Use of TIB Docket-Book Data to construct an Annual Abundance Index for Torres Strait Rock Lobster – 2017 Update

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1. Introduction

The Torres Strait Seafood Buyers and Processors Docket Book (TDB01), until recently was used in the TIB sector of the Torres Strait rock lobster fishery to record the catch sold by fishers (known as sellers on the Docket-Book) at the end of a fishing trip. It was replaced on 1 December 2017 by the mandatory Torres Strait Catch Disposal Record TDB02. However, unlike the Daily Fishing Log (TRL04) used in the TVH sector of fishery, which requires catch and effort data to be recorded for individual fishing operations related to each vessel tender, the Docket-Book required only aggregate catch and effort data to be recorded at the end of each trip. Nevertheless, both sets of catch and effort data recorded in each sector of the fishery have proven useful in constructing abundance indices for the fishery, and are now integral and equal weighted components of the Harvest Control Rule used to help determine an appropriate annual TAC. This document provides the latest update of the data and analyses undertaken for constructing the abundance index based on the Docket-Book data for the TIB sector (see Campbell et al, 2014, 2015, 2016).

2. Estimation of Total TIB Catch

A copy of the DB01 Docket-Book is shown in Appendix A. The docket-book records the transaction date, the name of the seller together with details of the catch (in weight) and the price obtained. Additional information is also provided regarding the vessel, the number of crew, the number of days fished and the fishing methods used. This information therefore provides a measure of both the catch and effort for a given seller (or fisher) during a fishing trip and hence can be used to gain a measure of the catch rate (weight of lobsters caught per day fished) during that trip.

However, there are a number of issues with the Docket-Book system which create problems with using this data for estimating the total catch and effort in the TIB fishery. These issues include:

i. The requirement that completion of the docket-book is only voluntary,
ii. The fact that catches recorded in the docket-book can also be reported elsewhere, including the TVH logbook,
iii. The fact that processors can also record catches in the docket-book, essentially creating duplicates.

Given the duplication of catch information from both the TVH sector and processors which occurs in the docket-book data, several filters have been developed and applied to this data in an attempt to identify and remove these duplicates. Further to these issues, several large TIB boats for a period of time only recorded their catch in the TVH-related logbook (TRL04) and these catch records need to be transferred to the TIB database. This occurred because some TIB operators believed the TRL04 Logbook was mandatory, though they later became aware reporting for TIB is currently voluntary.

Finally, between 2013 and 2016 two processors reported aggregate annual catch data to AFMA as the these catches were also not being recorded in the TDB01 Docket-Book. Each processor reported the catch for tailed and whole lobsters separately, so that for each year two catch records were added to the TIB database for each processor to account for these additional catches.

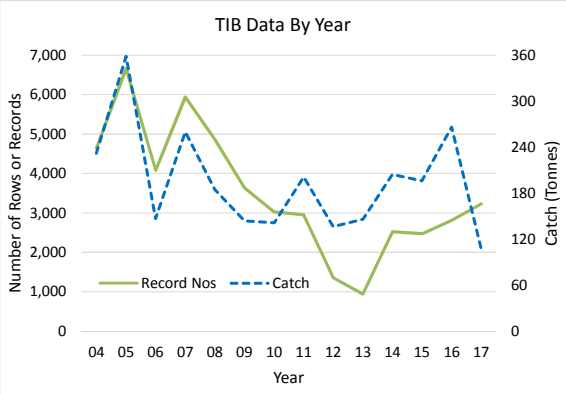
Considerable effort has gone into understanding the nature of both the TDB01 Docket-Book and TRL04 Logbook data so as to identify the catch records that should be assigned to the TIB sector of the fishery. A full description of the approach and data-rules used to identify and remove these duplicate records from the Docket-Book data is described in Campbell and Pease (2017). A total of 49,130 catch records have now been attributed to the TIB fishery covering the years 2004 to 2017. A few Docket-Book records (37) having a zero catch of lobsters are not included in this total as it is assumed that other species may have been targeted on these trips. Note, a catch record for the purpose of the data summarised in this report pertains to the catch and effort information provided on a single page in either the TDB01 Docket-Book or TRL04 Logbook and for which a unique Record-Number (Record-No) is attributed. Within the TIB database there are usually multiple rows of catch information associated with each catch record (defined by its unique Record-No) as the catch is separately recorded by process form and perhaps grade.

The number of catch records and the associated estimate of the total catch of rock lobsters in the TIB sector each year, and by data source, is shown in Table 1 and Figure 1. Between 2004 and 2007 all TIB related catch is sourced from the TDB01 Docket-Book, and the number of catch records each year varied between 4,082 and 6,664. After this time, and between 2008 and 2015, a portion of the total catch attributed to the TIB sector was recorded in the TRL04 Logbook. While the related catch was usually small (<10 tonnes) this catch nevertheless represented over 20% of the total TIB catch in both 2012 and 2013. Finally, between 2013 and 2016 a significant portion of the total TIB catch (between 33% in 2014 and 55% in 2016) was attributed to the aggregate catch data provided by several processors (as this catch was not recorded in the Docket-Book).

Table 1. Number of distinct TIB Record Nos by year and the related catch by data source. Note, PRC relates to the aggregate catch provided by several processors.

	Records by Data Source			Total	Catch by Data Source			Total Catch	
Year	TDB01	TRL04	PRC	Records	TDB01	TRL04	PRC	(kg)	Tonnes
2004	4642	0	0	4,642	232,031	0	0	232,031	232
2005	6664	0	0	6,664	358,474	0	0	358,474	358
2006	4082	0	0	4,082	146,946	0	0	146,946	147
2007	5939	0	0	5,939	260,122	0	0	260,122	260
2008	4755	114	0	4,869	174,724	10,223	0	184,947	185
2009	3540	95	0	3,635	135,898	7,964	0	143,862	144
2010	2962	62	0	3,024	135,517	5,686	0	141,203	141
2011	2945	9	0	2,954	200,144	1,025	0	201,168	201
2012	1185	167	0	1,352	107,391	29,032	0	136,423	136
2013	763	175	2	940	57,157	33,562	55,411	146,130	146
2014	2487	32	2	2,521	135,450	2,456	66,662	204,568	205
2015	2443	25	2	2,470	118,066	1,333	76,904	196,303	196
2016	2806	0	4	2,810	118,726	0	147,380	266,106	266
2017	3228	0	0	3,228	106,356	0	0	106,356	106
Total	48,441	679	10	49,130	2,287,000	91,283	346,357	2,724,640	2,725

Figure 1. (a) Number of distinct TIB catch records and associated catch (in tonnes) by year, and (b) the proportion of the annual TIB catch by data source.



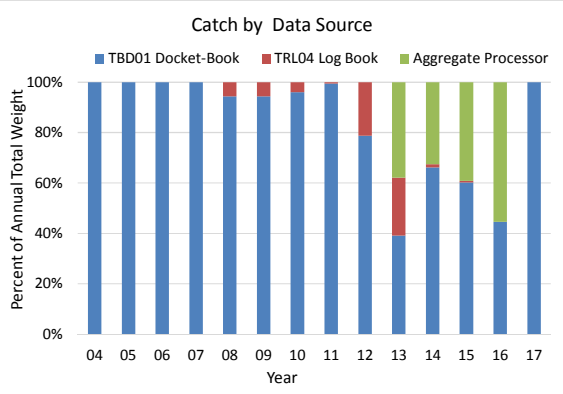


Table 1 indicates that the TIB data for 2017 is seen to be sourced entirely from the Docket-Book data (the first time since 2007). This change was the result of ongoing requests by AFMA for the Docket-Book to be used for the recording all catches. While it has been noted that a substantive portion of the total TIB catch was reported in aggregate form between 2013 and 2016, and which helps to explain the lower number of Record-Nos during this period, the large reduction in Record-No in 2012 and 2013 appears anomalous. Whether or not other catches were also not been recorded in the Docket-Book during these or in other years remains unknown.

3. The TIB Docket-Book Data

The number of distinct vessel-symbols and seller-names associated with the 49,130 TIB catch records identified above is 1,167 and 2,322 respectively. However these numbers are inflated due to different spellings and mistakes often associated with a single vessel-symbol or seller-name. Attempts have been made to correct these names, and as a result the number of distinct vessel-symbols and seller-names has been reduced by nearly half, to 656 and 1,084 respectively. However, the percentage of all records (and total catch) without a vessel-symbol remains high at 72.3% (and 73.6% respectively). On the other hand, only 1.3% of all records (and 3.5% of the total catch) have no associated seller-name.

The frequency of the fishing methods associated with all Record Nos is shown in Table.2. Just over 41% of all records, and 39.5% of the total catch, are associated with hookah-diving, while free diving and lamp fishing are associated with 26% and 4.8% of the total catch respectively. Smaller amounts of the catch are also associated with the handling and trolling, and for around 2.5% of all records the catch is associated with some combination of these five fishing methods. However, the catch method for 11.8% of all catch records (and 26.2% of the total catch) remains unknown.

The distribution of all Record Nos (and catch) across each of the 21 TIB areas (shown in Figure 1) is given in Table 3. Around 42% of the records and slightly over a quarter (27.2%) of the catch have come from the Thursday Island region, with another 17.7% and 10.0% of the total catch coming from the Mabuiag and Badu regions respectively. Ten of the 21 regions each account for less than one-percent of the total catch over all years (and only 1.4% in total). However, across all records the region fished remains unknown for 7.6% of all records (and 20.7% of the total catch).

Table 2. Number of TIB catch records (and associated catch in kilograms) by fishing method.

METHOD	N-recs	%	Catch	%
HOOKAH DIVING	20357	41.4%	1,075,159	39.5%
FREE DIVING	17380	35.4%	719,588	26.4%
UNKNOWN	5792	11.8%	714,749	26.2%
LAMP FISHING	4435	9.03%	130,658	4.80%
FREE DIVING-LAMP FISHING	371	0.76%	25,661	0.94%
FREE DIVING-HOOKAH DIVING	243	0.49%	25,262	0.93%
DIVING UNSPECIFIED	214	0.44%	15,897	0.58%
HANDLINING-FREE DIVING	141	0.29%	7,182	0.26%
HOOKAH DIVING-LAMP FISHING	31	0.06%	3,139	0.12%
TROLLING-FREE DIVING	44	0.090%	1,293	0.047%
HANDLINING	30	0.061%	812	0.030%
UNKNOWN-HOOKAH DIVING	18	0.037%	933	0.034%
FREE DIVING-HOOKAH DIVING-LAMP FISHING	11	0.022%	1,485	0.055%
HANDLINING-TROLLING-FREE DIVING	18	0.037%	561	0.021%
UNKNOWN-FREE DIVING	13	0.026%	419	0.015%
FREE DIVING-UNKNOWN	12	0.024%	659	0.024%
HOOKAH DIVING-UNKNOWN	3	0.006%	284	0.010%
UNKNOWN-LAMP FISHING	3	0.006%	49	0.002%
UNKNOWN-FREE DIVING-LAMP FISHING	3	0.006%	228	0.008%
TROLLING	3	0.006%	202	0.007%
LAMP FISHING-FREE DIVING	1	0.002%	53	0.002%
UNKNOWN-FREE DIVING-HOOKAH DIVING	1	0.002%	18	0.001%
TROLLING-DIVING UNSPECIFIED	2	0.004%	146	0.005%
HANDLINING-FREE DIVING-UNKNOWN	2	0.004%	30	0.001%
DIVING UNSPECIFIED-LAMP FISHING	1	0.002%	32	0.001%
HANDLINING-TROLLING	2	0.004%	22	0.001%
HANDLINING-DIVING UNSPECIFIED	1	0.002%	2	0.000%
ROD AND REELING-FREE DIVING	1	0.002%	30	0.001%
UNKNOWN-TROLLING-FREE DIVING	1	0.002%	74	0.003%
FREE DIVING-TROLLING	1	0.002%	13	0.000%
Total	49,135	1	2,724,640	1

The number of recorded days-fished associated with the above TIB catch records (c.f. Table 4) varies between 1 and 16 days, though is only one, two or three days for 75.6%, 6.2% and 3.1% of all catch records respectively. The days-fished remains unknown (i.e. not recorded) for 11.4% of these records (but for 26.3% of the total catch). Finally, the number of crew varies between 1 and 14 (c.f. Table 5), though is only numbers one or two for 59.1% and 26.9% of records respectively. The number of crew remains unknown for 11.8% of all records (and 28.2% of the total catch).

