PERSPECTIVES

Fisheries assessment: what can be learned from interviewing resource users?

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Abstract: Fishers have detailed knowledge of their resources, their environment, and their fishing practices that is rarely systematically collected. We conducted three types of interviews with coastal Newfoundland fishers to identify the range of information available, to see if it could be quantified, and to explore its potential for reconstructing trends within fisheries. These fishers have many terms for Atlantic cod (*Gadus morhua*), each associated with characteristic patterns of seasonal movement and availability to gear and indicating the location of several coastal spawning areas. They described a variety of changes in fishing practice. Of the four changes that could be quantified, all contributed to decadal-scale increases in catch efficiency prior to 1992, while change in catch per unit of effort for cod was consistently negative at decadal scales. For these fishers' lumpfish (*Cyclopterus lumpus*) roe fishery, catch per unit of effort was consistently negative in the 1990s. We describe ways to access the large reservoir of information held by fishers, the use of several cross-checks to identify consistent patterns, and the use of trends and patterns to broaden the basis for interpreting quantitative surveys used in fisheries assessment. Local information from resource users can be assembled in forms usable in quantitative stock assessments.

Résumé : Les pêcheurs possèdent au sujet de leurs ressources, de leur milieu et de leurs pratiques de pêche des connaissances détaillées qui sont rarement recueillies de façon systématique. Nous avons mené auprès de pêcheurs côtiers de Terre-Neuve trois types d'entrevues pour déterminer l'étendue de l'information disponible, voir s'il était possible de la quantifier et explorer son potentiel pour tenter de reconstituer les tendances présentes dans les pêches. Ces pêcheurs possèdent plusieurs termes pour décrire la morue *Gadus morhua*, dont chacun est associé à des caractéristiques particulières des déplacements saisonniers et de la vulnérabilité aux engins de pêche, et ils ont indiqué l'emplacement de plusieurs frayères côtières. Ils ont décrit un grand nombre de changements dans les pratiques de pêche. Les quatre changements qui ont pu être quantifiés ont tous contribué à des augmentations d'échelle décennale dans l'efficacité de capture avant 1992, tandis que le changement dans les captures par unité d'effort (CPUE) pour la morue était régulièrement négatif à l'échelle décennale. Dans la pêche de la lompe *Cyclopterus lumpus* pour les oeufs, pratiquée par ces pêcheurs, le CPUE était régulièrement négatif dans les années 90. Nous décrivons des façons d'accéder au vaste réservoir d'information détenu par les pêcheurs, l'emploi de plusieurs recoupements pour repérer les patrons réguliers, et le recours aux tendances et aux patrons pour élargir la base d'interprétation des relevés quantitatifs employés dans les évaluations. L'information locale fournie par les utilisateurs de la ressource peut être rassemblée sous une forme utilisable pour les évaluations quantitatives des stocks.

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Introduction

Resource users develop detailed knowledge of their resources, their environments, and their fishing practices. This information has long been used by some fisheries scientists as background knowledge (Smith 1994; Hutchings et al. 1997). It is regularly used to generate testable hypotheses (e.g., Taggart and Frank 1987). Resource users' knowledge is rarely collected in a systematic fashion. When it is, highly structured formats (telephone surveys, logbook programmes)

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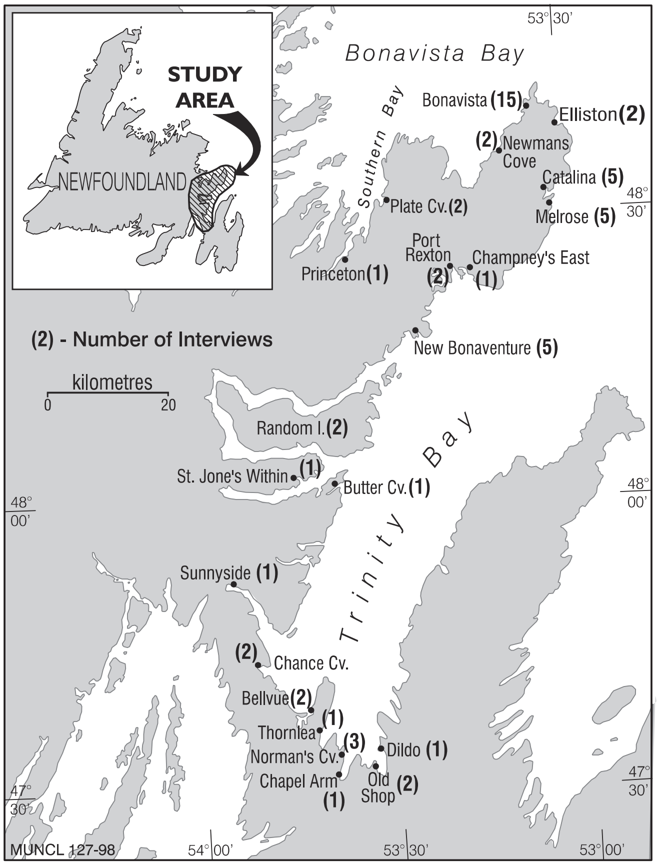


Fig. 1. Study area and geographic distribution of 56 interviews with inshore and longliner fishers.

tap only a limited range of the information present, and programmes often suffer from inconsistent participation. In general, little of fishers' information has been used, relative to what is present or to what might be used in resource management (Berkes 1993; Pinkerton 1994).

Personal interviews with fishers can elicit large amounts of information on both commercial and noncommercial species related to fish behaviour and fishing practices. Hutchings (1996) identified three ways in which information from guided personal interviews could be used in scientific assessments. First, local knowledge of the dates when fish are caught in fixed-gear locations can provide information on seasonal and directional fish movements. Second, fishers can provide information pertaining to stock structure. Fishers can provide information on movement patterns (through catch patterns), spawning grounds (presence of females in ripe and running condition), juvenile habitat (e.g., bycatch of juvenile Atlantic cod (*Gadus morhua*) in caplin traps), and spatial patterns in fish morphology. This information is useful in conjunction with genetic information (e.g., Ruzzante et al. 1996), tagging experiments (e.g., Lear 1984), and morphometric studies used in identifying stocks. Third, catch rate data obtained from fishers have the potential to reflect local changes in fish abundance (Hutchings and Myers 1994). This list of uses can be extended. For example, fishers can provide a full account of their activity and observations including the distribution of effort and changes in fishing practice that need to be examined when catch per unit of effort (CPUE) is used to track stock size. Fishers can contribute to quantitative surveys of abundance, as in acoustic surveys of herring stocks in the Bay of Fundy (Stephenson 1998). Fishers can identify former as well as current spawning areas (Ames 1998). Information from fishers can be used to identify changes in terminal mortality (mortality rate in the oldest age-class), a parameter that is poorly estimated in research surveys and that notoriously leads to overestimation of stock size in assessments based on virtual population analysis or related forms of population reconstruction (Hilborn and Walters 1992).

The body of information held by fishers has an important role to play in fisheries assessment. When this body of information matches scientific assessments, uncertainty is reduced and assessments become more convincing to resource users. When the two sources of information diverge, information from both sources needs to be reexamined (Evans 1996). Yet while this body of information has a role to play, there remain practical impediments to its use. Scientific terms do not match the terms that fishers use to organize their knowledge (Johannes 1993). The geographic range of information from each fisher is limited. Knowledge is unevenly distributed among fishers, being more concentrated among older fishers and skippers. It is largely oral, rather than written, and subject to the effects of memory loss.

We describe a systematic means of assembling and cross-checking information from fishers based on three kinds of interview: one to define terms, one that allows geographically limited information collected by individuals during their careers to be assembled to identify recurrent patterns of change, and one that allows verification, refinement, and updating of information on particular fisheries. To illustrate this approach, we report the results from personal interviews with fishers in the Bonavista and Trinity Bay, Newfoundland, area inshore small-vessel (<35 ft) and nearshore larger-vessel (>35 ft) fisheries (Fig. 1). Our objectives were to (*i*) demonstrate both the amount and types of information that result from personal interviews informed by knowledge of local terms for fish and fishing areas, (2) use this information to document the diversity of changes in fishing practices that had taken place in local fisheries during fishers' careers, (3) determine whether any of these changes in practice could be quantified, and (4) determine whether trends in CPUE can be identified by assembling results from detailed personal interviews.

