested a distinct pulse to inshore waters, a phenomenon also noted by Nyman and Conover (1988) for *P. saltatrix* in waters of the USA.

Juveniles inhabit shallow waters over tidal flats adjacent to mangrove forests in the western part of Moreton Bay (Blaber and Blaber 1980; Morton 1990). The high conservation value of such areas is recognized for providing juveniles with abundant food resources (Morton *et al.* 1993) and protection from predation by larger fishes (Blaber and Blaber 1980). The declaration of Fish Habitat Areas such as those of Moreton Bay affords protection to nursery habitats against environmental degradation and ensures annual recruitment (van der Elst 1976).

Juveniles undergo extensive local movements throughout Moreton Bay but remain within its relatively sheltered waters while less than 210 mm (LCF) (Morton *et al.* 1993). Sexually mature at 260 mm and 280 mm (LCF) for males and females respectively (Bade 1977), *P. saltatrix* then leaves sheltered waters for the ocean beaches.

Commercial Catches

Annual recorded commercial catches were approximately 300 t between 1945–46 and 1973–74 before declining to about 200 t for 1974–75 to 1980–81 and for 1988–89 to 1990–91. Anecdotal evidence suggests that catches were also of this order during the period 1980–81 to 1988–89 when fisheries statistics were not collected. Since 1990–91 the mean annual reported commercial catch has declined further to about 145 t (Fig. 3). The apparent decline in commercial catch may be driven to some extent by market forces which make it less profitable for commercial fishers to target *P. saltatrix* schools when prices are low; the quantities of fish harvested during these periods are thought to be less than when higher prices are offered to the commercial fishers.

In a typical season about 75% of the Queensland commercial catch is taken by ocean beach fishers using

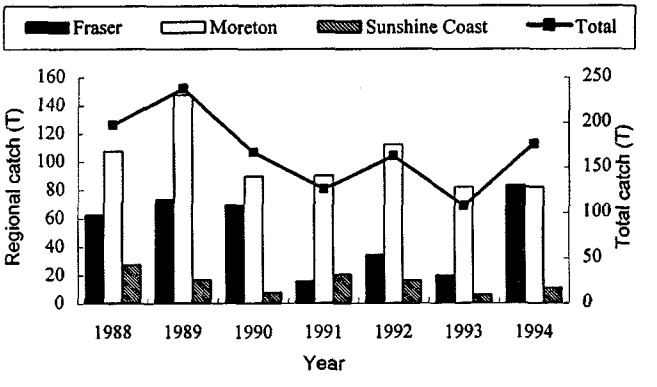

Fig. 3. Commercial tailor catches in Queensland, 1989–94. Catches are by region: Fraser Island (Breaksea Spit to Hook Point, Fraser Island); Sunshine Coast (Double Island Point to Caloundra); and Moreton (Caloundra to the Queensland–NSW border).

large seine nets with the remainder from tunnel net and set gill net operations within sheltered waters. The largest tailor catches—about 75% of the annual total—are made in July and August. Approximately 60% of the entire catch is taken in the Moreton region (Fig. 3), from Caloundra to the Queensland–NSW border with most taken on North Stradbroke Island. The next most important region is Fraser Island where for 1988–94 an average of 30% of the total annual catch was taken. The Sunshine Coast region (Double Island Point to Caloundra) accounts for less than 10% of the annual commercial catch.

Management of the commercial ocean-beach fishery is highly regulated with fish taken between Breaksea Spit, north of Fraser Island, to the Queensland–NSW border only between 1 April and 31 August. Limited commercial harvesting on Fraser Island may also occur during but outside the closure boundaries until 31 March the following year. Limits apply to mesh size and the minimum and maximum lengths of beach seine fishing nets, and the number of crew.

