MANAGEMENT OF THE HAURAKI GULF SNAPPER FISHERY; A NEW APPROACH

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"Like the hero of a western movie, MSY rode in off the range, caught the villians at their work, and established order of a sort. But now its time for MSY to ride off into the sunset. The world today is too complex for the rough justice of a guy on a horse with a six-shooter. We urgently need the same kind of morality, but we need much more sophistication."

(Larkin, 1977)

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LIST OF ABBREVIATIONS

ASY - Adequate sustainable yield

FMAC - Fisheries Management Advisory Committee

FMD - Fisheries Management Division (of MAF)

FMP - Fisheries Management Plan

FMT - Fisheries Management Team

ITQ - Individual Transferable Quota

MAF - Ministry of Agriculture and Fisheries

MEY - Maximum Economic Yield

MSY - Maximum Sustainable Yield

OSY - Optimum Sustainable Yield

RFMO - Regional Fisheries Management Officer

TAC - Total Allowable Catch

ABSTRACT

Fisheries management objectives, both in New Zealand and overseas, have changed markedly in the last two decades. It is now acknowledged that objectives other than maximising biological (MSY) or economic (MEY) yields must be taken into account in fisheries management. The new overall management objective is the Optimum Sustainable Yield (OSY). OSY-based management, which must account for all relevant objectives, cannot in practise be successful. No single optimum yield exists that meets all, or even most, fisheries management objectives. In New Zealand, successful management is further hindered by a lack of fisheries data and management experience.

'Satisficing' is a management approach which does not remove the 'multiple-objective' management problem, but allows positive management in spite of it. Instead of attempting to maximise management objectives, reasonable minimum levels of achievement are set for each objective. A management process which incorporates the satisficing management approach and associated concepts is described.

The satisficing approach to management could be used within, but is not required by, the New Zealand fisheries management structure. Neither the overall New Zealand fisheries policy, nor the Individual Transferable Quota allocation system can be used with the satisficing management approach without modifications. The policy would have to be changed so as not to advocate a single optimum yield, and the ITQ allocation system would require restrictions or incentives to make it amenable to non-economic management objectives. At present the ITQ allocation system is also inconsistent with the overall fisheries policy, in that it is influenced only by economic objectives.

CHAPTER ONE

INTRODUCTION

Over the past twenty years there have been major changes in the objectives of fisheries management. In this time fisheries managers have recognised that biological objectives, which for decades were considered the only management objectives worth pursuing, are only part of a range of important fisheries management objectives. This recognition was mostly involuntary. The failure of most attempts to achieve biological objectives (Larkin, 1972), the demonstration by workers in non-biological fields (for example Gordon, 1954) that achievement of biological objectives may preclude the achievement of non-biological objectives, and the growing awareness of the importance of non-biological objectives, together forced fisheries managers to reconsider their 'parochial' approach to management. As a result, the scope of fisheries management has been broadened to include economic, social, and other objectives.

Whilst now free of biological 'tunnel vision', the new management approach has presented fisheries managers with new problems. Instead of having to achieve one, albeit inadequate, objective, managers must now achieve a number of often conflicting objectives. Given the low level of success in achieving a single objective, it is little wonder that the task of achieving multiple objectives simultaneously has caused managers great difficulty.

One possible method for coping with the 'multiple-objective' problem in fisheries management forms the basis of this report. Methods of coping with the problem are presently used by fisheries managers, but more often they are used by default rather than by design. The 'satisficing' management approach discussed in this report, is not purported to solve the problems of multiple objective management, but rather to allow for positive fisheries management in spite of these problems.

The satisficing management approach is discussed in relation to New Zealand fisheries management. Management of New Zealand's fisheries is handicapped by a few important factors, the most notable of which is the very small scale of past management. During the period from the 1920s to the 1960s, the fishing industries of most developed countries underwent major expansion, but in New Zealand, the extreme preservation attitude of one person in particular, and of fisheries management in general, meant that fisheries developed only slowly. The major fisheries management crises faced by other countries were not experienced here, and there was little incentive to develop an intensive management system. In particular, this has resulted in a very poor fisheries data base.

The problems associated with small-scale management have recently been exacerbated by the rapid expansion of the country's fisheries. Since 1978 New Zealand fisheries managers have been responsible for the management of the eighth largest (by area) Exclusive Economic Zone in the world - a task they are less than well prepared for, given the level of fisheries data and understanding. Thus, whilst fisheries managers of other developed countries are tackling the major challenge of determining relationships between stock size and recruitment levels, New Zealand fisheries managers are still trying to make reasonable stock size estimates. Fisheries management in New Zealand is developing rapidly, but for a time it will be handicapped by its late start in intensive management.

New Zealand's fisheries management had not started effectively managing for biological objectives, when these objectives were superseded by the new multiple objective management approach. This has not prevented the new approach being introduced in this country, and recent legislation now requires that the multiple objective approach be used in the management of New Zealand's inshore fisheries. New Zealand managers are therefore in a more difficult situation than many of their overseas colleagues, who at least have the experience of managing for specific biological objectives.

This lack of data and experience is not accompanied by a corresponding simplicity of New Zealand fisheries, which are in general as complicated, and difficult to manage as fisheries in other countries. Finding a solution to the multiple-objective problem in New Zealand's fisheries, will therefore be at least as difficult, if not more so, than in other countries.

Of New Zealand's inshore fisheries, the Hauraki Gulf Snapper Fishery presents some of the biggest management problems. The fishery comprises a number of quite different commercial fishing methods and a large amateur fishery, and is based on one major fish species and several species of lesser importance. This diversity causes many problems for the fishery's managers, but also provides scope for achieving a variety of management objectives. This makes the Hauraki Gulf Snapper Fishery an appropriate case study with which to discuss the use of the satisficing management approach in New Zealand fisheries management.

The remainder of the report follows a similar format to the preceeding discussion. In Chapter Two, the evolution of fisheries management objectives is outlined. The 'satisficing' management approach is described in the latter part of this chapter in relation to the present trends in management objectives. Chapter Three is a brief outline of the development of fisheries management in New Zealand, in which five phases of management are identified. Recent legislation and management proposals are considered in order to identify current New Zealand management objectives.

The description of the Hauraki Gulf Snapper Fishery contained in Chapter Four is reasonably detailed. Not all of the information in this chapter is directly relevant to the management objectives discussed in the next chapter, but a good understanding of the Gulf Fishery and its problems is helpful in understanding the wider implications of those objectives. Features of the fishery described include, the physical nature of the Gulf, the biology and abundance of the snapper, the different fishing methods, and the regulations used in the management of the fishery. For those familiar with the Hauraki Gulf Snapper Fishery and/or those only interested in the satisficing management approach, Chapter Four can be used for reference only.

In Chapter Five a selection of possible management objectives are discussed. Biological, energy, employment, and economic objectives are discussed in some detail, and two other objectives are considered briefly. Where practicable, data describing the Hauraki Gulf Fishery are used to examine the extent to which the fishery might be manipulated so as to satisfice these objectives.

Having earlier described the satisficing management approach in general terms, it is appropriate to discuss how it might work in practise. This is done in Chapter Six. An eight-step fisheries management process which incorporates satisficing and associated concepts is described, and the extent to which the different steps could be accomplished within the present New Zealand fisheries management structure is discussed.

In Chapter Seven New Zealand's overall fisheries policy (as far as it can be identified), and the soon-to-be-introduced Individual Transferable Quota (ITQ) allocation system are discussed from the perspective of management by satisficing. An interesting, and important inconsistency between the policy and the ITQ allocation system is discussed, and related to the satisficing process.

CHAPTER TWO

THE EVOLUTION OF FISHERIES MANAGEMENT OBJECTIVES

2.1 INTRODUCTION

Integral in the process of fisheries management is the use of objectives. They are not always stated explicitly, but every management decision is made with regard to some desired state or set of conditions for the fishery. This desired state of conditions is described by objectives. Even the 'do nothing whenever possible' attitude is a type of objective.

Objectives are one level of a hierarchical management process. At the highest level is the underlying philosophy or set of beliefs on which all management decisions are based. Decisions about this level of management are usually made high in the political structure, often by people far removed from the resource being managed. At the next level are objectives. Their function is to specify in definite terms how the resource is to be managed, in light of the underlying philosophy. Thus, a belief that food production is of paramount importance leads to the objective that the catch from a fishery should be maximised. The next level comprises the management methods used to implement the objectives, and in fisheries restrictions, taxes, subsidies, and a variety of other implementation techniques.

Fisheries management objectives change over time. In a sense, objectives are a synthesis of all of the great variety of information received by fisheries managers, and it is therefore little wonder that as this information changes, so too do the management objectives. The types of information by which management objectives are influenced include the state of the fish stock being managed, traditional management objectives, implementation limitations, the results of previous management attempts, the prevailing attitudes toward resource management in general, and the immediate and future needs of the people for which the fish stock is being managed. These are summarized in Figure 2.1.

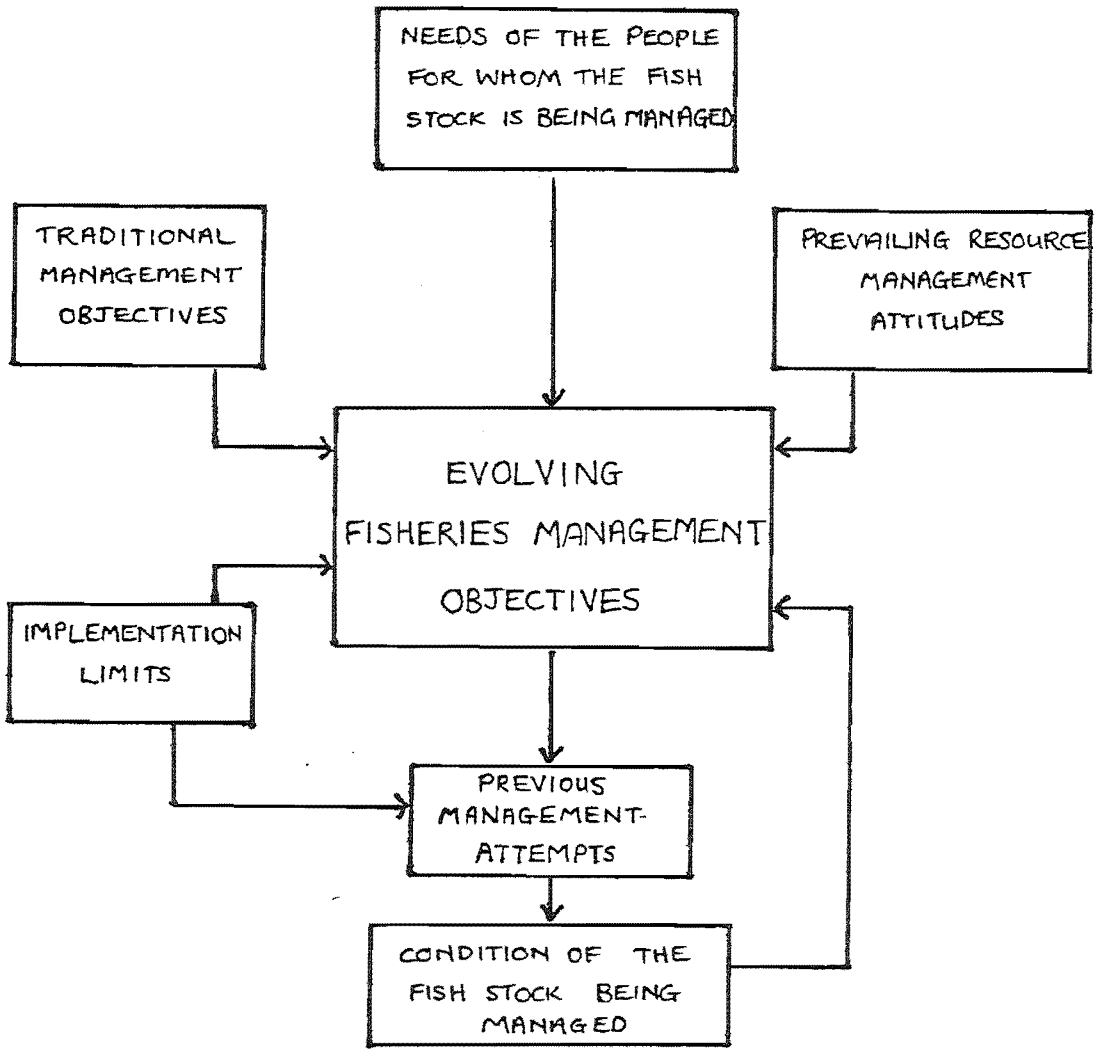


Figure 2.1 Types of information which influence the setting of fisheries management objectives.

As objectives change or evolve, trends are identifiable. Identification of such trends can provide interesting insights into the historical management of a fish stock. For instance, if the management objectives of a particular fisheries management regime can be identified, the effectiveness of the implementation methods used in achieving those objectives can be determined. This can be of value when deciding on new objectives for the fishery, and when choosing new implementation methods.

In this chapter the trends in only two fisheries management objectives are discussed. These are the desired rate of stock exploitation, and the precision with which this rate is derived and applied. The choice of these objectives results from their particular relevance to the Hauraki Gulf Snapper Fishery, the management case study under consideration. Trends in other objectives are alluded to, and to some extent traced, but only insofar as they provide a better understanding of the two major trends being discussed.

The chapter is not a comprehensive history of fisheries management. Instead, the history of fisheries management has been viewed from the perspective of the objectives being considered, and representative ideas, regulations and theoretical work have been picked out to illustrate some of the change in these objectives. Additionally, some of the factors and events influencing their evolution, and the effectiveness with which the objectives as a whole have been applied, are discussed. In particular, the evolution of stock and yield assessment techniques, and of the management methods used to implement objectives, are not discussed in depth in this section. A summary of the evolution of stock and yield assessment techniques is given by Irving (1985), and management methods are discussed in detail by the Central Fisheries Management Planning Team (1984).

2.2 EARLY MANAGEMENT OBJECTIVES

The earliest fisheries management objectives which can be inferred from the literature were apparently contradictory in nature. On the one hand, the 'freedom of the high seas' principle expounded by Hugo Grotius in 1608 (Nielsen, 1976), which has influenced thinking until the present day, implied an objective of freedom to use the sea and it's resources at will. On the other hand, there were examples of regulations which implied a strong stock preservation objective. These include the 1679 Brookhaven, Long Island, regulation whereby only 10 boats were permitted to be used (McHugh, 1978), and the 1714 British regulations controlling minimum mesh sizes and catchable fish length (Russell, 1942). The objectives of the latter regulations were quite clear.

> "And whereas of late years the breed and fry of sea fish has been greatly prejudiced and destroyed by the using of nets of too small size or mesh, and by other illegal and unwarrantable practices: Be it enacted...".

The apparent contradiction in management objectives is easily resolved. Whilst the 'freedom to exploit' objective was of a general nature, the preservation objective applied to specific resources. Another example illustrates this further. As far back as 1278 it was recognised that the fish resource of lakes and rivers were exhaustible and restrictive regulations were enacted, presumably with the objective of preserving the stocks. In spite of these early regulations, sea resources were long believed to be inexhaustible. Thus the general 'freedom' objective held, except where a particular resource was in danger. In many ways this has changed little up to the present day, although the number of resources in danger has increased.

In spite of the nineteenth century belief in the inexhaustibility of the ocean's resources, fishermen knew otherwise, and at times used their own initiative to preserve fish stocks. British fishermen had complained before 1850 that fish stocks and catch rates were declining, but successive commissions investigating the problem concluded that fish stocks were inexhaustible. The strength of their conviction was such that in 1868 all previous restrictions on sea fishing were repealed, thus clearing the way for complete freedom of exploitation. However, the North Sea fishermen voluntarily closed some fishing grounds from 1890 to 1892 in an attempt to prevent complete decimation of the fish stock in those areas (Nielsen, 1976).

During the early fisheries management period there was no exploitation rate aimed for, and therefore no level of precision is attributable. Management consisted of either 'do nothing', in the belief that there was no problem, or of attempts to preserve stocks by reducing fish catches - especially of young fish. This was achieved either by closing fishing grounds, restricting effort, or restricting mesh sizes and the catchable size of fish. As far back as 1873 there was some notion that an optimum yield existed, but its exact size was not known (Neilsen, 1976).

2.3 BIOLOGICAL OBJECTIVES

The late eighteenth century and the early nineteenth century marked the beginning of the great era of the biologist in fisheries management. Most modern fisheries management has revolved around biological objectives, and it is only relatively recently that this dependence on biological objectives has declined, and with it the exalted position of the biologist in fisheries management.

The main objective of early 'biological fisheries managers' was to ensure an adequate supply of mature fish (Russell, 1942). This objective resulted in measures designed to ensure that every fish was allowed to spawn once, and grow to a reasonable size. However, a different view was taken by Peterson (Russell, 1942). He observed that fish grew fastest when young, and advocated the harvesting of young fish to benefit from this high production rate. Furthermore he, and later Armstrong, suggested the possibilty of "thinning out" fish stocks so that the remaining fish would have more food, and hence grow faster (Russell, 1942).

The idea of an optimum yield, as developed by various workers prior to World War Two, is summed up by Russell (1942).

> "Put in a nutshell [the overfishing problem] is this, that up to a point you can increase yield by increasing fishing, but after this maximum is reached the more you fish the less you catch".

Russell also introduced a simple equation describing the size of a fish stock in successive years.

$$S_2 = S_1 + (A + G) - (C + M)$$

where S_2 and S_1 are the stock sizes (in weight) in successive years, A is the weight of new recruits, G is the growth of the original fish and the new recruits, C is the total catch and M is the natural mortality. He concluded that equilibruim (stabilisation) is attained when C + M equals A + G and posed the "natural" question:

"At what level of stabilisation should we get the greatest weight of catch?".

Without explicitly stating it as an objective, Russell seemed to assume that the objective of fisheries management was to maximise the yield (by weight) from a fish stock.

Graham (1943) contributed to the understanding of overfishing with his "great law of fishing". This law states that

"fisheries that are unlimited become unprofitable".

In many respects Graham stated for fishing, what Hardin (1968) later described with such clarity for all commonly owned resources, in his "Tragedy of the Commons". Armed now with the knowledge that a maximum sustainable yield (MSY) exists and that regulations were required to achieve it, fisheries managers set about the task of finding and achieving that tempting but elusive figure.

Larkin (1977) descibes the 10 years after World War Two as the golden age for MSY. Much research was devoted to refining techniques for determining MSY for different fish stocks, and statisticians had no doubts about their employment. Anyone questioning the wisdom of using MSY was ignored. In fisheries management, anything other than biological considerations were the "mistier mumblings of the social sciences".

The precision with which MSY could be calculated increased rapidly during this period. One line of research involved the intensive study of population dynamics. If it were possible to determine all the major factors influencing the fish in a stock, and how the influence of these factors changes with changing population size and exploitation rate, the MSY could be calculated along with the optimum exploitation rate. The calculations involved in this technique are, of course, torrid, and increasingly the fisheries biologist was also required to be a mathematician, if he was to remain a 'comprehensive" fisheries manager. (For those interested in mathematical masochism, Beverton and Holt (1957) cover the fish population-dynamics field very well).

Using somewhat simplier mathematical techniques, Schaefer (1954) developed a technique for estimating the "surplus production", and hence the MSY of a fish stock, from catch-effort data (Figure 2.2). In theory at least, the precision in calculating MSY was high. Unfortunately the precision of application was not.

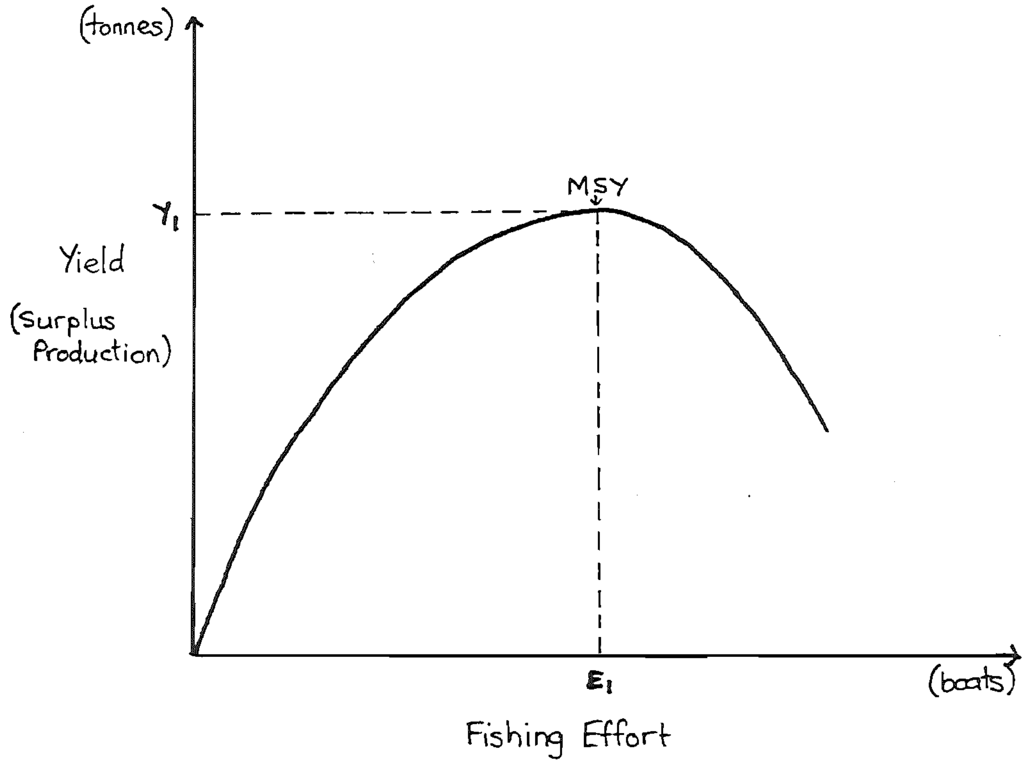


Figure 2.2 The Schaefer surplus production fisheries model, showing the maximum sustainable yield (MSY).

Larkin (1972) in his understandably "confidential" memorandum, described the MSY track record of fisheries managers. He concludes that examples of the management of a fish stock at MSY are very few, and even for these it is not certain whether that objective has been achieved. When the number of successes is compared to the number of attempts, the record is dismal. Larkin concludes:

> "In brief, for all our knowledge, we have not frequently demonstrated an ability for management".

In spite of the fact that attempts to achieve the MSY objective were rarely successful, MSY became the cornerstone of fisheries management. It has been enshrined in numerous local and national legislations, and commonly forms the basis of international agreements. Why did MSY become so ubiquitous in fisheries management, and why has it remained so long? Nielsen (1976) provides some possible answers.

1. "Biologists were charter members of the fisheries management profession". Biology is what biologists know, and their management tools are therefore biological. Since MSY is the only distinctive point in terms of biological yield (apart from extinction or zero production), it was the obvious yield to aim for.

2. MSY is objective and therefore fisheries managers could sidestep political and other pressure for different yields by stressing the need for a biological maximum.

3. Maximising food resources was a worthy public goal.

Most importantly, MSY was something to aim for. In a management field such as fisheries, where virtually every parameter describing the system is in constant flux, it is little wonder that when offered a single definable value, managers should zealously pursue this objective. However, even the advocates of MSY were eventually forced to accept that non-biological factors were important fisheries management considerations.

2.4 "MISTIER" OBJECTIVES

H. Scott Gordon's seminal work on the economic theory of the fisheries (Gordon, 1954) is usually considered as the 'beginning of the end' of MSY, and the dawn of a new era in fisheries management. As Larkin (1977) noted, a few fisheries managers had previously challenged MSY and most managers compromised it at times. However, he suggests that the first group was ignored, and that in compromising MSY, managers "knew that they were sinning". It required a professional in another field to show that biology was not alone in claiming an optimum fishery yield.

Gordon (ibid) showed that the yield at which economic benefits are maximised is likely to be less than MSY. The economic maximum occurs where the difference between costs (assumed to be proportional to fishing effort), and income (assumed to be proportional to yield), is greatest. In Figure 2.3, the Schaefer model shown in Figure 2.2 has been developed further (after Gordon 1954) to show the Maximum Economic Yield (MEY). At any level of effort less than or greater than the level required to catch the MEY, less money is earned. It should be noted that MEY applies to the fishery as a whole and not to individual fishermen. Within the overall MEY, each fisherman maximises his own income, usually by maximising his catch.

After Gordon's work, the theory of fisheries economics received considerable attention by academics. Nielsen (1976) suggests that the increasing preoccupation with determining how to maximise the economic revenue from fisheries (see, for example Christey and Scott, 1965), and the increasing concern over property rights, led to biological criteria being to some extent ignored in fisheries management. This may have been true in the theoretical side of management, but MEY was not widely used in practical fisheries management. Larkin (1972) concluded that,

> "it is very doubtful that any marine or freshwater fishery in the world can be pointed to as a working

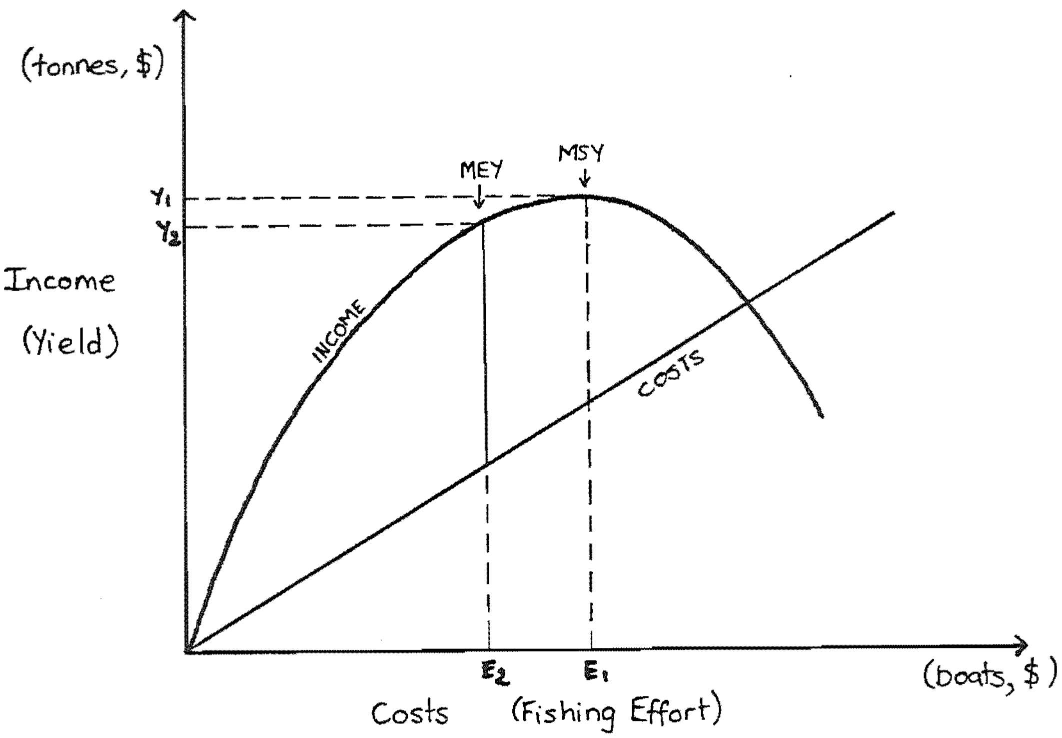


Figure 2.3 The Schaefer model modified to show the maximum economic yield (MEY).

example [of management for MEY]".
Although this might indicate that the concept of MEY in fisheries management has been a failure, MEY served an important role.

In spite of MEY receiving little use in fisheries management, it opened the way for a variety of 'attacks' on MSY. Involved in the attack were the many proponents of 'Optimum Sustainable Yield' (OSY), and, for perhaps different reasons, workers like Larkin (1972, 1977). Some of the criticisms of MSY are listed below since they show the 'requirements' that any MSY-replacement would require. Some criticism of MEY is also included. The criticisms are taken from Larkin (1977), Crutchfield (1975) and Radovich (1975).

1. "MSY may not be sustainable." For a number of reasons, reducing a fish stock to the size which gives the MSY may endanger the stock. Such a reduction reduces the number of spawning age classes, which increases the severity of a failure in egg or larval survival. The fact that many spawning fish are young means that egg quality may be lowered. With a smaller population, the effect of any catastrophic decline in stock is likely to be more severe, and the possibility of depensatory mortality perhaps a major problem. All these factors are complicated by the fact that most fish stocks being managed are not single stocks but comprise a number of sub-stocks, each with different population characteristics. Environmental conditions fluctuate, and where such fluctuations are prevalent, Walters (1980) advocates that harvest rates should be lower than the maximum rates calculated from models.

2. There is usually insuffcient data to be able to calculate MSY. The models used to calculate MSY are just that - models. As such they represent the fish stock, but only to the extent allowed by the amount and accuracy of data on which it is based. With respect to the population-dynamics techniques for calculating MSY, it is still not possible to predict recruitment accurately. Without such fundamental information, yield estimates must remain speculative. The Schaefer surplus production model, which is also commonly used to determine MSY, relies on assumptions which have been shown to be invalid in some circumstances. (For more detail see Section 4.3.2) Cicin-Sain (1978) claims that since MSY is based on incomplete and often competing data, it is not objective, and is therefore

open to political influence.

3. MSY is not an economic yield (see earlier discussion and Figure 2.3)

4. MSY is inflexible and unresponsive to human needs and desires. Firstly, there is no obligation to take the maximum yield from a fish stock just because it is possible to obtain that yield. Money might be better spent obtaining food from different sources, provided different sources exist. Secondly, food is only one of the benefits to be had from a fishery. For example, in a sports fishery it might be more appropriate to manage the stock for maximum abundance, rather than for maximum yield. There are, in addition to these, a host of other social reasons for the argument that yields other than MSY may be the best management objective.

The same criticisms of MSY (with the exception of number 4), apply equally to MEY.

With deficiencies as extensive as these, it is little wonder that the use of MSY as the dominant management objective is declining. Larkin's (1977) epitaph for MSY summarises its problems:

M.S.Y.
1930's - 1970's

Here lies the concept, MSY,
It advocated yields too high,
And didn't spell out how to slice the pie,
We bury it with the best of wishes,
Especially on behalf of fishes,
We don't know yet what will take it's place,
But hope it's good for the human race.

Optimum Sustainable Yield (OSY) is seen by some as the natural successor to MSY and MEY. Others consider it to be of no management value whatsoever. The concept of OSY had its origins in the earlier 'compromises' of MSY noted by Larkin (1977), but was only codified in the early 1970's. It was the focus of a major symposium in 1975 (see Roedel, 1975), and has been the subject of much research since then. It has also formed the basis of the 'new style' of fisheries management, where the biologist and economist no longer play pre-eminent roles.

There are many definitions of OSY. However, in general the various definitions are variations on a similar theme; the yield which maximises the overall benefits to the country which owns the fish stock. Some definitions go further and specify which factors are to be taken into account. Roedel's (1975) definition mentions four factors: biological, economic, social and political values, whilst the Canadian commercial fisheries policy has as its goals,

> "to maximise food production, preserve ecological balance, allocate excess optimally, provide for economic viability and growth, optimize distribution and minimize instability in returns, ensure prior recognition of economic and social impact of technological change, minimize dependence on paternalistic industry and government, and protect national security and sovereignty" (Larkin, 1977).

In short, anything which might contribute to the welfare of anyone in society can be considered when determining OSY. The list shown in Table 2.1 gives an indication of the number of considerations which some workers believe should be included in OSY calculations. The list refers to the implementation of limited licensing, but it is equally applicable to the determination of OSY. Orbach (1978) provides a similar list.

Competing interests in the marine environment

FISHERMEN
- A. Current Fishermen
  - 1. Commercial
    - a. Part-time boat owners/crew
    - b. Fulltime boat owners/crew
  - 2. Sports
- B. Potential Fishermen
  - 1. Commercial
  - 2. Sports

PROCESSORS
- A. Owners
- B. Laborers

SUPPORT INDUSTRIES
- A. Boat Builders
- B. Suppliers
- C. Others

RESOURCE ENHANCEMENT DEVELOPERS

RESOURCE MANAGERS

SPECIAL GROUPS: TREATY INDIANS

ORGANIZED PUBLIC INTEREST GROUPS

COASTAL COMMUNITIES

THE GENERAL PUBLIC
- A. Preservation of resource for future generations
- B. Protein value
- C. Economic value
- D. Product price and availability
- E. Aesthetic enjoyment
- F. Recreation
- G. Preservation of independent life-style option
- H. Preservation of part-time occupation option
- I. Cost/effective management
- J. Public accountability in decision-making

DOMESTIC

Use of fishery resources is circumscribed by competing uses for the marine habitat (other rights and interests):

- Marine transportation
- Navigation
- Habitat protection
- Marine mammal protection
- Marine mining
- Logging
- Road Construction
- Energy generation (dams, nuclear power plants)
- Waste disposal
- Recreation
- Aesthetic enjoyment
- Flood control
- Use of herbicides for agricultural purposes

INTERNATIONAL
- Allocations to foreign fishing
- International negotiations
- Law of the seas

Table 2.1 Social and cultural factors for consideration when calculating OSY. (From Cicin-Sain, 1978).

For each factor used in determining OSY, there is a separate objective. Each objective is the optimum value for the factor as perceived by the fisheries managers or by others contributing to the determination of OSY. For example, if employment is a factor being considered, the objective might be to provide the maximum possible number of jobs - say 1500 - in a fishery. To distinguish this concept from another, introduced below, it is emphasized that an objective is the optimum value for a particular factor. If this value is not attained, the objective is not achieved.

With so many objectives to consider, the determination of OSY is very difficult. Larkin (1977) pointed out that it is impossible to maximise two things simulataneously, let alone a long list of objectives. He goes further by suggesting that OSY, in its interpretation, "is a recipe for heaven or hell", unless some form of priority is possible. Croker (1975), at a symposium on OSY, claimed that OSY is "very difficult to define" and "impossible to achieve", but still useful in that it allows everyone to define their own optimum.

Two main methods have been developed to circumvent the problems of using OSY. The first is to use a compromise between OSY and the earlier MSY or MEY, and the other is to do away with the idea of a single optimum yield. These are discussed below, the former briefly, and the latter in more depth.

Perhaps because of the continuing strong influence of biologists and economists, MSY is often used as a basis for determining OSY. The normal procedure is to start with MSY and modify it as necessary to allow for the multitude of objectives which must be considered when calculating OSY. This is the form of OSY written into many fisheries policies (including New Zealand's policy).

An indication of the momentum gained by MSY is that it, and not MEY, is usually used in OSY calculations, even though the latter would appear more appropriate. Except where food and/or protein is in short supply, the use of MSY is not justified. It could also be said that a profit-seeking country is always short of money, and that MEY is therefore an appropriate starting point for any OSY. Predictably, economists like Crutchfield (1975) and Anderson (1982) are in agreement with such sentiments.

In discussing the second method of circumventing the "OSY problem" it is useful to refer back to the second major objective dealt with in this section. That is the precision with which the desired yield is calculated and applied. Throughout the MSY era (and where it existed, the MEY era), fisheries managers sought to refine their techniques so as to be able to calculate the desired yield as accurately as possible, and manage the fishery to obtain this exact yield. By the time OSY was becoming popular, managers were realising the impossible nature of their task. No amount of research seemed sufficient to obtain answers to problems such as the stock-recruitment relationship, and however intensely one managed a fishery, the desired result was seldom achieved. With the increasing use of OSY, a new approach to the problem is now required.

2.5 SATISFICING

The best description for one new approach is that used by Opaluch and Bockstael (1984). They use the term "satisficing" (presumably from satisfy and suffice), to describe a proposed fisheries management approach where the aim is not to determine or achieve an optimum level, but rather to achieve,

> "an acceptable range of target levels of effort."

Only approximate biological, social, and economic minimum requirements would be needed to define the acceptable range, and so the amount of research required to be carried out on fish stocks would be considerably reduced. Although Opaluch and Bockstael (ibid) do not describe the origin of the term satisficing, it has been used by Simon (date unknown) to describe a method of achieving compromise between specialist and general interests in management conflicts.

Using different terminology, Pope (1983) described a similar process. He identified a number of trade-offs which have to be made in managing a fishery and graphed them on a very complicated-looking set of triangular axes (Figure 2.4). He then listed some possible constraints. These he termed "whinges", since the overall aim of the approach he advocates is that of managing for the "minimum sustainable whinge" (MSW). The four whinges he identified are shown below, and each is shown as a constraint in Figure 2.4.

Whinge 1. Marketing managers might consider that catching less than 75% of the MSY might annoy consumer or retail organisations and lead to complaints that management was solely to profit fishermen and not the consumer.

Whinge 2. Scientific advisors might consider that taking the full MSY might lead to variable annual catches. They might advise therefore that only 90% of the estimated MSY be taken.

Whinge 3. Fishermen's organisations might object to employment dropping to less than 60% of the maximum possible.

Whinge 4. Vessel owners' organisations might argue that unless profits were at least 10% of costs there would be a crying need for subsidy.

The area defined by these constraints is the area which satisfies all the whinges, thus keeping everyone (that is, everyone whose whinge was noted), happy. In light of Larkin's (1980) advice to fisheries managers to,

> "pursue whatever option is available in engendering greater public satisfaction",

management by such a concept would appear to have considerable merit. Now, instead of aiming for an OSY the manager aims to achieve ASY (Adequate Sustainable Yeild).

The concept of satificing is a pragmatic response to the problems of fisheries management. As shown earlier, it has usually proven impossible to accurately calculate MSY for a fishery. In the satificing approach, complete accuracy is not sought, but instead a relatively safe maximum yield is determined. Obviously, the more accurately this figure is known the higher the yield can safely be set. However, since optimization of yield is not required, large amounts of money need not be spent in research to try to get ever closer to the maximum yield.

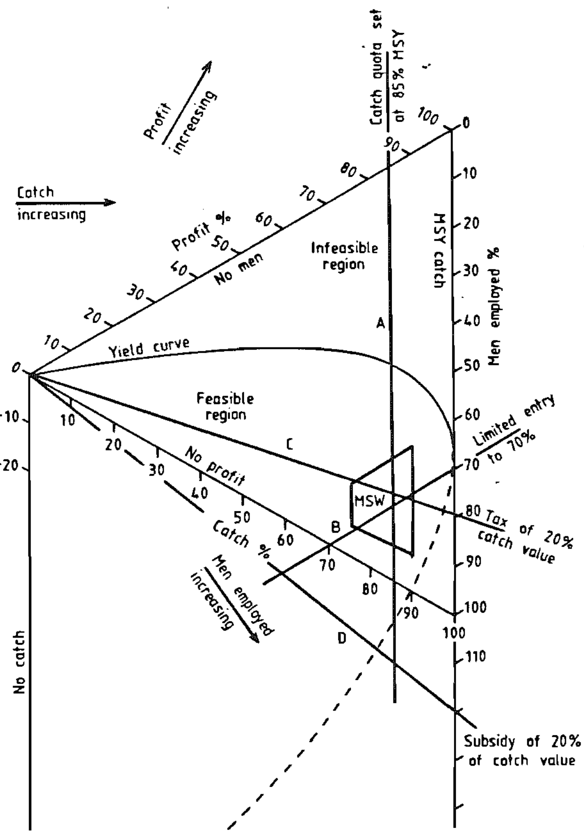


Figure 2.4 Triangular diagram with a catch constraint (TAC), man-power constraint, landing tax, and landing subsidy related to the MSW target area. (After Pope, 1983).

Similarly, there is uncertainty in the implementation side of management. Anderson (1984) has pointed out that regulations used in implementing management objectives,

> "must be viewed, directly or indirectly, as another source of uncertainty."

Hannesson (1984) went further and asserted that the whole structure was a source of uncertainty. He suggested that whilst increasing management may reduce the natural uncertainties regarding fish stocks, natural uncertainties may be replaced by institutional uncertainties. This uncertainty spells doom for any attempt to satisfy objectives completely, but if instead objectives need only be satisfied, this uncertainty can be planned for and coped with.

The satisficing process can be used intuitively or as the basis for mathematical calculations. In theory at least, any number of objectives can be included in the process, provided their relationship to other objectives is known. When a large number of variables are considered together, computer-based calculations become necessary, but regardless of size, the principles used in the process are the same. The process is described in more detail in Chapter Six.

An important point to note when considering the process of satisficing is that a 'satificed' area may not exist. Larkin (1977) and Anderson (1982) have shown that more than one objective cannot usually be achieved. In fact, Anderson (ibid) suggests that if objectives are true objectives, and not just management perspectives, they will conflict. Since in the satisficing process, objectives need not be achieved in full, but only satisficed to some specified level, it is possible to satisfice more than one objective. Whether or not all objectives are satisficed depends on the number of objectives, the levels at which they are satisficed, and of course, the nature of the fishery.

Even when it is not possible to satisfice every objective, much can be learned from the satisficing exercise. First, the objectives which are not satisficed, and the extent to which they are not satisficed, can be determined. This gives an indication of how loud the remaining whinges will be, and whether they are acceptable. Second, it can often be determined how much the minimum requirements of the objectives would have to be changed for a particular objective to be satisficed. As Pope (1983) commented after presenting his paper,

> "you had to decide who you were prepared to have moaning and who you were not prepared to have moaning."

Information obtained from the satisficing process should be invaluable for making this decision.

2.6 STATEMENT OF OBJECTIVES

Before concluding this chapter it is of interest to briefly consider the recent trend in a feature of fisheries management. This feature is the degree to which objectives are explicitly stated, and the recent trend (or desired trend) is toward their being more explicitly stated. It will be shown that this trend is of particular relevance to the problems of achieving OSY, and to the process of satisficing.

In the past, fisheries management objectives have rarely been stated explicitly (Larkin, 1972, 1977). When implementation methods have been used to manage fisheries, the predicted (or hoped for) results of these methods are usually "vague and fluffy". Thus, when the results of a management strategy become known, it cannot be determined if the strategy has succeeded, because the predictions or objectives are stated in such a general and conditional way that they are always achieved. This form of management experience can contribute little to refining future management objectives.

Both Larkin (1972) and Anderson (1982) emphasise the need for management objectives to be explicitly stated. Anderson (ibid) stresses that they must be stated in such a way that success and failure criteria are unambiguous and quantifiable. Only then is it possible to evaluate whether a management strategy is successful. This 'openness' also has an important role in modern fisheries management in general.

