Assessment of Lingcod (*Ophiodon elongatus*)

for the

Pacific Fishery Management Council

in 2003

by

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Executive Summary

Stock

This assessment applies to lingcod (*Ophiodon elongatus*) in the full Pacific Fishery Management Council (PFMC) management zone (the US-Vancouver, Columbia, Eureka, Monterey, and Conception INPFC areas). Separate assessment models were constructed to describe population trends in the northern (LCN: US-Vancouver, Columbia) and southern (LCS: Eureka, Monterey, Conception) areas.

Catches

Commercial Landings

Commercial lingcod catch history in California waters is available beginning 1916 (personal communication Brenda Erwin, PSMFC) and averaged 428 mt between 1916 and 1955. Commercial lingcod landings in Oregon were first reported in 1950 (Mark Freeman, personal communication) and averaged 264 mt between 1950 and 1953. Washington commercial lingcod landings were first reported in 1937 (anonymous, 1956, WDFW report) and averaged 106 mt until 1955.

Catch data were compiled from agency reports and personal communication for all years preceding 1981. The PacFIN database was queried for catch information in subsequent years. Landings peaked in 1985 at 3,129 mt in northern waters (Columbia and Vancouver INPFC areas) and in 1974 at 1,735 mt in southern waters (Eureka, Monterey and Conception INPFC Areas). Commercial fishery restrictions under lingcod rebuilding management (1998-present) dropped catches to an annual average below 135 mt in both northern and southern waters in recent years.

Over the last two decades, trawl gear has made up the majority of commercial landings for the northern (83%) and southern (62%) coast. In recent years (1998-2002), commercial fishery restrictions constrained the trawl portion of the catch to 54% and 45% for the northern and southern coast, respectively. In 2002, coastwide commercial landings totaled 223 mt and were distributed as follows by INPFC area: U.S.-Vancouver 63 mt (22%), Columbia 52 mt (30%), Eureka 63 mt (27%), Monterey 35 mt (16%), Conception 10 mt (5%).

Recreational Landings

Recreational fishers in California have targeted lingcod since the early 1940's and catch averaged 65.3 mt annually between 1947-1954. Recreational lingcod catch information is not available until 1977 for Oregon waters. Removals averaged 52.3 mt annually between 1977 and 1979. Recreational lingcod catch in Washington was first estimated in 1967 to be 25.3 mt, and annual catch estimates have been provided since 1975.

Recreational catch estimates were extracted from the RecFIN database for years 1980–1989 and 1993 to present for California waters. California recreational catch estimates for all other years were compiled previously in the 2000 lingcod assessment (Jagielo et al., 2000). Oregon recreational catch data were provided by ODFW (Don Bodenmiller, personal communication). Washington recreational catch data were obtained from the WDFW Ocean Sampling Program.

Recreational catch in southern waters has declined dramatically since catch peaked in 1980 at 2,226 mt. In contrast, recreational catch in northern waters peaked at 236 mt in 1994; 127 mt was landed in 2002.

Historically, recreational landings have comprised a larger proportion of the total landings for the southern area, compared to the northern area. In recent years, the recreational portion of the total landings has increased substantially in both the southern and northern areas. In 2002, recreational fisheries harvested 83% of the total lingcod catch in the south and 52% in the north.

Data and Assessment

Present Modeling Approach and Assessment Program

The present assessment updates the previous coastwide assessment (Jagielo et al. 2000) and is implemented in Coleraine using the executable code COLERA20.EXE (Hilborn et al. 2000). Coleraine is a statistical catch-at-age model programmed in AD Model Builder with a Microsoft Excel user interface and has been used for New Zealand assessments including blue whiting, ling, elephant fish, orange roughy and black oreo; in 2000 for Icelandic cod; and recently on the U.S. west coast for sablefish (Hilborn et al. 2001).

In Coleraine, recruitments are assumed to follow a Beverton-Holt spawner recruit curve with a lognormal penalty function for recruitment deviates (Hilborn et al. 2000, section 1.2.3). The parameters are: average recruitment in the unfished state (R_0), steepness (h) - the fraction of recruitment obtained at 20% of virgin spawning biomass, and the standard deviation of annual recruitment residuals (Hilborn et al. 2000). In this stock assessment, the initial age composition was determined by assuming that the population was in equilibrium with a fixed, sex specific exploitation rate - U_{init}. (Hilborn et al. 2000, section 1.2.2).

As in the previous assessment, separate age structured models were constructed to analyze stock dynamics for the northern (LCN: US-Vancouver, Columbia) and southern (LCS: Eureka, Monterey, Conception) areas.

The LCN model incorporated the following likelihood components, which are described mathematically in Hilborn et al.(2000). Input data sources are specified by Table number in the body of the 2003 assessment document which follows:

1) Commercial Catch-At-Age: 1979-2002 (Table 7).
2) Recreational Catch-At-Age: 1980, 1986-2002 (Table 8).
3) Commercial Catch-At-Length: 1975-1978 (Table 11).
4) Recreational Catch-At-Length: 1981-1983 (Table 11).
5) NMFS Trawl Survey Catch-At-Age: 1992, 1995, 1998 and 2001 (Table 9).
6) NMFS Trawl Survey Catch-At-Length: 1986 and 1989 (Table 10)
7) WDFW Tag Survey Catch-At-Age: 1994-1997 (Table 9).
8) WDFW Tag Survey Catch-At-Length: 1986-1993 (Table 10).
9) NMFS Trawl Survey Biomass (mt): 1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998, and 2001 (Table 18).
10) WDFW Tag Survey Abundance (Numbers of Fish): 1986-1992 (Table 19).
11) Trawl Fishery Logbook CPUE Index: Washington and Oregon lingcod CPUE estimates (lbs/hr) derived from a Delta GLM analysis of trawl logbook information, 1976-1997 (Table 21).

The LCS model incorporated the following likelihood components:

1) Commercial Catch-At-Age: 1992-1998, 2000-2002 (Table 12).
2) Recreational Catch-At-Age: 1992-1998, 2000-2002 (Table 12).
3) NMFS Trawl Survey Catch-At-Age: 1995, 1998 and 2001 (Table 12).
4) NMFS Trawl Survey Biomass (mt): 1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998, and 2001 (Table 18).
5) Trawl Fishery Logbook CPUE Index: Oregon and California lingcod CPUE estimates (lbs/hr) derived from a Delta GLM analysis of trawl logbook information, 1978-1997 (Table 22).

Unresolved Problems and Major Uncertainties

Uncertainty regarding stock status is higher for the southern area relative to the northern area, primarily because historical data from the southern area were sparse relative to the northern area. The time series of fishery age data available for the southern (LCS) model is short and samples sizes are small, resulting in a shorter time series of estimated recruitments relative to the northern area. More assumptions about the early recruitments in the LCS time series were required, which resulted in greater uncertainty in the estimation of assessment parameters and stock productivity for the southern area. Age data for the NMFS trawl survey were sparse for both regions, but particularly for the southern region. Assumptions about fixed selectivity for this index of abundance were required for the LCS model.

Management-implemented minimum size limits have resulted in limiting the utility of fishery information for estimation of recent stock recruitment in both regions, and fishery trip limits have compromised the utility of recent fishery CPUE data as viable indices of abundance.

Management Reference Points

Comparison of the spawning stock estimates for 2002 with the estimates of virgin spawning stock size under the asymptotic fishery selectivity model assumption indicate that the recent coastwide spawning population size is approximately 25% of virgin levels (Table ES1). Under the domed fishery selectivity model assumption, the estimate of depletion was similar at 24%. By contrast, the model estimates of F_{45} differed between the asymptotic ($F_{45} = 0.12$) vs. domed

(F_{45} = 0.18) cases, indicating higher productivity under the domed fishery selectivity assumption. Consequently, projected yields under the domed fishery selectivity model assumption tend to be higher than under the asymptotic fishery selectivity model assumption (Table ES2).

When compared to the domed fishery selectivity model, the asymptotic fishery selectivity model is generally more consistent with the assumptions made in the previous lingcod stock assessment (Jagielo et al. 2000) and rebuilding analysis (Jagielo and Hastie 2001). (In the 2000 lingcod stock assessment, all fisheries were assumed to be asymptotic, with the exception for male fishery selectivity in the northern area, which was allowed to be dome shaped.) Estimates of F_{45} for the 2003 asymptotic model (0.12-north, 0.12-south) are similar to the estimates of F_{45} from the 2000 assessment (0.12-north, 0.14-south), with a slightly higher value for the south.

Spawning Stock Biomass

For the asymptotic fishery selectivity model, Coleraine estimates of the coastwide female spawning stock biomass declined from 22,918 mt in 1973 to 1,942 mt in 1994, and subsequently increased to 10,776 in 2003 (Figure ES1-Top). The trend over time was similar for the northern and southern areas. Female spawning biomass depletion (B_0/B_t) ranged from 0.53 in 1973 to a low of 0.05 in 1994, and subsequently increased to 0.25 in 2003.

For the dome shaped fishery selectivity model, Coleraine estimates of the coastwide female spawning stock biomass declined from 31,682 mt in 1973 to 1,897 mt in 1994, and subsequently increased to 10,665 mt in 2003 (Figure ES2-Top). Female spawning biomass depletion (B_0/B_t) ranged from 0.67 in 1973 to a low of 0.04 in 1994 and subsequently increased to 0.23 in 2003 (Figure ES2-Bottom). Estimated depletion was somewhat greater for the northern area compared to the southern area in the early part of the time series.

It should be noted that the Coleraine estimate of depletion can differ from the estimate obtained from the rebuilding analysis (Appendix II), because the rebuilding analysis computes B_0 using the average of recruitments from 1973-2002, while Coleraine uses the estimate of R_0 obtained in the model according to the formula provided in Hilborn et al.(2000). Additionally, the depletion values reported for Coleraine are with reference to 2003 spawning biomass, while those reported in the rebuilding analysis are with reference to 2002 spawning biomass.

Recruitment

For the asymptotic fishery selectivity model, estimated recruitment was higher in the early part of the time series and relatively low by comparison through the 1990's. From 1973-1985, coastwide recruitment averaged 3,173 (thousand age 1 fish). From 1986-2002, coastwide recruitment averaged 2,832 (thousand age 1 fish). For the dome shaped fishery selectivity model, coastwide recruitment averaged 3,527 (thousand age 1 fish) from 1973-1985; from 1986-2002, coastwide recruitment averaged 2,869 (thousand age 1 fish).

Exploitation Status

Under coastwide rebuilding management, the asymptotic fishery selectivity model estimates of exploitation rate (catch/available biomass) in the northern area averaged 0.03 (commercial fishery) and 0.02 (recreational fishery) in recent years (1998-2002). In the southern area exploitation rates averaged 0.03 (commercial fishery) and 0.11 (recreational fishery) for the same

period. Estimates from the dome shaped fishery selectivity model for the same time period were 0.03 (commercial-north), 0.03 (recreational-north), 0.07 (commercial-south) and 0.13 (recreational-south).

Management Performance

The first lingcod ABC's based on a quantitative assessment were implemented in 1995. A comparison of reported landings and ABC values shows good correspondence through 2001, when landings were typically at or below the target ABC values (Figure ES3). In 2002, landings exceeded the coastwide ABC by 17% and the coastwide OY was exceeded by 51%. Harvest in excess of the OY can be attributed in part to the northern California recreational fishery; RecFIN catch estimates increased from 140mt in 2001 to 430 mt in 2002.

Forecasts and Decision Table

Six rebuilding analysis projections were produced using separate sets of information derived from the present stock assessment (Appendix II). The six rebuilding analysis input files were: 1) a pooled, coastwide asymptotic fishery selectivity model; 2) a pooled, coastwide domed fishery selectivity model, 3) separate northern and southern area asymptotic fishery selectivity models, and 4) separate northern and southern area domed fishery selectivity models. The population projections were configured to begin in 2002 with rebuilding scheduled to occur by the start of 2009 (year 10 from the original rebuilding start year of 1999).

The projected coastwide yields for 2004-2008 under both the asymptotic and domed fishery selectivity assumptions are constrained by the ABC rule, for values of $P < 0.6$ (Table ES2). Coastwide ABC yield for 2004-2008 ranges from 1,820 mt to 2,053 mt for the asymptotic fishery selection model, compared to 2,141 mt to 2,123 mt for the domed fishery selectivity model.

Recommendations: Research and Data Collection Needs

Emphasis should be placed on improving fishery age structure sampling size and geographical coverage in both regions. More frequent and synoptic fishery independent surveys should be conducted in both regions to aid in determination of stock status and recent recruitment. In the southern region, the CPFV observer project CPUE data should be analyzed (on a reef-specific basis) using a General Linear Model (GLM) analysis, for evaluation as an index of abundance. Coastwide enumeration of at-sea discards (e.g. by an on-board observer program) is needed to properly account for total fishery mortality.

Table ES1. Management reference points derived from the 2003 lingcod stock assessment (Jagielo et al. 2003). Alternative models included the assumption of asymptotic vs. domed fishery selectivity. Under each assumption, rebuilding projection input files were constructed for 1) coastwide (northern and southern model data pooled) and 2) northern and southern area model data separately.

	Asymptotic Fishery Selectivity			Domed Fishery Selectivity		
	Coastwide	Northern	Southern	Coastwide	Northern	Southern
FMSY proxy	0.121	0.124	0.122	0.184	0.165	0.190
FMSY SPR / SPR(F=0)	0.45	0.45	0.45	0.45	0.45	0.45
Virgin SPR	12.41	13.27	11.20	11.77	13.27	11.20
Virgin Spawning Output (mt)	36967	19434	16969	37115	19518	18848
Target Spawning Output (mt)	14787	7774	6788	14846	7807	7539
Current (2002) Spawning Output (mt)	9160	5410	3751	8931	5679	3253
Depletion ($SpBio_{2002}/SpBio_{Virgin}$)	0.25	0.28	0.22	0.24	0.29	0.17
Spawning Output (ydecl) (mt)	4203	2226	1972	4077	2464	1608

Table ES2. Projected yield (mt) under model assumptions of asymptotic vs. domed fishery selectivity. Yields are shown for probability of recovery values ranging from P=0.5 to P=0.9, and for the 40-10 and ABC rules.

Model	Year	P= .5	P= .6	P= .7	P= .8	P= .9	Yr=Tmid	F=0	40-10 Rule	ABC Rule
Coastwide Asymptotic	**2004**	1843	1799	1750	1693	1631	1767	0	1429	1820
	2005	1947	1906	1859	1805	1744	1875	0	1753	1926
	2006	2006	1968	1924	1873	1816	1939	0	1970	1986
	2007	2043	2008	1967	1920	1866	1981	0	2085	2025
	2008	2069	2037	1999	1955	1904	2012	0	2102	2053
North Asymptotic	**2004**	1342	1328	1305	1285	1255	1339	0	1050	1109
	2005	1359	1346	1326	1309	1281	1356	0	1156	1149
	2006	1354	1343	1326	1311	1287	1352	0	1174	1168
	2007	1331	1322	1307	1294	1273	1330	0	1172	1168
	2008	1312	1304	1291	1279	1261	1311	0	1170	1166
South Asymptotic	**2004**	686	660	626	594	547	650	0	492	759
	2005	752	725	692	659	610	715	0	664	823
	2006	794	768	736	704	655	759	0	800	862
	2007	830	805	774	742	694	796	0	898	894
	2008	859	836	805	775	728	827	0	961	920
Coastwide Domed	**2004**	2058	2009	1962	1905	1838	2032	0	1616	2041
	2005	2135	2089	2045	1992	1930	2111	0	1966	2118
	2006	2138	2098	2058	2010	1953	2117	0	2137	2124
	2007	2139	2102	2066	2022	1969	2120	0	2182	2126
	2008	2135	2101	2067	2025	1976	2117	0	2167	2123
North Domed	**2004**	1512	1496	1478	1462	1440	1509	0	1164	1185
	2005	1477	1464	1449	1435	1416	1475	0	1198	1195
	2006	1438	1427	1414	1403	1387	1436	0	1194	1192
	2007	1376	1366	1355	1346	1332	1374	0	1165	1163
	2008	1339	1330	1320	1312	1300	1337	0	1148	1146
South Domed	**2004**	600	571	538	502	455	603	0	421	803
	2005	658	629	595	557	509	661	0	618	858
	2006	687	659	626	588	540	690	0	764	877
	2007	711	683	650	613	564	714	0	860	893
	2008	736	708	676	639	589	738	0	924	911

Figure ES1. Female spawning biomass (top) and depletion (bottom) estimated under the assumption of asymptotic fishery selectivity.

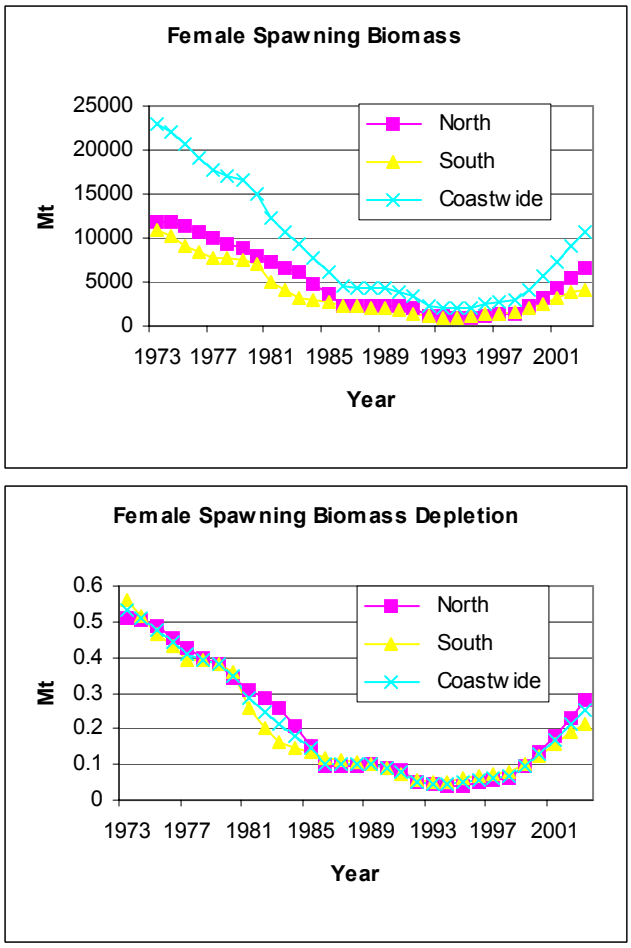


Figure ES2. Female spawning biomass (top) and depletion (bottom) estimated under the assumption of dome shaped fishery selectivity.

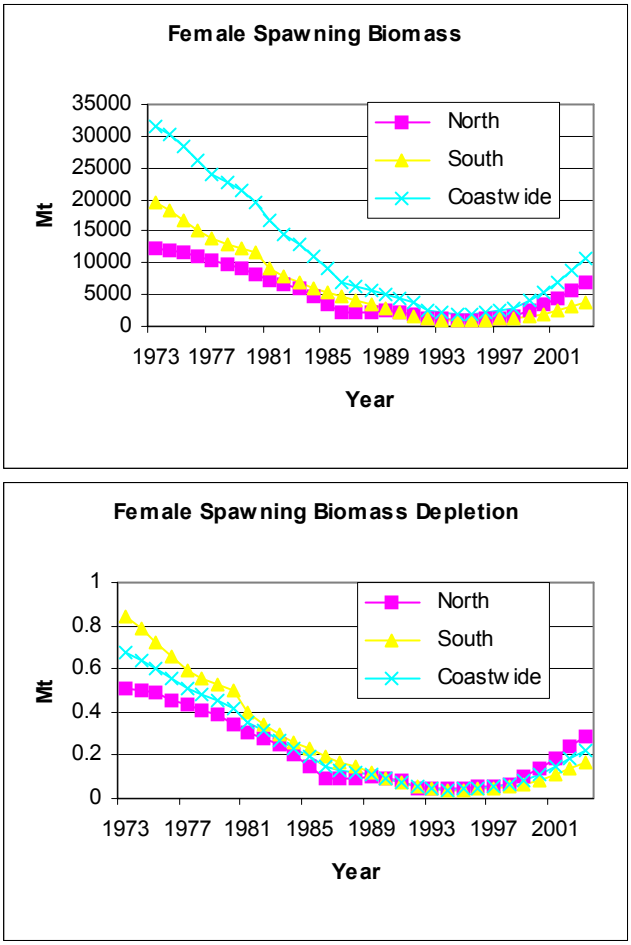
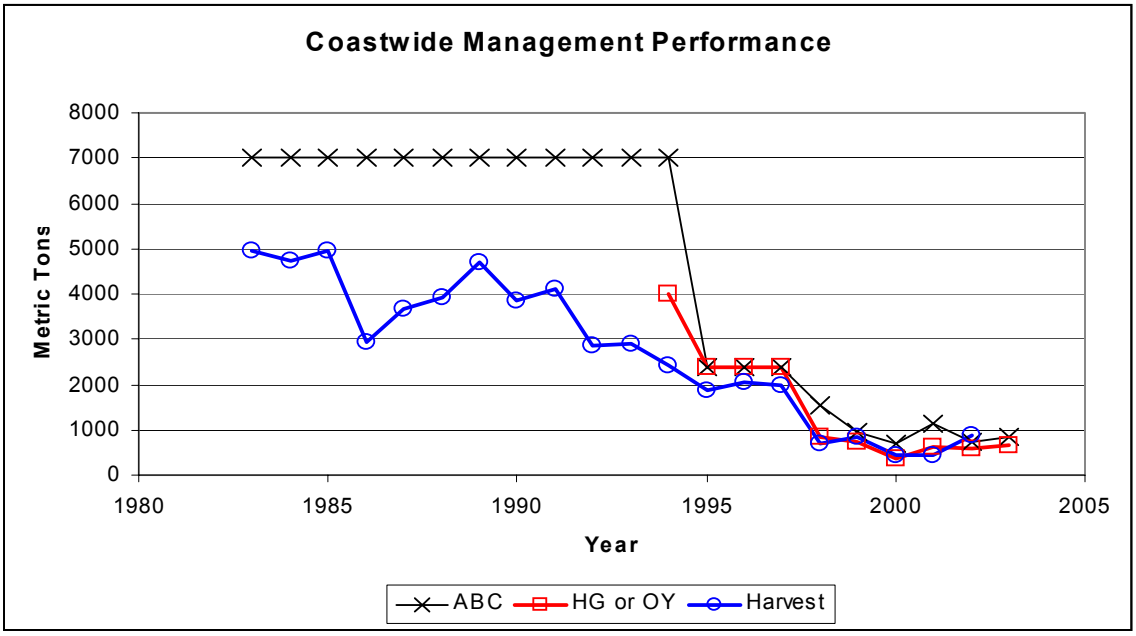


Figure ES3. Comparison of lingcod ABC, OY and landings (mt) between 1983 and 2003.



Introduction

Stock Structure and management Units

This document provides an updated coastwide assessment of the lingcod population in 2003 for the full PFMC management zone. Evidence from genetics analysis (Jagielo et al. 1996) and tagging studies (Cass et al. 1990, Jagielo 1995, Jagielo 1999a) suggest that the fish found within this entire area are of one intermingling stock unit. However, because of regional differences in data sources and data availability, the assessment was divided into two separately modeled units: Lingcod-North (LCN) and Lingcod-South (LCS), as it was in the previous assessment (Jagielo et al. 2000) (Figure 1). A study currently underway by WDFW indicates that there are significant differences in growth in lingcod found in southern Eureka, Monterey and Conception INPFC Areas), and northern coastal waters (Columbia and Vancouver INPFC areas). Based on this evidence, we continue to support and provide a separate assessment for southern and northern areas.

Life History

Lingcod (*Ophiodon elongatus*) are top order predators of the family *Hexagrammidae*. The species ranges from Kodiak Island in the Gulf of Alaska to Baja California, and its center of abundance is near British Columbia and Washington (Hart 1973). An analysis of genetic variation indicates that lingcod are genetically similar throughout the range (Jagielo et al. 1996). Among the *Hexagrammidae*, the genus *Ophiodon* is ecologically intermediate between the more littoral genera *Hexagrammos*, *Agrammus*, and *Oxylebius* and the more pelagic *Pleurogrammus* (Rutenberg 1962). Lingcod are demersal on the continental shelf, most abundant in waters less than 200 m deep, and patchily distributed among areas of hard bottom and rocky relief (Smith and Forrester 1973; Jagielo 1988). Lingcod are considered non-migratory, though some tagged individuals have moved exceptional distances and indirect evidence suggests a seasonal onshore movement associated with spawning (Jagielo 1995, 1999). Larval lingcod hatch in late winter and become epipelagic. When about 3 months old, juveniles settle on sandy bottom near eelgrass or kelp beds. By age 1 or 2, lingcod move into rocky habitats similar to those occupied by adults, but shallower. Fishery and survey data indicate that male lingcod tend to be more abundant than females in shallow waters, and the size of both sexes increases with depth (Jagielo 1994). In late fall, male lingcod aggregate and become territorial in areas suitable for spawning. Mature females are rarely seen at the spawning grounds and it is assumed that they move into spawning areas for only a brief time to deposit eggs. Following egg nest deposition, males assume a guardian role through the period of hatch-out. Hatch out is typically complete by April in Washington but has been reported as early as January and as late as June throughout the species range (Jagielo 1994). A more detailed review of lingcod life history can be found in Jagielo (1994), Adams and Hardwick (1992), and Cass et al. (1990).

History of the fishery

Lingcod have been a target of commercial fisheries since the early 1900's in California (CDFG Reports), and since the late 1930's in Oregon (Unpublished, ODFW Report, 1950) and Washington (Anonymous WDF Report, 1955) waters (Table 4). Recreational fishers have targeted lingcod since the 1920's in California. A modest recreational fishery (less than 20 mt annually) has taken place in Washington and Oregon since at least the 1970's.

Management

History

From 1983 through 1994, a coastwide ABC of 7,000 mt was in effect with the INPFC area components: US Vancouver (1000 mt), Columbia (4,000 mt), Eureka (500 mt), Monterey (1,100 mt) and Conception (400 mt) (Table 1). In 1994 a coastwide harvest guideline (HG) of 4,000 mt was established. Following an assessment for the northern area (Jagielo 1994), the coastwide ABC and Harvest Guideline were reduced for 1995 through 1997 to 2,400 mt with separate ABC's for the US Vancouver-Columbia (1,300 mt), Eureka (300 mt), Monterey (700 mt), and Conception (100 mt) areas. In 1998, following an updated assessment for the northern area (Jagielo et al.1997), the coastwide ABC was reduced to 1,532 mt with a Harvest Guideline of 838 mt. Separate ABC's by area were: Vancouver (including a portion of Canadian waters)-Columbia (1,021 mt), Eureka (139 mt), Monterey (325 mt), and Conception (46 mt). For 1999, the Council established a coastwide ABC of 960 mt and a Harvest Guideline of 730 mt, with area specific ABC's of US Vancouver-Columbia (450 mt), Eureka (139 mt), Monterey (325 mt), and Conception (46 mt). Following a new assessment for the southern area (Adams et al.1999) and a rebuilding analysis (Jagielo 1999b), the coastwide ABC for 2000 was reduced to 700 mt which included area values of US Vancouver-Columbia (450 mt) and Eureka-Monterey-Conception (250 mt). Subsequently, a coastwide stock assessment (Jagielo et al. 2000) provided a northern ABC was of 610 mt and a southern ABC of 509 mt. Based on a revised rebuilding analysis (Jagielo and Hastie 2001) the 2001-coastwide lingcod OY was set at 611 mt, which is the harvest level derived from a constant exploitation rate that was expected to have a 60-percent probability of rebuilding the stock to B_{msy} within 9 years. The coastwide lingcod OY was similarly set at 577 mt in 2002 and 651 mt in 2003.

Regulations

A history of lingcod commercial trawl trip limits is summarized in Table 2. No trip limits were in effect prior to 1995, and trip limits have become increasingly restrictive since then as annual harvest guidelines have decreased.

A history of PFMC enacted recreational size and bag limits is summarized in Table 3. In California, a 5 fish bag limit was enacted in 1980 followed by a 22 inch size limit in 1981. These regulations remained in effect for 17 years. In March 1998, the bag limit was reduced from 5 to 3 fish and concurrently the size limit was increased to 24 inches. The bag limit was lowered again from 3 fish to 2 fish with in January 1999. In January 2000, the size limit increased from 24 to 26 in. and a seasonal closure (January through February) was implemented from the U.S.-Mexico border north to Lopez Point (36 deg 00 min N., Monterey County), and for March through April from Lopez Point north to Cape Mendocino (40 deg 10 min N., Humboldt County) The bag limit remained at 2 fish. A gear restriction was also enacted at this time limiting the number of hooks to 3, although this was primarily directed toward rockfish effort.

Performance

The first lingcod ABC's based on a quantitative assessment were implemented in 1995. A comparison of reported landings and ABC values shows good correspondence through 2001, when landings were typically at or below the target ABC values (Figure 2). In 2002, landings

exceeded the coastwide ABC by 17% and the coastwide OY was exceeded by 51%. Harvest in excess of the OY can be attributed in part to the northern California recreational fishery; RecFIN catch estimates increased from 140mt in 2001 to 430 mt in 2002.

DATA

Catch

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Catch data were compiled from agency reports and personal communication for all years preceding 1981. The PacFIN database was queried for catch information in subsequent years and catch detail is presented by gear and INPFC area in Table 6.

Commercial landings peaked in 1985 at 3,129 mt in northern waters (Columbia and Vancouver INPFC areas) and in 1974 at 1,735 mt in southern waters (Eureka, Monterey and Conception INPFC Areas)(Table 5). Average catch between 1990-1997 declined 40 % and 35% since the 1980's in northern and southern waters, respectively. Under rebuilding management, commercial fishery restrictions in recent years (1998-present) reduced catches to an annual average of less the 135 mt in both northern and southern waters (Figure 3).

Over the last two decades, trawl gear has made up the majority of commercial landings for the northern (83%) and southern (62%) coast (Table 6). In recent years (1998-2002), commercial fishery restrictions constrained the trawl portion of the catch to 54% and 45% for the northern and southern coast, respectively. In 2002, coastwide commercial landings totaled 223 mt and were distributed as follows by INPFC area: U.S.-Vancouver 63 mt (22%), Columbia 52 mt (30%), Eureka 63 mt (27%), Monterey 35 mt (16%), Conception 10 mt (5%).

Recreational Landings

Recreational fishers in California have targeted lingcod since the early 1940's. Catch averaged 65.3 mt annually between 1947-1954 (Leet et al., 1992). Recreational lingcod catch information is not available until 1977 for Oregon waters and averaged 52.3 mt annually between 1977 and 1979. Recreational lingcod catch in Washington was first estimated in 1967 to be 25.3 mt and annual catch estimates have been provided since 1975.

Recreational catch estimates were extracted from the RecFIN database for years 1980–1989 and 1993 to present for California waters. California recreational catch estimates for all other years were compiled in the 2000 lingcod assessment (Jagielo et al., 2000). Oregon recreational catch data were provided by ODFW (Don Bodenmiller personal communication). The recreational catch in Washington was provided by the WDFW Ocean Sampling Program.

Recreational catch in southern waters has declined since catch peaked in 1980 at 2,226 mt (Table 5, Figure 4). In contrast, recreational catch in northern waters peaked at 236 mt in 1994. In 2002, 127 mt was landed.

Historically, recreational landings have comprised a larger proportion of the total landings for the southern area, compared to the northern area. In recent years, the recreational portion of the total landings has increased substantially in both the southern and northern areas. In 2002 recreational fisheries harvested 83% of the total lingcod catch in the south and 52% in the north (Figure 5).

Discard

There are three sources of discard information for lingcod. These include the federal Marine Recreational Fisheries Statistical Survey (MRFSS), and both the Washington Department of Fish and Wildlife (WDFW) and the NMFS West-Coast Groundfish Observer Programs. MRFSS have collected B1 (reported by angler to be dead) and B2 (reported by angler to be alive) catches since 1980. Estimates of lingcod discarded alive have increased substantially in response to 1) management changes in 1998 (the size limit increased from 22 to 24 inches), and 2) a seasonal closure in California waters beginning in 2000 (Table 6a). It is interesting to note that estimates of fish discarded dead have decreased over time. Estimated live lingcod discarded in southern California was 306,000 fish in 2002. This compares to a total landed catch of 25,000 fish. WDFW began collecting discard information from the recreational fishery in 2002 and estimated that 57% of the catch was discarded. WDFW does not collect information on the portion of the catch discarded live or dead.

Based on an earlier study (Ricky, WDFW unpublished report), the PFMC Groundfish Management Team used a 20% inflation factor to adjust landed catch to account for unobserved lingcod mortality (personal communication, PFMC) in the commercial fishery beginning in 2002. Data collected by the Groundfish Observer program in 2001-2002 estimated that the percent discard of total observed catch was 78.8%. Because lingcod lack a swim bladder, it is likely that there is a relatively good survival rate for these fish.

Age and Size Composition

Age composition data from the northern area is summarized for the commercial fishery in Table 7. These data were derived by weighting the raw age frequencies from each WDFW vessel sample by the total landed weight of lingcod from that vessel. The recreational fishery age composition data, compiled from WDFW and ODFW recreational fishery samples, are summarized in Table 8. Age compositions derived from samples taken on board the NMFS Triennial Trawl shelf survey and age compositions obtained from sub-samples of lingcod taken for aging as part of the WDFW Cape Flattery Tag survey are summarized in Table 9. Survey and fishery size composition data (cm) used in the northern model, with associated sample sizes, are summarized by data source in Tables 10 and 11, respectively.

Age composition data and sample size information for the southern area are summarized for the commercial and recreational fisheries, and the NMFS Triennial Trawl shelf survey in Table 12.

Natural Mortality, Length, Weight, and Maturity at Age

Vectors of length, weight, and maturity-at-age by sex are summarized for the northern area in Table 13. Parameter estimates for these relationships, and natural mortality estimates used in the LCN model are summarized in Table 14. Comparable information for the southern area is summarized in Tables 16 and 17. Figure 6 shows the fit of female and male LCS and LCN lingcod to the von Bertalanffy growth equation.

Abundance Indices

NMFS Triennial Shelf Trawl Survey

Survey estimates of biomass (metric tons) and the associated coefficients of variation (CV's) from the triennial survey for 1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998 and 2001 are summarized in Table 18. The total sum of lingcod abundance estimates from the US Vancouver and Columbia area for all depth strata (55-183 m, 184-366 m and 367-500 m) was incorporated into the LCN model. The total sum of the Eureka and Monterey biomass estimates for each year and depth strata was used in the LCS model. Geographic distribution of lingcod biomass (kg/ha) for all tow catch data is displayed in Figures 7, 8 and 9 for coastwide, northern and southern areas, respectively.

Biomass estimates have been revised using a filtered dataset that excluded "water hauls". A complete description of the tow analysis and identification procedures of "water hauls" can be found in AFSC Processed Report 2001-03 (Zimmermann et al., 2001). Generally, lingcod biomass estimates from the filtered dataset increased with one exception. The 1980 Columbia INPFC lingcod biomass estimate was reduced from 8,699 mt to 3,219 mt, a difference of 5,480 mt (Table 18 and Figure 10). The difference resulted from a single large lingcod tow that was identified as a "water haul" and excluded from the dataset.

WDFW Cape Flattery Tag Survey

Annually, from 1986-1992, WDFW sampled lingcod from an established survey area in a consistent manner using bottomfish troll (dingle bar) hook and line gear. This sampling was initiated for the purpose of capturing fish for release as part of a multiple-year mark-recapture experimental design (Jagielo 1991, 1995). From 1986-1992, estimates of lingcod abundance in the Cape Flattery survey area were derived using external tags (Table 19). Voluntary tag returns from the recreational lingcod fishery at Neah Bay, Washington were used as the method for obtaining tag recaptures. Annual sampling with bottomfish troll gear continued beyond 1992 to extend the length composition time series, which had shown value as a recruitment index for previous lingcod stock assessments (Jagielo 1994, Jagielo et al.1997, Jagielo et al. 2000).

Trawl Fishery Logbook Catch-Per-Unit-Effort (CPUE) Index

Similar to the 2000 assessment, two independently estimated trawl fishery CPUE indices were incorporated into the northern and southern assessment models. These indices have been revised since the 2000 assessment. The new indices were constructed from Washington, Oregon and California trawl fishery logbook and fish ticket data dating back to 1976 (Table 20). Skipper's tow-by-tow estimates of retained catch were reconciled with fish ticket data (landing receipts). The adjusted catch and the skipper's estimate of tow duration was used to compute lingcod CPUE (lbs/hour)(Figures 11-14).

Following data verification and screening, a total of 474,946 tows in the southern area and 490,971 tows in the northern area were used in the analysis. Because of significant changes in management beginning in 1998 both the northern and southern time series were truncated after 1997. Furthermore, the 1976 and 1977 tow data from the southern area were deemed of insufficient sample size and were dropped from the time series used in the assessment model.

Tow-by-tow catch rates (CPUE) were fitted in a two-stage model process using Delta-Lognormal GLM procedure to predict abundance indices across the time series for each area. The model included a year, month, depth, and location (PFMC area) effect. A bootstrap procedure was used to estimate the standard errors of the year by year index values. The STAT Team determined and the Star Panel concurred that the bootstrap estimates of standard errors were unrealistically low and opted to use an assumed annual CV of 0.20 in both the southern and northern index.

The revised northern trawl logbook index trend used in the present assessment model corresponds well with the logbook index trend used in the 2000 stock assessment and shows a sharply declining stock since 1976 (Figure 15). The revised southern trawl logbook index also corresponds well to the logbook index used in the previous assessment and indicates a declining stock since 1979 (Figure 16). A summary of the Delta GLM results for the northern area is presented in Table 21 and results from the southern area are presented in Table 22.

Other Candidate Indices Considered But Not Used

At the request of the lingcod Stock Assessment Team (STAT), recreational catch and effort data from WDFW Ocean Sampling Program and RecFIN were analyzed by Drs. Alec MacCall and Steve Ralston (SWFSC, Santa Cruz) for four different regions including Southern and Northern California, Oregon and Washington (Table 23, Figure 17). Candidate indices were derived based on the Delta-GLM approach (assuming gamma error structure) that was used recently for black (Ralston and Dick, 2003) and bocaccio rockfish (MacCall, 2003). Evaluation of these new candidate indices of abundance resulted in the determination that potential biases in the input data sources precludes their use in the lingcod stock assessment. The STAT team concerns include 1) high index variability, 2) lack of a discernable index trend, 3) implausible temporal changes in abundance, and 4) unresolved input data assumptions.

In particular, the Washington database did not contain discard information needed to convert the estimate to total catch, as was done in the other estimates. For the other regions, analysis of RecFIN data indicated that the time trend of catch type A (landed catch) was constrained by bag limits and not informative. Discard was an integral part of estimating a CPUE trend from RecFIN data. MacCall calculated a "direct" CPUE from the raw intercept data on Aangs (anglers), Bangs (boat anglers), A, B1 (reported by angler to be dead) and B2 (reported by angler to be alive), but found cases in the dataset where Aangs had a value of 1, but the type B catches clearly represented the entire boat. The resulting indices were highly irregular and disregarded. To standardize RecFIN estimates (for the final “direct” catch estimate), MacCall assumed Aangs caught B1 and B2 catches and produced alternative indices where the year values from the delta GLM of type A catch and Aangs were expanded by the ratio of RecFIN estimated total catch (A+B1_B2)/A. The delta method was used to estimate variances of the “indirect” estimates from the variances of all the pieces and some assumed co-variances.

Because we were not confident that the type A catch and Aangs was reliable, the indices were not incorporated as model indices of abundance. We are concerned that the resulting catch rates may be affected by sampling and/or data entry error. A full evaluation of data quality is needed before using these data as a trend of lingcod abundance.

In addition to the candidate recreational indices discussed above, Jagielo et al. (2000) previously reviewed and analyzed a number of possible data sources for abundance trend information. Four indices of abundance, three derived from recreational CPUE data in the southern area and one derived from the shrimp trawl fishery bycatch in the northern area, were evaluated as candidates for modeling in 2000. Those candidate indices were not incorporated in final modeling in the 2000 assessment because it was difficult to assure that they were unbiased and/or representative of lingcod relative abundance. Recreational CPUE datasets are often problematic for use as unbiased indices of abundance, because catch rates may be effected by 1) variable target species by boat, 2) un-documented search time, 3) un-reported discards ,4) unknown spatial effort shifts, and 5) bag limit effects. Uncertainty also exists in the estimates of landings and effort due to sampling error.

Exploratory analyses conducted with the commercial trawl logbook data were also evaluated and subsequently not used in the model. Tow-by-tow catch rates (CPUE) were fitted to a two-stage model process using a generalized additive model (GAM, non-parametric method) to predict abundance indices across the time series. The data sets were filtered for tows where tow location (latitude and longitude) was known. Because of the lack of tow location, especially in the early part of the time series, index values in the early part of the time series were based on extrapolation. A comparison of Delta GLM and GAM results showed inconsistencies over the time series that appeared to be based on this extrapolation. Additionally, the GAM results included a smoothing process which may not have properly reflected underlying covariance in the data. Thus, the STAT team determined and the STAR panel concurred that the GAM analysis should be considered a work in progress and should not be used in the stock assessment.

