Assessing Fishing Capacity: Implications For Capacity Reduction Programs

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NOAA Photo Library

Vessel Photo: Jose Corte; NOAA Photo Library

What Are We Going to Discuss Today?

- Introduce and discuss two concepts of excess capacity
- Present simple methods for estimating capacity without the mathematical rigor
- Discuss alternative goals and objectives for capacity reduction programs
- Using a relatively simple fishery, we are going to illustrate the potential fleet size corresponding to different goals and objectives of a capacity reduction program—specifically, a buyback program

Capacity and Related Concepts Defined

The obvious!

Too Much!

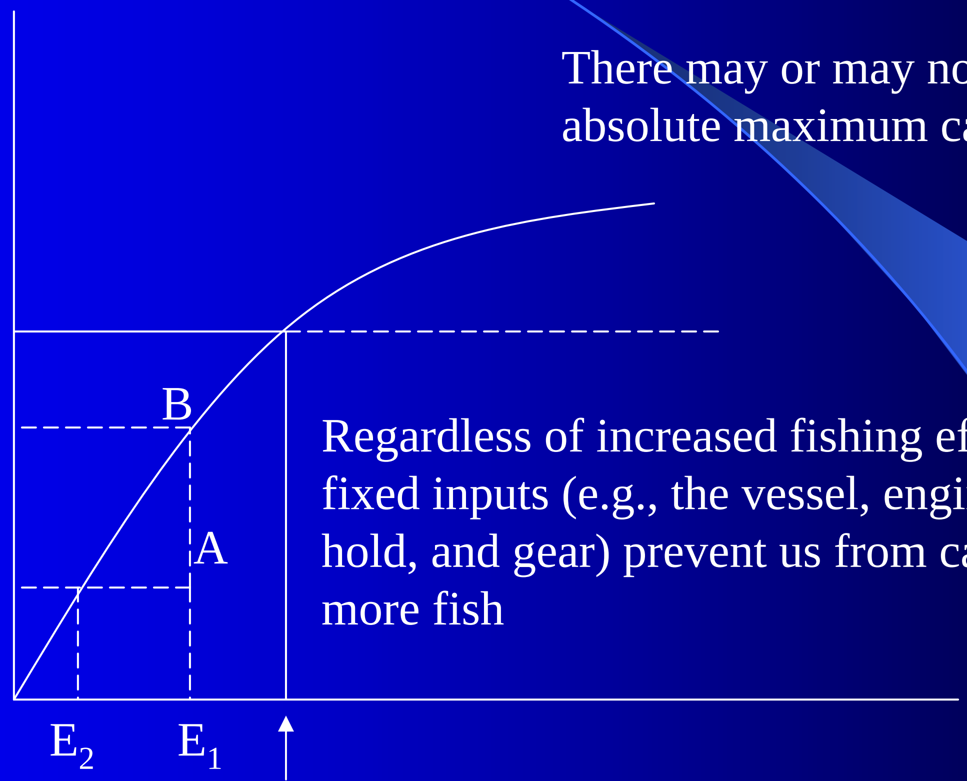
Source: Louisiana Fishing Magazine

You just cannot add anymore; the maximum amount given inputs (e.g., vessel size, days at sea, crew size, gear, etc.)

Formally: Capacity is the maximum output that can be produced given the available technology, capital stocks (e.g., engine and gear), customary and usual operating procedures, and no limits on the variable inputs (e.g., fuel or days)

One Picture of Capacity

Or a Real Simple Concept of Capacity



There may or may not be an absolute maximum catch

A physical concept of capacity

Regardless of increased fishing effort, our fixed inputs (e.g., the vessel, engine, vessel hold, and gear) prevent us from catching more fish

A Little Sidebar: Our catch-effort relationship represents the relationship between technically efficient production and fishing effort; production to the interior of our graph is deemed to be inefficient (e.g., point A—two options: expand output from A to B using E_1 or produce A using E_2 units of effort)

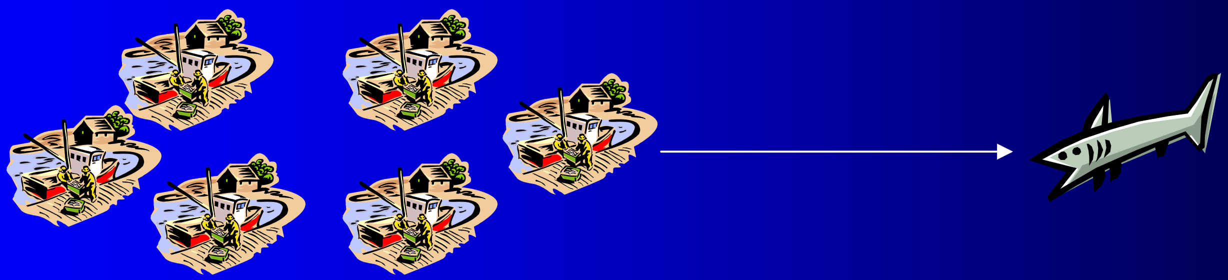
Alternative and More Formal Concepts of Capacity

