TORE BADENDUCK

THE SPATIAL IMPACT OF TECHNOLOGICAL INNOVATION ON A PELAGIC FISHERY THE NORWEGIAN HERRING FISHERY, 1960-1967

DEPARTMENT OF GEOGRAPHY
McGill University

MASTER OF ARTS

ABSTRACT

This research was conducted to assess the spatial impact of technical innovation on a pelagic fishery. In process, it has established the technical complexity of the fisheries under examination.

The research provides: 1) the first integrated study in fisheries from the resource base through to the production sector; 2) the first paper dealing with fisheries to calculate a rate of return per ton per fishing vessel, establishing that there has been a marked change in income (in both its spatial and temporal aspects) for the vessels with an innovation unit (powerblock or net seine winch) as compared to those without; and, 3) the illustration that the comparative distance between fisheries is important in explaining spatial variations in activity.

THE NORWEGIAN HERRING FISHERY, 1960-1967

THE SPATIAL IMPACT OF TECHNOLOGICAL INNOVATION ON A PELAGIC FISHERY: THE NORWEGIAN HERRING FISHERY, 1960-1967

by

TORE BADENDUCK

A thesis submitted to the Faculty of Graduate Studies and Research, McGill University, in partial fulfilment of the requirements for the degree of Master of Arts.

Department of Geography,
McGill University,
Montreal, Quebec.

October, 1969.

F R O N T I S P I E C E

NORWAY

20 counties *(fylke)*; 454 communes *(kommune)*, of which 47 are towns *(by)*. Ecclesiastical division: 1 069 parishes *(sogn)*.

Østlandet (East Norway):
1. Østfold, 2. Akershus, 3. Oslo, 4. Hedmark, 5. Oppland, 6. Buskerud, 7. Vestfold, and 8. Telemark fylke.

Sørlandet:
9. Aust-Agder and 10. Vest-Agder fylke.

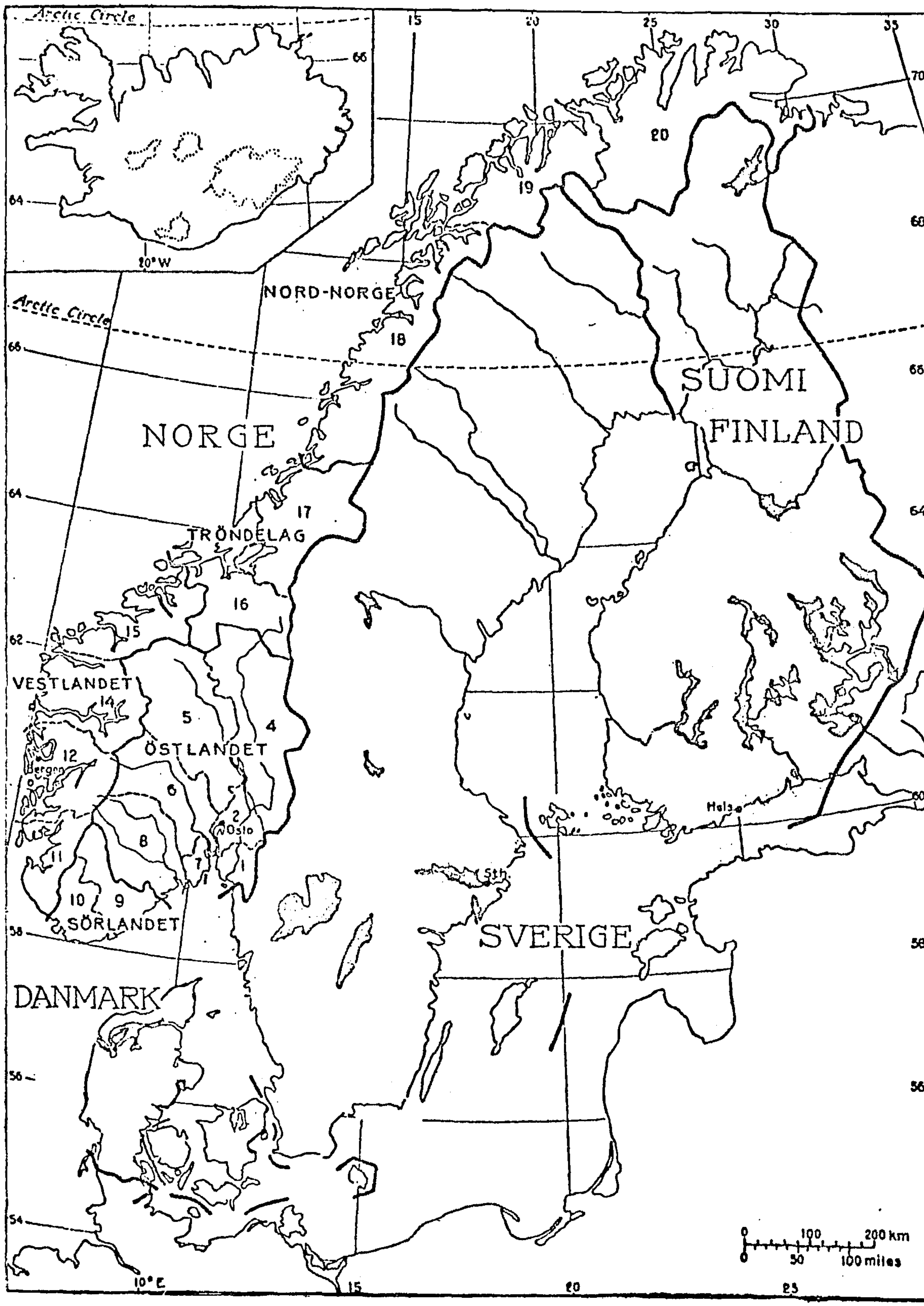
Vestlandet (West Norway):
11. Rogaland, 12. Hordaland, 13. Bergen, 14. Sogn og Fjordane, and 15. Møre og Romsdal fylke.

Trøndelag:
16. Sør-Trøndelag and 17. Nord-Trøndelag fylke.

Nord-Norge (North Norway):
18. Nordland, 19. Troms, and 20. Finnmark fylke.

1–17 Sør-Norge (South Norway).

S C A N D I N A V I A



After: Somme, 1968.

ACKNOWLEDGMENTS

Kind thanks must be expressed to the Northern Co-Ordinating Research Committee, Don Foote, and the Canadian-Scandinavian Foundation for making the field research possible. For additional funding during the write-up period, I am grateful to the Faculty of Graduate Studies and Research, and some close relatives.

I would like to express my thanks to fellow graduate students and close friends of the summer of 1969, particularly Dave Jones, who provided me with a good sounding board for ideas at various stages of the writing. My thanks are also extended to my thesis advisor, Jim Gilmour, even though I sorely tried his patience at times. I wish to thank Jim Hunt for aiding with the calculation presented in Chapter Eight and Sarah Nicholson for typing this manuscript. Furthermore, I would express my gratitude to those who provided obstacles to my research for from them I have learned a great deal. Special thanks go to Heike Weissner, a person who never knew nor will ever know the contribution that she made to the completion of this work.

I express my gratitude to all those whom I encountered while in the field conducting the research without whose aid the work would not have been possible.

Though I received advice from many, I must take the responsibility for all errors of omission and commission.

Tore Badenduck
October 29, 1969
Ste. Agathe-des-Monts,
Quebec, Canada.

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THE PROBLEM AND THE APPROACH

CHAPTER ONE

THE PROBLEM AND THE APPROACH

1.1. NATURE OF FISHING

Fishing is a particular variant of hunting and, as such, it is one of the most primitive of man's activities. The primal nature of fishing, however, does not imply that it is a simple activity to analyse. The fundamental difficulty in investigating fishing, as an economic activity, is that one must work from the fisheries, for which data are available, to the fishing vessels which participated in the particular fisheries under examination, instead of vice versa. A problem arises here, as the fisheries are seasonal and the participation information for any fishing vessel does not indicate to what other fisheries, if any, it might be related. The result is that one only has a particular portion of the year's activity accounted for. This fact of seasonal factor allocation creates difficulties as it allows for the possibility of a multiplicity of variables which cannot be isolated in any statistical analysis as they lie outside the realm of what is depicted by the available data.

Confronted with this problem and because it is "far better [to have] an approximate answer to the right question, which is often vague, than an exact answer to the wrong question which can always be made precise" (Tukey, 1962), it was decided to approach the current research in a general manner and, thereby, establish a conceptual framework within which subsequent inquiries might be conducted.

1.2. PURPOSE OF THE RESEARCH

This research was conducted to assess the spatial impact of a technical innovation on the economic geographic characteristics of a pelagic fishery. The innovation is a mechanical net hauling device which has been introduced in Norway since 1960. It is operated in conjunction with the purse seine fishing technique.

1.3. NATURE OF THE PROBLEM

This research is concerned with the spatial impact of the pattern of adoption, the product of a decision-making process. It is not involved with the actual decision-making procedure. This inquiry, therefore, utilizes the spatial acceptance pattern as the initiation point. It is in this emphasis on the pattern rather than the process that this work is differentiated from a diffusion study.

The problem is centred on analysing the regional effects that the innovation has had on two of the Norwegian Herring Fisheries in terms of the following parameters: 1) the distribution of landed catch by fishing method (Chapter Six); 2) the distribution of landed catch by region (Chapter Seven); 3) factor mobility in terms of continuity in participation in the two fisheries under study (Chapter Seven); and, 4) the rate of return per ton for the vessels of the fishing fleet (Chapter Eight).

Because of the complex nature of the interrelationships in fisheries, it was necessary to consider four additional aspects to achieve the delineated objective of the research. These were: 1) the nature of the biological resource (Chapter Two); 2) concurrent developments in electronic equipment (Chapter Four); 3) equipment changes associated with the adoption of the innovation (Chapter Five); and, 4) the position of the herring fishery within the fishing sector of the Norwegian economy (Chapter Six). A further reason for the inclusion of this material is the present dearth of work along the lines of this type of study.

1.4. SELECTION CRITERIA

Norway was chosen for this study for several reasons. First, it was revealed by a preliminary survey that statistics to conduct such a study were available. Secondly, this country is one of the developed nations of the world with a significant sector of its economy involved in fisheries. It was, therefore, reasoned that a study focused on how technical change has affected one sector of her fisheries would provide an interesting research topic in a field where the dearth of such inquiry is evident (Christy and Scott, 1965; James and Jones, 1954; Padgett, 1961; Walford, 1958). This research would, then, help to bridge a gap concerning the effect of technological change. Thirdly, the author was cognizant with the research material, conversant in the Norwegian language and had cognition of the country.

The time period of the study is 1960-67. This eight-year span was selected in order to provide a sufficiently large scope to enable a summation of the macro-scale changes which had occurred in the spatial-temporal setting from prior to the initial time of adoption, 1960, until complete acceptance, 1967.

In dealing with the Norwegian Herring Fishery, one is extensively concerned with the purse seining method of fishing. It is the modification that the purse seining technique has undergone as a consequence of the innovation adoption, the powerblock and net seine winch (Chapter Three), and its attendant effects that constitute the central theme of this research.

Two of the nine fisheries* which were dominated by the use of the purse seine technique were selected for closer study to illustrate the impact of the innovation. These two fisheries are: 1) North Sea Herring Fishery and, 2) Winter Herring Fishery.

The basis for this selection was that the former had its period of ascendency as a direct consequence of the innovation under examination and that the latter was the most significant of the seasonal herring fisheries until the early 1960's and the best known. A further criterion was that these two fisheries had the best available documented records. Thirdly, they held an important position in the fishing sector,

---

* The seven other fisheries in which purse seining is an important technique are: 1) Fat Herring; 2) Small Herring; 3) Fjord Herring; 4) Iceland Herring; 5) Sprat; 6) Capelin and, 7) Mackerel and Young Mackerel.

accounting for no less than 20 per cent by weight and 15 per cent by value of all landed catch in Norway for the duration of the study period after 1964, which was the year in which the innovation became generally accepted as a necessity.

1.5. RATIONALE FOR THE STUDY

The geographic literature is replete with studies dealing with the processes of spatial diffusion and it has been observed that "the literature abounds with descriptions of diffusion processes relevant to the locational distribution of innovation, culture traits and other economic, social, political or physical items." (Brown, 1968, p.iii.) It was observed, however, that little work had been done in terms of follow-up studies, namely, to try and assess these phenomena's spatial economic geographic impact. It was with a view to this deficiency in conjunction with the dearth of research oriented to marine industries (Padgett, 1961) in the geographical field that this inquiry was conducted.

1.6. METHOD OF APPROACH

The study is divided into five parts:

INTRODUCTION

THE NATURE OF THE BIOLOGICAL RESOURCE

INNOVATION

INNOVATION IMPACT

CONCLUSION

The introduction is sub-divided into six sections: 1) nature of fishing; 2) purpose of the research; 3) nature of the problem; 4) selection criteria; 5) rationale for the study; and, 6) method of approach.

The nature of the biological resource is concerned with the biological characteristics of herring. It is a resumé of the contemporary position of knowledge of herring and its population dynamics.

The innovation division is composed of three chapters. The initial one concentrates on the innovation, the powerblock and net seine winch. These are treated as one in the analysis focused on a description of the spatial and temporal pattern of adoption and in assessing their spatial impact on the economic characteristics of the two fisheries. The reason for this combination is that the two mechanical net hauling apparatuses perform, for all intents, the same function though they vary in positioning on board the fishing vessels and in their hauling capacities. This variation is explained in a discussion concerned exclusively with the innovation. The second chapter in this section places emphasis on the electronic gear which is in use and has been adopted concurrently with the main innovation. The third chapter of this division covers the associated changes attendant upon the adoption of the innovation. These changes are specific equipment modifications and further gear selection chosen to complement and, thereby, increase the efficacy and the efficiency of the mechanical net hauling device.

The innovation impact section comprises an additional three chapters. The first one deals with the herring sector of the fishing industry with particular emphasis on trends of the study period for the two seasonal fisheries under examination. The second chapter deals in a more concentrated manner with the spatial aspects of the North Sea and Winter Herring Fisheries for the years 1960-67. This is followed by a chapter focused on the assessment of the impact of the innovation (the powerblock and net seine winch) on two attributes of the above fisheries, namely, rate of economic return and employment.

The final division presents the conclusions derived from the study.

THE NATURE OF THE BIOLOGICAL RESOURCE

CHAPTER TWO

THE BIOLOGICAL CHARACTERISTICS OF HERRING - *Clupea harengus*

CHAPTER TWO

THE BIOLOGICAL CHARACTERISTICS OF HERRING - *Clupea harengus*

2.1. INTRODUCTION

The herring of the Northeast Atlantic are widely dispersed, extending from the Barents Sea in the north to the English Channel in the south. This dispersion was a major problem in determining the exact nature of the herring, as it was not known whether this entire range constituted one homogenous population or a number of different sub-groups which were allopatric (i.e. species in which little inter-breeding occurred). This question was important in determining the actual population dynamics of the herring.

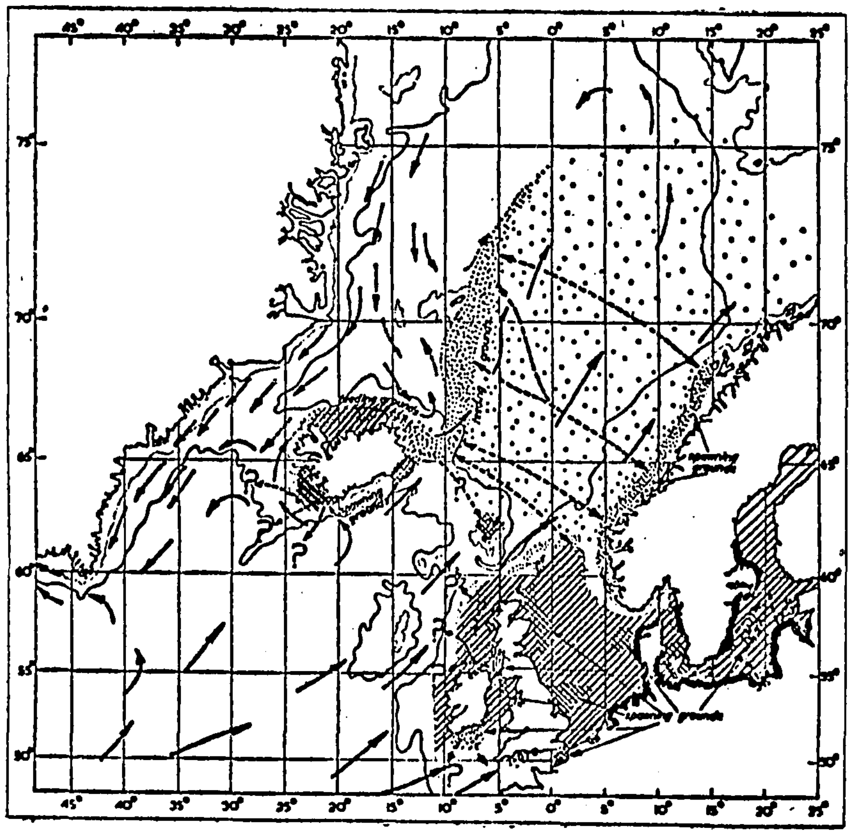
Heinke (1898) and his co-workers conducted the initial research on this matter (Parrish and Saville, 1965). The conclusion of their investigation of the morphological characteristics of herring was that it was not one population, but composed of a number of different groups. The consequence of these initial inquiries on morphological variations, which exhibited temporal consistency, was the continuance of work in this field. The extension of scientific endeavour has aided in a delineation of the groups that constitute the population.

In the establishment of the present classification system, two meetings have been of particular importance: the first was held at Lowestoft in Suffolk, England, in 1935; and the second in Copenhagen in 1956. The former was the first major conference devoted to the herring species investigation. The present parameters for each group were presented at the latter meeting. The criteria were set forth in a paper by Buckmann and Parrish (1958) (Parrish and Saville, 1965) and were structured with a view to a delineation based on allopatric breeding species, spawning time, localities and environmental constraints. The result of this work was a quaternary division of the herring population which has subsequently been aggregated into three distinct spatially variant groups: 1) Oceanic Group; 2) Shelf Group and, 3) Coastal Group.

Map 2-1 shows the spatial distribution of these three groups.

MAP 2-1

SPATIAL DISTRIBUTION OF HERRING GROUPS



Key: Dotted = Oceanic
Cross Hatched = Shelf
Black = Coastal

Source: Parrish and Saville, 1965, p.325.

The herring related to this study belong to the first two groups.

The Atlanto-Scandian herring is of prime interest in the Oceanic group; and the North Sea herring hold a comparable position in the Shelf group. The criteria for the group divisions are morphological, physiological and ecological. The differentiating characteristics are summarized in detail in Table 2-1.

Two points have to be considered prior to a more detailed look at the habits and migrations of the Atlanto-Scandian and North Sea stocks: the first is summarized in Diagram 2-1 which depicts the feeding relationships of herring at different stages. This illustrates the complexity of determining the exact nature of the population dynamics of herring. The second is that herring, unlike some fish, e.g. mackerel, possess an air bladder, which means that it does not constantly have to keep swimming. This will have more meaning subsequent to Chapter Four, in which search techniques are discussed.

2.2. THE NORTH SEA HERRING

The relevant research with regard to the North Sea herring is largely a product of scientific institutes outside

TABLE 2-1

BIOLOGICAL CHARACTERISTICS OF
OCEANIC AND SHELF HERRING

	Oceanic group	Shelf group
(a) General Distribution	Widespread, in 'oceanic' waters extending from northern Norwegian and Barents Seas to the Atlantic Seaboard of the British Isles and from Greenland to the Skagerak. Adults undertake long migrations, over deep water between feeding and spawning grounds.	Distribution in neretic 'shelf' waters of the North Sea and adjacent waters (Skagerak, Kattegat, English Channel, Irish Sea and Scottish West Coast). Movements of adults less extensive than Oceanic Group; restricted to Continental Shelf.
(b) Spawning place and time	Mostly in 'winter-spring', between February and May along Atlantic coasts of N. Europe, especially the W. coast of Norway, S. and W. coasts of Iceland and W. coasts of Scotland, in temperatures less than 12° C, and mostly between 6–8° C.	Mostly in 'summer-autumn' between August–December, on coastal and offshore banks in North Sea and adjacent areas, in temperatures less than 15° C, and mostly between 8–12° C.
(c) Longevity	Relatively long life-span; exploited population composed of large number of age-groups; maximum age (T_{max}) = 23–25 years (Beverton, 1963).	Shorter life span; exploited population composed of fewer age-groups; T_{max} 12–16 years.
(d) Growth	Reach large size; asymptotic length L_∞ = 35–37 cm; growth coefficient relatively low K 0·17–0·3 (Beverton, 1963).	Reach smaller size; L_∞ = 28–32 cm; growth coefficient larger; K = 0·35–0·50.
(e) First maturity	First maturity mostly reached at 3–9 years old; spawning recruitment range 5–6 years.	First maturity mostly reached at 3–5 years old; spawning recruitment range 2–3 years.
(f) Fecundity and egg size	Relatively low fecundities and large egg sizes (Baxter, 1959; Hempel, 1962).	Relatively high fecundities and small egg sizes.
(g) Morphological characters	Relatively high vertebral count, mean > 57·0; low K_2 count, mean < 14; high gill-raker count, mean about 48 (Krefft, 1958), otolith nucleus usually opaque (Einarsson, 1951; Parrish and Sharman, 1958).	Relatively low vertebral count, mean < 57·0; high K_2 count, mean > 14; low gill-raker count, mean about 46; otolith nucleus usually hyaline.

Source: Parrish and Saville, 1965, p.327.

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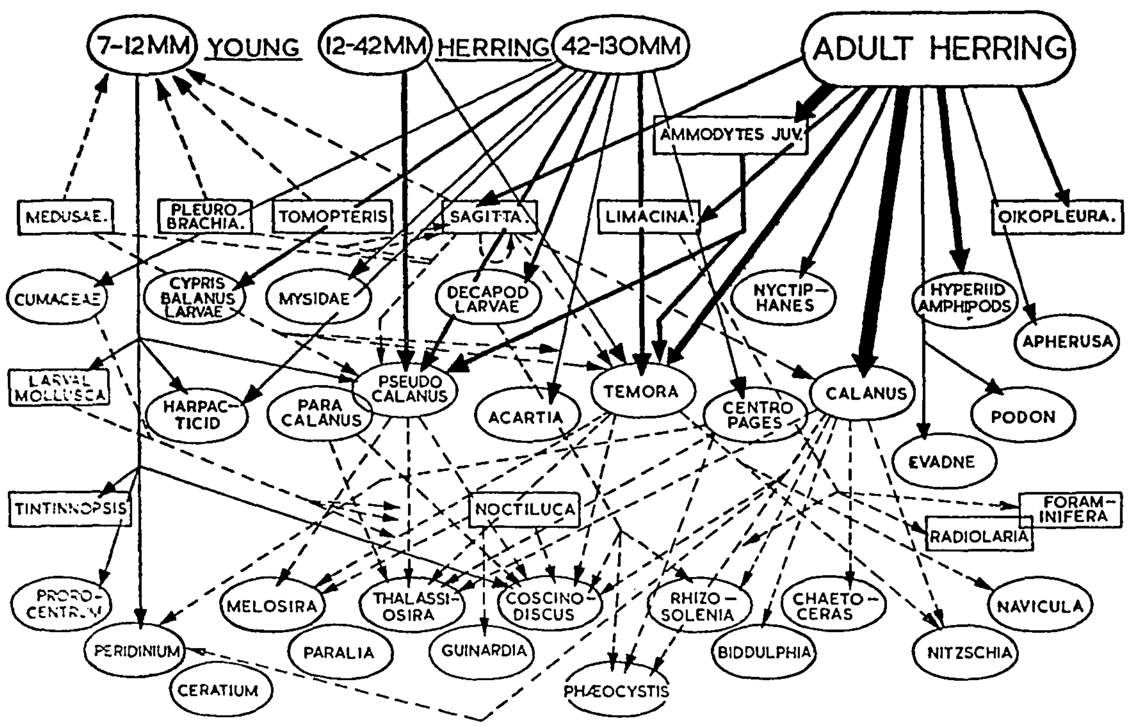
Source: Parrish and Saville, 1965, p.327.

DIAGRAM 2-1

FEEDING RELATIONSHIPS OF DIFFERENT STAGES OF HERRING



Source: Graham, 1956, p.124.

Norway. The reason for this is clear when it is noted that Norway only became a participant of any consequence with regard to herring in this area in 1963-64. The degree of this participation in terms of total landed catch is shown in Figure 2-1. (This graph is incomplete with regard to the international component because it was not possible to obtain data on this aspect beyond 1963.)

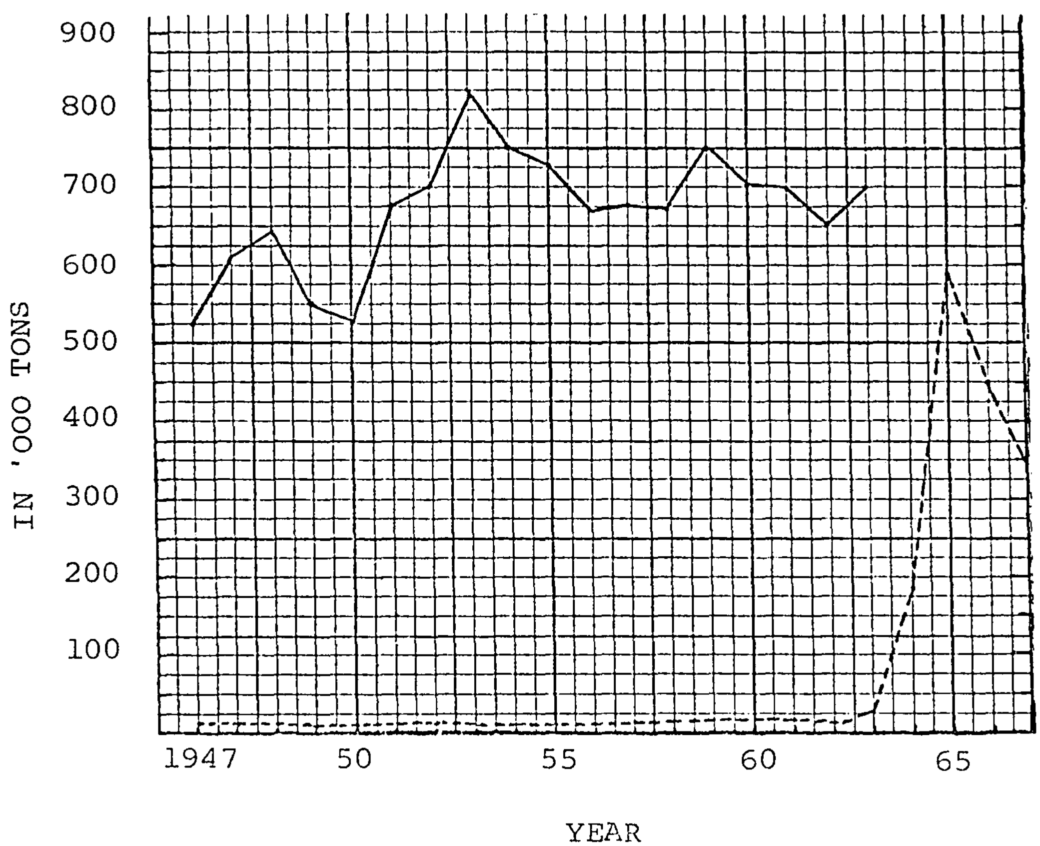
2.2.1. Survey

The Shelf group has been found to be geographically distinct from that of the winter-spring spawners of the Oceanic group. The differentiating criteria were tabulated in Table 2-1. This population has been broken down into three stocks: 1) Banks Stock; 2) Downs Stock and, 3) Kobberground Stock. The spatial pattern of these stocks is depicted on Map 2-2.

Biologically, the characteristics of the Banks and Kobberground herring are similar and are differentiated from the Downs herring by spawning area, spawning times, vertebral column counts and fecundities. In general, the Banks and Kobberground stock are late summer and autumn spawners. These stocks spawn from July to October in the northern and central portions of the North Sea and they may range into the

FIGURE 2-1

NORWAY'S POSITION IN TERMS OF TOTAL
LANDED CATCH OF NORTH SEA HERRING



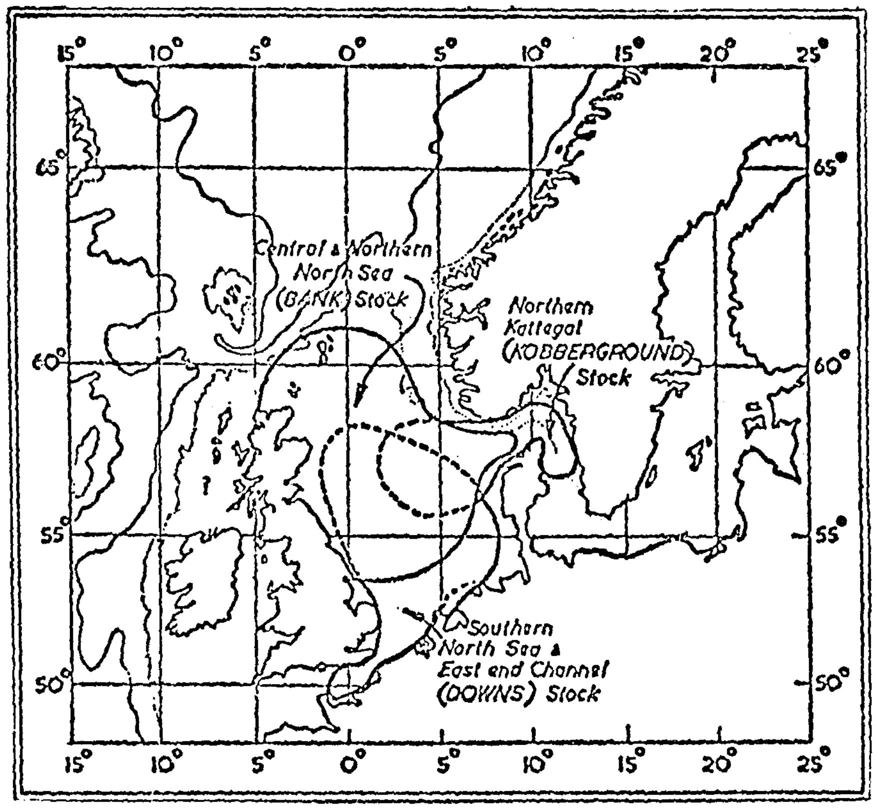
——————— TOTAL HERRING CATCH IN THE NORTH SEA.
(OTHER NATIONS.)

--------- THE NORWEGIAN HERRING CATCH IN THE NORTH SEA.

After: OECD, 1967, p.40A.

MAP 2-2

SPATIAL DISTRIBUTION OF NORTH SEA HERRING
STOCKS RELATED TO NORWEGIAN FISHING ACTIVITY



After: Parrish and Saville, 1965, p.338.

eastern North Sea and Kattegat region. The Downs stock tend to spawn in late autumn and early winter in the months from November to January, in the southern portions of the North Sea and the eastern English Channel (Parrish and Saville, 1965).

The major portion of Norway's North Sea herring catch is composed of members of the Banks and Kobberground stocks; and, of these, the former stock is the more important. A detailed discussion follows.

2.2.2. Banks and Kobberground Stocks

The division of the Banks and Downs stocks is reasonably well established. The Banks stock does not, however, appear to be completely homogenous and some work has suggested a tertiary division of this stock along the following lines:

> "1) a Scottish east coast (Buchan) group spawning from July to September;
>
> 2) an English east coast group spawning in September and October;
>
> 3) a Dogger (Bank) group spawning from September to November."
>
> ICES, 1936
> (Parrish and Saville, 1965, p.334.)

This division was the product of a committee in 1936 cited by

Parrish and Saville (1965). This research group suggested that there might also be a possibility of further differentiating a Jutland and northern Kattegat (synonymous with Kobberground) group. Since that time, work by a number of researchers has indicated that a number of parameters have shown consistent temporal variation. Some measurements and their significance are in conflict. Despite the uncertainty in identification criteria which would enable positive delineation of distinct groups, Parrish and Saville have suggested a division of the North Sea stocks into six sub-categories, two of which are of interest to this study:

> "1) a central and northern North Sea (Banks) summer-autumn spawning stock; spawning grounds from the Shetlands in the north and the Dogger Bank in the south (with possible extensions) to the North Minch and eastern North Sea; adult non-spawning distribution in northern and central North Sea, to the north of Scotland and extending into the Skagerak and Minch. It is also probable that there is at least partial segregation of the groups spawning in the northern (Buchan), central (Dogger) and eastern (Jutland Bank) North Sea.
>
> 2) northeastern Kattegat (Kobberground) summer-autumn spawning stock, spawning grounds, along the Swedish Kattegat coast, adult non-spawning distribution in Kattegat, Skagerak and eastern North Sea. Some mixing with the North Sea spawners may take place in eastern North Sea."
>
> (Parrish and Saville, 1965, p.339.)

2.3. THE ATLANTO-SCANDIAN HERRING

The term "Atlanto-Scandian herring" originated with A.C. Johansen (1919) (Devold, 1961). The distribution of stocks of the oceanic group associated with the traditional Norwegian Winter Herring Fishery are shown on Map 2-3. This map illustrates the spatial range of the three stocks:

1) Norwegian Winter-Spring Spawning Stock;
2) Icelandic Winter-Spring and Summer Spawning Stocks;
3) Faroe Islands Spawning Stock.

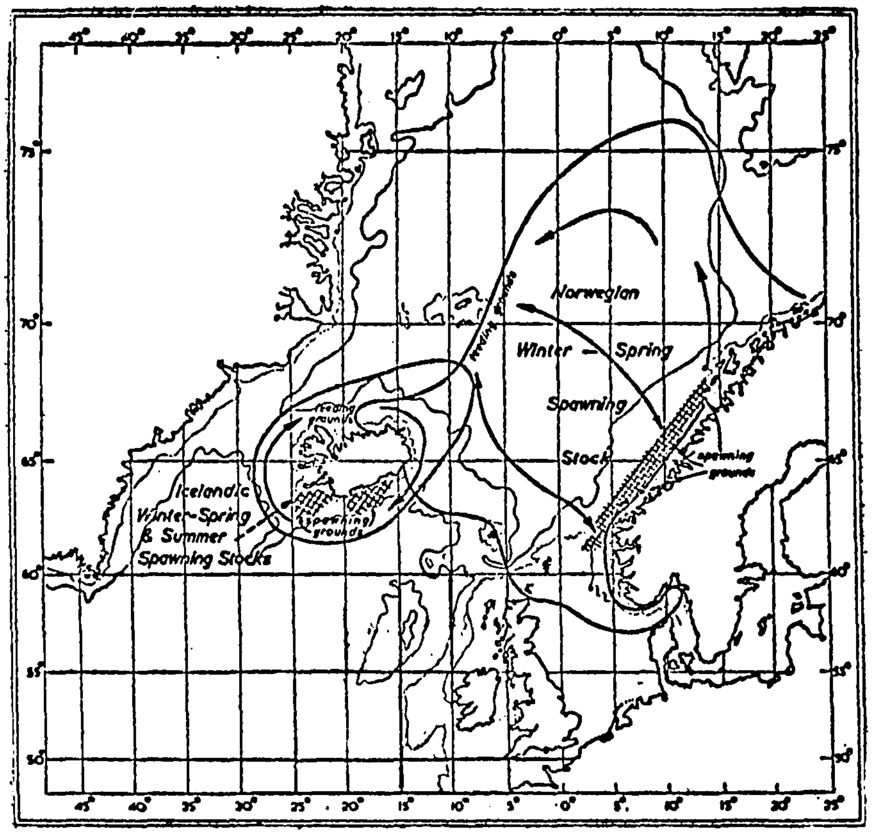
The last two have affected the seasonal pattern of activity in the past but are currently of diminished significance. The Norwegian winter-spring spawning stock has, until the exploitation of the North Sea stocks, been the dominant harvested sub-group of the Atlanto-Scandian herring population and, traditionally, the most renowned of the seasonal Norwegian Herring Fisheries.

2.3.1. Research

Literature concerning the Atlanto-Scandian herring abounds. The earliest known work on their biology was conducted by Dr. Axel Boeck in 1857. G.O. Sars continued Boeck's inquiries in the 1870's. It was a result of his efforts that the migratory nature of herring was first revealed.

MAP 2-3

SPATIAL DISTRIBUTION OF OCEANIC HERRING
STOCKS RELATED TO NORWEGIAN FISHING ACTIVITY



After: Parrish and Saville, 1965, p.333.

After G.O. Sars, there was a lapse until 1904 when Brock and Langesund produced a population identification by morphological analysis. The technique employed was vertebral column counts (Devold, 1961). (The vertebral column count represents the total number of vertebrae in the vertebral column including the urostyle. This is a biological species identification technique.)

Further investigation concentrated on trying to determine if the winter-spring spawning stock actually was composed of more than one group. The reason for this was the consistent variations in vertebral column counts that were observed to occur from samples taken from southern and northern Norway. The latter in the aggregate had a smaller count. This problem has now been resolved, because a temperature-vertebral column count relationship has been established. The connection linking these parameters is that, with a reduced water temperature in the nursery area, the vertebral column count is also diminished. The final conclusion, then, is that different nursery areas may exist but the evolutionary process has yet to cause mutually exclusive groups to be established.

Summarizing, it can be stated that the population exists as one entity. This was established by the above research; and by other research activities related to echo-sounding, sonar and tagging which has enabled the isolation of the particular stock. The mechanisms which control the population dynamics are, however, to date very poorly understood.

2.3.2. <u>Migratory Pattern</u>

The migratory characteristics of the particular herring stock have been reviewed by Devold (1961), who presents a summary of the annual cycle of migration.

The opening phase of the migration occurs in the beginning of January. At this time, the herring are found gathered to the southeast of Iceland on the interior of the polar front, travelling at a rate of five to seven nautical miles per 24 hours. This rate of travel is increased over threefold, to 20 to 40 nautical miles per 24 hours, when the herring penetrate the polar front into Atlantic water. No feeding takes place from the time the herring break through the polar front until they reach the Norwegian coast.

The herring spawn about one month after arriving along the coast. Once the spawn has been completed, the adult herring migrate out to sea and feeding is resumed.

The date that this occurs is usually no later than April. From April until June, feeding is concentrated over an extensive area stretching from the southern limits of the Norwegian Sea into the Barents Sea.

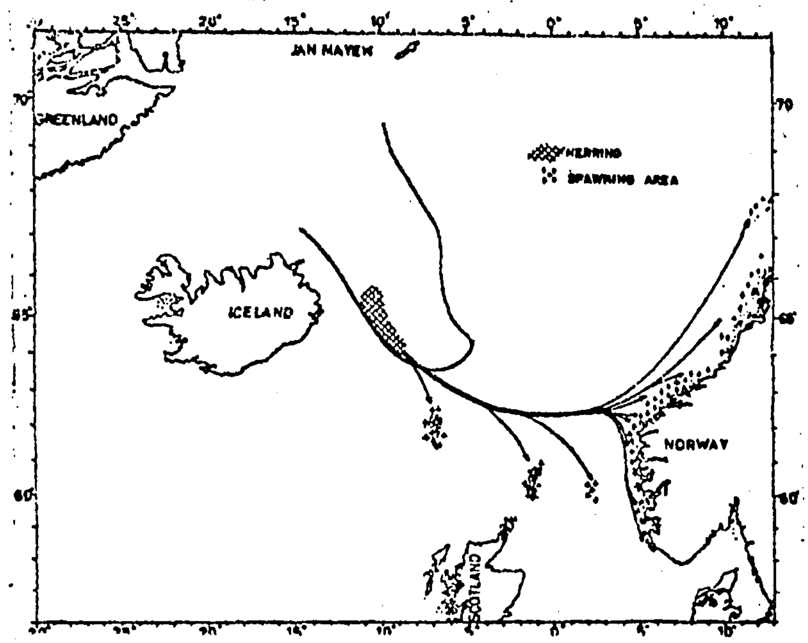
In the third phase, the herring migrate back towards the outside of the polar front and remain in this area from approximately July to September. For the duration of this phase, there is a progressive gravitation of the herring to the thermocline between the polar and Atlantic waters. The termination of this phase occurs when the herring start to penetrate the thermocline. Subsequently, there is a gradual regathering process on the interior of the polar front and it is from this area that the migration is again triggered around January. The four phases of this cycle are summarized by Map 2-4.