Methods

This research is based on results from two types of personal interviews and followup telephone interviews conducted with inshore and nearshore fishers living on the northeast coast of Newfoundland. The personal interviews were conducted in the summers of 1994 and 1995, roughly 2 years after the announcement of the moratorium on northern cod, and followup telephone interviews were conducted in December 1995 and 1996. Effectively accessing fishers' knowledge requires shared understanding of local terms for fish and fishing grounds and for fishing gear (Johannes 1993); thus, we began with 10 taxonomy/toponomy interviews. The main body of interviews consisted of personal interviews with 56 local fishers. Followup telephone interviews with a subsample of these fishers were used to supplement data on the lumpfish (*Cyclopterus lumpus*) roe fishery collected in the first set of interviews. Results from the research were presented at local feedback meetings attended by some study participants and some who had not participated in the study. Given the relatively small sample size and the limits of snowball sampling, we do not use inferential statsitics to generalize from these fishers to the larger population of fishers in the area or in Newfoundland as a whole.

The study area included the region between the communities of Princeton, Bonavista Bay, and Dildo, Trinity Bay (see Fig. 1). The area was chosen to capture a range of fishing locations from inner bays to outer headlands and a range of fishing technologies from coastal small boats to offshore vessels, as well as to relate findings to a wider study on the sustainability of coastal communities ongoing at Memorial University of Newfoundland.

Sampling design

Random sampling from a defined list of licensed fishers within the study area was not possible because of the absence of an accurate, up-to-date list of licensed fishers for the entire study area. It is also not recommended for this type of research. Many studies of resource users' ecological knowledge, including our own, employ snowball sampling to identify local "experts." Information is unevenly distributed among fishers, being concentrated among skippers, particularly those with long careers, those who are especially observant, and those who keep records (Mailhot 1993). Snowball sampling generates an ever-increasing set of interviews through a referral process in which interviewees are asked to provide additional, appropriate names for interviewing (Babbie 1989). For the taxonomy/toponomy interviews, we asked local fishers to recommend primarily older, retired fishers distributed throughout the study area. For the main body of personal interviews, we sampled throughout the study area with greater intensity in areas with larger numbers of fishers and concentrated on skippers. The sample was stratified by sector (inshore and nearshore) but weighted towards the inshore, <35 ft vessel sector, which has the largest number of boats in this area. Among those interviewed, fishing experience ranged from a maximum of 60 to a minimum of 12 years (six at 51–60 years, nine at 41–50 years, 13 at 31–40 years, 16 at 21–30 years, 22 at 12–20 years). Most (48) had served as skippers; another five were partners in enterprises without clearly designated skippers. The remainder had either served exclusively as crewmembers or their status in fishing vessels was not indicated in the transcripts. Followup telephone interviews were done with fishers who indicated in the original interviews that they had participated in the lumpfish roe fishery (n = 22).

Interview strategy and questions

Personal interviews were designed and carried out by a team of researchers involving social and natural scientists. At least two interviewers were involved, with one conducting the interview and the second helping the fisher record spatial information and monitoring the schedule to ensure that key areas were not missed. With the written permission of the fisher, personal interviews were taped and subsequently transcribed. They included a mapping component with spatial data recorded on nautical charts with Mylar overlays. Interviews lasted between 1.5 and 4 h and had a semistructured format in that they were guided by an interview schedule but fishers were given the opportunity to introduce information and to guide, somewhat, the course of the interview. Where fishers approved, tapes, transcripts, and digitized maps and Mylars are being archived in the Memorial University of Newfoundland Folklore Archives.

For the taxonomy/toponomy interviews, fishers were shown diagrams of fish and bird species and asked to identify those observed in their areas, provide local names for the species that they were familiar with, and locate, provide local toponyms for, and describe local spawning areas and fishing grounds.

The main body of 56 personal interviews had a career-history format and were guided by an interview schedule. The career-history interviews opened with basic demographics and information on training. Data were collected on all of the licenses held and vessels owned, when they were owned, as well as descriptions of engines, gear, and equipment used on each vessel. The timing of vessel ownership helped fishers reconstruct their fishing careers. Fishers were asked to describe a typical fishing season — species fished, timing, place, gear fished, landings — at the beginning of their careers, at one or two points of change during their careers, and at the end of their careers or just prior to the moratorium. Demographic information and information on fishing licenses, boats, and gear was summarized on a short questionnaire during these interviews. In most cases, the data recorded were from memory. In a few cases, fishers produced personal logbooks, which were then used as well. Career-history interviews provide much contextual information that increases the likelihood of accurate interpretation of responses, and they allow the interviewee to determine, to some degree, the direction of the interview, thereby accessing issues, observations, and interpretations that were not anticipated by the interviewer.

Observations are often correct, even when interpretations differ (Gunn et al. 1988). The main focus of the questioning was on what fishers were fishing for, what they were fishing with, where they were fishing, and what they observed. Interpretations of, for example, trends in fish abundance and causes of those trends were also sought, but these did not substitute for information on actual observations. For a more detailed discussion of fishers' knowledge and alternative methodologies for accessing it, see Neis et al. (1999).

Structured followup telephone interviews were done with a subsample of the original group of fishers who indicated that they had participated in the lumpfish roe fishery. These gathered more precise and more standardized information on catch and effort for this particular fishery and allowed us to update the information on an annual basis for 2 years.

We reported our results at followup meetings with fishers in the region. These meetings allowed us to check our findings with local fishers, including some who were not in the original sample, and provided some additional data. On-the-water discussions with 10 fishers from Melrose and Chance Cove, Trinity Bay, and a resulting coauthored report with these fishers provided additional data on fisheries in these areas and another check on some of the data in the original interviews (Fischer et al. 1997).

Data analysis

Stock distinctiveness is a central component of fisheries assessment. In a mixed-population fishery, small populations with high catchability risk progressive depletion (Hutchings et al. 1993). To assemble information on stock distinctiveness, we documented fishers' taxonomic terms for Atlantic cod and then used these to retrieve and interpret observations on the timing, location, and depth of particular cod fisheries, observations on the timing and direction of cod movements, and observations of cod spawning as indicated by cod with eggs or milt (fishers refer to this as "milk") "running" at the point of capture.

Changes in efficiency are a key piece of information in any fisheries assessment based on catch statistics, so it was of interest to attempt to quantify this change from the interview data. The standard way of quantifying efficiency is

$$C = qVB$$

where C is annual catch (tonnes per year), V is number of fishing units (vessels), and B is stock biomass (tonnes). Vessel efficiency q is called catchability in the literature; it has units of tonnes caught per tonne available, and for a vessel-year, q is percent per vessel-year. Efficiency q cannot be measured directly if catch C is being used to estimate biomass B. The standard solution to this problem is to take the ratio of commercial catch C_{comm} to research vessel catch C_{rv} for the same stock B; hence the product of the catch and vessel ratios will equal the efficiency ratio:

$$(C_{comm}/C_{rv})(V_{comm}/V_{rv}) = q_{comm}/q_{rv}.$$

By holding research vessel efficiency q_{rv} constant from year to year, the product of the catch and vessel ratios becomes a measure of commercial efficiency. Both the catch and the vessel ratios are measured each year. Consequently, several years of data are required to detect changes in commercial efficiency by the standard method of calibrating commercial against research vessel catches. This lag will lead to overestimation of stock size if efficiency is rising (Pope 1977). The need for timely information on trends in effort (qV) has long been known. We examine whether more timely assessments of changing efficiency could be obtained by interviewing fishers directly rather than relying on calibration of commercial and research vessel catches across multiple years.

Information on changes in fishing efficiency was collected from the short questionnaire summary of career-history interviews and checked against the transcripts. This information was summarized in a database. We divided fishers into two sectors: inshore (vessels <35 ft) and nearshore (vessels >35 ft). Three fishers who switched sectors (a third fishing strategy) were removed from the analysis.

Inshore cod fishers were divided into three generations on the basis of their period of entry into the fishery (1920s–1930s, 1940s–1960s, 1970s–1980s) and their careers were divided into three periods: start, middle, and end. This approach allowed us to present both longitudinal and cross-sectional data and to control for a probable tendency for efficiency to increase within generations as a consequence of career-related increases in purchasing power. Average horsepower (n = 38) and vessel capacity (n = 37) were calculated for each generation and each period, along with average number of cod nets (gill nets used for cod) (n = 37) and average number of traps per crew (n = 37). Changes in the total number of gill nets and traps owned by fishers in this sample (1980–1992) were also plotted.