Ageing error

Age reading error was modeled by incorporation of an age error transition matrix, which was developed from estimates of between-reader (within-lab) variability obtained from repeat age readings by two WDFW lingcod age readers (Figure 18). This age error transition matrix has not been modified since the last assessment.

Assessment

History of Modeling Approaches

The first assessment of lingcod provided to PFMC consisted of a yield-per-recruit analysis Adams (1986). Subsequently, an age structured assessment was prepared for a portion the northern area (PMFC areas 3A, 3B, and 3C-including Canada) by Jagielo (1994), using the Stock Synthesis model (Methot 1990). The assessment was subsequently updated to include the full Columbia INPFC area through 3C-N in Canada (Jagielo et al. 1997). Adams et al. (1999) subsequently conducted a length-based, age-structured assessment for the southern area (Eureka, Monterey, and Conception INPFC areas), using AD Model Builder (Fournier 1996). The first coastwide assessment of lingcod for the full PFMC management zone was conducted by Jagielo et al. 2000; that assessment (implemented in AD Model Builder) employed two age-structured models, conceptually and mathematically similar to the previous Stock Synthesis assessments of the northern area (Jagielo 1994, Jagielo et al. 1997).

Present Modeling Approach and Assessment Program

The present assessment updates the previous coastwide assessment (Jagielo et al. 2000) and is implemented in Coleraine using the executable code COLERA20.EXE (Hilborn et al. 2000). Coleraine is a statistical catch-at-age model programmed in AD Model Builder with a Microsoft Excel user interface and has been used for New Zealand assessments including blue whiting, ling, elephant fish, orange roughy and black oreo; in 2000 for Icelandic cod; and recently on the U.S. west coast for sablefish (Hilborn et al. 2001).

In Coleraine, recruitments are assumed to follow a Beverton-Holt spawner recruit curve with a lognormal penalty function for recruitment deviates (Hilborn et al. 2000, section 1.2.3); parameters are: average recruitment in the unfished state (R_0), steepness (h) - the fraction of recruitment obtained at 20% of virgin spawning biomass, and the standard deviation of annual recruitment residuals (Hilborn et al. 2000). In this stock assessment, the initial age composition was determined by assuming that the population was in equilibrium with a fixed, sex specific exploitation rate - U_{init}. (Hilborn et al. 2000, section 1.2.2)

As in the previous assessment, separate age structured models were constructed to analyze stock dynamics for the northern (LCN: US-Vancouver, Columbia) and southern (LCS: Eureka, Monterey, Conception) areas. To establish continuity between the previous and present assessments, the final data and parameter configuration for the northern area (LCN) model (derived in 2000) was implemented in Coleraine. The resulting estimates of female spawning biomass from Coleraine agreed well with the previous assessment results (Figure 19).

The following discussion covers the modeled data, model structure, and base model results; first for the northern area (LCN), followed by a discussion of the same topics for the southern area (LCS).

Lingcod-North (LCN): US-Vancouver and Columbia INPFC Areas

Model Description

List and Description of Likelihood Components in the LCN Model

The LCN model incorporated the following likelihood components, which are described mathematically in Hilborn et al.(2000); input data sources are specified by Table number:

12) Commercial Catch-At-Age: 1979-2002 (Table 7).
13) Recreational Catch-At-Age: 1980, 1986-2002 (Table 8).
14) Commercial Catch-At-Length: 1975-1978 (Table 11).
15) Recreational Catch-At-Length: 1981-1983 (Table 11).
16) NMFS Trawl Survey Catch-At-Age: 1992, 1995, 1998 and 2001 (Table 9).
17) NMFS Trawl Survey Catch-At-Length: 1986 and 1989 (Table 10)
18) WDFW Tag Survey Catch-At-Age: 1994-1997 (Table 9).
19) WDFW Tag Survey Catch-At-Length: 1986-1993 (Table 10).
20) NMFS Trawl Survey Biomass (mt): 1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998, and 2001 (Table 18).
21) WDFW Tag Survey Abundance (Numbers of Fish): 1986-1992 (Table 19).
22) Trawl Fishery Logbook CPUE Index: Washington and Oregon lingcod CPUE estimates (lbs/hr) derived from a Delta GLM analysis of trawl logbook information, 1976-1997 (Table 21).

The NMFS Trawl Survey Biomass, WDFW Tag Survey Abundance, and Trawl Fishery Logbook CPUE Index likelihood components were fit under a lognormal error structure (Hilborn et al. 2000, section 1.4.2). The fishery and survey catch-at-age and catch-at-length likelihood components were fit assuming a robust lognormal for proportions (Hilborn et al. 2000, section 1.4.1). In addition to the likelihood components listed above, a likelihood penalty component was included which corresponded to prior assumptions about recruitment variability (Hilborn et al. 2000, section 1.4.3).

Base Model Configuration

The LCN base model assumed a Beverton-Holt stock-recruitment relationship with lognormal error structure (with a steepness parameter h = 0.9 and CV = 1.0) to constrain wide variations in recruitment (Hilborn et al. 2000, section 1.2.3). Selectivity for the commercial and recreational fisheries and the NMFS and WDFW surveys was parameterized by a curve formed from two normal distributions (Hilborn et al. 2000, section 1.2.6). Three parameters are used in this formulation: 1) an age where selectivity = 1.0 (Full), 2) a standard deviation on the left side to describe ascending selectivity (Left), and 3) a standard deviation on the right side to describe descending selectivity (Right). The model did not incorporate an explicit treatment of discards. Base model inputs including priors, likelihood specifications, and fixed parameter values are tabulated in Appendix I, Tables 1 and 2.

Model Selection and Evaluation

Model selection was conducted beginning essentially with the STAR Panel approved formulation from the previous assessment (Jagielo et al. 2000) and proceeded using a procedure where alternate models were evaluated for model fit to the data (using the Akaike Information Criterion (AIC) (Akaike 1972)), and plausibility.

The base LCN model described herein employs one-period (time invariant) commercial and recreational fishery selectivity with estimation of both the left and right side portions of the selectivity curve (dome shaped fishery selectivity). Time invariant age of full selectivity for each of the NMFS and WDFW survey data were estimated, however it was necessary to hold the left and right side selectivity parameters fixed to obtain stable model results. A summary of negative log likelihood values, and both estimated and fixed model parameters of the LCN base model is provided in Appendix I, Table 3.

Base-Run Results

Base run (dome shaped fishery selectivity) model results are presented in Appendix I, Tables 1-3 and Appendix I, Figures 1-10. The Coleraine estimate of B_0 for the northern area is 23952 mt. The estimate of female spawning biomass for 2003 is 6859 mt. It should be noted that the Coleraine estimate of depletion (0.29) can differ from the estimate obtained from the rebuilding analysis (Appendix II), because the rebuilding analysis computes B_0 using the average of recruitments from 1973-2002, while Coleraine uses the estimate of R_0 obtained in the model according to the formula provided in Hilborn et al.(2000). Additionally, the depletion values reported for Coleraine are with reference to 2003 spawning biomass, while those reported in the rebuilding analysis are with reference to 2002 spawning biomass.

Uncertainty and Sensitivity Analyses

Coleraine estimates of the standard deviation of all model parameters (dome shaped fishery selectivity) is provided in Table 3a1.

The results of model profiling over selected fixed values used in the assessment are included in Appendix I, Tables 3a-3e.

A series of base model runs were conducted to examine the effect of different values of the historical exploitation rate (U_{init}) (Appendix I Table 3a). This parameter, which is assumed at a fixed value of 0.09 in the model, is used to estimate the initial age composition of the model in 1973. The profile over U_{init} ranged from 0.03 to 0.15. The value of 0.09 was selected for the final base model, because it was used in the previous assessment, and is consistent with the observed landings prior to 1973.

The base model was also profiled over different fixed values of natural mortality (M) (Appendix I , Table 3b). The profile over M ranged from 0.14-0.22 for females, and 0.26-0.38 for males. The values of 0.18 (females) and 0.32 (males), as used in previous assessments, were chosen for use in the 2003 final base model.

An additional series of model runs were conducted where the effect of different fixed values of the Beverton-Holt stock-recruitment steepness parameter (h) was evaluated (Appendix I, Table

3c). The profile over *h* ranged from 0.5 to 0.9. This parameter was set at the fixed value of 0.9 in the final base model.

Base model profiles were also conducted using different combinations of the Beverton-Holt stock-recruitment steepness parameter (*h*) and natural mortality (M) (Table 3d), and different combinations of assumed asymptotic and dome shaped fishery selectivity (Table 3e).

A retrospective analysis was performed to compare the base model estimates of spawning biomass with a base model configured with 1999 as the end year (Appendix I, Figure 11a). The estimates of spawning biomass agreed well for the 1973-1999 time series.

An historic analysis was conducted by plotting the estimates of spawning biomass from the previous assessment (Jagielo et al. 2000) with the estimates of spawning biomass from the present assessment (Appendix I, Figure 11b). Both assessments showed a similar declining trend over the time series, with particularly close agreement since 1992.

Lingcod South (LCS): Eureka, Monterey, and Conception INPFC Areas

Model Description

List and Description of Likelihood Components in the LCS Model

The LCS model incorporated the following likelihood components, which are described mathematically in Hilborn et al. 2000; input data sources are specified by Table number:

1) Commercial Catch-At-Age: 1992-1998, 2000-2002 (Table 12).
2) Recreational Catch-At-Age: 1992-1998, 2000-2002 (Table 12).
3) NMFS Trawl Survey Catch-At-Age: 1995, 1998 and 2001 (Table 12).
4) NMFS Trawl Survey Biomass (mt): 1977, 1980, 1983, 1986, 1989, 1992, 1995, 1998, and 2001 (Table 18).
5) Trawl Fishery Logbook CPUE Index: Oregon and California lingcod CPUE estimates (lbs/hr) derived from a Delta GLM analysis of trawl logbook information, 1978-1997 (Table 22).

As for the northern model, the NMFS Trawl Survey Biomass and Trawl Fishery Logbook CPUE Index likelihood components for the southern model were fit under a lognormal error structure (Hilborn et al. 2000, section 1.4.2), and the fishery and survey catch-at-age and catch-at-length likelihood components were fit assuming a robust lognormal for proportions (Hilborn et al. 2000, section 1.4.1). In addition to the likelihood components listed above, a likelihood penalty component was included which corresponded to prior assumptions about recruitment variability (Hilborn et al. 2000, section 1.4.3).

Base Model Configuration

The southern (LCS) model was configured in a manner very similar to the northern (LCN) model. The LCS base model assumed a Beverton-Holt stock-recruitment relationship with lognormal error structure (with a steepness parameter $h = 0.9$ and CV = 1.0) to constrain wide variations in recruitment (Hilborn et al. 2000, section 1.2.3). Selectivity for the commercial and

recreational fisheries and the NMFS survey was parameterized by a curve formed from two normal distributions (Hilborn et al. 2000, section 1.2.6). Three parameters are used in this formulation: 1) an age where selectivity = 1.0 (Full), 2) a standard deviation on the left side to describe ascending selectivity (Left), and 3) a standard deviation on the right side to describe descending selectivity (Right). The model did not incorporate an explicit treatment of discards. Base model inputs including priors, likelihood specifications, and fixed parameter values are tabulated in Appendix I, Tables 4 and 5.

Model Selection and Evaluation

Model selection was conducted beginning essentially with the STAR Panel approved formulation from the previous assessment (Jagielo et al. 2000) and proceeded using a procedure where alternate models were evaluated for model fit to the data (using the Akaike Information Criterion (AIC) (Akaike 1972)), and plausibility.

The base LCS model described herein employs one-period (time invariant) commercial and recreational fishery selectivity with estimation of left and right side portions of the selectivity curve. Compared to the northern (LCN) model, available data for the southern area are sparse. For the NMFS survey data, it was necessary to hold the age of full selectivity as well as left and right side selectivity parameters fixed to obtain stable model results. A summary of negative log likelihood values, and both estimated and fixed model parameters of the LCS base model is provided in Appendix I, Table 6.

Base-Run Results

Base run (dome shaped fishery selectivity) model results are presented in Appendix I, Tables 4-6 and Appendix I, Figures 12a-16. The Coleraine estimate of B_0 for the southern area is 23267 mt. The estimate of female spawning biomass for 2003 is 3806 mt. It should be noted that the Coleraine estimate of depletion (0.16) can differ from the estimate obtained from the rebuilding analysis (0.17)(Appendix II), because the rebuilding analysis computes B_0 using the average of recruitments from 1973-2002, while Coleraine uses the estimate of R_0 obtained in the model according to the formula provided in Hilborn et al.(2000). Additionally, the depletion values reported for Coleraine are with reference to 2003 spawning biomass, while those reported in the rebuilding analysis are with reference to 2002 spawning biomass.

Uncertainty and Sensitivity Analyses

Coleraine estimates of the standard deviation of all model parameters (dome shaped fishery selectivity) is provided in Table 6a1.

The results of model profiling over selected fixed values used in the assessment are included in Appendix I, Tables 6a-6e.

A series of base model runs were conducted to examine the effect of different values of the historical exploitation rate (U_{init}) (Appendix I Table 6a). This parameter, which is assumed at a fixed value of 0.07 in the model, is used to estimate the initial age composition of the model in 1973. The profile over U_{init} ranged from 0.03 to 0.10. The value of 0.07 was selected for the final base model, because it was used in the previous assessment, and is consistent with the observed landings prior to 1973.

The base model was also profiled over different fixed values of natural mortality (M) (Appendix I Table 6b). The profile over M ranged from 0.14-0.22 for females, and 0.26-0.38 for males. The values of 0.18 (females) and 0.32 (males), as used in previous assessments, were chosen for use in the 2003 final base model.

An additional series of model runs were conducted where the effect of different fixed values of the Beverton-Holt stock-recruitment steepness parameter (h) were evaluated (Appendix I Table 6c). This parameter was set at the fixed value of 0.9 in the model. The profile over h ranged from 0.5 to 0.9.

Base model profiles were also conducted using different combinations of the Beverton-Holt stock-recruitment steepness parameter (h) and natural mortality (M) (Table 6d), and different combinations of assumed asymptotic and dome shaped fishery selectivity (Table 6e).

An historic analysis was conducted by plotting the estimates of spawning biomass from the previous assessment (Jagielo et al, 2000) with the estimates of spawning biomass from the present assessment (Appendix I, Figure 17). Both assessments showed a declining trend over the time series and fairly close agreement in recent years; however, the present assessment shows a decline from substantially higher spawning stock size estimates early in the time series.

Coastwide Summary

Target Fishing Mortality Rates and Harvest Projections

As an overfished species with a rebuilding plan, target fishing mortality rates for lingcod are a function of alternative rebuilding trajectories, and are also constrained by the ABC rule. Six rebuilding analysis projections were produced using separate sets of information derived from the present stock assessment (Appendix II). The six rebuilding analysis input files were: 1) a pooled, coastwide asymptotic fishery selectivity model; 2) a pooled, coastwide domed fishery selectivity model, 3) separate northern and southern area asymptotic fishery selectivity models, and 4) separate northern and southern area domed fishery selectivity models. For both the asymptotic and domed fishery selectivity models, target fishing mortality and yield was constrained by the ABC rule. F_{45}% fishing mortality rates were 0.12 for the north, and 0.18 for the south (Appendix II, Table 1). Coastwide rebuilding yields for 2004-2008 (under the model assumption of asymptotic fishery selectivity) range from 1820 to 2053 mt**.** Coastwide rebuilding yields under the model assumption of dome shaped fishery selectivity range from 2041 to 2123 mt (Appendix II, Table 2).

Recommendations: Research and Data Needs

1) Emphasis should be placed on improving fishery age structure sampling size and geographical coverage in both regions.

2) More frequent and synoptic fishery independent surveys should be conducted in both regions to aid in determination of stock status and recent recruitment. Surveys of areas inaccessible to trawl survey gear should be conducted to address the issue of the habitat bias of trawl surveys.

3) In the southern region, CPFV observer project CPUE data should be analyzed (on a reef-specific basis) using a General Linear Model (GLM) analysis, and evaluated for use as an index of abundance.

4) Coastwide enumeration of at-sea discards (e.g. by an on-board observer program) is needed to properly account for total fishery mortality.

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Table 1. History of PFMC lingcod Acceptable Biological catches (ABC's), Harvest guidelines or Optimum yields (OT's) and landings. Source:PFMC SAFE 2001 document and personal communication with the PFMC Groundfish Management Team for most recent year's information.

	US Vancouver	Columbia	US Vancouver-Columbia		Eureka	Monterey	Conception	Eureka-Monterey-Conception		Coastwide		
Year	ABC	ABC	ABC	Landings	ABC	ABC	ABC	ABC	Landings	ABC	HG or OY	Harvest
1983	1,000	4,000	5,000	3,155	500	1,100	400	2,000	1,691	7,000		4,971
1984	1,000	4,000	5,000	3,163	500	1,100	400	2,000	1,555	7,000		4,719
1985	1,000	4,000	5,000	3,215	500	1,100	400	2,000	1,726	7,000		4,945
1986	1,000	4,000	5,000	1,396	500	1,100	400	2,000	1,517	7,000		2,934
1987	1,000	4,000	5,000	1,724	500	1,100	400	2,000	1,922	7,000		3,667
1988	1,000	4,000	5,000	1,763	500	1,100	400	2,000	2,044	7,000		3,930
1989	1,000	4,000	5,000	2,373	500	1,100	400	2,000	2,316	7,000		4,705
1990	1,000	4,000	5,000	1,868	500	1,100	400	2,000	1,966	7,000		3,845
1991	1,000	4,000	5,000	2,437	500	1,100	400	2,000	1,647	7,000		4,095
1992	1,000	4,000	5,000	1,391	500	1,100	400	2,000	1,467	7,000		2,870
1993	1,000	4,000	5,000	1,659	500	1,100	400	2,000	1,374	7,000		2,907
1994	1,000	4,000	5,000	1,449	500	1,100	400	2,000	1,091	7,000	4,000	2,424
1995			1,300	971	300	700	100	1,100	1,067	2,400	2,400	1,882
1996			1,300	1,120	300	700	100	1,100	937	2,400	2,400	2,070
1997			1,300	1,049	300	700	100	1,100	912	2,400	2,400	1,981
1998			1,021	225	139	325	46	510	496	1,532	838	707
1999			450	262	139	325	46	510	545	960	730	831
2000			450					250		700	378	446
2001			610					510		1,120	611	445
2002										745	577	873
2003										841	651	

Table 2. History of lingcod commercial trawl trip limits (thousand lbs) Source:PFMC SAFE 2001 document and personal communication with the PFMC Groundfish Management Team for most recent year's information. Note: Exception to commercial size limits: starting in 1996, trawl gear was allowed retention of 100 lb. at size less than minimum size limit.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
< 1995	No trip limit regulations											
1995	20	20	20	20	20	20	20	20	20	20	20	20
1996	40		40		40		40		40		40	
1997	40		40		40		40		40		40	
1998	1		1		1		1		1		1	
1999	1.5				1.5		1			0.5	0.5	0.5
2000	Prohibited				0.4	0.4	0.4	0.4	0.4	0.4	Prohibited	
2001	Prohibited				0.4	0.4	0.4	0.4	0.4	0.5	Prohibited	
2002 [1/]	0.8		0.8		1		1		0.5	0.5	0.5	0.5
2003	0.8		0.8		1		1		0.8		0.8	

Prohibited Periods
Commercial size limit 0f 22" `1995-1997 then 24" thereafter
Gear restrictions for rockfish retention beginning in 2001
[1/] South of 40^0 10' lingcod prohibited beginning July 1st

Table 3. History of lingcod size limits (inches) and recreational bag limits (number of fish): Source: PFMC SAFE 2001 document and personal communication with the PFMC Groundfish Management Team for most recent year's information.

State	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
					Daily Bag Limits					
Washington	3	3	3	3	3	2	2	2	2	2
Oregon	3	3	3	3	3	2	2	2	2	2
California	5	5	5	5	5	2	2	2	2	2
					Size Limits (inches)					
Washington	none	22	22	22	24	24	24	24	24	24
Oregon	none	22	22	22	24	24	24	24	24	24
California [1/]	none	22	22	22	24	24	26	26	22	22

[1/] Beginning in 2000; South of 34^0 27' N. Lat lingcod prohibited January-February and South of Cape Mendencino and north of 34^0 27' N. Lat lingcod prohibited March-June

Table 4. Estimated commercial lingcod catch (mt) for California (1916-1955), Oregon (1950-1953) and Washington ()1935-1955).

Historical Commercial lingcod landings

Year	California [1/] Total (mt)	Oregon 2[/] Total (mt)	Washington [3/] Total (mt)
1916	280		
1917	422		
1918	415		
1919	482		
1920	312		
1921	193		
1922	258		
1923	212		
1924	182		
1925	310		
1926	295		
1927	252		
1928	387		
1929	529		
1930	584		
1931	558		
1932	408		
1933	494		
1934	389		
1935	462		0
1936	344		0
1937	439		1
1938	293		0
1939	262		0
1940	314		10
1941	240		51
1942	143		41
1943	326		162
1944	338		523
1945	344		237
1946	524		229
1947	880		65
1948	933		132
1949	751		109
1950	869	312	92
1951	758	379	106
1952	620	224	93
1953	432	139	40
1954	430		66
1955	438		63
	428	264	106

[1/] Leet et al. 1992. California's living marine resources and their utilization

[1/] Forrester, 1973.

[2/] "Fisheries Statistics for Oregon 1950-1953" author Harrison S. Smith

[3/] Anonymous, 1955 WDF Commercial Fishing Statistical Report.

Table 5. Estimated commercial and recreational lingcod catch (mt) for northern (1916-1955) and southern areas (Eureka, Monterey and Conception), 1956 to 2002.

	Northern Area			Southern Area			
	U.S. Vancouver - Columbia			Eureka-Monterrey-Conception			Coastwide
Year	Commercial	Recreation	Total (mt)	Commercial	Recreation	Total (mt)	Total (mt)
1956	920		920	422	113	536	1,455
1957	1,000		1,000	744	114	858	1,858
1958	1,133		1,133	726	120	845	1,979
1959	1,863		1,863	638	94	732	2,594
1960	2,028		2,028	593	85	678	2,706
1961	1,875		1,875	653	70	724	2,599
1962	1,323		1,323	504	76	581	1,904
1963	938		938	514	83	597	1,534
1964	1,257		1,257	379	76	455	1,712
1965	1,538		1,538	369	100	469	2,006
1966	1,813		1,813	363	134	497	2,311
1967	1,244		1,244	426	131	557	1,800
1968	1,626		1,626	496	128	624	2,250
1969	1,148		1,148	505	98	603	1,751
1970	851		851	695		695	1,546
1971	1,009		1,009	952		952	1,961
1972	952		952	1,472		1,472	2,425
1973	1,326	76	1,402	1,615	403	2,018	3,420
1974	1,549	76	1,625	1,735	399	2,134	3,759
1975	2,019	85	2,104	1,447	429	1,876	3,981
1976	1,662	69	1,731	1,415	422	1,837	3,56
1977	1,671	76	1,747	769	284	1,053	2,79
1978	1,346	70	1,416	914	334	1,248	2,66
1979	2,211	82	2,292	1,434	340	1,774	4,06
1980	2,004	93	2,097	1,275	2,226	3,501	5,59
1981	1,907	128	2,035	1,397	1,169	2,566	4,60
1982	2,241	128	2,369	1,598	877	2,475	4,84
1983	3,069	114	3,183	1,218	586	1,804	4,98
1984	3,008	156	3,163	1,047	509	1,555	4,71
1985	3,127	90	3,217	752	974	1,726	4,94
1986	1,311	95	1,405	601	928	1,529	2,93
1987	1,623	111	1,735	980	950	1,930	3,66
1988	1,655	115	1,769	1,118	1,036	2,154	3,92
1989	2,230	146	2,376	1,356	964	2,320	4,697
1990	1,746	123	1,869	1,187	781	1,968	3,837
1991	2,320	119	2,438	844	803	1,647	4,085
1992	1,207	185	1,392	676	792	1,468	2,860
1993	1,429	231	1,660	779	457	1,236	2,896
1994	1,215	236	1,451	691	270	962	2,412
1995	861	113	974	610	287	897	1,871
1996	1,004	121	1,125	559	376	935	2,060
1997	932	117	1,049	636	281	917	1,965
1998	152	73	225	198	267	465	690
1999	168	96	264	190	360	550	813
2000	71	80	150	71	206	277	427
2001	67	91	158	88	178	266	425
2002	94	127	221	108	524	632	852
				Average Catch			
1960's	1,479		1,479	480	98	578	2,057
1970's	1,459	76	1,513	1,245	373	1,506	3,019
1980's	2,218	117	2,335	1,134	1,022	2,156	4,491
1990-1997	1,339	156	1,495	748	506	1,254	2,748
1998-2000	110	93	204	131	307	438	642

Table 6. Estimated commercial lingcod catch (mt) by gear and INPFC area, 1981 to 2002.

U.S Vancouver INPFC Area - lingcod landings in metric tons								
Year	Hook&Line	Other	Net	Pot	Trolls	Trawls	Shrimp Trawl	Total
1981	65.3	0.0	26.6	0.0	53.5	368.8	1.3	515.5
1982	67.6	0.0	76.6	0.4	115.3	336.5	0.2	596.6
1983	36.6	0.0	119.7	0.0	201.3	820.4	18.4	1196.4
1984	63.9	0.0	131.3	3.0	201.5	1346.5	2.1	1748.3
1985	100.2	0.0	247.2	0.5	178.0	1326.2	1.5	1853.6
1986	50.3	0.0	0.0	0.0	70.8	447.8	6.1	575.0
1987	94.5	0.0	0.2	0.0	43.6	589.2	4.3	731.8
1988	69.0	0.0	0.2	0.0	74.9	478.0	0.4	622.5
1989	91.2	0.0	0.1	0.0	119.1	789.2	0.2	999.8
1990	139.9	0.0	0.0	0.0	85.0	762.4	0.5	987.8
1991	80.9	0.0	0.0	0.0	26.0	1345.2	0.3	1452.4
1992	54.6	0.0	0.0	0.0	31.4	469.6	0.1	555.7
1993	35.9	0.0	0.0	0.0	20.3	595.0	0.8	652.0
1994	34.8	0.0	0.0	0.0	21.2	472.7	1.4	530.1
1995	21.3	0.0	0.0	0.0	8.8	260.0	2.8	292.9
1996	35.2	0.0	0.0	0.0	5.8	319.5	4.7	365.2
1997	35.5	0.0	0.0	0.0	12.1	253.2	0.2	301.0
1998	8.4	0.0	0.0	0.0	2.2	39.3	0.0	49.9
1999	15.1	0.0	0.0	0.0	1.8	29.9	0.1	46.9
2000	10.5	0.0	0.0	0.0	3.3	8.1	0.0	21.9
2001	12.4	0.0	0.0	0.0	1.7	11.0	0.1	25.2
2002	10.4	0.0	0.0	0.0	1.9	29.9	0.0	42.2

Columbia INPFC Area - lingcod landings in metric tons								
Year	Hook&Line	Other	Net	Pot	Trolls	Trawls	Shrimp Trawl	Total
1981	27.2	0.8	45.5	3.5	29.2	1208.4	76.8	1391.4
1982	47.8	0.0	0.2	3.2	24.3	1497.9	71.0	1644.4
1983	37.0	0.2	10.8	2.1	31.5	1706.9	84.4	1872.9
1984	34.7	0.2	3.0	0.8	17.4	1154.2	49.1	1259.4
1985	53.8	0.0	0.0	1.4	43.3	1129.9	44.8	1273.2
1986	52.9	0.0	0.0	0.6	43.8	554.5	83.9	735.7
1987	80.7	0.1	0.0	0.7	20.3	715.8	73.9	891.5
1988	75.8	0.0	0.0	0.7	19.2	903.2	33.2	1032.1
1989	99.5	0.0	0.0	0.2	28.8	1053.8	48.2	1230.5
1990	62.4	0.0	0.0	0.1	11.6	662.5	21.7	758.3
1991	32.1	0.0	0.0	0.4	4.1	813.5	17.1	867.2
1992	55.1	0.0	0.0	0.1	8.8	571.8	15.3	651.1
1993	59.0	0.3	0.0	0.3	12.3	678.8	26.6	777.3
1994	102.4	0.0	0.0	1.0	5.8	534.5	41.5	685.2
1995	39.3	0.0	0.0	0.3	4.4	482.6	41.1	567.7
1996	48.4	0.0	0.0	0.2	5.9	555.1	28.7	638.3
1997	58.0	0.0	0.0	0.5	9.0	544.9	18.4	630.8
1998	10.7	0.0	0.0	0.3	3.0	81.3	7.1	102.4
1999	12.0	0.0	0.0	0.2	4.8	75.6	28.1	120.7
2000	7.1	0.0	0.0	0.1	6.1	20.8	14.7	48.8
2001	10.8	0.0	0.0	1.4	5.0	18.1	6.5	41.8
2002	8.4	0.0	0.0	0.9	2.9	33.4	6.2	51.8

Table 6 (continued). Estimated commercial lingcod catch (mt) by gear and INPFC area, 1981 to 2002.

Eureka INPFC Area - lingcod landings in metric tons								
Year	Hook&Line	Other	Net	Pot	Trolls	Trawls	Shrimp Trawl	Total
1981	13.6	0.5	0.0	0.0	8.3	349.2	8.8	380.4
1982	15.2	2.4	0.0	0.4	12.9	510.9	12.8	554.6
1983	26.1	16.0	0.0	1.3	2.4	363.8	0.2	409.8
1984	5.2	15.4	0.0	0.2	3.4	262.8	1.0	288.0
1985	41.8	9.0	0.1	0.9	1.2	183.4	1.6	238.0
1986	81.6	16.7	0.0	1.8	8.5	95.1	3.5	207.2
1987	104.0	11.7	0.0	0.3	0.5	203.9	1.1	321.5
1988	106.8	22.1	0.0	0.3	0.3	179.7	3.1	312.3
1989	175.4	18.9	0.0	1.5	1.1	188.6	3.7	389.2
1990	173.6	8.8	0.0	0.3	4.1	231.6	3.4	421.8
1991	65.5	1.3	0.0	0.0	0.0	139.9	5.9	212.6
1992	59.3	1.8	0.0	0.1	0.0	105.0	3.7	169.9
1993	40.6	1.0	0.2	0.1	0.3	153.3	1.8	197.3
1994	53.8	0.7	0.3	0.2	0.2	160.3	12.5	228.0
1995	90.8	1.5	0.7	0.2	0.2	132.9	5.8	232.1
1996	73.9	0.0	0.0	0.2	2.8	118.0	8.5	203.4
1997	109.1	0.0	0.1	0.2	0.1	149.4	5.1	264.0
1998	40.4	0.2	0.0	0.2	0.6	56.8	1.0	99.2
1999	43.2	0.2	0.0	0.3	1.1	56.6	3.8	105.2
2000	21.7	0.0	0.0	0.4	0.3	19.6	0.5	42.5
2001	32.5	0.0	0.0	0.3	0.2	19.7	0.3	53.0
2002	38.3	0.0	0.0	1.1	0.1	23.5	0.1	63.1

Monterey INPFC Area - lingcod landings in metric tons								
Year	Hook&Line	Other	Net	Pot	Trolls	Trawls	Shrimp Trawl	Total
1981	38.2	5.4	8.8	2.7	21.2	771.5	0.3	848.1
1982	22.2	16.1	49.5	1.3	14.9	737.1	0.0	841.1
1983	10.0	85.6	80.8	0.5	1.7	580.9	0.2	759.7
1984	3.4	160.0	25.6	0.0	1.0	547.3	0.0	737.3
1985	15.3	158.8	90.0	1.6	3.7	220.0	0.0	489.4
1986	52.5	91.7	90.9	2.1	0.7	128.3	0.0	366.2
1987	66.1	73.0	159.0	0.9	1.1	315.7	0.1	615.9
1988	99.1	63.5	274.4	2.8	1.4	299.3	0.0	740.5
1989	197.5	70.9	215.4	2.2	0.4	415.7	0.0	902.1
1990	153.6	48.8	176.0	1.1	8.9	318.7	0.0	707.1
1991	131.0	23.4	103.1	0.9	0.7	299.7	0.0	558.8
1992	128.4	35.2	85.5	0.7	1.0	190.6	0.0	441.4
1993	110.1	3.0	106.0	0.3	2.6	277.5	0.1	499.6
1994	84.1	3.1	72.1	0.3	12.4	224.4	0.5	396.9
1995	73.8	1.2	48.9	0.9	8.9	184.9	0.4	319.0
1996	93.1	0.5	7.6	1.2	4.8	205.6	0.9	313.7
1997	89.8	0.1	27.4	2.0	1.9	218.8	0.9	340.9
1998	30.4	0.1	3.7	8.9	0.4	35.9	0.3	79.7
1999	24.4	0.1	0.8	1.6	0.6	42.3	0.2	70.0
2000	10.3	0.0	3.3	0.2	0.4	10.7	0.2	25.1
2001	14.8	0.0	0.4	0.6	1.2	9.9	0.0	26.9
2002	18.3	0.1	0.0	0.2	0.7	15.4	0.1	34.8

Table 6 (continued). Estimated commercial lingcod catch (mt) by gear and INPFC area, 1981 to 2002.

Conception INPFC Area - lingcod landings in metric tons								
Year	Hook&Line	Other	Net	Pot	Trolls	Trawls	Shrimp Trawl	Total
1981	5.3	0.1	10.4	0.5	1.4	149.2	1.7	168.6
1982	4.4	0.1	27.5	0.1	0.2	161.4	8.4	202.1
1983	0.9	0.5	4.8	0.0	0.1	41.9	0.3	48.5
1984	0.6	0.9	3.3	0.0	0.0	13.1	3.4	21.3
1985	1.1	3.2	9.6	0.0	0.0	10.6	0.3	24.8
1986	2.8	2.3	13.8	0.2	0.3	8.2	0.0	27.6
1987	6.2	3.3	17.1	0.2	0.7	14.9	0.0	42.4
1988	4.8	3.7	39.3	0.0	0.0	17.3	0.0	65.1
1989	4.3	4.3	34.4	0.5	0.0	21.5	0.0	65.0
1990	5.5	3.2	25.3	0.2	0.0	23.7	0.0	57.9
1991	11.0	2.9	43.8	0.1	0.0	14.7	0.0	72.5
1992	20.4	3.2	25.3	0.2	0.0	15.8	0.0	64.9
1993	24.8	2.6	44.1	0.1	0.0	10.0	0.0	81.6
1994	18.4	0.6	21.6	1.5	0.2	21.3	2.6	66.2
1995	27.8	0.4	8.1	3.1	0.2	17.0	2.2	58.8
1996	24.1	0.6	4.8	6.7	0.2	5.1	0.6	42.1
1997	17.4	0.0	2.4	5.2	0.1	5.1	0.4	30.6
1998	10.2	0.0	1.4	2.9	0.1	3.4	0.8	18.8
1999	10.3	0.0	0.4	2.1	0.0	1.5	0.2	14.5
2000	2.9	0.0	0.0	0.6	0.0	0.1	0.1	3.7
2001	5.8	0.0	0.3	1.2	0.0	0.8	0.1	8.2
2002	8.4	0.0	0.1	1.4	0.1	0.1	0.0	10.1

Table 6a. Estimates of lingcod discard, live and dead, in the recreational fishery by State.

MRFSS estimates of % lingcod catch (#'s of fish) that was discarded dead (B1 catches)

YEAR	SOUTHERN CALIFORNIA	NORTHERN CALIFORNIA	OREGON	WASHINGTON	ALL SUBREGIONS
1980	2%	36%	37%	40%	21%
1981	11%	23%	18%	140%	31%
1982	12%	10%	14%	126%	23%
1983	13%	7%	43%	57%	19%
1984	8%	6%	7%	33%	8%
1985	18%	6%	8%	45%	10%
1986	5%	12%	17%	150%	13%
1987	25%	16%	18%	106%	23%
1988	60%	44%	3%	1100%	45%
1989	5%	24%	2%	100%	17%
1993	50%	12%	na	na	9%
1994	13%	6%	na	na	3%
1995	14%	6%	na	na	4%
1996	0%	12%	na	na	8%
1997	0%	1%	na	na	1%
1998	0%	9%	na	na	6%
1999	0%	7%	na	na	5%
2000	0%	10%	na	na	6%
2001	0%	14%	na	na	7%
2002	20%	5%	na	na	14%
2003	0%	0%	na	na	7%

MRFSS estimates of % lingcod catch (#'s of fish) that was discarded live (B2 catches)

YEAR	SOUTHERN CALIFORNIA	NORTHERN CALIFORNIA	OREGON	WASHINGTON	SUBREGIONS
1980	6%	4%	0%	0%	5%
1981	35%	7%	4%	37%	12%
1982	16%	14%	6%	23%	12%
1983	31%	12%	17%	10%	14%
1984	27%	13%	0%	22%	13%
1985	59%	10%	0%	9%	16%
1986	162%	35%	0%	0%	59%
1987	107%	38%	2%	29%	46%
1988	122%	39%	3%	0%	52%
1989	70%	39%	2%	0%	38%
1993	117%	57%	57%	na	52%
1994	88%	61%	41%	na	45%
1995	157%	65%	58%	na	60%
1996	400%	46%	83%	na	68%
1997	75%	78%	477%	na	163%
1998	250%	81%	767%	na	220%
1999	378%	73%	76%	na	89%
2000	1867%	428%	253%	na	397%
2001	1733%	590%	147%	na	514%
2002	1224%	271%	95%	57%	374%
2003	3100%	167%	200%		387%

Note: the 2002 Washington estimate is derived from data collected by WDFW.

Table 7. Commercial fishery lingcod age composition used in the northern (LCN) model.

