Movement Patterns of Tagged Spiny Lobsters *Panulirus argus* on the Bermuda Reef Platform

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ABSTRACT

A tagging program for spiny lobsters (*Panulirus argus*) commenced in April 1997 using mainly sub-legal sized (< 92 mm CL) lobsters obtained from commercial trap fishers during the lobster open season (September 1- March 31). As of October 2000, a total of 576 lobsters have been tagged with Floy anchor T-bar tags. There have been 51 recaptures of tagged lobsters to date for a recapture rate of 8.9 %. The longest distance (point-to-point) moved by a recaptured lobster was 45.9 km, which is essentially the length of the long axis (NE to SW) of the Bermuda reef platform. Similar movements by other recaptured lobsters demonstrate that movements of this magnitude occur in both directions on the platform. All recaptures except one have been reported by commercial lobster trap fishers, the one exception being a recapture reported by a recreational lobster diver. The mean straight-line distance travelled by all recaptured lobsters regardless of time at liberty was 12.2 (± 11.4, SD) km. The range of days at liberty was 9 - 700 days with a mean value of 294 (± 168 SD) days. The assessment of movement patterns of spiny lobsters is an important element in the management of the limited entry lobster fishery because of the use of defined trapping areas on the reef platform as an integral part of the management program.

INTRODUCTION

Traditionally, commercial lobster fishing around Bermuda was conducted using Antillean arrowhead wire traps set on the reef platform and two offshore banks. These traps were used for both lobsters and fish with the funnel configuration and baiting procedure being modified dependent on the target species.

Knowledge of spiny lobster movement patterns on the Bermuda reef platform is limited. Sutcliffe (1952) examined the size frequency and sex ratio of lobsters caught in traps around Bermuda during the summer months. He found that migrations were associated with breeding and that there was as a definite relationship between depth and/or distance from shore and size of lobsters. Evans and Lockwood (1996) conducted a tag-recapture program for sub-legal sized (< 92 mm CL) *P. argus* on the Bermuda reef platform from August 1986 to September 1987. They concluded that undersized lobsters, particularly females, were capable of swift and lengthy migrations.

In 1990, the use of fish traps was banned as a management measure to aid in the recovery of overfished reef fish stocks. As a consequence, the commercial harvest

of spiny lobsters was curtailed as the same traps were used for lobsters. As the spiny lobster population was considered to be healthy, an experimental fishery was established to develop and test designs for a lobster-specific trap which would have a minimal reef fish by-catch. After testing several different designs and sizes with commercial fishers (Ward and Luckhurst 1996), an acceptable trap design was developed. In 1996, a highly regulated limited entry commercial lobster fishery was established (Luckhurst 1999) with the Bermuda Government leasing fixed allotments of standard lobster traps to licence holders on an annual basis. For the first three months of the lobster season (1 September- 30 November), trapping is restricted to waters beyond the 10-fathom bathymetric contour. However, for the remaining four months of the season (December - March) fishers are permitted to bring their traps into one of two designated inshore areas (see Figure 1). The central portion of the reef platform is permanently closed to commercial lobster fishing and acts as a reservoir for spiny lobster where there is only limited recreational lobster diving.

The availability of lobsters to the commercial fishery in the two designated inshore areas is dependent to some extent upon the movement of lobsters from surrounding localities into the two areas to replenish lobster numbers as they are removed by the fishery. One of the management concerns in developing this spatial configuration for the fishery was that these two inshore areas might become depleted of lobsters due to the concentrated fishing effort. The objective of the present study was to increase our understanding of spiny lobster movement patterns over the Bermuda reef platform by conducting a long term tag-recapture study to evaluate movements in relation to the spatial configuration of the fishery.

METHODS

The tagging program for spiny lobsters began in April 1997 and is ongoing, but the results reported in this paper are inclusive of those obtained up to October 2000.