The exact position where the herring schools strike the coast has varied in time and space. The quantity of fish has also varied. At the turn of the century, the influx of the main spawning group was in the Bohuslan and Skagerak area. This shifted to the area south of Bergen in the 1930's and has moved in the 1960's to a position off the coast of Møre and Romsdal county. There has been a quantitative

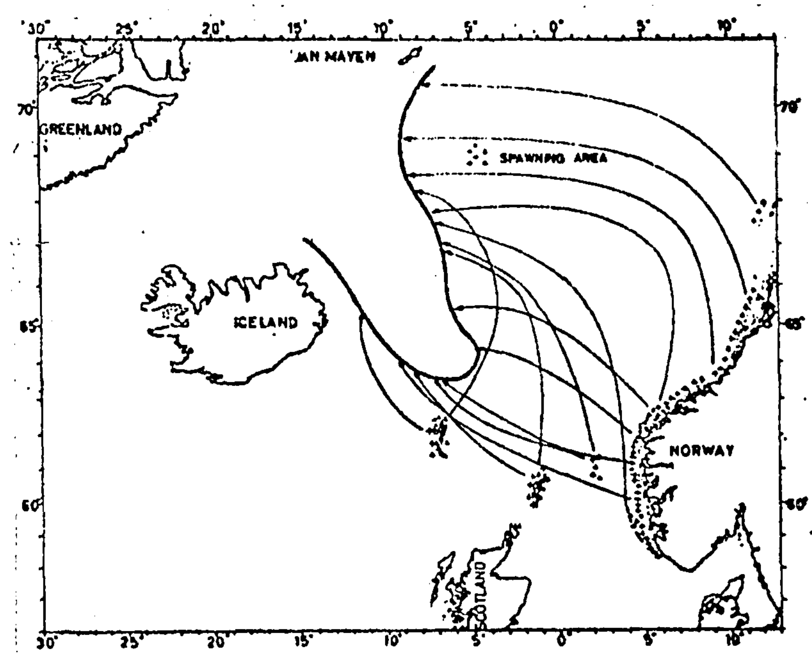
MAP 2-4

MIGRATORY PATTERN OF NORWEGIAN
WINTER-SPRING SPAWNING STOCK

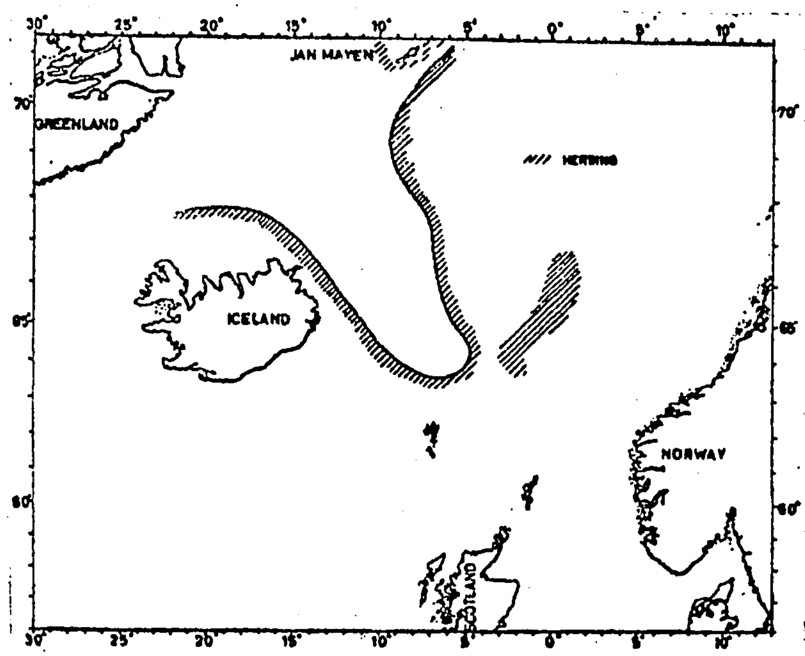
(a) January-March



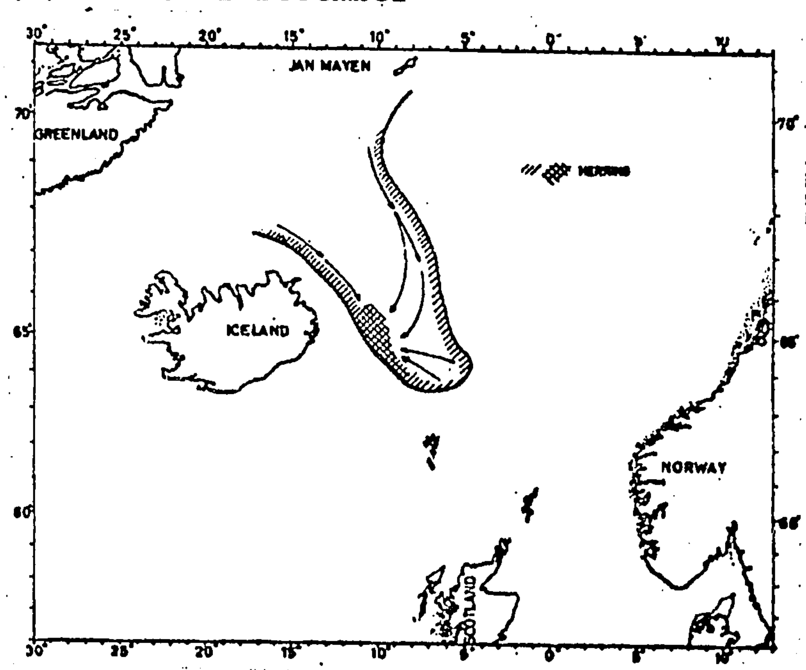
(b) April-June



(c) July-September



(d) October-December



After: Devold, 1961.

variation in landed catch concurrent with the shift. A portion of this variation is depicted in Figure 2-2 for a 20-year period 1947-67. The reason for this spatial, temporal and quantitative difference is believed to be due to a cyclic pattern exhibited by the herring. This topic is discussed in the next section.

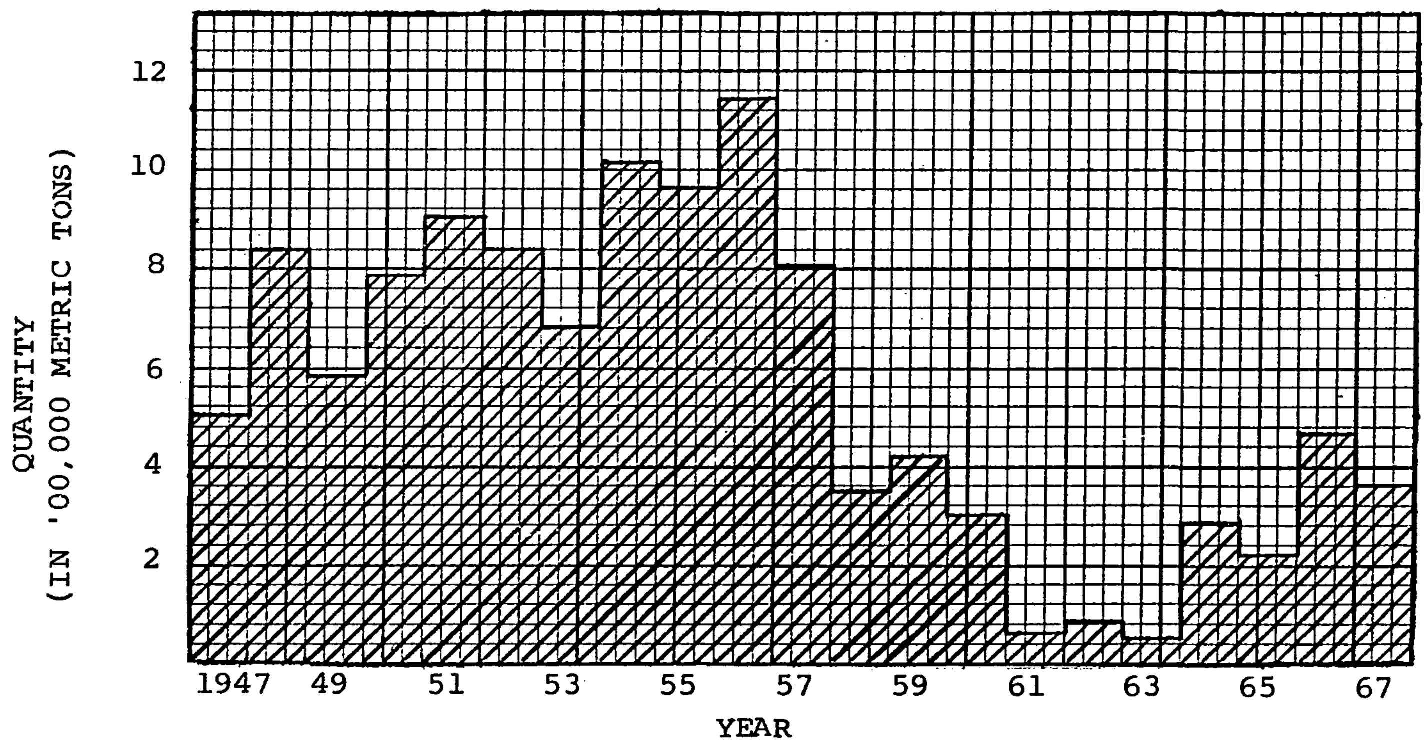
2.3.3. Theories on Variation

The reason for the growth of these theories is an historical one. Traditionally, the success or failure of the fishery has had a major impact on the coastal economy, because a large number of people participated in it during the winter season. Success or failure thus was important, as it impinged on the farmer-fisherman economy, that used to be more significant in the past on the outer coastal islands and contiguous areas of the mainland.

The precise nature of these theories has varied in scientific merit. One of the earlier hypotheses, by Ljungman in 1879, postulates that there existed a correlation between herring periodicity and sunspots (Tambs-Lyche, 1950). At the same time, another theory was put forward. This was that of Otto Peterson, who postulated that herring periodicity was related to the tides; furthermore, he thought that the

FIGURE 2-2

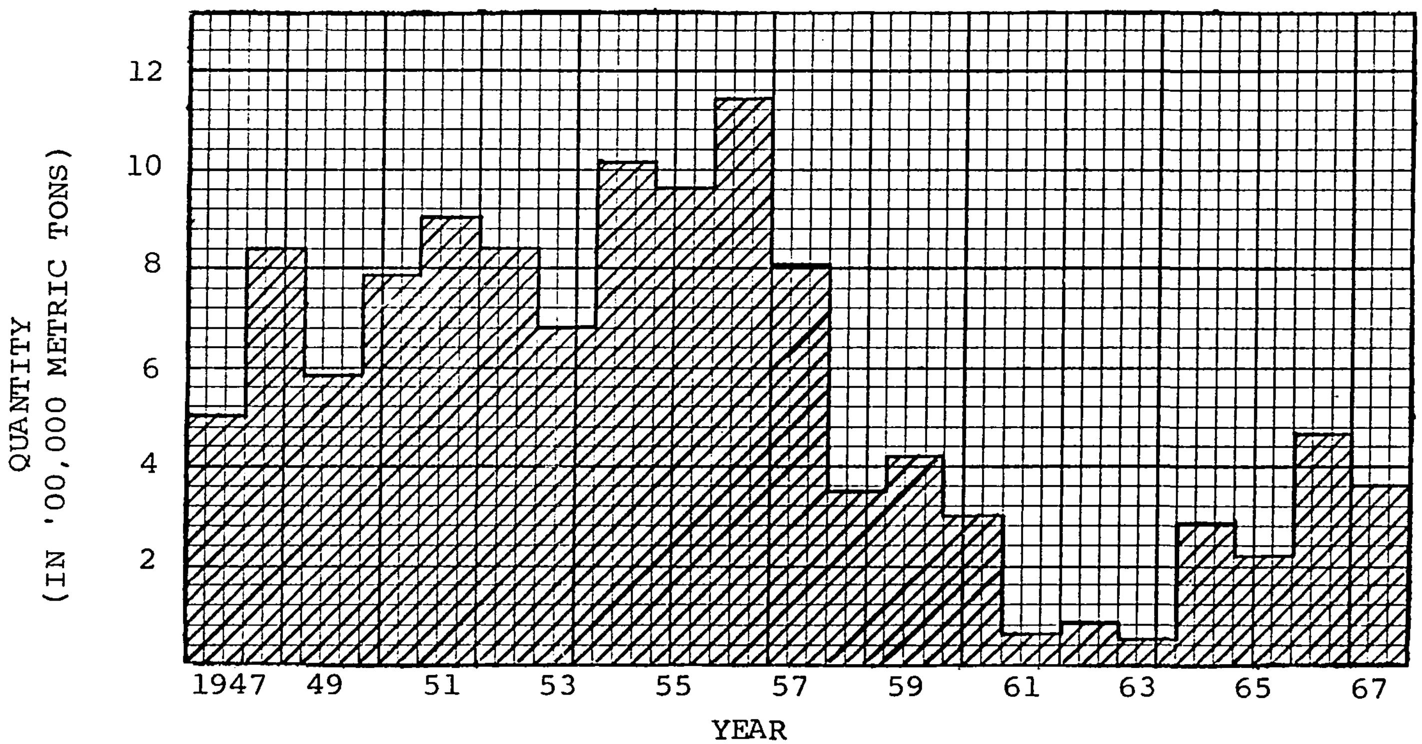
CATCH QUANTITY OF WINTER HERRING LANDED IN NORWAY: 1947-1967



Source: Vintersildfisket, 1947-67.

FIGURE 2-2

CATCH QUANTITY OF WINTER HERRING LANDED IN NORWAY: 1947-1967



Source: Vintersildfisket, 1947-67.

Norwegian winter-spring fishery was linked with that of Bohuslan, and that they alternated. Peterson was correct in his latter hypothesis, but was in error in his first one. The proof of a linkage between the two fisheries was confirmed shortly thereafter. At this time, Malm (1880) (Devold, 1959) conducted an analysis on herring lengths. His work on the Bohuslan and Skagerak herring showed that they had an average size from 27-35 centimeters. No other exploited group of herring was so large, exclusive of the winter-spring spawning stock. (See Table 2-1.)

The aforementioned work, then, delineated the geographic range and population sub-grouping of the Atlanto-Scandian herring relevant to this study. Two essential problems still remain to be explained:

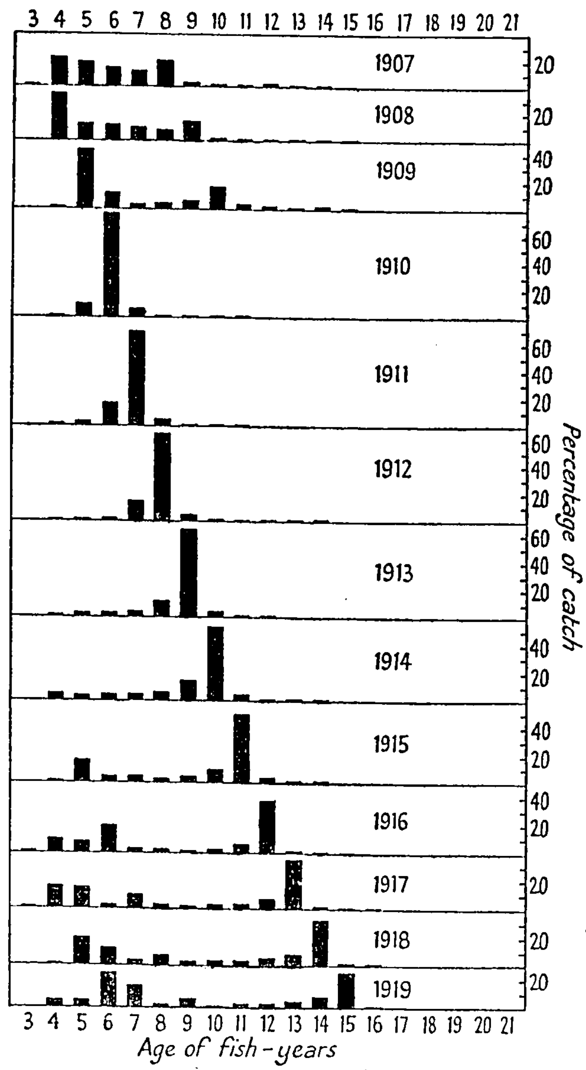
1. Quantity Variation Problem;
2. Spatial-Temporal Problem.

2.3.3.1. Quantity Variation Problem

In reviewing this problem, the literature shows that the quantity caught in any one year is highly dependent on a particular year class. Examples of this are easily seen in Figures 2-3 and 2-4. The reason for the year class dominance is, as yet, not known.

FIGURE 2-3

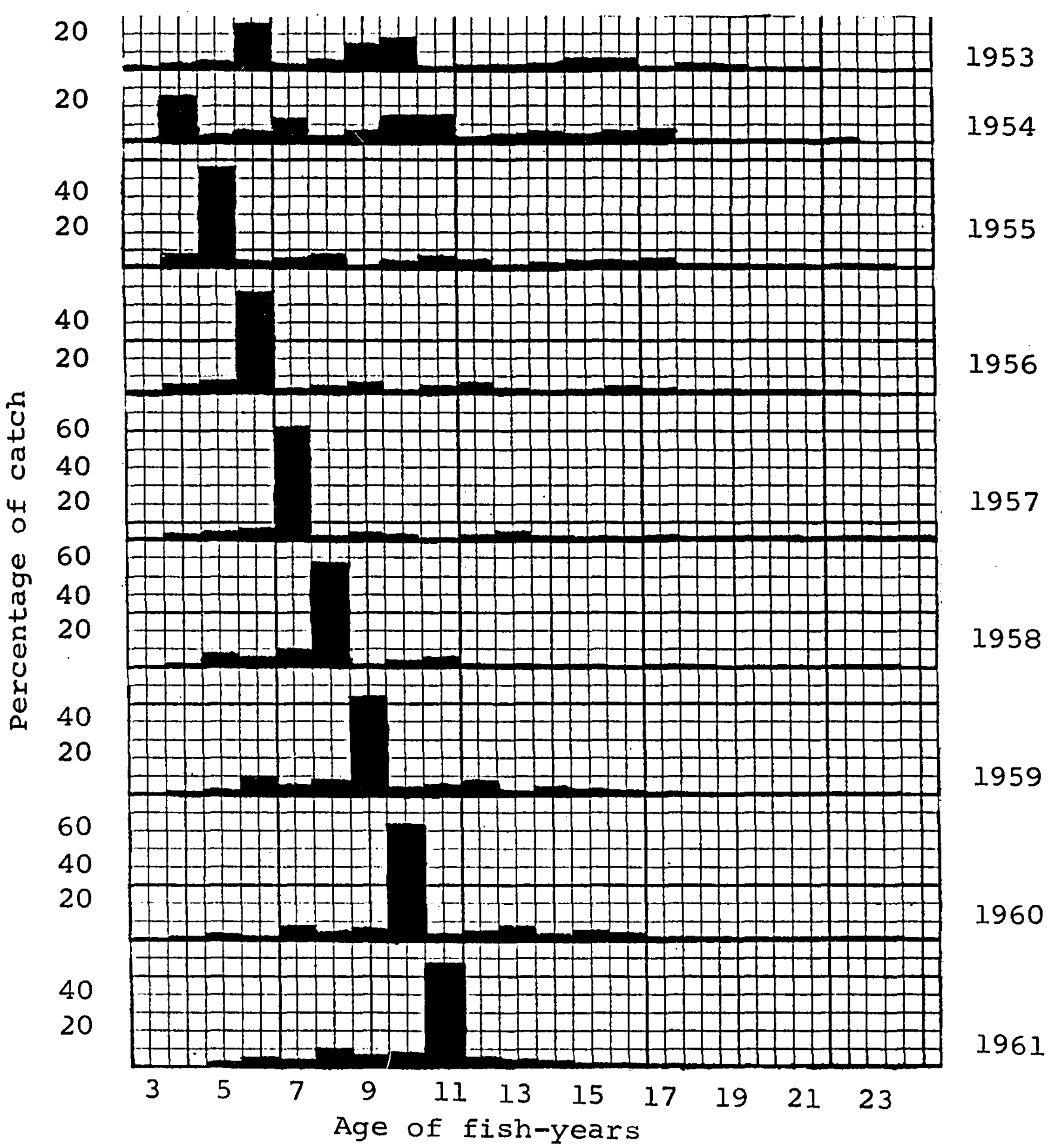
AGE COMPOSITION OF WINTER HERRING
CATCHES, 1907-1919



Source: Young, 1962, p.270.

FIGURE 2-4

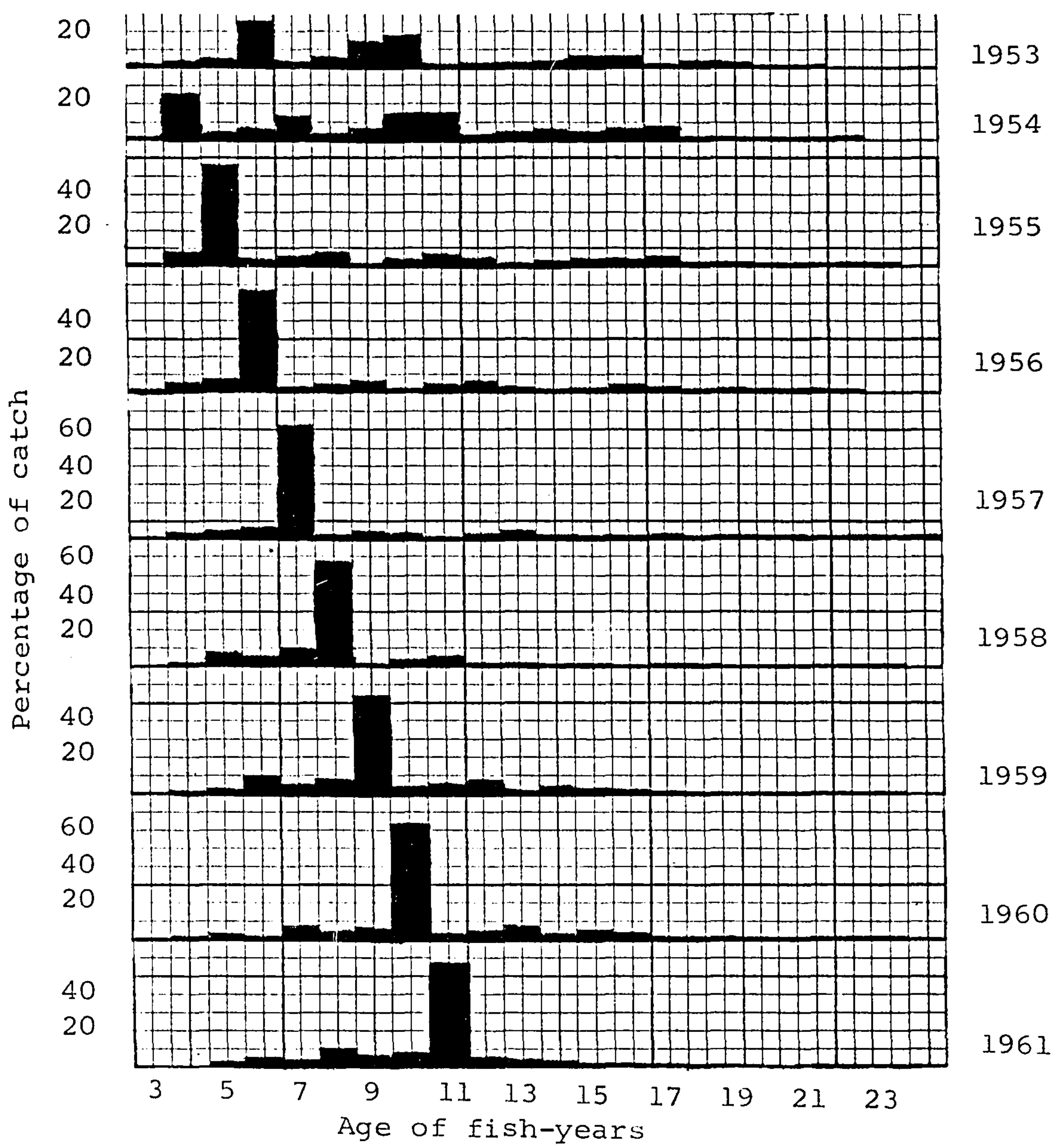
AGE COMPOSITION OF WINTER HERRING CATCHES,
1953-1961



Source: Devold, 1961.

FIGURE 2-4

AGE COMPOSITION OF WINTER HERRING CATCHES,
1953-1961



Source: Devold, 1961.

Preliminary statistical analysis has been conducted on the basis of using the size of the adult population as an indicator of the offspring for any particular year. The results have so far proved inconclusive. The approach used has been a simple linear regression model (Haraldsvik, 1958a); and the result, an approximate zero correlation. Apparently, no relationship exists between adult and offspring. However, this is obviously not true when one considers the logic of it. It may, however, be due to the multiplicity of biological factors which interplay. Possibly, in a macro analysis such as this, the differing components are counteracting each other and, thereby, producing this result. It may also prove, upon further investigation, that other environmental constraints are of more significance; or, put another way, a function of the biological nature of the parent is more significant than the use of a straight estimate of the adult population size to assess stock strength of offspring. This field has been poorly explored and further research on this aspect is required.

Previously, the discussion has been oriented towards the assumption that endogenous, not exogenous, biological factors are the prime motive force underlying population variation. There is one point that should be raised concerning this approach: some biologists have observed a significant variation in abundance in North America as a result of a fungus parasite, ichthysporidium. This disease appears approximately at 16-year intervals and work confirming the presence of this parasite have been cited by Fish, 1934; Scattergood, 1948; and Sindermann and Rosenfeld, 1954 (Garnett, 1967). This disease attacks a variety of body organisms with the production of "disorientation, erratic swimming motions, lethargy and early mortality when handled" (Garnett, 1967, p.16). No reference to this fungus was found in the European literature with respect to population dynamics.

One more aspect requires consideration prior to examining the second problem. The variation in landed catch quantity has been used as an indicator of the overall strength of any particular year's exploitable population. There are difficulties with such a measure being employed to indicate population size: environmental conditions can be very significant at any one position in time and space. The relevant parameters which impinge on this as a measurement technique are meteorological and oceangraphic. The susceptibility to environmental influence can be illustrated by the possible effect of meteorological conditions that may influence visibility. This aspect is relevant, as visibility was an important element in locating herring until approximately the beginning of the study period. Its role was a complementary one to the echo sounder which only measured a vertical column of water immediately beneath the fishing vessel and, as such, the echo sounder was useful but it was distinctly limited. This is, however, not to say that the echo sounder was of little import, for it was a significant improvement over the hand-operated sounder; but it still provided comparatively little information when juxtaposed with that provided by sonar. This point will become clearer in Chapter Four.

Two additional problems will suffice to further illustrate the importance of environmental factors and, therefore, the diagnostic nature of landed catch as a measurement technique. One is wave height, a function of wind velocity, fetch and imported storm effects. Its influence is felt in that it prohibits fishing above a wind strength of five to six on the Beaufort scale. Secondly, water temperature is important; for, if oceanographic stratification exists, it may keep the herring out of the effective reach of the fishing equipment, as temperature influences food availability. The latter is not as important today due to the increased net dimensions. This topic is dealt with in more detail in Chapter Five.

2.3.3.2. Spatial - Temporal Problem

The spatial - temporal variation has so far received little detailed scientific study. There appear to be a number of aspects of the herring biology and the physical environment that are involved in producing the variation. More work is required, however, on the topic beyond the preliminary nature of that done by Devold (1960, 1961) and Devold (1963) (Parrish and Saville, 1965). The result of his inquiries has shown that the hydrographic conditions combined with the arrival time of the herring on the coast may be critical. The relevant parameters have, however, not been formulated in a model which may be tested.

Devold (1961) has postulated that the spatial - temporal variation of the herring has a cyclic nature with a periodicity of a hundred years. This cycle starts with the herring being fished in the Bohuslan and Skagerak area. There is then a progressive shift out of this region to

Western Norway. This is concurrent with a later and later arrival on the coast. As the temporal aspect of later arrival on the coast continues, there is a continued northern shift. The conclusion of the cycle is marked by the eventual complete absence of the herring from the west coast; but, there may be a brief appearance of them in Northern Norway. The herring then reappear in the Bohuslan-Skagerak area. Devold maintains that "if this /explanation is valid then/ there is only one year /of/ the last two hundred /for/ which we do not know where the herring were. This was 1875 in which no herring fisheries were based on the Atlanto-Scandian herring." (Devold, 1961, p.5.)

Devold (1961) makes this hypothesis on the basis of catch statistics for an extended period of time. His explanation of the progressive spatial - temporal shift is based on a supposition that the herring take slightly more than a year to complete successive spawns. This produces a feedback mechanism on the migration pattern, which results in later and later arrivals on the Norwegian coast. The eventual consequence is that arrival is so late that the water temperature disparity between the coastal waters and the waters through which the herring have just passed is sufficiently large to deter the herring from crossing the thermocline into the warmer Baltic surface water. The reason for this reluctance appears to be that the herring prefer to maintain a favourable environment with a specific temperature tolerance. The net result is that the herring tend to stay in the deeper cold water and it is at this time that they "probably then pass through the Norwegian Channel into the Skagerak and spawn off the Norwegian south coast and off Bohuslan." (Devold, 1961, p.5.) The reason for the annual return is not known but it is attributed to a homing mechanism which is initiated at the time of initial hatching.

An illustration of the quantitative and spatial - temporal variation is depicted on Map 2-5.

2.4. DISSIMILITUDE OF STOCKS

There are two major points further differentiating the biology of these stocks:

1. Migratory Habits;
2. Quantity Variation.

2.4.1. Migratory Habits

The significant element is that the scale, in terms of range of the North Sea herring stocks, is contracted in

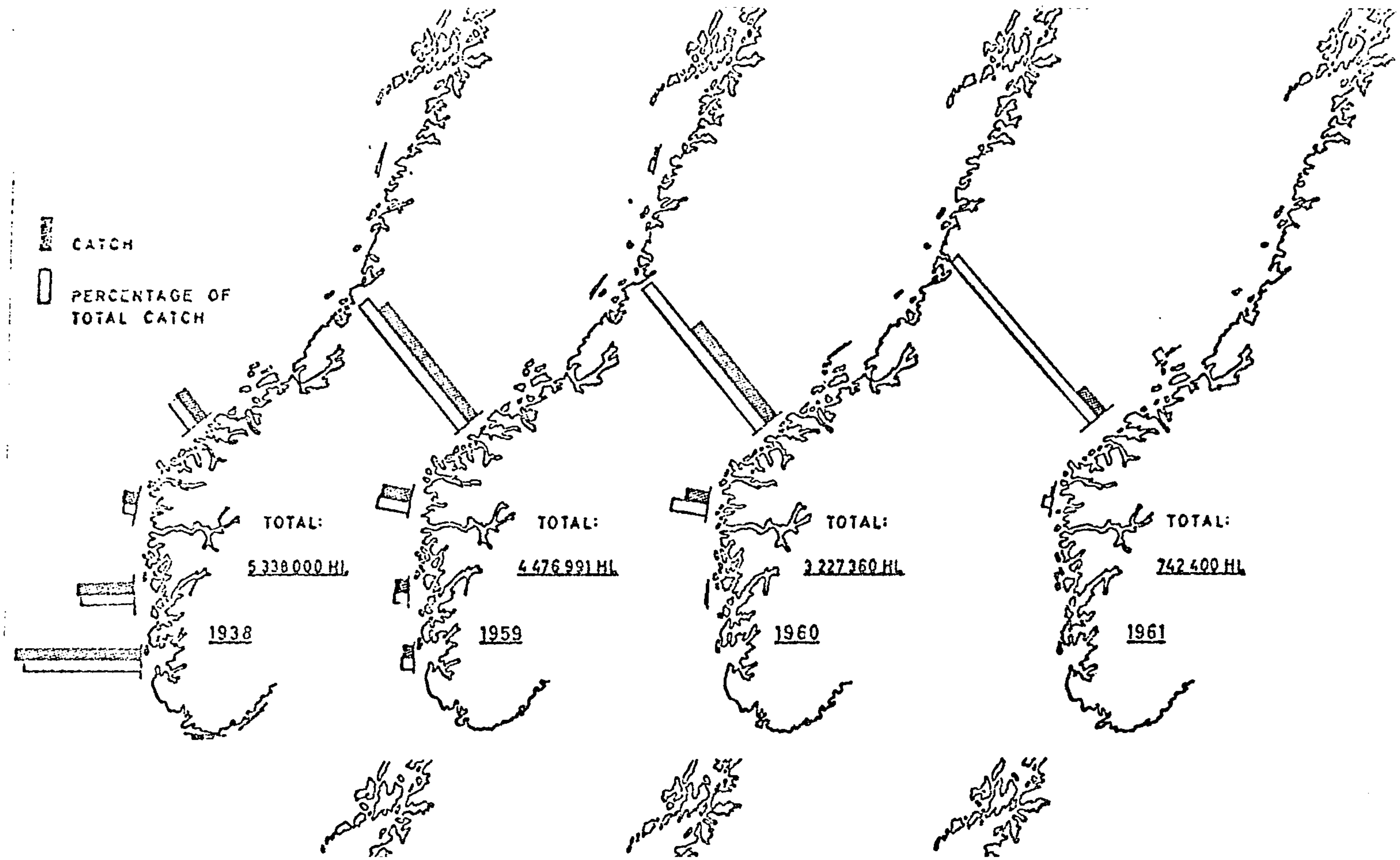
MAP 2-5

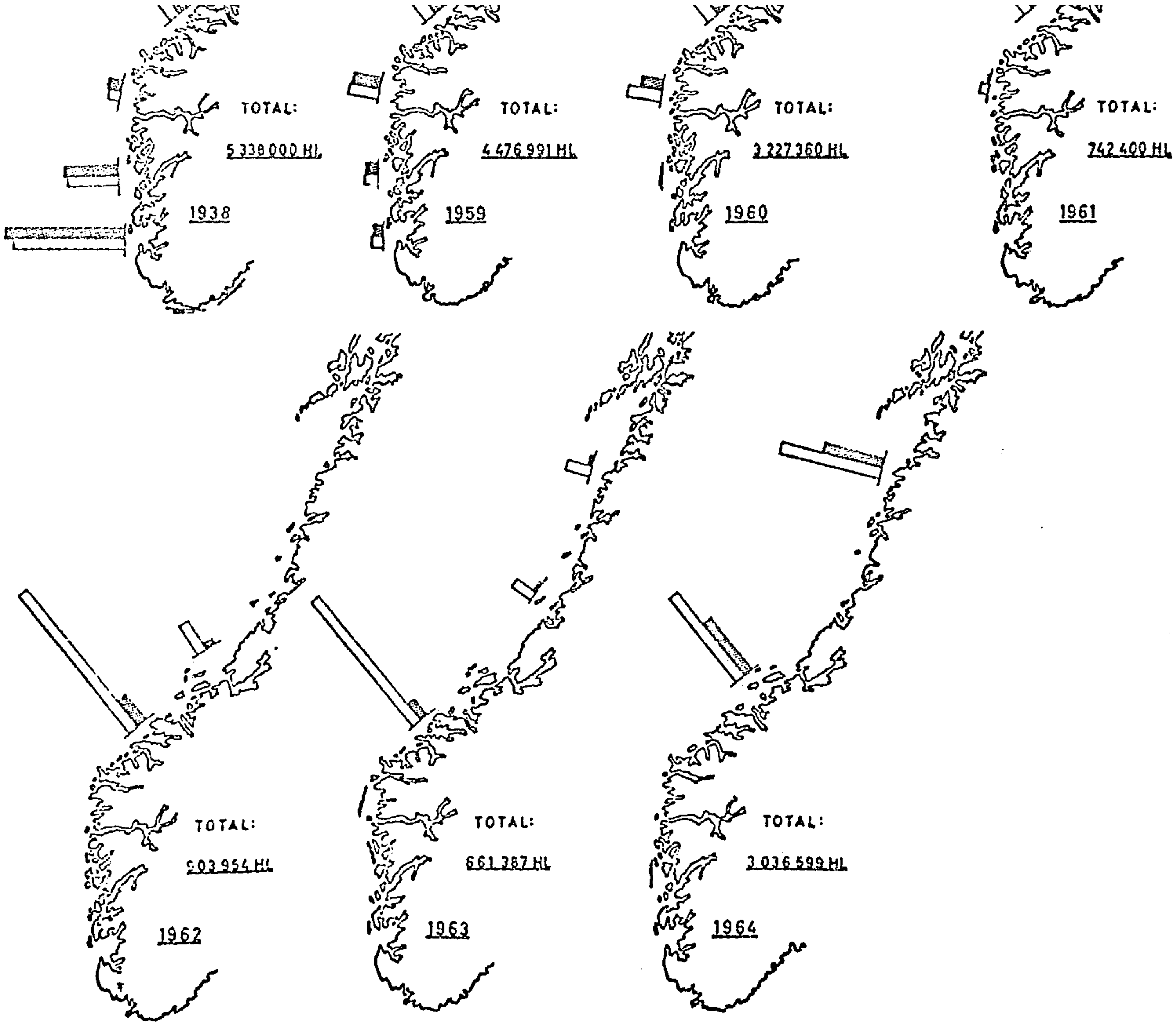
SPATIAL DISTRIBUTION OF LANDED CATCH OF WINTER HERRING: 1938, 1959-64.

Source: Devold, 1961.

MAP 2-5

SPATIAL DISTRIBUTION OF LANDED CATCH OF WINTER HERRING: 1938, 1959-64.




TOTAL:
5 338 000 HL
1938
TOTAL:
4 476 991 HL
1959
TOTAL:
3 227 360 HL
1960
TOTAL:
742 400 HL
1961
TOTAL:
503 954 HL
1962
TOTAL:
661 387 HL
1963
TOTAL:
3 036 599 HL
1964

comparison with that of the Norwegian winter-spring spawning stock. The general pattern of the North Sea herring stocks seasonal variation is delineated on Map 2-6. This comparatively limited range is important, in that it means that the resource is virtually available throughout the year as contrasted with the winter herring which are strictly seasonal.

2.4.2. Quantity Variation

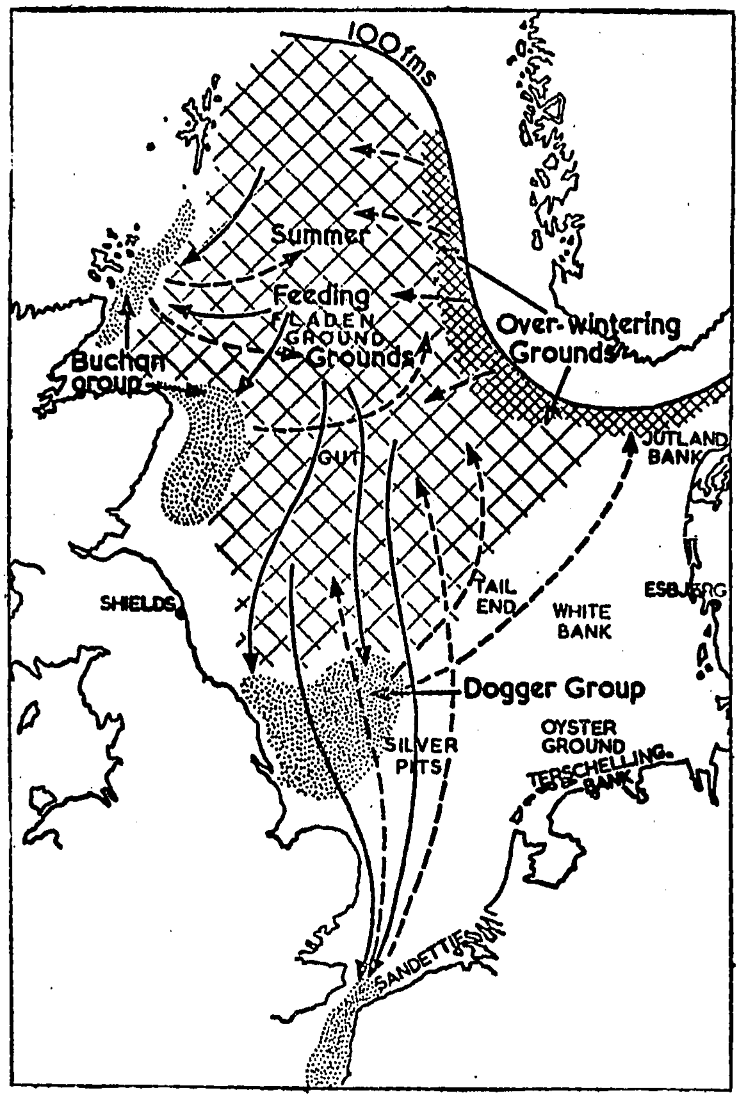
This is another parameter on which the two stocks vary in an evident manner. There have been no marked periodic shifts in the quantity of herring harvested from the North Sea since approximately the turn of the century, which is a significant difference from the Norwegian winter-spring spawning stock. There has been an increase in total harvested quantity in the years 1964-1967. This has been a product of increased fishing effort.

2.5. ASSIMILATION OF STOCKS

It is now evident that it is possible to segregate the various herring stocks on the basis of a variety of characteristics; but it is useful to note that the behaviour of herring within the mutually exclusive groups tends to be very similar on a number of aspects. These similarities are

MAP 2-6

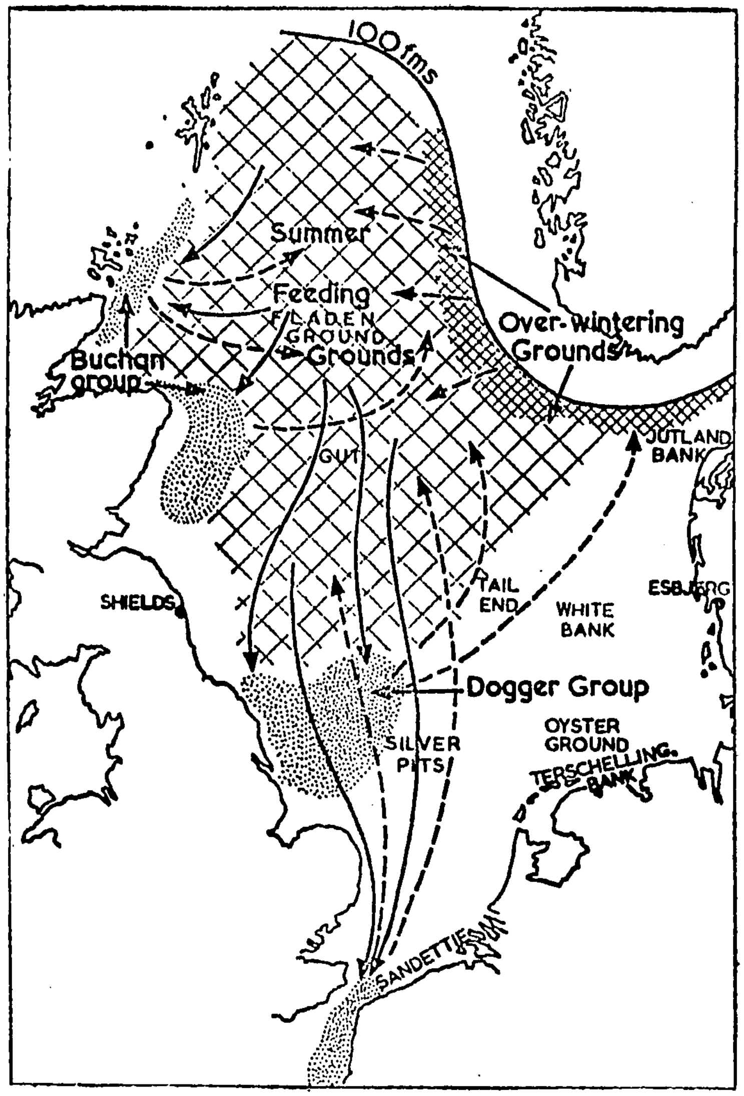
MIGRATORY PATTERN OF NORTH SEA HERRING



Source: Parrish and Saville, 1965, p.348.

MAP 2-6

MIGRATORY PATTERN OF NORTH SEA HERRING



Source: Parrish and Saville, 1965, p.348.

reflected in such things as nature of the sea bed on which spawning occurs, the degree of effective fertilization, food type and feeding habits (Blaxter and Holliday, 1963). There are two features in particular that warrant attention. These are:

1. Diurnal Activity
2. Shoaling Behaviour.

2.5.1. Diurnal Activity

The relevance of the daily regime of herring activity lies in that it facilitates locating and capturing the fish. The link here is that at night herring tend to come to the surface and spread out while feeding but for the duration of the daylight hours herring descend to variable depths and shoal. It is this shoaling activity that is important, as it greatly facilitates location by echo sounding and sonar techniques. The reasons for this and principles regarding these search procedures are discussed in Chapter Four.

2.5.2. Shoaling Activity

A shoal or school is defined "as a group of fish which are polarized or orientated in the same direction as to reaction to one another, rather than a common reaction to external stimulus." (Blaxter and Holliday, 1963, p.326.) Shoals have a regular internal spacing and move at a constant speed throughout. Aside from the aforementioned facility which this provides in locating the herring, there are several other aspects to note: namely, that it increases susceptibility to exploitation by the purse seining technique, while at the same time it seems that shoaling serves as an important mechanism in the survival of the species when under attack by all predators, except man.

2.6. POPULATION DYNAMICS

There is one final point to raise. This concerns the tests conducted to determine the exploitation status of a particular fish population. The method is to conduct an age-composition analysis of the landed catch. If this shows a decrease in representation of average age structure from previous years, it is a reasonable assumption that the biological mechanisms have been skewed. The interpretation then is that the resource is harvested in excess of its sustainable yield. Care must be used in the interpretation of the sustainable yield concept as it is possible to alter the age structure by varying fishing intensity. The problem is: at what age structure can we obtain the optimum yield? At present, it is not possible to answer this question.

