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Review of Northern Anchovy (*Engraulis mordax*) biology and fisheries, with suggested management options for British Columbia

Examen de la biologie et des pêches de l'anchois du Pacifique (*Engraulis mordax)* et options de gestion suggérées pour la Colombie-Britannique

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Abstract

In British Columbia, northern anchovy (*Engraulis mordax*) are at the northern most extent of their range (central British Columbia) and although part of the northern stock, local populations might be genetically distinct. For example, it is not clear if anchovy are resident in British Columbia or if they are migrants from southern locations. Thus, the highest priority should focus on determining stock(s) status in British Columbia, using molecular markers.

In contrast to the central and southern stocks, the northern stock is the smallest and least exploited of the three major northern anchovy stocks. British Columbia has supported intermittent commercial fisheries for this species, but data on their biology and distribution is limited. Northern anchovy landings peaked in 1941 (around 6000mt) but have since declined with less than 1mt landed between 1996 and 2001. Given considerable inter-annual variability in population biomass and low product demand, participation in northern anchovy commercial fisheries is declining. In addition to considerable inter-annual variability, the current biomass of northern anchovy in British Columbia is sufficiently low that commercial fisheries might not be practical or sustainable. Given existing data deficiencies, we recommend initiating a survey to determine background biomass and distribution data for northern anchovy in British Columbia. If there is interest in commercial fisheries, we suggest proceeding to Phase 1 via a scientific licence to address monitoring, catch reporting, and by-catch concerns.

Résumé

En Colombie-Britannique, l'anchois du Pacifique atteint la limite nord de son aire de répartition (centre de la Colombie-Britannique), et, bien qu'elles appartiennent au stock nordique, les populations locales pourraient être génétiquement distinctes. Par exemple, on ignore si l'anchois est résident en Colombie-Britannique ou s'il migre du sud. Ainsi, la première priorité devrait être de distinguer le ou les stocks de la Colombie-Britannique au moyen de marqueurs moléculaires.

Le stock nordique est le plus petit et le moins exploité des trois grands stocks d'anchois du Pacifique, les deux autres étant les stocks central et méridional. En Colombie-Britannique, cette espèce fait l'objet de pêches commerciales intermittentes, mais les données sur sa biologie et sa répartition sont limitées. Les débarquements d'anchois du Pacifique ont atteint leur maximum en 1941 (à environ 6 000 tm) mais ont diminué par la suite, se chiffrant à moins de 1 tm de 1996 à 2001. En raison de la grande variabilité de la biomasse de la population d'une année à l'autre et de la faible demande pour le produit, la participation aux pêches commerciales de l'anchois du Pacifique diminue. De plus, la biomasse actuelle de l'anchois du Pacifique en Colombie-Britannique est faible au point où sa pêche commerciale n'est peut-être pas réalisable ou durable. Étant donné le manque actuel de données, nous recommandons d'effectuer un relevé pour obtenir des données de référence sur la biomasse et la répartition de l'anchois du Pacifique en Colombie-Britannique. S'il y a un intérêt pour la pêche commerciale, nous suggérons de passer à la phase 1 en accordant un permis de pêche scientifique pour aborder les questions de la surveillance, de la déclaration des prises et des prises accessoires.

Introduction

Northern anchovy, *Engraulis mordax* (Girard 1854) are a small pelagic schooling fish distributed between Baja California, Mexico and central British Columbia, Canada. This is an important forage species for many predators, including fish, birds, and mammals (Olesiuk et al. 1990; Pacific Fishery Management Council 1998; Emmett et al. 2001). Three stocks (northern, central, and southern) are recognised (McHugh 1951) with the northern stock ranging from northern California to central British Columbia. Northern anchovy has been harvested infrequently in British Columbia since the late 1800s (Prince 1897) so little information on their biology or distribution is known from commercial catch records, especially at the northern edge of their range. Scientific assessments of northern anchovy stocks are rare with one assessment off Oregon and southern Washington in 1975–76 (Richardson 1981) and another in 1994–95 (Emmett et al. 1997). Although neither assessment included populations in British Columbia, the 1994–95 assessment indicated a decline in northern anchovy biomass (Emmett et al. 1997). This decline is consistent with available, intermittent commercial fisheries data for northern anchovy in British Columbia. Catch data recording was not implemented until 1982 when harvest logbooks were instituted, but between 1996 and 2000, there was no commercial catch. In British Columbia, the commercial fishery is opened only by variation order.

The purpose of this report is to provide managers with a source of information specific to the northern stock of northern anchovy, with special reference to British Columbia populations. The policy governing new and developing fisheries is to proceed through three developmental stages (Perry et al. 1999). This report represents “Phase 0”: a review of the available biological and fisheries information on the target species (or similar species elsewhere) using a variety of sources. Thus, the three main objectives of this report are:

1. review relevant biological and fisheries data for the three major stocks of northern anchovy, with emphasis on the northern one;
2. identify data deficiencies relevant to management needs, especially in British Columbia; and
3. recommend alternate management strategies based on available biological and fisheries data.

A Review of Northern Anchovy Biology

Northern anchovy, *Engraulis mordax* are the only representative of the Family Engraulidae found in British Columbia (Hart 1973). Two additional species, striped anchovy (*Anchoa hepsetus*), and silver anchovy (*E. eurystole*), have been reported once from the Atlantic Ocean (Scott and Scott 1988). Globally, the family Engraulidae consists of about 16 genera and 139 species (Scott and Scott 1988). Anchovy school for feeding, predator avoidance, migration, and reproduction with schooling beginning during the larval stage (11–12mm) (Hunter and Coyne 1982).

Northern anchovy are typically found in the upper mixed and surface layers of the continental shelf and adjacent deep-water regions. This fish is bluish or greenish above and silvery on the sides and belly, elongate and spindle-shaped with little lateral compression and can be distinguished by its short snout with a large, inferior mouth and gill covers (opercles) that are prolonged backwards, streamlining the appearance of the head (Hart 1973). Maximum length in British Columbia is approximately 168mm for females at 7 years and 153mm for males at 6 years (Pike 1951) but northern anchovy are typically shorter lived, averaging 3–4 years (Miller 1955).

Northern anchovy eggs are pelagic, ellipsoidal and 1.23–1.55mm in length lacking oil globules. As development proceeds, changes in buoyancy cause the eggs to sink slowly. Embryo development is temperature dependent, with accelerated development at higher water temperatures (Lo 1985). Key developmental times are provided in detail by Moser and Ahlstrom (1985) and Lo (1985) and are summarised here briefly. Within 30 hours, there is somite and notochord development with differentiation of the optic vesicles from the brain. The head region is distinguishable. Around 40 hours, the tail separates from the yolk mass and differentiation in the brain is visible. Around 45 hours the notochord is visible and the tail narrows and elongates such that it is half the length of the head. Around 55 hours the pectoral fin buds and the gut are apparent. The tail is now a quarter to half the length of the yolk sac. In the final stage before hatching the tail is longer than three-quarters of the length of the yolk sac. The embryo becomes active a few hours prior to hatching and emerges after approximately 65 hours. Length at birth is about 3mm. The yolk sac is large and elongated, tapering to a point posteriorly and is entirely absorbed 36 hours after hatching. Four days after hatching the mouth is functional and feeding begins (Bolin 1936). Larvae are pelagic and free floating and spend most of their first year in the surface currents, similar to other pelagic marine species (McHugh 1951).

