

Specialist and Generalist: Roles for Coping with Variability

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Abstract.—Two behavior patterns of fishermen, specialist and generalist, are evaluated as ways of coping with market and natural variability. Changes in these behaviors predicted by an analytical model are evaluated against data from several fisheries. The predictions and the data suggest that a mix of specialist and generalist fishing behavior is a way of coping with unpredictability. Management usually regards fishing behavior as homogeneous; as a result, many management rules discriminate against one type of behavior or the other.

Two interrelated issues need elaboration in the evaluation of fishing behavior and management systems. One is conceptualizing fishermen as a homogeneous population. The second is neglecting the stochastic problems resulting from market and natural variability.

The homogeneity of fishing populations enters models either as an initial assumption (Gordon 1953, 1954; Crutchfield and Pontecorvo 1969; Clark 1976; Anderson 1977) or when fishery scientists and managers associate the term “fisherman” with certain stereotypes about behavior (Smith 1974, 1981). To the extent that the distribution of fishing behaviors is known and approaches a normal distribution, the homogeneity assumption may be justified. Our observation, however, is that there are two behavioral types—specialist and generalist. The mix of specialists and generalists in a fishery varies with the stochastic variation in revenues due to natural or market factors. We hypothesize that adjustments to the mix of specialists and generalists are part of the process by which society copes with variability.

Some attention has been given to natural variability in biological models (Beddington and May 1977; Sissenwine 1977; May et al. 1979; Shepherd and Horwood 1979; McKelvey et al. 1980) and in economic analyses (Huppert 1979; Hanna 1982). Very little attention, however, has been given to the fishing strategies needed to cope with the variability in renewable resource productivity.

Concern for variability and uncertainty is common to theories in ecology and economics. In ecology, it is found in optimal foraging theory (Schoener 1971; Krebs 1978; McCleery 1978); in economics, portfolio theory deals with diversifi-

cation of investments (Markowitz 1952, 1959; Samuelson 1967; Francis and Archer 1971; Elton and Gruber 1981). McCay (1978, 1981) applied optimal foraging theory to the analysis of the behavior of fishermen. In this paper, we try to link the question of fishermen's behavior in coping with stochastic variation to the economic model for determining optimal effort in the exploitation of common property resources.

Specialists and Generalists

Observations of fishermen suggest two contrasting coping strategies. One is behavior that indicates a specialist who operates in one fishery. This is the fishing pattern used with traditional analytic models. The other is behavior that indicates a generalist who has alternative fishery and nonfishery options. The differences are overstated, as with all dichotomies. In actual practice, the fishery is composed of a gradation of types of participants who are more or less like the idealized specialist or generalist but who still represent two different behavioral distributions.

The specialist-generalist modes are distinguished (Table 1) by the number of activities, economic organization, and time perspectives of the fishermen. Specialists typically operate in only one fishery. Because they invest their effort in one fishery, their cost of changing to a new fishery is very high. The specialist looks more to the long term and needs a very high profit potential before switching to another fishery. The generalist mixes a number of activities. His economic decisions focus on keeping total variable costs to a minimum so he can easily enter and leave fisheries. His perspective is short term.

TABLE 1.—Differential characteristics of specialists and generalists.

Characteristic	Specialist		Generalist
Activities, occupations, fisheries	Few		Many
Income averaged over	Time		Opportunities
Variable costs	Operating costs	<	Operating costs + opportunity costs
Fixed costs	Capital costs	>	Switching cost
Time perspective	Long-term		Short-term

Specialists average their returns over time and prefer stability and consistency. They operate more efficiently in the fishery of their speciality. Generalists, by contrast, participate in many activities. They seek to minimize the cost of switching between activities by fishing multipurpose vessels. Generalists are portfolio builders. Because of their multiple activities, some of which may be outside the fishery, they have not been incorporated into standard fishery economic models.

Diversification in portfolio analysis has an extensive literature and theory that, in spirit, could be applied to fisheries. Specialists attempt to minimize objective risk by attaining a measure of technological control over their environment. Generalists accept a risky environment but hedge their income by maintaining a range of options. Unlike the situation in a normal investment market, fishermen invest in the harvest of a common property resource, so that each individual's production possibilities and degree of risk are influenced by the policies set and actions taken by the other fishermen.

The specialist-generalist distinction requires multispecies models. Because a generalist, by definition, operates in more than one fishery, generalist behaviors cannot be well understood from single-species models.

Variability

Deterministic models lead to management concepts and analyses that ignore both natural and market stochastic processes. We suggest that the mix of specialists and generalists plays an important role in how society copes with variability. Specialists continually fish one species or group of fish. They develop skills to do well consistently in one fishery. Generalists are always looking for new opportunities and prepare themselves to shift between activities.

Specialists represent the base load of a fishery. They are the fishermen who consistently land catches from the fishery year after year. Generalists crop the peaks or the excess in abundant years. The mix of these two fishing behaviors is a way

to cope with substantial annual variability in catch and income.

Variability can come from either market or natural factors. Market-induced variability is caused by surpluses or shortages locally or from other regions. Prices paid to fishermen fluctuate inversely with the magnitude of the previous year's catch, which in turn affects inventories. Inventories fluctuate according to catch and market conditions. Demand for inventories sends price signals to fishermen. As this demand changes, future prices to fishermen are affected. This pattern continues, for example, with Alaskan inventories causing fluctuations in prices received by west coast fishermen.