Figure 1. Spatial structure of the TIB data

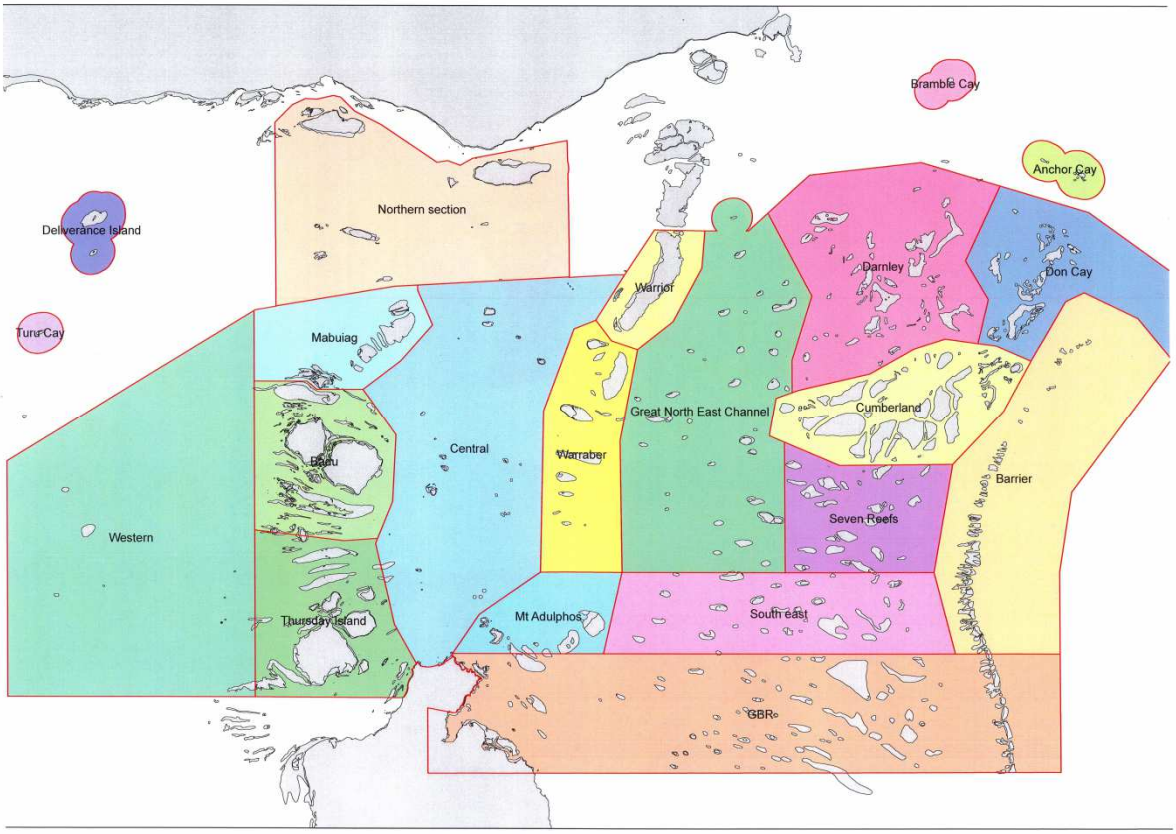


Table 3. Number of TIB records (and associated catch in kilograms) by region.

Area	Area-Name	N-recs	%	Catch	%
9	Thursday Island	20748	42.23%	741,336	27.2%
0	Unknown	3713	7.56%	563,278	20.7%
7	Mabuiag	6053	12.32%	454,694	16.7%
8	Badu	5535	11.27%	272,790	10.0%
12	Warraber	4166	8.48%	192,658	7.07%
11	Warrior	2882	5.87%	159,169	5.84%
14	Great NE Channel	1742	3.55%	96,626	3.55%
13	Mt Adolphus	682	1.39%	53,454	1.96%
17	Cumberland	782	1.59%	42,789	1.57%
16	Darnley	1217	2.5%	42,390	1.6%
10	Central	742	1.51%	38,634	1.42%
3	Northern Section	265	0.54%	27,703	1.02%
1	Turu Cay	230	0.47%	12,999	0.48%
15	South East	117	0.24%	10,897	0.40%
21	GBR	155	0.32%	10,083	0.37%
4	Bramble Cay	18	0.04%	1,470	0.05%
2	Deliverance Island	29	0.1%	1,348	0.0%
6	Western	21	0.04%	1,078	0.04%
18	Seven Reefs	8	0.02%	475	0.02%
20	Barrier	10	0.02%	345	0.01%
5	Anchor Cay	9	0.02%	238	0.01%
19	Don Cay	6	0.01%	189	0.01%
Total		49,130	1	2,724,640	1

Table 4. Number of TIB records (and associated catch in kilograms) by the number of days fished as recorded on docket-books.

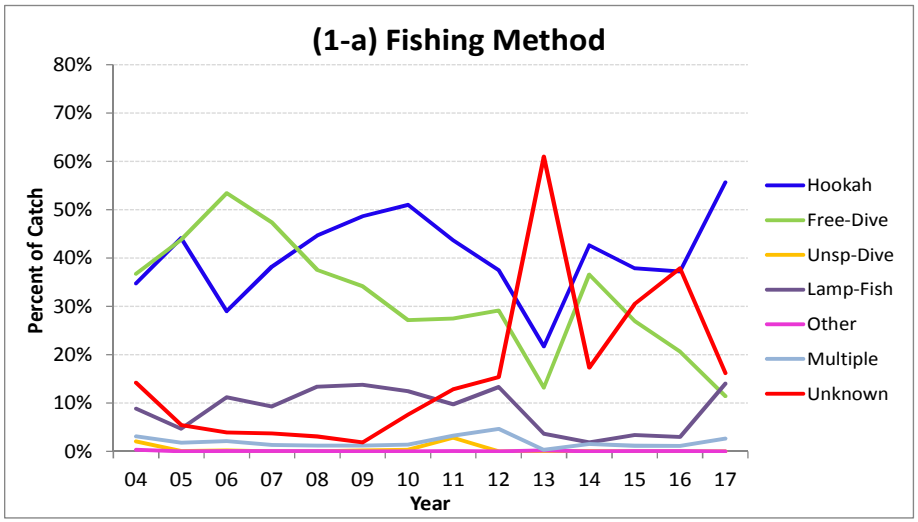
Days	N-recs	%	Catch	%
1	37,134	75.6%	1,371,597	50.3%
Unknown	5,591	11.4%	717,139	26.3%
2	3,052	6.2%	198,206	7.3%
3	1,502	3.1%	131,186	4.8%
4	695	1.4%	83,703	3.1%
5	553	1.1%	80,554	3.0%
6	186	0.4%	40,574	1.5%
7	174	0.4%	35,239	1.3%
8	95	0.2%	26,789	1.0%
9	69	0.1%	20,920	0.8%
10	32	0.1%	7,306	0.3%
11	20	0.0%	6,792	0.2%
13	8	0.0%	2,086	0.1%
14	6	0.0%	1,062	0.0%
12	8	0.0%	768	0.0%
16	3	0.0%	524	0.0%
15	2	0.0%	192	0.0%
	49,130	100.0%	2,724,640	100.0%

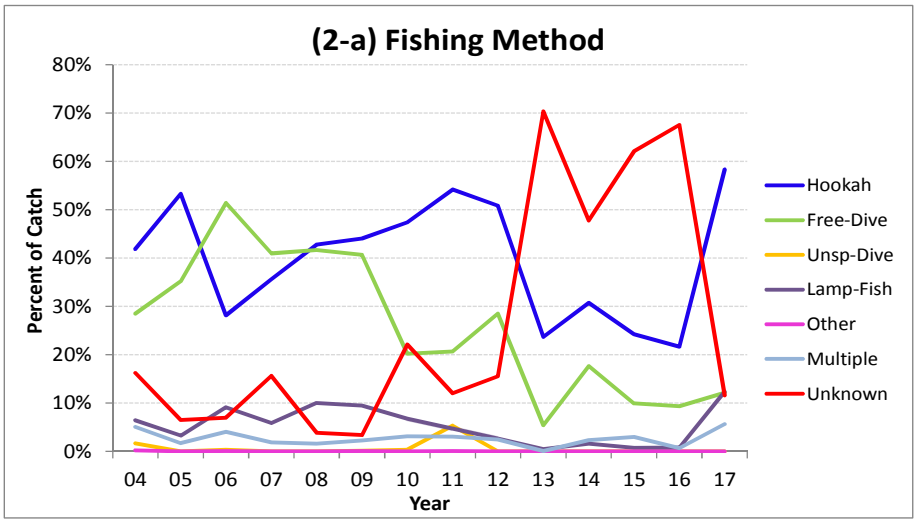
Table 5. Number of TIB records (and associated catch in kilograms) by the number of crew as recorded on docket-books.

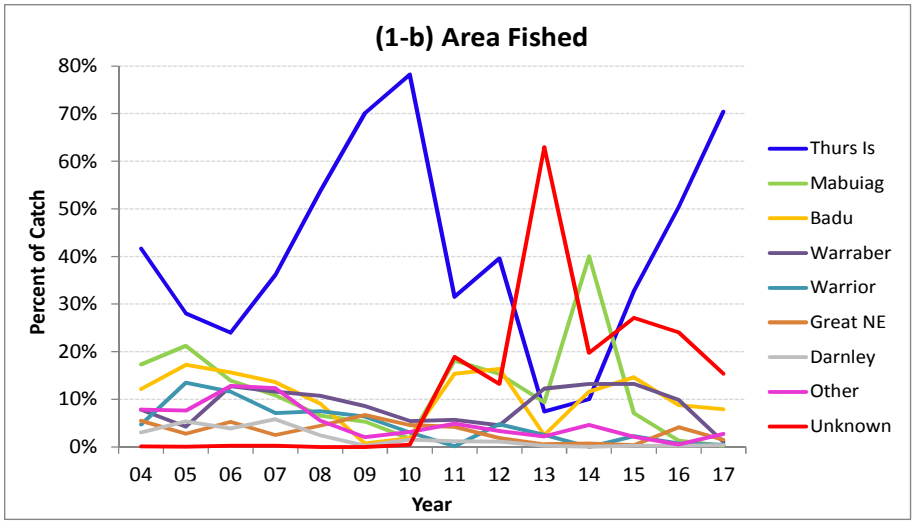
Crew	N-recs	%	Catch	%
1	29,038	59.1%	1,162,397	42.7%
Unknown	5,807	11.8%	769,655	28.2%
2	13,233	26.9%	731,346	26.8%
3	882	1.8%	46,643	1.7%
4	133	0.3%	6,655	0.2%
6	6	0.0%	3,844	0.1%
5	11	0.0%	2,492	0.1%
8	6	0.0%	1,086	0.0%
7	7	0.0%	285	0.0%
12	2	0.0%	99	0.0%
10	1	0.0%	60	0.0%
14	1	0.0%	37	0.0%
9	2	0.0%	31	0.0%
11	1	0.0%	9	0.0%
	49,130	100.0%	2,724,640	100.0%

The annual percentage of the TIB catch stratified by various levels of (a) fishing method, (b) area fished, (c) days fished and (d) number of crew are shown in Figure 3. The annual percent of blank (unknown) levels for each data field are also shown. After 2012 there was a significant increase in the proportion of the annual catch for which the information relating to these four effort variables remains unknown and this percent remains above 60% in 2016. This lack of information impedes the ability to construct indices of resource abundance that represent the distribution of lobsters across the TIB fishery based on the catch and effort data from this fishery. This is largely due to the high proportion of the total catch (>40%) in recent years which is not being recorded in the docket-books but instead is being supplied in aggregate form by processors. However, there is still room for improving the information recorded on docket-books (e.g. the fishing method was not completed for 20% of records in 2016, cf. Table 3b).

Figure 3a. Annual percent of (1) number of TIB catch records and (2) total TIB catch for the various levels of: (a) fishing method, (b) area fished in the data The percent of the annual catch for which each data field was not completed (and therefore remains unknown) is also shown.







