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Planning for changing productivity and catchability in the Maine lobster fishery

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ABSTRACT

Catches and biomass in the Maine lobster fishery have been at record levels in recent years despite sustained high exploitation rates. The fishery is almost completely based on lobsters just molting to legal size each year and thus is vulnerable to changes in environmental or ecological conditions that reduce recruitment. I use a bioeconomic model of the fishery that incorporates an empirically estimated vessel-level production function to evaluate how a reduction in recruitment might affect profitability and optimal effort levels relative to recent years. While large reductions in effort would almost certainly be required to maintain fishery profitability, the degree of effort reduction and the optimal seasonal distribution of effort and catch are sensitive to the time series of data used to estimate the production function. Because of the unidirectional upward trend in recruitment and catches, it is unclear whether changes in the production function are due to technological innovation or ecological change. However, the answer has important implications for the level of effort the fishery may be able to profitably support in the future.

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1. Introduction

American lobster (*Homarus americanus*) is the most valuable fishery in the northeastern United States and by far the most valuable fishery in Maine. Landings in Maine, which now account for over 80% of US commercial landings of American lobster, have grown dramatically over the last two decades with record landings of over 34,000 metric tons 2009 (Fig. 1). Although the gross value of the fishery is high, the profitability of the fishery is low (Thunberg, 2007) and is decreasing with increases in fuel and bait prices and recent declines in ex-vessel price. The fishery supports a large number of lobstermen and many coastal communities that are heavily dependent on the fishery and have few alternative sources of income and employment to offset a decline in productivity and profitability of the fishery.

Lobster that have just molted to legal size form the vast majority of catch, and the biomass of legal size lobster is fished down to about 20% of its annual peak (after the summer molt) each year. Recruitment to the fishery has been at record levels in recent years enabling annual catches in the last decade to average nearly three times the mean catches between 1950 and 1990. Minimum and maximum size limits and prohibitions on taking berried females help to ensure conservation of the brood stock but this does not fully explain the increases in productivity of the stock the last few decades.

There are a variety of explanations for the increased productivity and abundance of the Gulf of Maine lobster stock. A reduction in predation resulting from the decline of groundfish in the Gulf of Maine has been suggested as one of the causes of the increase in abundance, but this does not seem to provide a sufficient explanation (Steneck and Wilson, 2001). A reduction in predators may also have resulted in an indirect increase in stock productivity by expanding the suitable habitat for lobster and thereby expanding carrying capacity. Anecdotal evidence suggests that the fishery has expanded into areas where lobsters were not previously fished (Fogarty and Gendron, 2004). Another potential contributor to increased growth is the large amount of herring bait used in the fishery, much of which is consumed by lobsters that subsequently leave the trap or are returned to the water because they are undersized (Saila et al., 2002; Grabowski et al., 2010). Grabowski et al. (2010) note that trap density has increased fourfold over the last two decades and as much as 75,000 metric tons of herring bait was used in the fishery annually in recent years. All of these factors have likely contributed to the increase in lobster abundance and landings, but there is increasing evidence that recruitment to the fishery and subsequent landings are strongly driven by levels of settlement of post larvae which may be largely a function of environmental conditions including water temperature, currents and winds that affect the survival of larvae and post larvae and their dispersion and settlement (Drinkwater et al., 1996; Incze et al., 2006; Steneck and Wilson, 2001; Wahle et al., 2004).

Whatever the cause for the increased productivity of the stock, the fishery is highly vulnerable to a reduction in recruitment to the fishery (i.e. the size of the cohort molting to legal size each year)

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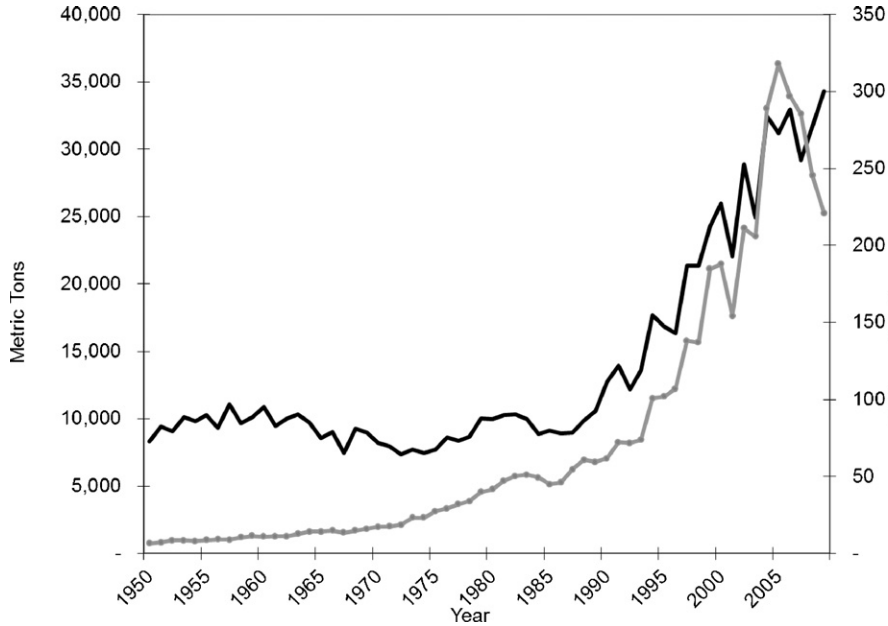

