Season Report 1991
Dampier Archipelago Humpback Whale Project
Western Australia

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1. ABSTRACT

During the 127 days of the 1991 field season off the Dampier Archipelago, northern Western Australia, 218 humpback whales were observed. Attempts were made to photograph, for each animal, the underside of the tail flukes and the shape and pigmentation of each side of the body. Of 206 whales photographed, 156 fluke photographs and 132 pairs of lateral body photographs were obtained. Three whales were resighted within the 1991 season while 4 whales have now been resighted between 1990 and 1991. A preliminary, conservative, Petersen estimate of the population resulted in 3300 (+134, -89) whales in the Group IV stock. A catalogue has been established and will be compared with existing collections in the northern and southern hemispheres. Observational data were recorded for each group of whales encountered. This is the second seasons' data collected in a planned five year population estimate study for the Southern Hemisphere Group IV feeding stock.

2. INTRODUCTION

The primary purpose of this project is to undertake a boat-based population estimate study over a five year period (1990 to 1994) to determine the size of the southern Hemisphere Group IV humpback whale stock. This stock winters off Western Australia, migrating south to summer feeding grounds in Antarctic Area IV (70o E - 130o E). Secondarily, we aim to determine the relationship of this stock to breeding aggregations elsewhere in the Southern Hemisphere. Boat-based photo-identification techniques employed successfully by researchers world-wide (see Katona and Beard, 1990) are being used. This report presents the second season's data from the planned five year project. The study was undertaken under the relevant State and Commonwealth Government research permits.

3. MATERIALS AND METHODS

Research was conducted daily, weather permitting, from a research station on Enderby Island in the Dampier Archipelago, northern Western Australia (20o 30' South; 116o 40' East) (Fig. 1). Details of field procedures are described in Jenner and Jenner (1991). Photographic and observational data, as well as song recordings, were collected as in the 1990 season with the following exceptions.

1) Our photographic technique has been modified from the techniques of Miles (1990) and Mizroch and Bigg (1990) to accommodate strong light conditions. The black and white film is no longer pushed to 1600 ASA but instead shot at its rated 400 ASA. With an aperture of f8 or f11 we were still able to obtain shutter speeds of 1/2000 or 1/1000 of a second. This reduces the grain size enabling enlarged images to remain quite detailed.

2) Our primary search area has shifted 10nm west of last season's position (Grids I7,I6,H7,H6 rather than I5,I4,H5,H4, see Fig. 5). This has shortened the trip to and from the main migratory area and allowed us to avoid long trips back to the Enderby Island base against the southwesterly sea breeze. Since the whales migrate past in an East-West direction and not North-South we are confident that this has not adversely affected the number of whales sighted.

As in 1990, copies of photographs have been provided to J. Bannister, Western Australian Museum, S. Mizroch, National Marine Mammal Laboratory, Seattle and J. Beard, College of the Atlantic, Bar Harbor, Maine, USA for comparisons with photographic data bases held at these institutions. In accordance with permit requirements a set of identifying photographs has also been provided to the Australian National Parks and Wildlife Service, Canberra, Australia.

4. RESULTS AND DISCUSSION

A. SEASON STATISTICS, For Total Period June 01-October 07, 1991.

Table 1 shows the total number of whales observed and subsequently photographed for each month of the season.

Table 1. Season Statistics.

	# Pods	Whales Obs.	Days On Water	Hrs On Water	Hrs /Whales(%)
June	1	2	10	56.3	0(0)
July	5	8	17	111.8	6.5(6)
Aug	50	118	20	132.9	32.5(24)
Sept	45	89	19	153.4	28.8(19)
Oct	1	1	2	15.7	0.5(3)
Total	102	218	68	470.1	68.3(15)

B. OBSERVATIONAL DATA

The graphs and tables in the following sections present data on all whales observed, including intraseason resights.

i. Peak Numbers and Direction of Migration

The highest number of whales (51) was seen in the August 22-28 period (Table 2). August accounted for 54% (118/218) of all encounters this season. The greater number of whales encountered in August was heading southwards (81%; 96/118), although there was a northward bound portion of 9% (11/118). Animals resting ("Nil" direction) also accounted for 9% (11/118) of the whales observed.

A Chi-square test was performed on the data in Table 2 to test if the number of whales observed throughout the season was influenced by time or location. The hypothesis that there was no interaction was rejected (Chi-square = 43.482, df 8, $P<0.001$). Therefore, because of the interaction, the effect of time or location could not be tested individually. From Table 2, most whales were seen in Zone I during the season except for Week 3 when the majority of whales were seen in Zone H.

Table 2. Time and location of whales for weekly periods between August 01 and October 02, 1992.

		LOCATIONS H	I	TOTALS
WEEKS	1	3	7	10
	2	2	5	7
	3	24	9	33
	4	8	40	48
	5	13	11	24
	6	1	16	17
	7	1	8	9
	8	11	15	26
	9	2	11	13
TOTALS		65	123	188

The peak of the southern migration in 1991 fell between August 19 and September 06 (Fig. 2). The daily "pulses" that can be seen over this period may be representative of "herds" of whales travelling together to maximize their breeding potential. Because of these pulses it may be preferable to view the data on a weekly, rather than daily, basis. When considered in this manner the highest mean rate of 1.32 whl/hr/wk occurs in the August 22-28 period (Table 3).

The point mid-way between the northward and southward migration was between August 08 and August 14 (Fig. 3). During the two weeks previous to this period (July 25- Aug 07) 71% (12/17) of the whales encountered were travelling north, 6% (1/17) were travelling south and 24% (4/17) were milling. During the following 14 day period (August 15- 28) 5% (4/89) were travelling north, 92% (82/89) south and 3% (3/89) were milling. Weekly plots (Fig. 3) show the progression in time of the southward migration from the mid-point in early August, to the peak in mid to late September, to the later stages of migration in October. At Point Cloates (22o 30'S) in 1952, Chittleborough (1965) calculated August 24 as the mid-way point and in 1953, August 20. The earlier mid-point at the Dampier Archipelago (20o 30'S) is consistent with its position further north.

Table 3. Peak Numbers and Direction of Migration, July, August & September, 1991.

Month	# Whales /week	#Whales /hour/wk	N-bound #	N-bound %	S-bound #	S-bound %	Nil #	Nil %
Jul 25-31	5	0.21	5	100	0	0	0	0
Aug 1-7	12	0.39	7	58	1	8	4	33
8-14	8	0.34	0	0	5	63	3	38
15-21	38	1.04	4	11	33	87	1	3
22-28	51	1.32	0	0	49	96	2	4
29-04	27	0.88	2	7	24	89	1	4
Sep 5-11	17	0.75	0	0	16	94	1	6
12-18	10	0.36	0	0	8	80	2	20
19-25	31	0.69	8	26	23	74	0	0
26-02	13	0.33	0	0	13	100	0	0
TOTAL	218	0.46	28	13	174	80	16	7

ii. Number of Pods and Pod size

The calculations for number of pods and pod size include affiliations and disaffiliations, to include the social dynamics of migratory pods. Thus if a pod of 1 adult affiliates with a pod of 2 adults later that day, the resulting pod of 3 adults is used for the daily pod and location calculations as well as its precursors.