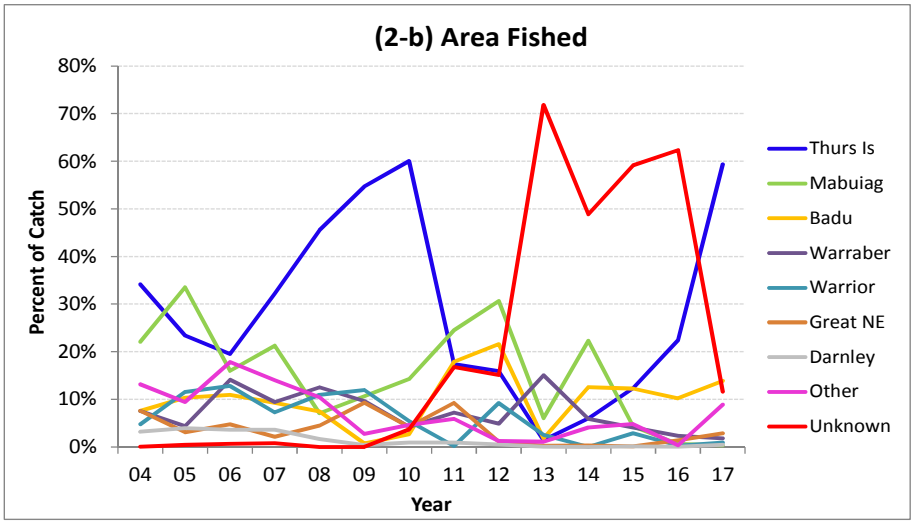
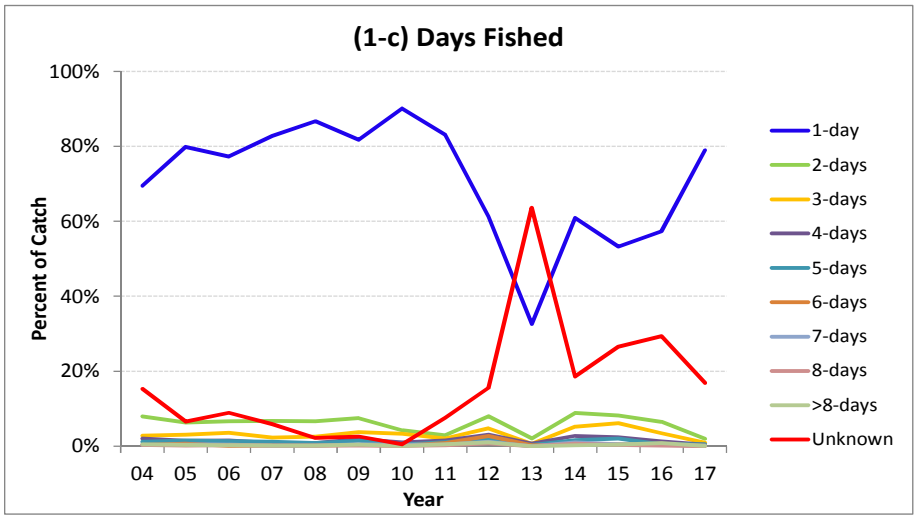
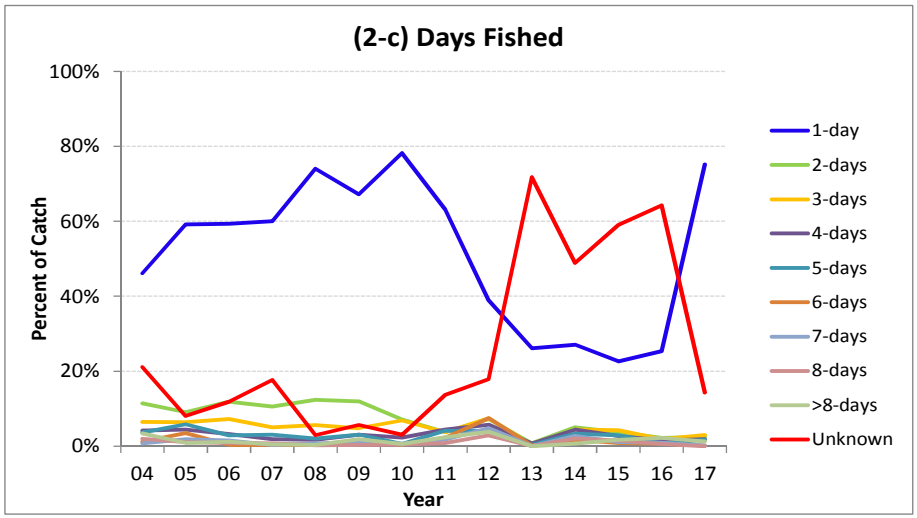
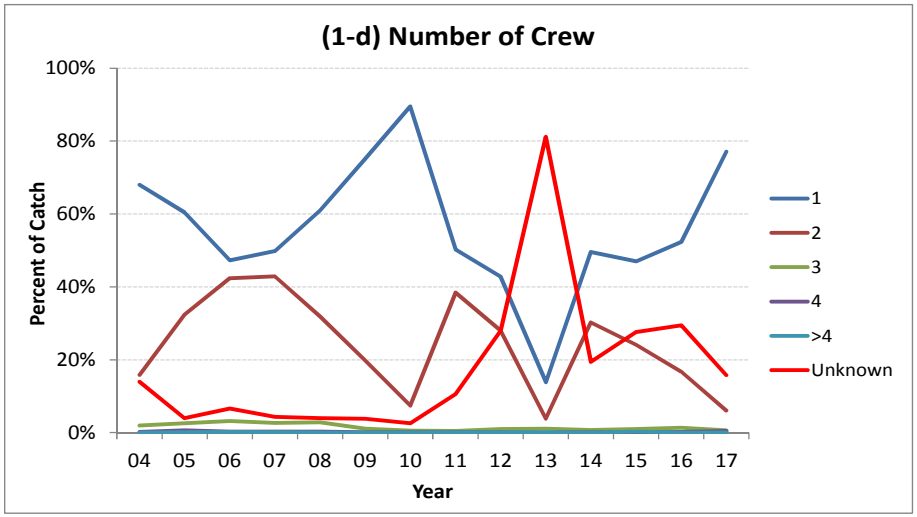
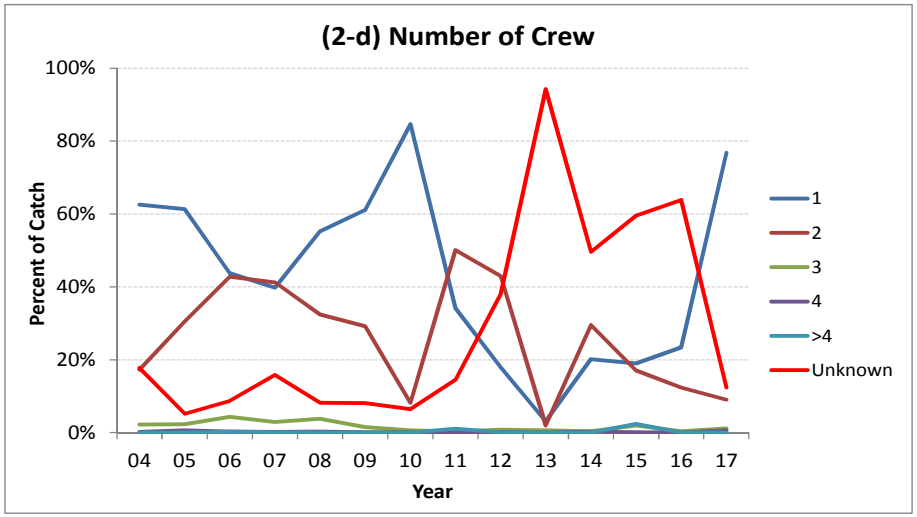


Figure 3b. Annual percent of (1) number of TIB catch records and (2) total TIB catch for the various levels of: (c) days fished and (d) number of crew The percent of the annual catch for which each data field was not completed (and therefore remains unknown) is also shown.









3. Selection of data used for CPUE analysis

Each catch record in the TIB data is associated with a Record-No, and the structure of the Docket-Book would seem to indicate that there should be a unique Record- Number for each vessel, date and seller-name. However, investigation of the data indicates that there are often multiple Record-Nos associated for a given vessel, date and seller-name. The reason for these multiple records remains unknown. In order to identity an appropriate data structure for analysis, the following procedure was adopted to filter the data:

1. The TIB data was aggregated over vessel-symbol, date and seller-name. Where the vessel-symbol or seller-name was null these fields were set to 'Unknown';
2. Only those records where the first fishing method listed in Table 2 was either 'Hookah diving' or 'Free diving' were selected. This resulted in a total of 37,243 aggregate records (hence-forth known as GLM records);
3. Only those GLM records having a unique Record-No were selected for analysis – accounting for 36,123 (97.0%) of the GLM records identified in the previous step. It was assumed that where the vessel or seller were unknown, that selection of only those GLM records having a unique Record-No limited the GLM records chosen to those associated with a single vessel and a single seller;
4. An additional check was made to ensure that the number of days fished, the number of crew on the boat, the fishing method and the area fished was unique for each Record-No. This was done to help eliminate data errors. Five records were eliminated for having two methods each;
5. Finally, GLM records were also deleted where either the number of days fished was not recorded (1718), the area fished was not recorded (641), the record pertained to the TVH logbook data (704) as the structure of the data for these records was different, or the weight of the catch was zero (26) or greater than 1000 kg (12);
6. Finally, the records for the year 2013 were also deleted due to the small number of records for this year (109) compared to all other years (between 681 and 5,170). The small number for 2013 was due to the fact that many of the fields on the Docket-Book were left blank.
7. This process resulted in 33,713 GLM records being created and selected.

The number of GLM records, and associated nominal CPUE, within each year, month, quarter and TIB area and the distribution of records per fishing method, days-fished and the percent of the catch which are tailed lobsters are shown in Tables 6a&b (and for each 2-way combination of the year, quarter and area effects in Appendix B). Due to the small number of records in some TIB areas, these records were combined with the records in an adjacent area so that the minimum number of records in any area was more than 200. This resulted in twelve areas to be used as spatial effects in the GLM analysis. Furthermore, for all records where more than one fishing method was used the fishing method was termed Mixed. Consequently, only three types of fishing methods were in the data. There were also 893 distinct seller-names (unknown for only 9 records) and 564 distinct vessels (but unknown for 70.7% of all records).

The substantive decline in the number of Records-Nos since 2010 has been noted earlier, with the average number of catch records per year decreasing from 3,535 between 2004 to 2010 to only 1,386 between 2011 and 2016. However, with the greater use of the Docket-Book after 2016 this situation improved substantially during 2017 when the number of records selected for the GLM analysis again exceeded 2000.

Table 6a. Number of GLM records within each year, month and quarter and associated nominal catch rate.

Year	N-Recs	CPUE
2004	3,059	33.3
2005	5,170	40.3
2006	3,017	26.6
2007	4,763	32.4
2008	3,711	31.9
2009	2,777	27.8
2010	2,247	33.4
2011	1,685	51.9
2012	681	46.9
2014	1,665	30.3
2015	1,454	25.2
2016	1,444	32.0
2017	2,040	28.0
Total	33,713	

Month	N-Recs	CPUE
1	2,179	31.6
2	4,511	38.3
3	5,502	38.2
4	4,012	37.2
5	4,034	34.9
6	3,593	34.2
7	3,421	31.8
8	2,575	30.8
9	1,789	27.5
10	37	23.8
11	6	23.7
12	2,054	27.0
Total	33,713	

Qtr	N-Recs	CPUE
1	11,639	35.5
2	7,785	30.5
3	2,097	26.9
4	12,192	37.1
Total	33,713	

Table 6b. Number of GLM records within each TIB area and distribution across each recorded fishing method and days-fished and the associated nominal catch rate.

TIB-Area	GLM-Area	N-Recs
1	6	74
2	6	20
3	6	190
4	16	14
5	16	3
6	6	15
7	7	4,667
8	8	4,733
9	9	15,074
10	10	373
11	11	2,172
12	12	2,707
13	13	475
14	14	1,343
15	15	102
16	16	912
17	17	698
18	15	8
19	16	3
20	15	10
21	15	120
Total		33,713

GLM-Area	N-Recs	CPUE
6	299	47.6
7	4,667	41.5
8	4,733	30.9
9	15,074	32.9
10	373	38.4
11	2,172	42.0
12	2,707	24.2
13	475	51.3
14	1,343	34.5
15	240	45.4
16	932	31.2
17	698	37.3
Total	33,713	

%-Tails	N-Recs	CPUE
<20%	7,149	23.7
20-40%	2,705	35.2
40-60%	2,285	35.9
60-80%	2,085	38.7
>80%	19,489	37.5
Total	33,713	

Method	N-Recs	CPUE
FREE	15291	31.6
HOOKAH	17830	36.7
MIXED	592	37.5
Total	33,713	

Days	N-Recs	CPUE
1	28,508	34.9
2	2,422	33.3
3	1,198	29.5
4	581	30.7
5	482	30.3
6	164	36.9
7	150	28.6
8	80	36.9
9	62	33.0
10	28	22.6
11	18	27.5
12	6	10.5
13	7	18.5
14	3	8.0
15	1	5.8
16	3	10.9
Total	33,713	

Unlike the TVH data where the measure of effort is hours-fished, the measure of effort for the TIB data is coarser, being days-fished. Furthermore, and as noted above, it has been assumed that each selected GLM record pertains to the catch and effort of a single fisher (or seller) during a given trip, i.e. it is assumed that the measure of effort (i.e. days fished) associated with each GLM record also pertains to the actual effort expended by that seller in obtaining the recorded catch. While the number of days fished for each Record-No in the GLM data is unique, there are instances nevertheless where for the same vessel, date and seller there are multiple Record-Nos where the number of days fished is different. Investigation of this issue undertaken with the AFMA data section indicated that the dates associated with these docket-book forms were most likely not correct (Campbell 2016a).

