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EFFORT TRENDS IN THE NORTH-EAST COAST PRAWN TRAWL FISHERY

Yvette Beurteaux and Dr Robert Coles

Fisheries Research Branch



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ABSTRACT

The availability, reliability, trends, and management implications of fishing effort data were investigated for the northern sector of the East Coast Prawn Trawl Fishery. Two of six data sources identified were considered useful for detailed analysis and their statistics described fishing effort trends accurately.

The number of trawlers using Cairns port increased from 121 vessels in 1980 to 419 in 1986. By comparison the total Queensland fleet declined during the 1980s. Trawler sea-time was positively correlated with vessel length and licence type for Cairns based trawlers. Skipper type (employed or owner) and mothership and fuel barge availability also influenced the duration of fishing trips. Larger dual-licenced trawlers (endorsed for the Gulf of Carpentaria Fishery and East Coast Trawl Fishery) spent a significantly longer time at sea in each year than smaller trawlers licenced for the east coast only. Between 1983 and 1986 the average annual fishing effort (boat days at sea) of dual-licenced trawlers increased from 214 +/- 20 (standard error (SE)) days to 253 +/- 12 SE days. On average, dual-licenced trawlers made fewer fishing trips of longer duration than trawlers licenced for the east coast only. The average annual effort expended by trawlers licenced for the east coast only did not change significantly between 1983 and 1986, even though seasonal closures had reduced the effective length of fishing seasons in 1985 and 1986. These trawlers spent an average of 206 +/- 4 SE days at sea in each year.

The seasonal closure introduced to reduce growth overfishing resulted in a pulse of fishing effort at the commencement of the 1986 fishing season. The effectiveness of the seasonal closure as a method of reducing the proportion of juvenile prawns in the commercial catch was most probably lessened by this pulse. The winter peak of effort usual for this fishery moved forward to March in 1986 as a result of closure implementation. A temporal and spatial breakdown of fishing effort within the study area showed that effort was not spread evenly throughout north-eastern trawl grounds.

Trends in catches per unit of fishing effort (CPUE) data are essential for effective fisheries management. Such data are not readily available for Australia's East Coast Prawn Trawl Fishery. The analyses presented here are a first step in providing a history of fishing effort for the northern sector of this fishery.

INTRODUCTION

The importance of the prawn trawl fishery to Queensland

Fishermen have been trawling for prawns along the east coast of Queensland for over a century (Smith, 1982). Rapid expansion in both the area trawled and the fishing capacity of the trawl fleet have occurred in recent decades, aided by advances in fishing technology and market growth (Jarzinski, 1982; Purnell-Webb, 1983; Anon, 1985; Hill and Pashen, 1986).

The prawn trawl component is the most economically viable part of the recently defined East Coast Trawl Fishery which extends from Sydney in NSW north to the Torres Strait. The prawn trawl fishery generates high levels of subsidiary income throughout Queensland and employs more people per wholesale dollar than many other primary industries (Hundloe, 1985).

Producers caught \$56m worth of prawns in 1982-3 (Anon, 1985). The total primary wholesale value of production may have been two or three times this figure due to black market sales (Seefried, 1983). In Cairns, the Port Authority reported that 3600 people were employed on trawlers and local support industries during 1985. Forty million dollars worth of prawns (primary wholesale value) passed through the port in that year (Cairns Port Authority, 1985).

Increased fishing capacity

Concerns about overfishing of Queensland's east coast prawn stocks were first addressed as a response to the introduction of a limited entry regime in the nearby Gulf of Carpentaria trawl fishery during 1977. A trawler length limit of 20 m and a combined net headrope-footrope limit of 88 m were introduced to prevent large Gulf of Carpentaria endorsed trawlers fishing in Queensland east coast state waters.

The Queensland east coast trawl fleet expanded from 699 trawlers in 1975 to 1154 trawlers in 1979 in response to increases in total prawn landings and record high prices (Jarzinski, 1982). Over the same period the value of prawns landed per trawler had decreased (Hill and Pashen, 1986). These factors stimulated the introduction of a limited entry regime to Queensland state waters in 1979. With broadly defined entry criteria and a long implementation period allowing for vessels under construction (approximately 2.5 years), trawler numbers rose further, and peaked at 1410 in 1981 (Jarzinski, 1982). Licence splitting by east coast endorsed Gulf of Carpentaria trawlers and the existence of a boat building subsidy also contributed to this increase (Hill and Pashen, 1986). The limited entry regime became truly effective in 1984 when the Commonwealth government introduced a complementary scheme to cover fishing grounds outside of Queensland state waters (seaward of the 3 nm territorial baseline). Some 1200 trawlers comprise the present Queensland prawn trawl fleet (Qld Fish Management Authority, 1986).

Fluctuations in the foreign exchange rate of the Australian dollar and the long-term dollar devaluation inflated the domestic and export

value of prawns during the 1980s. Both these market factors and the limited entry regime in itself have encouraged further capital investment in the fishery. Economic analyses suggest that a decrease in returns to capital has occurred and that a reduction in boat numbers is needed to rectify the situation (Moxon and Quinn, 1984; Anon, 1984; Hundloe, 1985; Hill and Pashen, 1986). These beliefs led to the formation of a comprehensive management plan for the East Coast Trawl Fishery in 1985 (Anon, 1985).

One of the major problems in developing effective management strategies for the fishery has been the very incomplete state of a catch and effort data base. This paper examines six sources of historical catch and effort data for the northern sector of the fishery (Fig. 1). The reliability, trends and management implications of available fishing effort data are evaluated in this report.

TREATMENT OF DATA

Data sources were identified by examining records held by government authorities and the fishing industry. Information provided by each source was collected, copied and stored at the Northern Fisheries Research Centre (Queensland Department of Primary Industries) in Cairns. A summary of the data sets and their intended purpose was tabulated, and is presented in Table 1. The six data sources vary in the extent and type of information they contain depending on the reason for their collection. The information available from each data source is summarised in Table 2.