Fishery	Year	Tot. No.Fish	Female Proportion-at-age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Com	1979	694	0.000	0.003	0.004	0.015	0.031	0.052	0.094	0.207	0.236	0.145	0.050	0.018	0.017	0.017	0.030	0.031	0.006	0.000	0.000	0.000
Com	1980	1853	0.000	0.004	0.019	0.029	0.051	0.113	0.120	0.128	0.134	0.087	0.049	0.038	0.025	0.015	0.015	0.008	0.006	0.002	0.000	0.001
Com	1981	1325	0.000	0.007	0.053	0.070	0.067	0.059	0.073	0.073	0.085	0.119	0.050	0.013	0.012	0.006	0.009	0.000	0.000	0.000	0.000	0.000
Com	1982	469	0.000	0.013	0.039	0.093	0.124	0.160	0.136	0.067	0.037	0.052	0.054	0.010	0.030	0.000	0.009	0.009	0.000	0.001	0.000	0.000
Com	1983	443	0.000	0.019	0.110	0.137	0.161	0.085	0.052	0.044	0.021	0.018	0.037	0.039	0.020	0.014	0.011	0.008	0.014	0.005	0.003	0.003
Com	1984	339	0.000	0.000	0.036	0.121	0.206	0.196	0.080	0.048	0.022	0.016	0.010	0.018	0.013	0.001	0.001	0.001	0.001	0.000	0.000	0.000
Com	1985	312	0.000	0.000	0.002	0.040	0.101	0.235	0.285	0.078	0.077	0.040	0.016	0.009	0.016	0.000	0.008	0.000	0.000	0.000	0.000	0.000
Com	1986	663	0.000	0.003	0.026	0.069	0.106	0.147	0.160	0.156	0.084	0.054	0.043	0.018	0.006	0.012	0.018	0.004	0.005	0.006	0.000	0.000
Com	1987	741	0.000	0.008	0.046	0.085	0.127	0.172	0.137	0.104	0.102	0.041	0.015	0.005	0.001	0.003	0.001	0.003	0.004	0.000	0.001	0.000
Com	1988	821	0.000	0.031	0.144	0.064	0.097	0.101	0.079	0.094	0.058	0.045	0.022	0.013	0.007	0.000	0.000	0.000	0.000	0.005	0.003	0.000
Com	1989	786	0.000	0.004	0.120	0.309	0.161	0.075	0.048	0.024	0.022	0.017	0.008	0.000	0.008	0.000	0.001	0.000	0.000	0.000	0.001	0.000
Com	1990	887	0.000	0.013	0.041	0.179	0.167	0.088	0.072	0.049	0.032	0.021	0.036	0.004	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1991	999	0.000	0.034	0.082	0.119	0.199	0.157	0.099	0.057	0.032	0.028	0.011	0.013	0.006	0.000	0.007	0.000	0.001	0.002	0.000	0.000
Com	1992	1140	0.000	0.175	0.142	0.119	0.085	0.071	0.083	0.042	0.026	0.010	0.015	0.009	0.000	0.004	0.008	0.001	0.000	0.000	0.000	0.000
Com	1993	1022	0.000	0.116	0.173	0.100	0.102	0.071	0.135	0.032	0.010	0.073	0.004	0.015	0.006	0.002	0.005	0.000	0.001	0.000	0.000	0.000
Com	1994	1034	0.000	0.107	0.308	0.194	0.095	0.039	0.019	0.025	0.011	0.006	0.002	0.003	0.001	0.001	0.004	0.000	0.000	0.000	0.000	0.000
Com	1995	1093	0.000	0.021	0.187	0.347	0.144	0.055	0.018	0.004	0.007	0.003	0.003	0.002	0.000	0.000	0.001	0.006	0.000	0.000	0.000	0.000
Com	1996	820	0.000	0.058	0.124	0.266	0.276	0.058	0.043	0.027	0.012	0.008	0.008	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000
Com	1997	673	0.000	0.028	0.165	0.200	0.159	0.135	0.041	0.032	0.020	0.033	0.024	0.001	0.002	0.003	0.008	0.002	0.000	0.002	0.000	0.000
Com	1998	706	0.000	0.023	0.224	0.269	0.155	0.081	0.041	0.018	0.007	0.004	0.001	0.001	0.003	0.000	0.001	0.000	0.001	0.000	0.000	0.000
Com	1999	750	0.000	0.011	0.087	0.247	0.223	0.105	0.064	0.049	0.027	0.007	0.002	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Com	2000	310	0.000	0.003	0.057	0.136	0.273	0.147	0.064	0.035	0.030	0.015	0.004	0.009	0.005	0.000	0.003	0.000	0.000	0.000	0.000	0.000
Com	2001	548	0.000	0.031	0.079	0.151	0.142	0.155	0.099	0.027	0.026	0.015	0.003	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2002	694	0.000	0.021	0.135	0.138	0.098	0.091	0.060	0.050	0.022	0.026	0.004	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
Com	1979	694	0.000	0.001	0.003	0.005	0.018	0.007	0.008	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1980	1853	0.000	0.000	0.009	0.014	0.031	0.053	0.018	0.016	0.009	0.001	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1981	1325	0.000	0.001	0.010	0.045	0.048	0.060	0.064	0.050	0.020	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1982	469	0.000	0.004	0.013	0.016	0.044	0.025	0.032	0.019	0.010	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1983	443	0.000	0.005	0.034	0.061	0.077	0.015	0.002	0.000	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1984	339	0.000	0.000	0.003	0.030	0.034	0.094	0.052	0.003	0.006	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1985	312	0.000	0.000	0.000	0.016	0.015	0.015	0.044	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1986	663	0.000	0.005	0.005	0.013	0.019	0.025	0.004	0.006	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1987	741	0.000	0.007	0.020	0.008	0.044	0.033	0.023	0.006	0.005	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1988	821	0.000	0.020	0.050	0.050	0.033	0.008	0.005	0.004	0.004	0.030	0.008	0.016	0.000	0.000	0.008	0.000	0.000	0.000	0.000	0.000
Com	1989	786	0.000	0.001	0.066	0.076	0.024	0.019	0.010	0.000	0.001	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1990	887	0.000	0.006	0.041	0.106	0.066	0.026	0.026	0.004	0.013	0.000	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1991	999	0.000	0.027	0.018	0.032	0.029	0.018	0.015	0.008	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1992	1140	0.000	0.074	0.072	0.017	0.013	0.014	0.005	0.008	0.000	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1993	1022	0.000	0.050	0.051	0.040	0.006	0.002	0.004	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1994	1034	0.000	0.024	0.091	0.047	0.013	0.002	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1995	1093	0.000	0.009	0.052	0.107	0.028	0.002	0.002	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1996	820	0.000	0.011	0.038	0.025	0.018	0.011	0.000	0.003	0.001	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1997	673	0.000	0.014	0.068	0.022	0.023	0.011	0.006	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1998	706	0.000	0.005	0.064	0.045	0.018	0.019	0.013	0.003	0.001	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1999	750	0.000	0.005	0.032	0.046	0.041	0.015	0.021	0.007	0.004	0.003	0.002	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000
Com	2000	310	0.000	0.000	0.013	0.023	0.107	0.054	0.010	0.009	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2001	548	0.000	0.014	0.015	0.069	0.062	0.048	0.028	0.017	0.011	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2002	694	0.000	0.031	0.069	0.069	0.062	0.018	0.044	0.015	0.015	0.013	0.007	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 8. Recreational fishery lingcod age composition used in the northern (LCN) model.

Fishery	Year	Tot. No.Fish	Female Proportion-at-age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Rec	1980	226	0.000	0.004	0.022	0.022	0.018	0.031	0.049	0.009	0.013	0.013	0.009	0.000	0.004	0.013	0.004	0.000	0.000	0.000	0.000	0.000
Rec	1986	341	0.000	0.003	0.015	0.056	0.062	0.053	0.062	0.062	0.050	0.032	0.026	0.018	0.012	0.009	0.009	0.003	0.006	0.006	0.003	0.000
Rec	1987	274	0.000	0.018	0.018	0.062	0.077	0.036	0.033	0.036	0.018	0.015	0.004	0.000	0.007	0.004	0.004	0.000	0.000	0.000	0.000	0.004
Rec	1988	250	0.004	0.044	0.112	0.044	0.024	0.008	0.004	0.000	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1989	227	0.000	0.013	0.044	0.062	0.040	0.031	0.040	0.013	0.013	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1990	207	0.005	0.019	0.029	0.068	0.063	0.034	0.010	0.000	0.010	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1991	247	0.000	0.004	0.065	0.040	0.032	0.077	0.057	0.012	0.028	0.012	0.012	0.016	0.012	0.004	0.016	0.008	0.016	0.000	0.000	0.000
Rec	1992	499	0.000	0.048	0.070	0.068	0.048	0.044	0.030	0.024	0.014	0.010	0.004	0.006	0.004	0.002	0.002	0.000	0.000	0.000	0.000	0.000
Rec	1993	530	0.002	0.049	0.096	0.081	0.049	0.038	0.023	0.015	0.006	0.008	0.002	0.002	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000
Rec	1994	449	0.000	0.009	0.076	0.114	0.085	0.085	0.024	0.011	0.007	0.009	0.009	0.004	0.011	0.000	0.000	0.002	0.002	0.000	0.000	0.000
Rec	1995	643	0.000	0.005	0.042	0.096	0.106	0.059	0.058	0.019	0.012	0.006	0.005	0.002	0.000	0.002	0.002	0.000	0.002	0.000	0.000	0.000
Rec	1996	461	0.000	0.007	0.098	0.143	0.117	0.069	0.048	0.015	0.013	0.007	0.004	0.002	0.000	0.002	0.004	0.000	0.000	0.000	0.000	0.000
Rec	1997	446	0.000	0.007	0.087	0.108	0.092	0.085	0.029	0.020	0.009	0.004	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1998	416	0.002	0.007	0.067	0.147	0.127	0.079	0.067	0.024	0.019	0.002	0.002	0.007	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1999	609	0.000	0.000	0.053	0.138	0.149	0.085	0.053	0.033	0.011	0.003	0.003	0.002	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000
Rec	2000	610	0.000	0.002	0.036	0.110	0.159	0.098	0.079	0.028	0.011	0.005	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2001	961	0.000	0.000	0.019	0.087	0.149	0.134	0.083	0.040	0.020	0.011	0.007	0.002	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2002	1098	0.000	0.001	0.054	0.160	0.147	0.095	0.074	0.036	0.015	0.015	0.011	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
Rec	1980	226	0.000	0.009	0.080	0.146	0.173	0.142	0.137	0.049	0.040	0.009	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1986	341	0.000	0.006	0.053	0.100	0.059	0.041	0.053	0.067	0.044	0.029	0.018	0.021	0.006	0.006	0.006	0.003	0.000	0.003	0.003	0.000
Rec	1987	274	0.000	0.091	0.113	0.109	0.109	0.073	0.073	0.044	0.015	0.015	0.000	0.015	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1988	250	0.000	0.216	0.372	0.080	0.056	0.020	0.004	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1989	227	0.000	0.044	0.194	0.220	0.123	0.057	0.035	0.031	0.018	0.009	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1990	207	0.000	0.034	0.135	0.242	0.237	0.072	0.019	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000
Rec	1991	247	0.000	0.028	0.113	0.109	0.069	0.126	0.028	0.065	0.012	0.012	0.012	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.004	0.000
Rec	1992	499	0.002	0.072	0.166	0.124	0.092	0.080	0.052	0.014	0.012	0.004	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1993	530	0.000	0.070	0.230	0.138	0.075	0.038	0.025	0.021	0.004	0.013	0.011	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1994	449	0.002	0.024	0.151	0.156	0.078	0.049	0.029	0.027	0.013	0.004	0.011	0.002	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1995	643	0.000	0.014	0.082	0.221	0.134	0.075	0.023	0.012	0.011	0.006	0.002	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.003	0.000
Rec	1996	461	0.000	0.007	0.087	0.111	0.121	0.078	0.028	0.024	0.002	0.002	0.007	0.000	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000
Rec	1997	446	0.000	0.013	0.099	0.173	0.110	0.067	0.056	0.004	0.013	0.007	0.009	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1998	416	0.000	0.010	0.058	0.120	0.127	0.065	0.041	0.022	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1999	609	0.000	0.000	0.048	0.128	0.123	0.087	0.043	0.021	0.010	0.000	0.005	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2000	610	0.000	0.002	0.034	0.077	0.148	0.108	0.054	0.026	0.007	0.003	0.003	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2001	961	0.000	0.002	0.016	0.083	0.106	0.114	0.058	0.034	0.020	0.009	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2002	1098	0.000	0.000	0.028	0.100	0.118	0.066	0.045	0.020	0.006	0.004	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 9. NMFS Trawl Survey and WDFW Cape Flattery survey age composition used in the northern (LCN) model.

Survey	Year	Tot. No.Fish	Female Proportion-at-age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
NMFS	1992	74	0.068	0.149	0.149	0.135	0.014	0.054	0.014	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.000
NMFS	1995	208	0.091	0.101	0.207	0.130	0.058	0.043	0.019	0.005	0.005	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	1998	367	0.114	0.101	0.120	0.112	0.109	0.090	0.049	0.014	0.003	0.003	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	2001	563	0.108	0.206	0.121	0.036	0.021	0.027	0.027	0.025	0.016	0.012	0.004	0.002	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
NMFS	1992	74	0.054	0.203	0.027	0.027	0.014	0.054	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	1995	208	0.043	0.067	0.077	0.058	0.034	0.029	0.014	0.005	0.000	0.000	0.005	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000
NMFS	1998	367	0.065	0.068	0.084	0.030	0.019	0.005	0.005	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	2001	563	0.085	0.171	0.091	0.021	0.005	0.005	0.005	0.004	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Female Proportion-at-age																			
WDFW	1994	100	0.000	0.000	0.000	0.040	0.150	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1995	281	0.000	0.107	0.053	0.046	0.018	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1996	511	0.022	0.147	0.104	0.051	0.012	0.002	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1997	498	0.010	0.197	0.139	0.024	0.010	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
WDFW	1994	100	0.000	0.000	0.000	0.280	0.420	0.080	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1995	281	0.000	0.206	0.185	0.295	0.060	0.014	0.007	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1996	511	0.031	0.319	0.225	0.070	0.012	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1997	498	0.014	0.309	0.227	0.046	0.014	0.008	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table10. NMFS Trawl Survey and WDFW Cape Flattery survey size composition data (cm) used in the northern (LCN) model.

Survey	Year	Tot. No.Fish	Female Proportion-at-size (cm) 28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
NMFS	1986	220	0.000	0.000	0.000	0.001	0.007	0.005	0.014	0.002	0.006	0.010	0.000	0.000	0.000	0.001	0.017	0.000	0.010	0.053	0.011	0.029	0.108	0.010
NMFS	1989	470	0.001	0.000	0.003	0.038	0.019	0.020	0.003	0.000	0.008	0.039	0.006	0.020	0.002	0.002	0.012	0.009	0.026	0.061	0.034	0.061	0.060	0.013
			Male Proportion-at-size (cm)																					
NMFS	1986	220	0.000	0.001	0.000	0.022	0.003	0.009	0.002	0.001	0.000	0.000	0.012	0.001	0.000	0.005	0.006	0.031	0.066	0.022	0.003	0.012	0.028	0.051
NMFS	1989	470	0.020	0.000	0.002	0.003	0.008	0.002	0.001	0.000	0.000	0.025	0.016	0.039	0.004	0.005	0.008	0.012	0.009	0.040	0.043	0.039	0.012	0.003
			Female Proportion-at-size (cm)																					
WDFW	1986	484	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.006	0.006	0.004	0.008	0.008	0.010	0.014	0.008	0.025	0.000	0.006	0.002	0.004
WDFW	1987	542	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.011	0.022	0.013	0.022	0.006	0.006	0.006	0.011	0.009	0.011	0.011	0.006	0.011	0.004	0.006
WDFW	1988	978	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.002	0.009	0.015	0.028	0.028	0.021	0.009	0.005	0.005	0.006	0.004	0.000
WDFW	1989	964	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.006	0.004	0.001	0.001	0.008	0.012	0.007	0.007	0.016	0.018	0.012	0.010	0.003
WDFW	1990	971	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.020	0.041	0.014	0.014	0.004	0.011	0.028	0.028	0.009	0.007	0.005	0.009	0.007	0.009
WDFW	1991	1017	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.017	0.024	0.010	0.010	0.013	0.025	0.036	0.029	0.013	0.007	0.005	0.011	0.003	0.004
WDFW	1992	1003	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.015	0.027	0.038	0.011	0.008	0.014	0.034	0.024	0.021	0.013	0.017	0.009	0.005	0.003	0.005
WDFW	1993		0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.015	0.024	0.040	0.030	0.012	0.013	0.019	0.025	0.026	0.012	0.005	0.006	0.003	0.003	0.003
			Male Proportion-at-size (cm)																					
WDFW	1986	484	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.029	0.017	0.045	0.056	0.089	0.085	0.066	0.103	0.058	0.074	0.074	0.029	0.029	0.019
WDFW	1987	542	0.000	0.000	0.000	0.000	0.000	0.006	0.020	0.042	0.046	0.031	0.015	0.018	0.054	0.066	0.055	0.089	0.083	0.089	0.057	0.042	0.031	0.028
WDFW	1988	978	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.002	0.004	0.017	0.045	0.102	0.137	0.131	0.072	0.043	0.049	0.044	0.049	0.040	0.021	0.021
WDFW	1989	964	0.000	0.000	0.000	0.001	0.000	0.000	0.001	0.004	0.015	0.017	0.015	0.015	0.032	0.058	0.141	0.150	0.150	0.103	0.054	0.025	0.025	0.022
WDFW	1990	971	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.024	0.037	0.039	0.020	0.019	0.036	0.050	0.044	0.025	0.062	0.080	0.115	0.071	0.051	0.016
WDFW	1991	1017	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.017	0.060	0.052	0.026	0.045	0.085	0.102	0.076	0.043	0.043	0.040	0.033	0.048	0.034	0.033
WDFW	1992	1003	0.000	0.000	0.001	0.000	0.000	0.011	0.028	0.080	0.103	0.060	0.029	0.044	0.074	0.077	0.067	0.039	0.027	0.021	0.022	0.013	0.013	0.012
WDFW	1993		0.000	0.000	0.000	0.000	0.000	0.002	0.027	0.084	0.114	0.107	0.062	0.059	0.069	0.076	0.047	0.032	0.017	0.022	0.014	0.007	0.003	0.003

Survey	Year	Tot. No.Fish	Female Proportion-at-size (cm) 72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
NMFS	1986	220	0.012	0.050	0.033	0.096	0.023	0.026	0.013	0.026	0.026	0.012	0.001	0.026	0.000	0.007	0.013	0.000	0.000	0.000	0.000	0.006
NMFS	1989	470	0.027	0.014	0.007	0.015	0.010	0.011	0.017	0.003	0.017	0.006	0.014	0.023	0.005	0.001	0.006	0.002	0.003	0.005	0.000	0.003
			Male Proportion-at-size (cm)																			
NMFS	1986	220	0.022	0.010	0.001	0.012	0.028	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	1989	470	0.018	0.052	0.000	0.003	0.007	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Female Proportion-at-size (cm)																			
WDFW	1986	484	0.002	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1987	542	0.007	0.006	0.000	0.002	0.000	0.004	0.000	0.000	0.000	0.002	0.002	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1988	978	0.004	0.006	0.005	0.006	0.002	0.003	0.000	0.001	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
WDFW	1989	964	0.002	0.002	0.002	0.003	0.001	0.003	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.001
WDFW	1990	971	0.014	0.012	0.014	0.004	0.002	0.000	0.002	0.000	0.000	0.000	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1991	1017	0.004	0.001	0.001	0.002	0.003	0.001	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1992	1003	0.002	0.003	0.001	0.001	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1993		0.000	0.002	0.000	0.002	0.001	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-size (cm)																			
WDFW	1986	484	0.029	0.019	0.019	0.010	0.010	0.000	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1987	542	0.013	0.015	0.002	0.009	0.002	0.002	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1988	978	0.024	0.011	0.007	0.007	0.001	0.002	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1989	964	0.016	0.017	0.004	0.004	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1990	971	0.009	0.009	0.012	0.004	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1991	1017	0.020	0.005	0.006	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1992	1003	0.011	0.009	0.002	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
WDFW	1993		0.002	0.000	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 11 Commercial and Recreational fishery size composition data (cm) used in the northern (LCN) model.

Fishery	Year	Tot. No.Fish	Female Proportion-at-size (cm) 28	30	32	34	36	38	40	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70
Com	1975	146	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	0.002	0.001	0.003	0.003	0.007	0.007	0.011	0.021	0.021	0.033
Com	1976	483	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.004	0.006	0.010	0.019	0.015	0.023	0.023	0.039
Com	1977	262	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1978	223	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.001	0.006	0.000	0.018	0.091	0.041	0.037	0.035	0.014	0.011
			Male Proportion-at-size (cm)																					
Com	1975	146	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.002	0.003	0.003	0.008	0.011	0.017	0.037	0.053	0.069	0.053
Com	1976	483	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.004	0.004	0.002	0.013	0.010	0.023	0.037	0.043
Com	1977	262	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1978	223	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.022	0.006	0.011	0.028	0.001	0.000	0.000
			Female Proportion-at-size (cm)																					
Rec	1981	98	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.010	0.000	0.000	0.000	0.010	0.010	0.000	0.000	0.000	0.010
Rec	1982	72	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.014	0.014	0.000	0.000	0.000	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1983	39	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.000	0.051	0.000	0.000	0.026	0.000	0.000	0.000	0.026	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-size (cm)																					
Rec	1981	98	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.020	0.000	0.020	0.000	0.020	0.082	0.061	0.102	0.071	0.071	0.041	0.071	0.031	0.031	0.133
Rec	1982	72	0.000	0.000	0.000	0.000	0.000	0.014	0.000	0.000	0.014	0.014	0.000	0.014	0.069	0.069	0.097	0.097	0.111	0.083	0.014	0.069	0.042	0.069
Rec	1983	39	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.026	0.051	0.000	0.026	0.000	0.000	0.051	0.000	0.128	0.103	0.051	0.128	0.026	0.103	0.000

Fishery	Year	Tot. No.Fish	Female Proportion-at-size (cm) 72	74	76	78	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
Com	1975	146	0.058	0.075	0.078	0.049	0.038	0.030	0.027	0.017	0.012	0.014	0.017	0.012	0.013	0.011	0.009	0.003	0.005	0.002	0.002	0.003
Com	1976	483	0.042	0.076	0.065	0.083	0.060	0.069	0.047	0.043	0.033	0.016	0.014	0.008	0.025	0.021	0.008	0.004	0.002	0.002	0.004	0.008
Com	1977	262	0.008	0.008	0.011	0.004	0.023	0.053	0.069	0.088	0.038	0.073	0.050	0.042	0.023	0.050	0.073	0.042	0.061	0.061	0.050	0.172
Com	1978	223	0.011	0.025	0.014	0.030	0.002	0.032	0.023	0.025	0.055	0.099	0.037	0.055	0.051	0.032	0.022	0.054	0.023	0.037	0.004	0.017
			Male Proportion-at-size (cm)																			
Com	1975	146	0.052	0.033	0.022	0.016	0.009	0.008	0.002	0.002	0.002	0.002	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000
Com	1976	483	0.039	0.017	0.014	0.012	0.004	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1977	262	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1978	223	0.000	0.006	0.011	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Female Proportion-at-size (cm)																			
Rec	1981	98	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.010	0.000	0.000	0.000
Rec	1982	72	0.000	0.000	0.000	0.000	0.014	0.000	0.014	0.000	0.014	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1983	39	0.000	0.000	0.000	0.026	0.051	0.051	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-size (cm)																			
Rec	1981	98	0.031	0.031	0.000	0.051	0.031	0.010	0.010	0.000	0.000	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1982	72	0.014	0.028	0.028	0.000	0.000	0.028	0.000	0.014	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1983	39	0.000	0.026	0.026	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Table 12. Age composition of fisheries and surveys used in the southern (LCS) model.

Fishery	Year	Tot. No.Fish	Female Proportion-at-age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Com	1992	289	0.000	0.138	0.289	0.091	0.041	0.041	0.000	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1993	787	0.000	0.267	0.301	0.083	0.034	0.012	0.009	0.005	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1994	538	0.000	0.088	0.241	0.135	0.041	0.047	0.017	0.005	0.023	0.001	0.011	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1995	267	0.000	0.016	0.079	0.261	0.107	0.068	0.033	0.014	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1996	302	0.000	0.028	0.226	0.138	0.097	0.104	0.019	0.005	0.004	0.000	0.001	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1997	728	0.000	0.031	0.173	0.198	0.160	0.053	0.055	0.033	0.009	0.008	0.001	0.001	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000
Com	1998	287	0.000	0.053	0.253	0.142	0.055	0.000	0.145	0.073	0.000	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2000	61	0.000	0.000	0.000	0.048	0.286	0.000	0.333	0.095	0.000	0.048	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2001	262	0.000	0.000	0.111	0.250	0.083	0.167	0.000	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2002	249	0.000	0.011	0.055	0.313	0.168	0.127	0.050	0.022	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
Com	1992	289	0.000	0.092	0.120	0.079	0.063	0.040	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1993	787	0.000	0.076	0.077	0.064	0.023	0.037	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1994	538	0.000	0.082	0.147	0.081	0.032	0.024	0.012	0.001	0.007	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1995	267	0.000	0.002	0.101	0.194	0.080	0.027	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1996	302	0.000	0.038	0.126	0.075	0.056	0.048	0.021	0.009	0.000	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1997	728	0.000	0.036	0.126	0.083	0.000	0.013	0.000	0.000	0.000	0.005	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	1998	287	0.000	0.000	0.093	0.036	0.038	0.019	0.019	0.019	0.036	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2000	61	0.000	0.000	0.000	0.048	0.095	0.048	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2001	262	0.000	0.000	0.056	0.083	0.194	0.028	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Com	2002	249	0.000	0.000	0.024	0.037	0.066	0.032	0.033	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Female Proportion-at-age																			
Rec	1992	49	0.000	0.000	0.020	0.061	0.020	0.082	0.000	0.041	0.041	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1993	294	0.000	0.024	0.156	0.173	0.099	0.065	0.041	0.037	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1994	196	0.000	0.010	0.107	0.133	0.117	0.082	0.051	0.046	0.015	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1995	525	0.000	0.006	0.053	0.215	0.114	0.040	0.029	0.013	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1996	545	0.002	0.007	0.110	0.110	0.180	0.101	0.040	0.020	0.013	0.004	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1997	212	0.000	0.000	0.052	0.151	0.118	0.085	0.038	0.024	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1998	70	0.000	0.000	0.014	0.114	0.214	0.086	0.100	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2000	48	0.000	0.000	0.000	0.083	0.125	0.104	0.063	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2001	396	0.000	0.000	0.000	0.040	0.114	0.149	0.093	0.056	0.043	0.028	0.008	0.005	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2002	409	0.000	0.000	0.010	0.049	0.144	0.095	0.095	0.059	0.020	0.017	0.005	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
Rec	1992	49	0.000	0.082	0.102	0.184	0.122	0.082	0.061	0.082	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1993	294	0.000	0.020	0.136	0.116	0.054	0.031	0.014	0.007	0.000	0.000	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1994	196	0.000	0.010	0.082	0.184	0.082	0.046	0.020	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1995	525	0.002	0.010	0.091	0.261	0.080	0.055	0.013	0.008	0.004	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1996	545	0.000	0.002	0.095	0.088	0.138	0.055	0.022	0.007	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1997	212	0.000	0.000	0.075	0.222	0.123	0.104	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	1998	70	0.000	0.000	0.014	0.129	0.129	0.100	0.057	0.000	0.014	0.000	0.014	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2000	48	0.000	0.000	0.000	0.104	0.167	0.146	0.083	0.042	0.042	0.021	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2001	396	0.000	0.000	0.003	0.040	0.111	0.162	0.073	0.040	0.020	0.013	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rec	2002	409	0.000	0.000	0.017	0.071	0.178	0.115	0.081	0.032	0.005	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Survey	Year	Tot. No.Fish	Female Proportion-at-age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
NMFS	1995	208	0.260	0.168	0.048	0.034	0.024	0.014	0.005	0.000	0.010	0.005	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	1998	221	0.226	0.231	0.072	0.027	0.032	0.018	0.009	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	2001	197	0.183	0.274	0.056	0.005	0.036	0.010	0.010	0.010	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
			Male Proportion-at-age																			
NMFS	1995	208	0.163	0.178	0.014	0.019	0.014	0.024	0.000	0.010	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	1998	221	0.122	0.149	0.036	0.036	0.018	0.018	0.005	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NMFS	2001	197	0.157	0.157	0.061	0.005	0.010	0.015	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005	0.000	0.000	0.000	0.000	0.000	0.000

Table 13. Lingcod length, weight, and fraction mature at age data used in the northern (LCN) model.

Males						Females					
	Length		Weight		Fraction		Length		Weight		Fraction
Age	(Cm.)	(In.)	(Kg.)	(Lbs.)	Mature	Age	(Cm.)	(In.)	(Kg.)	(Lbs.)	Mature
1	42.0	16.5	0.65	1.4	0.17	1	43.0	16.9	0.62	1.4	0.04
2	48.9	19.3	1.07	2.4	0.37	2	51.6	20.3	1.16	2.6	0.09
3	54.9	21.6	1.54	3.4	0.63	3	59.4	23.4	1.87	4.1	0.21
4	60.0	23.6	2.06	4.5	0.83	4	66.4	26.1	2.73	6.0	0.42
5	64.4	25.4	2.58	5.7	0.93	5	72.7	28.6	3.72	8.2	0.66
6	68.2	26.8	3.11	6.8	0.98	6	78.4	30.9	4.80	10.6	0.84
7	71.5	28.1	3.61	8.0	0.99	7	83.5	32.9	5.95	13.1	0.93
8	74.3	29.2	4.09	9.0	1.00	8	88.1	34.7	7.15	15.8	0.97
9	76.7	30.2	4.54	10.0	1.00	9	92.3	36.3	8.36	18.4	0.99
10	78.8	31.0	4.95	10.9	1.00	10	96.0	37.8	9.57	21.1	1.00
11	80.6	31.7	5.32	11.7	1.00	11	99.4	39.1	10.77	23.7	1.00
12	82.2	32.4	5.66	12.5	1.00	12	102.4	40.3	11.93	26.3	1.00
13	83.5	32.9	5.96	13.1	1.00	13	105.2	41.4	13.05	28.8	1.00
14	84.7	33.3	6.23	13.7	1.00	14	107.7	42.4	14.12	31.1	1.00
15	85.7	33.7	6.46	14.3	1.00	15	109.9	43.3	15.14	33.4	1.00
16	86.5	34.1	6.67	14.7	1.00	16	111.9	44.1	16.10	35.5	1.00
17	87.2	34.3	6.86	15.1	1.00	17	113.7	44.8	17.00	37.5	1.00
18	87.9	34.6	7.02	15.5	1.00	18	115.3	45.4	17.85	39.3	1.00
19	88.4	34.8	7.16	15.8	1.00	19	116.8	46.0	18.63	41.1	1.00
20	88.9	35.0	7.28	16.1	1.00	20	118.1	46.5	19.36	42.7	1.00

Growth Parameters:		Weight Parameters:		Maturity Parameters:		Growth Parameters:		Weight Parameters:		Maturity Parameters:	
Linf	91.816869	a	0.003953	Alpha	1.060	Linf	130.18329	a	0.00176	Alpha	0.994
K	0.149260	b	3.214900	Beta	2.506	K	0.104103	b	3.397800	Beta	4.323
L1	41.999173					L1	42.98222				

Table 14. Lingcod biological parameters used in the northern (LCN) model.

Parameter	Male Estimate	Female Estimate
Growth[1]		
Linf	91.817	130.183
K	0.149	0.104
L1	41.999	42.982
T_0	-3.097	-2.850
n	6274	16884
Length-Weight[2]		
a	0.003953	0.001760
b	3.214900	3.397800
R sq	0.52	0.71
n	5149	12079
Maturity[3]		
Alpha	1.060	0.994
Beta	2.506	4.323
n	15	21
Natural Mortality[4]		
M	0.32	0.18
Fecundity[5]		
a		2.82406E-04
b		3.0011

[1] Growth Model: L = Linf + (L1-Linf) * exp(K * (1-Age))

[2]Length Weight Model: $W = a*L^b$

[3]Maturity Model: P = 1/(1+exp(-Alpha * (Age-Beta)))

[4]Natural Mortality: Data source: Jagielo (1994); derived from an average of values using methods of Hoenig (1983), Alverson and Carney (1975), and Pauly (1980).

Table 15. Intentionally Omitted.

Table 16. Mean length, weight and fraction of lingcod mature at age used in the LCS model. Survey data only were used for ages 1-3. Survey and fishery data were used for ages 4+.

Males						Females					
	Length		Weight		Fraction		Length		Weight		Fraction
Age	(Cm.)	(In.)	(Kg.)	(Lbs.)	Mature	Age	(Cm.)	(In.)	(Kg.)	(Lbs.)	Mature
1	34.3	13.5	0.34	0.7	0.06	1	35.1	13.8	0.31	0.7	0.04
2	43.7	17.2	0.75	1.6	0.18	2	45.6	18.0	0.76	1.7	0.11
3	51.3	20.2	1.25	2.7	0.43	3	54.7	21.5	1.41	3.1	0.29
4	57.4	22.6	1.79	3.9	0.72	4	62.5	24.6	2.23	4.9	0.55
5	62.3	24.5	2.32	5.1	0.90	5	69.3	27.3	3.16	7.0	0.79
6	66.2	26.0	2.82	6.2	0.97	6	75.2	29.6	4.17	9.2	0.92
7	69.3	27.3	3.27	7.2	0.99	7	80.2	31.6	5.20	11.5	0.97
8	71.8	28.2	3.66	8.1	1.00	8	84.6	33.3	6.24	13.7	0.99
9	73.7	29.0	3.99	8.8	1.00	9	88.4	34.8	7.24	16.0	1.00
10	75.3	29.7	4.28	9.4	1.00	10	91.7	36.1	8.20	18.1	1.00
11	76.6	30.2	4.51	10.0	1.00	11	94.6	37.2	9.09	20.0	1.00
12	77.6	30.6	4.71	10.4	1.00	12	97.0	38.2	9.92	21.9	1.00
13	78.4	30.9	4.87	10.7	1.00	13	99.2	39.0	10.68	23.5	1.00
14	79.1	31.1	5.00	11.0	1.00	14	101.0	39.8	11.37	25.1	1.00
15	79.6	31.3	5.11	11.3	1.00	15	102.6	40.4	11.99	26.4	1.00
16	80.0	31.5	5.20	11.5	1.00	16	104.0	40.9	12.55	27.7	1.00
17	80.4	31.6	5.27	11.6	1.00	17	105.2	41.4	13.04	28.8	1.00
18	80.6	31.7	5.32	11.7	1.00	18	106.2	41.8	13.48	29.7	1.00
19	80.8	31.8	5.37	11.8	1.00	19	107.1	42.2	13.87	30.6	1.00
20	81.0	31.9	5.40	11.9	1.00	20	107.9	42.5	14.22	31.3	1.00

Growth Parameters:		Weight Parameters:		Maturity Parameters:		Growth Parameters:		Weight Parameters:		Maturity Parameters:	
Linf	81.693959	a	0.003953	Alpha	1.240	Linf	112.81069	a	0.00176	Alpha	1.129
K	0.223233	b	3.214900	Beta	3.233	K	0.144902	b	3.397800	Beta	3.814
L1	34.252704					L1	35.113463				

Table 17. Lingcod biological parameters used in the southern (LCS) model.

Parameter	Male Estimate	Female Estimate
Growth[1]		
Linf	81.694	112.811
K	0.223	0.145
L1	34.253	35.113
T_0	-1.435	-1.573
n	986	1780
Length-Weight[2]		
a	0.003953	0.001760
b	3.214900	3.397800
R sq	0.52	0.71
n	5149	12079
Maturity[3]		
Alpha	1.240	1.129
Beta	3.233	3.814
R sq	0.989	0.994
Natural Mortality[4]		
M	0.32	0.18
Fecundity[5]		
a		2.82406E-04
b		3.0011

[1] Growth Model: L = Linf + (L1-Linf) * exp(K * (1-Age))

[2]Length Weight Model: $W = a*L^b$

[3]Maturity Model: P = 1/(1+exp(-Alpha * (Age-Beta)))

[4]Natural Mortality: Data source: Jagielo (1994); derived from an average of values using methods of Hoenig (1983), Alverson and Carney (1975), and Pauly (1980).

Table 18. NMFS trawl survey lingcod biomass estimates by INPFC area for combined depth strata. Note: The shallow depth strata was 50-100 fm. in 1977, and 30-100 fm. for all other years.

NMFS Trawl Survey lingcod biomass (mt) estimates for combined depth strata by INPFC

Standard analysis which includes all good perfromance hauls.

Year	Conception	Monterey	Eureka	Columbia	US Vancouver	Monterey + Eureka	CV	Columbia +US Vancouver	CV
1977	69	1,800	274	12,648	2,277	2,074	0.32	14,925	0.77
1980		671	431	8,699	1,281	1,102	0.29	9,979	0.65
1983		1,467	494	4,026	1,805	1,962	0.33	5,831	0.15
1986		611	316	1,828	988	926	0.21	2,816	0.12
1989	54	2,107	473	3,649	1,863	2,580	0.20	5,512	0.29
1992	27	484	148	3,071	1,069	632	0.24	4,140	0.49
1995	42	703	179	1,320	552	881	0.28	1,872	0.16
1998	34	651	219	2,002	1,018	871	0.27	3,020	0.26
2001	85	693	654	3,903	1,324	1,347	0.12	5,227	0.27

Including all good perfrmance hauls, but excluding tows identified as "water hauls"

Year	Conception	Monterey	Eureka	Columbia	US Vancouver	Monterey + Eureka	CV	Columbia +US Vancouver	CV
1977	74	2,368	624	12,773	2,270	2,993	0.14	15,043	0.77
1980		929	608	3,219	1,361	1,537	0.31	4,580	0.31
1983		1,523	556	4,306	1,962	2,079	0.33	6,268	0.16
1986		611	315	1,860	951	926	0.21	2,812	0.12
1989	54	2,168	540	3,933	1,922	2,708	0.20	5,856	0.30
1992	32	476	154	3,071	1,084	630	0.25	4,155	0.49
1995	46	703	199	1,329	555	901	0.27	1,884	0.16
1998	34	651	219	2,002	1,018	871	0.27	3,020	0.26
2001	85	693	654	3,903	1,324	1,347	0.12	5,227	0.27

Difference in estimated biomass (mt) by including and excluding "water hauls"

Year	Conception	Monterey	Eureka	Columbia	US Vancouver	Monterey + Eureka	Columbia +US Vancouver
1977	5	569	350	125	-7	919	118
1980	0	258	177	-5,480	81	435	-5,399
1983	0	55	61	280	157	117	437
1986	0	0	-1	33	-37	-1	-4
1989	1	61	67	284	60	128	344
1992	6	-8	6	0	15	-2	15
1995	3	0	20	9	3	20	12
1998	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0

Table 19. WDFW Cape Flattery tag survey index used in the northern (LCN) assessment. Estimates for the years 1986-1992 were obtained from Jagielo (1995).

Year	Number of Fish	Standard Deviation
1986	119700	18800
1987	208500	31800
1988	165400	19000
1989	149000	13500
1990	123800	10300
1991	114400	9500
1992	127300	11000

Table 20. Number of logbook tows used to develop trawl logbook CPUE indices in southern and northern waters.

Total number of logbook tows by PMFC Area

Year	1A	1B	1C	2A	2B	2C	2C	3A	3B	3C
1976	0	0	0	673	2783	1433	1433	3966	0	0
1977	0	0	0	447	1290	1747	1747	2051	0	0
1978	2048	9495	8702	985	1951	1638	1638	3142	0	0
1979	2472	10552	12756	1764	3007	1981	1981	5583	0	0
1980	2036	8895	7958	1137	1101	1048	1048	4479	0	0
1981	5566	19492	16002	3701	3806	1396	1396	5270	0	0
1982	2412	10345	7970	2845	5267	4503	4503	8446	0	0
1983	1494	9416	7465	2330	5324	1195	1195	4912	0	0
1984	1683	6883	7629	1657	2320	1927	1927	5644	0	0
1985	2699	8366	7142	1140	2784	2928	2928	3606	0	0
1986	2865	9941	5151	770	1432	2053	2053	5520	4338	3816
1987	3030	6630	5070	1415	5016	2765	2765	10821	3520	3287
1988	3182	6847	6209	1456	5117	7490	3751	11027	4607	4077
1989	4338	8000	5777	1431	5232	12348	6183	12492	5711	5352
1990	3622	6483	5601	1504	4786	10598	5319	9211	4491	5759
1991	3296	8931	5197	1736	6713	14917	7504	12067	5630	6460
1992	3393	10158	4210	1487	5468	14288	7190	10485	4936	5905
1993	2450	9936	4205	1827	5674	8702	8702	8491	4797	5711
1994	2662	8995	3940	1531	3888	7176	7176	7130	3674	4951
1995	2721	8688	4986	1372	3699	9378	4696	7205	3825	3230
1996	2697	9568	4968	1424	3320	9388	4699	8199	3605	2643
1997	1867	8000	4763	1717	3550	9194	4603	5706	2072	2271
1998	2673	5792	3776	2184	3228	7516	3759	4236	2066	2262
1999	3403	5258	4064	1637	2712	6026	3014	4341	1809	1841
2000	1702	3692	3278	728	2095	5423	2716	4451	2045	1638
2001	2261	3090	3078	1161	2140	6376	3195	3574	2072	1935
2002	3310	4640	3114	726	1278	4345	2176	3337	2560	1577
	69,882	208,093	153,011	39,665	90,908	154,599	96,117	169,375	61,758	62,715

Table 21. Summary of estimated Delta GLM logbook index results in the northern region, indicating: 1) sample size (# of tows), 2) the percentage of tows with lingcod present (2003 index % positive), and 3) the computed index values used in the 2003 LCN stock assessment model. The logbook index values used in the 2000 assessment are provided for comparison.

Northern Area Trawl Logbook Index

Year	2000 Index Index Value	2003 Index # of Tows	% Positive	Index Value
1976		9,615	62%	20.33
1977		6,835	52%	16.16
1978		8,369	54%	10.79
1979		12,552	58%	11.37
1980		7,676	64%	11.32
1981		11,868	63%	13.33
1982		22,719	50%	9.29
1983	335.9	12,626	51%	9.32
1984	218.3	11,818	44%	6.99
1985	296.7	12,246	36%	6.26
1986	271.6	19,212	23%	3.58
1987	287.0	28,174	31%	4.24
1988	218.1	39,808	27%	4.56
1989	201.2	53,483	25%	5.45
1990	201.1	45,443	23%	4.36
1991	157.4	60,704	22%	3.94
1992	153.8	55,370	19%	2.23
1993	102.9	42,077	28%	2.74
1994	157.6	33,995	28%	2.82
1995	40.6	36,715	21%	2.47
1996	127.3	36,543	22%	2.54
1997	123.0	31,987	21%	2.36

Table 22. Summary of estimated Delta GLM logbook index results in the southern region, indicating: 1) sample size (# of tows), 2) the percentage of tows with lingcod present (2003 index % positive), and 3) the computed index values used in the 2003 LCS stock assessment model. The logbook index values used in the 2000 assessment are provided for comparison.

Southern Area Trawl Logbook Index

Year	2000 Index Index Value	2003 Index # of Tows	% Positive	Index Value
1978	44.51	21,230	34%	5.80
1979	49.23	27,544	47%	11.75
1980	45.79	20,026	47%	9.57
1981	49.65	44,761	46%	7.29
1982	45.62	23,572	47%	7.37
1983	29.16	20,705	43%	8.88
1984	25.46	17,852	39%	7.56
1985	15.53	19,347	31%	3.56
1986	17.41	18,727	24%	3.10
1987	27.25	16,145	33%	5.42
1988	26.32	17,694	31%	5.63
1989	28.99	19,546	32%	7.30
1990	29.97	17,210	28%	6.18
1991	22.27	19,160	31%	3.75
1992	18.58	19,248	27%	3.12
1993	20.51	18,418	28%	3.84
1994	21.56	17,128	25%	3.63
1995	20.35	17,767	25%	3.87
1996	16.65	18,657	26%	3.12
1997	18.81	16,347	28%	3.30

Table 23. Recreational lingcod CPUE for boat-based fisheries using the "indirect" method on RecFIN creel data for northern California, southern California and Oregon. WDFW sport creel data was used to develop the Washington lingcod CPUE index.