4. General Linear Model Analysis

As with the analysis of the TVH data in previous years, General Linear Models (GLM) were fitted to the TIB data selected in the previous section in order to standardise the CPUE to account for changes in the distribution of records across a number of effects (Year, Month, Quarter, Area and Fishing-Method). As mentioned previously, the measure of effort for the TIB data is days-fished. The catch rate associated with each GLM record was then defined to be the mean weight of lobsters caught per day-fished, i.e.

$$CPUE = \frac{Weight\ of\ landed\ lobsters}{Number\ of\ days\ fished}$$

In order to investigate the influence of the various effects on the catch rate associated with each GLM data record, the following two models were fitted to the data records described in the previous section. All GLMs were weighted as described in Campbell (2016c).

GLM-1: Main Effects only

CPUE = Intercept + Year +Quarter + Area +Method + Proportion-Tails + SOI
/ distribution = gamma, link = log

GLM-2: Main Effects + Quarter*Area Interaction

*CPUE = Intercept + Year +_Quarter *Area +Method+ Proportion-Tails + SOI*
/ distribution = gamma, link = log

where:

a) *Year* has 12 levels: 2004-2012, 2014-2016 (see below)
b) *Quarter* has 4 levels: (1) Jan-Mar, (2) Apr-Jun, (3) Jul-Sep, and (4) Oct-Dec.
c) *Area* has the 12 levels as shown in Table 6b.
d) *Fishing-Method* has 3 levels: (1) Hookah, (2) Free Diving, and (3) Mixed methods
e) *Proportion*-Tails has 5 levels: (1) <20%, (2) 20-40%, (3) 40-60%, (4) 60-80%, and (5) ≥80%
f) *SOI* is the monthly value of the Southern Oscillation Index

All effects were fitted as categorical effects except for SOI which was fitted as a continuous variable.

The above models were fitted to the TIB described in the previous section with the following filters: a) the 66 data records where the number of days fished was greater than 9 were excluded as the mean catch rates for these records was substantially below those where the number of days fished was between 1 and 9 days, and b) the 319 records where the catch was less than 1.0kg or greater than 300 kilograms as these could also be outliers. This left a total of 33,348 records.

Using the results from each GLM an annual abundance index was constructed based on the standardised CPUE calculated for each of the (Year, Quarter, Area) strata. As the standardised -CPUE is taken as an index of the density of fish within each strata, an index of the abundance of lobsters across the fishery in each year and quarter is given by:

$$Index(year = y, quarter, q) = \frac{1}{\sum_{a=1}^{NA} Area_a} \sum_{a=1}^{NA} Area_a .stdCPUE(y, q, a)$$

where $Area_a$ is the spatial size of each of the *NA Area* effects included in the GLM. Finally, an index of abundance for each year can be obtained by taking the average of the *NQ* quarter indices in each year.

$$Index(year = y) = \frac{1}{NQ}\sum_{q=1}^{NQ}\left[\frac{1}{\sum_{a=1}^{NA} Area_a}\sum_{a=1}^{NA} Area_a.stdCPUE(y,q,a)\right]$$

Finally, a relative annual abundance index, B_y, was calculated such that the mean index over all years equals 1, i..e:

$$B_y = \frac{Index(year = y)}{\frac{1}{NY}\sum_{i=1}^{NY} Index(year = i)}$$

For those models which do not included an interaction with the Year effect (i.e. models GLM-1 and GLM-2), the relative abundance index, B_y, reduces to the simpler form:

$$B_y = \frac{\exp(Y_Y)}{\frac{1}{NY}\sum_{i=1}^{NY}\exp(Y_i)}$$

where Y_i , *i=1, NY* are the parameters estimates relating to *NY Year* effects included in the model. In these situations the abundance is independent of the relative size of each *Area* effect included in the GLM.

No models including an interaction with the *Year*Area* interaction effect were fitted as there were a number of *Year*Area* strata having no data records (c.f. Appendix B) and construction of an abundance index from a model including a *Year*Area* interaction would entail the need to impute catch rates for those strata for which the number of records is zero or small (and, hence, maybe unrepresentative). While there was only one *Year*Quarter* strata having no data records (c.f. Appendix B), unlike previous years no models including an interaction with the *Year*Quarter* interaction effect were fitted due to the need to know the spatial extent occupied by lobsters within each TIB fishing region (required to construct the abundance index – see Campbell 2016c) and the related uncertainty noted in previous reports about the spatial size of each GLM-area.

As a sensitivity analysis several alternative model runs were conducted. First, the Seller-Name was fitted as an additional effect to the above two models. To ensure that there was sufficient data for parameter estimation of each *Seller* effect only those sellers which had fished for three or more years and for which there were 30 or more data records where included in the analyses. Second, as seen from Table B(i) in Appendix B the data coverage for many of the GLM-areas has been poor since 2012 with only four areas (GLM-areas 7, 8, 9 and 12) having a reasonable data coverage in recent years. As this poor data coverage will influence our ability to estimate representative *Area* effects for many areas, the analysis was repeated where the above models were fitted only to the data for GLM-areas 7 (Mabuiag), 8 (Badu), 9 (Thursday Island) and 12 (Warraber). A summary of the number of records fitted to each model is shown in Table 7.

Table 7. Summary of models fitted to the TIB data.

(a) All Areas

Model		# Fitted Parameters	# Sellers Parameters	Records	AIC
1	Main Effects	33	0	33,348	301,262
2	Main Effects + Q.A	66	0	33,348	299,606
3	Model 1 + Seller-Name	275	242	27,828	244,847
4	Model 2 + Seller-Name	308	242	27,828	244,308

(b) Four Areas Only

Model		# Fitted Parameters	# Sellers Parameters	Records	AIC
1	Main Effects	25	0	26,896	236,191
2	Main Effects + Q.A	34	0	26,896	235,932
3	Model 1 + Seller-Name	205	180	22,344	186,547
4	Model 2 + Seller-Name	214	180	22,344	186,388

5. Results and Abundance Indices

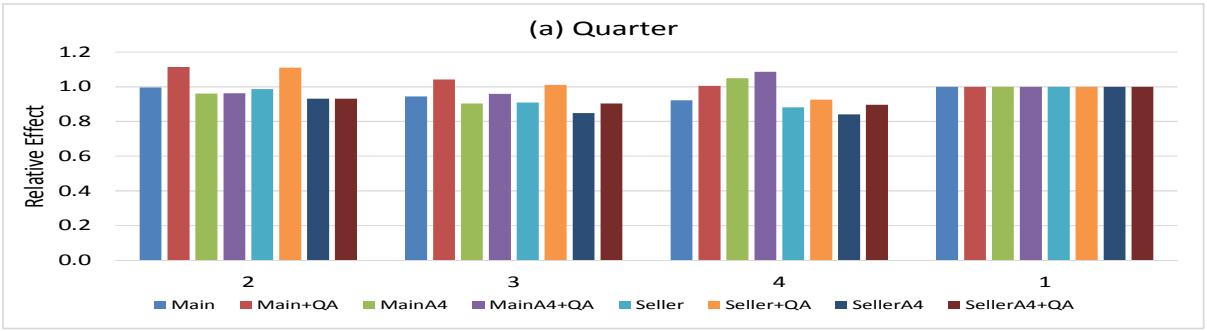
(a) Standardising Effects

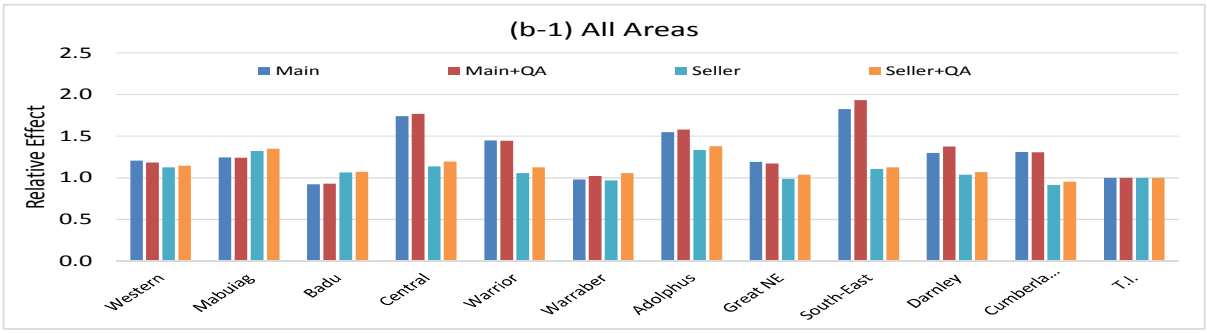
Statistics for the Type 3 contrasts computed for each fitted effect indicated that each effect was highly significant. A comparison of relative influence of each level of the *Quarter*, *Area*, *Method* and *Proportion-Tails* effects for each GLM model is shown in Figure 4. For each effect the values have been scaled so that the influence of each effect is relative to that of the last level of each effect (i.e, Qtr=1, Area=T.I., Method= Hookah and %-Tail >80%). For those models which included the *Quarter*Area* interaction the *Quarter* and *Area* effects were determined by calculating the mean effect across all areas and quarters respectively.

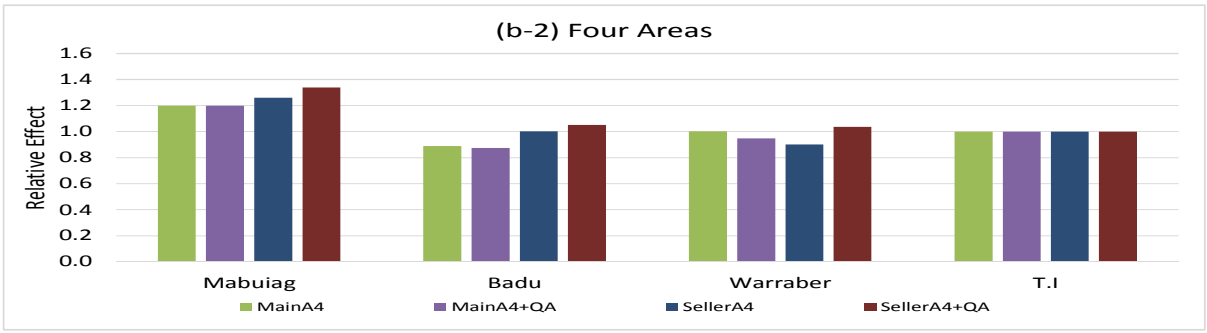
Relative CPUE is similar across the four quarters of the year, though taking the average effect across the individual results for the eight models for each quarter indicates that CPUE is highest during the first and second quarters and lowest in the fourth quarter. However, this result is influenced by the variation shown between the results for those models with all 12 areas included and those limited to only four areas. For example, the second quarter has the highest relative CPUE when averaged across models with all areas included, but for those models limited to only four areas the CPUE for this quarter is 10% lower (and the first quarter has the highest relative CPUE).

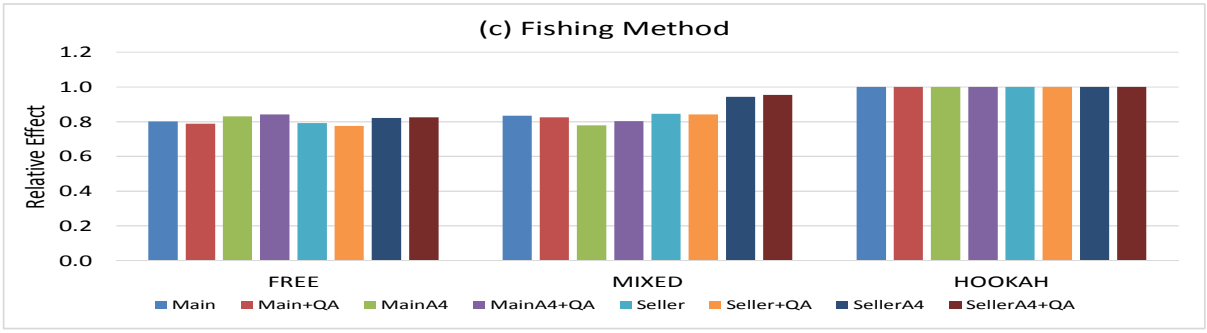
Relative CPUE varies considerably between the various areas included in the GLM. There is also considerable variation in the relative effect for a particular area between the different models. For example, for the two models with all areas and no *Seller* effect the relative CPUE's vary between 188% (for South East) to 93% (for Warraber), while for the two models which include the *Seller*-effect, the relative CPUE's varies between 134% (for Mabuiag) to 94% (for Cumberland). For the four models limited to the four area effects, the relative CPUE is higher in Mabuiag for the two sets of models with and without the *Seller* effect, while there is some variation in relative CPUE for both Badu and Warraber across these models.