The majority of the lobsters used in this tagging program were obtained during the last two months of each spiny lobster season (February, March). Sub-legal sized lobsters (< 92 mm carapace length (CL)) were obtained from commercial trap fishers. Each lobster was measured (CL), sexed, tagged between the carapace and abdomen on its dorsal side with a Floy anchor T-bar tag, and then released on the reef platform. Global Positioning System (GPS) readings were taken at each release site.

When a tagged lobster was recaptured, the site of capture was noted, the lobster was re-measured (for growth increment) and then returned to the fisher, provided it was of legal size (min. 92 mm CL), otherwise it was returned to the sea. It was not always possible to obtain all of the requested data for the recaptured lobster. GPS readings for the site of recapture were often not available and thus the recapture location was estimated based on information provided by the fisher.

For each recaptured lobster, the sites of release and recapture were plotted on a chart of Bermuda (British Admiralty chart No. 334) and the distance between the two points was measured to give the straight-line distance (km) moved by the

lobster. This is a minimum estimate of distance travelled as there was no active tracking of tagged lobsters. Also, the time at liberty (days) (= date of release to date of recapture), and growth increment (mm) (= CL at recapture - CL at release) were calculated.

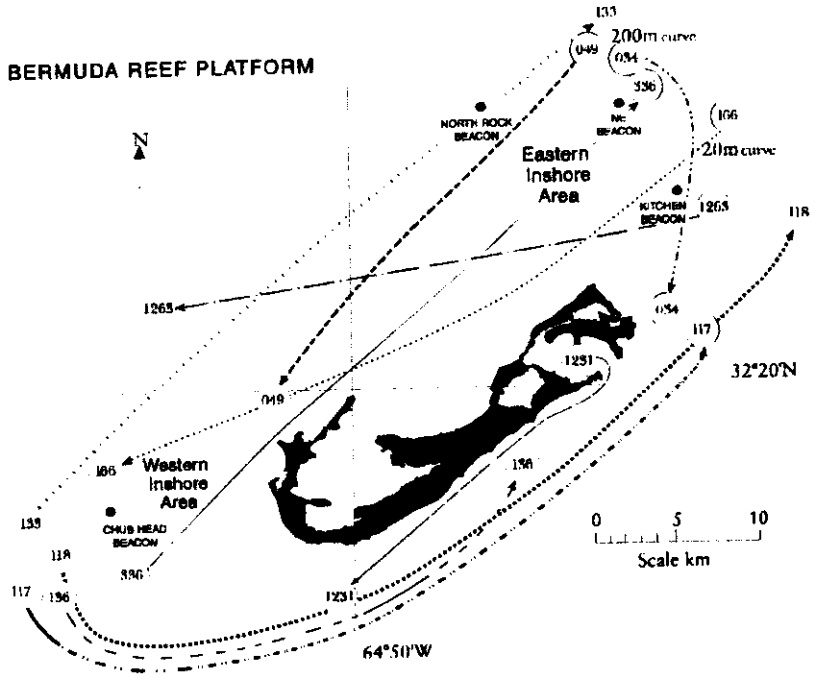

Figure 1. Map of Bermuda reef platform indicating minimum distance tracks of selected tagged lobsters and location of the two inshore areas designated in the lobster management program.

RESULTS

Five hundred and seventy-six *P. argus* were tagged between April 1997 and October 2000. By the end of October 2000, 51 tagged lobsters were recaptured (Table 1) for a recapture rate of 8.9 %. All but one of the tag returns were from commercial trap fishers, the one exception was a lobster caught by a recreational diver.

Table 1. Summary data for Bermuda spiny lobster tag-recapture program.