Larvae begin to resemble the adult form around 25mm in length. Scales are fully formed and overlapping by the time the larvae reach 41mm. British Columbia anchovies are the fastest growing of all Pacific stocks in their first year of life (Parrish et al. 1985). It is unknown if the northern stock shows regional variability in juvenile growth rates, as does the central stock which could lead to geographical differences in stock structure (Parrish et al. 1985). Small size differences exist between males and females of northern anchovy in British Columbia. Average length at age for females are 107, 128, 140, 149, and 157mm at ages 1, 2, 3, 4, and 5 respectively (Pike 1951). Average length at age for males are 105, 126, 138, 146, and 153mm at ages 1, 2, 3, 4, and 5 respectively (Pike 1951). Despite growing faster during their first year, British Columbia fish are slightly smaller than comparable central populations based on length at age data. However, ageing northern anchovy is sometimes problematic. Both scales (Miller 1955) and otoliths (Parrish et al. 1986) have been used to age northern anchovy. New growth rings appear in winter with maximum growth during the summer months. However, otoliths become more difficult to read with increasing fish age and scales are

easily dislodged, especially in smaller fish, resulting in regeneration. Check rings can complicate ageing as observed for the South African anchovy, *E. capensis* (Waldron 1994).

Northern anchovy are indiscriminate daytime filter feeders, feeding on any prey of suitable size rather than selecting for specific species (Koslow 1981). Random stomach samples from adults demonstrate zooplankton and eggs are major prey items as are small fish, including some cannibalism, while larvae feed predominantly on copepods (Baxter 1967; Hunter and Kimbrell 1980; Booman et al. 1991). Pacific sardine (*Sardinops sagax*) and northern anchovy are remarkably similar in their biology, habitat and feeding behaviour and are the two dominant forage fish in the California Current System (Ahlstrom 1966). Ahlstrom (1966; 1967) suggested there may be a limit to the biomass of sardine plus anchovy that could be accommodated in the California Current System and that one species may increase at the expense of the other. This theory was later refuted using scale deposition rate data obtained from sediment core samples from the Santa Barbara Basin where sardine and anchovy are common (Soutar and Isaacs 1974; Baumgartner et al. 1992). It was determined from time series analysis of these core samples that there was no significant correlation between scale deposition rates for the two species. These authors suggested that fluctuations in relative abundance might be due to oceanic conditions that favoured one species over the other over time and geography. O'Connell (1998) studied core sediments from Saanich Inlet and determined herring and hake were the dominant species with anchovy scales making up less than 3% of the overall scale deposition, a finding contrary to the Santa Barbara Basin core samples where anchovy were one of the dominant species. This study provided further evidence that northern anchovy only appear sporadically in British Columbia. A reconstruction of the past 250 years of the California Current system using scale deposition data confirmed anchovy (and sardine) are highly variable over longer time periods (Holmgren-Urba and Baumgartner 1993).

There are three major stocks of northern anchovy distributed over their entire range between Baja California, Mexico and British Columbia, Canada. The northern stock ranges from northern California to central British Columbia with major spawning areas adjacent to Oregon and Washington States. The central stock ranges from central California to northern Baja California while the southern stock is confined to the area between central and southern Baja California. Morphological differences in northern anchovy, including differences in vertebral counts, anal, dorsal, and pectoral fin ray counts, and gill raker counts support the existence of three major stocks (McHugh 1951; Vrooman et al. 1981). These observed differences correspond to a latitudinal gradient. Mean vertebral counts were similar between northern and central stocks and significantly higher than the southern stock (McHugh 1951; Vrooman et al. 1981). The number of anal fin-rays increased from north to south with a significant delineation point between central and northern stocks (McHugh 1951; Vrooman et al. 1981). Mean dorsal and pectoral fin ray counts increased north to south with northern and central stocks

having similar counts, significantly lower than southern stocks (McHugh 1951; Vrooman et al. 1981). Mean number of gill rakers increased from north to south and significant differences existed among all three stocks (McHugh 1951; Vrooman et al. 1981). Maintenance of these three major stocks could be enhanced by genetic isolation. It is believed that northern anchovy populations spawn independently with little or no mixing (McHugh 1951). Unfortunately, these morphological characteristics (excluding vertebral counts) also differ between sexes, complicating stock identification (McHugh 1951). Studies on blood proteins also support the maintenance of three major stocks of northern anchovy (Vrooman et al. 1981). Also, using allozymes, Hedgecock et al. (1989) detected considerable genetic variation both between and within populations of northern anchovy belonging to the central stock. Stock sub-structure in British Columbia might be identified with molecular techniques and could address the possible existence of resident and migratory populations.

There are conflicting reports regarding the distribution of northern anchovy in British Columbia. Catch records and research data indicate they occur in low densities in bays and inlets of southern British Columbia during summer months. Without exact locations noted, the most northern occurrences have been reported in the Queen Charlotte Islands and north of Port Hardy, Vancouver Island (Roach and Harrison 1948; McHugh and Fitch 1951; Hart 1973). This data is slightly contrary to Pike (1951) who described the distribution of anchovy to include inlets of southern British Columbia, occurring as far north as Ogden Channel, south of Prince Rupert. Historical catch data has recorded landings of anchovy as far north as Bella Bella from Fitzhugh Sound (Dominion Bureau of Statistics 1922–1952; Department of Fisheries 1952–1969) but uncertainty exists about exact catch locations. Small numbers of juvenile and adult anchovy were collected in the Strait of Georgia in two-boat surface trawl surveys during the spring and summer of 1967 and 1968 (Barraclough et al. 1968; Robinson 1969) and in herring purse seine surveys conducted in the 1990s (Hay et al., unpubl. data). Neither study encountered anchovy north of Vancouver Island. Similarly, data collected from bi-annual coastal hake and salmon surveys north to the Alaskan border have not sampled anchovy north of Vancouver Island (D. Welch, pers. comm.). Using current and historical catch records and referenced reported sightings, the maximum northern boundary for the northern stock in British Columbia appears to be central British Columbia south of Fitzhugh Sound.

The distributions of marine species often change depending on season so it is likely that the winter distribution of northern anchovy is different from its summer distribution. Winter distributions of British Columbia populations have not been investigated but anecdotal observations suggest anchovy overwinter on the bottom nearshore (Pike 1951). Similarly, Laroche and Richardson (1980) showed mature and immature anchovy remained nearshore during fall and winter with only adults moving offshore during the summer. However, larval and juvenile anchovy have been collected in plankton tows made 5–6km off the mouth of the Columbia River between January and March 1975 (Laroche 1976) and more recently appeared in

offshore surveys adjacent to Oregon State in January 2000. Since northern anchovy are not typically caught as by-catch in commercial shrimp trawls or groundfish research surveys during the winter, it is plausible that they remain nearshore during the winter with some offshore advection of individuals.

The sex ratio of schools of adult anchovy are approximately equal, becoming slightly male dominated during spawning which occurs in the upper mixed layers from the end of June to the end of August for the northern stock (McHugh 1951; Klingbeil 1978). This contrasts the year round spawning of the most southern populations and shows the effects of water temperature on spawning (McHugh 1951). Spawning locations in British Columbia are not documented and it is unclear if this species spawns locally or migrates from southern locations. Another warm-water species, the Pacific sardine, also migrates to British Columbia from southern locations when conditions are favourable (Hart 1973). Research data and catch information indicate anchovy appear in British Columbia during late spring and spawning could occur in bays and inlets of southern British Columbia during the summer months (Pike 1951). This is in agreement with Vrooman et al. (1981) who showed the northern stock spawns during the summer while the other stocks (i.e., central and southern) primarily spawn in late winter (although year round spawning is possible). However, there are no direct observations to support local spawning. Robinson (1969) found larval anchovy (<25mm) during July in the Strait of Georgia in 1967 but no eggs, a finding consistent with Blackburn (1973) who found ripening females were abundant at the same time in Puget Sound. However, actual spawn has not been documented for British Columbia and there is growing uncertainty to anchovy spawning in Washington State. It is possible that spawning occurs offshore or south of British Columbia and larval individuals captured here were transported on oceanic currents. Albacore tuna stomach samples collected 130–330km off Washington State and British Columbia contained post-larval anchovy (Pike 1951; Richardson 1981) but it is unclear where the tuna were feeding and could have transported anchovy from nearshore locations. The determination of spawning locations should be a high priority for any assessment for northern anchovy.

