HOW INDIVIDUAL TRANFERABLE QUOTA PROGRAMS AFFECT FISHING FLEETS

Robert L. Clarke, Jr.

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A paper submitted in partial fulfillment of the requirements for the degree of

Master of Science

Oregon State University

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INTRODUCTION

As late as the end of the nineteenth century, many people involved in management of the world's fisheries believed marine fish stocks to be so great as to be essentially inexhaustible (Cushing, 1988). One hundred years later, it is plainly evident that this is not the case. As the twentieth century comes to a close, many of the world's fisheries are in a state of crisis. Currently, over half of the world's major fisheries are either fully or over-exploited. In the United States, over one third of the federally managed species for which there are data are at or approaching over-exploitation (NOAA, 1998; Collins, 1996). Around the globe, there have been complete closures for commercially important stocks such as herring and capelin in Iceland, cod in Atlantic Canada, striped bass and Atlantic salmon along the U.S. Atlantic coast, and certain species of salmon in the Pacific Northwest. Finally, the United Nations Food and Agriculture Organization has predicted that, despite increasing demands growing populations will place on ocean production, without major changes in fisheries management, world-wide landings are likely to remain at current levels and could possibly fall as much as 25% (NOAA, 1998).

One of the driving forces behind the over-exploitation of fish stocks is the fact that, throughout history, fish stocks have primarily been viewed as open access resources subject to exploitation by anyone with the means to participate. One of the consequences of this view is that exclusive ownership of the resource is not established until the fish are harvested. Without being able to establish ownership of the resource until harvest, fishers are forced into competing against one another to gain possession of the resource. As a result, fishers are unable to choose the most economically efficient levels of harvest, because whatever one fisher does not catch, another fisher will (Wieland, 1992).

As long as fish stocks are considered open access resources, fishers will concentrate their efforts on establishing ownership of the resource rather than on making the most efficient use of the resource. The outcome is that too much effort will be directed at catching fish, and fish stocks will inevitably be over-exploited. This idea, that the use of common resources is inherently fraught with inefficiencies, was made famous by Hardin (1968) in his landmark article, "The Tragedy of the Commons." In it, Hardin demonstrates that the ultimate destination of all common resources is ruin: that as each individual pursues his or her own best interest, common resources are destined to be destroyed by overuse.

The failure of effort limitation programs

As early as the 1840s, managers began to protect fish stocks by regulating the application of physical capital in certain fisheries (Hanna, 1997; Cushing, 1988). During the last century, managers have enacted a myriad of regulations, limiting everything from the size of vessel engines to the use of barbed hooks, in order to control fishing effort and reduce pressure on fish stocks. Despite this, fishers have always found ways to increase effort by investing capital in variables uncontrolled by regulations. As a result, effort limitation programs did not halt the investment of capital and, therefore, were largely ineffective in constraining harvests (Anderson, 1995; Arnason, 1993a).

In addition to failing to control the input of capital, effort limitation programs did nothing to address the problem of competition inherent in open access fisheries. Open access fisheries are governed a "rule of capture" in which ownership of fish can only be claimed through harvest. The rule of capture motivates individual fishers to increase their effort in order to increase their share of the harvest (Boyce, 1992). There is no incentive to defer or limit harvests in the interest of conservation or efficiency because, individually, fishers are unable to have any impact on the condition the fishery. Under the rule of capture, conservation or efficiency-minded fishers cannot prevent the decline of the stock because others will continue to fish, reaping benefits at their expense. As a result, all individuals are motivated to increase their capital investment in order to catch as many fish as possible, regardless of the condition of the stock (Arnason, 1993a).

The failure of total catch programs

During the 1950s, Canadian economists Gordon and Scott addressed this problem by publishing a series of articles in which they showed that open access fisheries can result in the expansion of fishing capacity to the point that stocks are reduced to a level far below the maximum sustainable yield. As fish stocks became increasingly depleted, most fisheries management programs began to protect stocks by imposing limits on annual harvests. These programs, called total allowable catch (TAC) programs, are currently the most common method of protecting fish stocks (Arnason, 1993a). By restricting total harvests to biologically sustainable levels, TACs were successful in protecting many stocks. They were, however, ineffective in halting the expansion of fishing capacity (Anderson, 1995).

Rather than preventing expansion of fishing capacity, TACs actually exacerbate the problem, encouraging further increases in capacity as fishers rush to catch as much fish as possible before the TAC is reached and fishing is closed. This process of encouraging capital investment in order to increase the share of harvest is known as the "race for fish." It is the natural result of all open access, competitive fisheries, which are governed by the rule of capture (Casey et. al., 1995). In an open access fishery, catching fish inefficiently is better than not catching them at all, provided costs are less than revenues (Anderson, 1986). So, while TACs may produce biologically stable fisheries, they ultimately lead to fleets in which more capital than necessary is employed, a condition called overcapitalization.

The major source of increased effort in open access fisheries was expansion of fishing fleets themselves. Following World War II, many governments began heavily subsidizing their fishing fleets (Collins, 1996). Even with total harvests capped by TACs, fisheries continued to attract new entrants. This is because, with no restrictions on access, fishers will continue to enter a fishery as long as they can reasonably expect to generate above average profits.

Above average profits are known as economic rent or, more often, just rent. Rent is the greater than normal profit that is generated above the minimum that is necessary to attract a specific quantity of input (Schiller, 1994). For example, the rent that is generated by a fisherman would be the amount of revenue earned after taking into account the minimum amount of costs necessary to catch fish, plus the minimum amount of salary the fisherman could make by doing some other, equivalent job. The higher the rents are in a fishery, the more incentive there is for people to participate.

Rent and overcapitalization

As long as above normal profits can be generated in a fishery, fishers and capital will continue to enter since, by earning rents, they are earning more than is necessary given their amounts of input. The influx of fishers and capital eventually leads to overcapitalized fisheries, in which there are more vessels than necessary. As a result, rents in the fishery become depleted to the point that economic profits are zero (Arnason, 1993a).

During the 1960s, managers made major attempts to solve overcapitalization problems by creating limited entry programs. Limited entry programs were designed to prevent already overcapitalized fleets from getting any larger by limiting the number of vessels allowed to participate. Limited entry programs were successful in controlling the growth of fishing fleets, but they failed to address the problems associated with the competitive nature of fishing. In the end, limited entry programs were unsuccessful in controlling overcapitalization because they allowed licensed fishers continued to invest capital in areas not restricted by the limited entry programs (Squires et. al., 1995; McCay and Creed, 1990).

Although TACs had been proven successful in protecting the biological integrity of many important stocks, effort control and limited entry programs failed to solve the basic problem of competitive fisheries: the race for fish that leads to overcapitalization. Too much effort chasing too few fish continued to result in inefficient use of resources and greater than desired pressure on fish stocks. Rents generated by fish stocks continued to fall and capital that could have been put to use elsewhere continued to needlessly enter the fishing industry. Overcapitalization itself helped fuel the problem as political pressure was exerted to increase TACs in order to keep overcapitalized fleets fully employed (Hannesson, 1996; Arnason, 1993a).

The development of individual quotas

The idea of managing fisheries by individual quotas rose out of the failure of other types of management programs to effectively control open access, competitive fisheries (Arnason, 1993a). Individual quota management is a relatively recent development in fisheries management. Individual quota management seeks to reduce the wastefulness that is the ruin of many common resources by granting guaranteed rights of harvest to individual fishers.

For the most part, individual quota programs were not possible until the 1970s. Prior to that, the territorial sea of coastal states was generally limited to a maximum of 12 miles. Outside 12 miles, the oceans were considered the high seas, meaning coastal states had no right of ownership over ocean resources more than 12 miles beyond their shores. Due to the transitory nature of fish stocks and the fact that most commercially important stocks were harvested outside of 12 miles, sovereign states were unable to control most of the ocean's fisheries. With coastal states unable to exert any form of ownership beyond 12 miles, the establishment of individual harvest rights was virtually impossible (Hannesson, 1996).

In the mid-1970s, the United Nations Conference on the Law of the Sea began reaching a consensus that coastal states should have exclusive rights over their fisheries out to 200 miles (Christie, 1994). With the creation of these rights, sovereign states were finally able to claim meaningful ownership of their fisheries, thereby facilitating the eventual granting of individual harvest rights. In 1975, Iceland extended its exclusive economic zone to 200 miles and, shortly thereafter, established the world's first major individual quota management system (Arnason, 1996; Muse, 1991). Since 1976, roughly 40 programs have been implemented throughout the world.

Individual quotas were proposed as a means of addressing overcapitalization through the elimination of competition in fisheries in the early 1970s (Casey et. al., 1995; Boyce, 1992). Individual quotas attempt to eliminate competition through the establishment of individual harvest rights. These rights establish a form of ownership prior to capture, which changes the incentive of the individual fisher. Freed from competing with fellow fishers under the rule of capture, under individual quota management, fishers can concentrate on minimizing their costs and maximizing the value of their catch, rather than competing with one another to establish ownership (Casey et. al., 1995; Arnason, 1993a). With their share of harvests guaranteed, individual fishers are no longer motivated to increase capital investment in order to increase their harvests. Accordingly, a major goal of many individual quota programs is to reduce the amount of excess effort in a fishery (McCay, 1996).

Individual quota management, however, is not without its critics. Most of the criticism revolves around two issues. The first issue concerns the appropriateness of privatizing resources that, until recently, have been open to the general public. The second issue concerns the effect that granting individual rights may have on both the fishing industry and fishing communities. Among the most important and most frequently cited concerns is that the efficiency gained through establishment of individual harvest rights will be translated into consolidation of productive capacity and concentration of economic power within fishing communities, resulting in social disruptions as fisheries shift from livelihood fisheries to accumulation fisheries (Davis, 1996). Some people feel, by facilitating consolidation of productive capacity, individual quota management will lead to fewer fishing vessels and fewer fishing jobs (Hannesson, 1996; Anderson, 1995). This controversy is so significant, the primary regulatory act for managing fisheries in the United States, the Magnuson-Stevens Fishery Conservation and Management Act (16 U.S.C. 1853), was recently reenacted with language specifically stating "the Secretary (of Commerce) may not approve or implement before October 1, 2000, any fishery management plan, plan amendment, or regulation...which creates a new individual fishing quota program."

Purpose

As will be shown in this paper, some amount of consolidation has occurred under almost every individual quota program that has been implemented. In the most severe cases, fishing fleets have lost over 70% of their vessels. Because of the devastating impact such losses can have on fishing communities, it is vital that the potential for consolidation of fishing fleets be considered when evaluating prospective management programs. The purpose of this paper is to emphasize the importance of considering the individual characteristics of each fishery and each individual quota program, rather than totally dismissing or totally embracing individual quota programs as potential management tools.

Definitions and assumptions

A wide variety of individual quota programs have been adopted as part of fisheries management plans throughout world. In general, individual quota programs can be broken down into two categories based on the whether or not the harvest rights are transferable. Individual quota (IQ) programs refer to all systems in which individual fishers or firms are granted the right to harvest specified amounts of catch. Individual transferable quota (ITQ) programs are those IQ programs in which the harvest rights may be transferred between individuals and firms, usually in the form of sales or leases. All ITQ programs are IQ programs, but not all IQ programs are ITQ programs.

Two other terms often mentioned in discussions of IQ programs are individual fisherman's quotas (IFQ) and individual vessel quotas (IVQ). These terms define the entity to which the harvest rights are assigned. IFQ programs assign harvest rights to individual fishers, while IVQ programs assign the harvest rights to specific vessels. If these rights are transferable, then they are sometimes referred to as ITFQ programs and ITVQ programs. The T is often assumed to be understood so, occasionally, IQ, IFQ, and IVQ are used when discussing programs in which the harvest rights are, in fact, transferable.

This paper will deal almost exclusively with ITQ programs for two reasons. First, they are by far the most prevalent types of programs. Second, transferability is crucial to the issue of fleet consolidation. Without transferability, aggregation of quota shares is practically impossible. For this reason, fishery managers desiring to reduce the number of vessels in a fishery invariably choose to make harvest rights transferable. For the purposes of this paper, ITQ will be used to denote programs that grant harvest rights to either individual fishers, individual firms, of both. In those instances in which harvest rights are granted to vessels, it will be specifically noted.

This paper will focus on the potential change in the number of fishing vessels in fisheries that are brought under ITQ management. Because the loss of fishing vessels often means the loss of jobs within fishing communities, whether or not an ITQ program will significantly decrease the number of vessels in a fishing fleet is an extremely important aspect to consider. One way that ITQ programs can cause a reduction in the number of vessels is through the aggregation of quota. Since, by definition, ITQ programs allow quota to be transferred, quota aggregation can occur when fishers increase their amounts of quota through the purchase or lease of quota that was allocated to others. When several fishers use a single vessel to fish quota that had been previously fished by more than one vessel, the total number of vessels in the fleet will decrease and the average amount of quota per vessel will increase. This results in the loss of vessels, a concentration of quota among fewer individuals, and possible loss of fishing industry jobs. For the purposes of this paper, this will be referred to as consolidation of the fleet or, at times, just consolidation.

ITQ systems can cause other types of consolidation. For instance, it is possible to have consolidation of quota ownership without a reduction in the number of fishing vessels. Many fisheries are prosecuted both by owner-operated vessels and vessels that are part of a company-owned or leased fleet. Owner-operated vessels are those in which the owner of the vessel makes his living by operating his vessel, harvesting fish, and selling the catch. In these cases, the owner of the vessel is an independent individual, free to succeed or fail in varying degrees based on his own knowledge and skill. The independent life style associated with owner-operated vessels can be highly valued and an integral part of many fishing communities. Company-owned vessels, on the other hand, are vessels that are owned or leased by firms (often fish processing companies) that employ captains to operate the vessels for wages. The catch that is landed is owned by the company, and the company succeeds or fails based on its ability to generate a profit from the vessels it owns or leases.

Introduction of ITQ programs can, in certain situations, affect the number of owners without necessarily changing the number of vessels. For instance, a specific firm could increase its amount of quota by purchasing it from an owner-operator, then purchase or lease a vessel to fish the additional quota. After equilibrium is established, the number of vessels in the fishery might remain the same, but the number of owner-operators would decrease, while the amount of quota held by fishing companies would increase. This type of consolidation is a serious concern to fishing communities because of both the change in lifestyle that comes with the loss of owner-operated vessels, and the change in wealth distribution that comes as more individuals shift from ownership to wage-based earnings. While consolidation of quota ownership is an extremely important issue, it will not be addressed in this paper. Throughout this paper, the term consolidation will be considered to mean a reduction in the number of vessels accompanied by an increase in either the average amount of catch or the average amount of quota per vessel.

Finally, for the sake of simplicity, all hypothetical vessels in this paper will be assumed to be full-time participants in the fishery with no opportunity to switch between fisheries as seasons close or allowable catch quotas are reached. Although this critical assumption is unrealistic for many fisheries, incorporating part-time participation severely complicates the economic analyses. Even if vessels participate in more than one fishery, the same basic principles underlie the potential consolidation under ITQ programs. Therefore, for the purposes of clarity and simplicity, this paper will assume that there is no part-time participation.

This paper is divided into five sections. The first section discusses basic economics and describes how some of the principles addressed in agricultural economics literature can be applied to fisheries economics. The second section describes the way in which management programs can affect the economics of a fishery. The third section describes how ITQ programs affect the economics of a fishery. The fourth section describes how the amount of consolidation can vary according to the individual characteristics of the fishery and the specific regulations of the ITQ program. The sixth section contains a discussion and conclusions. ITQ program summary tables and economic figures are included at the end of the text.

SECTION I

The need for management

Many of today's modern fisheries began centuries ago, when vessels were powered by sail, captains navigated by the stars, and hemp was the only material available for lines and nets. There was little need to regulate fishing because technology, or lack thereof, severely limited the rate at which fishers could harvest fish. Without the advantages of internal combustion, electronic navigation, and synthetic lines, there was little possibility of overfishing most commercial stocks. This belief was widely held as late as 1883, when Professor T. H. Huxley, in his inaugural address to an international fisheries exhibition in London stated: "the multitudes of these fishes (at sea) is so inconceivably great that the number we catch is relatively insignificant; and, secondly, that the magnitude of the destructive agencies at work upon them is so prodigious, that the destruction effected by the fisherman cannot sensibly increase the death rate" (Cushing, 1988).

A fish stock's sustainable annual catch is determined by its reproductive capacity, which cannot be expanded (Arnason, 1993a). This was recognized as early as 1843, when England sought to protect spawning stocks by establishing minimum mesh sizes and minimum catch lengths for brill, turbot, codling, whiting, mullet, sole, plaice, dab, and flounder. As fishing technology improved, man's ability to harvest adult fish began to exceed the reproductive capacity of some stocks. By 1893, a Select Committee of the British House of Commons was appointed to consider adopting various measures to preserve and improve fisheries in the seas around the British Isles. Measures under consideration by the Committee included the protection of defined areas, the fixing of closed seasons, and certain gear restrictions (Cushing, 1988). Although none of the Committee's recommendations were acted on at the time, their consideration indicates, by the late 1800's, man had the capability to overfish major commercial stocks in the North Sea.

As more fisheries began to suffer from overfishing, management of commercial fish stocks became more commonplace. In 1902 the International Council for the Exploration of the Sea was formed, in part, to address the problem of overfishing. This was followed by the formation of the International Fisheries Commission in 1923 and the Pacific Salmon Commission in 1937 (Cushing, 1988). Rapid technological advances and a post-World War II expansion of fishing fleets continued to increase the pressure on commercial stocks, and regulations were continually added and modified in attempts to keep stocks from being exhausted.

Today, due to modern technology, the unexploited fishery surpluses of the past are now fully utilized and, in many cases, over-utilized (Hanna, 1997). Worldwide, 70% of fish stocks have been reported as "depleted" or "almost depleted," while in the United States, 40% of managed fisheries have been reported as "overexploited" (Collins, 1996). Virtually every commercial fishery in the world is under some sort of regulation to prevent overfishing. These regulations have historically attempted to regulate fishing capacity by placing restrictions on seasons, gear, geographic area, and permits (Smith and Hanna, 1990). By placing constraints on the manner in which fishers are allowed to operate, fisheries management plays a vital part in determining the economics of a fishery. Fishery management programs essentially dictate the costs of fishing by restricting the time, methods, and amount of fishing permitted. It is critical, therefore, to understand exactly how management programs affect the short and long-run costs of commercial fishing.

Using agricultural cost curves

There has been much research during the past few decades into the short and long-run costs of producing agricultural products. Because of the similarities between agricultural production and commercial fishing, the results of some of this research can be applied to the fishing industry. Farming and fishing are both resource extraction industries that require capital and labor to produce a product. Both industries produce food products that must be further processed in order to reach the consumer market. Both industries require heavy capital investment in similar kinds of equipment: tractors, combines, and irrigation equipment for farming; vessels, refrigeration equipment, and fishing gear for fishing. Both industries have similar variable costs such as labor and fuel. Farming and fishing are both greatly influenced by varying environmental conditions in both the short and long term. Farming and fishing both require access to a finite natural resource: farmers need access to land and fishers need access to stocks of fish. Finally, both farming and fishing firms exist in a wide variety of sizes, from single family operations to multinational conglomerates.

Further evidence of the similarity between farming and fishing can be found in the changes both industries have undergone during the past few decades. A major trend in U.S. agriculture has been a steady reduction in the number of farms, accompanied by a corresponding increase in average farm size. The driving force behind this trend has been technological advancement, which has reduced production costs (Albrecht, 1992). As farms became more technologically advanced, fixed capital costs (investment in machinery) became relatively more important than variable costs (labor). Higher fixed costs had to be spread over more units of production (Brown, 1989). However, farmers that employed technological improvements were able to minimize production costs and, therefore, earn temporary windfall profits (Albrecht, 1992).

