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Managing the Sea Urchin Fishery: An Economic Perspective

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ABSTRACT

In less than two decades, the lowly sea urchin has evolved from a destructive pest to the most valuable fish export from the State of California. In 1988, over 49 million pounds were taken from California coastal waters. About 90 percent of the processed urchins are exported to Japan. There is concern that too many urchins are being harvested, posing a threat to the fishery. The California legislature voiced its concern by directing the California Department of Fish and Game to study and report on the health of the fishery. To reduce the annual take, California imposed a moratorium on the issuance of new harvest permits and closed the fishery for one week each month contingent on the size of the previous year's harvest. These policies are economically inefficient, and they allow the economic rent from the urchin fishery to be captured by the urchin harvesters. To reduce the harvest in an efficient manner, a landing tax or a transferable permit/quota system is recommended.

INTRODUCTION

Garrett Hardin penned "The Tragedy of the Commons"[1] in 1968. In his article Hardin describes the problems that arise when private property rights to a resource do not exist. In such a case, "the commons" are treated as a free good. The inevitable result is the overexploitation and possible destruction of the resource. Although Professor Hardin did not mention them specifically, the main thrust of his argument applies to open access fisheries like the California sea urchin fishery, which is currently threatened by overharvesting.

As recently as 1970, sea urchins were considered a pest in California because they damaged and sometimes destroyed the kelp beds.[2] Giant kelp provides food and shelter for many fish, invertebrates (including sea

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1. Hardin, *The Tragedy of the Commons*, 162 Science 1243, 1243-48 (1968).

2. North & Pearse, *Sea Urchin Population Explosion in Southern California Coastal Waters*, 167 Science 209 (1970).

urchins), and mammals, and is harvested commercially.[3] About 150,000 tons of kelp are taken from California waters annually.[4] Processed kelp is used in such diverse products as ice cream, beer, antibiotics, dyes, and welding rods.[5]

Many suggestions had been made to control the sea urchin population to prevent destruction of the kelp beds. In 1972, the Department of Commerce, National Marine Fisheries Service suggested harvesting and processing sea urchins and exporting the roe to Japan where it is considered a delicacy.[6] The suggestion proved profitable. By the 1980s sea urchins had become the most valuable fishery export from California.

This paper begins with a description of the sea urchin and its habitat. A brief historical sketch of the development of the sea urchin fishery in the United States follows. Recent regulations designed to prevent the overharvesting of urchins are discussed and analyzed from the perspective of economic efficiency. Because most of the sea urchins that are exported from the United States are taken from California coastal waters, the analysis focuses on the policies adopted by the State of California to protect its fishery.[7] Finally, recommendations are made to improve the efficiency of sea urchin fishery regulations.

THE SEA URCHIN AND ITS HABITAT

Sea urchins, like starfish, sea cucumbers, sea lilies, and brittle stars, are members of the *Phylum echinodermata*. Echinoderm means spiny skin. This vividly describes sea urchins with their hard, spiny shells.

Sea urchins are members of the nearshore community that surrounds the giant kelp beds. Giant kelp is a brown algae.[8] It prefers shallow waters between the depths of 20 to 60 feet. Two species of sea urchins, red and purple sea urchin, are common in California kelp forests.[9] Of these, only the larger red sea urchin reaches sizable commercial value although small quantities of purple urchins are now being harvested. Sea urchins grow slowly, taking four to five years to reach the minimum commercially harvestable size of four inches.[10]

3. Kato, *Sea Urchins: A New Fishery Develops in California*, 34 Marine Fisheries Rev. 23 (1972).
4. *Id.*
5. *Id.*
6. *Id.* at 23-30.
7. Urchins are also harvested commercially from the coastal waters of Maine, Oregon, and Washington.
8. The scientific name of giant kelp is *Macrocystis pyrifera*.
9. The scientific names of red and purple sea urchins are *Strongylocentrotus franciscus* and *Strongylocentrotus purpuratus*, respectively.
10. Kato & Schroeter, *Biology of the Red Sea Urchin, Strongylocentrotus franciscus, and Its Fishery in California*, 47 Marine Fisheries Rev. 1, 8 (1985).