Recreational lingcod catch-per-unit-effort (CPUE) for boat-based fisheries

	Southern California [1/]		Northern California [1/]		Oregon [1/]		Washington [2/]
YEAR	CPUE	SE	CPUE	SE	CPUE	SE	CPUE
1980	0.12	0.03	1.02	0.20	0.89	0.15	
1981	0.08	0.02	0.62	0.14	0.78	0.17	
1982			0.34	0.10	1.08	0.17	
1983	0.03	0.01	0.35	0.09	1.06	0.18	
1984	0.01	0.01	0.44	0.09	0.57	0.07	
1985	0.04	0.01	0.41	0.06	0.64	0.07	
1986			0.59	0.11	0.37	0.08	
1987			0.59	0.14	0.65	0.10	
1988	0.04	0.02	0.74	0.21	0.43	0.05	
1989	0.14	0.03	0.59	0.11	1.00	0.09	
1990							0.49
1991							0.47
1992							0.63
1993					1.23	0.08	0.76
1994	0.06	0.03			1.32	0.09	0.83
1995					0.77	0.10	0.53
1996	0.09	0.05	0.65	0.07	0.94	0.10	0.48
1997			0.70	0.16	1.25	0.10	0.47
1998	0.09	0.03	0.73	0.13	0.50	0.06	0.24
1999	0.12	0.03	0.52	0.06	0.59	0.06	0.37
2000	0.08	0.05	1.51	0.28	0.50	0.06	0.24
2001	0.23	0.17	0.83	0.17	1.03	0.17	0.32
2002	0.34	0.09	1.18	0.18	0.99	0.18	0.11

[1/] RecFIN creel data used in the analysis.
[2/] WDFW creel data used in the analysis.

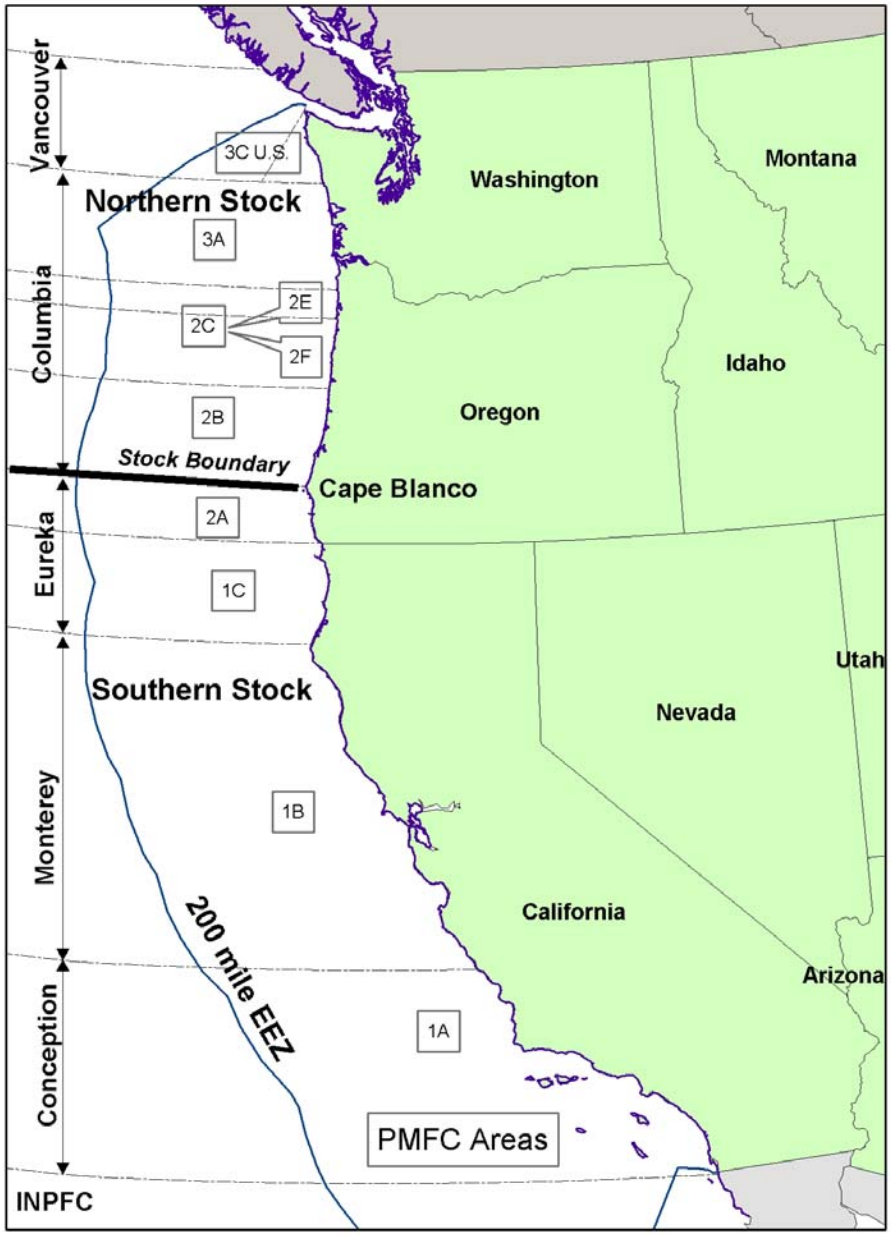


Figure 1. Lingcod stock boundaries and location of PMFC and INPFC Areas.

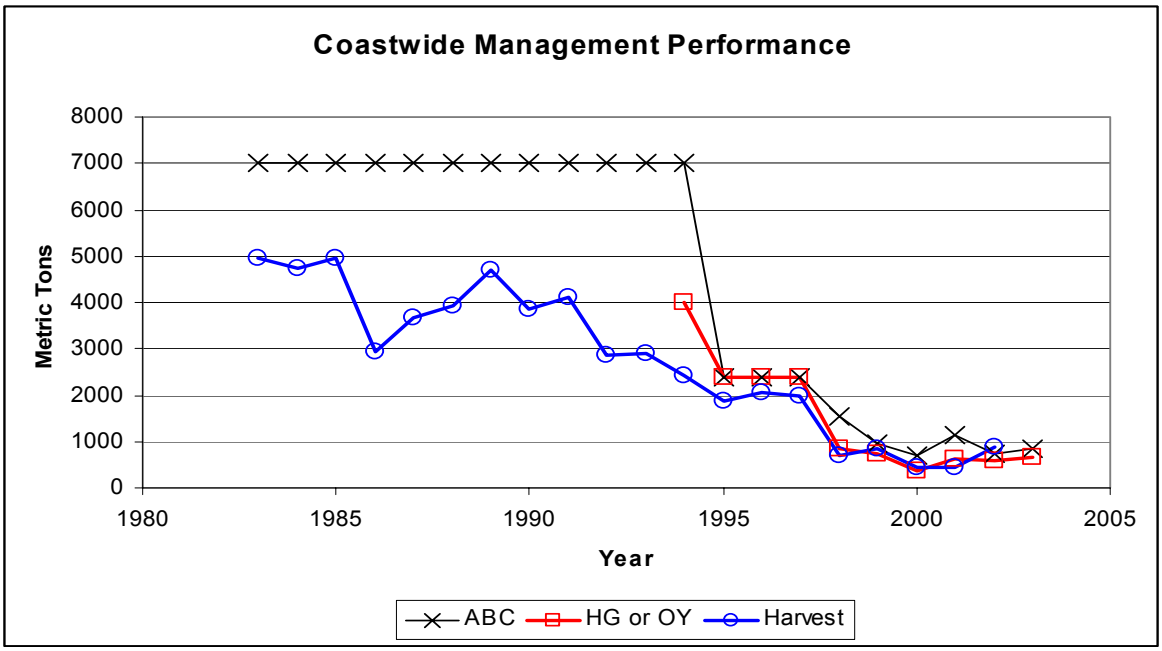


Figure 2. Comparison of lingcod ABC, OY and landings (mt) between 1983 and 2003.

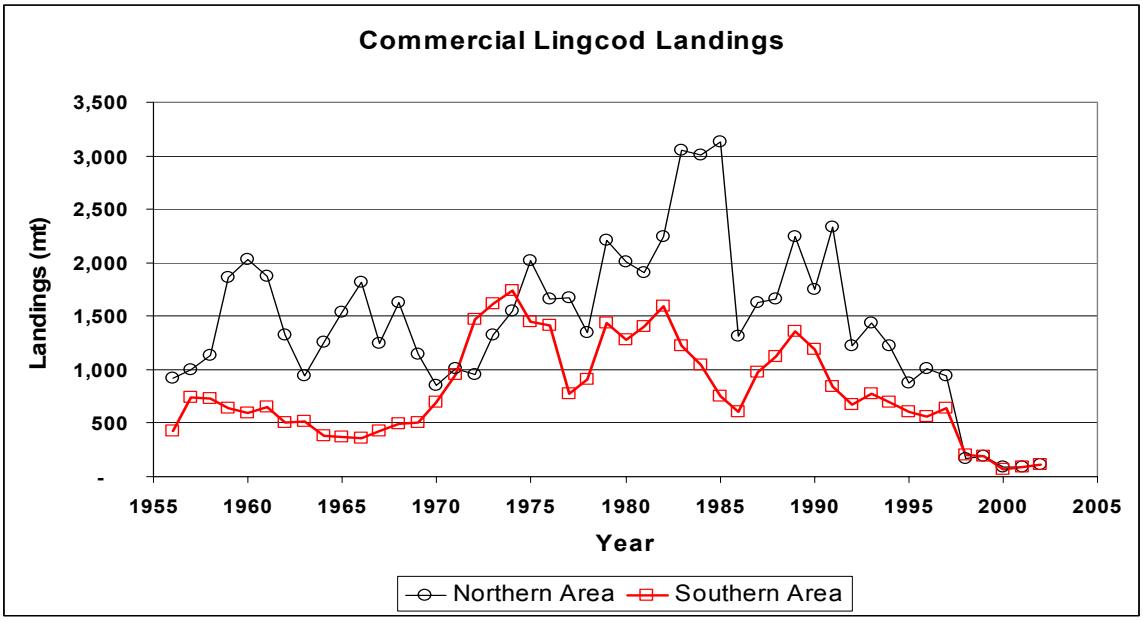


Figure 3. Comparison of commercial lingcod landings in the northern (U.S. Vancouver and Columbia) and southern (Eureka, Monterey and conception) areas.

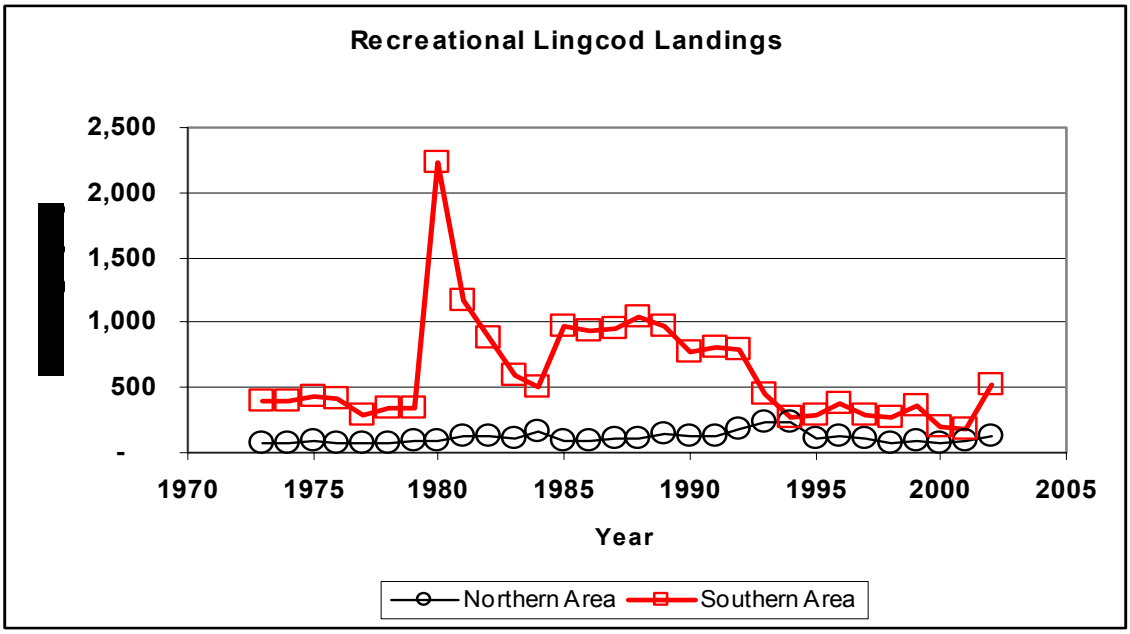


Figure 4. Comparison of recreational lingcod landings in the northern (U.S. Vancouver and Columbia) and southern (Eureka, Monterey and conception) areas.

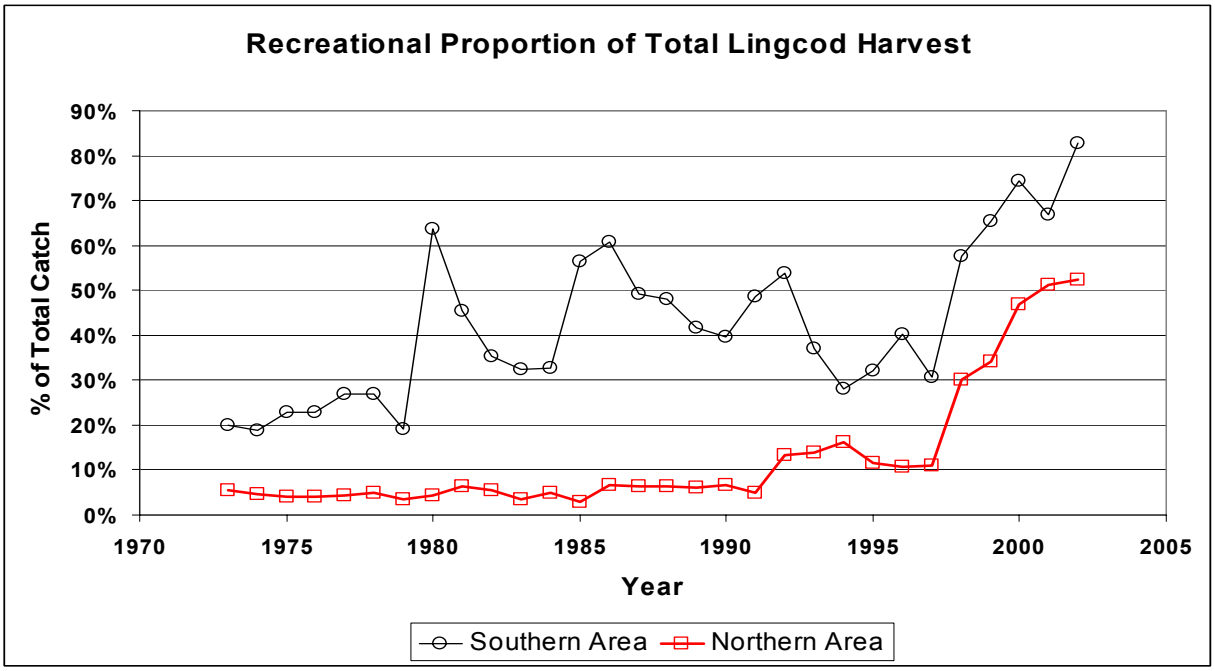


Figure 5. Recreational proportion of total lingcod harvest in the southern (INPFC Areas Eureka, Monterey and Conception) and northern areas (INPFC areas Columbia and U.S. Vancouver).

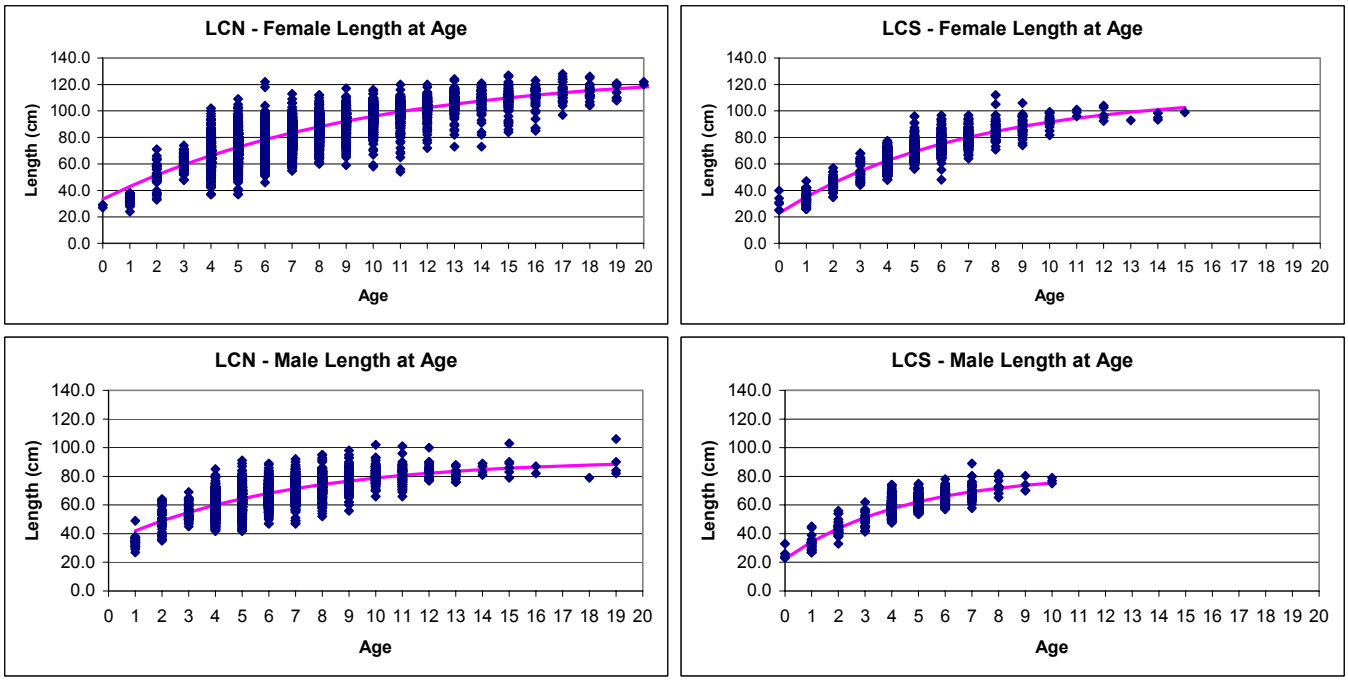


Figure 6. Length-at-age data fit to the von Bertalanffy growth model for the northern (LCN) and southern (LCS) areas. Survey data only were used for ages 1-3. Both survey and fishery data were used for ages 4+.

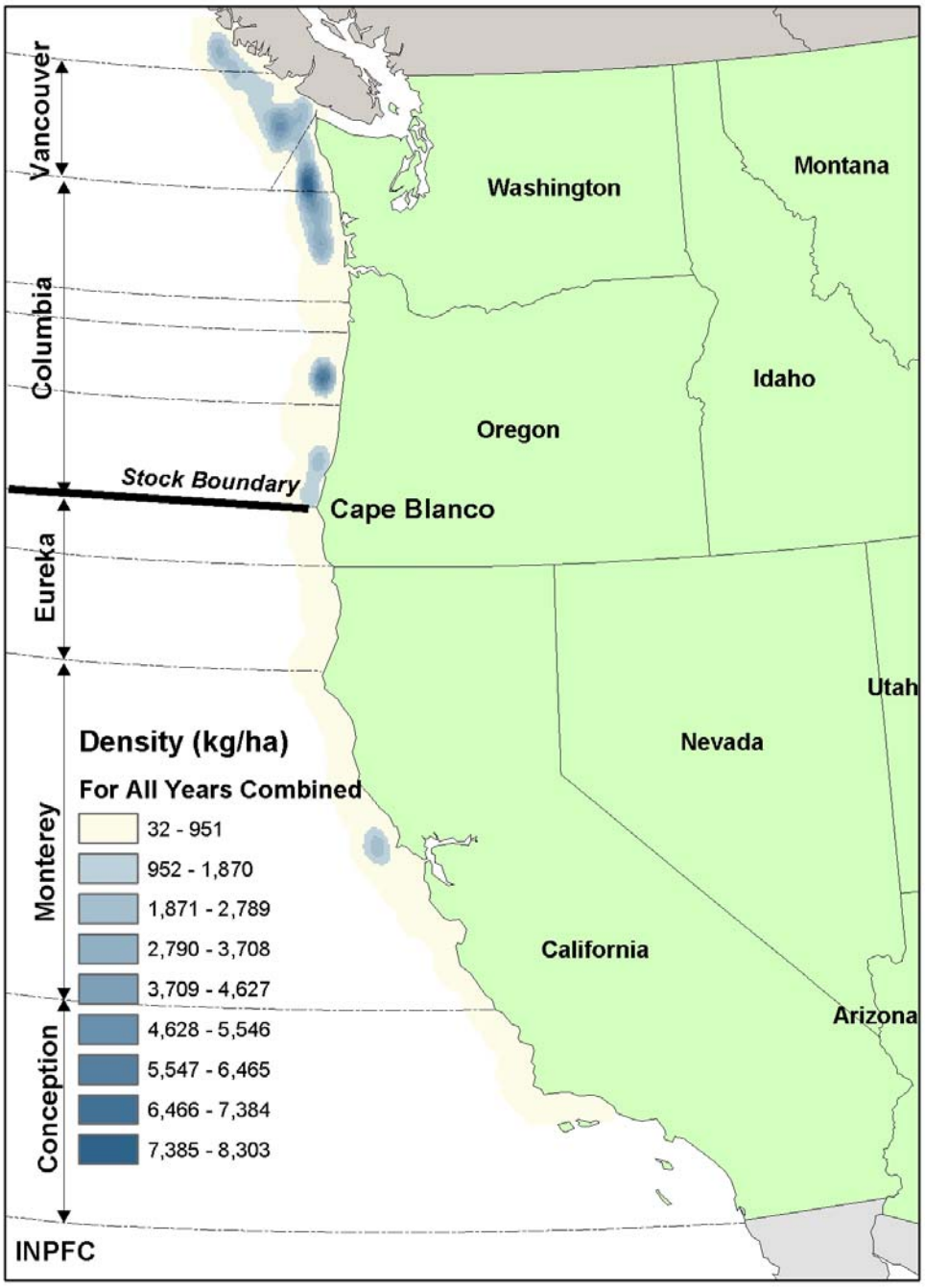


Figure 7. Coastwide distribution of lingcod (kg/ha) from the NMFS tow catches across all years and areas.

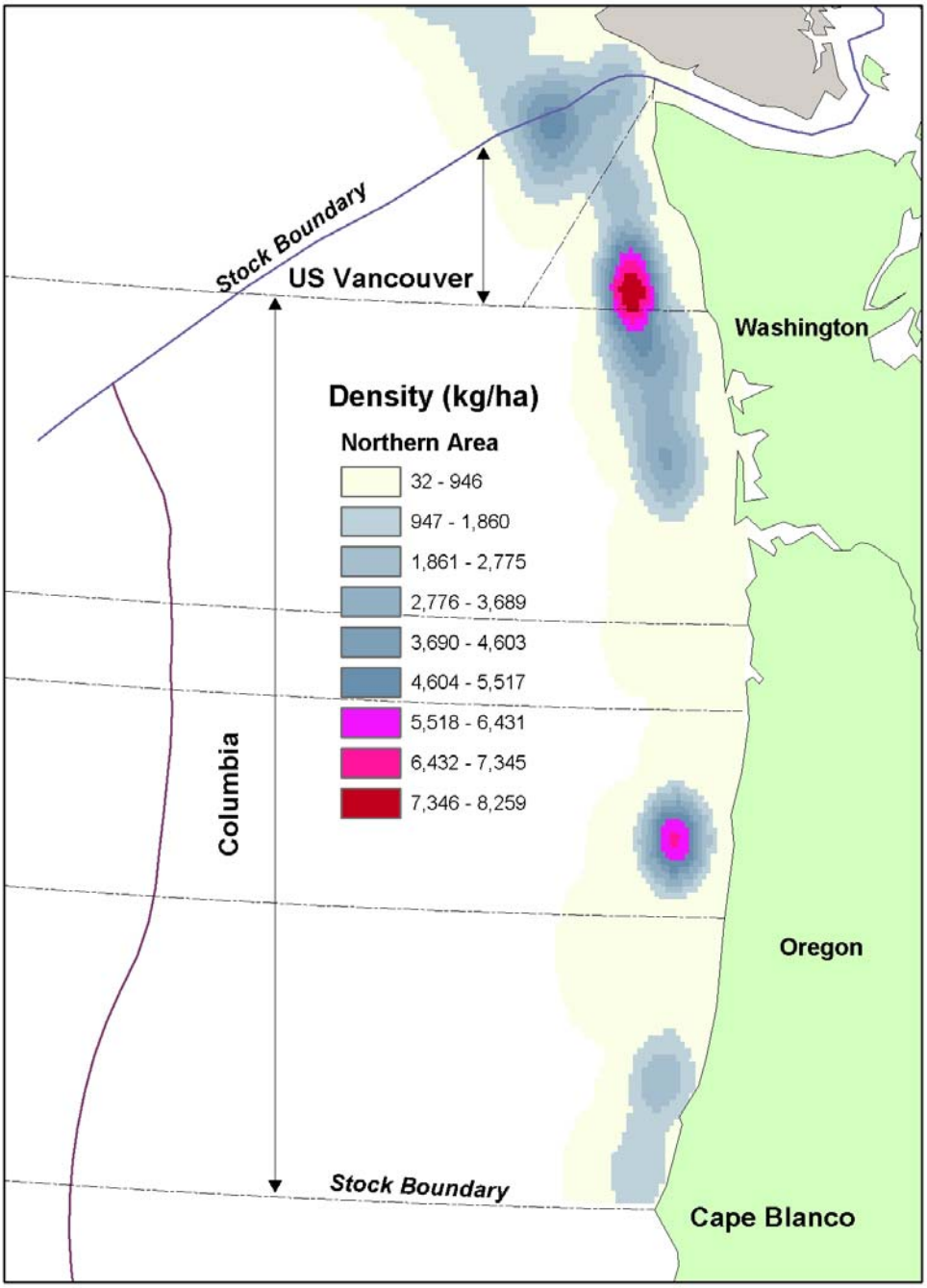


Figure 8. Northern distribution of lingcod (kg/ha) from the NMFS tow catches across all years.

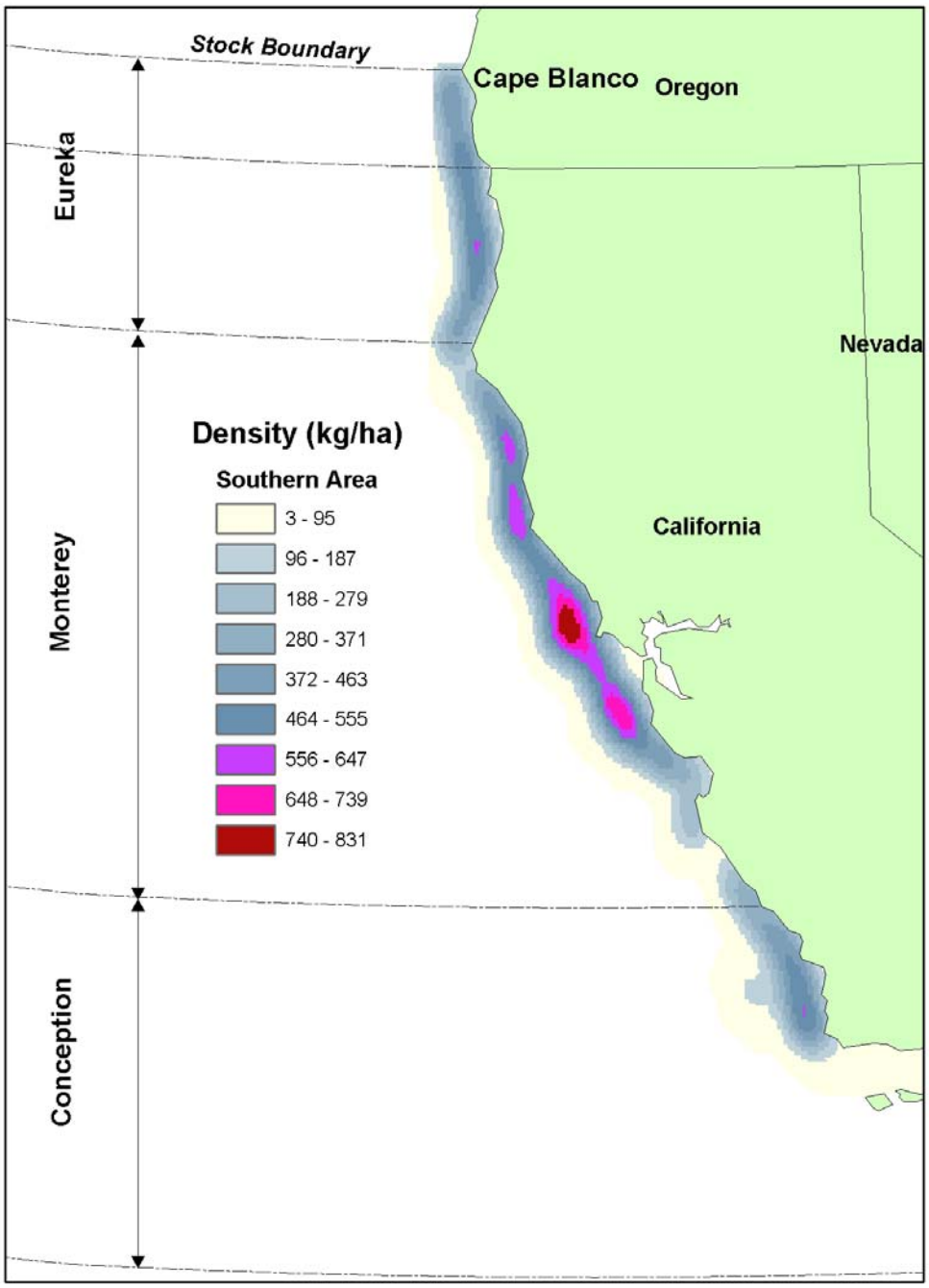


Figure 9. Southern distribution of lingcod (kg/ha) from the NMFS tow catches across all years.

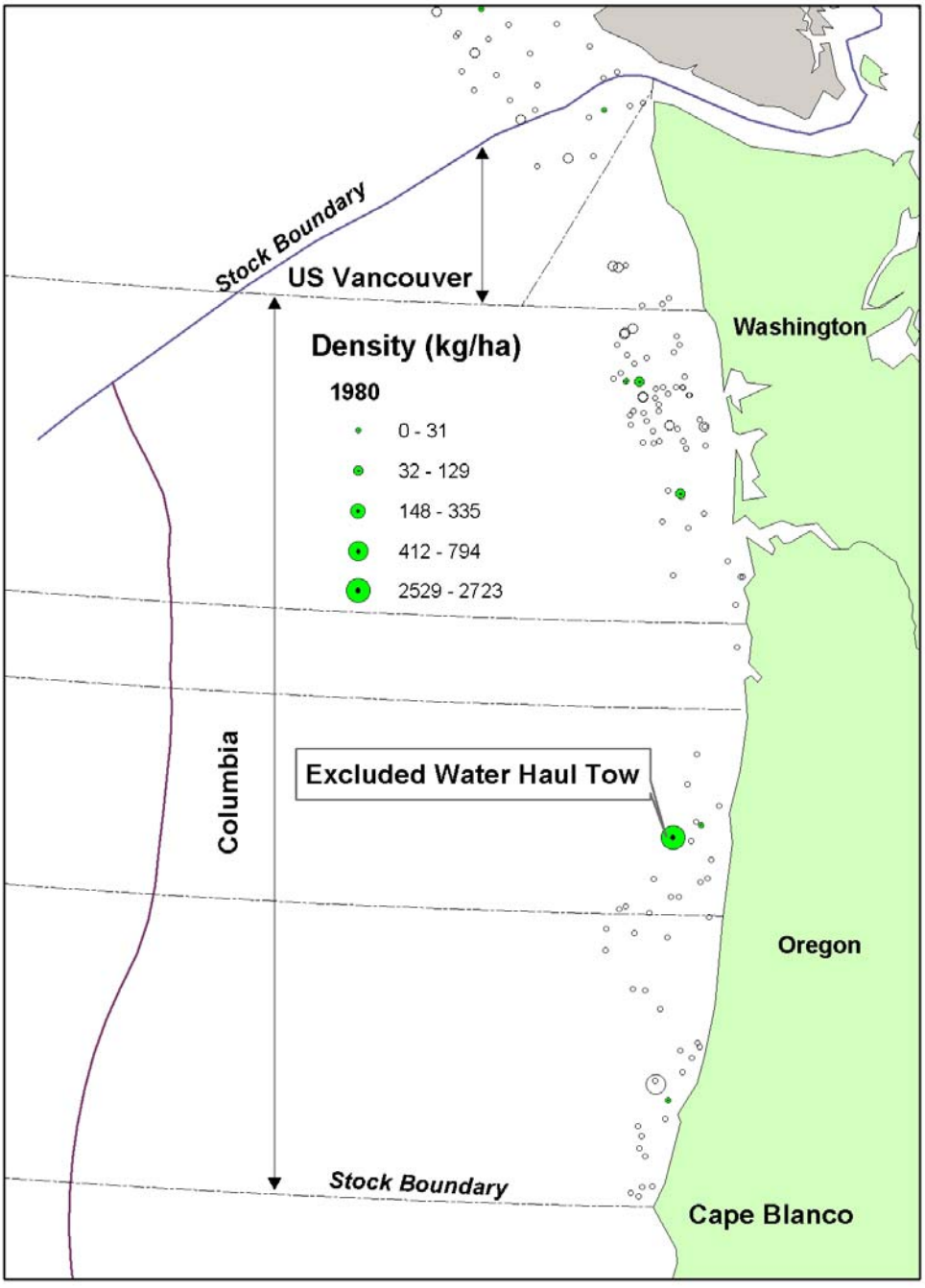


Figure 10. Location of excluded "water haul" tows (dark circles) from the 1980 NMFS Triennial Trawl Survey lingcod biomass estimate.

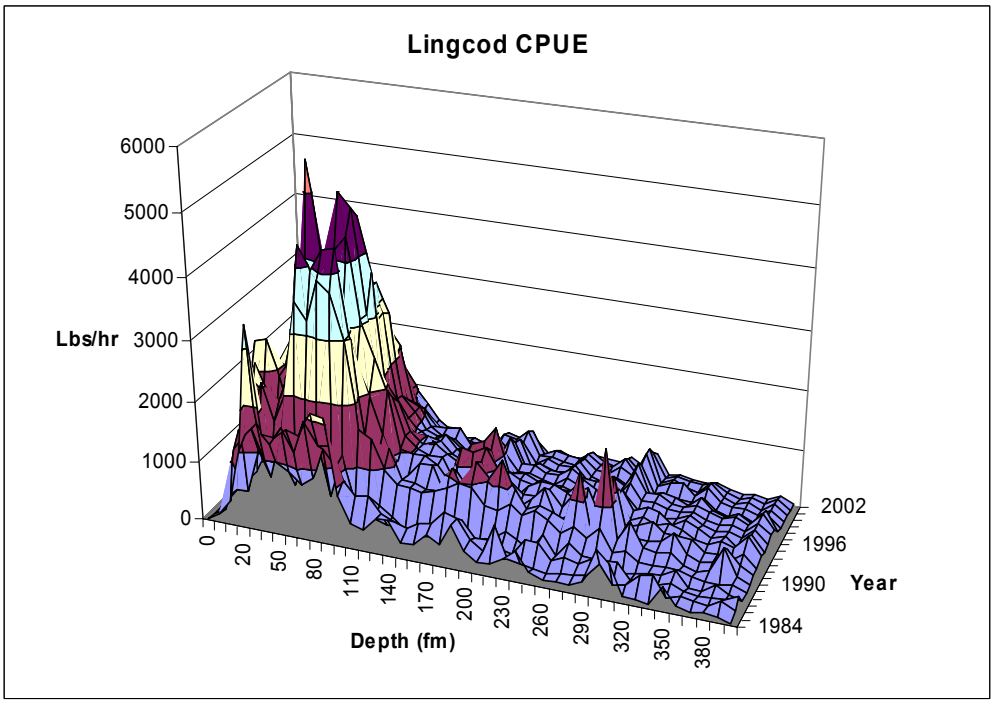


Figure 11. Mean lingcod CPUE calculated from raw data for all tows with a recorded depth.

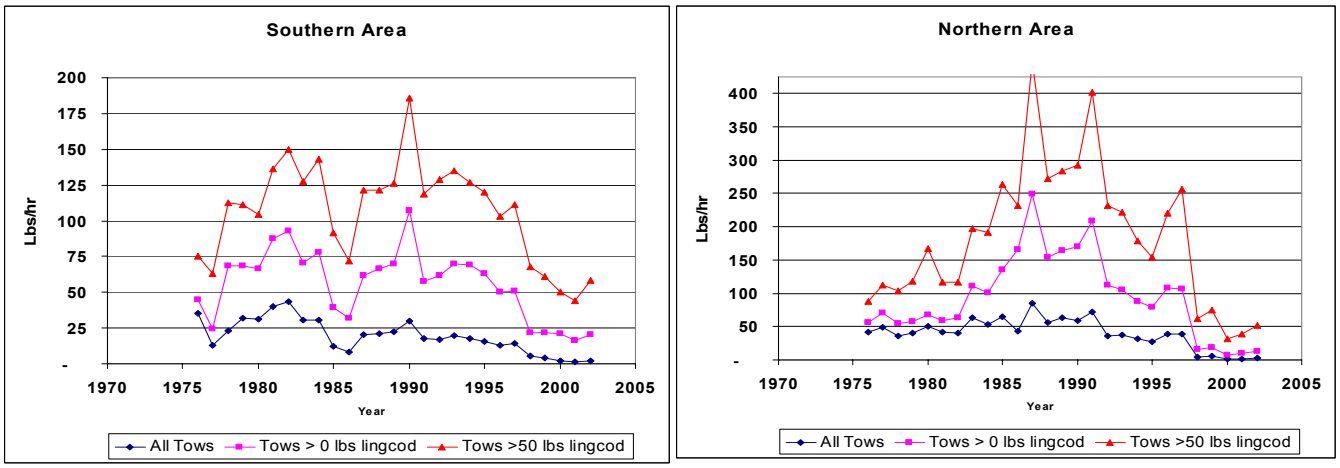
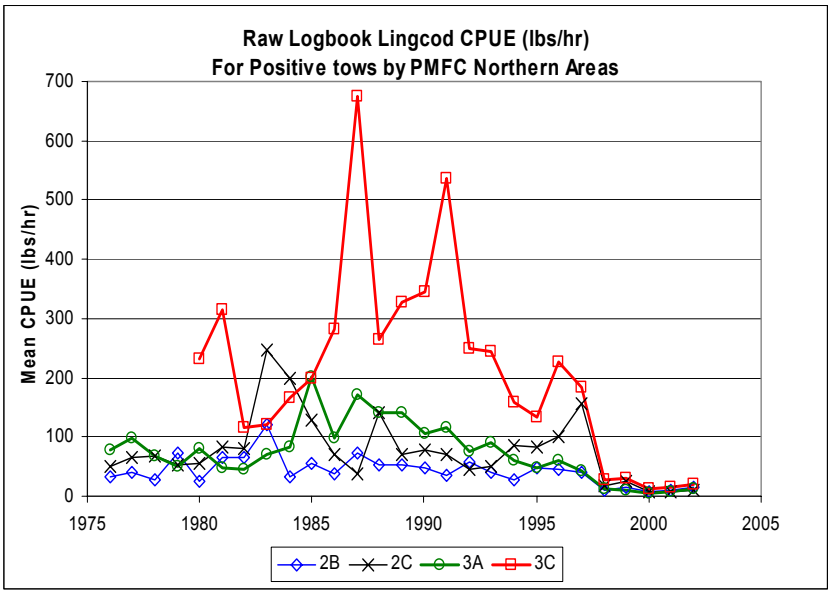


Figure 12. Mean CPUE for the southern and northern areas calculated from raw data for all tows, tows with >0 lbs lingcod catch, and tows with >50 lbs lingcod catch.



