Quota allocation in crisis fisheries

October 30, 2003

We investigate the fair allocation of fishing quotas given total allowable catch (TAC) for each species in a multi-species fishery. In situations like the one currently facing New England's fisheries, it might be necessary to impose quotas, restricting the amount of catch of fish by each existing fishing company. Individual quotas for each fishing company are preferable to an overall fishery catch constraint, but the mechanism by which individual quotas are calculated is not clear.

Here we define one notion of fairness of quota allocation and form a linear program to maximize average revenue in each company while constraining the results to be *fair*.

Variable	Description
S	Set of fish species
J	Set of fishing companies
TAC_s	Total allowable catch for species s
c_{js}	Cost per ton of landed fish of species s incurred by company j
p_s	Wholesale price per ton of species s
a_{js}	1 or 0 indicator for whether or not company j has the ability to fish for species s
$\text{NR}_j = \sum_s (p_s - c_{js}) x_{js}$	Net revenue to company j
r_j	Number of fishermen employed by company j
x_{js}	Quota imposed on company j regarding species s

Table 1: Parameters for the fish quota LP model.

We assume that this is a depleted fishery, thus the quota which is imposed on a company will be met exactly. We neglect bycatch (the other species of fish caught in addition to the target species) although including it does not fundamentally change the model.

While many objective functions are possible, here we choose to have the largest possible revenue per employee, and have that value be shared across all the companies. We call this value L. This gives rise to the following linear program.

$$
\begin{array}{ll}
\max & L \\
\text{s. t.} & \sum_{j \in J} x_{js} \leq \text{TAC}_s \qquad\qquad \forall s \\
& x_{js} \leq a_{js} \text{TAC}_s \qquad\qquad \forall j, \ s \\
& (\sum_s (p_s - c_{js}) x_{js})/r_j = L \quad \forall j, \\
& x_{js} \geq 0 \qquad\qquad\qquad\quad \forall j, \ s
\end{array} \qquad (1)
$$

The first constraint imposes that the total amount of fish caught is below the Total Allowable Catch, for each species.

The second constraint takes care of the following obvious restriction: if a company does not have the capability to fish for species s, then the allowable catch x_{js} will be set to zero. Since "if" statements are not allowed in a linear program, tricks like this are often used. We could have used any large enough number on the right hand side multiplying the a_{js}, but here TAC was convenient.

The third constraint assures that the net revenue per employee is equal to the same value, called L, for every company. This is the most dubious constraint from a policy standpoint, although it is not clear what a more appropriate constraint might be in a situation like the one facing New England fisheries today.

Finally, we require the quotas to be non-negative, and we maximize the net revenue per employee.