A record low annual commercial tailor catch of 106 t in 1993 (Fig. 3) occurred at a time of drought affecting the eastern coast of Australia. Mann (unpublished data) noted that sea surface temperatures off the coast of northern NSW were reported by tuna fishers to be unusually low (about 17°C) for an extended period during 1993. Similar impacts of adverse environmental conditions have been recorded for sea mullet (Halliday, personal communication), which undergo a similar seasonal northward migration. In 1993 the reported commercial sea mullet catches (1200 t) were below average and the lowest recorded since commercial fishing logbooks were introduced in 1988.

Anecdotal evidence from commercial fishers in recent years suggests that some *P. saltatrix* schools remain in deep water offshore and wide of the surf zone, thereby being unavailable to capture by current methods. It is uncertain whether these fish are part of the same stock(s) as those seen inshore and whether these fish spawn in offshore areas. If spawning activity occurred over an extended area including deeper waters nearer to the edge of the continental shelf, then the significance of the current area closure as a management tool may need to be re-evaluated. Further areas may need to be protected to ensure seasonal refugia for spawning.

Recreational Catches

P. saltatrix are targetted by recreational fishers mainly between June and October. Pollock (1980) estimated the 1979 recreational catch (September–October) from Fraser Island, a major location for recreational fishing, to be about 180 t. A creel survey of recreational *P. saltatrix* anglers at Fraser Island in September and October 1993, covering 1735 people (Mann, unpublished data) provided an estimate of the level of the recreational catch and data to implement a recreational bag limit. In 1993 Mann (unpublished data) estimated a recreational catch of between 20 and 30 t for the same period—a substantial reduction from the 1979 estimate but which may also reflect different data collection methods to that of Pollock (1980). Nevertheless, both recreational and commercial fishers considered *P. saltatrix* to be less abundant on Fraser Island beaches in 1993 than in previous years (Mann, unpublished data).

The average weight of individual *P. saltatrix* in 1993 at Fraser Island was estimated to be about 0·56 kg (Mann, unpublished data) compared with an earlier estimate of 1 kg (Pollock 1980). The absence of schools of clupeid forage fishes and a large proportion of lean *P. saltatrix* with smaller *P. saltatrix* in their gut (Mann, unpublished data) suggests that the lack of suitable prey contributed to low numbers and low average weight of individual fish taken by recreational anglers on Fraser Island beaches and possibly other areas during 1993. Anglers generally favoured a recreational bag limit to further protect spawning stock.

Future Research

The high recapture rate for adults tagged in 1988 (Table 3) and evidence of *P. saltatrix* spawning activity in near-shore waters around Indian Head and Waddy Point during the peak of the fishing season indicated a need for an annual fishing closure at Fraser Island to reduce the fishing pressure on the spawning stock (Halliday 1990). This has effectively shifted fishing effort away from the known spawning peak in September, to August and October. However the impacts on the spawning stock have not been investigated and the extent of spawning activity at these other times remains unclear. Further plankton sampling for eggs and larvae within the closed and adjacent waters would determine the appropriateness of the timing and boundaries of the closure.

Current and proposed management strategies are deliberately conservative in view of the available evidence regarding *P. saltatrix* stocks in eastern Australian waters. However, to determine the condition of these stocks further research is required into the spatial and temporal patterns of spawning, mechanisms of larval dispersal and recruitment, the role of environmental variation in stock level dynamics, and patterns of resource usage (especially during the spawning season).

Acknowledgments

We express our gratitude to Dr John Beumer who kindly agreed to review the manuscript and who provided many constructive comments and suggestions. We also thank Mr Ian Halliday for providing important technical information, Ms Melissa White for editing the manuscript, Mrs Joan Greenwood for sorting plankton samples, Dr Jack

Greenwood for identifying plankton and providing specific technical advice on their affinities and Ms Kym McKauge for specialized computing expertise.

References

Anon. (1987). Tailor tagging project; summary of results. Queensland Department of Primary Industries. 5 pp.

Bade, T. (1977). The biology of tailor (*Pomatomus saltatrix* Linn.) from the east coast of Australia. M. Sc. Thesis, University. of Queensland. 117 pp.