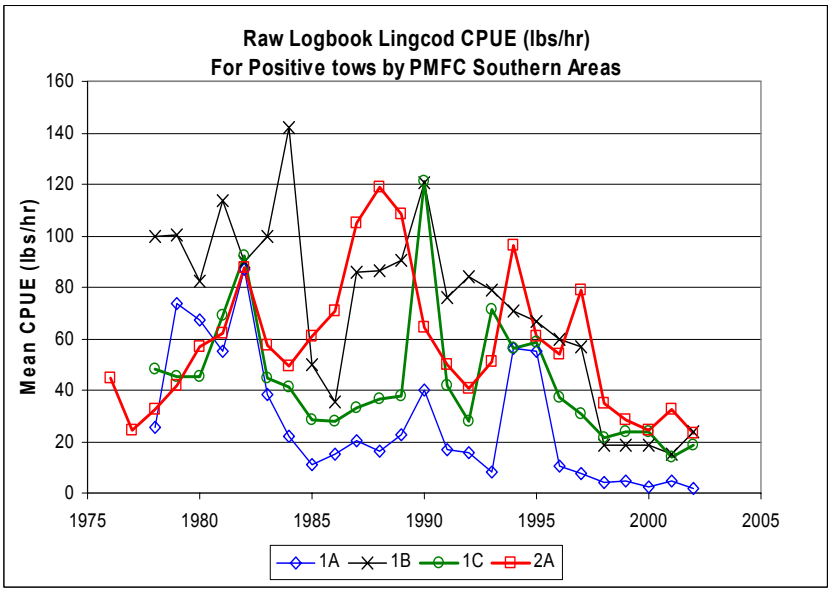


Figure 13. Mean CPUE by PMFC areas in the southern and northern areas calculated from raw data for tows with >0 lbs lingcod catch.

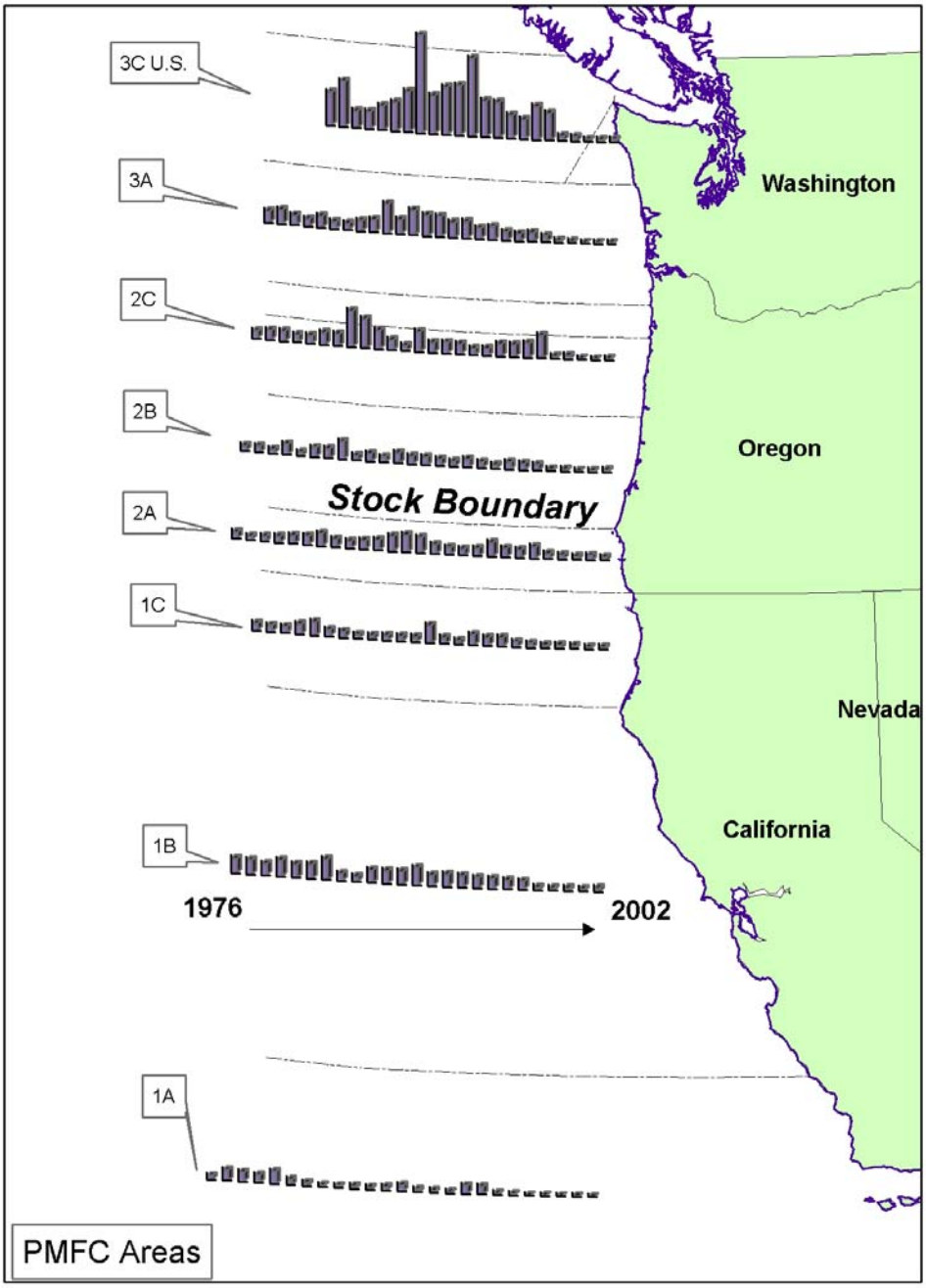


Figure 14. Time series (1976-2002) of observed lingcod trawl logbook CPUE (lbs/hr) by PMFC Area.

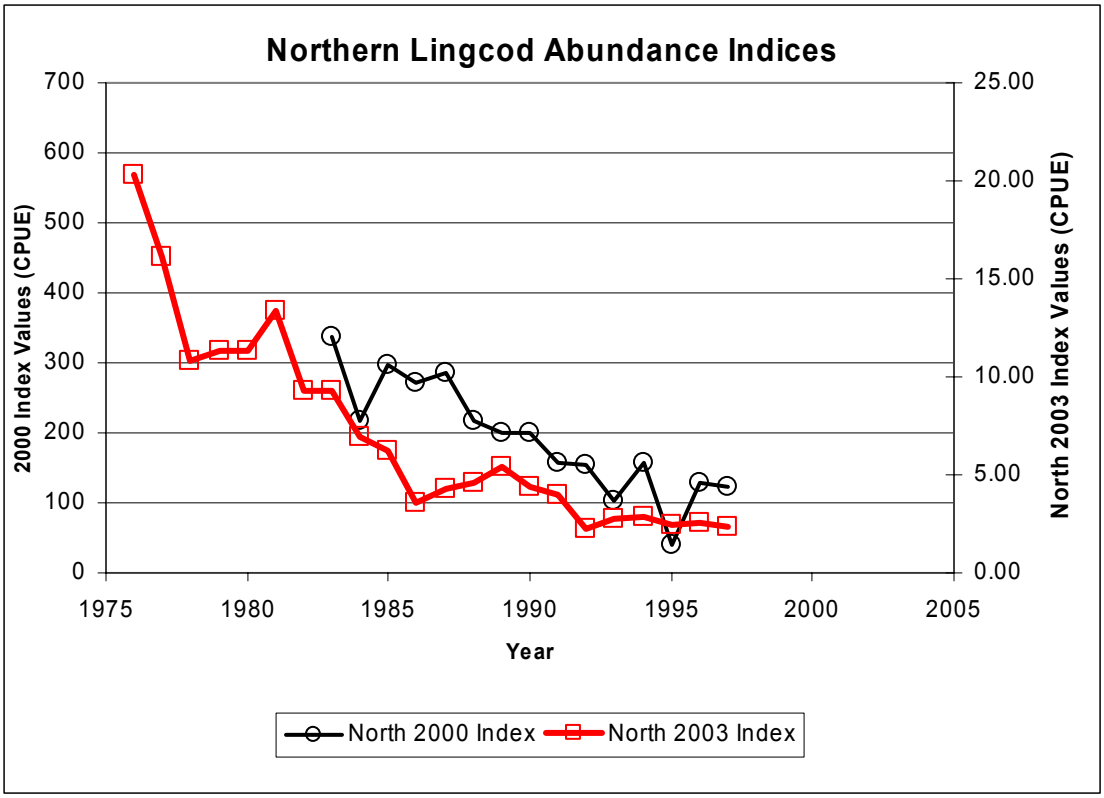


Figure 15. Comparison of the northern trawl logbook lingcod abundance trend to the northern trawl logbook index used in the 2000 lingcod stock assessment.

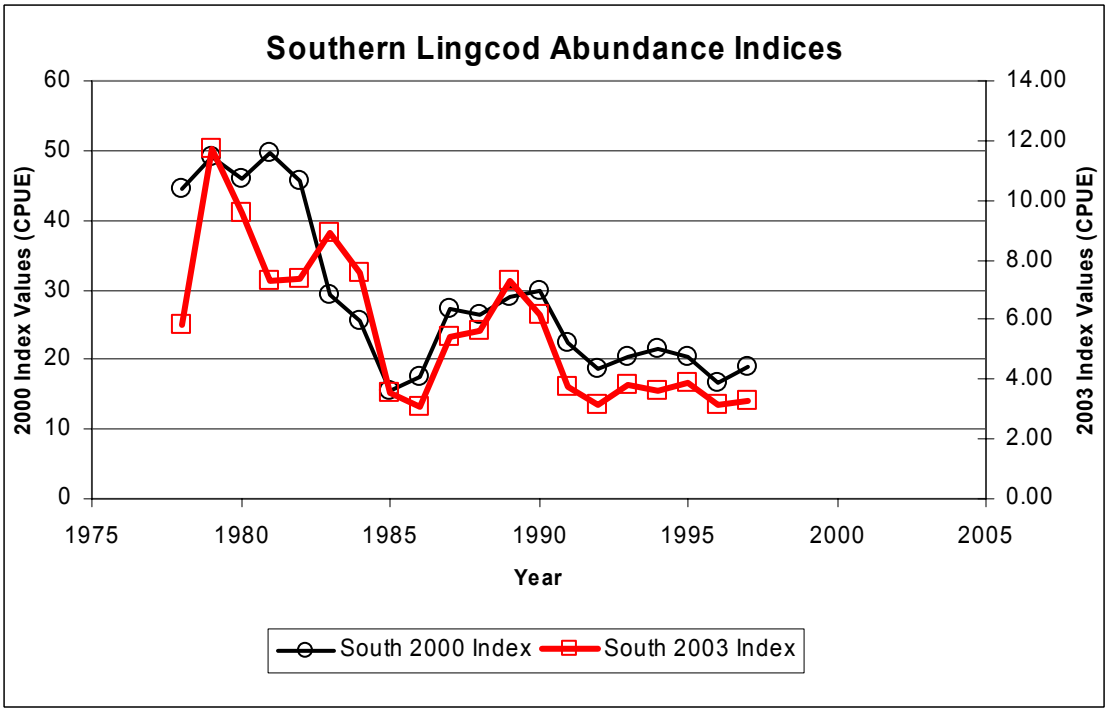


Figure 16. Comparison of the southern trawl logbook lingcod abundance trend to the southern trawl logbook index used in the 2000 lingcod stock assessment.

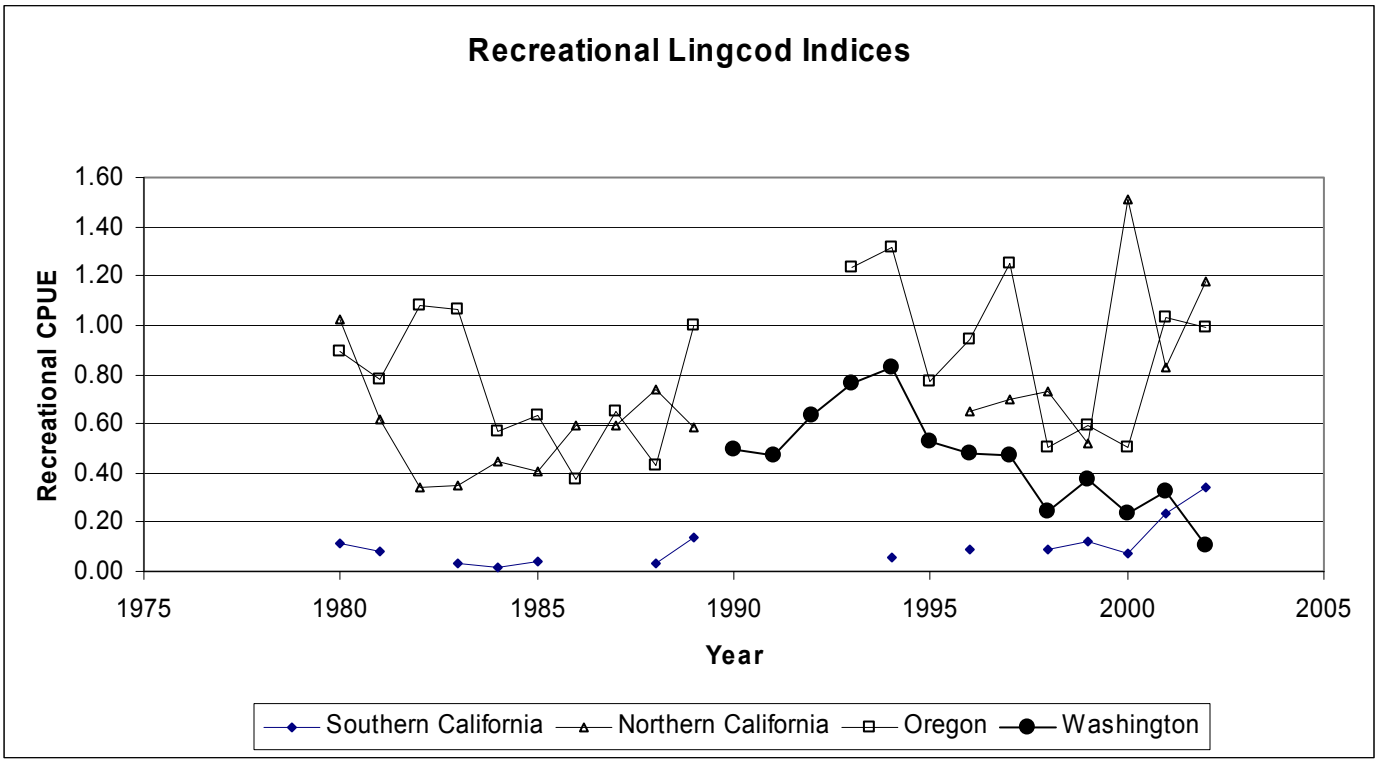


Figure 17. Candidate recreational lingcod CPUE for boat-based fisheries using the "indirect" method on RecFIN creel data for northern and southern California and Oregon and using WDFW sport creel data for the Washington index. These indices were not used in the base models.

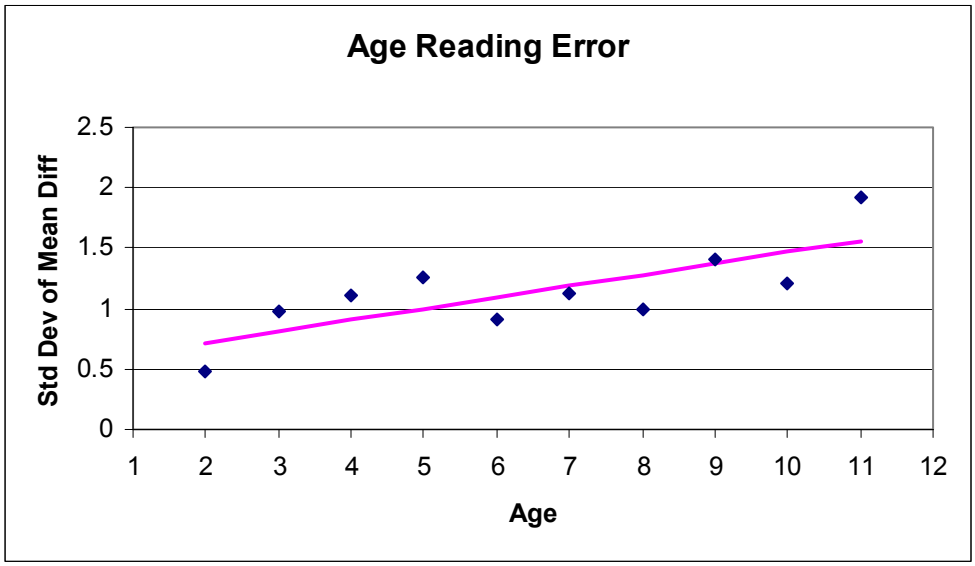


Figure 18. Between-reader (within-lab) estimates of WDFW age reading error variability.

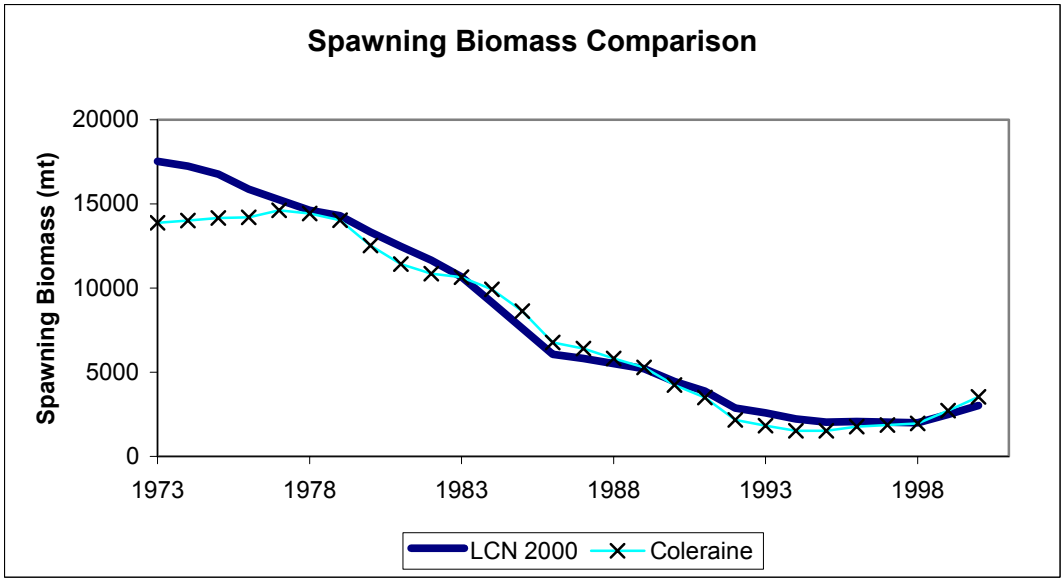


Figure 19. Comparison of LCN model estimates of spawning biomass (mt) (Jagielo et al. 2000) with Coleraine estimates of spawning biomass using the same input data.

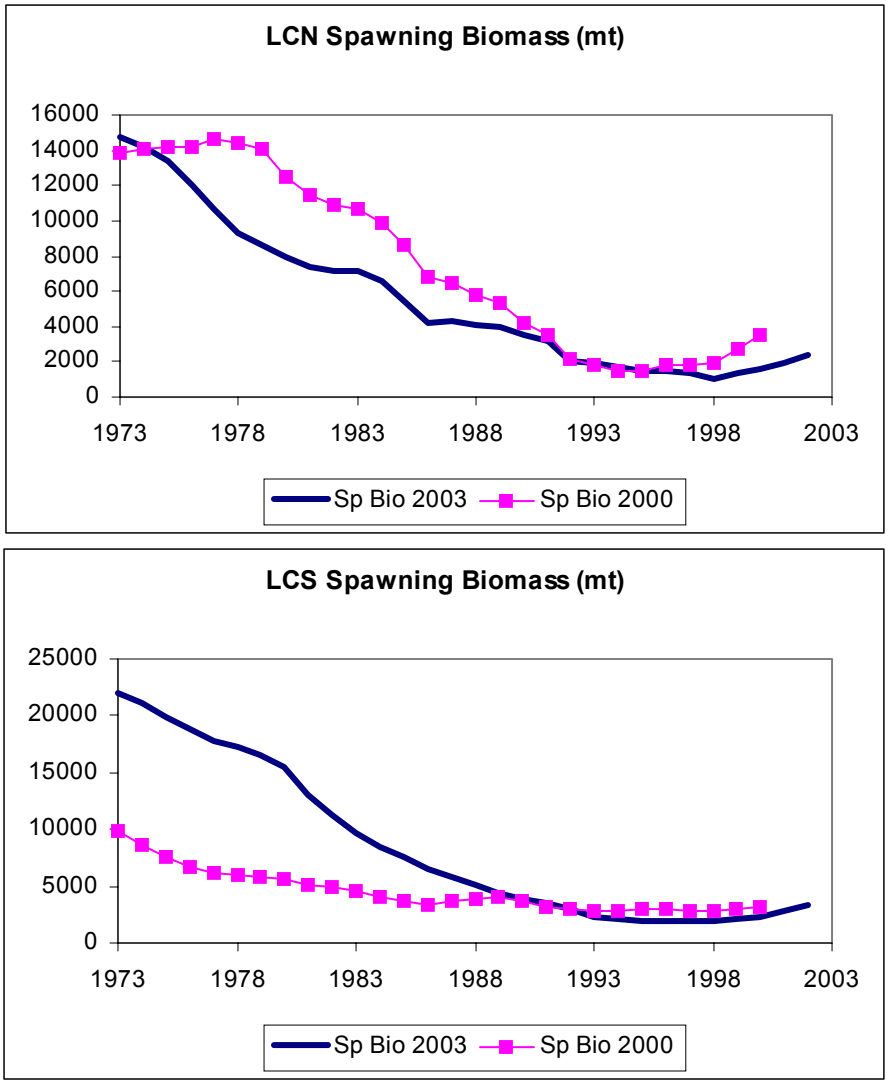


Figure 20. Comparison of LCN and LCS model estimates of spawning biomass (mt) from the 2000 assessment (Jagielo et al. 2000) with estimates of spawning biomass from the present assessment.

Appendix I. Base Model Output.

Assessment of Lingcod for the Pacific Fishery Management Council in 2003

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Figure 6. Coleraine output for the northern area (LCN) base model: Model fits to commercial fishery catch-at-length.

Figure 7. Coleraine output for the northern area (LCN) base model: Model fits to recreational fishery catch-at-length.

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Lingcod South (LCS): Eureka, Monterey, and Conception INPFC Areas

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Table 5. Coleraine input for the southern area (LCS) base model: Likelihood and fixed parameter specifications.

Table 6. Coleraine output for the southern area (LCS) base model: Negative log likelihood values (top), parameter estimates (outlined in bold), and fixed values used in the model (shaded).

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Table 6a. Coleraine output for the northern area (LCS) base model: Profile over historical exploitation rate (U_{init}).

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Figure 12a. Coleraine output for the southern area (LCS) base model: Vulnerable biomass, exploitation rate, stock recruitment, and spawning biomass.

Figure 12b. Coleraine output for the southern area (LCS) base model: Estimated selectivity for the commercial fishery, recreational fishery, and NMFS trawl survey.

Figure 13. Coleraine output for the southern area (LCS) base model: Model fits to indices of abundance; NMFS trawl survey and trawl logbook.

Figure 14. Coleraine output for the southern area (LCS) base model: Model fits to commercial fishery catch-at-age.

Figure 15. Coleraine output for the southern area (LCS) base model: Model fits to recreational fishery catch-at-age.

Figure 16. Coleraine output for the southern area (LCS) base model: Model fits to NMFS trawl survey catch-at-age.

Figure 17. Coleraine output for the southern area (LCS) base model: Historical analysis comparing spawning biomass estimates from the 2003 base model with spawning biomass estimates from the 2000 base model.

Table 1. Coleraine input file for the northern area (LCN) base model: Priors.

Priors

Phase	Low Bound	High Bound	Prior Type (0=uniform, 1=normal, 2=lognormal)	Mean	CV	Seed Value
R0 (Recruitment in virgin condition)						
1	0.1	1000000	0	0	0	1804.62
h (steepness of spawner-recruit curve)						
-1	0.01	5	0	0.7	1	0.9
M (natural mortality)						
-1	0.05	0.15	0	0.1	0.1	0.18
-1	0.05	0.15	0	0.1	0.1	0.32
Log init dev prior: deviates for initial age structure: uniform or normal only						
-5	-15	15	1	0	0.1	0
log rec dev prior (uniform or normal only)						
2	-15	15	1	0	0.2	0
Initial R (= # 1-yr olds in yr 1/R0; unfished = 1)						
-1	0	2	0	1	0.1	1
Initial u (exploitation rate for initial age structure; 0=unfished)						
-1	0	0.1	0	0	0.1	0.09
-1	0	0.1	0	0	0.1	0.09
Plus scale						
-1	0	2	0	0	0.6	1
-1	0	2	0	0	0.6	1
Age of full selectivity - Females						
3	1	18	0	4	0.6	4.00
3	1	18	0	4	0.6	4.00
Fishery age of full selectivity difference by sex (Delta)						
3	-5	5	0	0	0.6	0
3	-5	5	0	0	0.6	0
Fishery variance of Left side of selectivity curve (for both sexes)						
4	-15	15	0	0	0.6	-12.1568
4	-15	15	0	0	0.6	-15
Fishery variance of Right side of selectivity curve (for both sexes)						
4	-15	15	0	0	0.6	14.9999
4	-15	15	0	0	0.6	2.87946
Fishery age of full selectivity deviation by year						
-5	-15	15	1	0	0.1	0
-5	-15	15	1	0	0.1	0
Fishery variance of Left side selectivity by year						
-1	-15	15	1	0	0.1	0
-1	-15	15	1	0	0.1	0
Fishery variance of Right side selectivity by year						
-1	-15	15	1	0	0.1	0
-1	-15	15	1	0	0.1	0
Log q CPUE						
1	-15	15	0	0	0.1	-6.72892
Log q CPUE error						
-1	-5	5	0	0	0.6	0
Log q Survey						
1	-5	5	0	0	0.2	-0.276796
1	-5	6	0	0	0.2	4.80661
Survey age of full selectivity - Females						
3	1	15	0	0	0.6	4.24582
3	1	15	0	0	0.6	7.43203
Survey age of full selectivity difference by sex (Delta)						
3	-5	5	0	0	0.6	-1.09
3	-5	5	0	0	0.6	-5
Survey variance Left side selectivity						
5	-15	15	0	0	0.6	-0.219137
5	-15	15	0	0	0.6	-0.830671
Survey variance Right side selectivity						
5	-15	15	0	0	0.6	4.5791
5	-15	15	0	0	0.6	4.78909

Table 2. Coleraine input file for the northern area (LCN) base model: Likelihood and fixed parameter specifications.

Likelihoods (1= norm; 2 = lognorm; 3= robust norm; 4=robust lognorm; 12 = robust lognormal for proportions)

CPUE likelihood Type
2

Commercial catch at age likelihood type	
12	12

Commercial catch at length likelihood type	
12	12

Survey likelihood type	
2	2

Survey Index type (1=weight; 2=numbers)	
1	2

Survey vulnerability type (1=age; 2=length)	
1	1

Survey no-sex C@L likelihood type	
0	0

Survey catch at length likelihood type	
12	12

Survey catch at age likelihood type	
12	12

Fixed Parameters

Bi-scalar of length-weight relationship	
0.0018	0.0040

bii exponent of length-weight relationship	
3.3978	3.2149

L-infinity of the vonBertanlanffy growth equation	
130.1833	91.8169

k of the vonBertanlanffy growth equation	
0.1041	0.1493

t0 of the vonBertanlanffy growth equation	
-2.8497	-3.0970

Brody parameter	
0.2000	0.2000

Mean length of age 1 fish	
42.9822	41.9992

Length at oldest age	
118.1188	88.8944

S.d. of length at age of 1-year old fish	
2.7223	2.0968

S.d. of length at age of oldest fish	
9.9838	7.5582

Table 3. Coleraine output file for the northern area (LCN) base model: Negative log likelihood values (top), parameter estimates (outlined in bold), and fixed values used in the model (shaded).

B0	23952
Depletion	0.29
No. of Parameters:	**51**
Likelihoods AIC:	**-14946**
Trawl Logbook CPUE	4.7
Com Catch-At-Age	-1955.8
Rec Catch-At-Age	-1567.0
Com Catch-At-Length	-810.3
Rec Catch-At-Length	-626.4
NMFS Trawl Survey	2.9
WDFW Tag Survey	1.7
NMFS Survey Catch-At-Age	-318.1
WDFW Survey Catch-At-Age	-353.2
NMFS Survey Catch-At-Length	-318.9
WDFW Survey Catch-At-Length	-1606.4
	0
	0
Penalties: B-H Recruitment	22.6
Total Likelihood:	**-7524.2**
Parameters	
R0	1805
h	0.9
M Females	0.18
M Males	0.32
Rinit	1
Uinit Females	0.09
Uinit Males	0.09
Init Plus Grp Resid Females	1
Init Plus Grp Resid Males	1
Selectivity - Full Com	4.00
Selectivity - Full Rec	4.00
Selectivity - Left Side Com	-12.16
Selectivity - Left Side Rec	-15.00
Selectivity - Right Side Com	15.00
Selectivity - Right Side Rec	2.88
Selectivity - Full - Yr Error Com	0
Selectivity - Full - Yr Error Rec	0
Selectivity - Left - Yr Error Com	0
Selectivity - Left - Yr Error Rec	0
Selectivity - Right - Yr Error Com	0
Selectivity - Right - Yr Error Rec	0
Trawl Logbook CPUE - log(q)	-6.73
Trawl Logbook CPUE - q Yr Error	0.00
Trawl Logbook CPUE q	0.00
NMFS Trawl Survey q	-0.28
WDFW Tag Survey q	4.81
Selectivity - Full NMFS Survey	4.25
Selectivity - Full WDFW Survey	7.43
Selectivity - Left NMFS Survey	-0.22
Selectivity - Left WDFW Survey	-0.83
Selectivity - Right NMFS Survey	4.58
Selectivity - Right WDFW Survey	4.79
Log Initial Age Comp Dev	0.00
Log Rec Dev	-0.2891

Table 3a.1. Coleraine output for the northern area (LCN) base model. Standard deviation of estimated parameters under the dome shaped fishery selectivity model.

index	name	value	std dev
1	R0	1.8046e+003	5.6175e+001
2	log_RecDev	-2.8907e-001	1.7899e-001
3	log_RecDev	-3.1635e-001	1.9415e-001
4	log_RecDev	-1.3456e-001	1.7700e-001
5	log_RecDev	-2.0427e-001	1.9747e-001
6	log_RecDev	-2.2905e-001	1.9279e-001
7	log_RecDev	-1.5507e-001	1.8728e-001
8	log_RecDev	-1.4527e-001	1.8877e-001
9	log_RecDev	4.2838e-001	1.6512e-001
10	log_RecDev	-8.9725e-002	1.7300e-001
11	log_RecDev	3.5796e-002	1.9356e-001
12	log_RecDev	-3.8628e-001	1.5556e-001
13	log_RecDev	-8.7539e-002	1.6889e-001
14	log_RecDev	-5.6214e-002	1.8895e-001
15	log_RecDev	7.6997e-001	8.4586e-002
16	log_RecDev	-1.9187e-001	1.4136e-001
17	log_RecDev	-4.5506e-001	1.5797e-001
18	log_RecDev	-2.1885e-001	1.2306e-001
19	log_RecDev	1.2543e-002	1.1650e-001
20	log_RecDev	6.7353e-002	1.0712e-001
21	log_RecDev	4.3182e-002	1.1598e-001
22	log_RecDev	-2.0990e-001	1.6596e-001
23	log_RecDev	7.1103e-002	1.3459e-001
24	log_RecDev	2.8221e-001	1.4720e-001
25	log_RecDev	1.6941e-001	1.5865e-001
26	log_RecDev	-6.2276e-002	1.6827e-001
27	log_RecDev	3.9475e-002	1.7187e-001
28	log_RecDev	2.3747e-001	1.8825e-001
29	log_RecDev	8.4688e-002	2.1109e-001
30	log_RecDev	2.8128e-003	2.0038e-001
31	log_RecDev	0.0000e+000	2.0000e-001
32	log_RecDev	0.0000e+000	2.0000e-001
33	Sfullest	4.0000e+000	2.0585e-003
34	Sfullest	4.0008e+000	6.0985e-005
35	Sfulldelta	2.2791e-003	3.6505e-001
36	Sfulldelta	-7.5684e-004	1.2916e-004
37	log_varLest	-1.2369e+001	3.2042e+002
38	log_varLest	-1.5000e+001	4.3806e-002
39	log_varRest	1.5000e+001	3.8942e-001
40	log_varRest	2.8795e+000	4.8134e-001
41	log_qCPUE	-6.7289e+000	5.2017e-002
42	log_qsurvey	-2.7680e-001	1.5135e-001
43	log_qsurvey	4.8066e+000	7.6105e-002
44	surveySfullest	4.2458e+000	4.2222e-001
45	surveySfullest	7.4320e+000	1.4611e-001
46	surveySfulldeltaest	-1.0930e+000	2.2191e-001
47	surveySfulldeltaest	-5.0000e+000	1.2529e-005
48	log_surveyvarL	-2.1914e-001	6.3816e-001
49	log_surveyvarL	-8.3067e-001	2.8254e-001
50	log_surveyvarR	4.5791e+000	1.3811e+000
51	log_surveyvarR	4.7891e+000	1.2618e+000
52	Ro_mcmc	1.8046e+003	5.6175e+001

Table 3a. Coleraine output for the northern area (LCN) base model: Profile over historical exploitation rate (U_{init}); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold. Note: Runs 4 and 5 did not fully converge.

B0		26853	27556	28072	28079	29503
Depletion		0.16	0.15	0.14	0.13	0.12
		RUN1	**RUN2**	**RUN3**	**RUN4**	**RUN5**
Input File		nu1out.txt	nu2out.txt	nu3out.txt	nu4out.txt	nu5out.txt
No. of Parameters:		47	47	47	47	47
Likelihoods	**AIC:**	**-14888**	**-14886**	**-14884**	**-14919**	**-14886**
Trawl Logbook CPUE		4.2	4.3	4.3	4.2	4.4
Com Catch-At-Age		-1950.1	-1951.4	-1953.6	-1962.6	-1961.4
Rec Catch-At-Age		-1566.1	-1565.5	-1564.5	-1566.3	-1565.7
Com Catch-At-Length		-809.5	-808.9	-808.7	-810.3	-808.0
Rec Catch-At-Length		-630.2	-630.4	-630.6	-629.5	-630.2
NMFS Trawl Survey		5.7	6.0	6.4	8.6	6.7
WDFW Tag Survey		5.3	5.5	5.7	5.1	5.6
NMFS Survey Catch-At-Age		-315.5	-315.4	-315.2	-349.1	-314.7
WDFW Survey Catch-At-Age		-339.2	-339.1	-339.0	-337.9	-338.7
NMFS Survey Catch-At-Length		-316.0	-316.5	-317.1	-303.4	-318.3
WDFW Survey Catch-At-Length		-1606.5	-1606.5	-1606.4	-1600.1	-1604.5
		0	0	0	0	0
		0	0	0	0	0
Penalties: B-H Recruitment		26.9	28.0	30.0	34.9	34.9
Total Likelihood:		**-7490.9**	**-7489.8**	**-7488.8**	**-7506.4**	**-7489.8**
Parameters						
R0		2023	2076	2115	2116	2223
h		0.7	0.7	0.7	0.7	0.7
M Females		0.18	0.18	0.18	0.18	0.18
M Males		0.32	0.32	0.32	0.32	0.32
Rinit		1	1	1	1	1
Uinit Females		**0.03**	**0.06**	**0.09**	**0.12**	**0.15**
Uinit Males		**0.03**	**0.06**	**0.09**	**0.12**	**0.15**
Init Plus Grp Resid Females		1	1	1	1	1
Init Plus Grp Resid Males		1	1	1	1	1
Selectivity - Full Com		4.00	4.00	4.00	3.94	3.99
Selectivity - Full Rec		4.00	4.00	4.00	4.00	4.00
Selectivity - Left Side Com		-15.00	-15.00	-15.00	-6.28	-5.54
Selectivity - Left Side Rec		-15.00	-15.00	-15.00	-15.00	-15.00
Selectivity - Right Side Com		4.76	4.89	5.15	15.00	15.00
Selectivity - Right Side Rec		2.65	2.61	2.55	2.53	2.55
Selectivity - Full - Yr Error Com		0	0	0	0	0
Selectivity - Full - Yr Error Rec		0	0	0	0	0
Selectivity - Left - Yr Error Com		0	0	0	0	0
Selectivity - Left - Yr Error Rec		0	0	0	0	0
Selectivity - Right - Yr Error Com		0	0	0	0	0
Selectivity - Right - Yr Error Rec		0	0	0	0	0
Trawl Logbook CPUE - log(q)		-6.71	-6.71	-6.72	-6.80	-6.79
Trawl Logbook CPUE - q Yr Error		0.00	0.00	0.00	0.00	0.00
Trawl Logbook CPUE q		0.00	0.00	0.00	0.00	0.00
NMFS Trawl Survey q		-0.12	-0.11	-0.10	-0.27	-0.09
WDFW Tag Survey q		5.00	5.00	5.00	5.00	5.00
Selectivity - Full NMFS Survey		5.17	5.18	5.20	2.88	5.22
Selectivity - Full WDFW Survey		8.87	8.87	8.88	8.91	8.90
Selectivity - Left NMFS Survey		1.00	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey		1.00	1.00	1.00	1.00	1.00
Selectivity - Right NMFS Survey		4.00	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey		3.00	3.00	3.00	3.00	3.00
Log Initial Age Comp Dev		0.00	0.00	0.00	0.00	0.00
Log Rec Dev		-0.3164	-0.3173	-0.3136	-0.3398	-0.3502

Table 3b. Coleraine output for the northern area (LCN) base model: Profile over natural mortality rate (M); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold. Note: Runs 4 and 5 did not fully converge.

B0	37513	32531	28072	24706	23597
Depletion	0.11	0.12	0.14	0.16	0.20
	RUN1	**RUN2**	**RUN3**	**RUN4**	**RUN5**
Input File	nm1out.txt	nm2out.txt	nm3out.txt	nm4out.txt	nm5out.txt
No. of Parameters:	47	47	47	47	47
Likelihoods AIC:	**-14827**	**-14882**	**-14884**	**-14937**	**-14947**
Trawl Logbook CPUE	4.5	4.4	4.3	4.1	4.3
Com Catch-At-Age	-1955.0	-1947.6	-1953.6	-1968.2	-1975.4
Rec Catch-At-Age	-1558.7	-1564.5	-1564.5	-1563.5	-1563.4
Com Catch-At-Length	-799.4	-808.5	-808.7	-813.4	-814.2
Rec Catch-At-Length	-631.4	-630.4	-630.6	-629.0	-628.0
NMFS Trawl Survey	6.5	9.1	6.4	7.0	4.9
WDFW Tag Survey	12.3	5.9	5.7	5.5	5.3
NMFS Survey Catch-At-Age	-315.6	-361.7	-315.2	-307.7	-318.4
WDFW Survey Catch-At-Age	-348.6	-339.5	-339.0	-338.7	-339.2
NMFS Survey Catch-At-Length	-317.3	-278.9	-317.1	-335.3	-316.4
WDFW Survey Catch-At-Length	-1588.9	-1606.1	-1606.4	-1606.6	-1607.3
	0	0	0	0	0
	0	0	0	0	0
Penalties: B-H Recruitment	31.1	30.0	30.0	30.5	27.5
Total Likelihood:	**-7460.5**	**-7487.8**	**-7488.8**	**-7515.4**	**-7520.3**
Parameters					
R0	1692	1917	2115	2338	2762
h	0.7	0.7	0.7	0.7	0.7
M Females	**0.14**	**0.16**	**0.18**	**0.2**	**0.22**
M Males	**0.28**	**0.3**	**0.32**	**0.35**	**0.38**
Rinit	1	1	1	1	1
Uinit Females	0.09	0.09	0.09	0.09	0.09
Uinit Males	0.09	0.09	0.09	0.09	0.09
Init Plus Grp Resid Females	1	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1	1
Selectivity - Full Com	4.00	4.00	4.00	3.94	3.94
Selectivity - Full Rec	4.00	4.00	4.00	4.00	4.00
Selectivity - Left Side Com	-15.00	-15.00	-15.00	-5.58	-6.17
Selectivity - Left Side Rec	-15.00	-15.00	-15.00	-15.00	-15.00
Selectivity - Right Side Com	4.51	4.62	5.15	15.00	15.00
Selectivity - Right Side Rec	2.37	2.49	2.55	2.51	2.55
Selectivity - Full - Yr Error Com	0	0	0	0	0
Selectivity - Full - Yr Error Rec	0	0	0	0	0
Selectivity - Left - Yr Error Com	0	0	0	0	0
Selectivity - Left - Yr Error Rec	0	0	0	0	0
Selectivity - Right - Yr Error Com	0	0	0	0	0
Selectivity - Right - Yr Error Rec	0	0	0	0	0
Trawl Logbook CPUE - log(q)	-6.66	-6.66	-6.72	-6.79	-6.81
Trawl Logbook CPUE - q Yr Error	0.00	0.00	0.00	0.00	0.00
Trawl Logbook CPUE q	0.00	0.00	0.00	0.00	0.00
NMFS Trawl Survey q	0.06	-0.35	-0.10	0.14	-0.16
WDFW Tag Survey q	5.00	5.00	5.00	5.00	5.00
Selectivity - Full NMFS Survey	5.30	3.49	5.20	5.31	5.24
Selectivity - Full WDFW Survey	8.68	8.87	8.88	8.97	8.97
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey	3.00	3.00	3.00	3.00	3.00
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00	0.00
Log Rec Dev	-0.3619	-0.3151	-0.3136	-0.3685	-0.3849

Table 3c. Coleraine output for the northern area (LCN) base model: Profile over B-H spawner-recruit steepness (*h*); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold. Note: Run 5 did not fully converge.