As production costs dropped, prices eventually fell, making the use of high technology compulsory. Smaller and less competitive farms, unable to recover the higher costs of capital and land, tended to be consolidated in larger, more profitable farms (Albrecht, 1992). From 1984 through 1994, the number of farms in the United States fell from over 2.3 million to just over 2 million, while the average farm size increased from just under 440 acres to almost 480 acres (U.S. Dept. of Labor, 1996).

Like farming, a major trend in the fishing industry has been technological advancement that has resulted in an increase in capital expenditures and a decrease in the need for labor. This is supported by the U.S. Department of Labor (1996), which states that employment in the fishing industry may be restrained by the growing number of large vessels and improvements in fishing technology that have increased the efficiency of fishing operations and limited the expansion of crews. The total commercial landings in the United States grew from under 3.5 million tons in 1987 to over 4.7 million tons in 1995. During the same period, the estimated number of commercial fishing vessels and boats fell from 102,600 to 99,600. Further, while the total number of vessels fell, the number of small vessels fell even more dramatically. From 1987 to 1996, the number of boats (fishing vessels generally under five gross tons) dropped from roughly 79,000 to roughly 66,700, while the number of larger vessels (those over five gross tons) increased from roughly 22,700 to 32,800 (U.S. Dept. of Commerce, 1997). While these vessel numbers are only estimates, this information tends to support the similarity between agriculture and fishing in that the trend in fishing vessels, like the trend in farms, is toward fewer, more highly capitalized vessels capable of greater production.

Given the high degree of similarity between the agriculture and fishing industries, the principles of agricultural short and long-run costs can be applied to the short and long-run costs of fishing. Traditionally, both short and long-run cost of production curves have been thought of as U-shaped. As firms spread their fixed costs over more production, the average cost of production declines (Anderson and Powell, 1973). Eventually, however, increasing amounts of variable resources are required to produce more product. As the cost of variable resources increases, the average cost of production levels off and then begins to rise, producing an upward sloping curve. Each individual firm will have a unique average cost curve based on the cost of its fixed resources (Madden and Partenheimer, 1972), and for each firm there will be an amount of variable resources that results in a minimum average cost of producing a unit of product (Doll and Orazem, 1984).

If we think of a single vessel fishing operation as a firm, then the average cost per unit of catch will decline as its fixed costs (vessel, nets, etc.) are spread over increasing amounts of catch. However, as the vessel increases its effort in order to produce more catch, variable costs begin to rise for reasons such as increasing labor and fuel expenses, higher maintenance requirements due to increased time at sea, increased gear loss, etc. Eventually, the vessel's average cost per unit of catch begins to rise (Doll, 1988). Since every vessel has unique fixed and variable costs, each vessel will have a unique average cost curve with a specific amount of catch for which the vessel's average cost per unit of catch is a minimum. A typical average cost of production curve for a fishing vessel is shown in figure 1.

An average cost curve in which one or more resources are assumed to be fixed over a given period of time is known as a short-run average cost (SRAC) curve (Madden and Partenheimer, 1972). For example, in the short run, a farmer cannot change the size of his farm and, likewise, a fisher cannot change the size of his vessel. Since these costs are fixed for the immediate future, the cost curves associated with operating those firms are considered short-run cost curves.

In the long run, however, all resources are variable. Over time, a firm owner is able to change the size of his operation by changing the size of his factory, farm, or vessel. The long-run costs for any industry can be approximated by a curve tangent to the SRAC curves for all the individual firms within the industry. This curve is know as the long-run average cost (LRAC) curve. The LRAC curve represents the average total costs incurred by a firm producing a given amount of output (Madden and Partenheimer, 1972). A typical average LRAC curve is shown in figure 2.

Economies of scale

Figure 2 also illustrates economies of scale. Initially, long-run average costs in the industry decrease as increasing firm size allows for the use of more efficient technologies and the employment of a more specialized workforce. The economic condition in which increased production results in a lower average cost per unit of production is called an economy of scale. Economies of scale favor expansion, because by increasing production, firms are able to reduce their cost per unit of output, which results in increased profits. Eventually, however, industry long-run average costs begin to rise due to inefficiencies such as managerial limitations and bureaucratic red tape. The economic condition in which increased production results in a higher average cost per unit of production is called a diseconomy. Diseconomies favor those firms that are efficient at lower levels of output (Doll and Orazem, 1984).

There is much evidence to indicate that LRAC curves in agriculture do not follow a classic, U-shaped pattern depicted in figure 2. Madden and Partenheimer (1972) found that, "under real life farming conditions,...L(R)AC curves are often 'flat' or nearly horizontal over wide ranges of farm size." Anderson and Powell (1973) state that a synopsis of agricultural economic research conducted in the U.S. found that most LRAC curves are L-shaped rather than U-shaped. In addition, their observations of Australian agricultural industries confirmed "significant economies of size exist for small to medium sized farms and, thereafter, AC curves are nearly horizontal." Hall and LeVeen (1978) also found evidence of L-shaped LRAC curves in California and little evidence of increasing production costs for larger firms.

Figure 3 shows several different LRAC curves. $LRAC_1$ depicts an industry in which an economy of scale exists throughout the relevant range of total output, Y. In this case, greater amounts of output result in lower average unit costs. A fishery such as this would tend to favor vessels that could produce large catches at lower unit costs. $LRAC_2$ depicts an industry in which there is a diseconomy. In this case, average unit costs increase as the amount of output increases. A fishery such as this would favor vessels capable of efficiently producing smaller catches. $LRAC_3$ depicts an industry in which there are constant returns to scale. In a fishery such as this, average unit costs remain constant, regardless of the amount of catch. In terms of efficiency, there would be no economic advantage to producing larger or smaller catches.

Doll and Orazem (1984) acknowledge, even in situations where economies of scale prevail at all levels of output, all average cost curves eventually turn upward. Manufacturing firms and service companies eventually become inefficient due to managerial complications: larger farms face increasing numbers of unpredictable situations requiring more attention (Madden and Partenheimer, 1972), lumber companies run out of the most productive forest land and are forced to use less productive land, service company chains face decreasing numbers of top managers, etc. This eventually drives up average costs and creates an upward turn in the LRAC curve. However, since

LRAC curves can be L-shaped over wide ranges of output, for the purposes of simplicity and clarity in diagramming, only the L-shaped portion of the LRAC curves will be depicted in this paper.

The backward bending supply curve

Unlike farming, where production on one farm does not affect the effort required to produce crops on other farms, harvesting of fish by one fisherman directly affects the effort required for others to harvest fish. As individual fishers harvest fish, the number of fish remaining is decreased. As the number of fish decreases, more and more effort must be expended in order to find and catch additional fish. Therefore, as an individual fisher harvests fish, he raises the cost of harvesting for all other fishers. This produces curves in which costs increase as the amount of harvest increases. The result is an average cost curve which is always upward sloping, giving rise to the "backward bending supply curve" often discussed in fisheries economics literature. Since L-shaped average cost curves appear to conflict with traditional backward bending supply curves, it is important to note the differences between the two.

Specifically, backward bending supply curves only address the effort involved in actually capturing fish. Since removing a single fish increases the amount of effort required to catch the next fish, the cost of catching fish will increase as the number of fish caught increases. In this situation, economies of scale could not exist, because producing larger amounts of catch would cost more than producing smaller amounts of catch. This focus on fishing effort, however, neglects many of the start-up costs involved in fishing (e.g. the initial cost of the vessel and gear). Once paid, these costs do not change, regardless of the abundance of the stock. For example, a vessel that costs $100,000 and experiences variable costs of $10,000 per ton for the first ton of fish it catches experiences an average cost of $110,000 per ton. Even if harvesting the first ton of fish causes variable costs to rise to $20,000 for the second ton, the average cost per unit of production drops to $65,000 per ton for the second ton of fish. In this case, the average cost per unit production of the individual vessel experiences a significant economy of scale even though variable costs have doubled. Therefore, individual average cost curves can reflect declining average costs while, at the same time, the industry-wide removal of fish results in increasing costs with increased harvests.

The economics of individual fishing vessels

On an individual basis, a vessel will continue to fish as long as the revenue it gains from each additional unit of catch is more than the cost of producing that unit of catch. In economic terms, the increase in variable cost required to produce an additional unit of output is known as marginal cost. A typical marginal cost (MC) curve is depicted in figure 4. There are two important relationships between marginal cost curves and average cost curves. First, both curves always start at the same point, since the marginal cost of producing the first unit and the average cost of producing the first unit are the same. Second, average cost curves always begin to increase at the point where marginal cost equals average cost.

As depicted in figure 4, when total production reaches Y_a units, the marginal cost of producing the Y_{ath} unit is equal to the average cost per unit of producing Y_a units. Since the cost of producing the next unit, Y_{a+1}, is greater than average cost of producing Y_a units, it follows that the average cost of producing Y_{a+1} units must be greater than the average cost of producing Y_a units. As a result, the marginal cost curve will always intersect the average cost curve at the minimum cost per unit production.

The economics of a fleet

Total market demand for fish is met by individual vessels supplying various amounts of catch. All vessels will produce catch as long as marginal revenue (the ex-vessel price) is greater than marginal cost. However, since each individual vessel has unique marginal and short-run average cost curves, each vessel will produce different amounts of catch. The total amount of fish supplied to the market will be dictated by the both the ex-vessel price and the individual cost curves of the vessels in the fishery.

For simplicity sake, the following discussion will assume that ex-vessel prices do not change with increasing production. For example, in figure 5, when the ex-vessel price is increased from P_1 to P_2, it will be assumed that the price will remain P_2 despite the increase in production that results from vessel b entering the fishery. In reality, the increase in catch supplied by vessel *b* might cause the ex-vessel price to drop, so the market supply curve would be something different than simply sum of the catches of vessels *c* and *b*. Regardless of the assumptions, the same basic principles apply: as the ex-vessel price increases, less efficient vessels are able to enter the fishery, and the market supply will reflect the entry of the additional vessels.

In figure 5, when ex-vessel prices are between P_m and P_1, only vessel *c* will supply fish. This is because, with the price below P_1, only vessel *c* can produce fish at an average unit cost that is less than the price (note that at prices below P_m, no fish will be supplied). The market supply curve at these prices is Y_c, and it is equivalent to the marginal cost curve of vessel *c* because, at prices between P_m and P_1, vessel *c* supplies the entire market.

As the ex-vessel price increases from P_1 to P_2, however, vessel *b* is able to supply fish because the price is now greater than vessel *b*'s average costs. At any given price between P_1 and P_2, vessels *c* and *b* will both supply fish, with each vessel supplying fish until its marginal costs equal the ex-vessel price. The market supply curve at these prices becomes the sum of the two marginal cost curves, $Y_c + Y_b$. As the ex-vessel price rises to between P_2 and P_3, vessel *a* is able to supply fish. The market supply becomes the sum of the three marginal cost curves, $Y_c + Y_b + Y_a$, with each vessel supplying fish until their marginal costs equal the ex-vessel price.

A fleet can consist of any combination of vessel numbers and types, each vessel having its own SRAC curve tangent to the LRAC curve for the fishery. Each vessel will supply various amounts of fish according to its cost curves and the ex-vessel price. Figure 6 depicts an L-shaped LRAC curve for a hypothetical fishery in which the fleet consists of three types of vessels: types *a*, *b*, and *c*. In the short run, vessel type is fixed, so fishers are only capable of producing catch based on the type of vessel they currently own. Each vessel type has an amount of catch (Y_a, Y_b, and Y_c) for which the unit cost (C_a, C_b, and C_c) is minimum. In the short run, the market is supplied a total amount of fish equal to the sum of the individual catches of all vessels in the fleet.

In general, type *a* and *b* vessels will produce smaller amounts of catch at higher costs than type *c* vessels. This is reflected in their relative SRAC curves and their relative amounts of catch ($Y_a < Y_b < Y_c$). Since type *a* vessels produce lesser amounts of catch than type *c* vessels ($Y_a < Y_c$), a fleet that is mostly type *a* vessels will be less consolidated. It will require more vessels with smaller amounts of catch to supply the market than a fleet that is mostly type *c* vessels. Conversely, a fleet that is mostly type *c* vessels will be more consolidated, requiring a fewer number of vessels with larger amounts of catch to supply the market.

In this fishery, assuming all vessels receive the same price for their catch, type *c* vessels will be the most profitable because they produce catch at the lowest average unit cost ($C_c < C_b < C_a$). In the long-run, where there are no fixed inputs, fishers can choose between the lower capacity, type *a* and *b* vessels, and the higher capacity, type *c* vessels. Since type *c* vessels are more profitable, there will be an incentive for fishers to switch to the larger, more profitable type *c* vessels. This is an example of how economies of scale, as depicted by L-shaped LRAC curves, provide incentives for a fleet to consolidate.

In addition to economies of scale, constant returns to scale can also encourage consolidation of fishing fleets. As shown in figure 7, fishers that decide to operate higher capacity, type *d* vessels, will not realize any significant reduction in unit costs ($C_c \approx C_d$). They will, however, be able to produce larger catches without incurring higher unit costs ($Y_d > Y_c$). On an individual basis, as long as catching more fish does not increase unit costs, more catch will mean more revenue, and fishers will have an incentive to increase the capacity of their vessels. Consolidation of fishing fleets, therefore, can also result from flat LRAC curves that reflect constant returns to scale.

SECTION II

Management raises the cost of fishing

In order to achieve biological objectives, managers enact various types of regulations that prohibit or restrict specific fishing methods, create restricted seasons, limit vessel numbers, require vessel licenses, restrict vessel size, or establish various catch limits. All these regulations act to increase the total cost of fishing (Muse and Schelle, 1989; Anderson, 1995). The increase in costs will increase the price, resulting in less demand for fish while, at the same time, making it physically harder to overfish the stock. In addition, because they alter the cost of fishing, management systems inherently alter a fishery's average cost curves.

Regulations raise the cost of fishing by increasing either fixed costs, variable costs, or both. Fixed costs are those costs that do not vary with the rate of output, while variable costs are those that are dependent on the rate of output (Schiller, 1994). The way in which regulations change the LRAC curve depends on which costs the regulations increase. Regulations that create or emphasize economies of scale will encourage consolidation, while regulations that create diseconomies will produce fleets with greater numbers of vessels. Therefore, knowing how a management program is likely to affect a fishery's LRAC curve is important to predicting the program's effect on the fleet.

To demonstrate how increasing fixed costs changes a fishery's LRAC curve, we can examine a hypothetical fishery in which regulations have been enacted that require vessels to purchase licenses. By requiring vessels to purchase licenses, the cost of fishing is increased by a fixed amount (the amount of the license fee), regardless of how much catch a vessel lands. The result is the fishery's average unit costs are increased substantially at lower levels of catch. However, as the total amount of catch increases, the increase in average unit costs decreases, because the fixed cost of the license is spread over greater amounts of catch.

Tables 1 and 2 illustrate this point. They list the costs of two hypothetical fisheries, one with no fee, the other requiring a license. The variable costs for both fisheries are $5 per unit of catch. The fixed costs for the unregulated fishery are $10. In the licensed fishery, the fixed costs are increased to $20 through the addition of a $10 license fee. The effect on the average unit cost differs dramatically according to the total amount of catch. When the total catch is just one unit, the $10 license fee results in a $10 increase in the average unit cost. When the total catch is 10 units, the increase in the average unit cost is only $1. By the time the total catch reaches 100 units, the effect of the license fee on the average unit cost is negligible.

Units of Catch	Fixed Costs	Variable Costs	Total Costs	Avg. Unit Cost
1	10	5	15	15.0
10	10	50	60	6.0
100	10	500	510	5.1

Table 1 - Costs in an Open Access Fishery

Units of Catch	Fixed Costs	Variable Costs	Total Costs	Avg. Unit Cost	Change
1	20	5	25	25.0	10.0
10	20	50	70	7.0	1.0
100	20	500	520	5.2	0.1

Table 2 - Costs in a Fishery with License Fees

On the other hand, increasing the variable costs of a fishery creates a completely different result. Managers often increase variable costs by enacting regulations that create specific gear restrictions. Gear restrictions are designed to decrease fishing efficiency through such means as prohibiting specific methods of fishing, increasing the mesh size of nets, limiting the number of hooks per line, etc. By decreasing efficiency, gear restrictions increase the amount of effort (cost) required to produce each unit of catch. The result is unit costs are increased by the same amount, regardless of the amount of catch.

Table 3 illustrates this point. It lists the costs of a hypothetical fishery in which variable costs are increased through a gear restriction regulation. In this case, the fixed costs remain $10, but the gear restriction raises the variable costs from $5 to $10 per unit catch. Compared to the unregulated fishery, the gear restriction results in a $5 increase in the average unit cost, regardless of the amount of catch.

Units of Catch	Fixed Costs	Variable Costs	Total Costs	Avg. Unit Cost	Change
1	10	10	20	20.0	5.0
10	10	100	110	11.0	5.0
100	10	1000	1010	10.1	5.0

Table 3 - Costs in a Fishery with Gear Restrictions

Cost increases change LRAC curves

Figure 8 shows how increases in fixed and variable costs affect a fishery's LRAC curve. $LRAC_{UN}$ represents the long-run average cost curve of an unregulated fishery. $LRAC_{FX}$ shows the effect of increasing fixed costs by adding a license fee. Note that the increase in the average unit cost is largest when the amount of catch is relatively small, however, as the amount of catch increases, the increase in the average unit cost approaches zero. $LRAC_{VR}$ shows the effect of increasing variable costs through gear restrictions or similar regulations. In this case, the average unit cost is increased by a uniform amount, regardless of the amount of catch.

Figure 9 illustrates the effect of increasing variable costs on a hypothetical fleet composed of various numbers of three types of vessels: types *a*, *b*, and *c*. When variable costs are increased, $LRAC_{UN}$ is raised to $LRAC_{VR}$, subjecting all vessels to the same increase in average unit costs. In this case, the SRAC and MC curves are increased by the same amount for all vessels. All vessels will produce catch until their marginal costs equal the ex-vessel price, P. Profits will be reduced because of the increase in costs, but all vessels will remain profitable because the ex-vessel price is greater than their average costs. There will be no consolidation, because all vessels will continue to produce essentially the same amounts of catch. In this example, assuming no change in the ex-vessel price, increasing variable costs does not change the economies of scale, so the composition of the fleet should not change.

Figure 10 illustrates the effect of increasing fixed costs. When fixed costs are increased, $LRAC_{UN}$ moves to $LRAC_{FX}$. In this case, type *a* vessels become unprofitable, because the increase in LRAC makes it impossible for them to produce catch at an average unit cost that is below the ex-vessel price, P. Type *b* and *c* vessels, however, experience little change and continue to produce the same amounts of catch. If the total demand does not change, more type *b* and *c* vessels will enter the fishery to replace the unprofitable, type *a* vessels. In this case, increasing fixed costs has changed the fishery's LRAC such that a greater number of type *a* vessels are replaced by a fewer number of type *b* and *c* vessels, resulting in consolidation of the fleet. This demonstrates that those management programs that increase fixed costs will encourage more consolidation relative to those programs that increase variable costs.

TACs change LRAC curves

Another common method of protecting stocks is to place an upper limit on the total amount of fish allowed to be harvested. This is done by establishing a total quota or total allowable catch (TAC) for the fishery (Arnason, 1993a). Under a TAC program, once the TAC is reached, the season is closed and further harvest is prohibited. This encourages fishers to increase their fishing capacity in order to be able to catch more fish in shorter amounts of time (Muse and Schelle, 1989).

