



A PROCEDURE TO CLASSIFY SPINY LOBSTERS AS LEGAL OR SUBLEGAL
BASED ON TAIL WIDTHS

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Based on conservation and management considerations the Western Pacific Regional Fishery Management Council (WPRFMC) has decided to prohibit the harvesting of spiny lobsters with carapace lengths less than 7.7 cm. Lobsters with carapace lengths greater than or equal to 7.7 cm are termed legal sized or legal and those with carapace length less than 7.7 are termed sublegal. Many lobster vessels freeze the lobster tails at sea and land only the frozen tails. Thus for purposes of onshore enforcement, it is necessary to have a procedure to determine whether a lobster was of legal or sublegal size based only on tail measurements. Using data collected on the RV Townsend Cromwell a discriminant analysis was used to develop such a classification procedure.

DATA

Two data sets were used for the discriminant analysis. One data set consists of carapace length, tail width, and tail length measurements on 1,652 live spiny lobsters trapped over the past 4 years throughout the Northwestern Hawaiian Islands (NWHI). In this data set 15% of the lobsters are sublegal and 85% are legal sized (Table 1). The second data set consist of carapace length and tail width measurements on 116 live lobsters which were then "tailed" and frozen. After freezing, the tail width of the frozen tails were recorded. These lobsters were trapped at Necker and Maro banks during April 1981 and contained 53% sublegals and 47% legals (Table 2).

The tail width measurements for both data sets were measured as the distance between the lateral notches on the first tail segment.

ANALYSIS

Discriminant analysis is a statistical procedure which classifies an observed individual in one of a given set of populations. In the present analysis we will use the procedure to classify a lobster as either belonging to one of two populations, sublegal or legal, based on tail measurements.

To apply discriminant analysis the following information is needed:

1) The relative frequency of legal and sublegal lobsters in the trappable population.

Recent size-frequency data from Maro bank show that 25% of the trappable population is sublegal; at Necker bank, 53% of the trappable population is sublegal. As fishing effort continues at Maro the percent of sublegals in the trappable catch will probably increase. As an average estimate of the relative percent of sublegals and legals in the trappable population at the commercially fished banks, the values of 40% sublegal and 60% legal have been chosen.

2) The relative weights for the loss function which measures the loss from misclassifying a sublegal as a legal and the loss from misclassifying a legal as a sublegal.

Based on the assumption that these two types of losses are equal, equal weights are used.

The discriminant analysis procedure now estimates the classification function which is optimum in the sense that it minimizes the probability that a lobster selected at random from the trappable population is incorrectly classified as legal or sublegal. The discriminant analysis was first performed using both tail width and tail length variables. The results showed that tail length did not provide any additional information or improvement in the

classification of a lobster as sublegal or legal over that provided solely by tail width. Application of the BMDP computer program for discriminant analysis to the tail width data results in the following classification rule:

If tail width \geq 5.1 cm, classify the lobster as legal.

If tail width $<$ 5.1 cm, classify the lobster as sublegal.

Based on the sample of 1,652 lobsters this classification procedure correctly classifies 94.9% of the sublegals and 86.8% of the legals. The empirical size-frequency distribution of tail widths can be used to obtain an estimate of the percent of correct classifications for various values of the minimum tail width for legals (Table 3). From Table 3 it can be seen that as the minimum tail width for classification as legal increases, the percent of correct classification for sublegals increase and the percent of correct classification for legals decreases. Based on this table, the probability that a lobster chosen at random from the trappable population is correctly classified is maximal when the minimum tail width for classification as legal lies in the interval between 5.0 and 5.1 cm. This empirical result is in close agreement with our estimate of 5.1 cm obtained from the discriminant analysis.

It should be recalled that the tail width measurements for the 1,652 lobsters used in this analysis were taken on live lobsters. To determine if freezing of the lobster tails has an effect on the tail width, a regression analysis was performed regressing frozen tail width on live tail width based on the set of 116 lobsters for which tail width measurements were taken before and after freezing. The intercept for this regression was set at zero. The estimate of the slope was 1.0036 (standard error = 0.0018, $R^2 = 0.999$). This regression suggests that there is no appreciable change in tail width due to

freezing and hence a lobster will be classified as legal if the width of the frozen tail is equal to or exceeds 5.1 cm.

Application of this procedure to classify the lobsters from the sample of 116 frozen tails results in correctly classifying 100% of the sublegals and 100% of the legals.

Since discriminant analysis estimates the classification function which maximizes the probability that a lobster chosen at random from the trappable population will be correctly classified (as either sublegal or legal) based on the tail width measurement, the classification function will necessarily be sensitive to the proportion of sublegals and legals in the trappable population. Table 4 presents the minimum tail width for classification as legal sized and the percent of correct classification for three distributions of sublegals and legals in the trappable population. As the proportion of legals in the trappable population increases it becomes more important to correctly classify the legals and hence the minimum tail width for correct classification decreases. While discriminant analysis is sensitive to changes in the underlying population parameter it is more robust to changes in the sample structure. Table 5 presents the estimates of discriminant analysis for the original sample of 1,652 lobsters and two truncated population derived from this sample obtained by removing all lobsters greater than 10 and 9.25 cm, respectively.

Table 1.--Size frequency of carapace length for a sample of 1,652 lobsters from the NWHI in 5-mm size categories.

Carapace length (mm)	Frequency (percent)
65-69	0.5
70-74	4.4
75-79	10.3
80-84	18.8
85-89	19.9
90-94	15.2
95-99	10.2
100-104	8.5
105-109	5.0
110-114	4.0
115-119	2.3
120-124	0.8

Table 2.--Size frequency of carapace length for a sample of 116 lobsters from Necker and Maro banks.

Carapace length (mm)	Frequency (percent)
65-69	3.9
70-74	17.6
75-79	25.5
80-84	2.9
85-89	12.7
90-94	13.7
95-99	9.8
100-104	6.9
105-109	3.9
110-114	1.0
115-120	2.0

Table 3.--Percent of sublegals and legals correctly classified as a function of minimum tail width based on the empirical size-frequency distribution.

Minimum tail width for classification as legal sized (cm)	Percent of sublegal correctly classified ¹	Percent of legals correctly classified ¹	Probability of correctly classifying a lobster chosen at random ²
4.7	40.5	99.6	0.76
4.8	62.3	97.9	0.84
4.9	79.8	94.3	0.89
5.0	87.5	92.4	0.90
5.1	95.3	86.2	0.90
5.2	99.4	79.6	0.88

¹Estimated from a sample of 1,652 lobsters.

²Based on the relative frequency of sublegals as 0.4 and legals as 0.6 in the trappable population.

Table 4.--Discriminant analysis for several different frequencies of sublegals and legals in the trappable population.

Population frequency		Minimum tail width for classification as legal (cm)	Percent of correct classification	
Percent sublegal	Percent legal		Sublegal	Legal
50	50	5.2	99.2	80.2
40	60	5.1	94.9	86.8
25	75	5.0	77.8	96.5

Table 5.--Discriminant analysis for samples with several different ranges of carapace length.

Carapace length range in sample (cm)		Minimum tail width for classification as legal (cm)	Percent correctly classified	
Minimum	Maximum		Sublegal	Legal
6.5	12.4	5.1	94.9	86.8
6.5	10.0	5.0	94.6	85.3
6.5	9.25	5.0	86.8	88.9