THE SEA URCHIN FISHERY

Although the American commercial sea urchin fishery began in the early 1970s, the history of the sea urchin fishery dates back several hundred years to the era of the sea otter fur trade. Originally, sea otters ranged along the Pacific rim from the northern Japanese islands northward to the Aleutian islands, then south along the North American coast to Baja California.[11] The sea otter has the distinction of being the only marine mammal lacking a layer of blubber to insulate it from the cold. To maintain body temperature, sea otters are endowed with a magnificent pelt and a seemingly insatiable appetite. Trade in their thick, luxurious pelts led to the otter's downfall in the nineteenth century as they were hunted to near extinction.[12]

The sea otter's favorite food is shellfish, particularly sea urchin. Sea otters eat the equivalent of 20 to 30 percent of their body weight each day to maintain their 100 degree body temperature.[13] At this rate an adult will consume about 5,000 pounds of food each year. Sea otters have such enormous appetites that they can reduce sea urchin, abalone, and other shellfish populations below commercial levels.[14]

The elimination of the sea otter from coastal waters allowed shellfish populations to grow. The abalone fishery boomed in the early and middle twentieth century. The annual abalone harvest reached its peak in 1957 at over 5 million pounds per year.[15] "Thereafter, about 4 million pounds were harvested annually until 1969 when a serious decline began. The decline has continued and in some places the fishery has disappeared altogether."[16] By 1988, the commercial abalone harvest had declined to only 548,583 pounds.[17]

Abalones and sea urchins compete with one another for food and shelter. As abalone populations were depleted by sport and commercial divers, the sea urchin population grew unchecked. In 1970, marine biologists reported more than fifty urchins per square meter in some areas.[18]

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11. The scientific name of the sea otter is *Enhydra lutris*.

12. Armstrong, *The California Sea Otter: Emerging Conflicts in Resource Management*, 16 San Diego L. Rev. 249, 252 (1979).

13. *Id.* at 252.

14. *See* Lowery & Pearse, *Abalones and Sea Urchins in an Area Inhabited by Sea Otters*, 23 Marine Biology 213, 213-19 (1973); Estes & Palmisano, *Sea Otters: Their Role in Restructuring Nearshore Communities*, 20 Science 1058, 1058-60 (1974); Wendell, Hardy, Ames, and Burge, *Temporal and Spatial Patterns in Sea Otter, Enhydra Lutris, Range Expansion and In the Loss of Pismo Clam Fisheries*, 72 California Fish & Game 197, 197-212 (1986).

15. P. Haaker, K. Henderson & D. Parker, Dep't of Fish & Game, State of California, Marine Resources Leaflet No. 11, California Abalone (1986).

16. *Id.*

17. Only 118,087 pounds were harvested during the first three months of 1989. Dep't of Fish & Game, State of California, California Commercial Fish Landings By Region (March 1989).

18. North & Pearse, *supra* note 2.

Ironically, today's sea urchin fishery owes its existence to excessive harvests of two other species, the sea otter and abalone.

Several factors coalesced to make the sea urchin fishery a commercial success in the 1970s. First, as noted above, the sea urchin population increased to record levels in the 1960s as a result of the demise of the sea otter and the reduction in abalone populations. Second, the advent of commercial air freight between the United States and Japan allowed the sea urchin, which is generally consumed raw and fresh, to be flown to market in Japan. Third, the dollar depreciated significantly against the Japanese yen.

From the mid-1940s to August 1971, the yen-dollar exchange rate was determined by the fixed exchange rate, Bretton Woods system.[19] Under the Bretton Woods system, the yen-dollar exchange rate was approximately 360 yen per dollar. In August 1971, President Nixon ended the dollar's convertibility to gold at $35 per ounce, signaling the end of the Bretton Woods system in favor of a system of floating exchange rates.[20] Under the floating exchange rate system, the dollar depreciated against the yen during the 1970s.