As technology and fishing pressure increases, TACs are reached in shorter and shorter amounts time. In extreme cases, openings can be as little as one or two days per year (Casey et. al., 1995). Fisheries with such extremely short openings are frequently referred to as derbies because of the frantic pace of operations and the fact that fishers are often lined up on the fishing grounds prior to the start of the openings (Gauvin et. al., 1994). Examples of derby fisheries include the Alaska halibut fishery prior to 1995 (NPFMC, 1991), the British Columbia halibut fishery prior to 1991 (Casey et. al., 1995), and the Atlantic wreckfish fishery prior to 1992 (Gauvin et. al., 1994).

Like all management programs, TAC regulations affect a fishery's LRAC curve. By forcing fishers to compete with one another for shares of a fixed catch, TACs encourage fishers to invest in greater amounts of fishing capacity in order to catch as much fish as possible before the TAC is reached and the season closes. This increased investment raises fixed costs. TACs also provide incentives for fishers to operate in less than ideal conditions such as fishing during inclement weather, having to fish under time constraints that force them to leave fouled gear rather than retrieve it, having to fish in less productive areas rather than take time to transit to more productive areas, etc. Operating in such less than ideal conditions increases variable costs. Increasing both the fixed and variable costs of fishing changes the LRAC curves as previously discussed.

In addition to increasing costs, TAC regulations can have another effect on a fishery's LRAC curve. Derby fisheries provide an interesting example of this. In derby fisheries, the amount of catch individual vessels can make is limited by the extremely short amount of time they are allowed to fish. When openings are severely restricted, vessels are limited to the amount of catch they can make in a few days or weeks. This can make it impractical for very large vessels to participate because, given such short periods of time, it would be impossible for very large vessels to catch enough fish to defray their large fixed costs.

Figure 11 demonstrates this effect. The LRAC curve for a hypothetical, unregulated fishery is represented by $LRAC_{UN}$. Initially, the stock is sufficient to support a fleet of various numbers of type *a*, *b*, and *c* vessels. As fishing technology improves, fishing pressure increases, the stock is jeopardized, and a TAC is established. Further increases in technology result in the TAC being reached in shorter and shorter amounts of time. Eventually, the fleet becomes capable harvesting the entire TAC in just a few days. Ignoring the increases in the fixed and variable costs, the time constraint established by the TAC causes $LRAC_{UN}$ to shift $LRAC_{TAC}$.

The shift in the LRAC curve makes type *c* vessels economically inefficient. Because of the time constraints created by the short opening, type *c* vessels cannot achieve average unit costs lower than C_c. At a market price of P_m, type *c* vessels are incapable of generating a profit. TAC management has created a diseconomy which forces fishers to use less efficient, lower capacity type *a* and *b* vessels. The lower catch capacity of these vessels means that more of them will be required to supply the market and the fleet will end up being comprised of an increased number of smaller vessels.

SECTION III

The effects of ITQs on LRAC curves

Like any other management program, ITQs have a direct impact on the shape of a fishery's LRAC curve. As has been previously demonstrated, those management programs that create or enhance economies of scale will promote fleet consolidation, while those that create diseconomies will result in fleets with greater numbers of lower capacity vessels. Therefore, in order to assess whether or not an ITQ program will result in consolidation, one thing that must be determined is whether or not ITQ programs create or enhance economies of scale.

The defining aspect of ITQ programs is the granting of exclusive, transferable harvest rights to a distinct number of participants (Hannesson, 1996). By granting exclusive harvest rights (quota), ITQ programs allow individual fishers to concentrate on minimizing costs and maximizing the value of their quota, as opposed to competing with fellow fishers to catch as much of the TAC as fast as possible (Arnason, 1993a). In addition, by making quotas transferable, ITQ programs allow fishers to buy or sell their quota based on the price being offered and their expectations of the amount of revenue they will derive from fishing (Squires et. al., 1995).

Once an ITQ program is established, anyone desiring to enter the fishery or increase their catch must purchase or lease quota from another quota holder. The purchase or lease of quota represents an increase in the fixed costs of fishing. It is important to note ITQ programs increase fixed costs, not variable costs. This is because, although the total cost of quota does change with the *amount* catch (obtaining greater amounts of quota requires greater costs), the increase is fixed in that the cost of quota does not vary with the *rate* of catch.

For example, two fishers desiring to catch similar amounts of fish will have to pay similar amounts for their quota. This is a one-time, fixed expenditure that must be paid prior to commencing operations. Even though they have purchased the same amount of quota, they may employ different styles and patterns of fishing that result in completely different variable costs and rates of catch. They may also produce completely different total catches unless, of course, they both catch their entire quotas. The cost of the quota is not a variable. Rather, it is a fixed cost that must be paid for the opportunity to harvest a specific amount of fish. Although it costs more for the opportunity to catch more fish, the price of quota does not vary with either the rate of application of input or the rate of production of output. The price of quota, therefore, is a fixed cost.

Analysis of current ITQ programs shows the purchase of quota can represent a substantial increase in fixed costs. In the Australia bluefin tuna fishery, where the ex-vessel price of fish is about $600 per tonne, quota has sold for up to $2,200 per tonne (Townsend, 1992). In the Alaska halibut fishery, analysis of ITQ transfer information shows an average quota cost of $7.31 per pound (Muse et. al., 1996a), while the average ex-vessel price in 1993 was just $1.25 per pound (Casey et. al., 1995). These costs represent the equivalent of between three and six years worth of catch. In the U.S. surf clam fishery, leasing quota has been reported to cost as much as 50% of the landed value of the catch (Townsend, 1992). In Iceland, quota leases in five of the most valuable fisheries ranged from 18% to 70% of the landed value (Eythórsson, 1996). As these values indicate, implementation of ITQ programs can result in substantial increases in fixed costs for fishers desiring to enter the fishery or increase the size of their operations.

New entrants into the fishery are not the only ones to experience an increase in fixed costs when ITQ programs are implemented. Fishers who receive quota and continue to fish experience an increase in their opportunity costs. Opportunity cost is the value of something given up in order to pursue an alternative opportunity (Schiller, 1994). By deciding to fish, fishers forgo the opportunity to earn a living elsewhere in the economy. Prior to an ITQ system, the total opportunity cost to fishers who chose to fish was the cost of what they could have earned doing something else, plus the cost of what they could have earned by employing their capital elsewhere. Once a fisher has been granted quota, however, in order to continue fishing, he must forgo the same opportunity to work and employ his capital elsewhere, plus the additional opportunity to sell his quota and employ that capital elsewhere. As was previously shown, foregoing the sale of quota can represent a substantial increase in opportunity costs to those fishers who receive quota and choose to remain in the fishery. Opportunity costs are fixed costs because they do not vary with the rate of output.

ITQ programs increase fixed costs of both future entrants and existing participants by requiring new entrants to purchase quota and increasing the opportunity costs of fishers who receive quota. As previously discussed, increasing a fishery's fixed costs increases its economies of scale and promotes consolidation of the fleet. Therefore, all other things being equal, implementing an ITQ program on a fishery should result in a consolidation of its fishing fleet. Figure 12 illustrates this point.

In figure 12, an ITQ program is imposed on a hypothetical fishery with an LRAC curve of $LRAC_{UN}$ and a fleet consisting of various numbers of type *a* and *b* vessels. Implementing an ITQ program shifts $LRAC_{UN}$ to $LRAC_{IQ}$, reflecting an increase in fixed costs. Because increasing fixed costs raises average unit costs for lower capacity vessels more than it does for higher capacity vessels, type *a* vessels experience a substantial increase in their SRAC and MC curves. Type *b* vessels, on the other hand, are essentially unaffected. This has the effect of accentuating the economies of scale already present in the fishery, making type *b* vessels more profitable relative to type *a* vessels.

As successful fishers try to expand their operations and other fishers try to gain entry, they must purchase quota from existing owners. Owners of the higher capacity, more profitable type *b* vessels will have less incentive to sell their quota than owners of the lower capacity, less profitable type *a* vessels. More owners of type *a* vessels will leave the fishery than owners of type *b* vessels. In addition, new entrants with sufficient capital will be encouraged to buy more quota and operate higher capacity, type *b* vessels. By increasing the fishery's fixed costs, the ITQ program has accentuated the economy of scale, creating incentive for the fleet should consolidate into fewer vessels with a higher average capacities per vessel.

The effects of ITQs on TAC managed fisheries

As noted in the introduction, individual quota programs are a relatively new method of managing commercial fisheries. The earliest ITQ programs were not implemented until the 1970s. Since then, over 35 individual quota programs have been created throughout Australia, Canada, Iceland, New Zealand, and the United States (Muse, 1991). In almost every instance, individual quota programs were initiated only after some combination of TAC and limited entry programs had failed to produce an economically stable fishery (Muse, 1991; Muse and Schelle, 1989). Since ITQ programs are almost always enacted on fisheries in which TACs have been in place for some years, it is necessary to understand how adopting an ITQ program changes the economics of a fishery that has been under TAC management.

It was previously shown that TAC management can lead to shortened fishing seasons as fishers invest increasing amounts of capital in the fishery to catch larger portions of the TAC in shorter and shorter periods of time. These shortened seasons alter the LRAC curve of the fishery. In extreme situations, such as derby fisheries, TAC regulations can create diseconomies that make the use of high cost, higher capacity vessels uneconomical. This was shown in figure 11. As a result, fishing fleets under TAC management can be made up of a greater number of smaller capacity vessels than would otherwise exist. Since ITQ programs remove the constraints imposed by shortened seasons, they can also remove some of the diseconomies that prevent higher capacity vessels from operating. Figure 13 illustrates this point.

In figure 13, $LRAC_{TAC}$ represents the long-run average costs of a fishery in which TAC management has resulted derby style fishing. Because of the derby conditions, the fleet is composed of a large number of lower capacity, type *a* vessels. Implementation of an ITQ program does two things: it increases fixed costs and it removes the constraints created by the short openings. As a result, $LRAC_{TAC}$ shifts to $LRAC_{IQ}$, the SRAC and MC curves for type *a* vessels increase, and time constraint that effectively prevented the operation of type *b* vessels is removed. Since type *b* vessels have lower average unit costs, fishers will have an incentive to switch to higher capacity, type *b* vessels. Implementing an ITQ program in this fishery has created an economy of size that will result in consolidation of the fleet.

ITQ programs, therefore, are capable of promoting fleet consolidation through three different processes. First, ITQ programs increase fixed costs to new entrants by requiring them to purchase quota in order to be able to participate in the fishery. The increase in fixed costs affects lower capacity vessels more than higher capacity vessels, making higher capacity vessels relatively more profitable. Second, ITQ programs increase the opportunity costs of fishers who are granted quota and choose to remain in the fishery. Since these opportunity costs are fixed costs, owners of lower capacity vessels experience a greater increase and are therefore more likely to leave the fishery. Finally, in fisheries where TAC management has produced extremely short openings, ITQ programs can remove diseconomies that were created by the short openings, making it possible for higher capacity vessels to enter the fishery.

All ITQ programs are not the same

So far, this discussion of ITQ programs has dealt with hypothetical programs in which quota shares can be traded freely and there are no limitations on the amount of quota that may be owned. Such programs increase fixed costs and can eliminate the diseconomies created by short openings, eventually resulting in consolidation of the fleet. This has been recognized by many fisheries experts including Arnason (1993a) who states, "if catch quotas are transferable…they will tend to revert to the most efficient fishing firms." The result of increased fishing efficiency is fewer fishing vessels and fewer fishers (Hannesson, 1996). Grafton (1996) confirms these observations stating, in most Canadian fisheries, "the number of vessels employed in the fisheries declined with the introduction of ITQs."

The concern that ITQs may lead to undesirable amounts of quota aggregation and fleet consolidation can be seen by the fact that many ITQ programs have been structured to limit the amount of quota that can be owned by any one individual or firm. The Alaska halibut IFQ program establishes eight separate regions, each with its own TAC. Quota ownership is generally limited to no more 1% of the TAC in any given area (Muse et. al., 1996a). The Alaska sablefish IFQ program establishes six regions and limits quota ownership to no more than 1% of the total TAC for all six areas, with exceptions being made only if the excess quota was received during the initial allocation (Muse et. al., 1996b). In New Zealand, quota ownership is limited to 20% of the TAC for inshore fisheries and 35% of the TAC for offshore fisheries (Grafton, 1996).

Restricting ownership of quota, however, can affect a fishery's LRAC in a manner similar to short openings. Short openings limit a vessel's amount of catch by restricting fishing time. This creates diseconomies that prevent higher capacity vessels from operating economically by not allowing them to distribute their higher fixed costs over sufficient amounts of catch. By placing a maximum limit on the amount of quota any one firm can own, certain ITQ programs can do the exact same thing: limit the amount of catch to a degree such that larger vessels are rendered uneconomical.

For instance, vessels that require large amounts of halibut in order to operate profitably will be effectively excluded from the Alaskan halibut fishery if they cannot generate a profit on amounts of catch less than 1% of the TAC. This can be seen in figure 11 by simply substituting "maximum catch permissible by ITQ regulation" for "maximum catch possible during opening." In both cases, the fishing fleets will consist of higher numbers of vessels with lower average amounts of catch. Under certain circumstances, a change such as this can have an even more dramatic effect on a fishery's fleet. This is illustrated in figure 14.

In figure 14, an ITQ program is implemented on a fishery with an LRAC of $LRAC_{UN}$. As a result, the LRAC changes to $LRAC_{IQ}$ and type *b* vessels become unprofitable because they cannot obtain enough quota to allow them to operate economically. The market will be supplied by a higher number of type *a* vessels. However, should the market price drop from P_1 to P_2 because of the introduction of fish from another source, such as net-pen aquaculture, the entire fleet will be forced out of business: type *a* vessels cannot produce fish at low enough average costs, and ITQ regulations do not allow the operation of larger, more cost competitive type b vessels. In this situation, by trying to limit fleet consolidation, the ITQ program has created an economic situation in which aquaculture has displaced the entire fleet.

Another means of restricting the concentration of quota is to place limits on quota transferability. Several ITQ programs have adopted such restrictions. In Iceland, all fisheries are managed by individual vessel quotas. In addition, all commercial fishing vessels must hold valid licenses, and licenses are issued only to those vessels that were in the fishery as of 1990 or their replacements (Arnason, 1993b). Although quota shares are transferable and completely divisible, the license restriction limits the potential buyers to those few firms with access to a licensed vessel (Arnason, 1996). The limits on transferability, therefore, restrict the number of potential quota owners to only those with access to a previously licensed vessel.

The Alaska halibut and sablefish ITQ programs also place restrictions on the use and transferability of quota. The Alaska halibut ITQ program has over 30 different categories of quota based on different geographic areas and different vessel types. Under most circumstances, quota shares from one category cannot be used in, or transferred between, different categories (Muse et. al., 1996a). The Alaska sablefish ITQ program has 18 different categories of quota share which, under most circumstances, can only be used within their own category (Muse et. al., 1996b). By dividing the TAC into different categories, the Alaska halibut and sablefish ITQ programs limit the potential buyers of quota to those firms that operate similar types of vessels in the same geographic area. This places significant limits on quota transferability.

ITQ programs that place limits on quota transferability reduce the pool of potential buyers from all those interested to only those who qualify. Reducing the pool of potential buyers reduces the value of the quota, thereby limiting the ability of owners to make decisions most economically advantageous to them (Arnason, 1996). This reduction in value means the increase in fixed costs will also be less. By reducing the increase in fixed costs, ITQ programs that restrict transferability should result in less consolidation than ITQ programs with no restrictions.

SECTION IV

Fleet consolidation: it's all relative

The previous section showed implementing ITQ management programs can result in consolidation of fishing fleets through any combination of increasing fixed costs, increasing opportunity costs, and removing diseconomies caused by extremely short openings. The previous section also described how placing restrictions on quota ownership and transferability can limit consolidation and, under certain circumstances, eliminate consolidation altogether. A review of ITQ programs in place worldwide, however, shows consolidation is the general rule. Almost every major fishery placed under ITQ management has seen some concentration in either the number of quota holders, the number of vessels participating in the fishery, or both (NMFS Alaska Region, 1997; Squires et. al., 1995). New Zealand's ITQ program and the Victoria, Australia abalone fishery are two notable exceptions. New Zealand fisheries initially experienced significant quota share consolidation when the system was implemented in 1987, but, by 1994, they had returned to pre-ITQ conditions (Annala, 1996). However, the number of fisheries under ITQ management increased significantly between 1987 and 1994. Therefore, quota shares may have undergone consolidation within specific fisheries, while the addition of other fisheries resulted in the ITQ program, as a whole, showing little signs of consolidation.

The elimination of excess fishing capacity through consolidation of fishing fleets can be viewed as either a major benefit or serious flaw of ITQ programs. In situations where consolidation is perceived as a detriment, some ITQ programs seek to limit consolidation by establishing restrictions on quota ownership and transferability. Examples include previously discussed ITQ programs in Alaska, Iceland, and New Zealand. In other situations, ITQ programs were designed with the specific intent of removing excess fishing capacity. Examples of ITQ programs in which reduction of excess capacity was the primary objective include the U.S. surf clam and ocean quahog fishery, the U.S. wreckfish fishery, and the Australian bluefin tuna fishery (McCay et. al., 1996; Gauvin et. al., 1994; Wesney, 1989).

When analyzing the consolidation that has occurred under different ITQ programs, it is important to distinguish those ITQ programs in which removal of excess capacity was a primary objective from those programs in which it was either a secondary objective or an unintended consequence. This distinction is necessary because statistics on fleet consolidation under programs specifically intended to remove excess capacity are often used as empirical evidence to challenge the use of ITQ programs in general. Many of those opposed to implementing ITQ systems on the basis of job loss and excessive fleet consolidation do just that: they cite the degree of consolidation that has occurred under programs designed to reduce fishing capacity as proof that all ITQ programs inherently result in fleet reductions in excess of 50 percent.

Comparing ITQ programs is difficult because each program and each fishery is unique. Every program has different objectives and regulates fisheries that have different economic conditions and different management histories. Predicting the degree of consolidation of a specific fishery based solely on results that occurred in a completely different fishery is, at best, imprecise and, at worst, intentionally misleading. Rather than offering past results as evidence of future effects, what is really needed is a framework in which to compare different ITQ programs and their relative effects on fishing fleets.

A framework for comparing ITQ programs

An adequate framework for comparing relative amounts of fleet consolidation under different ITQ programs should consider the following: the degree of overcapitalization and characteristics of the stock, the degree to which the program limits quota ownership and transferability, how the previous regulations have shaped the LRAC curve, the nature of the harvest rights, the value of the fishery, the degree of mechanization in the fishery, and whether the fishery is a single or mixed species fishery. Each of these factors will affect the amount consolidation that can occur. Understanding how these factors effect consolidation is an important part of understanding the impact of implementing ITQ programs.

The degree of overcapitalization and characteristics of the stock

Perhaps the most important aspect of a fishing fleet's potential for consolidation under an ITQ program is the amount of overcapitalization in the fleet and the characteristics of the stock prior to adopting the ITQ program. In a unregulated fisheries, these two factors are invariably connected: since overcapitalization inherently produces a race for fish that results in stock declines and, conversely, even stock declines that occur for reasons unrelated to fishing pressure will result in an overcapitalized fleet.