Career length differed among the three generations because of the announcement of the northern cod moratorium in 1992. We quantified change in efficiency, as an annual percentage, for two intervals: start of career (year) to midcareer (year) and midcareer to late career (year of retirement or moratorium). Where data permitted, percent change per year was calculated for vessel capacity (pounds) (n = 26), engine size (horsepower) (n = 29), boat length (feet) (n = 36), cod nets (maximum number of nets at one time) (n = 23), and traps (number owned) (n = 34). For boat length (BL) the annual change was calculated as

$$\Delta\text{BL/year} = (\text{BL}_{mid} - \text{BL}_{start})(\text{BL}_{start})^{-1} \times (\text{Year}_{mid} - \text{Year}_{start})^{-1}$$

and

$$\Delta\text{BL/year} = (\text{BL}_{end} - \text{BL}_{mid})(\text{BL}_{mid})^{-1} \times (\text{Year}_{end} - \text{Year}_{mid})^{-1}.$$

Both annual rates were then plotted against Year_{mid}. Similar calculations and plots were made for capacity, engine size, cod nets, and traps.

Vessel size for longliner (nearshore) fishers ranged from 38 to 64 ft and the main gear was gill nets. Where data availability permitted (seven out of nine fishers), we computed percent change in boat size, horsepower, capacity, gear amounts, and CPUE using the same formula as for inshore data.

Information on landings and changes in CPUE is also important in fisheries assessment. We analysed these data for both cod and lumpfish roe fisheries. For cod, fishers were asked to describe a good, average, and poor season of landings at different phases in their careers and, where possible, to provide remembered real landings for years just prior to the moratorium (n = 35).

We tabulated catches and effort (nets) and then computed change in nets (ΔNets), changes in catch (ΔC), and change in CPUE (ΔCPUE):

$$\Delta\text{Nets} = (\text{Net}_{final} - \text{Net}_{initial})/\text{Net}_{initial}$$

$$\Delta C = (C_{final} - C_{initial})/C_{initial}$$

$$\Delta\text{CPUE} = ((C_{final}/\text{Net}_{final}) - (C_{initial}/\text{Net}_{initial}))/(C_{initial}/\text{Net}_{initial}) = (1 + \Delta C)/(1 + \Delta\text{Net}) - 1.$$

Similar calculations were then made for the lumpfish roe fishery using data from career-history interviews with 22 fishers active in this fishery, supplemented by information from followup telephone interviews. We used the original interviews to examine whether the spatial scale of this fishery increased between 1980 and 1996. Change in CPUE was calculated as a percentage (ΔCPUE) and then taken as an annual rate by dividing by the number of years from the initial to final date. Per annum values were plotted against start date to examine changes in CPUE over time.

Results

Cod stock distinctiveness

The interview transcripts provided several kinds of information relevant to understanding stock structure: information on seasonal locations of cod, the direction and timing of movement, and spawning. Cod are locally referred to as "fish." These fishers distinguished between "capelin fish" and "herring fish." In the Bonavista area, the term "capelin fish" or "fish that come with the capelin" refers to the cod that arrive on the fishing grounds in late May – early June and are associated with the arrival of migrating capelin. These are generally described as "blackbacked" or "sunburnt" and are intercepted by the coastal trap and gillnet fisheries. Most are believed to migrate to the coast from "offshore," but this may include areas of Trinity and Bonavista bays outside the traditional inshore fishing grounds. Consistent with tagging data and based on information derived from tags that they had returned to the Department of Fisheries and Oceans (DFO), these fishers knew that these capelin fish could come from several offshore banks, from deeper areas closer to the Bonavista area, and sometimes from outside the bay.

Tagging research, as well as some landings data, and information on spawning locations suggest that some cod overwinter inshore in the study area (Hutchings et al. 1993; Taggart et al. 1995; Lilly 1996). Information supporting this conclusion came primarily from observations by fishers within Trinity and Bonavista bays, in contrast with those from the Bonavista area. The former refer to "herring fish," which follow herring into the arms and reaches of Bonavista and Trinity bays in the fall, after October, and then overwinter in these areas and disperse in pursuit of migrating herring in the spring (March–May). Herring cod were har-

Fig. 2. Identified locations for winter gillnetting of cod and observed cod spawning aggregations.

vested in deeper (16–24 fathoms, 1 fathom = 1.8288 m) cod traps and in gill nets in the spring and in gill nets when they returned to the arms with the herring in the fall. In the Chance Cove area, a late fall and early winter cod gillnet fishery took place at depths of between 80 and 150 fathoms in the late 1970s and early 1980s. In Princeton (Bonavista Bay), cod would begin moving back into Southern Bay in December and could be jigged and gillnetted through the ice up as far as Charleston until mid-January. Small winter fisheries involving jigging and gillnetting through the ice were reported in Bull Arm, Southwest Arm above Hatchet Cove, and in the Charleston area (Southern Bay), Bonavista Bay (see Fig. 2).

Another indication of overwintering fish was the appearance of smallish trap cod, brownish in colour, that were harvested in certain areas as early as mid-April and May, prior to the arrival of the capelin and the capelin fish. Believed to overwinter in Trinity Bay, these cod were smaller and occupied a different depth (in and around the rocks and kelp) than herring cod. They were harvested in shoal-water traps (8–12 fathoms). Larger, brownish cod have been observed in some abundance in shoal water since the moratorium.

Another term for cod used by fishers, “breeders” or “mother fish,” referred to very large, pale or “white” fish, sometimes with large amounts of spawn in them. It was widely believed that these mother fish were fished out after the introduction of gill nets in the 1960s. Several fishers said the pattern of feeding and movement of the large, old breeders or mother fish seemed to differ from that of smaller fish. Fishers thought that these fish settled out and stayed in deep gullies or channels year-round rather than migrating offshore or inshore with the herring and caplin. Mother fish were found in the arms and deeper areas or “trenches” of Trinity and Bonavista bays and in the deeper water off the Bonavista headland in the 1950s and 1960s.

Previous research has documented cod spawning aggregations and individual spawning fish in various locations in Trinity and Bonavista bays (Hutchings et al. 1993; Potter 1996; Rose 1996; Smedbol and Wroblewski 1997). Fisher interviews described cod spawning in these general locations, but some additional locations were also identified. Mature cod are referred to by fishers as “spawny” or as “running” with eggs and milt. Figure 2 shows the locations of such cod identified in these interviews. These include an aggregation observed in a June–July gillnet fishery off Hopeall Head in 50–60 fathoms of water that was believed to have been fished out by the mid-1980s. A Chapel Arm fisher reported observing spawning cod on one occasion in a fall trap fishery in the early 1990s. Spawning cod were observed in a summer gillnet fishery northeast of the Bellevue Peninsula that targeted large breeders in deepwater in the 1960s (also see Hutchings et al. 1993). They were also observed in the June trap fishery near Thornlea. A Chance Cove fisher described gillnetting cod in 110–120 fathoms of water in the fall and winter in the late 1970s that included some big, spawny ones. He reported seeing the spawn running out on the ice. A spawning aggregation was observed on Heart’s Ease Ledge in the summer months. Smedbol and Wroblewski (1997) found this aggregation by talking to fishers (K. Smedbol, Department of Biology, Memorial University of Newfoundland, personal communication) and then reported quantitative information. Fishers in the Butter Cove and St. Jone’s Within areas also described catching spawning cod in the summer months in May or June. Most of the spawny cod that they would get would be in the gill nets.

In 1996, a spawning aggregation was “discovered” in Smith Sound (Fig. 1) during a scientific survey and then quantified acoustically (Rose 1996). Fishers described two spawning aggregations in the Smith Sound area: one observed in the 1960s, in association with the introduction of gill nets into an area above Bluff Point in Smith Sound in 30–50 fathoms of water, and the second fished more recently in the area off Hickman Harbour, adjacent to the Thoroughfare, in depths of 90 fathoms and more. Fishers followed this latter aggregation as it migrated out of Smith Sound to this spawning area. Fish were observed to be spawning in early May and mid-June, dispersing after mid-June. An older, retired fisher from Trinity described fishing trawls in 150–180 fathoms of water in the summer in the middle of Trinity Bay. Some of the cod that they caught in this fishery would be spawny. Similarly, some of the large breeders that they caught in the spring off Catalina were observed to be ready to spawn. These cod were also mostly from the deep water. A Bonavista fisher described a possible spawning aggregation located in a gulch 20–21 mi off Cape Bonavista in June or July during the 1970s (see Hutchings et al. 1993 for scientific documentation of spawning in these areas). Fishers also reported observing spawning cod in the King's Cove and Princeton areas in May and June. In a separate set of interviews with Bonavista Bay fishers, Potter (1996) identified a spawning area for cod in Southern Bay. Some fishers observed that in recent years, they were finding cod spawning in shoaler water and at smaller sizes than in the past.

Efficiency

During the interviews and subsequent feedback meetings, fishers described a variety of changes in fishing practice during their careers. The sequence of boats and the length, engine power, and capacity of each were usually remembered, without recourse to written records. Many reported increases in boat length during their careers, but others stayed under the 35-ft limit for licensing reasons. More notable were changes in engine power, which was not regulated, and hence did not tend to stop at a fixed upper limit. Increases in engine power were accompanied by increases in boat capacity, longer trips from shore, and the introduction of mechanical hauling devices.