B0	35141	31331	28072	25212	23977
Depletion	0.07	0.11	0.14	0.20	0.28
	RUN1	**RUN2**	**RUN3**	**RUN4**	**RUN5**
Input File	nh1out.txt	nh2out.txt	nh3out.txt	nh4out.txt	nh5out.txt
No. of Parameters:	47	47	47	47	47
Likelihoods AIC:	**-14783**	**-14856**	**-14884**	**-14917**	**-14931**
Trawl Logbook CPUE	4.4	4.4	4.3	4.4	5.0
Com Catch-At-Age	-1954.7	-1949.5	-1953.6	-1959.6	-1959.0
Rec Catch-At-Age	-1558.9	-1562.7	-1564.5	-1566.4	-1566.5
Com Catch-At-Length	-795.5	-806.7	-808.7	-810.6	-809.9
Rec Catch-At-Length	-632.0	-631.8	-630.6	-628.8	-628.1
NMFS Trawl Survey	12.8	8.5	6.4	4.3	3.2
WDFW Tag Survey	9.7	5.5	5.7	5.5	5.2
NMFS Survey Catch-At-Age	-315.3	-314.2	-315.2	-316.4	-317.2
WDFW Survey Catch-At-Age	-345.6	-339.2	-339.0	-339.7	-342.0
NMFS Survey Catch-At-Length	-317.6	-316.7	-317.1	-317.3	-316.6
WDFW Survey Catch-At-Length	-1589.8	-1606.0	-1606.4	-1607.0	-1608.8
	0	0	0	0	0
	0	0	0	0	0
Penalties: B-H Recruitment	43.9	33.4	30.0	26.0	22.0
Total Likelihood:	**-7438.6**	**-7474.9**	**-7488.8**	**-7505.6**	**-7512.6**
Parameters					
R0	2648	2361	2115	1900	1807
h	**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
M Females	0.18	0.18	0.18	0.18	0.18
M Males	0.32	0.32	0.32	0.32	0.32
Rinit	1	1	1	1	1
Uinit Females	0.09	0.09	0.09	0.09	0.09
Uinit Males	0.09	0.09	0.09	0.09	0.09
Init Plus Grp Resid Females	1	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1	1
Selectivity - Full Com	4.00	4.00	4.00	3.95	3.87
Selectivity - Full Rec	4.00	4.00	4.00	4.00	4.00
Selectivity - Left Side Com	-15.00	-15.00	-15.00	-2.83	-4.95
Selectivity - Left Side Rec	-15.00	-15.00	-15.00	-15.00	-15.00
Selectivity - Right Side Com	4.34	4.55	5.15	15.00	15.00
Selectivity - Right Side Rec	2.32	2.43	2.55	2.69	2.81
Selectivity - Full - Yr Error Com	0	0	0	0	0
Selectivity - Full - Yr Error Rec	0	0	0	0	0
Selectivity - Left - Yr Error Com	0	0	0	0	0
Selectivity - Left - Yr Error Rec	0	0	0	0	0
Selectivity - Right - Yr Error Com	0	0	0	0	0
Selectivity - Right - Yr Error Rec	0	0	0	0	0
Trawl Logbook CPUE - log(q)	-6.72	-6.68	-6.72	-6.78	-6.74
Trawl Logbook CPUE - q Yr Error	0.00	0.00	0.00	0.00	0.00
Trawl Logbook CPUE q	0.00	0.00	0.00	0.00	0.00
NMFS Trawl Survey q	0.01	-0.12	-0.10	-0.11	-0.15
WDFW Tag Survey q	5.00	5.00	5.00	5.00	5.00
Selectivity - Full NMFS Survey	5.31	5.19	5.20	5.19	5.17
Selectivity - Full WDFW Survey	8.80	8.86	8.88	8.89	8.88
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey	1.00	1.00	1.00	1.00	1.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey	3.00	3.00	3.00	3.00	3.00
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00	0.00
Log Rec Dev	-0.4229	-0.3194	-0.3136	-0.3104	-0.2775

Table 3d. Coleraine output for the northern area (LCN) base model: Profile over combinations of natural mortality rate (M) and B-H spawner-recruit steepness (*h*); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold.

B0	45025	21087	29030	30300
Depletion	0.08	0.38	0.10	0.20
	RUN9	**RUN10**	**RUN11**	**RUN12**
Input File	nhlml.txt	nhhmh.txt	nhlmh.txt	nhhml.txt
No. of Parameters:				
Likelihoods AIC:				
Trawl Logbook CPUE	4.2	5.7	3.9	4.4
Com Catch-At-Age	-1943.1	-1968.2	-1969.1	-1930.2
Rec Catch-At-Age	-1564.9	-1563.6	-1563.0	-1569.8
Com Catch-At-Length	-793.8	-812.6	-809.8	-804.7
Rec Catch-At-Length	-628.9	-625.3	-629.1	-628.2
NMFS Trawl Survey	6.9	3.8	10.3	3.9
WDFW Tag Survey	2.4	1.9	4.3	1.4
NMFS Survey Catch-At-Age	-309.3	-338.9	-320.5	-334.5
WDFW Survey Catch-At-Age	-358.9	-353.8	-341.7	-353.4
NMFS Survey Catch-At-Length	-329.9	-316.0	-316.7	-316.0
WDFW Survey Catch-At-Length	-1581.4	-1607.6	-1598.0	-1603.5
	0	0	0	0
	0	0	0	0
Penalties: B-H Recruitment	37.9	22.4	41.5	22.9
Total Likelihood:	**-7458.8**	**-7552.0**	**-7487.9**	**-7507.7**
Parameters				
R0	2031	2469	3398	1367
h	**0.5**	**0.9**	**0.5**	**0.9**
M Females	**0.14**	**0.22**	**0.22**	**0.14**
M Males	**0.26**	**0.38**	**0.38**	**0.26**
Rinit	1	1	1	1
Uinit Females	0.09	0.09	0.09	0.09
Uinit Males	0.09	0.09	0.09	0.09
Init Plus Grp Resid Females	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1
Selectivity - Full Com	4.00	4.00	4.00	4.00
Selectivity - Full Rec	4.00	4.00	4.00	4.00
Selectivity - Left Side Com	-15.00	-6.82	-15.00	-15.00
Selectivity - Left Side Rec	-15.00	-15.00	-15.00	-15.00
Selectivity - Right Side Com	4.14	15.00	4.75	5.11
Selectivity - Right Side Rec	2.64	2.81	2.35	3.09
Selectivity - Full - Yr Error Com	0	0	0	0
Selectivity - Full - Yr Error Rec	0	0	0	0
Selectivity - Left - Yr Error Com	0	0	0	0
Selectivity - Left - Yr Error Rec	0	0	0	0
Selectivity - Right - Yr Error Com	0	0	0	0
Selectivity - Right - Yr Error Rec	0	0	0	0
Trawl Logbook CPUE - log(q)	-6.66	-6.74	-6.79	-6.66
Trawl Logbook CPUE - q Yr Error	0.00	0.00	0.00	0.00
Trawl Logbook CPUE q	0.00	0.00	0.00	0.00
NMFS Trawl Survey q	0.60	-0.51	-0.22	-0.28
WDFW Tag Survey q	5.00	4.75	5.00	4.91
Selectivity - Full NMFS Survey	4.00	2.79	4.44	2.42
Selectivity - Full WDFW Survey	7.49	7.45	8.54	7.40
Selectivity - Left NMFS Survey	-15.00	0.01	-0.04	-0.45
Selectivity - Left WDFW Survey	-0.73	-0.82	0.58	-0.86
Selectivity - Right NMFS Survey	2.43	14.98	3.76	4.95
Selectivity - Right WDFW Survey	3.15	6.80	2.81	3.53
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00
Log Rec Dev	-0.3847	-0.3245	-0.3913	-0.2312

Table 3e. Coleraine output for the northern area (LCN) base model: Profile over combinations of domed and asymptotic fishery selectivity; Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold.

B0	27761	24824	26807	25713
Depletion	0.13	0.11	0.11	0.13
	RUN3	**RUN4**	**RUN5**	**RUN6**
Input File	ndcdsin.txt	nacasin.txt	ndcasin.txt	nacdsin.txt
No. of Parameters:	51	49	50	50
Likelihoods AIC:	**-14879**	**-14857**	**-14796**	**-14877**
Trawl Logbook CPUE	4.6	6.1	5.8	5.7
Com Catch-At-Age	-1954.6	-1954.6	-1953.7	-1963.9
Rec Catch-At-Age	-1563.7	-1566.6	-1537.4	-1547.8
Com Catch-At-Length	-808.9	-813.0	-810.3	-811.4
Rec Catch-At-Length	-630.3	-617.3	-623.5	-638.3
NMFS Trawl Survey	4.4	6.7	5.6	4.9
WDFW Tag Survey	5.6	6.4	5.1	6.6
NMFS Survey Catch-At-Age	-328.3	-313.1	-314.6	-315.3
WDFW Survey Catch-At-Age	-338.9	-340.2	-337.6	-340.1
NMFS Survey Catch-At-Length	-304.5	-319.7	-317.4	-318.7
WDFW Survey Catch-At-Length	-1608.3	-1606.7	-1606.8	-1605.6
	0	0	0	0
	0	0	0	0
Penalties: B-H Recruitment	32.1	34.3	36.5	35.6
Total Likelihood:	**-7490.7**	**-7477.7**	**-7448.2**	**-7488.3**
Parameters				
R0	2092	1870	2020	1937
h	0.7	0.7	0.7	0.7
M Females	0.18	0.18	0.18	0.18
M Males	0.32	0.32	0.32	0.32
Rinit	1	1	1	1
Uinit Females	0.09	0.09	0.09	0.09
Uinit Males	0.09	0.09	0.09	0.09
Init Plus Grp Resid Females	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1
Selectivity - Full Com	4.00	4.00	4.00	4.00
Selectivity - Full Rec	4.00	4.00	3.70	4.00
Selectivity - Left Side Com	-15.00	-11.68	-9.82	-11.21
Selectivity - Left Side Rec	-15.00	-14.47	-14.47	-15.00
Selectivity - Right Side Com	**5.28**	**15.00**	**5.81**	**15.00**
Selectivity - Right Side Rec	**2.51**	**15.00**	**15.00**	**1.64**
Selectivity - Full - Yr Error Com	0	0	0	0
Selectivity - Full - Yr Error Rec	0	0	0	0
Selectivity - Left - Yr Error Com	0	0	0	0
Selectivity - Left - Yr Error Rec	0	0	0	0
Selectivity - Right - Yr Error Com	0	0	0	0
Selectivity - Right - Yr Error Rec	0	0	0	0
Trawl Logbook CPUE - log(q)	-6.72	-6.72	-6.76	-6.75
Trawl Logbook CPUE - q Yr Error	0.00	0.00	0.00	0.00
Trawl Logbook CPUE q	0.00	0.00	0.00	0.00
NMFS Trawl Survey q	-0.20	-0.04	-0.10	-0.07
WDFW Tag Survey q	5.00	5.00	5.00	5.00
Selectivity - Full NMFS Survey	5.01	5.28	5.16	5.22
Selectivity - Full WDFW Survey	8.84	8.91	8.80	8.87
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey	1.00	1.00	1.00	1.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey	3.00	3.00	3.00	3.00
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00
Log Rec Dev	-0.3050	-0.3909	-0.3151	-0.2782

Figure 1. Coleraine output for the northern area (LCN) base model: Vulnerable biomass, exploitation rate, stock recruitment, and spawning biomass.

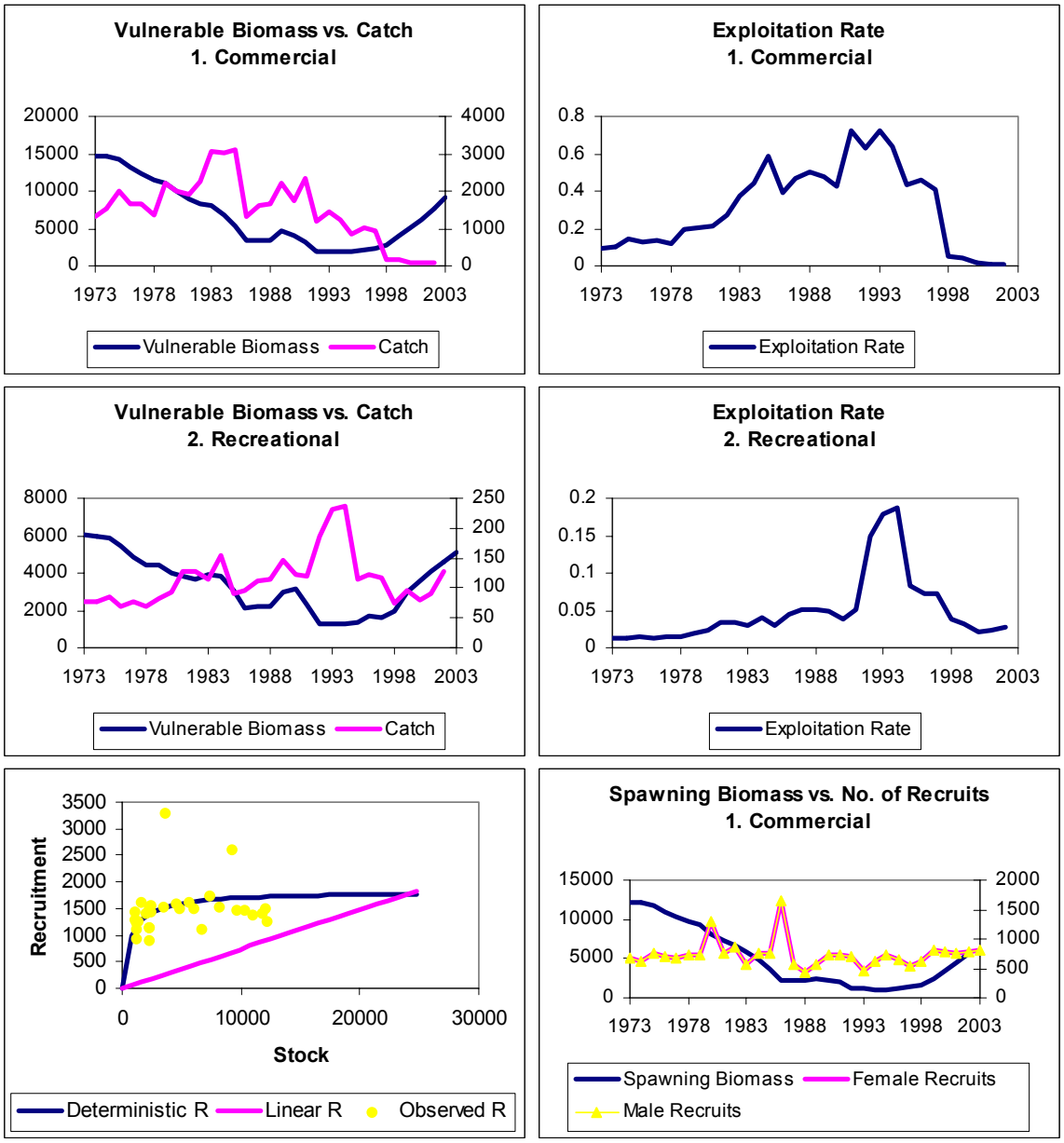


Figure 2. Coleraine output for the northern area (LCN) base model: Estimated selectivity for the commercial fishery, recreational fishery, NMFS trawl survey, and WDFW tagging survey.

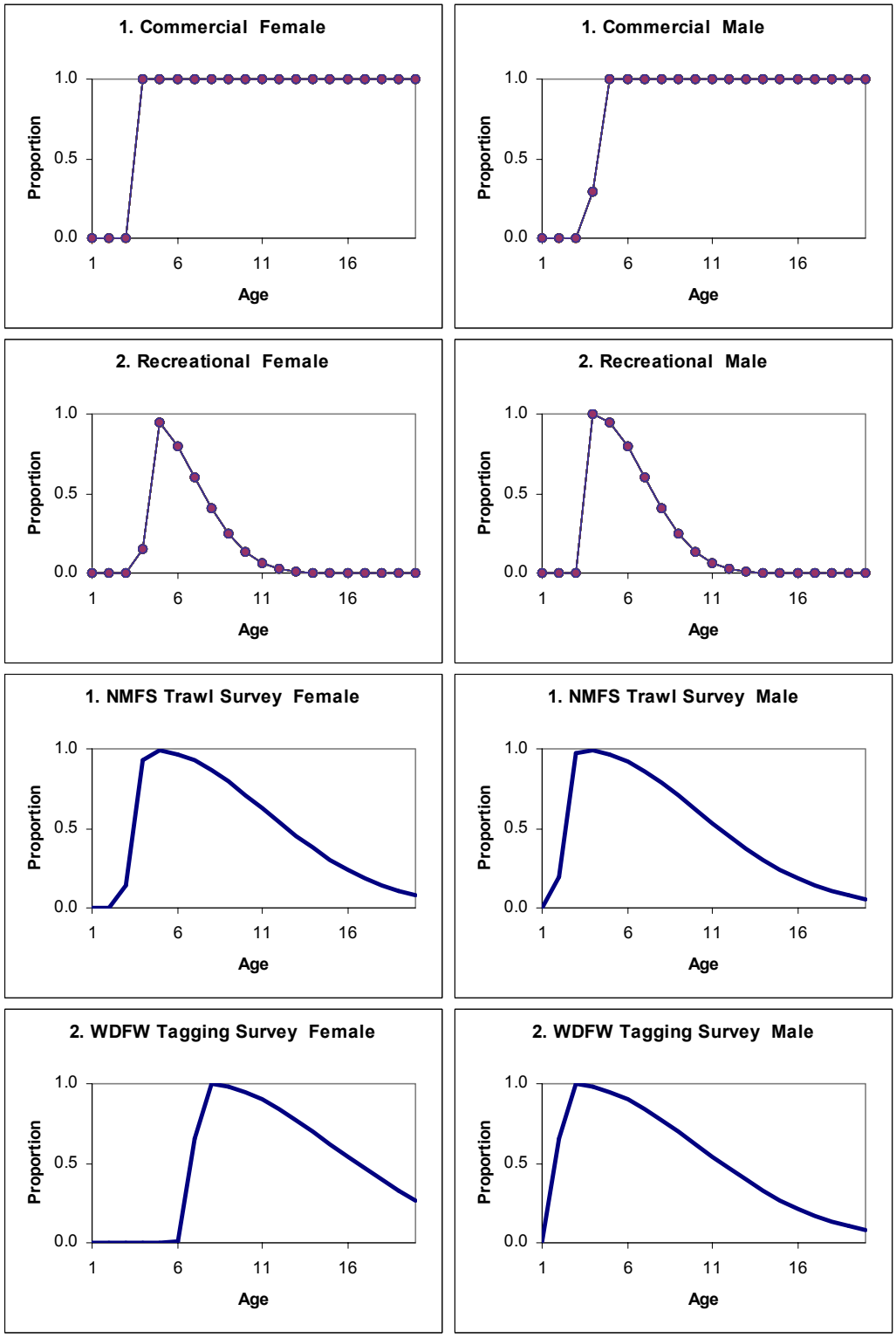


Figure 3. Coleraine output for the northern area (LCN) base model: Model fits to indices of abundance; NMFS trawl survey, WDFW tagging survey, and trawl logbook.

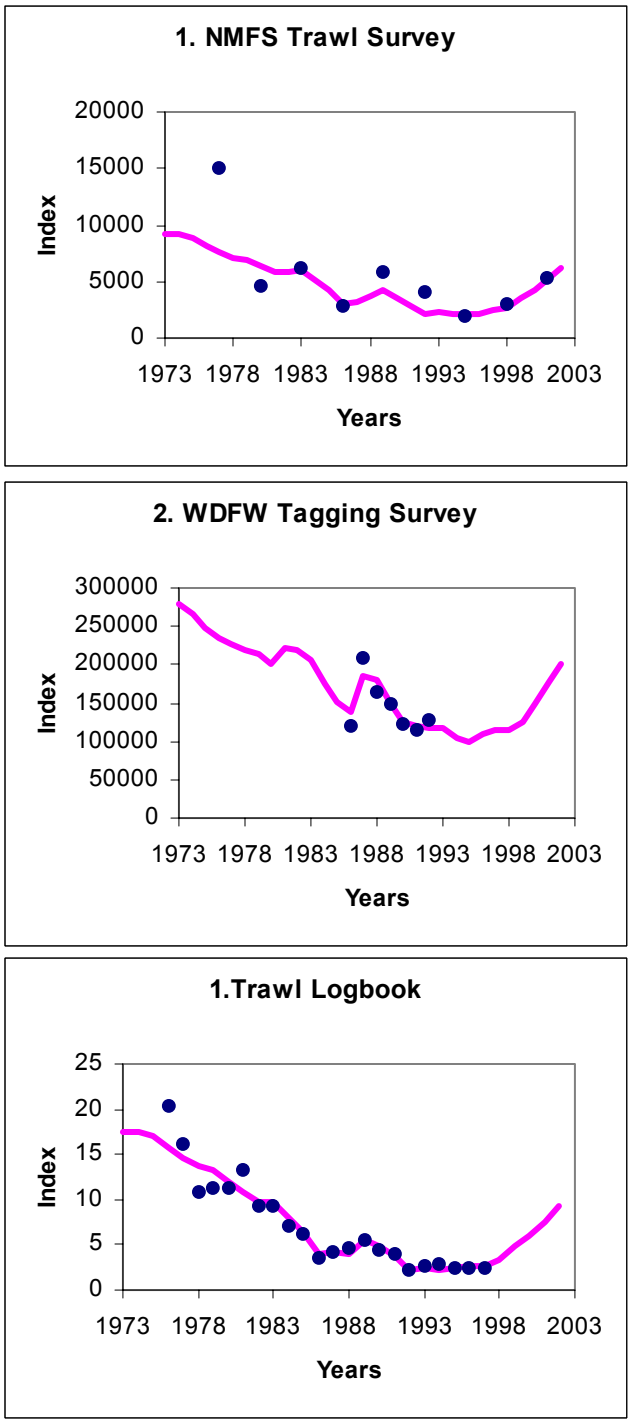


Figure 4. Coleraine output for the northern area (LCN) base model: Model fits to commercial fishery catch-at-age.

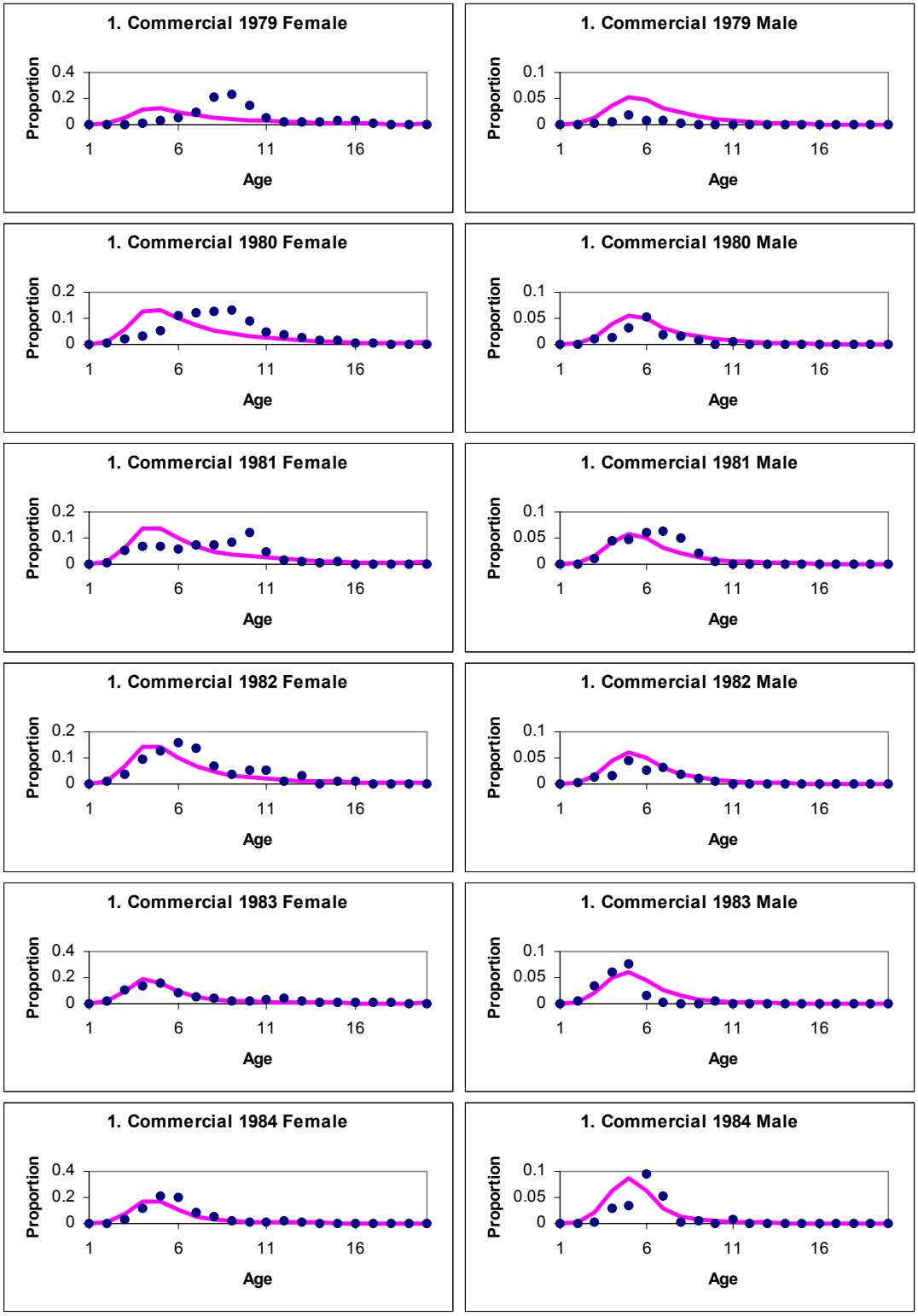


Figure 4, continued. Coleraine output for the northern area (LCN) base model: Model fits to commercial fishery catch-at-age.

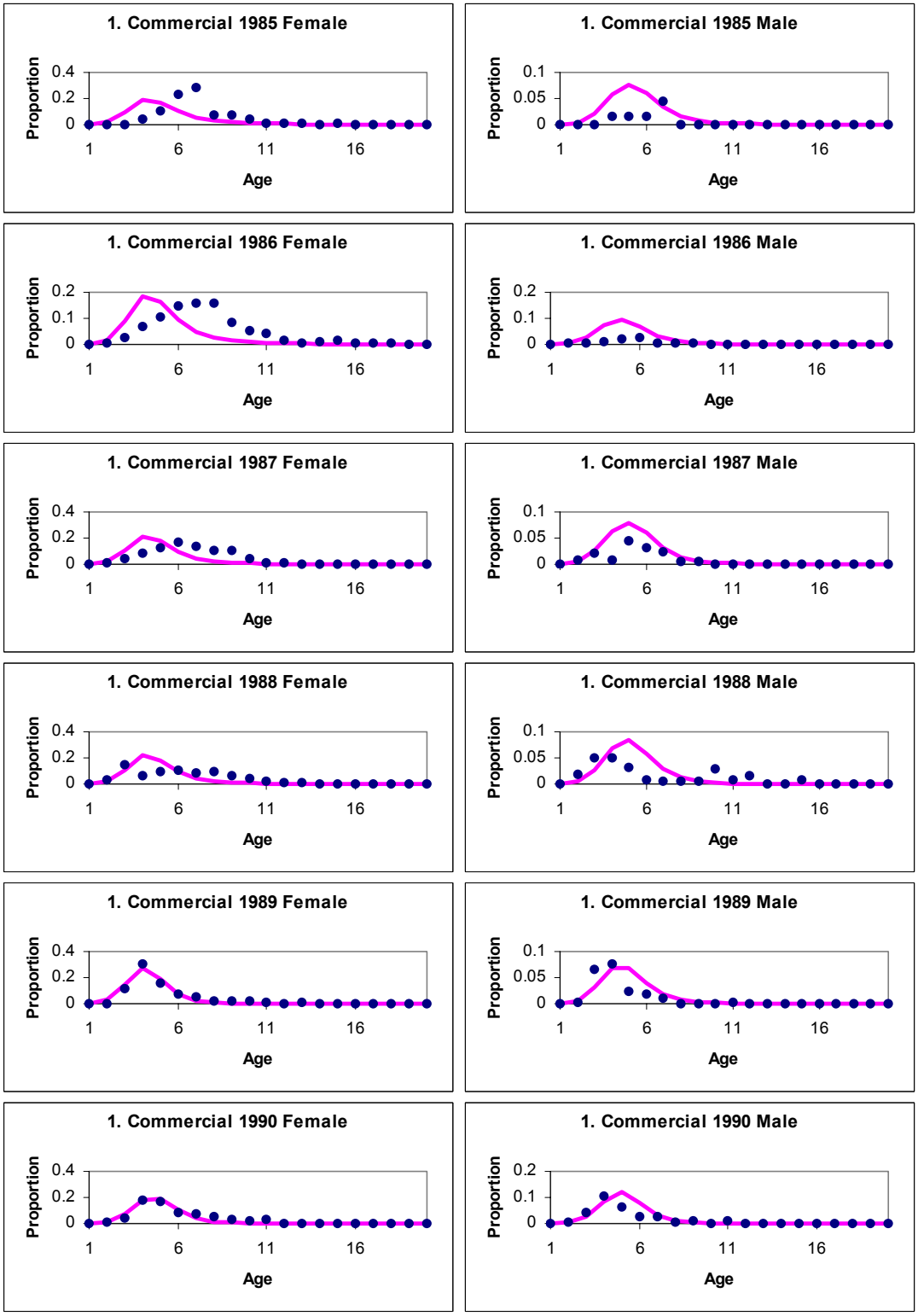


Figure 4, continued. Coleraine output for the northern area (LCN) base model: Model fits to commercial fishery catch-at-age.

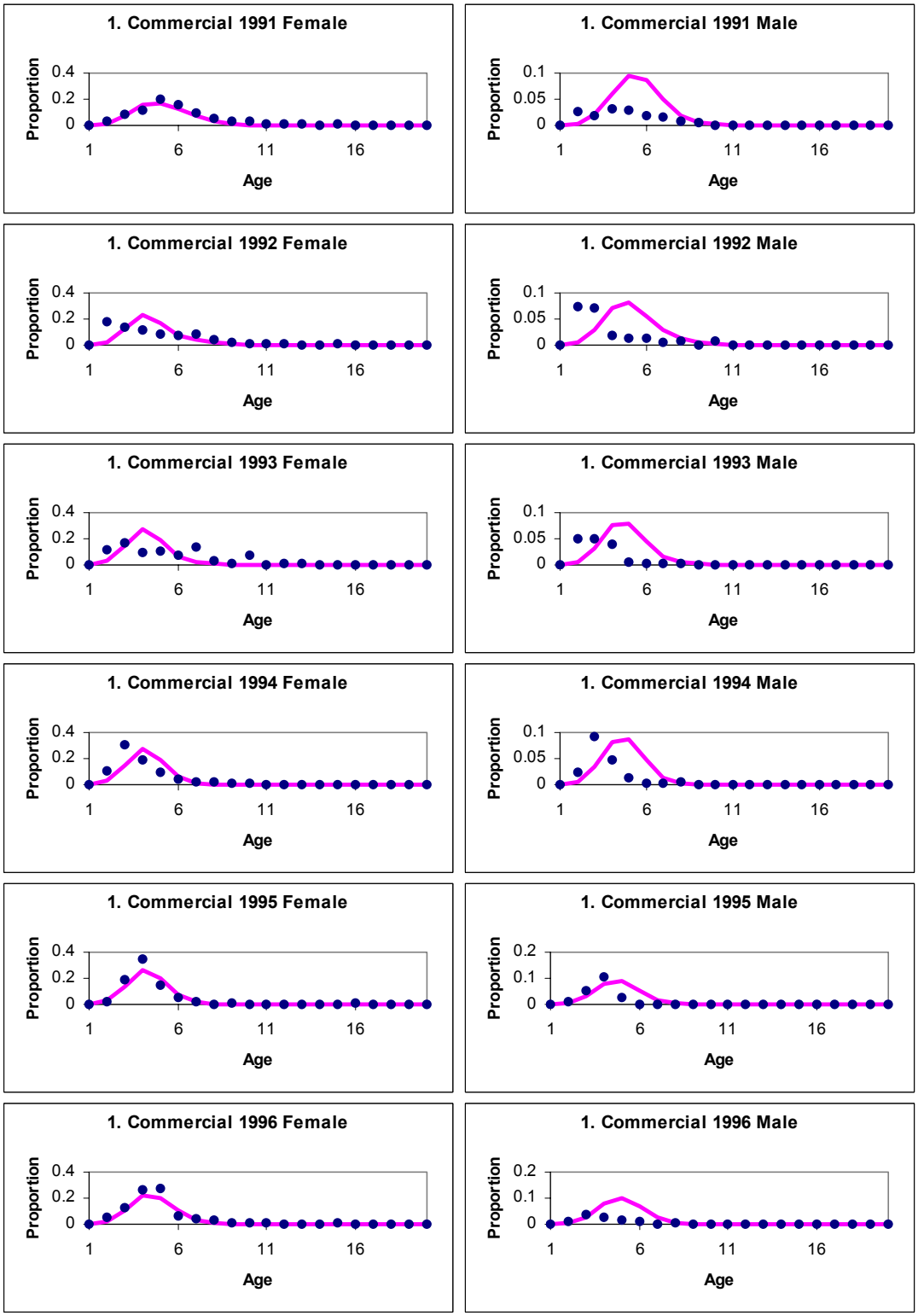


Figure 4, continued. Coleraine output for the northern area (LCN) base model: Model fits to commercial fishery catch-at-age.

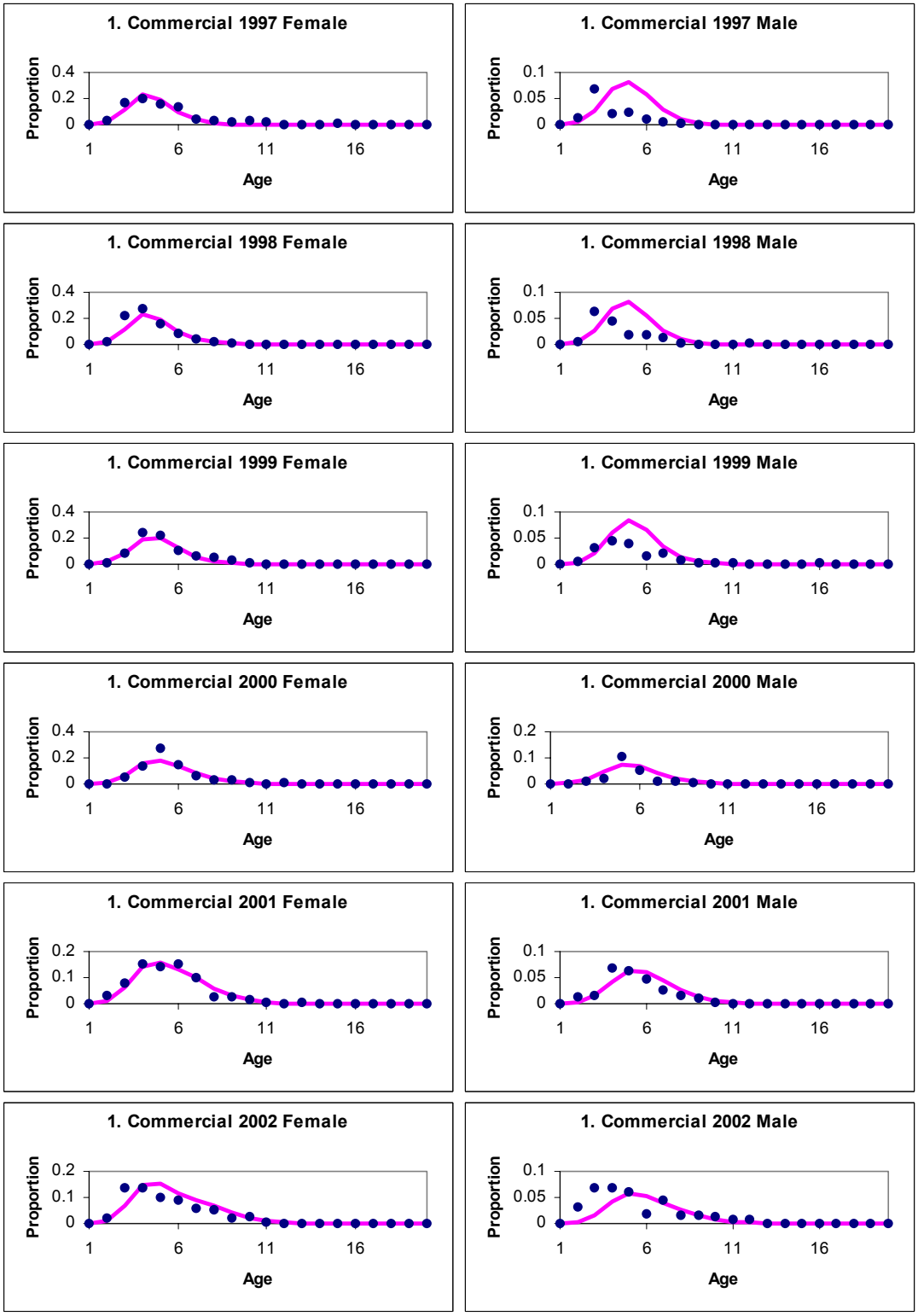


Figure 5. Coleraine output for the northern area (LCN) base model: Model fits to recreational fishery catch-at-age.

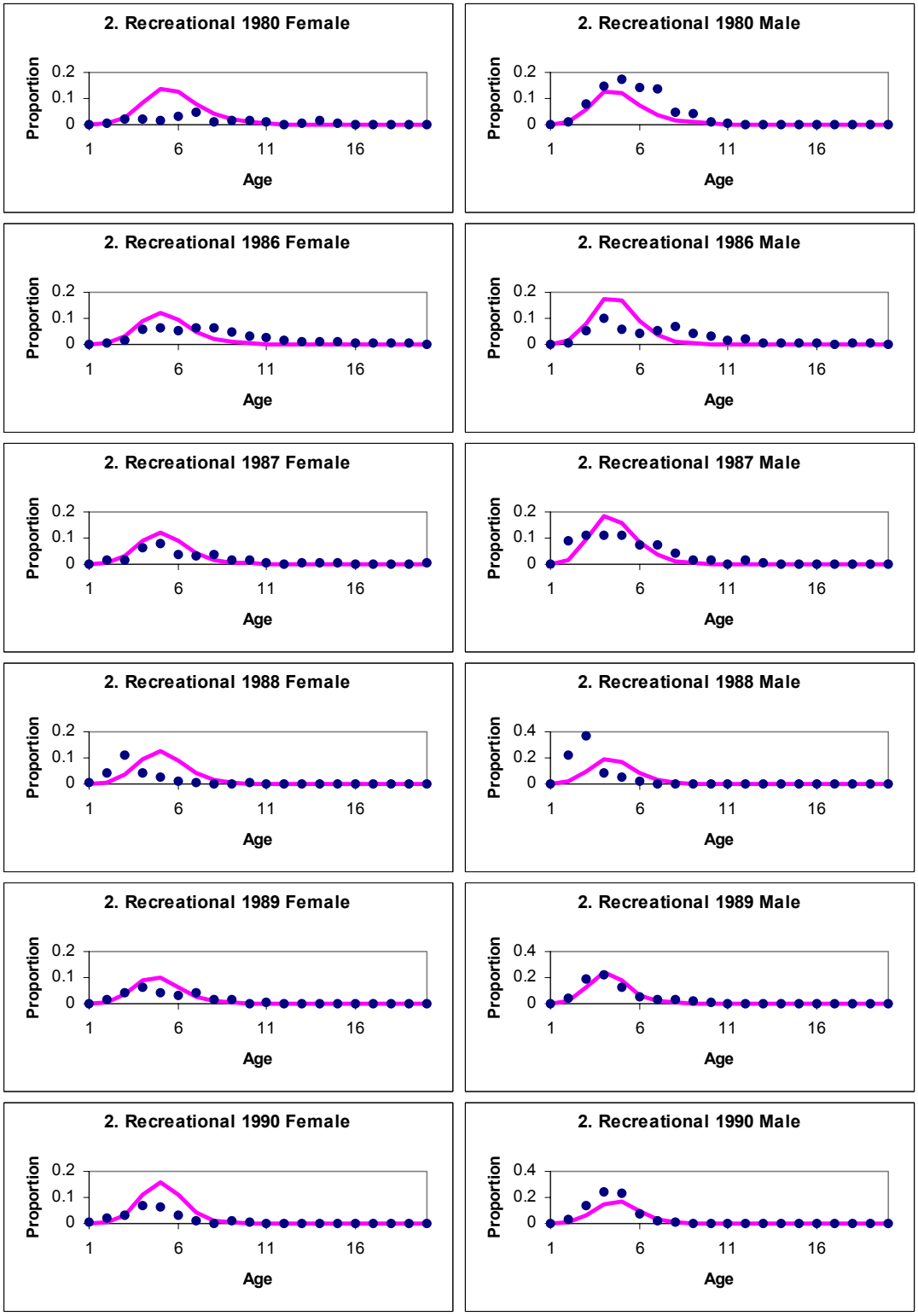


Figure 5, continued. Coleraine output for the northern area (LCN) base model: Model fits to recreational fishery catch-at-age.