Tag #	Date of release	Size at release (mm CL)	Sex	Growth increment (mm CL)	Days at Liberty	Distance Moved (km)	Nominal Direction
T1209	16-Apr-97	82.0	F	13	216	14.6	NNE
T1231	16-Apr-97	91.0	M	?	189	20.8	SW
T1263	17-Apr-97	84.0	M	12	200	22.5	W
T1264	17-Apr-97	90.0	F	?	700	1.6	S
T1280	17-Apr-97	86.0	M	28	665	4.7	SW
T1330	17-Apr-97	90.0	F	6	258	3.2	NW
T1358	17-Apr-97	89.0	F	?	520	5.6	NE
T1383	17-Apr-98	120.0	M	15	281	7.4	N
T0006	28-Oct-98	85.0	M	0	21	0.0	-
T0021	3-Nov-98	91.0	M	?	132	9.5	N
T0034	3-Nov-98	88.0	F	0	9	3.4	N
T0048	20-Nov-98	90.0	M	?	129	13.2	WSW
T0049	20-Nov-98	86.0	F	8	435	27.0	SW
T0055	20-Nov-98	89.0	M	0	125	6.4	SW
T0057	20-Nov-98	88.0	M	?	50	7.7	SSW
T0060	20-Nov-98	89.0	F	2	335	13.0	W
T0077	20-Nov-98	90.0	M	23	465	10.5	S
T0078	20-Nov-98	88.0	F	?	303	?	?
T0082	20-Nov-98	84.0	M	?	45	10.5	W
T0084	20-Nov-98	85.0	F	0	55	4.7	WSW
T0087	20-Nov-98	84.5	F	23	429	10.5	SW
T0091	20-Nov-98	87.0	M	22	419	8.4	SW
T0117	1-Dec-98	85.0	M	13	339	38.0	ENE
T0118	1-Dec-98	87.0	M	8	296	45.5	ENE
T0127	1-Dec-98	87.0	F	?	672	9.3	SSE
T0133	1-Dec-98	87.0	M	18	359	42.6	NE
T0136	1-Dec-98	82.0	M	13	286	24.1	ENE
T0139	1-Dec-98	90.0	M	20	457	12.1	E
T0151	4-Dec-98	87.0	F	11.5	670	1.6	S
T0153	4-Dec-98	87.0	F	8	298	6.6	S
T0155	4-Dec-98	85.0	M	0	108	9.7	SW
T0156	4-Dec-98	87.0	F	4.5	285	10.9	NW
T0163	4-Dec-98	85.0	F	?	106	9.2	W
T0166	4-Dec-98	87.0	F	9	419	31.5	SW
T0183	21-Jan-99	87.5	F	?	69	12.4	SE
T0188	21-Jan-99	91.3	M	13	413	7.7	SE
T0216	12-Feb-99	85.4	F	11.6	391	20.9	W
T0221	12-Feb-99	81.1	F	12.5	227	12.2	NE
T0267	29-Mar-99	88.0	F	9	332	5.6	W
T0290	1-Apr-99	89.0	F	9	304	0.0	-
T0302	1-Apr-99	87.3	F	13	280	9.5	NNW
T0304	1-Apr-99	87.8	F	7	350	6.4	W
T0305	1-Apr-99	92.0	F	7.5	333	3.2	W
T0306	1-Apr-99	90.9	M	19	336	5.6	N
T0312	1-Apr-99	90.5	M	17.5	309	7.7	NNW
T0317	16-Dec-99	84.5	F	12.5	310	4.0	S
T0334	16-Dec-99	91.5	M	?	297	4.0	S
T0336	16-Dec-99	90.0	M	5	298	45.9	NE
T0346	16-Dec-99	90.5	F	?	292	4.0	S
T0361	29-Jan-00	88.0	F	7	233	16.4	SW
T0274	23-Mar-00	90.0	F	5	163	4.8	SW

The results indicate that tagged lobsters show highly variable movement patterns. Of the 51 tag-recaptured lobsters, 25% were caught within 5 km of the release site (Table 1) while 10 tagged lobsters undertook movements exceeding 20 Km from their release site. The longest straight-line movement documented in our study was 45.9 km (Table 1) which is essentially the entire length of the Bermuda reef platform. A select number of the longest movements of tagged lobsters on the reef platform are indicated in Figure 1. These results suggest that lobsters readily move in either compass direction following the long axis (NE - SW) of the reef platform. However, as these are straight-line projections, there are no means to determine the actual track followed by tagged lobsters and these projections thus provide only minimum estimates. Active tracking could be accomplished by acoustic tagging of lobsters but this aspect was beyond the scope of the present study.