Fig. 1. Maine lobster landings (black line) and landed value (grey line with circles) from 1950 to 2009.
Source: http://www.maine.gov/dmr/commercialfishing/historicaldata.htm.

which is affected by lagged larval settlement and juvenile growth and survival. While it is difficult to guess when and to what degree a reduction in recruitment might occur, it is important to consider the reductions in fleet size and effort levels that may be required to keep the fishery economically viable and how the overall profitability of the fishery may be affected. It is widely accepted by managers, and also by the majority of license holders, that there is already excess effort in the fishery. A survey of Maine lobster license holders by the Maine Department of Marine Resources in 2008 found that 56% of respondents saw the need to reduce the number of traps being fished in their area and 51% favored an across the board cut in the trap limit (http://www.maine.gov/dmr/rm/lobster/effortquest7-17-08.pdf). Reductions in recruitment and catch will intensify the need for effort reductions. However, thousands of lobstermen, their families and communities are dependent on the fishery, and large reductions in effort are likely to be difficult to achieve, particularly in the short run. Recent studies suggest that estimates of post larvae settlement may be useful in predicting recruitment to the fishery 5–8 years later (Incze et al., 2006; Wahle et al., 2004). Knowledge of how reductions in recruitment will affect economically viable fleet size and effort levels, along with advance warning of recruitment declines may help facilitate long range planning for the fishery and the communities that depend on it.

I construct a bioeconomic model of the fishery that I use to evaluate how revenues, costs, and net income to fishermen may change with different effort levels and seasonal exploitation patterns and different levels of recruitment to the fishery. The model suggests that large reductions in effort will be required just to keep the fishery economically viable let alone maximize profit. However, the level of effort reductions required and predicted impacts on profits are sensitive to the time series of data used to estimate the production function embedded in the model.

2. Methods

I construct a numerical bioeconomic model that embeds an empirically estimated monthly demand model and a vessel-level daily production function that determines the catch, revenue, cost and profits associated with alternative monthly effort levels given specified biomass and input prices. Modeling the intra-annual distribution of catch and effort is critical because fishery landings are highly concentrated in the late summer and fall and the distribution of catch and effort over the year greatly impacts the total effort required to take a given level of catch as well as the harvest costs and the value of the catch. The monthly model captures seasonal changes in catchability, congestion effects that reduce catch rates when effort levels are high, effects of changes in fishable biomass on catch rates, and the impact that monthly landings have on price. I use the model to estimate the monthly effort levels and soak times that would maximize either net revenues or economic profit given recent biomass and recruitment levels, and for a scenario in which biomass and recruitment levels fall to the levels observed in the late 1980s prior to the expansion of the fishery.

2.1. Production function

A production function is estimated using individual level data on retained catch and effort collected through a port sampling survey that has been running since 1966.[1] The survey collects data on retained catch, traps hauled, and average soak times from a randomly selected sample of lobstermen each month. Since 2001, bait use is also recorded. I use a translog specification to model daily retained catch as

$$\ln(q) = \sum_{m=1}^{12} \alpha_m d_m + \sum_{k=1}^{K} \beta_k \ \ln(x_k) + \frac{1}{2}\sum_{k=1}^{K}\sum_{l=1}^{K} \gamma_{kl} \ \ln(x_k)\ \ln(x_l) + \varepsilon \quad (1)$$

where q is the retained catch in pounds from one observed trip (typically one day of fishing); d_m are dummy variables representing the month fishing took place; x_k are the values of the explanatory variables which include: number of traps hauled that trip, the average soak time, average kilograms of bait per trap, the estimated total

[1] The port sampling data was provided by Carl Wilson from the Maine Department of Marine Resources. This program collects catch and effort data directly from lobstermen as they land their catch. It began in August 1966 and is still in operation. Ten lobster buying locations (dealers buying directly from the fishermen) are selected at random each month, April through December. http://www.maine.gov/dmr/rm/lobster/research.htm#P.