- Capacity is really an economic concept
- It corresponds to the output level that either maximizes profits, maximizes revenues, or is the output level corresponding to cost minimization
- It can also be modified to reflect social concerns (e.g., level of employment)
- Unfortunately, few fisheries of the US have adequate economic data to estimate any economic concept of capacity—other than that corresponding to revenue maximization
- For our purposes, we estimate a “technological-economic concept;” that is, we consider the physical concept of capacity, but because we use actual data, our estimates reflect economic behavior and adjustments. We cannot, however, use our estimates to determine capacity output if output or input prices change

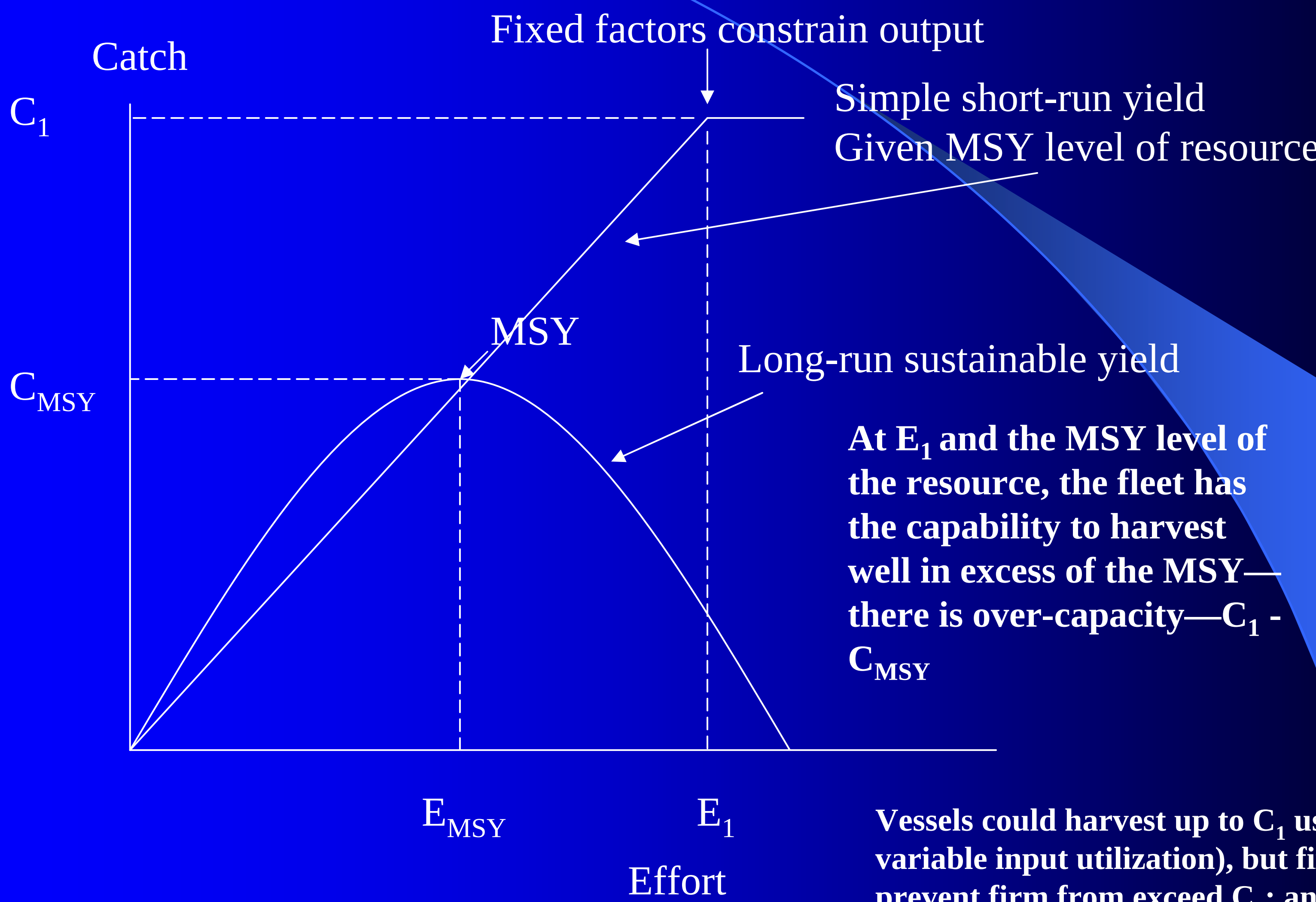
OK, WE ARE ENTERING OVERKILL

Excess and Over-Capacity

- Excess capacity is said to exist when a vessel (firm) or fleet (industry) has the capability to harvest more than is actually being harvested using the same capital stock or platform; the difference between what could be harvested and what is actually harvested represents excess capacity
- On the other hand, the agency (NOAA) is concerned about sustainability and desired resource levels; the agency has, thus, come up with the concept of over-capacity
- Over-capacity is said to exist when a fleet has the capability to harvest more than is sustainable in the long-run given the desired or optimal level of the resource (e.g., MSY or some other OY)



More on the Concept of Over-capacity



At E_1 and the MSY level of the resource, the fleet has the capability to harvest well in excess of the MSY—there is over-capacity—C_1 - C_{MSY}

Vessels could harvest up to C_1 using E_1 (full variable input utilization), but fixed factors prevent firm from exceed C_1; any level of landings less than C_1 also indicates excess capacity

Capacity and Capacity Utilization

- Capacity utilization is a measure of the actual use of the capital stock (e.g., the vessel) relative to the potential use of the capital stock—for example, a fishing vessel might be useable for 200 days a year, but is only used 50 days a year
- More formally, capacity utilization—CU– is measured in terms of the ratio of the actual output to the potential capacity output;
- CU is typically constrained to be less than or equal to one in value; an economic based measure of CU, however, may be less than, equal to, or greater than one in value—that is, a firm may be using too many or too few inputs to produce the capacity output at a given economic level (translated—producers are paying too much or too little to produce a given output level relative to the capacity output level)
- Often we use an inverse of CU to determine the percentage by which actual output could be increased if firms operated at full capacity utilization

Another Concept (2): Variable Input Utilization

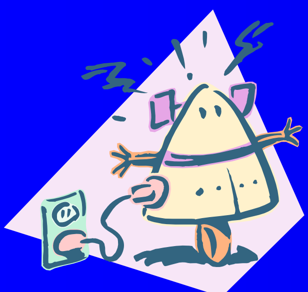
- Variable input utilization (VIU) is simply a measure of the level of actual variable inputs used relative to what is necessary to produce the capacity output
- We also typically measure VIU in terms of its inverse
- I/VIU indicates the percentage by which the variable inputs need to be expanded (1/VIU > 1.0) or contracted (1/VIU < 1.0) to produce the capacity output—we call this the full variable input utilization
- For the purpose of assessing capacity, we use 1/VIU to estimate the expansion or contractions in days at sea and crew size necessary for the capacity output

OK, ENOUGH OF THE NOISE

Methods for Estimating Capacity and Concepts

(Focusing only on Physical Concept)

- **Census/Federal Reserve—sophisticated peak-to-peak approach; done with a survey; asks firms and producers what is their capacity output, and then uses a sophisticated statistical analysis to estimate capacity—not done for fisheries**