The dollar rebounded in the early 1980s, but has since fallen sharply to its lowest levels since World War II. During 1988, a dollar could be exchanged for 128 yen. The yen-dollar exchange rate since 1971 is shown in Figure 1. As the dollar depreciates relative to the yen, American goods, including American sea urchin roe, become less expensive to the Japanese.

The first commercial landings of red sea urchin recorded by the California Department of Fish and Game (CDFG) were taken off Southern California in 1971.[21] The take was only 200 pounds.[22] During the 1970s the fishery grew rapidly. The harvest first exceeded 10,000,000 pounds in 1976.[23] By 1979, the harvest reached 20,000,000 pounds. The harvest briefly peaked in 1980 and fell through 1984.[24]

This period of declining harvests corresponds to a period of strength in the dollar. Since late 1984 the dollar has fallen sharply and urchin harvests have skyrocketed. The harvest exceeded 30,000,000 pounds for the first time in 1986, and exceeded 40,000,000 pounds for the first time in 1987. In 1988 the harvest climbed to 49,321,468 pounds[25] (see Figure 2). During the 1980s, increasing numbers of urchins have been harvested

19. For a concise description of the Bretton Woods system and the floating exhange rate system, see C. McConnel, Economics 866-72 (10th ed., 1987).

20. *Id.*

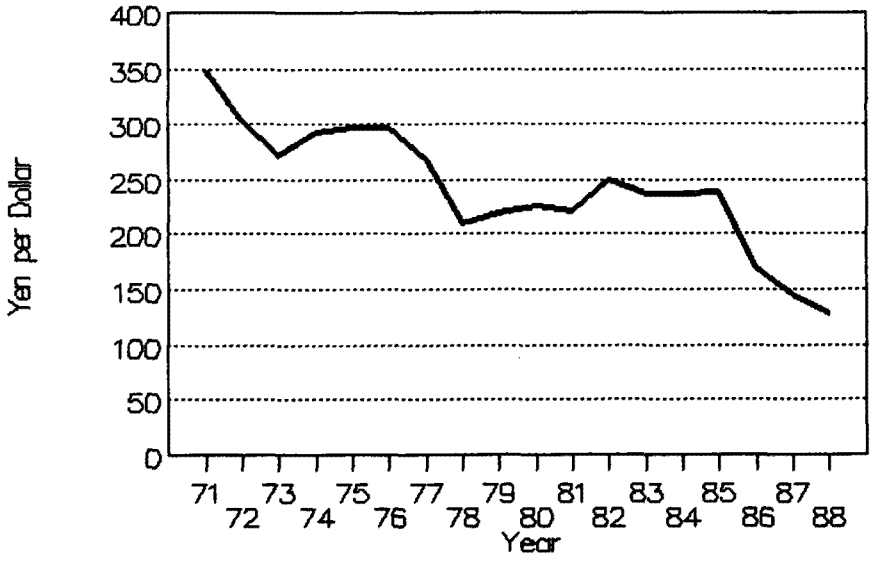
21. California urchin harvests are published by the State of California, Dep't of Fish & Game, Marine Resources Division in two reports, Annual 1A Report, Catch by Species/Origin/Month (published annually) and Commercial Fish Landings By Region (published monthly).