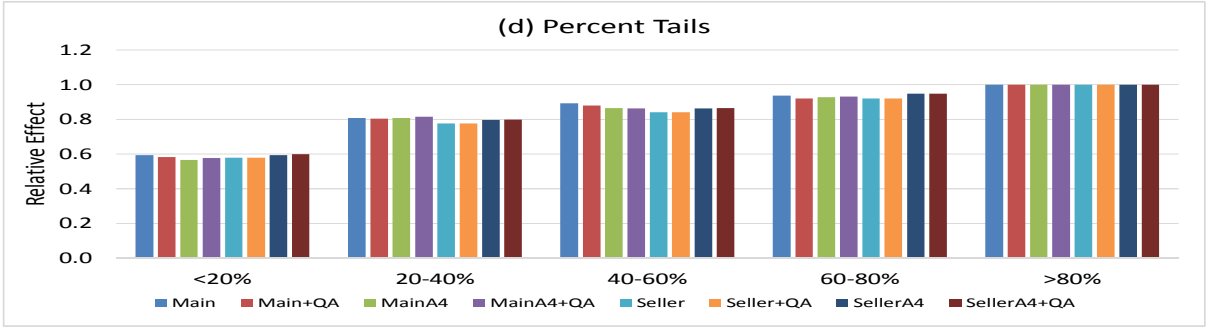
Figure 4. Comparison of relative influence of each level of the Quarter, Area, Method and Percent-Tails effects for each fitted model. Results are shown for both model runs. Note, for each effect the values have been scaled so that the influence of each effect is relative to that of the last level of each effect (i.e, Qtr=1, Area=T.I., Method= Hookah and %-Tails= '>80%').











Apart from the four area only models including a Seller effect for mixed fishing, the relative CPUE of each fishing method is similar across all models. On average the CPUE for hookah fishing is found to be around 24% higher than for free diving and 17% higher than for mixed fishing. This latter result is to be expected if mixed fishing is a combination of the two other fishing methods.

Finally, the relative CPUE across all models is similar for each category of the proportion of the catch which is tails with the relative CPUE increasing as the *Proportion-Tails* increases in the catch. Across all models, the relative CPUE within each %-tails category is 0.58, 0.80, 0.86, 0.93and 1.00 respectively.

(b) Annual Abundance Indices

The relative abundance indices based on each of the eight GLM models listed in the previous section are listed and displayed and in Table 8 and Figures 5&6 respectively. Relative to the nominal index, each of the standardised indices displays a number of substantive shifts, being lower than the nominal index at the start of the time-series and for 2011 and 2012 and higher than the nominal index for 2009 and 2010 and since 2014. These changes are likely due to shifts in the percentage of the catch which are processed as tailed or whole lobsters (c.f. Figure 7). There are some small differences, especially for the last year, in the relative indices between the all areas, no *Seller*-effect model with and without the *Quarter*Area* interaction included (c.f. Figure 5a) but these differences are negligible for the other models (c.f. Figure 5b-d). There are also some differences between the models which include all 12 GLM-areas and those which only include the four selected GLM-areas, with these differences being similar across the two sets of models with and without the *Quarter*Area* interaction included (c.f. Figure 6).

Using the Akaike Information Criteria (AIC) as a measure to select the relative quality of the different statistical models fitted to a given set of data (where a lower value is better), then based on the results shown in Table 7 the models with the *Quarter*Area* interaction included are found to provide a better fit to the data for all the four sets of models. Although not shown in Table 7, the AIC measure also indicates that between the two models with and without the *Seller*-effect included and fitted to the same set of data as Models 3 and 4 (i.e. 27,828 records) that the model including the *Seller*-effect provides the better fit. Based on these observations, Model 4 is therefore seen as the preferred model. Of the two sets of models fitted to the data

Table 8. Relative abundance indices based on standardised CPUE data for the TIB fishery. Note, each index is scaled so that the mean of the index over the all years is equal to 1.

Year	Nominal	Main	Main+QA	Main.A4	Main.A4+QA	Seller	Seller+QA	Seller.A4	Seller.A4+QA
04	0.97	0.89	0.89	0.91	0.90	0.88	0.87	0.90	0.90
05	1.17	0.92	0.94	0.95	0.97	1.03	1.03	1.04	1.05
06	0.82	0.71	0.73	0.68	0.69	0.76	0.76	0.72	0.72
07	0.99	0.83	0.84	0.86	0.86	0.86	0.86	0.89	0.89
08	0.98	0.96	0.93	0.97	0.95	0.90	0.89	0.92	0.91
09	0.87	0.90	0.90	0.89	0.88	0.88	0.87	0.84	0.84
10	1.01	1.05	1.04	1.10	1.07	1.06	1.06	1.05	1.05
11	1.48	1.32	1.32	1.29	1.29	1.40	1.37	1.24	1.22
12	1.31	1.19	1.22	1.24	1.26	1.26	1.26	1.26	1.25
14	0.88	0.85	0.89	0.85	0.87	0.90	0.93	0.92	0.95
15	0.72	0.91	0.93	0.90	0.90	0.90	0.92	0.93	0.94
16	0.96	1.24	1.24	1.31	1.30	1.27	1.28	1.34	1.34
17	0.84	1.24	1.14	1.06	1.05	0.90	0.90	0.93	0.93
Mean	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Figure 5. Relative indices of resource availability based on each the models fitted to the catch and effort data for the TIB fishery.

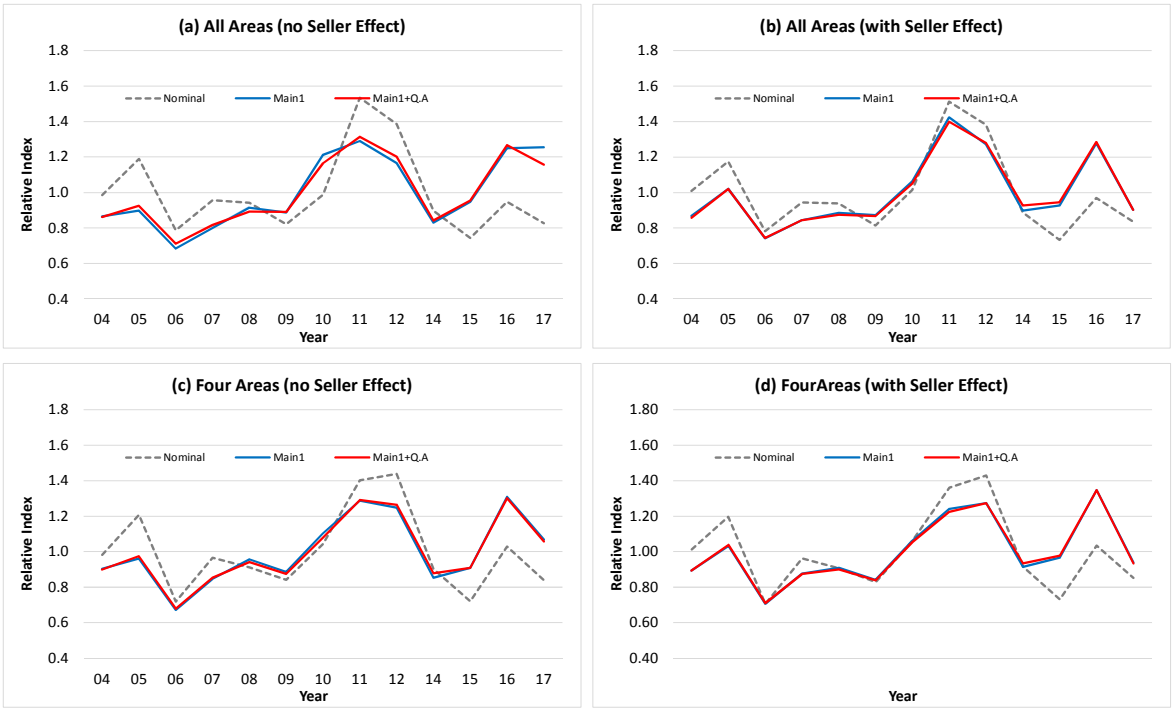


Figure 6. Comparison of the relative indices of resource availability based on (a) Main-Effects only and the (b) Main Effects + Quarter*Area interaction models fitted to the catch and effort data for the TIB fishery.

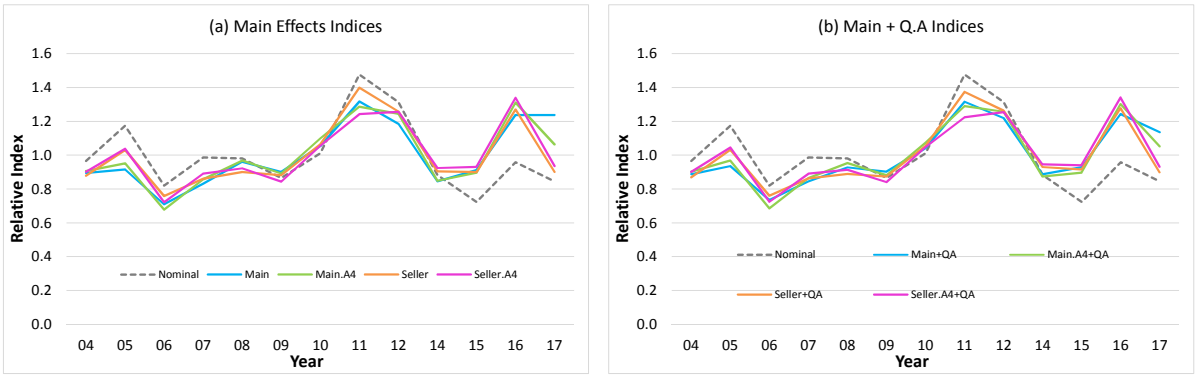
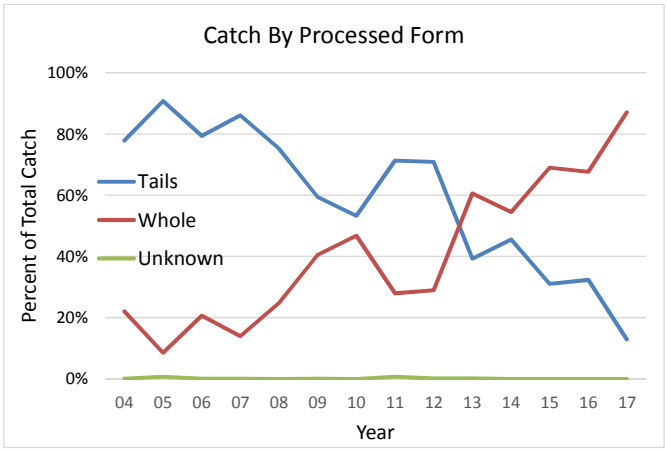


Figure 7.Percent of total annual catch (whole weight) by processed form.



for all 12 GLM-areas or just the four selected GLM-areas it can be argued that as the *Area*-effect are assumed to the same across all years, and despite the poor data coverage in some areas in more recent years, that the latter model only provides an index across the smaller region comprising the selected four areas while the former model should provide a better index across the entire fishery.

5. Comparison with other indices

A comparison of the TIB abundance indices with two of the preferred indices based on the standardised CPUE from the TVH fishery is shown in Figure 8 while the Pearson correlation, ρ, between each of these indices is shown in Table 9. A number of differences are seen between each set of indices. In particular, the standardised TIB indices each display a considerably flatter trend over time than the TVH indices. Despite this, the peaks and troughs in each of the TIB and TVH indices generally coincide. For example, local maximum occur for the years 2005, 2011 and 2016 while local minimum occur for 2006, 2009, 2015 and 2017. This similarity is also reflected in the relatively high correlation (ρ =0.76) between the TIB index (*seller+Q.A*) and the two TVH indices. As both the TIB and TVH fisheries are fishing the same resource, this result is not unexpected. The reasons for the flatter trend in the TIB indices remain uncertain and warrants further investigation but may be due to the more limited data collected from this fishery, in particular the courser scale measure of effort collected from the TIB fishery (day) in comparison to that collected in the TVH fishery (hours). There is also a problem with the decline in the amount of data available for analysis from the TIB fisher in more recent years, and its more limited spatial extent. due to the fact that some of the data fields in the docket-book were not completed and that a large proportion (>40%) of the data was not recorded on the docket-book.