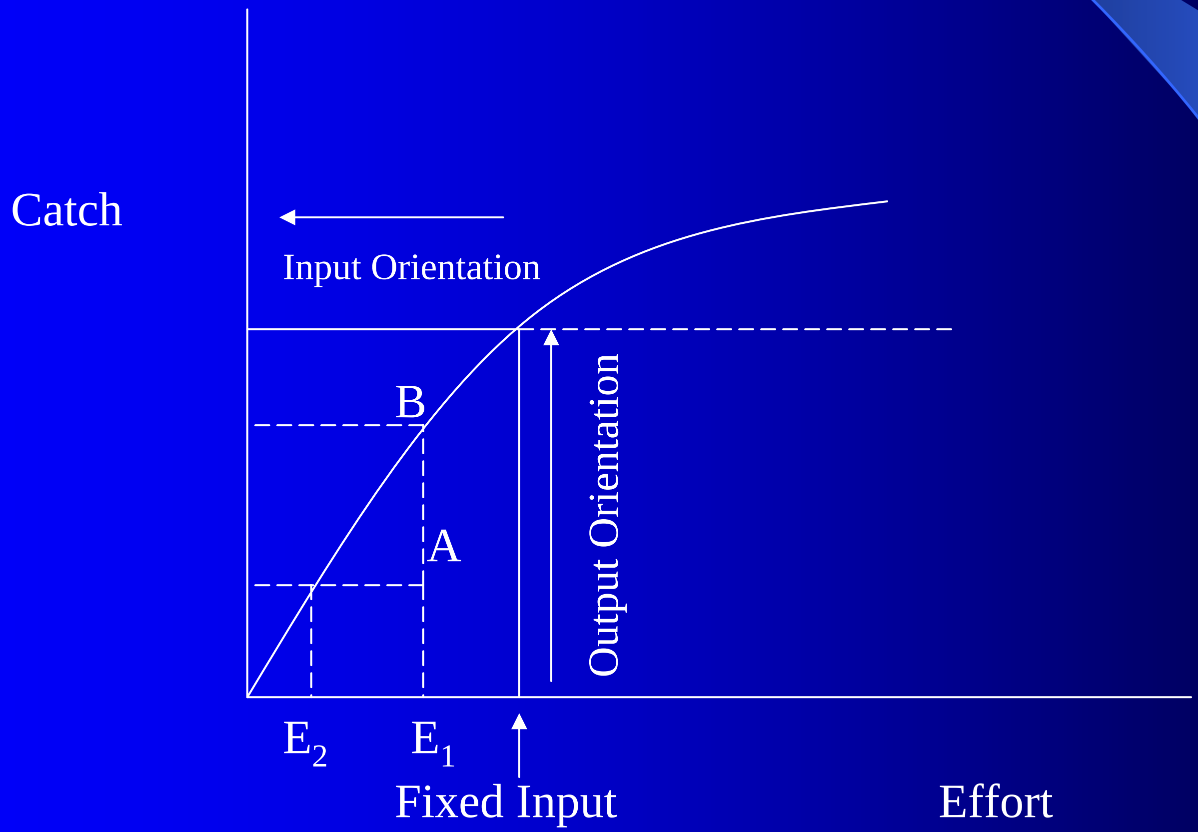


- **Stochastic production frontier—requires specification and estimation of a complex catch-effort relationship, and then via mathematical manipulation, estimates capacity output—has problems for more than one output and also has some statistical limitations, but does accommodate noise**
- **Third approach, and the one used for this study—data envelopment analysis or DEA (not to be confused with Drug Enforcement Administration)**

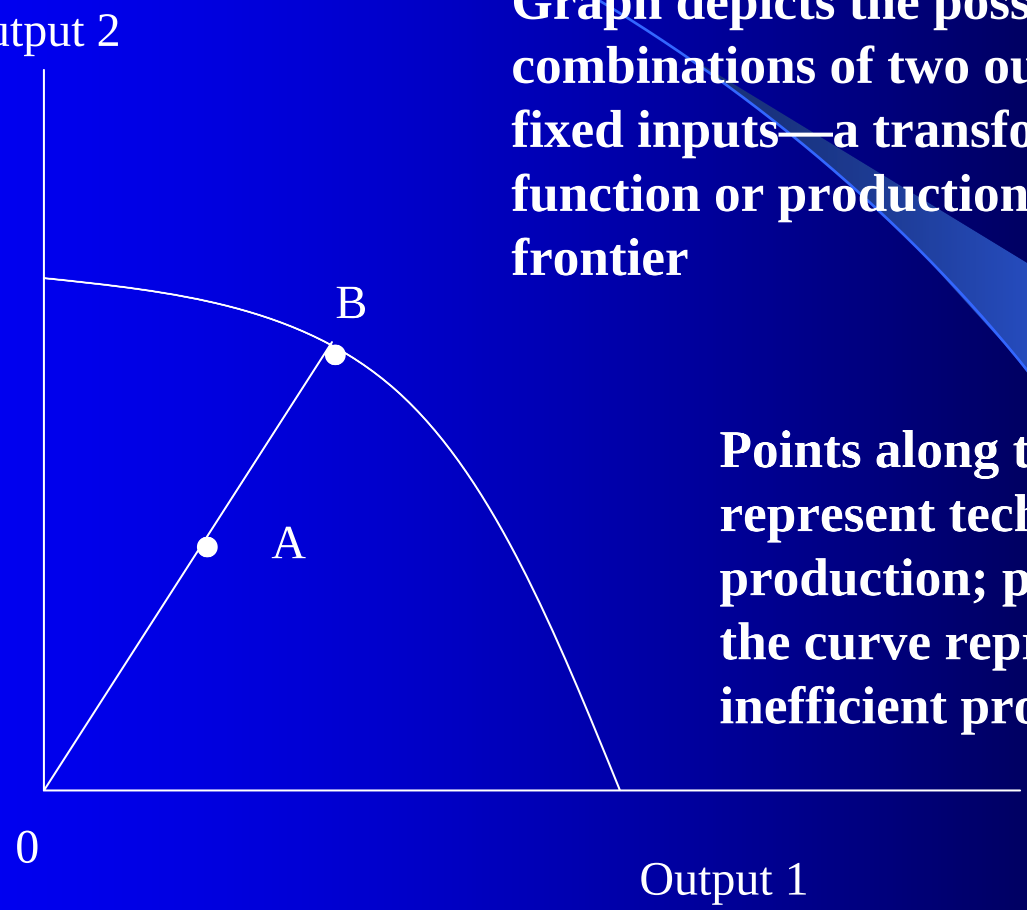
Each method has its strengths and weaknesses, and thus far, DEA appears to be the preferred approach