22. Annual Report 1A (1972), *supra* note 21.

23. Annual Report 1A (1976), *supra* note 21.

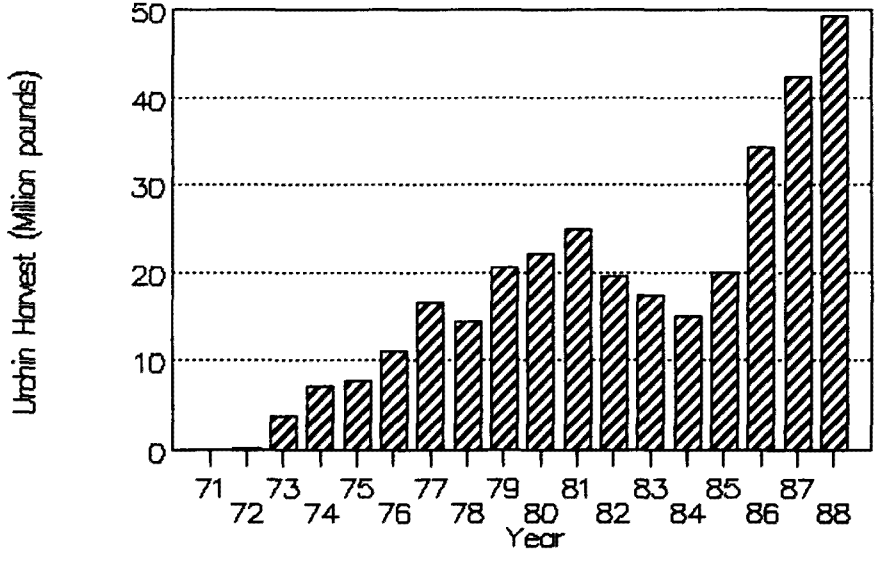
24. Annual Report 1A (1979 through 1984), *supra* note 21.

25. Commercial Fish Landings by Region (Dec. 1986, Dec. 1987 and Dec. 1988), *supra* note 21.



Source: International Monetary Fund, International Financial Statistics, Monthly Volumes, 1971-88.

FIGURE 1. Japanese Yen per Dollar (Annual Average, 1971-1988).



Source: California Department of Fish and Game

FIGURE 2. Annual California Sea Urchin Harvest.

from the colder waters of northern California. David Parker, Marine Biologist for CDFG Marine Resources Branch, describes the meteoric growth in the harvest as "the typical 'gold rush' situation."[26]

Divers harvest urchins one at a time. They dislodge sea urchins from the ocean bottom with short-handled rakes and scoop them into large mesh bags. Because the urchins are selected individually, only the larger, commercially valuable specimens need be taken. An inflatable rubber tube is attached to the mesh bags. It is filled with air, floating the bag to the surface, as the bag reaches its capacity. Urchin divers typically work for only three to four hours per day because of the cold.[27] In that short time span, each diver harvests about 2,000 to 2,200 pounds of urchins.[28]

Once harvested, the urchins are brought to shore and sold to processing plants. At the plants, the urchin shell is split and the urchin's orange sex organs are removed and cleaned. The urchin's sex organs are euphemistically called "roe" or "uni." They are the edible portion of the urchin and constitute 5 to 10 percent of the sea urchin's weight.[29] The highest quality roe is packed in wooden trays and flown to Japan. Each tray contains 8 to 9 ounces of uni. The best quality roe recently sold for as much as $63.00 per tray wholesale.[30] Lower quality roe is used in salted and cooked products.[31]

The rapid growth of the urchin harvest has caused concern over the long term health of the fishery. One California diver wrote:

> The sea urchin harvesting industry in Northern California is gravely imperiled . . . by unsustainable and rapidly escalating rates of harvesting. Forceful and rapid action by the Department of Fish and Game is required to protect the long-term viability of the urchin resource. . . . The resource is being destroyed now, not in the future. In the future, there may be little left to destroy—or to save.[32]

Several protective measures have been suggested, including: (a) a prohibition on harvesting young urchins less than three inches in size, (b) a limit on the number of divers, (c) a limit on the amount of urchin each diver may harvest, (d) a fishing season for urchins, (e) closure of fishery areas, and (f) an increase in the sea urchin landing tax. The California legislature considered these suggestions and passed legislation imple-

26. D. Parker *quoted in* Stein, *Urchin Message: State Petitioned to Set Harvesting Rules as Spiny Shellfish Gains Popularity as Food*, Los Angeles Times, Mar. 10, 1987, at 3.