Figure 8. Comparison of the selected TIB and TVH resource indices.

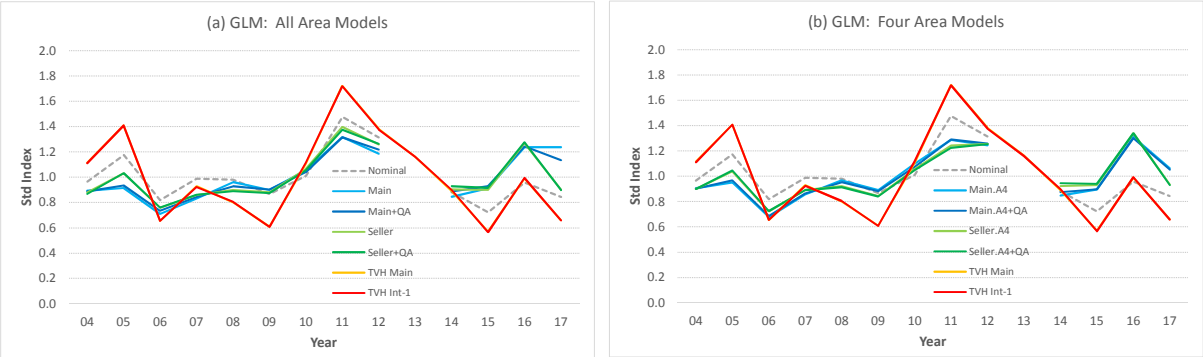


Table 9. Pearson correlation between the various TIB and TVH-based indices.

	All Areas		Four Areas	
Model	TVH-Main	TVH-Int1	TVH-Main	TVH-Int1
Main	0.49	0.49	0.61	0.61
Main+QA	0.57	0.57	0.64	0.64
Seller	0.78	0.78	0.68	0.69
Seller+QA	0.76	0.76	0.68	0.68

6. Concluding Remarks

For the Torres Strait rock lobster fishery there are currently two sources of catch and effort data, those for the TVH and TIB sectors. The TRL04 Logbook data from the TVH sector is believed to provide a relatively complete and good source of catch and effort data for this sector (e.g. Campbell eta al, 2017). Improvements in compliance to ensure that all fields in the Logbook are completed (e.g. area fished and hours fished) would improve the utility of these data. Also, a better recording of the locations of the fishing effort (i.e. at the tender level) would also improve the accuracy of the data for standardising catch rates. On the other hand, the data for the TIB sector is less complete and the measure of effort (days fished) is less accurate and incomplete in many instances. However, given the potential for this sector to grow in importance in future years there is a need to assess the utility of these data to provide a useful index of resource abundance.

The results presented above indicate that while the TIB-based indices have the potential to capture the major trends stock abundance, they likely lack the detail required to track finer inter-annual trends in abundance. There are several reasons for this outcome. In particular, the measures of catch and effort in the TIB data are coarser (trip-based) compared to the tender-hours based data for the TVH data. Indeed, for the TIB data it remains unknown how many hours per trip fishing actually occurred and whether there are differences between the different sellers and trends over the years.

Finally, it has been noted that either the Docket-Book or many of the fields in the Docket-Book were not completed in recent years, though there were improvements in 2017. With the introduction of the new Torres Strait Catch Disposal Record (TDB02, shown in Appendix A) it is hoped that the improvements seen in data recording will continue. While the recording of several data fields (e.g. Fisher Name, Fisher Type, Boat Symbol, and catch details) will be mandatory in the new form, it is also essential that the other fields in the voluntary sector of the form (e.g. detailing fishing effort and methods) are completed if the required information is to be available for standardising the TIB catch and effort data. As with the TVH data, continued effort needs to be placed on ensuring the completeness and accuracy of these data if they are to be used on a continuing basis.

References

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Campbell, R.A., Pease, D. 2017. Separating TIB, TVH and Processor catch records from Docket-Book Data. Report to AFMA – 2017 Update. Information paper to be presented to the 21st meeting of the Torres Strait Rock Lobster Resource Assessment Group, held 12-13 December 2017, Cairns.

Campbell, R.A, Plaganyi, E., Deng, R., 2017. Use of TVH Logbook Data to construct an Annual Abundance Index for Torres Strait Rock Lobster – 2017 Update. Information paper to be presented to the 21st meeting of the Torres Strait Rock Lobster Resource Assessment Group, held 12-13 December 2017, Cairns.

Appendix A (i). The old Buyers and Processors Docket Book (TDB01) used in the TIB sector of the Torres Strait rock lobster fishery.

Torres Strait Seafood Buyers and Processors Docket Book

RECIPIENT CREATED TAX INVOICE

FOR Name:.....

Address:.....

.....

A.B.N.:.....Lic. No. .....

Seller:				**Book No.**	**Page No.**
Seller's ABN:		Seller's Licence No.			
Seller's Address:			Date:		

Fishing effort and boat details – Traditional Inhabitant Boat (TIB) only

Boat symbol:		No. of divers/fishers:	
Days fishing:		Area fished: From map (write no. of area most fished)	

Methods used: (tick box, use more than one if needed)
☐ Hookah (MDH) ☐ Handline (LHL) ☐ Drop line (LDR)
☐ Free dive (MDF) ☐ Rod and reel (LRR) ☐ Other– specify
☐ Lamp fishing (MLF) ☐ Troll (LTL)

Non Traditional Inhabitant Boat (TIB) fishers & buyers of PNG & east coast product only

Region Fished: (tick box) ☐ Torres Strait ☐ East Coast Queensland ☐ Papua New Guinea

Has the seller recorded their catches elsewhere?: (tick box)
☐ YES (please indicate) → ☐ TRL04 Logbook ☐ TSF01 Logbook ☐ Other →
☐ No

Details of catch being sold

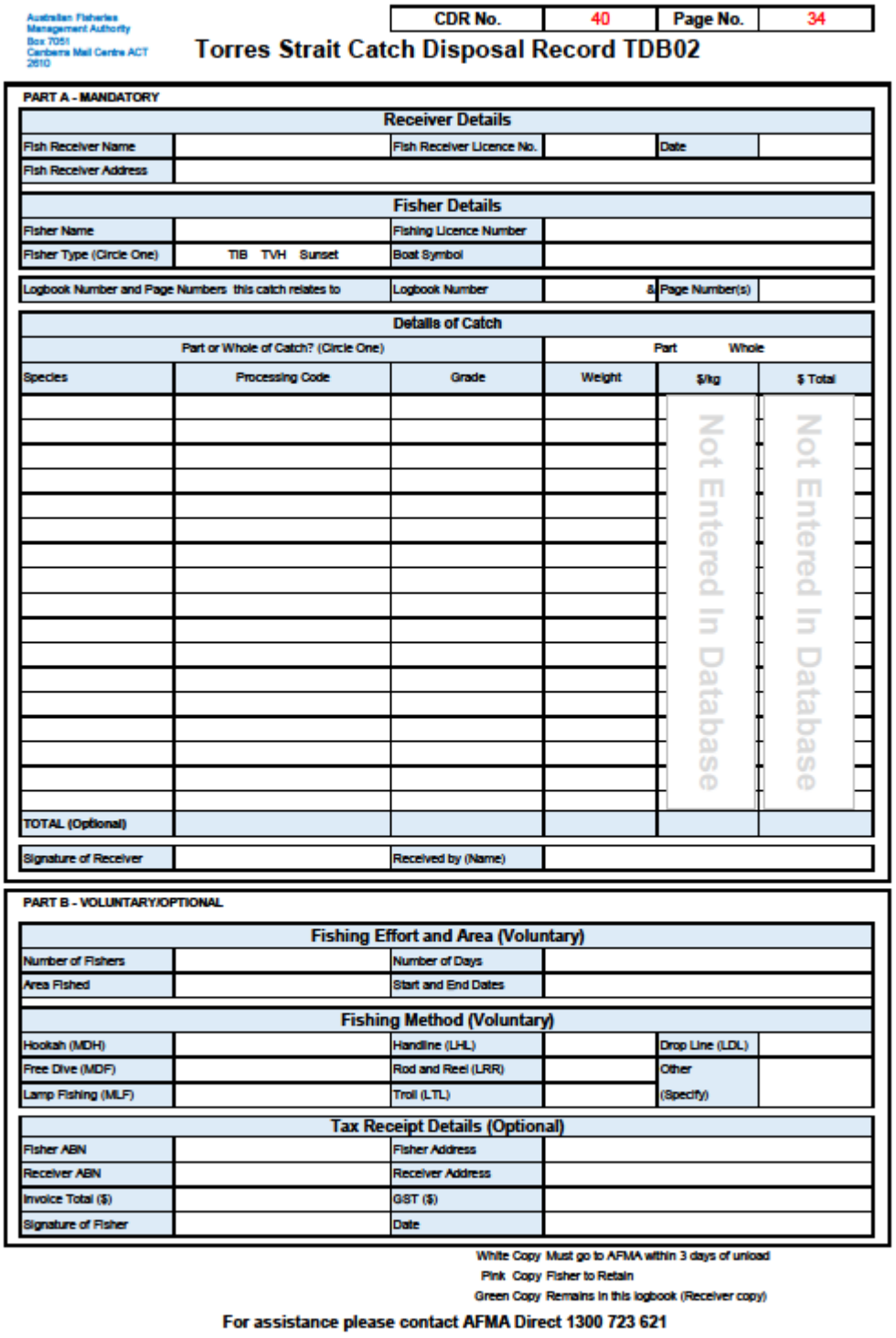
Species	Processing Code	Grade	Kg	$/Kg	$/Kg	Amount
				SEEN BY AFMA (OPTIONAL)	NOT SEEN BY AFMA	NOT SEEN BY AFMA
Completed by:					Subtotal	
Signature:					GST	
Payment received:					**TOTAL**	

Australian Fisheries Management Authority
PO Box 376
Thursday Island QLD 4875

For assistance
Phone: (07) 4069 1990
Fax: (07) 4069 1277

WHITE COPY: **Fisher** (seller)
YELLOW COPY: **AFMA**
PINK COPY: **Buyer** (you)

Appendix A (ii). The new Torres Strait Catch Disposal Record (TDB02) to be used in the TIB sector of the Torres Strait rock lobster fishery.



Australian Fisheries Management Authority
Box 7051
Canberra Mail Centre ACT 2610

CDR No.	40	Page No.	34

Torres Strait Catch Disposal Record TDB02

PART A - MANDATORY

Receiver Details

Fish Receiver Name		Fish Receiver Licence No.		Date	
Fish Receiver Address					

Fisher Details

Fisher Name		Fishing Licence Number	
Fisher Type (Circle One)	TIB TVH Sunset	Boat Symbol	

Logbook Number and Page Numbers this catch relates to	Logbook Number	&	Page Number(s)	

Details of Catch

Part or Whole of Catch? (Circle One)			Part	Whole	
Species	Processing Code	Grade	Weight	$/kg	$ Total
				Not Entered In Database	Not Entered In Database
TOTAL (Optional)					

Signature of Receiver		Received by (Name)	

PART B - VOLUNTARY/OPTIONAL

Fishing Effort and Area (Voluntary)

Number of Fishers		Number of Days	
Area Fished		Start and End Dates	

Fishing Method (Voluntary)

Hookah (MDH)		Handline (LHL)		Drop Line (LDL)	
Free Dive (MDF)		Rod and Reel (LRR)		Other	
Lamp Fishing (MLF)		Troll (LTL)		(Specify)	

Tax Receipt Details (Optional)

Fisher ABN		Fisher Address	
Receiver ABN		Receiver Address	
Invoice Total ($)		GST ($)	
Signature of Fisher		Date	

White Copy Must go to AFMA within 3 days of unload
Pink Copy Fisher to Retain
Green Copy Remains in this logbook (Receiver copy)

For assistance please contact AFMA Direct 1300 723 621

Appendix B (i). Number of GLM data records, total number of days fished, total catch weight, and associated CPUE in each Year*Area strata. Note, strata with less than 10 records are shaded (dark shading where number is zero) and nominal CPUE is only shown for strata where the number of the days fished is 10 or greater.