An example of a relatively rapid movement of a tagged lobster was an individual which moved 9.5 km in just nine days (Table 1). In contrast, two of the tagged lobsters were recaptured at their respective release sites with one being at liberty for over 10 months (Table 1). However, it is not possible to determine whether these lobsters had moved extensively during their time at liberty. A preliminary analysis suggests that there is no clear difference in the average distance moved by sex although the sample size is small. As virtually all of the tagged lobsters were sub-legal (<92 mm CL), it is not possible to determine if there is a size effect on distance moved. The mean straight-line distance moved by all recaptured lobsters regardless of time at liberty was 12.2 km (± 11.4 SD). This suggests that movements are generally quite extensive although the sample size is insufficient to make a broad generalization.

The range of days at liberty was 9 – 700 with a mean value of 294 days (± 168 SD). Tagged lobsters were released during different months of the season (Table 1) but those released in April could not be recaptured during the five month closed season (April 1 - August 31). This factor could bias the estimate of mean days at liberty. However, the results indicate that lobsters are at liberty on average about 10 months. The longest period at liberty was almost two years (Table 1).

Accurate size measurements were obtained from 38 of the 51 recaptured lobsters allowing an estimate of the growth increment during the time at liberty (Table 1). The five recaptured lobsters which did not moult (zero growth increment) had a mean time at liberty of 64 days. All were released in November/ December when the water temperature is declining and therefore the lack of growth is not unexpected. In comparison, the maximum growth increment was 28 mm CL for a male released at 86 mm CL which remained at liberty for 665 days (Table 1).

DISCUSSION

The lobsters in our study exhibited highly variable but often extensive movement patterns on the Bermuda reef platform. Sutcliffe (1952) documented movement patterns associated with reproduction. He found that sexually mature

females migrated from the reef platform toward deeper water on the southern edge of the platform apparently after mating but before egg hatching. In a further study, Sutcliffe (1953) determined that lobsters larger than 145 mm CL were most frequently found in the lagoon area of the platform and were relatively uncommon further offshore. The majority of these large lobsters were males, and long term trapping results indicated that they did not migrate to the edge of the reef platform. Thus, it appears that smaller but sexually mature lobsters undertake the most extensive movements.

As the lobsters tagged in our study were almost all of sub-legal size (< 92 mm CL), we are unable to comment on movement patterns in relation to size. With a limited data set, Evans and Lockwood (1996) suggested that sub-legal sized lobsters might travel faster than larger, sexually mature individuals. The fastest movement documented in our study was an 88 mm CL female which moved 9.5 km in nine days (Table 1). The short-term movements of tagged lobsters in the study by Evans and Lockwood (1996) were generally smaller.

In terms of distance moved, there were 10 lobsters which were recaptured more than 20 km from their release sites. The maximum distance moved was 45.9 km by a 90 mm CL male with an additional three lobsters moving over 40 km (Table 1). The longest distance recorded by Evans and Lockwood (1996) for a tagged lobster was about 40 km, but the majority moved much smaller distances. Despite comments by Evans and Lockwood (1996) concerning clockwise or counterclockwise movements around the reef platform, it is not possible from conventional tagging data to make such assertions. A program with active tracking would be necessary to determine movement directions.

It is clear from the data presented here that lobsters are capable of extensive movements across the reef platform encompassing the two designated inshore areas used in the limited entry lobster management program. On the basis of these preliminary results, we conclude that lobster movements on the reef platform are probably sufficient to allow for the replenishment of these inshore areas following harvesting by the fishery at current levels of fishing effort. Close monitoring of the fishery will be necessary to ensure that the current management program can continue to provide sustainable harvest levels.

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