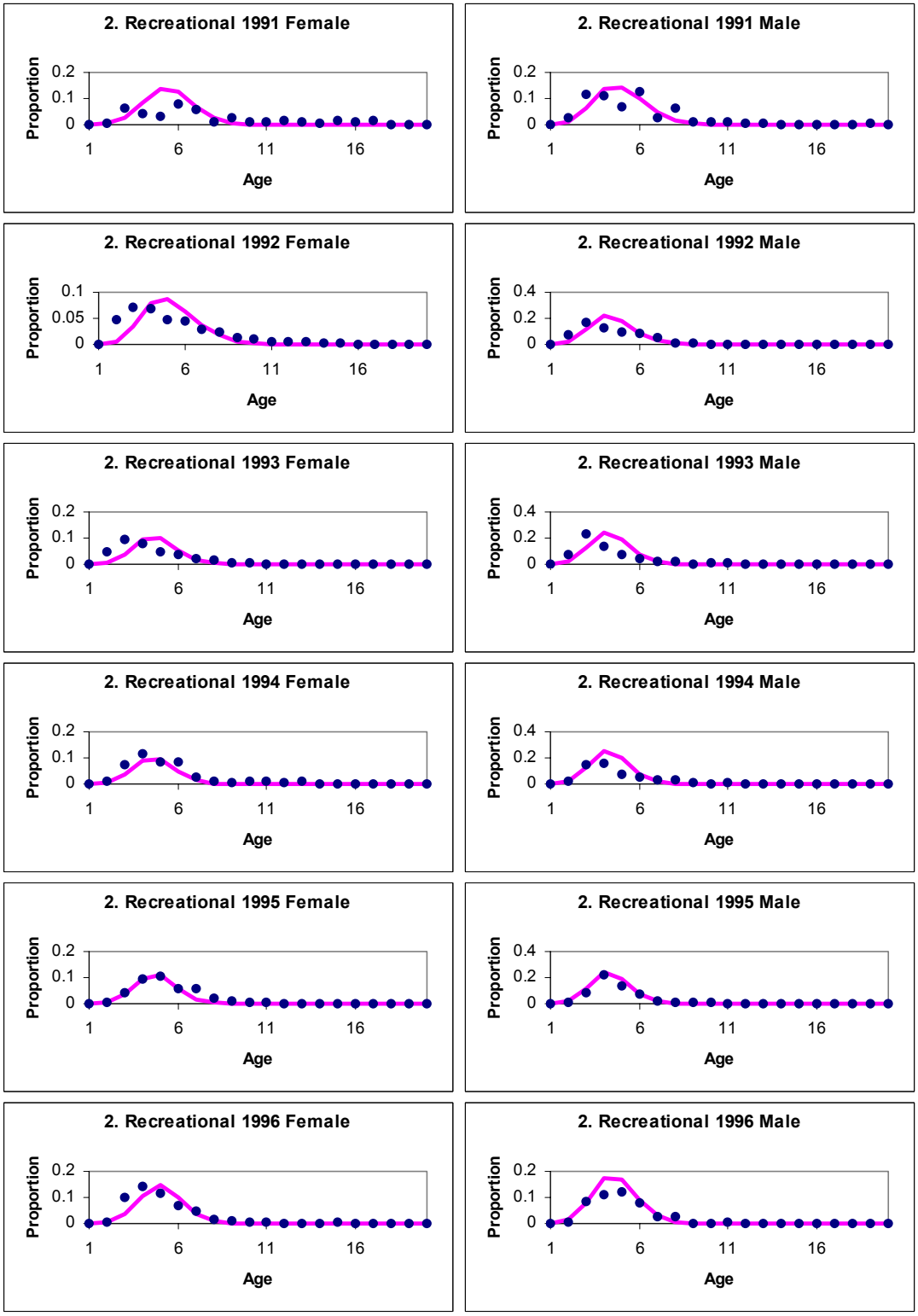


Figure 5, continued. Coleraine output for the northern area (LCN) base model: Model fits to recreational fishery catch-at-age.

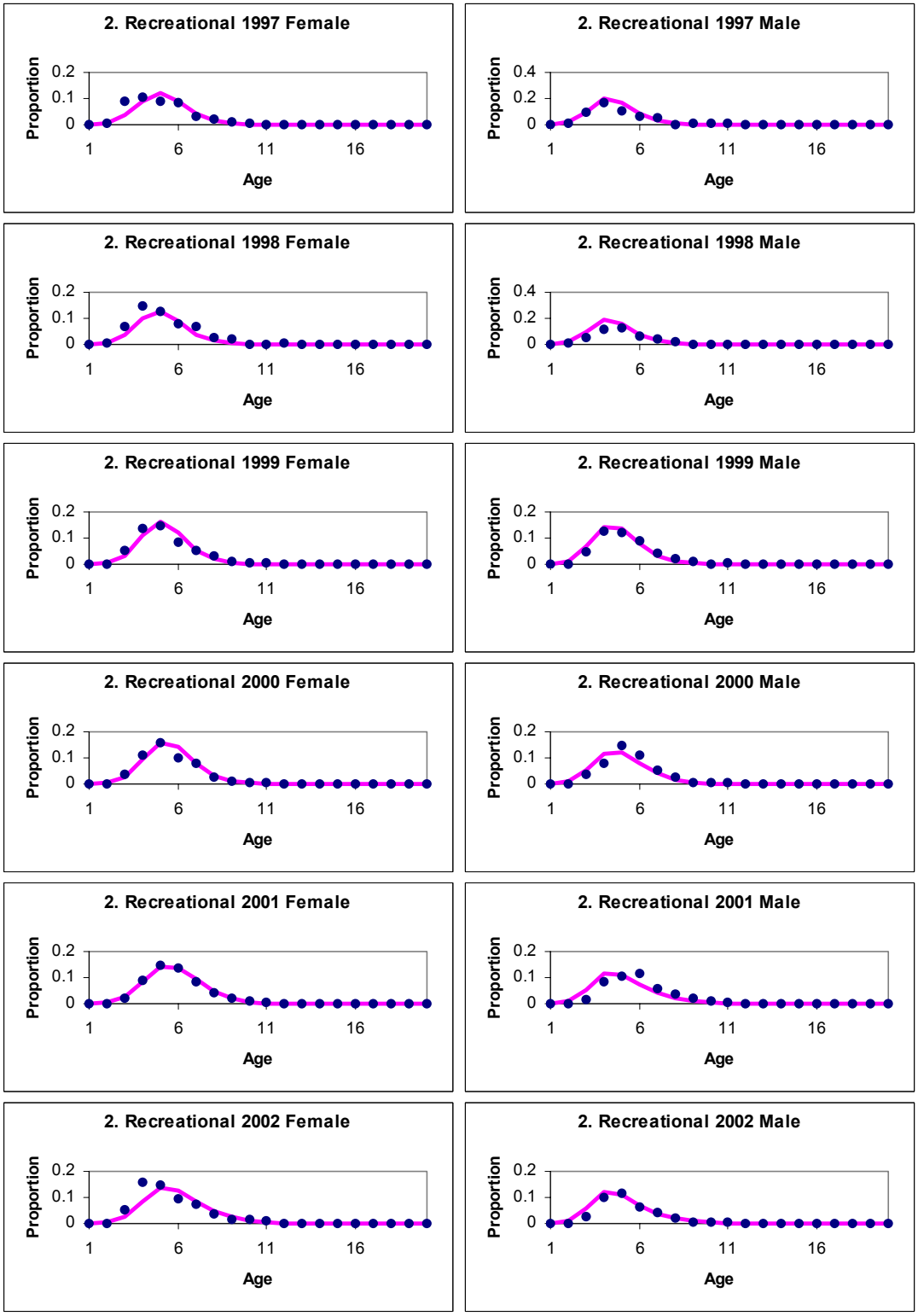


Figure 6. Coleraine output for the northern area (LCN) base model: Model fits to commercial fishery catch-at-length.

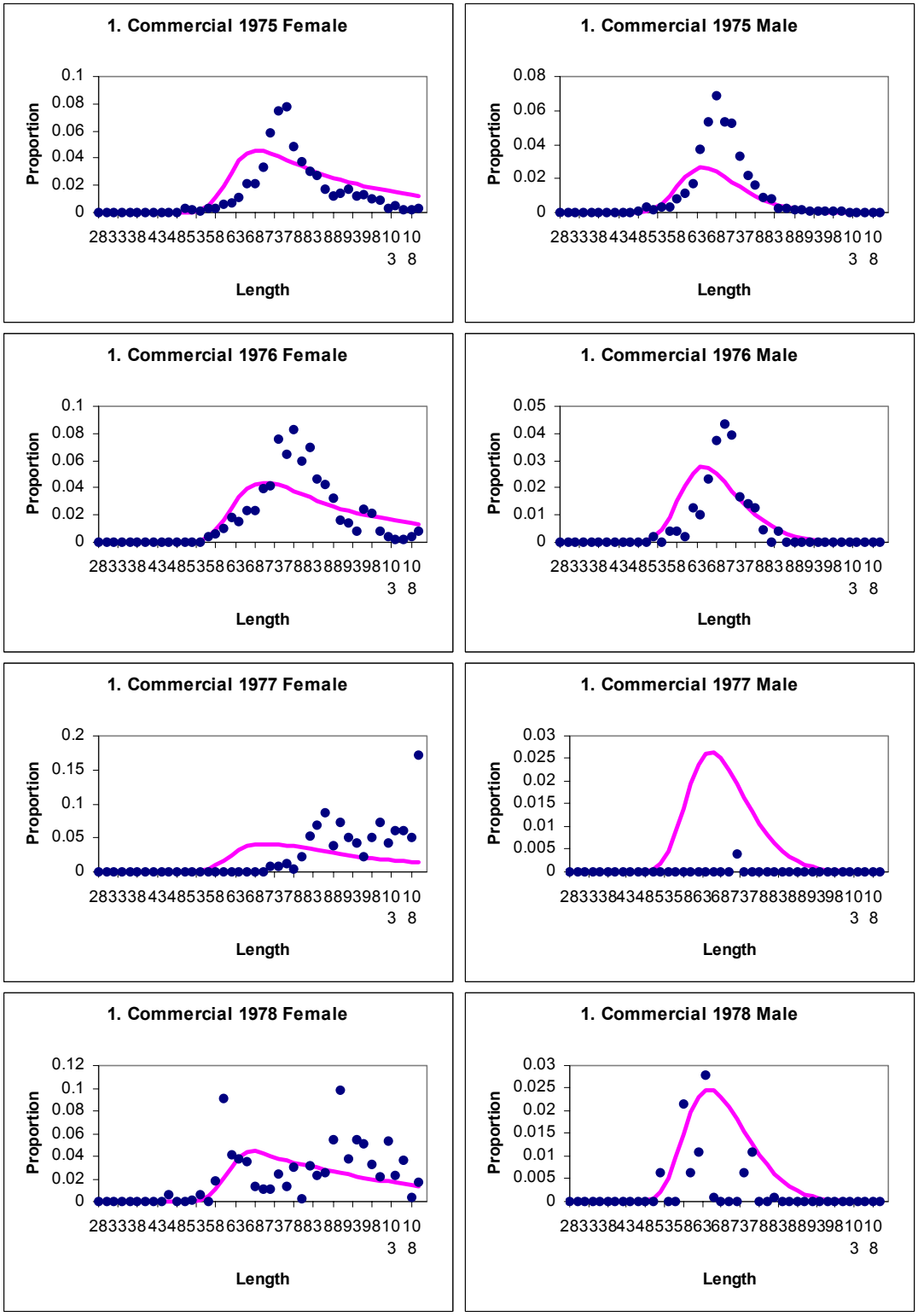


Figure 7. Coleraine output for the northern area (LCN) base model: Model fits to recreational fishery catch-at-length.

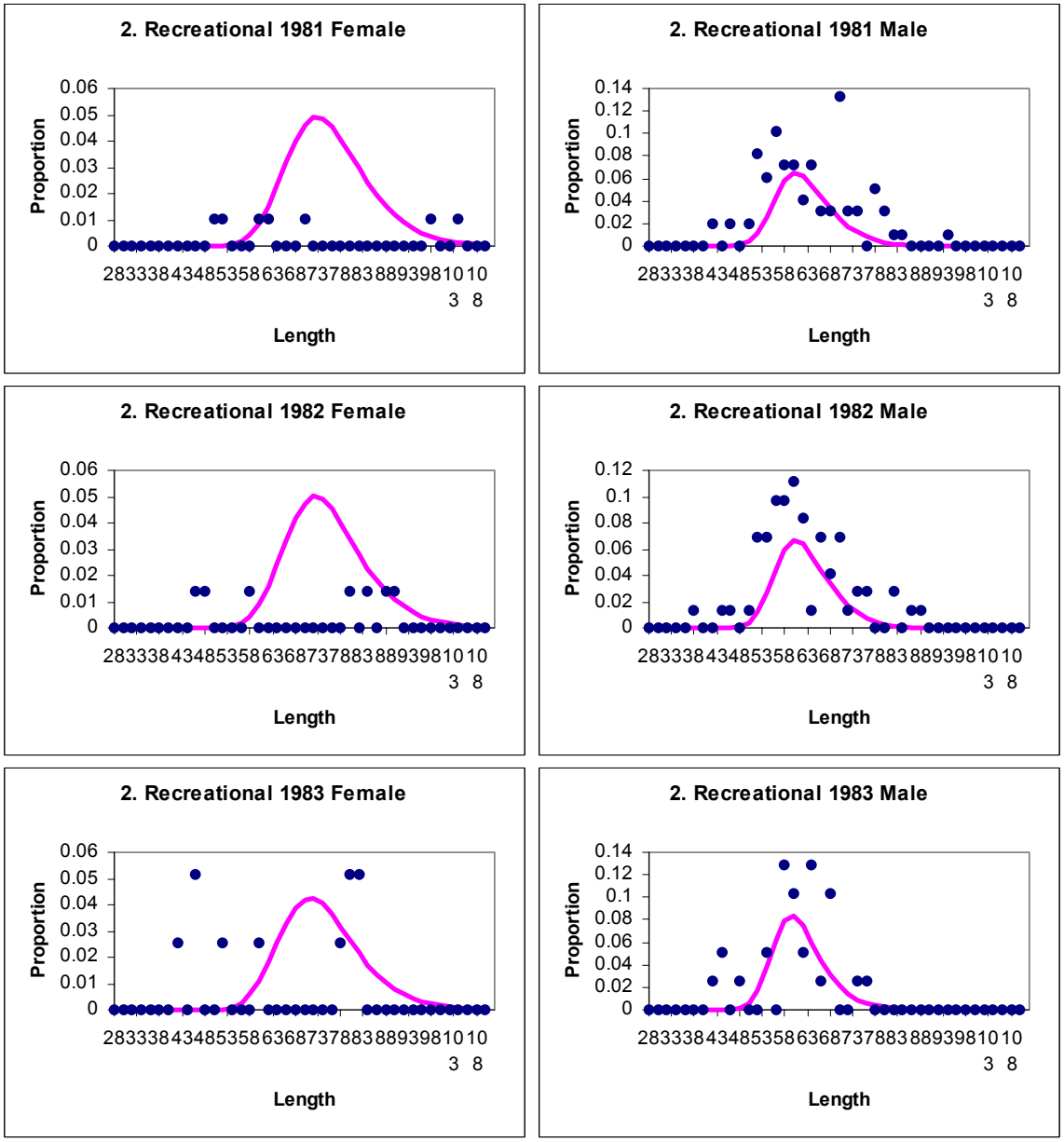


Figure 8. Coleraine output for the northern area (LCN) base model: Model fits to NMFS trawl survey catch-at-age.

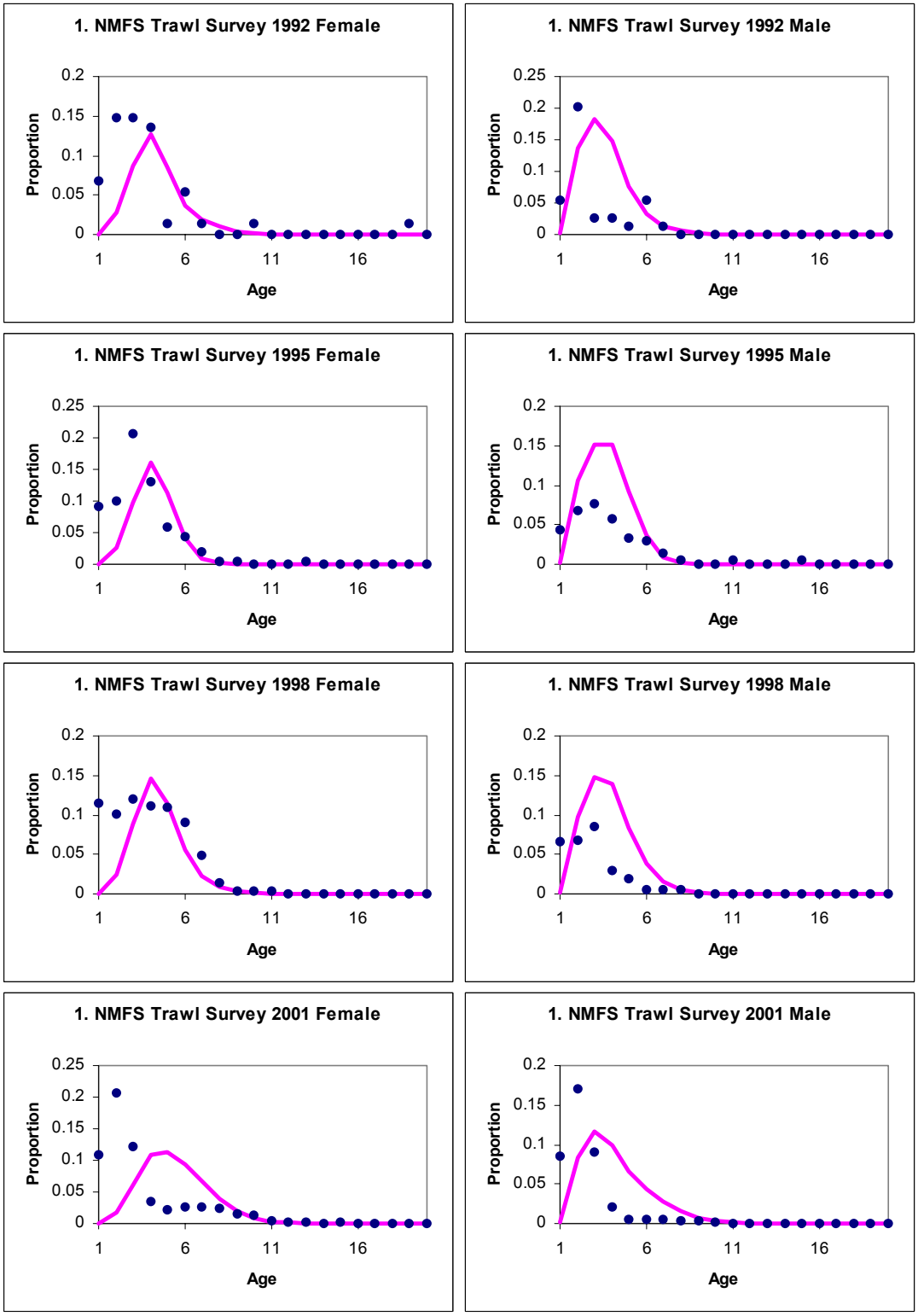


Figure 9. Coleraine output for the northern area (LCN) base model: Model fits to WDFW tagging survey catch-at-age.

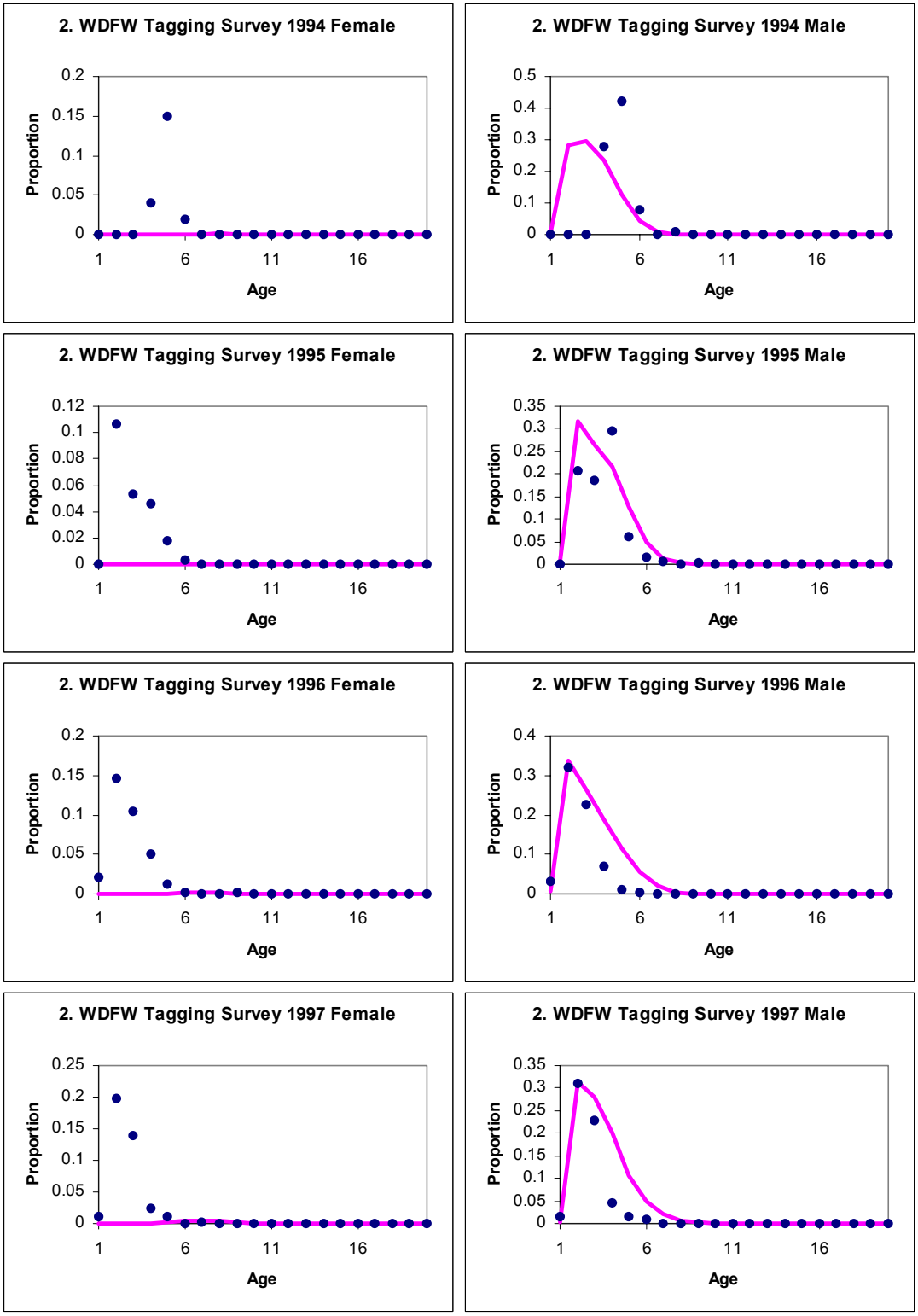


Figure 10. Coleraine output for the northern area (LCN) base model: Model fits to NMFS trawl survey and WDFW tagging survey catch-at-length.

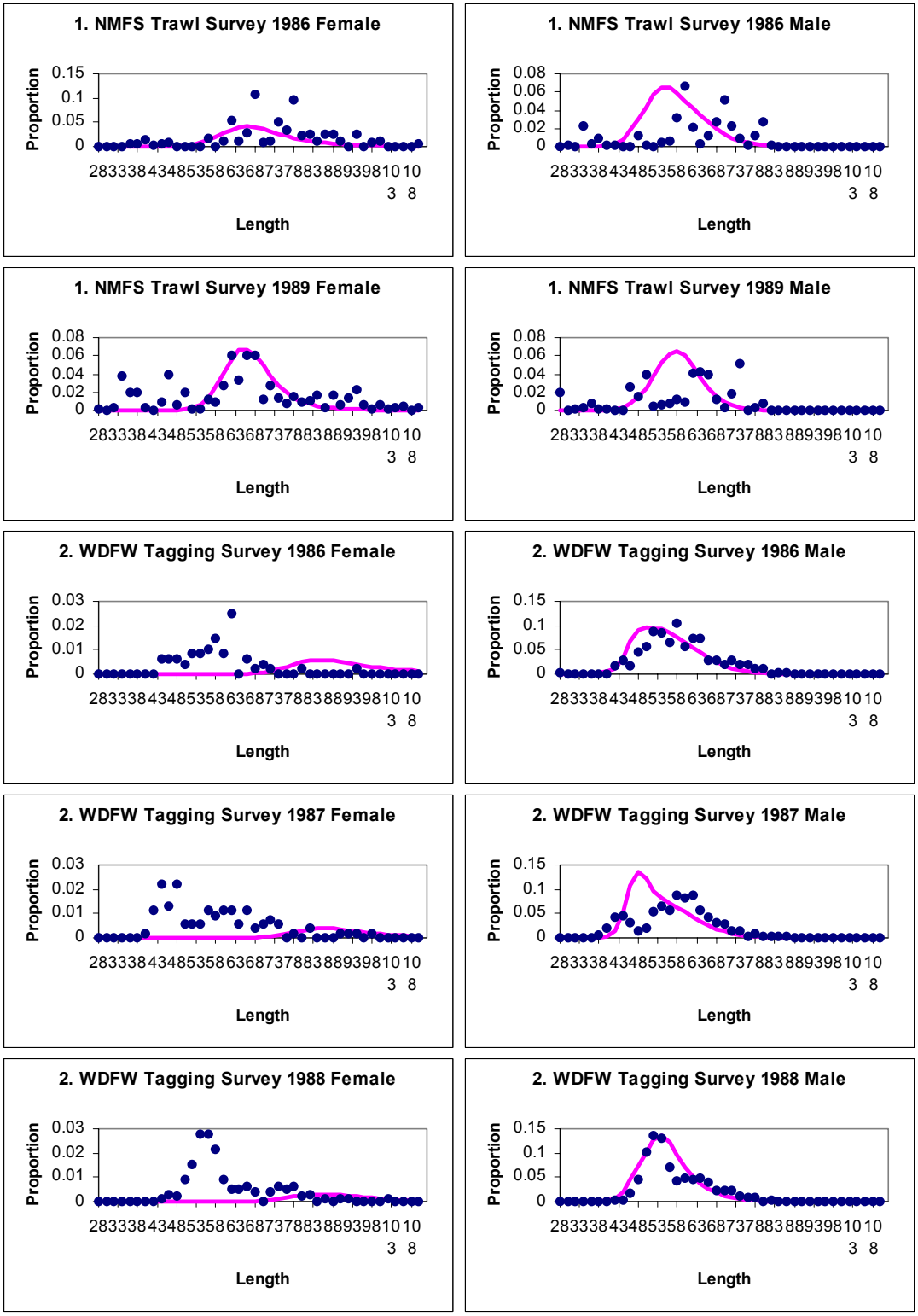


Figure 10, continued. Coleraine output for the northern area (LCN) base model: Model fits to NMFS trawl survey and WDFW tagging survey catch-at-length.

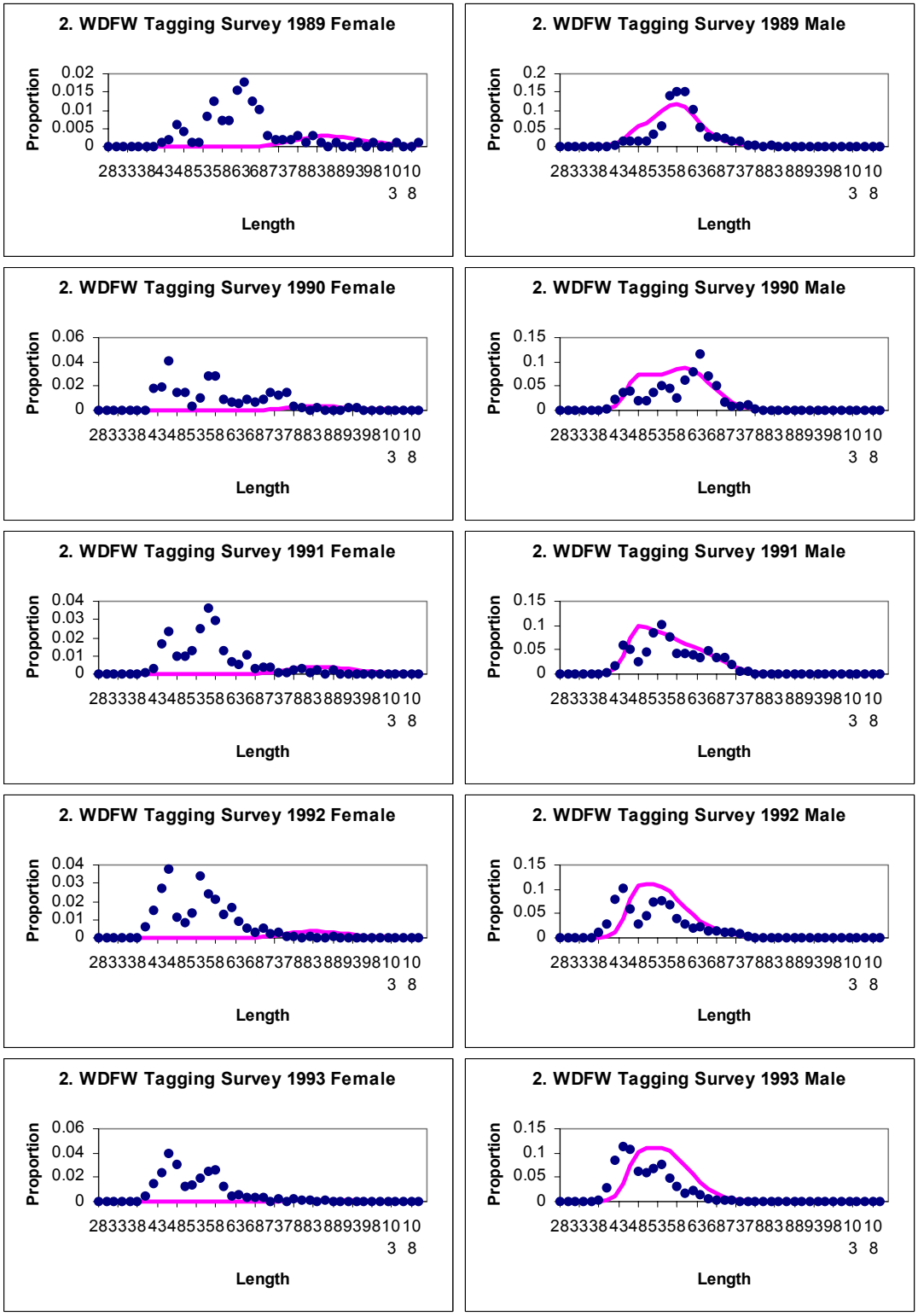


Figure 11a. Coleraine output for the northern area (LCN) base model: Retrospective analysis showing a comparison of base model estimates of spawning biomass with a base model configured with 1999 as the end year.

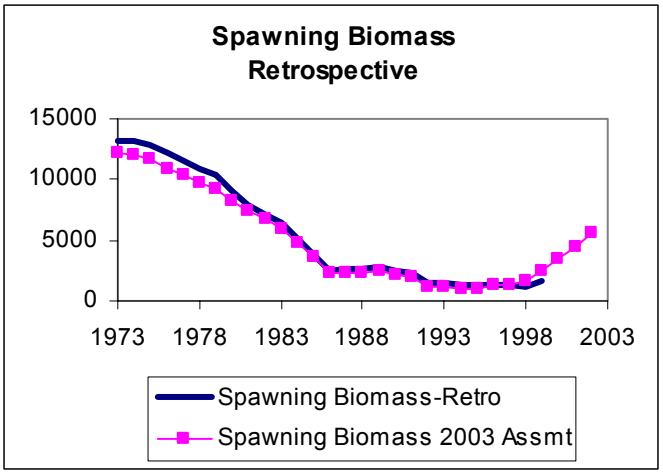


Figure 11b. Coleraine output for the northern area (LCN) base model: Historical analysis comparing spawning biomass estimates from the 2003 base model with spawning biomass estimates from the 2000 base model.

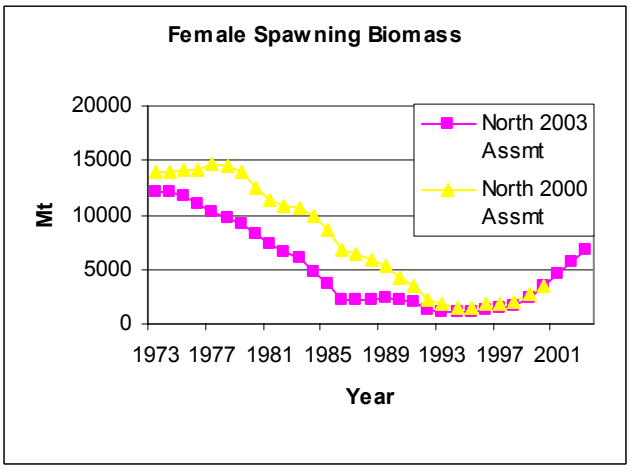


Table 4. Coleraine input for the southern area (LCS) base model: Priors.

Priors

0=uniform
1=normal
2=lognormal

Phase	Low Bound	High Bound	Prior Type	Mean	CV	Seed Value
R0 (Recruitment in virgin condition)						
1	0.1	1000000	0	0	0	2100
h (steepness of spawner-recruit curve)						
-1	0.01	5	0	0.7	1	0.9
M (natural mortality)						
-1	0.05	0.5	0	0.1	0.1	0.18
-1	0.05	0.5	0	0.1	0.1	0.32
Log init dev prior: deviates for initial age structure: uniform or normal only						
-5	-15	15	1	0	0.1	0
log rec dev prior (uniform or normal only)						
2	-15	15	1	0	0.3	0
Initial R (= # 1-yr olds in yr 1/R0; unfished = 1)						
-1	0	2	0	1	0.1	1
Initial u (exploitation rate for initial age structure; 0=unfished)						
-1	0	0.25	0	0	0.1	0.07
-1	0	0.25	0	0	0.1	0.07
Plus scale						
-1	0	2	0	0	0.6	1
-1	0	2	0	0	0.6	1
Age of full selectivity - Females						
3	1	18	0	9	0.1	3.1
3	1	18	0	9	0.1	4.4
Fishery age of full selectivity difference by sex (Delta)						
4	-5	5	0	0	0.6	0
4	-5	5	0	0	0.6	0
Fishery variance of Left side of selectivity curve (for both sexes)						
4	-15	15	0	0	0.6	-2.2
4	-15	15	0	0	0.6	-1.59
Fishery variance of Right side of selectivity curve (for both sexes)						
4	-15	20	0	0	0.6	1.27
4	-15	20	0	0	0.6	4.08
Fishery age of full selectivity deviation by year						
-5	-15	15	1	0	0.1	0
-5	-15	15	1	0	0.1	0
Fishery variance of Left side selectivity by year						
-5	-15	15	1	0	0.1	0
-5	-15	15	1	0	0.1	0
Fishery variance of Right side selectivity by year						
-5	-15	15	1	0	0.1	0
-5	-15	15	1	0	0.1	0
Log q CPUE						
1	-15	15	0	0	0.1	-5
Log q CPUE error						
-1	-5	5	0	0	0.6	0
Log q Survey						
1	-5	5	0	0	0.6	-1.6
Survey age of full selectivity - Females						
-3	1	15	0	0	0.6	2
Survey age of full selectivity difference by sex (Delta)						
-3	-5	5	0	0	0.6	-0.98
Survey variance Left side selectivity						
-1	-15	15	0	0	0.6	1
Survey variance Right side selectivity						
-1	-15	15	0	0	0.6	4

Table 5. Coleraine input for the southern area (LCS) base model: Likelihood and fixed parameter specifications.

Likelihoods (1= norm; 2 = lognorm; 3= robust norm; 4=robust lognorm; 12 = robust lognormal for proportions)

CPUE likelihood Type	
2	
Commercial catch at age likelihood type	
12	12
Commercial catch at length likelihood type	
0	0
Survey likelihood type	
2	
Survey Index type (1=weight; 2=numbers)	
1	
Survey vulnerability type (1=age; 2=length)	
1	
Survey no-sex C@L likelihood type	
0	
Survey catch at length likelihood type	
0	
Survey catch at age likelihood type	
12	

Fixed Parameters

Bi-scalar of length-weight relationship	
0.00176	0.003953
bii exponent of length-weight relationship	
3.3978	3.2149
L-infinity of the vonBertanlanffy growth equation	
112.8106921	81.6939587
k of the vonBertanlanffy growth equation	
0.144901796	0.223232852
t0 of the vonBertanlanffy growth equation	
-1.573476868	-1.434670218
Brody parameter	
0.2	0.2
Mean length of age 1 fish	
35.11346278	34.25270385
Length at oldest age	
107.8592173	81.01141723
S.d. of length at age of 1-year old fish	
2.453914279	2.005470452
S.d. of length at age of oldest fish	
6.611169688	12.64731616

Table 6. Coleraine output for the southern area (LCS) base model: Negative log likelihood values (top), parameter estimates (outlined in bold), and fixed values used in the model (shaded).

B0	23267
Depletion	0.16
Input File	sfinalD.txt
No. of Parameters:	**42**
Likelihoods AIC:	**-4119.35**
Trawl Logbook CPUE	7.74394
Com Catch-At-Age	-901.306
Rec Catch-At-Age	-944.034
	0
	0
NMFS Trawl Survey	11.1914
NMFS Survey Catch-At-Age	-285.437
	0
	0
Penalties: B-H Recruitment	10.1668
Total Likelihood:	**-2101.7**
Parameters	
R0	2078.06
h	0.9
M Females	0.18
M Males	0.32
Rinit	1
Uinit Females	0.07
Uinit Males	0.07
Init Plus Grp Resid Females	1
Init Plus Grp Resid Males	1
Selectivity - Full Com	3.06415
Selectivity - Full Rec	4.3183
Selectivity - Left Side Com	-2.11419
Selectivity - Left Side Rec	-2.2295
Selectivity - Right Side Com	1.68597
Selectivity - Right Side Rec	18.6204
Selectivity - Full - Yr Error Com	0
Selectivity - Full - Yr Error Rec	0
Selectivity - Left - Yr Error Com	0
Selectivity - Left - Yr Error Rec	0
Selectivity - Right - Yr Error Com	0
Selectivity - Right - Yr Error Rec	0
Trawl Logbook CPUE - log(q)	-6.04198
Trawl Logbook CPUE - q Yr Error	0
Trawl Logbook CPUE q	0.002377
NMFS Trawl Survey q	-1.16592
Selectivity - Full NMFS Survey	2
Selectivity - Left NMFS Survey	1
Selectivity - Right NMFS Survey	4
Log Initial Age Comp Dev	0
Log Rec Dev	0.099238

Table 6a1. Coleraine output for the northern area (LCS) base model: Standard deviation of estimated parameters under the dome shaped fishery selectivity model.

index	name	value	std dev
1	R0	2.0781e+003	2.3782e+002
2	log_RecDev	9.9238e-002	3.1898e-001
3	log_RecDev	6.5530e-002	3.0707e-001
4	log_RecDev	4.2964e-002	2.9432e-001
5	log_RecDev	2.5791e-001	3.0380e-001
6	log_RecDev	3.3624e-001	2.7087e-001
7	log_RecDev	4.2634e-002	2.6969e-001
8	log_RecDev	8.8769e-002	2.7599e-001
9	log_RecDev	2.5288e-001	2.6224e-001
10	log_RecDev	3.0206e-002	2.4572e-001
11	log_RecDev	-3.8550e-001	2.4041e-001
12	log_RecDev	-5.0205e-001	2.4508e-001
13	log_RecDev	-2.6237e-001	2.5661e-001
14	log_RecDev	4.7283e-002	2.5628e-001
15	log_RecDev	1.8749e-001	2.6556e-001
16	log_RecDev	2.1493e-001	2.4760e-001
17	log_RecDev	-4.3479e-002	2.3085e-001
18	log_RecDev	-2.3003e-001	2.0221e-001
19	log_RecDev	-3.7178e-001	1.3290e-001
20	log_RecDev	-6.6480e-002	1.6114e-001
21	log_RecDev	7.0937e-002	1.6600e-001
22	log_RecDev	-5.3427e-001	2.7745e-001
23	log_RecDev	1.4631e-001	2.1832e-001
24	log_RecDev	-7.3920e-002	2.5899e-001
25	log_RecDev	1.7241e-001	2.1276e-001
26	log_RecDev	-3.2389e-001	2.2811e-001
27	log_RecDev	-2.2586e-001	2.0123e-001
28	log_RecDev	-4.4538e-001	2.3628e-001
29	log_RecDev	2.6815e-001	2.5132e-001
30	log_RecDev	1.9006e-001	2.5074e-001
31	log_RecDev	-5.7526e-006	3.0000e-001
32	log_RecDev	0.0000e+000	3.0000e-001
33	Sfullest	3.0641e+000	1.5985e-001
34	Sfullest	4.3183e+000	8.7773e-001
35	Sfulldelta	6.1139e-001	5.2049e-001
36	Sfulldelta	-5.4450e-002	1.7624e-001
37	log_varLest	-2.1142e+000	1.8501e+000
38	log_varLest	-2.2295e+000	5.3795e+000
39	log_varRest	1.6860e+000	3.3559e-001
40	log_varRest	1.8620e+001	2.5797e+003
41	log_qCPUE	-6.0420e+000	1.1102e-001
42	log_qsurvey	-1.1659e+000	8.1025e-002
43	Ro_mcmc	2.0781e+003	2.3782e+002

Table 6a. Coleraine output for the southern area (LCS) base model: Profile over historical exploitation rate (U_{init}); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold.