Natural variability is influenced by conditions such as temperature, upwelling, and salinity that affect reproductive habitat. When conditions are "right," survival increases and the fish stock is more plentiful. Less favorable conditions reduce recruitment and survival.

The hypothesis is that a multipurpose fishery composed of specialists and generalists is economically more efficient whenever there is market or natural variability, or both. The degree of variability should influence the mix of specialists and generalists.

Even if the variability can be explained and the pattern is known, the specialist-generalist mix is still valuable. An example would be a fishery in which there are predictable peaks. Here, specialists would take from the continuous base and generalists would move in to take the peaks. Generalists, then, meet peak loads that occur at predictable intervals. Recreational and commercial fishing activities could be managed to complement one another in this situation.

Analytical Model

Our analysis draws together ecological theory on specialist-generalist adaptive strategies with the line of thought represented in bioeconomic analyses of Gordon (1954), Crutchfield and Zellner (1962), and Clark (1976). It involves a mathe-

mathematical model that incorporates two important changes. One is the distinction of two classes of fishermen—specialist and generalist. The second is the stochastic effects of market and natural variability. McKelvey (1983) gave a mathematical description of the model and our objective here is to summarize and apply the model.

The model is designed to focus on a single biological stock, e.g., pink shrimp (*Pandalus jordani*). A fleet of specialized boats (operated by “shrimpers”) is supplemented by a back-up fleet of flexible, general-purpose vessels (operated by “midwater trawlers”). The trawlers, who may ordinarily harvest groundfish, will be attracted into the shrimp fishery only in a good year. One must model both short-term (“in-season”) fishing patterns and long-term evolution in the size of the shrimp fleet.

The dominant stochastic elements of the shrimp fishery are taken to be the annual recruitment variation and seasonal shrimp market price and, for trawlers, variable opportunity costs of foregoing their alternative fishery. With the operating and opportunity costs set at the beginning of the season, the within-season operation of the fishery is modeled in a wholly deterministic fashion. Shrimp biomass declines under the pressure of fishing, the intensity of which is determined by the behavioral response of the fishermen to current prices, costs, and stock levels. Fishermen are assumed to be motivated by profit-maximizing goals, although the aggregate of their private decision making will not actually achieve, in the absence of management intervention, the socially desirable Pareto optimum.

At the beginning of the season, the size of the shrimp fleet is assumed to be fixed, with the individual fishermen treating capital costs as sunk. There are, however, annual start-up costs, so that in a particularly poor season a part of the existing shrimp fleet may remain idle. Those shrimpers who do enter will fish until their marginal returns from shrimp drop to the level of marginal costs. The trawlers, however, having the alternative of harvesting groundfish, enter (if at all) in such numbers as to balance their *average* net return against that obtainable in the groundfish fishery. This is the classical behavioral assumption of the common.

Let us denote by C_α and C_β the unit operating cost per unit time of fishing effort within season by shrimpers (α), and trawlers (β) operating in the shrimp fishery. The corresponding start-up costs are K_α and K_β . Thus, the total cost of shrimping

for a season of length T for shrimpers and trawlers, respectively, will be

$$C_\alpha T + K_\alpha; C_\beta T + K_\beta. \quad (1)$$

We assume that operating costs of shrimpers in most years are less than those of general-purpose trawlers, while trawler start-up costs are less than those of shrimpers:

$$C_\alpha < C_\beta; K_\alpha > K_\beta. \quad (2)$$

The first of these inequalities reflects the greater operating efficiency of the shrimpers and the current opportunity costs to trawlers of foregoing their alternative fishery. The second reflects that K_β is merely a switching cost for trawlers, who are already engaged in fishing.

Under optimal management, by a sole owner, it is efficient to minimize fleet start-up costs by utilizing the smallest fleet capable of taking the harvest and by operating this fleet as long as fish are available. We are assuming that, under such management, the total cost per unit time of shrimping effort is smaller for shrimpers than for trawlers. Given optimal management,

$$(C_\alpha + K_\alpha/T) < (C_\beta + K_\beta/T). \quad (3)$$

It is in this sense that shrimpers are said to be more efficient than trawlers in the shrimp fishery. In the model, it is assumed that the inequalities (2) and (3) hold in every year; that is, shrimpers will always have an advantage over trawlers in the shrimp fishery as long as they can operate for the entire natural season. It would be sufficient to require that (2) and (3) hold only on average. This would somewhat complicate the model, but would not change the character of its predictions.

If, then, total costs to shrimpers are less than current returns from harvest, it will be best for a sole owner to harvest at a level where marginal returns match unit costs and, in so doing, to utilize shrimp boats up to the capacity of the “alpha” fleet. Only when “alpha” capacity is insufficient (i.e., when fleet capacity is a binding constraint) will it be appropriate to utilize a supplementary trawler or “beta” fleet.