2.7. SUMMARY

This Chapter has been presented as a study of the different characteristics of the herring species in order to provide an insight into the biological nature of the resource which is being harvested by the fisheries under consideration.

I N N O V A T I O N

CHAPTER THREE

THE POWERBLOCK AND NET SEINE WINCH

CHAPTER THREE

THE POWERBLOCK AND NET SEINE WINCH

3.1. INTRODUCTION

This Chapter provides basic descriptive information on the powerblock and net seine winch. These are two separate devices but subsequent to this Chapter they will also be dealt with, interchangeably, under the common term - the innovation. The powerblock is the older; the first one was sold in Norway in December, 1960 (Rapp Fabrikker, 1968) and this type was the most important until 1965-66. At this time, the net seine winch came into production and shortly thereafter it started to replace the powerblock.

3.2. DEFINITION

For the purpose of this study, the powerblock and net seine winch are defined as mechanical net hauling devices. They are operated from the aft section of the boat deck. There are five different manufacturers producing a number of types, all of which can be classified as either a powerblock or a net seine winch. The former is a one-piece unit while the net seine winch has the hauling operation broken down into two or three steps, depending on the type.

3.3. DEVELOPMENT

The history of the innovation can be summarized in two phases: 1) Icelandic Phase; and 2) Norwegian Phase.

3.3.1. Icelandic Phase

The powerblock was first developed in America by Puretic and it came into production in the middle 1950's. It was manufactured by Marine Construction and Design Company (MARCO) in Seattle, Washington, U.S.A. (Anderson, 1968; Tande, 1968.)

This phase was initiated in 1956 when Inguar Palmasson, the Icelander, visited Vancouver and became familiar with the powerblock. Upon his return to Iceland, he worked with its implementation for several years. It was not until 1959, however, that the Icelanders were able to overcome the technical problems of net design and team organization to enable them to effectively utilize the innovation (Nilsen-Nygard, 1968).

3.3.2. Norwegian Phase

Initial testing was conducted by the Norwegian manufacturing firm which had the licence production rights for Europe, and the Fisheries Directorate in the Winter Herring Fishery of 1960. At this time, powerblocks were installed and tested in three boats: 1) Smyl; 2) Senior; and 3) Vagar. The results of the trials were not extremely successful. Two reasons for this were: 1) the Icelandic purse seine net which had been adapted to the powerblock was not used; and 2) the resource availability, i.e. difficulties were incurred by a large number of fishermen that year. (Fiskeridirektøren, 1963; Jacebson, 1968.)

Subsequent to the initial trials, Torgerson* of Davanger, outside Bergen, acquired one of the powerblocks, which had been used in the aforementioned tests, in December, 1960. He used it for sprat and tunny fishing. The results

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* Bertin Torgerson is generally referred to as the first to have actually used the powerblock for commercial fishing. In a paper by Torunn Torgerson (1967), his daughter, a reference is made to Trygve Olsen as being the first in 1959. It was not possible to obtain much additional information on this matter. The paper was based mainly on a personal interview with her father.

were good but not exceptional. The winter of 1961 then was the opening phase. Through the early part of 1961, several other boats tried the equipment with not too much success. As a consequence, Bertin Torgerson and two others, who had been confronted with technical problems, travelled to Iceland in the fall of 1961 at the invitation of Palmasson. The result of the trip was the importation of the design for the first ringnet to be constructed in Norway. It was tested by Torgerson's boat, Radek.

By 1962, few positive results of sufficient magnitude had occurred. In that year, three other fishing vessels - Polarfart, J.M. Senior and Harmoni - participated in the Iceland Herring Fishery with the proper equipment and marked positive results were obtained. Torgerson tried in the North Sea that year but unfortunately the fishery was unsuccessful in 1962.

Despite the partial success in 1962, little more was done until 1963. At this time, Torgerson started in the North Sea for herring and the results were extremely successful. From then on the importance of the innovation seems to have been validated.

There were two exogenous variables which also played a role, one favourable and one prejudicial. The former was the visual contact of the Norwegians with the Icelanders in the herring fishery off Iceland in the summer. The importance was that the Norwegians saw the Icelanders succeed and make money fishing with the power-block while they themselves had to sit in port due to unfavourable weather conditions. The prejudicial viewpoint was reflected in the official stance at the time of the innovation's introduction. The official outlook was strongly opposed to the innovation for a variety of reasons: the most important one being they thought it was unacceptable nonsense. The fishermen were also somewhat against the innovation as none wished to be the first and then possibly not succeed. The justification for the latter outlook was that in the middle and late fifties the Winter Herring Fishery was still providing good prices and wages and there was, therefore, no strong urge to try something new in 1960. This view, as far as the fisherman was concerned, had changed by 1963-64 for over the intervening period the Winter Herring Fishery experienced a steady decline and the belief that it was only temporary had by then been shaken.

3.4. DESCRIPTION

3.4.1. Power System and Capacities

Both the powerblock and net seine winch are operated by high pressure hydraulic systems. In general, the powerblock has a smaller hauling capacity than that of the net seine winch. The range in power output varies from 3100 pounds at a rate of 125 feet per minute to 10,000 pounds at a rate of 90 feet per minute.

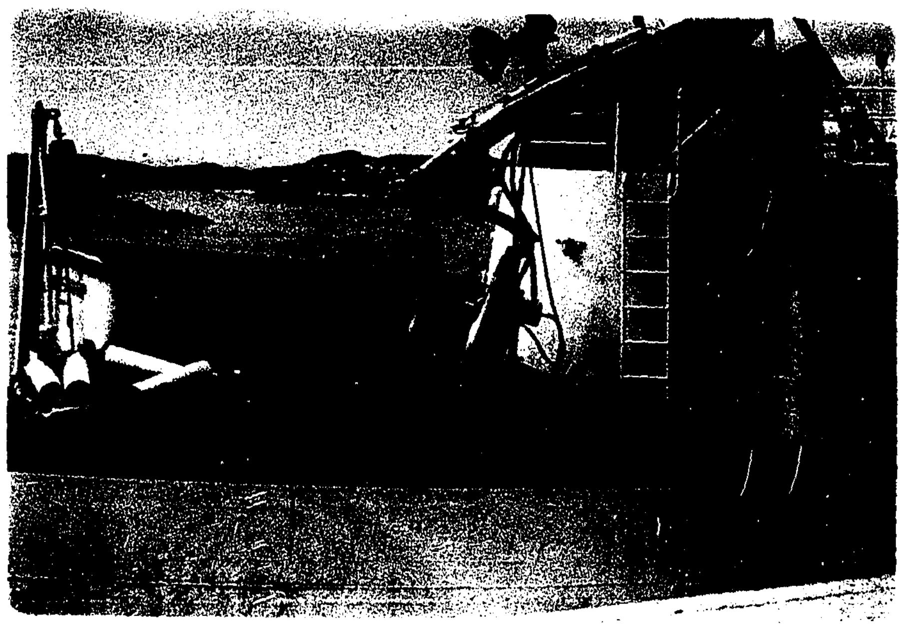
3.4.2. Position on Fishing Vessel

The difference in positioning is depicted in Photographs 3-1 and 3-2. The reason for the variation is the mode of operation. The powerblock is operated in a mobile fashion, being permitted to swing freely from a crane arm. The purpose of this is to enable the block to compensate for the variations in angle of approach that the net might take when being hauled in due to the pitching and rolling of the fishing vessel. The powerblock is also higher above the deck than the net seine winch when in operation.

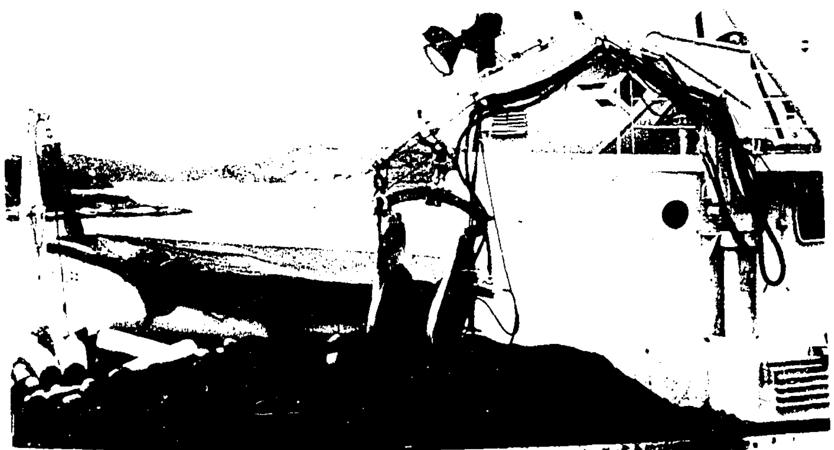
The net seine winch illustrated in Photograph 3-2 has two components: the main unit, the hauling mechanism, is operated fixed to the deck, further forward than the

PHOTOGRAPH 3-1

THE POWERBLOCK



WERB



PHOTOGRAPH 3-2

THE NET SEINE WINCH

powerblock and lower down. The effect of this alteration in positioning has been to produce greater stability coupled with additional hauling capacity. The second unit of this arrangement is an hydraulically operated transport roller located on a mobile arm which functions independently of the main unit and higher up than the powerblock. The advantage of this separation of the hauling procedure into two steps is that the higher transport roller facilitates the spreading out of the net on the boat deck without impairing stability. This is because the transport roller is separate from the hauling procedure, and thus only the weight component of the net and no other force vector of significant size acts on it.

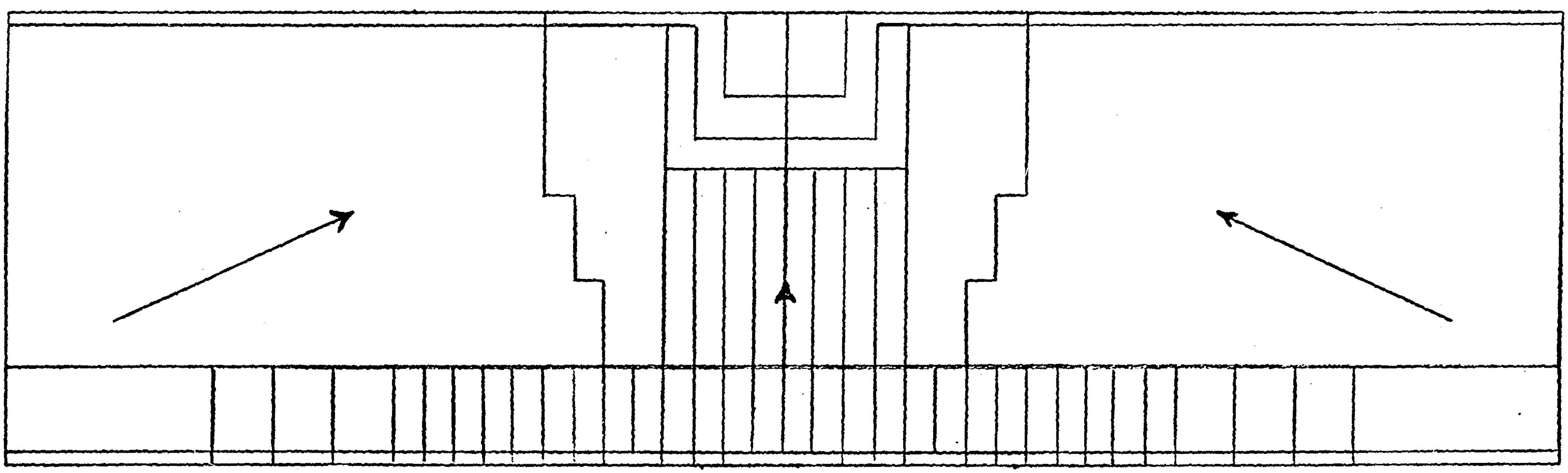
The stability problem has been of concern, as reflected in Fiskets Gang (1964, 1965) in which government regulations concerning this matter were published. The necessity for such regulations was due to the accidents which occurred because of improper installation and use - a product of lack of knowledge in the operation of the powerblock.

3.5. PURSE SEINE TECHNIQUE

During the study period, this technique has undergone a significant change. The alteration has had such an impact that two varieties may be delineated: 1) Two-Dory System; and 2) Ringnet. The differentiating elements are reflected in the net structure which has had to be changed to accommodate the innovation. This difference is shown in Diagrams 3-1 and 3-2. The elemental variation is the position of catch concentration. In the two-dory system, the concentration occurs in the middle of the net as illustrated in Diagram 3-1. This shows a progressive increase in mesh density with movement towards the centre-top portion of the net from the outer extremities. In Diagram 3-2, which illustrates the ringnet, the comparable mesh density increase is directed towards one end of the net. The reasons for this difference in procedure is due to the nature of the two fishing techniques. The dissimilarity is summarized in Diagrams 3-3 and 3-4. The two-dory system is depicted in Diagram 3-3. In this method, one-half of the net is located in each of the two dories. In shooting the net, each dory proceeds in a semi-circle until they meet. Once the rendezvous has been completed, the dories then commence the net drying-up procedure by hand, herding the catch up and towards the centre of the net. The main vessel comes up to the side of the net and starts the brailing

DIAGRAM 3-1

THE TWO-DORY PURSE SEINE NET

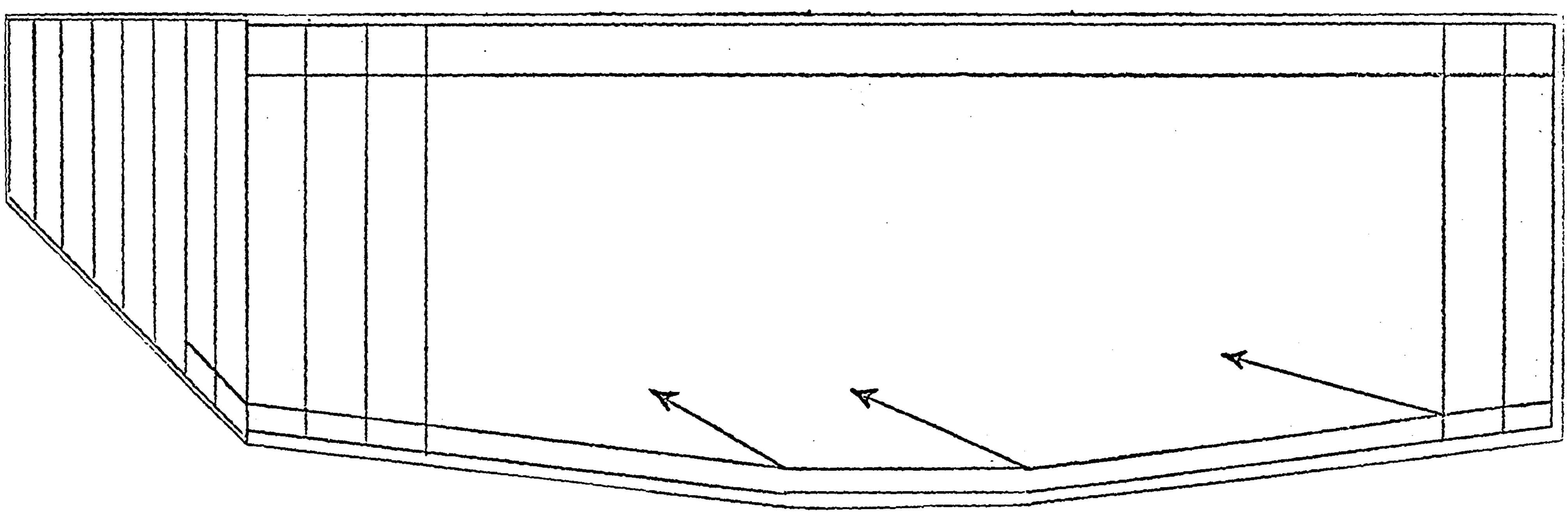


→ = Direction of net mesh density increase.

After: Brobak, 1966, p.35.

DIAGRAM 3-2

THE RINGNET

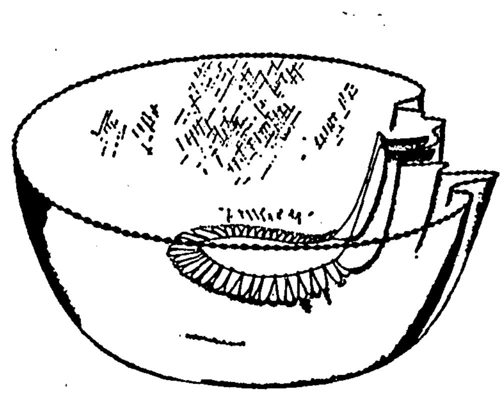


= Direction of net mesh density increase

After: Brobak, 1966, p.37.

DIAGRAM 3-3

THE TWO-DORY PURSE SEINING PROCEDURE

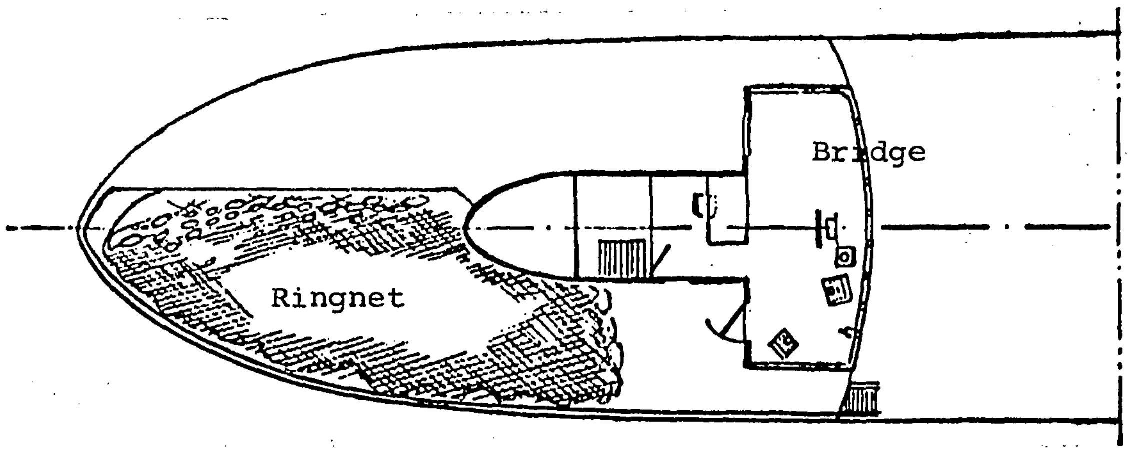


Source: Gerhardsen, 1964, p.84.

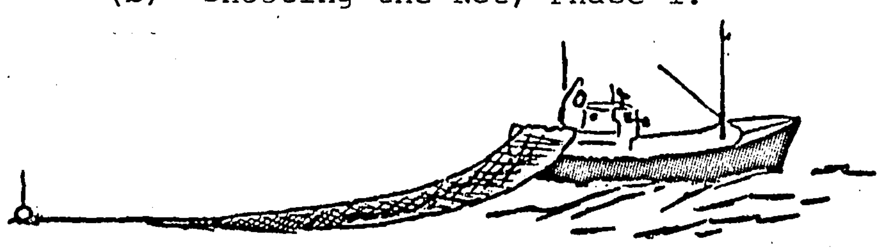
DIAGRAM 3-4

THE RINGNETTING PROCEDURE

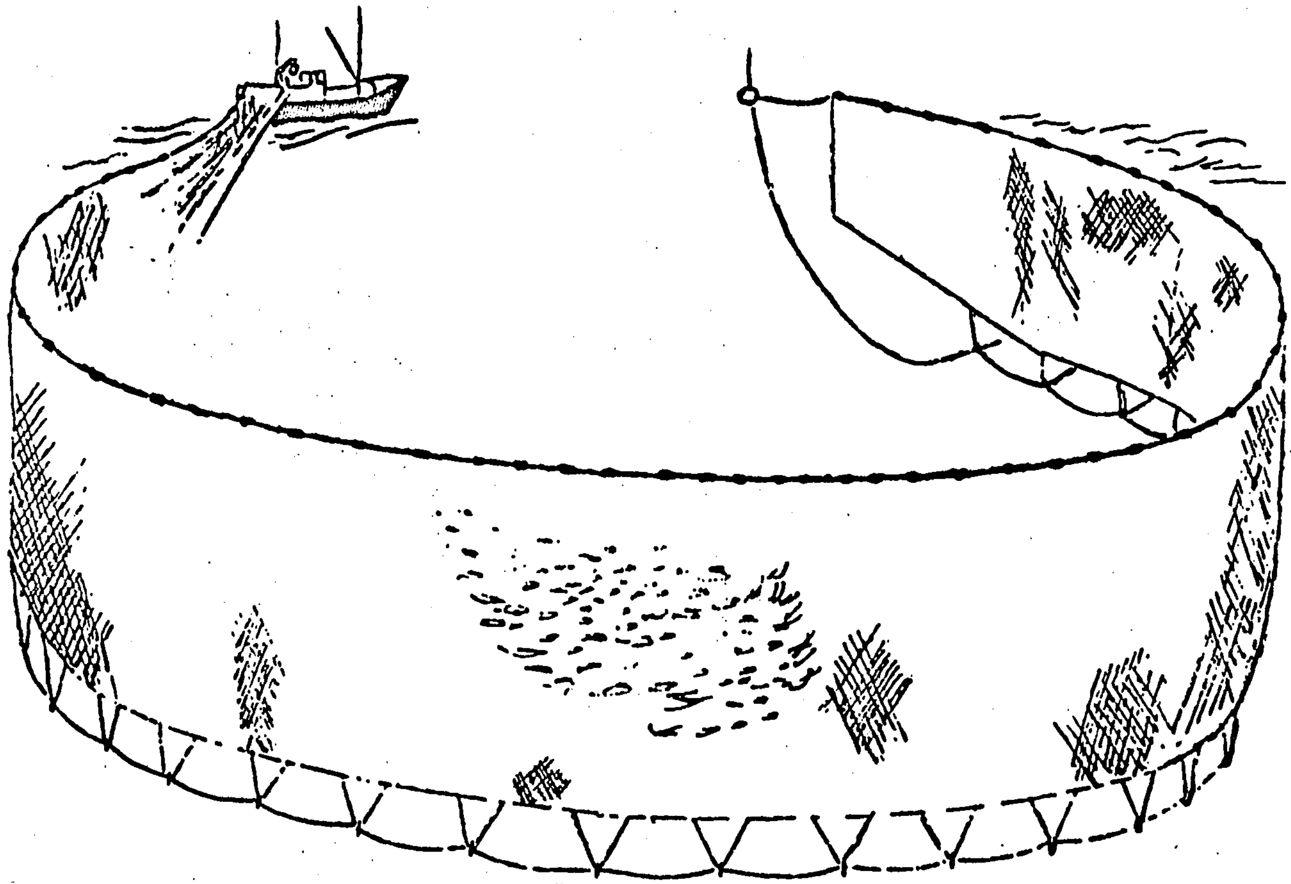
(a) The Aft Portion of the Fishing Vessel.



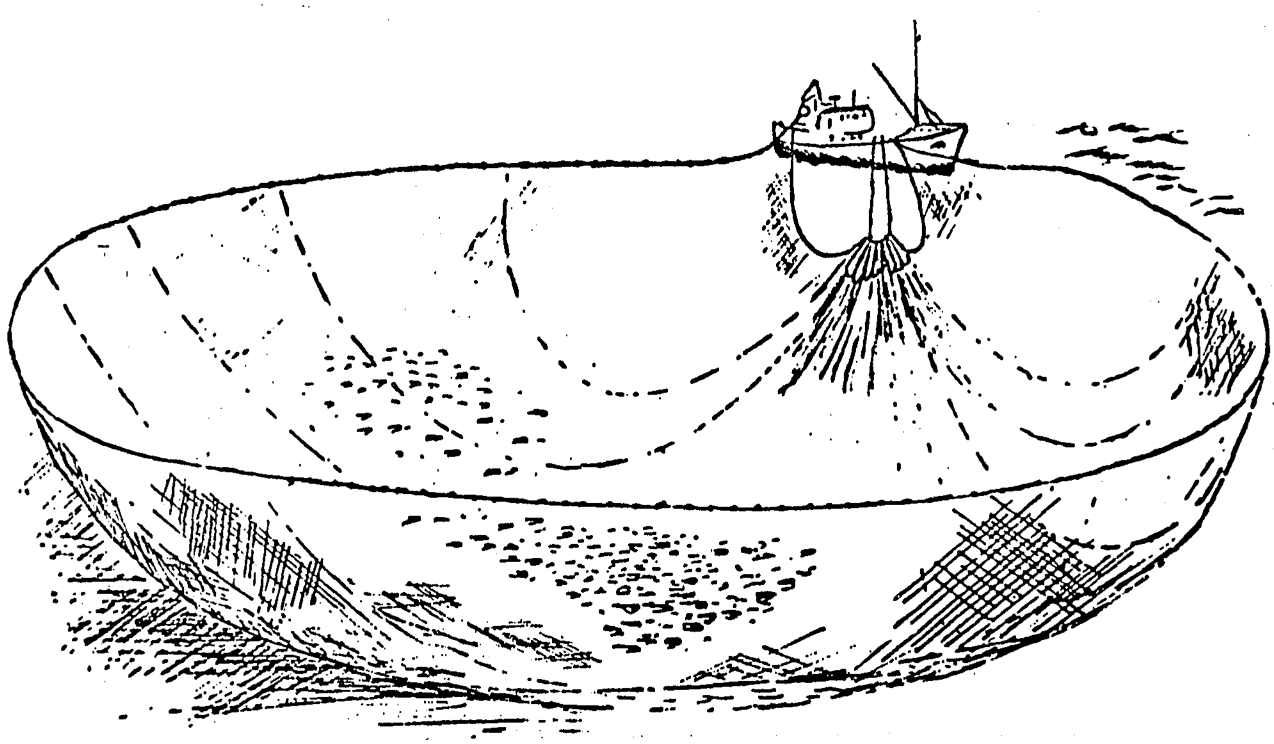
(b) Shooting the Net, Phase 1.



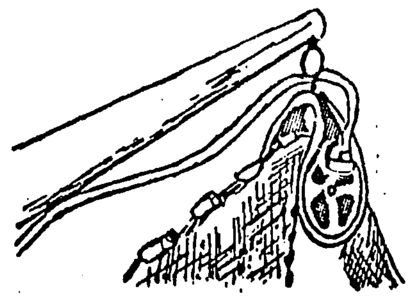
(c) Shooting the Net, Phase 2.



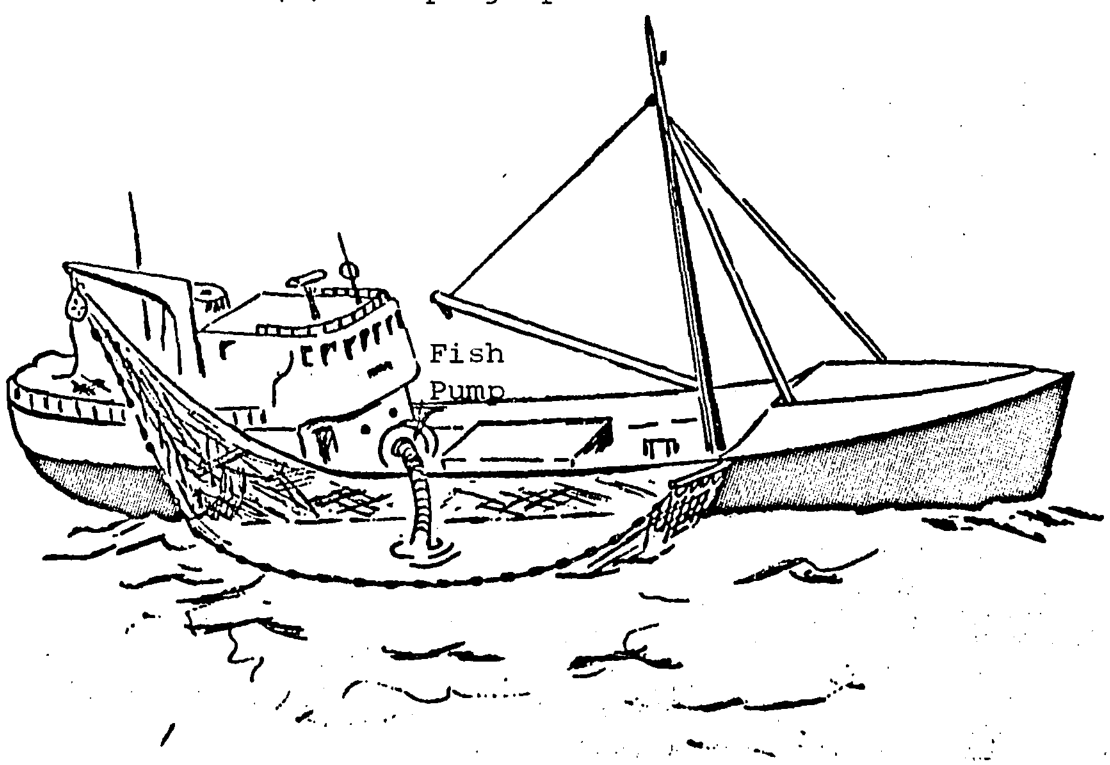
(d) Pursing the Net.



(e) Powerblock in Operation.



(f) Pumping Operation.



operation* when the catch is sufficiently concentrated. In the ringnet method, illustrated in Diagram 3-4, it will be noticed that concentration occurs at one end of the net as the main vessel in this technique sets and dries up the net.

3.6. STATISTICAL SOURCES

Five manufacturers produce variations of the innovation and each was visited. These companies are ranked below in order of sales made for the duration of the study period:

1. Rapp Fabrikker, Bodø.
2. P. Bjørshol Mek. Verksted, Langøy near Kristiansund North.
3. Aukra Bruk A/S, Aukra.
4. Hov Hydraulisk Industri A/S, Eide, Nordmøre.
5. A/S Hydema & Co. Oslo.

3.7. STATISTICAL DATA

In collecting the data, one assumption was made for practical considerations. This was that the invoice date was taken as identical to the installation date. A summary

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* This was the sole method employed to load the catch prior to the use of the more recently adopted fish pump.

of the available data according to fivefold classification is presented in Table 3-1. This Table shows the distribution by county of the number of innovation units sold in a cumulative total for the period 1960-67.

TABLE 3-1

SPATIAL PATTERN OF THE INNOVATION UNITS SOLD: 1967*

County	Boats with Date	County Date	County No Date	Unspecified Date	Unspecified No Date	Total
Finnmark	8	27	-	-	-	35
Troms	66	14	-	-	-	80
Nordland	78	39	-	-	-	117
Nord-Trøndelag	6	1	-	-	-	7
Sør-Trøndelag	33	3	-	-	-	36
Møre og Romsdal	118	46	-	-	-	164
Sogn og Fjordane	17	3	-	-	-	20
Bergen-Hordaland	103	13	-	-	-	116
Rogaland	35	5	-	-	-	40
Vest-Agder	4	3	-	-	-	7
Remaining Counties	-	2	-	-	-	2
Unspecified	-	-	-	11	-	11
	468	156		11		635

* Source: Aukra Bruk A/S, P. Bjørshol Mek. Verksted, Hov Hydraulisk Industri, A/S Hydema & Co., Rapp Fabrikker.

This preliminary data presentation shows that only ten counties have had a role in the development and that the three most important ones are:

1. Møre og Romsdal.
2. Bergen-Hordaland.
3. Nordland.

The first thing to note is that of the 635 units sold, only 468 could be allocated to a boat with a date. This is approximately 74 per cent of known sales for the time period. It is worthwhile to observe that the total number allocated is in excess of the number of boats participating in either of the two fisheries in any one year. This discrepancy can be explained in that some boats have had several units during the study period. Another reason is that there has been a turnover of participating fishing vessels; and, therefore, more boats than actually listed in any one year have been connected with the two fisheries for the duration of the study period.

Table 3-2 shows the spatial spread of the innovation. This Table breaks the sales information down on a semi-annual basis by county. There appears to be a discrepancy of 89 units between Table 3-1 and Table 3-2. The reason for this is the

TABLE 3-2

SPATIAL-TEMPORAL PATTERN OF THE INNOVATION SALES
BY COUNTY FOR HALF-YEAR PERIODS

Year	1960		1961		1962		1963		1964		1965		1966		1967	
County	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.	1st.	2nd.
Finnmark		-	-	-	-	-	2	1	1	-	-	3	6	2	8	3
Troms		-	1	-	-	-	5	3	9	9	10	7	8	6	11	3
Nordland		-	-	-	1	4	8	8	8	8	13	5	6	8	1	4
Nord-Trøndelag		-	-	-	-	-	-	1	1	1	1	-	1	1	-	-
Sør-Trøndelag		-	-	-	-	2	1	2	3	6	5	1	4	3	4	2
Møre og Romsdal		-	-	-	-	-	3	1	7	18	25	29	21	22	13	3
Sogn og Fjordane		-	-	-	-	-	-	-	1	1	4	7	6	-	1	2
Bergen-Hordaland		1	2	2	-	3	2	3	4	21	16	14	16	13	12	6
Rogaland		-	-	1	-	-	2	-	-	1	7	6	7	8	4	2
Vest Agder		-	-	-	-	-	-	-	-	1	-	1	-	1	2	-
Remaining Counties		-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
Total		1	3	3	1	9	23	19	34	66	81	73	75	64	58	25
Cumulative Total:		1	4	7	8	17	40	59	93	159	240	313	388	452	510	535

Source: Aukra Bruk A/S, P. Bjørshol Mek. Verksted, Hov Hydraulisk Industri, A/S Hydema & Co., Rapp Fabrikker.

elimination of those powerblocks produced by one manufacturer, having a minimum radius of less than 28 inches. This corresponds to the minimum size used in the pelagic fisheries. These smaller units are normally used with the purse seine technique when it is employed in the inshore fisheries.

3.8. COST

The powerblock ranges in price from 45-55,000 kroner * (Gerhardsen, 1966), while the net seine winch costs from 90,000-135,000 kroner. The latter figure is total cost with installation.

3.9. SUMMARY

This Chapter has presented a survey of the attributes of the innovation which are necessary in understanding the present conditions of the fisheries to be examined.

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* To obtain the comparable price in U.S. dollars, divide by a factor of 7.

CHAPTER FOUR

ELECTRONIC EQUIPMENT

CHAPTER FOUR

ELECTRONIC EQUIPMENT

4.1. INTRODUCTION

This Chapter, which delineates the electronic equipment employed in fishing, is included in order to facilitate an understanding of the current conditions in the fisheries under examination. To achieve this purpose, the Chapter is divided as follows:

4.2. SEARCH EQUIPMENT

4.3. COMMUNICATION EQUIPMENT

4.4. NAVIGATION EQUIPMENT

The reason for its inclusion is that the innovation has not been the sole varying parameter for the duration of the study period; but, it is only one of a number of changed components of which it is almost impossible to isolate the separate effects. It is, therefore, fundamental to be aware of these electronic devices.

The period covered by this Chapter includes a time span previous to the study period to establish the concept of acceptance thresholds.

The data are from the Winter Herring Fishery as it is the sole seasonal fishery for which equipment data are documented. Fishing vessels are grouped according to the fishing technique employed. Three categories of fishing techniques were chosen to exemplify the adoption rates of the electronic equipment for the study period. The reason for their selection was that they dominated total catch. These methods are: 1) Purse Seine; 2) Drift Net; 3) Trawl. The purse seine category has been further subdivided into two groups: 1) Two-Dory System and 2) Ring-netting. These fishing techniques are explained in Chapter Six.

4.2. SEARCH EQUIPMENT

4.2.1. Echo Sounder

4.2.1.1. History

The first echo sounder was installed in 1930-31 in the Stavanger area and was used for sprat fishing. The second was installed in the vicinity of Bergen and was employed for sprat fishing as well as herring fishing (Evensen, 1968).

The usefulness of the echo sounder as a search tool was quickly recognized (Fiskets Gang, 1936a). At the same time, additional recognition of its importance was given by the Norwegian Government in that it eliminated a tariff which had previously been imposed on the importation of echo sounders (Fiskets Gang, 1936b).

The adoption rate of this unit was slow, despite the government action, until after World War II. By 1947, echo sounders were becoming fairly common and experience was showing that they could be of considerable use (Fiskets Gang, 1947).

4.2.1.2. Operating Principles

An echo sounder has been defined as "an electronic instrument designed to measure the vertical distance from the surface of the water to the sea bottom and, in the case of the fishing industry, to indicate also the presence and location of any object between these extremities." (OECD, 1967, p.3.)

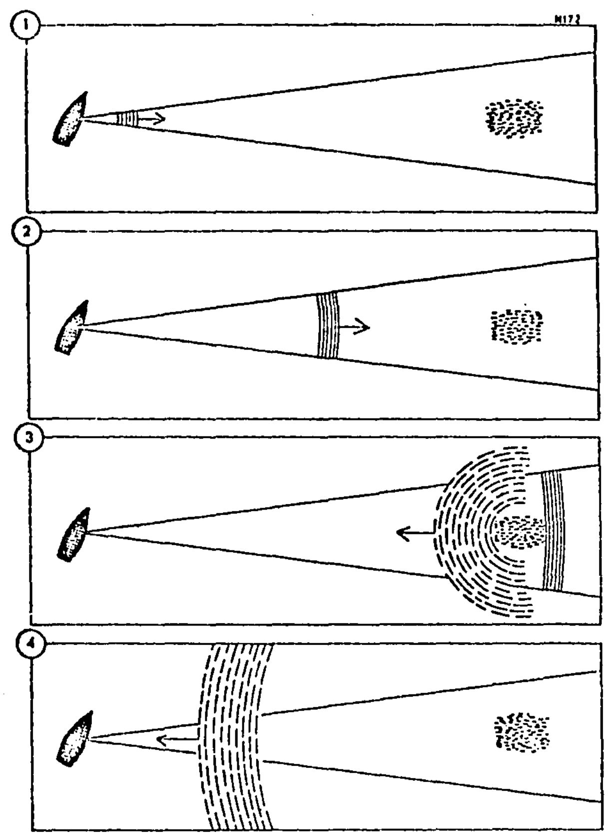
The fundamental principle on which an echo sounder operates is the rate variability of sound wave transmission through different media and the effect this has on the sound waves. The echo sounder sends out waves in a vertical position from a transducer, pulse initiator, located in a fixed position on the bottom of the vessel towards the ocean floor. The unit registers the time of a wave's departure from the transducer until the return of its echo. The time difference is then converted into a depth variation on a continuous recording graph. If there is anything of sufficient density variation from the water between the vessel's hull and the sea floor, a reflection will also be obtained from it. This will be recorded and its depth registered in a similar manner, as previously mentioned.

Diagram 4-1 schematically illustrates the fundamental operating principles. This shows the method by which sound waves are used to locate fish. It will be noted that this diagram is a representation of a horizontal, not a vertical, cross-section; and thus shows the sonar operation and not the echo sounder. The principle is identical for both; and a sonar unit, when operated in the vertical position, is an echo sounder.

There are a variety of recording methods for the data obtained by this unit. The most common is a damp iodine paper with a moving stylus. (For additional information on this and other technical aspects, see OECD, 1967.)

DIAGRAM 4-1

OPERATING PRINCIPLES OF
LOCATION BY SOUND IN WATER



Source: Simonsen Radio, 1965, p.81.

4.2.1.3. Arrangement

The transducer of the echo sounder is fixed to the bottom of the fishing vessel's hull. This is connected to a recording device which is found on the bridge. The characteristics of an echo sounder beam are presented in Diagram 4-2.

4.2.1.4. Present Status

After 1950 few purse seiners were built without echo sounders (Knutzen, 1968). It is now common to find more than one such unit on board a fishing vessel. The reason for this is that new models with improved capabilities are continuously being developed and adopted. The old one is not removed for three reasons: 1) the manufacturers do not accept trade-ins; 2) the cost of removal is expensive; 3) it has been found advantageous to have two units on board. A second echo sounder avoids costly returns to port in case of failure of the first one.

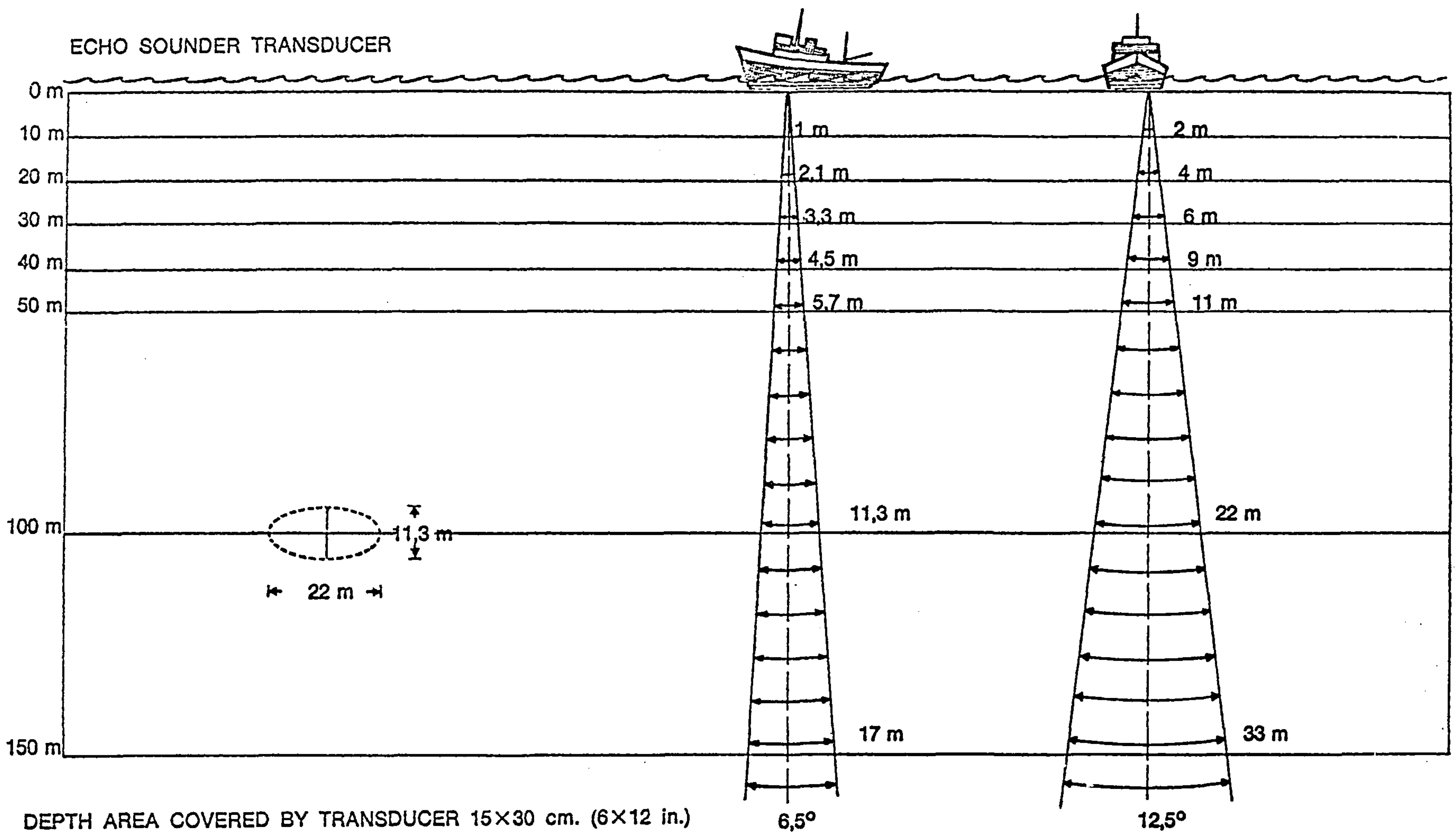
4.2.2. Sonar

4.2.2.1. History

Sonar is an abbreviation for "sound navigation and ranging". Early developments were initiated prior to World War II; however, it was during the war, because of its

DIAGRAM 4-2

CHARACTERISTICS OF AN ECHO SOUNDER BEAM



Source: Simrad, 1968.

effectiveness in locating submarines, that significant headway in development was made.