In both managing for OSY and in the process of satisficing, it would be unusual for everyone to be kept happy. Objectives will certainly not all be achieved and will probably not even be satisficed. If fisheries managers can accept that achieving multiple objectives is impossible, and thereby acknowledge that they themselves are not necessarily at fault if objectives are not achieved or satisficed, fisheries management will become more realistic. Instead of the public being led to believe that with sufficient expenditure on fisheries management, all objectives can be achieved, they can be told that achieving, and usually even satisficing, all objectives is impossible. Managers can then select and state their priority objectives and set about satisficing them without having to attempt to achieve every objective. To some extent this is occurring, especially in severely overfished fisheries where managers have been forced to acknowledge that they cannot achieve their multiple objectives. However, a clear statement regarding the limits of fisheries management would in most cases be of great value.

It has been shown that there have been major changes in management objectives during the history of fisheries management. At first a combination of stock preservation and 'freedom to exploit' objectives resulted in apparent conflict between various management measures. Stock preservation measures then became more sophisticated as the biology of fish stocks became better understood, and eventually in the 1930s the concept of MSY was introduced. MSY remained the dominant management objective until the 1970s, in spite of increasing evidence that the MSY concept was limited in accuracy and implementability, and was only one of a number of possible yield objectives. The momentum of MSY was such that MEY did not receive much attention by managers before the concept of OSY was introduced.

OSY, although virtually impossible to define, is an acknowledgement that many factors are important in the management of fisheries. Of the two methods being developed to cope with the problems of determining and implementing OSY, one uses MSY or MEY as a baseline yield for later modification, and the other involves satisficing. In the process of satisficing, the achievement of every objective is not sought. Instead, a reasonable minimum level of each objective is aimed for. By redefining the aim of fisheries management, satisficing brings successful management into the realm of possibility, but still cannot usually please all parties with interests in the fishery.

There is a need for management limits and objectives to be stated clearly. Then those who are not pleased with the outcome of management decisions will at least understand why the decisions were made the way they were, even if they do not agree with the reason.

CHAPTER THREE

NEW ZEALAND FISHERIES MANAGEMENT

New Zealand fisheries management has been influenced by world fisheries management trends but has retained its independence in a number of aspects. In the previous chapter the trends of two major fisheries management objectives were described. This chapter is a more general overview of the development of fisheries management in New Zealand. Where possible management objectives have been identified, although the sometimes erratic development of this country's management makes this identification difficult for some periods. The history of New Zealand fisheries management up to the late 1960s, and the events and personalities by which it has been influenced are discussed by Slack (1969) and it is upon this work that most of the following account is based.

Five more or less well defined phases can be seen in the evolution of New Zealand fisheries management. In two of these phases the major objective has been to develop the great potential of our fisheries resources, in another two the objective has been to conserve fish stocks by limiting catches. It must be noted that during no phase were all the enacted regulations consistent with the prevailing theme or attitude.

Phase one of New Zealand fisheries management lasted until about the end of the nineteenth century. Most of the regulations enacted during this time were restrictive in nature, emphasising the protection and conservation of stocks and specifying penalties for infringing the various limitations in force at the time. It can be inferred from the type of regulations which existed that the overall objective of fisheries management at this time was to preserve stocks, although whether this was a stated objective is unknown. Clearly, New Zealand fisheries management by this stage must have been sufficiently removed from the influence of British fisheries management that it did not follow the 1868 British example of repealing all restrictions on fishing. There was however some assistance for fisheries development. In 1885 the Fisheries Encouragement Act, promoted by the then Prime Minister, Robert Stout, established the portfolio of Minister of Marine, and provided for land to be set aside for fishing villages and for the payment of an export incentive. This incentive was paid up to 1904.

The start of the second, predominantly development-oriented phase of fisheries management was ill-defined. The licensing of all fishing boats and the introduction of statistical returns required by the Ammendment Act of 1903, and the many restrictions in the major Fisheries Act of 1908 may be seen as a continuation of the earlier restrictive phase. However there were definite 'pro-development signs'. To assist the fishing industry the Government organized a series of two coastal and two deepwater trawl surveys in 1900-01 and 1907 respectively. The then Chief Inspector of New Zealand Fisheries, L. F. Ayson, reported that although the surveys were preliminary in nature, they revealed that there were immense areas of suitable grounds for trawling off the coast of New Zealand and that fish were abundant.

To assist in the development of the industry, outside help was sought. In 1914 the House of Representatives secured the services of a Canadian fisheries expert to advise and report on New Zealand's fisheries. Professor Prince spent four months in New Zealand and submitted reports with many recommendations, which on the whole promoted the expansion of the fishing industry. The recommendations covered such topics as increasing the sizes of fishing boats, providing various financial incentives for fishermen, providing fishermen with technical instruction, developing new products and markets, increasing fisheries research work, and creating a fishery department. Prompted by further recommendations in 1918 from Ayson the Government set up a Fisheries Commission, and in 1919 passed the Fishing Industry Promotion Act.

Among other provisions the Act allowed for 25000 pounds annually, in loans of up to 5000 pounds, to be allocated to assist in the development of any sector of the fishing industry. In spite of the fact that very little of this money was ever made available to the fishing industry, the industry continued to develop through the early 1920s. Slack (1969) suggests that

> "had Ayson remained as Chief Inspector of Fisheries, it seems likely that a steady growth of the industry might have prevailed..."

As it was, he retired in 1926 and phase two of New Zealand Fisheries Management ended.

The start of New Zealand management's policy's third phase was abrupt. A. E. Hefford succeeded Ayson as Chief Inspector of Fisheries and immediately imposed his own very different objectives on fisheries management in New Zealand. His emphasis was on the preservation and conservation of the country's fish stocks, most of which he seemed to believe were depleted or in immminent danger of becoming so. Most of his recommendations were aimed at restricting the industry, even during the depression when economic factors, rather than reduced fish stocks, caused a major decline in fish landings. This pessimistic view was, in time, taken up by some Parliamentarians who requested that a Commission of Enquiry look into sea fishery resources in general and the fishing industry in particular.

The overall theme in the Committee's recommendations can be inferred from a summary of the Committee's report (Anon, 1938):

> "there is a need for conservation at many points in order to ensure the continuity of supply of [fish]".

Although only 37 of the recommendations were restrictive in nature, most of the remainder encouraged improvements in the conditions of the present industry rather than the expansion of the industry. Hefford's 'anti-export' view was adopted by the Committee and the phasing out of exports was among its recommendations. As a result of the Committee's recommendations, in 1937 all sections of the fishing industry were licensed under the Industrial Efficiency Act, with the Marine Department as the sole licensing authority.

The conservation theme continued to be developed through the 1940s. The 1945 Fisheries Ammendment Act ("to make better provision for the conservation of sea fisheries"), required that all fish catches be unloaded at the boat's specified home port, a provision that at times severely restricted fisheries development. The act also relicensed the catching sector under the control of the Marine Department. Although Hefford retired in 1946, his influence remained. It is noted in the Report of the Fishing Industry Committee (Anon, 1963) that,

> "the most common ground for declining licence applications has been that of conservation of fish stocks."

This restrictive preservation-oriented management of New Zealand's fisheries continued for many years.

Like the earlier development phase, the start of the fourth phase of New Zealand fisheries policy cannot easily be defined. On the official front, in 1958, the Secretary of Marine reported that the 1957 Fishing Industry Advisory Council saw the need for a new licensing system. On the popular (or unpopular at times) front, Professor Richardson of Victoria University brought attention to what he saw as New Zealand's under exploitation of its large fisheries resource. Some controversy ensued, but it was the increasing presence of Japanese fishing boats in New Zealand waters from 1959 which had the greatest effect in challenging the 'Hefford-outlook' on New Zealand fisheries. The Report of the Fishing Industry Committee (Anon, 1963) indicates the influence of these occurrences.

> "[The Japanese presence] did cause an awakening to the fact that if vessels could come all the way from Japan and fish in New Zealand waters, the industry in New Zealand should be capable of expansion."

In 1961 a select committee was formed to inquire into and report on the fishing industry in New Zealand. The committee's investigation was thorough and its recommendations extensive. The overall objective appears to have been to free up the fishing industry and promote its development. In stating what it believed to be the objective of fisheries management, the Committee left no doubt that it advocated MSY and not MEY or any other yield.

> "In the interest of the nation the objective of fisheries management should be the harvesting of the maximum amount of food from our marine resources and not the maximum financial return individually to those engaged in the industry" (Anon, 1963).

Of major importance were those recommendations which resulted in both the relaxation of the fishing boat licensing system, and the establishment of the New Zealand Fishing Industry Board, whose overall function was to promote the fishing industry of New Zealand.

The remaining years of the 1960s and the early 1970s saw the development of the fishing industry as recommended by the 1961 Select Committee. New fishing methods were demonstrated and adopted, the Fisheries Research Division of the Marine Department was established, and money was made available for the purchase of new fishing boats. Although once again only a small proportion of the allocated money was actually used to provide loans, investment in the fishing industry increased rapidly during this time.

The transition to the present phase of fisheries policy was in a sense dramatic. Throughout the 1970s, expansion of the fishing industry had been rapid. The territorial limit had been extended to 12 miles in 1967, and on April 1, 1978, New Zealand's 200 mile Exclusive Economic Zone (EEZ) came into existence. As part of its "Think Big" strategy, the Government promoted the rapid development of the New Zealand fishing industry to exploit the country's new fish resources. Included in the promotion measures were the provisions for duty-free imports of fishing boats (MAF, 1979), and for the formation of joint venture agreements between New Zealand and overseas companies (Clark, 1984). Rapid development of the fishing industry did occur, but the increased fishing effort was not restricted to the new deepwater sections of the EEZ (Jarman, 1983). Instead fishing effort increased in the inshore fisheries, some of which were already overfished. Thus, only a few years after the declaration of New Zealand's EEZ, it became apparent that unless immediate measures were taken to protect inshore fish stocks, disaster was imminent.

Whilst the management of the deep-sea fisheres proceeded smoothly, the inshore fishery was in turmoil. To allow more time in which to develop new fisheries policies, a moratorium on the issue of fishing licences was declared in October 1980 (MAF, 1982a). In another interim measure in March 1983 the Hauraki Gulf, one of the hardest hit fisheries, was made a controlled fishery under the provisions of the 1977 Fisheries Ammendment Act.

At about this time the National Fisheries Management Advisory Committee (NAFMAC) was established to,

> "consider and advise on matters of importance related to the fishing industry".

This it did. The discussion document produced by the Committee (NAFMAC, 1983) summarized the extent of the overfishing problem and presented various alternatives by which the situation might be remedied.

Following one of the alternatives suggested by NAFMAC (1983), it is proposed that in the latter part of 1985, an effort reduction scheme will be implemented, to be followed by a fishery resource allocation system based around individual transferable quotas (ITQ's). The effort reduction scheme will primarily involve a "buy-back" of the rights of fishermen to fish. Those fishermen remaining in the fishery will be allocated a quota related to their catches in previous years. The quota entitles the fishermen to catch a specified quantity of fish in a year, and quotas may be bought and sold in whole or in parts. Details of the ITQ buy-back proposals are explained in MAF (1984b, 1984c).

In October 1983 the long awaited Fisheries Act became law. It was the culmination of many years of work and discussions by those involved in the fishing industry, and was designed to provide both immediate measures to alleviate inshore fisheries problems, and a framework within which other measures could be implemented. The Act provided for the establishment of a new, regionally-based fisheries management system in which regional fisheries management plans play an important part. The regional management system has been set up and various stages of the fisheries management plan process are presently underway. Although the management structure is quite distinct from the proposed buy-back and ITQ proposals, the ITQ system will be implemented within the regional management set-up (MAF, 1984d).

The overall objective of the fifth phase of New Zealand Fisheries Management can be inferred both from the aims of the buy-back and ITQ 'package', and from the stated purpose of the fisheries management plans. The two major aims of the package designed to restructure the inshore finfish fisheries, are as follows:

(a) Achieving long term continuing maximum economic benefits from the resources;

(b) Preserving a satisfactory recreational fishery.

(From MAF, 1984)

These appear to advocate a management approach with MEY as the primary objective, with some allowance for recreational fisheries, but not for any other considerations. However in the list of 'principles' on which the restructuring proposals are based, further 'objective-like statements' are found (MAF, 1984d). These include efficient harvesting of the resources, equitable distribution of catches, maximising fishermens' flexibility in harvesting, and enhancing - not just preserving - the recreational fishery.

The objectives which can be inferred from the stated purpose of management plans are more explicit, but follow along the same lines. In the 1983 Fisheries Act, that purpose is,

> "to conserve, enhance, protect, allocate and manage the fishery resources within New Zealand fisheries waters having regard to the need for:
>
> (a) Planning, managing, controlling, and implementing such measures as may be necessary to achieve those purposes;
>
> (b) Promoting and developing commercial and recreational fishing;
>
> (c) Providing for optimum yields from any fishery and maintaining the quality of the yield without detrimentally affecting the fishery habitat and environment.
>
> ""Optimum", in relation to the maximum sustainable yield from a fishery, means the maximum sustainable yield from that fishery, modified for the purposes of a management plan by any relevant economic, social, recreational, or ecological factor."

The objectives are fairly typical of those based upon the concept of optimum sustainable yields, although it is interesting to note that MSY remains the baseline yield, to be modified as appropriate.

It appears that in intent at least, the present phase of fisheries management policy lies between the earlier, development-oriented and preservation oriented management phases. Although there is at present, a preoccupation with reducing excess fishing effort in over-fished fisheries, this does not mean that the policy is especially preservation-oriented. Other parts of the policy encourage the development of commercial and recreational fisheries. Like the OSY concept on which it is based, the policy is an attempt to account for all possible management objectives, including the of expansion of the fishing industry, and preservation fish stocks. Depending how the Act is interpreted, it could be used to emphasise either of these management objectives.

CHAPTER FOUR

THE HAURAKI GULF SNAPPER FISHERY

4.1 INTRODUCTION

In order to effectively discuss management options for a fishery it is necessary to be aware of at least some aspects of that fishery. Hefford (1929), explained that,

> "a proper appreciation of Fishery conditions, and particularly an answer to the question as to whether they are as satisfactory as they might be or ought to be, can only be obtained by reference to the past - by comparison of present conditions with those of the past and by studying the trend of affairs over intervening years".

This chapter provides some of the background information required for such a discussion of the Hauraki Gulf Snapper Fishery. Section 4.2 contains a brief description of some physical aspects of the Hauraki Gulf, Section 4.3 outlines the general biology of the snapper and the size of the Hauraki Gulf snapper stock, and in Section 4.4 the history and present status of the snapper fishery are discussed. Section 4.5 is a discussion of the regulation and management of the Hauraki Gulf Fishery.

In spite of being New Zealand's most studied, and best known fishery, our understanding of some aspects of the Hauraki Gulf Snapper Fishery is poor. This is in part due to the complexity of the fishery. However, it is also a result of inadequate, and at times inappropriate fishery data collection, and of the limited amount of research conducted on some aspects of the fishery.

4.2 THE HAURAKI GULF

Boundaries

The Hauraki Gulf is a large embayment on the north-east coast of New Zealand's North Island, bounded generally by the Coromandel Peninsula and various islands. However, defining the precise boundaries of the Gulf is not straightforward. Various geographical, hydrological, and demographic factors, and their interpretation by writers of different reports, laws and statistical systems, have combined to make the historical definition of its boundaries imprecise.

From a geographical perspective, the Gulf is best described as the area south of a line drawn between Cape Colville and Cape Rodney (Figure 4.1). This area is usually referred to as the "Inner Gulf", or the "Gulf Proper" (Paul, 1967). Hydrologically speaking, the Gulf is larger than this. Mercer (1979), in his report of hydrological research conducted on the northeast coast of the North Island, concludes that the mass of water within a line from Cape Colville to Great Barrier Island to Little Barrier Island to Cape Rodney, is distinct from the water masses surrounding it. He bases this conclusion on temperature, salinity and tidal data. Use of fishing activity provides only limited guidance for setting boundaries. The Inner Gulf is fished mainly by boats based in Auckland, Thames and Coromandel, but these same boats fish other areas as well, with the larger trawlers venturing as far as the Mahia Peninsula (Paul, 1977). The activities of smaller longlining boats would correspond more closely to the geographical Gulf although they tend not to fish the centre of the Gulf area.

Different boundaries have been used in each of three fisheries data collection systems used in the Hauraki Gulf. Area 3 of the Marine Department system used from 1936 until 1982 comprised the area within a line from Bream Head to Mokohinau Island to Great Barrier Island to Mercury Island to Tokarahu Point. Publications by Paul (1974, 1976, 1977), and Vooren and Coombs (1977) specify similar boundaries.

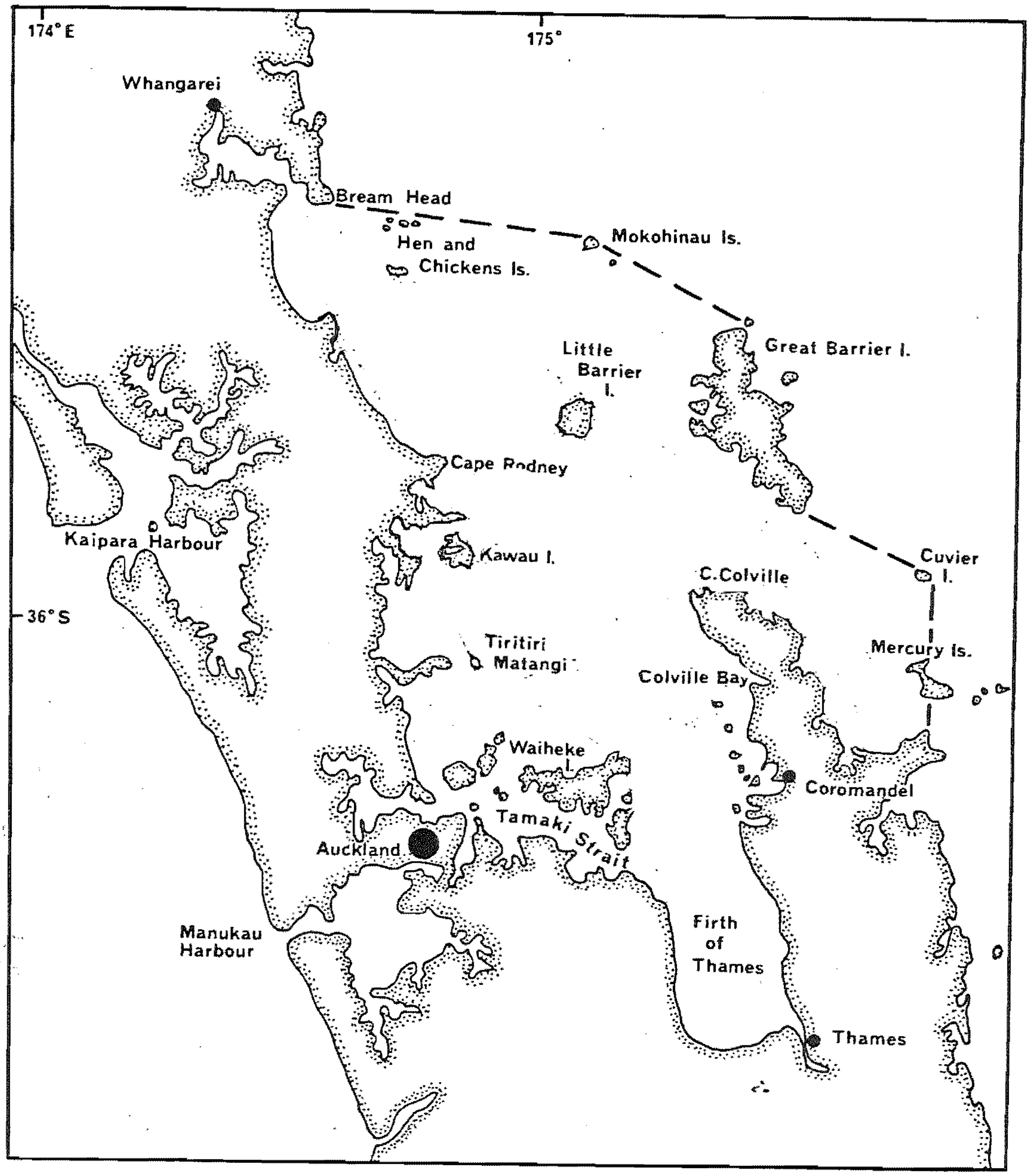


Figure 4.1 The Hauraki Gulf region. (Modified after Paul, 1977).

The inner and outer Gulf areas are separated by the new statistics system introduced by the MAF in 1982. Areas 006 and 007 comprise the inner Gulf, and area 005 includes the area inside a line from Cape Colville to Great Barrier Island to Bream Tail (Figure 4.2). The Hauraki Gulf Controlled Fishery, which came into existence in 1983 comprises the new statistical areas 005, 006 and 007. However this definition of Gulf boundaries has not been used by other government departments. In the "Census of Fishing", published in 1982 by the Department of Statistics, the Gulf area is divided through the Firth of Thames so that the Thames - Coromandel area is combined with the Bay of Plenty, and the remainder of the gulf with Auckland West Coast fishing areas. Although the different boundaries are in the most part only an inconvenience, the differences in statistical areas reduce the usefulness of the available data on the Hauraki Gulf Fisheries.

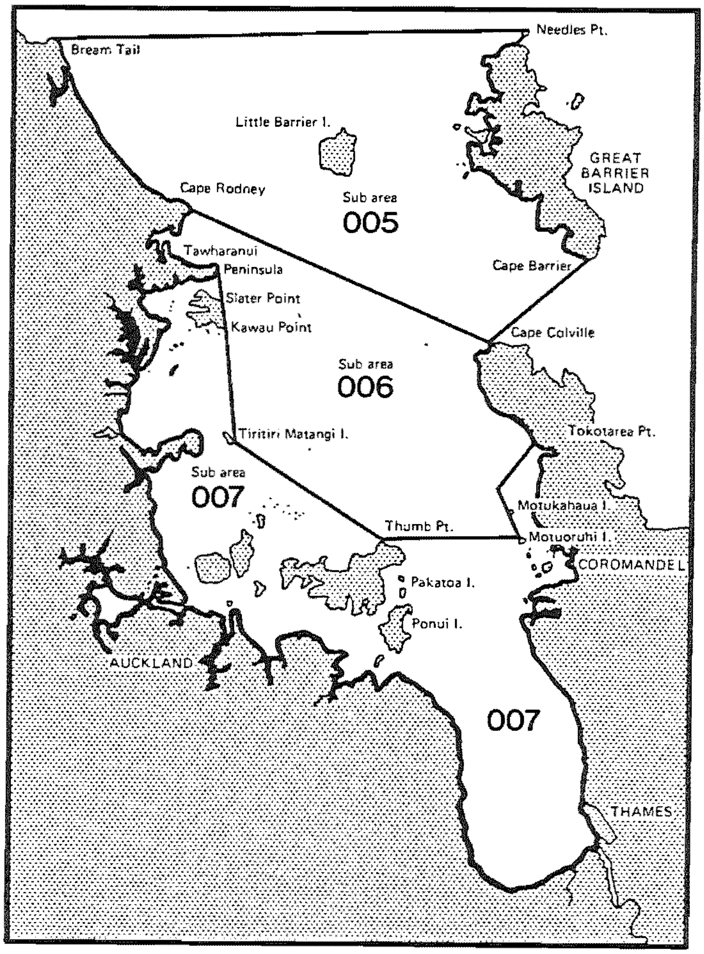


Figure 4.2 The Hauraki Gulf, showing fishing areas 005, 006 and 007. (From MAF, 1984f).

Geography and Hydrology

Paul (1968) described the general geography of the Hauraki Gulf. The inner Gulf is approximately 2400 km in area, 112 km of which consists of shallow harbours, and 1800 km of which is less than 40 m deep. Using the outermost boundaries, the outer Gulf is approximately 3350 km and is mostly between 40 m and 100 m deep. Bottom substrates range from fine mud where depths are less than 20 - 30 m, to sandy mud at about 100 m depth. Fine sand occurs in the Colville Channel and on beaches north of Cape Rodney. Although there are some reefs and areas of 'foul ground', most areas of the Gulf are relatively clear of obstructions.

The hydrology of the Gulf has been described in varying detail by a number of writers. Selected temperature and salinity readings from Mercer (1979) are shown in Table 4.1 as representative of hydrological conditions in the Gulf. The results of this 1973-74 survey are similar to those reported by Paul (1968) for a 1965-66 survey.

Table 4.1 Typical seasonal variations in water temperature and salinity in the Hauraki Gulf (after Mercer, 1979).

	Temperature °C		Salinity ‰	
	Surface	Bottom	Surface	Bottom
Firth of Thames	13.5 - 22.5	12.8 - 20.3	34.27 - 35.57	33.40 - 35.12
Central Gulf	14.2 - 22.5	13.5 - 19.6	34.34 - 35.62	34.78 - 35.62
Outer Gulf	15.6 - 21.7	14.5 - 18.6	35.11 - 35.55	35.27 - 35.54

Paul (1968) observed that thermal stratification occurs in spring and summer, and that thermoclines are irregular in position and size. Near-shore surface temperatures decrease rapidly in autumn and the Gulf is isothermal through winter.

The Gulf, especially its outer areas, is influenced by the the East-Auckland Current. It is this current which is largely responsible for the sub-tropical temperatures experienced in the Gulf area. Within the Gulf, current direction is generally southward into the Gulf on the flooding tide and northward from the Gulf on the ebbing tide. These general tidal flows are disrupted in the vicinity of the numerous Gulf Islands.

4.3 THE SNAPPER

4.3.1 General Biology

The snapper is New Zealand's most studied fish. Since its description by Forster in 1801, a variety of studies have focussed on aspects of this species including its distribution, feeding, growth, reproduction, population structure, and commercial exploitation. Crossland (1981) summarized much of this work, and unless otherwise referenced the information presented in Section 4.3 is based on this publication.

Although invariably known as snapper, Chrysophrys auratus (Forster, 1801) (Figure 4.3) belongs not to the true snappers (family Lutjanidae), but to the sea bream (family Sparidae). Attempts have been made to reclassify C. auratus and the similar Australian species C. unicolor and C. guttulatus as a single species Pagrus auratus, but these attempts have been unsuccessful (Paul, 1976). Although "Bream" or "brim" are used by some fishermen to describe small snapper, the species is in the most part known simply as snapper. The maori name "tamure" is no longer in common use.

C. auratus is found only in New Zealand waters. It is most abundant in northern waters, its range limited by the lower water temperatures found further south. Figure 4.4 shows the relative abundance of snapper in New Zealand coastal waters. Although generally uncommon in South Island waters, the warmer waters of Tasman Bay and the Marlborough Sounds support moderate sized snapper populations.

There is biochemical evidence (Smith et al, 1978) to suggest that the New Zealand snapper population comprises two, and possibly three, genetically distinct stocks. The two main stocks are found in East Coast and West Coast waters with South Island snapper belonging to the West Coast stock. There may be some mixing of these stocks in the Ninety Mile Beach area. Hawkes Bay snapper, although on the East Coast,

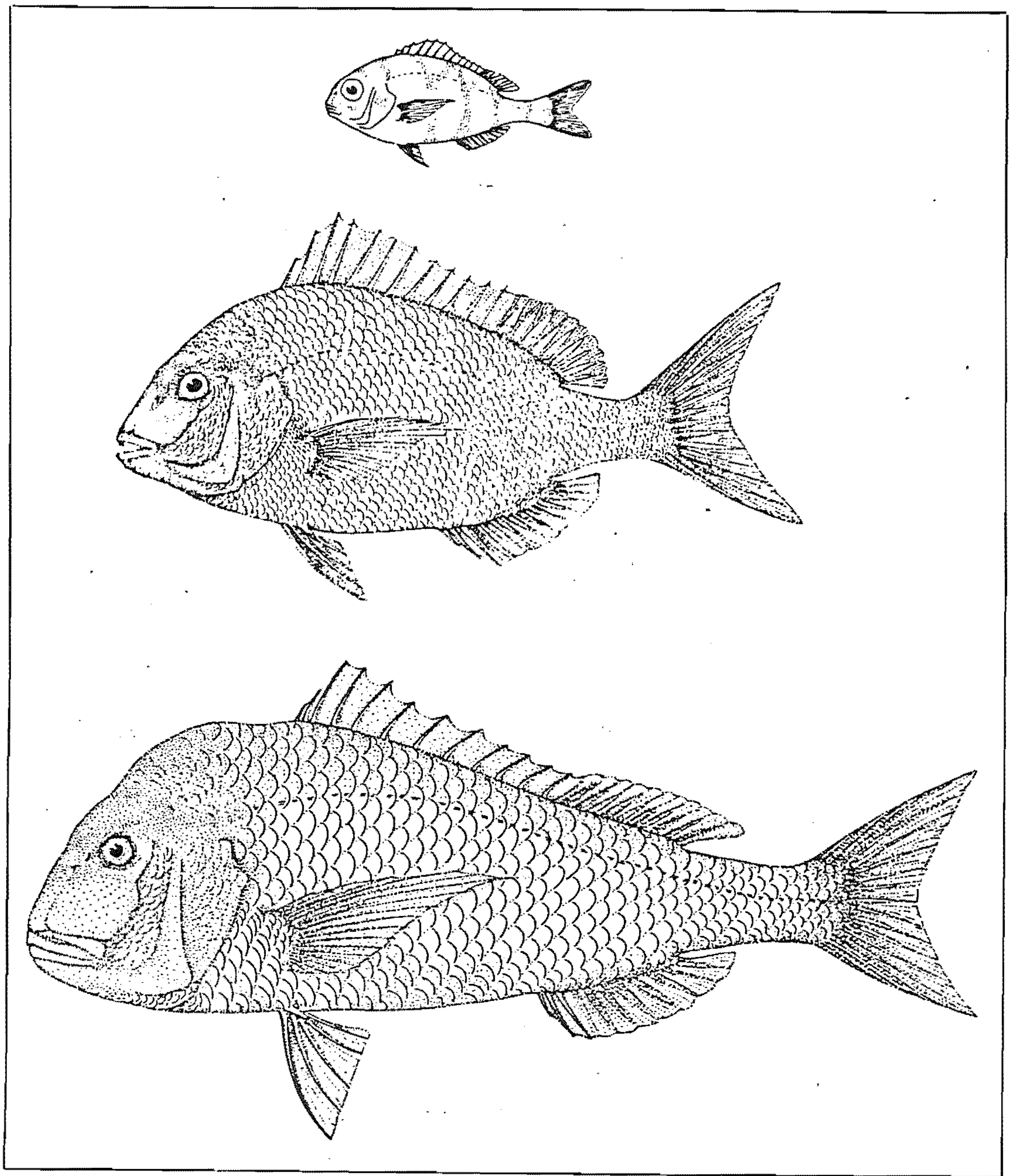


Figure 4.3 The New Zealand snapper, *Chrysophrys auratus* (Forster, 1801). Top: 0-year juvenile about 3 months old, about 4 cm long. Middle: Small adult 6–10 years old, about 30 cm long. Bottom: Large adult over 25 years old, about 75 cm long. Each drawing has been generalised from several specimens, and the three do not conform to a common scale.

are most similar to West Coast stocks and may comprise a third stock. The genetical differences which separate the stocks may be influenced by water temperatures.

In many respects the snapper is an opportunist. Its range extends from shallow water to depths of about 200 m, and it is found on mud, sand, and rock substrates in bays and harbours and on open coasts. In northern waters it is usually the most common demersal species in areas of sand and

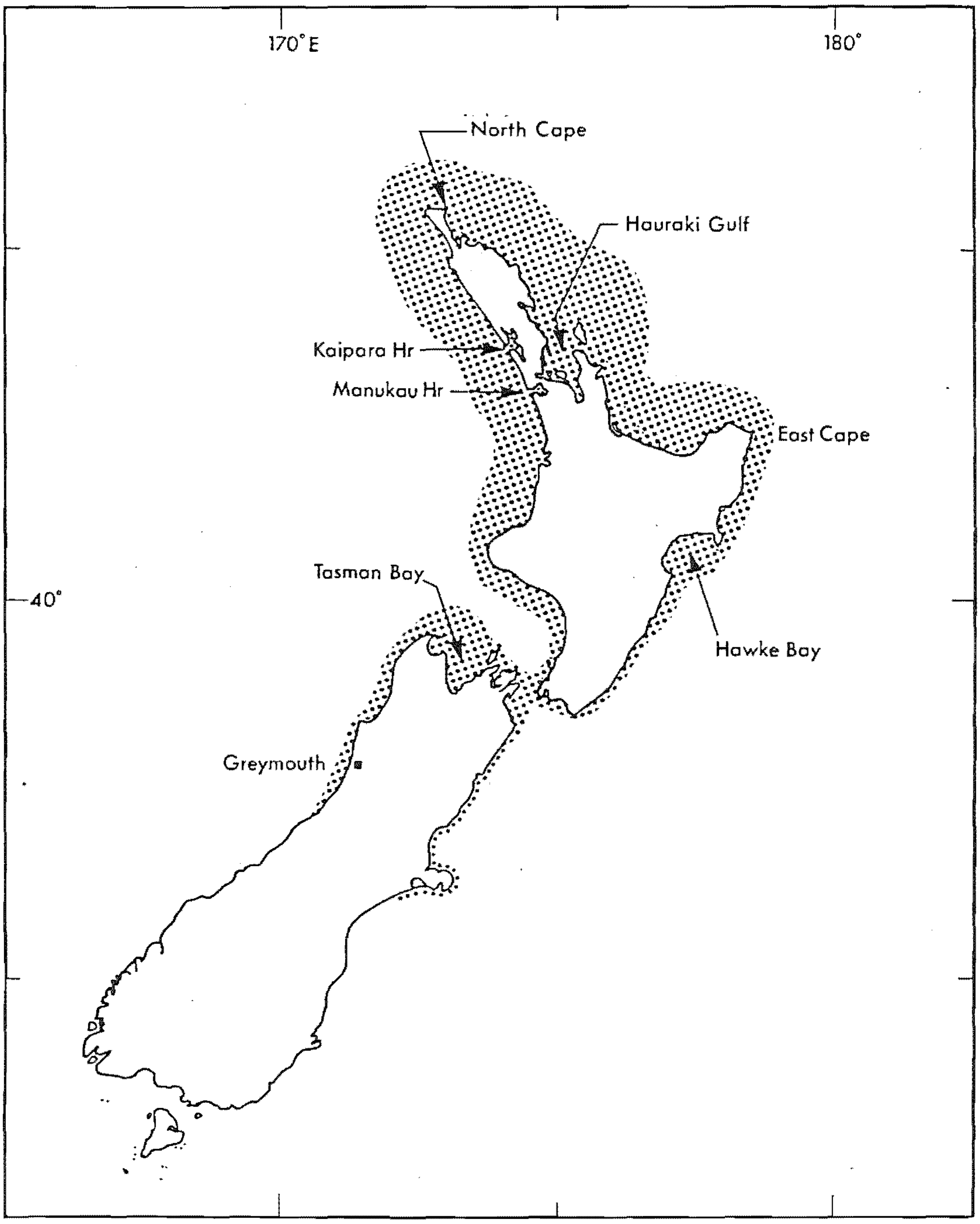


Figure 4.4 Distribution of snapper. The width of the hatched area approximately indicates abundance (from Crossland, 1981).

mud, although it is less common where the substrate is rocky, and in southern waters. In general, small juvenile snapper are found in shallow water and larger juveniles in progressively deeper water, but there appear to be no distinct nursery grounds (Paul and Elder, 1979). The winter movement of snapper away from the coast is more distinct in sexually mature fish (Paul, 1976).

The snapper is similarly an opportunistic feeder. Stomach content analyses have shown that snapper eat whatever food is available in the greatest abundance, and that they are not species selective. Figure 4.5 gives an idea of the range of food eaten by the snapper. Although there is no difference between the diets of male and female snapper, diet changes with size. Small snapper tend to eat mainly soft-bodied animals whereas the adult diet contains numerous hard-bodied animals such as sea eggs, brittle stars, and shellfish. Young fish feed throughout daylight hours but larger fish feed mostly in the morning. There are only slight annual variations in feeding.

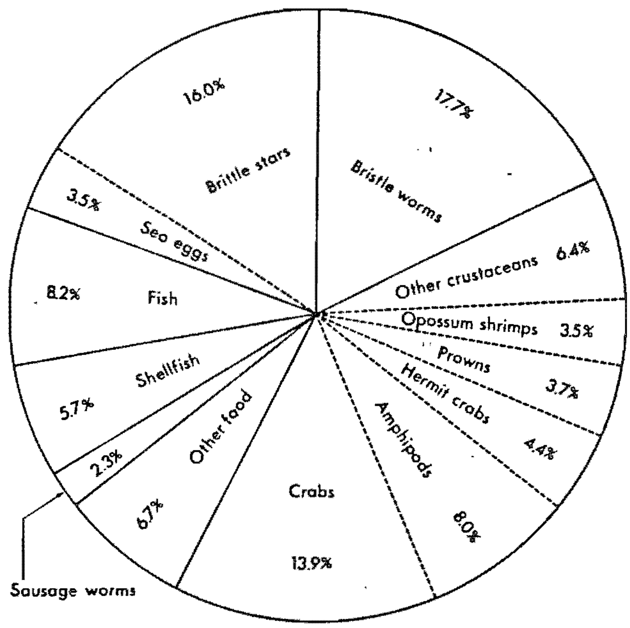


Figure 4.5 Composition of the diet of adult snapper (from Crossland,1981)

Paul (1976) studied snapper growth in the Hauraki Gulf and some of his conclusions are presented here. Snapper are slow growing and live for up to sixty years. Figure 4.6 shows the mean length of snapper in two parts of the Hauraki Gulf. Weight increase show a similar pattern. It can be seen that until the 16 years old, snapper from the Firth of Thames are both longer and heavier than snapper from the central Gulf. From the 17 years old, central Gulf snapper are longer and heavier. These differences in growth are small and may be linked to feeding, since growth is initially faster in the shallow warm areas where food is likely to be more abundant. Variations in growth rates may also be indicative of the presence of different populations or stocks of snapper in the Hauraki Gulf. There is no difference between the growth rates of male and female snapper. Snapper in the gulf become sexually mature at 23-30 cm length, with most being mature by 25 cm length which corresponds to ages of 4-5 years.

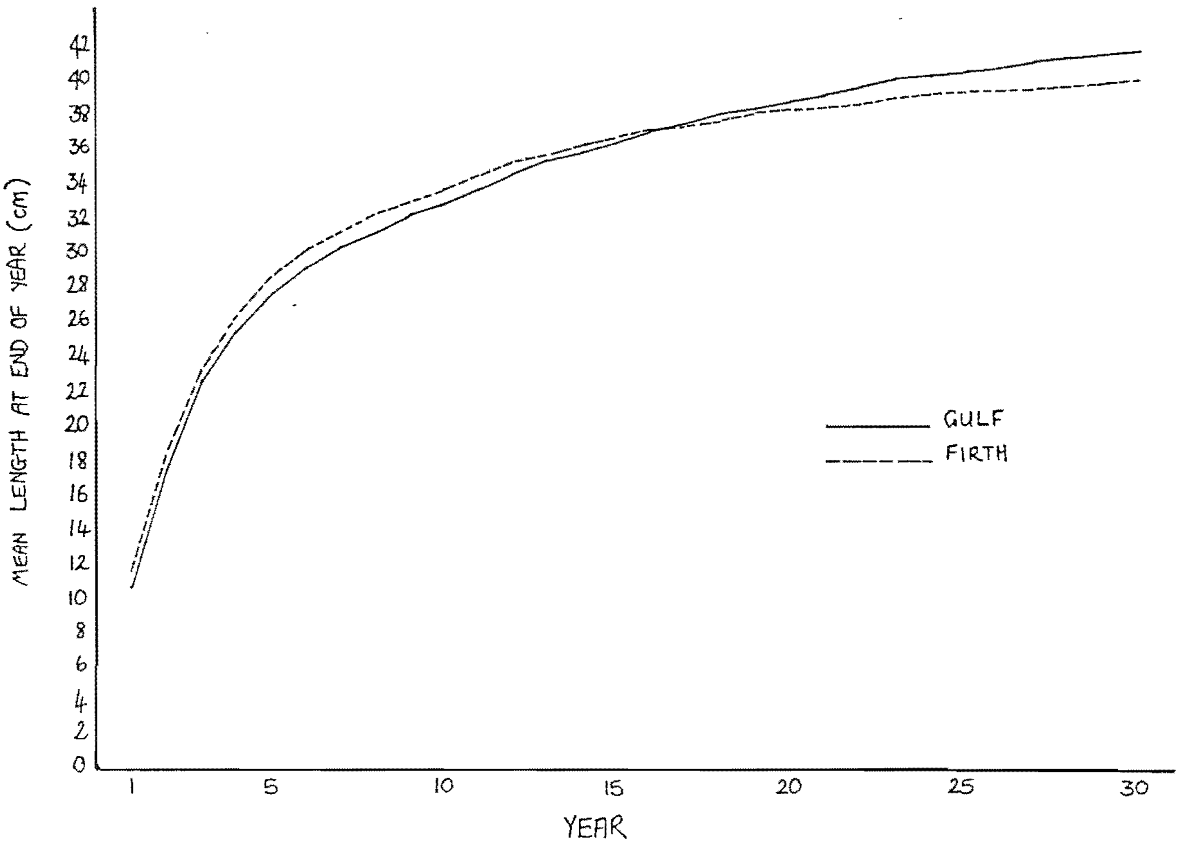


Figure 4.6 Mean length vs age for snapper from the central Hauraki Gulf and the Firth of Thames. (After Vooren and Coombs, 1977).

The annual breeding cycle of snapper in the Hauraki Gulf can be divided into four phases according to gonad maturity (Crossland, 1977a). Breeding occurs over about 3.5 months from October to January, after which there is a 2-3 week period while the spent gonads recover. The period from February to August is one of resting, and during September the gonads develop prior to the next breeding season.

In the Gulf, known spawning areas are between Little Barrier Island and Great Barrier Island (Crossland, 1977a), and on the west side of the inner Gulf from Kawau Island to Waiheke Island (Crossland, 1980). Spawning usually occurs in depths of 20-70 m, although it may also occur on open coasts. It is thought that spawning normally occurs near the bottom, but surface spawning has been reported. Where the water is turbid or of low salinity, spawning does not take place. For example, no spawning occurs in the Tamaki Strait or in the Firth of Thames.