An entirely different fleet mix can be predicted if the shrimp fishery is operated as common property under conditions of open access, especially when the time for fishing is constrained by administrative or market requirements. Arguing in the customary way, one predicts an excessive level of effort at open access, compared to that which would be efficient, and hence a shortened season as biological, economic, or administrative con-

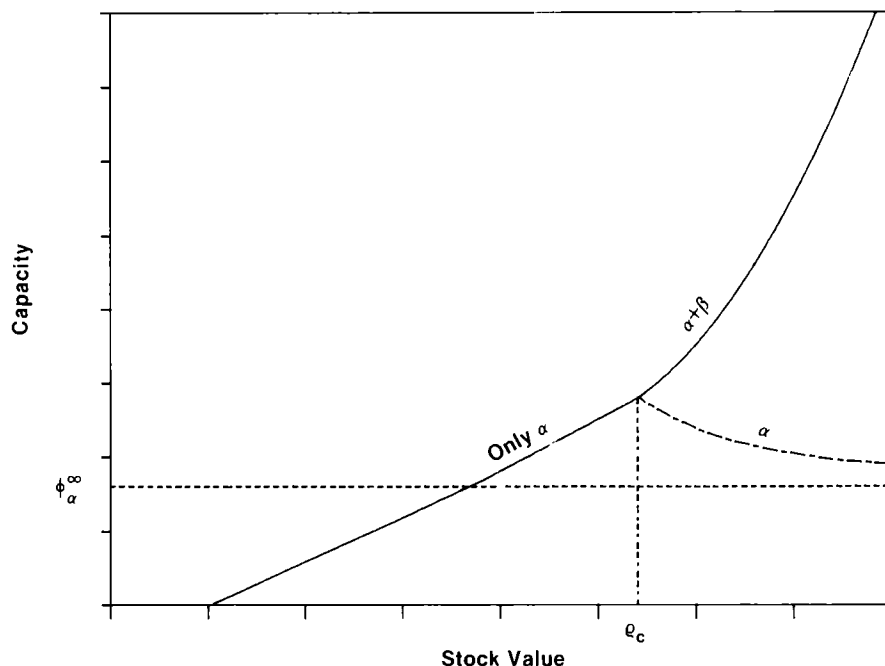


FIGURE 1.—The specialist–generalist mix in an open-access fishery of steadily growing value (adapted from McKelvey 1983). Up to a critical value ρ_c , alpha-fleet capacity grows as only specialists α enter. When ρ_c is exceeded, specialists decline as they are displaced by generalists β . Beyond ρ_c , the fleet is a mix of alpha and beta vessels. With continued growth, generalists crowd out specialists. The alpha vessels decline toward the capacity needed to take only the reserve stock (ϕ_{α}^{∞}), which is inaccessible to the less efficient generalists. In a fluctuating environment, constraints on rapid change in alpha capacity require a partial replacement of alpha vessels by beta vessels before ρ_c is reached.

straints come into play. By inequality (2), however, a sufficiently shortened season will reverse the direction of the inequality in (3); i.e., total costs of operation will be higher for all vessels, but trawlers are affected less than shrimpers and so tend to become relatively more competitive.

One can expect both excessive total effort and a changed mix of vessel types in common-property operation of the fishery: in this case, a greater reliance on multipurpose trawlers. In a good year, trawlers will enter the shrimp fishery during the early season to participate in the harvest of the abundant stocks. Though the trawlers eventually will depart and leave the residual stock to the shrimpers, their temporary involvement will have diluted the returns-to-effort for shrimpers. Moreover, the richer the harvest the more pronounced will be this effect. If, over a period of time, the fishery environment evolves through steadily improving market prices or enhanced stocks, the multipurpose trawl vessels will dominate the fleet more and more (Figure 1). Under either regime, the numbers switching out of the groundfish fish-

ery will be highly variable from year to year according to the stochastic variations in shrimp recruitment and prices and the stochastic opportunity return in the groundfish fishery itself.

The size of the trawler fleet fishing for shrimp determines the annual profitability of the shrimpers and, over the long run, the entry–exit decisions of shrimpers. The modeling requires explanation of this behavior in the open-access fishery, and a comparison of such operation with that of a profit-maximizing sole owner or industry-wide manager.

If investment costs are constant and levels of investment or disinvestment are unconstrained, the optimal policy is to maintain a shrimper fleet size at which *expected* annual net revenues equate at the margin to unit costs of utilizing capital. If these expectations are the same from year to year, then an optimal equilibrium size of fleet can be determined and, along with it, a fluctuating level of reliance on trawler vessels.

An important assumption is that trawlers have a positive, expected opportunity cost of foregoing an alternative fishery so that trawlers maintain a

profitable operation, on the average, without ever entering the shrimp fishery at all. With this assumption, the trawler fleet size is determined exogenously to the model. The assumption appears to be valid for examples considered in this paper. It fails when the generalists are obligatorily so; i.e., when they must work both fisheries to survive. If this is the case, a modeling analysis must determine both fleet sizes simultaneously, and the conclusions of the present analysis are substantially modified.

Revenue variability due to environmental or market conditions is central in all of this. In the absence of fluctuation (or even with small fluctuation), optimal policy would call for a single component fishery that relies entirely on an optimal capacity fleet of the specialist vessels. In contrast, coexistence of vessel types will be optimal in a fluctuating environment. The particular mix of vessels that is best will depend on the details of the stochastic variation. The role of trawlers clearly will be auxiliary when variation is small. The optimal capacity of the shrimper component of the fleet may be more or less than would be appropriate in an unvarying fishery with parameters set at the mean. This reflects the particular trade-off to be struck between surplus capacity in poor years and inadequate capacity in good ones.