During the 1980s, electronic devices (navigational aides and sonar) became widespread. The effect that these have on fishing practice is profound, although not obvious. With exact positioning, a large number of gill nets can be left in the water between visits, greatly increasing the number of nets that can be fished per boat. Acoustic fish finders further increased the mobility of the gillnet fishery, allowing nets to be moved to areas known to have fish.

Changes in gear design and material also tended to increase efficiency. More durable material allowed gill nets to soak longer and reduced loss from torn traps. Most trap fishers changed the design of their traps from traditional to modified (winged), Japanese, or long-range traps (a rectangular Labrador design that could be set in previously unutilized berths) in the 1970s and 1980s. These changes, often associated with reductions in mesh size outside of the drying twine, are believed to have increased their catches by retaining smaller fish, increasing the number of possible berths, and allowing them to fish more traps efficiently by holding fish better. The introduction of sounders made it easier to fish a larger number of traps. Sounders reduce the time spent hauling traps by allowing small or zero catches to be identified before hauling. The introduction of power blocks reduced the time to empty a trap and increased the number of traps that a crew could haul in a day. Power blocks also made it easier to move large gear (traps) during the season, if catches at the first mooring were low, and allowed traps to be set in deeper water and where tidal currents require heavy moorings.

Of the many changes in practice, four were readily quantified: capacity (tonnes per vessel), gear (nets per vessel), engine power (horsepower = 2700 kJ/vessel-hour), and triptime (vessel-hours per vessel-year). The relationship of these components to overall efficiency q_{comm} is

$$q_{\mathrm{comm}} = \mathrm{gear}^{a} \times \mathrm{capacity}^{b} \times \mathrm{power}^{c} \times \mathrm{triptime}^{d} \times q_{\mathrm{other}}.$$

We have chosen to call q_{comm} efficiency rather than catchability because the term catchability implies changes in fish behaviour rather than changes in fishing practice and fish abundance.

Based on the principle of homogeneity of units, $b = -a$, $c = d$, and hence:

$$q_{\mathrm{comm}} = \mathrm{gear}^{1} \times \mathrm{capacity}^{-1} \times \mathrm{power}^{1} \times \mathrm{triptime}^{1} \times q_{\mathrm{other}}$$

where q_{other} is tonnes per kilojoule per net-vessel, a measure of maximum delivery rate (tonnes per kilojoule) relative to nets fished by each vessel.

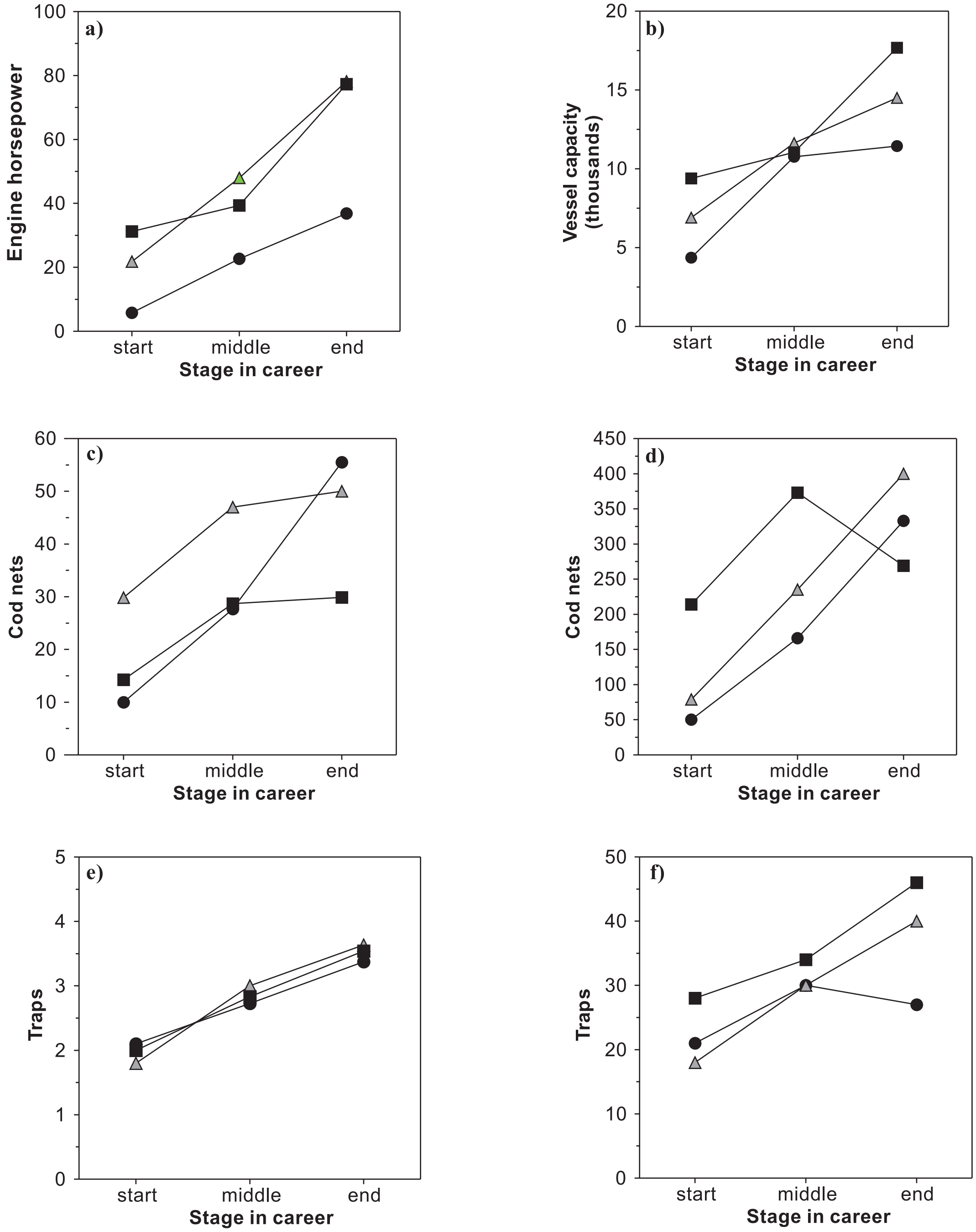
Figure 3 shows both generational and intergenerational trends in efficiency. Engine power increased throughout fishing careers, regardless of the generation of entry into the fishery (Fig. 3*a*). Capacity also increased, with greater change for third-generation fishers than for earlier generations (Fig. 3*b*). Average number of cod nets per crew increased for all three generations of gillnetters, roughly doubling from the start to the middle of the career, and doubling again for first-generation fishers (Fig. 3*c*). Total number of cod nets owned by first-generation fishers increased from 50 at the start of their careers to 214 at the end (Fig. 3*d*). Trends for second-generation fishers were similar. Number of cod nets owned by third-generation fishers increased to midcareer and then decreased. Fishers generally attributed this decrease to declining catches from cod nets. Number of traps per crew increased for all three generations, rising by one trap from the start to the middle and rising again from the middle to the end of their careers (Fig. 3*e*). Total number of traps increased throughout the careers of second- and third-generation fishers. In contrast, total number of traps owned by first-generation fishers tended to decline after midcareer (Fig. 3*f*). On most measures, third-generation fishers started out and ended up with higher levels of effort than previous generations.

Annual rate of change (percent per year) was plotted against year for engine power, capacity, boat length, and gear. Rate of change in vessel capacity was positive and generally under 20%/year for most fishers before 1980. Capacity increased even more rapidly after 1980 (Fig. 4*a*). Annual rate of increase in engine power accelerated after 1970 for fishers in the early part of their careers as well as for those in the latter part of their careers (Fig. 4*b*). These changes in power and capacity were not reflected in boat length, which on average did not change during the same period for the same fishers (Fig. 4*c*). Annual percent change in number of nets was positive and under 25%/year for most gillnetters (Fig. 4*d*). This reflects the practice of adding a few nets each year. Annual percent change in number of traps was small (under 15%/year) and positive for most fishers (Fig. 4*e*).

Components of effort increased for the inshore fishers interviewed, so it was of interest to find out whether their landings increased or not during a period when landings by the entire inshore sector fluctuated around 200 000 t/year from 1920 to 1992 (Hutchings and Myers 1995). Figure 5 shows reported poor, average, good, and, for 1991, recalled catches for some fishers by year. There was no long-term increase in landings by the sample group, which thus did not differ from the entire inshore fishery in catch trends.