Northern anchovy are multiple batch spawners with no mature ova carried into the next year (McHugh 1951). Sexual maturity may be achieved after the first year but most fish mature during their third year at lengths between 130–140mm (Richardson 1981). Hunter and Goldberg (1980) used an ovary classification based on the degeneratory state of postovulatory follicles to determine spawning frequency for the southern stock. Based on the incidence of 1-day-old postovulatory follicles and the time required to develop mature eggs, they were able to determine that mature females spawned every 6–7 days at the beginning of the season, becoming longer as the spawning season progressed. Pike (1951) and Richardson (1981) suggested the northern stock produced three batches per year. However, neither study provides conclusive spawn frequency data for the northern stock so caution must be exercised in any biomass calculation.

Fecundity estimation has proven problematic for northern anchovy. Hence, several estimates for both the northern and central stocks using a variety of methods exist. Pike (1951) estimated 144 000 oocytes per female from the northern stock based on counts of all oocytes greater than 0.20mm. MacGregor (1968) counted the most advanced, non-hydrated, yolked oocytes (≥0.50mm) and subsequently estimated 574 oocytes per gram female total body weight for the central stock. Hunter and Goldberg (1980) estimated 389 oocytes per gram female ovary-free body weight for the central stock based on hydrated oocytes and ovarian follicle condition. Laroche and Richardson (1980) used counts of the largest, most advanced, ovulated oocytes (>0.60mm) to estimate 720 oocytes per gram female total body weight or 826 oocytes per gram female ovary-free body weight for the northern stock. Hence, it appears the northern stock has a greater total fecundity than the central stock but differences due to methodology can not be excluded. Hunter et al. (1985) suggested that batch fecundity fluctuated inter-annually in response to environmental or biological conditions (i.e., water temperature, food availability, etc.) but additional data are needed to verify this hypothesis.

For many fish species, spawning biomass estimates are often derived from egg and larval surveys (e.g., Sette and Ahlstrom 1948; Smith 1972). However, biomass estimates for northern anchovy have proven problematic. Richardson (1981) used an egg production method to estimate the biomass of populations in Oregon State in 1975 (262 506 to 769 511mt) and 1976 (144 654 to 1 005 263mt) with an estimated spawning biomass of 800 000mt in 1977. However, due to errors associated with fecundity estimates, Parrish et al. (1986) questioned these estimates and suggested actual biomass was overestimated. The Coastal Pelagic Species Fishery Management Plan (1998) subsequently revised estimates for the Oregon State population to be 116 000 and 87 000mt, for 1975 and 1976, respectively, considerably lower than the initial estimates.

Emmett et al. (1997) and Schwartzlose et al. (1999) suggest the northern stock has declined significantly. For example, Emmett et al. (1997) found anchovy eggs at only one station and at very low densities (40 eggs m^{-2}). In contrast, Richardson (1981) found significantly higher densities in 1975 and 1976 averaging 265 eggs m^{-2} and 89 eggs m^{-2}, respectively for stations that had anchovy eggs present. Despite considerable variability in biomass estimates, there are indications the northern stock is declining. For example, Emmett et al. (2001) show that in addition to continual declines in anchovy biomass, sardine is replacing anchovy as the dominant pelagic forage species in many areas. The return of sardine to British Columbia has re-initiated a commercial fishery for this species, which might result in by-catch of northern anchovy. By-catch is a concern for any fishery but for fisheries in the Strait of Georgia in particular where large schools of forage species intermix and consist of northern anchovy, sardine, and mackerel (Hart 1973). Without substantiated data on spawning frequency and batch fecundity, egg deposition estimates are not a reliable method to estimate northern anchovy biomass (R. Emmett, pers. comm.). Furthermore, dramatic

fluctuations in biomass are not atypical for northern anchovy. MacCall and Prager (1988) showed northern anchovy populations increased dramatically in the 1950s and have since fluctuated without any general trend at much lower levels. Washington, Oregon and British Columbia catch records support this observation (Tables 1 and 2).

Formal assessments have not been made for northern anchovy in British Columbia, probably due to limited data for this species. Globally, various methods of assessment have been investigated for other anchovy species including hydroacoustics (Masse 1996), trawl coupled with hydroacoustics (Chashchin 1996), hydroacoustics and egg-production (Hampton 1996), and catch-at-age assessment models (Pertierra et al. 1997). The central stock of northern anchovy has been extensively studied and various models have been used to estimate biomass for this stock including daily egg production models (Lasker 1985), stock synthesis models (Methot 1989) and simple parsimonious biomass dynamic models (Jacobson et al. 1994). Given the lack of data for British Columbia, it is unclear which method would be most appropriate and additional studies are required. Also, there is evidence that increased larval abundance does not translate to increased recruitment for northern anchovy (see Peterman et al. 1988), possibly complicating assessments for this species. Stock assessment might be further complicated by the existence of sub-stocks in the northern stock. Such population structure has been detected in other anchovy species using multivariate analyses of morphometric and meristic characteristics (Junquera and Perez-Gándaras 1993) and genetic analyses (Bembo et al. 1996; Díaz-Jaimes et al. 1999).

A Review of Northern Anchovy Fisheries

Midden sites demonstrate the Nuu-Cha-Nulth First Nations of the West Coast of Vancouver Island used northern anchovy from undefined areas (D. Hall, pers. comm.). There is no recorded use of anchovies by First Nations of the Hecate Strait ecosystem (encompassing the geographical area of the Queen Charlotte Islands and across to the mainland), the most northern extent of this species in British Columbia (Jones 1999).

Commercial fisheries for northern anchovy in British Columbia have been intermittent. Coastal fisheries have operated since 1939 but catches have varied significantly between 0 and 6100mt (Pike 1951; Figure 1). Marketing of the product was attempted in the 1940s but was unsuccessful likely due to competition from European imports (i.e., marinated, cured, paste). Currently, northern anchovy are fished for bait using seine nets. Almost all fishing occurs during the summer months when large schools of adults migrate into the bays and inlets of British Columbia, likely from southern locations in U.S. waters. Catch is not related to the number of licences issued from year to year and catch in subsequent seasons can be higher or lower than the previous one (Table 1; Figure

1). Furthermore, spawning biomass does not necessarily provide a good measure of recruitment, at least for the central stock of northern anchovy off southern California (Prager and MacCall 1993) and abundance of recruits does not necessarily reflect larval survival (Peterman and Bradford 1987). These highly variable catches can result from periodic fluctuations in abundance, possibly due to high mortality at the larval or juvenile stages (see Peterman et al. 1988). The last large influx of northern anchovies to British Columbia occurred in the mid-1980s when large, dense schools were observed in Barkley and Clayoquot Inlets on the West Coast of Vancouver Island. Aerial surveys estimated individual schools to represent 50–100mt such that the total coast-wide biomass estimate of northern anchovy was between 16 000–60 000mt for British Columbia (Hay and Ware, unpubl. data). This surge resulted in increased commercial catches lasting five years (Table 1). Although no additional survey data is available, catch records indicate this influx was short-lived and the population returned to typical, lower levels beginning in the early 1990s. This type of high inter-annual variability may prevent future expansion of commercial fisheries for northern anchovy in British Columbia.

It is possible that commercial catches of northern anchovy are related to environmental variables. This species is a warm-water species (Hart 1973) and landings might increase in years when water temperatures are warmer. This relationship was examined using reported commercial catches and available sea surface temperature data (Figure 2). This relationship was only valid during the late 1930s to early 1940s. It should be noted that factors other than environmental variables such as market demand and landed product value also will influence the desire of fishermen fish for anchovy. Independent biomass assessments for northern anchovy are not available and commercial landings do not necessarily reflect available biomass.