Research with a view to application of sonar to fishing started in 1947 with a Norwegian Government research vessel (Simonsen Radio A/S, 1966). Commercial work followed in the early 1950's, but it was not until 1959 that it was commonly recognized as a necessary and highly beneficial piece of equipment for fishing (Knutzen, 1968).

4.2.2.2. Characteristics of the Device

The principle of operation is identical to that of the echo sounder, which has been discussed. The differentiating element is that the sonar unit has a mobile transducer in lieu of the fixed one of the echo sounder. The transducer is mounted on an arm that is raised or lowered according to the need. When not in use, it is raised into the hull unit to protect it from physical abrasion. This is particularly important when docking in a port where it is so shallow that the vessel, when fully loaded, scrapes bottom. The main control unit is located on the bridge.

4.2.2.3. Technical Specifications

Since its introduction, various changes have been made in the construction and the capabilities of the sonar unit. The most important changes that have occurred are: 1) the range of possible sounding has increased; 2) the tilt angle of the transducer has been increased; and, 3) automatic search programs have been developed. The increase in range of sounding has been from 1200 metres to 3500-4000 metres from the bow of the fishing vessel. The transducer can now be tilted through 90^{o} whereas previously it was 45^{o} or less. Rotation is possible through 360^{o}. The two aforementioned changes as well as the optional beam width are shown in Diagram 4-3. The automatic search programs have also been important.

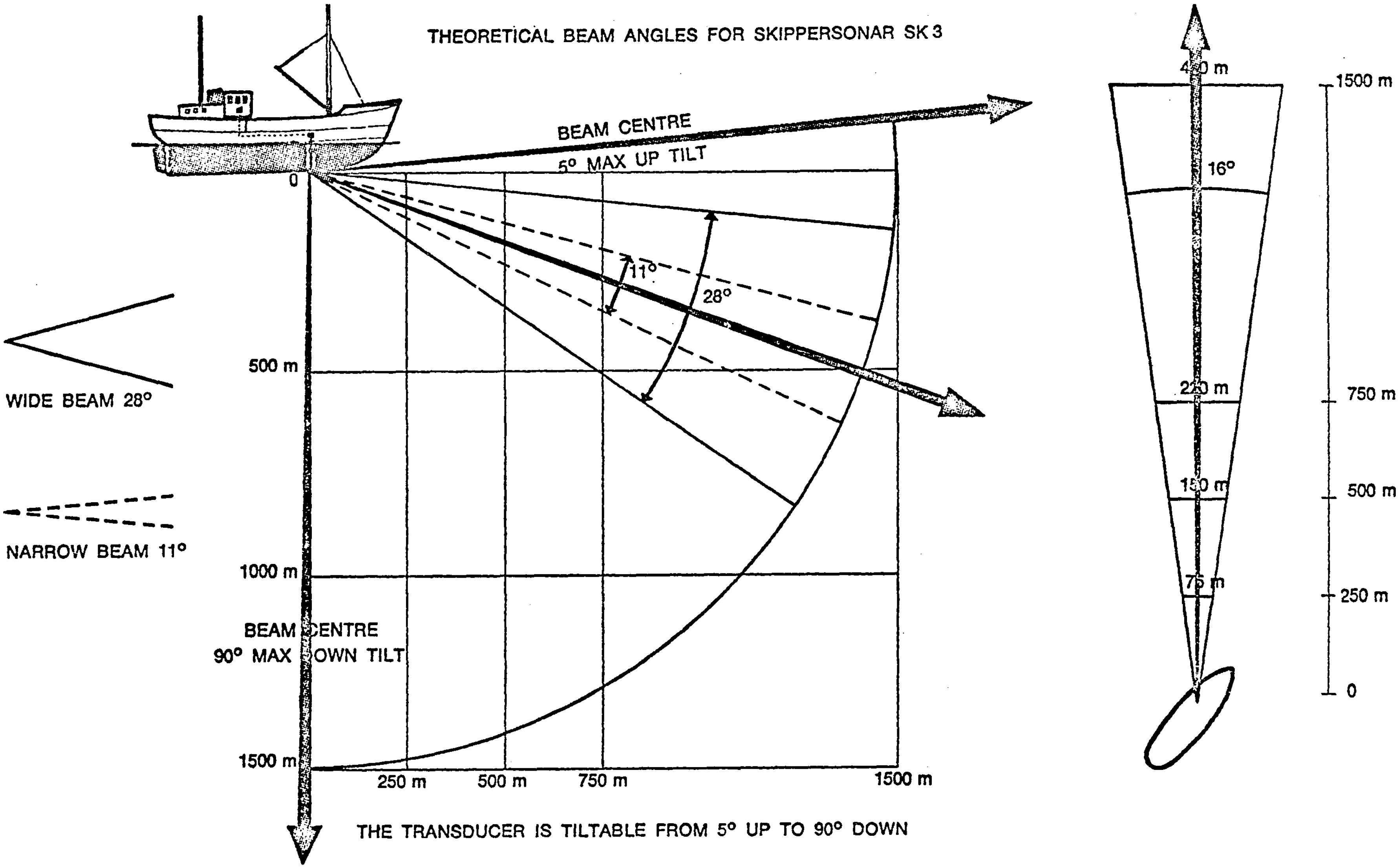
4.2.2.4. Operation

There are normally three types of search programs in the automatic sonar units. Program one is usually side-to-bow. In this the transducer starts from 80-90^{o} off the bow and increments in steps of a specified number of degrees towards the bow. Once it reaches the bow, it swings to the opposite side and repeats the procedure. This program is normally employed in the general search routine at the maximum sounding range of the unit.

Program two operates the transducer in a constant side-to-side sweep. This is used normally for only a

DIAGRAM 4-3

OPERATING CHARACTERISTICS OF A SONAR UNIT



Source: Simrad, 1968.

limited number of degrees of the compass and it is employed mostly in close contact search when homing on a possible catch. When this option is used the sounding range is reduced as the boat approaches the shoal and this provides a more detailed view of possible catch.

The third program is a manual contract option which enables the operator to search out a target if it was passed when program one was in use. This, therefore, provides the possibility of relocating the shoal and then deploying program two. The latter is normally employed until the bossboat* is on the water. At that point, the main fishing vessel's unit is shut off so as not to interfere with the sonar on board the small search vessel.

4.2.2.5. Installation

The main sonar unit is installed in a housing in the hull bottom. It is raised and lowered by a chain drive mechanism. The position of installation can be seen in

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* This is an open boat of approximately 25 feet equipped with a sonar unit and operated by two men: the boss and his apprentice. The boss is the man in charge of directing the casting procedure. This boat is normally lowered to the water to make a final assessment of catch possibilities prior to casting.

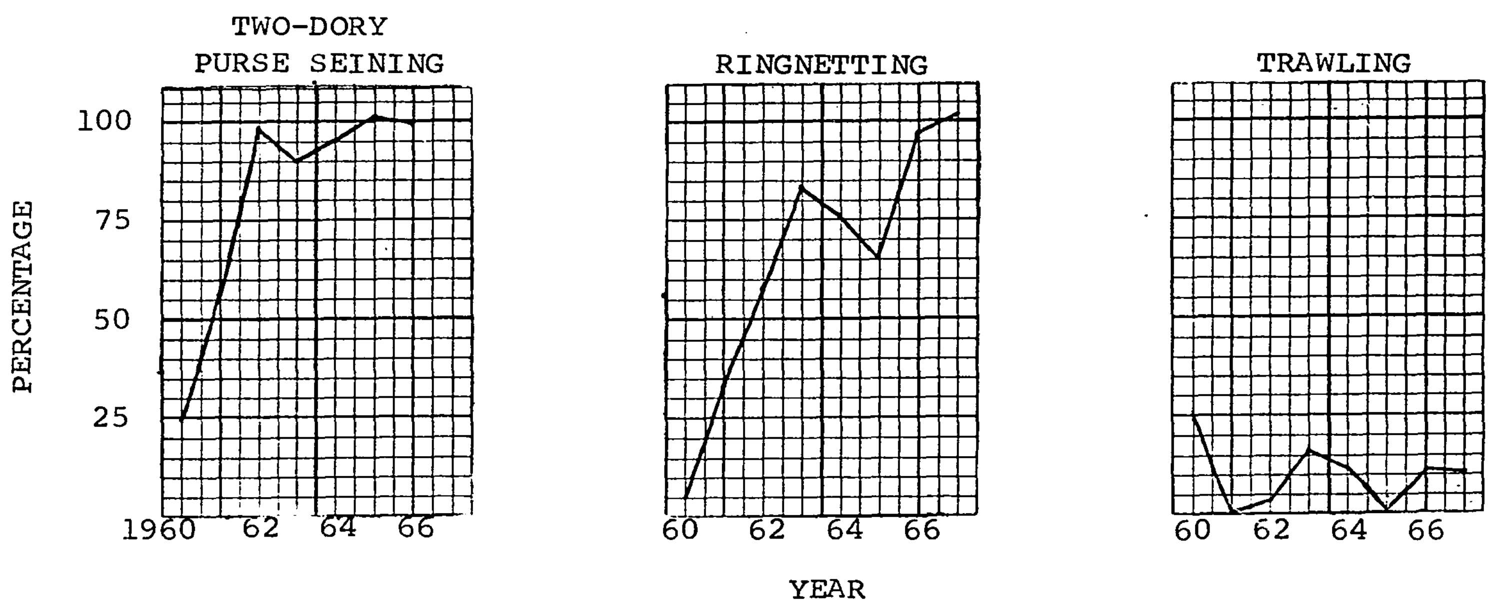
Diagram 4-3. The installation of the sonar unit in the bossboat is similar but,there, the device is operated manually.

4.2.2.6. Present Status

Figure 4-1 shows the adoption rates of sonar units from the beginning of the study period. In these data, it is not possible to differentiate the main vessel unit from that of the bossboat. Drift netting was not included in this figure as it was insignificant. The most marked increase occurs in the purse seine group. The two-dory purse seine category appears to exhibit the strongest growth pattern. The percentage increase, however, is due more to a reduction in absolute numbers of vessels in this group than to a marked adoption pattern. The reason for the increase, then, is that the better equipped vessels would tend to remain longer in an endeavour than the poorly adapted units. By 1967, this group had no further members. The strength of this decline and other patterns is discussed in Chapter Seven. The ringnetting group is the only one which shows an absolute as well as relative growth rate. The trawling category has fluctuated between 0-25 per cent and this represents the situation well, in that this fishing

FIGURE 4-1

ADOPTION RATES OF SONAR UNITS
IN THE MAJOR FISHING CATEGORIES



Source: Vintersildfisket, 1960-67.

technique has yet to make wide use of sonar units.

By 1967, the ringnetting technique had an excess of one unit per vessel. The reasons for this are comparable to those previously delineated for the echo sounder.

One further point must be pursued. This is that the growth of sonar acceptance has paralleled that of the innovation, i.e. the powerblock and net seine winch, but it has proceeded at a slower rate. It is because of this differential in acceptance rates that I believe that the innovation is the more important of the two. What appears to have happened is a push-pull effect, in that the innovation came first and increased catch possibilities, whilst search ability lagged initially but was then followed by an upsurge in the sale of sonar units with increased search capacities. The analogy might be made that the innovation and the sonar unit are like two separate balls on the crest of a slope linked by string. The innovation rolled off first and consequently was closely followed by the sonar unit.

4.2.3. Biological Link Between Herring and Current Search Equipment

In Chapter Two, dealing with the nature of the biological resource, particular attention was drawn to one aspect of herring. This was that it possessed an air bladder. This point is raised here because it is the presence of the air bladder that facilitates its harvesting. The reason is that it provides a very good media distinction for sound wave reflection. This, then, benefits the locational and estimation problems involved in assessing the practicality of casting.

The relevance of this is more easily seen when it is noted that mackerel, which are also fished by the ringnet technique, do not possess an air bladder. A problem arises here in that what may be believed to be a small school of herring may in fact be a large mackerel school. The reason for the confusion is that mackerel do not provide as strong a media distinction as herring for the purpose of the sound wave locating technique. The consequence of this possible incorrect identification is that the catch may be so large that the net may break under the additional weight strain with the concomitant result of increasing operating costs. Some fishermen now maintain that it is possible to differentiate the two by practice from the observation of the behavioural pattern of mackerel on the sonar unit.

The weight strain problem is of particular importance due to the growth in the size of fish catches made possible by the increased net dimensions which have taken place since the adoption of the innovation. This problem, which requires more rapid loading of the catch, has been solved largely by the adoption of the fish pump. A discussion of net dimension alterations, fish pumps and other changes which have occurred due to the innovation are dealt with in Chapter Five.

4.3. COMMUNICATION EQUIPMENT

4.3.1. Radio Telephone

4.3.1.1. History

Radio telephones were first introduced into the herring fleet in 1945. It took until the period 1950-52 before it became evident that it was a very useful piece of equipment.

4.3.1.2. Purpose

Radio telephones were adopted as the necessity for improved inter- and intra-fleet communications were realized.

The initial difficulty of internal linkages required a solution as it had a fundamental role to play in the harvesting procedure. The specific difficulty was that on occasion a fishing vessel's catch might exceed its loading capacity. It would then have to call a helper*. The communication imperspicuity between the fleet and the land-based production sector of the fishery had to be bridged. The reason for this was due to the nature of the fish marketing procedure in Norway. All herring are centrally marketed through several firsthand sales organizations who control prices and which have different geographical limits. The difficulty becomes more lucid when one remembers the strong seasonal characteristics of herring and their spatial-temporal pattern of landings. The procurement does not present excessive difficulties for the fleet, as it is sufficiently mobile; but, as production capacities have a fixed location, an allocation problem exists under present conditions.

One further use of radio, which may not have been realized initially, is for the purpose of monitoring other

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* Helpers are vessels which participate only indirectly in the fishing procedure in that they may be called upon by a fishing vessel to load catch which it cannot carry as it is sufficiently loaded; or to prevent the main vessel from drifting into its own net and becoming entangled.

conversations. By so doing, it is possible to ascertain a good deal of information on the rest of the fleet with regard to the success or the failure of others. This aids in the decision-making process of whether or not to try another particular area.

4.3.1.3. Trends

Short wave radios gradually replaced the earlier models as increased dependability was required. The replacement trend has now shifted to a substitution of the short wave monad with the single-side-band unit. The reason for this is that the latter takes up less air space in transmitting and is more effective. This is important with the current competition for air space for radio communication. The matter has been regarded as sufficiently relevant that the Norwegian Government will not permit installation of any other radio type after January 1, 1973 and by 1981 all units must be of the single-side-band variety (Knutzen, 1968).

Another trend has been the shift from a simplex to duplex transmitting system. The former uses one frequency for receiving and transmitting while the latter receives and transmits on different frequencies (OECD, 1967,p.12)

The reason for the shift is to improve convenience and ease of communication.

4.3.1.4. Present Status

The data on radio telephones are rather confusing but it can be noted that one unit is always found on each boat and quite often two. The confusion is due to a separation of receiver and transmitter units instead of just counting the number of simplex and duplex units in use as separate entities.

4.3.2. Walkie-Talkie

4.3.2.1. History

This is probably the latest piece of new equipment which has been added to the accoutrement of electronic gear employed today. It was first introduced in 1962 (Knutzen, 1968). No data exist on the numbers currently in use but they appear to be common.

4.3.2.2. Description

This is a hand-operated unit, one part of which is located in the bossboat and the other located on the bridge. It operates on the citizens' band frequency with a range of approximately two miles.

4.3.2.3. Purpose

This unit is used to improve communication between the bossboat and the main fishing vessel at time of catch. This communication is vital for it is the bossboat that directs the catch procedure and for this reason it has been adopted as it improves the link between the main fishing vessel and itself. Communication had previously been by hand signal.

4.4. NAVIGATION EQUIPMENT

4.4.1. Automatic Direction Finder

4.4.1.1. Nature of the Device

The automatic direction finder (ADF) is composed of "a radio receiver with /a/ rotating frame aerial" (OECD, 1967, p.9). By rotation of this frame, it is possible to obtain the direction of maximum signal strength of a particular frequency and simultaneously derive a compass bearing.

4.4.1.2. Purpose

The ADF unit has two functions: the first is to aid in straight navigational problems; the second, and now perhaps more important, is to obtain bearings on other radio telephone conversations which are always monitored, as previously mentioned. The purpose of the direction monitoring of particular conversations is that in the event that a boat calls a helper or reports to the sales organization that he is returning to discharge his catch, it is possible to get a radio fix on him and thus take advantage of the information concerning catch possibilities. The range is about 50 nautical miles.

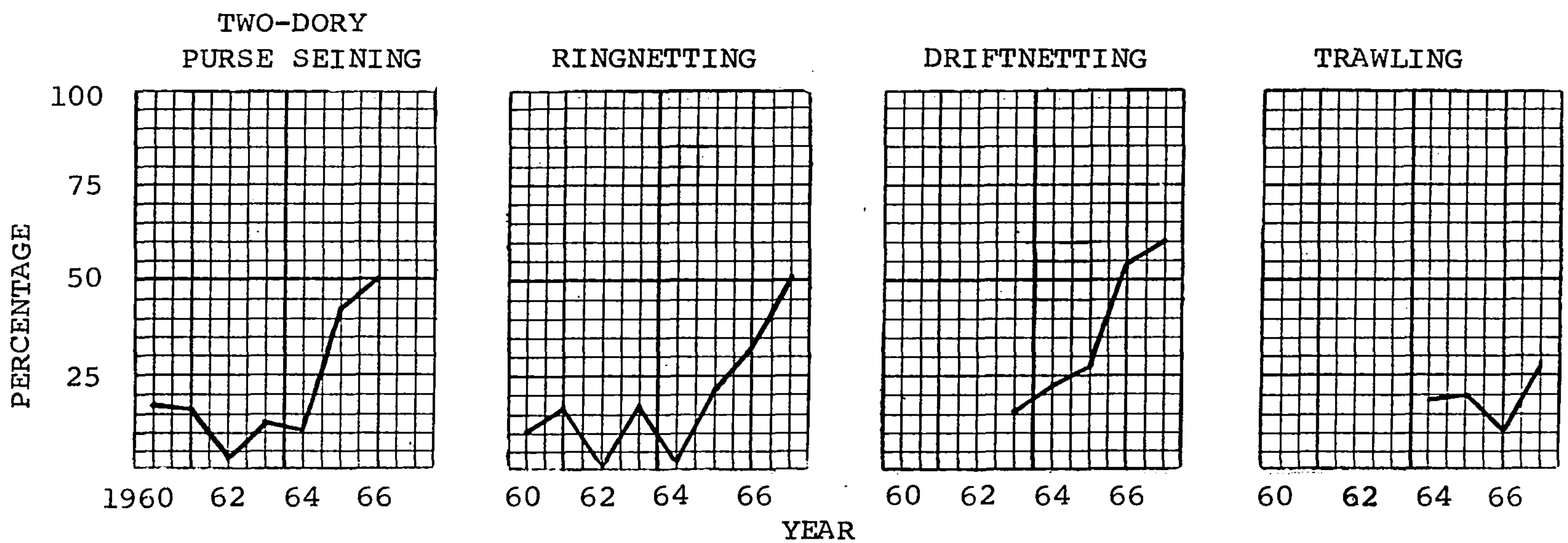
This mode of information acquisition is particularly important to the herring fishery as this fish species is usually found in scattered concentrations and seldom mixed with a sizable number of other fish.

4.4.1.3. Present Status

Figure 4-2 shows the growth rate of adoption of ADF units. The important element is that the acceptance of this unit has been the slowest of all the electronic equipment for which data are available. At present, it is installed on slightly more than 50 per cent of the fishing vessels. The reason for the slow rate of acceptance is not clear. In interpreting these graphs, one must take care not to over-emphasize a particular category to that of any other in that the percentages do not indicate the sample size from which they were obtained. In this respect then one must exercise the caution that was exhibited for the sonar

FIGURE 4-2

ADOPTION RATES OF ADF UNITS
IN THE MAJOR FISHING CATEGORIES



Source: Vintersildfisket, 1960-67

data interpretation.

4.4.2. Radar

Radar is an abbreviation for "radio direction and range". It was developed during World War II and has made inroads into the fishing industry.

4.4.2.1. Nature of the Device

The operating principle of the device is the reflection of short, strong pulses which are transmitted and received by a rotating antenna. The reflected pulses are presented on a cathode ray tube in a Plan Presentation Indication (PPI). This shows everything in relation to the boat which is at the centre of the screen.

4.4.2.2. Purpose

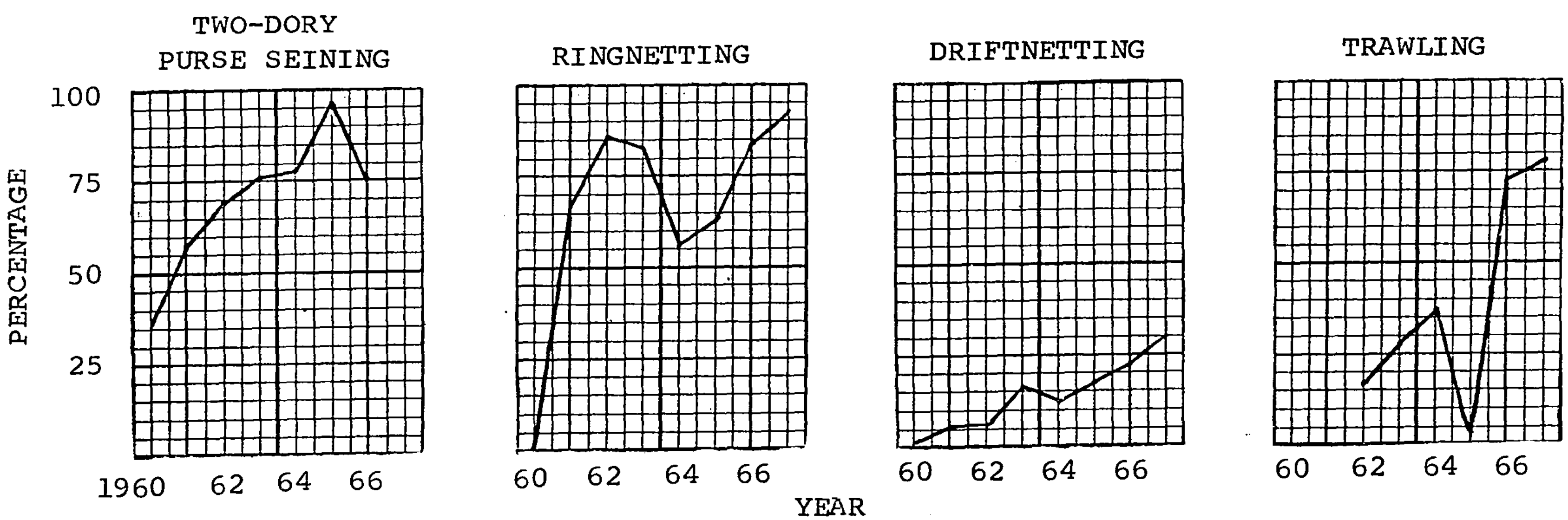
The implementation of radar has been due to a general concern for improved navigation and safety. This may be the reason for its strong acceptance recently by the herring fishermen for, on occasion, space at sea while fishing is often at a premium if good catches are being made.

4.4.2.3. Present Status

In Figure 4-3 the same caution as previously exercised must be taken. The ringnet group here, as in

FIGURE 4-3

ADOPTION RATES OF RADAR UNITS
IN THE MAJOR FISHING CATEGORIES



Source: Vintersildfisket, 1960-1967.

the previous data, actually exhibits the most significant growth pattern.

4.4.3. Decca Navigator

This is a position-fixing system which utilizes "unmodulated continuous wave low frequency signals /that/ are transmitted from land-based Decca stations and lines of position are determined by phase measurement between emissions" (OECD, 1967, p.9).

This unit has been of considerable use in the North Sea area as it is surrounded by Decca chains and has, thereby, facilitated location problems for fishing vessels operating there. The significance of this is that it has increased the environmental tolerance of the fishing vessels and thereby expanded possible fishing time. The importance of the Decca Navigator will increase in the future with the opening of the Norwegian transmitting chain in the spring of 1968. This, coupled with the proposed expansion to establish an Icelandic link, will be important to the fishermen who operate in the area of the Northeast Atlantic Ocean (Johansen, 1968).

4.4.3.1. Present Status

It was not possible to obtain detailed data on this unit. The reason being that up to 1966 all sales were managed from London and serviced in Norway while in that year a Norwegian firm took over the production on a contractual agreement and now performs both functions.

To date, 351 fishing vessels have installed Decca units from the Norwegian firm but it is not known in which particular fishery they participate.

4.5. THE CONCEPT OF ACCEPTANCE THRESHOLDS

I define "acceptance thresholds" as that period of time between the initial innovation and its general usage in the industry. Interestingly, for a series of innovations through time, this acceptance threshold period tends to decrease, probably due to the psychological factors such as the progressive conditioning to change.

4.6. COST

Prior to closing this Chapter, it is felt that a list of prices for some of the various types of equipment that were mentioned here should be presented. This is done in Table 4-1.

TABLE 4-1

COST OF ELECTRONIC EQUIPMENT

Echo Sounders	1,365 - 107,000 kr.*
Sonar	9,850 - 250,000 kr.
Radar	15,570 - 67,100 kr.
Radio Telephones	1,450 - 77,800 kr.
Decca Navigator	7,685 - 9,050 kr.

Source: OECD, 1967, p.14; Simrad, 1967.

4.7. SUMMARY

This Chapter has provided a review of the electronic equipment of prime importance to the Herring Fishery and ancillary electronic devices of a more general nature but also utilized in the fishing process of the North Sea and Winter Herring Fisheries.

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* To obtain the comparable price in U.S. dollars divide by a factor of 7.

CHAPTER FIVE

EQUIPMENT CHANGES SUBSEQUENT TO THE INNOVATION ADOPTION

CHAPTER FIVE

EQUIPMENT CHANGES SUBSEQUENT TO THE INNOVATION ADOPTION

5.1. INTRODUCTION

The spatial attributes of changes in the two fisheries under examination are presented in Chapter Seven. It has previously been indicated (in Chapter Four, which was concerned with electronic equipment) that there have been concurrent changes in other equipment exclusive of the powerblock and net seine winch. There is no doubt that a link exists between the innovation and the electronic gear, but this link is more difficult to establish in terms of cause and effect than the connections which are drawn here between the innovation and other technical equipment that has come to be employed in the fisheries subsequent to the adoption of the innovation. This Chapter is concerned with presenting a qualitative and quantitative assessment, where possible, of these changes which have occurred since the inception of the innovation.

It will be noted that the drive mechanisms of all the mechanical gear discussed in this Chapter are hydraulic. The trawl winch is the sole one which can be obtained with high or low pressure versions of this drive mechanism. The fish pump and transverse thrusters employ the high pressure system. The high pressure hydraulic systems tend to dominate the field because they are much lighter, more compact and stronger per unit size and weight than a comparable low pressure unit of the same power rating.

5.2. THE PURSE SEINE NET

5.2.1. Construction Materials

The important change occurred prior to the study period in 1958 (Krohn-Hansen, 1968). At that time, cotton, which had been the material most commonly used in net construction, was replaced by nylon and a number of other synthetic fibres. The change had three effects: first, it meant that nets no longer had to be dried, thereby increasing possible fishing time. Second, the material was stronger. Third, the new synthetic fibres were lighter. The consequence of this was a possible increase in net dimension for a net of increased size could be made to weigh the same as the older, smaller cotton net. The added strength factor became particularly important when the innovation really came into effective use.

5.2.2. Dimensional Characteristics

As mentioned above, the dimensional characteristics changed with the development of new net-making material. The changes are summarized in Table 5-1.

TABLE 5-1

ALTERATIONS IN PURSE SEINE NETS*

Year	Material	Net Type	Dimension	
			Depth	Length
1958	Cotton	Two-Dory Net	30-40	130-150
1958	Nylon	Two-Dory Net	50-60	220-240
1963	Nylon	Ringnet	80-90	280-300

* Source: Krohn-Hansen, 1968.

The most important item in Table 5-1 is that the dimensional characteristics doubled in the period, 1958 to 1963.

5.3. THE TRAWL WINCH

5.3.1. Purpose

This piece of equipment has been adopted to replace the hand hauling operation of the two-dory system by a mechanical device. The adoption was necessary as it was the most efficient way to cope with the required increase in speed of hauling of the purse seine line that became necessary because of the adoption of the innovation. It also solved the wire placement problem that had been prevalent in the two-dory system and those vessels that still employed another type of winch to do the job. (The number of vessels believed to be using the latter method today are few.)

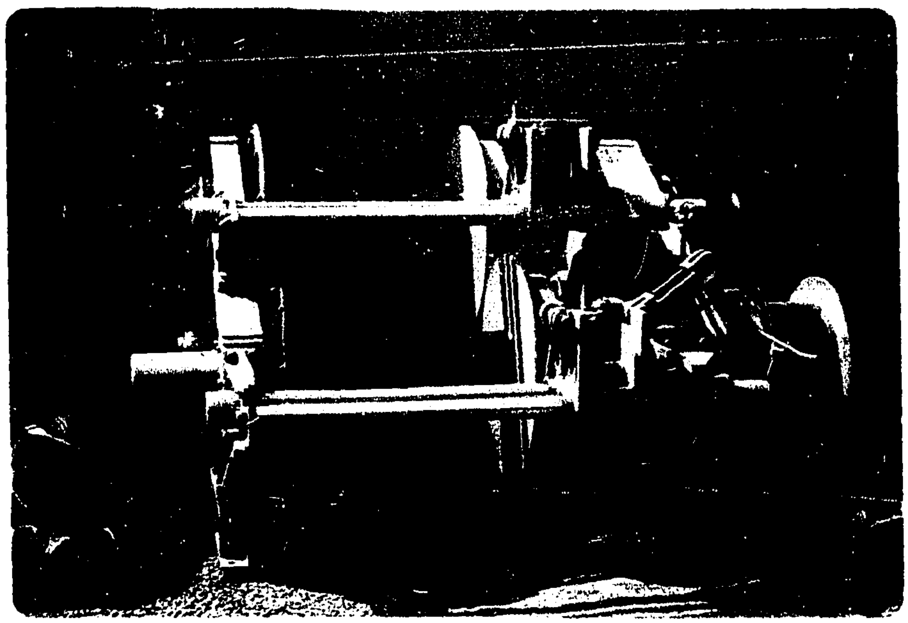
5.3.2. Types and Capacities

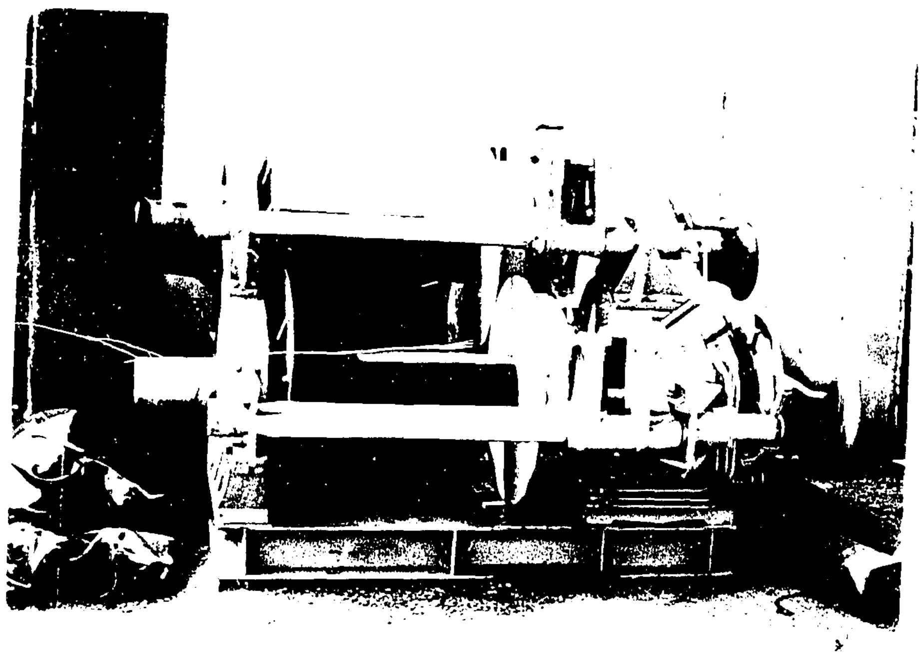
This winch has one of two structures: 1) double spool, one on top of the other as shown in Photograph 5-1; or 2) two spools side-by-side as shown in Photograph 5-2. The comparative advantages of one over the other are difficult to assess. The only possible one being that the former occupies less space than the latter.

The working capacity of the winch is a function of

PHOTOGRAPH 5-1

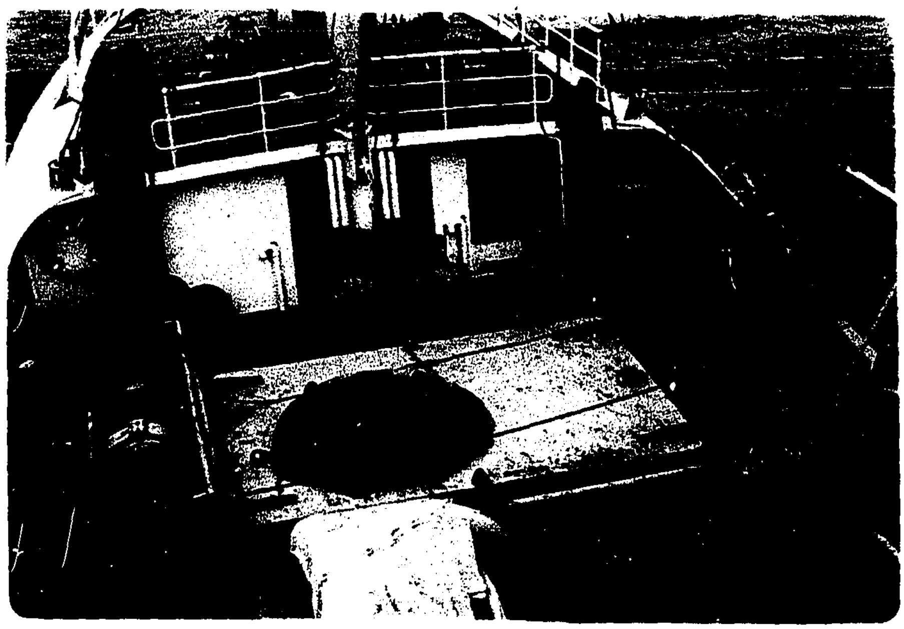
THE TRAWL WINCH: OVER-UNDER ARRANGEMENT

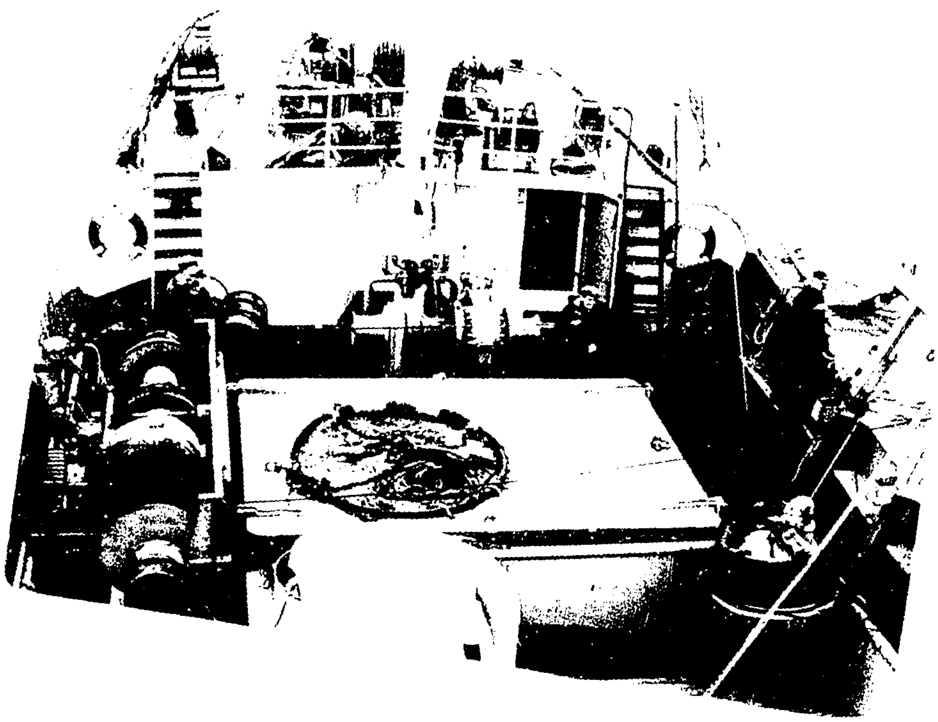




PHOTOGRAPH 5-2

THE TRAWL WINCH: SIDE-BY-SIDE ARRANGEMENT





the amount of wire on the drum. Depending on the size of the winch, the hauling capacity may be as high as 18 metric tons to as little as 1400 kilograms with rates of wire take-up ranging from 24 metres per minute to 160 metres per minute.

5.3.3. Position on Vessel

This winch is located in one of two positions: one is parallel to the edge of the port side of the vessel - this positioning is illustrated in Photograph 5-2. The second location can be in a transverse position under the deck of the fo'c'sle. Of the two positions, the former is now generally regarded as the most efficient as it affords a more direct pulley system with only one unit on the starboard side of the vessel (shown in Photograph 5-2 on the right-hand side of the vessel); while the latter positioning requires that an additional set of pulleys in the middle of the vessel be installed to direct the purse seine line cable to the winch.

5.3.4. Operation

Upon shooting the net, the purse line cable is run out off one spool. Once the net is completely out, the cable is then retrieved and hauling takes place with the use of both spools. The reason for this is that more power can be obtained from the winch if hauling is done on two spools, resulting in a smoother, quicker job. Once the rings (the metal loops through which the purse line cable runs) are up, i.e. when the net is completely pursed, they are then transferred to the supporting wire running parallel to the starboard side, and the cable is then rewound to one spool in order to be in readiness for the next casting operation.

5.4. THE FISH PUMP

5.4.1. History

The first fish pump was installed on board Lull, a vessel from Møre og Romsdal, in the summer of 1964. This was a suction pump. The pressure pump was not developed and marketed until the summer of 1966. Since the latter's inception, a total of 244 units have been sold. The spatial-temporal pattern of adoption is presented in Table 5-2. It will be noted that the total in Table 5-2 is less than that of the previously quoted figure because it was not possible to acquire installation dates for all the units sold and sales in 1968 have been eliminated.

TABLE 5-2

SPATIAL-TEMPORAL PATTERN OF FISH PUMP ADOPTION: 1964-1967

County / Year	1964 1st.	1964 2nd.	1965 1st.	1965 2nd.	1966 1st.	1966 2nd.	1967 1st.	1967 2nd.
Finnmark	-	-	-	-	-	1	1	-
Troms	-	-	1	-	1	2	5	8
Nordland	-	-	-	1	1	4	14	2
Nord-Trøndelag	-	-	-	-	-	-	-	1
Sør-Trøndelag	-	-	-	-	1	1	1	4
Møre og Romsdal	-	1	1	1	2	13	10	10
Sogn og Fjordane	-	-	-	1	-	2	6	3
Bergen-Hordaland	-	-	1	2	7	13	5	15
Rogaland	-	-	-	1	-	5	5	2
Vest-Agder	-	-	-	-	-	-	-	2
Other	-	-	-	-	-	1	1	-
Total		1	3	6	12	42	48	47
Cumulative Total		1	4	10	22	64	112	159

Source: A/S Hydema & Co., 1968; Rapp Fabrikker, 1968.

5.4.2. Purpose

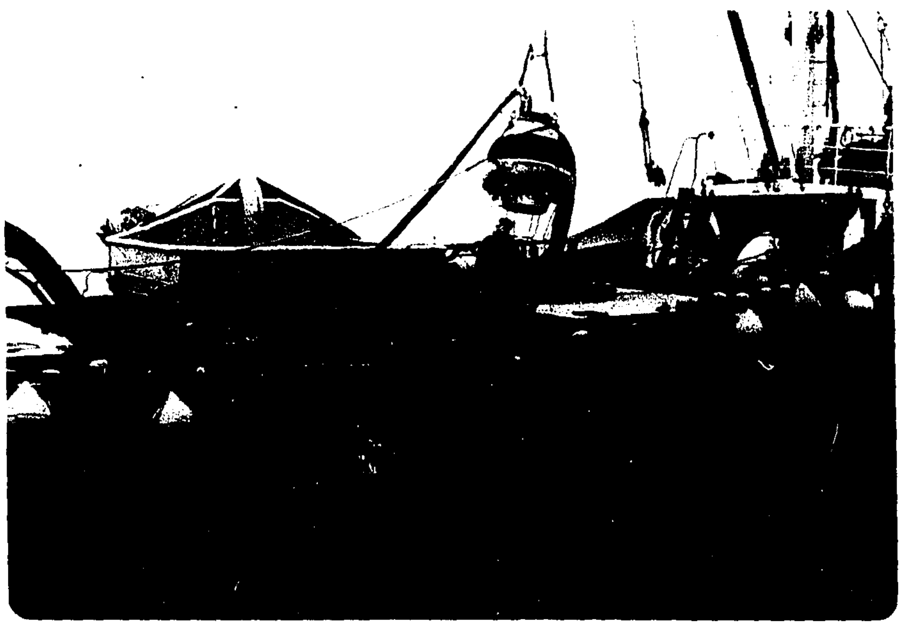
The fish pump has been adopted in order to facilitate more rapid loading of the catch, because with the bigger nets the fish are more compacted and also constitute a greater total mass. Now, because of these two factors, more fish die and sink to the bottom of the net and for this reason it has become important to have a device that can load the fish faster than the older brailing method, and to reduce the weight stress that may build up on the net on the occasion of a large catch.