The accuracy of measures of fishing effort data was assessed by cross-checking among data sets and comparing the results statistically. Trends in fishing effort were evaluated using two main sources:

- . data for a sample of 85 trawlers recorded in Cairns port berthage information (1983 to 1986); and
- . daily sightings of trawlers at sea between Cairns and Sharp Point (Fig. 2) using aerial surveillance post flight reports (PFR) for 1983 and 1986.

Other data sources appearing in Table 1 were used to assess the validity of the two main sources.

All variables other than trip length and duration were statistically analysed using Student's t-tests and analysis of variance. Trip length and duration data did not conform with the assumptions for parametric analysis and were analysed using a non-parametric Mann Whitney (MW) U test.

The north-eastern trawl grounds were divided into eight different study areas (Fig. 2). This enabled comparison of trawler effort by area from the aerial surveillance PFR. The data was treated as sampling without replacement. Trawler numbers for days in which there were no flights were inferred from data for flight days, on the assumption that all days were statistically similar. Average monthly trawler sightings were estimated for each study area and a total averaged for all areas and all months. Yearly figures were then calculated from the monthly data.

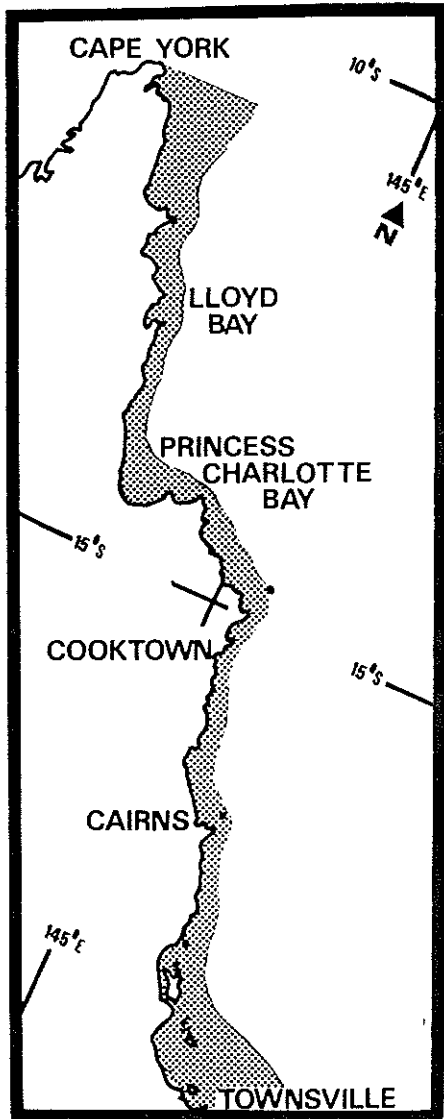


Figure 1. Prawn trawling grounds within the northern sector of the East Coast Prawn Trawl Fishery

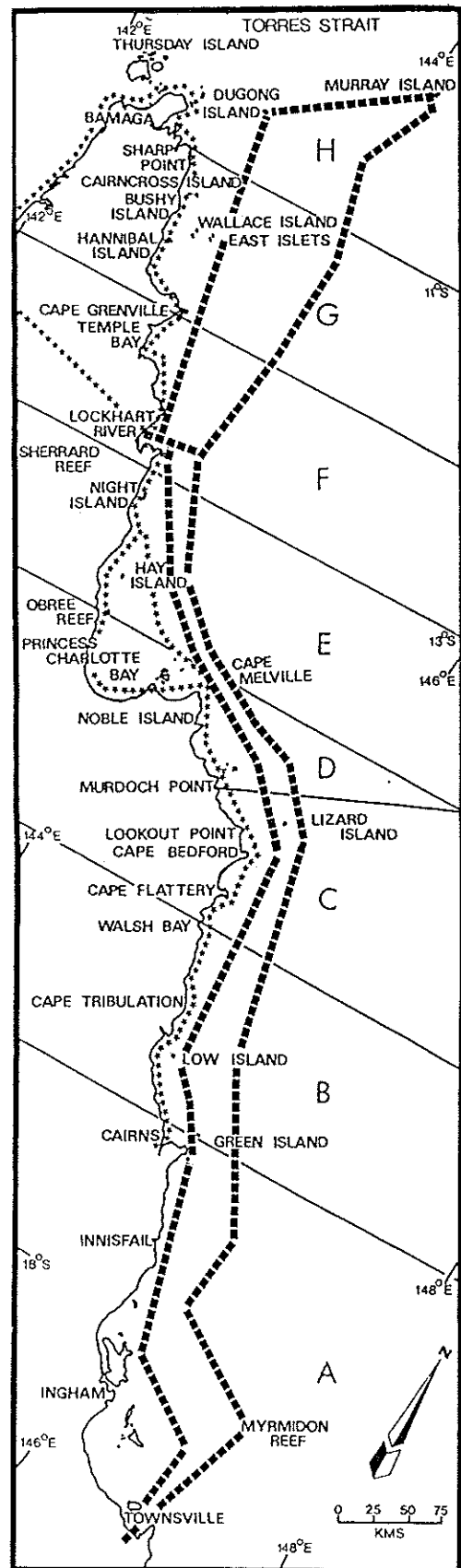


Figure 2. Study areas and aerial surveillance flight paths between Townsville and Torres Strait (Refer to key shown on page 5).