In an unregulated fishery, vessels will enter a fishery as long as they can obtain revenues greater than their costs. Individually, vessels will fish until the revenue gained from the last unit of catch equals the cost of producing the last unit of catch (the point where marginal revenue equals marginal cost). As long as each vessel produces higher than normal profits, vessels will continue to enter the fishery, and the total amount of fishing will increase. This increase will eventually result in greater amounts of effort producing lower marginal revenues and smaller catches. Individual vessels will react by reducing their catches to the point where their marginal costs equal the new, lower marginal revenues. The result is a larger number of vessels producing smaller catches individually, but doing more fishing in total (Anderson, 1986). With more vessels producing less catch than they are capable of producing, the fleet is overcapitalized.

Figure 15 shows the effect of implementing an ITQ program on a hypothetical fleet of various numbers of type *a*, *b*, and *c* vessels. As discussed previously, notice that the effect of raising fixed costs by implementing the ITQ program has a much greater effect on type *a* vessels than type *b* and *c* vessels. In this situation, implementing the ITQ program has raised the LRAC curve such that type *a* vessels are no longer profitable and must leave the fishery. Since a fleet that is more overcapitalized will contain a larger number of smaller capacity vessels than a fleet that is less overcapitalized, a more overcapitalized fishery will consist of more type *a* vessels. Therefore, the more a fishery is overcapitalized, the greater the amount of consolidation that will occur when an ITQ program is implemented.

The characteristics of the stock can play an integral role in the amount of overcapitalization in a fleet. As previously discussed, open access fisheries inherently increase fishing pressure. The increased pressure can result in stock declines that amplify overcapitalization, since stock declines often occur at paces that exceed the rate at which vessels leave the fishery. This means fisheries that have undergone rapid stock declines are much more ripe for consolidation than fisheries which have relatively stable stocks. As a result, ITQ programs implemented on fisheries with declining stocks should result in more consolidation than programs implemented on fisheries with stable stocks. This is logical, since fisheries experiencing rapid stock declines are likely to undergo consolidation regardless of whether or not an ITQ program is implemented.

Examples of fisheries that were severely overcapitalized and experiencing rapid stock declines prior to implementation of ITQ programs include the U.S. surf clam and ocean quahog fishery, the U.S. wreckfish fishery, and the Australia bluefin tuna fishery. In the surf clam fishery, during the three years preceding the implementation of an ITQ program, the TAC fell from approximately 3.39 million bushels to 2.85 million bushels (NMFS Northeast Region, 1997). At the time the ITQ program was implemented, surf clam vessels were only permitted to fish six hours every two weeks (Wang, 1995). Given this situation, it is clear overcapitalization and stock decline played a significant role in the 73% reduction in the number of vessels that occurred when the ITQ program was implemented.

In 1991, the year prior to implementation of the U. S. wreckfish ITQ program, there were approximately 90 permits and 38 active vessels in the fishery. Economic analysis conducted in 1990 suggested the fishery could support only 20 vessels. Given this, overcapitalization clearly played an important role in the consolidation that took place when the ITQ program was implemented in 1991. Further, the catch per unit of effort (measured in catch per vessel per day) fell from 934 fish in 1991 to 543 in 1996 (NMFS

Southeast Region, 1997), even though the TAC remained constant at two million pounds. This indicates stock abundance may have been declining significantly. If this was the case, then the stock decline may also have contributed to consolidation of the fleet.

Declining stocks clearly contributed to consolidation that took place when an ITQ program was implemented in the Australia bluefin tuna fishery in 1984. In the five years prior to ITQ implementation, Australian bluefin tuna catches doubled, reaching almost 21,000 tons. This happened despite a 1983 warning by biologists from the southern bluefin tuna fishing nations that total catches should be urgently reduced. The year the ITQ program was implemented, Australia reduced its TAC from 21,000 tons to 14,500 tons. In 1985, Australia reached an agreement with Japan to further reduce its TAC to 11,500 tons in exchange for monetary compensation (Geen and Nayar, 1988). This amounted to a 45% reduction in the TAC that, in all likelihood, would have occurred regardless of whether or not the ITQ program was implemented. Clearly, TAC reductions played a significant role in the consolidation that occurred under the ITQ program.

Quota ownership and transferability restrictions

Restrictions on quota ownership and transferability are another important aspect to consider when evaluating potential for fleet consolidation under an ITQ system. As previously discussed, restrictions on ownership and transferability can lessen potential consolidation through two mechanisms: by reducing the value of quota and by creating diseconomies through placing limits on quota ownership. Ownership can be restricted in numerous ways including placing caps on the amount of quota that can be owned by any one individual or firm, limiting ownership to previous participants in the fishery, restricting foreign citizens from owning quota, requiring quota owners to be onboard vessels that are fishing the quota, and assigning quota only to licensed vessels.

Capping quota ownership, however, does not guarantee the fleet will be immune from consolidation. Even programs that create no change in the number of quota owners can result in significant consolidation. By pooling quota shares and using a single vessel to fish, quota owners can reduce the number of vessels in the fleet. This is seen as a particularly significant problem in situations where large amounts of quota are owned by individuals or firms that are not located within the fishing community. Such "absentee" owners are perceived as being more likely to aggregate quota, resulting in more consolidation.

Some ITQ programs have sought to limit the pooling of quota by requiring owners to be present when fishing their quota, or by assigning quota to individual vessels. The Alaska halibut ITQ program attempts to limit consolidation by placing a cap on quota ownership and by requiring, in most circumstances, quota owners to be onboard when fishing. Even under these rules, however, it is possible for several owners to use the same vessel. In the Alaska halibut ITQ program, the ratio of the number of persons registered as making landings to the number of vessels making landings increased from 1.01 to 1.26 in the first year of the program. This corresponds to the 26% decrease in the size of the fleet. It is important to note, however, one of the stated purposes of the Alaska halibut IFQ program was to provide "constrained" opportunities for consolidation (Muse et. al., 1996a).

Under the Icelandic demersal fishery ITQ program, quotas are issued only to vessels (or their replacements) that participated in the fishery prior to the implementation of the quota program. This has essentially barred larger capacity vessels from entering the fishery. The result has been "relatively small reductions in the capital and labor used in the fishery" (Muse and Schelle, 1989).

Although many factors affect consolidation, it is useful to compare the results of restricted programs, such as the Alaska halibut program, to other, less restricted programs. The U.S. surf clam fishery and the U.S. wreckfish fishery are both managed under unrestricted ITQ programs. Both fisheries have undergone drastic consolidation. The number of vessels in the surf clam fishery fell 73%, from 128 in 1990 to 34 in 1996 (NMFS Northeast Region, 1997). The number of vessels in the wreckfish fishery fell 76%, from 38 in 1991 to nine in 1996 (NMFS Southeast Region, 1997). In the Australia bluefin tuna fishery, which is managed under an ITQ program in which the only restriction is a prohibition against foreign ownership (Muse and Schelle, 1989), the number of participating vessels fell 73%, from 136 vessels in 1984 to 37 vessels in 1987 (Wesney, 1989; Geen and Nayar, 1988).

When compared to the 26% reduction in vessel numbers that took place under the Alaska halibut program, the drastic amount of consolidation observed under the unrestricted programs supports the contention that restrictions on quota ownership and transferability can help limit consolidation. It must be noted, however, all three of the fisheries addressed above were severely overcapitalized and facing dramatic stock declines. Because of the characteristics of the fisheries, the removal of excess capital was the primary objective of those ITQ programs.

Finally, restrictions on quota transferability can limit consolidation in much the same manner as restricting ownership. As previously discussed, restricting transferability reduces the value of quota by reducing the number of potential buyers. This reduces the increase in fixed and opportunity costs, thereby reducing potential consolidation. Examples of programs that restrict transferability include the Alaska halibut and sablefish fisheries, which restrict transfers of quota between different vessel classes and different geographic regions (Muse et. al., 1996a), and the Icelandic groundfish fishery, which places some restrictions on the transfer of quota between geographic regions (Arnason, 1996).

Regulations in effect prior to the ITQ program

It is also important to consider the regulations in effect at the time ITQ programs are adopted. This is because the various regulations (gear restrictions, vessel size limitations, license limitations, etc.) in effect prior to ITQ management are invariably kept in place as part of the ITQ program. A good example of this is the Alaska halibut fishery. Prior to implementation of the ITQ program, the Alaska halibut fishery had evolved over time into a fixed gear fishery (Muse et. al., 1996a). Limiting the fishery to fixed gear eliminated the potential economies of scale that might have been possible had fishers been allowed to employ alternative fishing methods. An ITQ program that removed this gear restriction and allowed quota owners to use other fishing methods might have radically changed the LRAC curve. For instance, the introduction of trawlers might have produced economies of scale that were not possible to achieve with fixed gear. By keeping various gear, size, and license restrictions in place, ITQ programs limit potential consolidation by restricting potential economies of scale to only those achievable under the accompanying regulations. Therefore, it is important to realize the potential for consolidation under ITQ programs can be affected by the regulations in place at the time the program is implemented.

Nature of harvest rights

The nature of the harvest rights granted under an ITQ program also affects the value of the quota and, therefore, the potential for consolidation. Harvest rights can be granted either as absolute quantities of fish (either numbers or weight) or as proportions of the TAC. Absolute quantities are a more valuable right because they are not subject to uncertainties associated with changing TACs, since fishers are guaranteed the right to harvest a specific amount of fish regardless of the characteristics of the stock (Squires et. al., 1995). Because absolute quantities are a more valuable right, ITQ programs based on absolute quantities should experience greater increases in fixed and opportunity costs, producing more consolidation.

Absolute quantity rights, however, do not allow for managers to adjust TACs according to the characteristics of the stock. As a result, almost all ITQ systems base their harvest rights on proportions of the TAC. New Zealand's ITQ program initially granted harvest rights in absolute quantities but quickly changed when managers found the sum of the quota in some stocks was greater than the biologically-based TAC. A government sponsored buyback scheme was implemented and, once the extra quota was removed, the quota allocation was switched to percentages of the TAC (Annala, 1996).

Because the TAC will often vary from year to year, there is a degree of uncertainty associated with owning proportional quotas. Madden and Partenheimer (1972) found farm enlargement is frequently limited by uncertainty since, as firms become larger, the number of unpredictable situations becomes burdensome. The degree of uncertainty associated with proportional quotas, therefore, should make them less valuable than absolute quotas. As a result, ITQ programs based on less valuable, proportional quotas should result in less consolidation than ITQ programs based on absolute quotas.

Finally, harvest rights may be granted either for limited periods of time or in perpetuity. Obviously, the value of quota allocated for limited periods of time is less that the value of quota allocated in perpetuity. Therefore, potential consolidation should be less for programs that grant harvest rights limited to specific periods of time. An example of a fishery in which harvest rights were granted for a limited period of time includes New Zealand's ITQ program, in which harvest rights were initially granted for a period of ten years (they were later made perpetual) (Clark et. al., 1988). In Wisconsin's Green Bay yellow perch fishery, uncertainty as to the continuation of the program is said to have constrained quota transfers and may have reduced quota value (Muse and Schelle, 1989). It must be noted, however, a common feature of ITQ programs that grant perpetual rights are clauses permitting the revocation harvest rights for violation of fisheries regulations and for stock conservation, making even absolute quotas subject to some degree of uncertainty.

Value of the fishery

Potential consolidation of fishing fleets also depends on the overall value of the fishery. For consolidation to take place, economies of scale must be present. In order for economies of scale to be present, there must be sufficient value in the fishery over which to distribute the fixed costs associated with the operation of larger vessels. This was observed in the agricultural industry by Albrecht (1992), who noted geographic regions that were highly productive were more conducive to farm concentration than regions that were less productive. All else being equal, higher productivity translates to more revenue, and farmland with higher productivity was more apt to have fewer, larger farms.

Applying this to fisheries, it follows that the more valuable the fishery, the more potential for fleet consolidation. Large vessels require enormous amounts of resource abundance in order to be profitable (Squires, 1988). In order to operate larger vessels under an ITQ program, the fishery must have enough value, either through abundance of fish or high ex-vessel prices, to be able to fund increases in both variable costs (i.e. labor, maintenance, fuel, etc.) and fixed costs (i.e. additional quota, additional gear, larger vessels, etc.). Because more revenue is available in high value fisheries, there is more opportunity for efficient fishers to fund expansion of their operations and, therefore, a greater potential for consolidation.

Observation of fisheries throughout the world reveals the largest fishing vessels are present only in extremely high value fisheries like the Pacific pollock fishery. The ex-vessel value of the Pacific pollock fishery was roughly $260 million in 1995 (U.S. Bureau of the Census, 1997). A single vessel the size of the largest vessels in the pollock fishery would certainly be capable of harvesting the entire TAC of a lower value fishery such as the wreckfish fishery. However, with an approximate ex-vessel value of only $833,000 in 1996 (NMFS Southeast Region, 1997), the wreckfish fishery is not productive enough to support the use of such a large vessel. As a result, the fishery is currently prosecuted by nine vessels, not one.

Examples of low value fisheries that have undergone relatively little consolidation include four fisheries on the inland waters of North America. In 1983, the provincial government of Ontario, Canada created an ITQ program for all its fisheries on Lake Erie and Lake Ontario. The only limit on quota ownership and transferability was a prohibition against transfers of quota between relatively large geographic "quota areas." In the two years under the ITQ program, the number of license holders fell only 10%, from 931 in 1984 to 836 in 1987. Additionally, the number of vessels actually increased, from 1021 in 1983 to 1023 in 1985, and the number of large vessels (over 40 feet) fell from 500 in 1984 to 275 in 1985 (Muse and Schelle, 1989).

On Lake Winnipegosis in Manitoba, Canada, the commercial pickerel fishery was placed under an ITQ system in 1990. When the ITQ program went into effect, the entire TAC was only 580,000 pounds. It was divided into units and allocated to 29 license holders, with a restriction that no single license holder could accumulate more than eight quota units. As of July, 1991 not one fisher had left the fishery (Muse, 1991).

In Wisconsin, the Lake Michigan chub fishery was placed under ITQ management in 1983. The TAC, which can vary between roughly 1.8 and 2.3 million pounds, is divided (by a rather complicated formula) between the top 32 fishers. Although none of the top 32 fishers can permanently increase their share through the purchase of quota, a provision for quota leasing makes it possible for one license holder to harvest over 50% of the TAC. Despite this possibility, quota consolidation does not appear to be an issue in the fishery (Muse and Schelle, 1989).

When ITQ programs were adopted in these fisheries, all three were under TAC management with relatively stable stocks. However, all of these ITQ programs had relatively few restrictions on quota ownership and transferability. Although the stability of the fisheries prior to the implementation of the ITQ programs may have helped lessen the amount of consolidation, the lack of restrictions on quota ownership and transferability certainly made consolidation possible should it have been economically advantageous. The fact that these low value fisheries underwent such little consolidation supports the contention that lower value fisheries may be subject to less consolidation than higher value fisheries.

Degree of mechanization

The degree of mechanization possible within a fishery will also affect the potential for consolidation. In agriculture, less technologically advanced farming methods result in nearly horizontal LRAC curves in which per unit costs are relatively equal, regardless of the amount of output. This means that in less technologically advanced agricultural industries, larger farms should not have any competitive advantages over smaller farms (Doll and Orazem, 1984). As a result, where the ability to employ mechanization is limited, there should be less consolidation of farms. This correlation was confirmed by Albrecht (1992), who found a positive correlation between lower levels of mechanization and reduced amounts of farm concentration. Extending this to the fishing industry, fleet consolidation should be less in fisheries prosecuted by less mechanized, more labor intensive fishing methods.

Conversely, implementing ITQ programs on fisheries that have the potential for increased mechanization should result in more consolidation than implementing ITQs on less mechanized, more labor dependent fisheries. In the Alaska halibut fishery, the evolution of management regulations resulted in a fixed gear, derby fishery in which openings lasted just 24 hours. Because of the short openings, is was not practical for large, automated longliners to participate because they could not produce enough catch to recover their high fixed costs. Also, regulations prohibited mechanized trawlers from participating in the fishery. If an ITQ program were implemented which lifted the prohibition against trawling and did not place caps on quota ownership, it is likely that the fishery would have seen the entry of larger, more mechanized vessels. This would have resulted in consolidation of the fleet into fewer, more mechanized vessels.

In contrast, the abalone fishery in Victoria, Australia is a highly labor intensive dive fishery prosecuted by single divers operating from small boats. There is no practical means of mechanizing the process of removing abalone one-at-time by hand. Therefore, per unit costs in the abalone fishery should be subject to much less change under an ITQ program than per unit costs in fisheries where increased mechanization (e.g. switching from handlines to trawling, employing larger winches capable of handling larger nets, etc.) could significantly reduce per unit costs. Since economies of scale associated with increased mechanization cannot be realized, consolidation under the Victoria, Australia program should have been limited. In fact, when the ITQ program was implemented in the fishery in 1988, there was no reduction in the number of vessels (Sanders and Beinssen, 1996).

Single stock or multispecies fishery

One final factor that can affect potential consolidation under an ITQ program is whether the fishery is a single stock or multispecies fishery. The New England groundfish fishery is a mixed stock fishery in which a diverse number of species are primarily harvested by bottom trawling. The New England fishing industry has generally remained an individually owned, single vessel fishery, despite the curtailing of foreign fleets that occurred with the adoption of the 200 mile EEZ in the mid 1970s. Rather than expanding into large scale operations like the previous foreign fleets, the New England fleet has retained its limited scope of operation (Squires, 1988).

One reason for this may involve the difference in marginal costs and marginal revenues between single stock fisheries and multispecies fisheries. Economies of scale present in single stock fisheries may not be present in multispecies fisheries due to variations in species composition. The individual species in a multispecies fishery will all have different marginal revenues because of their different ex-vessel prices. The different species will also have different marginal costs because the makeup of species assemblages will vary with both the geographic area and the time of year. These variations impose upper and lower limits on the economies of scale for coastal multispecies fisheries (Squires, 1988). The fact that the multispecies New England fishing industry did not consolidate into large-scale trawler fleets when the foreign vessels were forced out is an indication coastal multispecies fisheries have different economies of scale than distant water fleets. While this lack of consolidation occurred under open access management, there are multispecies fisheries in New Zealand that have showed relatively little consolidation under ITQ programs.

New Zealand's ITQ program was implemented over a period of four years, beginning with individual company transferable quotas for deepwater trawl fisheries in 1983. As of 1987, the program covered 32 inshore and deepwater species (Clark et. al., 1988). There were relatively few restrictions on ownership and transferability, the main restriction being ownership caps of 20% of the quota for any one species in any single management area and a 35% cap on the total catch for any one species throughout all management areas (Muse and Schelle, 1989).

Most species in New Zealand are caught as part of multispecies trawl fisheries. Under New Zealand's ITQ program, fishers experienced bycatch problems because TACs did not account for natural variations in stock size (Annala, 1996). Stock size variations result in species composition changes that can make it difficult for fishers to match their catches to their quota holdings. Under the New Zealand ITQ program, fishers sometimes exceeded their bycatch quotas prior to meeting their target species quotas. Although quotas are freely tradable, fishers had difficulty in purchasing sufficient quota to cover their bycatches (Geen, 1987). Since the single stock quota can be fished to its limit without worrying about bycatch limits, all else being equal, the value of quota in a multispecies fishery should be less than the value of quota in a single stock fishery. The reduced quota value should result in less consolidation in multispecies fisheries.

In fact, there appears to have been little consolidation under New Zealand's ITQ program. During the first year of the program, the number of quota holders dropped only 2.5%, from 1,800 to 1,755 individuals or firms (Muse and Schelle, 1989). During that same time, the number of vessels actually increased from 2,331 to 2,600, although there was a decrease in the number of standard, owner-operated vessels and an increase in the number of both larger, company-owned vessels and smaller, part-time vessels. Also, the speculative purchase of squid vessels made to substantiate claims for future squid quotas may have distorted this figure (Clark et. al., 1988). Finally, although the ten largest quota holders increased their share of total quota from 67% in 1987 to 82% in 1989, by 1994 their total holdings had returned to 68%. However, holdings of the top three quota holders rose from 28% to 44% (Dewees, draft).