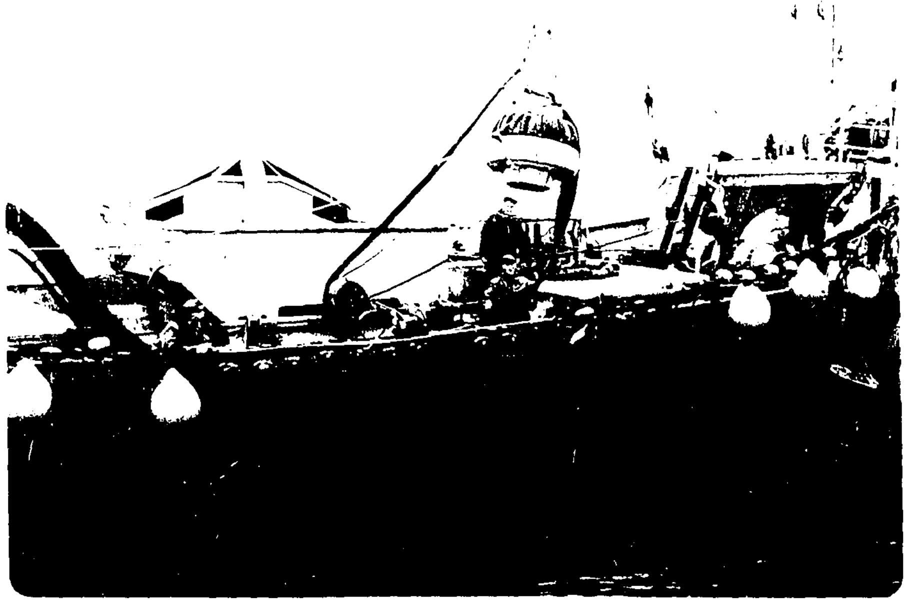
5.4.3. Types, Capacities and Aspects of Operation

There are two types now in operation. Both operate on the centrifuge system. One is a suction pump, as shown in the last step of the purse seine procedure depicted in Diagram 3-4. The other is a sinkable pressure pump. This is shown in Photograph 5-3. The official maximum rated capacity ranges from 2500 hectolitres per hour for a suction pump and 3500 for the pressure pump. It is known, however, that the latter can be operated up to speeds of 5,000 hectolitres per hour. The older brailing method had a capacity on the larger vessels of approximately 2500 hectolitres per hour. The importance of this unit is then that it allows any vessel to install a pump and thus at least double its loading speed but if it is a smaller vessel, it may treble the maximum loading speed.

PHOTOGRAPH 5-3

THE SINKABLE PRESSURE PUMP





In assessing the two, the most important difference is that the suction pump requires a strong, rigid hose (which is cumbersome to work with) in comparison with the sinkable pump which needs only a fairly light and flexible hose. (This is possible with the sinkable pump as no pressure must be maintained throughout its length, a requirement which must be fulfilled by the hose to be used by suction pump.) Furthermore, the pressure pump can raise fish from greater depths as it can be lowered into the herring mass while the suction pump can operate solely to the theoretical maximum of 32 feet given a 100 per cent efficient pump, due to atmospheric pressure considerations.

One additional feature linked to pumping capacity is the question of internal fish damage, i.e. bone structure being destroyed. This is not particularly relevant to fish delivered to the reduction process as this technique of utilization grinds up the fish but it is important, especially now, for if the internal body damage is high, the fish cannot be used for consumer products. The relevance of this point becomes clearer if one realizes that this might be the sector which could help to solve the current allocation problems of these fisheries, as the meal and oil market is presently glutted and the available prices are low. The point to be made then is: what are the comparative advantages of the brail method, suction pump or pressure pump with regard to this aspect? To date, no facts have been accumulated on this matter. The field concerned with advantages and disadvantages of the different equipment has been monopolized by the expression of value judgments (which is not in itself bad, except that no one has bothered collecting the facts on either side). In view of the importance of this type of question to the fisheries under consideration, the present circumstances are remarkable.

5.4.4. Position on Vessel

The fish pump units are located with respect to the sorting bin which is centrally located on the deck of the vessel, as shown in the foreground of Photograph 5-2. The suction pump is normally located aft of this unit and is centrally placed on deck, as shown in Diagram 3-4, feeding into the rear of the sorting bin. The pressure pump is a mobile unit that feeds into the sorting bin from the port side.

5.4.5. Statistical Data

A summary of the spatial-temporal aspect of sales was presented in Table 5-2. The top three counties are the same here as those that had a dominant position in other aspects previously mentioned, namely: Nordland, Møre og Romsdal and Bergen-Hordaland. An additional feature concerning the fish pump is the contracted time period between its inception and acceptance when compared with the innovation, sonar and echo sounder. This, then, provides support for the "acceptance threshold" theory presented in Chapter Four.

5.5. TRANSVERSE THRUSTERS

5.5.1. Purpose

Transverse thrusters are propellers which are mounted in such a way as to enable the main fishing vessel to manoeuvre in a lateral direction to the long axis of the ship. The main purpose of these thrusters has been to enable the fishing vessel to directly control its position with respect to the net, and thereby prevent itself from becoming entangled in its own net. An ancillary function is to aid manoeuvrability in ports or other limited spaces. The transverse thrusters replace the "slepebaat".*

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* This is a boat about 30 feet long with an engine of about 100 h.p. that is launched by the main fishing vessel in the event of a catch and holds the main vessel out of its net.

5.5.2. Position on Vessel

The transverse thrusters are located in the bow and stern of the vessel in tunnel shafts which run lateral to the long axis of the fishing vessel. Their position is depicted in Diagram 5-1. They can reverse rotation but they do not have variable pitch propellers to do this. The extremities of the tunnels are covered by a grid to prevent the net being caught in the blades of these propellers.

5.5.3. Capacities and Operation

The ratings range from 75-300 h.p. per unit, i.e. each propeller. At present it is generally believed by the manufacturers that the units now in operation and purchased to do the proper job are too small. What are the facts? No one knows for sure.

The propellers are controlled from the bridge of the fishing vessel by a number of techniques, one being graduated dials for each propeller unit to facilitate acquiring the proper balance of power.

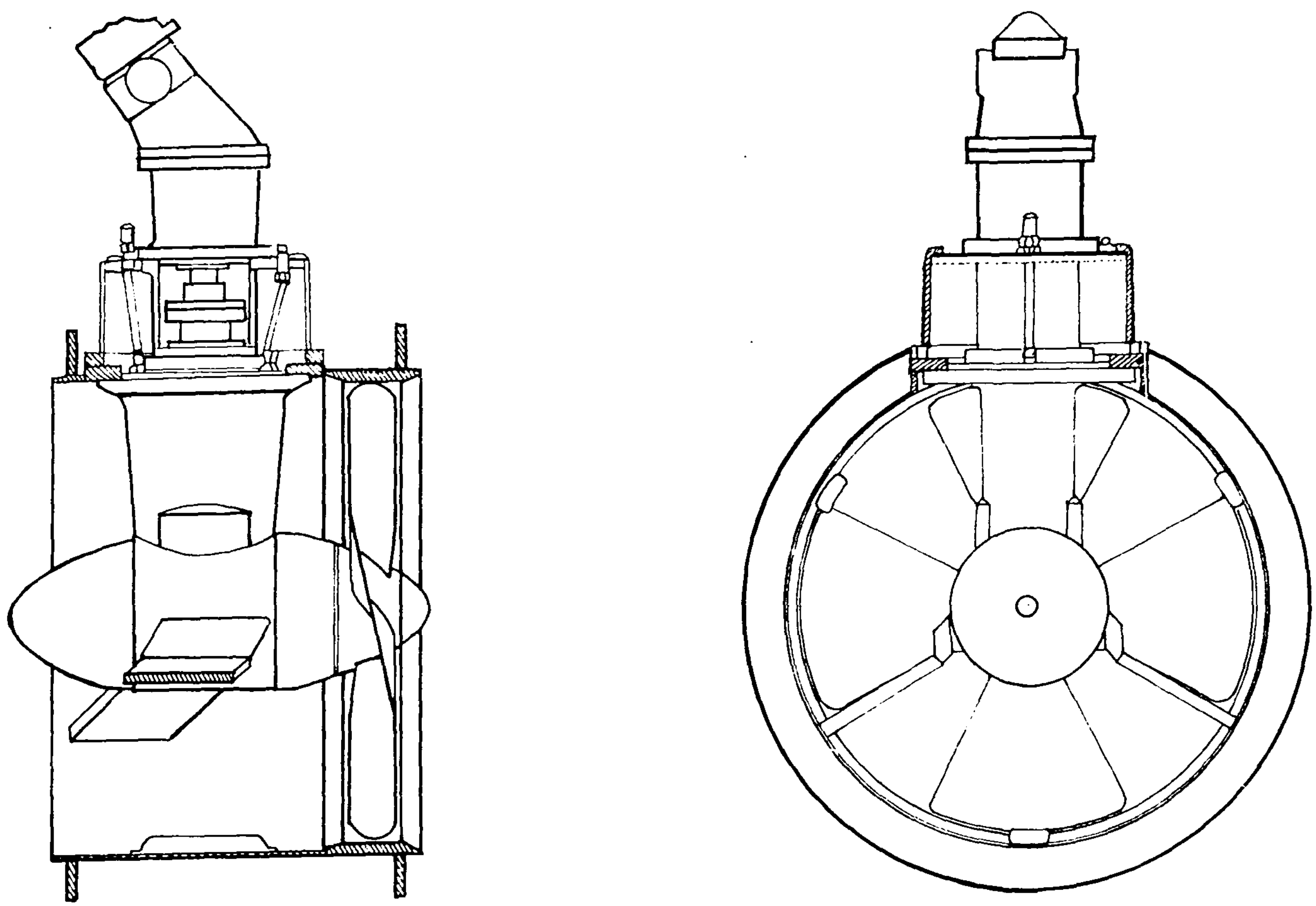
5.5.4. Comparative Advantage

The important benefit gained by the installation of the transverse thrusters is that of direct control of the main vessel's position at any time, which is better than the

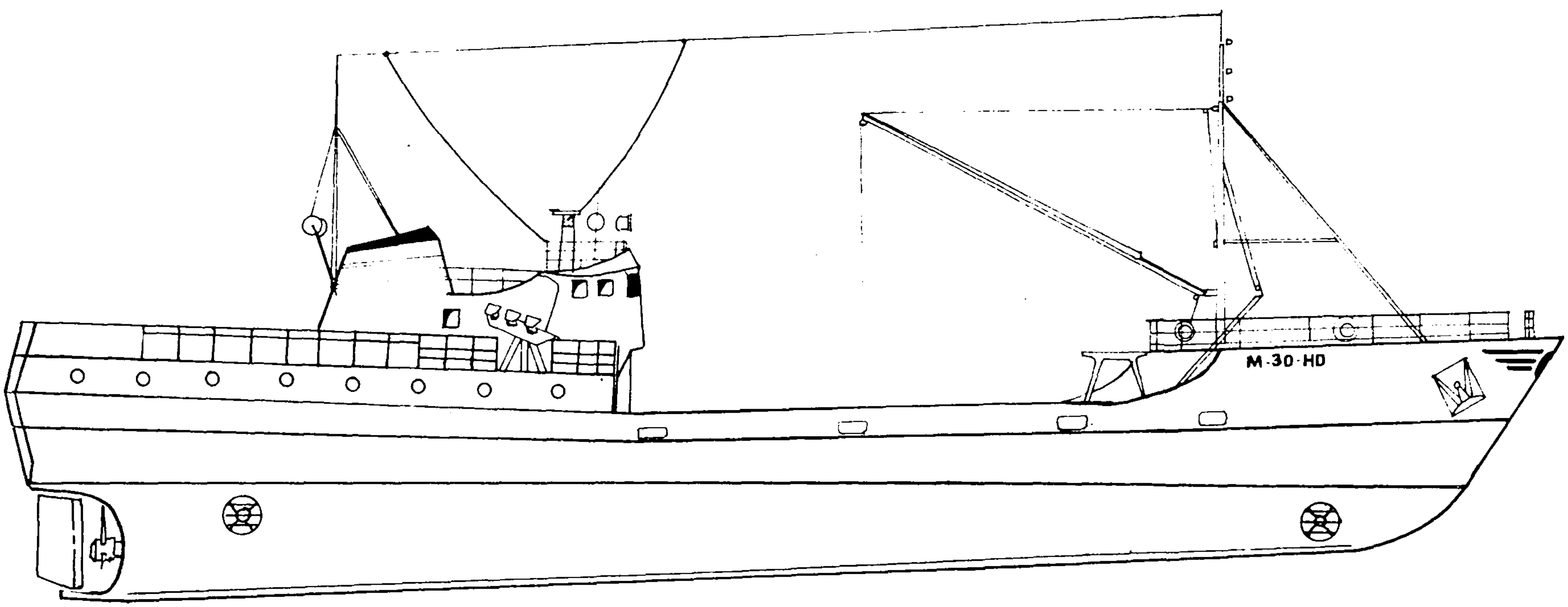
DIAGRAM 5-1

TRANSVERSE THRUSTERS

(a) Cross-section. (b) Front View.



(c) Position on Vessel.



After: Ulstein Proprellar A/S

control available when one must avail oneself of the towing services of a helper unit or a slepebaat. From this, one must not conclude that transverse thrusters have completely replaced the older method of using a tow boat, for it is actually the latter that is still in dominance as transverse thrusters were just introduced in 1966.

5.5.5. Statistical Data

The total number of units known to be sold since its inception is 45. One will note a difference between this number and the total in Table 5-3 which illustrates the spatial-temporal nature of the distribution. The reason is that it was not possible to acquire dates for all the units and those sold after December 31, 1967 were eliminated. Furthermore, note that two of the three counties which have previously been cited as forerunners with respect to other equipment reappear here. They are: Møre og Romsdal and Bergen-Hordaland.

TABLE 5-3

SPATIAL-TEMPORAL PATTERN OF
TRANSVERSE THRUSTER ADOPTION, 1966-1967

Year / County	1966 1st.	1966 2nd.	1967 1st.	1967 2nd.
Finnmark	-	-	-	-
Troms	-	1	3	-
Nordland	-	1	-	-
Nord-Trøndelag	-	-	1	1
Sør-Trøndelag	-	2	1	-
Møre og Romsdal	2	2	2	3
Sogn og Fjordane	-	-	-	1
Bergen-Hordaland	4	-	2	-
Rogaland	-	-	-	-
Vest-Agder	-	-	-	-
Other	-	-	-	-
Total	6	6	9	5
Cumulative Total	6	12	21	26

Source: Brunvoll, 1968; A/S Hydema & Co., 1968; Rapp Fabrikker, 1968; Ulstein Propeller A/S, 1968.

5.6. COST

Table 5-4 concludes the capital equipment price summaries that are presented in this study.

TABLE 5-4

COST OF EQUIPMENT ASSOCIATED WITH THE INNOVATION*

Ringnet	230-310,000	kroner/
Trawl Winch	50- 90,000	"
Fish Pump	60,000	"
Transverse Thrusters	200,000//	"
Slepebaat	40- 80,000	"

/ To obtain the comparable price in U.S. dollars divide by a factor of 7.

// with installation

* Source: Andersen, 1968; Brunvoll, 1968; Gerhardsen, 1966; Krohn-Hansen, 1968.

5.7. SUMMARY

This Chapter completes the description of the most important technical changes that have occurred during the study period in the procurement sector of the fishery. It illustrates once again the tendency toward increasing mechanization of various aspects of the fisheries and its overall increasing technical complexity.

The information presented in this and previous chapters concludes a review of the conditions of the technical sector within the fisheries under examination.

INNOVATION IMPACT

CHAPTER SIX

THE HERRING SECTOR OF THE FISHING INDUSTRY

CHAPTER SIX

THE HERRING SECTOR OF THE FISHING INDUSTRY

6.1. INTRODUCTION

This Chapter delineates some fundamental aspects of the North Sea and Winter Herring Fisheries in a non-spatial framework. The purpose is to facilitate understanding of the spatial aspects of these two fisheries which appear in Chapters Seven and Eight. In presenting the material, the main aim has been to review the trends of the study period.

6.2. NATURE OF THE STATISTICAL DATA

A consideration of the measurements employed is fundamental to a presentation of trends which have occurred in the two fisheries. Catch statistics form the bulk of the official published government data* and current methods of

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* On occasion throughout this Chapter and the remainder of the study, data will only be presented to the year 1966. The reason for this is that the official data for 1967 has yet to be published.

analysis tend to revolve around them. It is necessary to be cognizant of two aspects on which this type of statistic provides little information, namely: 1) fishing intensity; and 2) resource availability. Research is required on the linkages between fishing intensity, resource availability and catch statistics. Only through a better understanding of these connections and the nature of the individual components will the economics of fisheries be understood. Furthermore, the results of such an analysis may prove that it would be desirable to employ some other or additional measurements than those used to compile the published statistics, to facilitate more detailed work.

One further point must be kept in mind and this is that the fisheries under study are seasonal in nature and, therefore, the data presented for each represents only a portion of the total factor allocation of a harvesting unit for a year. This is very important to remember in a study dealing with fisheries.

6.3. THE NATIONAL SETTING

This section indicates the importance of the North Sea and Winter Herring Fisheries within the fisheries sector and the national economy. The resources harvested by these two fisheries go mainly to the reduction process. The reduction sector is the dominant fish processing technique in use; and the purse seine method, which now revolves around the use of innovation (the powerblock and net seine winch), is the most important one employed in harvesting for this process.

In a recent study, Nordset delineated the position of the fisheries nationally and the rank of the reduction process within this category (1968, p.28). He states that the fisheries, as a whole, which were in third place in 1966, occupied second in 1967. The reduction sector, furthermore, contributed almost 30 per cent to this category. The sector averaged 1127 million kroner in 1966-67 (or the equivalent of two-thirds of the total of all fisheries exports), thereby making it the largest single foreign exchange creator for Norway.

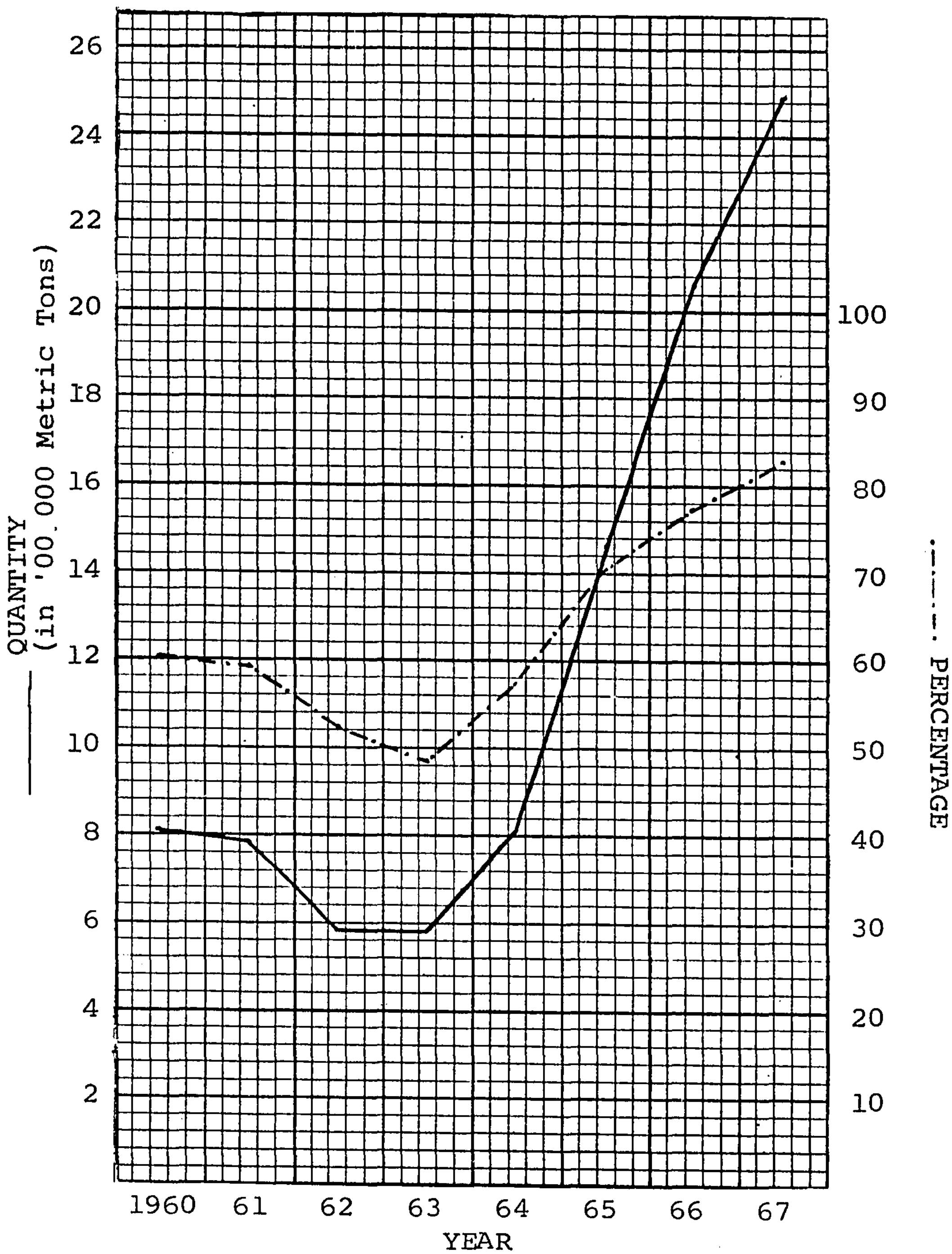
To provide a more complete picture of the changes that the innovation has initiated, it is necessary to consider a number of fisheries in addition to the North Sea and Winter Herring Fisheries. These are: 1) Capelin; 2) Fat Herring; 3) Fjord Herring; 4) Iceland Herring; 5) Mackerel and Young Mackerel; 6) Small Herring; and, 7) Sprat. These fisheries are all inter-linked in participation, the exact degree of connection is not known. However, each group employs the purse seine technique; and, therefore, each has to some degree been influenced by the innovation. The group just mentioned reflects a growth pattern which appears to parallel that of the innovation adoption. Unfortunately, the exact connection is, at present, difficult to establish. Ninety-five per cent of the catch of these fisheries was by the purse seine technique. When totalled, this group accounted for almost 83 per cent by weight and 46 per cent by value of all landed catch in Norway.

(Note: The reason for the difference between the proportions which the weight and value categories contribute to their respective groupings is that the major portion of the catch goes to secondary production, i.e. reduction, which has a lower market value than that going to primary processing, i.e. consumer products).

Figures 6-1 and 6-2 summarize the position of

FIGURE 6-1

COMPARISON OF STUDY GROUP IN RELATION TO TOTAL QUANTITY OF LANDED CATCH IN NORWAY, 1960-1967*



* 1967 data is provisional.

Source: Norges Fiskerier, 1960; Fiskeristatistikk, 1961-66.

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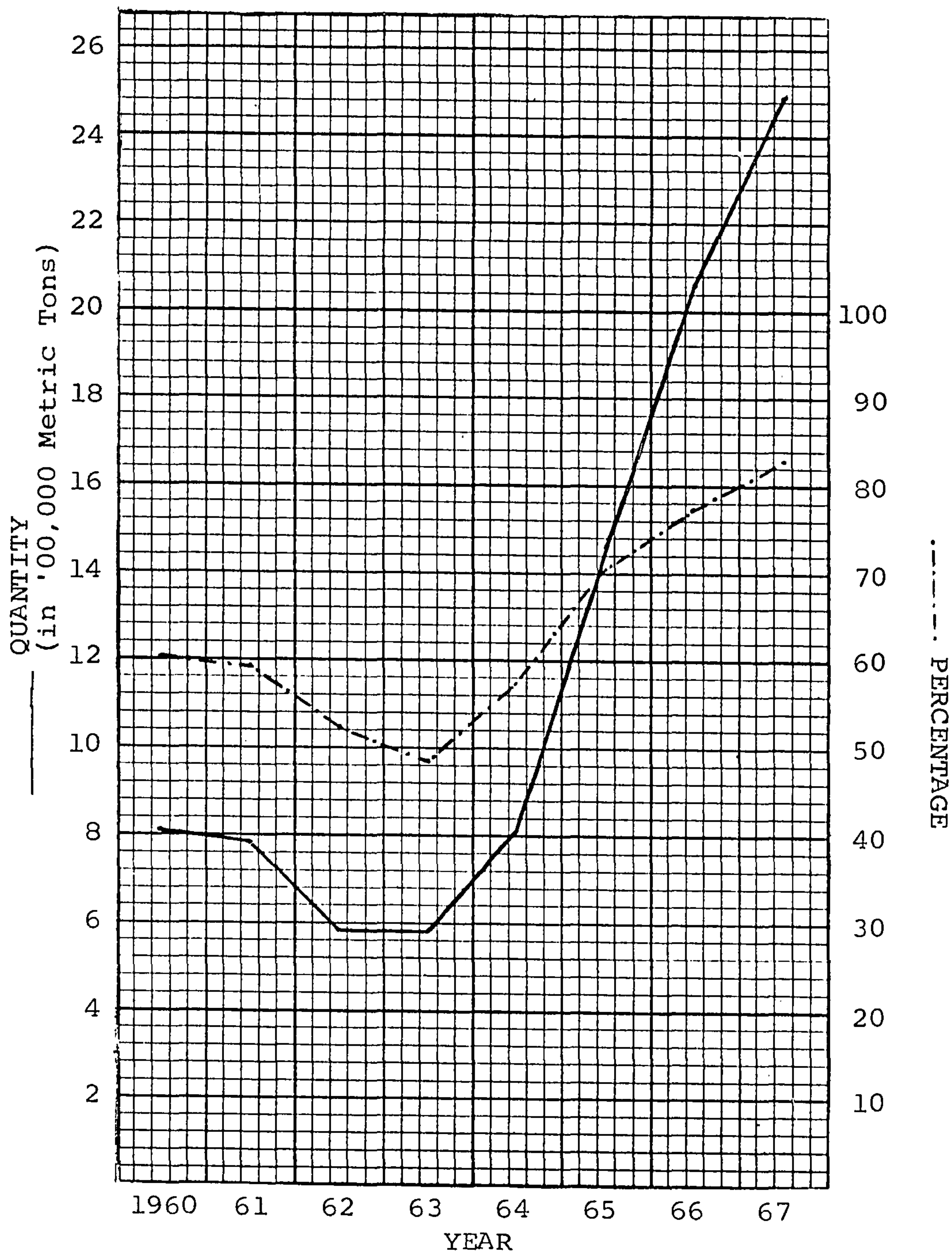
COMPARISON OF STUDY GROUP IN RELATION TO TOTAL QUANTITY OF LANDED CATCH IN NORWAY, 1960-1967*

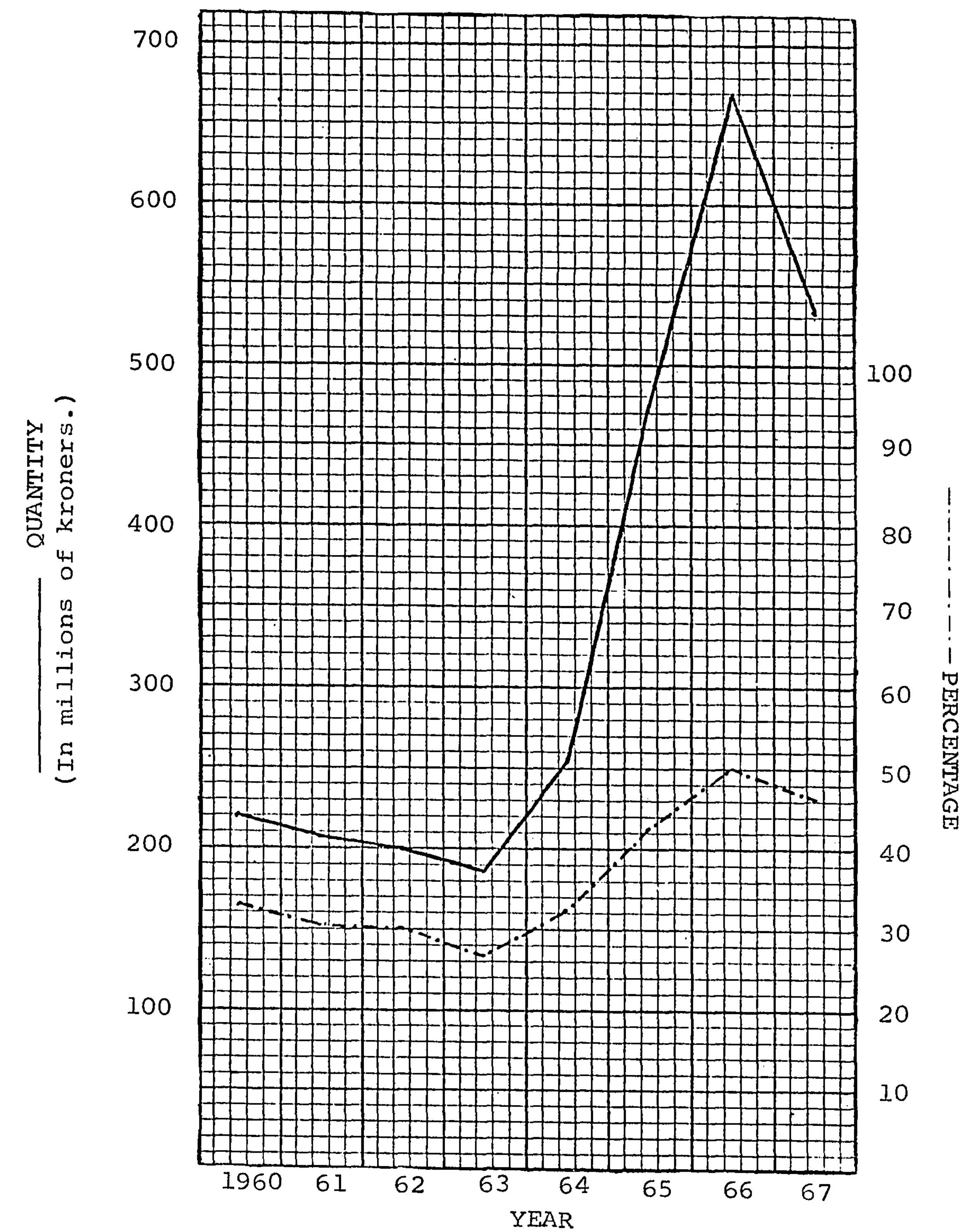


* 1967 data is provisional.

Source: Norges Fiskerier, 1960; Fiskeristatistikk, 1961-66.

FIGURE 6-2

COMPARISON OF STUDY GROUP IN RELATION TO
TOTAL VALUE OF LANDED CATCH IN NORWAY, 1960-1967*

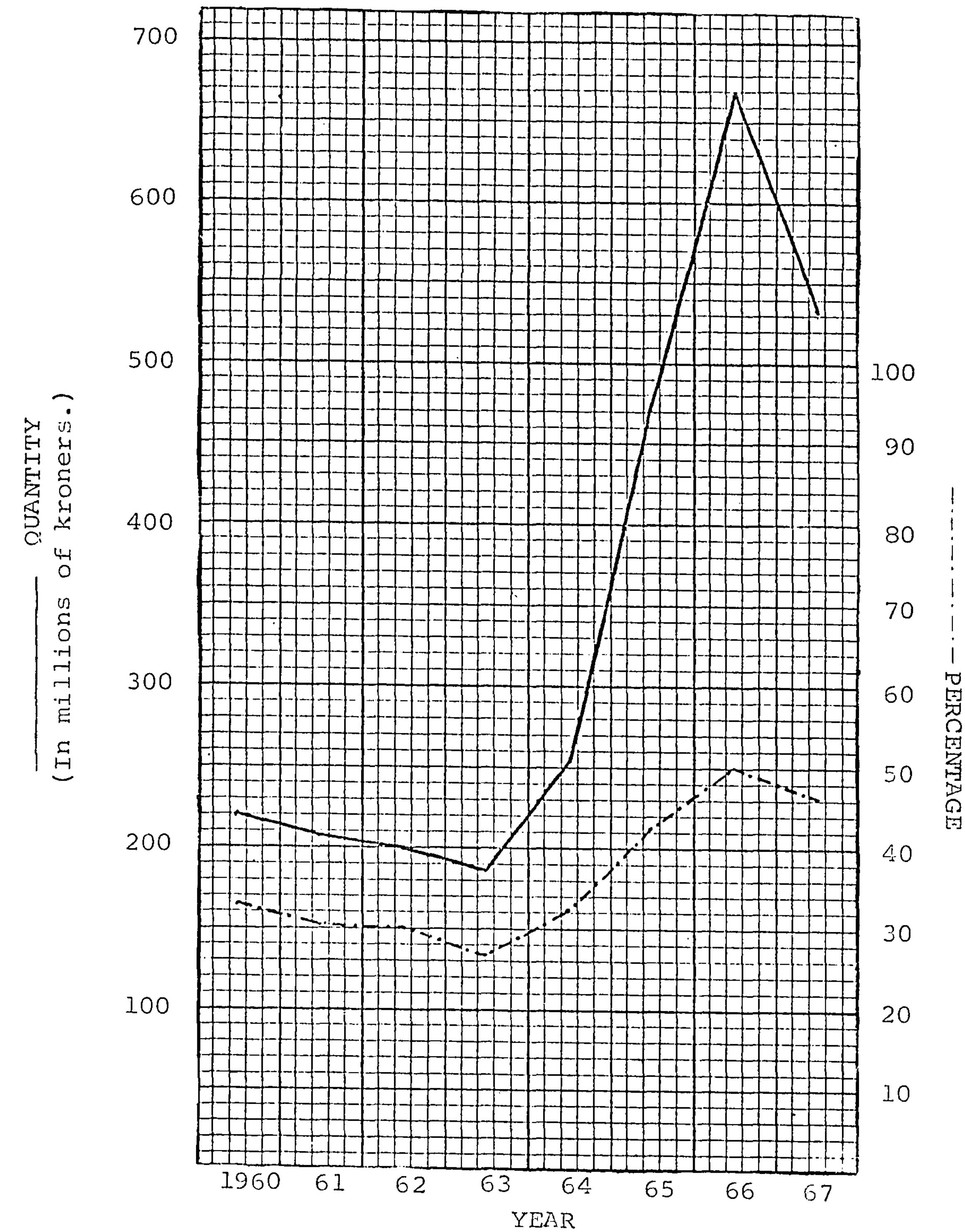


* 1967 data is provisional.

Source: Norges Fiskerier, 1960; Fiskeristatistikk, 1961-66.

FIGURE 6-2

COMPARISON OF STUDY GROUP IN RELATION TO
TOTAL VALUE OF LANDED CATCH IN NORWAY, 1960-1967*



* 1967 data is provisional.

Source: Norges Fiskerier, 1960; Fiskeristatistikk, 1961-66.

the above fisheries for the study period.*

The two fisheries under investigation then form components - albeit varying - of the most rapidly developing sector of the fisheries economy.

6.4. FISHING METHODOLOGY

The three most important techniques in terms of landed catch over the period are described to familiarize the reader with their method of employment.

6.4.1. Trawl

Trawling is not a new technique but its development in Norway has been comparatively recent. There are a variety of trawl types but that which has been most important is

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* It is useful to observe that the position of fjord herring and sprat in the aggregate is small; so that if further investigation along this line is to be conducted, it is recommended that they be dropped from consideration and that work be concentrated on the remaining seven fisheries. A determination of the nature of the inter-relationships would be fundamental to a complete understanding of the full impact of the innovation on the Norwegian fishing economy. As this is beyond the scope of this thesis, due to a lack of data and the magnitude of the effort, it is recommended that this be a possible start on future research for it is through these types of studies that one will be able to understand the exact nature of the fisheries. A study of the spatial distribution of the landed catch of this group would be very useful in trying to assess the feasibility of current expansion plans with regard to reduction processing capacity which are now being considered.

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shown in Diagram 6-1. This shows the two-vessel pelagic trawl, which has been important in the North Sea Herring Fishery (Gerhardsen, 1964, p.85).

6.4.2. Drift Net

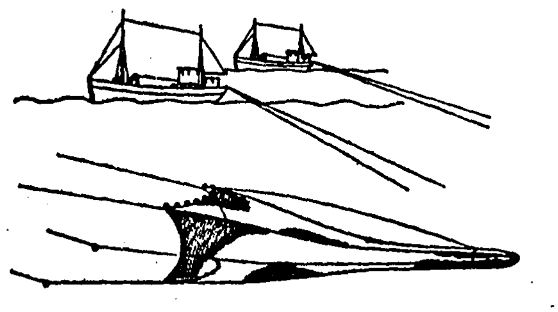
The drift net is a particular type of gill net. It is set out from the bow of the vessel, as depicted in Diagram 6-2. The bottom line of the net is just sufficiently weighted so that the net sinks. The top of the net is fastened by a short lanyard to the main cable which in turn is attached to plastic floats. The main line connecting the lanyard to the vessel is the rider.

6.4.3. Purse Seine

A description of this technique was provided in Chapter Three. One item must be mentioned here. This is that the catch statistics record only the purse seine category and do not separate the landed catch according to that contributed by the two-dory system and ringnetting, individually. The failure to do so is important for the former virtually dominated production at the commencement of the study period to the exclusion of the latter while the situation had been completely reversed by 1967 in which year ringnetting was the sole variant of the purse seining technique

DIAGRAM 6-1

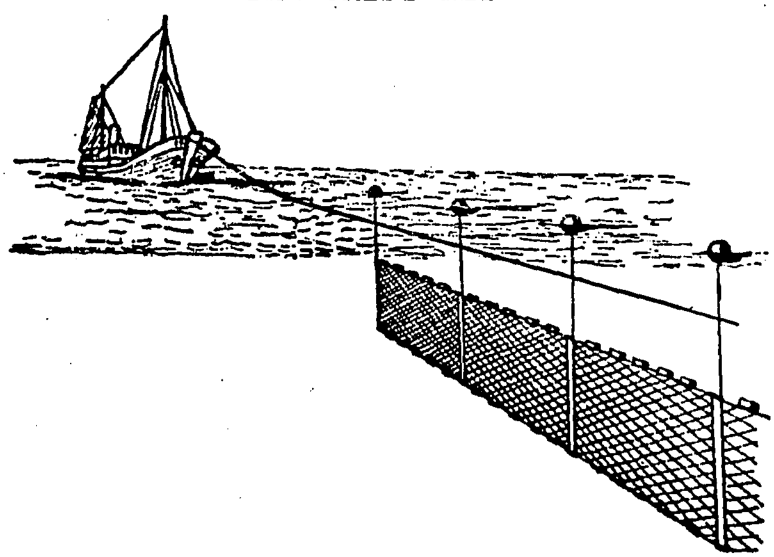
TWO-VESSEL PELAGIC TRAWL



Source: Gerhardsen, 1964, p.85.

DIAGRAM 6-2

THE DRIFT NET



After: Brobak, 1966, p.30.

being employed. The trends are depicted later in this Chapter. This lack of statistical separation in recording is unfortunate as it would have provided useful information for preliminary assessment of the two techniques.

6.5. TRENDS IN THE PROCUREMENT SECTOR

6.5.1. North Sea and Winter Herring Fishery

6.5.1.1. Catch

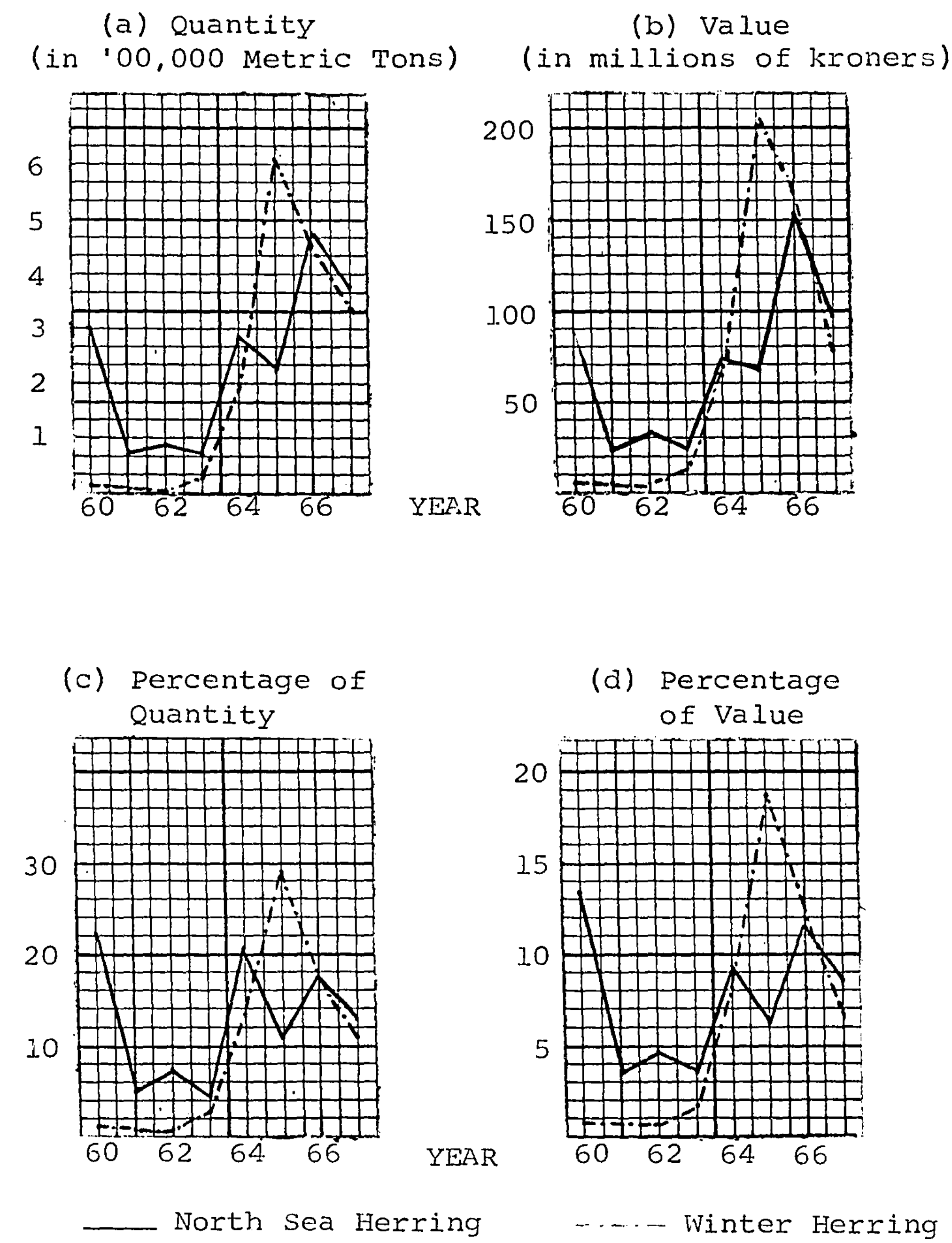
6.5.1.1.1. Quantity and Value

The position of these two fisheries in terms of landed catch by weight for the duration of the study is depicted in Figure 6-3(a). The North Sea herring catch has increased from a minimum in 1962 of 12,000 tons to a maximum in excess of 600,000 tons in 1965 after which there has been a drop to approximately 330,000 tons in 1967. The winter herring have also exhibited a marked variation from a minimum of 61,000 tons in 1963 to a maximum of 460,000 tons in 1966.