Key to study areas and aerial surveillance flight paths shown in Figure 2

Study Area	Trawl Ground	
A	Cairns south	
B	Green Is. - Walsh Bay	
C	Walsh Bay - Murdoch Pt.	
D	Murdoch Pt. - Obree Rf.	
E	Obree Rf. - Sherrard Rf.	
F	Sherrard Rf. - Cape Grenville	
G	Cape Grenville - Sharp Pt.	
H	Sharp Pt. - Torres Strait	
Surveillance Flight	Flight Path	Flight Frequency
1. offshore (reef) ■■■■■■■	a) Lockhart River to Dugong and Murray Islands. Return outer reef. b) Myrmidon Reef to Lockhart River via. outer reef. Return inner reef.	5 each month 5 each month
2. inshore *****	a) Weipa to Bamaga and then along the coast to Lockhart River. b) Cairns to Lockhart River along east coast. Return via. Cape Melville, Lizard Is. and Low Island.	every day 5 days in 7

TABLE 1: Summary of data sources

Data Set	Data Source	Reason Data Collected
1. Cairns Berthage Information	Cairns Port Authority and Piermaster's Office	A record of port useage to enable the collection of berthage fees.
2. Aerial Surveillance Post Flight Reports (PFR) (QLD)	Australian Coastal Surveillance Authority (ACT)	To detect the entry of foreign people and vessels to Australian waters and isolated coastlines.
3. Private Log Books	Trawler Skippers	An informal record of product caught (species, amounts) at particular locations and dates for personal reference.
4. Interview Surveys	Various Institutions	To provide economic, fishing gear and sea-time data and to record anecdotal information.
5. Export Inspection Service Records	Commonwealth Department of Primary Industries and Energy (Cairns Brisbane and Canberra)	To ensure Australian product standards are maintained at all stages of handling in registered export establishments.
6. Cold Storage Tally Sheets	Refrigerated Transport and Storage Establishments	To provide each establishment with a comprehensive record of product unloaded and sold.

Table 2. Summary of details provided by each data set (* indicates details available)

Detail Provided	Private Log-books	Surveys	Aerial Surveillance (PRP)	Export Inspection Service Records	Cairns Berthing Information	Cold Storage Tally Sheets
1. Skipper's name	*	*		*	*	*
2. Vessel identification	*	*		*	*	*
3. Vessel parameters (eg. length)	*	*		*	*	*
4. Daily vessel location			(at sea)		(in port)	
5. Vessel days at sea		(average)				
6. Vessel days/nights actually fished		(average)	(if daylight fishing)			
7. Vessel days for each trip	*	*			*	
8. Catch dates	*	(average)				
9. Date of unloading	*					
10. Place of unloading	*			(first and last for each unloading)		*
11. General area/s fished	*	*	*	*		
12. Shot duration	*	*				
13. Fishing gear details	*	*				
14. Average trawl speed/s	*	*				*
15. Catch weights	*					*
16. Species caught	*			(average)		*
17. Where catch sent (eg. Cairns, Japan)	(details vary)			(details vary)		(sometimes)
Time span over which records have been kept	variable	variable	1979-87	1979-87	1963-87	1984-87

ACCURACY OF THE DATA

Berthage records

Berthage records provided a measure of trawler effort based on the number of days a vessel was at sea. The reliability of these data as a measure of fishing effort (expressed as the number of days at sea) was tested by comparing a subsample of trawler berthage records with information on the same vessels in export inspection service and interview survey records.

Pairwise comparison of sea days for a subsample of 16 trawlers' berthage records in 1983 and their 1983 export inspection service records showed no significant difference in trawler effort calculated by either method (Student's t statistic (t) = 0.30, probability (p) = 0.76, 16 degrees of freedom (df) for the sample statistic derived as $N - 1$). A comparison of 1986 berthage data for a second subsample of 36 vessels with interview data from Beurteaux (1986) also showed no significant difference in the calculation of trawler effort ($t = 1.63$, $p = 0.11$, 36 df).

The similarity in the results of effort measured from different sources suggests that trawler berthage information provides a reliable estimate of effort measured as days at sea.

Aerial surveillance post flight reports

Surveillance data provide a measure of trawling effort based on the average number of trawlers sighted in the surveyed area each day. In the area between Cairns and Bushy Island, the principal trawling areas occur within 25 km of the coast (Fig. 1 and Fig. 2). Specific trawl grounds are very localised. Areas most consistently fished include the grounds between Cooktown and Lookout Point, between Noble Island and Cape Melville, and between Princess Charlotte Bay and Lloyd Bay (Purnell-Webb, 1983). North of Bushy Island the trawl grounds are further offshore, following the 'sandbanks' area from Dugong Island to the Torres Strait (Beurteaux, 1986).

Flight frequency and flight routes covered in the aerial surveillance PFR for the area north of Townsville are shown in Fig. 2. It is not possible to determine a measure of effort for individual vessels from the aerial surveillance PFR as these provide numbers of trawlers only and not individual identification. For this reason it is not possible to test the accuracy of surveillance data by comparison with other fishing effort measures.

Flights along inshore coastal areas provide the most comprehensive trawler effort data available (expressed as the average number of trawlers present in an area each day) and should include almost the whole population of trawlers present on the trawl grounds each day. Trawl grounds in the centre of Princess Charlotte Bay are missed by the aerial surveillance methodology. Trawlers are also not separated from other fishing vessels in the records after June 1986. These problems have been accounted for in the analysis of fishing effort trends (Beurteaux, 1986).

TRENDS IN FISHING EFFORT

Berthage data

Number of trawlers using Cairns port facilities

The number of trawlers using Cairns port increased during the 1980s to 419 in 1986, even though the total Queensland fleet had declined over the same period (Fig. 3). Over 20% of the Queensland trawl fleet now regularly use Cairns port facilities and the northern fishing grounds.

Changes in sea-time (fishing effort) and trip length

Analysis of berthage records showed that 34% of the variation in trawler sea-time was related to the vessel length and licence type of the trawlers sampled. Other variables (such as weather, breakdowns, catch rates, skipper type (owner or employed) and the use of motherships and fuel barges etc.) would be expected to make up the remaining variation.

Fishing effort for trawlers licenced to fish only on the east coast has not changed significantly since 1983 ($f = 0.52$, $p = 0.67$, 150 df), although a reduction in the length of the fishing year occurred in 1985 and 1986 as a result of seasonal closures. These trawlers spent on average 206 \pm 4.3 SE days at sea in each year after 1983 (Table 3, Fig. 4). The number and duration of fishing trips between 1983 and 1986 remained the same for all licenced trawlers (Table 4).