The timing of spawning depends largely on water temperatures. Spawning usually occurs when the surface temperature is between 16 and 21°C (bottom temperature 15-17 ° C) and, most importantly, when the temperature is rising. Snapper are serial spawners and release a number of batches of eggs during the breeding season. The number of batches spawned is not known but Crossland (1977a) thinks that it is "considerably more than three".

Total egg production is large but variable. Although the fecundity of snapper is proportional to the length of the fish, it varies greatly between individual fish and may also vary between seasons. So many eggs are produced that some are not spawned, but rather are resorbed at the end of the spawning season. Table 4.2 shows the fecundity of different length snapper from the Hauraki Gulf in two breeding seasons. Of particular interest is the 74-fold difference between the number of eggs spawned by first-time spawners and older fish.

The large egg production is in part facilitated by a 3-4 year egg development process (Crossland, 1977a). In this process oogonia mature to primary eggs and may remain at this stage for up to four years before developing into mature eggs prior to release. This system results in a large stock of primary eggs which enables the snapper to maximise its egg production every season, regardless of whether the season is favourable.

Table 4.2 Fecundity of different length snapper from the Hauraki Gulf (from Crossland, 1981).

Length (cm)	Fecundity 1974-75	1975-76
25	297 000	83 000
30	616 000	393 000
35	1 134 000	798 000
40	1 912 000	1 754 000
45	3 021 000	3 430 000
50	4 528 000	6 164 000

Egg mortality is also large and variable. In the warm season of 1975-76 egg mortality was estimated to be 64%, but in 1976-77, a cooler season, only 26%. Although in warmer seasons fewer eggs survive to become larvae, those which do have more food, and consequently a larger number survive the larval stage than in cooler seasons. Larval mortality is high but the exact rate is unknown.

The calculated mortality of Hauraki Gulf Snapper less than six years old is 46%, but this high rate may be an anomaly caused by emigration from the Gulf (Vooren and Coombs, 1977). The adult snapper mortality rate has been calculated at about 10%, most of which is caused by fishing. Adult snapper have few natural predators.

There is widespread belief among fishermen that there are separate resident (in the Gulf) and migratory snapper stocks (Vooren and Coombs, 1977; L. Duncan, 1982). Although earlier tagging studies (Paul, 1967) did not support this belief, more recent work by Crossland (1982) showed that some fish congregating in the inner Gulf prior to spawning had come from the outer Gulf. Presumably other snapper may have come from outside the Gulf, but since until very recently few snapper have been tagged in the areas adjacent to the Gulf, this is not known.

The theory developed by Vooren and Coombs (1977) to explain the radical difference in the mortality rates of snapper less than 6 years old and those more than 6 years, lends some support to the idea of separate stocks. They propose that snapper may live in the Gulf for the early years of their life, but that many of them move to areas of rough, largely unfishable areas outside the Gulf, returning only in spring to spawn. The high mortality rate of young snapper would then result partly from their emigration from the Gulf, and partly from increased fishing pressure on those young snapper remaining.

The structure of snapper populations is influenced not only by migration, but also by the strength of individual year classes. For example, through the 1960's snapper from the 1962 year class were abundant, first as juveniles in research trawls, and by 1969 as part of the commercial catch (Paul, 1970). Later work by Paul (1976) showed that the 1968 year class was similarly dominant. Age class, or cohort, dominance is not unusual in fish populations and one well documented example is that of the North Sea herring fishery as shown in Figure 4.7.

It appears (Paul, 1982a) that variability in year class success is more dependent on spring-time temperatures when that class was spawned than on the size of the parent stock. Warm temperatures during the spawning season apparently result in better survival of eggs, larvae, and juveniles. In a study of the Gulf of Maine, Sutcliffe et al (1977) noted that of 17 commercial marine species of fish and shellfish investigated, the catches of 10 species showed statistically significant correlations with sea temperatures. If year class success is related to spring temperatures in this manner, then two features should be observed in subsequent years. First, when the fish in the year class corresponding to warm spring temperatures have reached catchable size they should be strongly represented in snapper catches for a number of years. The dominance of a strong year class in catches might diminish through time since a proportionately larger number of this year class would be caught. Second,

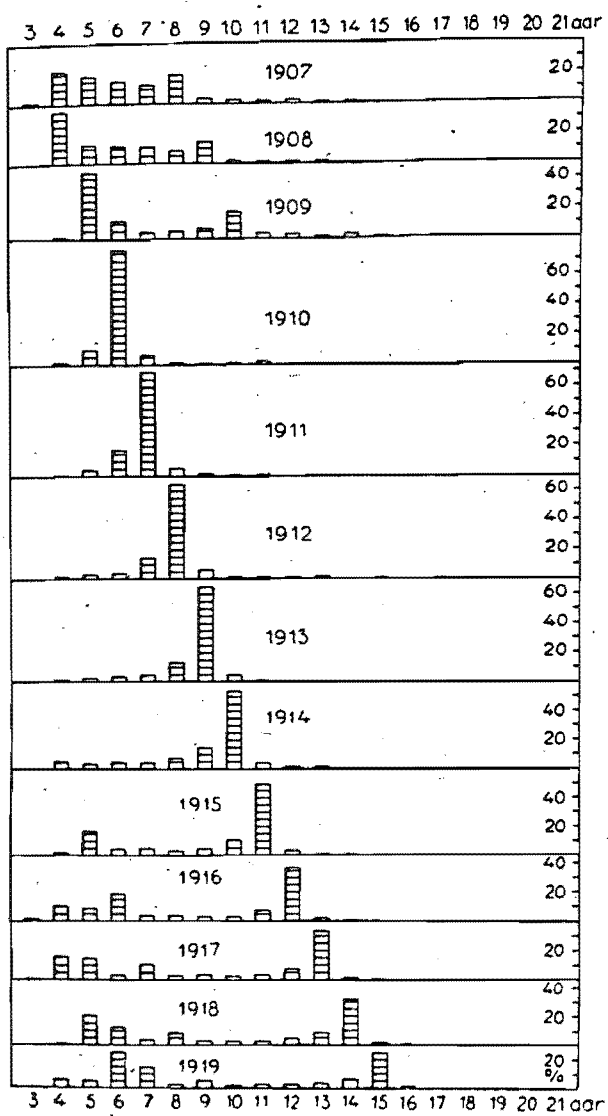


Figure 4.7 Age - composition of the Norwegian herring, 1907-19, showing cohort dominance. (From Russel, 1942).

where a number of favourable spawning seasons occur in successive years snapper stocks should increase in size. Good catch rates and large catches would therefore be expected to result.

As shown earlier, year class dominance does occur. However, dominant year classes do not always correspond to warm spawning seasons. The strong year class of 1962 does correspond to the warm spring temperatures of 1961, but the strong 1968 year class corresponds to only a slightly warmer than usual spring in 1967. Furthermore, other warm spawning periods like 1958 and 1959 did not apparently result in very stong year classes in 1959 and 1960. Obviously year class dominance is dependent on more than just spawning season temperatures.

Since 1925 there have been three major periods when spring temperatures were relatively high. These are shown in Figure 4.8 along with the snapper landings into Auckland, and the snapper catch rates for corresponding years. It can be seen that to some extent catch rates and snapper landings correspond to the average spawning season temperature 5-10 years previously. Even even allowing that much of the catch data is not of high quality, and that sea temperatures were inferred from air temperatures, nonetheless it is also clear that snapper landings and catch rates are influenced by other factors in addition to spawning season temperatures. Thus whilst spawning season temperatures may be useful for predicting general trends in future snapper stocks, they cannot at present be used for accurate predictions.

4.3.2 Hauraki Gulf Snapper Stocks

An estimation of the size of a fish stock and its sustainable yield are two of the most important requirements for effective management of that stock. Other information such as recruitment rates and mortality rates are important, but if the size and yield of the stock which is being managed are unknown, the results of any management actions can only be guessed. Unfortunately, stock size and yield are difficult to determine.

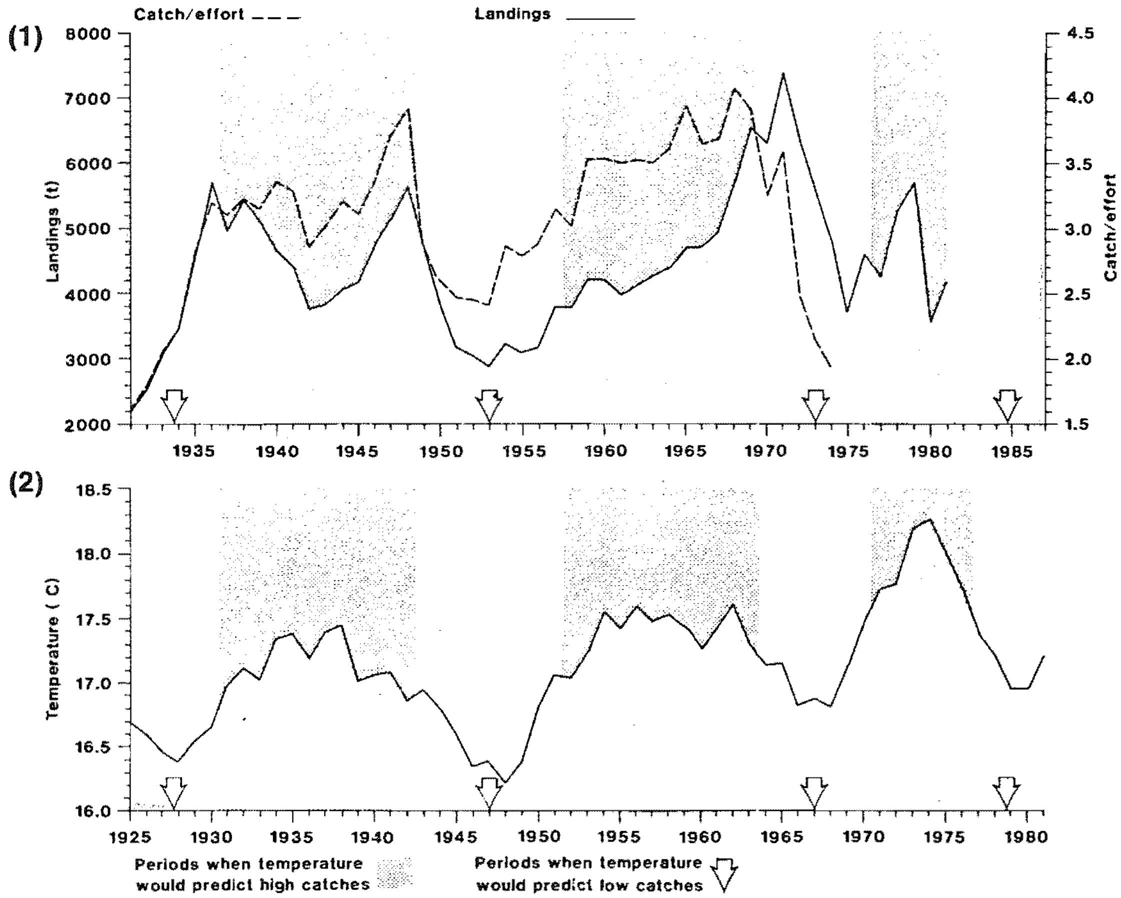


Figure 4.8 The relationship between Hauraki Gulf spawning season temperatures, and snapper catch rates and snapper landings at Auckland. Temperature plotted as 5-year running average. (From Paul, 1982a).

The difficulties involved in estimating stock sizes stem from the fact that measurements must be made indirectly. Often when estimating the size of terrestial populations it is possible to count the population directly, or at least a sizable proportion of it. In the marine environment this has only proved possible with large, surface-frequenting animals such as whales. The only method by which an exact count of a fish stock can be made is to catch, and then count, the whole stock. This is obviously unrealistic. First, it is virtually impossible to catch all of a fish stock, and second, even if it were possible, it would have the rather undesirable effect of wiping out the stock! Other, less direct methods must therefore be used.

Estimations of fish stocks all involve subsampling of some type. This means that a small proportion of the stock is caught, and inferences regarding the whole stock are made from what can be learnt about this sample and its relationship to the whole stock. Inherent in these methods is the need to rely on a variety of usually untestable assumptions. The accuracy of the stock estimates are dependent on the validity of these assumptions.

Four different estimations of Hauraki Gulf Snapper stocks or annual yield have been made and a fifth is presently being conducted. Although this is more than for any other New Zealand fish stock, even this number of estimates is not sufficient if the stock size is to be known accurately. Allen (1983) has described the need for regular stock estimations to be made in conjunction with other research into factors affecting the fish stock under consideration. The stock estimations of the Hauraki Gulf snapper stock are described below. It should be noted that due to the different techniques used, not all of the estimations are comparable.

Elder (1979) used a classical surplus production model to estimate the maximum sustainable snapper yield from the Hauraki Gulf. He concluded that the equilibrium yield for Area 3 of the earlier statistical system (see Section 4.2) was 4153 tonnes from 7402 standard trawler days. To obtain this figure, the catch per unit of standardised effort was plotted against standardised effort, and from the resulting function the expected catches at different levels of effort were calculated. The level of effort resulting in maximum yield was then easily identified.

Surplus production models such as was used in this study suffer from a number of limitations and possible drawbacks. They rely on the chosen unit of effort remaining standard over the period of the study. In the Hauraki Gulf fishery fishing is by means of four major methods, each with different catch per unit effort figures. In this study the fishing effort of the different fishing methods was standardised into 'trawler days', because it was thought that trawling had changed the least over the period of the study. As Elder has noted, it is likely that the amount of effort represented by a trawler day probably increased through the study period as fishing equipment became more efficient, and as more hours of each day were used for fishing. If fishing effort did increase, the equilibrium yield would have been overestimated. In the Hauraki Gulf amateur fishing accounts for a considerable proportion of the total catch, and it is also likely that there is considerable under-reporting of commercial catches (MAF, 1984a). The extent to which the yield estimates have been affected by inaccuracies in the catch statistics is unknown.

At an even more basic level the underlying assumption of population size catch per unit effort proportionality - is probably not justified. Models such as the one used in the study rely on the assumption that catch rates are proportional to the total stock size. Thus as total stock size decreases, so too does the rate at which fish are caught. It has been shown that, especially for schooling fish, this is definitely not the case. Even as the population decreases, fish remain in schools, and easily catchable. In the case of the Pacific Sardine, this phenomenon resulted in the commercial extinction of the species. In the Hauraki Gulf a large proportion of the mature snapper stock schools in the central Gulf for spawning. It is likely therefore that at least during the spawning season catch rates might not reflect the actual snapper abundance.

The errors associated with the predictions from this method may be considerable. Elder (1979) reports the error indices to be 5% for the maximum equilibrium yield and 16% for the optimum fishing effort. However, these indices relate only to the predictions of yield and effort from data which is assumed to be correct. If, as is probably the case, the data are not accurate, then the errors involved would be greater than those indicated by the error indices.

In the form used in the study the surplus production model can provide only a single estimate of maximum equilibrium yield. Allen (1983) has observed that the results of Paul (1982) indicate the need to modify the basic yield estimate to account for the effect of spawning season temperatures. In the study in question, a series of warm springs in previous years probably led to a higher than average estimation of stock size. Yield and effort estimates may also have to be modified to account for other causes of stock fluctuations. For example the earlier yield estimate applies to the snapper stock during the 1961-74 period, and not the 1984 snapper stock. It is apparent that as a result of continued overfishing the Hauraki Gulf snapper stock can no longer sustain a yield of 4150 tonnes. Unmodified surplus yield model predictions can only be considered at best a rough guide.

Paul (1974) analysed the same catch-effort data using a simpler method. He standardised effort to "seiner-days" and compared changes in catch per unit effort with changes in total snapper catches. From this comparison he concluded that the decline in the Gulf Snapper fishery in 1972 was due to a number of factors, and that catches of more than about 4500 tonnes per year were accompanied by a declining catch rate and could not be maintained for many years. No maximum catch level was determined but it was concluded that the present high catch rate could not be maintained.

Crossland (1980) has estimated the size of the Hauraki Gulf snapper stock from egg surveys conducted in 1974-75 and 1975-76. Plankton-net trawls were made in Gulf spawning areas throughout the spawning seasons, and from the number of snapper eggs caught, estimates of the total number of snapper eggs in the Gulf (P) were made. In a previous study (Crossland, 1977b), the relationship between length and egg production was calculated. Combining this earlier data with the mean length of spawning female snapper and egg mortality rates in the 1980 study, the mean fecundity (F) was calculated. Once the proportion of mature females in the total stock (K) had been determined, the total number of mature snapper (M) was estimated using the relationship: M=P/KF. Using this technique and the mean weight of mature fish the stock size was estimated to be 56000 tonnes.

Clearly, this technique relies on a number of important assumptions. It must be assumed that the samples used to estimate total egg numbers, the length-fecundity relationship, the mean length of fish and the egg mortality rate were representative of the whole population. Crossland concluded that the errors involved with estimating total egg numbers, although potentially large, were not quantifiable.

Over and above the usual sampling assumptions, others must be made regarding the area over which the estimated snapper stock is spread. As discussed previously, snapper from the outer Gulf and probably further afield enter the inner Gulf to spawn. Depending on the extent of the spawning migration the estimated snapper stock could represent the snapper from an area very much larger that the area sampled in the study (the inner Gulf).

The fourth estimation of Hauraki Gulf Snapper Stocks was by means of tagging. In this study (Crossland, 1980) a total of 5260 snapper were tagged in different areas of the Gulf. Once the number of recovered tags was modified to account for tag losses and natural mortality, the stock size was estimated by the Petersen method. In this, the simplest of capture-recapture calculation methods, the proportion of tagged fish in the total snapper catch is assumed to be the same as the proportion of tagged fish in the whole snapper stock. Therefore, if the total number of tagged fish, the total catch, and the number of tagged fish caught, are known, the total population can be estimated. Using this technique for the longline and set net fisheries in the inner Gulf, the snapper population was estimated to be 36-43 million fish.

Perhaps more than any other technique, tagging suffers from inherent methodological problems. Some of the problems can be considered minor. These include estimating tag losses, natural mortality and the effect of tagging on fish survival. The major problem lies in estimating the proportion of tags returned. Although the return of tags is encouraged by various reward schemes and publicity campaigns, the proportion of tags returned is unknown. Additionally, if tagging is used to determine the importance of different fishing methods, a problem arises in that tags are more likely to be returned by some specific types of fishermen, e.g. recreational, rather than others, e.g. those using 'power' fishing methods. The importance of a fishing method can therefore be easily over or under-estimated.

Since the tagging method is reliant on a record of the total catch, any inaccuracies in catch records will affect population estimates. In the Hauraki Gulf it is believed that the reported commercial catch may be as little as 60% of the actual commercial catch. Snapper estimates from the study were accordingly modified from 36-43 million to 60-71 million snapper. Paul (unpublished) has suggested that the mean annual catch over a long time period may be a reasonable estimate of the maximum sustainable yield of a fishery. Using the assumption that between half and three-quarters of the fish landed at Gulf ports was caught in the Gulf, he concluded that the mean annual catch was between 2550 and 3825 tonnes. It should be noted that these figures do not take into account the possibly large amount of snapper caught by amateurs, and the amount not reported by commercial fishermen.

It is clear that in spite of the work done on Hauraki Gulf snapper stocks, the results so far provide only a rough guide to the stock size and maximum sustainable yield. Reasons for the lack of precision, include the inadequate - and probably inaccurate - catch statistics, methodological limitations, and the fact that in fisheries management terms the four studies conducted on the Gulf snapper stocks represent only initial attempts at stock and production estimation. More work is required to determine more accurately average stock size and production, and the way in which these are affected by various environmental and fisheries-related factors. Until this work is completed, the existing estimates must be used. However, the use of figures such as Elder's (1979) estimate of maximum sustainable yield must be used with caution, and where necessary, revised to ensure stock protection.

4.4 THE FISHERY

4.4.1 Introduction

The Hauraki Gulf Snapper Fishery is one of the most important fisheries in New Zealand. In addition to providing large quantities of the country's most popular fish to local markets, the fishery is a major source of fish for lucrative export markets. The fishery provides jobs, both on fishing boats and in processing and support industries. Adjacent to New Zealand's largest population centre, it is undoubtedly the country's most important amateur fishery. More so than any other New Zealand fishery, the Hauraki Gulf Snapper Fishery is a multi-method fishery, and thus supports participants with very different lifestyles, and provides special problems for its managers.

This section is a brief description of the history and present-day status of the fishery. The place of the fishery in a national and local context is described, along with its relationship to other fisheries in the area. Major historical events and trends in the fishery are then outlined prior to a description of the different fishing methods used. Some aspects of the fishery are discussed in other sections and in this section are dealt with only briefly or not at all.

The snapper is one of New Zealand's most significant inshore finfish. It no longer comprises as large a proportion of the total catch as it has done previously, but remains one of the top species by weight and by value. Figure 4.9 shows the proportion of the 1983 total inshore catch which each of the major species forms. The higher prices paid for snapper means that the snapper catch was worth more than the barracouta catch, even though the latter was larger in terms of weight.

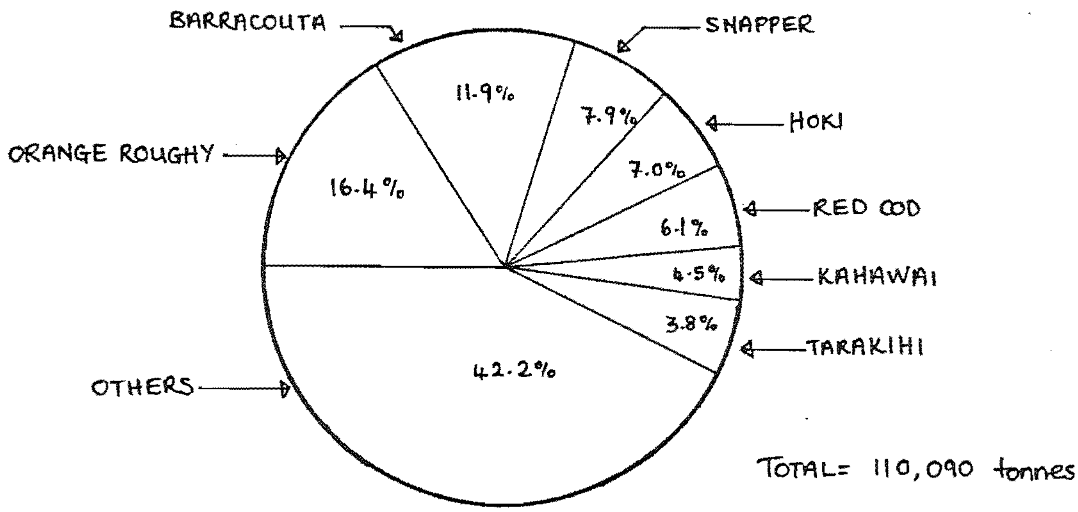


Figure 4.9 Species composition of the 1983 New Zealand domestic finfish catch (by weight).

The Hauraki Gulf has always been the most important snapper fishery in New Zealand. Initially about 90% of New Zealand's total snapper catch was landed at Gulf ports. Although this Figure had fallen to about 60% by 1960, and to 40% by 1982 (after MAF, 1983a), as other fisheries developed, none of the other snapper fisheries have overtaken the Gulf in importance. Not all of the snapper landed at Gulf ports is caught in the Gulf. Trawlers in particular often fish well beyond the Gulf and return to a Gulf port to unload. A. Duncan (1982) estimated that trawlers catch between one third and two thirds of their catch within the Gulf, and Paul (unpublished) suggests that of the total snapper landings at Gulf ports between half and two thirds is from the Gulf.

Although the Hauraki Gulf is best known for its snapper, other fish are also caught. Most of the other fish species are taken as by-catch when targetting for snapper, or as an alternative catch when snapper are not abundant, but there is some target fishing for other species. In particular, flounder form the basis of a major fishery in the Firth of Thames. The species composition of the total catch from areas 005, 006, and 007 (the areas comprising the Gulf) is shown in Figure 4.10, and a list of the species forming a significant part of the Gulf catch is shown in Table 4.3. Additionally, the Hauraki Gulf supports a major scallop fishery, which in November 1978 was made a controlled fishery. Mussel and oyster farming is common in the Gulf and new areas have recently been designated as being available for this purpose (Bartrom, 1984).

4.4.2 History

Paul (1977) has outlined the early history of the Hauraki Gulf Snapper Fishery. Snapper were an important food item for the maoris who have lived in the Gulf area for at least 500 years. Fish was also traded with inland tribes, and then with the early Europeans for other food and clothing. Initially European fishermen were interested mainly in whales and seals (Watkinson and Smith, 1972), but in the latter part of the nineteenth century commercial fishing for coastal finfish gradually developed. In the Gulf the main methods were handlining, set netting and beach seining, from rowboats and sail boats.

The introduction of trawl fishing to the Hauraki Gulf is described by Hefford (1929), the then Chief Inspector of Fisheries. Trawling commenced in Hawkes Bay in the last few years of the nineteenth century and in 1899 the steam trawler "Minnie Casey" was used in the Gulf. Despite the fact that the Minnie Casey was only used with the inefficient beam type of trawl (see Appendix A), both professional and amateur fishermen believed it was responsible for rapidly reducing Gulf snapper stocks. They presented a petition containing more than 1000 signatures to Parliament, and after some investigations trawling was banned from the inner Gulf. The Minnie Casey ceased fishing in 1904, apparently as a result of these restrictive regulations.

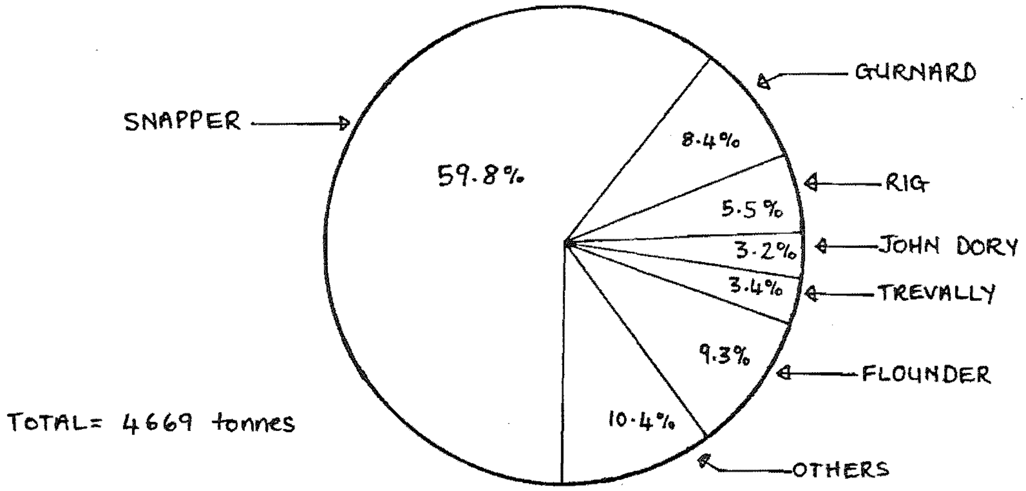


Figure 4.10 Species composition of the 1983 Hauraki Gulf finfish catch (by weight). (From MAF, unpublished data).

Table 4.3 Fish species of the Hauraki Gulf Fishery

Snapper	*Chrysophrys auratus*
Tarakihi	*Cheilodactylus macropterus*
Trevally	*Caranx georgianus*
Flounder	*Rhombosolea plebeia*
Gurnard	*Chelidonichthys kumu*
Barracouta	*Thyrsites atun*
Northern Jack Mackerel	*Trachurus novaezelandiae*
Rig	*Mustelus lenticulatus*
Kahawai	*Arripis trutta*
John Dory	*Zeus faber*

Other methods of fishing continued to be used. From 1906 to 1910 snapper were plentiful enough for dealers to have to limit the quantity of fish bought from fishermen, although from 1908 there snapper were reported to be scarce in the Tamaki Strait. By 1912 longline fishing had been adopted by some fishermen and was reported to be a great improvement on the handlines used previously.

Although government sponsored experimental trawls took place in 1901 and trawl restrictions were relaxed somewhat in 1907, trawling did not recommence in the Gulf until 1915. This time however, the more efficient 'Otter trawl' was used. Four trawlers were used in 1915, five in 1916 and six in 1917. From 1916 the Auckland City Council operated two steam trawlers in conjunction with its municipal fish-market. The venture proved uneconomical and ended in 1923.

The new Danish seining method of fishing was introduced to the Gulf in 1923. By 1920 trawler catch rates in the Gulf had declined and new trawlers were being built sufficiently large to be able to fish in other areas such as the Bay of Plenty and the West Coast. However the smaller trawlers could not be safely used outside of the Gulf, and it was these boats that from 1923 were converted into Danish seiners.

The new method proved very successful, and within two years there were 22 of the newer oil-engined boats using the Danish seining method. Very large catches were taken, especially in the schooling season, and at one stage the market was oversupplied. Once more, net and line fishermen complained that the new type of power fishing was harming their fishing. In 1924 the Firth of Thames was closed to Danish-seining and in 1926 mesh sizes were restricted and spawning areas closed for the spawning season. In 1929 after further complaints by Thames fishermen most of the inner Gulf was closed to seiners over 15 m long. Paul (1977) notes that it is not known whether the closure of the Gulf to large seiners preceded or followed an increase in the number of 10-15 m diesel powered seiners.

The history of the Hauraki Gulf Snapper Fishery from 1930 until the 1970s is documented by Paul (1977, and unpublished). Most of the following section is based on this work. Annual snapper landings into Auckland and other Gulf ports from 1931 to 1983 are shown in Figure 4.11, and the number of fishing boats registered for each fishing method over the same period is shown in Figure 4.15.

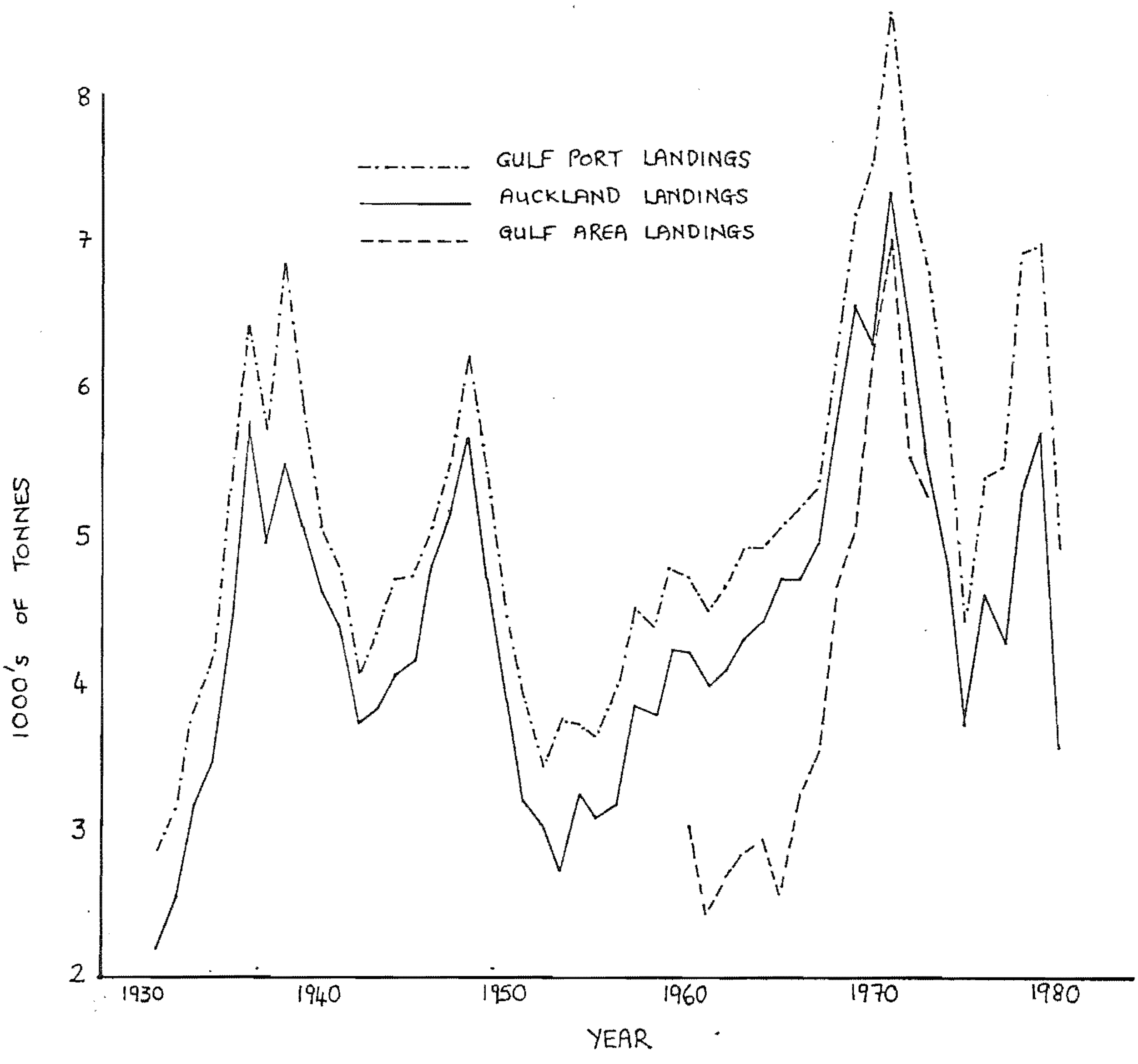


Figure 4.11 Auckland and Gulf port snapper landings from 1930-1980. (After Anon, 1984).

As predicted by the Marine Department in 1930, the Depression resulted in reduced fish landings, including Hauraki Gulf snapper. Snapper prices were low but as a result of high unemployment the number of fishermen in the gulf increased. Returns to fishermen were correspondingly low. Trawlers, with their high operating costs were hit hardest and by the end of 1931 only one remained in operation. A ready supply of cheap, line and net-caught snapper meant that Danish seiners were under-utilized at this time.

From 1932, exports of snapper to Australia increased rapidly (Figure 4.12). This provided an incentive for the expansion of fishing effort in the Gulf. However the many exporting companies were disorganised and by 1937 price cutting resulted in poor returns and eventually, decreased exports. The initially good export prospects had resulted in overcapitalisation of the fishery which caused major problems. After the export boom had peaked demand for snapper was low and the prices paid to fishermen became so low that in October 1936 they went on strike. Prices were increased as a result. Exporting was then coordinated through one company and higher prices were obtained. However a government committee determined that exports were the source of most problems in the fishing industry and recommended that they be phased out. Although not phased out completely, exports remained very low until after the war.

Most of the increased fishing effort during the 1930s was in Danish seining and in 1938 the seining fleet peaked at 49 boats. The number of net and lining boats declined as some temporary fishermen returned to other jobs, and others switched to Danish seining. Economic problems resulted in variable snapper landings by steam trawlers, and in 1939 these boats were requisitioned for use by the Navy. Without the steam trawlers snapper catches through the war years were lower than in previous years, but catches by the The mining of some parts of the Gulf during the war, which reduced the area available for fishing, may have affected snapper landings. slowly declining Danish seining fleet remained reasonably stable. At the end of the war steam trawling in the Gulf recommenced. Although few in number they significantly increased snapper catches. In 1952 the steam trawlers became uneconomical and ceased operation.

The rapid decline in snapper landings between 1949 and 1952 caused considerable concern. From 1948 to 1952 half of the Danish seiners were converted to motor trawlers, and the new trawlers being built were larger than previously. New regulations forced the trawlers to work further from shore and new trawl gear enabled them to fish on previously unfishable rough ground. Both of these factors had the effect of increasing tarakihi catches and decreasing snapper catches. The change to trawling may have been due to increased demand for tarakihi, increased costs involved in Danish-seining, or a reduction in catch per unit effort in seining operations. Such a reduction occurred in 1949 and coincided with the conversion to trawling by many seiners. The actual reason for the drop in snapper catches may be a combination of any or all of these factors, but will probably never be known for certain. The reduction in snapper catches from the Gulf led to new trawl restrictions and the exploitation of more distant fishing grounds, and stimulated research into the Hauraki Gulf snapper stocks.

From a low point of 2878 tonnes in 1953 snapper landings into Auckland increased slowly throughout the 1950s. The slow recovery rate was in part a result of the effort being expended on catching tarakihi. In 1952 the requirement for fishing boats to unload catches at their home port was waived for Auckland trawlers fishing on the West Coast out of Manakau. Some boats previously fishing in the Gulf started fishing from Manakau which became an important fishing port as West Coast snapper stocks were exploited. The lack of detailed catch data for this period makes analysis difficult, but it appears that through the 1950s Hauraki Gulf snapper stocks recovered from their diminished state of 1950. Danish seine catch rates (albeit calculated in 'seiner-years' increased throughout the 1950s, as did the proportion of snapper in their catches.

From 1960 to 1967 there were few changes in the Hauraki Gulf Snapper Fishery. Total snapper landings into Gulf ports increased steadily, but not dramatically. The number of trawlers and danish seiners remained relatively constant, but the number of longline and set net boats relatively constant, but the number of registered longline and set net boats first declined - probably as a result of the 1963 delicensing of the fishing industry - and then increased with the increasing popularity of part-time fishing.

The period from 1967 to 1971 saw major changes in the Hauraki Gulf Snapper Fishery. From the gradually increasing catches of the mid-1960s, catches in 1968 started to rise dramatically. The rise was a result of greatly increased catches by the Danish seining fleet. From the peak of 7353 tonnes in 1971, snapper landings into Auckland declined rapidly to a low of 3278 tonnes in 1975. Landings increased to 5685 tonnes in 1979, but dropped again to 3575 tonnes in 1980. By 1983 landings had dropped below 3000 tonnes for only the second time since 1932.

The preceeding discussion has focussed mainly on the Auckland snapper fishery and snapper landings into Auckland. Figure 4.11 shows that in general, the trends apparent in the Auckland based fishery were mirrored, albeit at a lower level, in the Thames snapper fishery. Snapper landings at the other Gulf ports, Whangarei and Coromandel, are small in comparison to Auckland landings and show only minor fluctuations.

The importance of Hauraki Gulf snapper exports has varied through the history of the fishery. As shown in Figure 4.12 there was an export boom between 1932 and 1940, but then only a gradual increase in exports until 1968 when the next export boom started. The export data shown are for the whole of New Zealand, but since Hauraki Gulf snapper catches have traditionally formed a large part of the total New Zealand snapper catch, the data are probably a reasonable estimate of Gulf snapper exports. In 1983 5,217 tonnes of snapper in various forms was exported from Auckland (Department of

Statistics, unpublished data).

Snapper exports are now very varied. Figure 4.13 shows the variety of snapper products exported from Auckland in 1983. Fresh and chilled whole fish made up 60 percent of the exports by weight, but accounted for a greater proportion of the exports by value because of the higher prices paid for these products. Snapper exported from Auckland may have been caught in a number of fishing grounds but a large proportion are probably from the Hauraki Gulf.

4.4.3 Fishing Methods

Introduction

The Hauraki Gulf Snapper Fishery is truly a multiple method fishery. Four fishing methods - trawling (single and pair), Danish seining, set netting and longlining - provide the bulk of the commercial catch, but other methods such as dahn lining, beach seining, and especially handlining, are common among amateurs in the fishery. There are many differences between the various fishing methods, and it is necessary to understand these differences and some of the interactions between those using the different methods if the fishery is to be effectively managed. In this section the relative importance of the different commercial methods is shown and then various aspects of the different methods are discussed. Most of the information is from Paul (1977) and L. Duncan (1982). A short discussion of the amateur fishery is also presented. A description of the actual fishing process used in each of the fishing methods is given in Appendix A.