The reason for the rise in catch from the North Sea can be attributed to the innovation which resulted in increased fishing effort in this area. The slump after 1965 does not represent a failure of the raw material supply but it reflects largely the impact of government imposed

FIGURE 6-3

QUANTITY AND VALUE OF LANDED CATCH FOR THE
NORTH SEA AND WINTER HERRING FISHERIES, 1960-1967



Source: Norges Fiskerier, 1960;
Fiskeristatistikk, 1961-1966.

fish stops* in the summers of 1966 and 1967. Data that would make it possible to segregate the two effects is non-existent. The variation in the winter herring species is also a product of two main components: first, biological availability and second, the innovation. Segregation of the effects is again impossible because of the lack of data.

It is worthwhile at this point to consult Chapter Two, Figure 2-2. This graph depicts the variation in landed catch of winter herring from 1947-67. The item to note is that the current increase during the study period, though substantial, just raised the total catch of 1966 to a position slightly higher than one-third of the 1956 maximum. The increase, then, reflects just a positive perturbation on an otherwise generally declining trend.

The necessity of additional measurements that should be made, as outlined in the section on the nature of the statistical data, is now reinforced by the above considerations.

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* A fish stop is a government control mechanism which prohibits the landing of a certain fish specie for a specified period of time. In 1966, fish stops, applied to North Sea herring fishing, lasted for two months, while in 1967 their duration increased to two and one-half months plus an additional three months during which quotas were imposed (Haraldsvik, 1968b).

The catch value of each group is shown in Figure 6-3(b) and it will be observed that the minima and maxima occur in the same years as that of landed catch by weight. This would be expected so no further consideration is given to this point.

6.5.1.1.2. Comparative Positions

The contribution made by each of the two fisheries in terms of total landed catch in quantity and value in Norway is shown in Figures 6-3(c) and (d). The North Sea herring have ranged from 1.1 per cent by weight and .7 per cent by value in 1962 up to 29.1 per cent and 18.7 per cent in 1965 respectively. The winter herring during the same period have oscillated from 22.4 per cent by weight and 13.5 per cent by value in 1960 to 5.2 per cent and 3.6 per cent in the years 1961 and 1963.

6.5.1.2. Participation

Table 6-1 summarizes the available participation data for the North Sea Fishery. It will be noted that it is not complete as it was not possible to obtain a measure of the number of participating trawlers. The most important thing to note is the remarkable increase in fishing vessels that has taken place since 1962, the first year of the fishery with the purse seine technique.

TABLE 6-1

NORTH SEA HERRING FISHERY:
FISHING VESSEL PARTICIPATION
1962-1967

Year	No. of Boats
1962	1
1963	16
1964	195
1965	284
1966	334
1967	326

Source: Gerhardsen, 1966; Noregs Sildesalslag, 1967-1968; Sild-og Brislingslaget, 1965-1966.

In dealing with the Winter Herring Fishery, depicted in Table 6-2, the most significant aspect of the table has been the decrease from the total of 1,156 fishing vessels in 1960 to 377 vessels in 1967. The strongest decrease occurred in the two-dory system and drift net techniques. The trawl classification experienced some decline, though not as strong as might have been expected. The reason is that the technique has never been of major importance to the fishery and its participation has been along the line of filling a seasonal gap in the normal yearly fishing cycle. The ringnet category is the sole one to exhibit an increase, particularly after 1963.

TABLE 6-2

WINTER HERRING FISHERY:
PARTICIPATION BY FISHING TECHNIQUE
1960-1967

Category / Year	1960	1961	1962	1963	1964	1965	1966	1967
Purse Seine Group:								
Two-Dory System	420	238	180	192	122	61	4	-
Ringnet	19	6	7	6	58	133	290	339
Drift Net	717	565	327	275	175	80	22	10
Trawl	-	6	18	36	79	5	43	28

Source: Vintersildfisket, 1960-1967.

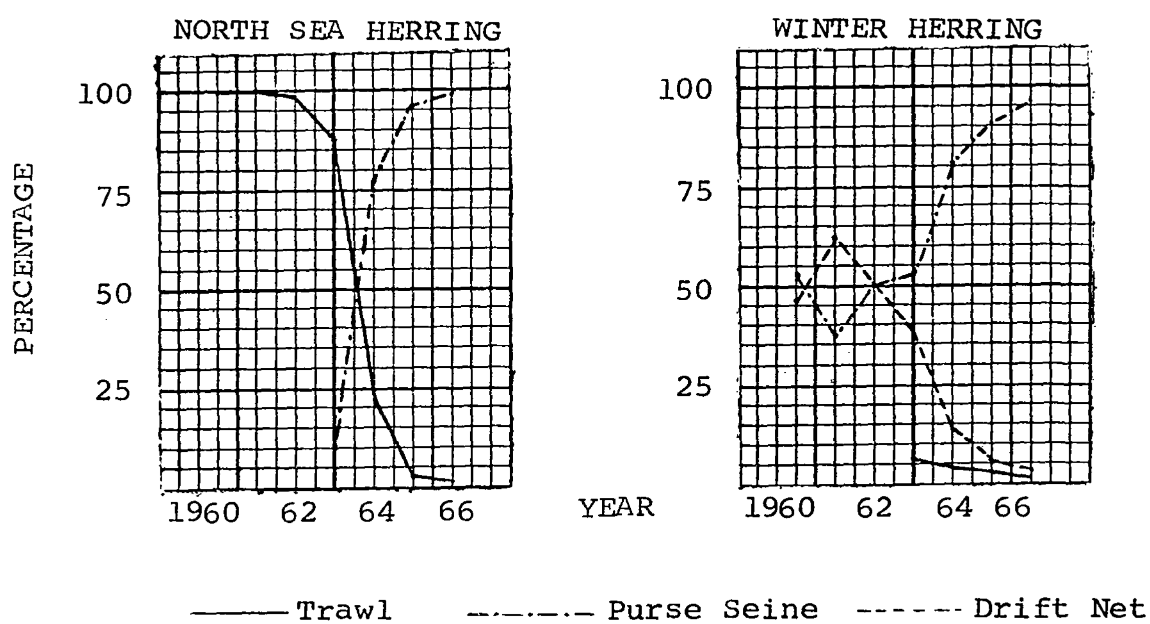
One question arises from this data. How is it that there are 19 units in the ringnet category in 1960 when this was the year that the innovation was introduced? This contradicts the data presented in Chapter Three. It has not been possible to resolve this difficulty, for the statistical source material did not explain the basis of the category but merely structured the classification. Reference was made to other sources in an effort to clarify this matter but it has not been possible to resolve the difficulty.

6.5.2. Fishing Techniques

The trends in technique utilization are depicted in Figures 6-4(a) and (b). These show percentages of total catch landed by the different methods employed. The most important item to note has been the emergence of the purse seine technique to one of virtual complete dominance. In the North Sea Herring Fishery, it has increased from 10 per cent in 1963 - its year of inception - to 98.5 per cent in 1966. A similar but less strong specialization trend has occurred in the Winter Herring Fishery, where the utilization of the purse seine technique has risen from 37.5 per cent in 1961 to 96.6 per cent in 1966.

FIGURE 6-4

PERCENTAGE OF CATCH QUANTITY BY TECHNIQUE,
1960-1967.



Source: Norges Fiskerier, 1960;
Fiskeristatistikk, 1961-1966.

6.5.3. Winter Herring Fishery

The following presentation is based on data stratification according to fishing technique.

6.5.3.1. Vessel Capacities

The trends are summarized in Table 6-3. No data were available for the trawl category. The drift net category has changed very little and with its concomitant decrease in seasonal participation, no attempt has been made to explain it.

TABLE 6-3

WINTER HERRING FISHERY:
FISHING VESSEL CAPACITIES BY HARVESTING TECHNIQUE
1960-1967
(in hectolitres)

Category / Year	1960	1961	1962	1963	1964	1965	1966	1967
Purse Seine								
Two-Dory System	2630	NA*	2771	2850	2925	3455	3350	-
Ringnet	685	NA	2780	2820	1680	1950	2122	2357
Drift Net	730	760	780	840	735	785	704	685
Trawl	NA	NA	NA	NA	NA	NA	NA	NA

* not available.
Source: Vintersildfisket, 1960-1967.

The interesting changes have occurred in the purse seine category. It appears that the continuous capacity increase in the two-dory system group from 2630 hectolitres* in 1960 to 3350 hectolitres in 1967 is an anomalous characteristic for a declining group. Several probable reasons are: 1) smaller vessels are less successful, therefore they tend to drop out of the category, thereby raising the mean; 2) larger vessels are generally owned and operated by the more successful skippers, which tend to enhance their profitability; 3) the increased profitability decreases their propensity to adopt the innovation and to change categories. Thus, "Who needs it?" might be a common attitude of the more successful ones. The subjective outlook is important and the difficulty in attempting to judge these attitudes in an objective manner is a major problem.

In considering the ringnet category, the increase from an average of 685 hectolitres in 1960 to 2820 hectolitres in 1963 can be attributed to the small number of vessels participating in this category. This creates the possibility of radical changes in vessel capacity means by the addition

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* One hectolitre of fresh herring equals 93 kilograms or 10.7 hectolitres equal one metric ton.

or subtraction of a couple of vessels. In 1964, there was a sharp slump. This was due to a number of vessels of reduced capacity entered in this category. The reason is that the innovation, because of its labour-reducing effects and increase in hauling efficiency, made it possible for a number of smaller vessels to participate successfully in the fishery. A steady increase occurred from 1964, at which time the average capacity was 1680 hectolitres compared to 2357 hectolitres in 1967. The increase in capacity has been a product of the improved economic return, which has proved to be sufficiently strong to warrant further investment in terms of either the purchase of a new vessel or increasing the capacity of the older vessel. The reason for this trend was accelerated by the tax structure which is very progressive. A consequence of this was to invest the increased earnings to avoid the higher income tax brackets where one was working almost exclusively for the state.

6.5.3.2. Employment

The employment pattern is reflected in Table 6-4. The most remarkable trend is the overall decrease in the labour force from 16,686 in 1960 to 4,109 in 1967. The labour decrease naturally correlates with the vessel

TABLE 6-4

WINTER HERRING FISHERY:
EMPLOYMENT BY FISHING TECHNIQUE
1960-1967

Category / Year	1960	1961	1962	1963	1964	1965	1966	1967
Purse Seine								
Two-Dory System	8623	4853	3557	3780	2438	1250	82	-
Ringnet	177	59	65	51	583	1396	3240	3878
Drift Net	7847	5393	3018	2634	1633	771	213	95
Trawl	39	46	134	191	433	33	226	136
	16686	10351	6774	6656	5077	3450	3761	4109

Source: Vintersildfisket, 1960-1967.

participation data as it is a direct result of this reduction. This, coupled with the previous data, then demonstrates the effect that the innovation has had on rationalizing the industry. As in the data on vessel participation, the strongest declines have occurred in the two-dory system and drift net technique. The former has declined from 8,623 in 1960 to zero in 1967 while the latter has changed from 7,847 in 1960 to 95 in 1967. The trawl category does not exhibit any particular trend for the same reason as mentioned in the vessel participation discussion. The ringnet category is the sole one that shows a consistent increase in employment over the period rising from 177 in 1960 to 3,878 in 1967. The take-off occurred in 1963-64. The variations prior to this period are difficult to explain, as has been previously mentioned.

6.5.3.2.1. Crew Size

Table 6-5 represents the average number of personnel per vessel for the differing categories under study. It is presented for two reasons: the first is to illustrate the stable employment situation within the differing fishing techniques; and, second, to provide the data which serve as a basis for the number of personnel to be allocated to a particular vessel according to technical equipment in the analysis of Chapter Eight.

TABLE 6-5

WINTER HERRING FISHERY;
CREW SIZE BY FISHING TECHNIQUE
1960-1967

Category / Year	1960	1961	1962	1963	1964	1965	1966	1967
Purse Seine								
Two-Dory System	20.5	20.9	20.6	20.3	20.0	20.5	20.5	-
Ringnet	9.3	9.8	9.3	8.5	10.1	10.5	11.1	11.4
Drift Net	10.9	9.5	9.3	9.6	9.3	9.6	9.7	9.5
Trawl	4.7	5.7	5.6	5.3	5.5	6.6	5.3	4.9

Source: Vintersildfisket, 1960-67.

In the two-dory system, there appears to be little relationship between vessel capacity and employment, for as fishing boat size has increased, the number of personnel has remained comparatively constant. This may be explained by the fact that return on revenue has not been sufficiently great to enable the employment of additional personnel. The ringnet category has shown some fluctuation. The variations up to 1963 are not explained, for reasons previously given. The probable cause of the increase after 1963 is that the advent of bigger vessels entering the fishery may have had crews of 13. This may therefore account for the growth of the mean to 11.4 in 1967 from 10.1 in 1964.

6.6. TRENDS IN THE PRODUCTION SECTOR

6.6.1. North Sea Herring Fishery

6.6.1.1. Quantity and Value*

The trends in production are reflected in Figures 6-5(a) and (b). The reduction sector is the most important processing technique and after 1964 it was the almost exclusive method of utilization. The reasons for this are twofold: first, the biological element and, second, processing capacity. The first point is that the North Sea herring have food in the stomach when caught, unlike the

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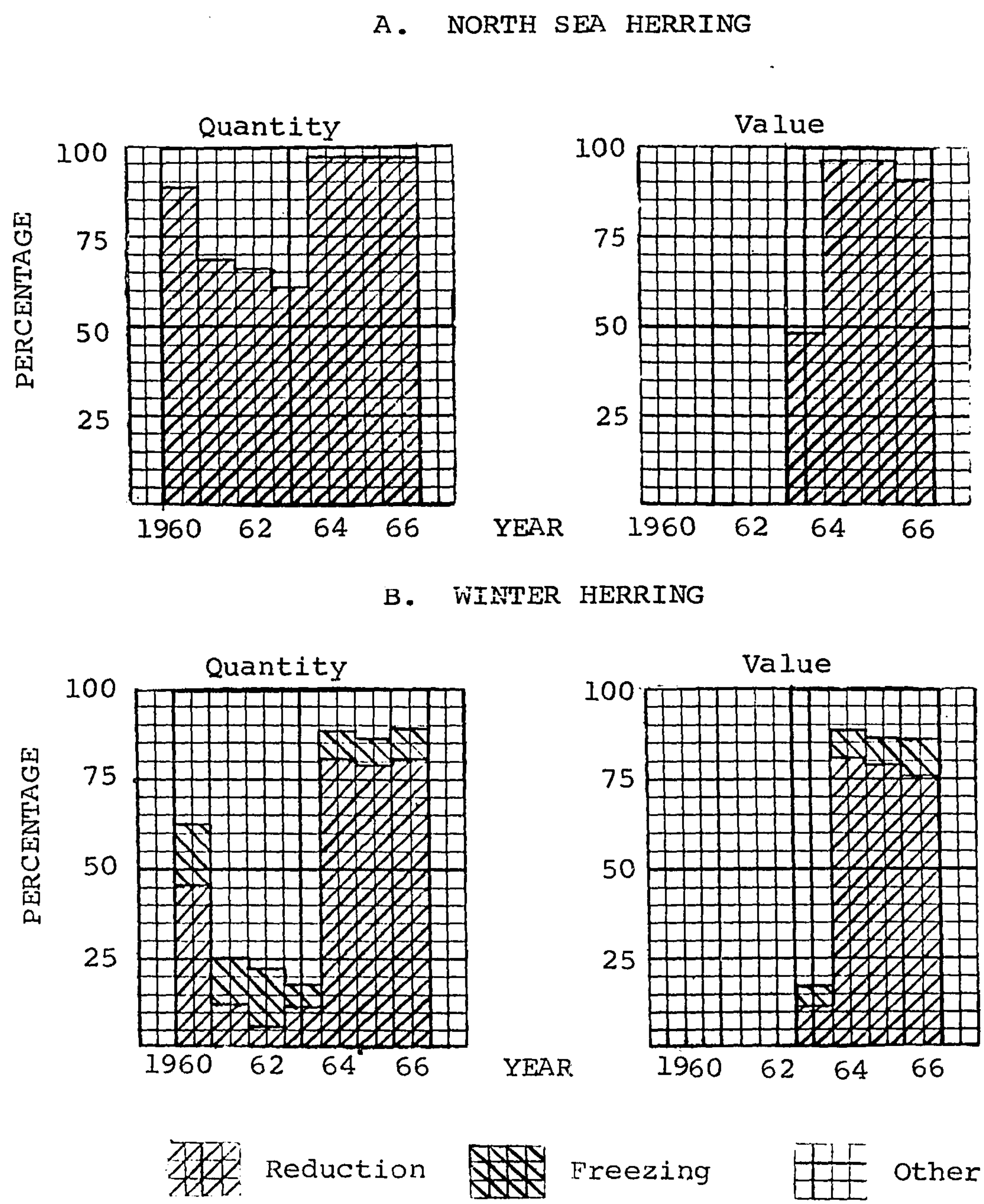
* The value data first became available in 1963.

FIGURE 6-5

QUANTITY AND VALUE OF PROCESSED CATCH FOR THE NORTH SEA AND WINTER HERRING FISHERIES, 1960-1967.

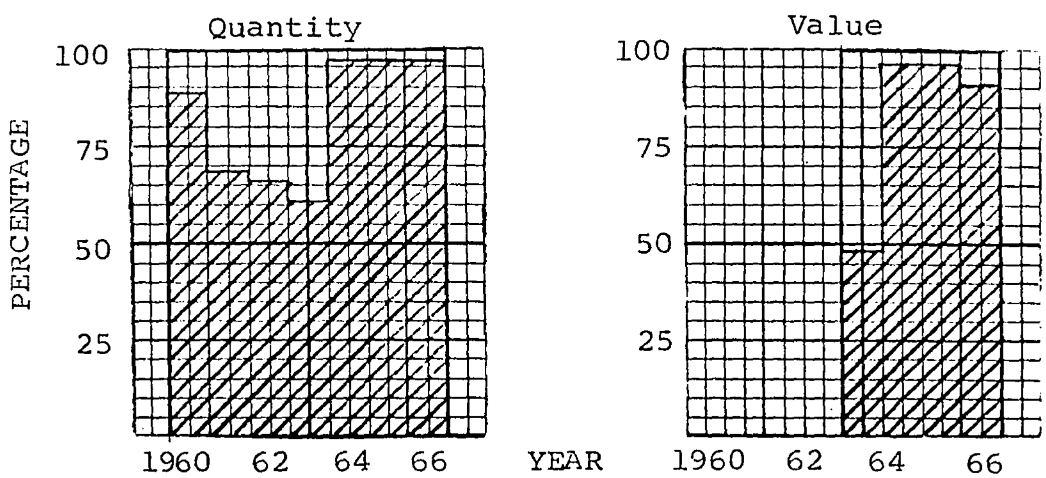


Source: Norges Fiskerier, 1960;
Fiskeristatistikk, 1961-1966.

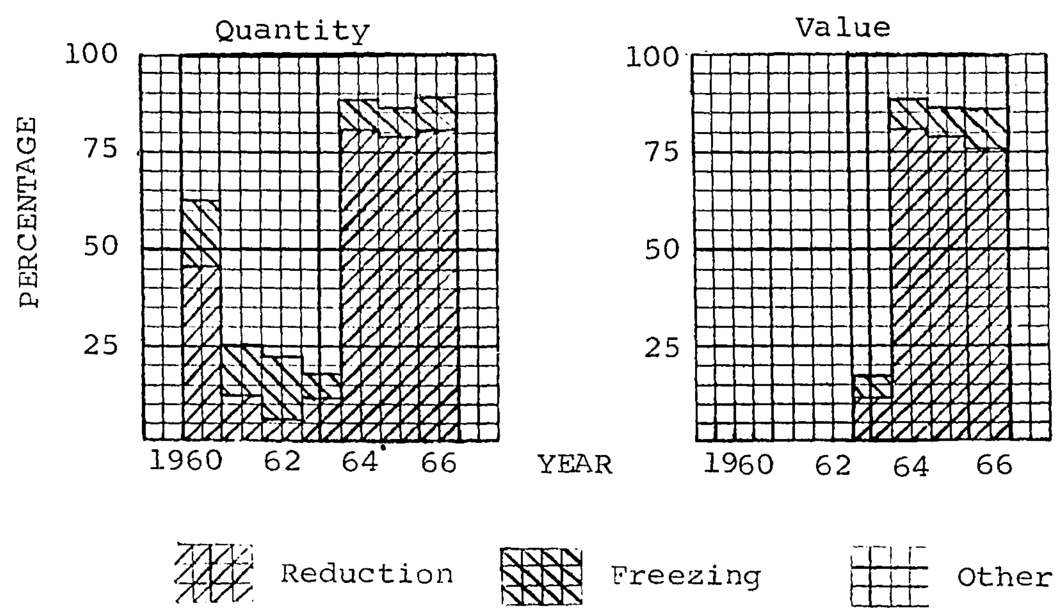
FIGURE 6-5

QUANTITY AND VALUE OF PROCESSED CATCH FOR THE NORTH SEA AND WINTER HERRING FISHERIES, 1960-1967.

A. NORTH SEA HERRING



B. WINTER HERRING



Source: Norges Fiskerier, 1960;
Fiskeristatistikk, 1961-1966.

winter herring which have none. This means that the bacteria in the stomach contents tend to decompose the body faster than the winter herring. This was the main reason until 1963. Second, after 1963, harvesting increased at such a rate that reduction was the only method that could possibly cope with the amount landed. The trend of values parallels the quantity distribution.

6.6.2. Winter Herring Fishery

6.6.2.1. Quantity and Value

Figures 6-5(c) and (d) represent the position of the different items produced from winter herring in terms of quantity and value. The fundamental aspect concerning the quantity utilized for each category of production is the general decline from 1960 and in particular after 1963, exclusive of the reduction sector which had increased to more than 80 per cent by 1966, of all landed catch. In the value of production, a decline has been experienced by all groups except freezing and reduction.

The increase in the freezing category is due largely to the idea that the consumer product sector may possibly furnish a solution to the present problem of the diminishing prices received from products of the reduction process. This sector increased from 5 per cent to 11 per cent of the value of the processed product from 1963 to 1966.

6.6.3. Production Changes

Two questions concerning production are of interest. First, has there been any modification in processing technique which might improve efficiency?; and, second, what has happened to total processing capacity?.

The answer to the first question is that no major modification has been made in the processing technique as the current method employed is basically the same as when it was initially formulated. The size of the individual components has been altered at the various stages of the process, thereby increasing effectiveness and reducing labour costs to some degree. I have no measure of this.

In answer to the second question regarding processing capacities, the trend for the individual counties are summarized in Tables 6-6 and 6-7. All capacities are in hectolitres per day of possible production, which is derived from a theoretical calculation based on the main components in the production process. The significant aspect to note is the growth which has taken place in Northern Norway rising from a low of 8.3 per cent of increased plant capacities for the period 1958 to 1963 to 24.7 per cent from 1963 to 1967.

TABLE 6-6

REDUCTION PLANT CAPACITIES BY COUNTY: 1958, 1963, 1967

(in hectolitres per day)

Year / County	1958	1963	1967
Finnmark	1,200	43,730	45,090
Troms	-	34,670	33,386
Nordland	19,730	34,110	35,680
Nord-Trøndelag	2,000	3,400	3,400
Sør-Trøndelag	10,980	10,580	10,580
Møre og Romsdal	94,540	124,880	132,470
Sogn og Fjordane	45,320	41,110	45,980
Bergen-Hordaland	47,540	39,890	41,390
Rogaland	186,610	139,860	162,350
Vest-Agder	-	-	7,000
	407,720	472,340	515,890
	(14.9%)		(8.8%)

Source: Bransjeraadet for Sildolje-og Sildemelindustrien 1961; Nordset, 1968.

TABLE 6-7

PERCENTAGE OF REDUCTION PLANT CAPACITIES
BY COUNTY: 1958, 1963, 1967*

(in percentages)

Year / County	1958		1963		1967	
Finnmark	.3)		9.3)		8.7)	
Troms	-)		7.4)		6.4)	
Nordland	4.8)	8.3	7.2)	26.8	6.9)	24.7
Nord-Trøndelag	.5)		.7)		.7)	
Sør-Trøndelag	2.7)		2.2)		2.0)	
Møre og Romsdal	23.1)		26.4)		25.6)	
Sogn og Fjordane	11.1)		8.7)		8.9)	
Bergen-Hordaland	11.7)	91.7	8.5)	73.2	8.0)	75.3
Rogaland	45.8)		29.6)		31.4)	
Vest-Agder	-)		-)		1.4)	
	100.0		100.0		100.0	

* Derived from Table 6-6.

The growth rate for Northern Norway lay below that of the national level for the initial period; but for the second period, it averaged three times the national average.

This poses an interesting question as to whether the raw material base has been the criteria for the growth or if other considerations have been of prime importance. It is hoped to provide a partial answer to this in the subsequent chapters as a significant expansion is now planned and the interesting aspect is whether the developments correlate in space with raw material supply.

6.7. SUMMARY

This Chapter has provided a predominantly non-spatial summary of events which have occurred in the procurement and production sectors of the fishing industry, of which the case studies constitute a portion for the time period, 1960-67. It has posed some questions which will be answered within the text of the thesis, as well as some questions as to future research possibilities.

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CHAPTER SEVEN

THE NORTH SEA AND WINTER HERRING FISHERIES: 1960-1967

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7.1. INTRODUCTION

One of the fundamental problems of any inquiry is that of measurement and it is at this juncture that the difficulties inherent in understanding the nature of fishing arise. The core of the problem is dichotomous: first, the fisherman participates in a number of fisheries or other activities in the period of a year and, second, the raw data representing the activity are available from a number of different First-Hand Sales Organizations*. As a consequence

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* Different First-Hand Sales Organizations exist which have "exclusive rights to control of the first-hand sales of fishery products. Because conditions differ widely from one district to another and since a large number of fish species are involved, it has been found convenient to establish several sales organizations, each with a restricted scope of operation. The activities of [these organizations] are geographically defined, while others are established to handle certain species of fish irrespective of where they are caught or landed." (Nordset and Aasbø, 1959, p.20.)

of point one, an effort is made to clarify the nature of seasonal and yearly links. To accomplish this, two measurement techniques are developed in this Chapter: 1) participation linkage and, 2) factor mobility. The purpose of these measurements is to provide, for the first time, rigorous statements on the problem of the pattern of activity within the fisheries for which data were available. Point two presented another difficulty in that there was a quality difference in the available records and because of this, it was not possible to isolate a complete seasonal pattern of activity for any of the fishing vessels for which different data were also available. The result was that one had only a particular portion of the year's activity accounted for. This fact of seasonal factor allocation created difficulties as it allowed for the possibility of a multiplicity of variables to exist which could not be isolated in a statistical analysis as they lie outside the realm of what is depicted by the available data.

From the above, it is clear that the problem which had to be faced was dichotomous in nature: try to understand two segments of the fishery sector of the economy, which by themselves are not entirely comprehensible without the whole;

or, two, attempt to comprehend the whole, which would not be lucid without a view of the nature of the individual components. Furthermore, the raw data available on the technical innovations discussed in Chapters Three to Five were only accessible with sufficient accuracy in three instances: 1) the innovation (the powerblock and net seine winch); 2) the fish pump and, 3) the transverse thrusters.

The result, then, was that it was decided not to attempt rigorous statistical tests on the impact of the innovation as the value of any conclusions would be dubious at this point of investigation into fishing because current knowledge is of a very preliminary nature. The study was, therefore, focused on endeavouring to understand what was occurring within the North Sea and Winter Herring Fisheries and to gain an appreciation of the interrelationships and measurement problems that are extant. To this end, the spatial assessment of the impact of the innovation presented in this Chapter and Chapter Eight may appear weak to those who see statistics as the sole solution to current research problems. I would, however, remind them that the most important element of statistical analysis lies in the choice of statistical method and the interpretation of the results.

At this point, rigorous statistical analysis did not appear to lend itself to the possibility of the most judicious solution.

The historical view which is presented in this Chapter spans a period substantially larger than the otherwise narrow temporal focus of the study to provide a perspective for assessing recent developments. The North Sea Herring Fishery is an international fishery in terms of its participants, while the Winter Herring Fishery is mainly national.

7.2. PARTICIPATION LINKAGE BETWEEN THE NORTH SEA AND WINTER HERRING FISHERIES

7.2.1. Definition

I have defined the participation linkage as a value derived by dividing the total number of common fishing vessels of one or more fisheries by the total number of fishing vessels in the fisheries under examination. The derived value then is multiplied by 100 to give a percentage value which indicates the extent of the connection between the fisheries under consideration. Implicit in this definition is another concept, that of factor mobility. The latter concept is employed later in this Chapter but, to eliminate possible confusion, I define it here. Factor mobility is a value derived by dividing the fishing boats in year X + N, which are still participating from the year X, by the total active in year X and multiplying it by 100 to obtain a percentage figure. X nominally represents any year while N is an integral number representing the elapsed years from that initially designated as X. N is normally positive to facilitate computation.

A distinction, however, must be made at this point between these two concepts as the former measure represents factor mobility between fisheries in only one calendar year while the latter represents continuity of participation within a particular fishery between years.

7.2.2. The Data

A participation linkage analysis was executed for the North Sea and Winter Herring Fisheries. The results are summarized in Table 7-1. This Table presents the events on the county level and also provides the national position. It was calculated for the years 1964-67 only as no county data on participation were available prior to 1964 for the North Sea Herring Fishery.

TABLE 7-1

PARTICIPATION LINKAGE ANALYSIS FOR THE NORTH SEA
AND WINTER HERRING FISHERIES: 1964-1967

County	1964 Common	1964 Total	1964 %	1965 Common	1965 Total	1965 %	1966 Common	1966 Total	1966 %	1967 Common	1967 Total	1967 %
Finnmark	2	6	33.3	3	8	37.5	2	10	20.0	0	10	-
Troms	18	32	56.3	27	45	60.0	18	48	37.5	7	38	18.4
Nordland	23	56	41.1	34	52	65.4	20	56	37.5	12	50	24.0
Nord-Trøndelag	1	4	25.0	3	9	33.3	3	8	37.5	4	6	66.7
Sør-Trøndelag	21	35	60.0	23	39	59.0	27	36	75.0	22	42	52.4
Møre og Romsdal	30	93	32.3	60	119	50.4	89	150	59.3	117	149	78.5
Sogn og Fjordane	3	16	18.8	8	15	53.3	16	20	80.0	21	22	95.5
Bergen-Hordaland	30	76	39.5	48	76	63.2	68	89	76.4	89	104	85.6
Rogaland	12	26	46.2	15	26	57.7	19	30	63.3	25	29	86.2
Vest-Agder	-	-	-	-	-	-	1	6	16.7	4	5	80.0
Oslo	0	1	-	-	-	-	-	-	-	0	1	-
National Position	140	345	40.5	221	389	56.8	263	453	58.1	301	456	66.0

7.2.3. The Analysis

The pattern reflected by the data in 1964 is difficult to assess. The initial disparities between counties were reduced by 1965 and it was only by the year 1966 that it was possible to discern a spatial trend. This trend depicts a marked increase in participation linkage in the counties south of Sør-Trøndelag inclusive. By 1967, this trend had shifted to include only the counties south of Møre og Romsdal inclusive. One might desire to include in the same category both Nord and Sør-Trøndelag, but here one must remember that percentages are relative measures and that an absolute decline took place north of Møre og Romsdal except for Nord-Trøndelag between 1966 and 1967. The latter was included with the other northern counties as it accounted for a one-vessel increment and the county total was only six vessels. In 1967, then, a division occurred between Sør-Trøndelag and Møre og Romsdal partitioning the country into northern and southern sections.

7.2.4. The Results

In evaluating the initial disparities as shown in 1964, it would seem that they are a reflection of the innovation adoption depicted in Chapter Three. The disparity which existed at that time reveal one interesting point, namely, the location of the manufacturer is important to the adoption for two reasons: 1) proximity in case of repair; and, 2) more important, proximity to the manufacturer which is an important psychological variable in the decision-making procedure as frequency of contact, or the possibility of it, is significant.

Point two may be supported by the fact that the greatest frequency of sales of the innovation unit occurred closest to the manufacturer's location. It may also indicate another possibility, namely, that the first innovation unit acceptances are more dependent on this frequency of contact with the manufacturer than later sales. The reason for this is that subsequent to the initial sales the acceptors would act as propagators and probably be more successful ones than the manufacturer, if they were satisfied with the equipment. The acceptor's strongest influence would tend to be in his immediate action space, primarily his home community and, secondly, the area covered in his pattern of fishing activity. The result of this would be to produce the strongest growth in the proximity of the manufacturer while the point dealing with the proximity to repair, may aid in explaining departures from the general trend of innovation acceptance as depicted in Chapter Three.

Point one is noted to be less important because it is dependent on the fishery in which any particular vessel is actively participating and as there are a number of places along the coasts where repairs might be performed. Both points could, however, only be further substantiated by a sample questionnaire, a difficult thing to conduct in fishing.

Note, then, that three specific areas appear to be important with a view to being centres of innovation spread. These are: 1) Troms-Nordland; 2) Møre og Romsdal and, 3) Bergen-Hordaland. (The third might appear anomalous in view of the location data of the manufacturers presented in Chapter Three, but it was in this area that the innovation was first marketed and the area has since remained in the fore of development.)

If we now consider the division that had developed by 1967, it is possible to suggest two factors which might have contributed to the spatial differentiation: 1) comparative distances between the fisheries discussed here and alternative ones, e.g. the Small and Fat Herring Fishery, the Capelin Fishery or some other form of activity; and 2) the decreasing profitability through the four-year period due to fish stops in 1966 and 1967 in the North Sea Herring Fishery in conjunction with factor (1) (see Chapter Eight for more detail). With reference to the first item, one point must be raised. This is that the distance component is complicated by the question of the duration that fishing operations have been taking place away from the vessel's home port. Item two is affected by item one in a downward spiralling manner for if distance is sufficiently great, it reduced the return per ton and, concommitantly, profit. Therefore, if, for example, the marginal disutility of the North Sea Herring Fishery for a fishing vessel became greater than the marginal utility for the Fat and Small Herring Fishery, a factor shift would occur, thereby reducing profitability even more as time of participation in the North Sea Herring Fishery would be diminished. At present, it is difficult to determine which of the two factors is more important because of their interrelationships and current data availability.

7.3. NORTH SEA HERRING FISHERY

7.3.1. Historical Perspective

7.3.1.1. Pre-Twentieth Century

"Herring has been one of the most important species of fish exploited commercially in the North Sea for many centuries." (Parrish and Saville, 1967, p.409.) Historical records have traced activity in this field to the first century A.D. in both England and Scotland. These initial developments were followed by a growth in herring harvesting by Britain and other countries "to become one of the largest and most famous of all the sea fisheries in Europe." (Parrish and Saville, 1967, p.409.)

Between the 12th and 16th centuries, herring were harvested in the Baltic area and contributed a significant amount to the prosperity of the Hanseatic League. It was the "sudden failure of this /Baltic/ fishery, allegedly due to the migration of the shoals of the Baltic herring to the North Sea, that was largely responsible for the League's decline." (Parrish and Saville, 1967, p.409.) (Note: If one considers current knowledge on population distribution, as presented in Chapter Two, it is not inconceivable that the Baltic Fishery was probably based on a combination of the Atlanto-Scandian and North Sea herring stocks.)

The Hanseatic League possessed the controlling position with respect to herring production from the 13th to the 15th century. It was subsequent to the League's decline that Holland and, later, Britain became prominent in the herring fishery and the related trade; a position they held until the early part of the 20th century (Parrish and Saville, 1967, p.409).

7.3.1.2. <u>Twentieth Century Developments</u>

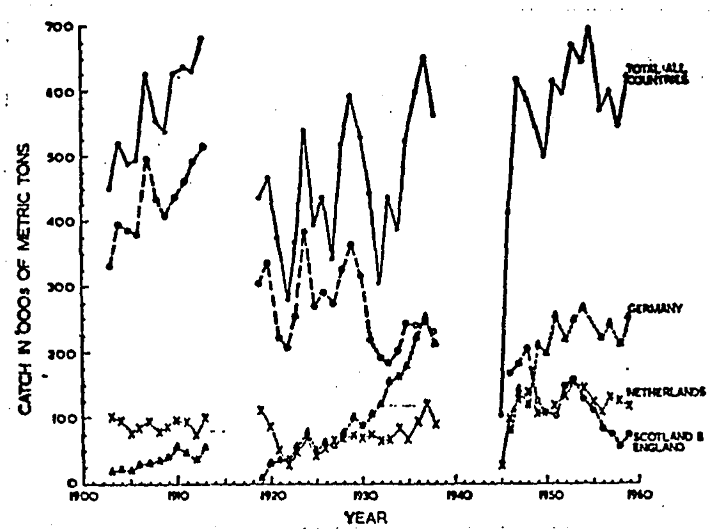
7.3.1.2.1. <u>The Period 1900-1960</u>

The two areas which were exploited by Holland and Britain were: 1) the northwest North Sea off the Scottish East Coast and around the Shetlands and, 2) the southern North Sea off East Anglia and the English Southeast Coast. The former area was harvested from late May to early September and the stocks exploited were members of the Banks and Downs group. The catch from the latter area was based on adult members of the Downs stock for the months of October and November (Parrish and Saville, 1967: cite ICES, 1966).

Prior to World War I at least three-quarters of the total herring landings were made by Britain; Holland ranked second, and Germany a distant third. Figure 7-1

FIGURE 7-1

TOTAL AND NATIONAL LANDINGS OF HERRING
FROM THE NORTH SEA, 1906-1960



Source: Parrish and Saville, 1967, p.411.

summarizes the main events in the North Sea Herring Fishery for the period 1906-60, in terms of landed catch. Briefly, the trends have been summarized by Parrish and Saville (1967) as follows:

> "1) A marked decrease in landings by the British fishery /occurred/. Whereas in the period 1900-13 its landings averaged over 400,000 tons, in the inter-war years they averaged less than 300,000 and, moreover, they fell to about 200,000 tons after 1930.

2) A steady, marked increase in landings by the German fishery to reach, in the 1930's, the same level as the declining British one.

3) A steady but less spectacular increase in landings by the Dutch fishery.

4) An increase in the number of countries participating in the fishery. France and, to a lesser extent, Belgium developed substantial herring fisheries during the 1920's and 1930's."

(Parrish and Saville, 1967, p.410-11.)

7.3.1.2.2. Post-1960

This period should be noted for its dramatic change in national realignment which took place when Norway started to participate in the region. Norway's position has been delineated previously with regard to all other nations in Figure 2-1. (The reader is now referred to this Figure to obtain a review of what occurred between 1960-67.) Note that Norway leap-frogged from a position of insignificance to one of overwhelming dominance in the North Sea Herring Fishery within a very short period of commencement of its activity.

7.3.2. Spatial Pattern of Harvesting

National supremacy has been altered as a result of new fishing techniques developed by the different participating nations. The German trawl replaced the British drift net; and, now, the German trawl has ceded its dominant position to the Norwegian purse seine. Concurrent with the changes in supremacy of a particular nation, associated with the development of new techniques, there has been a change in both temporal and spatial aspects of the fishery, i.e. the fishing season has been lengthened with a concurrent expansion in the area harvested. A summary of the trends is presented in Maps 7-1 and 7-2. (Map 7-2 depicts what has occurred since the introduction of the Norwegian purse seiners. It is a product of a combination of work by Haraldsvik (1968b) and Parrish and Saville (1967).) The feature to note about these maps is that the exploited area has increased to such an extent that at present all areas outside of the territorial limits in the northern area of the North Sea are now completely exploited.

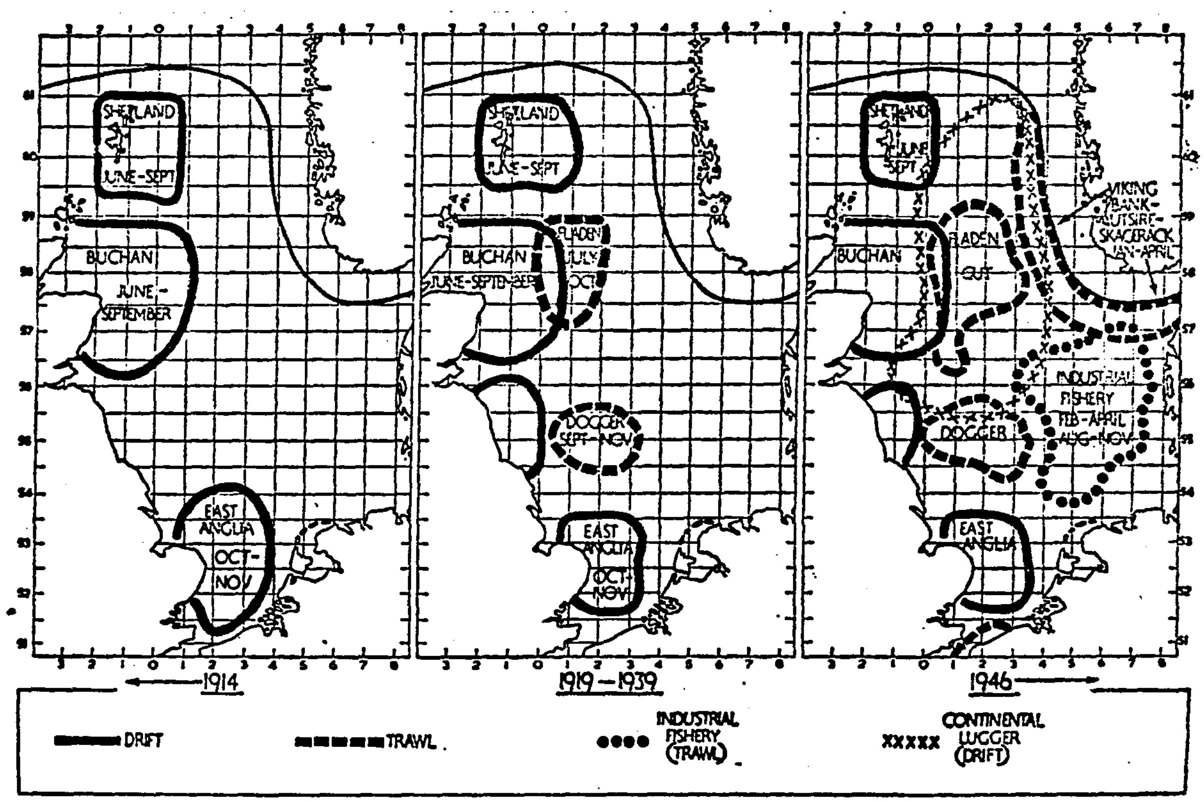
Additional factors may have contributed to these spatial changes. They are:

> "1) A change in the pattern of recruitment in the herring stocks.
>
> 2) A decrease in abundance and increase in the apparent mortality rate of the fully recruited age groups.
>
> 3) A possible decrease in the level of recruitment to the Downs stock."

(Parrish and Saville, 1967, p.419.)