The highest number of pods was seen in August, where 49% (50/102) of the pods and 54% (118/218) of the whales were encountered (Table 1). The average pod size increased towards the last week of August and then again in the third week of September. The mean pod size for the season was 2.07 + 0.24 (95% CI), indicating that the integral migrating unit was two whales. The pods ranged in size from one individual to eight. This range is due to large, active pods of between 4 and 8 whales on their way south whilst northbound whales were seen in equal numbers of ones and twos. The average pod size of northbound whales was 1.63 + 0.30 (95% CI) while southbound pods averaged 2.41 + 0.42 (95% CI).

iii. Location of Whales

The Dampier Archipelago and the area extending to the edge of the continental shelf off the Archipelago has been divided into five nautical mile square areas (Figs. 4 & 5). The data collected reflect the distance off-shore

that humpback whales were most frequently encountered. This distance is expressed as "Zones" (A - T) extending at 5 nautical mile intervals north of Dampier. We have plotted the locations of whales recorded by local helicopter pilots as well as our boat-based study. Due to the configuration of the coastline whales we refer to as northbound are in fact heading east to north-east and those heading west are called southbound.

a. Helicopter Observations

Helicopter pilots reporting sightings on a supplied data sheet while flying out to oil drilling platforms north and west of Dampier allowed us to estimate the proportion of whales that migrate within the range of our vessel. Starting on August 08 and continuing until October 04, 1991, and therefore inclusive of the peak of the migratory body recorded by the boat survey, 27 pods were sighted, totalling 45 whales. Seventy-four percent (20/27) of these pods were within 25nm north of our base (up to Zone I) which is within our average daily vessel range (Fig. 4). Whales were sighted as far north as the North Rankin A Production rig approximately 60nm NW of the northern most tip of the Dampier Archipelago. The edge of the continental shelf is within 10nm of this position so it is likely that whales migrate over the entire width of the continental shelf. From the sightings reported, however, the main flow of the southern migration appears to move along a 10-20nm wide corridor between the northern-most tips of the Dampier Archipelago and the Monte Bello Islands.

Helicopter data will continue to be studied in future seasons to monitor the southern migration and, as well, to establish the migratory path of the northern migration. Helicopter data give access to an area that could not possibly be accurately surveyed by one research vessel. However, it should be noted that there are some inherent problems in a non-dedicated survey technique such as this. Some of these include:

1) Pilots may fly at different heights or different speeds depending on weather conditions or personal preference.
2) Non-surface active (resting or swimming) pods are less likely to be spotted by untrained observers than surface active (breaching or splashing) pods.
3) Observer bias is likely because of the large number of pilots operating with differing levels of enthusiasm for the project.

b. Boat Survey

Over the 1991 season 58% (126/218) of the whales encountered were in Zone I, however during Week 3 there was a large number of whales observed in Zone H (Table 4). As mentioned in B (i) the Chi-square test for the influence of location and time on the number of whales encountered showed an interaction. A possible biological reason for Week 3 containing differences between the expected and the observed is simply the high number of whales observed at this time, particularly August 19 (21 whales), which was the highest of any one day this season. The large number of whales and interacting pods caused the flow of the migratory body to cover a larger area and resulted in more whales observed than expected in Zone H.

Table 4. Location of whales observed from the boat in Zones E to J (see Fig. 5) for June 01 to October 07, 1990.

Month	Zones (Distance) North of Dampier (nm) E (5)	F (10)	G (15)	H (20)	I (25)	J (30)	Total
June	2	0	0	0	0	0	2
July	0	0	2	3	3	0	8
August	2	2	5	47	61	1	118
September	0	1	3	20	61	4	89
October	0	0	0	0	1	0	1
Total	4	3	10	70	126	5	218

Using Zones H and I only, a Chi-square test was performed on the data in Table 5 to test if the number of whales observed is influenced by location or direction of movement (north, south, or nil). The hypothesis was rejected (Chi-square = 6.88, df 2, $P<0.05$). We largely observed and photographed southward migrating whales (17 north and 171 southbound) and these whales were found most often in Zone I (56 in Zone H and 115 in Zone I) (Fig. 5).

Whales resting ("Nil") at the Dampier Archipelago made up the smallest proportion of the whales observed (7%, 16/218).

Table 5. Number of whales migrating North, South or Nil for Zones E through J for June 01,1991 to October 07, 1991.

Dir	Zones E	F	G	H	I	J	TOT
N	0	0	5	11	6	4	26
S	0	0	4	56	115	1	176
NIL	4	3	1	3	5	0	16
TOT	4	3	10	70	126	5	218

c. Northern Migration

Boat surveys were conducted in June and July, 1991, in an attempt to record the peak of the northward migration past the Archipelago. Only two whales were sighted in 10 days of searching in June and 8 whales in 17 days in July. Only seven more northbound whales were sighted before the beginning of the peak of the southern migration in the third week of August. We must therefore assume that the bulk of the northbound migration was missed due to the limited range of our vessel (~10nm north of the Archipelago).

Chittleborough (1965) reports that the main stream of migrating humpback whales at the Western Australian whaling stations passes within 10nm of the coast. If, however, whales migrating past the Dampier Archipelago towards their presumed breeding area(s) to the northwest follow as short a course as possible to their destination, their "best course" would take them 40-50nm north of the northern-most tip of the Dampier Archipelago (Fig. 6).

Northbound whales were observed in Zones G, H, I and J over the course of the season with the highest proportion 42% (11/26) encountered in Zone H (Table 5).

d. Southern Migration

Southbound whales were found in both Zones H and I and one individual in Zone J (Fig. 5). Sixty-five percent (115/176) of the southbound whales were in Zone I (Table 5).

Topographical features such as Legendre Island and Madeleine Shoals, which extend off the NW tip of Legendre Island, provide a definite barrier and landmark to southward bound whales following the coastline and may be the reason for the high number of encounters in this area (Fig. 5). Chittleborough's (1965) report that the mainstream of humpback whales migrating past Australian whaling stations passes within 10 miles of the coast is consistent with our findings for the southern migration but, as discussed in the previous section, does not hold true for the northern migration.