Relative importance

In the 80 or so years of regulated commercial snapper fishing in the Hauraki Gulf, the importance of the different fishing methods has changed considerably. Figure 4.14 shows the snapper landings into Gulf ports by different methods, and Figure 4.15 gives an indication of the number of boats using each method at different times in the fishery's history. It

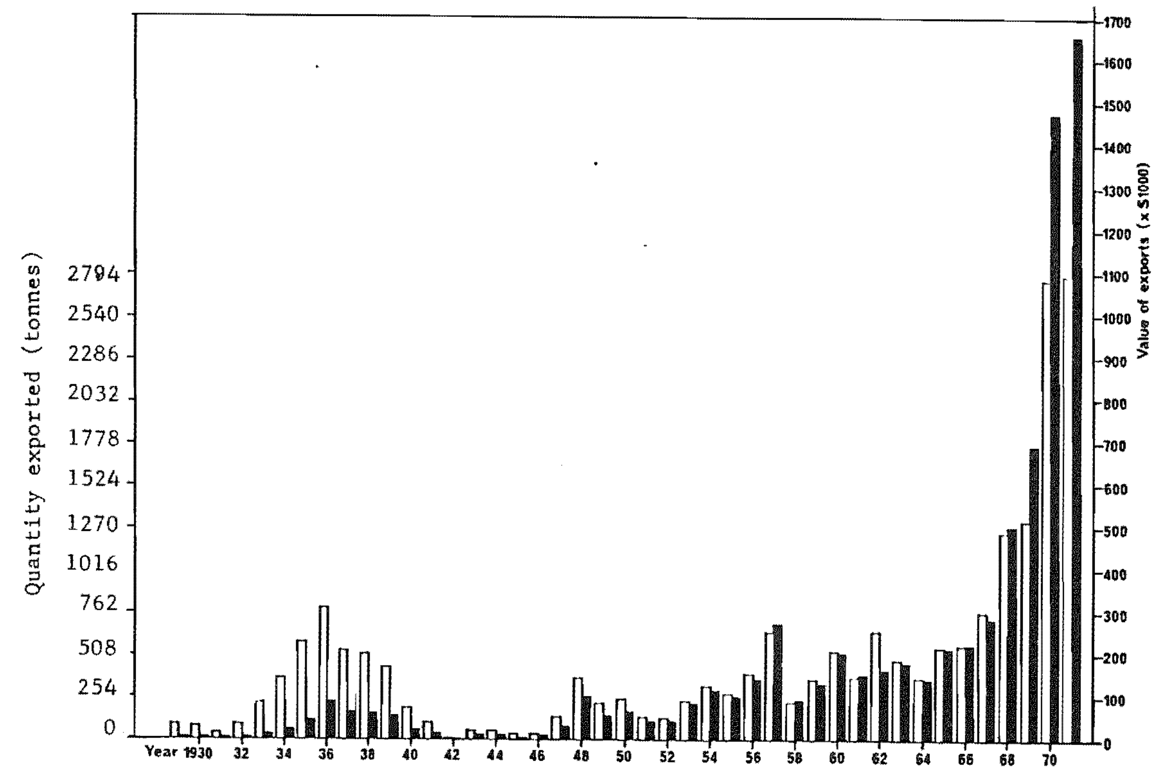
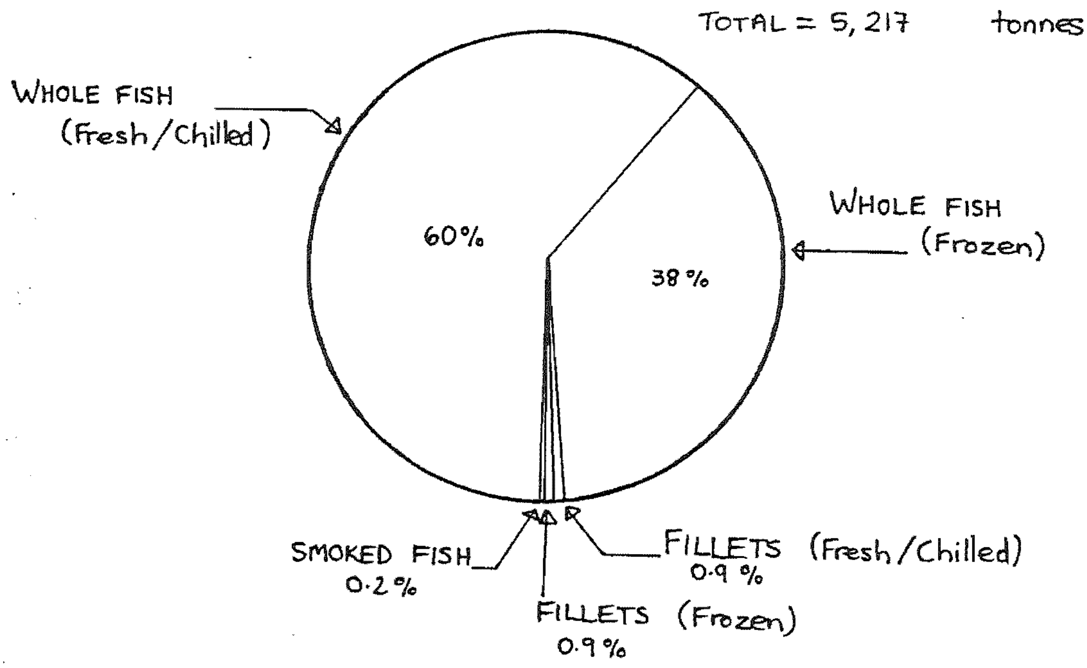


Figure 4.12 Exports of snapper from New Zealand, by weight and value, 1929-1971. (Modified after Paul, 1977).

Figure 4.13 Snapper exports (ex Auckland) by product type. (1983) (After Department of Statistics, unpublished data).



can be seen that the structure of the fishing fleet has changed so much that steam trawling, motor trawling, pair trawling, Danish seining, and the combined static methods (longlining and set netting), have all at different times been the most important fishing method in the Gulf.

Apart from the war years when they were requisitioned for naval duties, steam trawlers were used continuously from 1915 to 1952 in the Hauraki Gulf, although the number of vessels varied considerably. In the late 1910s and early 1920s steam trawlers were the most important form of fishing in the Gulf in terms of fish landings. Steam trawling ceased primarily because it became uneconomical.

The overlap between steam trawlers and motor trawlers was short. One motor trawler was registered in 1946, and numbers increased steadily from 1949. By 1952, the year steam trawlers ceased operations, there were 29 trawlers fishing from Auckland. The trawler fleet remained relatively stable until 1973, when it again increased in size. Few trawlers were based at other Gulf ports prior to 1970. However those trawlers based at Auckland were used on fishing grounds other than the Gulf so that the trawler fishing effort in the Gulf was probably less stable than the number of Auckland registered trawlers. From the mid 1950s until the Danish seining boom starting in 1968, trawling was responsible for the largest catches of snapper in the Hauraki Gulf.

The increased snapper landings between 1977 and 1980 were largely a result of pair trawl catches, and during this period pair trawlers caught more snapper than any other method. New regulations then restricted the use of this method to the outermost part of the Gulf - and there only from September to February. Snapper catches declined from a 1979 peak, and by 1983 few boats in the Hauraki Gulf were involved in pair trawling. In that year the pair trawl snapper catch from the Gulf was only 178 tonnes.

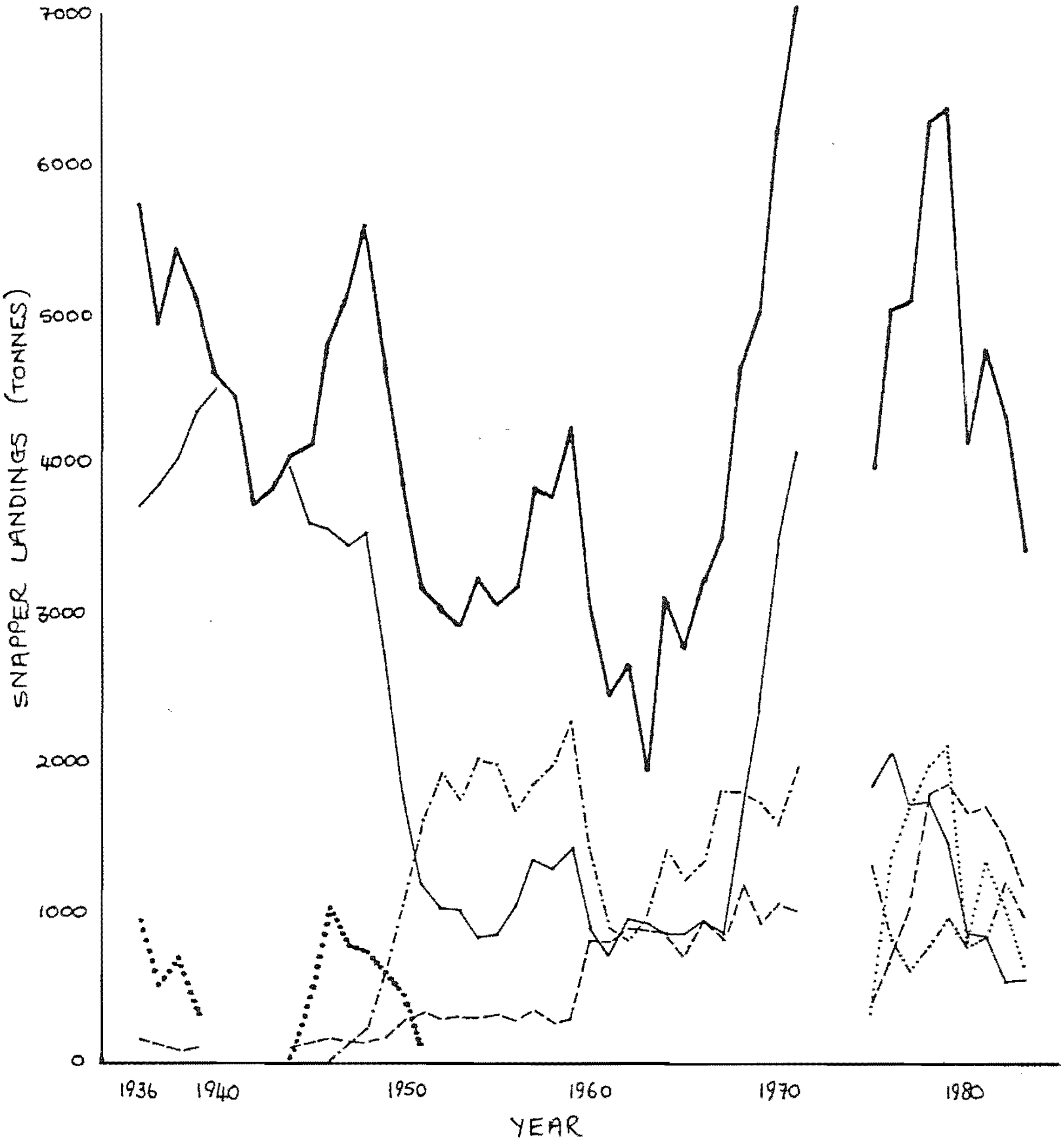


Figure 4.14 Snapper landings into Gulf ports by fishing method, from 1936-1983. (Data from Anon, 1984; MAF, 1984a; Paul, 1977).

STEAM TRAWL (-1951)
MOTOR TRAWL (1946-)
PAIR TRAWL (1975-)
SINGLE TRAWL (1975-)
DANISH SEINE
LINES + NETS
TOTAL LANDINGS

Danish seining was introduced to the Hauraki Gulf in 1923 and was immediately successful. At first the fleet comprised mainly small boats converted to seining, but in the 1930s many seiners were purpose built. Until 1950 seining was responsible for the largest proportion of snapper landings

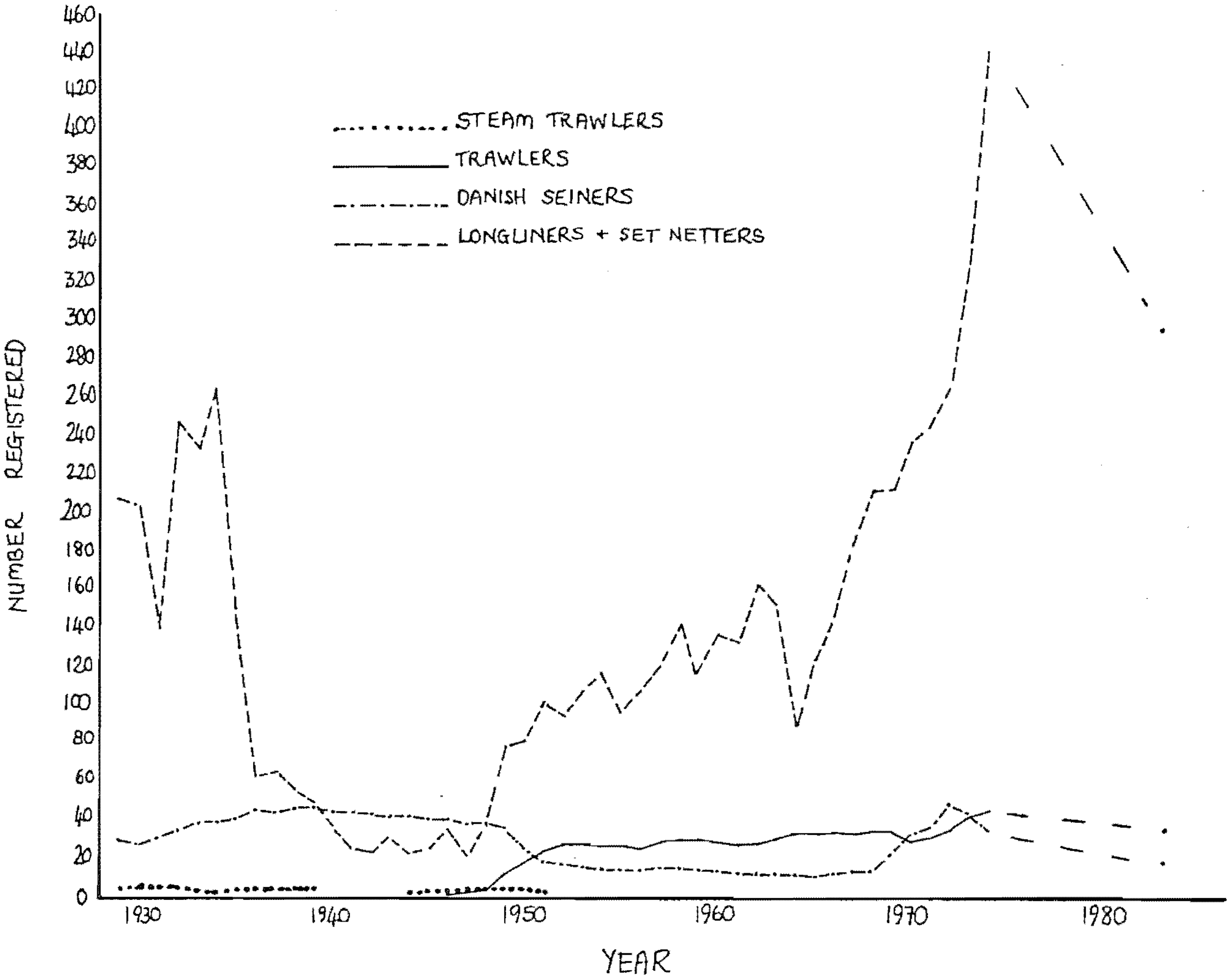


Figure 4.15 Numbers of boats registered for use in each fishing method in the Hauraki Gulf, from 1928-1983. (Data from Anon, various ; MAF, 1984a).

into Gulf ports. The seining fleet peaked in the late 1930s, but declined in the late 1940s and early 1950s as seining became uneconomical and motor trawling commenced. Many seiners were converted to trawlers. Through the late 1950s and much of the 1960s the seining fleet was relatively stable and the method took second place to trawling in terms of snapper landings. This changed with the introduction of a new type of net.

In 1968 the Skagen seining net was first used in the Hauraki Gulf. By 1969 Danish seine snapper landings were about 35% higher than trawl landings and 16% higher than the previous year's seine catch. Many trawlers were converted to seiners and it was this method that was largely responsible for the snapper "bonanza" of 1968-72. Since then snapper catches from seining have declined to the extent that by 1983 they were similar to those from single trawling and considerably less than those from longlining. Pair Danish seining, for which advantages similar to pair trawling are claimed, has been used in the Gulf, although it is now, like pair trawling, restricted to the outermost part of the Gulf.

As with the power fishing methods, the static fishing methods - set netting and longlining - have varied in importance in the Hauraki Gulf. In the depression, the number of boats out of Auckland registered as using static methods was up to 267, and during the war the number was as low as 23. Until the mid 1970s the total catch by these methods was only a relatively small part of the total Gulf landings. However, from 1977 snapper catches from longlining have increased dramatically and it now ranks as the most important method in terms of catch. Snapper catches by those using set netting also increased in 1977, but peaked in 1978 and dropped again to previous levels.

Distribution

Fishermen using the different methods are not spread evenly between Hauraki Gulf ports. Table 4.4 shows the distribution of boats around different areas of the Gulf registered for Gulf fishing. It can be seen that trawlers are based almost exclusively in the main ports, Auckland and Whangarei. Danish seiners are based only in Auckland and Thames. Although a large number of set net boats are Auckland based there is also a large concentration of boats using this method in the Firth of Thames region. Many of the boats registered for set netting are trailable and are not necessarily based at a port. Longlining is the most ubiquitous commercial fishing method in the Gulf. It is common in the larger ports but is also the major fishing

Table 4.4 Distribution of registered fishermen in the Hauraki Gulf area in 1984, by fishing method and registration address.

Location	Pair trawl	Single trawl	Danish seine	Multiple power	Set net	Longline	Multiple static	Total
Whangarei	4	4	-	3	2	5	3	21
Warkworth	-	1	-	3	4	42	6	56
Auckland	-	28	13	3	39	44	5	132
Thames	-	0	7	4	52	17	7	87
Great Barrier	-	-	-	-	-	19	-	19
Waiheke	-	-	-	-	1	15	7	23
Kawau	-	-	-	-	-	-	1	1
Whitianga	-	1	-	-	-	6	-	7
Northland	-	-	1	-	-	1	-	2

method in many of the smaller Gulf ports and on the Gulf Islands.

Fishing areas

The area fished in the Gulf depends on the fishing method used. Differences in fishing areas are in part a result of the different restrictions applying to each method, and in part due to the nature of the fishing methods themselves. The restrictions now applying to the different methods are summarised in Figure 4.16. Fishing grounds commonly fished by boats using each of the methods are shown in Figure 4.17.

Pair trawlers are restricted to fishing in the outermost part of the Gulf. The only pair trawlers presently registered for Gulf fishing are based at Whangarei, the closest port to the pair fishing area. Single trawling is restricted mostly to the outer Gulf. Virtually all the permissable area in the Gulf is trawled, along with areas outside Great Barrier Island to the north east of the Coromandel Peninsula. During the day, trawling is usually done in the central areas of the Gulf where the water tends to be turbid, and at night in the deeper, clearer water further offshore. In the spawning season, trawling effort is concentrated in the spawning grounds in the central Gulf.

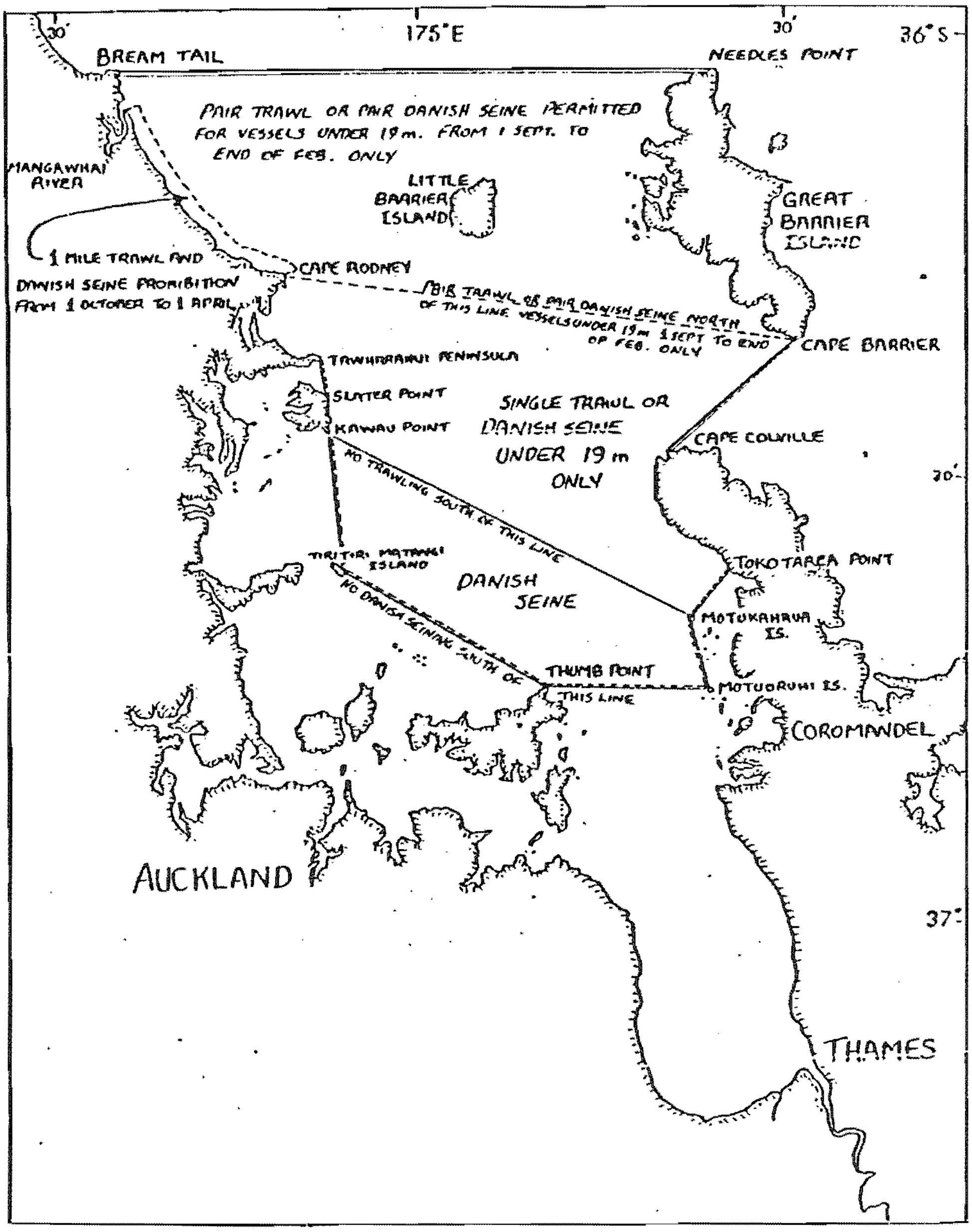


Figure 4.16 Hauraki Gulf, showing area restrictions for different fishing methods. (From Paul, unpublished).

Danish seiners are permitted to fish in all the areas fished by trawlers, and additionally in a large area of the inner Gulf. Although seiners fish all of the permissable areas in the inner Gulf, along the mainland coast of the outer Gulf and the northeast coast of the Coromandel Peninsula, most seining occurs south of the trawl restriction line. Seining is particularly effective in catching schooling fish and much of the annual seining snapper catch comes from the Gulf

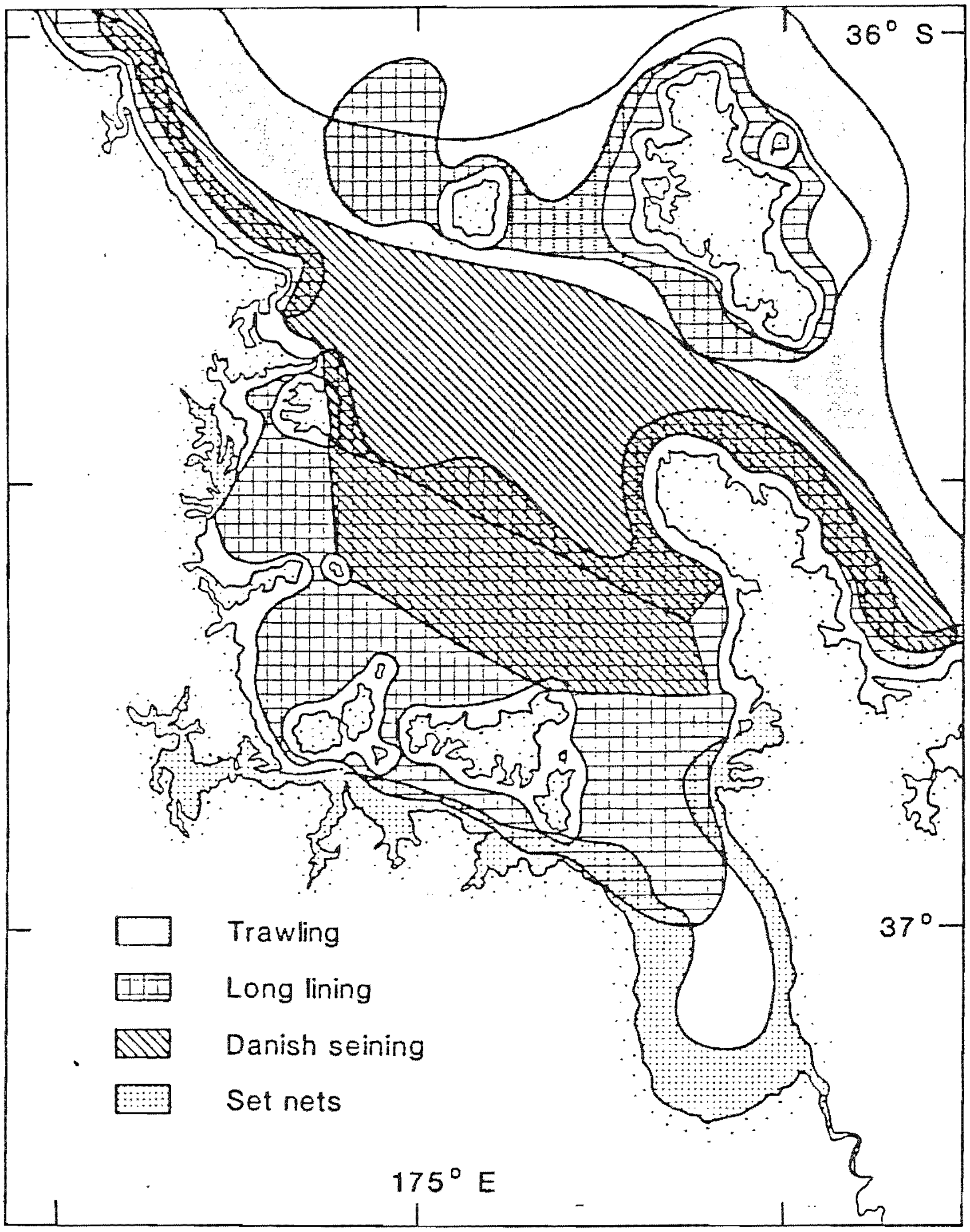


Figure 4.17 Fishing grounds of different fishing methods in the Hauraki Gulf area. (From Anon, 1984).

spawning grounds in spring and summer.

There are no restrictions on the areas in which longliners and set nets may be used. Longliners fish most of the inner Gulf except the Firth of Thames and the deeper central area. This method is also used around Great Barrier and Little Barrier Islands, along the mainland coast of the outer Gulf and the northeast Coromandel coast. From November to March, set netting is mainly used around the coast of the Firth of Thames and on the coast and in the estuaries at the southwest of the Gulf. In these areas the target species is usually flounder but some small snapper are caught. From May to October many of the set net fishermen place their nets in the deeper water at the entrance to the Firth of Thames to catch the larger 'winter' snapper.

Catch composition

The species composition of catches in the Hauraki Gulf differs between fishing methods. From Figure 4.18 it can be seen that the most 'snapper specific' methods in the gulf are longlining (93% of the total catch), other methods (84%) and Danish seining (81%). Set netting is the least snapper specific method (19%) and the two trawling methods are intermediate. The relatively small differences between these figures and the percentages given by A. Duncan (1982) for 1978-80 may be due to real changes in catch composition, but are just as likely to be a result of the earlier figures being based on fish landed at Gulf ports (and Manakau), whilst the present figures are from Gulf (only) catch data.

Combining catch data from the whole Gulf obscures some important differences in species composition of catches. For example, in area 007 (see Figure 4.2) where most of the set netting in the Gulf is concentrated, snapper comprise only 18% of the total catch. The largest part of the catch is flounder (36%). However, in area 006 flounder comprises only 9% of the set net catch whilst snapper comprises 37%. Area-related differences in the catch composition of other methods are less pronounced, but it must be remembered that although the Hauraki Gulf has been designated as one fishery, it is by no means homogeneous.

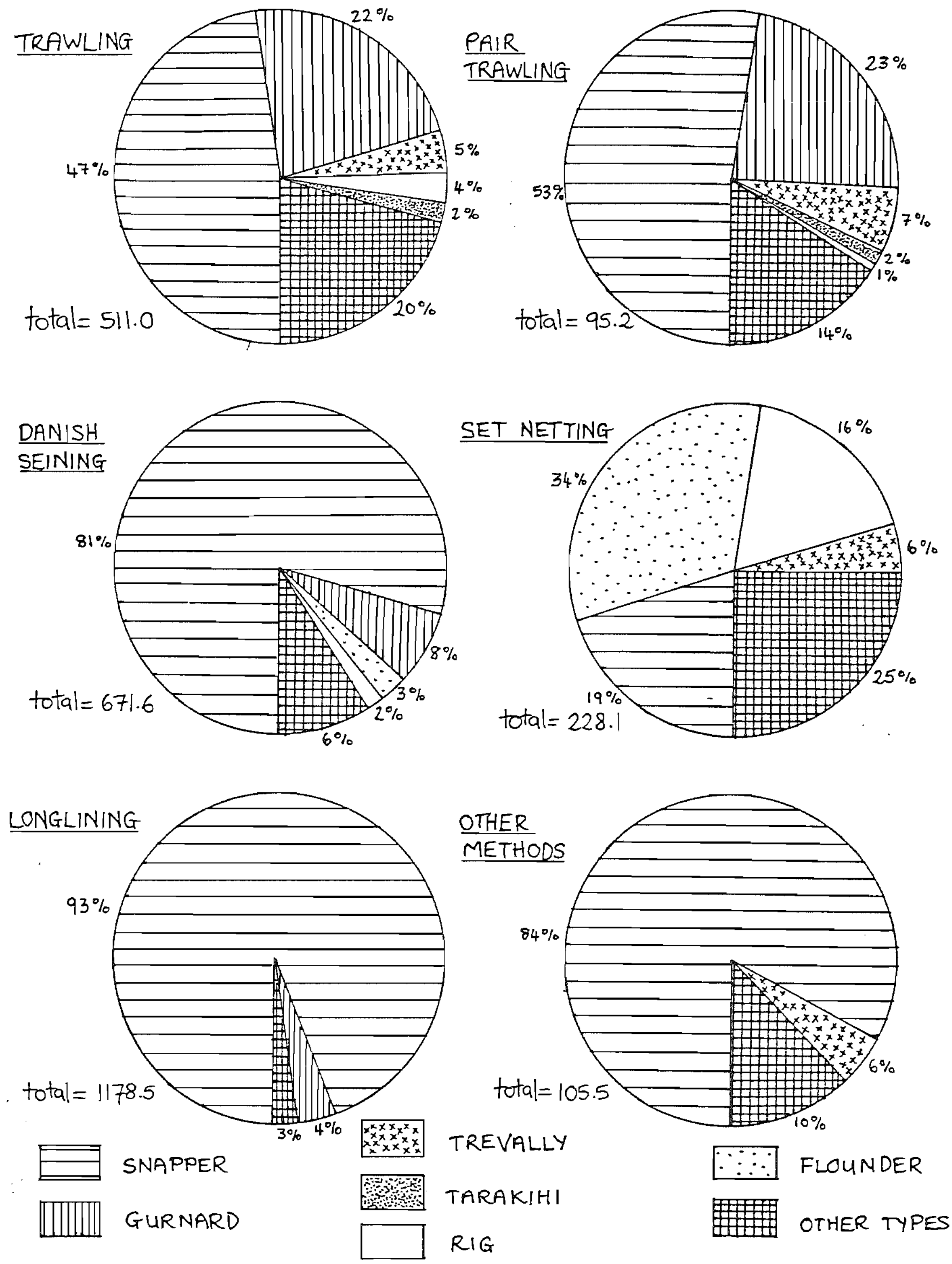


Figure 4.18 Catch composition of different fishing methods in the Hauraki Gulf. (After MAF, unpublished).

<u>Fishing boats</u>

In the Hauraki Gulf, most boats used in the power fishing methods conform to the same general design but many different types of boats are used for set netting and longlining. Boats purpose built for trawling tend to be larger and more powerful than those used for other fishing methods, but in the Gulf, where most boats have been used for both trawling and Danish seining, there is little difference between the boats using these two methods. Design tends to reflect the age of the boat rather than whether it is a trawler or seiner. Generally the older and smaller boats tend to be of wooden construction, whilst new and large boats tend to be made of steel. The only 'alternative' materials used are fibreglass and ferro-cement and such boats are rare. Pair trawlers are similar to single trawlers, and in fact most have been used for single trawling. The main difference is that more powerful winches may be required to handle the larger net used by pair trawlers. All power fishing boats in the Gulf are diesel powered, and because of length restrictions, all have registered lengths of less than 19 m. Many of the Gulf trawlers and seiners were built or imported for the companies Sanfords and Jaybels and are of similar design. The replacement cost of some of the larger trawlers may be as high as 500,000 dollars.

The size of trawlers and seiners (over 9m) means that they must comply with strict Ministry of Transport (MOT) regulations. Each year, boats must be surveyed by a MOT inspector who checks its seaworthiness and that it carries the correct safety and navigation equipment. The skippers of these boats must pass the necessary examination and gain a coastal or deep-sea ticket. Fishermen are critical of the restrictions since the annual survey is expensive, many of the survey requirements are thought to be irrelevant to Gulf fishing, and perhaps because most of the smaller longline and set net boats, which are less than 6 m or 10.67 m are not subject to the same regulations. Recent regulation changes requiring that only two, rather than three, buckets with 'FIRE' written on them, need be carried on boats, are unlikely to placate the trawl and seine fishermen.

Longline boats range from aluminium dinghies through a variety of launches to purpose built longliners. Many of the launches were ex-pleasure launches and were owned by the fishermen prior to their starting commercial fishing. As such they provide a very cheap way of getting started as a fisherman. Propulsion is either by petrol or diesel engine, and hull construction is predominantly of wood, although some of the smaller boats are fibreglass or aluminium. The amount and type of fishing gear and electronic equipment varies between boats, but is generally increasing as it becomes more difficult to take reasonable sized catches. A very well equipped longliner might cost more than 40,000 dollars (Dickie,1983).

Set net boats also vary considerably in design. There are a few larger boats, but many are fast, planing boats, often powered by outboard motors. Fuel efficiency is therefore usually low. Some of the largest set net boats are equipped with net reels, but most fishermen make do with net haulers, or haul the nets by hand. Construction may be wood, aluminium or fibreglass, and although costs vary considerably they are similar to those of longliners.

Fishermen

Just as the type of boat varies between fishing methods, so too do the fishermen. Again there is a great diversity within the fishery and even within fishing methods, but some generalisations can be made.

The skippers of trawlers and seiners tend to be career fishermen. They are generally experienced fishermen, having spent many years working in the industry or on vessels other than fishing boats, and all have qualified for either a coastal, deep-sea or other types of skipper's ticket. Those who own their own boats have a major financial commitment in the industry, and in addition to spending most of the week fishing, must find the time to maintain their boats. Other skippers work on company owned boats and in some instances a lease-to-buy system is worked whereby over a number of years a skipper will buy a boat from a company. Maintenance and unloading of company boats is not usually the responsibility of the skipper. Deckhands, of whom there are usually one or two per boat, tend to be younger than the skippers and often straight from school. Their commitment to the industry is less than that of the skippers, although some may use their position to start working towards becoming a skipper themselves.

Trawling trips tend to be for 4-6 days, during which time trawling may be more or less continuous. Where this is the case the crew tends to work in shifts. Clearly, considerable commitment to fishing is required of men with families, because for long periods they may only see their families for a day or so each week.

Longline and set net fishermen have diverse backgrounds. Some are 'orthodox' fishermen - similar in many respects to trawl and seine fishermen - but the relatively low capital requirement and the fact that qualifications are not necessarily required, make these methods the obvious choice for anyone wanting to try their hand at commercial fishing. The diversity of backgrounds is interesting; along with those who have worked on fishing boats all their working lives, longline and set net fishermen include former businessmen seeking a simpler lifestyle, skilled manual workers, and even former naval personnel. Many boats are operated single handed, although there has been an increasing tendency to make use of a deckhand - sometimes a family member or friend. Fishermen using the larger set net boats make 3-5 day fishing trips, but the average length of fishing trips for longline and set net fishermen is 1-2 days. Often they leave on one day and return the next.

Financial situation

The financial 'crisis point' of New Zealand's inshore fishery (Brun) (MAF, 1982b), applies equally to the Hauraki Gulf fishery. Financial problems are not uncommon amongst Hauraki Gulf fishermen, and throughout the history of the fishery, have resulted in major changes in the number of fishermen using each method. The present financial problems in the

Gulf fishery affect virtually all fishermen and have been caused by rapidly increasing costs (especially fuel), and decreasing catches. Thus, in spite of increasing prices paid for fish, some fishermen's costs now exceed their sales of fish. It is worthwhile to consider recent trends in the financial situation of fishermen using different fishing methods.

The financial situation of Gulf fishermen was studied by A. Duncan (1982), and that of all New Zealand fishermen by NAFMAC (1983). In each study, fishermen using each of the major commercial fishing methods were surveyed and their financial situation analysed. Different figures are presented in these studies representing the variable and fixed expenses, contribution margin, depreciation and net income. Of these, perhaps the best figure for comparing the financial situation of fishermen using different fishing methods over a number of years is net income. Table 4.5 shows the net incomes of fishermen from 1979 to 1983. The 1979-1981 data are from A. Duncan (1982) and apply only to Hauraki Gulf and Manakau fishermen using boats less than 19 m long (the limit for use in the Gulf). 1981-83 figures are from NAFMAC (1983) and apply to all New Zealand fishermen. The figures for trawling in the second study are for fishermen using boats less than 15 m long and those using boats between 15 and 18 m. The data therefore has distinct limitations, as neither group of data exclusively represents fishermen from the Hauraki Gulf, the boat lengths in the 1981-83 figures do not conform exactly to Gulf fishing boat lengths, and the 1983 figures are only estimates. However, even with these limitations the data provides a useful overview of the incomes of fishermen using each of the fishing methods in the Hauraki Gulf.

Some features are immediately obvious from the income figures. First, the average incomes of all fishermen except Danish seine fishermen are well below the New Zealand average, and for some methods in some years, they are ridiculously low. It is unlikely that a full-time fisherman would survive on 800 dollars for a year. Instead, some costs

Table 4.5 Average annual net income before tax for different fishing methods (in dollars).

Method	1979*	1980	1981**	1982	1983
Trawling	4886	9050	9755 (400-7500)	(4200-10000)	(800-3300)
Danish seining	15785	14868	25512 (17200)	(24200)	(13000)
Set netting	1414	1323	2913 (4700)	(5700)	(4200)
Longlining	1399	275	2449 (5000)	(8700)	(8400)
Average N.Z. wage	154	180	231	271	293

* 1979-81 From A.Duncan (1982): 1. Averages for Hauraki Gulf and Manukau fishermen only.
2. Set netting biased toward full time fishermen. Trawling figures for all boats 19m.

** 1981-83 From NAFMAC (1983): 1. Averages for all New Zealand fishermen.
2. Trawling figures are for boats less than 15m and between 15 and 18m.

such as depreciation are not immediate, and the money for these can be used to supplement incomes in bad years. However, boats do depreciate, and this money must be paid eventually if a boat is to be replaced or refitted, thereby reducing profits in good years. The low incomes of set netters and longline fishermen are due in part to the fact that many of the fishermen using these methods are only part-time fishermen.

The second notable point is that the incomes of fishermen using power fishing methods have, overall, declined between 1979 and 1983, whilst those of fishermen using static fishing methods have increased. Likely reasons for this are discussed below.

Trawling and seining require large catches of fish to remain financially viable. Trawlers and seiners represent large capital investments, use large amounts of expensive diesel fuel, and on average require more crew than the static fishing methods. To make a profit, catches must be large, and more so since with the quality of the fish caught (especially trawl-caught fish) being poorer than in other methods, the prices for which they can be sold are also low. The recent very large increases in fuel prices have hit the power fishing methods particularly hard. Since 1976 the total catch of trawl-caught snapper in the Hauraki Gulf has remained relatively stable, and that of Danish seine-caught snapper has steadily declined. Only the increasing prices of paid for snapper have meant that some fishermen can still make profits using these methods. Although the highest profits were made in Danish seining, NAFMAC (1983) notes that this method is especially dependent on snapper (81% of catches) and that any decline in snapper stocks would severely affect fishermen using this method. L. Duncan (1982) suggested that some fishermen using Danish seining have changed to other methods because of very low profits. The profits shown in Table 4.5 refer only to those fishermen who have continued Danish seining - presumably those who are most successful.

Static fishing operations require only small annual snapper catches to remain financially viable. A. Duncan (1982) calculated the required amounts to be 18.1 tonnes and 7 tonnes per year for longlining and set netting respectively. Longlining in particular is fuel efficient, and the sale price of the high quality longline-caught fish is high. Set netting is not particularly fuel efficient and the quality of set net-caught fish varies considerably, but profits from this method have increased. It has the advantage of not being especially dependent on snapper (only 19% of the total catch), and like longlining, the capital involved is much less that in power fishing methods. The average crew size is also smaller.

The increasing profitability of longlining led to a larger longlining fleet, although this and the commercial set net fleet were sharply reduced in size when the Hauraki Gulf became a controlled fishery and most part-time fishermen were excluded.

Hauraki Gulf amateur fishery

The amateur fishery is one of the biggest 'unknowns' in the management of the Hauraki Gulf Snapper Fishery. It is known that amateur fishing in the Gulf is popular, and that amateurs take a significant proportion of the total snapper catch. What is not known with much accuracy is how many amateur fishermen there are, how often they fish, and the size of the total amateur catch. In this section what is known about the amateur fishery in the Hauraki Gulf is summarised. Amateur fishing regulations are shown in Section 4.5.

Any confusion over who is an amateur fisherman, has been removed by the 1983 Fisheries Act. In the Act, the requirements for classification as a commercial fisherman are defined, with anyone not conforming to these requirements being defined as an amateur. The requirements of specified in the Act are as follows.

- those who fish for sale (or intend doing so) all year, or for a specified season of the year and who rely wholly or substantially on their activities for their income;

  or

  - in the case of a company or body, that it has a sizeable investment in the fishing industry, or intends making one;

  or

  - individuals who fish solely for eels or take seaweed commercially and can prove their legitimate involvement in their business even if this does not otherwise comply with the provisions of this definition.

In practical terms these requirements are enforced by MAF using the criteria shown below.

a) That the fisherman has caught the equivalent of $10,000 fish (wetfish at $2.00 per kg - others at $1.00 per kg) during the 1982 calendar.

b) That a controlled fishery license is held.

c) That approval has previously been granted under the Fisheries Moratorium Notice 1982;
or
d) That the fisherman has earned at least 80% of his income from fishing
or
e) That it is a vital part of his annual subsistence income.

(From MAF, 1983a)

Anyone not meeting these requirements will not receive a fishing permit, and will therefore be classed as an amateur fisherman, and is subject to the amateur fishing regulations.

The amateur fishing methods used in the Hauraki Gulf are typical of other fisheries. Probably the most common method is line fishing from boats, although surf-casting from beaches is also very popular. The 'kon-tiki' raft method for taking the fishing line offshore is a variant of surfcasting. Set nets, beach seine nets, and longlines are used by amateur fisherman as well as by commercial fishermen. The elusive nature of the snapper means that few are taken by divers.

Some estimates of the number of amateur fishermen using the Gulf have been made. Information presented here is taken from Irving (1985).

In 1981 Tortell estimated that there were some 45,000 pleasure boats (<7m) in the Auckland area, suggesting about 100,000 boat-borne fishermen or at least boaties, in the same area. In the 1975 New Zealand Recreational Survey 6.7% of respondents rated salt-water fishing, and 1.15% rated scuba diving, as one of their three most favoured forms of recreation. Assuming similar percentages in 1984, the population of 1.6 million in the Auckland area would include over 107,000 keen fishermen, and over 18,000 divers. The actual numbers are likely to be higher because water sports are probably more popular in the Auckland region that elsewhere in the country, and because boating, fishing and diving are generally increasing in popularity.