Dual licenced trawlers are able to trawl in both the Gulf of Carpentaria and Queensland East Coast fisheries. These trawlers recorded consistently higher levels of effort in each year than trawlers licenced only for the east coast (Table 3). Effort increased from 214 \pm 20.5 SE sea days in 1983 to 252.8 \pm 11.9 SE sea days in 1986 for dual licenced trawlers (Fig. 4). The apparent reduction in effort (Fig. 4) during 1985 and 1986 for trawlers licenced only for the east coast was not statistically significant (Table 5). Dual licenced vessels undertook significantly fewer trips each year than vessels licenced only for the east coast (MW statistic (z) = 9.35, $p = 0.00$), and each trip was longer ($z = 9.25$, $p = 0.00$).

Trawler length was also related to effort measures (Pearson's correlation coefficient (r) = 0.3408, $p > 0.05$) and licence type (Table 6). Dual licenced trawlers were significantly larger than those licenced only for the east coast ($t = 8.83$, $p < 0.05$, d.f. = 220). These larger trawlers are of greater capacity (for example fuel, refrigeration space) and are more often driven by employed skippers than are east coast only licenced trawlers. Beurteaux (1986) showed that trawlers of large capacity and trawlers driven by employed skippers make, on average, longer fishing trips than small, owner driven vessels.

Summer closures and fishing effort

The time trawlers spent in port during the summer off-season was initially compared for two years before trawling closures were implemented (1983 and 1984).

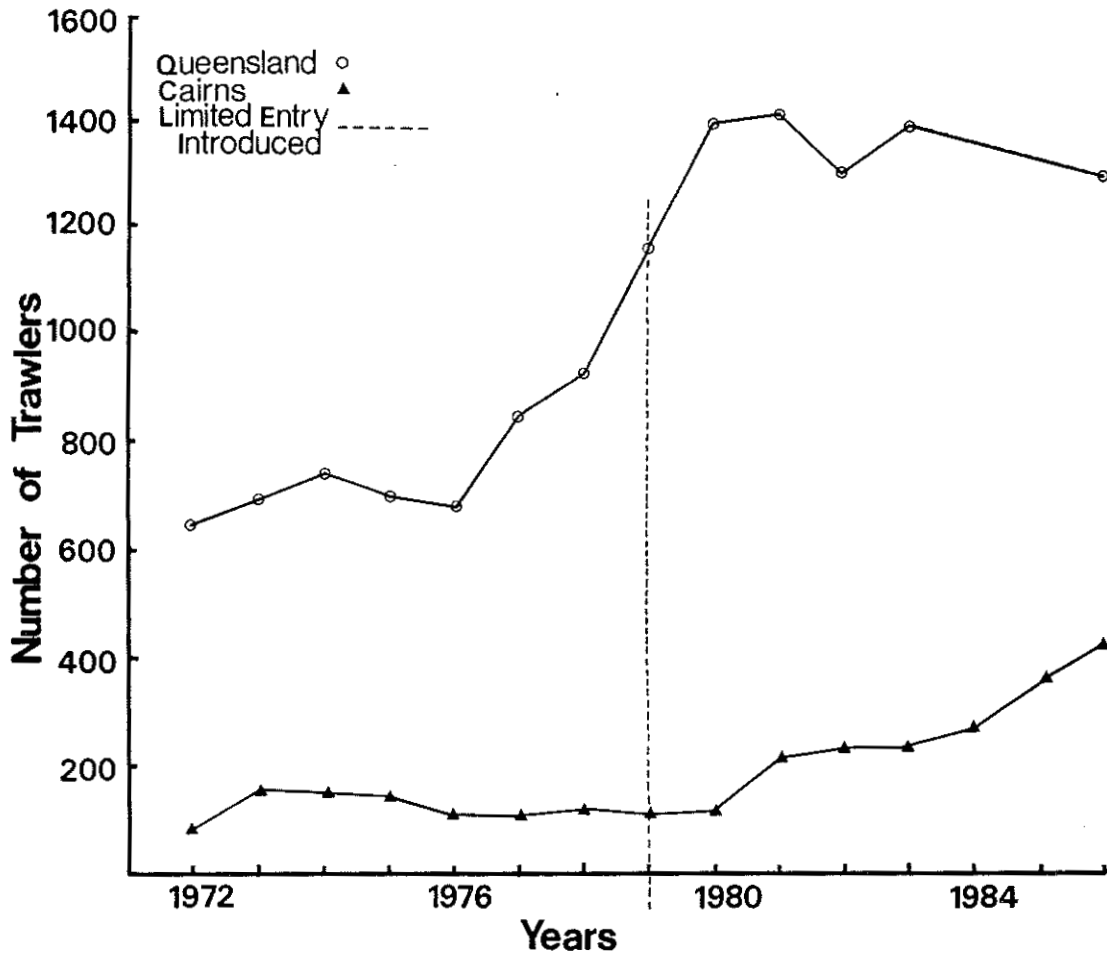


Figure 3. Number of trawlers using Cairns port compared with the total Queensland fleet (1972 - 1986)

source: Cairns berthage records, QFMA licence data and records collated by QDPI

TABLE 3. Average annual sea-time (fishing effort) for differently licenced trawlers

Licence Type	1983			1984			1985			1986			All Years		
	N	Average No. of days	S.E.	N	Average No. of days	S.E.	N	Average No. of days	S.E.	N	Average No. of days	S.E.	N	Average No. of days	S.E.
1. Dual licenced trawlers	16	214.1	20.54	17	237.9	12.40	20	247.5	11.15	20	252.8	11.96	76	244.9	6.16
2. East coast only licenced trawlers	37	208.5	7.91	30	213.4	10.78	39	198.7	8.79	45	201.4	8.55	158	205.6	4.31
3. All trawlers	52	214.2	7.30	47	222.3	8.31	59	215.3	7.51	65	217.2	7.54	228	217.1	3.82