In open access, too, a balance will be struck between these two considerations of capacity, but now the equilibrium level of alpha-fleet size will be too low, compared to the efficient level. The effect is accentuated as the shrimp fishery becomes richer due to increasing prices or enhanced stocks. The open-access fishery becomes more and more dominated by generalist trawlers although, paradoxically, the remaining shrimpers see a lessening degree of fluctuation in their annual take as the burden of risk shifts to the trawlers. Should the fishery experience a sharp decline, generalists would drop out in greater numbers than specialists. Generalists have the alternate fishery and when switching plus the opportunity costs exceed average revenues, they will drop out before the specialists, who face a much higher switching cost.

Our objective is to evaluate these hypotheses against actual situations. Unfortunately, fisheries do not always neatly fit the requirements for testing this analytical model. Needed cost and earnings data by vessel, and information on switching behavior and probability distribution for the stochastic variation in revenues, are not available in most cases. We have had to use behavioral descriptions to evaluate theoretical predictions.

Qualitative evaluation of several fisheries does provide, however, some elements for a test. First, we look at fisheries that evolved toward being either more specialized or more generalized to see if conditions predicted by the model existed. Then we look at the more complicated Oregon shrimper-trawler interaction. Because adequate data are not available, the results reported are only suggestive. An adequate test would require time-series data on vessel capital plus operating, switching, and opportunity costs. We are not aware of any fishery where these data have been systematically gathered.

Australian Prawn and Rock Lobster Fishery

Evolution toward specialization occurred in the Australian prawn fishery (primarily *Penaeus merguensis*; Meany 1979). This was managed as a limited-entry fishery from the start. Specialists operated company boats and, with the stabilizing influence of limited entry, the number of specialists increased. The analytical model assumes fishermen are profit maximizers. It predicts that, where variability is restricted, specialists will be more successful in the fishery.

The western Australian prawn fishery began in 1952. The fishery was pursued in three areas and yields were relatively stable in two of them. In the third area, yields were quite variable. The price paid between 1966 and 1976 doubled when figured in constant dollars. There was a comparable increase in gross revenue.

The prawn fishery was started with generalist boats taken from the rock lobster (*Panulirus longipes cygnus*) fishery. Most of the boats were owned by individuals and the rest belonged to fish companies which were granted exclusive, shore-based processing rights. Company boats would be analogous to the specialist fleet because their primary purpose was to support the processing facility. They were trip boats and could operate more efficiently than the rock lobster vessels which initially had the advantage of being available. The privately owned rock lobster vessels had more options and freedom of movement, although this was not discussed in detail by Meany (1979).

When the prawn fishery was started, two-thirds of the licenses were allocated to companies in the two areas that developed the greatest fishing stability. Initially, the situation was that "many of the licenses issued to the processing companies were utilized by privately owned boats under contract" so that the percentage of company boats was less than half. For several years, the privately

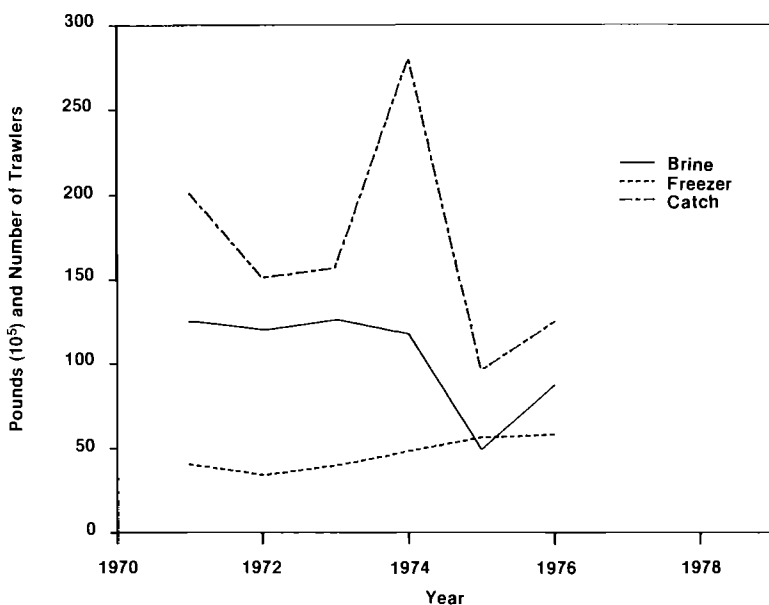


FIGURE 2.—Changes in numbers of freezer (specialist) and brine (generalist) trawlers in relation to the catch of prawns in the Gulf of Carpentaria.

owned generalist boats predominated but, by 1977, “these [had] all been replaced by new, company-owned boats” (Meany 1979).

The trend after 1952 was for rock lobster boats to be replaced by more specialized prawn fishing boats, and the level of company control gradually increased to 80% by 1977. Because the companies were integrated fishing and processing operations, operating and start-up cost data for the fishery were not available. Descriptive evidence indicates that natural variability did not enter into the operation of this fishery and it evolved, as the model predicts, toward greater specialization.

The third prawn fishing area represents a special case. In that area, there was much more variability in the annual catch. Thirteen licenses were issued initially and in no year were they all used. Company takeover was not an issue as this fishery remained highly variable and generalists were better adapted for it.