New Zealand's ITQ program has very few restrictions on quota ownership and transferability. The harvest rights granted under the New Zealand program were made perpetual in 1985. The estimated capitalized value of the fishery is high, estimated to be between NZ$550 million and NZ$765 million based on data from 1986 through 1988 (Linder et. al., 1992), and the majority of the fishing is done by trawling, which means the fishery is highly mechanized. Despite these factors, all of which would tend to increase consolidation, New Zealand's fleet has remained relatively stable, both in terms of the number of vessels and distribution of quota.

The degree of consolidation that has occurred under New Zealand's ITQ program may be open to some debate. There has been an increase in vessel numbers, but there was also an increase in the number of species brought under ITQ management during the period. Also, while the number of large, company-owned vessels and small, part-time vessels increased, the number of standard, owner-operated vessels decreased. If the average catch per vessel of the full-time participants has increased, then a case could be made for consolidation having taken place in that, for the full-time participants, fewer vessels are making greater catches. If the average catch per vessel for full-time participants has decreased, then more vessels are making smaller catches per vessel and there has been no consolidation. If this is the case, and consolidation has not taken place, then the fact that most of New Zealand's catch is produced in a multispecies trawl fishery supports the contention that multispecies fisheries can be subject to less consolidation than single stock fisheries.

A case of non-consolidation

The abalone fishery in the Western Zone of Victoria, Australia provides evidence that, under the right circumstances, ITQ programs can be implemented without an automatic consolidation of the fleet. Abalone in Victoria's Western Zone are fished by individual divers who work with a single deckhand from boats ranging from five to eight meters in length. In 1968, in order to reduce fishing effort, the Victorian government introduced regulations in which license fees were greatly increased and no new entrants were permitted. By 1984, the number of divers had dropped from 30 to 16. In 1984, divers were given the right to sell their licenses, with each new entrant required to buy two licenses, one of which had to be retired. This further reduced the number of divers to 14. In 1988, an ITQ program was implemented permitting both one-for-one sales and the leasing of quota. Based on concerns that the stock may have been overexploited, the ITQ program also reduced the total TAC by 20% as a conservation measure (Sanders and Beinssen, 1996).

Under the ITQ program, the divers realized an economic gain by being allowed to sell their quota on a one-for-one instead of two-for-one basis. They also realized an economic gain from being able to lease their quota. As previously discussed, these gains increased both the fixed costs to new entrants and the opportunity costs of those who were granted quota. This should have promoted consolidation. Under the ITQ program, however, the number of divers did not change (Sanders and Beinssen, 1996).

Many factors played a role in the lack of consolidation of the abalone fleet. The increase in fixed and opportunity costs that resulted from the allocation of quota was offset by a 20% reduction in the amount of quota. Also, the fleet had already lost much of its excess capital, shrinking from 30 vessels to 14 over the previous two decades. TACs had been stable for years, and although there were some concerns about over exploitation, there were no signs of imminent stock depletion. Although shares were fully transferable, they appear to not be divisible, and ownership appears to be tied into possession of a license, which essentially limits divers to one quota. None of the regulations in effect when the ITQ program was implemented were changed, so there were no great changes in the fishery's economies of scale. The value of the fishery, $8 million, is relatively low when compared to large programs such as those in New Zealand, Iceland, and Alaska. Finally, abalone diving is highly labor intensive and not capable of great degrees of mechanization. The fact that no consolidation occurred in the Victoria, Australia abalone fishery clearly demonstrates that consolidation is not inherent to all ITQ programs, but rather, is dependent on the characteristics and the status of the fishery, along with the specific regulations of the ITQ program.

SECTION V

Discussion

Summaries of ten major ITQ programs reviewed for this paper are contained in tables 4 through 13. Each of the previously identified factors is listed. Where appropriate, the degree to which each factor is present within the fishery is rated on a relative scale of low, moderate, or high. The tendency of each individual factor to increase, decrease, or not affect the potential for consolidation is listed as increase, decrease, or neutral.

In these tables, all fisheries are listed as having perpetual harvest rights that are allocated as percentages of the TAC. Where information on the nature of rights was not specifically available, this was assumed to be the case. Since all the programs had the same type of harvest rights, the relative effect was listed as neutral. Had some programs assigned quota for fixed periods, the relative effect would have been to decrease potential consolidation, because the value of time restricted quota is less than that of perpetual quota. Had some programs assigned quota as absolute quantities, the effect would have been to increase potential consolidation, because quota allocated as absolute quantities is more valuable.

The value of fisheries was arbitrarily assigned as low for fisheries of less than $10 million, moderate for fisheries between $10 million and $100 million, and high for fisheries greater than $100 million. Mechanization was judged to be low for dive fisheries; moderate for fixed gear fisheries; and high for trawl, purse seine, and drift net fisheries. Finally, the classification of the amount of consolidation was arbitrarily assigned as moderate for fleets that experienced a decrease in vessel numbers of less the 33%, and high for those that experienced vessel decreases greater than 33%.

As these tables indicate, there has been some degree of consolidation in virtually every ITQ program reviewed. This was also true for the inland fisheries reviewed but not listed because of a lack of data on many of the factors. However, while the results of New Zealand's ITQ program may be subject to debate, results of the Victoria, Australia abalone fishery demonstrate consolidation is not inherent to all ITQ programs.

The overriding factor in the potential for consolidation appears to be the degree of overcapitalization of the fleet. In every case where overcapitalization was judged to be high, consolidation was high, except for programs where substantial restrictions were placed on quota ownership and transferability. In some instances, specifically the Icelandic herring and capelin fisheries, there was a high amount of consolidation despite substantial ownership and transferability restrictions. On the other hand, some of the fisheries on the inland waters of North America experienced relatively little consolidation despite having few restrictions on quota ownership and transferability. This was most likely due to relatively low levels of overcapitalization and the relatively low value of the fisheries.

It must be noted, in the three fisheries for which the amounts of consolidation were the highest (Australia bluefin tuna, U.S. surf clam, and U.S. wreckfish), reduction of capital was the primary objective of the ITQ program and no attempts were made to limit the decrease in vessel numbers. This is in contrast to the Alaska and British Columbia halibut fisheries, which were so severely overcapitalized they had both deteriorated into the worst of derby conditions. Despite the severe overcapitalization present in these fisheries, the ITQ programs were designed to allow only limited amounts of consolidation. As a result, both fisheries experienced only moderate amounts of consolidation.

Conclusions

This paper has shown the amount of consolidation that occurs when ITQ programs are implemented can vary widely according to the individual characteristics of the ITQ program, the nature of the fishery, and composition of the fleet. Since the potential decrease in vessel numbers and the corresponding loss of jobs are such important issues when considering the adoption of an ITQ program, it is vital that the fishery be assessed individually as to its potential for consolidation. To decry the use of all ITQ programs based on the results of a few, specific programs ignores the uniqueness of individual fisheries and the wide range of ITQ programs possible. Given the importance of the world's fisheries and the current state of global fish stocks, full consideration should be given to all potential management programs, ITQ programs included.

Alaska Halibut			
Factor	**Description or Rating of Factor**	**Effect on Consolidation**	**Notes**
Overcapitalization/ Characteristics of Stock	High	Increase	Increased effort and TAC reductions had reduced the fishery to derby conditions. TAC had fallen 12% during 5 preceding years.
Previous Regulations	TAC Gear Restrictions	Increase Decrease	By switching from TAC-induced derby conditions to year-round ITQs, economies of scale should develop. By maintaining fixed gear regulations, economies of scale limited to only those capable of being achieved with fixed gear.
Quota Restrictions	High	Decrease	Quota ownership capped at 1% of TAC in any region. Transferability restricted between regions and vessel classes. Owner must be present when quota is fished (with some exceptions).
Nature of Rights	Perpetual Pct. of TAC	Neutral	
Value of Fishery	High	Increase	Roughly $83 million in 1996.
Mechanization	Moderate	Neutral	Fixed gear restriction prevents use of more mechanized trawlers.
Single/Multi Species	Single	Increase	
Consolidation	**Moderate**		Vessel numbers decreased 26% from 3846 to 2841. Catch per vessel remained relatively constant due to decrease in TAC.
Data obtained from U.S. Dept. of Commerce, 1997 and Muse et. al., 1996a			

Table 4 - Alaska Halibut Fishery

Alaska Sablefish			
Factor	**Description or Rating of Factor**	**Effect on Consolidation**	**Notes**
Overcapitalization/ Characteristics of Stock	Unknown	Neutral	Amount of overcapitalization undocumented. TAC had risen 5% during preceding 4 years.
Previous Regulations	TAC Gear Restrictions	Neutral Decrease	TACs had remained relatively constant and seasons were not severely restricted. By maintaining fixed gear regulations, economies of scale limited to only those capable of being achieved with fixed gear.
Quota Restrictions	High	Decrease	Quota ownership capped at 1% of total TAC. Transferability restricted between regions and vessel classes. Owner must be present when quota is fished (with some exceptions).
Nature of Rights	Perpetual Pct. of TAC	Neutral	
Value of Fishery	High		Roughly $109 million in 1996.
Mechanization	Moderate	Neutral	Fixed gear restriction prevents use of more mechanized trawlers.
Single/Multi Species	Single	Increase	
Consolidation	**Moderate**		Vessel numbers decreased 18.5% from 1382 to 1126. Catch per vessel increased 15.5%.
Data obtained from U.S. Dept. of Commerce 1997, and Muse et. al., 1996b			

Table 5 - Alaska Sablefish Fishery

Australia Abalone			
Factor	**Description or Rating of Factor**	**Effect on Consolidation**	**Notes**
Overcapitalization/ Characteristics of Stock	Low	Decrease	ITQ program reduced total TAC by 20% as a precaution.
Previous Regulations	TAC Lim. Entry	Decrease	Previous limited entry program had reduced number of participants from 30 to 16 during the previous 20 years.
Quota Restrictions	Unknown Assumed High	Decrease	Undocumented, quota assumed to be allocated in indivisible blocks. Undocumented, license assumed to be required in order to own quota. Undocumented, number of licenses assumed to be fixed.
Nature of Rights	Pct. of TAC	Neutral	Undocumented, assumed to be perpetual.
Value of Fishery	Low	Decrease	Roughly $8 million.
Mechanization	Low	Decrease	Labor intensive dive fishery.
Single/Multi Species	Single	Increase	
Consolidation	**None**		The number of divers remained constant at 14. Catch per diver remained constant.
Data obtained from Sanders and Beinssen, 1996			

Table 6 - Australia Abalone Fishery

Australia Bluefin Tuna			
Factor	**Description or Rating of Factor**	**Effect on Consolidation**	**Notes**
Overcapitalization/ Characteristics of Stock	High	Increase	The fishery was facing a severe reduction in TAC. From 1983 to 1986 the TAC fell from 21,000 t to 11,500 t
Previous Regulations	TAC	Increase	Falling TACs contributed to overcapitalization.
Quota Restrictions	Low	Increase	Limited to Australian companies or citizens. No caps on ownership, no trade restrictions.
Nature of Rights	Unknown	Neutral	Undocumented but assumed to be percentage by weight of TAC. Undocumented but assumed to be perpetual.
Value of Fishery	Moderate	Neutral	$43 million in 1986.
Mechanization	Moderate	Neutral	Mechanized purse seine fleet. Less mechanized hook and line fleet
Single/Multi Species	Single	Increase	
Consolidation	**High**		Vessel numbers decreased 73% from 1984 to 1987. Catch per vessel increased.
Data obtained from Geen et. al., 1990; Wesney, 1989; and Geen and Nayar, 1988			

Table 7 - Australia Bluefin Tuna Fishery

British Columbia Halibut

Factor	Description or Rating of Factor	Effect on Consolidation	Notes
Overcapitalization/ Characteristics of Stock	High	Increase	Increased effort and TAC reductions had reduced the fishery to derby conditions.
Previous Regulations	TAC Lim. Entry Gear Restrictions	Increase Increase Decrease	By removing limited entry regulations and TAC induced derby conditions, economies of scale should develop. By maintaining fixed gear regulations, limited economies of scale to only those capable of being achieved with fixed gear.
Quota Restrictions	High	Decrease	Quota assigned to licensed vessels only and holdings were capped at four quota shares. No permanent transfers, only annual leases allowed. Vessels may not lease or lease out more than two shares.
Nature of Rights	Pct. of TAC	Neutral	Assumed to be perpetual.
Value of Fishery	Moderate	Neutral	Roughly $21 million in 1993.
Mechanization	Moderate	Neutral	Fixed gear restriction prevents use of more mechanized trawlers.
Single/Multi Species	Single	Increase	
Consolidation	**Moderate**		Number of vessels decreased 17% from 1991 to 1993.
Data obtained from Casey et. al., 1995			

Table 8 - British Columbia Halibut Fishery

Iceland Capelin

Factor	Description or Rating of Factor	Effect on Consolidation	Notes
Overcapitalization/ Characteristics of Stock	High	Increase	Stock thought to be seriously threatened by overfishing in 1980 despite increasingly extensive season restrictions.
Previous Regulations	TAC Lim.Entry	Neutral	Despite declining TACs, retaining limited entry regulations restricted economies of scale to only those that could be achieved with existing vessels or replacements.
Quota Restrictions	High	Decrease	Quotas assigned to licensed vessels only. Licenses limited to past participants or their replacements. Transfers of seasonal quota between geographic regions restricted during fishing season.
Nature of Rights	Perpetual Pct. of TAC	Neutral	
Value of Fishery	Moderate	Neutral	Roughly $48 million in 1990.
Mechanization	High	Increase	Fishery prosecuted by a purse seine fleet.
Single/Multi Species	Single	Increase	
Consolidation	**High**		Number of vessels decreased 43% from 1980 to 1993. Average vessel size has increased substantially.
Data obtained from Arnason, 1996 and Arnason, 1993b			

Table 9 - Iceland Capelin Fishery

Iceland Demersal			
Factor	**Description or Rating of Factor**	**Effect on Consolidation**	**Notes**
Overcapitalization/ Characteristics of Stock	High	Increase	Increased effort had reduced cod fishing days from 323 in 1977 to 215 in 1983. Sharp drop in demersal stock and catch levels occurred in 1983.
Previous Regulations	TAC Lim. Entry	Neutral	Despite declining TACs, retaining limited entry regulations restricted economies of scale to only those that could be achieved with existing vessels or replacements.
Quota Restrictions	High	Decrease	Quotas assigned to license vessels only. Licenses limited to past participants or replacements. Transfers of seasonal quota between geographic regions restricted during fishing season.
Nature of Rights	Perpetual Pct. of TAC	Neutral	
Value of Fishery	High	Increase	Roughly $723 million in 1990.
Mechanization	Varied	Increase	Fleet is comprised of roughly 990 of trawl and longline vessels, with about 80 deep-sea trawlers; 30 deep-sea freezer trawlers; and the rest multipurpose gillnet, longline, and trawl/purse seine vessels.
Single/Multi Species	Multi	Decrease	
Consolidation	**Moderate**		Vast array of vessel types and numbers, combined with lack of data on vessel numbers made determination difficult. In addition, loophole in ITQ regulations allowed influx of small (<10GT) vessels. Number of quota holders decreased 27% from 1894 to 1994. Value of fishing capital decreased 15% from 1990 to 1992. Large vessels almost doubled their ITQ share.
Data obtained from Arnason, 1996; Pálsson and Helgason, 1995; and Arnason, 1993b			

Table 10 - Iceland Demersal Fishery

Iceland Herring			
Factor	**Description or Rating of Factor**	**Effect on Consolidation**	**Notes**
Overcapitalization/ Characteristics of Stock	High	Increase	Dramatic stock decline in 1969 produced fishing moratorium. When fishing resumed in 1975 severe overcapitalization persisted despite limited entry.
Previous Regulations	TAC Lim.Entry	Neutral	Despite declining TACs, retaining limited entry regulations restricted economies of scale to only those that could be achieved with existing vessels or replacements.
Quota Restrictions	High	Decrease	Quotas assigned to license vessels only. Licenses limited to past participants or replacements. Transfers of seasonal quota between geographic regions restricted during fishing season.
Nature of Rights	Perpetual Pct. of TAC	Neutral	
Value of Fishery	Moderate	Neutral	Roughly $17 million in 1990.
Mechanization	High	Increase	Fleet is comprised of purse seine and drift net vessels.
Single/Multi Species	Single	Increase	
Consolidation	**High**		Number of vessels decreased 54% from 1975 to 1993. Total catch increased 100% from 1980 to 1993. Average vessel size has increased substantially.
Data obtained from Arnason, 1996 and Arnason, 1993b			

Table 11 - Iceland Herring Fishery

New Zealand			
Factor	**Description or Rating of Factor**	**Effect on Consolidation**	**Notes**
Overcapitalization/ Characteristics of Stock	Unknown	Neutral	High number vessels prosecuting various numbers of species made assessing overcapitalization impractical.
Previous Regulations	TAC	Neutral	Some species were under TAC regulations, but no derby situations were present and there few drastic TAC reductions.
Quota Restrictions	Low	Increase	Relatively high caps on quota ownership: 20% of TAC for any one species in any one area and 35% of total TAC for any one species.
Nature of Rights	Perpetual Pct. of TAC	Neutral	
Value of Fishery	High	Increase	Value of all species under ITQ management over $NZ 500 million.
Mechanization	High	Increase	Most fisheries prosecuted by trawling
Single/Multi Species	Multi	Decrease	Most of NZ fisheries are mixed species fisheries
Consolidation	**None**		Vessel numbers and quota ownership remained relatively constant. Unable to determine average catch per vessel data.
Data obtained from Dewees, draft; Lindner et. al., 1992; and Clark et. al., 1988			

Table 12 - New Zealand Fisheries

U.S. Surf Clam			
Factor	**Description or Rating of Factor**	**Effect on Consolidation**	**Notes**
Overcapitalization/ Characteristics of Stock	High	Increase	Increases in vessel numbers and fishing effort, combined with TAC decreases, had resulted in openings of six hours every two weeks.
Previous Regulations	TAC Lim. Entry	Increase	By removing limited entry regulations and TAC induced derby conditions, economies of scale should develop.
Quota Restrictions	None	Increase	
Nature of Rights	Perpetual Pct. of TAC	Neutral	Undocumented, assumed to be perpetual.
Value of Fishery	Moderate	Neutral	Roughly $57 million.
Mechanization	Moderate	Neutral	Actual landing and onboard processing requirements unknown, assumed to be similar to fixed gear harvesting.
Single/Multi Species	Single	Increase	
Consolidation	**High**		Number of vessels decreased 73% from 1990 to 1996. Catch per vessel increased 210% from 1990 to 1996. Reduction of excess capacity was a primary goal of ITQ program.
Data obtained from U.S. Dept. of Commerce, 1997; NMFS Northeast Region, 1997; and Wang, 1995			

Table 13 - U.S. Surf Clam Fishery

U.S. Wreckfish			
Factor	**Description or Rating of Factor**	**Effect on Consolidation**	**Notes**
Overcapitalization/ Characteristics of Stock	High	Increase	During the preceding year, 38 vessels were active in a fishery that could only support 20. CPUE decreased 42% from 1991 to 1996.
Previous Regulations	TAC	Increase	TAC regulations led to derby conditions in years prior to ITQ
Quota Restrictions	None	Increase	
Nature of Rights	Perpetual Pct. of TAC	Neutral	
Value of Fishery	Low	Decrease	$833,000 in 1996.
Mechanization	Moderate	Neutral	Fishery is prosecuted by hook and line.
Single/Multi Species	Single	Increase	
Consolidation	**High**		Vessel numbers decreased 76% from 1991 to 1997. Catch per vessel has also fallen due to declining CPUE. Reduction of excess capacity was a primary goal of ITQ program.
Data obtained from NMFS Southeast Region, 1997 and Gauvin et. al., 1994			