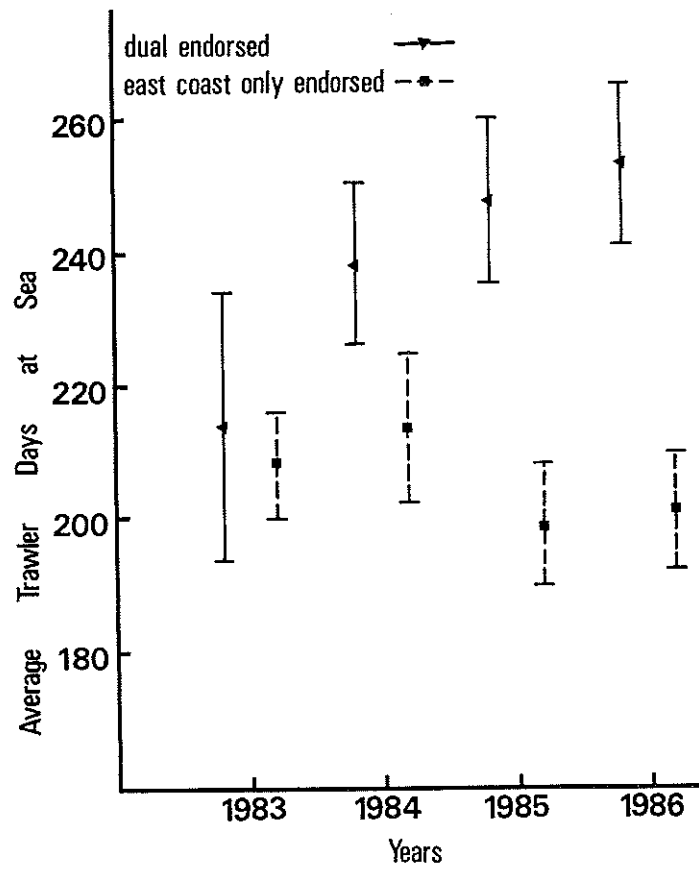


Figure 4. The average annual effort for dual and east coast only licenced trawlers using Cairns (1983 - 1986)

Mean trawler days at sea and 95% confidence limits are shown.

TABLE 4. Significance values for trip length and number of trips per year for differently licenced trawlers

Licence Type	Anova	F	d.f.	Sig.
1. Dual licenced trawlers	No. trips per year	1.95	3, 68	ns
	No. days per trip	1.03	3, 68	ns
2. East coast only licenced trawlers	No. trips per year	1.37	3, 147	ns
	No. days per trip	0.46	3, 147	ns

TABLE 5. Average length and number of fishing trips for differently licenced trawlers

Licence Type	N	Trip Length (days)				Number of Trips (annually)			
		Average	S.E.	Mode	Range	Average	S.E.	Mode	Range
1. Dual licenced trawlers	72	91.8	1.55	24	13-332	4.4	1.26	3	1-22
2. East coast only licenced trawlers	151	27.4	1.56	17	1.5-125	11.3	0.37	8	2-150
3. All trawlers	223	47.6	3.68	17,47	5-332	7.8	0.29	3	1-26

TABLE 6. Average length of differently licenced trawlers

Licence Type	N	Average Length (metres)	S.E.
1. Dual licenced trawlers	72	16.8	0.18
2. East coast only licenced trawlers	151	14.6	0.18
3. All trawlers	223	15.3	0.15

A further comparison of the time trawlers spent in port during the summer off-season was made for a two-year period when closures were in force (1985 and 1986) (Table 7). There was no significant difference in the time spent in port during the summer off-season in either period for dual licenced trawlers ($z = 0.32$, $p = 0.75$). East coast only licenced trawlers were in port for longer in the summer off-season during the closure years ($z = 2.41$, $p = 0.02$).

TABLE 7. Days in port during the summer off-season for differently licenced trawlers

Days in Port						
Licence Type	Years before closures (1983-84)			Years during closures (1985-86)		
	N	Average No. of days	S.E.	N	Average No. of days	S.E.
1. Dual licenced trawlers	32	71.2	6.42	40	75.5	6.34
2. East coast only licenced trawlers	67	67.2	4.71	84	78.5	4.01
3. All trawlers	99	65.6	3.81	124	77.5	3.39

Aerial surveillance post flight reports

Trawlers using north-eastern trawl grounds

Analysis of surveillance PFR for 1983 and 1986 reveals an increase between 1983 and 1986 in the total number of trawlers operating on trawl grounds between Cairns and Sharp Point (Table 8, Fig. 5). A 33.7% increase in the annual average number of trawlers sighted by aerial surveillance on north-eastern trawl grounds between 1983 and 1986 can partly be explained by a 78.3% increase in the annual number of trawlers visiting Cairns port (Fig. 3).

TABLE 8. Average daily vessel sightings between Cairns and Sharp Point in the years 1983 and 1986

Year	Average Daily Sightings (N of vessels)	S.E.
1983	44.446	0.158
1986	66.102	0.879