Data Envelopment Analysis or DEA

- **This is simply a mathematical approach which seeks to determine the maximum expansion of outputs or contraction of inputs, given either the level of available fixed inputs or the desired level of outputs (there is another approach—directional distance function)**

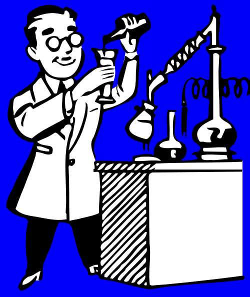


The Basics of DEA



Graph depicts the possible combinations of two outputs given the fixed inputs—a transformation function or production possibilities frontier

Points along the curve represent technically efficient production; points interior to the curve represent inefficient production



With DEA, we seek to define the frontier or points along the possibilities function; if a firm was operating at A, its output could be increased to point B or by the distance 0B/0A

That is about as technical as we want to get!

DEA Model of Capacity Output

$$\underset{\theta,z,\lambda}{Max}\,\theta$$

$$s.t.$$

$$\theta u_{jm} \le \sum_{j=1}^{J} z_j u_{jm}, m = 1,2,\ldots,M,$$

$$\sum_{j=1}^{J} z_j x_{jn} \le x_{jn}, n \in F_x,$$

$$\sum_{j=1}^{J} z_j x_{jn} = \lambda_{jn} x_{jn}, n \in V_x,$$

$$z_j \ge 0, j = 1,2,\ldots,J,$$

$$\lambda_{jn} \ge 0, n \in V_x$$

Economists and mathematics, they just won’t go away

We do this once, and that is enough for anybody!

The Black Sea Bass Pot Fishery

- Initially, we thought we might finally have a nice, simple fishery to analyze—NOPE, NOT SO!
- First, it was recognized that the pots or traps are the primary gear used to harvest black sea bass
- We discovered, however, that there are likely to be several different pot fisheries; some based on the fact black sea bass are the only species reported as being landed and others based on landings of multiple species. Then, there are further groupings based on different levels of activity, vessel size, engine size, and other factors
- To address the multiple fishery nature, we conducted a cluster analysis, which provides information sufficient for determining groupings of the fisheries

Some Basics

- We focus on the expansion of outputs given the fixed inputs (vessel size in length, engine horsepower, and other variables)
- To accommodate customary and usual operating procedures, however, we assume that the number of gear (pots for this fishery), number of hauls, and time fished per gear are fixed or held constant—this may be in error since number of gear, hauls, and time fixed could be varied by the vessel operator and crew
- We allow days at sea and crew size to be variable
- We seek to determine an output level at which the fixed factors restrict further expansions—this is the capacity output

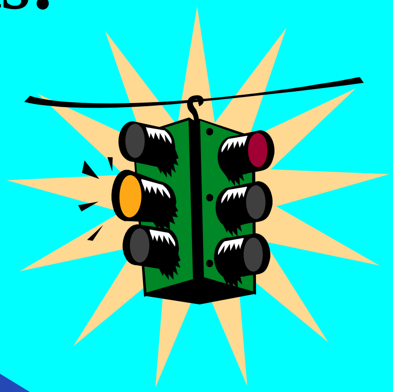
Some Basics on Our Fisheries

Summary of Mean Trip-level Values for Ten Fisheries, 1995-2001

Single Species					
Cluster	Horsepower	Vessel Length	Crew	Days Away	Seabass Landings
1	276	33	2	1	128
2	422	40	2	2	1,041
3	500	40	2	1	595
4	270	35	2	1	370
5	422	66	2	2	1,827
Multi-species					
Cluster	Horsepower	Vessel Length	Crew	Days Away	Seabass Landings
1	333	36	2	1	317
2	479	41	3	1	378
3	540	43	2	1	563
4	561	43	2	1	488
5	399	38	2	2	1,295

Range for Days Away: Single-species—1-12 days; Multi-species—1-11 days.