Dawbin (1956) shows that humpback whales migrating past New Zealand shores follow quite different routes on their northward and southward migrations. He concludes that this is result of the physical orientation of the New Zealand land mass rather than factors such as food availability, water temperature, depth or current flow. Similar physical factors may affect the distance off-shore that humpback whales pass the Dampier Archipelago on their northward and southward migrations. The continental shelf (depth < 100fa) is wider at the Dampier Archipelago than near any of the former west coast whaling stations (80nm cf. 20nm at Albany, 70nm at Carnarvon and 10nm at Pt. Cloates) and may result in wider dispersion of the migrating whales there. Further south off Perth, Western Australia (latitude 31o S), the northern and southern migratory routes also appear to be distinct. The northern migration remains well off-shore while the southern migration passes within 10nm of the coast (Burton, 1991) and is the focus of commercial whale-watching ventures during September and October.

e. Intraseason Resights

There were three intraseason resights in 1991. Two were whales first observed heading north and later sighted moving south. The first animal was a single adult photographed northbound on July 28, in Zone H, which was resighted 29 days later on August 26, in Zone I, southbound with five adults. The second was an adult of a two adult pod photographed northbound, in Zone I, on August 02 and resighted 17 days later on August 19, in Zone H, travelling south with a subadult. The whales in these cases would have presumably migrated further north and then passed by Dampier on their way south again. These are the only two whales that we have been able to photograph in the two seasons of observation which have followed the same northern and southern migratory path at Dampier.

Whales do not appear to remain in the Dampier Archipelago region for extended lengths of time. The longest period of residency recorded thus far was an animal photographed during 2 consecutive days on August 22 and 23, 1991.

iv. Age Class

Determination of age class for humpback whales is an important factor in the analysis of fluke identification photos for the purpose of population estimates. Carlson, Mayo and Whitehead (1990) showed that the greatest degree of change in fluke pigmentation occurred during the first two years of life. In this survey, particular attention has been paid to the analysis of flukes of whales identified as subadults so that the chance of an over estimate due to missed matches is minimized.

The majority of whales seen throughout the season were categorized as Adults (89%, 193/218). Whales categorized as Subadults accounted for 25% (2/8) of the observed whales in July, 5% (6/117) in August and 6% (5/89) in September (Fig. 7). No Subadults were encountered in October. Calves were present in two months, accounting for 2% (2/117) of the whales encountered in August and 10% (9/89) in September. One yearling was sighted in late June.

Chittleborough (1965) showed off Albany (35o 05'S), W.A., that immature males and females are seen in highest numbers in June and July, in the vanguard of the northern migration. The low number of whales encountered over these two months in 1991 is most likely due to the off-shore limits of our vessel.

The increasing proportion of cows with calves towards the end of September (Fig. 7) is presumably due to segregation within the migratory stream. At Byron Bay (28o S) on the east coast of Australia, Chittleborough (1965) showed a similar segregation of cows with calves within the southbound migratory body.

v. Cow/Calf pods

A total of eleven cow/calf pods was observed, two in August and nine in September. Cows with calves were found in zones E, G and H. One of the two pods observed in August was resting inshore between East and West Lewis Islands (grid E6) the other was off-shore, north of Rosemary Island (grid H6) migrating

slowly southwest. Two pods, each of adults (possibly cows) and subadults were found migrating north in late July and early August.

The age of the two calves observed in August was estimated to be between 1 and 2 weeks old (see Jenner and Jenner, 1991). The nine pods seen in September were all off-shore heading south with 2 to 4 week old calves. Two of the eleven cow/calf pairs were "escorted" by another whale as has been described by Baker and Herman (1984).

The low proportion of escorted cow/calf pods recorded again this season (one in 1990 season) will be compared with observations in following seasons. The escorts, presumably courting males, in these associations have been shown to be very transient (Mobley and Herman, 1984) and perhaps during migration are less likely to be observed travelling with cow/calf pods than travelling between cow/calf pods.

vi. Song Recordings

Whale song was recorded only when the songs were very loud and clear and we could be sure of making a good recording. Seven songs were recorded during the season, one each in June, July and August and four in September. The longest song recorded was 0.47 hour (Table 7) and the shortest 0.05 hour. One song was recorded in Zone H, and the remaining six in Zone I.

Whale song was heard consistently on a daily basis after July 03 in areas north of Zone G. Only 8 whales were observed in July despite the persisting song heard daily. The presence of song in both June and July on a regular basis is consistent with our theory of the existence of a northward bound migratory path that is considerably further off-shore than the southern migratory path.

Whales observed or recorded singing in other studies have been assumed to be male (Winn et. al., 1973, Glockner, 1983) and have been so identified in our Identification Catalogue. Of the seven singers we recorded, two observed in September were swimming north against the flow of the majority of the migratory body while singing. These males may have been trying to maximize their exposure, and thus their mating potential, to as many southbound females as possible.
The remaining five singers recorded were either milling or their migratory direction could not be determined while they were singing.

Table 7. Date, Zone and Length of Song Recorded for the Songs Recorded from August to October, 1990.

Date	Zone	Time Recorded (hours)	Migratory Direction
Jun 06	I	0.05	?
Jul 18	I	0.32	?
Aug 02	I	0.38	Nil
Sep 11	I	0.20	?
Sep 19	I	0.42	Nil
Sep 20	I	0.06	North
Sep 21	H	0.16	North

C. PHOTOGRAPHIC DATA

i. Photographic Observations

Of the 218 whales observed over the course of the season, 206 were photographed, resulting in a total of 551 identification photographs. Each whale photographed has been given an observation number. Types of photographs for each individual have been assigned to one of 5 categories (see below). At sea we endeavoured to match each individual's right and left lateral body with its fluke by making sketches and assigning descriptive names. On some occasions it was not possible to positively match flukes with corresponding lateral bodies. For these whales (5 individuals) we have assigned separate observation numbers to both fluke and lateral body photographs resulting in an increased number of photographic observations (206 + 5 = 211 in total). The categories affected are "fluke only", "2 lateral body" and "1 lateral body".

Identification numbers have been assigned to whales with photographic observation numbers in categories containing a fluke photograph of good photographic and recognition quality. Fluke photographs receiving an identification number have been graded by photographic and recognition quality following Mizroch et al. (1990). Whales identified by lateral body photographs

only, have not been given identification numbers. They will retain their observation number until subsequent sightings match the lateral bodies with a fluke photograph at which time they will be given a corresponding identification number. Lateral body photographs also provide a reliable means of resighting individuals with fluke photographs of poor photographic or recognition quality.

Ninety-four percent (206/218) of the whales observed were identified through photographs. Seventy-six percent (156/206) of the whales photographed were identified with fluke photographs. The apparently high proportion of whales that present flukes among those whales seen in our study area is encouraging as this may reduce population estimate biases due to differences in fluking rates between different age/sex classes.