Estimates of the Hauraki Gulf amateur catch are based on fish tagging studies. Of the 200 tags returned in a 1976 tagging survey in the Gulf, 20.5% were returned by amateur fishermen. Based on 1979-80 data the amateur catch was estimated to be about 30% of the total catch. In a Bay of Plenty snapper tagging programme the amateur catch was also estimated to be about 30% of the total. However, amateur tag return rates are believed to be higher that commercial tag return rates, which, if true, means that the amateur catch would be less than the 20-30% calculated.

Assuming an amateur catch of about 20% of the total, and not allowing for under-reporting of commercial catches, the amateur catch might be larger than 1750 tonnes. This appears to be a very large figure for an amateur fishery, but it would be more than reached by 100,000 fishermen each catching an average of twenty 1.0 kilogram snapper in a year. Earlier estimates of the amateur fishing population suggest that this is not unreasonable.

It is evident that whilst not well known, the amateur fishery is a significant component of the Hauraki Gulf Snapper Fishery. As other parts of the fishery are subject to increasing restrictions, it may be that the amateur fishery should be more closely regulated. It is clearly one of the major information gaps in the management of the fishery, and requires considerable study.

4.5 MANAGEMENT AND REGULATION

4.5.1 Introduction

As one of New Zealand's oldest and most intensively fished fisheries, it is little wonder that the Hauraki Gulf is also one of the most intensively managed fisheries. Regulations were first introduced to the Gulf in May 1902, and since that time a wide range of regulations have been implemented, especially in recent years. A major aid to determining future management policies for a fishery is to analyse the effects of previous management decisions on that fishery. In this section the regulations used in the Hauraki Gulf Fishery, and the institutions involved in its management, are discussed

Management of the Hauraki Gulf Fishery in many ways reflects the evolution of New Zealand Fisheries Policy. However, since the problems in managing the Hauraki Gulf Fishery have often been more severe and encountered earlier than in other fisheries, special regulations - not always in line with overall national policies - have been used. In the implementation of fisheries policies in the Hauraki Gulf Fishery, almost every type of management method has been used. They include open access, closed areas, closed seasons, effort restrictions, mesh restrictions, size restrictions, bag limits, catch quotas, limited entry, enforced effort removal, and, in the near future, property rights in the form of individual transferable quotas (ITQs) and payment of economic rent. The only major management method which has not been used is the private ownership of the fishery as a whole. The institutions involved in the management of the Gulf are fewer in number, but have shown considerable changes over the history of the Gulf Fishery.

4.5.2 Management Methods

The use of the various management methods has been additive rather than sequential. In some cases, existing restrictions were revoked when new restrictions were enforced, but the major management methods have been introduced with other types of management still in place. In this section, the major methods used in the management of the Hauraki Gulf Fishery are discussed. Where appropriate, the reasons for implementing the particular method, the arguments accompanying its introduction, and the effectiveness of the method are also discussed.

Open access

The earliest form of fisheries management in the Hauraki Gulf was open access. It could be argued that the open access prior to 1902 cannot be classed as a management method since no action on the part of the fisheries management agency was taken. However, fisheries management regulations were made as far back as 1885, and had the Hauraki Gulf Fishery been severely over-exploited before 1902, it is likely that regulations would have been used to restrict fishing effort, thus ending the open access situation. As it was, the open access method of fisheries management was adequate during the early stages of the Gulf Fishery.

Area and effort controls

By far the most common management method used in the Hauraki Gulf Fishery is a combination of closed areas and effort controls. In a very few areas, all fishing (commercial and amateur) has been banned, but in general the area restrictions have applied only to certain fishing methods or to some of the boats using a fishing method.

The earliest restrictions, from 1902 to 1920, applied to trawlers. In these years trawlers were banned from a large but variable part of the inner Gulf (Figure 4.19). It is interesting to note that the present day trawl line, although different in precise location, bans trawlers from a similar sized portion of the Gulf as in the 1907-19 restrictions.

When Danish seining was introduced to the Gulf, it was progressively restricted from the inner Gulf. However, the area limits on Danish seining have never been as restrictive as those applying to trawling.

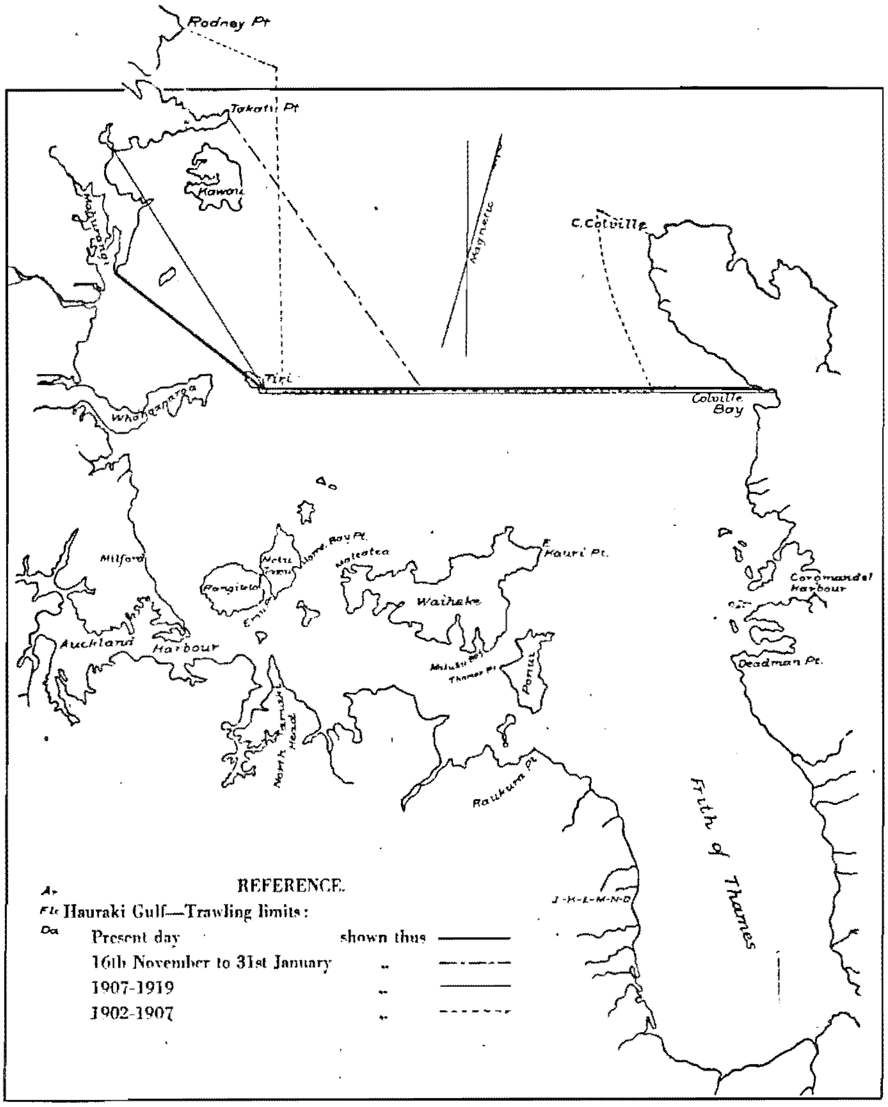


Figure 4.19 Area restrictions for trawlers in the Hauraki Gulf from 1902-1928. (From Hefford, 1928).

At various times two additional factors were used in conjunction with area limits. These were seasonal limits and effort restrictions. Figure 4.19 shows the 1919 seasonal trawl limits which applied between November and January. Since then, seasonal and area limits together have often been used in the Hauraki Gulf to limit both trawlers and Danish seiners. Seasonal restrictions are not so popular in the present day management of the Hauraki Gulf Fishery, and only two are in use. These restrict pair trawlers and pair Danish seiners to fishing in only part of area 005 from September to February, and ban all trawling and seining from the Cape Rodney - Mangawhai River coast area from October to April.

Effort restrictions were used extensively in the Hauraki Gulf. Early effort restrictions affected Danish seiners, and in these regulations effort or size was defined by engine horsepower (Figure 4.20). In 1972 the Danish seine regulations were simplified, and in the process the effort restrictions were done away with. Today the only effort restriction is the 19 m upper length limit which applies to all boats fishing in the Hauraki Gulf. The Ministry of Transport regulations regarding boat safety also depend on boat length, but these regulations are only indirectly related to fisheries management methods. It might be said that the major purpose of the earliest regulations (and some of the later ones), was to quieten a rather vocal group of people. Somewhat less cynically, Paul (1977) suggests that the early restrictions up to about 1920 were designed to,

> "make appropriate adjustments between conflicting interests of different groups of fishermen".

Paul (ibid) also claims that it was not until after 1920 that regulations were primarily concerned with conserving Hauraki Gulf snapper stocks. However Hefford (1929), albeit probably colouring the situation by his own outlook, suggested that the reason for the conflicting interests was the alleged decline in snapper stocks, presumably in the Auckland region of the Gulf. The question of what was the purpose of the early regulations then becomes a question of whether a regulation enforced in response to a perceived decline in stocks can be considered a conservation regulation.

Later regulations were clearly aimed at preserving snapper stocks, and to a lesser degree to reducing conflicts between fishing methods. In particular, the seasonal closures of the spawning grounds in the west of the inner Gulf were designed to protect spawning snapper. Effort restrictions were also

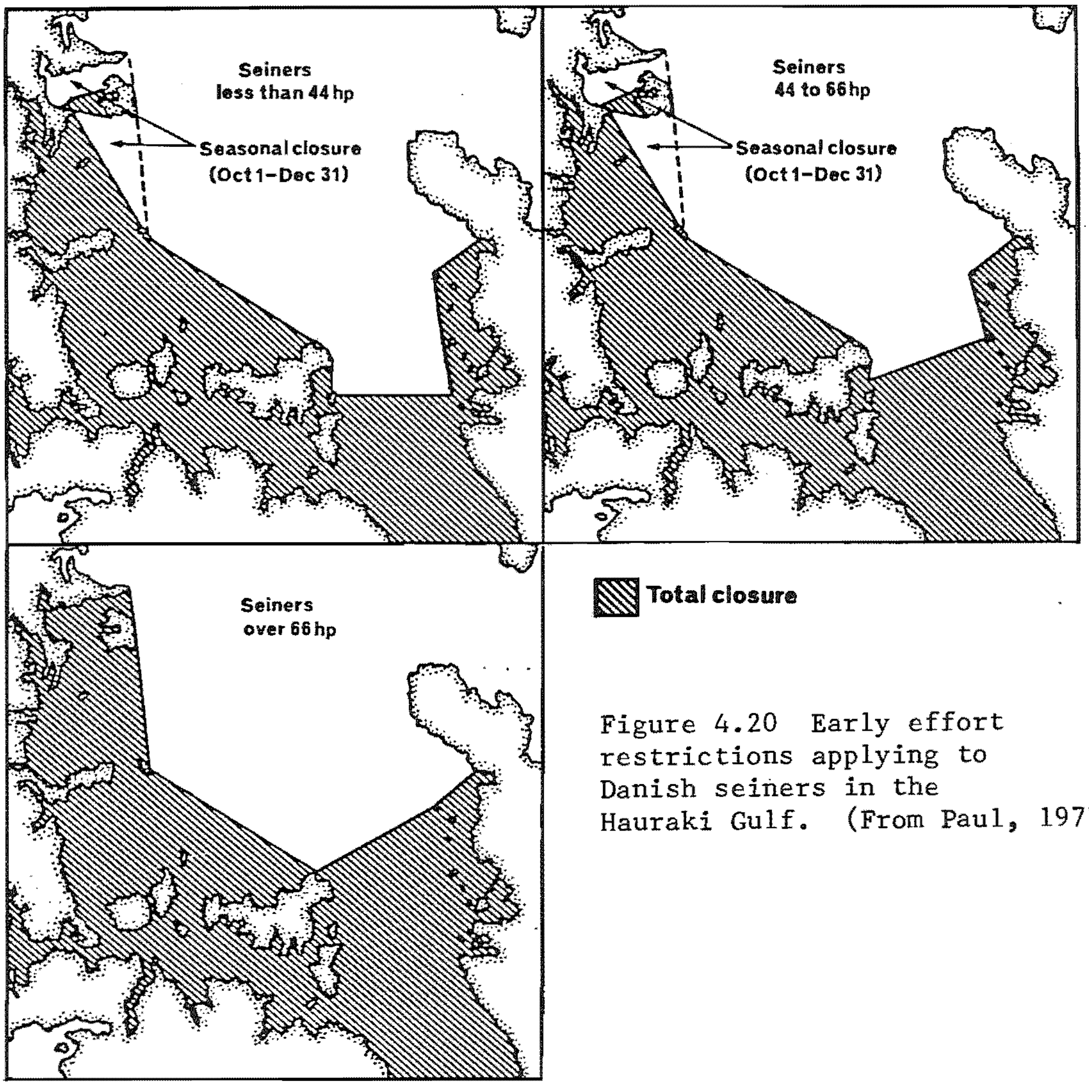


Figure 4.20 Early effort restrictions applying to Danish seiners in the Hauraki Gulf. (From Paul, 1977)

an attempt to reduce fishing pressure on the inner Gulf fishing grounds. The closing of parts of the Gulf to power fishing, and the various effort restrictions were also an attempt to reduce pressure on the inner Gulf fishing grounds. The seasonal closing of the area between Cape Rodney and the Mangawhai River is presumably an attempt to reduce the commercial fishing pressure over the summer months in what is a popular amateur fishing area.

The effectiveness of these regulations is questionable. It is apparent that for a while the vocal 'anti-trawl' group was quietened by the 1902 regulations, although only until the reintroduction of steam trawling in 1915 and of Danish seining in 1923. As for limiting conflicts between those using different fishing methods, the regulations have been only partly successful. It is true that there are few conflicts in the areas of the Gulf where power trawling is banned. In these areas any remaining conflicts are between fishermen competing for prime locations in which to set their gear. However, in the Danish seining area in the middle of the inner Gulf there has at times been conflict between longline and Danish seine fishermen.

Most seiners resent the fact that after taking large catches in their own areas, longline fishermen then fish in the seining areas (L. Duncan, 1982). The presence of longlines restricts the area in which seiners can work, and at times longlines are 'fished up' in seine operations. Set nets are not usually used in the seine area and are not involved in the conflicts. Conflict over pair trawling has mostly been concerned with the alleged damage these boats do by taking whole schools of snapper and by dragging large weights across the sea bottom. The conflict between pair trawl fishermen and other fishermen is complicated by Auckland vs Whangarei disputes over who should be eligible to fish in the Hauraki Gulf Fishery.

The suggestion that each method be restricted to its own area in the Gulf has not been implemented. L. Duncan (1982) says that MAF officials claim that this would inhibit any evolutionary changes in the profitability of different fishing methods. The bias towards static fishing methods is obvious, since the present area restrictions allow evolving static fishing methods to be used in power fishing areas, but not the reverse. Thus whilst the regulations may have gone some way to reducing conflicts between fishermen using different fishing methods, they have certainly not eliminated them, and may in some instances have heightened conflicts.

The various restrictions have gone some way to preserving snapper stocks in the Hauraki Gulf. Snapper stocks have at times during the history of the fishery been depleted, and are depleted now, but without the restrictions, the situation would undoubtedly be worse. Trawlers, and later Danish seiners, would have progressively reduced snapper stocks to below fishable levels, starting near Auckland and moving out into the Gulf. Since it is least expensive to fish close to port, the snapper in these areas would have been given no chance of recovery. Vooren and Coombs (1977) found that the snapper stocks in the Firth of Thames (which is protected from power fishing) contains a considerably higher proportion of fish older than three years than in the central and outer Gulf. The ban on power fishing has probably had the effect of providing a sanctuary for the snapper - at least to the extent allowed by static fishing methods.

Whilst the effort restrictions on Danish seine boats in different areas of the Gulf appear excessively complicated, restriction of larger boats probably contributed to the overall fishing effort restriction. Similarly, the present 19 m length limit also restricts total fishing effort to some degree.

No doubt the seasonal restrictions on fishing in spawning areas reduced the mortality of snapper in those areas. However, if the reasons given for the abolition of spawning season restrictions are correct, the effectiveness of the restrictions in maintaining overall stock size, must be doubted. Spawning-area fishing restrictions are usually designed to allow fish to spawn before being caught. If fishing is restricted in spawning areas, fishing pressure will be transferred to other parts of the Gulf. Whilst catch rates might not be as high as in the spawning areas, fish are still caught, and are thus prevented from spawning in the future. Furthermore, since recruitment of snapper is more dependent on water temperatures than on egg numbers, some reduction in the already excessive numbers of eggs is probably not a major problem. On the positive side, snapper can be taken much more efficiently in the spawning areas since they are grouped in spawning schools.

Minimum mesh size restrictions have always been a part of the management of the Hauraki Gulf Fishery. In 1903 the minimum mesh size in the cod-end of trawl nets was set at 4 inches (10.2 cm), and in the remainder of the net 5 inches (12.5 cm) and later 4.5 inches (11.4 cm) (Cassie, 1955). Initially Danish seining mesh restrictions were the same, but the minimum cod-end mesh size was raised to 4.5 inches in 1926, and to 5 inches in 1936. Whilst the purpose of a minimum mesh size restriction - to allow small fish to escape - is obvious, the reason for setting the restrictions at the level they were, is not. Those involved with setting the mesh size were probably influenced by existing restrictions in other countries, since no research on the subject had been done in New Zealand. The reason implied by Cassie (1955) for the larger mesh restrictions for Danish seining nets is simply that at the time seiners were taking a large proportion of the total catch.

In 1955 Cassie investigated the relationship between mesh size, fish length, and escapement. Although not able to determine the mesh size resulting in the highest yield of snapper, he suggested that catches would be improved if the 4 inch trawl mesh restriction was increased to 5 inches. He calculated that over 250 tonnes of undersized snapper which was then being wasted, might be saved by the larger trawl mesh. At the time Cassie presented his results, the fishery was reasonably stable (Paul, 1977), and no further action was taken. Only in 1977 and 1980 was the trawl mesh minimum size restriction increased to 5 inches for parts of the Gulf. Thus although mesh restrictions have no doubt contributed to the maintenance of snapper stocks, their effect could have been enhanced by earlier use of larger mesh restrictions.

Total quotas

A snapper catch quota has only recently been used in the Hauraki Gulf and has been ineffective (MAF, 1984a). The quota was set at 3500 tonnes for trawlers and seiners in area 006, and was modified to 3800 tonnes for all fishing methods in all Gulf areas (005, 006, and 007) in 1980. The main reasons for its ineffectiveness are that snapper catches are not accurately known, and that the quota is probably too high. Quite apart from the fact that under-reporting of catches may be as much as 20-30% of recorded catches (MAF, ibid), the statistics collection system is too slow to provide catch totals in time to prevent the quota from being exceeded. The quota was not reached in 1983 despite increased fishing effort, which indicates that either the quota is too high or that there is considerable under-reporting. To further complicate the quota system, the Gulf amateur catch is certainly large, but also unknown, and thus connot be included in any quota.

There are a variety of amateur fishing restrictions. Longlines are restricted to 50 hooks and set nets are limited to 1 per person, 60 m (max) in length and 100 mm (min) mesh size. For all methods there is a 25 cm minimum fish size limit, and a daily bag limit of 50 fish per person. No fish caught by amateurs may be sold. The effect of these restrictions is impossible to calculate since the number of amateurs, the amount of fishing they do, the number and size of fish they catch, and the extent to which they abide by the regulations are unknown. However, it is unlikely that a daily bag limit of 50 fish could significantly reduce the overall amateur snapper catch since it is unlikely that this limit could often be attained.

Limited entry

Limited entry restrictions in the Hauraki Gulf Fishery have taken various forms. Although from 1903 all fishing boats had to be licenced, it was not until the 1937 Industrial Efficiency Act that the issue of licences in all New Zealand's fisheries could be, and was, restricted. The issue of some licences was refused, but the extent to which this limited fishing effort in the Hauraki Gulf is not known. Certainly the number of registered fishing boats in the Gulf declined at this time, but it is not known if this decline was result only of restrictive licensing. The 1963 delicensing of the fishing industry removed the provision for limited entry.

The next form of limited entry, again applying to all New Zealand fisheries, was the entry moratorium of October 1980 (MAF, 1982b). Unfortunately, as has been the case in overseas fisheries, the effect of the moratorium was probably to increase rather than decrease fishing effort. In 'classical' fisheries management a moratorium usually precedes a more severe form of limited licensing. To ensure that they will obtain a license in the later licensing regime, those fishermen who have a license but have been doing little fishing often increase their fishing effort to prove their commitment to the industry. From the point of view of reducing effort, the moratorium was unsuccessful. Mindful of the fact that a new licensing system was to be introduced within a few years, it is possible that fishing effort would have been less had no moratorium been declared. However, many new fishermen might have started fishing which would have increased fishing effort.

In March 1983 the Hauraki Gulf became a controlled fishery. This was the next form of limited entry and also provided for the enforced removal of some fishing effort from the fishery. Under the controlled fisheries regulations, those fishermen not meeting the requirements to be classified as a full-time fisherman were not issued with a license to commercially fish in the Gulf. However, it appears that the requirements for commercial fishing status were either set too low, or were applied too leniently. Whatever the reason, the number of fishing boats removed from the Gulf Fishery was fewer than the reduction calculated by the Fisheries Industry Board (A. Duncan, 1982) and recommended by Fisheries Management Division (MAF, 1984a) (Table 4.6).

The controlled fishery status for the Hauraki Gulf has probably caused more problems than it solved. The large number of boats left in the fishery ensured that any reduction in catch resulting from the exclusion of some boats, could easily be made up by increased fishing effort (or improved catch rates) of the remaining boats. Some of the fishermen who lost their license may be continuing to fish as 'pseudo-amateurs', the only difference being that now their catches are not recorded because they do not fill out fishing returns. Even if they abide by the 50 fish bag limit, their annual catch could theoretically be in excess of 8 tonnes.

Table 4.6 The number of full time fishing vessels by method that MAF recommended could be supported by the Hauraki Gulf snapper resource compared to the number of boat authorities granted by the Fisheries Licensing Authority (FLA).

	Methods				Total (All Methods)
	Trawl	Danish seine	All lines	All nets	
Number of fishing units recommended to FLA by MAF	13 or 21	19 or 23	72 or 88	32 or 39	136 or 171
Number of boat authorities granted by FLA in 1983	44[2]	25	182	123	374

(From MAF, 1984a).

Whilst they probably did not reduce fishing effort, the regulations did cause conflicts. Those fishermen who lost their license to fish in the Gulf were obviously displeased, especially since some had few alternatives for employment (L. Duncan, <u>pers. comm.</u>). Fishermen remaining in the Gulf consider that the regulations did not reduce fishing effort sufficiently, and fishermen in areas adjacent to the Gulf are concerned that fishermen displaced from the Gulf Fishery will fish in their area, thereby increasing fishing effort in already overfished fisheries (Clement and Walsh, 1983). Fisheries Management Division (MAF,1984a) concluded that,

> "the controlled fishery has not been effective in limiting fishing effort while the priveleged access enjoyed by those currently licensed to fish in the Gulf and the unnecessary conflicts so created are of little tangible benefit to the fishing industry as a whole."

Future controls At the time of writing, no other major management methods have been used in the Hauraki Gulf Fishery, although this will soon change. The new requirements for classification as a commercial fisherman, which were introduced in the October 1983 Fisheries Act, do not apply specifically to the Hauraki Gulf Controlled Fishery. However, the effort reduction scheme and the ITQ-based management system planned for introduction in October 1985 will include the Gulf Fishery. These planned management measures hold great potential for the successful biological management of the Hauraki Gulf Fishery.

Under the proposed ITQ management regime the total Gulf snapper catch can theoretically be set at any level. Whether this total eventuates in reality is another matter. Whilst ITQs are reasonably simple to police in fisheries where there are few boats using only a few ports, fisheries such as the Hauraki Gulf, where there are many boats and many places where fish are landed, pose major policing problems. In an attempt to better police the system, fish landings will only be permitted in specified ports and almost all sales of fish will require documentation in triplicate. In spite of these regulations and the heavy penalties for those caught breaking them, evasion will no doubt occur by both fishermen with quotas and those without. Furthermore, the abiding problem of controlling amateur catches will not be solved by the use of ITQs.

The proposed use of royalties will have little affect on fishing effort. It is planned that when ITQs are introduced, the level of royalty payments will at first be low, and will only increase as the economics of fishing improves (MAF, 1984b). Linked as they will be to the profitability of the fishery, royalties will have the effect only of lowering the value of the quota, and encouraging fishermen to catch their quota in the most efficient manner. They may also result in increased illegal fishing since the profitability of such fishing would be greater than if no royalties were payable.

The management methods used in the Hauraki Gulf Fishery have slowed but not stopped the increase in fishing effort. Like Christey's (1973) 'leaky bucket' analogy, various ways have been found to increase fishing effort whilst complying with the various direct effort restrictions. To effectively control fishing effort in this manner, every new innovation and increase in efficiency would have to be restricted, and the fishery would continue to become uneconomical. Limited entry, and even enforced removal of fishing effort, have not solved the problem. Tackling the overfishing problem from the other side by carefully controlling catches appears to hold the most promise for successful management of the Hauraki Gulf Fishery.

4.5.3 Management Institutions

Different institutions have been involved in the management of the Hauraki Gulf Fishery. Fisheries matters were dealt with by Parliament as a whole until 1885, when the portfolio of Minister of Marine was created. It is not known when an Auckland representative of the Marine Department was first employed, but Hefford (1929) refers to the "local [fisheries] Inspector" writing reports as early as 1906-07. It may have been much earlier. In September 1972 the Fisheries Management and Fisheries Research sections of the Marine Department were transfered to the new Ministry of Agriculture and Fisheries (MAF).

Since 1972, fisheries management throughout New Zealand has been the responsibility of MAF. Throughout most of the history of New Zealand fisheries management, management has generally been conducted on a national basis, but in the MAF era there have been moves towards regional management (Cunningham, 1983). The controlled fisheries provisions of the 1977 Fisheries Ammendment Act require that regional considerations must be taken into account in the management of controlled fisheries, but do not represent a major decentralisation of management. Being the only controlled finfish fishery in New Zealand, the Hauraki Gulf has been influenced more by these regulations than other fisheries.

Regionally based management is one of the major changes brought about by the 1983 Fisheries Act. Four coastal management areas have been defined, each with a management team and a Fisheries Management Advisory Committee. Each Fisheries Management Area is to some extent autonomous, and it is expected that this autonomy will increase as the later stages of the Fisheries Mangagement Plans are implemented. The new management structure is shown in Figure 4.21. The workings of this set up can most easily be described by considering the development of a Fisheries Management Plan (FMP).

The Fisheries Management Advisory Committee (FMAC), if appointed, is responsible to the Minister of Fisheries for the preparation of the FMP. In practise the FMAC functions more in a coordinating role, with the actual work of preparing the FMP being done by the Fisheries Management Team (FMT). In preparing the FMP, the management team obtains information from many sources. These include fishery user-group organisations, port liason committees, the Fisheries Research and Economic Divisions of MAF, and other agencies and organisations. Through the Regional Fisheries Management Officer the Director-General of Fisheries, and the National Fisheries Management Group of FMD also advises the management team.

When the draft FMP is completed it is submitted to the Minister. If it meets with his general approval it is then made available to the public for inspection, who may lodge an objection or submission to the Director-General. The Director-General, or at his discretion, the Fisheries Authority, considers the submissions and then makes recommendations to the Minister. When the Minister gives his final approval of the FMP, it becomes part of the regulations of the 1983 Fisheries Act.

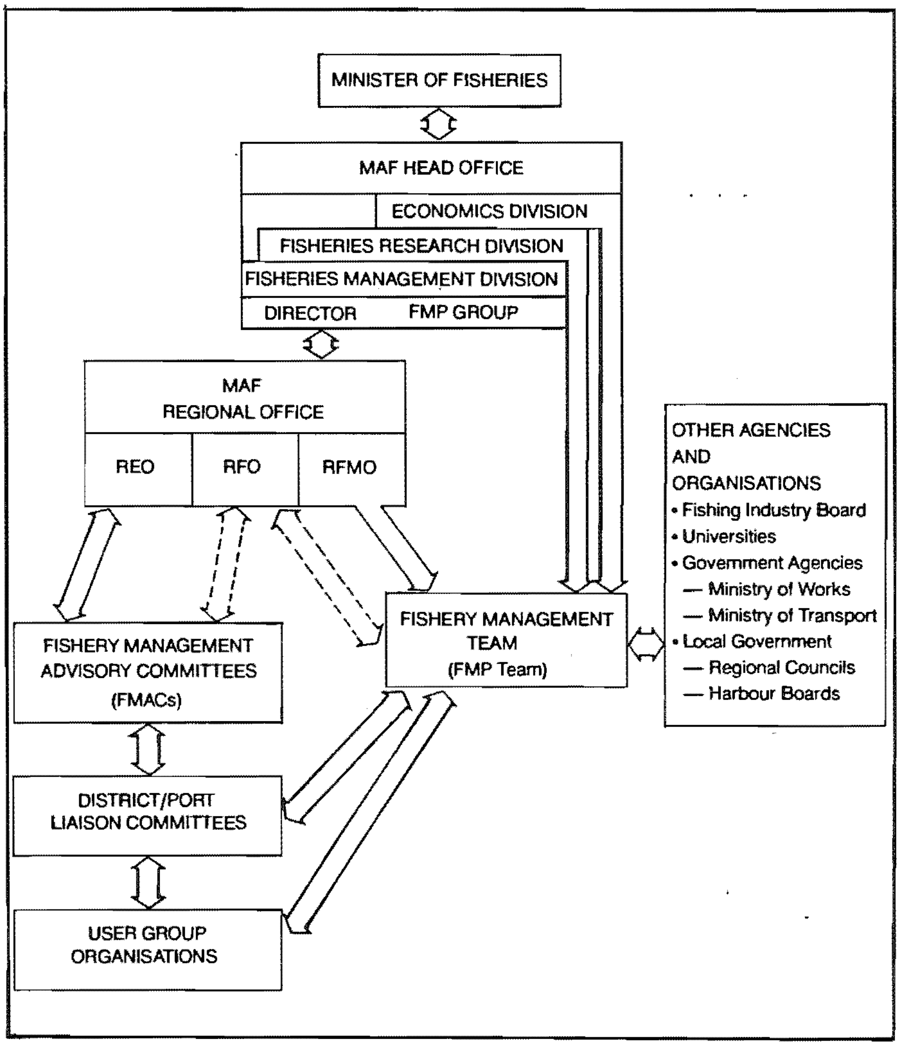


Figure 4.21 Fishery management structure and consultative network. (From MAF, 1984g).

The management institutions described so far apply to all New Zealand fisheries, but there is an institution concerned only with the Hauraki Gulf Snapper Fishery. The Hauraki Gulf Snapper Advisory Committee was formed in 1978. It comprised representatives of the fishing industry and non-voting MAF advisors, and was set up under the auspices of the Fishing Industries Board to advise MAF on the management of the Hauraki Gulf Fishery (Paul, unpublished). There were no representatives of local authorities or amateur fishermen on the Committee.

The Advisory Committee had a number of inherent problems. In spite of representation being confined to the commercial fishing industry, agreement on regulatory measures for the Hauraki Gulf Fishery was difficult to secure. Eventually, some relatively minor ammendments to Gulf regulations were agreed upon. These included size restrictions on trawlers and Danish seiners, the banning of pair trawling (a regulation which was later revoked), increased trawl mesh size, and a revised snapper quota (Paul, ibid). Overall it appears that the Hauraki Gulf Snapper Advisory Committee contributed little to resolving the major problems facing the Hauraki Gulf Fishery.

CHAPTER 5

MANAGEMENT OBJECTIVES FOR THE HAURAKI GULF SNAPPER FISHERY

5.1 INTRODUCTION

It was shown in Chapter Two that there are many possible objectives for the management of a fishery. Regardless of whether overall management is by means of satisficing, use of a modified MSY or MEY, or some other method, the various objectives important in defining OSY or ASY must be identified. In this chapter possible management objectives for the Hauraki Gulf Snapper Fishery are discussed.

Every fishery has unique features, and the Hauraki Gulf is no exception. The differences mean that suitable management objectives differ between fisheries, depending on factors like those shown in Figure 2.1. In Chapter Four various details of the Gulf Fishery and its management were described, and in Chapter Three the development of the national fisheries management system under which the Gulf Fishery is managed was outlined. Based on these, it is possible to evaluate the importance and suitability of different management objectives for the fishery.

In this chapter only selected objectives are discussed. With the introduction of social objectives to fisheries management there is now a long list of objectives which should probably be considered if management efforts are to be comprehensive. However, to do justice to all these objectives would require extensive training in the social sciences and a lot of time, neither of which I have. The choice of objectives for discussion in detail was influenced by my own interests, by what I initially considered the most important objectives, and by the limits of information availability. In Sections 5.2 - 5.5, each management objective is discussed in general terms and then in the context of the Hauraki Gulf Fishery, with figures drawn from the fishery where possible and appropriate. These figures are used in Chapter Six. Other possible management objectives for the Gulf fishery are listed and briefly discussed in Section 5.6.

5.2 BIOLOGICAL OBJECTIVES

There is still a need for biological objectives in fisheries management. Although it is clear that, except where protein is in short supply, MSY is usually not a justifiable objective for fisheries management, Anderson's (1982) claim that specific biological objectives are unnecessary is misleading. He suggests that,

> "achievement of properly stated economic and social objectives will, of necessity, properly maintain the stock".

This view is unrealistic. It is true that achievement of other objectives requires that the stock be maintained, but that very requirement means that some biological objectives at least are necessary. Anderson seems to advocate the use of biological objectives without calling them biological.

Critical minimum stock size

Whilst support for other biological objectives varies, support for the maintenance of a viable fish stock is unanimous. This is largely a consequence of the fact that virtually no other objectives - biological, economic, or social - are possible if the fish stock is reduced to commercial or biological extinction. This is certainly the view taken by the fisheries management team responsible for the management of the Hauraki Gulf, which claims that

> "the principal objective of fisheries management is to ensure the sustainability of fisheries stocks" (FMD, 1984).

Preservation as a management objective therefore warrants further discussion.

Opinion is divided as to whether Hauraki Gulf snapper stocks are in danger. In the discussion of stock size and production in Section 4.3.2 it was concluded that neither the population size nor the sustainable yield are known with much precision. Most people agree that overfishing is occurring and that the yield is smaller than it could be, but on the crucial question of whether it is growth overfishing or recruitment overfishing, not everyone is agreed. Whether the snapper stocks are in danger depends largely on which type of overfishing is occurring.

It was Cushing (1973) who drew attention to the distinction between growth and recruitment overfishing. Growth overfishing occurs when fish are caught too young, and the total yield is therefore less than if the fish had been allowed to grow bigger before being caught. Recruitment overfishing occurs when the stock of mature fish is reduced so much that spawning is reduced and there are too few recruits to maintain the stock. Growth overfishing is largely an economic problem, but recruitment overfishing is a serious biological (and economic) problem.

There is good evidence to suggest that recruitment overfishing is not occurring in the Hauraki Gulf Snapper Fishery. Paul (1982b) and Colman (1982) concluded that there was no evidence to show that the production of juvenile snapper in the Gulf was declining, and in fact it probably increased between 1977 and 1980. Circumstantial evidence associated with the number of eggs spawned by snapper (see Section 4.3.1) suggests that for recruitment overfishing to occur, either the stock of mature snapper would have to be reduced to a very low level, or there would have to be a series of successive cold spawning seasons. There is no evidence to suggest the first problem, and little that can be done should the second problem occur.

That growth overfishing is occurring there is little doubt. If it could be known with certainty that the present yield is sustainable, even if well below maximum, the issue would be primarily economic and social rather than biological. However, in spite of the fact that recruitment overfishing does not seem to be occurring, and catches are within the 50 year range (Boyd, 1982), catches are declining, and the stock size below which recruitment overfishing occurs is not known. Wilson (1982) cautions against the assumption of there being a single, safe minimum stock size, and advocates instead the concept of a stock size at which the probability of a good recruitment is reduced. After all, enough sufficiently cold, successive spawning seasons could result in recruitment failure for any sized stock. Wilson (ibid), suggests the problem for fisheries managers is as follows.

> "If the level of the critical minimum is not well known, the problem is to determine the factors, especially those that might be subject to management control or influence, which are likely to reduce the chances of populations approaching the critical minimum."

This is very much the situation with Hauraki Gulf Snapper stocks.

There are three major factors likely to cause the stock to approach a critical minimum level. Two of these can be controlled to some extent, but the other cannot. Spawning season temperatures are completely beyond the control of fisheries managers, and short of breeding a new stock of snapper less susceptible to cold spawning conditions, nothing can be done to influence its effect on recruitment. Disease and environmental factors other than temperature may also affect spawning success, but these too are probably outside of management control. Thus, regardless of any management measures, there will always be a degree of environmental uncertainty regarding recruitment.

Pollution, and other habitat-destroying factors may influence spawning success. Boyd (1982) suggested that one of the keys to maintaining maximum snapper production was the prevention of,

> "degradation or destruction of the fisheries habitat",

but it is not known to what extent (if any) snapper are already influenced by this factor. It is well known that eggs and larvae of fish are often more susceptible to pollutant-induced mortality, and if pollution levels were sufficient to impair spawning success, the effective critical minimum stock size would be increased. Pollution control can only be considered a long term, and in the case of the Hauraki Gulf, probably preventative, fisheries management measure.

The major controllable factor likely to result in a critical sized fish stock is fishing mortality. As shown in Section 4.5, management regulations have so far not prevented an erratic increase in fishing pressure in the Hauraki Gulf, although the pending ITQ system may be more successful in this task. Assuming that with a suitable regulatory system and sufficient policing, the snapper catch could be controlled, the question then becomes what catch level is appropriate to prevent recruitment overfishing. As with the critical minimum stock size, there is no single optimum catch level.

The major determinants of the allowable catch level (TAC) are the selected objectives of management. Critical minimum stock size will only affect the setting of the TAC if the catch required to achieve or satisfice the other objectives is likely to cause the snapper stock to go below the critical minimum. Where this is the situation, a trade-off must be made. The benefits of more closely achieving the objectives must be weighed against the costs of possible recruitment failure. Whilst it is unlikely that these costs and benefits can be easily quantified, an intuitive trade-off, at least, must be made.

One other possible management technique for reducing the problem of critical minimum stock size is worthy of note. For some fish species it is common practice to enhance recruitment by 'reseeding' with artificially-reared juveniles, and this practice has been suggested for New Zealand Snapper stocks. At a symposium set up to investigate the prospects for reseeding and the associated practice of snapper farming (Smith and Taylor, 1982), there was some support for reseeding, but a general conclusion was that there is no need for reseeding in the Hauraki Gulf. It has not been shown that there is a shortage of juvenile fish and it is possible that any additional juvenile fish would exceed the carrying capacity of the Gulf environment. Reseeding does not at present appear to be a justifiable management technique.

Other species

The Hauraki Gulf Fishery is neither a fully single species fishery, nor a true multi-species fishery. Although the major proportion of the Gulf catch is snapper (59.8% in 1983) (see Figure 4.10), it does not compare with single species fisheries like those based on tuna or other pelagic fish. However, taken as a whole, the Gulf Fishery is not sufficiently multi-species based that fishermen can switch between whichever species is most abundant in the manner described by Wilson (1982). As such, the Hauraki Gulf Fishery is something of an enigma, suffering both the problems of multi-species and single species fisheries.

The snapper is not the only overfished species in the Gulf. Table 5.1 shows the catch reductions required for each of the major Gulf species, for both the immediate future to enable fish stocks to be rebuilt, and for the longer term if maximum sustainable yields are to be taken. Other than snapper, those species most in need of catch reductions are trevally, tarakihi, rig and gurnard. The 1983 catches of tarakihi and groper (29.5 and 2.2 tonnes respectively) are below the required interim yield, but this may in part be an artefact of the change from a statistical system based on Gulf port landings to one based on Gulf area catches. Certainly Gulf catches of groper and rig need reducing.

The catches of some species can be increased. In particular, it is thought that the commercial flounder fishery, based in the Firth of Thames, can be expanded from 400 tonnes annually to 450 tonnes annually. Other species which can take more intense fishing pressure are barracouta and the jack mackerels. Catches of john dory are at the estimated maximum yield.

Species	1981/82 Average Annual Catch (domestic) (t/yr)	Interim Yield (t/yr)	Change from 1981/82 (%)	Long-term Yield (t/yr)	Change from 1981/82 (%)	Reduction in Catch (1981 to 82) Required to Achieve Interim Yield (plus sign (+) indicates an increase) (t)
Snapper	4,200	2,800	- 33	3,800	- 10	1,400
Trevally	550	50	- 90	100	- 82	500
Tarakihi	300	100	- 67	200	- 33	200
Red Cod	0	0		0		0
Red Gurnard	500	400	- 20	400	- 20	100
Rig	200	50	- 75	50	- 75	150
School Shark	100	100		100		0
Blue Warehou	0	0		0		0
Gropers	50	30	- 40	30	- 40	20
Flounders	400	450	+ 13	450	+ 13	+
Soles	0	0		0		0
Monkfish	0	0		0		0
John Dory	250	250		250		0
Barracouta	350	500		500		+
Jack Mackerels	0	500		500		+
Total Prime Species	6,550	4,230	- 35	5,380	- 18	2,320
Total Listed Species	6,900	5,230		6,380		
Total All Species	8,600					

Table 5.1 Calculated total allowable catches (TACs) for various species in the Hauraki Gulf, to allow rebuilding of fish stocks. (From NAFMAC, 1983).

The extent of the 'multi-species' problems depends largely on the species selectivity of fishing methods (Figure 4.18). For example, 34% of overall set net catches comprises flounder, which can take more fishing pressure, but 19% comprises snapper and 16% rig, both of which require large catch reductions. None of the other fishing methods catch large quantities of species which can take more fishing pressure. Two of these species, barracouta and jack mackerels, are caught by pelagic fishing methods like purse seining which are not used in the Hauraki Gulf. Flounder are mostly concentrated in the Firth of Thames area where power fishing is not permitted. Flounder are not caught on longlines.