In addition to the move to larger, more powerful vessels and increased gear, a clear spatial shift also occurred in the inshore and nearshore sector. The four skippers with the largest vessels at the time of the moratorium (1992) began

Fig. 3. Generational differences in (*a*) average engine horsepower, (*b*) vessel capacity, (*c*) average number of cod nets per crew, (*d*) total number of cod nets, (*e*) average number of cod traps per crew, and (*f*) total number of cod traps for first-generation (solid circle), second-generation (shaded triangle), and third-generation (solid square) fishers interviewed.



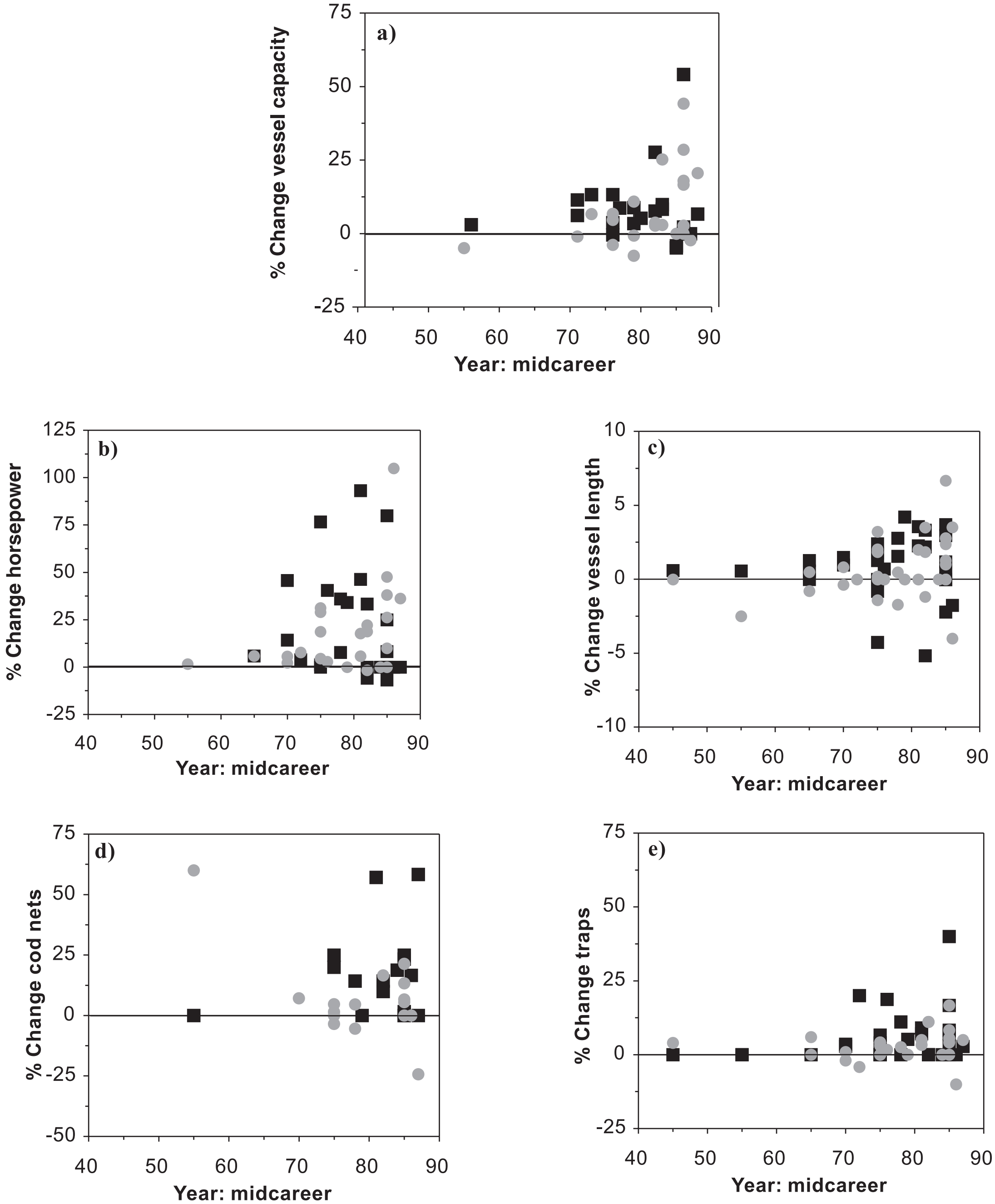
their longliner careers fishing between 8 and 20 mi from their home port. As their boat, horsepower, gear, and capacity increased, their fishing grounds shifted to 50–80 mi offshore and, a few years later, to distances often in excess of 100 mi to an area known as the Virgin Rocks and beyond (Neis et al. 1999).

Similar changes in the spatial scale of the lumpfish roe fishery have also occurred. We compared the spatial distribution of fishing in our interview data with that in Mercer (1980). He showed that the lumpfish roe fishery in the study area concentrated exclusively in the area between Southern Bay, Bonavista Bay, and Port Rexton, Trinity Bay. Our interviews identified additional lumpfish fishery locations, so that the fishery now extends down the west coast of Trinity Bay and across to Thornlea and Norman's Cove at the bottom of the bay.

Landings and catch relative to effort

These results suggest that the rate at which fish were intercepted by gear decreased and that catch rates were maintained by increasing other components of effort, including engine power, boat capacity, and amount of gear. For gill

Fig. 4. Percent change per year in (*a*) vessel capacity, (*b*) engine horsepower, (*c*) boat length, (*d*) number of cod nets, and (*e*) number of traps for start to midcareer (solid square) and for midcareer to end of career (shaded circle).



nets, we computed CPUE as catch per net, which was taken as proportional to interception rate (catch per square metre of net) under the assumption of no decrease in panel length or panel height per gill net (a change in catch per gill net can result either from a change in rate of interception (catch pee square metre) or from a change in panel area (square metres per net) due either to longer or to higher panels):

$$\text{CPUE} = \text{catch/net} = (\text{catch/m}^2 \text{ of net}) \times (\text{m}^2 \text{ of net/panel}).$$

The change in CPUE was computed as

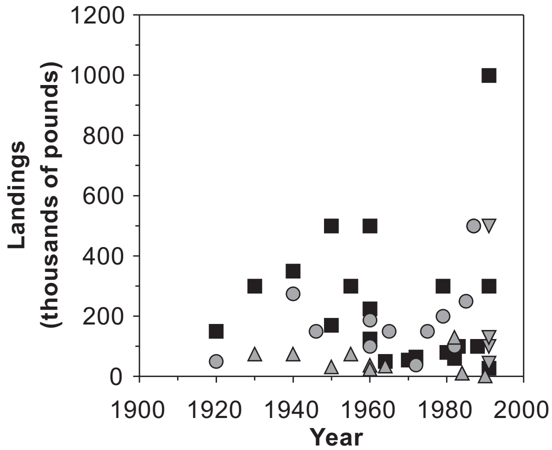
$$\Delta\text{CPUE} = (\text{CPUE}_{\text{final}} - \text{CPUE}_{\text{initial}})/\text{CPUE}_{\text{initial}}.$$

Changes in boat size, horsepower, capacity, and gear amounts were calculated in the same way, as a percentage of the initial value.

Cod fishery

We computed change in CPUE for cod for seven of the nine fishers using longliners (38- to 65-ft boats). Increases in boat length during their career varied from –36 to +32% (Table 1). The single negative value was the result of a longliner skipper abandoning his longliner when confronted with lower catches and longer times away from home to maintain catch rates. Horsepower and capacity increased more than boat length with the exception of the fisher who abandoned

Fig. 5. Poor (shaded upright triangle), average (shaded circle), good (solid square), and 1991 recalled (shaded inverted triangle) catch estimates (pounds) reported by interviewed fishers, vessels <35 ft, 1920s–1990s. Quintals (112 lb of dried cod) converted to 500 lb round weight per quintal.



longlining. Number of nets increased in all cases, with increases varying from 20 to 300% during a career. All seven longliner fishers experienced a reduction in CPUE, with the reductions varying from 14 to 65% (Table 1). Panel length remained at 15.2 m (50 ft), and hence, we attribute change in CPUE to declines in rate of interception.

A similar analysis was undertaken for inshore fishers. Of the five inshore gillnet fishers for whom we could compute percent change in CPUE, all experienced declines that ranged from 48 to 96%. We attribute this to declines in interception rate, in the absence of change in panel length or height.