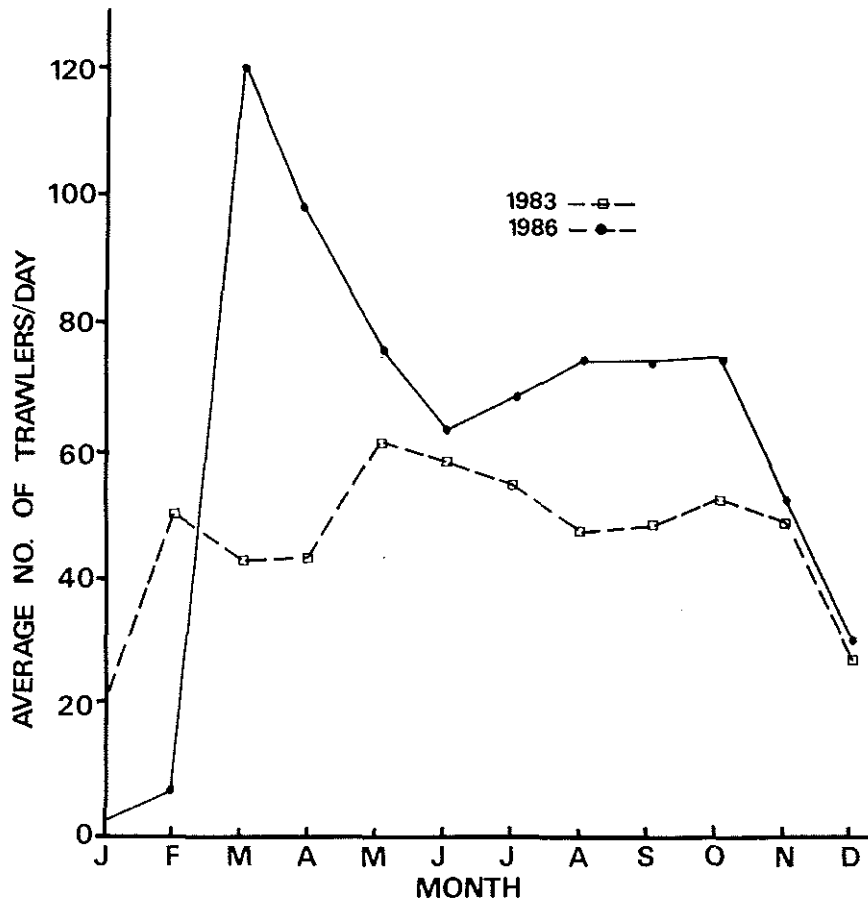


Figure 5. The average number of trawlers sighted each day between Cairns and Sharp Pt. (1983, 1986)

Summer closures and fishing effort

Trawler effort based on average daily trawler sightings each month on north-eastern trawling grounds was compared for each of the study years (1983 and 1986). Figure 5 shows that trawler effort was spread more evenly throughout 1983 than in 1986. The closure to trawling in 1986 reduced the effective fishing year by two months (that is, January and February were excluded) but does not account for the reduction in effort after October of that year. A pulse effect induced by the closure is evident at the commencement of the 1986 trawling season. Average daily trawler sightings were 176% higher in March of 1986 than in March of 1983.

Changes in effort on major trawl grounds

A 72.7% increase in trawler effort occurred between March 1983 and March 1986 in area D (Fig. 6). This area includes the extensively trawled major tiger prawn ground of Princess Charlotte Bay (Fig. 2). The reduction in fishing effort here after July 1986 was greater than in other areas.

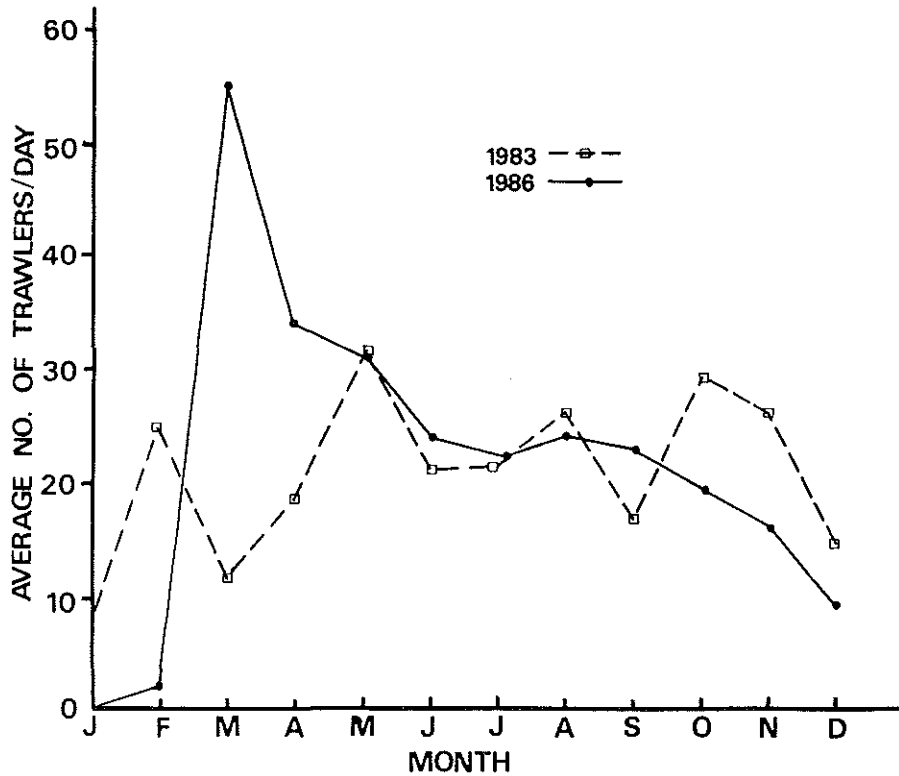


Figure 6. The average number of trawlers sighted each day in study area D (1983, 1986)

In 1983, 21.2% and 45.2% of the total fishing effort occurred in areas C and D respectively (Table 9). Area C includes the major trawl grounds of Cape Bedford and Cape Flattery (Fig. 2). These areas experienced the least annual change in effort from 1983 to 1986 (Table 9). Fishing effort at these sites may have already reached a maximum sustainable (or higher) level.

Fishing effort increases in areas B and G between 1983 and 1986 were greater than the average figure of 33.7%. Comparison of individual trawler anchorages in area G from aerial surveillance data shows that effort north of Hannibal Island to Bushy Island, and east to the East Islets has increased greatly (Fig. 7, Table 10). The lowest annual effort increase in the vicinity of these islands was 66.7% at Wallace Island, while the highest annual effort increase was 891.7% at Bushy Island and Cairncross Island (Fig. 7, Table 10). Trawlers were sighted at some anchorages in area G for the first time in 1986. These data support anecdotal information provided by Cairns based trawlermen, suggesting that the increasing use of sonar and satellite navigation technology by the trawl fleet has enabled significant expansion in area G (Beurteaux, 1986).