Clark and Kirkwood (1979) studied the mix of freezer and brine trawlers in the Gulf of Carpentaria prawn fishery (primarily *Penaeus merguensis*, plus *Penaeus esculentus*, *Penaeus semisulcatus*, and *Metapenaeus endeavouri*). This fishery started in 1965 with 10 trawler vessels and increased to 165 by 1971. Freezer trawlers are trip-oriented specialists. They fish only prawn stocks and their vessels are designed for this fishing activity. Brine trawlers are generalists who mix the

fisheries in which they operate. The stocks of prawns are “subject to wide unpredictable annual variation” (Clark and Kirkwood 1979).

Clark and Kirkwood sought to model the optimum mix of the two types of trawlers. They did not, however, try to model impacts from the annual variability in catch. Clark and Kirkwood (1979) provided a 6-year run of data from 1971 to 1976. The changes in numbers of both types of vessels in relation to the total prawn catch are shown in Figure 2. The most interesting aspect of this fishery relative to specialist–generalist behavior is the response to the sudden decline in 1975.

Freezer trawlers have a large capital investment, three to four times greater than the brine trawlers. We do not know, but predict from the model, that the generalists (brine trawlers) received information about lower-than-normal catches and stayed with their normally profitable activities elsewhere. No data were provided about how the brine trawlers knew not to enter the prawn fishery in 1975, but their numbers declined by nearly 60% from the previous year. The numbers of specialist freezer trawlers actually showed a slight increase in 1975. This represented investment in the more competitive specialist vessels which had been stimulated by the previous growth of the Australian prawn fisheries. It was a building program that had the objective of phasing out foreign-built and -crewed trawlers.

Territoriality of Specialists

Fishing strategies that provide the stability needed for a specialist adaptation often involve territoriality. The maintenance of territories, which limits the freedom of egress by generalists, is costly in terms of the time required to police them. Marine territorial rights usually can be bought and sold or are tied with land-based property rights. In some territorial systems, additional gear is required to maintain or use them. Territorial rights, then, try to extend the operating time of specialists by limiting the freedom of egress by generalists.

Acheson (1972, 1975a, 1975b) and Bowles (1973) showed that Maine lobstermen evolved two types of territories for exploiting American lobster (*Homarus americanus*). Acheson (1975b) noted an evolution from solely perimeter-defended to more nucleated territories from the early 1900s to 1950s.

"Perimeter-defended territories," those areas maintained for an exclusive group of lobstermen, characterize the specialist adaptation. The fishermen in these territories tend to fish mainly lobster. There are higher capital requirements for the perimeter-defended territories because ownership of land adjacent to fishing grounds is required.

"Nucleated territories," those areas which could not be restricted to the exclusive use of one group, came about because a generalist adaptation was made possible with increased use of gasoline engines, depth finders, and larger multipurpose boats. In areas where perimeter-defended territories still exist, such as on Matinicus Island, "no one is allowed to fish in the island's territory unless he owns land on the island. A major argument against selling land to 'summer people' is that thereby an island family may lose its fishing rights" (Acheson 1975b).

Specialist fishermen from perimeter-defended territories mention how this protects the full-time nature of the member's fishing occupation. An older fisherman stated that if the boundaries of perimeter-defended areas were not maintained, "we would all have to be part-time fishermen" (Acheson 1975b). Fishermen in perimeter-defended territories, which are often associated with islands, strongly defend their rights because "residents of islands do not have the alternative economic opportunities that men from the mainland harbors have" (Acheson 1975b).

A similar territorial arrangement is found among Columbia River salmon gillnetters (Thygesen 1978). In that fishery, two types of gear, diver and

drift gill nets, distinguish the specialist and the generalist. Gillnetters with diver nets maintain "drift rights." These are informal property rights to river areas that are passed down among family members. The rights also can be bought and sold. Usually four to six fishermen own rights to a particular drift. They draw lots to determine the fishing order and, on a particular night, each will fish the drift in turn.

The diver gill net differs from the drift gill net in that it sweeps along the river bottom, which is where the larger chinook salmon (*Oncorhynchus tshawytscha*) tend to be caught. A drift net floats on the surface. Drift gillnetters are less bothered by trees and obstructions washed into the Columbia River than the diver gillnetters because they fish near the surface. The drift areas of diver gillnetters have to be cleared of this debris. Therefore, in addition to the requirements for more costly nets and the ownership of drift rights, the specialist diver-net fishermen have to clear debris from their drifts with a boat called a snag puller.

Diver-net fishermen are more specialized. They fish more efficiently than the generalist drift-net fishermen. Those with diver nets are more likely to consider gillnetting as their occupation. Drift netters do not need a drift right to fish and often they mix drift gillnetting with other types of gill-net activity or other occupations. Longshoremen, teachers, truck drivers, loggers, and mill workers are other jobs held by drift gillnetters.

Shorter seasons have produced opportunities for the generalist's drift-net adaptation. Restricted seasons work against the specialist diver-net fisherman because, with short seasons, having a restricted territory to fish is less of an advantage. The gill-net season has declined from a 9-month season to one that opens for a few days at a time three or four times a year.