The Results: But First Some Caveats!



- **The analysis is at the trip level for each year—1995,…,2001**
- **Analysis is limited only to observations having complete data (information on landings, vessel characteristics, and variable input usage) for the pot fishery between 1995 and 2001, which limits the analysis**

Percentage of Total Landings of Sea Bass and Vessel Count

Year	Percent	Number of Vessels Landings Sea Bass	Number of Vessel in Analysis
1995	60	370	54
1996	73	339	38
1997	72	357	81
1998	72	339	71
1999	69	310	65
2000	71	260	61
2001	73	243	51
1995-2001	70	746	151

Last, we do not allow number of pots per trip, trips per year, or hauls per trap or time fished per trap to change—as such, we are likely to underestimate capacity output, but likely to depict customary and usual operating procedures

Some Results

Although we considered actual, mean, and median capacity levels per vessel per year, we consider here only the mean capacity output per vessel per year

Year	Number of Vessels	Observed Landings	Capacity Output	Vessels Required to Harvest Reported Landings | Mean Capacity	Reported Days Per Year	Days Required for Capacity Output Per Year
1995	54	298,770	637,386	25	17	17
1996	73	463,014	906,182	37	19	20
1997	81	493,676	1,064,153	38	18	21
1998	71	468,163	1,048,482	32	19	20
1999	65	460,462	933,444	32	17	19
2000	68	333,698	670,184	30	14	16
2001	51	360,831	783,399	23	21	24
1995-2001	151	2,878,614	6,043,230	72	18	19

Remember that if we allow the number of trips per vessel to increase per year, which is a very realistic possibility, the number of vessels required to harvest the reported level of landings would be smaller

Reducing Capacity in the Fishery

This is where it gets tricky!

- NOAA Fisheries and the Councils have no clearly specified goals or objectives for reducing capacity.
- It is important to understand that there are many possible options (e.g., maximize technical efficiency, maximize capacity utilization, maximum number of vessels allowed in fleet, maximize revenue, maximize profit, minimize costs, etc., etc.!)
- Past buyouts in New England have attempted to purchase the most capacity given a fixed budget.
- For our analysis, and since we do not have a specified biological TAC, we consider arbitrary TACs of 250,000, 500,000, 750,000, 1,000,000, 1,250,000, and 1,500,000 pounds per year and the maximization of technical efficiency and the maximization of capacity utilization