TABLE 9. Average daily trawler sightings in 1983 and 1986 for trawled areas between Cairns and Sharp Point

Trawled Area from Figure 2	Daily Trawler Sightings				Percentage Increase in Sightings (1983 - 1986)
	1983		1986		
	Average No. Sightings	S.E.	Average No. Sightings	S.E.	
A	No inshore flights in Area A				—
B	5.505	0.055	15.539	0.435	182.2
C	9.866	0.076	10.865	0.404	10.1
D	20.982	0.116	22.058	0.578	5.1
E	3.768	0.047	4.944	0.260	31.2
F	4.788	0.036	6.294	0.106	31.4
G	1.537	0.022	2.402	0.082	56.3
H	Torres Strait data not yet analysed				—

TABLE 10. Annual trawler sightings in 1983 and 1986 for anchorages in study area G (Figure 7) (Refer also to key shown on page 18).

Anchorage see Figure 7	No. of Vessels Sighted		Percentage Increase in Sightings (1983 - 1986)
	1983	1986	
1	281	808	187.5
2	110	137	24.5
3	12	119	891.7
4	77	88	14.3
5	10	38	280.0
6	1	26	250.0
7	4	16	300.0
8	8	16	100.0
9	9	16	77.8
10	3	12	300.0
11	2	10	400.0
12	5	10	100.0
13	3	4	66.7
14	2	4	100.0
15	0	2	200.0
16	0	1	100.0

Key to trawler anchorages shown in Figure 7 and Table 10

Anchorage No.	Anchorage Name
1	Margaret Bay, Thorpe Pt.
2	Cape Grenville, Home Is., Hicks Is.
3	Bushy Is., Cairncross Is.
4	lower Shelburne Bay
5	Ussher Pt.
6	East Islets, Halfway Is.
7	Hannibal Is., Pirie Is.
8	Orford Ness, Orford Bay
9	False Orford Ness
10	Sadd Pt., Furze Pt.
11	Tern Is.
12	Cockburn Is., Magra Is., Guthray Rf.
13	Wallace Is., Boydong Is.
14	Hunter Pt., Hunter Rf.
15	Arnold Is.
16	Bird Is.

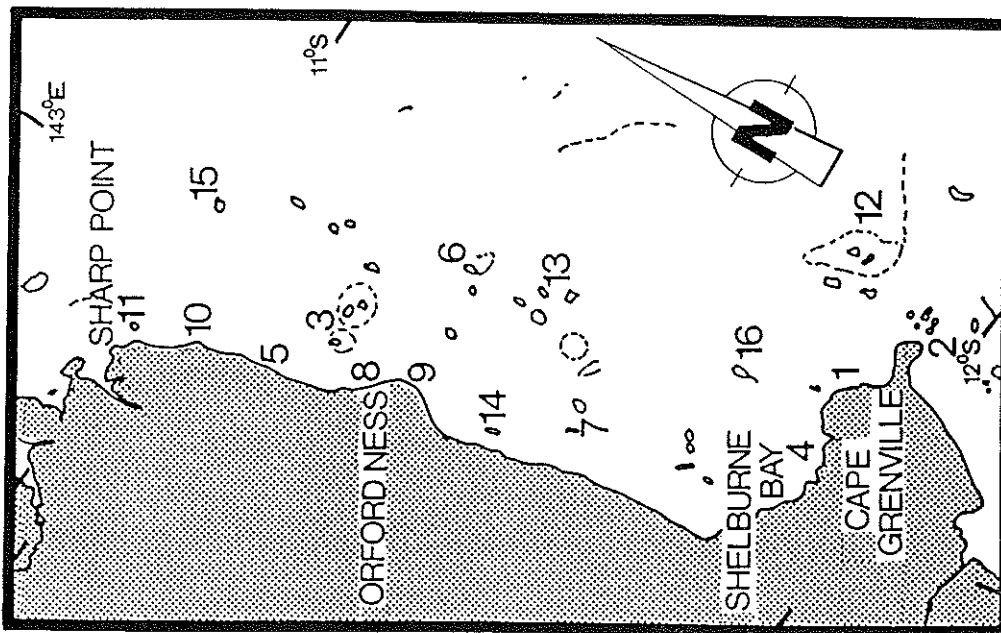


Figure 7. Primary trawler anchorages in study area G (1983, 1986).

(Refer to accompanying key).

DISCUSSION

Results presented in this study indicate that Cairns port berthage data and aerial surveillance data provide a reliable historical record of trawler effort for the north-eastern coast. It is anticipated that export inspection service records will provide correspondingly accurate catch data. It would be of great benefit for the management of the fishery if these data bases were supplemented by a representative sample of private log books and cold store tally sheets. Private logs and tally sheets can furnish the only **detailed** historical information in the absence of formal logbooks.

With long-term details on actual trawling time (days, hours), trawl speeds, size and species composition of catches, and data for specific trawl grounds, comprehensive trends in CPUE could be deduced for the north-eastern trawl fishery. In the meantime, however, certain tendencies are already apparent. Previous evidence based primarily on data from southern Queensland has indicated trends of increasing effort, decreasing CPUE and decreasing returns to capital for the East Coast Prawn Trawl Fishery. We have now conclusively documented a trend of increasing effort for the north-eastern sector of the fishery.

The effect of such trends can not be completely assessed until corresponding catch data are analysed. Studies undertaken for prawn trawl fisheries in the nearby Gulf of Carpentaria (Poiner and Harris, 1986) and in Torres Strait (Channels *et al.*, in press) show that trawling effort affects both the diversity and the abundance of species trawled. Poiner and Harris (1986) noted that diversity changes were usually associated with habitat modification, while reduced abundance was related directly to fishing pressure.

Increases in the number of trawlers operating along the north-eastern coast (in time and space) and increases in the amount of effort expended by each trawler, could result in a drop in the CPUE, and in a change in the relative abundance of target species. Circumstantial evidence provided by industry suggests that both the CPUE and the relative abundance of the most economically viable prawn species are already decreasing on some north-eastern trawl grounds (Beurteaux, 1986). In the extreme case a recruitment failure would result. Evidence suggests that this has already occurred in the Arabian Gulf shrimp fishery (NFC, 1982) and the Australian Exmouth Gulf tiger prawn fishery (Penn and Caputi, 1985).