Table 14 - U.S. Wreckfish Fishery

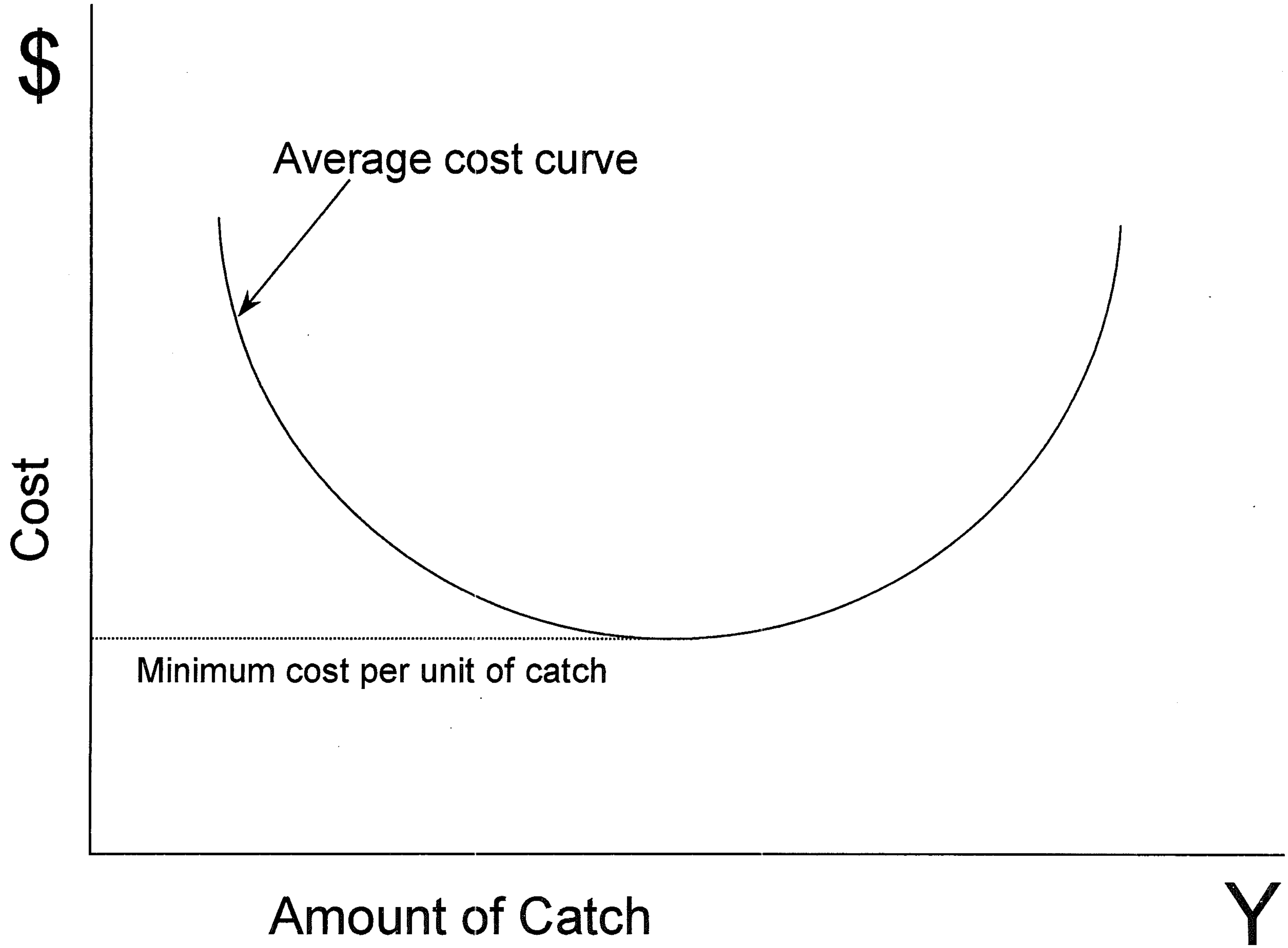

Figure 1 - Average Cost Curve

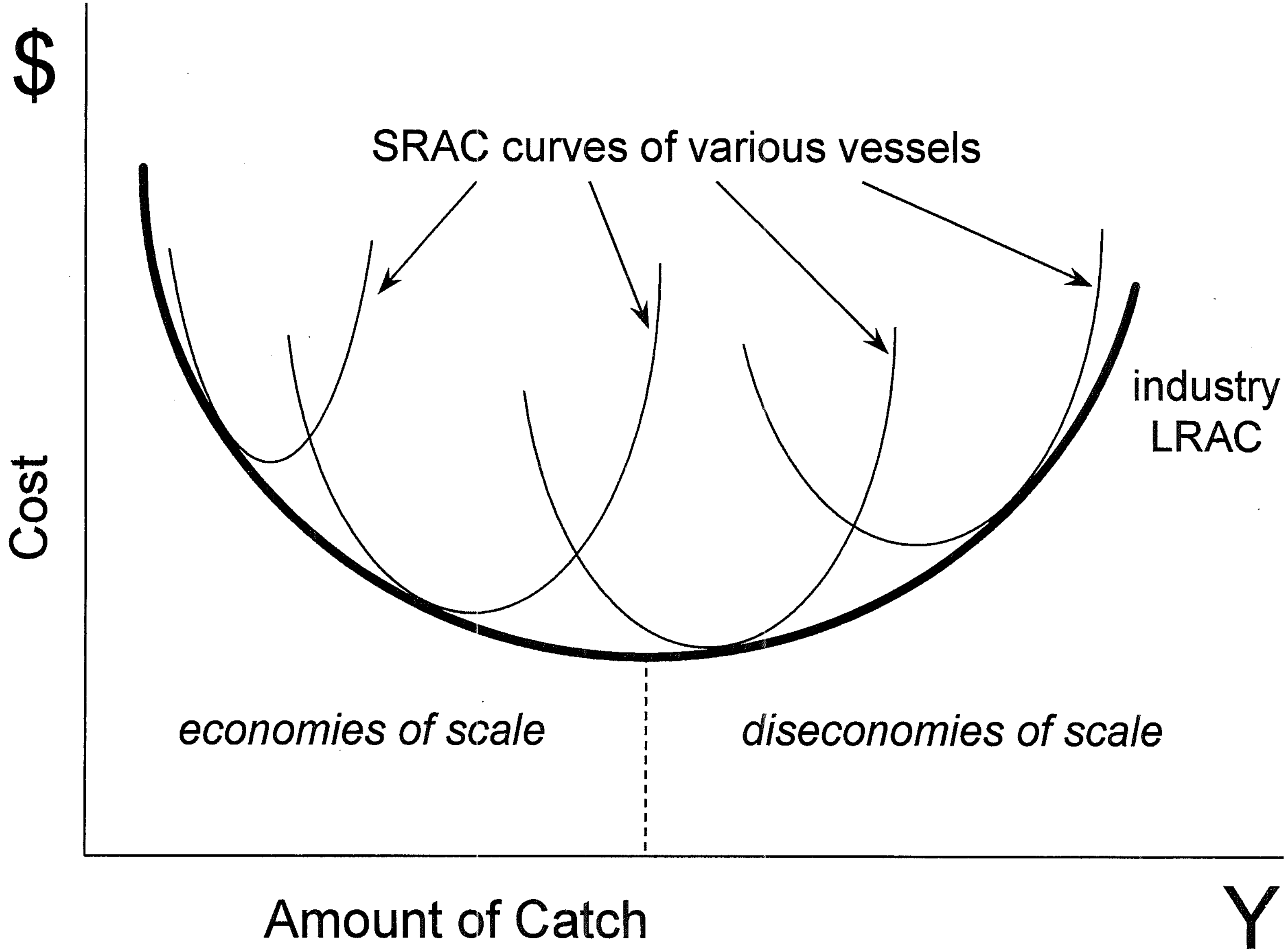

Figure 2 - Long-run Average Cost Curve and Economies of Scale

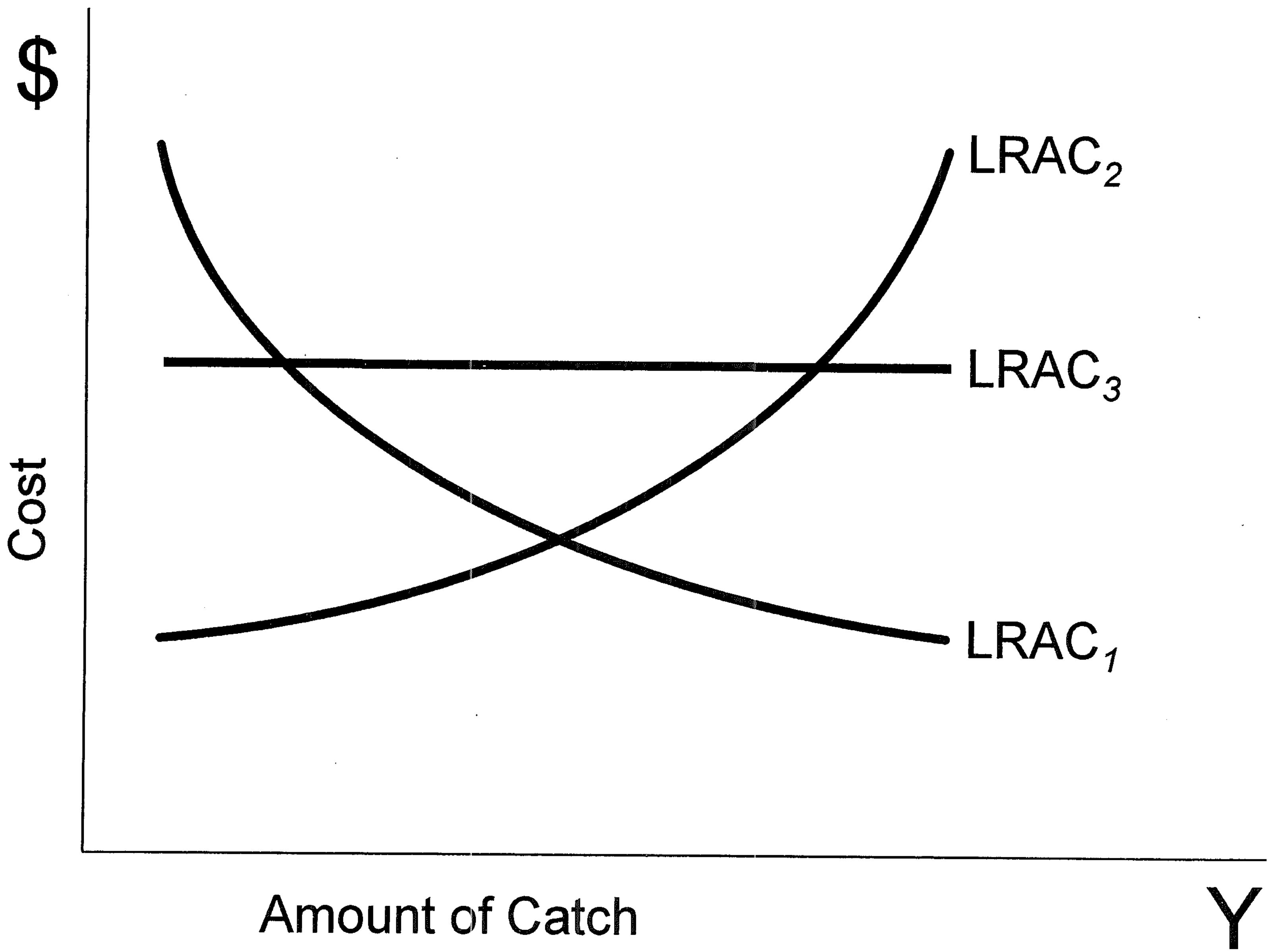

Figure 3 - Various Long-run Average Cost Curves

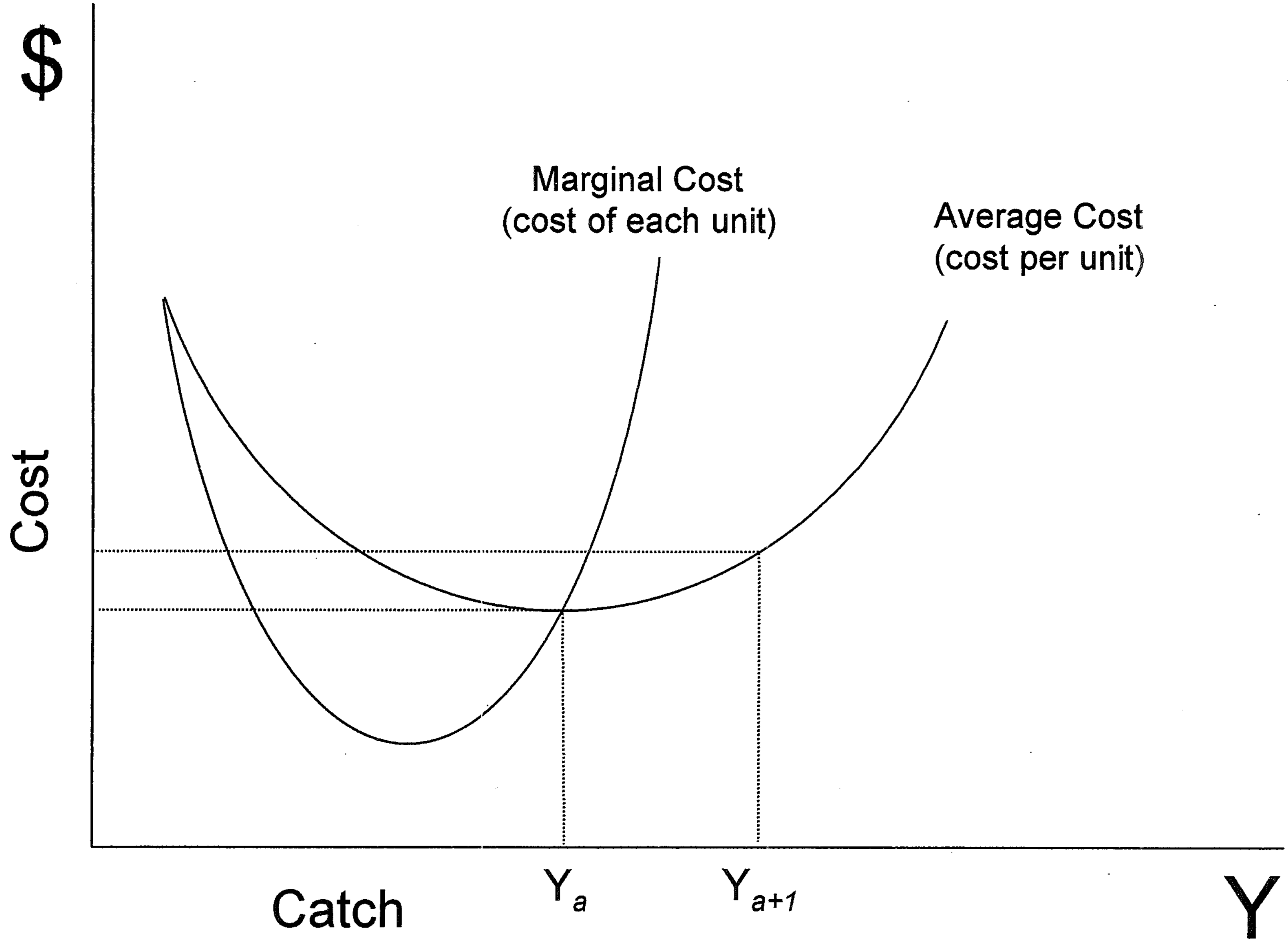

Figure 4 - Marginal and Average Cost Curves

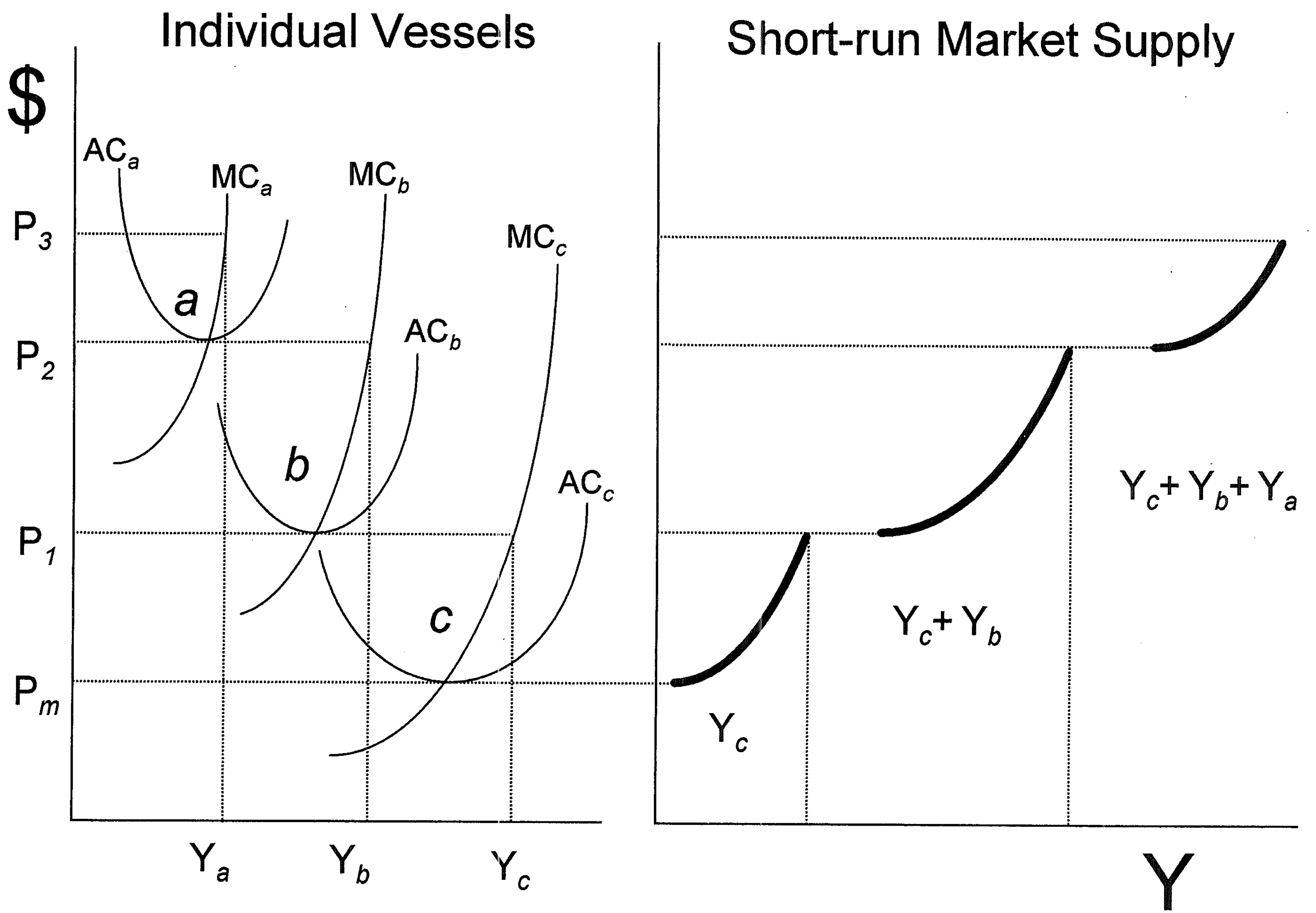

Figure 5 - Individual Vessel Cost Curves and Short-run Market Supply

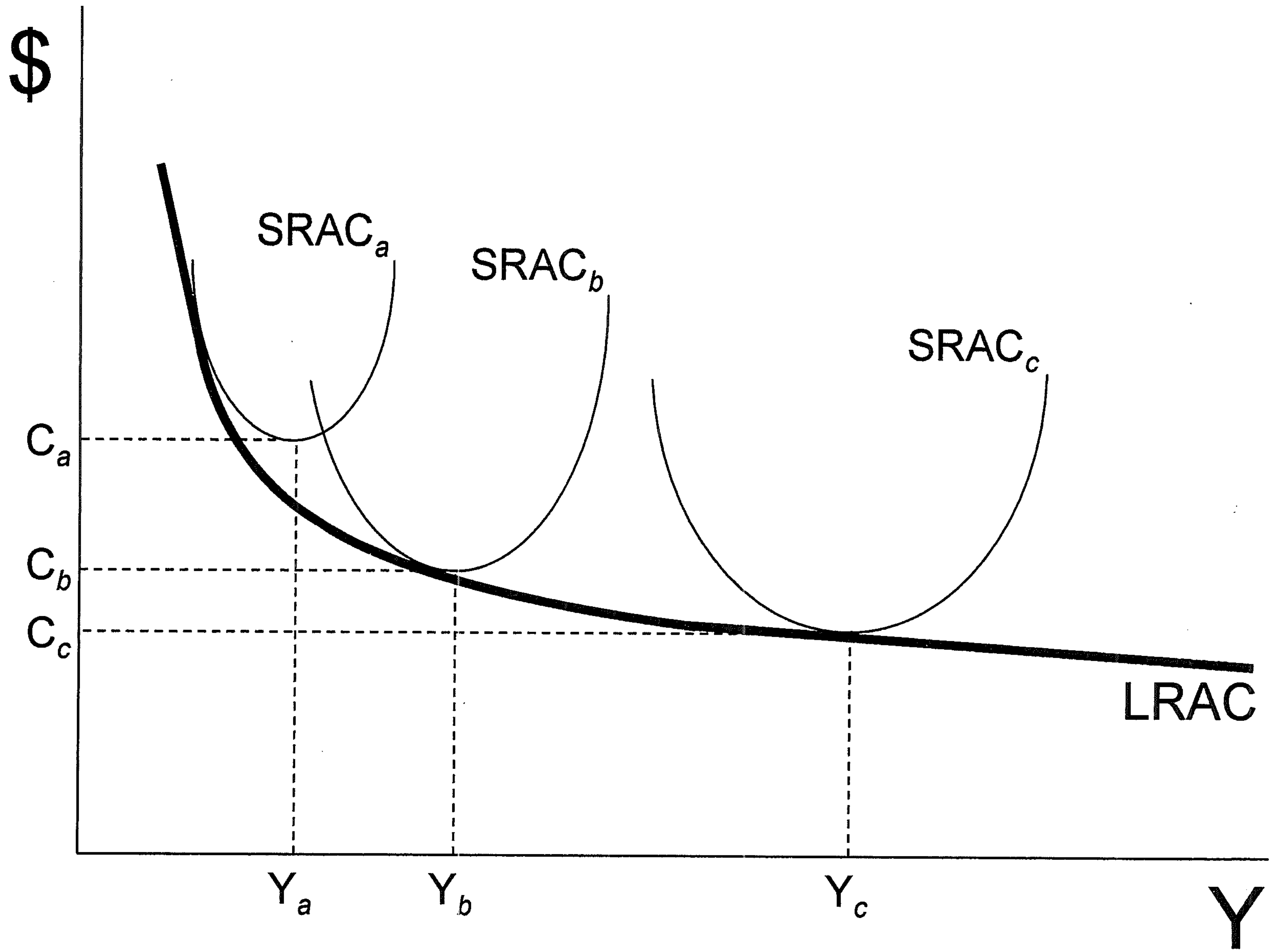