Change in CPUE was then calculated for trap fishers. CPUE was again computed relative to the area of the gear that intercepts fish, in this case the trap leader (a change in catch rate can result either from a change in rate of interception (catch per square metre of leader) or from a change in leader area (square metres of leader per trap)):

$$\text{CPUE} = \text{catch/trap} = (\text{catch/m}^2 \text{ of leader}) \times (\text{m}^2 \text{ of leader/trap}).$$

Assuming no change in leader area or escape rate, catch rate per trap is proportional to interception rate.

The career-history interviews allowed us to compute percent change in CPUE for seven cod trap fishers. Of these, six experienced a decline in trap CPUE ranging from 13 to 375%. One experienced an increase of 33%. Changes in leader length could not be examined using our data. Escape rate from traps likely decreased during this period due to design changes and more durable netting. Consequently, the observed drops in CPUE likely underestimate the drop in interception rate by these trap fishers.

CPUE declined in the nearshore gillnet fishery pursued by longliners, the inshore gillnet fishery pursued by smaller boats, and the inshore trap fishery. Efficiency increased; hence, we attribute decreases in CPUE to decreases in rate of interception. These decreases in CPUE were not restricted to periods of a few years, and hence, cannot be attributed to temporary declines in availability due to oceanographic conditions or fishing down of strong year-classes in the late 1980s.

Lumpfish roe fishery

Similar declines in CPUE have also occurred in the lumpfish roe fishery. Those fishers that we interviewed who were active in the lumpfish roe fishery (n = 22) unanimously reported that effort, as measured by numbers of fishers and numbers of nets per crew, had increased substantially between the mid-1980s and 1996 (Table 2). Nearly all of these 22 fishers reported an increase in the number of nets that they were using, with percent change ranging up to 900%.

Fishers were also asked to describe changes in their landings of lumpfish roe over time. Fishers who maintained records of their catches were asked to consult these in answering this question. Some checked their receipts, and others relied exclusively on memory. Declines in CPUE ranged from 99% for fisher 23 to 64% for fisher 50 (Table 2). The decline in CPUE, computed as an annual rate, was much greater for recent entrants into the fishery than for fishers who were engaged in the fishery for a decade or more (Fig. 6).

Discussion

This paper demonstrates how personal, career-history interviews, particularly when informed by taxonomy/toponomy interviews and supplemented by followup interviews targeting specific issues, can collect large amounts of information from fishers useful for fisheries assessment. Our findings bear on questions of stock distinctiveness, trends in efficiency in inshore and nearshore fisheries, trends in landings and CPUE, and extending fisheries assessment to include the large amounts of information uncovered by personal interviews.

Stock distinctiveness

The 1992 moratorium on northern cod has highlighted the need to explore the distinctiveness of cod stocks inshore throughout Newfoundland (Hutchings et al. 1993). A significant amount of research on the population structure and migratory and spawning behaviour of these stocks has taken place since 1990, much of it in Bonavista and Trinity bays (e.g., see Hutchings et al. 1993; Rose 1993; Taggart et al. 1994; Wroblewski et al. 1994; Carr et al. 1995; Lilly 1996; Ruzzante et al. 1996, 1997). However, as recently as 1996, the stock status report for 2J3KL cod commented that a major source of uncertainty was related to knowledge concerning "the relationship between inshore cod and fish that used to be widely distributed over the shelf" (Shelton 1996, p. 4). In recent years, an apparent gap between the absence of cod in offshore research vessel surveys and anecdotal and some systematic observations of cod in coastal Newfoundland bays has reinforced commitment to developing a better scientific understanding of different stock components (Rice 1997) and of population dynamics for these stocks.

The recalled observations of fishers reported on here are generally consistent with existing scientific information related to stock structure but provide additional information not readily available in scientific data. Personal interviews show that these inshore and nearshore fishers commonly distinguish between cod that they harvest on the basis of shape,

Table 1. Percent change in efficiency and CPUE between the first and final years in the gillnet fishery, vessels >35 ft.

Fisher ID No.	First year	Final year	Boat length		Capacity		Gear		Catch		CPUE (% change)
			First	% change	First	% change	First	% change	First	% change	
27	1979	1992	40	+32	10 000	+700	120	+225	10 000	+30	–60
21	1972	1992	38	+20	9 000	+70	60	+300	10 000	+62	–60
23	1978	1992	38	0	11 000	0	60	+150	9 500	+43	–43
14	1976	1989	42	+19	25 000	+35	100	+300	25 000	+39	–65
24	1967	1992	41	–36	5 500	+16	80	+50	5 500	+27	–15
41	1976	1992	38	+3	11 000	+109	60	+200	11 000	+16	–61
28	1988	1992	40	0	24 000	+90	72	+20	24 000	+3	–14

Table 2. Lumproe catch (pounds) and effort (nets) of fishers interviewed on Bonavista Peninsula, Newfoundland.

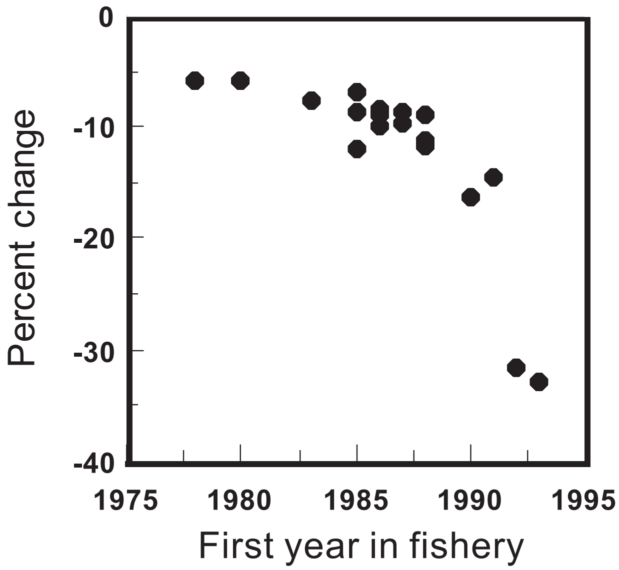
Fisher ID No.	Year	Initial catch	Nets	Year	Final catch	Nets	ΔNets (%)	ΔCPUE (%)
23	1978	1000/haul	6	1995	100/haul	50	+100	–99
1	1978	1400/haul	20	1994	174/haul	50	+150	–95
48	1980	4500/season	15	1995	1000/season	30	+100	–89
42	1980	500/season	6	1996	200/season	30	+400	–92
37	1983	2500/season	5	1995	1100/season	25	+400	–91
45	1984	450/haul	20	1991		25	+25	
53	1985	200/haul	12	1995	200/haul	40	+233	–70
55	1985	300/week	5	1993	150/week	50	+900	–95
38	1985	15 000/season	20	1995	4000/season	40	+100	–87
32	1986	9000/season	20	1996	2500/season	50	+150	–89
47	1986	200/day	20	1995	100	40	+100	–75
26	1986	750/haul	12	1996	30/haul	37	+208	–99
50	1987	100/week	12	1996	50/week	45	+317	–64
6	1987	100/day	12	1995	100/day	40	+233	–70
3	1988	35 000/season	50	1996	3500/season	50	0	–90
5	1988	300/haul	35	1995	75/haul	50	+43	–82
11	1988	4500/season	32	1996	2000/season	50	+56	–72
42	1990	80/day	30	1995		50	+67	
t6[a]	1990	16 000/season	20	1996	850/season	50	+150	–98
31	1991	280/haul	25	1996	76/haul	25	0	–73
46	1992	4000/season	10	1995	400/season	20	+100	–95
22	1993	60/day	12	1995	60/day	35	+190	–66

Note: Per day, every day; per haul, all nets in 1 day at irregular intervals; CPUE, catch per net. See text for calculation of ΔNets and ΔCPUE.
[a]Taxonomy interviews.

diet, colour, size, the depth at which they are fished, whether they are "spawny," and the timing and direction of their movements. A more detailed discussion of these and related findings can be found in Fischer et al. (1997) and Neis (1998). A comparison of interview data from fishers in the Bonavista area and from within the bays, informed by their taxonomic terms for cod, suggests that the temporal and spatial dynamics of the cod fisheries in these two areas differ. Observations from sampled fishers at the bottom of Trinity and Bonavista bays provide strong evidence of observed overwintering cod that is largely absent from interviews done in the Bonavista area. The former fishers have intercepted cod migrating into the arms in the bays in the fall and participated in fall, winter, and spring fisheries for these cod during the 1980s. Differences in observations between fishers within the bays and those in the Bonavista area are consistent with tagging and landings data indicating that fisheries in these areas draw to differing degrees on overwintering cod and cod migrating from offshore with the "capelin fish" (Lilly 1996). Fishers' observations suggest that the spatial and temporal distribution of cod may be related not only to stock structure but also to the size structure of fish populations. They had observed apparent size-related differences in depth and behaviour that have been documented for other species, with many believing that large, old cod settle out in deep trenches in the Bays and observing that these cod differ in terms of colour and behaviour from shoaler water cod (Fischer et al. 1997; Merrett and Haedrich 1997).