Our results indicate a recent intensification of the seasonal south-to-north migration of trawlers first recorded in 1979 (Williams, 1981). The introduction of motherships, fuel barges and seasonal closures to north-eastern trawling grounds may have enhanced this migration. Beurteaux (1986) has shown that the increased availability of fuel on north-eastern trawl grounds brought about by the introduction of private

motherships and fuel barges from 1980-81 provided Cairns trawlers with the potential to extend their average trip duration by a factor of three.

During 1979, fishing effort was spread fairly evenly along the whole Queensland coast (Williams, 1981). In 1983 and 1986 trawler effort was not spread evenly through north-eastern trawl grounds, either in time or by area. Many trawlers visited north-eastern trawl grounds only at the commencement of the fishing season in each year (Fig. 5), while much of the annual increase in effort during 1986 involved expansion of the areas trawled. These factors also explain the apparent discrepancy in the annual effort increase from 1983 to 1986 when comparing berthage data (Fig. 3) with aerial surveillance records (Fig. 5 and Table 8).

The increase in fishing effort noted in Area B may be partly explained by its proximity to Cairns. As Cairns is the only major port for the north-eastern trawl grounds, most trawlers return there after each trip. This factor, and the 78.3% increase in the annual number of trawlers visiting Cairns in 1986 as compared with 1983 (Fig. 3) would lead to an apparent increase in effort close to Cairns.

It is possible that the major trawl grounds in areas C and D were already fully exploited in 1983 as they have not experienced a large annual increase in effort since that time. Most of the annual increase in effort for the whole north-eastern sector from 1983 to 1986 involved expansion into new off-shore red spot king prawn grounds where the aid of modern navigational technology is required. It is likely that further expansion in the north will be possible only into similar such off-shore areas which are largely restricted to discontinuous inter-reef patches. Without vessel-specific CPUE data, expansion in the area trawled will mask reductions in overall CPUE that may be occurring on inshore trawl grounds.

The usual winter peak in trawler effort (Williams 1980, 1981 and this study in 1983) shifted forward to March in 1986 as a result of the 1985-86 closure (Fig. 5). This closure was introduced to prevent the capture of juvenile prawns and thus reduce growth overfishing on the north-eastern coast. In March-April 1986, an unusually large volume of juvenile prawns arrived on the Brisbane market, possibly as a result of this pulse in effort (Penwarden, pers. comm.). An overall reduction in the possible returns to fishermen for the 1986 season may have resulted from this event as juvenile prawns command a lesser price than adult prawns.

The rapid reduction in effort which occurred in area D after August 1986 (Fig. 6) suggests a corresponding drop off in catches. If the number of mature female prawns left in Princess Charlotte Bay was significantly reduced as a result, it is possible recruitment may have been affected in the 1987 season. Until catch data can be assessed to determine the economic benefits of the closures and more is known about the migration and intermingling of prawn stocks, the long term effects of pulses of fishing effort on the recruitment levels of each target species remain unknown.

Sea-time (fishing effort) for Cairns-based trawlers licenced to fish only on the east coast did not change with the introduction of closures, although these vessels spent longer in port over the off-season in closure years. It is likely that these vessels reduced their non-working days

during the season, using their time in port more effectively by refitting during closures. Cairns-based dual licenced trawlers were apparently not greatly affected by the implementation of seasonal closures on the Queensland east coast, having always spent this time in port to refit.

A trend of increasing sea-time for Cairns-based dual licenced trawlers may indicate a problem of decreasing returns for these vessels which must now spend longer at sea to be profitable. It is possible that dual licenced trawlers are the least efficient components in both the Gulf of Carpentaria and Queensland east coast fisheries. Larger, high-powered company trawlers and their accompanying spotter planes are probably more time efficient in locating and trawling boils of banana prawns in the Gulf of Carpentaria, while smaller, low-powered trawlers licenced for the east coast only, may be more cost-effective on the disjointed trawl grounds of the north-eastern coast. Dual licenced trawler overheads are certainly higher than those of east coast only licenced trawlers because they are significantly larger, employ more crew and generally travel greater distances to fishing grounds (Beurteaux, 1986). Fifty-six of the 87 dual endorsed vessels in the East Coast Trawl Fishery were based in Cairns port in 1986 (Qld Fish Management Authority, 1986).

Trends in fishing effort identified indicate that the East Coast Prawn Trawl Fishery is in a state of change. Changes in effort documented for trawl grounds in the north-eastern sector of this fishery since 1983 have resulted from the interrelationship of many factors. These factors include:

- . an increase in the number of trawlers fishing on north-eastern trawl grounds;
- . an increase in the geographic extent of trawled grounds due to advances in navigational technology within the trawl fleet;
- . changes in the seasonal pattern of fishing effort on north-eastern trawl grounds partly resulting from closure implementation; and
- . changes in sea-time for Cairns-based trawlers related to trawler length and licence type, skipper type (employed or owner) and the introduction of mothership and fuel barge facilities to north-eastern trawl grounds.

As the interrelationship of causal factors and the long-term implications of fishing effort trends are not well understood, both an **accurate** and **detailed** monitoring capability will be essential for the continued prosperity of this fishery.

CONCLUSIONS

- . The East Coast Prawn Trawl Fishery is in a state of change and the implications for management should be closely monitored.
- . Dual-licenced trawlers are possibly inefficient in both the Gulf of Carpentaria and East Coast Prawn Trawl Fisheries.

- . Seasonal closures have not reduced the annual sea-time of any class of trawler.
- . Time spent in port now occurs in a single block for east coast licenced trawlers rather than being spread across the year.
- . Commonly used north-eastern trawl grounds appear to be fished to maximum sustainable levels.
- . Fishing effort on the north-eastern coast has increased on trawl grounds north and east of Shelburne Bay in recent years.

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