In the management of multi-species fisheries, 'species objectives' must be clearly defined. For example, it may be determined that snapper catches must be reduced, regardless of whether the maximum yield of other species is taken. Alternatively, it might be decided that the flounder catch in the Firth of Thames should be maximised, in spite of the damage this may do to rig and snapper stocks. Obviously, if set nets can be placed so as to catch flounder without catching much rig or snapper, and catch limits can be enforced, management is made easier. However in general, the desired yields of all species will not be achieved simultaneously, and compromise will be required. A clear statement of species objectives, with attendant reasons, is required if the apparent mismanagement of some species is to be understood by the fishermen and others.

It can be seen that some biological objectives are still required in fisheries management. Whilst the yield aimed for may be mostly determined by economic and social objectives, the objective of maintaining a viable fish stock requires that recruitment fishing be prevented. In a multi-species fishery it is not always possible to manage each species optimally, and the management of some species may have to be compromised to allow better management of more important species. This problem is exacerbated where the catch composition of fishing methods cannot be changed.

5.3 ENERGY OBJECTIVES

Like many industries fishing relies heavily on the use of energy. What distinguishes fishing from most other industries is its high dependence on energy in the form of non-renewable petroleum products, and the severity of the problems involved in reducing this dependence. Over recent years fuel shortages, and especially large fuel price rises, have highlighted this dependence and its resulting problems. In this section, energy use by the fishing industry and in particular the differences in energy efficiency between fishing methods are discussed.

Two distinct aspects of energy use in fishing can be identified. First, the 'energy ratio' is the energy which must be used in fishing to obtain a unit of energy in the form of fish. Second, the 'energy cost' is the cost of the energy required to obtain a dollar unit of fish. Energy costs form a large proportion of total fishing costs, and are therefore an important factor influencing the profitability of fishing.

At a time when non-renewable energy sources are recognised as finite, and food sources in some countries in short supply, it is important to consider whether the energy used in food production is being used most efficiently. If it were possible to obtain more food by using energy in another form of primary production, then from an energy viewpoint it would be best to redirect the energy inputs in food production. Steinhart (1974) shows that coastal fishing has an energy ratio of approximately 1.0 (one unit of energy is obtained for each unit of energy used), and distant-water fishing a ratio of about 15. The former lies between range-fed beef production and grass-fed beef production, whilst the latter ratio is similar to that of feedlot beef production. Templeton (1981) calculated the energy ratio for the Otago coastal fishery to be 20.0. By comparison, all crop production ratios are below 1.0, with wet rice culture in some parts of South East Asia as low as .02. From an energy perspective then, distant-water fishing is an inefficient means of food production and coastal fishing is only reasonably efficient. The same energy investment in other types of food production would produce a better food energy return.

However, protein yield is also an important aspect of nutritional value. Carroz (1984) claims that in some developing nations fish products account for up to one quarter of the animal protein consumed. As shown in Figure 5.1, the protein content of fish relative to its energy content is high. Unfortunately, fish protein is not cheap. A unit of fish protein costs 1.3 times more than a unit of protein from meat, and 6.2 times more than a unit of protein from soya beans (after Slack, 1979). Although the energy investment required to obtain protein from different food sources is unknown, it is likely to be similar to the cost of protein production.

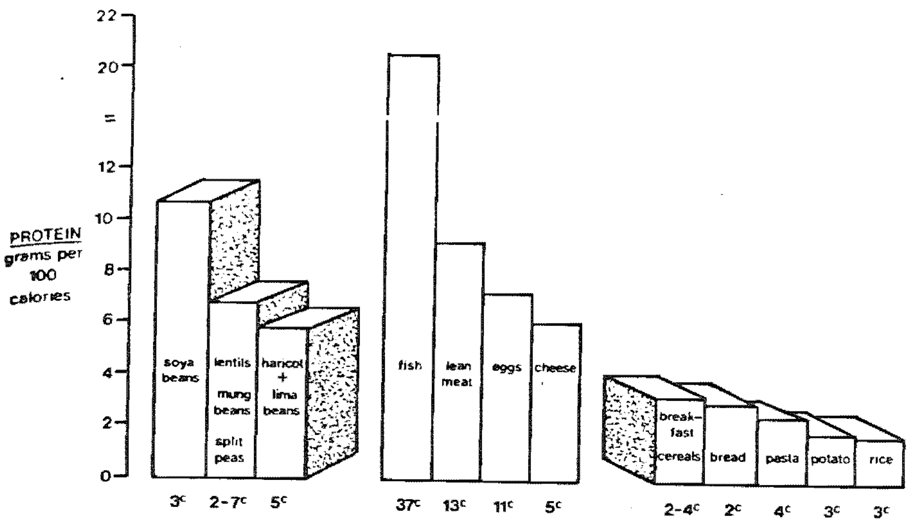


Figure 5.1 The cost of, and protein supplied by, 100 calories of legumes, animal products and cereals. (From Slack, 1979).

In spite of the relatively poor energy ratio and protein/invested energy ratio, commercial fishing continues. Why? Quite simply, there is profit to be made in catching fish for sale. In countries where there is limited scope for the development of other protein sources, fish protein is valued more highly than the energy required to catch the fish, and so fishing occurs. For countries such as New Zealand, where fish are a relatively unimportant source of protein, fishing can remain profitable for a number of reasons. Fish protein can be exported to countries where it is more highly valued, and in New Zealand fish is to some degree a delicacy, or at least a change from the normal diet, and thus commands a sufficiently high price to make catching profitable.

The decision as to whether fishing is a justifiable use of energy is beyond the scope of this report. Such a decision can only be made at a government level and must take into account the availability of energy, the availability of alternative forms of protein, and whether or not the country concerned can afford to use energy to satisfy a luxury need - if in fact fish is classed as a luxury.

Even if energy is not in short supply, there is a financial cost involved in its use. Since the fishing industry is so dependent on energy use and energy costs tend to form a major portion of the total costs involved in fishing, any opportunities to increase the efficiency of energy use in fishing are important, if only from a financial perspective. So from both energy ratio and energy cost perspectives it is important to keep energy use as low as possible. In this vein the 'moral' suggested by Slack (1979) makes good sense.

> "... we should try and keep the energy cost of fishing down either by low technology fishing, or by developing higher technology fishing to strict energy accounting standards."

In its broadest sense fishing may be thought of as the process by which fish are transferred from their natural habitat to the consumer. This process involves a number of different stages, each one of which requires energy input. It is true that energy is required for fish growth, but this is usually only directly relevant to the management of fish farms, and not of natural fish stocks.

In his energy study of the New Zealand Fishing Industry, Riepen (1981) divided the fishing process into the following five sectors: catching, processing, storage, distribution and retailing. Since this report is concerned primarily with the catching sector of the Hauraki Gulf Snapper Fishery, sectors other than the catching sector will be discussed only in so far as they interact with the catching sector. Riepen further breaks down the energy inputs to the catching sector of the fishing industry into direct and indirect energy components. The only direct component suggested by Riepen is fuel. Indirect components include energy inputs in boat construction, equipment and ice.

Indirect energy inputs

In the Hauraki Gulf, boat construction is primarily of wood or steel, although ferro-cement, aluminium, fibreglass/GRP, and fibreglass over wood construction are also found in the fleet. Trawlers and Danish seiners are usually wood or steel, longliners are mostly constructed from wood, and set netters are wood, aluminium or fibreglass. In his report Riepen considers the energy input in the construction of a few fishing boats of various lengths constructed of steel, wood or fibreglass. He assumed an amortisation period of 20 years and divided the construction energy input by the boat's expected catch over those 20 years. The results are expressed as the number of megajoules of construction energy per kilogram of fish caught. Figures range from 0.8 MJ/kg to 1.7 MJ/kg and show little correlation with either construction material or boat size. There is perhaps a gradual decrease in the construction energy input per kilogram of fish caught with increasing length of steel boat although this is inconclusive. In view of there being no clearly observable relationships between the data, and since the maximum variation is about 1 MJ/kg - a figure Riepen considers insignificant - he has used the average figure of 1 MJ/kg as representing the boat construction energy input to fishing by all types and sizes of boats.

The 'equipment energy' input is similar to the boat construction energy. In calculating the energy input resulting from fishing equipment, Riepen assumed that New Zealand fishing operations are similar to those of the Scottish fishing fleet reported on by the Energy Studies Unit of the University of Strathclyde. The conclusion of this study is that regardless of fishing method, the equipment energy input is about 1 megajoule of energy per kilogram of fish landed. The amortisation period used in the Scottish study is not specified by Riepen but he presumably believed the results adequately represent the New Zealand situation.

Using only rough estimates, Riepen calculated the amount of energy used in making ice for the New Zealand fishing fleet. Assuming that ice is used at a ratio of 1:4 with fish and that the production of ice requires 200 MJ/tonne, he estimated the energy contribution of ice to be only 0.1 MJ per kilogram of fish landed.

Thus the total indirect energy input to fishing is assumed to be the same for all the types and sizes of fishing operations involved in the Hauraki Gulf Snapper Fishery.

1.0	+	1.0	+	0.1	=	2.1 MJ/kg
(construction)		(equipment)		(ice)		(total indirect energy)

Direct energy inputs

Direct energy inputs to fishing operations vary considerably. Differences attributable to factors like weather, season, skill, and luck, are difficult to quantify, but those attributable to fishing method can be quantified. Table 5.2 shows the direct and indirect energy inputs to different fishing methods. The figures are from Riepen (1981) and refer to the 1978 fishing fleet. There may have been some changes in fuel efficiency since that time, but is unlikely that the relative efficiencies of the different methods will have changed much.

Table 5.2 Energy use per tonne of fish caught using different fishing methods. (MJ energy/tonne fish)

Method	Direct (fuel)	Indirect	Total
Single trawling	12800	2100	14900
Pair trawling	10100	2100	12200
Danish seining	8000	2100	10100
Set netting	13800	2100	15900
Longlining	4800	2100	6900

(Modified after Riepen, 1981)

In Table 5.3 the energy efficiency of each method is shown relative to longlining. The data is not entirely applicable to the Hauraki Gulf fleet since the value of fish is calculated for an average New Zealand catch, and not for a catch with a high proportion of high value fish like snapper. This will have the effect of slightly underestimating the energy efficiency by value of snapper-specific methods such as longlining and Danish seining.

Table 5.3 Energy use of different fishing methods relative to longlining, based on value and weight of catch.

	Longlining	Set netting	Danish Seining	Single Trawling	Pair Trawling
Value	1.0	1.93	1.24	2.30	2.78
Weight	(1.0)* 1.0	(2.30) 2.87	(1.46) 1.67	(2.15) 2.67	(1.76) 2.11

* Figures in brackets are after Riepen (1981). Unbracketed figures are after Department of Statistics (1982).

From Table 5.3 it can be seen that both in terms of energy efficiency by weight of fish and by value, longlining is easily the most efficient method, and Danish seining the next most efficient. Set netting is the least energy efficient method by weight, but by value is more efficient than either pair or single trawling. In the Hauraki Gulf only about 20% of the average set net catch comprises snapper, whilst about 45% of the average trawl catch comprises snapper. Thus in the Gulf, set netting may be less energy efficient by value than trawling.

The importance of fuel efficiency depends on both fuel availability and fuel costs. Since the cost of fuel is usually related to its availability, it is convenient to consider fuel prices as representing both price and availability. Table 5.4 shows the price of diesel from 1971 to 1982. The January 1985 basic and bulk diesel prices are 67.5 and 67.4 c/l respectively, of which sales tax comprises 7.2 c/l. Petrol prices have increased by similar amounts. 1984 predictions by the Ministry of Energy suggest that the diesel price has levelled out, and may in fact decrease during 1985, after which it should remain nearly constant. However, the recent problems at the Marsden Point Refinery Expansion Project indicate that this prediction may be overly optimistic.

There are few simple ways in which the fuel efficiency of fishing boats can be improved. In the "Fisherman's guide to saving diesel" the Ministry of Energy (1981) suggests that propeller nozzles, variable pitch propellers, fuel flow meters, and large mesh nets can all contribute to using diesel more efficiently. However, even these measures are unlikely to result in savings large enough to off-set the increased price of diesel. The Ministry of Energy (ibid) concludes that heavy fuel oil is the only reasonable alternative to diesel in fishing boats, and even this is suitable only for large boats. There are at present purpose-built wind powered fishing boats in Lyttleton and in the Hauraki Gulf, but it would take a major change in fishermen's attitudes before this method becomes significant

	c per litre Basic Price	Bulk Price	Increase %	c per Gallon
1 January 1971	3.30	3.20		15.8
1 February 1971	3.78	3.68	+ 9.5	17.2
25 January 1974	5.98	5.88	+ 61.5	27.2
19 April 1974	8.67	8.57	+ 46.5	39.5
25 February 1975	9.17	9.07	+ 5.9	41.7
15 December 1975	13.87	13.77	+ 52.4	63.07
1 April 1977	16.17	16.07	+ 16.7	73.57
17 May 1979	17.17	17.07	+ 6.2	78.05
28 August 1979	18.77	18.67	+ 9.3	85.32
17 November 1979	25.17	25.07	+ 38.5	114.42
12 February 1980	30.77	30.67	+ 22.2	139.88
13 May 1980	32.77	32.67	+ 6.5	148.97
5 August 1980	36.97	36.87	+ 12.8	168.07
24 February 1981	40.07	39.97	+ 8.4	182.16
21 July 1981	42.37	42.27	+ 5.7	192.61
17 February 1982	42.17	46.07	+ 9.0	209.89
15 June 1982	49.97	49.87	+ 8.2	227.16
6 August 1982	56.67	56.77	+ 13.4	257.62

Basic Prices are subject to a rebate of 0.10 c per litre (0.5 c per gallon) if purchases are between 33 000 and 1 365 000 litres (given in Bulk Price column) and a further 0.10 c per litre for purchases over this figure (i.e. on total consumption).
Local body tax 0.33 c has been deleted in arriving at the final figures.
Source: N.Z. Fishing Industry Board

Table 5.4 Price of diesel fuel to fishermen. (From MAF, 1982c).

in the fishing industry. Wind-powered boats would only be practicable for use with static fishing methods.

Fishermen claim that they are in a "Catch 22" situation (MAF, 1982c), They are dependent on diesel, and with the price of diesel increasing fishing profits are being eroded. The final irony is that rather than subsidise diesel use by the fishing industry, the Government has applied a diesel tax.

Should the Government decide to reduce energy use by the fishing industry it has two main alternatives. First, it can further increase the tax on diesel and thereby use economic pressure to remove inefficient fishermen from the fishery. Second, it can directly restrict the use of energy-inefficient methods. The first method has the disadvantage of allowing energy-inefficient, but economically-efficient operations to continue fishing, but the second method may be seen as too 'interventionist'. The choice would depend on how necessary it was to reduce fuel energy use.

Increasing fuel prices, if not increasing fuel scarcity may cause major changes to the fishing industry. France (MAF, 1982c) suggested that,

> "the fuel bill [alone] is in excess of the operating budget",

and Cushing (1983) commented that,

> "the price of fuel may well play a part in reducing the great excess number of [fishing] vessels throughout the world".

Fisheries managers must decide whether or not it should attempt to influence these changes.

5.4 EMPLOYMENT

The importance of employment as a consideration in fisheries management depends on a number of factors. These include the general level of unemployment in the area, the number of unemployed fishermen, the cost of increasing fisheries-related employment, and the cost of supporting unemployed people.

Since most fish can be caught by a variety of fishing methods, each employing a different number of people to catch the same amount of fish, there is potential to manipulate the fishing fleet composition and influence the amount of fisheries-related employment. However, there are often major costs involved with this type of manipulation, and careful consideration of all relevant factors is important. Increasing employment on fishing boats requires the use of fishing methods with lower labour productivities. In most industries, labour is one of the most expensive inputs, and therefore an enforced reduction in labour productivity would be expensive. If a decrease in labour productivity was accompanied by an increase in capital productivity, the cost of increasing employment would not be so expensive.

General unemployment levels may be of only limited importance when determining the desired level of fishing employment. If there is little or no unemployment, employment of more people in the fishing industry would be at the expense of causing vacancies in other industries, and can therefore be considered as a cost. In the more usual situation where there are at least moderate levels of unemployment, few people may be suitable for, or want to, work on fishing boats. Although the required skills differ between fishing methods and between positions of seniority on boats, most require some fisheries related skills and qualifications. The qualifications may only be obtainable through technical institute courses. Furthermore, the lifestyle of a fisherman is generally very demanding, and very poorly paid in comparison with other jobs involving similar skills. Thus even where fisheries jobs are available, they might not be eagerly sought.

What is of relevance is the number of unemployed fishermen. Skilled as they are in fishing, fishermen may have difficulty obtaining other jobs, and may not want to work in occupations other than fishing. It might also be considered that fishing skills are an investment, which is wasted if not used in fishing. Wilson (1982) suggests that especially skills or knowledge related to finding fish are the most important factors in fishing success. Even if it were more economical to pay fishermen the unemployment benefit than to create jobs for them, additional social objectives might justify the economically inefficient creation of jobs.

We are warned however, not to over-rate the importance of employment (and other "secondary" objectives). Crutchfield (1975) gives two examples to show that emphasis on job creation in fisheries management may be unwarranted. He notes that the whole fisheries rationalisation scheme in Washington would increase unemployment less than the year to year changes in employment by the Boeing Aircraft Company. Furthermore, most of those who lost the right to fish were qualified in other occupations for which there were vacancies.

In another instance, the use of Drum seiners in the Californian anchovy fishery would have cost 200-300 jobs, but would have saved an estimated 3-4 million dollars. Crutchfield (ibid) summarizes the situation as follows:

> "In short there simply are not enough people engaged in commercial fishing in most areas to justify the adoption of grossly inefficient fishing and management techniques on the grounds that unacceptable unemployment would be created by a more rational operation of the fishery."

Notwithstanding such a warning, the Norwegian Fisheries Policy,

> "gives explicit support to labour-intensive fisheries and recommends the phasing out of one of the few profitable fisheries, (the factory

trawlers)" (Hannesson, 1984).

Where employment is important, regulated inefficiency may be acceptable in fisheries.

In New Zealand, fishing has never been a major source of employment on a national basis. Figure 5.2 shows the full-time and part-time employment in the catching sectors of the New Zealand and Hauraki Gulf fishing industries. Until the early 1960s employment levels in the industry were relatively constant. The 1963 delicensing resulted in a large increase in the numbers of full-time and part-time fishermen in New Zealand in general, but had little effect on the numbers of full-time fishermen in the Hauraki Gulf Fishery. Part-time fisherman numbers in the Gulf increased during the 1970s.

Statistics are not readily obtainable for years after 1975, but the number of registered fishermen probably increased until the entry moratorium was declared in 1980. The controlled fisheries regulations reduced the number of registered fishermen in the Gulf from somewhere over 1000, to 348. Most of those boats excluded in this move were small 1-2 man boats. Almost all the fishermen who lost the right to fish had some other employment, although this was not always sufficient to make a reasonable living.

Classifying fishermen as skilled or unskilled is difficult. Certainly some new deckhands may be relatively unskilled, but of the remainder, skills are probably proportional to the number of years spent working in the fishery. Those who lost the right to fish the Gulf when it became a controlled fishery would on the whole be the least skilled of the the Gulf fishermen, and therefore, regardless of fishing method, it is reasonable to assume that those now fishing in the Gulf are at least moderately skilled.

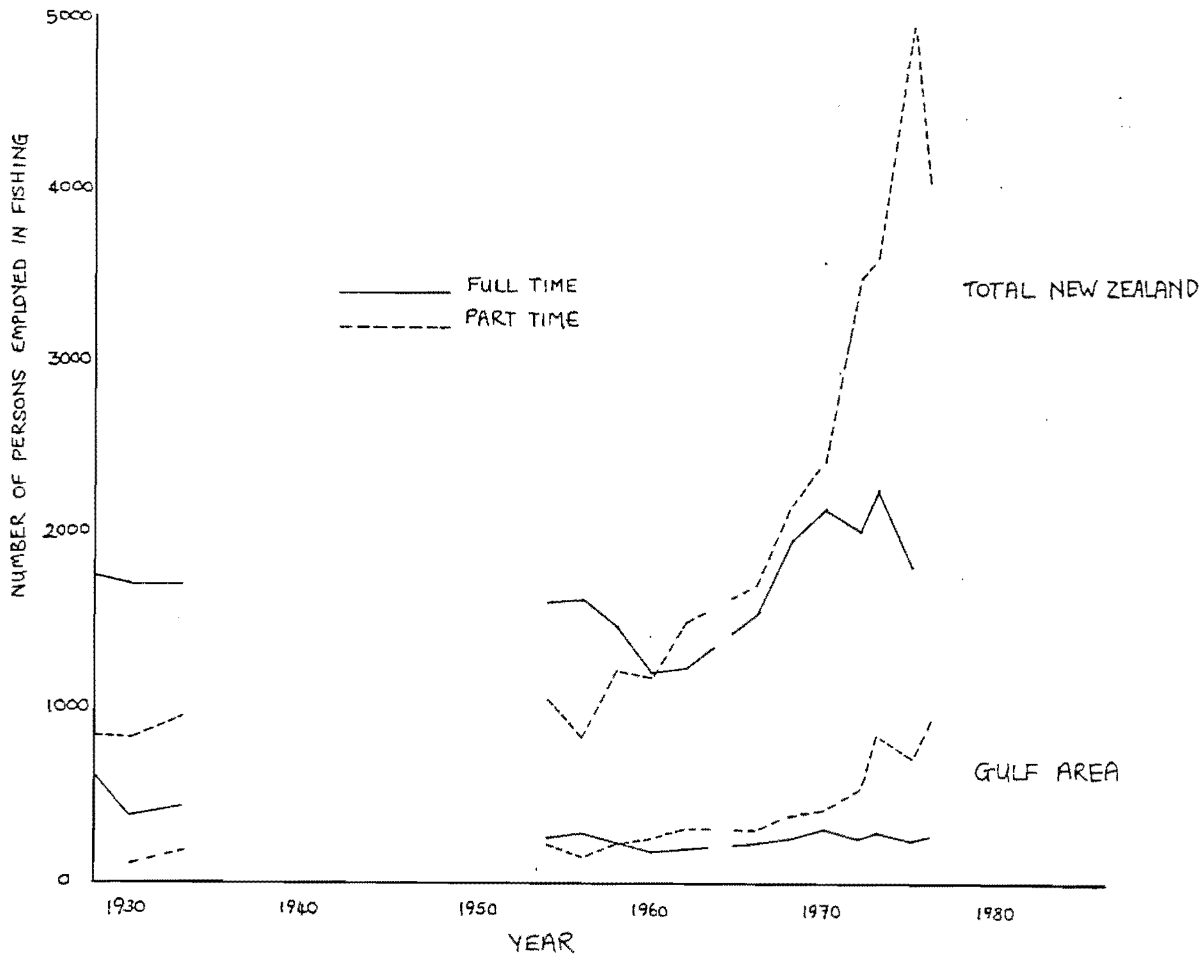


Figure 5.2 Full-time and part-time employment in the New Zealand and Hauraki Gulf Fisheries from 1928-1976. (Data from Anon, various).

In the Gulf area, general unemployment is moderately high, but registered fishing unemployment is low. Historical fishing unemployment figures are not available since fishermen are combined with farm workers for the purposes of unemployment records. However, the present day fishing unemployment figures for the Gulf region are available and are shown in Table 5.5.

Immediately obvious is the relatively low level of unemployment recorded for fishermen. Whilst this may be an accurate representation of the situation, it might be artificially low for a number of reasons. Unemployed people have some say as to what occupation they are classified

Table 5.5 Numbers of unemployed fishermen, and total number of unemployed persons in the Hauraki Gulf area. (Sept-Nov. 1984).

Centre	Unemployed Fishermen	Total unemployment
Auckland	9	8426
Takapuna	6	1055
Manukau	6	1381
Hamilton	10	1859
Whangarei	9	798

(From Department of Social Welfare, unpublished data).

under, and it may be that the generally poor outlook for fishing in the Gulf region has resulted in some unemployed fishermen choosing to be registered under the occupation in which they hope to find employment. From some areas of the Gulf such as the Islands and parts of the Coromandel Peninsula, it may be inconvenient to regularly visit a Labour Department office, and unemployed fishermen may not have bothered to register. Still others, normally resident in the Gulf region, may have shifted temporarily to other fishing areas.

If these figures are a true indication of the number of unemployed fishermen, then from the fishermen's perspective there is little need to increase fisheries employment levels. The possible exception is in small fishing communities where there are few other jobs. It is doubtful whether general unemployment levels justify measures to increase fisheries employment, although they may be sufficiently high to influence any management decisions resulting in more fishermen losing their jobs.

Any manipulation of the fishing fleet to influence employment levels is dependent on the labour productivities of the different fishing methods. Table 5.6 shows the different fishing methods classified according to two types of labour productivity. The standard labour productivity is the dollar output of the fishing operation per person employed. The labour productivity (in dollars) is shown for each fishing method relative to longlining. Of more relevance in an overfished fishery is the amount of snapper required to keep a fisherman employed in each of the fishing methods. These are also shown in Table 5.6, along with the theoretical maximum number of people that could be employed if only one fishing method was used in the Gulf.

Data from A. Duncan (1982) were based on the quantity of fish (assuming 1981 catch compositions) required for economic breakeven in each of the fishing methods. Data from 1983 MAF fishing returns are based on the number of registered fishing boats in the Hauraki Gulf Controlled Fishery (MAF, unpublished data), and on the reported 1983 catches for statistical areas 005, 006, and 007 (MAF, unpublished data). When calculating the number of fishermen using each fishing method from the 1983 data, those boats licensed for both trawling and Danish seining were counted as trawlers, and the number of boats licensed for set netting and longlining was split between the two methods.

Clearly there is a major difference between the 1981 and 1983 figures. Average crew sizes are little different, but the 1983 theoretical total employment figures are 1.3-3.0 times those for 1981. There are a number of possible explanations. First, the composition of the catch of each method has changed, which would have changed the value of the catch, and hence the amount of snapper required to financially support a fisherman. However, changes in catch composition were small, and inconsistent between methods. Second, the value of most species has increased, which would explain some of the increase in the number of fishermen the industry could theoretically support. However, prices have not increased sufficiently to account for the large differences, especially

Table 5.6 Labour productivity and the theoretical maximum employment for each of the major fishing methods in the Hauraki Gulf, assuming a TAC of 2800 tonnes of snapper, and the use of that method only. See text for explanation.

Method	Labour productivity relative to long-lining	Average crew size		Tonnes of snapper required to employ one person		Total people employed	
Trawler	2.9	2.17*	(2.44)**	32.44	(13.51)	86	(207)
Danish seine	3.4	2.17	(2.19)	19.91	(14.71)	141	(190)
Set net	1.1	1.20	(1.44)	5.83	(1.93)	480	(1451)
Longline	1.0	1.41	(1.60)	12.84	(4.57)	218	(613)

* Figures calculated from Duncan (1982)
**Bracketed figures calculated from 1983 fishing statistics (MAF, unpublished)

since increased costs have to some extent eroded the increased incomes.

More likely explanations depend on the different types of calculation methods used. The 1981 figures are based on the amount of snapper required to make a reasonable profit from fishing, whilst the 1983 figures are based on actual fisheries data. It is obvious that many fishermen in the Hauraki Gulf are not making a reasonable profit, and the fishery can therefore 'support' more fishermen. Although this undoubtedly accounts for some of the difference between the 1981 and 1983 figures, under-reporting of catches is probably also a factor. If fishermen are selling unreported fish, the data would indicate that fishermen are surviving on smaller catches than in reality. Under-reporting may be as high as 20-30% (MAF, 1984a), and may therefore explain much of the 1981-83 differences.

Particularly in the case of set netting, the assumption that existing data can be used to predict conditions if only a single fishing method were to be used in the Gulf, is unrealistic. Set netting is used only in the coastal areas of the Firth of Thames and Inner Gulf, and is not used in the deeper areas in the centre of the inner Gulf or in the outer Gulf. Furthermore, since snapper comprises only 20% of the average set net catch, such employment extrapolations as in

Table 5.6 would require that the other species in the catch would make up a similar proportion of the much larger catch. Since some of the species in the catch are found only in parts of the Gulf, this would not happen. Thus in spite of the fact that set netting at present employs more people for each tonne of snapper caught than any other method, it could not practically be used to take all, or even a major part of the Gulf Snapper catch.

Longlining is snapper specific and could theoretically be used to take most, if not all, of the snapper catch. Taking the snapper TAC of 2800 tonnes (from NAFMAC, 1983), using only longlining, would theoretically provide about 218 jobs (using the 'reasonable profit' employment estimate). If the TAC was taken by a combination of methods in the same proportion as the 1981 Gulf fishing fleet, as suggested by A. Duncan (1982), the total number of jobs provided in the catching sector would be about 167-183. Taking the snapper TAC with only trawlers would provide only about 86 jobs.

Although both theoretical and speculative, these figures give some indication of the extent to which fisheries managers could influence employment levels by manipulating the composition of the fishing fleet. Whether or not such manipulation should be used depends on the social and economic costs involved. Social costs will be determined in part by the prevailing societal attitude towards unemployment, and by other factors such as the acceptability of displacing career fishermen (trawl and seine fishermen) from their normal jobs. The economic costs are discussed in Section 5.5.

There are other important employment-related aspects of fisheries management. These include issues such as the extent to which the fishery should be regulated, the problem of special areas where employment is scarce, the effect of fleet composition on employment levels in the fish processing and boat servicing industries, and the other social issues.

5.5 ECONOMIC OBJECTIVES

MEY is not a single objective. A variety of economic factors can be used to form objectives, and like other types of objectives, it is usually not possible to maximise more than one of them simultaneously. Perhaps some of the popularity of MEY is that the one term can be used to describe often quite different objectives, the only common feature being that they are measured in dollars.

Differences between objectives often arise from the accounting stance used. For example, it must be determined for whom an economic objective is being sought. An objective to maximise individual fishermens' incomes may do little to maximise the income of the region or of the country as a whole. Another example is the inclusion or exclusion of costs like the payment of the unemployment benefit to unemployed fishermen, or the effects of changes in the catching sector on other industries. Factors like these can make a major difference between otherwise similar economic objectives. So that objectives may be differentiated, these factors must be specified.

The choice of economic objectives and their achievement is affected by the characteristics of the fishery being managed. In any particular fishery some economic objectives will be more important than others, and some will be easier to achieve than others. In this section some economic objectives relevant to the Hauraki Gulf Snapper Fishery are discussed in the context of the fishery.

The most common objective associated with MEY is that of maximising economic rent. This is achieved when the difference between the total income and the total costs in the fishery is greatest. Maximum economic rent from the fishery also corresponds with maximum individual fishermens' profits, but it is usually taken for granted that it is also the best from a societal point of view. Either it is assumed that society will benefit from the reinvestment of fishermens' profits, or that the excess profit will be removed from the fishermen. Profits can be removed by taxing inputs to the fishing operation, or by charging a royalty on catches.

Three key problems are evident in this objective. First, the levels of catch and effort associated with MEY can rarely be identified with precision, and even if they can be, attainment of these levels is often impractical. Second, it is difficult to redistribute fishermens' profits to society as a whole. Taxes and royalties appropriate for good fishing years seem unfair in poor years, and the management system cannot adjust taxes quickly enough to achieve acceptable levels every year. Instead, society must usually rely on the 'flow on' effects of fishermens' incomes for its benefits from the fishery.

The third, and most important problem with maximising the economic rent from the fishery is that MEY may not maximise anything except individual fishermens' incomes. There may be other factors which are deemed to be more important than economic factors, and if this is the case, MEY is not in society's best interest. However, even if other objectives are considered less important than economic maximisation, from a wider economic perspective, MEY may not be the maximum economic yield.

An example of this problem is that of employment in the fishery. Waugh (1983) has suggested (Figure 5.3) that employment can be substituted for effort in the classic surplus production model. MEY (where 'E' represents employment) is then considerably higher than the maximum economic yield, and larger even than MSY. Management for 'maximum employment yield' would reduce individual fishermens' profits, but would result in more people being employed. Where unemployment is high, these extra jobs may be very valuable to society.

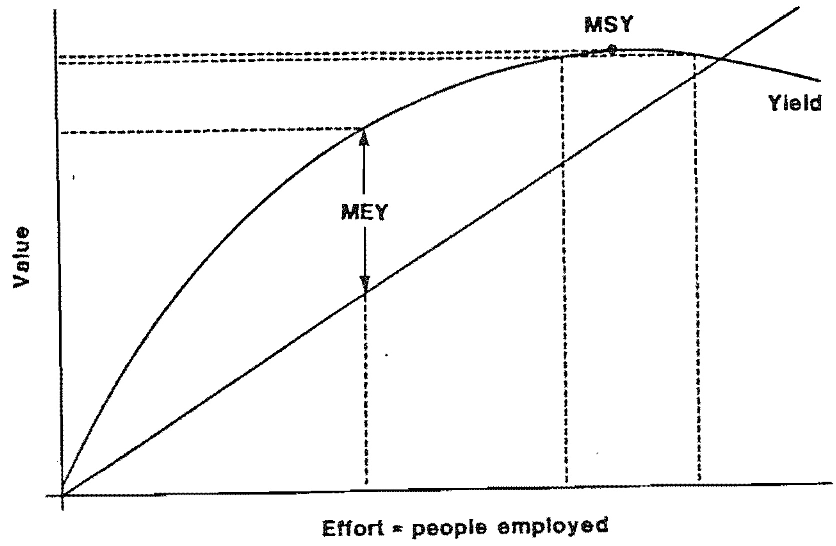


Figure 5.3 A classic surplus production model with 'people' substituted for 'effort'. (From Waugh, 1983).

It is difficult to know what economic savings to attribute to the creation of a job. One method of valuation is to use the amount of unemployment benefit that would have to be paid to someone if the job did not exist. In January, 1985 the unemployment benefit was $75.02 per week (single rate), and $162.42 per week (married rate). Alternatively, if flow on effects are considered, it might be appropriate to use the average fishermens' wage. There is no fishermens' award rate, but the minimum weekly wage is $92.17. The average New Zealand weekly wage is $284.51. Any one of these figures, or a combination, could be used to determine the societal economic value of a fisheries job.

When choosing a TAC, costs like unemployment may mean that the best yield is not MEY. The costs of not maximising individual fishermens' profits must be weighed against the savings which can be made by choosing a TAC other than MEY. Only then can the economically optimum yield start to be determined.

In Chapter Seven, the problem of allocating the TAC in a manner consistent with the way it was set, is discussed. Here, it is sufficient to recognise that if individual fishermens' profits are to be maximised, then the TAC should be taken by fishermen using the most economically efficient fishing methods.

The changes in predominant fishing method during the history of the Hauraki Gulf Snapper Fishery suggests that the relative economic efficiencies of the methods have also changed. Whilst there are various measures of economic efficiency, including capital productivity and net factor productivity, the simplest indicator of overall economic efficiency is net profit. As shown in Table 4.5, the profits from trawling have been declining and are low, those from Danish seining, moderately high but declining, those from set netting, low and relatively stable, and those from longlining, moderate and increasing. Based on these figures, the methods providing the best incomes are Danish seining and longlining. If the 1979-83 trends continue, longlining should become more profitable than Danish seining, a situation that may have already eventuated (L. Duncan, 1982).

The relative profitability of the fishing methods could, and if history is anything to go by, will, change. However, high fuel prices, and the better return from high quality longline-caught snapper, mean that it is likely that longlining will remain one of the most profitable fishing methods, at least in the near future.

In spite of money being the major factor determining how fishermen fish, some extra incentive might be needed to encourage fishermen to use the most profitable fishing method. This anomaly arises because of tradition, and because of asset fixity. Even if it means a lower income, a fisherman may prefer to continue using the method he is familiar with rather than learn a new method. Just as important is the fact that fishermen cannot usually change fishing methods without incurring a financial loss. If a fishermen wants to sell, say a trawler, because trawling is uneconomic, it is likely that others too will be selling trawlers and market prices will be low. Fisheries Management Division (MAF, 1984a) suggest that one of the reasons that,

> "an increasing number of fishermen appear to be finding fishing uneconomic but are choosing to remain in the fishery",

is the depressed market for fishing boats.

Another economic objective regarding different fishing methods is their labour intensity. As shown in Section 5.4 different methods require different numbers of fish to catch the same quantity of snapper. The benefits resulting from the creation of a job are discussed above. It is interesting to combine these factors and calculate the economics of employment in the different fishing methods.

From Table 5.6 using the more conservative estimates, it can be seen that if longlining was used to take the Hauraki Gulf snapper TAC, 132 more fishermen would be employed than if trawling was used to take the same TAC. Using the less conservative 1983 figures, 406 extra fishermen would be employed. If each job is valued at the married persons' unemployment benefit ($162.42 per week), then the annual economic value to society of the extra jobs is $1.11M, and $3.43M repectively for the two estimates. If the value of a job is higher because of social factors, then the overall values to society will be correspondingly higher.

To some extent, by default, employment-intensive fishing methods are already being encouraged in the Hauraki Gulf. The closure of large parts of the inner Gulf to power fishing methods for biological purposes, has had the effect of setting aside part of the fishing grounds for employment-intensive fishing methods like set netting and longlining. Other methods by which 'desirable' fishing methods might be encouraged are discussed in Chapter Seven.

Another economic objective is that of maximising the overseas earnings of the fishery. Assuming fixed prices, overseas earnings can be increased either by increasing the quantity of fish exported, or by increasing the quality of exported fish; higher quality fish usually attracting higher prices. At present anyway, the quantity of snapper caught in the Hauraki Gulf cannot, or at least should not be increased. Any increase in the quantity of fish exported can therefore only occur at the expense of less snapper being available on local markets. Given New Zealanders' liking for snapper, this is probably not an ideal alternative.

Provided the market for Iki jime snapper is large enough, the quality of overall snapper exports can be improved. A much higher price is obtained for this higher quality product, and if more of the present exports of lower quality snapper were caught and exported as Iki jime, overseas earnings could be significantly increased. Iki jime snapper are normally only caught by longline fishermen, and increasing exports of Iki jime would require more emphasis on longlining, and less on other fishing methods.

An unfortunate consequence of higher quality snapper exports would be an increase in local snapper prices. It is likely that if fish could be sold at high prices overseas, a high local price would have to be offered to prevent them from being sold overseas. A requirement for a percentage of catches to be offered to local buyers at specified prices would alleviate this problem, but would also reduce the profits of fishermen.

Overseas earnings can in effect be increased by reducing imports. In the Hauraki Gulf Fishery, major components of the fishery which are imported are fuel and some boats. Fishing methods which are fuel efficient would cause less expenditure on fuel than energy intensive fishing methods. In the Gulf fishery, only the largest trawlers are imported. A ban on boat imports would reduce the import costs of the fishery, but would not be popular among those fishermen who find it cheaper to import boats.

Another economic objective is that of minimising management costs. Like other management systems, fisheries management can grow beyond a cost-effective size (Larkin, 1982). Although Howard (1984) has pointed out that,

> "the fishery provides [fisheries managers] with useful and meaningful employment",

provision of extra management jobs is certainly not the major objective of fisheries management. The size of the management agency should be appropriate for the objectives and satisficing levels chosen for the fishery. More intense management does not always result in a more 'optimally' run fishery.

Anderson and Lee (1984) have shown that management costs may affect the optimum yield of a fishery. If management costs are included in economic analyses, the overall cost function for the fishery is increased, and the MEY is reduced. MEY may not be the desired yield but it is likely that inclusion of management costs would influence any yield, the level of which relied at least in part on economic criteria. It may be more economical to accept, and manage for, a moderate level of non-compliance with regulations and management uncertainty rather than increase the size of the management structure.

Depending on the fishery, there may be other, more specific economic management objectives. As with other objectives, the more economic objectives there are, the greater the difficulty in achieving them. The economics of a fishery cannot be resolved into one objective, and therefore some method of choosing and ranking objectives, and determining satisficing levels, must be used.

5.6 'OTHER' MANAGEMENT OBJECTIVES

In this section brief mention is made of two objectives particularly relevant to the Hauraki Gulf Snapper Fishery. These are the objectives associated with the traditional Maori fishery, and with the amateur fishery. Largely as a result of lack of information these objectives are considered only in general terms.

Traditional fisheries

As shown in Section 4.4.2, the Maoris have fished for snapper in the Hauraki Gulf for hundreds of years. In recent years, both in New Zealand and overseas, there has been increasing recognition of the rights of groups with an historical record of resource use or ownership, and this has included rights associated with fish resources. In the U.S.A. a judge determined that the equal rights section of the Fisheries Conservation and Management Act (1976) means that fifty percent of the TAC should be allocated to traditional (Indian) fishermen. In New Zealand, the Waitangi Tribunal recognised the need to protect a Taranaki shellfish fishery from pollution so that the Ati awa tribe could continue to use their traditional fishing grounds.

There are two main types of objectives within the field of traditional fisheries. One concerns the ownership of the fishery, and as in the U.S. case, can have far-reaching effects on fisheries management. The other type concerns the right of traditional fishermen to continue fishing in their traditional way.

The objective of returning ownership of a fishery to its original owners is often antagonistic with other management objectives. If ownership is returned, the fishery is immediately subject to limited entry restrictions, and there will probably be enforced exclusion of other fishermen from the fishery. These actions may be inconsistent with other objectives. Furthermore, if a fishery reverts to traditional ownership, management will be in whole or in part the prerogative of the owners, who will manage the fishery so as to meet their own management objectives.

Where traditional management objectives involve only the right to continue fishing in traditional ways, conflict with other objectives will probably not be as great. An example of this type of fishing is where the hosts of a Hui (gathering) may want to provide guests with traditional seafoods. Not being commercial fishermen, they are restricted by the normal amateur fishing regulations and may be unable to collect sufficient food for their Hui. Special exemption from the regulations would be required for sufficient food to be collected legally. Under section 66 of the 1983 Fisheries Act the Director-General of Fisheries can give exemptions for a variety of specified reasons, and, "for any purpose approved by the Minister." If the Hui organisers can convince the Minister of the validity of their request, it would presumably be permitted. Provided exemptions to allow for traditional fishing are not excessive, they would have little affect on other management objectives.