Summary of Range of Vessels

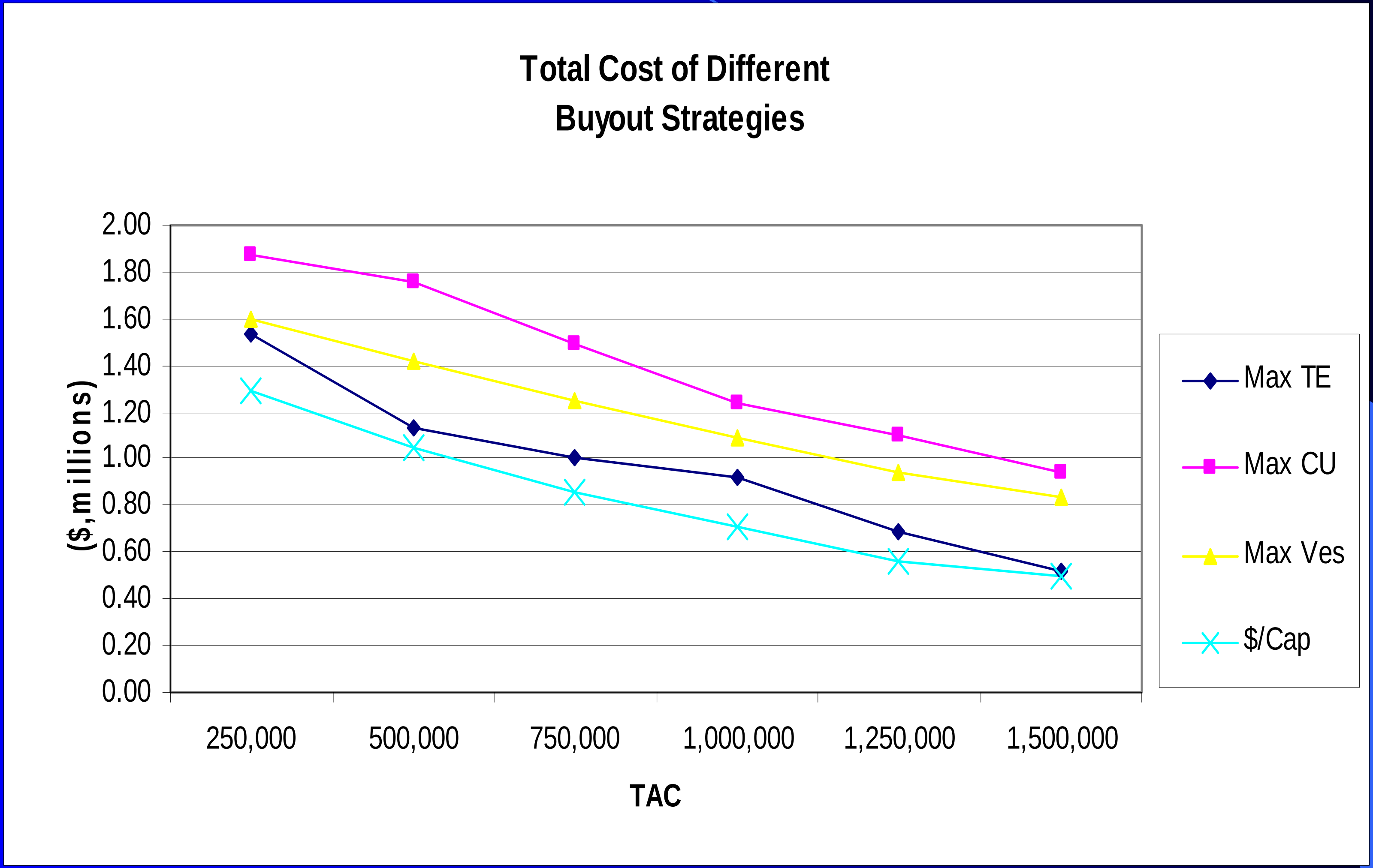
TAC	Maximize TE	Maximize CU	Maximize #	Full-time	Potential #
250,000	47	34	81	1	151
500,000	57	43	101	2	151
750,000	72	64	113	3	151
1,000,000	79	83	122	5	151