The whales photographed during the 1991 season off Perth by C. Burton are still being compared to our photos at the time of this report.

a. Number of Photographic Observations per Category
(June 1 - October 05, 1991).

Fluke + 2 Lateral Body:	94
Fluke + 1 Lateral Body:	37
Fluke only:	25
2 Lateral Body:	39
1 Lateral Body:	16
Total	211 (206 indivs)

b. Number of Fluke Photos: 156
(includes FL + 2LB; FL + 1LB; FL ONLY)

c. Number of Paired Lateral Body Photos: 132
(includes FL + 2LB; 2LB)

d. Number of Intraseason (1991) Resights:
resighted x 1: 3
resighted x 2: 0

e. Number of Interseason Resights:
1990-1991: 4

Two of the four interseason resights were seen on similar dates in each year, as follows:

WA0040 August 17, 1990 & August 21, 1991
WA0030 August 18, 1990 & August 22, 1991
WA0100 September 22, 1990 & September 06, 1991
WA0122 October 21, 1990 & August 19, 1991

ii. Population Estimate

The Petersen estimator is a closed population model that requires only two samples and is therefore appropriate for a preliminary population estimate at the end of our second season. It assumes the following:

1) The population is closed
2) All animals have the same probability of being caught in the first sample
3) Marking does not affect the catchability of an animal
4) The second sample is a simple random sample
5) Animals do not lose their marks
6) All marks are reported on recovery Seber(1982)

Hammond (1986) suggests that for studies using photographs of naturally marked whales, Bailey's (1951) modified estimator is best used since it allows for sampling with replacement. The Bailey's modified estimator is calculated as:

$$N = \frac{n1(n2+1)}{m2+1}$$

where n1 and n2 are the number of animals marked in the first and second samples and m2 is the number of recaptures in the second sample. From our data n1 = 90, n2 = 109, and m2 = 2 resulting in N = 3300.

Following Tillman and Grenfell (1980) after Seber (1973, p. 189) an approximate 95% confidence interval for N is given by:

$$\frac{4d}{(1.96 + (4L - 1))2} < N < \frac{4d}{(-1.96 + (4L - 1))2}$$

where d = n1 x n2, corresponding to n1 and n2 in the Bailey's modified estimator equation and L = n1+1. The limits defined are asymmetrical about the estimate with the result, 89<N<134.

The population photographed off the Dampier Archipelago is therefore estimated at 3300 whales with a lower limit of 3211 (95% CL) and an upper limit of 3334 (95% CL).

Only whales identified (marked) by good quality tail fluke photographs and resighted (recaptured) with good quality tail fluke photographs during August and September were used for this estimate. By "good" we mean that the fluke was focused and exposed properly, the entire trailing edge and notch are visible and less than 1/3 of the remainder of the fluke is submerged.

This assessment is consistent with J. Bannister's (pers. comm.) current estimate of this population at 3000+ animals which has been derived from aerial survey data collected off Shark Bay from 1976 to 1991.

5. CONCLUSIONS

We concluded in 1990 that by sampling during the August to October period we were primarily working with the southern migration past the Dampier Archipelago. Our second season's results were consistent with this assessment indicating that 90% of the whales encountered during this period were southbound or milling. The numbers of whales observed on a daily basis over this period in both 1990 and 1991 are shown in Figure 8.

Although the period of June to July must then contain the largely northbound whales in this region, we were not able to observe more than 10 whales during these two months of observation in 1991. The northbound whales must therefore travel further off-shore in this area than we are able to monitor in our research vessel. If the whales travel on a "best course" from the Monte Bello Islands towards the Kimberleys, their route would take them approximately 50nm north of the northern most point in the Dampier Archipelago (Fig. 6). During the 1992 field season we will operate from the Monte Bellos during June and July in an attempt to record both the peak of the northern migration and their migratory heading in this region.

Over the course of the season whales were encountered in six of the eighteen Zones designated off Dampier (E, F, G, H, I and J). The highest proportion was found in Zone I, 25 nautical miles north of Dampier. Since 74% of the whales sighted by the helicopter pilots were also inshore of Zone I, and theoretically within the range of our research vessel, we can assume that the majority of the whales in the southern migration follow a relatively narrow route between the Dampier Archipelago and the Monte Bello Islands. The northern migration, however, does not use this same route.

Whales encountered that were heading north can probably be grouped into one of two categories; 1) those whales heading towards the northern breeding/calving grounds (away from the main northern route) and, 2) those whales which have begun their southern migration but have stopped and turned around to initiate or respond to further breeding opportunities. Northbound whales seen in June, July and early August most likely will fall into Category 1 while those observed heading north after the 21st of August will most likely fall into Category 2. The southbound pods observed were on average larger than northbound pods, most likely due to interactions between Category 2 whales.

There was again a low proportion of subadults and calves observed this season. Subadults may only be present in the early weeks of the northern and southern migrations as suggested by Dawbin (1956) and Chittleborough (1958b, 1958c, 1965). Since we were not in a position to observe the majority of the northern migration during both the 1990 and 1991 seasons, it is possible that subadults are northbound in June and southbound in July, at the vanguard of the northern and southern migrations, but remain further off-shore than we can monitor. It is also possible that most subadults do not migrate as far north as Dampier since they are not sexually mature and therefore have little to gain from migrating that far from their Antarctic food source.

The low number of cows with calves may simply be due to the difficulty involved in spotting them. Both cows and calves characteristically lie very low at the surface, breathing often but shallowly and the cows rarely raise their flukes. If more surface active pods are passing the Archipelago there may be a positive spotting bias towards these and a negative spotting bias towards the cow/calf pods. Larger numbers of cow/calf pods are reported from the Perth region (Burton, 1991) where commercial whale watching vessels, which have a higher observation platform, spot many of the pods. All of the cow/calf pods observed off Dampier this season and all but one last season were either resting or migrating south. This information, together with the estimated age of the observed calves, leads us to believe that the main calving ground(s) is further north of the Dampier Archipelago by approximately 1-2 weeks travel time.

Of the 156 tail fluke identifications collected this season, 109 (70%) were of "good" quality. These, together with the 90 "good" fluke photographs

from the previous season were used to calculate the most conservative of our preliminary population estimates. Possible violations of the estimates' assumptions are as follows.

1) This population may not be a closed population since Chittleborough (1959b) and Dawbin (1964) have shown that small numbers of whales do change tropical breeding grounds between seasons. The extent to which this influences our estimates can only be determined after the Western Australian catalogue has grown to a sufficient size as to represent a large portion of the population and is then compared to catalogues being compiled in other parts of the southern hemisphere. At this point, no matches have been found between our 1990 catalogue and the several collections curated at the National Marine Mammal Laboratory in Seattle, Washington nor at the College of the Atlantic in Bar Harbor, Maine (S. Mizroch and J. Beard, pers. comm.) which include southern hemisphere and Antarctic animals.