27. Kato & Schroeter, *supra* note 10, at 10.

28. *Id.*

29. Stein, *supra* note 26.

30. Chipello, *A Miracle in Maine: Sea Urchin Is Turned to Golden Uni*, The Wall Street Journal, Mar. 18, 1988, at 1.

31. For a complete description of sea urchin processing, *see* Kato & Schroeter, *supra* note 10, at 12-17.

32. Stein, *supra* note 26.

menting several of them. Current measures affecting the fishery are described below.[33] In addition to these measures, the legislature directed CDFG to study the fishery and report on its well-being by January 1, 1991.[34]

CURRENT REGULATIONS AND TAXES

California currently regulates the urchin harvest by issuing permits, collecting a landing tax, limiting the fishing season, and restricting harvest methods.

Permits

Before 1985 anyone was allowed to harvest urchins. Since 1986, CDFG requires an annual permit to take urchins.[35] The permit is valid from April 1 to March 31 of the following year and cannot be transferred.[36] Its price was increased from a nominal $25.00 per year to $250 per year in 1987.[37] By 1987, 737 divers held permits.[38] A moratorium was imposed in 1987 on the issuance of new permits by the California State Legislature to restrict the number of divers harvesting urchins.[39] Only those persons holding 1986-87 permits were eligible to obtain 1987-88 permits. Similarly, a 1987-88 permit was required to obtain a 1988-89 permit. Unless extended by CDFG, the moratorium on the issuance of new permits will expire in 1989.[40]

Landing Tax on the Urchin Harvest

California levies a tax of $0.0013 per pound on the sea urchin harvest.[41] A surtax of $0.005 per pound has been imposed on the urchin take.[42] The surtax will remain in effect until January 1, 1991 or until the revenue from the fee has reached $300,000, whichever comes first.[43] The funds raised by the temporary tax will be used by CDFG to study and enhance the sea urchin fishery.[44]

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33. *See infra* text accompanying notes 35-47.
34. Cal. Fish & Game Code § 9056 (West 1989).
35. Cal. Admin. Code, tit. 14, § 120.7a (1987).
36. Cal. Admin. Code, tit. 14, § 120.7(4)(b) (1987).
37. Cal. Admin. Code, tit. 14, § 120.7(4)(d) (1987).
38. Hauser, *Urchin Harvest Worries Divers*, Santa Barbara News Press, Apr. 15, 1987, at B1.
39. Cal. Admin. Code, tit. 14, § 120.7(4) (1987).
40. *Id.*
41. Cal. Fish & Game Code § 8051(a) (West 1989).
42. Cal. Fish & Game Code § 8051.1(a) (West 1989).
43. Cal. Fish & Game Code § 8051.1(c) (West 1989).
44. Cal. Fish & Game Code § 8051.2 (West 1989).

Limiting the Fishing Season

The fishing season for sea urchins is currently restricted contingent on the previous year's harvest.[45] If the harvest in the previous calendar year exceeds 10,000,000 pounds in Northern California (north of the Monterey-San Luis Obispo County line) *or* exceeds 18,000,000 pounds in Southern California, divers will be prohibited from taking urchins one week each month from May through September. This restriction was imposed for the first time in 1988.

Other Regulations

Rakes, airlifts, or other handheld appliances may be used to harvest sea urchins. However, divers may not disturb "rocks or other mineral materials, aquatic plants, fish or other aquatic life" while harvesting urchins.[46] In particular, divers harvesting urchins cannot concomitantly harvest lobsters or abalone.[47]

ECONOMIC ANALYSIS OF CURRENT REGULATIONS AND TAXES

The Economic Meaning of Resource Conservation

Before analyzing the regulations and taxes governing the sea urchin fishery, the criteria by which they will be judged must be defined. Economists widely agree that fisheries and other natural resources should be managed to maximize the value of the economic rent that can be derived from the resource.[48] Economic rent is the difference between the discounted revenue that can be derived from a resource and the discounted opportunity cost incurred in deriving this revenue. Maximizing the economic rent from a resource is the economic definition of resource conservation. Within the economics profession it is also called economic efficiency or Pareto optimality. Wasteful policies reduce the net present value of the economic rent from a natural resource.