Figure 6 - Economies of Scale Encourage Consolidation

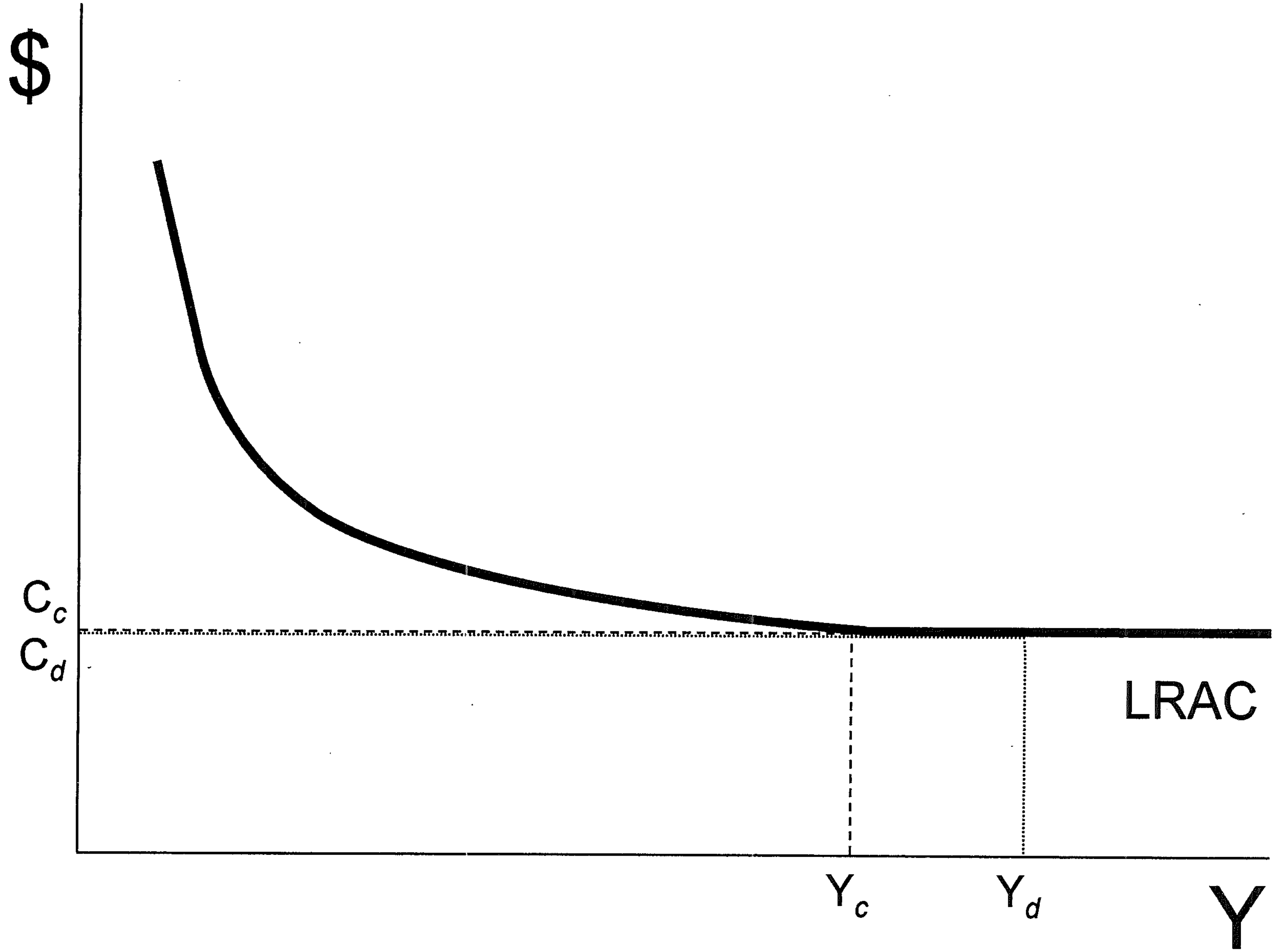

Figure 7 - Constant Returns to Scale Encourage Consolidation

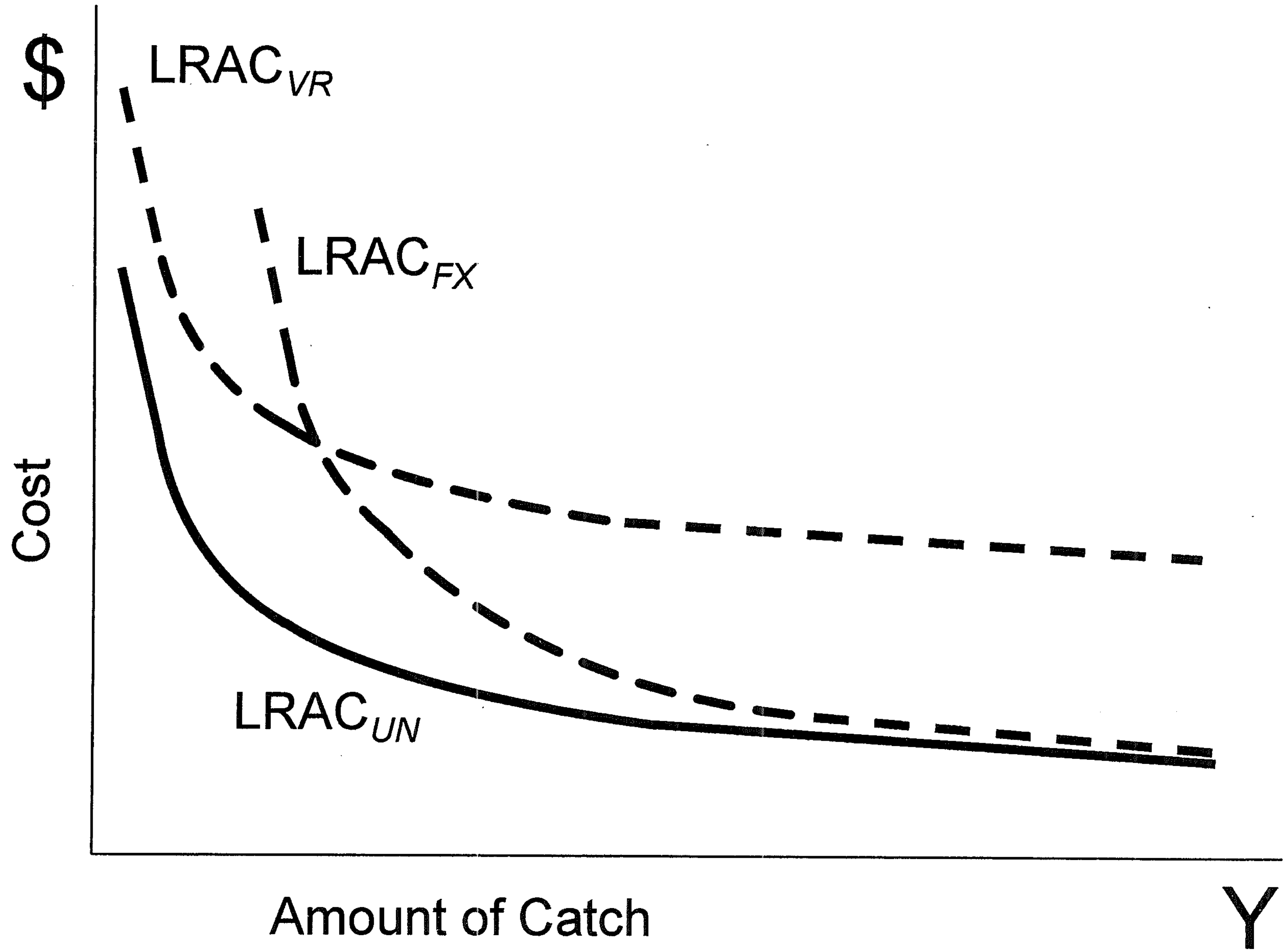

Figure 8 - The Effect of Increasing Fixed and Variable Costs on LRAC Curves

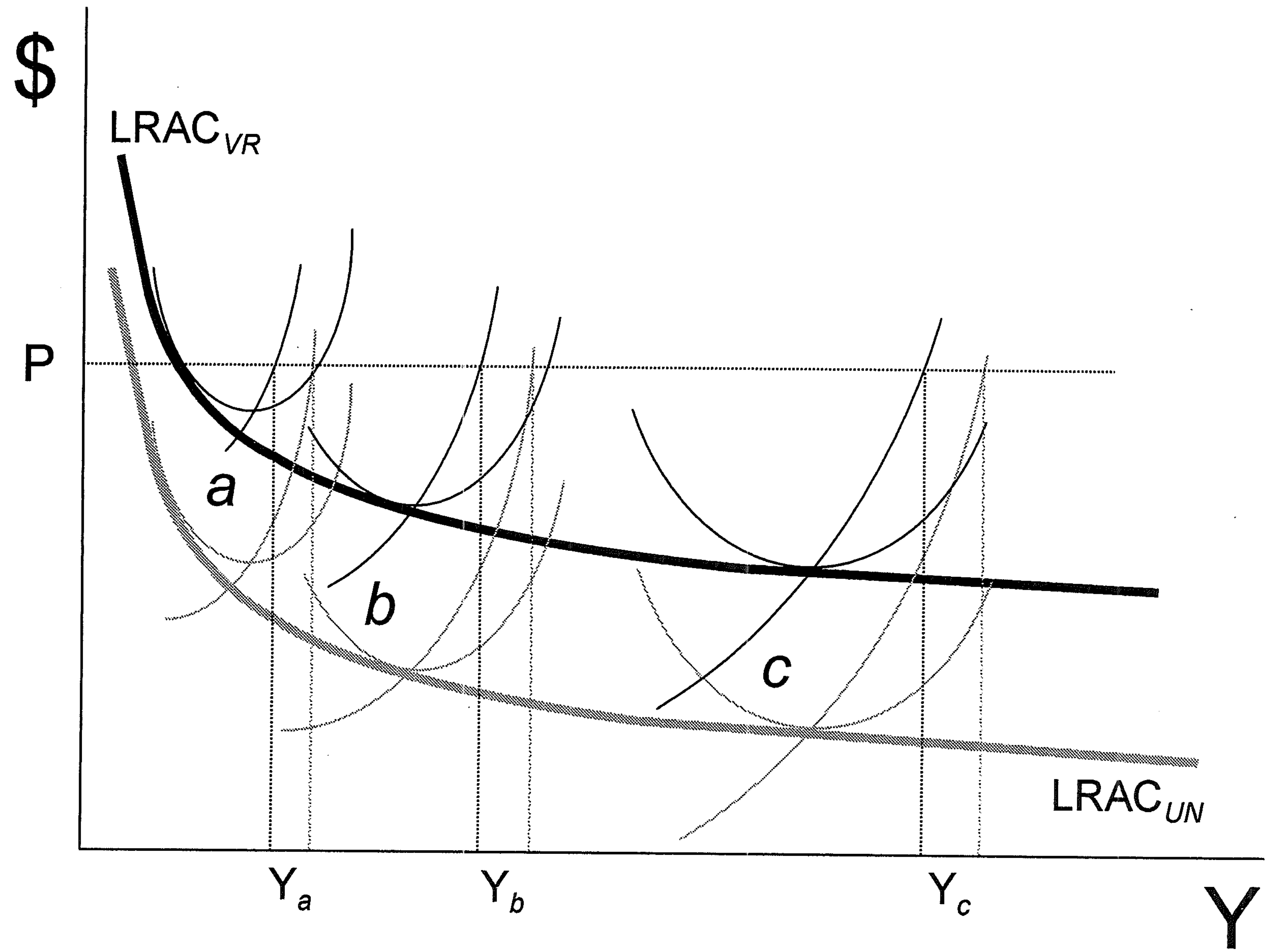

Figure 9 - The Effect of Increasing Variable Costs on LRAC and SRAC Curves

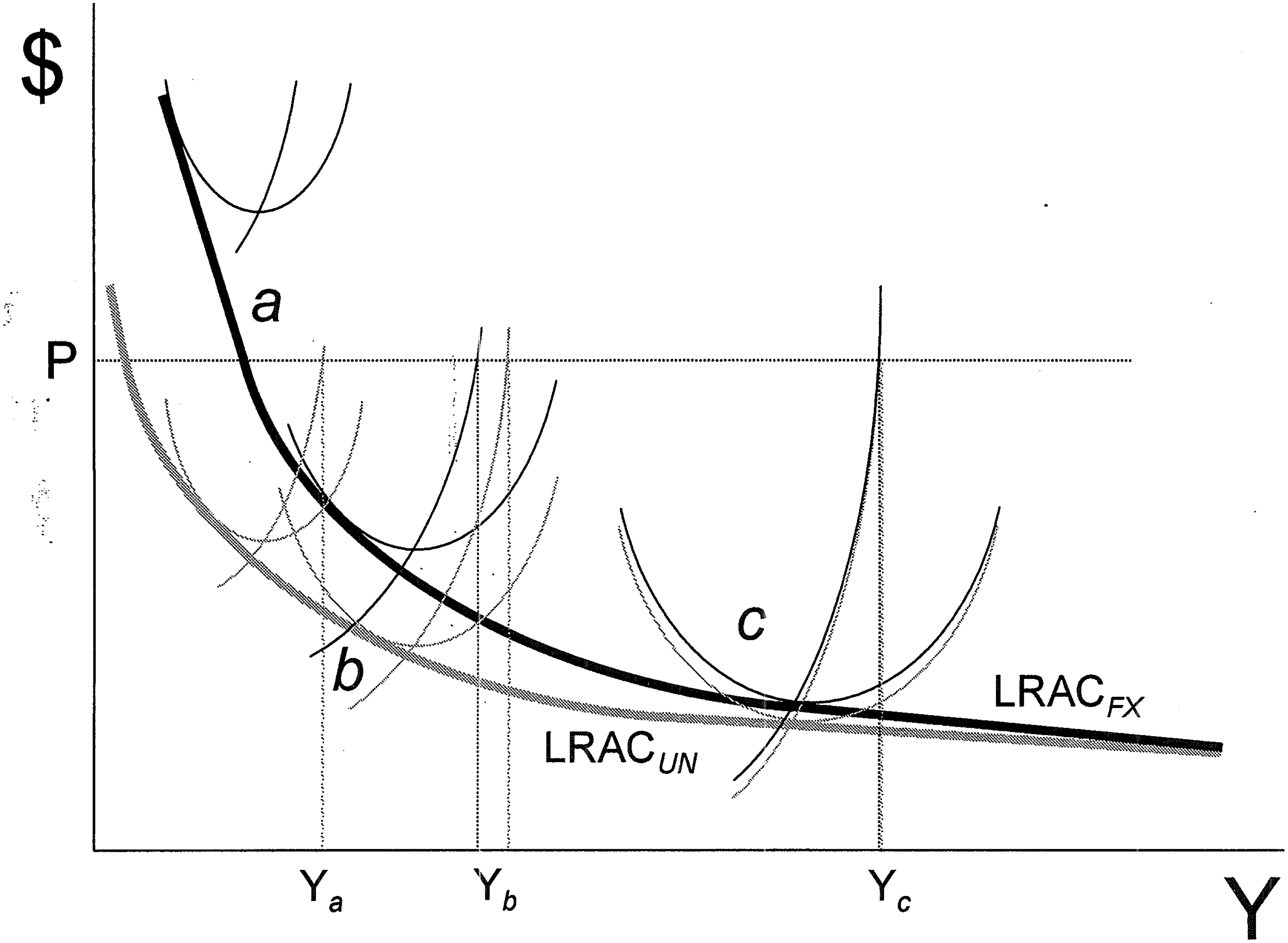

Figure 10 - The Effect of Increasing Fixed Costs on LRAC and SRAC Curves

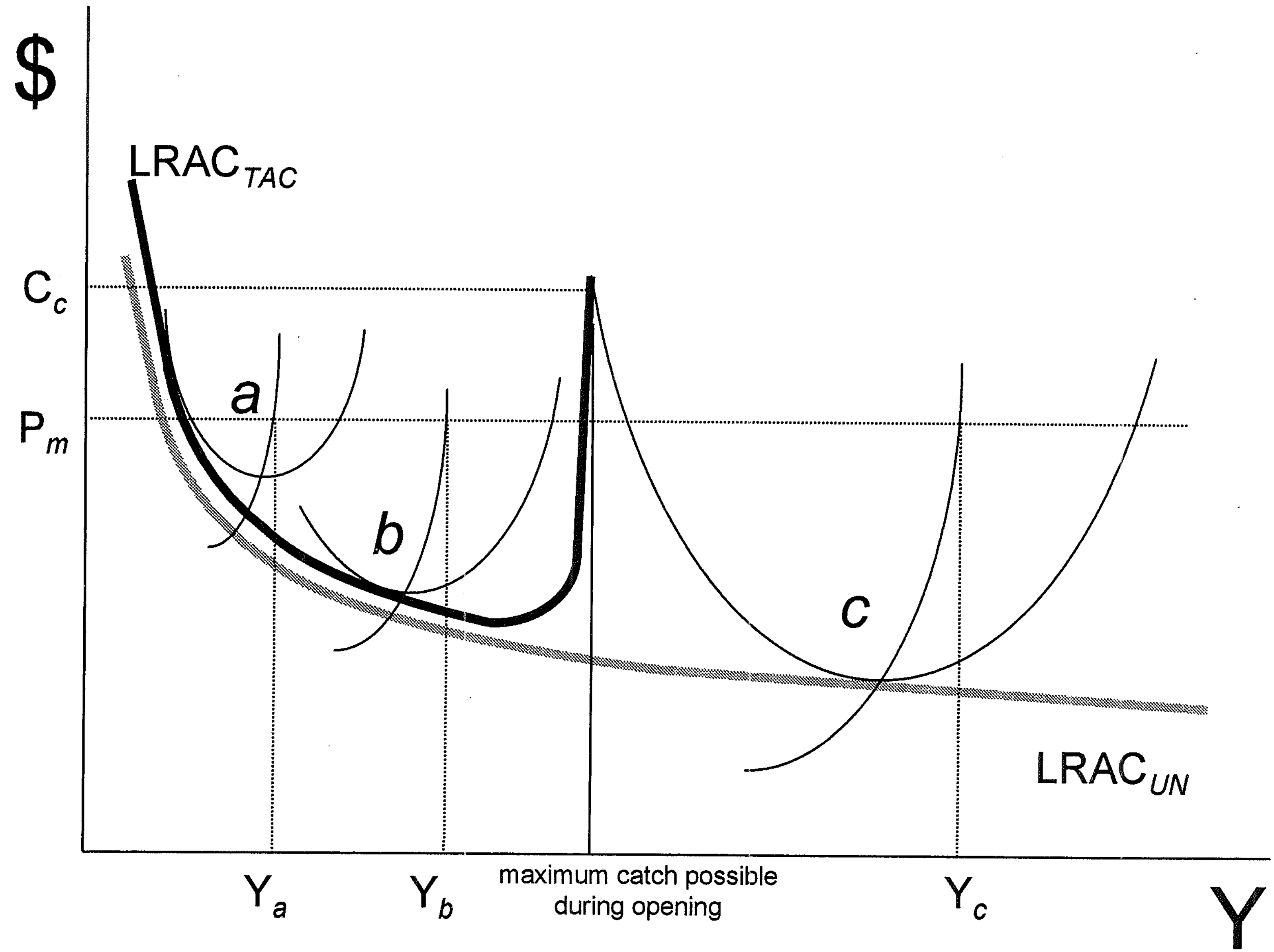