Generalist Baymen

An alternate case illustrates the evolution toward generalist behavior in a fishery where there is open access and a great deal of market and natural variability. McCay (1981) uses optimal foraging theory to explain the generalist fishing behavior of the baymen in Shoal Harbor, New Jersey. Because data were inadequate to measure the "costs and benefits of alternative strategies," McCay used a set of behavioral hypotheses to denote how baymen adopted a generalist strategy. She indicated that Shoal Harbor baymen are somewhat unique relative to most New Jersey fishermen, who tend

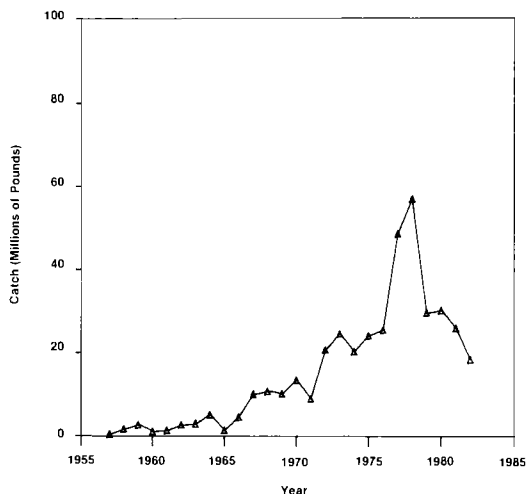


FIGURE 3.—Oregon shrimp catches in millions of pounds, 1957–1983, showing growth of the fishery since 1957.

to fish offshore and be more specialized. The interesting aspect of McCay's (1981) research as it relates to baymen is their ability to cope with "a great deal of temporal variability and unpredictability." In an open-access situation with high market or natural variability, the model predicts that the fishery will evolve toward mostly generalist participation.

Market prices received by fishermen in the fresh fish markets of New York, Philadelphia, and Baltimore are characterized by rapid market changes, "depending on day-to-day and sometimes hour-to-hour assessments of supply and demand conditions" (McCay 1981). Natural variability includes both the diversity of fish available and the unpredictability of quantity. To cope with this variability, the baymen capture a broad variety of species. McCay (1981) says the term "bayman" also connotes "jack-of-all-trades." Baymen also are "occupational pluralists," mixing other jobs with fishing.

Oregon Shrimp–Trawl Interaction

McKelvey's (1983) analytical model was developed from a discussion of the interaction between the Oregon shrimp and trawl fisheries. The shrimp fishery grew at an increasingly rapid rate through 1978, but it decreased to levels of the early 1970s by 1983 (Figure 3). The trawl fishery was stable through the early 1970s and then grew very rapidly from 1978 to 1982 (Figure 4).

There was open access into the shrimp fishery

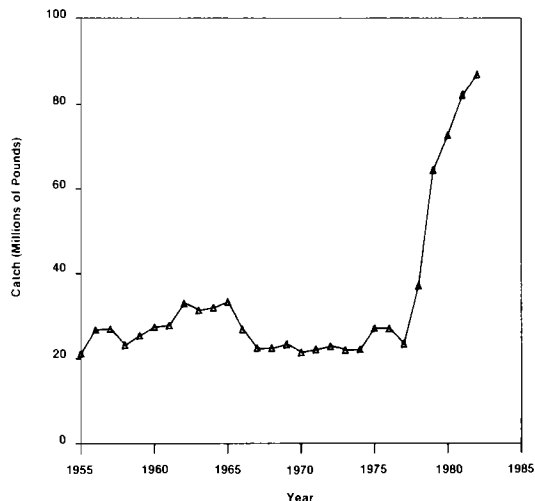


FIGURE 4.—Total Oregon trawl catches in millions of pounds, 1955–1983. After 1978, the fishery exploded, with new gears being used to catch previously unexploited populations and species.

until 1980. At that time the number of permits to fish shrimp was restricted. The model predicts that, with high natural variability and open access, the ratio of generalists in the fishery should increase. The fact that both the trawl and shrimp fisheries were growing rapidly complicates the analysis. We are working on explicitly modeling both fisheries, but this work is not completed. In addition, a totally new fishery developed in which both shrimpers and trawlers could participate. This was mid-water trawling for selected rockfish (*Sebastes* spp.) and Pacific whiting (*Merluccius productus*).

Shrimp fishing began off Oregon in 1957 when Ruth Day of Charleston demonstrated that processing by handpicking shrimp was commercially feasible (W. Q. Wick, personal communication). The work force grew to 2,000 women employed on a piecework basis handpicking shrimp. Then, in 1968, the minimum wage law upset the delicate balance between the productivity and wages of these pickers. Almost overnight, mechanical pickers were economically more feasible. Catches continued to increase through 1978 then, in the next 2 years, catches returned to 1972–1976 levels (Figure 3).

Usually shrimp boats are regarded as specialized vessels. They operate over smoother bottoms than do trawlers. Many of the vessels were built on the Gulf coast and were moved to the Pacific coast when word of the new fishery spread. Most entered the fishery in the late 1960s and early 1970s. They are not rigged to easily become trawlers. Some

shrimpers engage in the crab (*Cancer magister*), albacore (*Thunnus alalunga*), and troll salmon (chinook and coho [*Oncorhynchus kisutch*] salmon) fisheries; thus, relative to the shrimp fishery, these people are generalists.