There is an Integrated Fisheries Management Plan (IFMP) for northern anchovy in British Columbia that controls licensing and is reviewed annually by Fisheries and Oceans (http://www.pac.dfo-mpo.gc.ca/ops/fm/mplans/plans02/Anch02pl.PDF). It is unlimited entry and requires possession of a personal commercial fishing licence and a personal “ZK” category licence. Gear is restricted to seine net with a maximum length of 365.8m (200 fathoms). There is a maximum allowable catch per licence of 10mt; however, the licence holder may apply for an amendment for additional catch. It is a condition of the licence that the licence holders submit a harvest log each season, even for zero catches. However, in general, compliance with this regulation has been poor (Table 1). The fishery is closed year round, open only by variation order. Variation orders are issued when a licence holder contacts Fisheries Management at Fisheries and Oceans Canada and requests an opening. However, despite having the opportunity to fish (evidenced by the number of licences issued [Table 1]), landings since the early 1990s have been negligible, possibly indicative of product demand or anchovy availability.

In contrast to small, localised commercial fisheries in British Columbia, the central and, to a lesser extent, southern stocks have supported substantial fisheries both in California and Mexico, respectively (Pelagic Fisheries Management Council 1998; Tables 2 and 3). Prior to 1947 anchovy were used almost exclusively for bait with catch rarely exceeding 5000mt (Miller 1955). However, when sardine catches decline, landings of northern anchovy increase. For example, in California 39 000mt of northern anchovy were harvested in 1953 (Table 3), but catches rapidly decreased in response to low market demand. In 1965 an experimental reduction fishery was initiated. This reduction fishery peaked in the mid-1970s accounting for 90% of the total US harvest and was surpassed in the 1980s by non-reduction fisheries (Opsomer and Conrad 1994; Figure 3). Mexico began fishing anchovy during the 1970s, and increases in stock abundance and market prices (for fishmeal and oil) resulted in combined landings of northern anchovy from California and Mexico as high as 425 000mt in the early 1980s (Shimada et al. 1999; Table 3; Figure 3). However, more recently, low reduction prices and reduced biomass have resulted in a greatly diminished anchovy fishery, with landings of less than 12 000mt in California and less than 8000mt in Mexico in 2000 (Table 3). Anchovy landings increased in California in 2001 (Table 2) but it is unknown if this trend will persist.

Both the central and northern stocks are managed collectively in the United States under the Coastal Pelagic Species Fishery Management Plan (Pelagic Fisheries Management Council 1998). This fishery operates as a limited entry fishery south of 39°N and an open access fishery north of 39°N. Interestingly, the plan covers five species (northern anchovy, pacific sardine, pacific mackerel, pacific herring and squid) with the northern anchovy fishery operating on two platforms, a commercial (seine) fishery and a live bait fishery. Commercial landings of anchovy from the northern stock (Washington and Oregon) are generally small, less than 60mt per year as is the bait fishery, only operating 1–4 boats per year. Small school sizes, around 4mt, are a limiting factor to further fishery development (Richardson 1981), a situation similar to British Columbia.

In addition to the commercial anchovy fisheries, recreational fisheries exist for northern anchovy. In British Columbia, the recreational fishery is regulated through the ‘British Columbia Tidal Waters Sport Fishing Guide’. A Tidal Sport Fishing Licence is required and allows for a coastal daily limit of 20kg and a possession limit of 40kg. Gear is restricted to dipnet (no restriction on mesh size or frame size), herring jig, herring rake or cast net. No recreational user information exists for this species in British Columbia. In Oregon State, anchovy are classified as a “Non-Game fish” as are herring, smelt and sardine. Gear is restricted to angling, dipnet, cast net, and herring jig with any number of hooks. In marine waters, a combined total of 11.4kg of herring, anchovy, smelt, and sardine are allowed daily. In Washington State, anchovy are classified as a “Forage Fish” as are herring, sardine, sand lance, and smelt. The season is open year-round and there are no minimum size limits. The daily limit is 4.5kg of combined herring, smelt, anchovy, sardine, and sand lance. Gear is restricted to dipnet or jig.

Discussion

Very little background information is available for northern anchovy in British Columbia. Commercial fisheries for northern anchovy in British Columbia have been intermittent, evidenced by large temporal gaps in reported catch (Figure 1). In 2001, five commercial licences were issued (Table 1). It is difficult to discern whether decreased catches in recent years is due to low biomass, knowledge gaps concerning the distribution of northern anchovy around British Columbia, and/or poor market conditions for this species. Therefore, there is considerable doubt that a commercial fishery for northern anchovy in British Columbia would be sustainable. Much uncertainty about sustainability arises from the high inter-annual variability associated with this species. It is important to note that globally, anchovy fisheries often have negative annual surplus production (ASP) that would result in decreased biomass even without fishing pressure (Jacobson et al. 2001).

Ware (1999) encountered similar data deficiencies when developing a management framework for Pacific sardine in British Columbia. However, major differences exist in data available for sardine and that available for anchovy. First, stock assessments are made annually for sardine. No assessments are routinely made for the northern stock of northern anchovy. Second, Ware (1999) was able to determine a migration rate for sardine based on population dynamics. This information is not available for northern anchovy in British Columbia and it is unknown if only older age-classes migrate north or if the entire population migrates. Despite these differences, it might be possible to adapt some parts of the sardine management framework to suit northern anchovy.

One key management concern is the ability to discriminate between different populations or stocks. It is unclear if northern anchovy maintain resident populations in British Columbia or if they migrate annually from more southern locations. Genetic markers have been used successfully to differentiate fish stocks (e.g., Taylor and Bentzen 1993; Díaz-Jaimes et al. 1999) and might be used to discern between resident and migratory northern anchovy populations in British Columbia. A second approach to determine the migratory nature of these stocks is the use of tagging studies. Tagging studies on herring have shown a tendency for individuals to stray between different management stocks (i.e., Ware and Schweigert 2001). Either approach might highlight the amount of movement within the northern stock and if stock sub-structure exists.

Recommendations

Historical catch records, research cruise data and commercial by-catch records from the last decade all indicate northern anchovy will rarely attain or maintain sufficient population sizes in British Columbia to support any long-term commercial fishery. However, if there is commercial interest, the fishery needs to conform to the Precautionary Approach to Fisheries Management (Fisheries and Agriculture

Organisation 1995) adopted by Fisheries and Oceans Canada. The following recommendations are made with those ideas in mind.

1. Stock identification should be a priority and should focus on determining whether northern anchovy in British Columbia are permanent residents or migrants from southern locations (or a combination of the two). The use of molecular markers would be well suited to address these issues.
2. Develop an assessment program to determine the status of northern anchovy in British Columbia, especially with respect to biomass and distribution. Initial data collection should focus on determining baseline data prior to opening of a commercial fishery.
3. Any northern anchovy fishery in British Columbia needs to be actively monitored. The most serious concern about this commercial fishery is by-catch. This fishery has the potential to impact herring and juvenile salmon (Hay and Ware, unpubl. data) but also species typically associated with sardine schools due to a number of similarities between northern anchovy and Pacific sardine.
4. Establish a long-term program capable of evaluating the effects of harvest strategies on growth and recruitment of northern anchovy in British Columbia. This would be consistent with a “Phase 1” report based on the guidelines of Perry et al. (1999) and could be initiated using scientific licences.
5. Consult with various user groups, including First Nations, to determine the expected use and potential interest in northern anchovy fisheries in British Columbia.

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References

Ahlstrom, E.H. 1966. Distribution and abundance of sardine and anchovy larvae in the California Current region off California and Baja California, 1951-64: A summary. U.S. Fish Wildl. Serv. Spec. Sci. Rep. No. 534.

Ahlstrom, E.H. 1967. Co-occurrences of sardine and anchovy larvae in the California Current region off California and Baja California. CalCOFI Rep. 11:117-135.

Barraclough, W.E., Robinson, D.G., and Fulton, J.D. 1969. Data record. Number, size composition, weight and food of larval and juvenile fish caught with a two-boat surface trawl in the Saanich Inlet April 23-July 21, 1968. Fish. Res. Board Can. Man. Rep. Ser. No. 1004.

Baumgartner, T.R., Soutar, A. and Ferreira-Bartrina, V. 1992. Reconstruction of the history of pacific sardine and northern anchovy over the past two millennia from sediments of the Santa Barbara basin, California. CalCOFI Rep. Vol. 33:24-40.

