Fisheries Management Issue: Setting a maximum size limit ("slot limit")

A report provided to the *ad hoc* Spiny Lobster Advisory Board by the Florida Fish and Wildlife Conservation Commission Staff

April 11, 2006

Description and rationale: Size limits are typically used to protect the breeding stock in a fishery. The minimum size is often set at a size large enough that individuals will have an opportunity to breed at least once. The setting of a maximum size for harvest also has implications regarding reproduction. Maximum size limits have been used in other fisheries to protect the largest females which typically produce many more eggs than smaller individuals.

For spiny lobster, the typical number of eggs produced per clutch of a 3 inch carapace length female is 300 thousand eggs. A 3 ½ inch carapace length female produces 500 thousand eggs, a 4 inch carapace length female produces 700 thousand eggs, and a 4 ½ inch carapace female produces nearly one million eggs per clutch. Larger female lobsters not only produce far more eggs per clutch than do smaller female lobsters, but evidence from field and laboratory studies suggest that larger female lobsters also produce more clutches per breeding season than do smaller females. Whereas a 3-inch carapace length female may produce two clutches, by the time female lobsters attain a 4-inch carapace, the typical number of clutches per breeding season is three, perhaps four clutches.

The rationale for protecting large male lobsters also impacts the reproductive output of the lobster population. Laboratory evidence shows that female lobsters preferentially mate with males larger than themselves. Large males are also capable mating more often and produce larger spermatophores than smaller males and thus may improve fertilization rates. Studies conducted in the Dry Tortugas during the 1970's also suggest the importance of large males to the spiny lobster population. In the early 1970's, when lobsters were harvested in the Dry Tortugas National Park (DTNP), researchers conducting a survey of the population found that large female lobsters (more than 4 ½ inch carapace length) rarely carried eggs if at all. Subsequent research conducted in the DTNP in the 1990s, after twenty years of protection from harvest, found the size structure of the lobster population had increased, and large males were observed frequently, as were large females carrying eggs. They concluded that the absence of eggs-bearing females observed in the 1970s was due to the rarity of males of sufficient size to mate with large females.

Current size regulations: The minimum legal size for harvesting a lobster is 3 inches carapace length. There is no maximum size limit. No changes to the minimum size have been recommended.

Projected cost and benefits: The primary cost of a maximum size limit would be the loss of harvest and the primary benefit would be an increase in egg production. Cost and benefit would vary across Florida due to local differences in the size distribution of lobsters. Projected cost and benefits have been calculated for 5, 4 3/4, 4 ½, 4 1/4, and 4 inch carapace lengths. In general, the percentage loss of harvest is roughly equal to the percentage increase in egg production.

The Florida East Coast harvest contains the largest lobsters and therefore would see greater immediate cost and benefits than other regions. For example, a 4 inch maximum size would prevent 26% of the lobsters in that region from being harvested and would increase egg production by 31%. A 5 inch maximum size would remove 2% of the harvest and increase egg production by 1%.

The Florida Keys (Key Largo to Marquesas) harvest contains the smallest lobsters. A 4-inch maximum size would remove 4% of the lobsters from harvest and increase egg production by 3%. A 5-inch maximum size would remove less than 0.1% of the lobsters from harvest and egg production would not increase. However, as more female lobsters grow above the maximum size, egg production would also increase. In the Florida Keys, the long-term increase in egg production resulting from a 4-inch maximum size limit could exceed 9%. The long-term increase in egg production resulting from a 5-inch maximum could exceed 1%. Summary tables projecting cost and benefit for various maximum sizes in different regions of Florida are provided.

Discussion points:

Increasing egg production can potentially increase recruitment and offset short-term decreases in landings in a fishery. Unfortunately, the potential for increased recruitment in the Florida's spiny lobster fishery cannot be reliably estimated because the larvae may travel long distances before settling. The percentage of larvae that might directly settle in Florida is unknown. It is possible, but also unknown, that some portion of Florida's lobster egg production enhances lobster populations elsewhere, which in turn could enhance Florida's lobster population.

Adult male lobsters grow faster than adult female lobsters. As a consequence, more males than females will reach a maximum size limit. Although some large males are required to mate large females, an excess of large males could develop in the lobster population. Over time, this consequence may permit the introduction of some form of limited "trophy" lobster fishery, particularly the opportunity for special permitted tournaments.

Some means will likely need to be found that would prevent lobsters larger than the size limit from being used as "bait".

Regional differences in cost could be resolved by selecting different maximum sizes in different parts of the state.

Table 1. Cost benefit analysis of a maximum size limit on the lobster fishery with pounds of lobster lost, percentage of total harvest, number of lobsters lost, and number of eggs gained with percentage gained.

Examples are given for 5 inch, 4 3/4 inch, 4 ½ inch, 4 1/4 inch, and 4 inch maximum size carapace length.