2) Since we are using the photographs collected only during August and September which represent the majority of the southern migration we feel that the second assumption that there is an equal probability of being caught in the first sample is reasonable although heterogeneity or inherent individual variability may have an unknown effect on the catchability of an individual (Hammond, 1990). Helicopter flights flown regularly at various but consistent angles to the presumed migratory path have indicated that 74% of the whales observed travel along a route that is accessible to our vessel. During the 1990 season, 70% (138/196) of the photographed whales were identified with fluke photographs. This high figure may be due to the fact that the whales are migrating steadily past the Dampier Archipelago and, with a few exceptions such as resting cow/calf pods, are not resident in the area for long periods of time. Few animals encountered have been classified as subadults which has the effect of decreasing the chance of a bias due to different fluking rates between different age classes (Perkins et. al., 1985) but also causes concern that juvenile whales may not have an equal chance of being sampled at our current location.

3) The third assumption that marking does not affect the catchability of an animal is probably valid since photography is a benign marking technique and we rarely follow whales longer than 30 minutes to obtain these photos.

4) Our second sample is a simple random sample. We go to the same spot on the migratory path every day but "new" whales traverse that area daily. This is the area (Zone I) which allows us to photograph the majority of the southern migration and is also within the limit of our vessel's range.

5) We feel confident that the assumption that animals do not lose their marks is valid. Work presented by several authors, which this project is based on, confirm this (see IWC Special Issue 12). Whales, however, may gain marks from attacks by predators or physical contact with other humpbacks although this should not affect resightability by trained workers except in the case of amputations. Both dorsal fin and tail-fluke (single and double!) amputations are present in this population.

6) The final assumption that all marks are reported on recovery is also valid because we only included good quality photographs in the analysis.

Less conservative estimates can also be calculated using a combination of good fluke photographs and good lateral body photographs, or only good lateral

body photographs. These estimates and their biases will be discussed in more detail in future papers.

The black and white photo-identification prints collected this season off the Dampier Archipelago will be compared with the existing collection curated by J. Bannister at the Western Australian Museum and also with identification photographs taken by C. Burton and H. Rosenbaum in the Perth region. Currently arrangements are being made for a comparison of the Western Australian collection with those taken in South Africa and Tonga.

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Figures

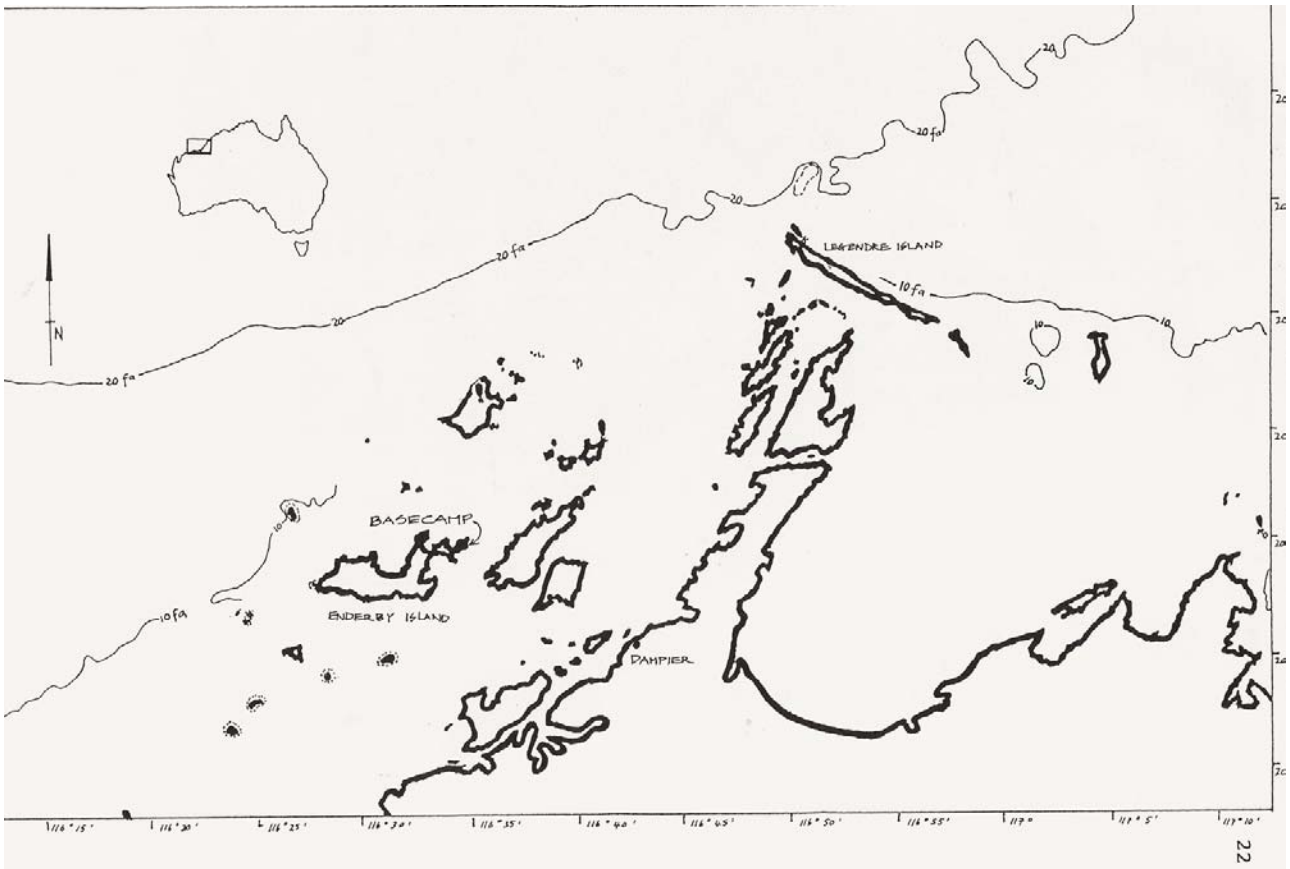

Fig. 1 The Dampier Archipelago Study Area.