Bell, J. D., Pollard, D. A., Burchmore, J. J., Pease, B. C., and Middleton, M. J. (1984). Structure of a fish community in a temperate tidal mangrove creek in Botany Bay, New South Wales. *Australian Journal of Marine and Freshwater Research* **35**, 33–46.

Blaber, S. J. M., and Blaber, T. G. (1980). Factors affecting the distribution of juvenile estuarine and inshore fish. *Journal of Fish Biology* **17**, 143–62.

Deuel, D. D., Clark, J. R., and Mansueti, A. J. (1966). Description of embryonic and early larval stages of bluefish, *Pomatomus saltatrix*. *Transactions of the American Fish Society* **95**, 264–71.

Halliday, I. (1990). Tailor tagging project; summary of 1988 and 1989 results. Queensland Department of Primary Industries. 8 pp.

Hamon, B. V., and Tranter, D. J. (1971). The East Australian Current. *Australian Natural History* December, 129 –133.

Kendall, A. W., and Naplin, N. A. (1981). Diel - depth distribution of summer ichthyoplankton in the middle Atlantic Bight. *US National Marine Fisheries Service Fishery Bulletin* **79**, 705–26.

Kendall, A. W., and Walford, L. A. (1979). Sources and distribution of bluefish, *Pomatomus saltatrix*, larvae and juveniles off the east coast of the United States. *US National Marine Fisheries Service Fishery Bulletin* **77**, 213–27.

Mann, R. (1992). Tailor project 1991; aerial survey of tailor stocks in south-east Queensland. Queensland Department of Primary Industries. 13 pp.

Middleton, J. H., and Cunningham, A. (1984). Wind-forced continental shelf waves from a geographical origin. *Continental Shelf Research* **3**, 359–81.

Middleton, J. H., Coutis, P., Griffin, D. A., Macks, A., McTaggart, A., Merrifield, M. A., and Nippard, G. J. (1994). Circulation and water mass characteristics of the southern Great Barrier Reef. *Australian Journal of Marine and Freshwater Research* **45**, 1–18.

Morton, R. M. (1990). Community structure, density and standing crop of fishes in a subtropical Australian mangrove area. *Marine Biology* **105**, 385–94.

Morton, R. M., Halliday, I., and Cameron D. (1993). Movement of tagged juvenile tailor (*Pomatomus saltatrix*) in Moreton Bay, Queensland. *Australian Journal of Marine and Freshwater Research* **44**, 811–16.

Norcross, J. J., Richardson, S. L., Massman, W. H., and Joseph, E. B. (1974). Development of young bluefish (*Pomatomus saltatrix*) and distribution of eggs and young in Virginian coastal waters. *Transactions of the American Fish Society* **3**, 477–97.

Nyman, R. M., and Conover, D. O. (1988). The relation between spawning season and the recruitment of young-of-the-year bluefish, *Pomatomus saltatrix*, to New York. *US National Marine Fisheries Service Fishery Bulletin* **86**, 237–50.

Pollock, B. R. (1980). Surprises in Queensland angling study. *Australian Fisheries* **39**, 17–19.

Pollock, B. R. (1984*a*). The tailor (*Pomatomus saltatrix*) fishery at Fraser Island and its relation to the life-history of the fish. *Proceedings of the Royal Society of Queensland* **95**, 23–28.

Pollock, B. R. (1984*b*). Effects of capture injury and tag-type on the recovery rate of tagged tailor, *Pomatomus saltatrix* (Linnaeus). *Queensland Journal of Agricultural and Animal Science* **41** (2), 121–23.

Van der Elst, R. (1976). Game fish of the east coast of southern Africa. 1. The biology of the elf, *Pomatomus saltatrix* (Linnaeus), in the coastal waters of Natal. Oceanographic Research Institute (Durban) Investigation Report No. 44.

Wilk, S. J. (1977). Biological and fisheries data on bluefish, *Pomatomus saltatrix* (Linnaeus). National Marine Fisheries Service, Northeast Fisheries Centre, Sandy Hook Laboratory. Technical Series Report No. 11, 56 pp.

Manuscript received 31 August 1995; revised and accepted 18 December 1995