Amateur fishery objectives

Amateur fishery objectives are based around meeting the needs and wants of amateur fishermen. However, the variety of reasons for which amateurs fish (see for example Royce, 1972), means that there are quite different objectives within the amateur fishing fraternity. Larkin (1982) suggests that,

> "the prime motivation for sport fishing is the desire for a recreational experience that may subsequently be shared with others for mutual enjoyment".

Within this overall motivation for fishing, there are a number of objectives which contribute to the overall recreational experience. These can be characterised as, the fishing experience itself (with or without catching fish), the ability to catch some fish, and the ability to catch fish of a reasonable size.

Amateur fishery objectives often conflict with commercial fishery objectives. In a commercial fishery, the most efficient method (however that is defined), is usually used. In an amateur fishery it is the inefficiencies like method restrictions and the use of light fishing tackle that contribute to the enjoyment of fishing.

A common commercial fishery objective is to maximise the biological yield (MSY), or the economic yield (MEY). If the symmetrical surplus yield model (see Figure 2.2) is a reasonable representation of the fishery, then these occur at or below the stock size which is about one half of the unexploited stock size. Whilst at this stock size the biological yield is greatest, there are fewer fish, and thus the amateur fisherman has less chance of catching a fish as quickly as with a larger stock. For the amateur fishery, maximum stock size may be desirable, even though the corresponding yield is low.

Optimum fish size may also be different for the amateur and commercial fisheries. Large fish are usually highly prized by amateur fishermen, but large fish are not common in a heavily exploited fishery. If the commercial fishing objective is to maximise biological yield, then ideally, all fish would be caught at a the age where increasing body mass in the fish stock just equals the losses due to mortality. At this age fish are much smaller than those fish likely to result in (true) stories of 'the big one which got away'.

When choosing amateur fishery objectives and satisficing levels, a number of factors should be borne in mind. First, by some measures of value, economic or otherwise, even fisheries like the Hauraki Gulf Snapper Fishery which support moderate sized commercial fisheries, may be more valuable as an amateur fishery than as a commercial fishery. Even though amateurs fish only in their leisure time, the leisure time of more than 100,000 people may be more important than the full time work of a few hundred people. Furthermore, the economic value of recreational fishing may be very high, compared even with the commercial fishery. The second factor is that commercial fishermen are usually better represented in the management process than amateurs, in spite of the fact that there are many more people involved in recreational fishing. If management is to be fair, then the views of the 'silent majority' may have to be actively solicited.

Third, and as a result of the lack of information on amateur fishing, any implementation and assessment of amateur fishing objectives will be imprecise. That is not to say that amateur objectives are any less important, but only that if they are to be satisficed, and managers are to know that they are satisficed, then more information on amateur fishing is required.

CHAPTER SIX

THE FISHERIES MANAGEMENT PROCESS

6.1 INTRODUCTION

In Chapter Two the satisficing approach to fisheries management was introduced. Subsequent chapters contain descriptions of the New Zealand fisheries management, of the Hauraki Gulf Snapper Fishery, and of management objectives appropriate for the Hauraki Gulf Fishery. In this chapter a management process which incorporates the satisficing approach is described, and where appropriate, it is compared with the existing New Zealand fisheries management structure. The suitability of New Zealand's fisheries management policy and major management technique for incorporating satisficing is discussed in Chapter Seven.

The satisficing approach to fisheries management has been developed to cope with the latest stage in the evolution of fisheries management objectives. Initially, the major objective of fisheries management was the preservation of fish stocks. As the biology of fisheries was better understood, the objective of MSY came to dominate fisheries management, to be replaced only recently by the objectives of MEY and then OSY.

In the 'pure' OSY approach to management, the fishery is managed so as to maximise the benefits accruing to society, and no a priori emphasis is given to any biological, economic or social objectives. However, the resulting need to achieve multiple objectives has proved impossible, and instead, a 'compromised' OSY approach, where OSY is determined by modifying MSY or MEY by 'other' considerations, is used.

The alternative 'satisficing' approach to the OSY problem has been inferred by some workers, and used intuitively to some extent by most fisheries managers, but has not been properly described. In this approach, reasonable minimum levels of achievement of each objective are specified, and the fishery is managed in such a way as to attempt to achieve these 'satisficing' levels. If the satisficing levels are set too high, all objectives may not be satisficed, but whereas achieving or satisfying multiple objectives is usually impossible, with reasonable achievement levels, satisficing is possible.

6.2 THE SATISFICING PROCESS

A fisheries management process incorporating the satisficing approach has not been described. Pope (1983) used the concept, but only as a tool for showing the effects of different fisheries management techniques on management objectives. Opaluch and Bockstael (1984), gave no indication of how the,

> "approximate biological, social, and economic minimum requirements"

should be determined, and went only as far as suggesting that that this task is one,

> "for which political processess are well suited".

Having described the satisficing approach to management, it is appropriate to now outline a process by which it might be implemented.

The ideas behind the process described below have various origins. I have drawn on some of the ideas of Holling (1978), on the ideas developed by the Centre for Resource Management 'Class of '84' (Anderson et al, 1985), and on my own views on conflict resolution and the management process. The process described is not purported to be the optimum management process - an 'objective' that is unlikely ever to be achieved. Rather, it is suggested as a process which satisfices the objective by providing a process of management into which the satisficing approach is incorporated. The fisheries management process has been described by other workers (see for example Anderson, 1982), but none have incorporated satisficing.

The proposed management process is shown in Figure 6.1. Although it could have been broken into more or less steps, the eight steps shown form convenient sections within which to discuss various aspects of the management process. The iterative nature of management means that arrows could have been drawn between each step and every other step, but for easier presentation of the natural flow of management, only the major connections between steps are shown. Each of the steps is discussed in more or less detail below.

Step 1 - Determine need for, and authority for, management

The first step in managing a fishery is establishing that a need for management, and the authority to manage, exist. In almost every fishery the need for some sort of management is recognised by most people, but for a new management system to be introduced there must be general recognition that the present system is inadequate. Among the three requirements suggested by Wilson (1982) as necessary for a management system to be introduced, is that there must be a recurring problem. In the case of the Hauraki Gulf Snapper Fishery, problems are occurring, and have done so for many years.

Even when the need for management, or the need for a new type of management, is accepted, some person or group must be given a mandate to manage the fishery. Without a clear management mandate, those attempting to manage the fishery will be thwarted when attempting to make changes to the fishery which disadvantage or inconvenience anyone, as most changes surely must.

In New Zealand, the 1983 Fisheries Act provides the mandate for fisheries management. Through this Act, the people of New Zealand effectively give the fisheries management mandate to the Minister of Fisheries, to various parts of the Ministry of Agriculture and Fisheries Fisheries Management Division, and in a limited sense, to the Planning Tribunal. In Chapter Three the advisory structure of New Zealand fisheries management was described. However, it is valuable to identify the groups designated with management authority within this structure.

From the Fisheries Act it is clear that the Minister of Fisheries has most of the authority in fisheries management matters. It is the Minister who appoints FMACs to prepare and advise on FMPs, who vets each FMP for suitability prior to its 'gazetting', and who gives final approval to an FMP after submissions have been called for and considered. Even where an appeal is made to the Planning Tribunal, the

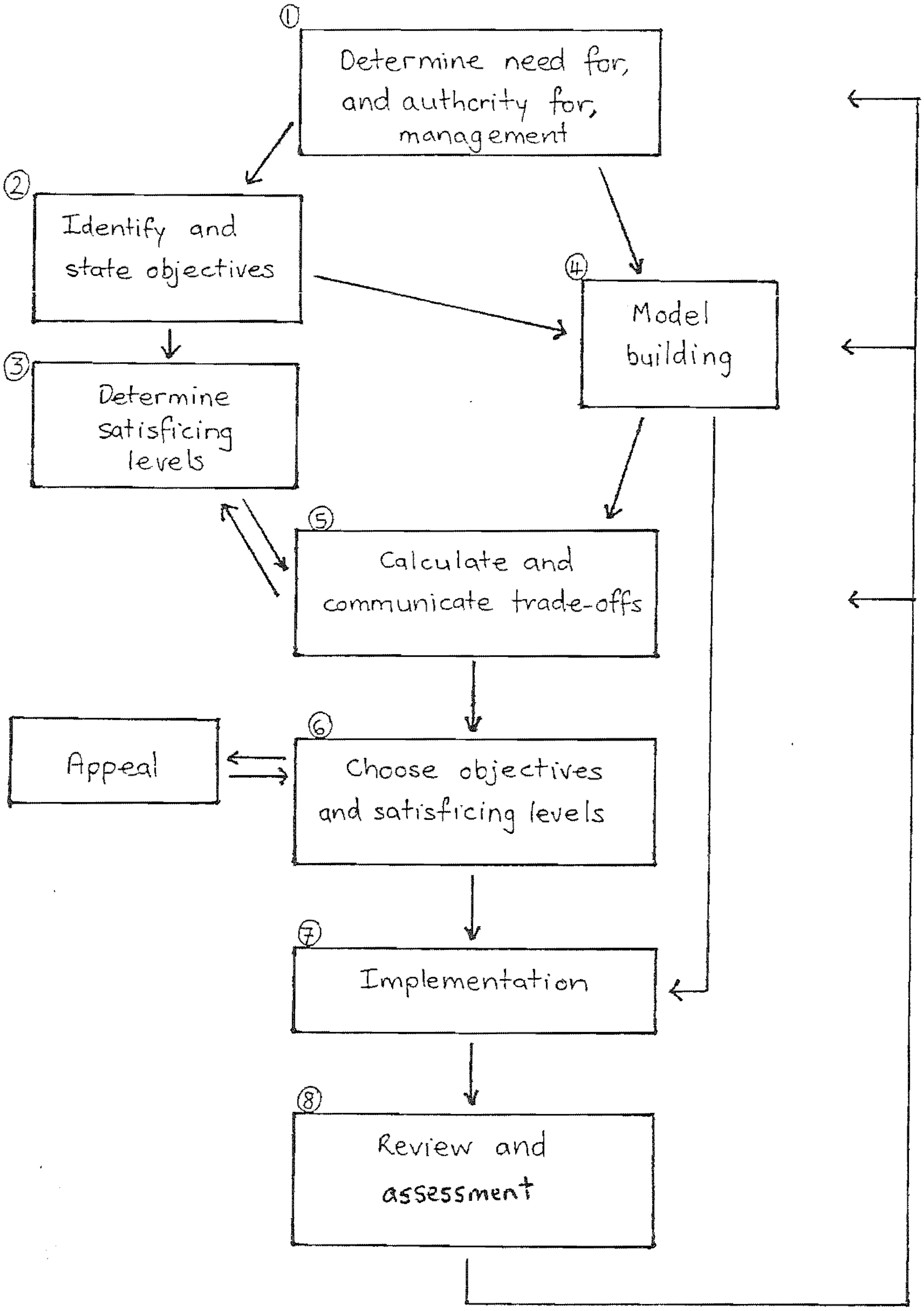


Figure 6.1 A fisheries management process which incorporates the concept of satisficing. See text for details.

Minister has authority to accept or decline the Tribunal's recommendations. The only group within the management structure who have authority not directly delegated by the Minister, is the Fisheries Authority. Included in the Fisheries Authority's management mandate is the authority to control the issue of licences for controlled fisheries, and to consider objections and submissions to FMPs. The only apparent control over the Fisheries Authority by the Minister is the fact that he appoints its members, and in some circumstances can have them removed from office.

Authority for the management of the Hauraki Gulf Fishery is delegated to the Regional Fisheries Management Officer (RFMO) and the local FMAC. The FMAC is responsible for the production of the FMP, in which any management objectives for the fishery are specified. The RFMO is responsible for the day to day running of the fishery, and along with the FMP team, is involved in researching and writing the FMP for the FMAC. Thus in practice, the management of the fishery has a large regional input, although the authority for this management remains with the Minister.

The need for a clear management mandate will become obvious in a later step of the management process. Most of the initial steps can be completed without the need for special authority, but in those steps involving the choice and implementation of management objectives, definite authority is required. If the existing management structure was to be used for a satisficing management process, authority levels below that of the Minister might have to be more clearly defined.

Step 2 - Identifying management objectives

Having established that there is a need for management, and that the authority to manage exists, the next step in the process is one of two which would normally be conducted simultaneously. For convenience these steps are discussed separately.

The identification of management objectives is essentially finding out what people want from the fishery. Everyone involved in the fishery, and those resident in the surrounding region, and even those in New Zealand as a whole, have a direct or indirect interest in the way that the fishery is managed. For those not directly associated with the fishery, objectives for its management will probably be of a general nature, such as maximising revenue from the fishery, or maximising overseas earnings. For people more directly associated with the fishery, objectives are likely to be more specific. They might include, maximising employment, the continued local supply of fish at the lowest possible price, or the right to continue fishing in the same manner - and catch some fish. Obviously there will be a wide range of possible objectives.

The problems involved in identifying people's wants and needs are considerable. Not only must those with an interest in the fishery be identified, but some method by which their opinions can be considered must be developed. Opinion can be solicited by methods such as questionnaires, but more commonly, use is made of interest groups, which it is assumed represent to a reasonable degree those with interests in the fishery.

Those groups with direct interests in the fishery, such as commercial and amateur fishermen, will likely be represented by their existing organisations, but those only indirectly involved, such as fish consumers in general, and the New Zealand public as a whole, will usually only be represented by management-appointed representatives. Orbach (1978) provides a checklist of those people and groups who should be considered in major fisheries management decisions, and from this it is obvious that directly or indirectly, many individuals and groups without official management representation have interests in fisheries management. Thus the success of objective identification is dependent on the extent to which fisheries managers actively solicit the opinions of the wider public for whom the fishery is being managed.

An important part of this step is the formulation of specific objectives. It is not sufficient simply to identify all those with interests in the fishery and their general views on its management. Instead, some specific objectives are required. Thus instead of recognising that the public of New Zealand has an interest in the management of the Hauraki Gulf Fishery, what it wants from the fishery should be identified and stated in a form that is useful in management (see Anderson, 1982).

The present fisheries management structure goes some way towards identifying management objectives. The Auckland FMAC, which is typical of the other three FMACs, comprises representatives of two commercial fishing organisations, of the Seafood Processors and Exporters Association, of the Fish Retailers Association, of the Underwater Association, of the Recreational Fishing Council, of the Maori Council, and of the Consumers Institute. Additionally, the Fisheries Management Team (FMT) is to consult with other Government and local body agencies and organisations (see Figure 4.21). Provided that members of the FMAC actively solicit the views of those they represent, and along with the FMT members, are available to hear the views of those not officially represented, most management objectives will be identified.

However, there may be value in dealing directly with the public as a whole rather than through organisations. A large proportion of the public, whilst interested in the management of the fishery, may belong to none of the organisations officially represented. A well designed opinion and survey used primarily in the Auckland and Gulf areas, could provide valuable information on what the public want from 'their' fishery. It would also allow fisheries managers to gauge the relative importance of each of the different management objectives identified.

Step 3 - Determine satisficing levels

The determination of satisficing levels is largely a continuation of the objective identification step. However, it is shown separately because satisficing levels are likely to be changed often in the management process as this step and a later step interact in an iterative manner. The objective identification step does not interact in the same way. Additionally, since the satisficing is what distinguishes this management process from others, it is helpful to isolate it in a separate step.

The satisficing step is where adequate minimum levels of each objective are identified. The management objectives identified in step two are mostly expressed in terms of ideals, such as maximising or minimising some factor. Aware that achieving any of these ideals is very difficult, and that achieving more than one is ususally impossible, in this step the fisheries manager seeks to identify the levels of each objective which will keep those people advocating the management objectives reasonably happy (or in Pope's (1983) terminology, keep their whinging to acceptable levels). Like step two, this step obviously requires close interaction with interest groups and others advocating management objectives.

Whereas identifying objectives is mostly a one-way process, determining satisficing levels involves two-way interaction between managers and the public. As shown in Figure 6.1, satisficing levels are likely to be modified as the trade-offs between the different management objectives become known. If the 'Holling style' of management is used, then the end result of this iterative interaction between the setting of satisficing levels and the calculation of trade-offs may be that the satisficing levels will be set in a way that all can be achieved. Holling (1978) advocates the involvement of all major affected parties in as much as possible of the management process. The trade-off calculation and communication step is discussed later.

Step 4 - Model building

The construction of a descriptive and analytical model can proceed simultaneously with the objective identification step. The purpose of this step is to draw together all the necessary and relevant information and data so that the relationships between the various management objectives can be defined. Information is obtained from a variety of sources and, depending on its complexity, is used in one of a number of ways to provide the required answers. Some aspects of the model and its construction are discussed below.

One function of the model is to draw together relevant information. In comparison to fisheries in other developed countries, relatively little is known about New Zealand fisheries. This leads to two problems. First, and rather obviously, there will be gaps in the descriptive model of the fishery. If the gaps occur in important parts of the model, then its analytical value will be diminished, and the inter-objective relationships defined from it will be more speculative. Some consolation is that use of a model at least allows information gaps to be identified, and further research can therefore be directed more effectively.

The second problem likely to result from information gaps is the use of irrelevant information. Where only limited information is available, there is a tendency to use everything that is available, regardless of its relevancy. This may result in some parts of the fishery being described in a disproportionate amount of detail. Holling (1978) emphasises that only information that directly contributes to solving the problem at hand - and not simply to making a more complex model - should be included. In a closely interacting model, the overall level of detail possible may be determined by that part of the fishery which is least well known. In this type of model, inclusion of additional levels of detail in other parts of the model will result in no greater accuracy, and may cause confusion.

The relevance of information is influenced by a number of factors. Of these, one of the most important is the management objectives identified in step two. It may be that little importance is place on objectives described by one part of the model. In such a case, information on that part of the fishery is necessary only as far as is required to provide answers regarding more important objectives. For example, if employment in the Hauraki Gulf Fishery was not an important concern, then detailed information on employment would be unnecessary, except where it was needed, for instance to provide answers on economic objectives. If management objectives, or their relative importance, change, so too may the relevance of different information. Again the theme is one of satisficing; enough information should be obtained to satisfice the requirements of the model, but no more.

There is a wide range of information which may be relevant. Undoubtedly at least some biological and economic information is required, and in addition, information on energy, employment, objective implementability, marketing possibilities and other factors may be required. Opaluch and Bockstael (1984) have recently drawn attention to the need to obtain some understanding of fishermens' behaviour when confronted with fishing restrictions. This is one factor among the often very relevant social aspects of fisheries which, perhaps because of the biological origins of fisheries management, tend to be poorly understood. As research continues and management experience builds up, the understanding of these factors should increase.

The second function of the model is to define the relationships between management objectives. Only if these are understood can the trade-offs between objectives be calculated, and the required management decisions be made effectively.

The term 'model' does not necessarily imply the use of computers, or even mathematics. Jeffers (1978) and Jorgensen (1983) define models as,

> "formal expressions of the essential elements of a problem in either physical or mathematical terms".

Models range from simple, intuitive, mental pictures of a fishery to complex computer models. The type of model used will depend on the answers sought, the quantity and quality of information available, and the skills and resources of the managers. Naturally the kudos associated with the use of complicated computer-based models is far greater than that accompanying the use of simple models, but the latter may be more appropriate in some fisheries. The use of computer models with insufficient information and data can be misleading, since the confidence limits associated with the results of other analyses are often forgotten when results are computer-produced. This feature caused one worker to comment that the problem with computer models is that people believe them.

Those models which involve a numerical description of the fishery can be classified in different ways. Of the eight descriptors used by Jorgensen (1983), one of the most important is that of 'steady state' versus 'dynamic' models. The former model type can be thought of as a 'slice in time', in which parameters and variables have fixed values. In dynamic models, parameters and variables can be changed to describe the state of a system through time. Fisheries show considerable temporal variation and dynamic modelling techniques are therefore usually most appropriate. However, to construct a dynamic model usually requires more information, greater modelling skills, and more resources than are required for steady state modelling. The choice of model type is therefore not straightforward.

Dynamic and steady state modelling are discussed in more detail in Appendix B. Included in this discussion is an example of the use of GOAL programming, a type of steady state modelling. The example uses some data taken from Chapters Four and Five to calculate the optimum fleet composition for the Hauraki Gulf Fishery. The model is incomplete and based on only one year's data, and the results are therefore of little practical value. The example does show how steady state modelling or optimising works, and gives an indication of how a more complete model could be used as a tool in the fisheries management process.

The model building step could be done within the present New Zealand fisheries management structure, but it is not explicitly required. The combination of the advisory structure (Figure 4.21), and the requirements of FMPs means that much of the information gathering role of the modelling step will be completed. However, the role of defining the relationships between management objectives is not specified in the requirements of FMPs or in any part of the management structure. That this function is not specified could impair the whole management process, because without an adequate modelling step, much of the basis for management is lost.

Within the FMAC, the FMT, and the various groups from whom these two seek advice, most of the information required for the modelling process is likely to be available. Where it is not, the all-important limits of the information will probably be known. The large information fields of fisheries biology and economics are covered by the Fisheries Research Division, Fisheries Management Division, and Economics Division of MAF and the FIB, and information on fishing methods and practices can be obtained from commercial fishermens' associations. However, as in most fisheries, the social aspects of New Zealand fishing are less well known. Of particular importance in the Hauraki Gulf are the amateur fishery, the traditional Maori fishery, the ability and willingness of fishermen to change between fishing methods, and the importance of fishing to small Hauraki Gulf communities. The management objectives likely to be important in the Hauraki Gulf fishery are such that information on these factors will be necessary if a model of the fishery is to be of much analytical value.

The requirement for the second part of the model building step can only be inferred from the 1983 Fisheries Act. In section 4. of the Act the purpose of FMPs includes,

> "having regard for....planning, managing...", and for "providing for optimum yields from any fishery".

Only if these functions of FMPs require the use of a model can modelling be said to be specified by the 1983 Act. Within the FMPs the relationships between some management objectives may be defined, but this will depend on the writers of the particular plan. The requirement for the definition of these relationships as far as is possible would increase the management value of FMPs.

The requirement for complex computer-based models is not advocated, in spite of Croker's (1975) claim that,

> "until we go into computer programmed models we will continue flying by the seat of our pants".

For many of New Zealand's fisheries the amount of information available is insufficient for even biological modelling to be successful, let alone bioeconomic, bioregunomic, or sociobioregunomic modelling! Instead, relationships between management objectives will probably only be determined in a qualitative, or perhaps very approximate quantitative manner. However, what is important in modelling is not the use or non-use of computers, but the fact that to the extent possible, inter-objective relationships are defined.

Enough is known of the Hauraki Gulf Fishery to allow some computer modelling to be done. But there are sufficient factors which are not well enough understood, such as the critical minimum stock size, the amateur snapper catch, and the behaviour of fishermen facing restrictions, that the predictive capabilities of the model would be limited. As shown in Appendix B, when there are more than a few uncertain factors included in a dynamic model, modelling efforts are concentrated mainly on testing the internal consistency of the model. Steady state models are affected less by this problem, but their predictive powers are limited because they can describe the fishery only at one point in time.

Step 5 - Calculation and communication of trade-offs

The calculation and communication of trade-offs is one of the linking steps in the management process. It is a continuation of the previous step in that the model-derived relationships are used to calculate trade-offs, but it is a separate step in that it involves the transfer of information from the fisheries specialists to the decision-makers and fishery participants. Regardless of the quality of any model, the model will be a waste with respect to management unless the relationships defined in it are communicated well. Although usually accorded little prominence in the management process, it is a very important step.

Trade-offs are calculated from the relationships between the different management objectives. Using these relationships together, in the model, it is possible to determine the affect that changing the satisficing level of one objective has on the satisficing of other objectives. It may be that the satisficing of one objective precludes the satisficing of other objectives, but that a change in that level will allow other objectives to be satisficed as well. By calculating the trade-offs associated with all the major management objectives, managers and decision-makers are better equipped to determine what should be sought in the management of the fishery.

Holling (1978) identified four types of information which should be communicated. These are, the data base, the technical methods, the results of the analyses,and the conclusions derived from these results. Holling (ibid) further suggests that for each of these types of information there are the actual numbers, and their degree of believability. Both must be communicated. Whilst the primary purpose of the communication step is to help non-specialists understand how different management objectives inter-relate, sufficient background information to engender the right degree of confidence in the conclusions must also be communicated. Too little confidence might result in over-cautious decisions, and too much confidence in rash decisions. Thus the additional effort required to communicate the various types of information is a necessary cost of effective management.

Communication of trade-offs both to participants in the fishery and to decision-makers is important. Communication with fishery participants should be a two-way process with the reciprocal flow being in the form of modified satisficing levels. Since participants are able to see the extent to which some objectives cannot be satisficed if other objectives are to be satisficed, they may be encouraged to modify the satisficing levels for which they are responsible. With adequate communication and at least a modicum of cooperation on the part of participants, levels may be modified sufficiently for most objectives to be satisficed.

The need for communication with decision-makers is obvious. Notwithstanding any modifications that can be made to satisficing levels, fisheries management decisions will almost certainly inconvenience some fishery participants, and sometimes severely. Decisions must therefore be based not only on the best information available, but on information which is well understood. Furthermore, it is important that decision-makers also know the limits of the information they are presented with, so that when making decisions they can take into account the probability of their information being wrong, and the likely consequences of it being so. In general, decision-makers are not skilled in the technical aspects of fisheries management and are therefore very reliant on the information provided by their advisors. They do, however, take most of the blame if their decisions are wrong - even if the wrong decision were caused by wrong information. Advisors therefore have the responsibility to see that information is communicated to decision-makers clearly, and that its limits are well understood.

Some innovative methods have been developed to communicate model-derived information clearly (see Holling, 1978). If a computer is used in the modelling step, the model program can often be modified so as to allow 'hands on' experimenting. The decision-maker or fishery participant selects from a range of management actions, and the program shows the results of those actions on a number of management objectives. Figure 6.2 shows a typical output of this type of program. The user can try different management actions and explore the necessary trade-offs between management objectives.

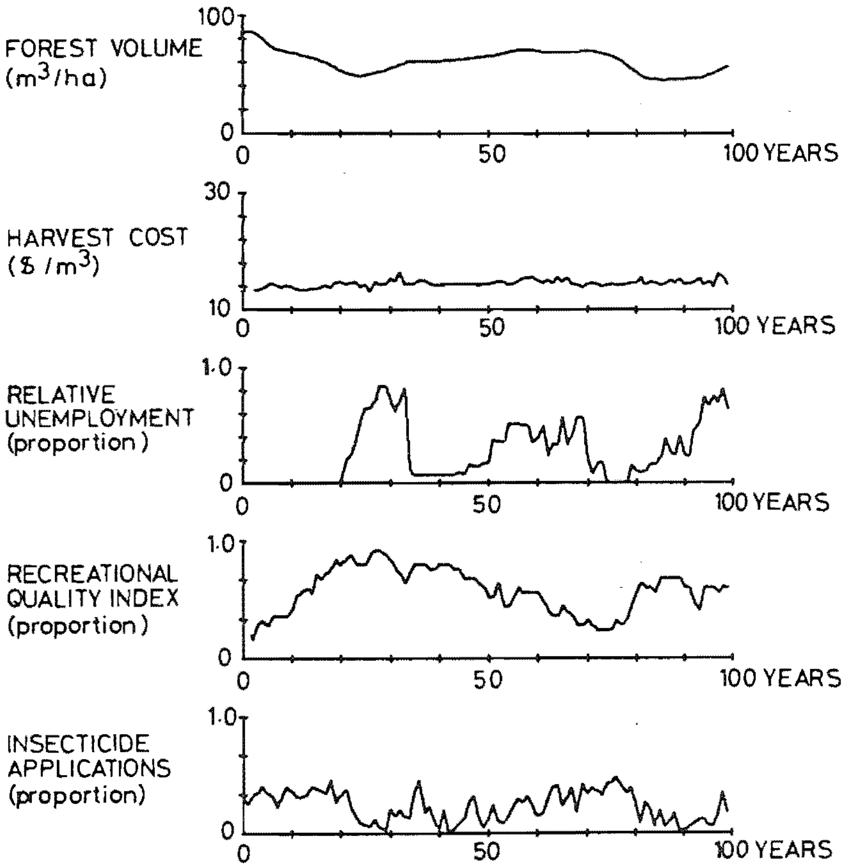


Figure 6.2 Output of a computer program designed to communicate management objective trade-offs, for a forestry management program. (From Holling, 1978).

A non-computer version of 'hands on' experimenting is the nomogram. In this method (Figure 6.3), equal value lines (isopleths) are drawn on graphs representing the relationship between two particular management actions and selected management objectives. A transparent overlay with appropriately placed marks can then be moved about, and the effects of different combinations of management actions observed. Alternatively, films, slide shows and other more conventional methods of communication may be used.

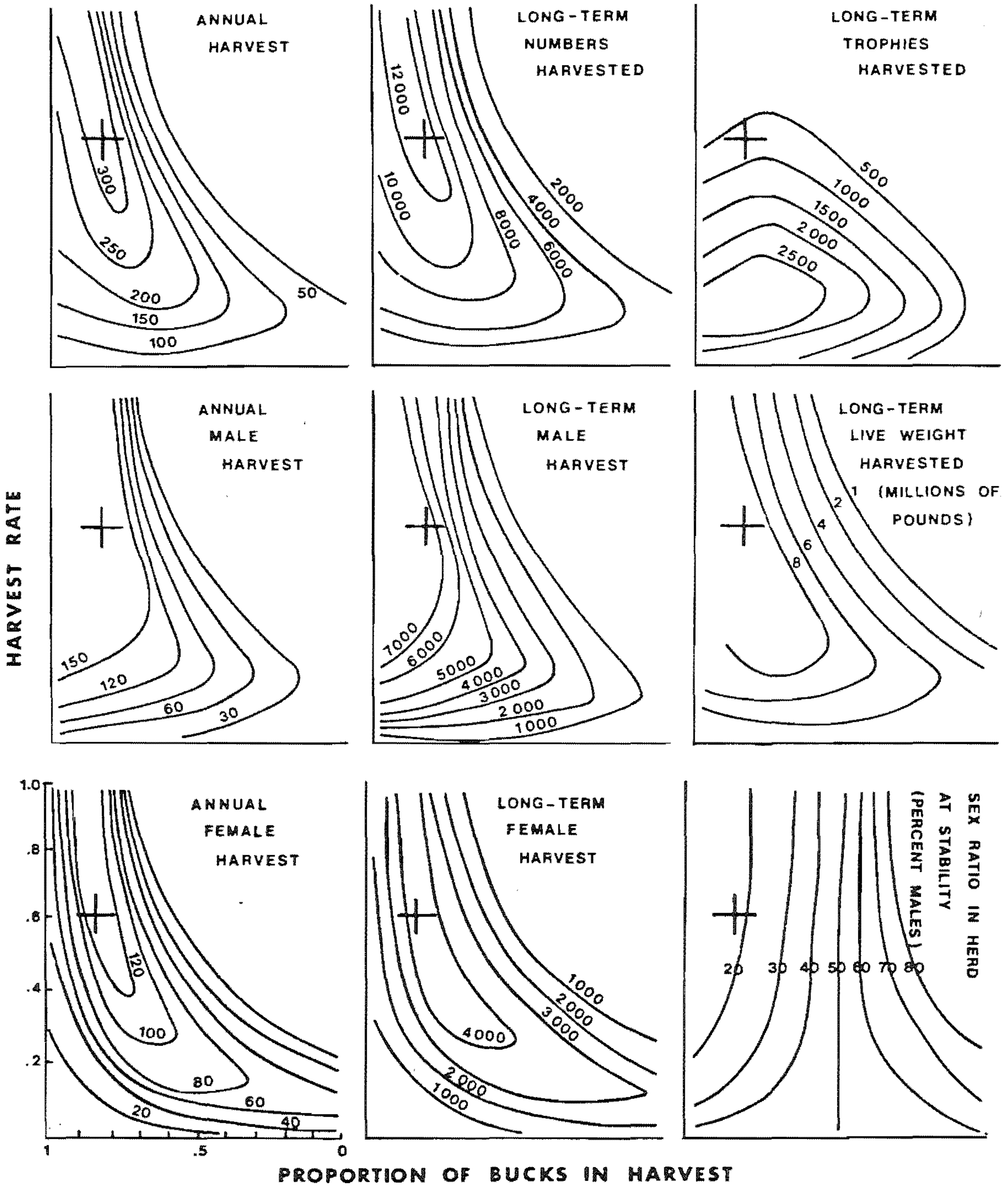


Figure 6.3 Example of a nomogram approach to communicating management trade-offs for a deer management program. The X on each graph indicates the value of that particular indicator given the combination of the two management options. (From Holling, 1978).

In the New Zealand fisheries management structure the FMP is the 'official' method of communication. Although it does not necessarily include definitions of the relationships between management objectives, it does contain most of the relevant information known about the fishery. Special communication aids like nomograms and interactive computer programs are not used in communicating to decision-makers, but recently a slide presentation has been used in an attempt to explain to fishery-participants some of the trade-offs associated with the use of Individual Transferable Quotas.

The extent to which more sophisticated communication methods are required will depend largely on the successful calculation of management objective trade-offs. When trade-offs are more accurately known, the use of these techniques will be worthwhile. Their use would then promote better understanding by fishery participants, and probably enable more satisficing level modifications to be made.

Step 6 - Choosing objectives and satisficing levels

It matters little who makes the final decision on fisheries management objectives, provided they have the necessary expertise. What is very important is that an identifiable person or group be given the authority to make such decisions. Often in fisheries there is a need to take decisive action based on only limited information. In situations like these there is a tendency for no action to be taken, possibly because no-one has, or wishes to, exercise the authority to make a decision that has a moderate chance of being wrong. Instead, the fishery is allowed to become gradually worse. Paul and Elder (MAF, 1978), when referring to the Hauraki Gulf snapper fishery, called for "brave men and the cooperation of local fishermen". In a sense, that is what a decision-maker must be - brave. If he is wrong, he will be criticised, possibly censured, and just possibly, sacked. (Larkin, 1972). However, if the management system is designed in a realistic way, anyone forced to make a decison would not be criticised from within management unless negligence on the part of the decision-maker can be shown. A wrong decison does not of itself constitute negligence.

Even if a decision is wrong, much can be learnt if the reasons for the decision, and the decision itself, are well documented. In his confidential memorandum, Larkin (1972) challenges fisheries managers on this point. He cites an hypothetical example where managers inform the public of the following prior to the fishing season.

1. The fact that they don't know what the annual salmon run will be;

2. Their intention that this year the fishery will be managed so as to provide as much information as possible without destroying the stock, creating financial ruin, or causing extreme social stress; and

3. Their proposed management methods and the scientific basis for them.

The managers must then "rigidly adhere to the stated plan". Once the results of this management strategy are known, whether good or bad, the managers then have a well documented "brutally honest self-assessment". Future management objectives can be modified as required.

The choosing of management objectives for a fishery must be done in a clear and unambiguous manner, which requires that the role of the decision-maker be clearly defined. Only to the extent that this occurs can present management actions be used to improve the future management of fisheries. If the decision-making role is blurred, praise or blame for successful or unsuccessful management cannot be apportioned fairly, and those involved in management will not learn from the results of their own decisions. Similarly, if objectives are not clearly stated, they can always be construed to have been achieved, and little is learnt from the management experience.

Openness like this also has the advantage that fishery-participants know exactly where they stand, and why. They may not agree with the reasoning behind a decision, but can at least acknowledge that it is based on reason, and not simply designed to hinder their fishing endeavours.

The authority structure in New Zealand fisheries management was explained in Section 4.5 and earlier in this chapter. Recent moves to completely revise the inshore fishery by introducing ITQs are an indication of the fact that within this structure, the authority for 'brave' decision-making does exist. However, the openness that should accompany such decisions is to some extent missing. For example, it is not known outside fisheries management circles how the 'optimum yield' of each fishery is determined, nor whether TACs are the same as the optimum yields. The Fisheries Act defines OSY as the MSY modified by any relevant economic, social, recreational, or ecological factors, but how this has been interpreted for each fishery is a mystery to most fishery participants. Until the rationale behind the determination of OSY is made known, it will be difficult to obtain the much-needed respect of fishery participants.

At present, fisheries management objectives are not well stated. The overall policy can be inferred from the purpose for FMPs given in the Fisheries Act, and at the more detailed level, the management methods or techniques being used have been explained reasonably well. However, the policy does not contain specific unambiguous objectives. The closest thing to specific management objectives are the nine 'principles' underlying the Government's inshore fishery restructuring proposals (MAF, 1984e), but few of these are specific enough to be termed unambiguous. There are no clear indications of success and failure criteria, and therefore the success or failure of the management strategy will be largely subjective.

Step 7 - Implementation

The implementation step involves the choice and use of management techniques appropriate for the objectives and satisficing levels sought. There is a wide range of management techniques available, but these will not be discussed here. Instead, a few salient points regarding management objective implementation are identified.

The choice of implementation methods will be influenced by a number of factors. These include previous experience with the use of implementation methods, and information on the suitability of different methods for the particular fishery and for the objectives sought - either from the management model or other sources. Where there is a need to keep management and policing costs to a specified level, this may also have a major influence on the choice of implementation methods. Since these costs may affect the determination of optimum yield, they should ideally be taken into account in the choosing of management objectives and sufficing levels.

As with the previous step, implementation is reliant on there being a definite management authority. Without the necessary authority, and the judicial backing to support it, few implementation methods could be successful.

Step 8 - Review and assessment

This, the final step of the management process, is important in two ways. First, it allows for the management of the fishery to be refined and improved, so that the needs of more fishery participants can be met more fully. Second, it provides the 'brutally honest self-assessment' required by fisheries managers to improve their management abilities, so that their future management attempts are (even) more successful. Holling (1978) in particular, stresses the integral nature of assessment in the whole management process. Thus although often neglected by fisheries managers, the review and assessment step has the potential to be a major contributor to improved ongoing fisheries management.

Three 'feedback loops' from the assessment step are shown in Figure 6.1. The first is to the initial step in the management process, and shows that after assessing the results of the present type of management, it may be decided that it is inadequate, and that a different type of management is needed. Assessment may also indicate the need for a new authority to be defined.

The second feedback loop is to the model building level of the management process. The assessment may indicate that the overall management structure and authority are adequate, but that the model needs improving. Information from the assessment can be included in the model, along with any other information that the assessment has shown to be necessary. The additional information will allow the model to be used to more accurately determine the relationships between management objectives and the management objective trade-offs. The final feedback loop is to step 5, indicating that the assessment might reveal the need for better communication of the management trade-offs to the decision-makers.

Feedback loops to later steps are not appropriate. It is true that as a result of the assessment, objectives and satisficing levels may be changed. However, these changes should result from improvements in earlier steps of the management process. If these changes are made without the results of the assessment being used to improve the understanding of the fishery, then the experience which could be gained from the first management attempt would be lost.

As shown earlier, effective assessment is dependent on the clear statement of chosen objectives and satisficing levels, and of the reasons for their selection. This requires that the management process be designed with a review and assessment step in mind, something that can only come from an honest and objective approach to management. Instead of trying to engineer a management process whereby failures are covered up, it should be designed to reveal as much as possible about the failures. Of course, this will mean that the reasons for management failures will become known to fishery participants, a fact that managers would have to learn to accept. However, this is a necessary, and in the long term, probably a beneficial feature of the fisheries management process if it means that management failures are used as lessons, and not repeated.

CHAPTER SEVEN

SATISFICING, NEW ZEALAND FISHERIES MANAGEMENT POLICY, AND ITQs

In the previous chapter a fisheries management process incorporating the concept of satisficing was discussed. Where appropriate, the extent to which the New Zealand Fisheries Management structure allows for this type of management was also discussed. In this chapter, the suitability of the existing management structure is summarized, and then the suitability of New Zealand's overall fisheries management policy and its proposed major management technique (ITQs) for management by satisficing is discussed. An important inconsistency between the overall policy and the use of ITQs is also identified and discussed.

As shown in the previous chapter, the structure of New Zealand's fishery management generally allows for management by satisficing, but does not require it. The combination of the Fisheries Management Advisory Committees and Fisheries Management Teams should be able to identify most management objectives and most of the information needed for management of the fishery. However it is unlikely that they will identify satisficing levels. The FMP provides the basis of the management model. It is the major means of communication between specialists and decision-makers, but is not explicitly required to define or communicate the relationships and trade-offs between management objectives. Under the present system there is unlikely to be as much interaction between fishery managers and participants as is desirable. Clearer statement of the chosen management objectives and satisficing levels would also be valuable - especially in regard to gaining the confidence of fishery participants, and for assessment purposes.

New Zealand's present fisheries management policy is not very conducive to the satisficing management approach. The means by which the required OSY is obtained is itself questionable, but more importantly, the policy advocates a single optimum point. The satisficing approach is based on the assumption that no true optimum exists, and that if it did, it would be unattainable, Thus, whilst satisficing could possibly be used, it would not fit easily into the present policy.

The 1983 Fisheries Act requires that OSY be based on MSY. Giving such emphasis to what is almost an anachronistic yield figure is certainly not ideal, but is perhaps understandable in view of the level of knowledge regarding most of New Zealand's fisheries. In most fisheries, as in the history of fisheries management, MSY can be calculated before MEY. In coping with the 'OSY problem', New Zealand policy makers opted to use the 'modified baseline yield approach', and, given our fisheries data and level of understanding, MSY was the obvious choice of baseline yield, even though for many fisheries not even sufficient data to accurately calculate MSY exists.

The fisheries policy is misleading in that it implies that a single optimum yield exists. Once all the relevant factors have been accounted for in the determination of the 'OSY', it is doubtful that the yield would be optimum for anyone, let alone everyone. In fact there are many optimum yields, depending only on who the yield is being optimised for. Any overall optimum yield can only be one that minimises the amount of displeasure to fishery participants. Therefore in practice, it is by default, but not by purpose, a type of 'satisficing yield'.

If it is to be made realistic and honest, the fisheries policy should be changed. First, the MSY baseline for OSY should be done away with, since it is usually not known, and unless protein is short, is unlikely to have much relevance to an optimum yield. Instead, some maximum catch level based on the need to maintain at least a critical minimum stock size should be used. Second, instead of implying that an optimum exists and requiring that it be managed for, the policy should require something along the lines of,

> 'management so as to satisfice whichever objectives are considered important by the FMAC [or the Fisheries Authority or the Minister of Fisheries]'.