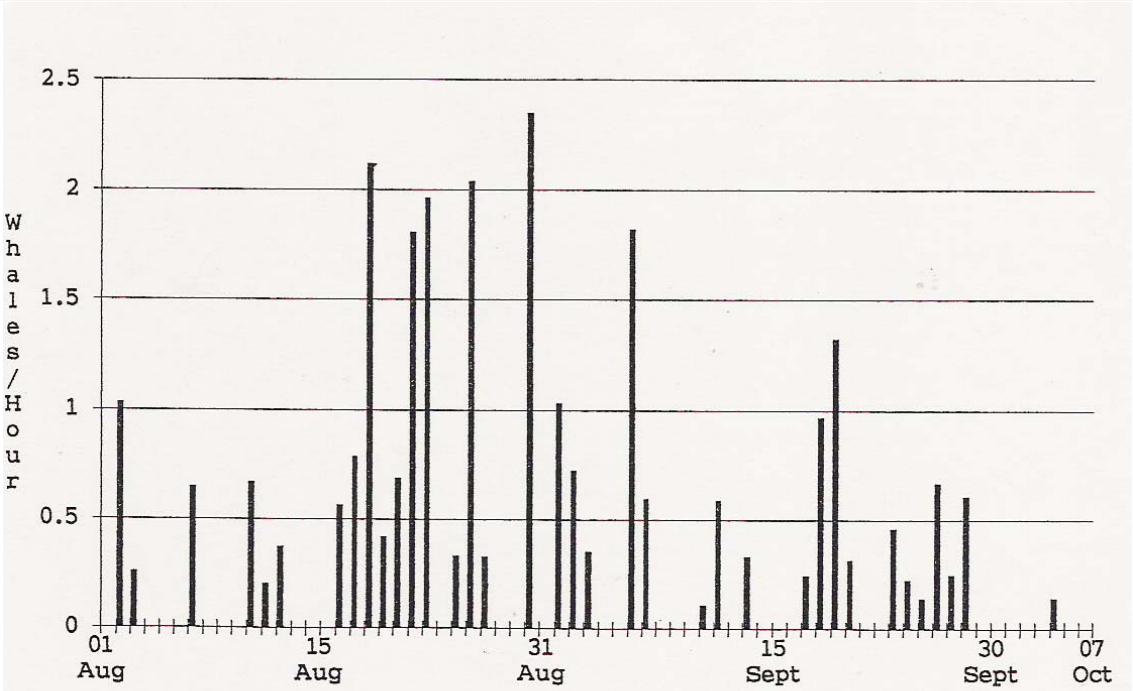

Fig. 2 Whales observed per hour for each day between August 01 to October 07, 1991.

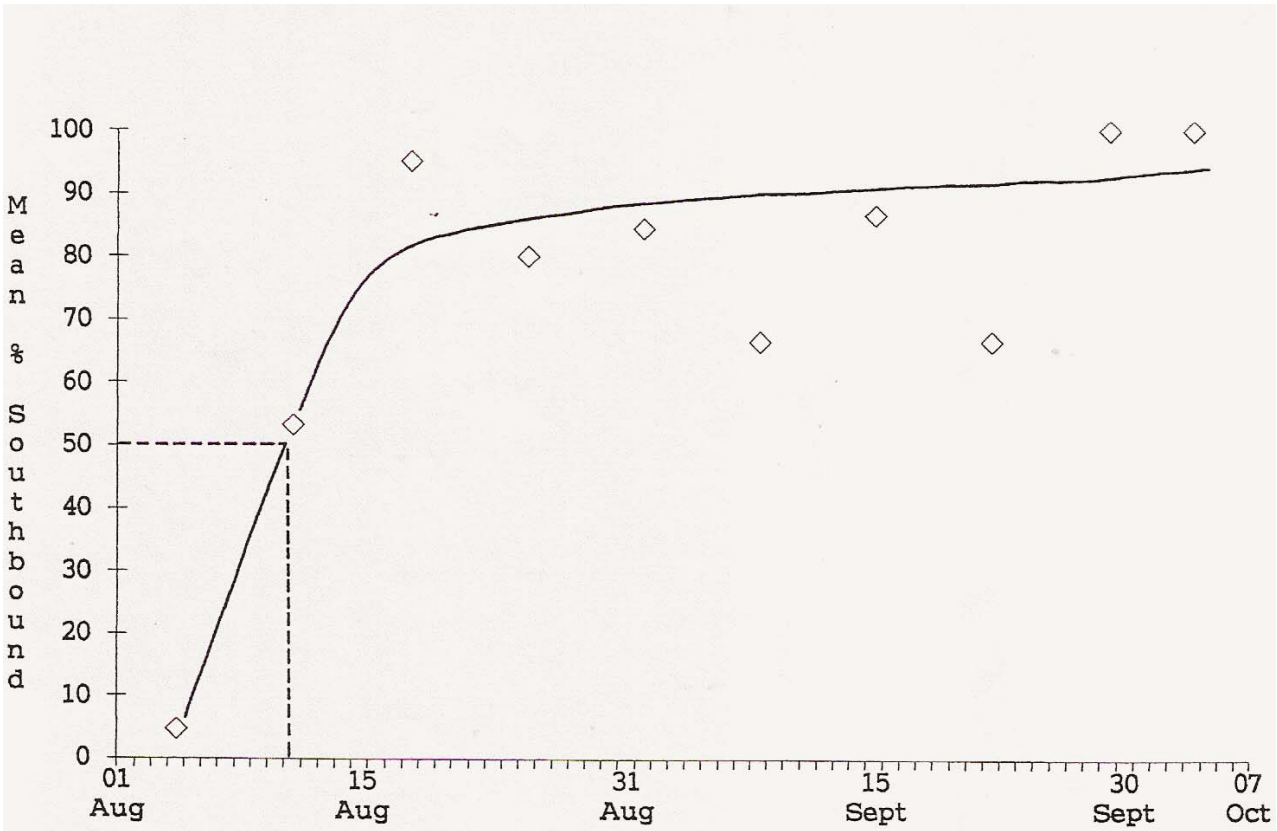

Fig. 3 Weekly means of the daily proportions of southbound whales, August 01 to October 07, 1991.