Under special circumstances private markets conserve resources. A necessary condition for markets to conserve resources is that all market participants bear the full opportunity cost of their actions.[49] Unfortunately, this does not happen in open access fisheries like the sea urchin fishery. Although the urchin harvesters bear the capital costs associated with the urchin harvest equipment, and the labor costs associated with employing

45. Cal. Admin. Code, tit. 14, § 120.7(4)(i) (1987).
46. Cal. Admin. Code, tit. 14, § 120.7(4)(f)(2) (1987).
47. Cal. Admin. Code, tit. 14, § 120.7(4)(f)(1) (1987).
48. *See* Crutchfield, *Economic Objectives of Fishery Management*, in The Fisheries: Problems in Resource Management 43, 45-46 (J. A. Crutchfield ed. 1965).
49. The opportunity cost of an activity is the value of what must be foregone to undertake the activity.

divers, they do not bear the cost of depleting the urchin population. This cost is borne by society as a whole. To maximize economic rent, the urchin depletion cost must be taken into account. This situation is shown in Figure 3.

Private harvesters in an open access fishery seek to maximize profits. In so doing they consider only their private costs. They will harvest an additional pound of sea urchins as long as the additional revenue derived from the harvested urchins (or marginal revenue) exceeds the additional cost of harvesting the urchins (or marginal cost). For the urchin fishery, which is comprised of many small harvesters and consumers, no individual market participant can alter the market price of urchins. All participants accept the market price as something that is beyond their control and take those actions to maximize their well being given this fact. It follows that the marginal revenue for urchin harvesters is the current market price of urchins. Profit maximization occurs at the level of harvest, *U1*, where marginal revenue equals private marginal cost.

The profit-maximizing harvest does not conserve resources. In order for economic rent to be maximized, the cost of depleting the urchin population must also be considered. The rent-maximizing harvest, *U2*, is found by equating the sea urchin price (a measure of the marginal benefit of sea urchins) with the social marginal cost (the private marginal cost plus the cost of depleting the urchin population).

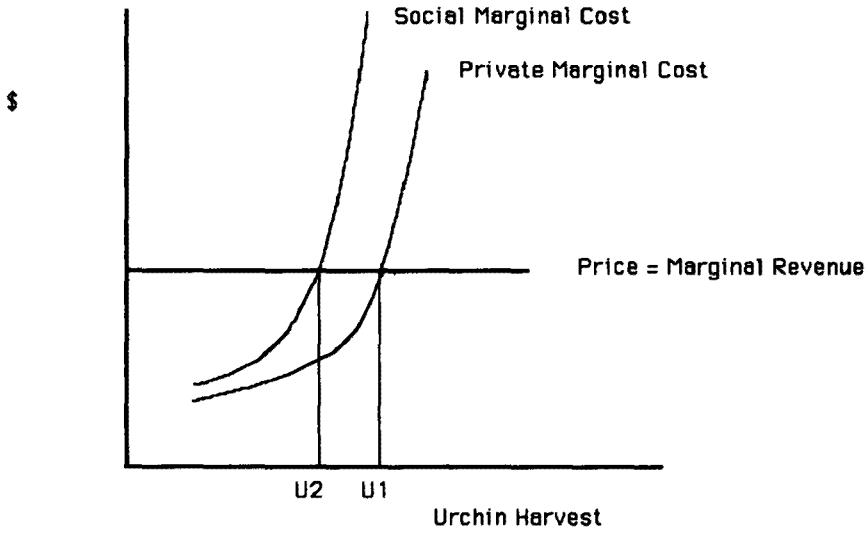

FIGURE 3. Private and Social Optimal Harvest.

Strategies to Reduce Harvest

Various strategies have been used to reduce the take from open access fisheries. These include taxes, subsidies, and a variety of regulations including restricting the fishing season, the number of harvesters, the fishing gear, and the size of the catch.