Trawlers move relatively freely among a number of bottom and midwater fisheries. They primarily fish for species of rockfish and for Dover, English, petrale, and rex soles (*Microstomus pacificus*, *Parophrys vetulus*, *Eopsetta jordani*, and *Glyptocephalus zachirus*, respectively), and other commercially important groundfish. The trawl fishery grew rapidly for a period after 1935 when the Oregon legislature revised commercial fishing laws to allow for reduction of pilchard (*Sardinops sagax*). The domestic trawl catches were relatively stable between 1955 and 1977 but this changed after 1978 when new species and populations were added to the fishery (Figure 4).

The growth of the Oregon shrimp and trawl fleets from 1975 to 1983 is outlined in Table 2. There was rapid growth in the number of vessels in the shrimp fishery through 1980 but lower catches in 1981 through 1983 resulted in a 54% reduction in fleet size. There was a permit system in effect, but the decline mostly reflects the reduction in shrimp revenues.

For this study specialists were defined as those fishing only for shrimp and landing over 5,000 lb a year. Data were combined and we could not track individual vessels. Surveys and observations of fishermen by Stephenson (1980) confirm that there was a group that stayed with one activity but there also were what Stephenson called "innovators"—those who continually switch activities. Furthermore, fishermen themselves distinguish the two groups by name: e.g., shrimpers and drag or bottom fishermen.

During the 9 years for which data are available, shrimp specialists accounted for an average of 29% of the vessels fishing shrimp. Every combination of shrimp, trawl, crab, albacore, and troll salmon mix was found. The most numerous generalist pattern during the period was formed by those who fished shrimp and trawled. A close second was the shrimp and crab mix.

Some combinations fluctuated widely. Shrimp and albacore generalists accounted for 40% of the vessels in 1981 but dropped to less than 1% in 1982. Shrimp and scallop fishing mixes were over 25% in 1981 but less than 4% in 1982. Troll salmon and shrimp generalists decreased by one-half between 1980 and 1983. In 1981, 12% of the vessels were used for a combination of shrimp, crab,

albacore, and troll salmon fishing but the next year only one vessel was involved in this pattern. Seasonal patterns indicated that once a vessel had been switched to shrimping it continued being used for shrimping. There is little evidence of fishermen switching back and forth between shrimp and fish during the shrimp season, which runs from April to October. This behavior reflects the cost of making a switch between fisheries.

If generalists crop the peaks of fisheries, then situations of rapid growth or decline in the shrimp fishery are most useful for evaluating dynamics in the specialist-generalist mix. In an open-access, growing fishery, the ratio of specialists should decline as generalists come in to crop the peaks. During decline, the ratio of specialists to generalists should increase as generalists find it harder to compete with the more effective specialists, and as their opportunities relative to the shrimp fishery improve elsewhere.

Dividing the data in Table 2 into three 3-year periods shows a tendency for the predicted pattern in the latest and earliest periods. For the period 1981–1983, the ratio of specialists increased as the fishery declined, although this pattern is complicated by the development of a scallop (*Patinopecten caurinus*) fishery in 1981. Profits were phenomenal for those who entered the scallop fishery at the right time in 1981. Because of the power required to drag the scallop dredges, shrimpers were ideally suited to entering the new fishery. The opportunity costs of not entering were so great that even some of the normally nonmobile specialist shrimpers could not let this opportunity pass. The decision, however, had to be timed according to weeks. Two boats operated at first. There were 15 in week 4 and, altogether, 106 participated during the 11-week season. One-fifth of the boats, however, took 90% of the catch.

The pattern for 1975–1977 also fits the model. Shrimp revenues increased threefold and, as predicted, the ratio of specialists decreased during this period of open access and of rapid increase in biomass taken. Note that, in both the 1975–1977 and 1981–1983 periods, numbers of vessels in the trawl fishery were relatively stable.

The middle 3-year period, 1978–1980, when there was rapid growth in numbers of both trawl and shrimp vessels, does not fit the pattern. This is a period when explicit modeling of both fisheries and data on opportunity costs are needed in order to explain fishing options more effectively. The ratio of specialists was highest in 1978 when one would have expected generalists to enter the

TABLE 2.—Oregon shrimp and trawl fishery comparisons, 1975–1983 (Carter 1981 and personal communication). Revenues are given in millions of dollars.

Year	Total number trawl vessels	Total number shrimp vessels	Trawl revenues, actual (adjusted ^a)	Shrimp revenues, actual (adjusted ^a)	Specialist ratio ^b
1983	194	127	16.4 (8.7)	4.7 (2.5)	0.35
1982	200	173	17.7 (9.4)	9.3 (4.9)	0.32
1981	168	251	13.2 (7.3)	11.9 (6.6)	0.24
Three-year mean ± SD					0.30 ± 0.06
1980	173	285	10.0 (6.1)	16.6 (10.2)	0.34
1979	155	204	10.6 (7.2)	12.8 (8.7)	0.30
1978	104	187	6.6 (5.1)	19.1 (14.7)	0.39
Three-year mean ± SD					0.34 ± 0.05
1977	81	103	3.4 (2.9)	15.5 (13.4)	0.18
1976	78	87	3.4 (3.2)	7.5 (7.0)	0.22
1975	78	93	3.0	4.9	0.25
Three-year mean ± SD					0.22 ± 0.04

^a Adjusted according to annual July Portland consumer price index, with 1975 = 100.