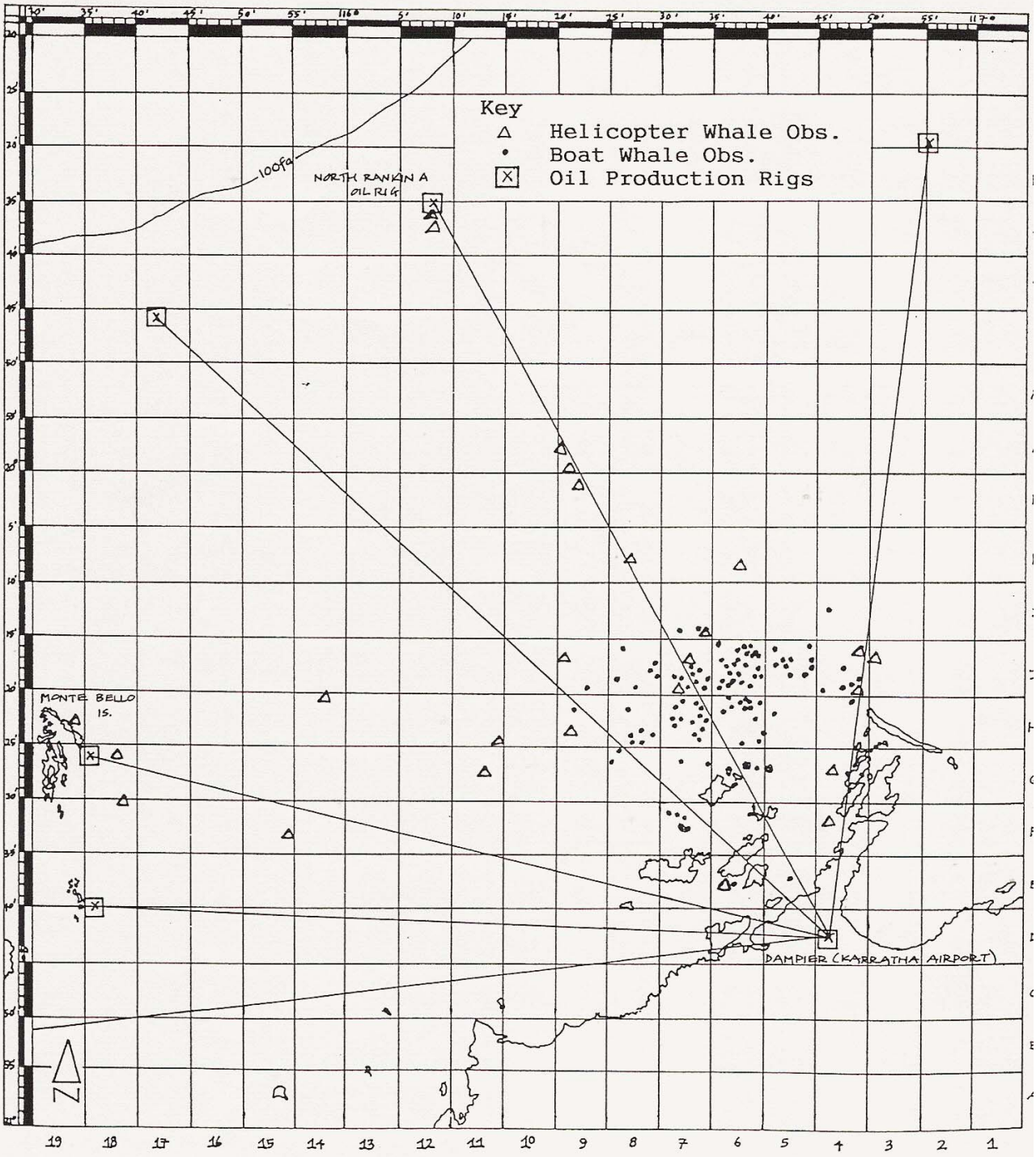

Fig. 4 Dampier Archipelago and surrounding area including route of helicopters to oil rig platforms. Grids in 5 nautical mile intervals.

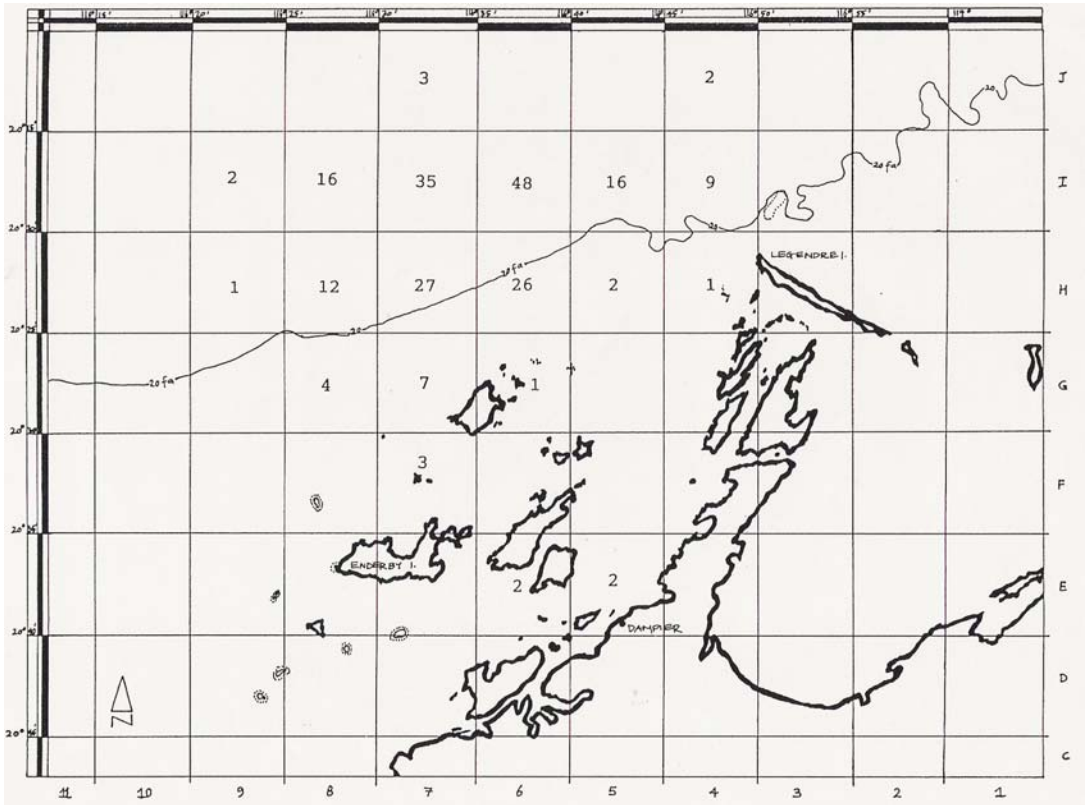

Fig. 5 Humpback whales observed per 5 nautical mile grid, Dampier Archipelago, 1991.