Five inch maximum size		Harvest lost				% egg production increase	
		Pounds	% of harvest	Numbers	% of harvest	short term	long term
Florida wide	total	17,156	0.3%	4,236	0.1%	0.2%	
	Females	3,091		761			
	Males	14,065		3,475			
Keys	total	1,900	0.0%	483	0.0%	0.0%	1.7%
	Females	0		0			
	Males	1,900		483			
Dry Tortugas	total	11,652	1.1%	2,817	0.3%	0.6%	
	Females	2,411		587			
	Males	9,242		2,230			
East Coast	total	12,741	2.3%	3,560	0.9%	1.2%	
	Females	2,317		624			
	Males	10,424		2,936			

4 3/4 inch maximum size

		Harvest lost				% egg production increase	
		Pounds	% of harvest	Numbers	% of harvest	short term	long term
Florida wide	total	32,457	0.6%	9,187	0.2%	0.4%	
	Females	6,337		1,727			
	Males	26,121		7,460			
Keys	total	5,701	0.1%	1,713	0.0%	0.1%	2.7%
	Females	1,023		312			
	Males	4,678		1,401			
Dry Tortugas	total	20,760	1.9%	5,762	0.7%	1.0%	
	Females	4,018		1,056			
	Males	16,742		4,707			
East Coast	total	18,532	3.4%	5,444	1.4%	2.3%	
	Females	4,633		1,340			
	Males	13,899		4,104			

4 1/2 inch maximum size

		Harvest lost				% egg production increase	
		Pounds	% of harvest	Numbers	% of harvest	short term	long term
Florida wide	total	85,781	1.5%	29,256	0.6%	1.0%	
	Females	18,238		5,785			
	Males	67,543		23,471			
Keys	total	24,412	0.6%	8,911	0.2%	0.2%	3.7%
	Females	2,777		926			
	Males	21,634		7,985			
Dry Tortugas	total	46,342	4.2%	15,305	1.8%	2.8%	
	Females	11,251		3,505			
	Males	35,091		11,800			
East Coast	total	47,488	8.7%	15,820	4.1%	8.9%	
	Females	17,374		5,705			
	Males	30,115		10,116			

4 1/4 inch maximum size

		Harvest lost Pounds	% of harvest	Numbers	% of harvest	% egg production increase short term	long term
Florida wide	total	172,025	3.0%	67,102	1.3%	2.4%	
	Females	41,886		15,409			
	Males	130,139		51,693			
Keys	total	61,980	1.5%	25,574	0.7%	0.8%	6.1%
	Females	9,063		3,486			
	Males	52,917		22,088			
Dry Tortugas	total	81,969	7.4%	30,862	3.6%	5.9%	
	Females	23,305		8,412			
	Males	58,664		22,450			
East Coast	total	85,711	15.7%	31,877	8.3%	20.6%	
	Females	39,381		14,617			
	Males	46,330		17,260			

Four inch maximum size

		Harvest lost Pounds	% of harvest	Numbers	% of harvest	% egg production increase short term	long term
Florida wide	total	386,862	6.7%	177,121	3.5%	6.1%	
	Females	103,246		44,586			
	Males	283,617		132,535			
Keys	total	164,889	4.1%	78,627	2.1%	3.0%	10.3%
	Females	33,036		14,879			
	Males	131,853		63,748			
Dry Tortugas	total	164,741	14.9%	72,948	8.4%	13.3%	
	Females	51,967		22,049			
	Males	112,774		50,899			
East Coast	total	143,623	26.3%	61,224	15.9%	30.5%	
	Females	57,913		23,394			
	Males	85,711		37,829			

Appendix 1. Calculating “long term” benefits in egg production.

Calculations were performed for the entire lobster fishery, along with the Dry Tortugas, Keys, and Florida East coast (Dade-Broward county line north). Calculations were based on harvests and TIP data for the 1999-2000, 2003-2004, and 2004-2005 seasons. Long term egg production increase for the Florida Keys was based on applying the Dry Tortugas size distribution to the Keys. This was done for the Keys because of the greater potential for change in the overall size distribution. Long term increases should occur in other areas but will not be as great as in the Keys.

Calculating the long term benefits requires some sort of model to project a new size distribution under a particular slot limit. The best model in the Keys region is the Dry Tortugas size distribution (unfished since 1975). The formulation takes the size distribution from the fishery (TIP data) and applies the Dry Tortugas size distribution (Marfin 518 data) to the fishery. Here are the steps.

1) Set up the TIP size distribution into a 1 mm frequency table (put in zeros where no lobsters were found). Do the same for the Marfin data and the fishery harvest projections calculated earlier.

2) Calculate the percentage of the total frequency for each 1 mm bin.

3) Project a new TIP number for each size class by taking Old TIP and adding to it the Marfin number for that size class *divided by the sum of the Marfin data, then times the sum of the TIP data* (this merely adds a Marfin number that is scaled to the TIP data), then multiply this by the probability of a lobster to get through the harvest size slot (I choose 10% for this exercise)

Now comes the hard part, reconstituting the fishery. One cannot merely take the ratio of the old TIP number and new TIP number and apply it to the fishery. For example one size bin might go from zero lobsters to three lobsters. That by a ratio would be an infinite increase.

4) Calculate the projected proportional increase for each size class in the fishery within the slot. This is equal to the (new TIP number divided by the sum of the old TIP lobsters within the slot) minus (the old TIP number divided by the sum of the old TIP lobsters within the slot). This is the proportional increase of lobster numbers by size class. Note, the proportions if calculated for old TIP numbers would be 1 (100%), the new numbers add up to more than 100% which they should because we are trying to project an increase in the population above the slot. The projected proportional increase defaults to zero below the proposed maximum legal size.

5) The new projected “harvest” by 1mm size classes is equal to the old harvest number plus quantity of the projected proportional increase (calculated in step 4) times the sum of the old harvest estimate (note; that proportional increase defaults to zero below the slot size).

6) The new egg estimate is recalculated using the new projected “harvest”