(a) Number of TIB RECORDS

	Year														
Area	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
6	39	33	63	47	7	6	4	12	5	0	57	20	1	5	299
7	637	1104	424	463	260	110	16	428	169	43	869	158	22	7	4710
8	440	986	569	710	389	23	50	362	191	18	277	350	218	168	4751
9	1338	1413	619	1683	2031	1991	1841	592	271	30	131	562	862	1740	15104
10	38	107	46	67	10	8	10	14	3	0	26	11	2	31	373
11	76	737	383	401	305	174	12	3	0	0	0	52	17	12	2172
12	137	165	338	525	281	213	124	92	19	15	284	283	226	20	2722
13	76	64	99	93	18	11	42	55	2	1	2	5	3	5	476
14	145	139	181	119	181	212	104	94	14	1	18	7	88	41	1344
15	14	38	26	90	40	26	2	1	0	0	0	2	1	0	240
16	93	254	120	287	78	3	41	32	7	1	0	4	3	10	933
17	26	130	149	278	111	0	1	0	0	0	1	0	1	1	698
Total	3059	5170	3017	4763	3711	2777	2247	1685	681	109	1665	1454	1444	2040	33822

(b) Total Number of DAYS_FISHED

AREA	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
6	99	39	84	78	10	7	6	14	6	0	110	52	1	11	517
7	828	2014	732	663	308	423	44	658	594	43	1100	223	24	27	7681
8	478	1018	601	757	451	28	66	631	617	42	834	966	700	278	7467
9	1486	1540	662	1928	2118	2044	1969	602	282	30	132	570	870	1758	15991
10	99	138	56	71	10	8	15	14	3	0	53	33	3	48	551
11	102	767	423	498	384	233	12	5	0	0	0	111	19	35	2589
12	394	410	646	714	474	404	244	103	20	43	556	546	423	27	5004
13	167	125	147	148	44	18	98	64	2	1	2	6	3	9	834
14	401	296	241	151	253	687	198	117	18	1	22	12	199	73	2669
15	65	67	46	128	75	30	4	1	0	0	0	5	1	0	422
16	123	318	129	290	79	3	45	33	11	1	0	5	3	11	1051
17	41	200	217	393	188	0	1	0	0	0	1	0	1	1	1043
Total	4283	6932	3984	5819	4394	3885	2702	2242	1553	161	2810	2529	2247	2278	45819

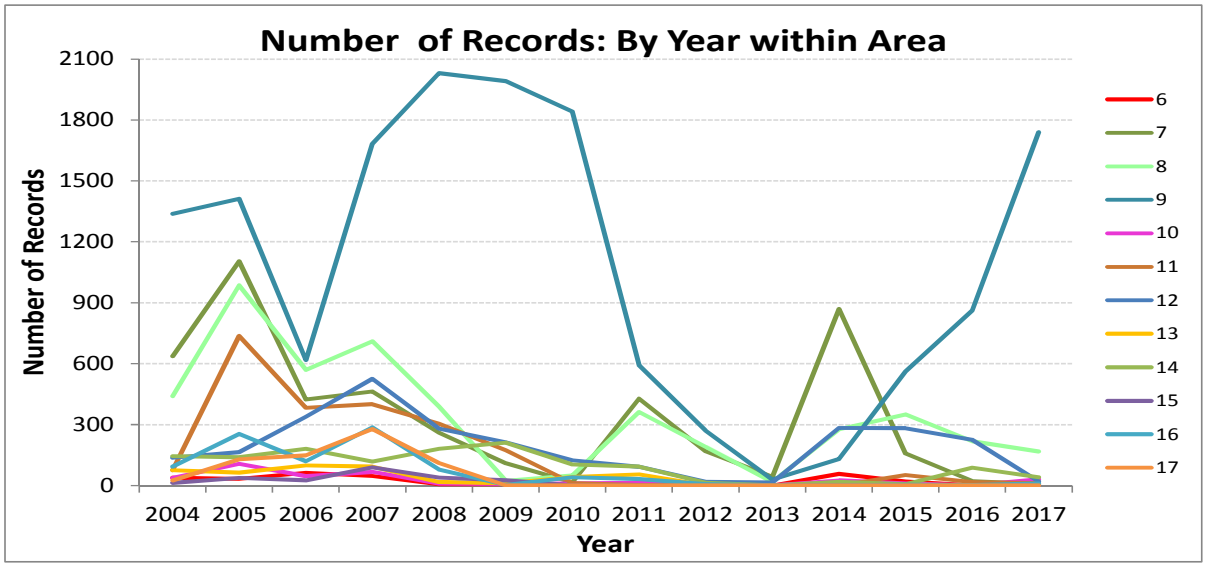
(c) Total CATCH_WEIGHT

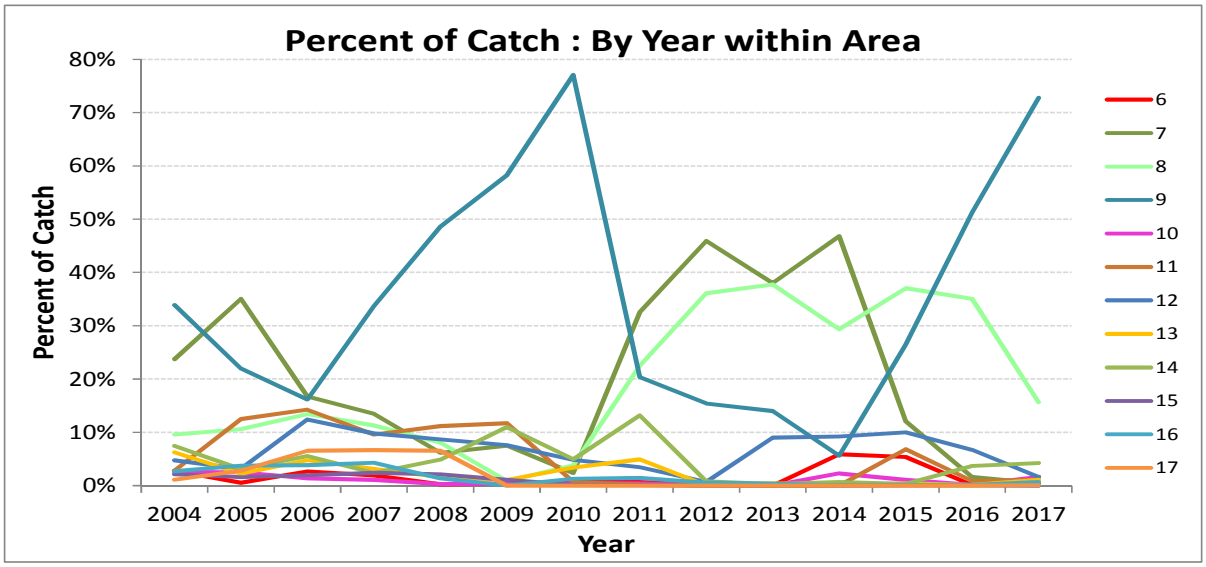
AREA	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
6	4043	1545	2863	3658	386	429	676	808	181	0	5016	3445	99	321	23469
7	33864	97824	17737	25445	8656	8118	2144	37908	33448	2205	39934	7709	1175	267	316433
8	13713	29529	14260	21289	11355	970	3485	26147	26308	2190	25039	23625	25227	9997	233134
9	48407	61355	17163	63511	68070	62857	69541	23735	11244	813	4805	16842	36914	46393	531651
10	3701	7067	1483	2065	462	411	420	529	62	0	1976	696	119	1067	20057
11	4097	34985	15125	18093	15660	12663	671	285	0	0	0	4371	652	708	107310
12	6806	8930	13181	18527	12170	8212	4374	4049	535	522	7866	6376	4836	1042	97427
13	8951	6365	5118	6017	2246	1159	3098	5756	70	27	31	316	126	722	40002
14	10651	8680	5915	4501	6865	11887	4479	15347	602	19	595	237	2683	2734	75193
15	3086	4447	2092	4577	2998	1196	143	135	0	0	0	27	54	0	18755
16	3877	10516	4103	8130	1969	66	1182	1723	405	22	0	89	89	428	32603
17	1641	7816	6970	12636	9166	0	31	0	0	0	20	0	15	62	38358
Total	142837	279059	106010	188449	140003	107968	90244	116422	72855	5798	85282	63733	71989	63741	1534392

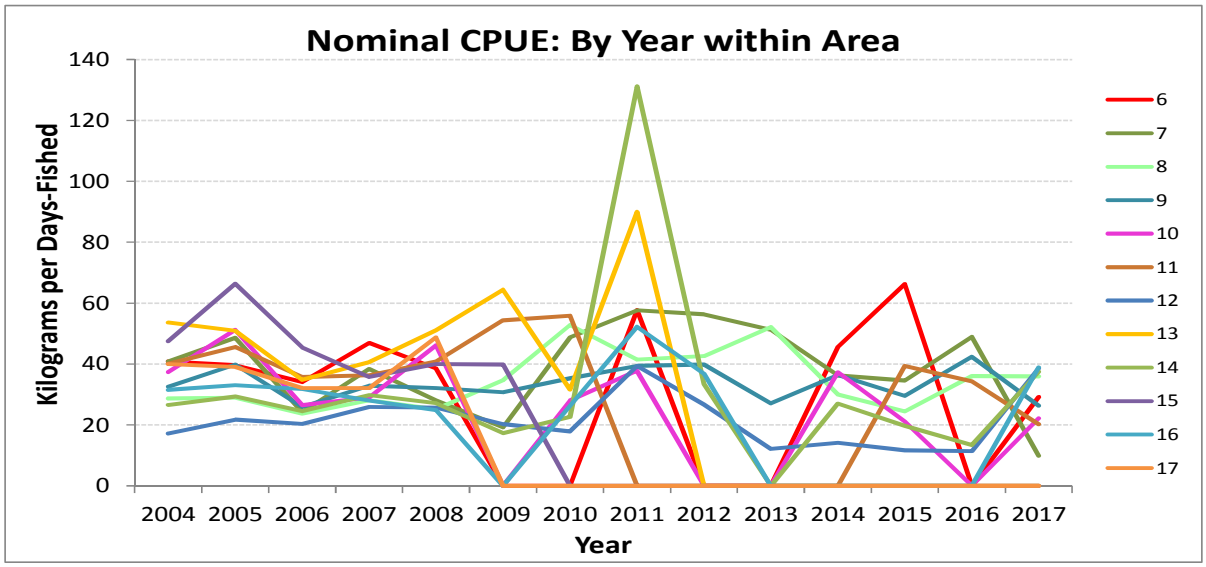
(d) Nominal CPUE

AREA	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
6	40.8	39.6	34.1	46.9	38.6			57.7			45.6	66.3		29.2	45.4
7	40.9	48.6	24.2	38.4	28.1	19.2	48.7	57.6	56.3	51.3	36.3	34.6	49.0	9.9	41.2
8	28.7	29.0	23.7	28.1	25.2	34.6	52.8	41.4	42.6	52.1	30.0	24.5	36.0	36.0	31.2
9	32.6	39.8	25.9	32.9	32.1	30.8	35.3	39.4	39.9	27.1	36.4	29.5	42.4	26.4	33.2
10	37.4	51.2	26.5	29.1	46.2		28.0	37.8			37.3	21.1		22.2	36.4
11	40.2	45.6	35.8	36.3	40.8	54.3	55.9					39.4	34.3	20.2	41.4
12	17.3	21.8	20.4	25.9	25.7	20.3	17.9	39.3	26.8	12.1	14.1	11.7	11.4	38.6	19.5
13	53.6	50.9	34.8	40.7	51.0	64.4	31.6	89.9							48.0
14	26.6	29.3	24.5	29.8	27.1	17.3	22.6	131.2	33.4		27.0	19.8	13.5	37.5	28.2
15	47.5	66.4	45.5	35.8	40.0	39.9									44.4
16	31.5	33.1	31.8	28.0	24.9		26.3	52.2	36.8					38.9	31.0
17	40.0	39.1	32.1	32.2	48.8										36.8
SUM	33.3	40.3	26.6	32.4	31.9	27.8	33.4	51.9	46.9	36.0	30.3	25.2	32.0	28.0	33.5

Appendix B (i). Number of GLM data records, percent of catch, and associated CPUE in each Year*Area strata. Note, nominal CPUE is only shown for strata where the number of the days fished is 10 or greater.







Appendix B (ii). Number of GLM data records, total number of days fished, total catch weight, and associated CPUE in each Year*Quarter strata. Note, strata with less than 10 records are shaded (dark shading where number is zero) and nominal CPUE is only shown for strata where the number of the days fished is 10 or greater.