MAP 7-1

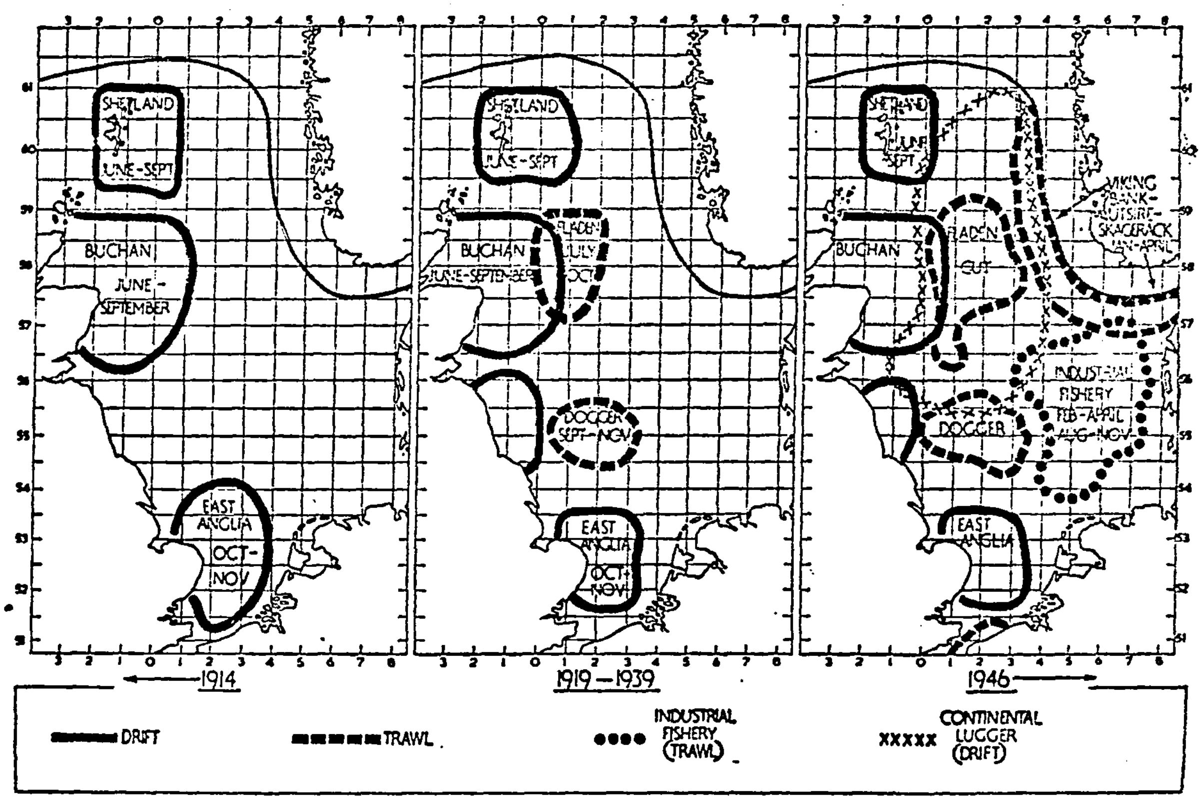
SPATIAL DISTRIBUTION OF HERRING FISHERIES IN THE NORTH SEA



Source: Parrish and Saville, 1967, p.412.

MAP 7-1

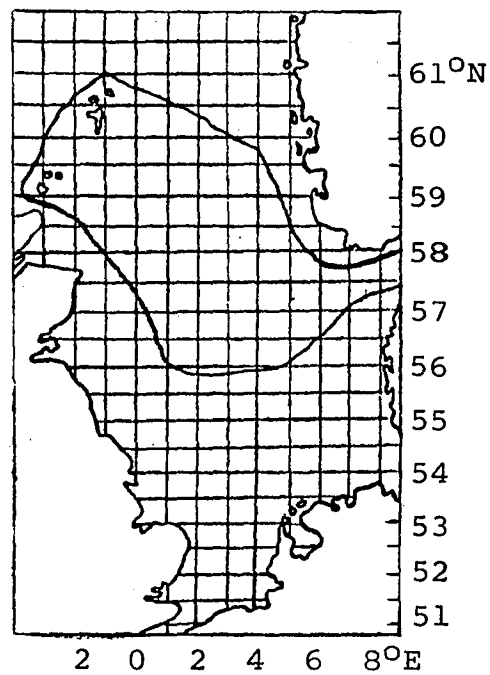
SPATIAL DISTRIBUTION OF HERRING FISHERIES IN THE NORTH SEA



Source: Parrish and Saville, 1967, p.412.

MAP 7-2

AREA OF NORTH SEA HARVESTED BY NORWEGIAN PURSE SEINERS, 1964-67



An interesting aspect is that, with the introduction of new techniques and their associated equipment, (it is worth noting the latter point, i.e. associated equipment, for in examining cause and effect linkages it is difficult to differentiate the effective cause) the northern half of the North Sea has, as far as herring exploitation by the Norwegians is concerned, expanded remarkably to that which has been depicted on Map 7-2. Note, however, that Norway is not the sole participant in the North Sea and, as a consequence, if one superimposes the 1946 map of Map 7-1 on Map 7-2, a considerable overlapping is noted to occur.

What is the significance of this overlapping? The answer lies in that the innovation under study has increased Norwegian contact with foreign nations by increasing the area harvested by Norwegians. Furthermore, the Norwegian manufacturing firms of the innovation are now selling units to competing nations. The effect of this will probably be that "capital investment /will tend/ to be excessive /as it previously has been/ in the nations bordering the North Atlantic. The consummate result of this /as in the past, will be/ a reallocation of fishing effort thus producing intensified utilization [already a characteristic of the Norwegian sector]. The net effect [will be] excessive capitalization, resource diminution and reduction of profit and economic rent." (Christy and Scott, 1965, p.126-127.) If these were the sole consequences, they would represent sufficient problems, i.e. the establishment of an equitable capital goods distribution to the North Sea Herring Fishery for the participating countries and problems relating to the natural resource base - is it being over-exploited? However, there are other elements which come into play. Summarily, the other elements link to political questions such as: the control measures which should be instituted to protect the herring resource, or should it be permitted to be fished out as the Downs stock, which is now disappearing? And, if oil is discovered in the North Sea, what, if any, pollution controls will be instituted? And, what consideration will be given to decide in favour of resource harvesting of not only herring which has long-range economic possibilities over the myopic economic perspective of resource exploitation? A host of other political problems exist but as they are not the prime focus of this study, no further consideration is made in this thesis.

7.3.2.1. Harvested Quantity and Resource Base

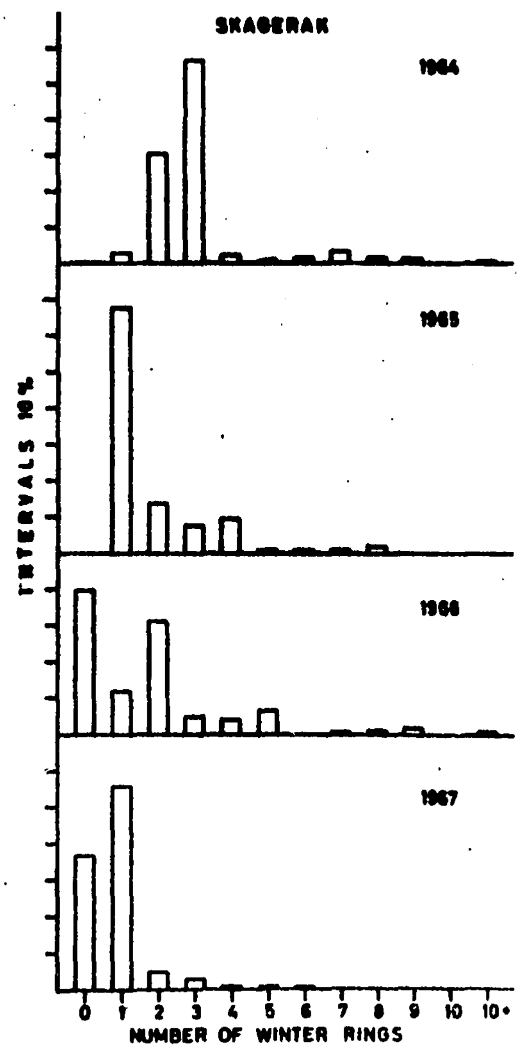
One question was posed above concerning the possibility of over-exploitation of the resource. In summarizing, the trend of landed catch and the area harvested, the question repeats itself. A method of indicating the possibility of over-exploitation is through age composition analysis. (This technique has been discussed in Chapter Two.)

Present indications are that in one of the three areas where the Norwegians have been active (the Skagerak), the mean age of the catch has dropped from 4.0 years in 1965 to between 2.6 - 2.7 years in 1966 and it was reduced again in 1967 (Haraldsvik, 1968b). The pattern of the age structure of the Skagerak catches is reflected in Figure 7-2 which summarizes what has happened. It is difficult to make any assumption about the other two areas, with regard to trend, for though the mean has remained fairly constant, the distribution about the mean has changed. Whether it is significant is difficult to answer because of the lack of current biological knowledge.

The above provides partial verification of one of the aspects raised by Christy and Scott's statement dealing

FIGURE 7-2

AGE COMPOSITION OF HERRING
CATCHES FROM THE SKAGERAK
1964-1967



Source: Haraldsvik, 1968b.

with the nature of capital investment in fisheries, namely, depletion of the natural resource.

7.3.3. Spatial Pattern of Participation

A summary of what has occurred is presented in Table 7-2. This shows participation according to the county of origin. The time period is only from 1964 to 1967, as it was not possible to obtain county data for the years 1962-64.

TABLE 7-2

VESSEL PARTICIPATION BY COUNTY FOR THE NORTH SEA HERRING FISHERY 1964-1967*

County / Year	1964		1965		1966		1967	
Finnmark	4)		3)		3)		-)	
Troms	26)		33)		23)		9)	
Nordland	33)	88	36)	101	23)	78	15)	52
Nord-Trøndelag	3)		5)		4)		5)	
Sør-Trøndelag	22)		24)		25)		23)	
Møre og Romsdal	43)		81)		120)		119)	
Sogn og Fjordane	3)		13)		19)		22)	
Bergen-Hordaland	47)	107	65)	183	85)	255	101)	274
Rogaland	14)		24)		27)		26)	
Vest-Agder	-)		-)		4)		5)	
Oslo	-)		-)		-)		1)	
	195		284		335		326	

*Source: Sild og Brislingsalslaget, 1965-66;
Noregs Sildesalslag, 1967-68.

The initial item to note is the increase that occurred from one vessel in 1962 (see Chapter Six, Table 6-1) to a maximum of 335 in 1966 and a slight drop off in 1967 to 326. The second and most interesting feature is the spatial trend which is represented by the data over the four-year period if one divides that data into two groups: 1) Southern Norway - all counties south of Sør-Trøndelag and, 2) Northern Norway - the counties north of Møre og Romsdal. Initially there is a small regional disparity in participation in the fishery: 107 vessels in Southern Norway and 88 in Northern Norway. This disparity grew in magnitude until 1967 when the difference was 274 to 52 respectively. This variation tends to support the two factors previously suggested by the participation linkage work: 1) comparative distances between the fisheries discussed here and alternatives, e.g. the Small and Fat Herring Fishery or some other form of activity; and 2) the decreasing profitability through the four-year period due particularly to fish stops in 1966 and 1967 in the North Sea Herring Fishery in conjunction with factor (1).

In comparing the spatial-temporal pattern of the innovation with that of regional participation presented in

Table 7-2, the difference is primarily a function of factor (2), in the commencement of the fishery, while it no doubt switches to factor (1) after a certain period of time that the vessel has been away from its home port. This change in the relative importance of factors is interesting as it raises the question of man as a satisfier against the concept of selfless, faceless, rational, economic man, homo economicus. In so doing, it leads to the possibility of this as another line of investigation in future to shed additional light on the nature of fishing.

7.3.4. Spatial Pattern of Landed Catch

The trends exhibited by the landed catch are shown in Table 7-3. The major portion of harvested fish was delivered in Southern Norway with a northerly shift in landed catch for the years 1964-66. A strong northward trend was exhibited in 1965; the reason was the size of the catch that year which was in excess of 600,000 metric tons. The shift in a northerly direction was a function of extant production capacity distribution. Problems existed in Southern Norway due to a delivery glut; therefore, some of the fish landed further south had to be transported northward to unused processing capacity. Even in the best year, however, Southern Norway was overwhelmingly dominant with regard to landed catch for the amount delivered to Northern Norway never exceeded one per cent of the total harvested quantity.

TABLE 7-3

PERCENTAGE OF WEIGHT OF LANDED CATCH OF NORTH SEA HERRING BY COUNTY OF DELIVERY 1960-1966

County / Year	1960	1961	1962	1963	1964	1965	1966
Nordland	-	-	-	-	-	.1	-
Sør-Trøndelag	-	-	-	-	-	.2	.2
Møre og Romsdal	-	-	-	-	.6	12.7	13.4
Sogn og Fjordane	-	-	-	-	.1	7.5	12.6
Bergen-Hordaland	37.2	19.2	10.4	15.3	6.5	17.2	14.7
Rogaland	49.6	52.2	51.2	63.2	86.4	59.8	57.7
Vest-Agder	13.2	28.6	38.4	21.5	6.4	2.5	1.4
	100.0	100.0	100.0	100.0	100.0	100,0	100.0

Source: Norges Fiskerier, 1960, Fiskeristatistikk, 1961-1966.

7.3.5. Factor Mobility

The factor mobility concept has not been examined previous to this research. As this concept was defined earlier, the focus here is on summarizing the events of the study period. The results are presented in Tables 7-4 and 7-5.

TABLE 7-4

NORTH SEA HERRING FISHERY:
FACTOR MOBILITY OF PARTICIPATING FISHING VESSELS,
1965-1967

Year	1965			1966			1967		
County	1965	1964	%	1966	1965	%	1967	1966	%
Finnmark	2	4	50.0	2	3	66.7	-	3	-
Troms	22	26	84.6	13	33	39.4	4	23	17.4
Nordland	27	33	81.8	16	36	44.4	8	23	34.8
Nord-Trøndelag	3	3	100.0	2	5	40.0	4	4	100.0
Sør-Trøndelag	19	22	86.4	19	24	79.2	21	25	84.0
Møre og Romsdal	31	43	72.1	59	81	72.8	101	120	83.3
Sogn og Fjordane	3	3	100.0	8	13	61.5	19	19	100.0
Bergen-Hordaland	36	47	76.6	53	65	81.5	79	85	92.9
Rogaland	10	14	71.4	21	24	87.5	23	27	85.2
Vest-Agder	-	-	-	-	-	-	4	4	100.0

TABLE 7-5

NORTH SEA HERRING FISHERY:
FACTOR MOBILITY OF PARTICIPATING FISHING VESSELS
BETWEEN 1964 and 1967

County / Year	1967	1964	%
Finnmark	0	4	-
Troms	3	26	11.5
Nordland	8	33	24.2
Nord-Trøndelag	2	3	66.6
Sør-Trøndelag	11	22	50.0
Møre og Romsdal	21	43	48.8
Sogn og Fjordane	2	3	66.7
Bergen-Hordaland	27	47	57.4
Rogaland	5	14	35.7
Vest-Agder	-	-	-
Oslo	1	-	-

Three things are evident from an examination of Table 7-4: 1) continuance in the fishery is seldom 100 per cent; 2) where it is highest or 100 per cent, it is normally in a county which is a marginal participant, e.g. Sogn og

Fjordane; and 3) the data suggest the possibility of a distance variable which might be used to isolate two groups - the northern three counties, i.e. Finnmark, Troms and Nordland, and the counties of Nord-Trøndelag and south inclusive.

Item one above is of interest as it provides a perspective on the magnitude of the factor shift within a particular fishery from year to year. Item two is relevant, particularly in the case of Sogn og Fjordane, as this county is one of the most economically backward of Southern Norway's counties, and it delineates a common property of this type of region. This is that it tends to exhibit a stronger or disproportionate regional specialization when compared with the other counties. (Note: Finnmark was not chosen to illustrate this point as the factors previously isolated in the participation linkage analysis and the spatial pattern of participants have had sufficient influence to prevent this type of statement to be made concerning Finnmark on the basis of the current data.) Item three possibly indicates a more equitable interpretation of division delimiting in a very rough sense the significance of a simple measure of distance. It brings to the fore the concept of comparative distance already raised in the participation linkage section and the subdivision in which the spatial pattern of participants was examined.

Table 7-5 presents a factor mobility assessment for the years 1964 to 1967. The reason was two-fold: first, to obtain an impression of the scale of overall turnover for the four-year period, and second, to determine if any new aspects were revealed by this approach. The results were: 1) that the marginal participating areas reappeared and 2) that there has been a significant turnover in the duration of four years.

7.4. WINTER HERRING FISHERY

7.4.1. Historical Perspective

The earliest mention of this fishery goes back as far as the 10th century. Even at that time, the herring played an important role in the coastal economy. Its biological capriciousness was also appreciated then. (Parrish and Saville, 1967).

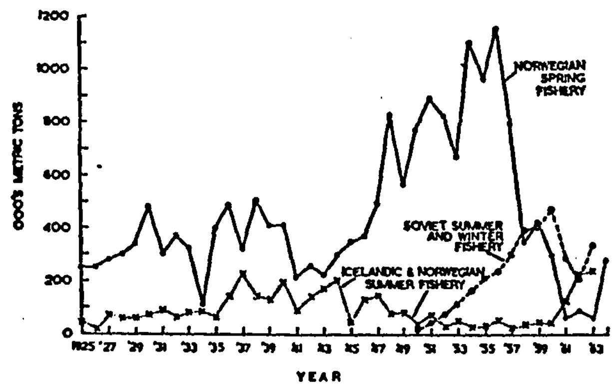
7.4.1.1. Twentieth Century Developments

7.4.1.1.1. Prior to 1960

Through the years three fisheries have exploited the Atlanto-Scandian herring stock, namely: 1) the Icelandic and Norwegian Summer Fishery; 2) the Soviet Summer and Winter Fishery; and 3) the Norwegian Spring Fishery (synonymous with the Winter Herring Fishery). The third fishery was the only one of any consequence exploiting the Atlanto-Scandian stock for the period 1925-58. As stated earlier, the fishing is almost exclusively national with the greater part of the fishing being conducted in the skerrygaard or open sea close to the coast. (Note: Foreign vessels are active outside the territorial limits as the fishery commences sometimes more than 120 nautical miles off-shore - Fiskeridirektøren, Vintersildfisket, 1960-67 - and continues to the territorial limits. A measure of this activity is, however, difficult to acquire.) The catch was divided almost equally between the purse seine and drift net techniques. The harvesting peak of more than 1,100,000 tons of herring was reached in 1956 as was shown in Figure 2-1. After 1956, there was a steady decline. The comparative position of the fisheries, based on the Atlanto-Scandian herring stock for the years 1925-64, is shown in Figure 7-3.

FIGURE 7-3

ANNUAL CATCHES OF NORWEGIAN SPRING SPAWNERS, 1925 - 1964



Source: Parrish and Saville, 1967, p.430.

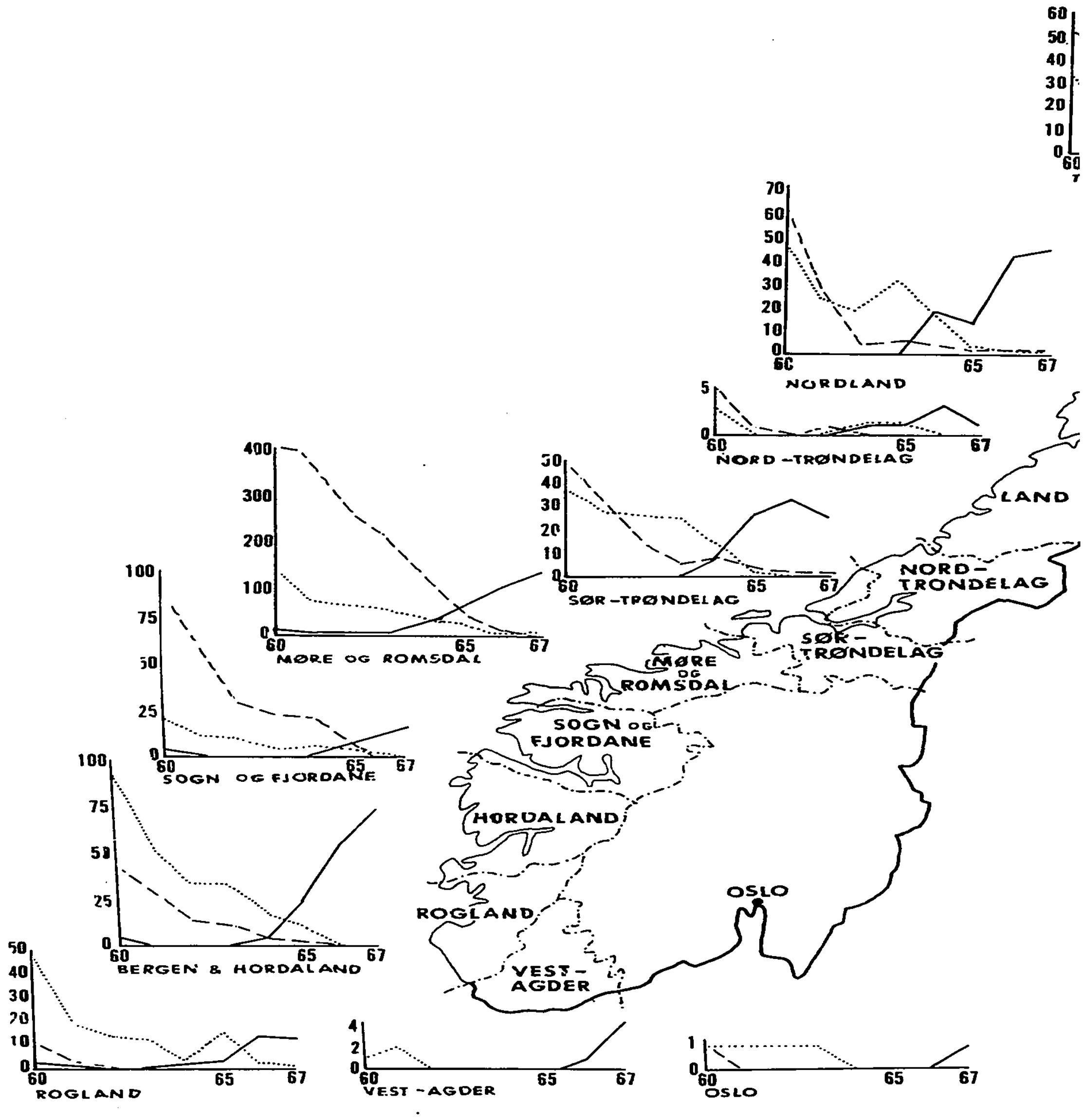
7.4.1.1.2. Post-1960

The decline in catch which had started in the previous decade continued and the quantity of landed catch reached a minimum in 1963, followed by an increase which was depicted in Figure 2-1. This increase can be attributed to the use of the innovation which has enabled harvesting to proceed to greater depths (due to net dimension increases which have taken place because of the innovation and the change in construction material, i.e. from cotton to synthetic materials) and for longer periods of time due to increased weather tolerance.

7.4.2. Spatial Pattern of Participants

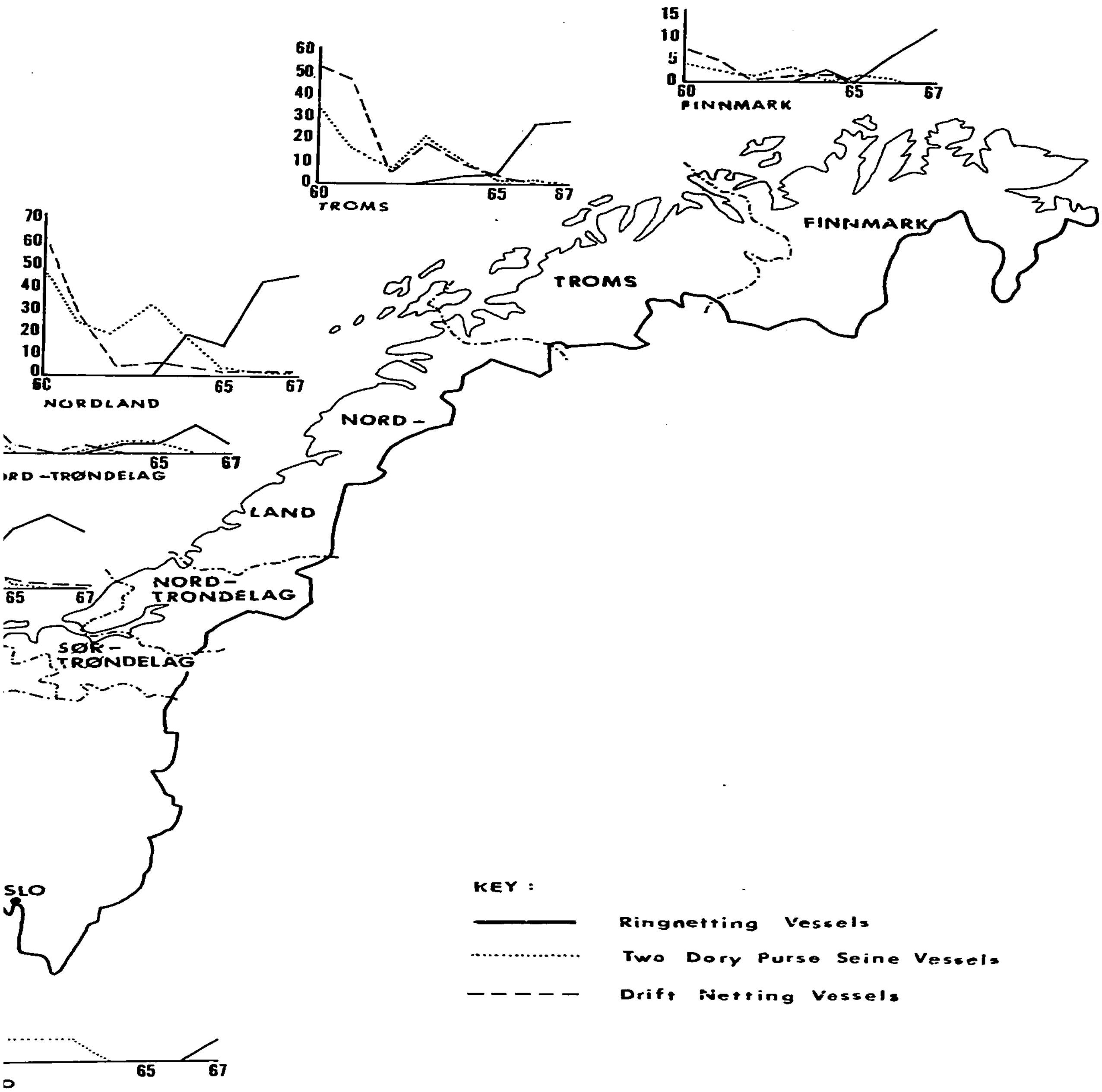
The data on this matter are separated according to fishing technique and are presented in Map 7-3. The thing to note is the marked decline of the two-dory system and drift net techniques in favour of the ringnetting fishing method. This replacement was so strong that it had completely eliminated the two-dory system and had substantially reduced the drift net harvesting technique by 1967.

The total number of vessels for each year over the period has varied from a peak of 1156 participating fishing vessels in 1960 to a minimum in 1965 of 274 boats, and then a rise to 349 boats in 1967. The decline which has taken place is important: a total of 807 fishing vessels. The magnitude of this decline is appreciable for an eight-year period and associated with this has been a significant labour reduction. The contraction has been in the order of magnitude of 12,600 men. (The rationalization which has occurred in the major categories have been summarized in Table 6-4 and the reader is referred to this for additional detail.) The largest portion of employment cut-backs came



MAP 7-3 SPATIAL PATTERN OF PARTICIPAN
HERRING FISHERY BY TECHNI(

After: Fiskeridirektøren – Vintersildfisket, 1960 –1967.



OF PARTICIPANTS IN WINTER
BY TECHNIQUES : 1960 -1967.

rsildfisket, 1960 -1967.

in the purse seine technique because of an increased efficiency which concurrently produced a decrease in the drift netting technique.

One note prior to proceeding: the data solely represents seasonal displacement from the Winter Herring Fishery and not necessarily terminal disemployment, i.e. unemployment. This fact increases the difficulty in discovering the regional effect of the innovation as there is no extant data which indicate what has happened to these men beyond their disengagement from the fishery under examination. The problem at present then is the recurrent metric one which has been mentioned in the introduction of this Chapter. (Note: There is a reason for the use of the term disemployment rather than unemployment as the former only indicates the men's removal from one form of activity, but it states nothing about a subsequent occupation or lack of one, while unemployment presumes that knowledge of the men's activity is known, i.e. no job.)

The above information prompts one question of possible importance: what, if anything, has been done regionally in view of the changes that have occurred? In attempting to answer this question, one is of course stepping into another realm but, to make any decisions on the nature of the action or non-action which has occurred, one must first have a measure of the effective scope of the changes and for this to occur, regional sample surveys would have to be conducted in order to provide some numerical figure on which decisions might be taken.

7.4.3. Spatial Pattern of Landed Catch

The events of the study period are summarized in Table 7-6. The dominance of Southern Norway in the fishery in terms of landed catch, as in the North Sea Herring Fishery is apparent. The relative positions were progressively reduced from 1960 to 1964 at which time 50.5 per cent of the catch was landed in Northern Norway. The percentage, however, decreased from 1964 on and in 1966 it was only 17 per cent. (Note: The division between Northern and Southern Norway in this case is the county line separating Sør-Trøndelag to the north from Møre og Romsdal to the south.)

TABLE 7-6

PERCENTAGE OF WEIGHT OF LANDED CATCH OF
WINTER HERRING BY COUNTY OF DELIVERY
1960-1966

Year County	1960	1961	1962	1963		1964		1965		1966	
Finnmark	-	-	-	-		1.1)		-		-	
Troms	-	-	-	.1)		21.5)		2.2)		1.1)	
Nordland	-	-	-	11.5)	16.0	18.1)	50.7	18.9)	32.2	7.8)	17.0
Nord-Trøndelag	-	-	.1	.9)		1.5)		2.4)		1.8)	
Sør-Trøndelag	-	4.8	6.2	3.5)		8.5)		8.7)		6.3)	
Møre og Romsdal	82.3	91.7	74.9	56.2		41.3		63.6		66.4	
Sogn og Fjordane	17.4	3.5	4.6	5.3		.9		.9		9.9	
Bergen-Hordaland	.3	.0	10.1	16.6		4.4		2.4		4.6	
Rogaland	-	-	4.1	5.9		2.7		.9		2.0	
Vest-Agder	-	-	-	-		-		-		.1	
	100.0	100.0	100.0	100.0		100.0		100.0		100.0	

Source: Norges Fiskerier, 1960; Fiskeristatistikk, 1961-1966.

7.4.4. Factor Mobility

The results of the factor mobility analysis are presented in Tables 7-7 and 7-8. The following things are evident from an examination of Table 7-7: 1) the continuance in the fishery is seldom 100 per cent; 2) there was a marked change in factor mobility between 1963 and 1964; and 3) there is no particular evidence of a distance variable.

Item one is of interest for two reasons. First, it exhibits the factor shift nature of the fishery and, thereby, affirms earlier findings of this Chapter. This stresses the necessity of considering the concept of factor mobility when dealing with fisheries. Second, it indicates the magnitude of annual turnover. Item two is significant as 1963-64 was the year in which a change in the magnitude of factor mobility occurred and it was also the time at which the innovation came into marked use. The reduction in the seasonal shift, between 1964 and 1967, suggests that with the additional capital invested, there has been an attendant specialization, caused by the technical changes, that has necessitated a stronger adherence to one particular part of a seasonal activity. Item three is noteworthy for its

TABLE 7-7

WINTER HERRING FISHERY:
FACTOR MOBILITY OF PARTICIPATING FISHING VESSELS,
1961-1967

County \ Year	1961 1961	1961 1960	%	1962 1962	1962 1961	%	1963 1963	1963 1962	%	1964 1964	1964 1963	%
Finnmark	1	4	25.0	1	1	100.0	1	1	100.0	2	3	66.6
Troms	6	28	21.4	2	8	25.0	7	7	100.0	10	13	76.9
Nordland	12	43	27.9	7	15	46.6	9	14	64.3	24	25	96.0
Nord-Trøndelag	-	1	-	-	-	-	-	1	-	-	-	-
Sør-Trøndelag	22	35	62.9	17	25	68.0	14	18	77.8	15	18	83.3
Møre og Romsdal	68	155	43.9	59	81	72.8	30	77	39.0	28	39	71.8
Sogn og Fjordane	9	22	40.9	7	10	70.0	3	9	33.3	3	4	75.0
Bergen-Hordaland	49	89	55.1	34	54	63.0	22	39	56.4	21	31	67.7
Rogaland	15	38	39.5	13	19	68.4	11	14	78.6	10	11	90.9
Vest-Agder	-	-	-	-	-	-	-	-	-	-	-	-
Oslo	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 7-7 (continued)

County / Year	1965: 1965	1965: 1964	1965: %	1966: 1966	1966: 1965	1966: %	1967: 1967	1967: 1966	1967: %
Finnmark	4	4	100.0	7	8	87.5	4	9	44.4
Troms	23	25	92.0	30	38	78.9	25	43	58.1
Nordland	36	45	80.0	36	50	72.0	35	50	70.0
Nord-Trøndelag	1	2	50.0	4	7	57.1	4	7	57.1
Sør-Trøndelag	25	32	78.1	27	35	77.1	32	33	97.0
Møre og Romsdal	60	80	75.0	75	99	75.8	110	128	85.9
Sogn og Fjordane	5	16	31.3	4	12	33.3	17	17	100.0
Bergen-Hordaland	27	57	47.4	39	54	72.2	68	72	94.4
Rogaland	8	23	34.8	11	15	73.3	19	21	90.5
Vest-Agder	-	-	-	-	-	-	1	2	50.0
Oslo	-	1	-	-	-	-	-	-	-

TABLE 7-8

WINTER HERRING FISHERY:
FACTOR MOBILITY OF PARTICIPATING
FISHING VESSELS BETWEEN 1960 and 1967

County \ Year	1967	1960	%
Finnmark	2	4	50.0
Troms	8	28	28.6
Nordland	12	43	27.9
Nord-Trøndelag	0	1	-
Sør-Trøndelag	10	35	28.6
Møre og Romsdal	48	155	31.0
Sogn og Fjordane	5	22	22.7
Bergen-Hordaland	23	89	25.8
Rogaland	4	38	10.5

distinct lack of spatial pattern. This poses a question of how distance is assessed in the decision-making process. It also raises the possibility of distance being assessed in different ways depending on the fishery involved.

Table 7-8 has been presented for the same reason as Table 7-5 for the North Sea Fishery; to provide a summary view of events for the whole period. The point to observe is the magnitude of the turnover that has occurred in the eight-year period leaving only 28.1 per cent of the original vessels of 1960 still active in 1967.

This, then, has summarized the events of the study period and combined with that of the North Sea Herring Fishery data provides an impression of the factor mobility. A more complete meaning of this work will only become possible when comparable research for other fisheries has been done and as a result it is not possible to state whether this exhibits the trends for fisheries in general.

7.5. JOINT TRENDS IN LANDED CATCH

This section is concerned with the spatial characteristics of the landed catch of the two fisheries under examination. The joint events are summarized in Table 7-9. The major portion of harvested herring is landed in Southern Norway. The joint trend exhibits a closer similarity to that of the Winter Herring Fishery with Northern Norway having a maximum of 30.5 per cent in 1964, and then having its position eroded to 8.6 per cent in 1966.

The point that the trends of this joint summary of landed catch brings to mind is a comparison of its spatial-

TABLE 7-9

PERCENTAGE OF WEIGHT OF LANDED CATCH OF THE NORTH SEA AND WINTER HERRING FISHERIES BY COUNTY OF DELIVERY, 1960-1966

Year / County	1960	1961	1962	1963	1964	1965	1966
Finnmark	-	-	-	-	.7)	-	-
Troms	-	-	-	.1)	12.9)	.6)	.5)
Nordland	-	-	-	7.5)	10.9)	5.2)	3.9)
Nord-Trøndelag	-	-	.1)5.5	.6)10.5	.9)30.5	.7)9.0	.9)8.6
Sør-Trøndelag	-	4.0	5.4)	2.3)	5.1)	2.5)	3.3)
Møre og Romsdal	78.0	75.6	65.2	36.8	25.1	26.6	40.1
Sogn og Fjordane	16.5	2.8	4.0	3.5	.6	5.7	11.2
Bergen-Hordaland	2.2	3.4	10.1	16.1	5.3	13.2	9.6
Rogaland	2.6	9.2	10.2	25.7	36.0	43.7	29.7
Vest-Agder*	.7	5.0	5.0	7.4	2.5	1.8	.8
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* This also includes Aust-Agder, Vestfold and Østfold as their total contribution was small.

Source: Norges Fiskerier, 1960; Fiskeristatistikk, 1961-1966.

temporal pattern with that of the reduction processing plant capacities (presented in Chapter Six) and its proposed expansion. The difference between the two leads to some very interesting questions: why are the two patterns not parallel in time and space?; and, what is the method by which catch is distributed?. A preliminary answer which is the sole one that can be posited in view of the scope of this research, is that the two fisheries only represent part of the raw material source for the reduction sector. To determine if the developments parallel in time and space, it would be necessary to obtain the spatial pattern of the landed catch of the group previously referred to in Chapters One and Six. If this were done and it were found that the developments were still not parallel in time and space, it would necessitate finding out why this is so.

7.6. SUMMARY

This Chapter has presented two measurement concepts, participation linkage and factor mobility, in order to facilitate cognition of the nature of fishing as an economic activity. In addition, a review of the spatial trends was conducted. This dealt with the spatial-temporal patterns of harvesting, regional participation and landed catch. In so doing, some important points have been raised; the most significant is the seasonal nature of fishing which complicates any work to be carried out when dealing with fishing as it increases the difficulty of measurement because it is an arduous task to isolate a yearly pattern of activity. The result is that it is difficult to formulate concrete statements expressing what has transpired from the currently available measurements as they do not possess the necessary accuracy. More detailed work would, therefore, have to conduct a sample survey to augment the current store of information.

CHAPTER EIGHT

THE EFFECT OF THE INNOVATION ON TWO OF THE ECONOMIC GEOGRAPHIC CHARACTERISTICS OF THE CASE STUDIES

CHAPTER EIGHT

THE EFFECT OF THE INNOVATION ON TWO OF THE ECONOMIC GEOGRAPHIC CHARACTERISTICS OF THE CASE STUDIES

8.1. INTRODUCTION

This Chapter deals with two aspects of the North Sea and Winter Herring Fishery: 1) rate of return per ton per fishing vessel and 2) employment. In working with the first item, averages were used for three reasons: first, it was thought that if there was a meaningful difference in income between the innovation vessels and the non-innovation vessels that this would be evident in the values of the rate of return in each of the three categories; second, no analysis of the distribution about the mean was used as the primary objective was to see what the aggregate effect had been, and, third, the vessels were not divided into specific size categories so that the meaningfulness of the nature of the distribution about the mean at this preliminary stage would be dubious. In dealing with item two, the purpose was to provide a set of alternate values of employment to those presented in Chapter Six, which were based on government data, for the analysis of this Chapter is founded on data from the First-Hand Sales Organizations.

It was not possible to assess the role of each innovation quantitatively because of data limitation; furthermore, it would not have been desirable to do so for though a good correlation would, in all probability, be found between sonar units and the rate of return, the causal link relating the two parameters would be weaker than that between the rate of return and the innovation (the powerblock and net seine winch). Because of the foregoing, the innovation was selected as the delimiting parameter for the analysis.

To this point, the inquiry has been conducted on the county level of spatial organization. It would have been possible to lower the level of inquiry to that of the township but this was not done for three reasons: 1) it was hoped that a preliminary study of this nature would elucidate any significant spatial variations or trends and, thereby, provide an insight into avenues for future research; 2) the earlier part of this work was focused on the county as the fundamental unit of spatial organization and it was thought to be desirable to maintain a consistent framework, and 3) there were major township revisions in the years 1964-65, thus increasing the difficulty of spatially collating the available statistical data.

One word of caution prior to proceeding: this is that the rate of return per ton is an aggregate measure encompassing, but its nature, the effect of all the technical apparatus on board the fishing vessel as well as the personnel and it also provides a reflection of environmental influences. Furthermore, the figure only represents part of a year of activity. The implications of this seasonality have been discussed in Chapters One and Seven but there is one more aspect to be dealt with. This is that the duration of each seasonal fishery is not the same each year. This creates an additional complexity. The reason that the extant data were not utilized is that they were a product of a stratified sample according to vessel sizes (length) which showed that a difference of as much as 20 days in duration of participation between different vessel size categories existed in any one year for the same fishery and the same differences were extant within the same category between years. The effect of this was to not attempt a rate of return per ton per day calculation but, rather, to isolate this as one of the considerations that must be incorporated into future work.

8.2. STATISTICAL DATA

Four sources were data imputs for the analysis of this Chapter:

1) The powerblock and net seine winch manufacturers (see Chapter Three).

2) The Herring and Sprat Sales Organization (Sild og Brislingsalslaget).

3) Noregs Herring Sales Organization (Noregs Sildesalslag).

4) Register for Norwegian Fishing Vessels (Register over Merkepliktige Norske Fiskefarkoster).

Number one provided the information previously summarized in Chapter Three. Numbers two and three provided the participation lists and gross income figures for the years 1964-67 of the North Sea Herring Fishery and 1960-67 for the Winter Herring Fishery. Number four was used to obtain the vessel specifications of the fishing vessels listed by two and three.

On the basis of these four sources, one common list for each county of annual participation was compiled to cover the study period 1960-67. The list totalled 961 vessels of which 48 were eliminated as they had no tonnage data. Included in this were fishing boats which had altered their capacity due to reconstruction during the period, and they were, therefore, classified as new vessels. The innovation (powerblock and net seine winch) data were added to the list. The total number of power-block vessels obtained for the period was 406. It will be noted that this is less than the total number of units allocated to fishing vessels as presented in Table 3-2, which was 468. The reason for this difference is twofold: 1) some vessels have had as many as three different units of the innovation*; and 2) some vessels had their capacity altered**. The vessels with altered capacities were dealt

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* There are two reasons for this: 1) larger, more powerful and better models were developed; 2) the earnings and/or loan conditions were sufficiently favourable to permit the purchase of a new unit shortly after the initial unit had been acquired. The link between these two is that the innovation made possible such an auspicious rate of return, coupled with loan capital, to permit propitious depreciation rates with a good return on capital.

** It was assumed that all changes occurred at the turn of the year. This, though most probably not the case, was done as no other data were available.

with as new vessels and in so doing it happened that the innovation unit was counted twice, on some occasions; but, because the objective was to determine the total number of purse seiners with the innovation unit over the period, this consideration was ignored. Because of this approach, the difference is probably not as marked as it might have been as the two trends are compensating.

8.3. STRUCTURE OF THE ANALYSIS

The analysis is focused on the changes which have occurred in one economic characteristic of the fisheries under observation, namely, the rate of return per ton for participating fishing vessels. To achieve this purpose, the data are stratified as follows: 1) all participating vessels; 2) non-innovation vessels; and 3) innovation vessels*.