Baxter, J.L. 1967. Summary of biological information on the northern anchovy *Engraulis mordax* Girard. CalCOFI Rep. 11:110-116.

Bembo, D.G., Carvalho, G.R., Cingolani, N., and Pitcher, T.J. 1996. Electrophoretic analysis of stock structure in Northern Mediterranean anchovies, *Engraulis encrasicolus*. ICES J. Mar. Sci. 53: 115-128.

Blackburn, J.E. 1973. A survey of the abundance, distribution, and factors affecting distribution of ichthyoplankton in Skagit Bay. M.S. Thesis, University of Washington, 136pp.

Bolin, R.L. 1936. Embryonic and early larval stages of the California anchovy. Calif. Fish Game 22:314-321.

Booman, C., Folkvord, A., and Hunter, J.R. 1991. Responsiveness of starved northern anchovy *Engraulis mordax* larvae to predatory attacks by adult anchovy. Fish. Bull. U.S. 89:707-711.

Chashchin, A.K. 1996. The Black Sea populations of anchovy. Sci. Mar. 60:219-225.

Department of Fisheries and Environment. 1977-1978. British Columbia catch statistics [1976-1977]. Queen's Printer, Ottawa. 2 vols.

Department of Fisheries and Forestry Canada. 1970-1971. British Columbia catch statistics [1969-1970]. Queen's Printer, Ottawa. 2 vols.

Department of Fisheries and Oceans. 1979-1982. British Columbia catch statistics [1978-1981]. Queen's Printer, Ottawa. 4 vols.

Department of Fisheries. 1952-1969. British Columbia catch statistics [1951-1968]. Queen's Printer, Ottawa. 18 vols.

Department of the Environment. 1972. Summary of fishing in British Columbia: [June, Aug, Sep., Dec.] 1972. Queen's Printer, Ottawa. 4 vols.

Department of the Environment. 1973. Summary of fishing in British Columbia: [May, June, July, Nov.] 1973. Queen's Printer, Ottawa. 4 vols.

Department of the Environment. 1972-1976. British Columbia catch statistics [1971-1975]. Queen's Printer, Ottawa. 5 vols.

Díaz-Jaimes, P., Uribe-Alcocer, M., and Ayala-Duval, E. 1999. Electrophoretic variation between the central and southern populations of the northern anchovy *Engraulis mordax* Girard 1854 (Engraulidae, Pisces) from Baja California, Mexico. Cien. Mar. 25: 579-595.

Dominion Bureau of Statistics, Fisheries Division. 1922-1949. Fisheries statistics of Canada [1920-1948]. King's Printer, Ottawa. 29 vols.

Dominion Bureau of Statistics, Fisheries Division. 1952-1972. Fisheries statistics of Canada [1949-1970]. Queen's Printer, Ottawa. 21 vols.

Emmett, R.L., Bentley, P.J, and Schiewe, M.H. 1997. Abundance and distribution of northern anchovy eggs and larvae (*Engraulis mordax*) off the Oregon coast, mid-1970's vs. 1994 and 1995. *In:* Forage fishes in marine ecosystems. Alaska Sea Grant College Program 97-01. pp. 505-508.

Emmett, R.L., Bentley, P.J., and Krutzikowsky, G.K. 2001. Ecology of marine predatory and prey fishes off the Columbia River, 1998 and 1999. NOAA Tech. Memo NMFS-NWFSC 51: 108 pp.

Fisheries and Agriculture Organisation. 1995. Precautionary Approach to Fisheries. Pt1: Guidelines On The Precautionary Approach To Capture Fisheries And Species Introductions. FAO Fish Tech. Paper 350 (1).

Girard, C. 1854. Descriptions of new fishes, collected by Dr. A.L. Heermann, naturalist attached to the survey of the Pacific railroad route, under Lieut. R.S. Williamson, U.S.A. Proc. Acad. Nat. Sci. Philad. 7:129-140.

Hampton, I. 1996. Acoustic and egg-production estimates of South African anchovy biomass over a decade: comparisons, accuracy, and utility. ICES J. Mar. Sci. 53: 493-500.

Hart, J.L. 1973. Pacific fishes of Canada. Bull. Fish. Res. Board Can. No. 180.

Hedgecock, D., Hutchinson, E.S., and Li, G. 1989. Genetic and morphometric variation in the Pacific sardine, *Sardinops sagax caerulea*: Comparisons and contrasts with historical data and with variability in the northern anchovy, *Engraulis mordax*. Fish. Bull. U.S. 87:653-671.

Holmgren-Urba, D., and Baumgartner, T.R. 1993. A 250-year history of pelagic fish abundances from the anaerobic sediments of the central Gulf of California. CalCOFI Rep. 34: 60-68.

Hunter, JR., and Coyne, K.M. 1982. The onset of schooling in northern anchovy larvae, *Engraulis mordax*. CalCOFI Rep. 23: 246-251.

Hunter, J.R., and Goldberg, S.R. 1980. Spawning incidence and batch fecundity in northern anchovy, *Engraulis mordax*. Fish. Bull. U.S. 77:641-652.

Hunter, J.R., and Kimbrell, C.A. 1980. Egg cannibalism in the northern anchovy, *Engraulis mordax*. Fish. Bull. U.S. 78:811-816.

Hunter, J.R., Lo, N.C.H., and Leong, R.J.H. 1985. Batch fecundity in multiple spawning fishes. *In* An egg production method for estimating spawning biomass of pelagic fish: Application to the northern anchovy, *Engraulis mordax*. *Edited by* R. Lasker. NOAA Tech. Rep. NMFS 36. pp. 67-78.

Jacobson, L.D., Lo, N.C.H., and Barnes, J.T. 1994. A biomass-based assessment model for northern anchovy, *Engraulis mordax*. Fish. Bull. U.S. 92: 711-724.

Jacobson, L.D., De Oliveira, J.A.A., Barange, M., Cisneros-Mata, M.A., Félix-Uraga, R., Hunter, J.R., Kim, J.Y., Matsuura, Y., Ňiquen, M., Porteiro, C., Rothschild, B., Sanchez, R.P., Serra, R., Uriarte, A., and Wada, T. 2001. Surplus production, variability, and climate change in the great sardine and anchovy fisheries. Can. J. Fish. Aquat. Sci. 58: 1891-1903.

Jones, R.R. 1999. Haida Names and Utilisation of Common Fish and Marine Mammals. *In* Back to the future, Reconstructing the Hecate Strait Ecosystem. *Edited* by N. Haggan and A Beattie. Fisheries Centre Research Reports 7(3). University of British Columbia Press, Vancouver, BC.

Junquera, S., and Perez-Gándaras, G. 1993. Population diversity in Bay of Biscay anchovy (Engraulis encrasicolus L. 1758) as revealed by multivariate analysis of morphometric and meristic characters. ICES J. Mar. Sci. 50: 383-391.

Klingbeil, R.A. 1978. Sex ratios of the northern anchovy, *Engraulis mordax*, off Southern California. Calif. Fish Game 64:200-209.

Koslow, J.A. 1981. Feeding selectivity of schools of northern anchovy, *Engraulis mordax*, in the southern California Bight. Fish. Bull. U.S. 79: 131-142.

Laroche, J.L., and Richardson, S.L. 1980. Reproduction of northern anchovy, *Engraulis mordax*, off Oregon and Washington. Fish. Bull. U.S. 78: 603-618.

Laroche, W.A. 1976. Larval and juvenile fishes off the Columbia River mouth. *In* Procedures of the 5th technical conference. Estuaries of the Pacific Northwest, April 1 and 2, 1976. Oreg. State Univ. Eng. Exp. Stn. Circ. No. 51. pp. 17-20.

Lasker, R. (ed.) 1985. An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy (*Engraulis mordax*). U.S. Dep. Commer., NOAA Tech. Rep. NMFS 36, 99 pp.