Such a policy would be both realistic and honest in terms of the knowledge and abilities of fisheries managers.

The ITQ management system is neither conducive to management by satisficing, nor consistent with New Zealand's overall fisheries management policy. Although the policy is primarily concerned with the setting of the fisheries yield (TAC), and ITQs with the allocation of that TAC, both deal with obtaining benefits from the fishery, and should therefore be consistent. Since it is a management approach, satisficing is involved with both the setting and allocation of TACs.

Although the two aspects of maximising benefits from a fishery are interdependent, it is convenient to separate them for discussion purposes. The TAC is set by fisheries managers according to the criteria they are required to consider. In New Zealand, this is the MSY-based OSY. The specified TAC is then allocated either directly, or by default, among participants in the fishery. The differences between the various participants means that the amount of benefits obtained from the fishery can also be influenced by changing the allocation of the TAC to different fishery participants.

Allocation of the TAC by means of ITQs accounts for only the economic objectives of management. One of the major advantages claimed for the ITQ system is that its use promotes economic efficiency (Anderson *et al*, 1984). Any uneconomic fishing units will theoretically be bought by more efficient fishermen, so that eventually all the quotas will be owned by economically efficient fishermen.

However, if ITQs are used, non-economic management objectives will influence the allocation of the TAC only if they are economically significant. For example, the objective of maximising employment would only influence TAC allocation if a fishing method which employed a lot of people also happened to be economically efficient. At present in the Hauraki Gulf Fishery it is apparent that employment, energy, and economic, management objectives coincide. That is, at present longlining is the best fishing method for maximising each of these factors. This need not be the case. In the future, methods using more energy and employing fewer people might become more economic than longlining, and even at present, factors which cannot be measured in dollar terms have no influence in the TAC allocation. Into the last category fit factors like the recreational and traditional fishing experiences.

The use of ITQs to allocate TACs is inconsistent with New Zealand's overall fisheries policy. The policy requires that relevant economic, social, recreational and ecological factors can influence the calculation of OSY, yet in allocating the TAC only economic factors are considered. There is scope within the ITQ system to use various restrictions to account for other management objectives, but Fisheries Management Division have emphasised that as far as possible, restrictions will be kept to a minimum so that fishermen can catch their quota of fish in whatever way they want. With or without restrictions, TAC allocation must be made amenable to non-economic management objectives if it is to be consistent with overall fisheries policy.

A simple hypothetical example illustrates the point clearly. In Section 5.4 it was shown how employment can be substituted for effort on the yield curve axis of a surplus production model, and how it may be appropriate to increase employment at the expense of an inefficient fishery. If this were the case, it would be inconsistent to allow the whole TAC to be taken by say trawling, which employs 2.5 times fewer people than longlining to catch the same amount of snapper. Little is gained by setting an inefficient TAC in order to increase employment, and then allowing employment levels to be eroded by the use of employment-efficient fishing methods.

Obviously the use of ITQs prevents the allocation of TACs by the satisficing type of management. Satisficing requires that minimum achievement levels be sought for a variety of objectives, and this cannot be done if only economic objectives are influential in the allocation process. Thus the ability to use non-economic objectives is also required if TAC allocation is to fit into the overall satisficing management process.

The argument that restrictions would negate all of the advantages of ITQs is unfounded. True, restrictions might reduce the economic benefits of the ITQ system, but it is abundantly clear - even from the fisheries policy - that it is acceptable to sacrifice economic efficiency for other management objectives. Larkin (1972) commented about economic efficiency,

> "we should not feel compelled to be economically efficient; but we should be economically inefficient to the degree we choose. ... The real question, then, is what to choose as a level of economic inefficiency, and this is quite clearly a social decision."

Provided that fisheries management success is measured in more than just dollars, a 'modified ITQ system' might be more successful than an unmodified system.

The ITQ-based allocation system could be made amenable to non-economic objectives either by restrictions or by incentives. The former would probably result in more precise modifications to TAC allocations, but the latter would be more acceptable to ITQ owners. Each method is discussed further below.

In New Zealand a precedent has been set for the use of allocation restrictions with ITQs. Owners of Deepwater Fishery Quotas are restricted to owning a maximum of 35% of the TAC for any one species (Clark, 1984). A similar 'monopoly prevention' restriction may be used in the inshore ITQ system (MAF, 1984b). Other restrictions could be used to ensure that some, or all quotas, could only be used by fishermen using a specified fishing method or methods. For example, if it was deemed necessary to increase overseas earnings, and the Iki jime market could be expanded, the use of snapper quotas might be restricted to those using methods capable of producing Iki jime-quality fish.

However, the use of restrictions like these to effect major modifications in the fishing fleet would be difficult. If the restrictions were applied before ITQs were allocated, fishermen might complain a bit about 'regulated inefficiency', but if restrictions were imposed after ITQs had been issued, complaints would be vociferous. Fishermen would argue that the quotas are owned by them, and that no-one has the right to restrict the way in which the quota is used. Even if quotas were issued with the proviso that restrictions could be introduced later, their introduction would meet with opposition.

The use of incentives is likely to be more acceptable to fishermen. Incentives, presumably financial, would be used to encourage fishermen to catch their quota's worth of fish in the way that best meets the management objectives of the fishery at that time. For example, if it was important to increase employment in the fishery, incentives would be paid to those fishermen using employment-intensive fishing methods. Alternatively, if liquid fuel energy was in short supply, fishermen using energy efficient fishing methods would be paid incentives.

Two major problems would hinder the effectiveness of an incentive system. First, fishermens' high degree of asset fixity means that incentives would have to be large to significantly change the fishery within a short period. To some extent this could be alleviated if, in addition to ongoing incentive payments, fishermen changing to preferable fishing methods were given extra financial assistance to change their equipment. Either way, incentives might be appropriate only for major management objectives which are likely to be constant for long periods.

The second problem is that payment of incentives might find little favour with the public. Although incentive payment precedents have been set in other primary industries, apparent free handouts are often unpopular with those who do not receive them. One way around this problem would be to reduce royalty payments rather than give incentives. It is proposed that as fisheries become more economically viable, a royalty will be paid for the privelege of using the fishery resource (MAF, 1984b). The size of the royalty is to be based on either the quota size or on the amount of fish caught. It would be a simple matter to reduce the size of the royalty payments in place of paying incentives for 'management approved' fishing practices. It is not known if royalties will ever reach a sufficient size to be used to significantly change the composition of the fishing fleet, but this method would probably be more acceptable to the public than straight incentive payments.

From the preceeding discussion it can be seen that neither New Zealand's fisheries management policy, nor the proposed ITQ allocation system, could easily be incorporated into the satisficing management approach. For this to happen, the policy would have to be changed so as not to require a single biologically-based optimum yield. The ITQ system would require the use of restrictions or incentives so that non-economic objectives could influence the TAC allocation. Without these changes, most of the benefits of the satisficing management approach would be lost.

CHAPTER EIGHT

CONCLUSION

Fisheries managers today face a major challenge. They are now required to manage fisheries in a way that takes into account not only biological management objectives, but also the many non-biological management objectives. In fisheries management, achievement of even one objective is rare, and the achievement of more than one objective simultaneously, is usually impossible. For New Zealand fisheries managers the task is made even more difficult by the lack of data and management experience. Their task is daunting.

The satisficing approach to fisheries management does not solve the multiple-objective problem, but rather, allows management to be effective in spite of this problem. Instead of the requirement to achieve optimum levels in a number of objectives, in the satisficing approach, a reasonable minimum level of achievement is set for each objective. If the satisficing levels are sufficiently low, all objectives may be satisficed. If not, some objectives will not be satisficed, but the interactive management process of which satisficing is ideally a part, should allow satisficing levels to be modified so that more are attained.

Of New Zealand's fisheries, the Hauraki Gulf Snapper Fishery could perhaps benefit most from the satisficing management process. It is one of the country's most intensively used fisheries, and in spite of different attempts at management, it is overfished. There is a great variety of fishery-participants, fishing because of different reasons, and using often quite different fishing methods. This diversity has made the management of the fishery more difficult, but also allows for a wider range of management objectives to be satisficed than in most other fisheries.

Possibly important management objectives for the Hauraki Gulf Snapper Fishery include biological, energy, employment, economic, amateur fishing, and traditional fishing objectives. The most important biological objective is that of maintaining the snapper stock above its critical size, which reduces the probability of recruitment overfishing to a reasonable level. This objective is made more difficult since the critical minimum stock size is not known, and recruitment is highly dependent on spawning season temperatures, over which fisheries managers have no control.

At present, most energy, employment, and economic objectives are best met by the longline fishing method. Among other factors, longlining has the major advantage over other fishing methods of being able to provide snapper for the lucrative Japanese Iki jime market. However, as in the past, fishery and market conditions may change so that other fishing methods better achieve economic objectives. Longlining is likely to remain the best method from the perspectives of employment and energy conservation.

However, not even large-scale use of longlining would achieve all the possible management objectives for the Hauraki Gulf Snapper Fishery. Objectives like the provision of high employment levels and the provision of abundant snapper for amateurs are irreconcilable with each other, and mostly irreconcilable with economic objectives. Therefore there is a need for some management process in which the necessary trade-offs between management objectives can be understood, and reasonable trade-offs chosen.

Unfortunately, the satisficing management approach could not easily be used within the present New Zealand fisheries management system. Although satisficing could be used under the present New Zealand fisheries management structure, the country's overall fisheries policy, and especially the ITQ allocation system, are not conducive to this type of management. The New Zealand fisheries policy of managing for OSY is unrealistic in that it is based on MSY, and misleading in that it advocates a single optimum yield. Neither the emphasis on MSY, nor the use of a single optimum yield is consistent with the satisficing management approach. The ITQ allocation system cannot effectively be used within the satisficing approach because it takes into account only economic objectives. Some means by which the ITQ system can be made amenable to non-economic management objectives is required before it could be used with satisficing.

It is noted that the ITQ system is also inconsistent with New Zealand's overall fisheries policy. The policy requires that when determining the OSY, a variety of management objectives must be taken into account. As shown above, when allocating a yield using the ITQ system, only economic objectives are considered.

It is apparent that New Zealand, like many other countries, has adopted the OSY-based fisheries management approach without knowing how to deal with all of the problems involved in its use. In particular, there is no provision for prioritising, or otherwise dealing with the many possible objectives which are to be considered when setting the OSY for a fishery. The inconsistency of the the OSY approach with the proposed unmodified ITQ allocation system, is an indication that the OSY policy is impracticable in its present form. The inconsistency of the proposed unmodified ITQ allocation system with the OSY policy, is an indication that the OSY policy is impracticable in its present form.

It is likely that the present OSY policy will result in a type of satisficing, but by default. Managers will attempt the impossible task of achieving a variety of management objectives, and will probably achieve none. Virtually all fishery-participants will be disappointed, and the fisheries manager will be unpopular.

In terms of fisheries yield, the end result of management by satisficing might be little different to that of the present management approach. The major difference is that fishery-participants would have been told that their objectives cannot be achieved in full. They would have identified some level of achievement which is a realistic minimum for that objective. Probably not all objectives would be satisficed, but the reasons for satisficing some objectives and not others would be clearly stated. Fishery-participants would then know why the fishery is being managed as it is, and the fisheries managers would be forced to undertake the "brutally honest self assessment", needed by every manager.

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"Call to me and I will
answer you and show you
great and unsearchable
things you do not know."

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APPENDIX A

FISHING METHODS IN THE HAURAKI GULF SNAPPER FISHERY

The following description of the fishing processess involved in the different fishing methods is taken from L. Duncan (1982), Graham (1943) and Riepen (1981).

1.0 TRAWLING

The earliest form of trawling as it is known today was beam trawling. Although more modern forms of trawling were in existence well before the turn of the century, it was beam trawling that was introduced to the Hauraki Gulf in 1899. The set-up of beam trawl gear is similar to that shown in the 1635 sketch in Figure 1. As the net was towed along the upper side of the net opening was kept open by a large beam. Graham (1943) makes reference to a beam measuring 55 feet in length and constructed from two oak trees scarfed together - and this towed by a sailing smack! The beam was kept off the bottom by large iron hoops at each end of the beam, and thus the net was kept open. Beam trawling was not used after 1904 in the Gulf and was succeeded by boats using otter trawls.

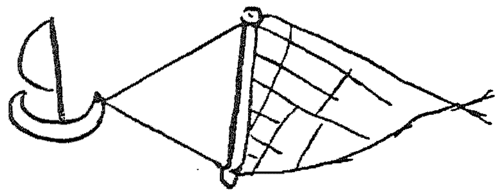

Figure 1 A 1635 sketch of a beam trawl. (From Graham, 1943).

The basic set-up of a single trawl operation is shown in Figure 2. A typical shoot of the net proceeds as follows. The cod end of the net is lifted over the side or stern of the boat and the remainder of the net is unwound over the stern from a net reel. The fly gear (cables from the top to the bottom of the net) are then attached to the otter, or trawl, boards, and once the net is seen to be deploying properly the towing warps are unreeled until the net is being dragged along the bottom.

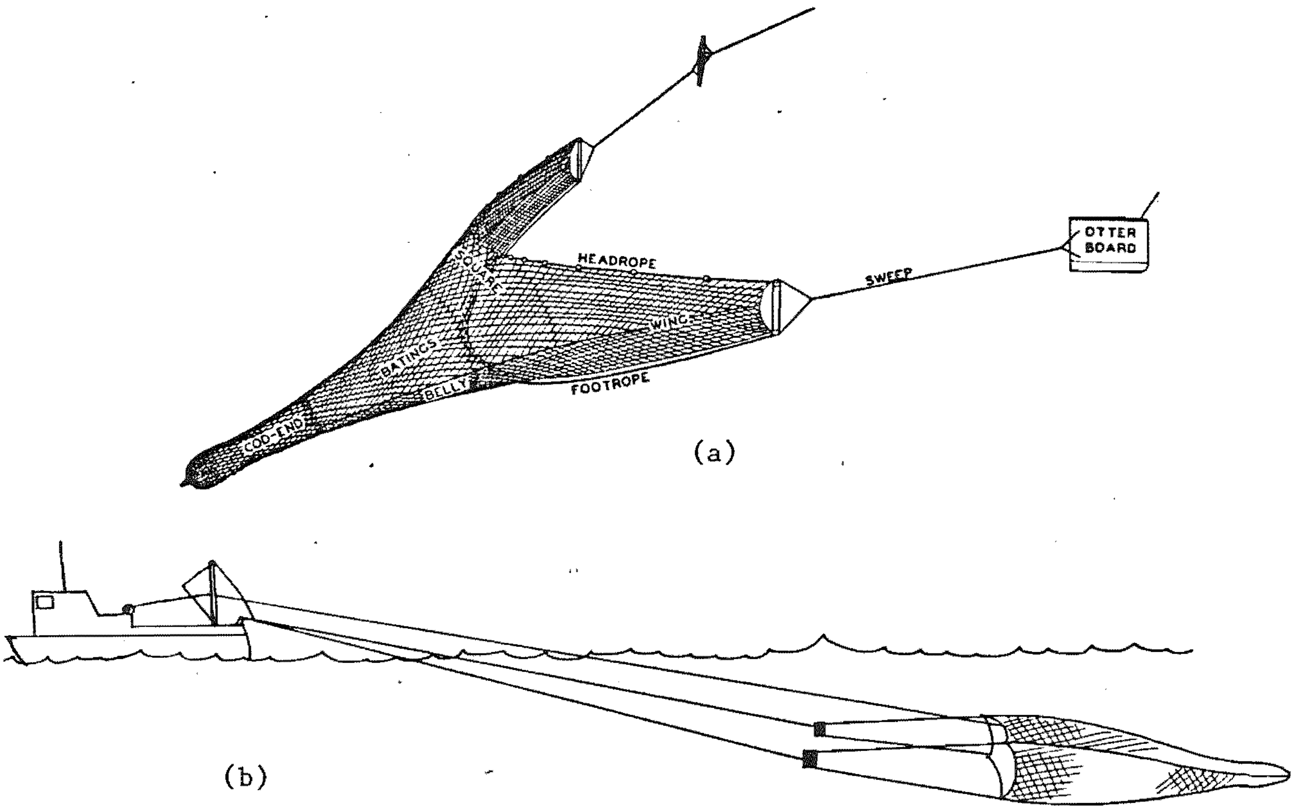

Figure 2 The single trawl net (a), and the trawl in progress (b). (From Riepen, 1981; Cassie, 1955).

The net, whose size depends on the power of the boat towing it, is towed along the bottom at about four knots for up to four hours. It is kept on the bottom by the weight of the trawl boards and by weights on the net. The mouth of the net is kept open by floats on the header rope and by the action of the trawl boards which keep the towing warps apart. As the net is towed along fish are herded into it by the barrier formed by the towing ropes and their associated turbulence and stirred-up mud. Fish pass into the cod end of the net where, if large enough not to escape through the mesh, they remain until hauled on board the boat.

Once the tow has been completed the initial procedure is reversed. The towing warps are winched in, the trawl boards removed, and most of the net is wound onto the net reel. Finally the cod end (which with luck is at least partly filled with fish) is lifted by derrick over the side or stern of the boat and emptied either directly into the fish hold or onto the deck. The cod end is then retied and another shot can be started.

Pair trawling is similar in many aspects to single trawling. The boats are usually single trawlers with minor modifications and the nets are similar to single trawl nets although often much larger. In a pair trawl shoot the operation proceeds as with a single trawl shoot except that instead of attaching trawl boards, weights are attached, and the boat with the net attaches a towing warp from the other boat to its net. Each boat then unreels its towing warp (or warps) until the net is being towed along the bottom. Whilst towing, which may be for up to four hours, one boat of the pair usually sets the course whilst the other maintains the correct distance between the boats.

The major difference from single trawl gear is that trawl boards are not used. Instead the two boats remain far enough apart to keep the mouth of the net open and heavy weights on the towing warps keep them on the bottom. At the end of the shoot the net is towed on the surface behind one of the boats and the cod end is lifted on board the other boat and emptied. After the last shoot the cod end and the remainder of the net is lifted on board the original boat.

The proponents of pair trawling claim that it is an efficient means of catching fish. The very large size of the net allows a large area to be swept with the result that catches are greater than for two single trawlers. Running costs are claimed to be lower since only one set of trawl gear is used between two boats and the work done by each boat is less than in single trawling. That these generalisations are not always the case was shown by Boyd and Parkinson (MAF, 1979) who calculated that for May and June of 1979 the catch per boat day at sea was less for pair trawlers than for single trawlers.

2.0 DANISH SEINING

Danish seining has been used for many years in North Sea waters and Graham (1943) refers to it as being a very efficient method when conditions are right. Those conditions include calm weather and a sea bottom free of obstructions.

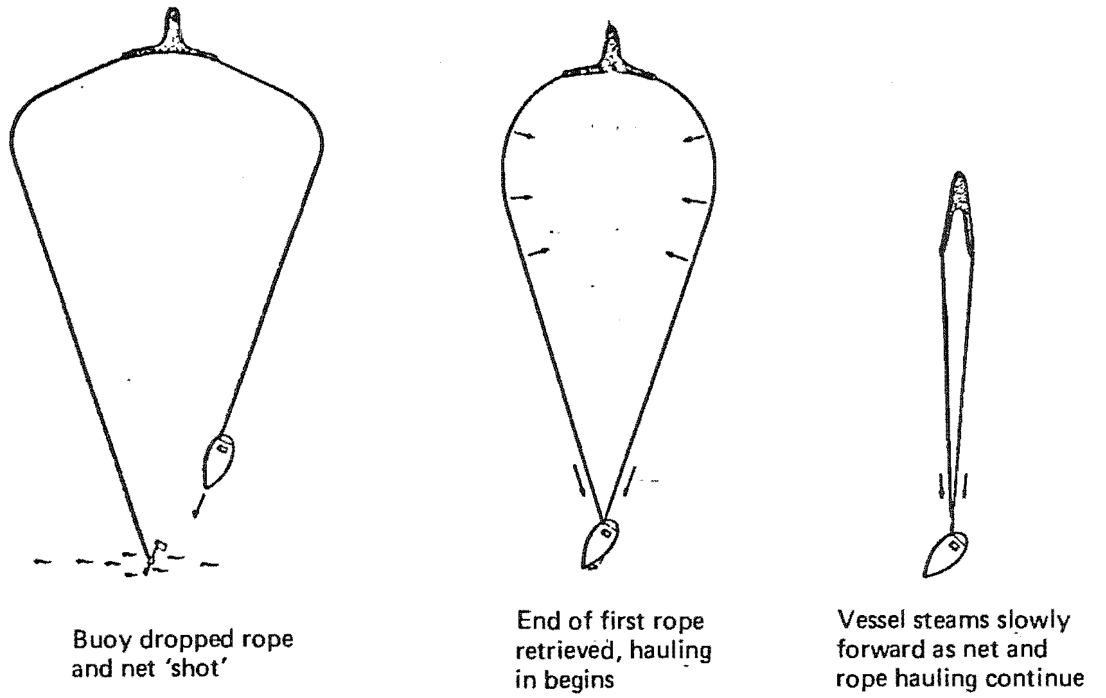

Figure 3 A Danish seine shoot. (From Riepen, 1981).

Although the Danish seine net is similar to the trawl net, the method by which it is used is not. In a typical Danish seine shoot (Figure 3), a dahn buoy is first put over the side and the attached rope run out in a big arc, generally with the tide. Up to 2.8 km of rope is run out before the net is dropped. The same length of rope is run out in another arc as the boat returns to the dahn buoy. The boat is kept more or less in the same position relative to the sea bottom whilst the warps are winched in and automatically coiled. As the warps are pulled across the bottom they stir up mud from the bottom which has the effect of herding fish towards the net. Once the warps are together the winching speed is increased and the boat is kept moving forward relative to the bottom. The body of the net is hauled on board by hand or by net hauler, and the cod end is then lifted on board using the derrick. A seine shoot takes about two hours and, unlike the trawl shot this length cannot be varied much.

3.0 SET NETTING

Set netting (Figure 4) is a relatively simple operation. A grapnel and dahn buoy at the end of the net are put overboard and the net is then run out over a roller as the boat is motored along. When the end of the net is reached the attached grapnel and dahn buoy are put overboard. When recovered, the net is hauled in either by hand, by net hauler, or on larger boats, onto a net reel.

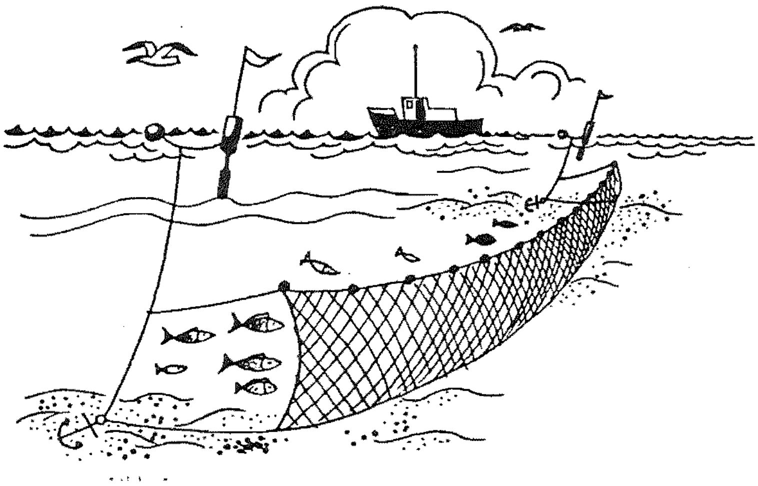

Figure 4 A set net in position for fishing.

The length of time for which nets are set (soaktime) varies, but when high quality fish are required soak times are often as short as two hours. If left for long periods, fish caught in the net deteriorate in quality and may be partially devoured by lice. Nets can be set in areas of clear sea bottom or over reefs and rough ground, the position largely depending in the fish species being sought.

4.0 LONGLINING

Longlining is similar in many respects to set netting. Instead of a net a long 'backbone' line is run out between the dahn buoys and grapnels (Figure 5). As the backbone is run out short lengths of line (snoods) with baited hooks on the end are attached to the backbone at regular intervals by means of snood clips. At greater intervals weights are attached to keep the backbone near the bottom, and depending on the length of the backbone, a number of buoy lines may also be attached. Typically 1000 hooks may be set by a longline fisherman each day on either one backbone line or spread between a number of lines. Like set nets, longlines can be set over smooth or rough ground. They are often set deeper than the normal depth of set nets.

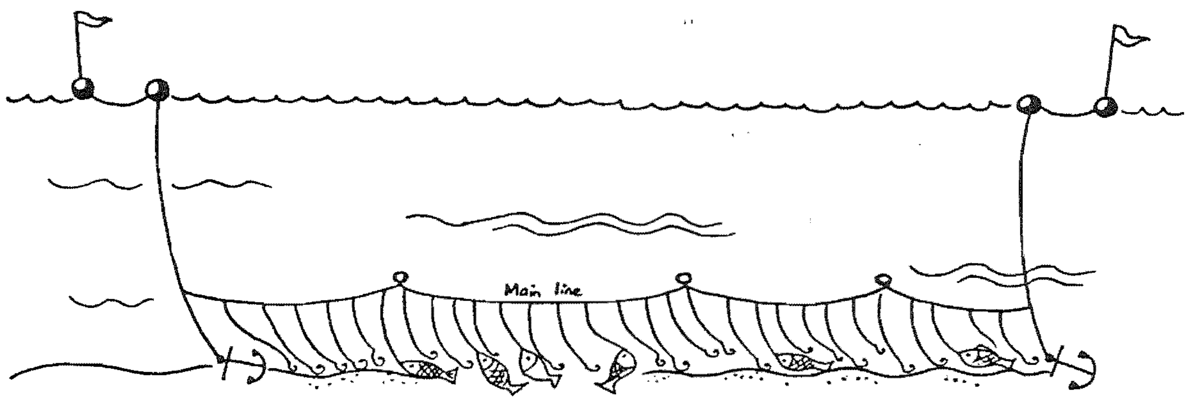

Figure 5 A longline set for fishing. (From Riepen, 1981).

The degree of automation involved in longline retrieval varies. Generally the line hauler stops hauling automatically when a snood clip is reached, thus allowing the snood (and hopefully the fish on the end of it) to be removed from the backbone line. The line hauler is then started again until the next snood clip is reached.

As with set netting soak times vary, but highest quality is maintained by using short soak times. To ensure snapper are maintained in prime condition they are spiked in the brain as soon as they are hauled on board and immediately packed in a plastic container and iced down. Otherwise they are put in an ice slurry and iced down later, or simply left on deck and then iced down between longline sets.

5.0 OTHER METHODS

There are three other commercial fishing methods used for catching fish in the Hauraki Gulf. They are however responsible for only a small part of the total catch and are probably more frequently used by amateurs. A few commercial fishermen use handlines although this is usually supplementary to another method, or used to catch bait by crayfishermen. Beach seining is used by a few commercial fishermen. In this method a net is either walked or towed out from, and back to the beach in an arc. The net is then dragged towards the beach by the attached ropes, hopefully catching any fish between the net and the beach. The final, and infrequently used method is dahn lining. This method is like using a vertical longline set close to a steep sea floor or reef.

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APPENDIX B

DYNAMIC AND STEADY-STATE MODELLING

1.0 DYNAMIC MODELS

Dynamic models have the great advantage of being able to describe systems which change over time. This allows system features such as non-linear responses of variables to changes in the system, and positive and negative feedback to be incorporated into the analysis (Jeffers, 1978). Potential predictive capabilities of dynamic models are far greater than those of static models since not only can predicted future values of parameters be included in the analysis, but also future values predicted by the model itself can be used. For example, the reproduction rate of a species may be related to the population of the species at that time, and to the carrying capacity of the environment. Predicted future values of the carrying capacity could be included in the model structure, whilst future population size and reproductive rates would be predicted from the model itself, the latter depending on the model-predicted population size.

Analysis in which dynamic models are used usually involve the use of a special language. This language, or set of symbols allows different types of systems to be represented in a common manner, both for ease of communication and for ease of programming. The particular set of symbols used was developed by Forrester (1961) for use in industry models but is also used for biological applications. Those system features with symbols are; state variables, auxillary variables, material flows, information flows, rate equations, parameters, and sinks (energy or nutrients). For illustrations of the symbols see Jeffers (1978) or presumably Forrester (1961). In some aspects this language is similar to that used by Odum (1983) in his energy analysis.

When using dynamic models the analyst has the choice of using modelling packages or simple computer languages. Each has advantages and disadvantages. Modelling packages such as DYNAMO, Continuous System Simulation Language (CSSL), Continuous System Modelling Program (CSMP), DSL, and SIMULA were developed for ecologists and would-be analysts who have little computing experience. It is true that they do allow the use of more sophisticated computing techniques without the normal requisite training, but only at the expense of forcing the analyst to view his system in a fashion dependent on the philosophy underlying the modelling package being used. Holling (1978) suggests that experience has shown simple language models to give the best results.

Regardless of the programming method chosen, dynamic modelling has important limitations and disadvantages. McClay and Parker (1978) draw attention to the need to use an appropriate time step-length. Their note of caution is directed at DYNAMO but is generally applicable to all time-dependent modelling methods. They show that where a long step-length is used and the rate of change of the integral is large, results can be wrong. To avoid this problem a very short step-length must be used which requires more computer time. In some modelling packages the step-length cannot be varied without recompiling the program and therefore it is inconvenient to test a range of length-steps.

The ease with which dynamic modelling can produce completely unrealistic models is noted by Jeffers (1978). Dynamic models are capable of describing systems with numerous interactions and feedback loops, so that a single wrong data point or model component could easily produce spurious results. Furthermore, because of the complexity of larger dynamic models it is difficult, if not impossible to trace an error through the model. The unpredictability of the models make it difficult to know if a result is reasonable or not.

Perhaps even more limiting is the uncertainty of basic parameters. To describe a system sufficiently for a reasonable dynamic model to be constructed, the values of many parameters must be known. Often this is not possible and estimates are used, with the hope that the model will show through internal consistency whether or not the estimate is reasonable. However as the number of uncertain parameters increases, the value of the model decreases. Jeffers (1978) suggests that with a few uncertain parameters the analyst must spend much time testing the sensitivity of the model to those parameters, and with more uncertain parameters the whole modelling exercise becomes one of testing for internal consistency. In such cases any predictive powers of the model are lost.

For those wanting a detailed account of the construction and use of a dynamic model, Knox (1984) is recommended.

2.0 STEADY-STATE MODELLING - GOAL PROGRAMMING

Goal programming is one of number of analysis methods coming under the heading of optimisation techniques, or alternatively, linear programming. Although this type of analysis is more commonly used by operations researchers involved in 'hard' analysis, it also has a place in fisheries management and similar 'soft' disciplines. The purpose of optimization techniques is to maximise or minimise some aspect or aspects of a system which is constrained by various parameters. Whilst other analysis methods can be used in optimization, special optimization techniques are purpose-designed and have some advantages over the non-specific techniques.

A linear program is essentially a group of mathematical equations describing a system. Some of the equations are constraining, and describe the parameters of the system. For example, in a resource utilization system, the total amount of raw material available in a year, might be a constraint. So might the maximum rate at which the raw material can be transported to the processing plant and the maximum rate of processing by the plant. Constraints may be specified as equalities (where an exact amount must be used, or goal attained), or as an inequality (where a quantity must, or must not be exceeded). Other equations are objective functions. These describe the relationships between different components and interactions in the system. For example, an objective function might show that the total amount of energy used in transporting raw materials is the amount used by method one plus the amount used by transport methods two and three. Objective functions are often linked with constraint functions. In this case the transport energy use objective function might be linked with a maximum energy use constraint.

Graphical calculation techniques can be used where there are only two variables, but more sophisticated techniques are required for systems with more variables. The most common method used for finding solutions is the 'Simplex' method (Jeffers 1978). In this method inequalities are removed by introducing additional non-constraining variables, and then a solution which meets all the constraints of the system is chosen. By a series of iterations this solution is improved by making small changes to the variables until the optimum solution is found.

Linear programming produces two major pieces of information (Jeffers, 1978). The first is the values of the variables required to give the optimum solution. If the results of the optimization are to be applied to a real situation then the variables are set at the required values, and if the analysis is accurate, the optimum value is achieved. This type of analysis also yields information on how the optimum result could be improved still further. In any system, some constraints will be binding and others will be 'slack'. Increasing one of the slack constraints would have no effect on the optimum solution since in the original system it is not affecting that solution. However increasing the value of a constraining variable will result in an improved optimum solution. Thus linear programming is a valuable tool where there is scope to modify the constraining variables in a system.

Goal programming differs from normal linear programming in its use of 'soft' constraints. Whilst the constraint equations in normal linear programs form a 'rigid boundary' around the feasible solution area, the boundary in Goal programming is flexible. Instead of constraint equations being specified only as equalities or inequalities, Goal programming allows for constraints to be as goals - targets to be achieved if possible, but if not, a solution is still found. The amount by which the target is under or over-achieved is specified in the output of the analysis. Each of the soft constraints in the program is assigned a priority. In the analysis first the hard constraints are satisfied, and then each of the soft constraints is satisfied in the order specified by the assigned priorities. Usually the highest priority constraints are achieved exactly and the lower priority constraints either under or over-achieved.

This type of programming has obvious application in the satisficing approach to management. Each management objective is represented by one or more equations, and each objective is assigned a priority depending on the importance assigned to it by the managers or decisionmaker. If a solution exists whereby all the objectives can be satisficed, the program output shows this solution. If no such solution exists, the program first satisfices the high priority objectives and then the progressively lower priority objectives.

This type of programming has both advantages and disadvantages for the manager. Traditional linear programming is often inappropriate for describing real systems because in real systems few constraints are fixed. This is especially so in biological systems. For example in a fishery the Maximum Sustainable Yield may be a good target for fisheries managers to aim for, but the uncertainty involved in measurements of fish stocks, and the inherent resilience of fish populations mean that it cannot be considered a hard constraint. Likewise, in a fishery system it is inappropriate to consider variables such as employment, energy use, and export earnings as hard constraints. These variables are more appropriately considered as soft constraints and Goal programming is therefore an appropriate analysis method. The usual advantages of being able to identify which of the hard constraints are constraining the solution, and the ability to do sensitivity analyses of different variables, are maintained in Goal programming.

Disadvantages with Goal programming fall into two categories; those associated with all forms of linear programming, and those specifically associated with Goal programming. Of the general disadvantages, the static nature of linear programming is probably the most important. The objective functions and constraint equations used in a linear program describe the system at a single point in time, or describe the 'average state' of the system. This feature is not so much of a disadvantage in physical systems where variables do not change very much through time, or where the changes are predictable. Where the future state of the system is known with reasonable certainty the equations can be used to describe the system in the future. However in systems where predictable and unpredictable changes in variables are commonplace, the static analysis method may be a very poor representation of the real system. Regular seasonal (and other) variation is obscured, and catastrophic events and equilibrium changes (Holling, 1978) cannot be accounted for.

In addition to its inability to adequately describe naturally changing systems, linear programming cannot cope with man-induced changes. For example, in a preliminary Goal programming example designed to evaluate different management strategies for the Hauraki Gulf Snapper Fishery, I used present day data to formulate equations by which to describe the fishery. These included equations describing the amount of energy used by different fishing methods to catch a specified quantity of snapper. However in calculating the optimum number of different of boats using the different fishing methods a new, lower total snapper catch was specified. This lower total catch would probably result in changes in the catch per unit effort figures for the fishery, and a change in the amount of energy used by boats to catch snapper. Thus linear programming can only properly be used where all objective functions and constraint equations describe the system in the same state. If linear programming is used (as above) its limitations must be recognized. Its use for optimizing systems in the future depends on the ability to predict the future state of the variables in the system.

Rosenthal (1983) has identified some of the additional drawbacks of Goal programming. The first is that by prioritising the different soft constraints, those with lower priorities may not be considered at all. This in fact occurred in the Hauraki Gulf analysis. When high employment and low energy consumption were given high priorities (preservation of snapper stocks was a hard constraint), lower priority soft constraints such as limiting the quantity of other fish species caught, were ignored. In the example, the flounder catch was "overachieved" by 1853.7 tonnes - a quantity of flounder that in reality is probably not available. This occurs because the analysis method focuses all its attention on satisfying the highest priority constraint, regardless of the values of other soft constraints. When the highest priority constraint has been satisfied, attention then turns to the soft constraint with the next highest priority. Although weightings can be applied to the values of the different variables, it this does not solve the problem.

The second problem is that Goal programming allows insufficient interaction between constraints with different priorities. Trade-offs, where a small underachievement in a high priority soft constraint would result in a very large improvement in a lower priority soft constraint, are intuitively right, yet are not permitted under the rigid priority system of this technique. Finally, Rosenthal suggests that Goal programming ignores "the nonconstancy of the rates at which benefits from objective achievements increase and ignores the nonconstancy of the rates at which decisionmakers will trade off attainments". Prioritizing and weighting is done only by ranking, and assumes that the difference between rankings 1 and 2 is the same as between rankings 2 and 3. This is seldom the case.

[The Goal programming example of optimising the Hauraki Gulf fishing fleet is shown on the following pages.]

6.3 REFERENCES

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 $$                                                                     $$
 $$                                                                     $$
 $$                    GOAL PROGRAMMING SOLUTION                        $$
 $$                                                                     $$
 $$                      -PROBLEM DESCRIPTION-                          $$
 $$              HAURAKI GULF SNAPPER TRIAL 1                           $$
 $$                                                                     $$
 $$                              -DATE-                                 $$
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0 CONSTRAINT SUMMARY

OROW NO.	ROW RIGHT-HAND-SIDE VALUE	ROW DESCRIPTION	ROW TYPE	NEGATIVE DEVIATIONS PRIORITY	NEGATIVE DEVIATIONS WEIGHT	POSITIVE DEVIATIONS PRIORITY	POSITIVE DEVIATIONS WEIGHT
R001	13440.00	ENERGY USE	B	0	0.00	3	1.00
R002	10000.00	EMPLOYMENT	B	2	1.00	0	0.00
R003	400.00	GURNARD	B	0	0.00	4	1.00
R004	100.00	TARAKIHI	B	0	0.00	4	1.00
R005	50.00	TREVALLY	B	0	0.00	4	1.00
R006	450.00	FLOUNDER	B	0	0.00	4	1.00
R007	500.00	BARRACOUTA	B	0	0.00	4	1.00
R008	500.00	JACKMACK	B	0	0.00	4	1.00
R009	50.00	RIG	B	0	0.00	4	1.00
R010	2800.00	SNAPPER	E	0	0.00	0	0.00
R011	10000000.00	GROSS VALUE	B	1	1.00	0	0.00
R012	1000.00	LONG LIMIT	L	0	0.00	0	0.00
R013	500.00	TRAWL LIMIT	G	0	0.00	0	0.00

SUMMARY OF INPUT INFORMATION

0

NUMBER OF CONSTRAINT ROWS.................	13
NUMBER OF NON-ZERO MATRIX ENTRIES..........	72
NUMBER OF VARIABLES(INCLUDING SLACK).......	27
NUMBER OF PRIORITIES.......................	4
NUMBER OF DECISION VARIABLES...............	5
NUMBER OF POSITIVE DEVIATIONAL VARIABLES...	11
NUMBER OF NEGATIVE DEVIATIONAL VARIABLES...	11
NUMBER OF ARTIFICIAL VARIABLES.............	2
NUMBER OF ITERATIONS TO FIND THE SOLUTION..	28

OPTIMAL VALUE OF DECISION VARIABLES

VARIABLE	DESCRIPTION	AMOUNT
X001		500.00
X004		1300.00
X005		1000.00

GOAL ACHIEVEMENT

GOAL LEVEL 1 IS NOT ACHIEVED IN THE FOLLOWING CONSTRAINTS-

GOAL ACHIEVEMENT

GOAL LEVEL 1 IS NOT ACHIEVED IN THE FOLLOWING CONSTRAINTS-
* R011, GROSS VALUE , IS UNDERACHIEVED BY 3350000.00 UNITS.

* SUMMARY-
GOAL 1 IS NOT ACHIEVED BY 3350000.00 WGTD UNITS.

GOAL LEVEL 2 IS NOT ACHIEVED IN THE FOLLOWING CONSTRAINTS-
* R002, EMPLOYMENT , IS UNDERACHIEVED BY 9628.10 UNITS.

* SUMMARY-
GOAL 2 IS NOT ACHIEVED BY 9628.10 WGTD UNITS.

GOAL LEVEL 3 IS NOT ACHIEVED IN THE FOLLOWING CONSTRAINTS-
* R001, ENERGY USE , IS OVERACHIEVED BY 15700.00 UNITS.

* SUMMARY-
GOAL 3 IS NOT ACHIEVED BY 15700.00 WGTD UNITS.

GOAL LEVEL 4 IS NOT ACHIEVED IN THE FOLLOWING CONSTRAINTS-
* R005, TREVALLY , IS OVERACHIEVED BY 391.70 UNITS.
* R006, FLOUNDER , IS OVERACHIEVED BY 1853.70 UNITS.
* R009, RIG , IS OVERACHIEVED BY 1109.70 UNITS.

* SUMMARY-
GOAL 4 IS NOT ACHIEVED BY 3355.10 WGTD UNITS.

GOAL SLACK ANALYSIS

0THIS SECTION ANALYZES GOAL CONSTRAINTS WITH -B- TYPE INEQUALITIES WHERE EITHER A NEGATIVE OR POSITIVE DEVIATION IS NOT GIVEN A PRIORITY LEVEL. THE VALUE WILL THEN REFLECT THE AMOUNT BY WHICH THE EXACT GOAL WAS NOT ACHIEVED, EVEN THOUGH THE MINIMUM OR MAXIMUM GOAL LEVEL WAS ACHIEVED.

	ROW NUMBER	GOAL DESCRIPTION	EXACT GOAL LEVEL	NEGATIVE SLACK	POSITIVE SLACK
0	R003	GURNARD	400.00	113.00	0000.00
0	R004	TARAKIHI	100.00	57.00	0000.00
0	R007	BARRACOUTA	500.00	482.00	0000.00
0	R008	JACKMACK	500.00	482.00	0000.00

RESOURCE UTILIZATION ANALYSIS

0 **ALL RESOURCES, AS EXPRESSED IN CONSTRAINTS, WERE USED**

0STOP