It is known that spawning areas for northern cod are discrete, often distant from other spawning areas, and that some are located in the bays. Such disjunct spatial distributions may indicate reproductive isolation among cod populations (Hutchings et al. 1993; Taggart et al. 1994). Interviewed fishers had observed cod in spawning condition, including some possible spawning aggregations, at several locations in Trinity and Bonavista bays. Whereas some of these spawn-

Fig. 6. Percent change in CPUE per annum in the lumpfish roe fishery of interviewed fishers, 1978–1996.



ing aggregations have already been scientifically documented, often with assistance from fishers, others have not and should be investigated. In some cases, these spawning aggregations may no longer exist.

In New England, interviews with older, retired fishers have produced maps of present and former spawning areas for cod and haddock. These interviews also generated information on the sequence and nature of the collapse of local stocks, highlighting localized fishing impacts (Ames 1998). Similarly, Trinity and Bonavista Bay fishers who had gillnetted very large, whitish cod in the deeper areas of the bays believed that these local aggregations of mother fish disappeared with the expansion of the gillnet fisheries in the 1960s and 1970s. They also observed juvenile cod, making associations between fluctuations in juvenile cod abundance and a large bycatch of juvenile cod in capelin traps in Trinity Bay (M. Morris, Memorial University of Newfoundland, unpublished data).

Efficiency

Fishers described a variety of innovations that are relevant to an assessment of changes in efficiency q_{comm}. Interviews showed that two components of q_{comm}, capacity and horsepower of inshore vessels, increased slowly in the 1960s, more rapidly in the 1970s, and still more rapidly in the 1980s. The number of traps per person increased steadily in the 1970s and 1980s and there were significant changes in mesh size and design. After 1980, the number of cod traps owned by the sampled fishers increased from 33 to 49 traps (n = 15). Cod nets per boat increased in the 1970s more than afterward. The number of gill nets owned by the sampled fishers increased from 1480 nets in 1980 to 2900 in 1991 (n = 25). Landings per boat fluctuated, with no long-term increase for the group interviewed. During this period, capacity, engine power, and gear amount increased in both the inshore and nearshore fisheries.

The spatial scales of the trap fishery and gillnet fisheries also increased. Some fishers at the bottom of Trinity Bay moved to St. Mary's Bay to trap cod in the late 1980s and early 1990s, and some from the middle of the bay (New Bonaventure area) moved to Labrador in 1987. Fishers from within Bonavista Bay are reported to have fished in the Bonavista area in the year or two prior to the moratorium. Hutchings and Myers (1994) identified important spatial changes in the inshore gillnet fishery, which began extending offshore onto new grounds as effort increased and catch per net declined (Fig. 7). Interviews with four gillnet fishers on longliners in the Bonavista–Catalina areas showed similar shifts in spatial scale accompanied by movements to larger boats, more gear, and more frequent hauling of that gear (Neis et al. 1999). They showed that these movements were a consequence of declining catches closer to shore and in the Bonavista area. Fishers said that they had to fish further afield and further offshore in order to maintain their catch rates.

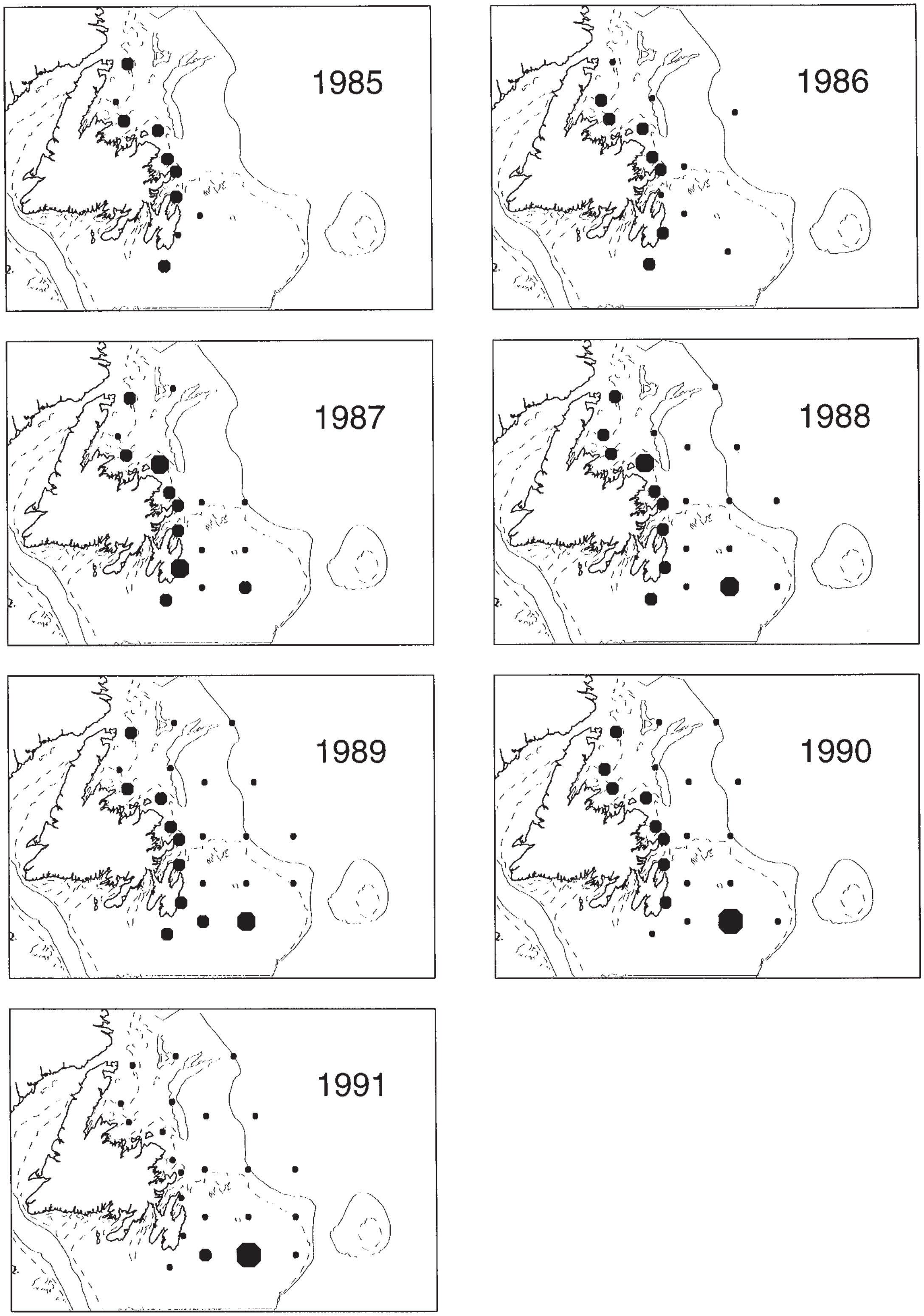
Fishers described a number of other innovations that contributed to efficiency. The interviews and subsequent public meetings suggest that innovation that increases efficiency is driven by multiple factors. Lower resource abundance is one important factor, with fishers reporting fewer and generally smaller fish after gillnet grounds had been fished for a few years and pressure to change gear design in the inshore trap fishery and the spatial scale of their fishing effort. Another factor is the need to provide for greater comfort and safety as the spatial scale of fishing expands. Another factor might be termed a "colleague effect," which refers to fishers feeling peer pressure to keep up with their colleagues in the move to bigger boats even if they do not fully feel a need to increase capacity and gear. A number of fishers mentioned the role of governments in encouraging the trend to larger boats through various loan and subsidy programs.

Landings and CPUE

For cod, results from interviewing resource users were consistent with results from analysis of purchase slip data. Spatial changes in gillnet fishing effort in the latter half of the 1980s and early 1990s are evident from purchase slip records compiled by the Statistical Coordinating Committee for the Atlantic Coast (DFO, Ottawa, Ont.). These data, which report the Northwest Atlantic Fisheries Organization (NAFO) unit areas in 3L from which cod were captured, reveal a significant offshore expansion of this fixed-gear fishery based on purchase slip data, suggesting that CPUE for cod in the inshore had begun to decline as early as the mid-1980s (Fig. 7). This decline could, in theory, have been the result of fishing out of a few strong year-classes, causing a short-term reduction in CPUE. Results from interviewing resource users show, however, that declines in CPUE began before 1980 and that these were associated with increases in boat capacity, engine power, and gear fished per boat. Declines in CPUE for the inshore cod fishery occurred over decades and cannot be attributed to short-term drops in stock size due to recruitment variability.