Lo, N.C.H. 1985. A model for temperature-dependent northern anchovy egg development and an automated procedure for the assignment of age to staged eggs. *In* An egg production method for estimating spawning biomass of pelagic fish: Application to the northern anchovy, *Engraulis mordax*. *Edited by* R. Lasker. NOAA Tech. Rep. NMFS 36. pp. 43-50.

MacCall, A.D. and Prager, M.H. 1988. Historical abundance of six fish species. CalCOFI Rep. 29:91-101.

MacGregor, J.S. 1968. Fecundity of the northern anchovy, *Engraulis mordax* Girard. Calif. Fish. Game 54:281-288.

Masse, J. 1996. Acoustic observations in the Bay of Biscay: schooling, vertical distribution, species assemblages and behaviour. Sci. Mar. 60: 227-234.

McHugh, J.L. 1951. Meristic variations and populations of northern anchovy (*Engraulis mordax*). Scripps Inst. Oceanogr. Bull. 6:123-160.

McHugh, J.L., and Fitch, J.E. 1951. An annotated list of the clupeoid fishes of the Pacific coast from Alaska to Cape San Lucas, Baja California. Calif. Fish Game 37:491-495.

Methot, R.D. 1989. Synthetic estimates of historical abundance and mortality of northern anchovy. Am. Fish. Soc. Symp. 6: 66-82.

Miller, D.J. 1955. Studies relating to the validity of the scale method for age determination of the northern anchovy (*Engraulis mordax*). *In* Age determination of the northern anchovy, *Engraulis mordax*. Calif. Dep. Fish Game, Fish Bull. No. 101. pp. 6-36.

Moser, H.G., and Ahlstrom, E.H. 1985. Staging anchovy eggs. *In* An egg production method for estimating spawning biomass of pelagic fish: application to the northern anchovy, *Engraulis mordax*. *Ed.* R. Lasker. NOAA Tech. Rep. NMFS 36. pp. 37-42.

O'Connell, J.M. 1998. Holocene fish remains from Saanich Inlet, British Columbia, Canada: A paleoecological study. M.Sc. Thesis, University of Victoria. 187pp.

Olesiuk, P.F., Bigg, M.A., Ellis, G.M., Crockford, S.J. and R.J. Wigen. 1990. An assessment of the feeding habits of Harbour seals (Phoca vitulina) in the Strait of Georgia, British Columbia, based on scat analysis. Can. Tech. Rep. Fish. Aquat. Sci. Rep. No. 1730, 135 pp.

Opsomer, J.-D., and Conrad, J.M. 1994. An open-access analysis of the northern anchovy fishery. J. Environ. Econom. Mgmnt. 27: 21-37.

Pacific Fishery Management Council. 1998. Coastal pelagic species fishery management plan. Amendment 8. Portland, Oregon.

Parrish, R.H., Mallicoate, D.L., and Mais, K.F. 1985. Regional variations in the growth and age composition of northern anchovy, *Engraulis mordax*. Fish. Bull. U.S. 83:483-496.

Parrish, R.H., Mallicoate, D.L., and Klingbeil, R.A. 1986. Age dependent fecundity, number of spawnings per year, sex ratio, and maturation stages in northern anchovy, *Engraulis mordax*. Fish. Bull. U.S. 84:503-517.

Perry, R.I., C.J. Walters, and J.A. Boutillier. 1999. A framework for providing scientific advice for the management of new invertebrate species. Rev. Fish Biol. Fisheries 9:125-150.

Pertierra, J.P., Lleonart, J., Lo, N.C.H. 1997. Application of a stage-specific matrix model and length-cohort based analysis to assess the anchovy fishery in Catalan coastal waters (NW Mediterranean Sea). Fish. Res. 30: 127-137.

Peterman, R.M., and Bradford, M.J. 1987. Wind speed and mortality rate of a marine fish, the northern anchovy (*Engraulis mordax*). Science 235: 354-356.

Peterman, R.M., Bradford, M.J., Lo, N.C.H., and Methot, R.D. 1988. Contribution of early life stages to interannual variability in recruitment of northern anchovy (*Engraulis mordax*). Can. J. Fish. Aquat. Sci. 45: 8-16.

Pike, G.C. 1951. Age, growth and maturity studies on the pacific anchovy (*Engraulis mordax*) from the coast of British Columbia. M.A. Thesis, University of British Columbia, Vancouver, B.C.

Prager, M.H., and MacCall, A.D. 1993. Detection of contaminant and climate effects on spawning success of three pelagic fish stocks off southern California: northern anchovy *Engraulis mordax*, Pacific sardine *Sardinops sagax*, and chub mackerel *Scomber japonicus*. Fish. Bull. U.S. 91: 310-327.

Prince, E.E. 1897. The fisheries of Canada. II(3):264-274. In Handbook of Canada. Brit. Ass. Adv. Sci. Toronto, 1897, 415 pp.

Richardson, S.L. 1981. Spawning biomass and early life of northern anchovy, *Engraulis mordax*, in the northern subpopulation off Oregon and Washington. Fish. Bull. U.S. 78:855-876.

Roach, S.W., and Harrison, J.S.M. 1948. Canning of anchovies. Fish. Res. Board Can. Prog. Rep. Pac. Biol. Stn. 77:108-111.

Robinson, D.G. 1969. Data Record. Number, size and food of larval and juvenile fish caught with a two boat surface trawl in the Straight of Georgia July 4-6, 1969. Fish. Res. Bd. Can. Man. Rep. No. 1012, 71 pp.

Schwartzlose, R.A., Alheit, J., Bakun, A., Baumgartner, T.R., Cloete, R., Crawford, R.J.M., Fletcher, W.J., Green-Ruin, Y., Hagen, E., Kawasaki, T., Lluch-Belda, D., Lluch-Cota, S.E., MacCall, A.D., Matsuura, V., Navarez-Martinez, M.O., Parrish, R.H., Roy, C., Serra, R., Shust, K.V., Ward, M.N., and Zuzanaga, J.Z. 1999. World fluctuations of sardine and anchovy populations. S. Af. J. Mar. Sci. 21:289-335.

Scott, W.B., and Scott, M.G. 1988. Atlantic fishes of Canada. Can. Bull. Fish. Aquat. Sci. 219: 731pp.

Sette, O.E., and Ahlstrom, E.H. 1948. Estimations of abundance of eggs of the Pacific pilchard (*Sardinops caerulea*) off southern California during 1940 and 1941. J. Mar. Res. 7: 849-874.

Shimada, A.M., Stanton, D.G., Hobart, W.L., and Chandler, M.D. 1999. Our Living Oceans: Report on the status of U.S. Living Marine Resources, 1999. Supt. of documents Washington D.C. 20402.

Smith, P.E. 1972. The increase in spawning biomass of northern anchovy, *Engraulis mordax*. Fish. Bull. U.S. 70:849-874.

Soutar, A., and Isaacs, J.D. 1974. Abundance of pelagic fish during the 19th and 20th centuries as recorded in anaerobic sediment off the Californias. Fish. Bull. U.S. 72:257-273.

Taylor, E.B., and Bentzen, P. 1993. Evidence for multiple origins and sympatric divergence of trophic ecotypes of smelt (*Osmerus*) in northeastern North America. Evolution 47: 813-832.

Vrooman, A.M., Paloma, P.A., and Zweifel, J.R. 1981. Electrophoretic, morphometric, and meristic studies of subpopulations of northern anchovy, *Engaulis mordax*. Calif. Fish Game 67:39-51.

Waldron, M.E. 1994. Validation of annuli of the South African anchovy, *Engraulis capensis*, using daily otolith growth increments. ICES J. Mar. Sci. 51: 233-234.

Ware, D.M. 1999. Life history of Pacific sardine and a suggested framework for determining a B.C. catch quota. CSAS Res. Doc. 99/204.

Ware, D. and Schweigert, J. 2001. Metapopulation structure and dynamics of British Columbia herring. CSAS Res. Doc. 2001/127.