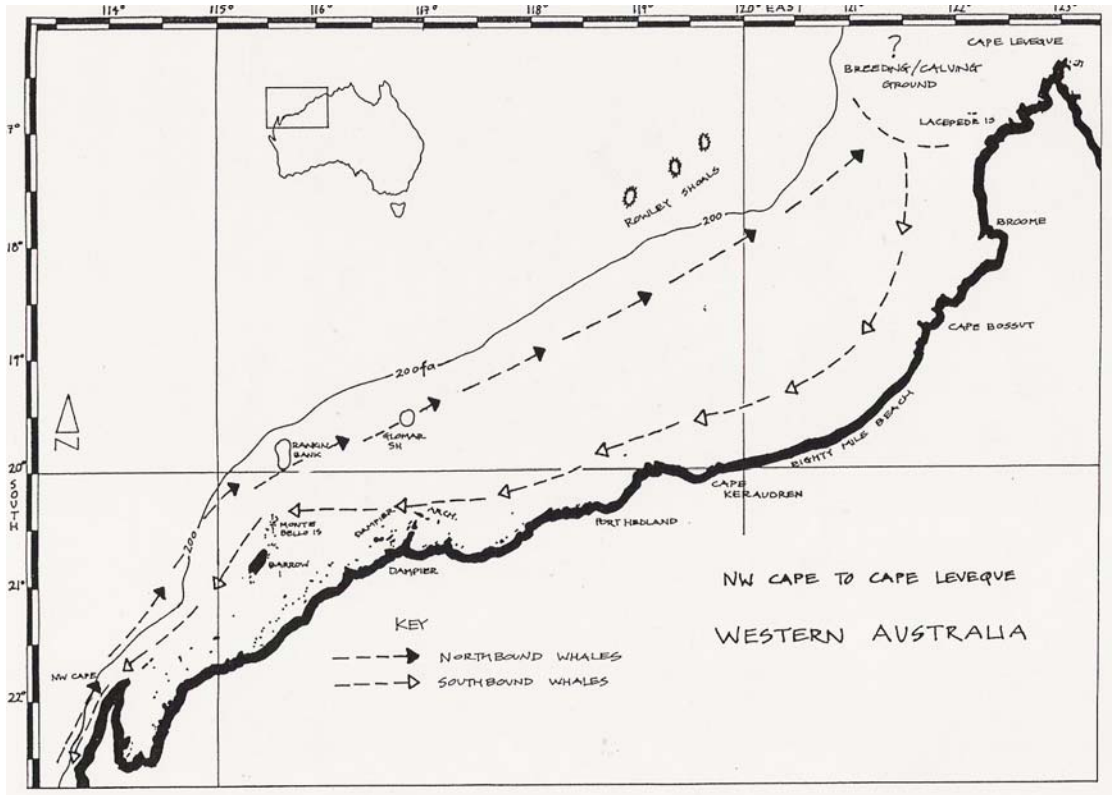

Fig. 6 Presumed routes for the northern and southern migrations off Northwestern Australia.

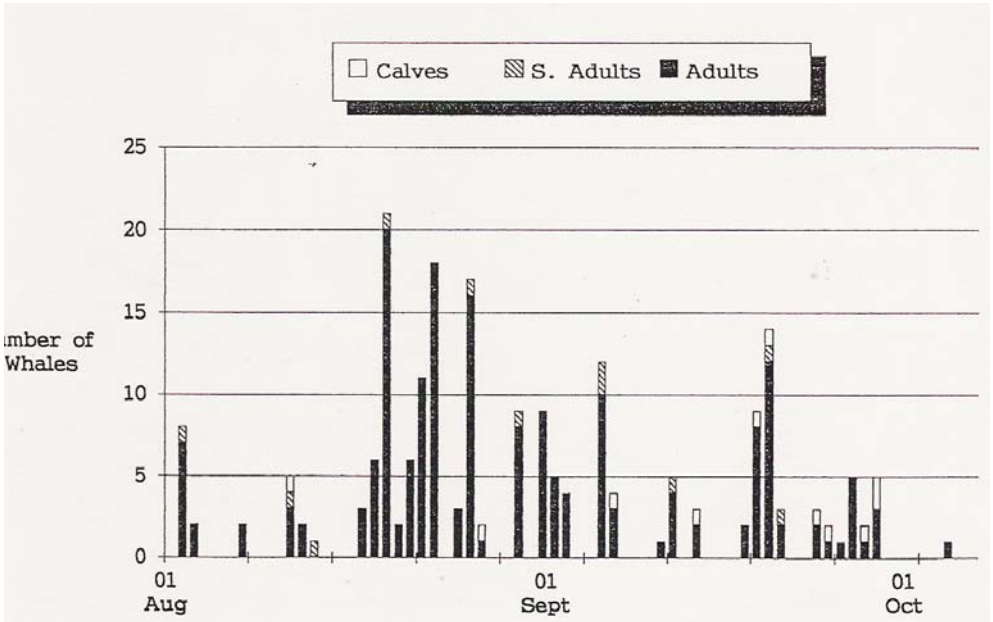

Fig. 7 Age class observations for Adults, Subadults and Calves during the period August 01 to October 07, 1991.

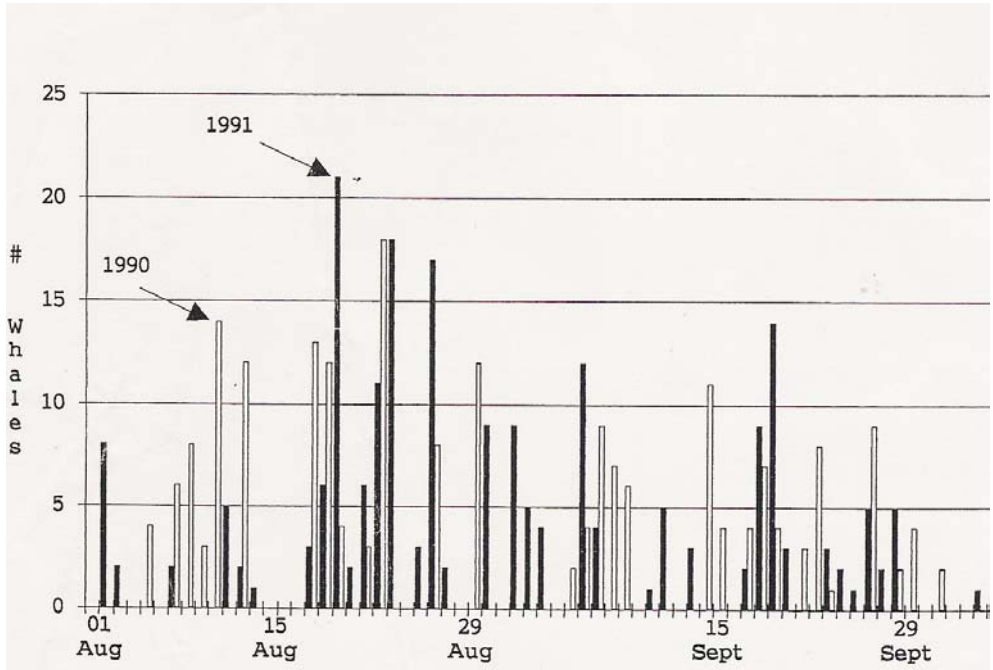

Fig. 8 A visual comparison of the 1990 and 1991 seasons off the Dampier Archipelago.