1,250,000	87	91	130	7	151
1,500,000	102	100	135	10	151

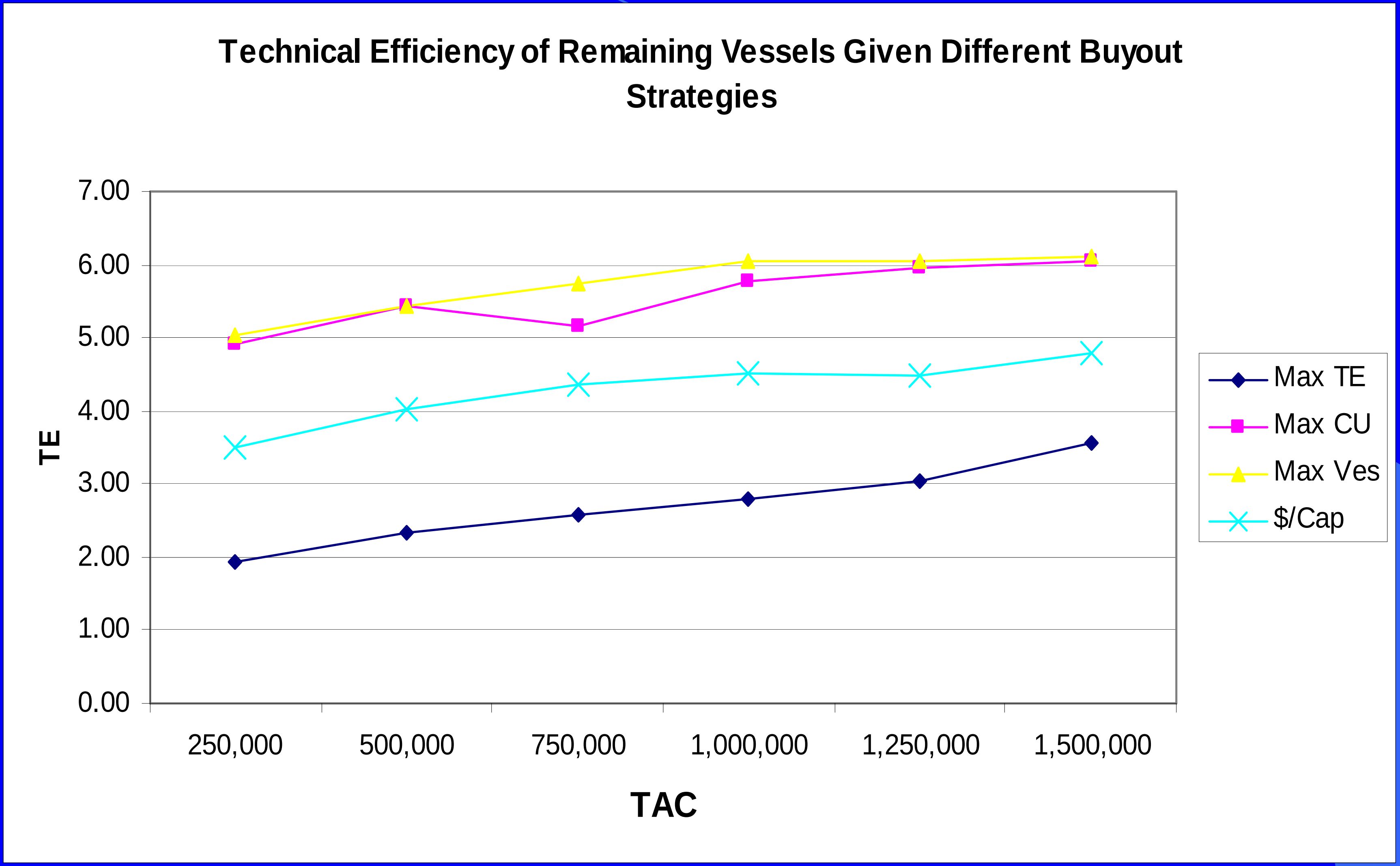
Year	# Vessels	Landings
1995	54	298,770
1996	73	463,014
1997	81	493,676
1998	71	468,163
1999	65	460,462
2000	68	333,698
2001	51	360,831