Figure 11 - The Effect of Restricted Openings on LRAC and SRAC Curves

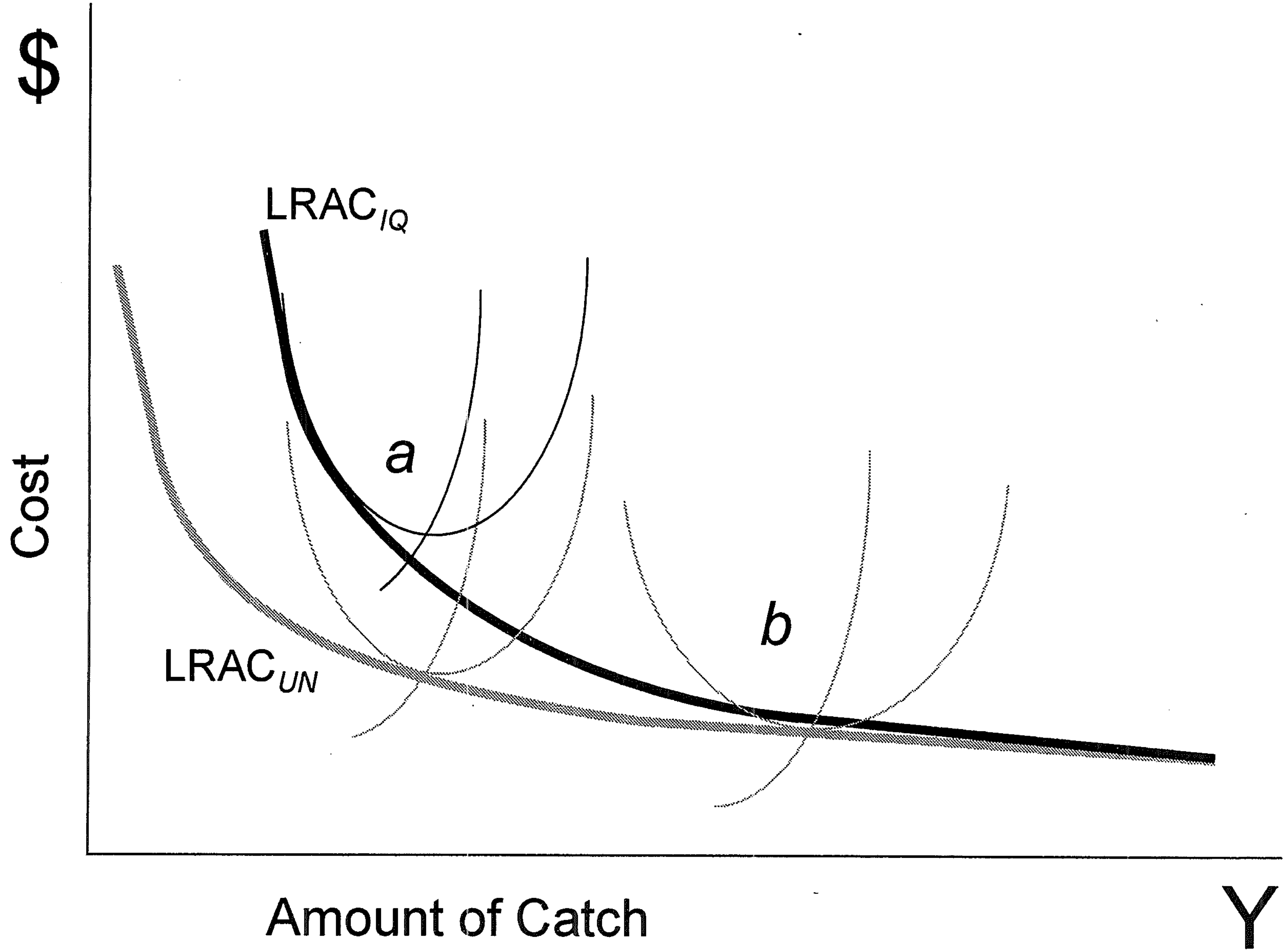

Figure 12 - The Effect of ITQs on LRAC and SRAC Curves

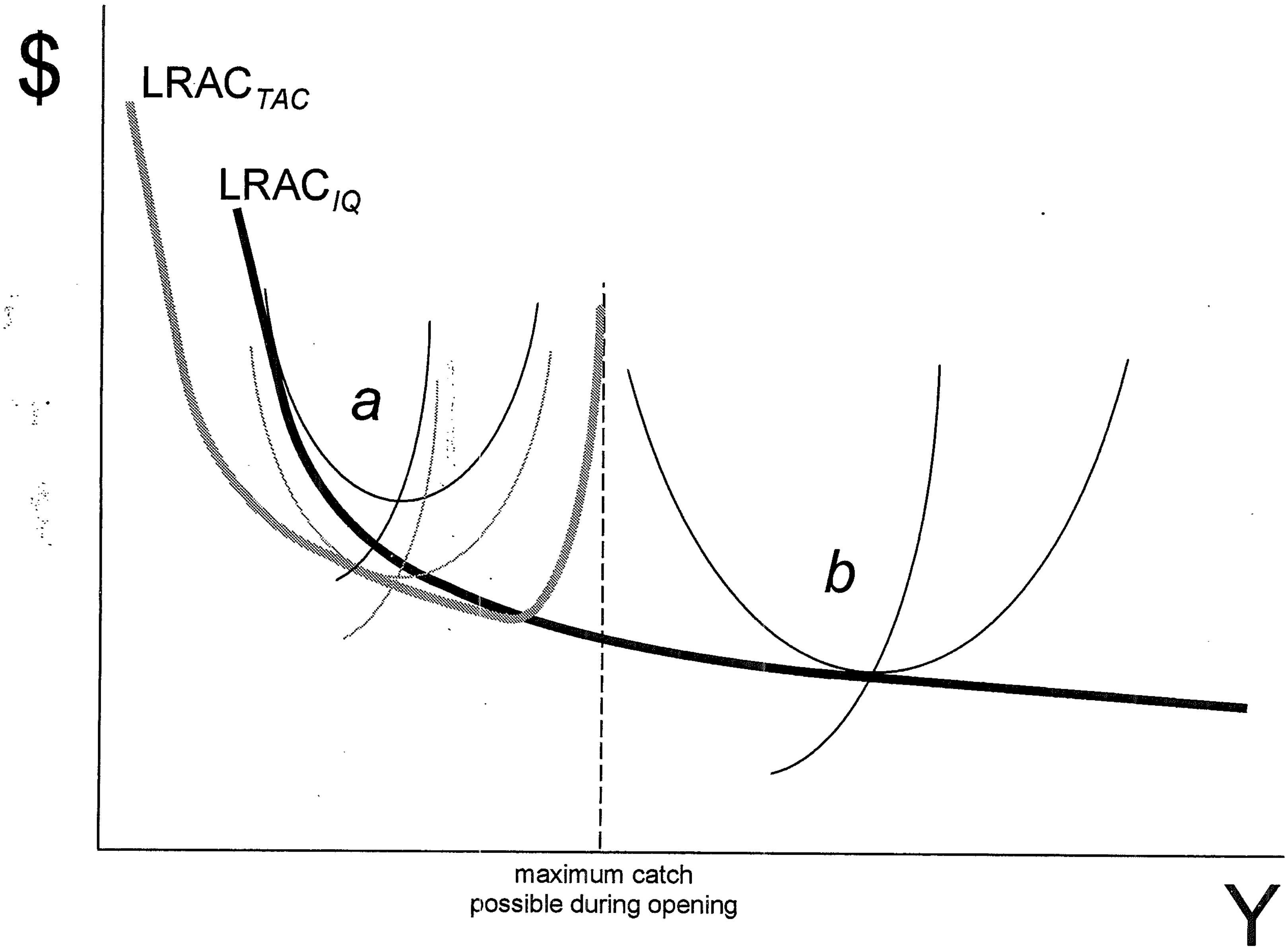

Figure 13 - The Effect of ITQs on LRAC and SRAC Curves in a Restricted Opening Fishery

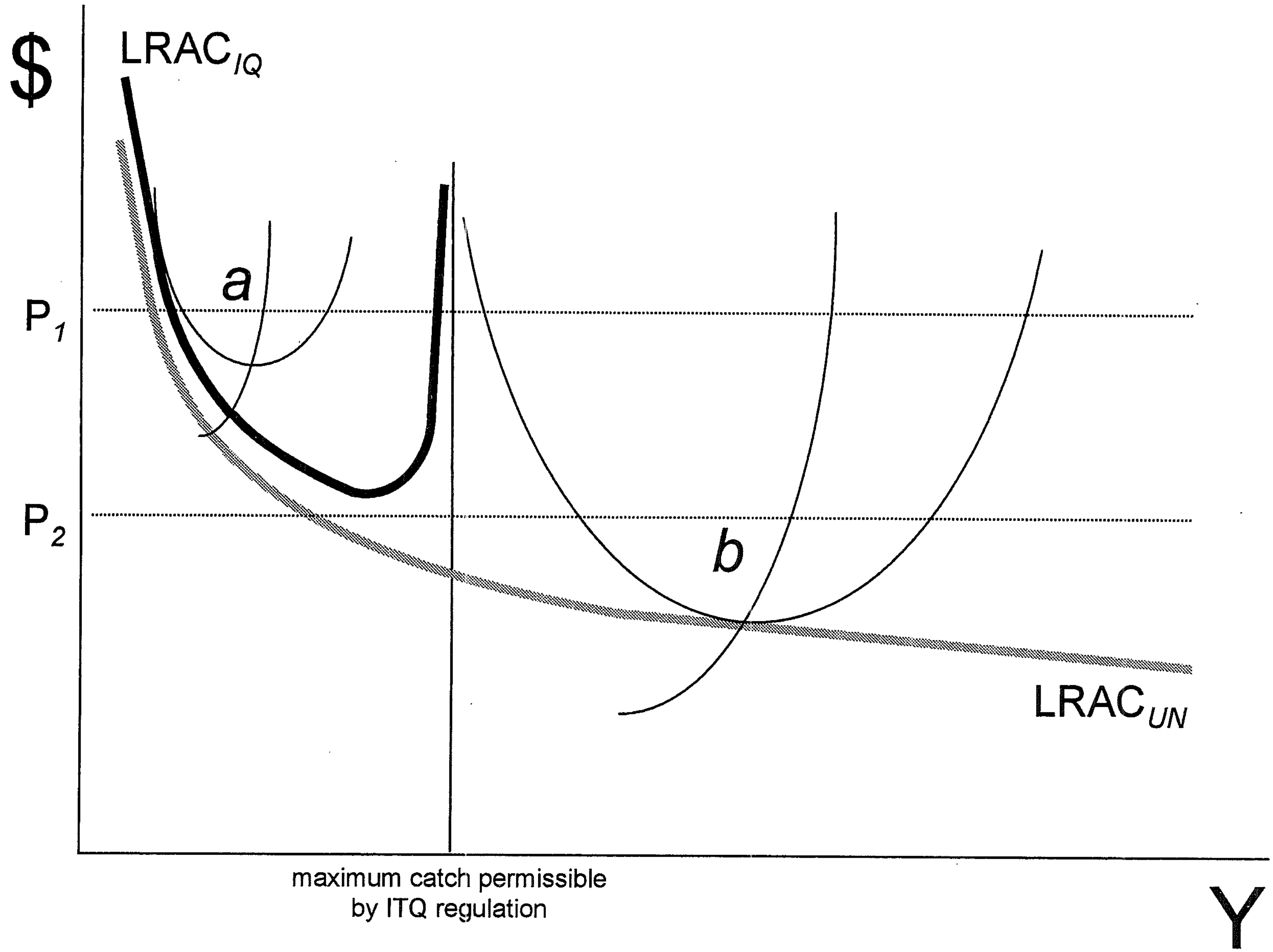

Figure 14 - The Effect of Limiting Quota Ownership on LRAC and SRAC Curves

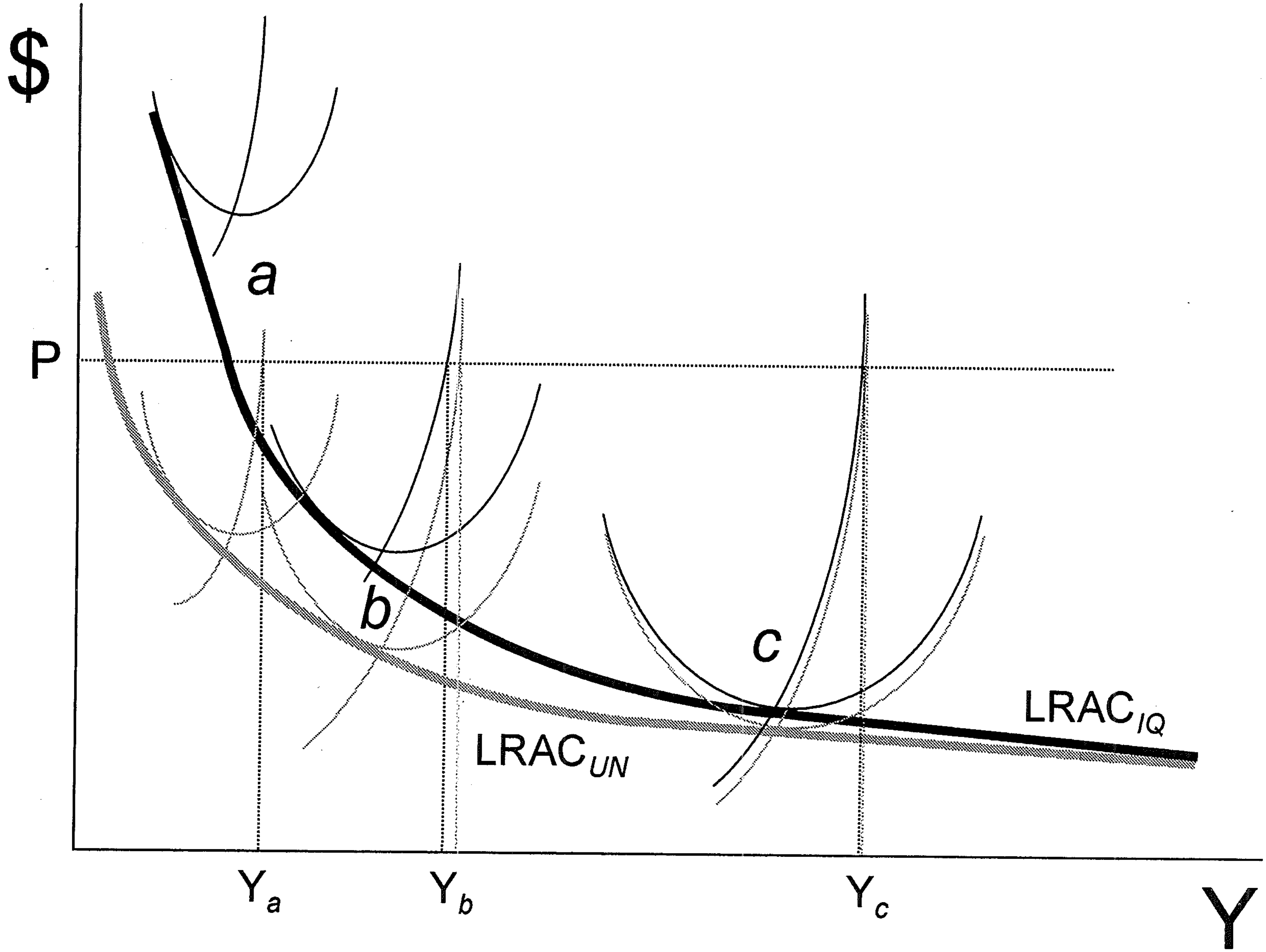

Figure 15 - The Effect of ITQs on LRAC and SRAC Curves in an Overcapitalized Fishery

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