(a) Number of TIB RECORDS

	Year														
Qtr	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
1	913	1434	1264	1833	1597	971	855	820	359	6	449	554	517	626	12198
2	921	2155	1014	1730	1220	1005	793	446	222	13	427	494	452	760	11652
3	835	1353	383	961	763	639	519	296	93	17	523	325	446	649	7802
4	390	228	356	239	131	162	80	123	7	73	266	81	29	5	2170
Total	3059	5170	3017	4763	3711	2777	2247	1685	681	109	1665	1454	1444	2040	33822

(b) Total Number of DAYS_FISHED

Qtr	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
1	1050	1876	1538	2226	1707	1269	941	847	781	6	860	923	917	723	15664
2	1482	2919	1440	2126	1450	1359	925	801	619	14	860	879	725	824	16423
3	1287	1844	573	1186	1079	1035	740	461	146	17	706	579	573	726	10952
4	464	293	433	281	158	222	96	133	7	124	384	148	32	5	2780
Total	4283	6932	3984	5819	4394	3885	2702	2242	1553	161	2810	2529	2247	2278	45819

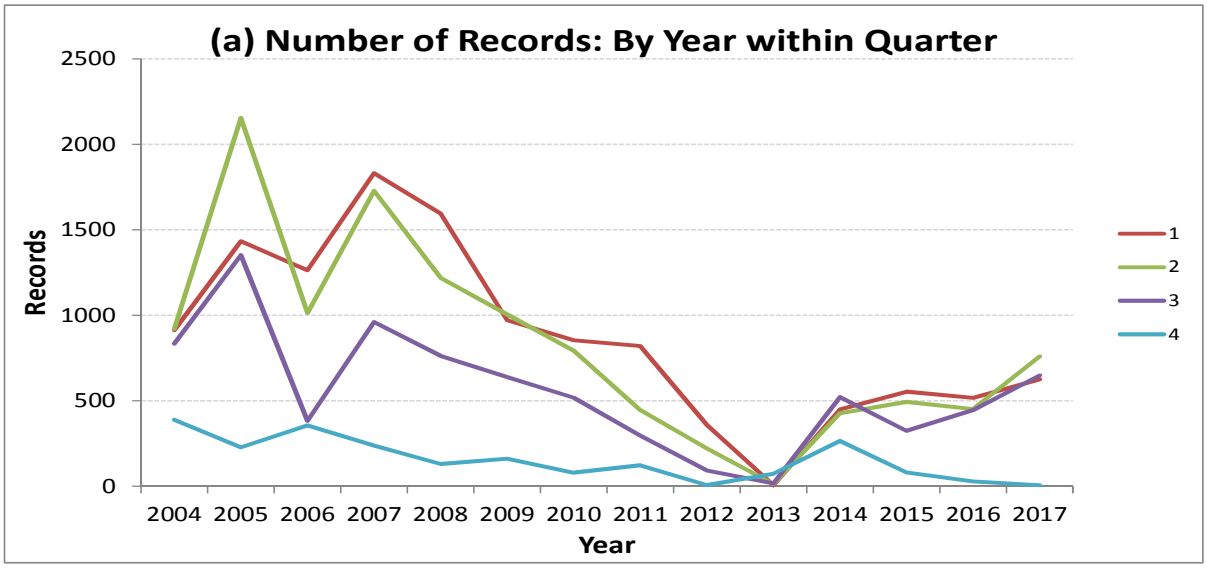
(c) Total CATCH_WEIGHT

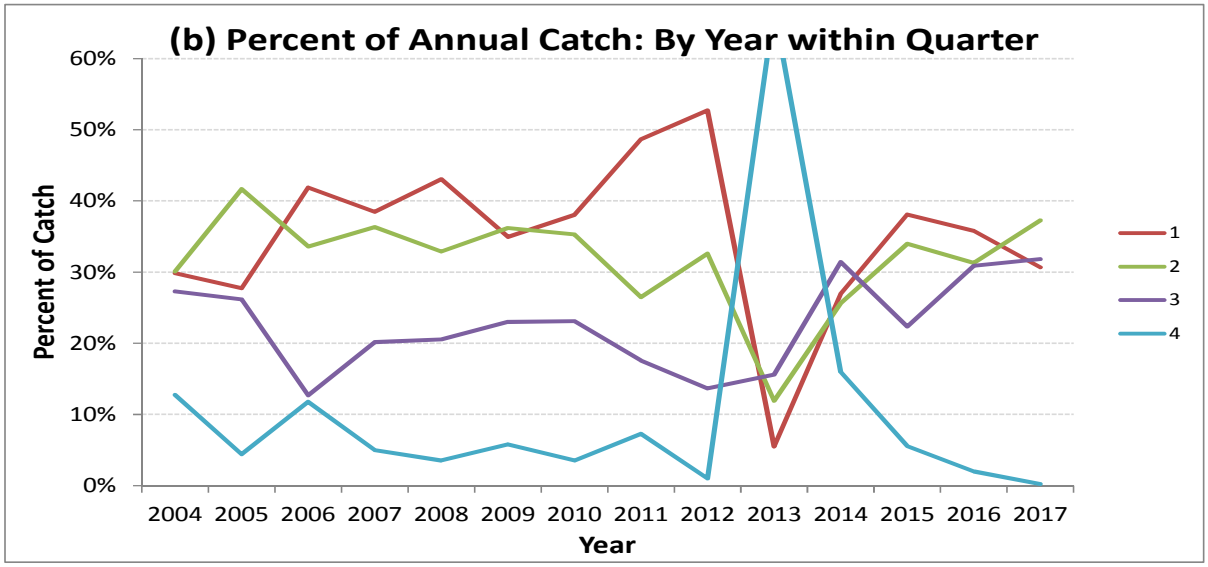
Qtr	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
1	41607	80138	43333	75577	58120	41536	32806	52929	38072	104	30268	23573	28812	21215	568090
2	52472	127796	35584	70084	46316	42089	31993	40209	28419	514	27509	22870	25455	22541	573851
3	35581	63063	14632	34454	30685	20173	22365	19466	6271	436	20397	13942	16956	19861	318281
4	13178	8064	12461	8336	4881	4170	3079	3817	92	4744	7109	3348	765	124	74169
Total	142838	279061	106010	188451	140002	107968	90243	116421	72854	5798	85283	63733	71988	63741	1534391

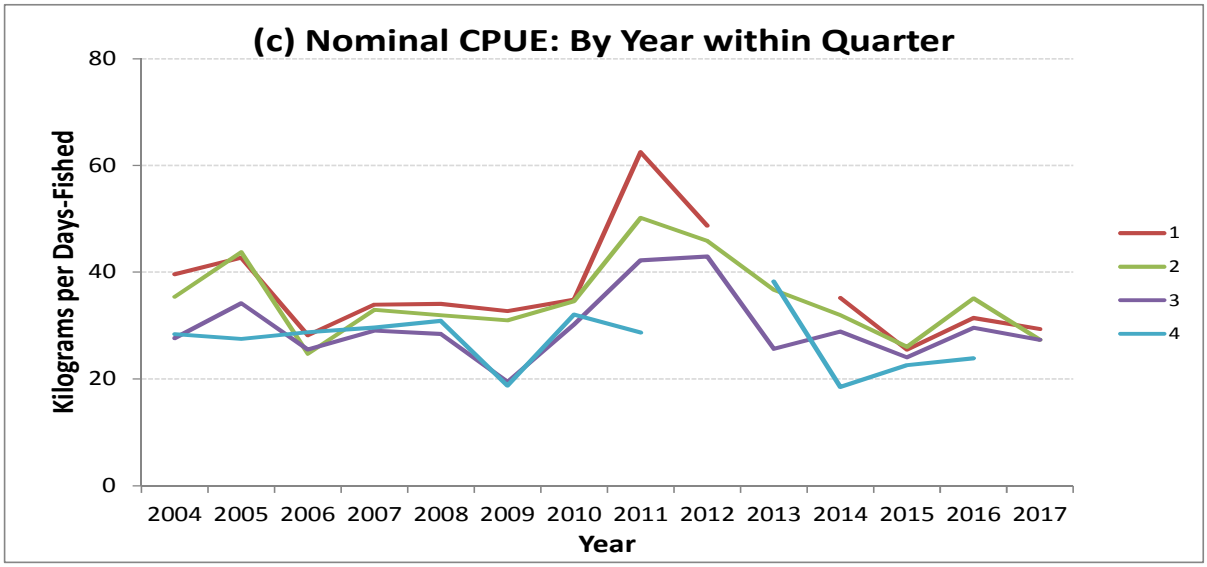
(d) Nominal CPUE

Qtr	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Total
1	39.6	42.7	28.2	34.0	34.0	32.7	34.9	62.5	48.7		35.2	25.5	31.4	29.3	36.3
2	35.4	43.8	24.7	33.0	31.9	31.0	34.6	50.2	45.9	36.7	32.0	26.0	35.1	27.4	34.9
3	27.6	34.2	25.5	29.1	28.4	19.5	30.2	42.2	43.0	25.6	28.9	24.1	29.6	27.4	29.1
4	28.4	27.5	28.8	29.7	30.9	18.8	32.1	28.7		38.3	18.5	22.6	23.9		26.7
Total	33.3	40.3	26.6	32.4	31.9	27.8	33.4	51.9	46.9	36.0	30.3	25.2	32.0	28.0	33.5

Appendix B (ii). Number of GLM data records, percent of catch, and associated nominal CPUE in each Year*Quarter strata. Note, nominal CPUE is only shown for strata where the number of the days fished is 10 or greater.







Appendix B (iii). Number of GLM data records, total number of days fished, total catch weight, and associated CPUE in each Area*Quarter strata. Note, strata with less than 10 records are shaded (dark shading where number is zero) and nominal CPUE is only shown for strata where the number of the days fished is 10 or greater.

(a) Number of TIB RECORDS

AREA	Q-1	Q-2	Q-3	Q-4	Total
6	108	110	68	13	299
7	2068	1254	1016	372	4710
8	2052	1593	822	284	4751
9	5084	5587	3761	672	15104
10	146	116	79	32	373
11	834	640	408	290	2172
12	789	983	679	271	2722
13	113	213	132	18	476
14	354	524	403	63	1344
15	85	90	56	9	240
16	353	276	198	106	933
17	212	266	180	40	698
Total	12198	11652	7802	2170	33822

(b) Total Number of DAYS_FISHED

AREA	Q-1	Q-2	Q-3	Q-4	Total
6	218	167	110	22	517
7	3077	2453	1707	444	7681
8	3007	2698	1334	428	7467
9	5284	5963	4023	721	15991
10	180	198	131	42	551
11	991	753	478	367	2589
12	1275	1937	1382	410	5004
13	155	372	268	39	834
14	673	991	881	124	2669
15	126	170	114	12	422
16	383	325	223	120	1051
17	295	396	301	51	1043
Total	15664	16423	10952	2780	45819

(c) Total CATCH_WEIGHT

AREA	Q-1	Q-2	Q-3	Q-4	Total
6	10998	8589	3278	604	23469
7	139312	109367	53933	13820	316433
8	98373	85424	37781	11556	233134
9	194498	203631	117003	16518	531651
10	6304	8207	3975	1570	20057
11	37419	36412	20904	12574	107310
12	26230	37408	26484	7305	97427
13	6576	21126	11263	1037	40002
14	23532	28709	20136	2816	75193
15	5612	8313	4358	472	18755
16	11193	10374	7033	4003	32603
17	8043	16289	12133	1892	38358
Total	568090	573849	318281	74167	1534392

(d) Nominal CPUE

AREA	Q-1	Q-2	Q-3	Q-4	Total
6	50.4	51.4	29.8	27.5	45.4
7	45.3	44.6	31.6	31.1	41.2
8	32.7	31.7	28.3	27.0	31.2
9	36.8	34.1	29.1	22.9	33.2
10	35.0	41.4	30.3	37.4	36.4
11	37.8	48.4	43.7	34.3	41.4
12	20.6	19.3	19.2	17.8	19.5
13	42.4	56.8	42.0	26.6	48.0
14	35.0	29.0	22.9	22.7	28.2
15	44.5	48.9	38.2	39.3	44.4
16	29.2	31.9	31.5	33.4	31.0
17	27.3	41.1	40.3	37.1	36.8
Total	36.3	34.9	29.1	26.7	33.5

Appendix B (iii). Number of GLM data records, percent of catch, and associated CPUE in each Area*Quarter strata. Note, nominal CPUE is only shown for strata where the number of the days fished is 10 or greater.