Table 1: Number of licences issued, harvest logs received and percent compliance for British Columbia commercial landings of northern anchovy between 1984 and 2001. Logbook reported landings also are provided.

Year	Licences Issued	Harvest Logs Received	Percent Compliance	Reported Catch (kg)
1984	31	--	--	25 946
1985	14	--	--	46 545
1986	18	--	--	40 625
1987	28	--	--	79 425
1988	9	4	44.4	54 010
1989	24	2	8.3	8 868
1990	20	1	5.0	0
1991	26	10	38.5	0
1992	21	8	38.1	25 991
1993	15	3	20.0	2 093
1994	14	12	85.7	0
1995	17	10	58.8	68
1996	20	10	50.0	0
1997	12	7	58.3	0
1998	40	8	20.0	0
1999	10	5	50.0	136
2000	5	1	20.0	68
2001	4	4	100.0	272

Table 2: Reported catch of northern anchovy from the United States. Washington and Oregon landings are from the northern stock and the California landings are from the central stock.

	United States Landings (mt)		
Year	Washington [*#]	Oregon [+]	California [#]
1975	--	17.2	--
1976	--	0.68	--
1977	--	0.09	--
1978	--	0.14	--
1979	--	0.32	--
1980	--	0	--
1981	1.3	0	52 285.3
1982	5.1	0.09	42 143.1
1983	2.9	0	4 426.7
1984	10.1	0	2 888.7
1985	11.7	0.01	1 625.8
1986	22.1	0	1 535.3
1987	77.6	0	1 389.7
1988	40.4	0.01	1 477.8
1989	61.8	0.01	2 449.3
1990	50.3	0	3 185.4
1991	54.5	0	4 013.8
1992	41.7	0	1 123.8
1993	44.2	<0.01	1 958.4
1994	69.5	0.09	1 788.8
1995	129.6	0.22	1 881.1
1996	85.6	0	4 419.0
1997	59.1	0	5 716.9
1998	102.5	0.01	1 477.4
1999	97.8	0	5 213.4
2000	78.7	0.14	11 735.6
2001	68.0	0	19 037.0

[*] M. Stanley, Washington Department of Fish & Wildlife, pers. comm.

[+] J. McCrae, Oregon Department of Fish & Wildlife, pers. comm.

[#] National Marine Fisheries Service, Landings, U.S.A.

Table 3: FAO (Fisheries and Agriculture Organization) reported commercial landings for the three major northern anchovy stocks. The northern stock represents catches in Washington and Oregon, the central stock represents catches in California, and the southern stock represents catches in Mexico. Canadian catches are shown in Table 1.

Year	Northern	Central	Southern
1950	0	2 213	0
1951	0	3 155	0
1952	0	25 303	0
1953	0	38 935	0
1954	0	19 237	0
1955	0	20 272	0
1956	0	25 801	0
1957	0	18 392	0
1958	0	5 263	0
1959	0	3 254	0
1960	0	2 295	1 900
1961	0	3 498	2 300
1962	0	1 254	3 300
1963	0	2 073	1 600
1964	0	2 257	5 100
1965	0	2 600	9 300
1966	0	28 250	13 400
1967	0	31 575	22 500
1968	155	14 096	15 700
1969	162	61 362	3 900
1970	200	87 300	5 100
1971	100	40 700	3 800
1972	0	68 000	6 100
1973	0	126 000	2 100
1974	3	80 165	42 291
1975	18	149 377	59 642
1976	1	119 530	79 383
1977	18	105 186	178 798
1978	0	16 048	180 142
1979	0	53 252	249 566
1980	0	48 509	325 560
1981	1	57 428	366 969
1982	5	46 857	318 070
1983	3	4 301	97 917
1984	10	8 062	126 892
1985	12	6 595	147 116
1986	23	6 072	116 905
1987	64	5 767	161 268
1988	36	5 600	113 724

1989	62	6 012	105 359
1990	50	5 932	61
1991	54	8 675	12 117
1992	43	6 162	3 406
1993	44	4 395	343
1994	78	3 702	195
1995	130	2 949	24 071
1996	86	4 419	9 598
1997	59	5 719	2 147
1998	103	1 450	782
1999	98	5 225	5 814
2000	0	11 487	7 973

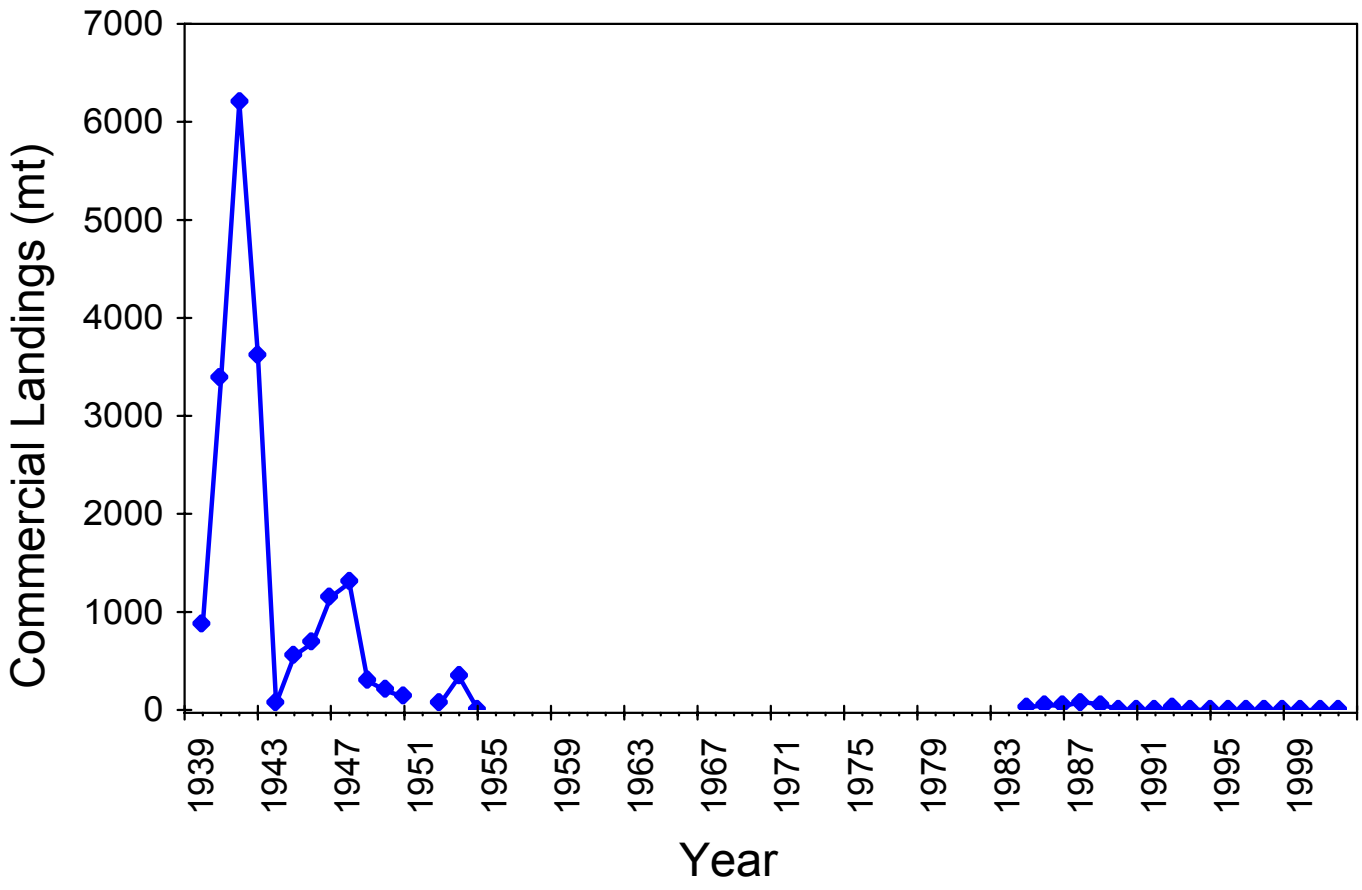

Figure 1: Reported commercial catch from the British Columbia northern anchovy fishery: 1939-2002. Data from: Dominion Bureau of Statistics (1922-1949; 1952-1972), Department of Fisheries (1952-1969), Department of Fisheries and Forestry Canada (1970-1971), Department of the Environment (1972; 1973; 1972-1976), and Department of Fisheries and Environment (1977-1978), Department of Fisheries and Oceans (1979-1982).