Based on mean values per vessel

Including Buyout Costs

- Structure of Post-buyout fleet has not included estimates of buyout cost
- Four strategies compared
  1) Maximum TE of remaining vessels
  2) Maximum CU of remaining vessels
  3) Maximize number of vessels
  4) Buyout based on bid to capacity ratio until TAC is met
- Bid Prices for each vessel were assumed to equal one year of revenue--Snowden, R. 1994. "The Complete Guide to Buying a Business"
- The analysis is only for vessels that were included in our sample. Buyout costs are therefore a lower bound on what a buyout would actually cost.


Total Cost of Different
Buyout Strategies
2.00
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
($,millions)
250,000
500,000
750,000
1,000,000
1,250,000
1,500,000
TAC
Max TE
Max CU
Max Ves
$/Cap



Technical Efficiency of Remaining Vessels Given Different Buyout Strategies
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
TE
250,000
500,000
750,000
1,000,000
1,250,000
1,500,000
TAC
Max TE
Max CU
Max Ves
$/Cap

Summary and Conclusions

The analysis indicates there is excess capacity. The fleet operating between 1995 and 2001 could have harvested about 2.1 times the level actually harvested.

Estimates are conditional on the biomass that exists during the period 1995-2001, and the customary and usual operating conditions that existed during the same time period. Our estimates are, thus, likely to be biased downwards relative to the capacity of the entire fleet.

The analysis also reveals that it is quite important to have well-specified goals and objectives for a capacity reduction program, and to include buyout costs when choosing among goals.

Food for Future Thought

- Our black sea bass fishery was a relatively simple fishery
- Many fisheries, however, involve not only numbers other species and gear types, they also involve the harvesting of undesirable outputs (e.g., juveniles, non-marketable species, sea turtles, etc.)
- This can easily be accommodated using a directional distance vector approach—DEA or stochastic multiple output distance function
- The directional distance function approach can also be used to estimate efficiency and capacity relative to essential fish habitat concerns
- Despite all the fancy methods, we still, however, need to really start focusing on economic-based measures of capacity

Lets Close on the Issue of Buybacks

- Should the U.S. government let fishermen fail?
- OR should the government force taxpayers to subsidize companies?
- Why should taxpayers keep a vessel owner in business?
- These questions are from a Cato Policy Analysis report, January 15, 1980—change fisher, fishermen, etc. to Chrysler
- FAST FORWARD: 09/11—Airlines needing assistance
- Chrysler bailout was $1.5 billion in 1980 ($3.0 billion in 2004), but Chrysler repaid the loan
- Airlines not asking for loan