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* The limits of this group have had to be set so that irrespective of a unit's installation date during the year the vessel did not become a member of this category until the year's end. This was done as there was no way to separate income data before and after the installation of the unit. Such a delineation, however, may produce errors but in view of the lack of a superior method of separation, this had to be accepted despite the possibility of it skewing the results of the non-innovation vessel group. In the year of adoption, a vessel was considered a member of the all vessels category only insofar as determining the average value for the three categories.

An ancillary aspect was to assess the employment within each fishery and to see what the changes had been in this aspect when compared with the data which were presented in Chapter Six because the data source for this Chapter is not the same. The difference in vessel participation between the two sources is shown in Table 8-1. The government statistics, which formed the basis for Chapter Six, are based on the inspector's office, which is set up for control of the Winter Herring Fishery and submits a final report each year, while the latter's list comprises all vessels which have delivered at least 50 hectolitres to the First-Hand Sales Organizations. The government statistics department attributes the difference to the fact that the vessels delivering smaller amounts of winter herring are not primarily occupied in that fishery and, therefore, do not report to the inspector's office as their catches are sporadic. The sales organization data are examined here in order to delimit the range within which the actual employment in the purse seine category would fall, thereby providing a better impression of the effect of the innovation.

TABLE 8-1

COMPARISON OF NUMBER OF PARTICIPATING FISHING VESSELS IN THE WINTER HERRING FISHERY BY SOURCE

Year	Noregs Sildesalslag	Government
1960	415	439
1961	213	244
1962	180	187
1963	146	198
1964	284	180
1965	318	194
1966	382	294
1967	417	339

8.4. NORTH SEA HERRING FISHERY

8.4.1. Economic Attribute - Rate of Return

8.4.1.1. National Level

A summary of the events in this fishery for the period of available statistics is presented in Table 8-2. There are three things to be noted from this Table: first, the consistently higher rate of return per ton for the innovation vessel category; second, the marked decrease in economic return for all groups after 1965; and, third, the closing of the gap between the three categories by 1967.

TABLE 8-2

RATE OF RETURN PER TON FOR FISHING VESSELS PARTICIPATING IN THE NORTH SEA HERRING FISHERY: 1964-1967*

Year	All Vessels	Non-Innovation Vessels	Innovation Vessels
1964	1510	1250	2900
1965	3110	2470	4120
1966	2000	1750	2170
1967	960	960	970

* Values are in kroner per ton.

One point must be considered prior to explaining the extant variation. This is that it was thought that a unit of the innovation was fundamental to entry into the North Sea Herring Fishery. Unfortunately, the basis for this assumption is not known. In conversation with a net boss on one of the innovation vessels, he stated that for a long time there had been speculation that the oceanographic currents in the North Sea were too strong to permit exploitation of the herring resources by the two-dory system. It was discovered, however, that subsequent to fishing in the North Sea, this was not the case; therefore, it may be that the two-dory system actually operated in the North Sea for a while.

With the above consideration in mind, one can proceed to explain the variation. Item one may be accounted for by the fact that the innovation was new in the beginning of the period and all did not possess it. If one does not accept the above consideration as valid, the non-innovation vessel category would have to be eliminated and the difference between the all vessels and the innovation vessel groups could be attributed to two factors: 1) the difference in the type of units in operation; and, 2) the differential in operating skills necessary for more efficient utilization of the innovation unit. Point two was probably more important at the outset while point one may be the reason for any variance which might now be found in the innovation group.

Item two is primarily a function of government fish stops (previously discussed in Chapter Six). The drop in the rate of return was marked. Decreases ranged from a factor of two and a half for the non-innovation vessels, going from 2470 kroner in 1965 to 960 kroner/ton in 1967, to three for the all vessels category, the drop being from 3110 kroner to 960 kroner/ton from 1965 to 1967, and a factor in excess of four times in the innovation category where the drop was from 4120 to 970 kroner/ton. This occurred in a period of three years. The government fish stops which had primarily been instituted to reduce fishing intensity due to production capacity difficulties and the world market situation in the herring meal and oil market, had a secondary effect which tended to further diminish income. The way this happened was that it changed the relative positions of the factor utility of the North Sea Herring Fishery with that of other fisheries, e.g. the Fat and Small Herring Fishery. The consequence was that when the level of marginal utility of the North Sea Herring Fishery became lower than that of the competing resources, a factor shift transpired. (The level of rate of return at which this occurred it is not possible to indicate due to data limitations.) The result of the factor shift was a further reduction in the rate of return for the North Sea Herring Fishery for two reasons: 1) dual participation was not possible; 2) the better vessels, in all probability, were the first to diagnose the trend and in departing they left the poorer vessels which would tend to reduce the mean for the various categories.

Item three may be attributed to the fact that all vessels had the innovation by 1967, if the consideration put forward is accepted. If the consideration is rejected, the reason for reduction in between group differences may be: 1) a reduction in the differential operating skills between the different categories; 2) the departure of the better vessels for other fisheries. Both of these would tend to reduce the inequality. Point one raises an interesting possibility for it suggests that in the aggregate, it may not make much difference as to which type of innovation unit is employed. The answer to this speculation would, however, have to be subject to further study.

8.4.1.2. County Level

The events on the county level of spatial organization are presented in Table 8-3. The main feature is the

TABLE 8-3

RATE OF RETURN PER TON FOR FISHING VESSELS PARTICIPATING IN THE NORTH SEA HERRING FISHERY BY COUNTY, 1964-1967*

County / Year		1964 No. of vessels	1964 Rate of return	1965 No. of vessels	1965 Rate of return	1966 No. of vessels	1966 Rate of return	1967 No. of vessels	1967 Rate of return
Finnmark	AV	4	20.7	3	32.1	3	4.7	-	-
	NIV	4	20.7	2	21.9	2	1.3	-	-
	IV	-	-	1	52.7	1	11.5	-	-
Troms	AV	27	11.9	33	22.7	23	9.1	9	4.0
	NIV	22	12.5	14	20.1	8	10.6	3	.9
	IV	5	8.9	19	23.9	15	8.2	6	5.6
Nordland	AV	32	17.5	36	24.0	23	4.3	15	2.0
	NIV	24	14.4	15	18.2	8	7.7	6	3.1
	IV	8	26.8	21	28.1	15	2.5	9	1.2
Nord-Trøndelag	AV	3	39.0	4	58.3	4	45.5	5	8.8
	NIV	2	20.7	1	1.1	1	22.5	1	1.9
	IV	1	75.7	3	77.4	3	53.1	4	10.6
Sør-Trøndelag	AV	22	18.8	23	48.3	25	21.6	24	6.7
	NIV	17	9.7	11	31.7	9	15.7	9	5.3
	IV	5	49.7	12	63.6	16	24.9	15	7.5
Møre og Romsdal	AV	42	11.1	81	25.5	115	20.0	117	9.9
	NIV	39	10.9	61	24.3	54	18.7	30	10.6
	IV	3	13.8	20	29.2	61	21.1	87	9.6

TABLE 8-3 (continued)

Year / County		1964 No. of vessels	1964 Rate of return	1965 No. of vessels	1965 Rate of return	1966 No. of vessels	1966 Rate of return	1967 No. of vessels	1967 Rate of return
Sogn of Fjordane	AV	3	11.9	12	42.8	19	27.6	22	11.3
	NIV	3	11.9	11	39.4	8	27.5	7	9.7
	IV			1	80.4	11	27.7	15	12.0
Bergen-Hordaland	AV	45	17.3	64	41.3	86	24.5	102	98.0
	NIV	38	14.2	32	27.6	29	17.5	29	8.1
	IV	7	34.1	32	55.1	57	28.0	73	10.5
Rogaland	AV	14	8.8	24	20.1	28	19.7	26	15.9
	NIV	13	8.9	22	19.2	11	17.0	3	53.9
	IV	1	8.0	2	29.7	17	21.5	23	11.0
Vest-Agder	AV	-	-	-	-	4	22.2	4	9.6
	NIV	-	-	-	-	2	37.7	1	.5
	IV	-	-	-	-	2	6.7	3	9.2
Oslo	AV	-	-	-	-	-	-	1	8.3
	NIV	-	-	-	-	-	-	1	8.3
	IV	-	-	-	-	-	-	-	-

AV = All Vessels NIV = Non-Innovation Vessels
IV = Innovation Vessels

* Rate of Return is measured in kroner x 10^2

consistently stronger position of the innovation group over the two categories, in all but a few instances. The reason for the weaker position of the innovation category in certain counties such as Nordland in 1966-67 is a function of three variables: 1) a decreasing rate of return through the years; 2) the possibility of resource substitution, i.e. the Fat and Small Herring Fishery; and, 3) the measurement problem in structuring the limits of the innovation which might tend to decrease its value.

One additional feature of this Table is the similarity between it and Table 7-4, which presented a factor mobility assessment for the North Sea Herring Fishery. The common property of these tables is the spatial variable, suggested by the figures of Table 7-4, which now reappears in Table 8-3. This lends strength to the concept of comparative distances between fisheries as being significant in trying to understand participation patterns that exist within fisheries.

8.4.2. Employment Attribute

A summary of employment is presented in Table 8-4. Two elements must be noted prior to a consideration

TABLE 8-4

EMPLOYMENT IN THE NORTH SEA HERRING FISHERY: 1964-1967*

County \ Year	1964	1965	1966	1967
Finnmark	80	51	51	-
Troms	495	489	325	126
Nordland	568	531	325	219
Nord-Trøndelag	51	53	53	64
Sør-Trøndelag	395	352	356	345
Møre og Romsdal	813	1460	1751	1557
Sogn og Fjordane	60	231	281	305
Bergen-Hordaland	837	992	1207	1383
Rogaland	271	462	407	313
Vest-Agder	-	-	62	53
Oslo	-	-	-	20
	3570	4621	4818	4385

* Calculated on a basis of innovation data previously presented in the text.

of this data. Point one has been raised previously in this thesis, namely, that the figures represent only seasonal employment because of the nature of fishing. Point two is concerned with the nature of the fishery as a consequence of the adoption of the innovation. This is that the species fisherman - in this case, the herring fisherman - has been converted to the methodological fisherman, i.e. ringnet fisherman. The latter tends to operate on an annual basis in a variety of fisheries rather than a seasonal basis as the former tended to do. The data in Table 8-4, therefore, may provide some estimate of men employed in ringnetting. The drop in employment from about 4800 to 4400 between 1966 and 1967 is a reflection of the affect of the fish stops imposed by the government. This, however, one must realize is only disemployment from one fishery not necessarily permanent disemployment from fishing.

.ne total employment may not be entirely correct for 20 men were allocated to each vessel with no innovation unit while 11 were allocated to the other vessels. This might produce an inflated value for the assumption was made that if the vessel did not possess a unit of the innovation then it was operating with the two-dory system in the North Sea. This may, however, not be correct for two reasons: 1) that provided in the "National Level" subsection; and, 2) it was not possible to obtain dates for all powerblock sales. One additional reason for an inflated value was that there were still some vessels allocated 20 men in 1967 on the basis of the innovation data; but, by 1967 adoption was virtually complete as the earlier innovation units were starting to be substituted for other models and for this reason the values might be high.

The information is presented here, despite its possible shortcomings, to provide some impression of employment scale within the North Sea Herring Fishery and, as such, it is useful until more accurate figures are available. No elaboration on spatial aspects concerning employment is made as the data is a result of the material presented in the rate of return section. One point, however, must be raised and this links with why no elaboration on spatial trends has been made, namely, the variation in the number and specifications of participating units from the different counties.

8.5. WINTER HERRING FISHERY

8.5.1. Economic Attribute - Rate of Return

8.5.1.1. National Level

The events of this period 1960-1967 are presented in Table 8-5. The most striking overall feature is the low rate of return at the beginning of the period with a minimum

TABLE 8-5

RETURN PER TON FOR FISHING VESSELS PARTICIPATING IN THE WINTER HERRING FISHERY: 1960-1967

Year	All Vessels	Non-Innovation Vessels	Innovation Vessels
1960	550	550	-
1961	210	210	-
1962	380	380	-
1963	370	364	490
1964	1080	1000	1700
1965	1040	860	1340
1966	1730	1530	1850
1967	890	790	930

occurring in 1961 at 210 kroner per ton and remaining at this comparatively low level until 1963 by which time it had risen to only 370 kroner per ton. In 1964, there was a marked increase to 1080 kroner per ton and the maximum level was attained in 1966 at 1730 kroner per ton. (Note: These figures refer to the all vessel category.) The absolute magnitude of the change, for the duration of the study period, was in the order of eight times the 1961 minimum. This represented an increase in excess of 1500 kroner or the equivalent of more than 210 dollars per ton for each vessel.

In comparing this table with Table 8-2, one observes that two of the aspects of that table are reflected in Table 8-5: 1) the consistently higher rate of return per ton for the innovation vessel category; and, 2) the closing of the gap between the categories by 1967. The reappearance of these trends is interesting as it provides an affirmation of what happens to one aspect of a fishery, i.e. the rate of return, as was explicated for the North Sea Herring Fishery. The drop which occurred from 1966 to 1967 was a function of two variables: 1) a smaller total catch - a result of poor weather; and, 2) a larger number of participants.

The meaning of the change in the rate of return is better understood when the per ton value is multiplied by the average vessel tonnage to provide the average income value-increment shown in Table 8-6. (Note: The average vessel capacities utilized are interpolated values from the

TABLE 8-6

AVERAGE INCOME VALUE OF THE AVERAGE PARTICIPATING FISHING VESSEL IN THE WINTER HERRING FISHERY: 1960-1967

Year	Return/Ton	Average Tonnage	Average Income Value*
1960	550	170	93,500
1961	210	177	37,200
1962	380	185	70,300
1963	370	192	71,000
1964	1080	200	216,000
1965	1040	207	215,300
1966	1730	215	372,000
1967	890	222	197,600

* Value in kroner.

averages of 1960 to 1967 based on the assumption that a steady increase occurred through the duration of the period, which may not be the case, but for the sake of the type of illustration presented here, it was thought to be a reasonable assumption.) This shows that the absolute change in gross income from 1961, the poorest year, to 1966, the richest year, for the average vessel was in the order of 335,000 kroner or 47,900 dollars. As noted in the introduction of this Chapter, one must be careful in attributing the increase strictly to the innovation for it is a reflection of all aspects of the fishery harvesting unit, i.e. equipment, crew and a reflection of environmental variables.

8.5.1.2. County Level

The rate of return per ton was calculated for each participating county and the results are presented in Table 8-7. The main feature, as in Table 8-3, is the consistently higher rate of return for the innovation category over two groups in all but a few cases. In Table 8-7, however, the trend of greater disparity between the all vessel and innovation vessel group does not appear as it did in Table 8-3. One reason posited there (when examining Table 8-3) is now applicable, namely, the measurement problem in structuring the limits of the innovation which might tend to decrease the difference. To further understand this variance, additional work would be required.

It is difficult to diagnose a strong spatial trend though there is a slight one showing reduced rates of return for Troms and Finnmark. The years 1965-66 showed a marked

TABLE 8-7

RATE OF RETURN PER TON FOR FISHING VESSELS PARTICIPATING IN THE WINTER HERRING FISHERY BY COUNTY, 1960-1967*

County	Year	1960		1961		1962		1963		1964		1965		1966		1967	
		NOV	ROR	NOV	ROR	NOV	ROR	NOV	ROR	NOV	ROR	NOV	ROR	NOV	ROR	NOV	ROR
Finnmark	AV	4	3.4	1	1.4	1	8.2	3	7.1	4	14.8	8	6.5	9	14.7	8	5.2
	NIV	4	3.4	1	1.4	1	8.2	3	7.1	3	14.7	5	6.7	6	15.5	3	4.4
	IV	-	-	-	-	-	-	-	-	1	15.2	3	6.2	3	13.0	5	5.6
Troms	AV	29	3.3	7	1.4	7	2.6	14	2.2	25	9.3	37	8.2	44	12.4	36	4.6
	NIV	29	3.3	7	1.4	7	2.6	14	2.2	21	9.9	15	7.0	14	11.3	8	5.2
	IV	-	-	-	-	-	-	-	-	4	6.1	22	9.1	30	12.5	28	4.4
Nordland	AV	43	4.3	15	2.0	14	4.6	25	5.2	43	13.8	47	10.5	49	18.3	44	7.3
	NIV	43	4.3	15	2.0	14	4.6	23	5.0	31	12.7	21	6.4	17	13.6	11	6.3
	IV	-	-	-	-	-	-	2	7.9	12	16.7	26	13.8	32	19.8	33	7.6
Nord-	AV	1	7.8	-	-	1	3.8	-	-	1	41.3	6	19.1	6	25.2	5	5.8
Trøndelag	NIV	1	7.8	-	-	1	3.8	-	-	-	-	3	6.9	3	13.7	2	4.4
	IV	-	-	-	-	-	-	-	-	1	41.3	3	31.2	3	36.6	3	6.8
Sor-	AV	34	4.9	25	1.7	18	4.1	18	7.5	31	14.8	33	15.3	32	17.5	35	9.5
Trøndelag	NIV	34	4.9	25	1.7	18	4.1	17	3.1	26	11.8	21	10.5	15	14.7	13	7.2
	IV	-	-	-	-	-	-	1	6.1	5	30.6	12	23.6	17	19.9	22	10.9
Møre og	AV	149	6.0	77	2.5	75	3.6	39	3.6	76	10.7	95	10.6	125	17.6	138	10.7
Romsdal	NIV	149	6.0	77	2.5	75	3.6	39	3.6	74	10.5	79	10.1	63	16.5	50	9.9
	IV	-	-	-	-	-	-	-	-	2	17.2	16	13.5	62	18.7	88	11.1

TABLE 8-7 (continued)

County	Year	1960 NOV	1960 ROR	1961 NOV	1961 ROR	1962 NOV	1962 ROR	1963 NOV	1963 ROR	1964 NOV	1964 ROR	1965 NOV	1965 ROR	1966 NOV	1966 ROR	1967 NOV	1967 ROR
Sogn og Fjordane	AV	22	6.1	10	2.2	9	4.6	3	3.1	12	8.9	13	6.2	17	16.6	22	9.9
	NIV	22	6.1	10	2.2	9	4.6	3	3.1	12	8.9	12	6.2	7	15.1	7	7.9
	IV	-	-	-	-	-	-	-	-	-	-	1	6.3	10	17.5	15	10.8
Bergen-Hordaland	AV	87	6.2	53	2.0	39	3.5	30	3.4	51	8.1	52	9.4	73	19.2	93	8.9
	NIV	87	6.2	53	2.0	37	4.5	28	3.5	47	7.8	23	6.3	17	14.6	21	6.3
	IV	-	-	-	-	2	3.0	2	1.4	4	12.1	29	11.8	56	20.6	72	9.7
Rogaland	AV	38	5.0	19	1.3	14	4.7	11	3.0	23	7.0	15	8.6	21	16.0	26	8.4
	NIV	38	5.0	19	1.3	14	4.7	11	3.0	21	7.3	13	9.1	6	16.2	1	7.0
	IV	-	-	-	-	-	-	-	-	2	4.7	2	5.9	15	15.9	25	8.5
Vest-Agder	AV	-	-	-	-	-	-	-	-	-	-	-	-	2	9.5	3	10.8
	NIV	-	-	-	-	-	-	-	-	-	-	-	-	2	9.5	-	-
	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	10.8

AV = All Vessels
NIV = Non-Innovation Vessels
IV = Innovation Vessels

NOV = Number of Vessels
ROR = Rate of Return

* Rate of Return is measured in kroner x 10^2

increase in the capelin harvest off the northern coast of Norway and this is probably the reason for the reduction in the rate of return. A statement proving this as a possibility for 1967 as well cannot be made as the seasonal catch statistics for capelin of 1967 are not yet available.

The reason for the weaker trend here than previously isolated is due to the Winter Herring Fishery having its central focus, i.e. main harvesting area, further north than the North Sea Herring Fishery. The result is the distances involved are not as large as they were for fishermen who participated in the North Sea; therefore, the distance effect would tend to be dampened.

8.5.2. Employment Attribute

Earlier in this Chapter a note on the marked difference between the official statistics and those obtained from the sales organizations was made. Because of the difference, it was decided to proceed along similar lines to those used with regard to the North Sea Herring Fishery in dealing with allocation and derive values for employment which might be compared with those of Chapter Six.

The results are presented in Table 8-8. The noteworthy feature of this table is the substantial drop which

TABLE 8-8

EMPLOYMENT IN THE WINTER HERRING FISHERY CALCULATED ON A BASIS OF THE INNOVATION DATA, 1960-1967

County	Year	1960		1961		1962		1963		1964		1965		1966		1967	
		NOV	EP	NOV	EP	NOV	EP	NOV	EP	NOV	EP	NOV	EP	NOV	EP	NOV	EP
Finnmark	NIV	4	80	1	20	1	20	3	60	3	60	5	100	6	120	3	60
	IV	-	-	-	-	-	-	-	-	1	11	3	33	3	33	5	55
Troms	NIV	29	580	7	140	7	140	14	280	21	420	15	30	14	280	8	160
	IV	-	-	-	-	-	-	-	-	4	44	22	242	30	330	28	308
Nordland	NIV	43	860	15	300	14	280	23	460	31	620	21	420	17	340	11	220
	IV	-	-	-	-	-	-	2	22	12	132	26	286	32	852	33	363
Nord-Trøndelag	NIV	1	20	-	-	1	20	-	-	-	-	3	60	3	60	2	40
	IV	-	-	-	-	-	-	-	-	1	11	3	33	3	33	3	33
Sør-Trøndelag	NIV	34	68	25	500	18	360	17	340	26	520	21	420	15	300	13	260
	IV	-	-	-	-	-	-	1	11	5	55	12	132	17	187	22	242
Møre og Romsdal	NIV	149	2980	77	1540	75	150	39	780	74	1480	79	1580	63	1260	50	1000
	IV	-	-	-	-	-	-	-	-	2	22	16	176	62	682	88	968
Sogn og Fjordane	NIV	22	440	10	200	9	180	3	60	12	240	12	240	7	140	7	140
	IV	-	-	-	-	-	-	-	-	-	-	1	11	10	110	15	165

TABLE 8-8 (continued)

County	Year	1960		1961		1962		1963		1964		1965		1966		1967	
		NOV	EP	NOV	EP	NOV	EP	NOV	EP	NOV	EP	NOV	EP	NOV	EP	NOV	EP
Bergen-	NIV	87	1740	53	1060	37	740	28	560	47	940	23	460	17	340	21	420
Hordaland	IV	-	-	-	-	2	22	2	22	4	44	29	319	56	616	72	792
Rogaland	NIV	38	760	19	380	14	280	11	220	21	420	13	260	6	120	1	20
	IV	-	-	-	-	-	-	-	-	2	22	2	22	15	165	25	275
Vest-	NIV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Agder	IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	33
			8040		5140		2192		2815		5041		4830		5474		5558

NIV = Non-Innovation Vessel
IV = Innovation Vessel

NOV = Number of Vessels
EP = Employed Personnel

occurred in the years 1960-62 affecting approximately 6000 men directly. After 1962, there was a steady increase in the employment resulting by the end of the study period in an absolute decline of only 2500 men.

In comparing these data with those presented in Chapter Six, one finds that the correct limits for employment probably lie within the limits drawn by selecting the years 1960-63 for the government statistics and 1964-67 from the sales organization data as the upper limit, and the lower limit being defined by choosing the years 1960-63 from the sales organization data and 1964-67 from the government sources.

The relevance of this consideration is seen in the difference column of Table 8-9 for this shows the range within which employment falls; it suggests that an effort should be made in future to standardize the measurement technique so as to reduce the difference. The advantage of a rectification is clear, for in trying to understand the phenomena under investigation, one is aided by accurate data.

TABLE 8-9

MINIMUM, MAXIMUM AND DIFFERENCE VALUES FOR EMPLOYMENT IN THE WINTER HERRING FISHERY ACCORDING TO GOVERNMENT AND SALES ORGANIZATION SOURCES: 1960-1967

Year	Minimum	Maximum	Difference
1960	8040	8800	760
1961	5140	4912	-228
1962	2192	3622	1430
1963	2815	3831	1016
1964	3021	5041	2020
1965	2646	4830	2184
1966	3322	5474	2152
1967	3875	5558	1680

The importance of a more accurate measure is seen when one compares them with the values in Table 6-4. If one uses the latter, one has an absolute reduction of approximately 5000 men while if the values of Table 8-8 are accepted as a valid possibility (and they should be), then the reduction that has taken place has only been approximately

2500 men or half the number calculated from the official statistics. As previously stated, the actual value probably lies between the two presented but the exact order of magnitude is difficult to establish. The reason is that the data which formed the basis for Table 8-9 was the innovation information. This was supplied by the manufacturers and it will be recalled from Chapter Three that only 74 per cent of that supplied could be allocated to vessels.

Now, if we make the assumption that all the two-dory system vessels, classified as such, were converted to innovation vessels, which may most probably be the case for 1967, this would reduce the difference between the values in Table 6-4 and Table 8-9 to approximately 1500 men. One must also be cognizant of the concurrent reductions in the other categories. Depending on which estimate one prefers, the total reduction in employment in the Winter Herring Fishery ranges between 11,300 (where purse seine reduction is 3500) and 12,600 (where the purse seine reduction is 5,000). In any event, the change has been marked.

8.6. SUMMARY

This Chapter has primarily been concerned with the rate of return concept. It has examined how it has varied for the innovation, non-innovation and all vessel categories for the North Sea and Winter Herring Fisheries. In so doing, two further aspects were dealt with: 1) what this innovation had meant for the average fishing vessel in terms of income; and, 2) how government regulation affected the rate of return. The result of this examination was that a spatial variable, namely, the concept of comparative distances between resources was found to be significant in understanding the spatial pattern of activity.

The employment problem was also considered and it provided a further illustration of the effect of the innovation. It depicted the necessity of standardizing the information with regard to participation as this affects a number of other parameters, i.e. employment (which has been examined here), average vessel capacities and the rate of return.

C O N C L U S I O N

CHAPTER NINE

CONCLUSION

CHAPTER NINE

CONCLUSION

9.1. INTRODUCTION

This research has approached the problem of fisheries as one unit, from the resource base through the technical sector, the main emphasis of the work, to a consideration of two economic aspects of the North Sea and Winter Herring Fisheries. The purpose was to create an understanding of the nature of the fisheries under examination by interrelating its various components. This was to provide, for the first time, a measure of the impact of a technological innovation in terms of the rate of return per ton.

This study has produced a number of conclusions and these are summarized under the following sub-headings:

9.2. RESULTS
9.3. FUTURE RESEARCH
9.4. IMPLICATIONS FOR FUTURE RESEARCH

In order to preserve continuity, these categories are divided along the lines of the thesis.

9.2. RESULTS

9.2.1. The Nature of the Biological Resource

The section summarized the spatial and biological characteristics of the North Sea and Winter Herring. In dealing with the spatial attributes, a view of the geographical and temporal mobility of the resource was obtained. This was significant as it illustrated a fundamental difference between fishing and most other forms of economic activity, namely, the possibility of a highly variable resource base. The discussion of the biological characteristics exhibited the nature of the complexities of the interrelationships that exist between the herring and its environment. This raised questions concerning the links between these two aspects which led to the discussion of the historical and extant theories on biological variation.

The result of the presentation was that it brought several points to light: 1) the shortcomings in available knowledge, e.g. the lack of information on variables controlling the pattern of the Atlanto-Scandian herring migration; 2) the biological aspects of herring relevant to harvesting, e.g.

the air bladder aiding in increasing media distinction and, thereby, facilitating location with echo sounders and sonar; 3) the problems of employing catch statistics as indicators of stock availability; and, 4) a measure of the exploitation status of the resource through year class analysis.

The work of this section, then, provided the knowledge about the resource which was necessary to a complete understanding of the fisheries under study. It was oriented towards illustrating the links between the herring and how this related to the types of equipment employed in the harvesting procedure, as was presented in Chapters Three to Five, and a measure which could be employed to indicate the status of the resource, i.e. year class analysis of catch.

9.2.2. Innovation

This division was composed of three chapters summarizing the major technical changes that had transpired in the study period, 1960-1967. The purpose of these chapters was threefold: 1) to describe the operating procedures and functions of the equipment, thereby providing an understanding of what types of apparatus were extant and how they were employed; 2) to examine, where possible, what the adoption rates for the various gear types had been; and 3) to provide cost summaries of apparatus, where possible.

These chapters, then, provided an impression of the magnitude of technical change in three ways: 1) the variety; 2) the rate and, 3) the capital which the various adoptions represented. Point one provided essential and fundamental knowledge. Point two was important because the rate of adoption gave rise to the concept of adoption thresholds. The significance was that it illustrated the possibility of weakening consumer resistance to acceptance of technical change-over time. The consequence of this was twofold: first, this was a favourable aspect, it might permit more rapid change to occur; and, two, this was an unfavourable result, it might mean that excessive capitalization, above that which normally takes place in fishing, could occur while not necessarily increasing efficiency in any way. Point three provided the possibility of calculating a rough estimate of the magnitude of the capital investment on equipment only. This was done by tabulating the minimum and maximum possible expenditures which were found to lie between 458,000 kroner (65,000 dollars) and 1,121,000 kroner (160,000 dollars) per vessel. A working average of 700,000 kroner (100,000 dollars) was employed as a reasonable estimate. This average was multiplied by the total number of innovation vessels isolated by this study - 400 - which provided a total expenditure figure of 280,000,000 kroner (or 40,000,000 dollars). This, then, represents, albeit a probably low figure, the amount invested on equipment for the fishing vessels which have been active in the North Sea and Winter Herring Fishery for the period 1960-67. The importance of the derived figure lies in the insight it provides on the scale of investment with regard to technical equipment. This has previously not been done.

One additional aspect was provided by this section. This was that the innovation unit data were appended to a list of participating fishing vessels for the North Sea and Winter Herring Fisheries and it served as the stratification basis for the rate of return per ton analysis that was presented in Chapter Eight.

9.2.3. Innovation Impact

This section was concerned with first presenting the general non-spatial framework in which these two fisheries related to the fishing sector as a whole. This was done in Chapter Six. The work of Chapter Seven focused on defining two measurement techniques not previously employed in fishing and a review of events dealing with three additional attributes of fishing: 1) harvesting; 2) participants; and, 3) landed catch. The final chapter of this section presented the return per ton accounting for each fishery and an assessment of the events in the employment sector.

Chapter Six presented what had transpired on the national level for the sector of the fishing economy of which the North Sea and Winter Herring Fishery were members, i.e. the purse seine sector. This provides a perspective from which to view the changes that had taken place. The events were discussed on a non-spatial level to provide an overview of the procurement and production sectors. In the examination of the procurement sector, the following points were covered: 1) catch - quantity, value and comparative positions of both fisheries in relation to the whole fishing sector; 2) number of participants; 3) fishing technique - changes in proportionate amount of harvesting by each; 4) vessel capacities; 5) employment; and 6) crew size.

The above depicted the following things. Point one illustrated the dramatic changes which had occurred. Point two exhibited the growth which had taken place in the North Sea Herring Fishery and the variation exhibited by the Winter Herring Fishery. Point three showed the substantial shift to purse seining that had transpired. Point four depicted the overall decrease in total capacity of the fleet while the individual vessels increased in size. Point five illustrated the reduction that had occurred in employment. Point six exhibited the stable employment situation for each vessel.

The production sector was viewed with a point to examine production trends in product terms and also production capacities and how they had altered spatially for the eight-year duration of the study period.

The work of Chapter Seven continued that of Chapter Six but on a spatial basis. In so doing, the first step was the structuring of two methods of measurement which would provide some impression of what the nature of participation was both within and between the fisheries. To this end, the participation linkage and factor mobility concepts were developed which provided for the first time a quantitative statement of what was actually occurring in participation. The North Sea Herring Fishery was then summarized by considering a brief historical perspective against which to assess the scope of current development. The inquiry proceeded from this point to examine the spatial pattern of harvesting which was noticed to have increased substantially in the period subsequent to 1963. This has had an effect on the resource in skewing the population status of the exploited herring stocks and radically modifying that of the Skagerak stock. The number of participants increased rapidly from 1962 to 1966 and a slight drop occurred in 1967. The pattern of landed catch was almost exclusively concentrated in Southern Norway.

A similar approach was applied to structuring the summary of the Winter Herring Fisheries. The historical summary was provided initially but it was not possible to examine the spatial pattern of harvesting as no suitable base map was available on which to depict the spatial harvesting data which were summarized in the official statistics. The spatial consideration of participation was executed for the dominant fishing techniques and exhibited a remarkable drop in the two-dory seining system and driftnetting in favour of ringnetting. An overall decline was also noted. The prime focus, i.e. main harvesting area, though it had been further north than that of the North Sea herring did not correspondingly shift the area of landed catch further north for, exclusive of 1964, the major portion of landed catch was concentrated in Southern Norway.

A joint summary of landed catch for both fisheries completed Chapter Seven and it reasserted the dominance of Southern Norway in terms of landed catch.

Chapter Eight changed the level of spatial inquiry from the macro to the micro scale, going to the county level, to investigate what had transpired by investigating the changes in two measures of economic activity: 1) the rate of return per ton, which has previously not been calculated for participating vessels for any fishery; and 2) the total employment per county. The chapter commenced with a listing of statistical sources and proceeded to a description of the structure of the analysis. The North Sea and Winter Herring Fisheries were examined on the national and county level. The basis for stratification was according to equipment installed, i.e. powerblock or net seine winch. A marked difference was observed between the rate of return for the differing groups with a substantially higher rate of return for the innovation vessels. One additional feature was that the innovation incremented the overall rate of return by more than 60 per cent for the Winter Herring Fishery from 1960 when no units were in use, to 1967 when complete adoption had taken place. (Note: A similar statement was not possible for the North Sea Herring Fishery as there was no substantial fishery previous to the implementation of the innovation in 1962.)

One further item in addition to the various groups exhibiting differing rates of return is the decline which transpired in the North Sea Herring Fishery. This provided for the first time a substantive example of what can happen when government controls are imposed. This decline is, however, only one aspect of its impact. To understand more thoroughly what occurred, another study examining the total linkage of the North Sea Herring Fishery with other sectors of the economy would have to be conducted.

The employment within the fisheries was then assessed and upon comparison of estimates, it was determined that a disemployment of a minimum of 11,300 and a maximum of 12,600 had occurred in the Winter Herring Fishery from

1960-67. No comparable estimate could be made for the North Sea Herring Fishery as it was a new activity; therefore, no meaningful statement could be made concerning disemployment due to acceptance of the innovation.

9.3. FUTURE RESEARCH

In view of what has been established, the following lines are those along which additional research should be guided. All possibilities are not delimited for pragmatic reasons of time and length.

9.3.1. The Nature of the Biological Resource

The result of the biological consideration was that it isolated three fronts on which work should be directed. The problems related to these research frontiers fall under the categories as delineated below.

9.3.1.1. Quantity - Variation Problem

There are three fundamental problems to be investigated: 1) year class occurrence; 2) ichthysporidium; and 3) statistical problem. Point one must be delved into to try and isolate the variables affecting this phenomenon. Point two must be checked to see if any work has been conducted along this line. Point three must be concerned with trying to establish connections between landed catch statistics and harvestable biomass; and, furthermore, to determine to what extent the former is a reliable indicator of the latter.

9.3.1.2. Sustainable Yield Concept

This inquiry is natural.. conducted with the immediately foregoing research work. The element here is to understand in reality, not only in theory, how harvesting at different rates can affect the population structure of the herring specie and to determine what the optimum yield could be.

9.3.1.3. Spatial-Temporal Problem

This problem was dealt with rather extensively in Chapter Two in the review of the historical and extant theories of which Devold's hypothesis is the most recent. The thing that might prove useful is to try to formulate a model which might either substantiate it or try to produce a superior explanation of the reality of events.

9.3.2. Innovation

The topic of technical innovation is complex, as was illustrated by Chapters Three to Five, and provides the possibility of suggesting multifarious specific research problems which require solutions. These research inquiries can be summarized into two main categories: 1) comparative cost efficiency studies of different models of the same type of equipment, e.g. high pressure versus low pressure hydraulic systems; and 2) comparative efficiency studies of selected vessels with known specifications to attempt to isolate the differences between certain defined groups. The significance of a spatial variable might be determined from such an approach.

9.3.3. Innovation Impact

There have been four main problems which have arisen from this consideration and these are as follows: 1) the isolation of different harvesting sectors; 2) the investigation of the spatial pattern of landed catch; 3) the extension of the rate of return per ton type of analysis to other fisheries and append a time variable to it; and, 4) the investigation of the spatial trends of harvesting areas.

Item one is suggested for it now appears that fishermen have been changed from specie harvesters to methodological harvesters who are active in a number of fisheries. By trying to isolate the seasonal pattern of the methodological harvesters, it may be possible to establish definitive and mutually exclusive harvesting sectors in the fishing category of the economy. This could be done in a preliminary fashion by the use of participation linkage to isolate complete patterns of seasonal activity. The academic and practical consequence of such inquiry is enormous for it would allow us to determine what the exact nature of the fishing is. Therefore, if this work proved successful, it would allow for the possibility of delimiting the leading sectors in terms of harvesting units of each fishery. The practical aspect of the latter is that it would provide an excellent information base on which to formulate effective and rational economic policies for both the private and public sectors, e.g. in such things as investment, as well as government policy infringing on other aspects.

Item two is suggested as a line of inquiry which requires immediate investigation, for the results of this study suggest that the spatial pattern of landed catch does not parallel that of the proposed spatial pattern of reduction processing capacity. This poses some important questions concerning what the basis for expansion has been. It is necessary, therefore, to further examine the pattern of landed catch to discover if the data from this work provided a skewed sample.

Item three is probably the most important aspect that this work has produced, as it provides one of the most stable and effective ways of measuring the economic status of the fishery because it takes into consideration the production unit, the fishing vessel, not just total production which does not tend to produce the best understanding of events. The next step in research here is to conduct similar investigations for other fisheries and at the same time, where possible, try and append a time variable. The latter is significant as it will facilitate for the first time a real calculation, not only theoretical measurements of fishing intensity to be obtained.

Item four is one that has received limited attention and this is strange when one considers the political and economic consequences of alterations occurring in this sphere. Work should be focused on having an up-to-date view of what the spatial situation is. Implications of this and other aspects of the present research which lie in the political sphere, extend beyond the limits of the thesis and are, therefore, not discussed.

9.4. IMPLICATIONS FOR FUTURE RESEARCH

9.4.1. Purpose

The material that follows is directed at what requirements must be fulfilled in order to create a meaningful study which takes the investigation of fisheries one additional step, in the spatial sense, than the present inquiry. This is presented for two reasons: first, to provide a framework within which future work should be conducted; and, second, to illustrate the difficulties that would be incurred in order to make this study more spatial than it is.

9.4.2. Method of Approach

The suggested method, it will be noted, follows that of the previous subdivisions of this chapter dealing with future research. The initial step would be to obtain participation lists for the extant fisheries and then try to derive harvesting sectors, that is, try to group the vessels together so that within-group variance is minimized and between-group variance is maximized. The result of this work is that it would provide us with distinct harvesting sectors for which the seasonal pattern of activity is known. Now, in order to examine what the full spatial impact of technological innovation has been, the measurement problem must be examined. This is done in the following sub-section.

9.4.3. Requisite Measurements

In the preliminary stages of an extension of the current work, it would be necessary to have some measurements of the following 25 variables for each vessel:

1) tonnage of vessel
2) type of vessel:
   a) wood
   b) steel
3) age of vessel
4) horsepower rating of engine
5) age of engine
6) fuel consumption per hour of operating at various speeds
7) fuel consumption per fishery
8) catch area
9) quantity of catch
10) landing place
11) number of days active in each fishery
12) income for each fishery
13) expenses for each fishery
14) technical equipment*:

		Yes	No
a)	powerblock or net seine winch	Yes	No
b)	echo sounder	"	"
c)	sonar	"	"
d)	radio telephone	"	"
e)	walkie-talkie	"	"
f)	ADF	"	"
g)	radar	"	"
h)	Decca Navigator	"	"
i)	net type		
	i. dimensional characteristics		
j)	trawl winch	"	"
k)	fish pump	"	"

l)	transverse thrusters	Yes	No
m)	slepebaat	"	"
n)	other	"	"

15) employment
16) days at sea
17) duration between visits home
18) location of home port
19) which vessels departed from fisheries under examination
20) reason for departure
21) what happened to crew
22) distribution of land based production facilities
23) capacity of production facilities
24) people employed in production sector
25) nature of employment**:
    a) sole
    b) main
    c) secondary.

* Numbers of each unit also, where applicable, as well as efficiency ratings for different models.

** This is for both procurement and production sectors.

9.4.4. The Analysis

The preliminary steps in the analysis might proceed as follows. The data on vessel engines, which had been rated in terms of fuel consumption per hour at different operating speeds under fishing conditions and had been rated according to variability of fuel consumption with age, could be coupled with total fuel consumption in order to obtain some estimate of distance covered while at sea. This combined with the total days from port departure to port arrival would provide two figures. Now, subtracting the former from the latter, one can obtain two things: 1) searching time and 2) fishing time.

The second possible step would be to take the value for total number of days per fishery and divide that into the already calculated rate of return per ton which would provide one with the gross daily rate of return. (Note: It is suggested that these calculations be done for gross income figures first and if no significant pattern is discovered, to then attempt a similar approach with net values.) The subsequent step would be to correlate this with the distance value arrived at from the fuel consumption data and see if a pattern emerged. This could then be followed by calculating a rate of return per ton per day per mile by dividing the former by the total number of miles per trip. The figures obtained should then be stratified according to vessel type and age. Additional correlations should be executed to test for pattern.

The above then depicts the general procedure for one form of analysis that might be executed. What would remain to be done would be to further stratify the data in a variety of ways according to the enumerated variables, testing at each step for pattern. There are a number of other methods of approach, such as multiple correlation and regression analysis as well as factor analysis which might be executed but as this section is only presented to orient the reader as to the difficulty of conducting a more elaborate spatial analysis than that presented in this thesis and to provide a conceptual framework for additional research, no more detailed work is presented.

9.5. COMMENT

This subdivision is included to raise two points: first, the necessity of integrating biological knowledge into the immediately foregoing suggested analysis; and, second, to explain the basis for suggesting necessary research in other fields.

In dealing with point one, the reason this was not done was to reduce the complexity of the suggested analysis in its formative stage, but it would have to be included in an advanced analysis, for all the measurements that were listed are functionally related to the natural resource. Point two was raised for the reason that in conducting an inquiry into fishing, it is meaningless to limit the effective scope to only one phase, i.e. the economic, when the value of the results is so largely influenced by the biological aspect. The study, therefore, stresses the necessity for a multi-disciplinary not a uni-disciplinary approach to problems concerning fishing.

9.6. SUMMARY

This final chapter completes the investigation as was set out in the introduction. It has provided a review of the items discussed as well as a number of suggested research topics and a method of approach which would have to be employed if a more rigorous statistical analysis was to be conducted.

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