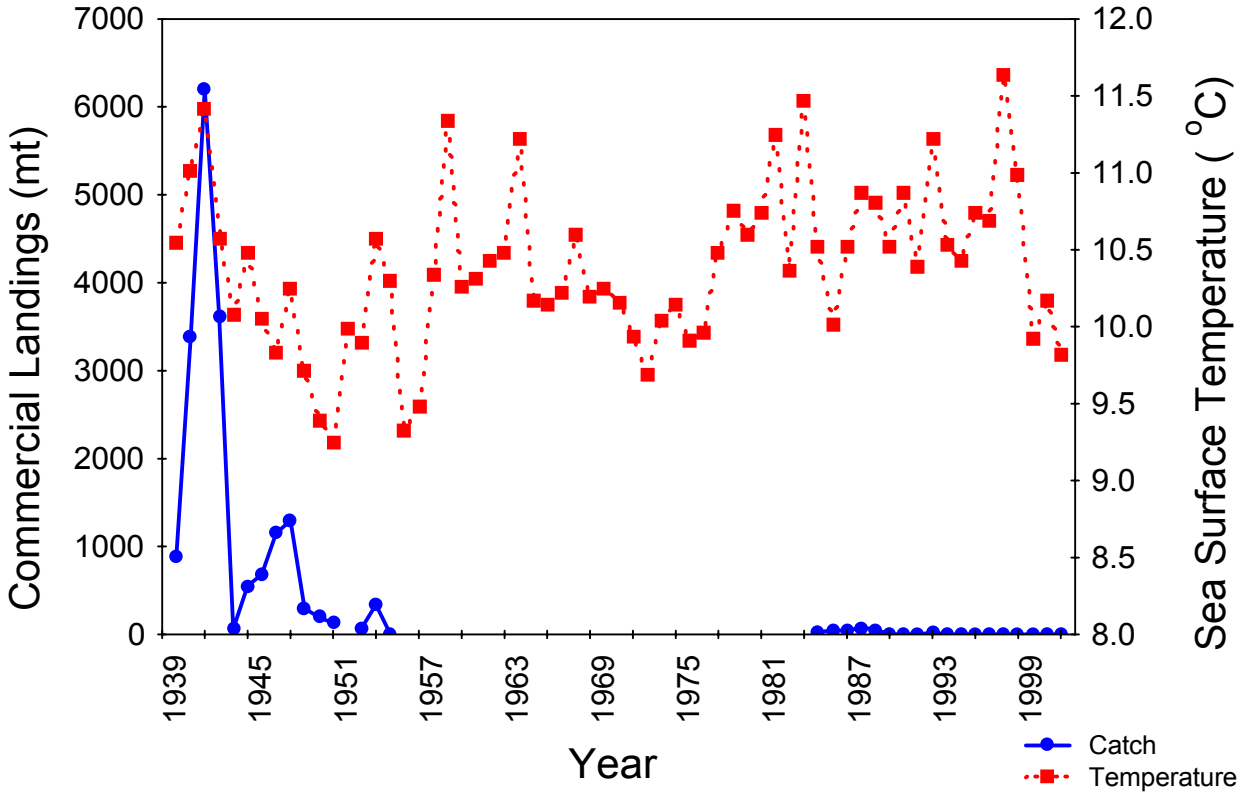

Figure 2: Relationship between commercial landings of northern anchovy in British Columbia and sea surface water temperature between 1939 and 2001. Water temperature data collected at Amphitrite Point.

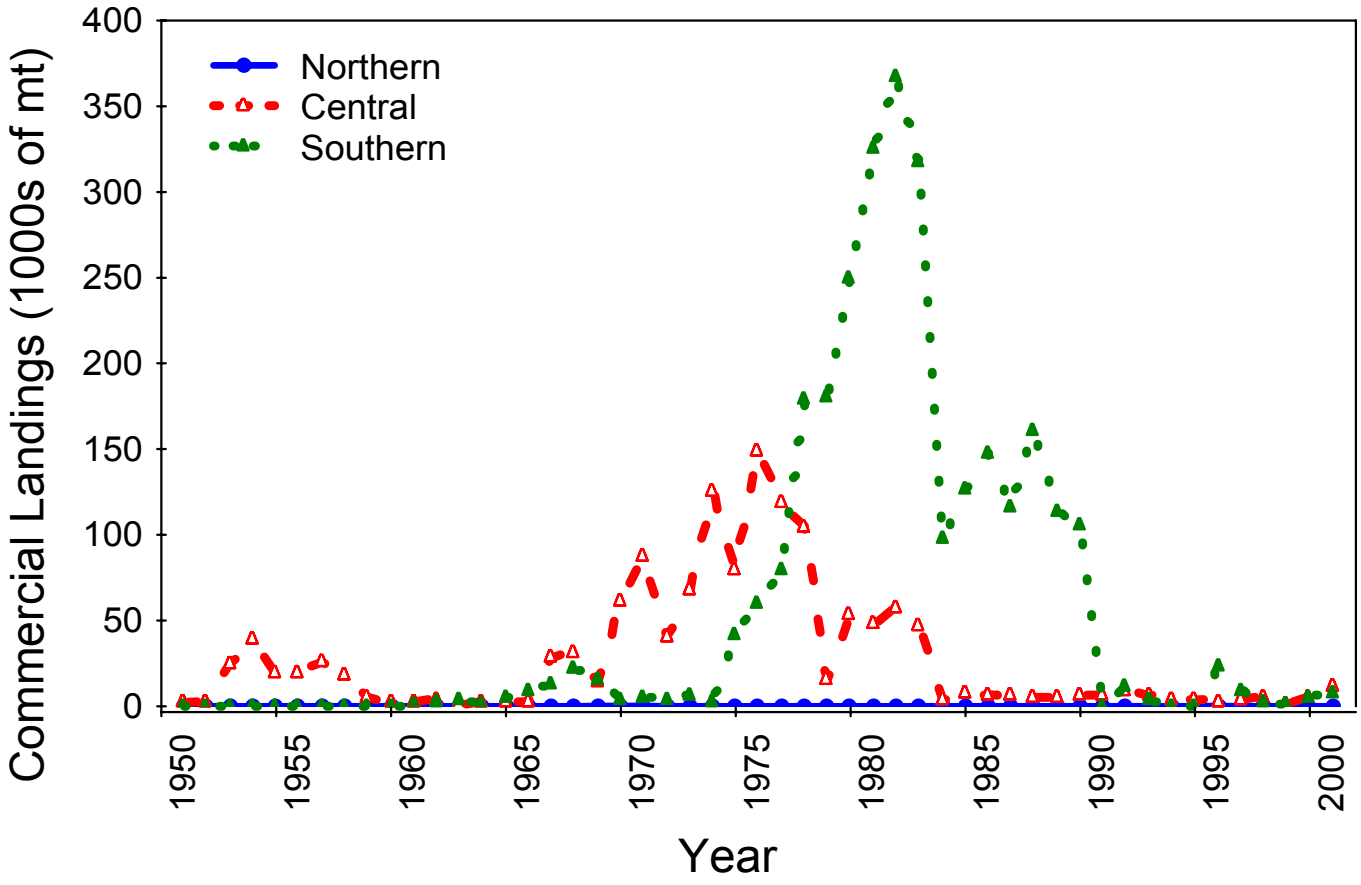

Figure 3: Commercial landings of northern anchovy for each of the three major stocks, northern, central, and southern, between 1950 and 2000 based on FAO reported landings.