The annual, non-transferable permit used in the urchin fishery reduces the harvest by restricting the number of divers. Although this reduces the harvest, it does not do so efficiently. When economic rent is maximized, the divers who can take urchins at the lowest cost harvest the urchins. By only allowing divers with existing permits to acquire a permit, and by not allowing permits to be transferred among divers, the low cost harvesters may not be allowed to harvest urchins. This result would be avoided if divers were allowed to transfer permits among themselves. If a new, more efficient diver wanted to enter the fishery, he would be able to purchase a permit from a less efficient diver. Less efficient divers would willingly sell their permits because the more efficient diver would pay more for the permits than the less efficient divers could earn by keeping them. If the permits were transferable, the economic rent from the fishery would accrue to the original owners of the permits.

Urchin harvesters favor fixing the number of non-transferable permits because (a) it reduces the harvest, and (b) it keeps potential competitors from entering the fishery. The reduced harvest decreases urchin supply, driving up urchin prices and profits. Increased profits attract individuals to the industry. However, the current system creates and protects monopoly power for divers currently harvesting urchins by prohibiting entry.

Although the urchin landing tax is intended solely to raise revenue, it could be used like the permit system to reduce the harvest. Furthermore, taxes on catch are economically efficient if the tax is equated with the cost of depleting the urchin resource that would not otherwise be born by urchin harvesters. This situation is shown in Figure 4. As discussed earlier, private firms will harvest *U1* urchins. Suppose that the optimal harvest is *U2*. This could be achieved by imposing a tax of t dollars per pound of urchin harvested. The harvesters perceive the tax as an increase in their marginal cost and reduce the harvest so that their perceived marginal cost (the private marginal cost plus t) is equated to their marginal revenue. Such a tax would not be popular among urchin harvesters because it would require divers to pay for an input, the urchin capital stock, that was previously available at no charge. The tax should be considered nonetheless, because it is economically efficient and raises revenue for the government (in Figure 4, the amount of the tax, *U2* multiplied by t, is the area of the shaded rectangle).

Like taxation, prohibiting harvests one week each month, imposing gear restrictions, and disallowing joint harvests of urchins with other

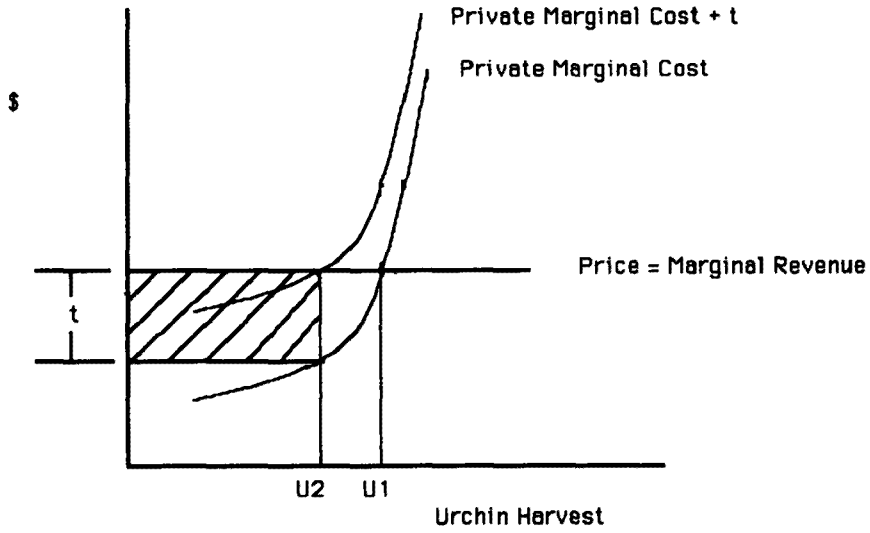

FIGURE 4. The Effect of Landing Tax on Harvest.

shellfish will reduce the urchin harvest, but are inefficient. Economic efficiency requires that the harvest be maintained at optimal levels, but that this harvest be accomplished at the minimum cost. The regulations described above reduce the harvest by increasing the cost of fishing. Divers are not allowed to harvest urchins at a time and with a mix of inputs that is most productive. Economic efficiency requires that urchin divers bear the full costs of their actions. These include the cost of depleting the urchin population and the cost associated with damaging the ocean bottom which gear restrictions are intended in part to prevent. However, regulations which result in unnecessary costs waste rather than conserve resources.