^b Ratio of vessels landing over 5,000 lb of shrimp with no other significant fishing activities to the total number of vessels landing shrimp.

shrimp fishery. Trawl revenues doubled between 1977 and 1978 and doubled again in 1979. This growth slowed in 1980. Shrimping, then, was not a competitive alternative when this kind of revenue was available from trawling.

A structural change occurred in the shrimp-trawl mix in 1978. Before 1978, the shrimping and trawling generalists operated nearly two-thirds of the shrimp vessels but this declined to less than one-third in 1978. Later the shrimp-trawl pattern did not exceed 40% of the vessels. The years 1978–1981 represented very rapid growth of such options as midwater trawling, joint ventures with foreign processors, and opportunities in other areas. Thus, despite the fact that 1978 was the best revenue year in the shrimp fishery, opportunities in other fishing activities were even greater.

Our model is not designed to handle the dynamics of both the target fisheries and the alternative fisheries. The middle 3 years, due to volatility in alternative fisheries, cannot be adequately predicted. It was during this period that the structure of offshore fisheries was changing in response

to the Fishery Conservation and Management Act. In the 1975–1977 and 1981–1983 periods, the change between the initial and final year was more than two standard deviations, but not in the 1978–1980 period.

The analysis of the shrimp-trawl interaction highlights many of the problems of testing this theory from case studies. The time period is not long enough to establish the degree of variability. We only explicitly modeled the shrimp fishery while we needed to model both fisheries and their interactions. Data on fixed, variable, and opportunity costs are not adequately known for the time period of the analysis. The costs to switch are not known in precise enough terms. Further, there are a variety of other factors such as federal loan programs for vessel construction and tax incentives that make the entry and exit decisions difficult to estimate precisely. Comparable data are not available for all case studies and the behavioral descriptions are very general and not operationalized. Would another analyst interpret behaviors assigned to specialists and generalists in the same way?

This analytical model provides a way for thinking about how fisheries should be conceptualized. It has been tested only with behavioral observations and not specific calculations. Results suggest so far that it does pose implications for fishery management.

Implications for Management

There are many fisheries in which the specialist-generalist relationship could be studied as an adaptation to market or naturally induced variability. Specialists are defined as those who concentrate on one activity, while generalists are those who develop a portfolio of activities. To pursue the study of the specialist-generalist mix, more data are needed on fixed, variable, and opportunity costs for each type of fishing activity. The specialist's capital costs are greater than the generalist's costs to switch fisheries. Generalists seek to reduce the cost of switching. On the average, their operating plus opportunity costs are greater than the specialists', which gives specialists an advantage in pursuing the fishery. Specialists will take more of a long-term view and average their good years with the bad. Generalists take a more short-term view and average income and costs over many activities (Table 1).

Because each group has different strategies for coping, management schemes influence each group differently. Limited entry, which allows fishing time

to be spread out, works against generalists, who gain advantage with shortened seasons. Seasons, especially shortened seasons, hurt the specialist because their catch effectiveness compared to the generalist is reduced. Catch quotas have the same impact on specialists as seasons. The only difference is that quotas make it difficult to know the length of a season.

The hypothesis is that a multipurpose fishery composed of specialists and generalists is the best adaptation. The ratio of specialists to generalists is a function of the variability in the fishery, the capital costs of entering the fishery, and the costs of switching between fisheries.

Another management aspect of the specialist-generalist mix is in the interplay between commercial and recreational fisheries. Commercial fishing is usually more capital-intensive, while recreational fishing is more labor-intensive.

Many fisheries evolve to become mainly recreation-oriented; this is a generalist pattern and is predicted by the model when there is open access and a high degree of variability. This results from the continual shortening of seasons, which discriminates against the more specialized commercial fishermen. With better understanding of the optimal specialist-generalist mix, a fishery might be managed for a mix of commercial and recreational participation.

Many other fisheries lend themselves to an evaluation of the specialist-generalist adaptation. During the first century of operation, Alaska salmon fisheries handled variability with a combination of specialist company-owned traps and generalist transient gillnetters from the lower 48 states. The Pacific halibut (*Hippoglossus stenolepis*) fishery has experienced shorter and shorter seasons. The once specialized halibut schooner has given way to generalized multipurpose vessels. New England has long- and short-trip boats and a day fleet (Poggie and Gersuny 1974; Peterson and Smith 1981). In the tuna fishery, there are seiners and bait boats (Orbach 1977). McCay (1978) compared the processes of intensification and diversification among Fogo Island fishermen of Newfoundland.

The number of fisheries with mixed specialist-generalist participation suggests that fishermen have adapted either to specialization or to foraging more broadly across several fisheries or occupational activities. Static economic models and management that neglects market or natural variability favor specialists; yet rules that set seasons and quotas, which restrict fishing time in order to pro-

tect the resource, promote a generalist adaptation. There are cases where, in the absence of management, institutions developed that established territoriality and expanded the specialist's niche. Observations of various fisheries suggest that there is no common pattern. Each fishery develops a mix of specialists and generalists that best handles the variability at a particular time, but the specialist-generalist mix constantly changes because the fisheries are unpredictable. Given enough data, the optimal mix can be calculated, but this is seldom the case. The participants, exercising the options available to them, set the specialist-generalist mix.

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