For lumpfish, a recent DFO study of CPUE produced results consistent with our findings that CPUE declined drastically in the lumpfish roe fishery in the 1990s (Myers et al. 1995). Another study based on interviews with fishers in Bonavista and Notre Dame bays produced similar results (Potter 1996). Limited historical data also support the con-

Fig. 7. Spatial distribution of gillnet catches of northern cod between 1985 and 1991. The four sizes of symbols, beginning with the smallest, represent catches of 1–100, 100–1000, 1000 – 10 000, and >10 000 t (to a maximum of 18 000 t). Depth contours are the 200- and 400-m isobaths. Each of the circles is positioned in the centre of the NAFO unit area from which the catches were reportedly taken (NAFO unit areas represented here include 3Ka to 3Ki, 3La to 3Lj, and 3Ls to 3Lr).



clusion that CPUE has declined dramatically since the 1970s. According to Mercer (1980), there were an estimated 50 crews fishing lumpfish in the Bonavista Peninsula region in 1979. They fished between three and 30 nets each for an average of 16.5 nets/crew. Landings in the region for 1979 totalled 85 467 kg for an average of 104 $kg \cdot net^{-1} \cdot season^{-1}$.

In the period between 1994 and 1996, an average of 432 fishers were licensed to fish for lumpfish roe in the same region. Based on the practices of our sample of fishers, we estimate they would have fished an average of 40 nets/vessel. With an estimated crew size of two, this would total 8748 nets. Landings in the region in 1995 were 82 379 kg for an estimated CPUE of 9.4 $kg \cdot net^{-1} \cdot season^{-1}$, indicating a reduction of 91% in CPUE between 1980 and 1995.

Interview data indicate that lumpfish catch rates in the study area may have declined by as much as 90% between 1980 and 1996 (Table 2), despite an increase in the spatial scale of this fishery from a concentration in the Bonavista area to most of the coastal area including areas of marginal lumpfish habitat. The data also indicate that the rate of decline in catch rates has accelerated in recent years (Fig. 6). Decreases in catch rates by passive gear reflect decreases in encounter rate between fish and gear. Such decreases can result from decreases in fish density, decreases in movement, or decreases in efficacy of capture. Decreases in movement at the scale of a decade have not, to our knowledge, been reported in any species of fish. Decrease in efficacy of capture has not been reported and would be surprising, given the increases in skill that typically occur within fisheries. Decreases in density can result either from a decrease in numbers or from an increase in area occupied. In species that establish territories during spawning, such as lumpfish, decreases in density due to increase in area occupied are unlikely because of competition for better sites. Because the changes that we observed occurred at the scale of hundreds of kilometres, we conclude that decreases in catch rates were due to decreases in population size. The fishers that we interviewed attributed the decline in lumpfish to the combined effects of increased numbers of fishers, increased numbers of nets, and the destructive effects of a roe fishery in which the females are killed for their eggs.

The lumpfish roe fishery was started in this area in 1969. Much of the existing Newfoundland-based research on lumpfish biology and CPUE in this fishery dates from provincial government studies carried out between 1978 and 1982 in association with experiments with fishing in new areas and with new gear (Mercer 1980; Blackwood 1982). Provincial researchers recommended that DFO carry out the scientific research necessary for management of this fishery. However, little additional research on lumpfish ecology, migration, and trends in size and catch rates was carried out during the subsequent decade. As of 1996, commercial CPUE data were extremely limited (Stevenson and Baird 1988). The first lumpfish management plan was not introduced until 1994 and the spatial scale of the fishery had not been monitored. These gaps have made it difficult for DFO to establish trends in lumpfish catch rates, age and length composition, sex ratio, and spatial scale occupied. In a fishery such as this, information assembled from structured interviews can provide useful information on trends.

Extending stock assessment to include resource users

Personal interviews, using a career-history approach, that are informed by awareness of the fish and place names used by fishers uncovered large amounts of information. When assembled, the information brought to light trends that are consistent across many fishers, across gear sectors, and across slight differences in the format of individual interviews. These trends are valid on an ordinal scale ("gear efficiency increased over decades") even if they cannot be applied on a ratio scale ("gear efficiency in the population increased by *x*%"). Our efforts to compute change in CPUE in the trap cod and lumpfish roe fishery showed that detail will be lost in a broad-ranging career-history interview but can be acquired, checked, or updated in short, relatively inexpensive followup telephone interviews. Our research also revealed that some fishers have maintained catch receipts and logbooks from earlier points in their careers. These alternative sources, which come to light during personal interviews, should ideally be consulted during interviews, but a return visit may be required. Fishers can also be urged to consult their records during a telephone followup. Reliability and internal consistency are increased by comparing results from different techniques (triangulation), by internal comparisons within and between transcripts, and with the results of feedback meetings and independent interviews and discussions with fishers, such as those held in Melrose and Chance Cove (Fischer et al. 1997).

Interviews can be used to provide information on long-term trends in efficiency, independent of catch rates. Often, calibration methods, based on regression of commercial versus research vessel catches, cannot be used for the inshore sector because of the absence of research vessel information for this area. Interviews could also be used to provide information and changes in efficiency at time scales of a year, more timely than information that arises from calibration methods. This could be accomplished by reinterviewing a group of index fishers each year. Information on boat capacity, engine power, and gear could be updated annually to provide measures of change in efficiency that are independent of stock size of landings. These measures are both independent and timely, and hence, more useful than calibration-based measures that assume commercial and research fishing on the same stock and that require several years to detect trends in efficiency.

Interviews could also be used to provide timely information on changes in terminal mortality. Assessment methods based on population reconstruction (e.g., virtual population analysis) are highly sensitive to errors in terminal mortality (Hilborn and Walters 1992). Terminal mortality from research vessel surveys will be imprecise because of the small number of fish caught and may be inaccurate (biased downward) for the same reason. A check on this, using independent data from interviews of resource users, is needed.

Fishers' knowledge of stocks is primarily acquired to optimize catches while minimizing effort. It is largely based on observations that take place on their fishing grounds during the fishing season. Individual knowledge thus tends to be localized and seasonal. We have shown that a sampling strategy that spreads interviews throughout a region and across sectors (<35 and >35 ft vessels) can permit the aggregation of local information to arrive at a regional perspective. In addition, the seasonality of fishers' observations can be minimized in career-history interviews that include information on fisheries for a range of species using a broad range of gears. Fishers tend to closely observe those environmental features that are linked to fishing success, such seasonal movements, habitat preferences, feeding behaviour, and abundance dynamics, and those physical attributes of fishing grounds that affect fish distribution, the performance of gear, and fishing time, such as wind direction, currents, water temperature and clarity, bottom characteristics, and local assemblage structures (related to bycatch and discarding) as well as gear fouling (i.e., slub on the nets). Their observations can have a temporal scale of as long as 40 or 50 years for older fishers and, as in the case of the lumpfish roe fishery, often include information on species and fisheries that has been poorly monitored in the past.

Finding ways to make comparisons between fishers' observations and data drawn from more traditional scientific sources could improve the potential for more informed and more accepted decisions on stock status and management. Personal interviews with a career-history format can generate a baseline of information for a particular fisher and, when data are aggregated, for local and regional fisheries where little scientific data exist. They can also provide the basis for the development of a relationship of trust, so-called "rapport" (Punch 1986). Such interviews need to be conducted in person rather than by mail or over the telephone. Where mail and telephone interviews are not preceded by a detailed, face-to-face interview, they can produce partial or flawed conclusions and can convey the message that assessment scientists are not interested in the results.

Systematic and careful collection of information from fishers as part of a comanagement regime could substantially improve the knowledge base for fisheries management and, relatedly, fisher compliance in the future (Pinkerton 1994). Resource users develop a detailed, small-scale understanding of population complexes, while scientific management typically aims at a larger scale. This mismatch in spatial scale can lead to different assessments of stock status and apparent disagreement where none may exist. Scientific models of population structure should be consistent with fishers' observations of spawning locations, predictable seasonal movements, and morphological differences. Fishers' observations can also help us interpret spatial and temporal variation in catch data, such as those contained in purchase slip data bases (Lilly 1996). Disagreements between local and larger scale perceptions of stock status indicate the need for nested assessments at different spatial scales (e.g., local seasonal, regional annual) and for multiple methodologies. Resource users are unlikely to assent to a statement of large-scale status that conflicts with their own direct experience but may be more likely to assent when larger scale understandings are compared through a composite of localized observations from fishers throughout a region.

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