A MARKET-BASED ALTERNATIVE

A market-based solution may solve the problem of excessive harvests. Over-harvesting occurs because the fishery is common property. A solution to the problem is to create private property rights to the fishery.

Private rights may be created by implementing a system of transferable permit/quotas. The permit/quotas would differ significantly from existing permits. Under current regulations, a diver must possess a permit to harvest urchins. The permit allows the diver to take an unlimited number of urchins. Under the alternative scheme, divers would possess a permit/quota (hereinafter "permit") to harvest urchins which would entitle its owner to a fixed quantity of urchins.

For example, suppose that CDFG determines that the annual urchin take should be limited to 20 million pounds each year. This catch could be achieved by issuing 4,000 permits each year; each permit would entitle its holder to take 5,000 pounds of urchins. Divers would be allowed to acquire as many permits as they desire subject to the overall limit. The permits would be fully transferable. Each day, when the divers bring their catch to shore, the catch would be weighed, and the catch allowed by the permit would be reduced accordingly. When the allowed catch is reduced to zero, the permit expires.

Permits would be sold by the government to the highest bidder. An auction would allocate permits efficiently because the divers that can generate the greatest value from each permit would submit the largest bids. By selling the permits to the highest bidder, the economic rent from the fishery accrues to the government.

The system also has the virtue that it would allow the government to adjust the overall size of the catch by buying or selling permits. Calculating the allowable harvest may be difficult. Furthermore, the optimal level of harvest may change over time. The transferable permit system would enable the government to adjust the allowed catch if errors occur or when adjustment becomes necessary due to changes in other conditions.

A disadvantage of a transferable permit system in which the permits are auctioned by the government is that it would be politically unpopular with the divers. As with an efficient landing tax, the auctioned permit system would require harvesters to pay for the use of the urchin capital stock. One way of placating divers may be to give the permits to divers currently holding permits rather than auction the permits to the highest bidder. As long as the permits are transferable, the method by which the government initially allocates the permits will have no bearing on their efficiency. The method of allocation by the government does, however, determine who will receive the economic rent from the fishery. By auctioning the permits to the highest bidder, the government collects the economic rent. By giving the permits to divers, the divers receive the economic rent from the resource. This alternative is undoubtedly preferred by the divers currently harvesting urchins.

Positive economic theory can provide no guidance as to which of these allocation schemes is preferred. This is an income distribution issue. Such a system would be efficient even if the permits were given away at no charge *if the permits are transferable*.

SUMMARY AND RECOMMENDATIONS

From its inception in the early 1970s, the American sea urchin fishery skyrocketed. The growth rate has been so dramatic that concern exists over the long term well-being of the fishery.

The California legislature voiced its concern by directing the CDFG to report on the health of the California sea urchin fishery by 1991. The State of California has also imposed a temporary moratorium on the issuance of urchin harvest permits, placed gear restrictions on harvesters, prohibited joint harvesting of sea urchins and other shellfish, restricted the fishing season contingent on the previous year's take, and levied a temporary landing tax on urchin harvests. The first four policies reduce harvests. The tax raises revenue.

Although the policies devised to reduce harvests should have the intended effect, they are inefficient because they do not achieve their harvest reductions at the minimum cost. If economic efficiency is the criterion by which these policies are to be evaluated, they should be discontinued. A landing tax could be used instead to reduce harvests efficiently, if the tax rate is set appropriately.

An alternative, efficient method of reducing harvests is a transferable permit/quota system. If a limited number of permits are auctioned by the government to the highest bidders, the system would have the additional benefit of allocating the economic rent from the fishery to the government. Despite its desirable resource conservation aspects, the transferable permit/quota system would probably meet with resistance from divers. It would be less preferred by divers to policies like the existing non-transferable permit system because it would be more costly to divers. A transferable permit/quota system is, however, worth pursuing because it protects the renewable urchin resource while enhancing the value of the fishery. By creating property rights to the urchin resource, a "tragedy of the commons" can be averted.