B0		26826	27127	28773	29020	28216
Depletion		0.16	0.16	0.15	0.15	0.15
		RUN1	**RUN2**	**RUN3**	**RUN4**	**RUN5**
Input File		su1out.txt	su2out.txt	su3out.txt	su4out.txt	su5out.txt
No. of Parameters:		42	42	42	42	42
Likelihoods	**AIC:**	**-4122**	**-4122**	**-4123**	**-4122**	**-4121**
Trawl Logbook CPUE		9.4	9.4	6.9	6.9	9.4
Com Catch-At-Age		-905.2	-905.1	-902.5	-902.6	-905.0
Rec Catch-At-Age		-945.7	-945.7	-944.4	-944.4	-945.7
Com Catch-At-Length		0	0	0	0	0
Rec Catch-At-Length		0	0	0	0	0
NMFS Trawl Survey		11.0	11.1	10.6	10.6	11.2
WDFW Tag Survey		0	0	0	0	0
NMFS Survey Catch-At-Age		-281.1	-281.1	-284.5	-284.5	-281.1
WDFW Survey Catch-At-Age		0	0	0	0	0
NMFS Survey Catch-At-Length		0	0	0	0	0
WDFW Survey Catch-At-Length		0	0	0	0	0
		0	0	0	0	0
		0	0	0	0	0
Penalties: B-H Recruitment		8.4	8.5	10.6	10.6	8.6
Total Likelihood:		**-2103.0**	**-2102.9**	**-2103.3**	**-2103.2**	**-2102.6**
Parameters						
R0		2396	2423	2570	2592	2520
h		0.7	0.7	0.7	0.7	0.7
M Females		0.18	0.18	0.18	0.18	0.18
M Males		0.32	0.32	0.32	0.32	0.32
Rinit		1	1	1	1	1
Uinit Females		**0.03**	**0.05**	**0.07**	**0.09**	**0.12**
Uinit Males		**0.03**	**0.05**	**0.07**	**0.09**	**0.12**
Init Plus Grp Resid Females		1	1	1	1	1
Init Plus Grp Resid Males		1	1	1	1	1
Selectivity - Full Com		3.00	3.00	3.12	3.12	3.00
Selectivity - Full Rec		4.38	4.38	4.41	4.41	4.38
Selectivity - Left Side Com		-15.00	-15.00	-2.19	-2.19	-15.00
Selectivity - Left Side Rec		-1.83	-1.83	-1.57	-1.57	-1.85
Selectivity - Right Side Com		2.53	2.52	1.30	1.30	2.50
Selectivity - Right Side Rec		4.22	4.22	4.13	4.13	4.21
Selectivity - Full - Yr Error Com		0	0	0	0	0
Selectivity - Full - Yr Error Rec		0	0	0	0	0
Selectivity - Left - Yr Error Com		0	0	0	0	0
Selectivity - Left - Yr Error Rec		0	0	0	0	0
Selectivity - Right - Yr Error Com		0	0	0	0	0
Selectivity - Right - Yr Error Rec		0	0	0	0	0
Trawl Logbook CPUE - log(q)		-6.2301	-6.2290	-6.0538	-6.0537	-6.2254
Trawl Logbook CPUE - q Yr Error		0	0	0	0	0
Trawl Logbook CPUE q		0.0020	0.0020	0.0023	0.0023	0.0020
NMFS Trawl Survey q		-1.2645	-1.2639	-1.2682	-1.2670	-1.2622
WDFW Tag Survey q		0	0	0	0	0
Selectivity - Full NMFS Survey		2.00	2.00	2.00	2.00	2.00
Selectivity - Full WDFW Survey		0.00	0.00	0.00	0.00	0.00
Selectivity - Left NMFS Survey		1.00	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey		0.00	0.00	0.00	0.00	0.00
Selectivity - Right NMFS Survey		4.00	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey		0.00	0.00	0.00	0.00	0.00
Log Initial Age Comp Dev		0	0	0	0	0
Log Rec Dev		-0.0310	-0.0297	-0.0072	-0.0057	-0.0253

Table 6b. Coleraine output for the southern area (LCS) base model: Profile over natural mortality rate (M); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold. Note: Run 2 did not fully converge.

B0		35764	32507	28773	25842	23363
Depletion		0.15	0.14	0.15	0.16	0.17
		RUN1	**RUN2**	**RUN3**	**RUN4**	**RUN5**
Input File		sm1out.txt	sm2out.txt	sm3out.txt	sm4out.txt	sm5out.txt
No. of Parameters:		42	42	42	42	42
Likelihoods	**AIC:**	**-4122**	**-4116**	**-4123**	**-4123**	**-4122**
Trawl Logbook CPUE		9.7	8.5	6.9	6.8	6.7
Com Catch-At-Age		-905.9	-902.4	-902.5	-902.6	-902.4
Rec Catch-At-Age		-945.8	-943.4	-944.4	-943.6	-942.6
Com Catch-At-Length		0	0	0	0	0
Rec Catch-At-Length		0	0	0	0	0
NMFS Trawl Survey		10.7	10.3	10.6	10.7	10.9
WDFW Tag Survey		0	0	0	0	0
NMFS Survey Catch-At-Age		-279.2	-281.7	-284.5	-285.5	-286.4
WDFW Survey Catch-At-Age		0	0	0	0	0
NMFS Survey Catch-At-Length		0	0	0	0	0
WDFW Survey Catch-At-Length		0	0	0	0	0
		0	0	0	0	0
		0	0	0	0	0
Penalties: B-H Recruitment		7.7	8.6	10.6	10.7	10.7
Total Likelihood:		**-2102.9**	**-2100.1**	**-2103.3**	**-2103.4**	**-2103.1**
Parameters						
R0		1960	2298	2570	2867	3174
h		0.7	0.7	0.7	0.7	0.7
M Females		0.14	0.16	0.18	0.2	0.22
M Males		0.28	0.3	0.32	0.35	0.38
Rinit		1	1	1	1	1
Uinit Females		0.07	0.07	0.07	0.07	0.07
Uinit Males		0.07	0.07	0.07	0.07	0.07
Init Plus Grp Resid Females		1	1	1	1	1
Init Plus Grp Resid Males		1	1	1	1	1
Selectivity - Full Com		3.00	3.07	3.12	3.13	3.15
Selectivity - Full Rec		4.39	4.33	4.41	4.41	4.42
Selectivity - Left Side Com		-15.00	-2.53	-2.19	-2.08	-1.96
Selectivity - Left Side Rec		-1.73	-2.21	-1.57	-1.61	-1.67
Selectivity - Right Side Com		2.59	1.86	1.30	1.27	1.25
Selectivity - Right Side Rec		4.09	4.18	4.13	4.23	4.40
Selectivity - Full - Yr Error Com		0	0	0	0	0
Selectivity - Full - Yr Error Rec		0	0	0	0	0
Selectivity - Left - Yr Error Com		0	0	0	0	0
Selectivity - Left - Yr Error Rec		0	0	0	0	0
Selectivity - Right - Yr Error Com		0	0	0	0	0
Selectivity - Right - Yr Error Rec		0	0	0	0	0
Trawl Logbook CPUE - log(q)		-6.2108	-6.1409	-6.0538	-6.0711	-6.0850
Trawl Logbook CPUE - q Yr Error		0	0	0	0	0
Trawl Logbook CPUE q		0.0020	0.0022	0.0023	0.0023	0.0023
NMFS Trawl Survey q		-1.2218	-1.2302	-1.2682	-1.2887	-1.3088
WDFW Tag Survey q		0	0	0	0	0
Selectivity - Full NMFS Survey		2.00	2.00	2.00	2.00	2.00
Selectivity - Full WDFW Survey		0.00	0.00	0.00	0.00	0.00
Selectivity - Left NMFS Survey		1.00	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey		0.00	0.00	0.00	0.00	0.00
Selectivity - Right NMFS Survey		4.00	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey		0.00	0.00	0.00	0.00	0.00
Log Initial Age Comp Dev		0	0	0	0	0
Log Rec Dev		-0.0312	-0.0305	-0.0072	-0.0003	0.0075

Table 6c. Coleraine output for the southern area (LCS) base model: Profile over B-H spawner-recruit steepness (*h*); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold.

B0		35277	30781	28773	26006	23264
Depletion		0.15	0.15	0.15	0.16	0.16
		RUN1	**RUN2**	**RUN3**	**RUN4**	**RUN5**
Input File		sh1out.txt	sh2out.txt	sh3out.txt	sh4out.txt	sh5out.txt
No. of Parameters:		42	42	42	42	42
Likelihoods	**AIC:**	**-4117**	**-4116**	**-4123**	**-4121**	**-4119**
Trawl Logbook CPUE		6.5	7.9	6.9	7.2	7.7
Com Catch-At-Age		-903.4	-904.6	-902.5	-901.9	-901.3
Rec Catch-At-Age		-944.4	-942.5	-944.4	-943.8	-944.0
Com Catch-At-Length		0	0	0	0	0
Rec Catch-At-Length		0	0	0	0	0
NMFS Trawl Survey		11.7	11.3	10.6	10.7	11.2
WDFW Tag Survey		0	0	0	0	0
NMFS Survey Catch-At-Age		-283.3	-280.7	-284.5	-285.0	-285.4
WDFW Survey Catch-At-Age		0	0	0	0	0
NMFS Survey Catch-At-Length		0	0	0	0	0
WDFW Survey Catch-At-Length		0	0	0	0	0
		0	0	0	0	0
		0	0	0	0	0
Penalties: B-H Recruitment		12.4	8.3	10.6	10.4	10.2
Total Likelihood:		**-2100.5**	**-2100.2**	**-2103.3**	**-2102.4**	**-2101.7**
Parameters						
R0		3151	2749	2570	2323	2078
h		**0.5**	**0.6**	**0.7**	**0.8**	**0.9**
M Females		0.18	0.18	0.18	0.18	0.18
M Males		0.32	0.32	0.32	0.32	0.32
Rinit		1	1	1	1	1
Uinit Females		0.07	0.07	0.07	0.07	0.07
Uinit Males		0.07	0.07	0.07	0.07	0.07
Init Plus Grp Resid Females		1	1	1	1	1
Init Plus Grp Resid Males		1	1	1	1	1
Selectivity - Full Com		3.14	3.14	3.12	3.10	3.07
Selectivity - Full Rec		4.39	4.45	4.41	4.42	4.28
Selectivity - Left Side Com		-2.41	-3.08	-2.19	-2.15	-2.11
Selectivity - Left Side Rec		-1.69	-1.58	-1.57	-1.53	-2.47
Selectivity - Right Side Com		0.97	1.78	1.30	1.46	1.68
Selectivity - Right Side Rec		3.07	3.78	4.13	4.56	12.56
Selectivity - Full - Yr Error Com		0	0	0	0	0
Selectivity - Full - Yr Error Rec		0	0	0	0	0
Selectivity - Left - Yr Error Com		0	0	0	0	0
Selectivity - Left - Yr Error Rec		0	0	0	0	0
Selectivity - Right - Yr Error Com		0	0	0	0	0
Selectivity - Right - Yr Error Rec		0	0	0	0	0
Trawl Logbook CPUE - log(q)		-6.0647	-6.1545	-6.0538	-6.0562	-6.0418
Trawl Logbook CPUE - q Yr Error		0	0	0	0	0
Trawl Logbook CPUE q		0.0023	0.0021	0.0023	0.0023	0.0024
NMFS Trawl Survey q		-1.4176	-1.3126	-1.2682	-1.2223	-1.1659
WDFW Tag Survey q		0	0	0	0	0
Selectivity - Full NMFS Survey		2.00	2.00	2.00	2.00	2.00
Selectivity - Full WDFW Survey		0.00	0.00	0.00	0.00	0.00
Selectivity - Left NMFS Survey		1.00	1.00	1.00	1.00	1.00
Selectivity - Left WDFW Survey		0.00	0.00	0.00	0.00	0.00
Selectivity - Right NMFS Survey		4.00	4.00	4.00	4.00	4.00
Selectivity - Right WDFW Survey		0.00	0.00	0.00	0.00	0.00
Log Initial Age Comp Dev		0	0	0	0	0
Log Rec Dev		-0.0406	-0.0418	-0.0072	0.0304	0.0987

Table 6d. Coleraine output for the southern area (LCS) base model: Profile over combinations of natural mortality rate (M) and B-H spawner-recruit steepness (*h*); Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold.

B0	42274	17952	28712	29002
Depletion	0.12	0.26	0.17	0.17
	RUN10	**RUN11**	**RUN12**	**RUN13**
Input File	shlml.txt	shhmh.txt	shlmh.txt	shhml.txt
No. of Parameters:				
Likelihoods AIC:				
Trawl Logbook CPUE	8.4	10.0	6.3	10.2
Com Catch-At-Age	-907.0	-904.5	-903.5	-904.4
Rec Catch-At-Age	-941.8	-943.7	-941.9	-945.5
	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0
NMFS Trawl Survey	11.6	12.9	11.9	11.8
NMFS Survey Catch-At-Age	-277.5	-283.8	-285.3	-280.2
	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0
Penalties: B-H Recruitment	10.5	9.3	12.7	9.0
Total Likelihood:	**-2095.8**	**-2099.9**	**-2099.7**	**-2098.9**
Parameters				
R0	2316	2439	3901	1589
h	**0.5**	**0.9**	**0.5**	**0.9**
M Females	**0.14**	**0.22**	**0.22**	**0.14**
M Males	**0.26**	**0.38**	**0.38**	**0.26**
Rinit	1	1	1	1
Uinit Females	0.07	0.07	0.07	0.07
Uinit Males	0.07	0.07	0.07	0.07
Init Plus Grp Resid Females	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1
Selectivity - Full Com	3.10	3.00	3.19	3.00
Selectivity - Full Rec	4.49	4.09	4.00	4.40
Selectivity - Left Side Com	-2.52	-14.34	-2.09	-14.87
Selectivity - Left Side Rec	-1.57	-4.80	-15.00	-1.66
Selectivity - Right Side Com	1.87	2.91	0.87	2.96
Selectivity - Right Side Rec	3.92	19.38	3.19	4.45
Selectivity - Full - Yr Error Com	0.00	0.00	0.00	0.00
Selectivity - Full - Yr Error Rec	0.00	0.00	0.00	0.00
Selectivity - Left - Yr Error Com	0.00	0.00	0.00	0.00
Selectivity - Left - Yr Error Rec	0.00	0.00	0.00	0.00
Selectivity - Right - Yr Error Com	0.00	0.00	0.00	0.00
Selectivity - Right - Yr Error Rec	0.00	0.00	0.00	0.00
Trawl Logbook CPUE - log(q)	-6.1675	-6.3072	-6.0970	-6.2420
Trawl Logbook CPUE - q Yr Error	0	0	0	0
Trawl Logbook CPUE q	0.0021	0.0018	0.0022	0.0019
NMFS Trawl Survey q	-1.2643	-1.3078	-1.4636	-1.1860
Selectivity - Full NMFS Survey	2.00	2.00	2.00	2.00
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00
Log Rec Dev	-0.0923	0.1251	-0.0246	0.0766

Table 6e. Coleraine output for the southern area (LCS) base model: Profile over combinations of domed and asymptotic fishery selectivity; Negative log likelihood values, parameter estimates, and fixed values used in the model. Best-fit model outlined in bold.

B0	28492	22525	27620	23809
Depletion	0.16	0.16	0.12	0.18
	RUN3	**RUN4**	**RUN6**	**RUN6**
Input File	sdcdsin.txt	sacasin.txt	sdcasin.txt	sacdsin.txt
No. of Parameters:	42	40	41	41
Likelihoods AIC:	**-4135**	**-4065**	**-4068**	**-4048**
Trawl Logbook CPUE	6.8	23.4	14.2	22.0
Com Catch-At-Age	-902.7	-898.1	-890.8	-896.7
Rec Catch-At-Age	-944.4	-937.8	-931.5	-925.7
	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0
NMFS Trawl Survey	4.9	6.2	5.5	6.1
NMFS Survey Catch-At-Age	-284.4	-280.9	-285.0	-280.7
	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0
Penalties: B-H Recruitment	10.6	14.4	12.4	9.8
Total Likelihood:	**-2109.3**	**-2072.6**	**-2075.2**	**-2065.2**
Parameters				
R0	2545	2012	2467	2126
h	0.7	0.7	0.7	0.7
M Females	0.18	0.18	0.18	0.18
M Males	0.32	0.32	0.32	0.32
Rinit	1	1	1	1
Uinit Females	0.07	0.07	0.07	0.07
Uinit Males	0.07	0.07	0.07	0.07
Init Plus Grp Resid Females	1	1	1	1
Init Plus Grp Resid Males	1	1	1	1
Selectivity - Full Com	3.13	2.00	2.01	2.99
Selectivity - Full Rec	4.40	4.07	3.76	5.86
Selectivity - Left Side Com	-2.21	-14.74	-7.54	-14.96
Selectivity - Left Side Rec	-1.60	-5.37	-11.25	0.63
Selectivity - Right Side Com	**1.27**	**15.00**	**3.82**	**20.00**
Selectivity - Right Side Rec	**4.09**	**15.00**	**10.48**	**0.00**
Selectivity - Full - Yr Error Com	0.00	0.00	0.00	0.00
Selectivity - Full - Yr Error Rec	0.00	0.00	0.00	0.00
Selectivity - Left - Yr Error Com	0.00	0.00	0.00	0.00
Selectivity - Left - Yr Error Rec	0.00	0.00	0.00	0.00
Selectivity - Right - Yr Error Com	0.00	0.00	0.00	0.00
Selectivity - Right - Yr Error Rec	0.00	0.00	0.00	0.00
Trawl Logbook CPUE - log(q)	-6.0561	-6.8967	-6.6475	-7.0207
Trawl Logbook CPUE - q Yr Error	0	0	0	0
Trawl Logbook CPUE q	0.0023	0.0010	0.0013	0.0009
NMFS Trawl Survey q	-1.3135	-1.2049	-1.2125	-1.2856
Selectivity - Full NMFS Survey	2.00	2.00	2.00	2.00
Selectivity - Left NMFS Survey	1.00	1.00	1.00	1.00
Selectivity - Right NMFS Survey	4.00	4.00	4.00	4.00
Log Initial Age Comp Dev	0.00	0.00	0.00	0.00
Log Rec Dev	-0.0370	-0.1698	-0.1171	-0.1390

Figure 12a. Coleraine output for the southern area (LCS) base model: Vulnerable biomass, exploitation rate, stock recruitment, and spawning biomass.

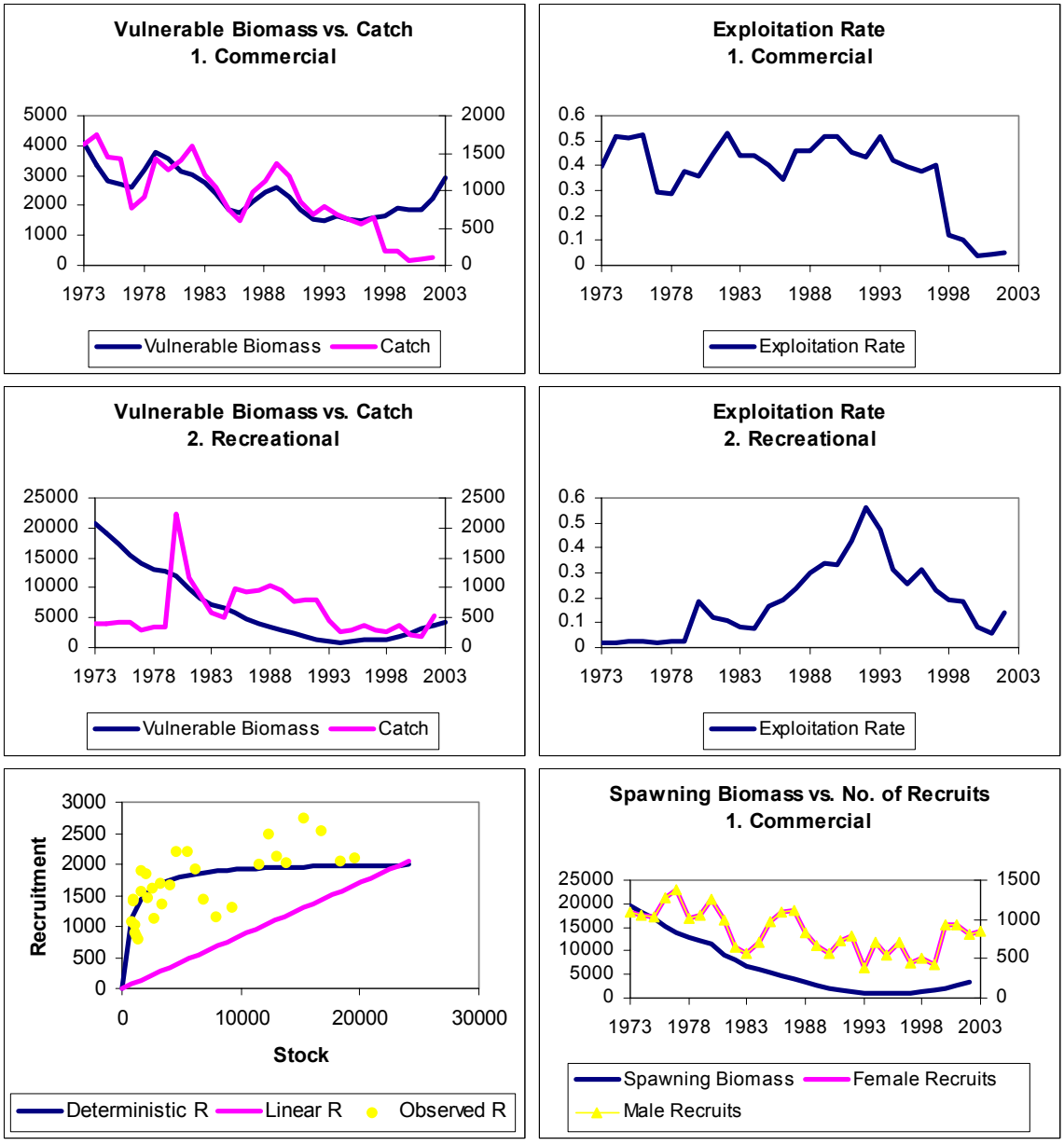


Figure 12b. Coleraine output for the southern area (LCS) base model: Estimated selectivity for the commercial fishery, recreational fishery, and NMFS trawl survey.

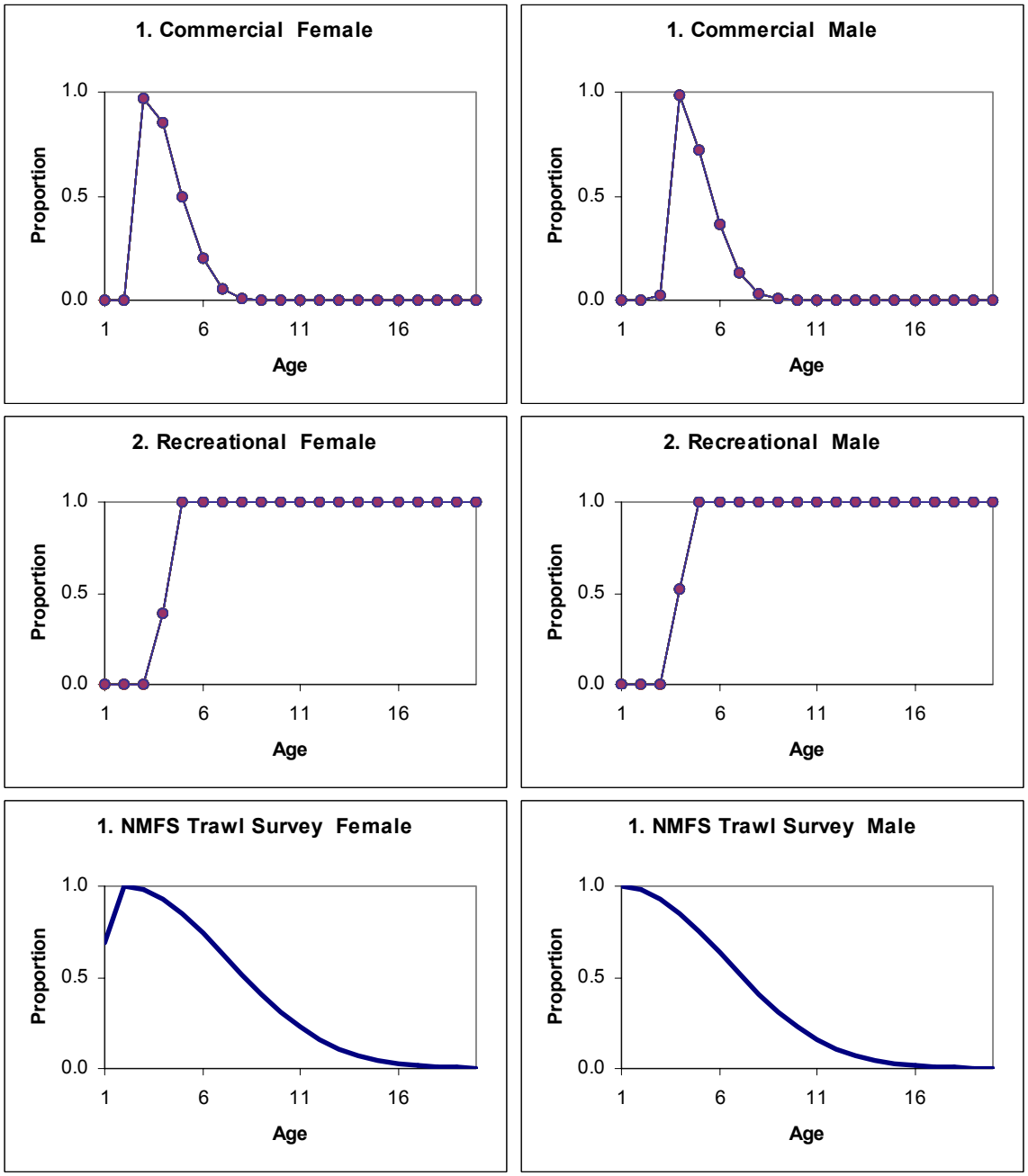


Figure 13. Coleraine output for the southern area (LCS) base model: Model fits to indices of abundance; NMFS trawl survey and trawl logbook.

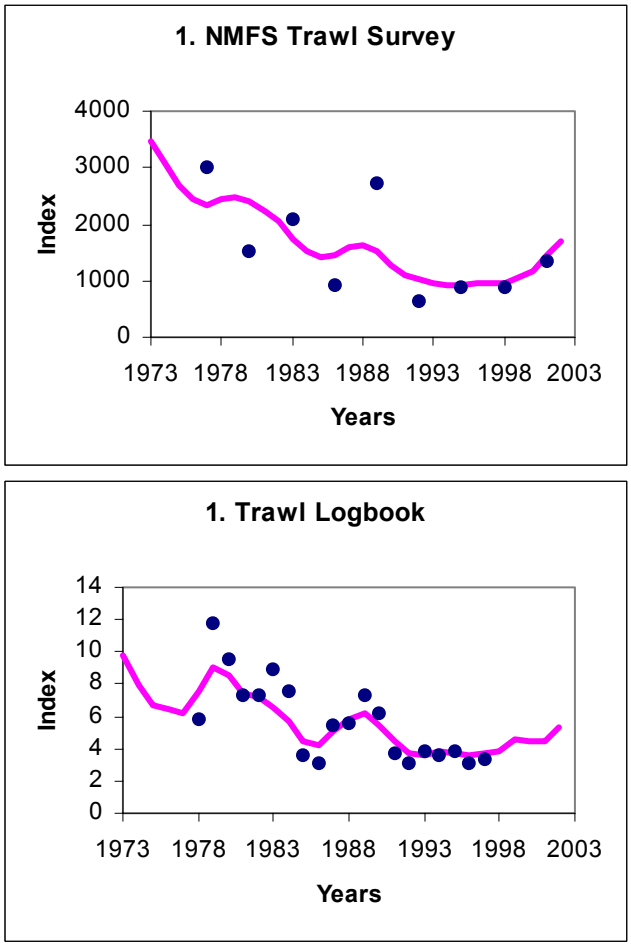


Figure 14. Coleraine output for the southern area (LCS) base model: Model fits to commercial fishery catch-at-age.

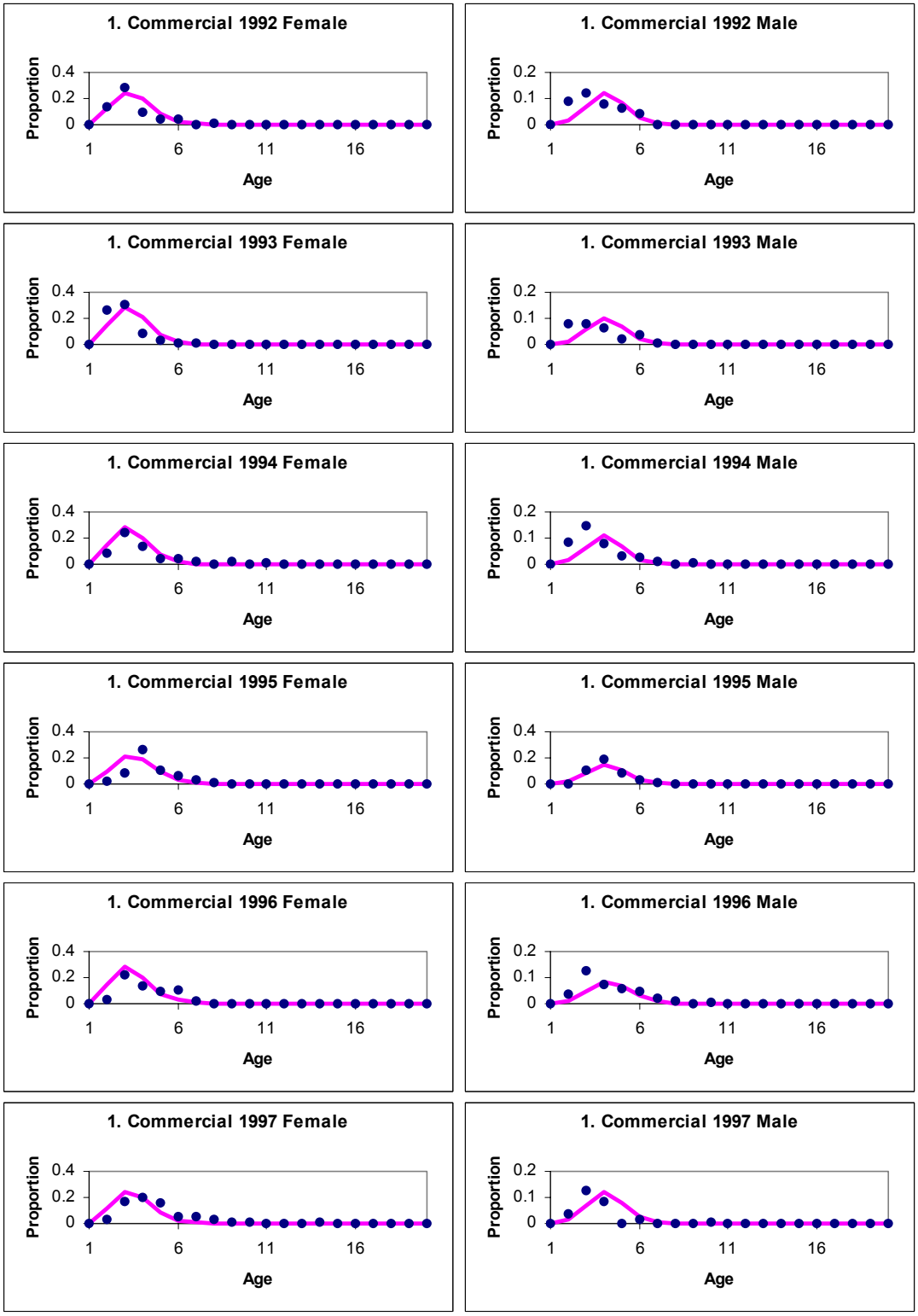


Figure 14, continued. Coleraine output for the southern area (LCS) base model: Model fits to commercial fishery catch-at-age.

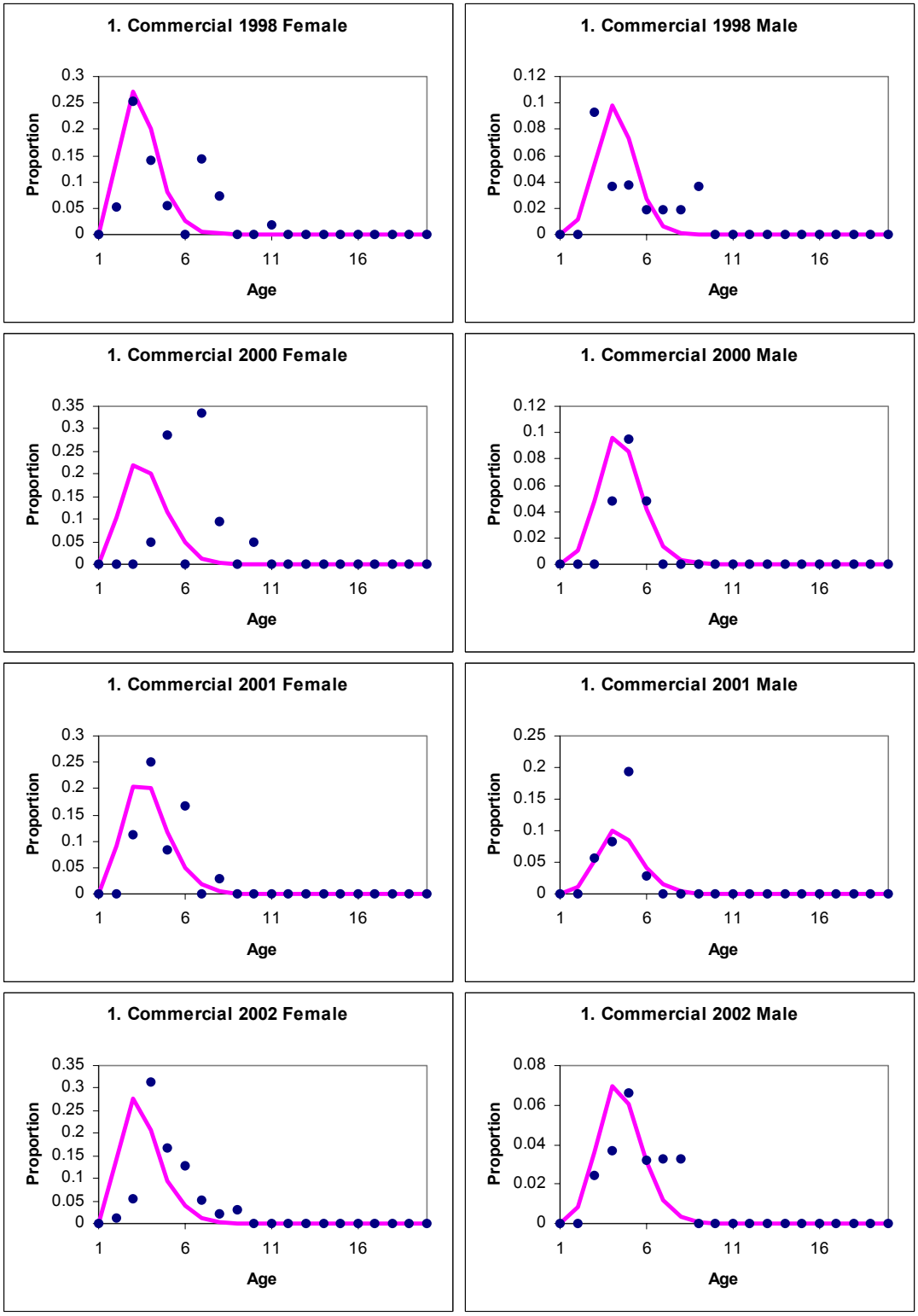


Figure 15. Coleraine output for the southern area (LCS) base model: Model fits to recreational fishery catch-at-age.

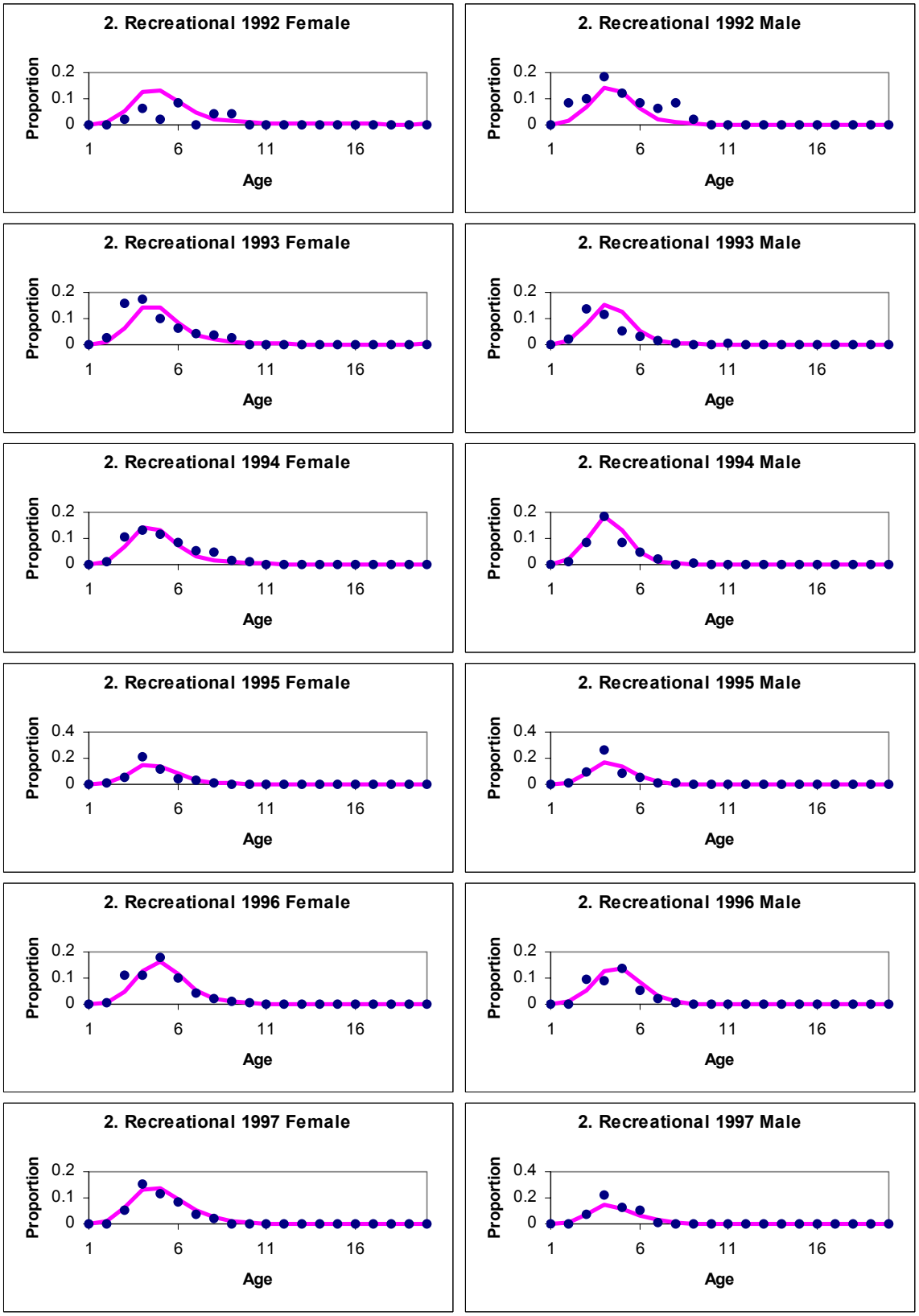


Figure 15, continued. Coleraine output for the southern area (LCS) base model: Model fits to recreational fishery catch-at-age.

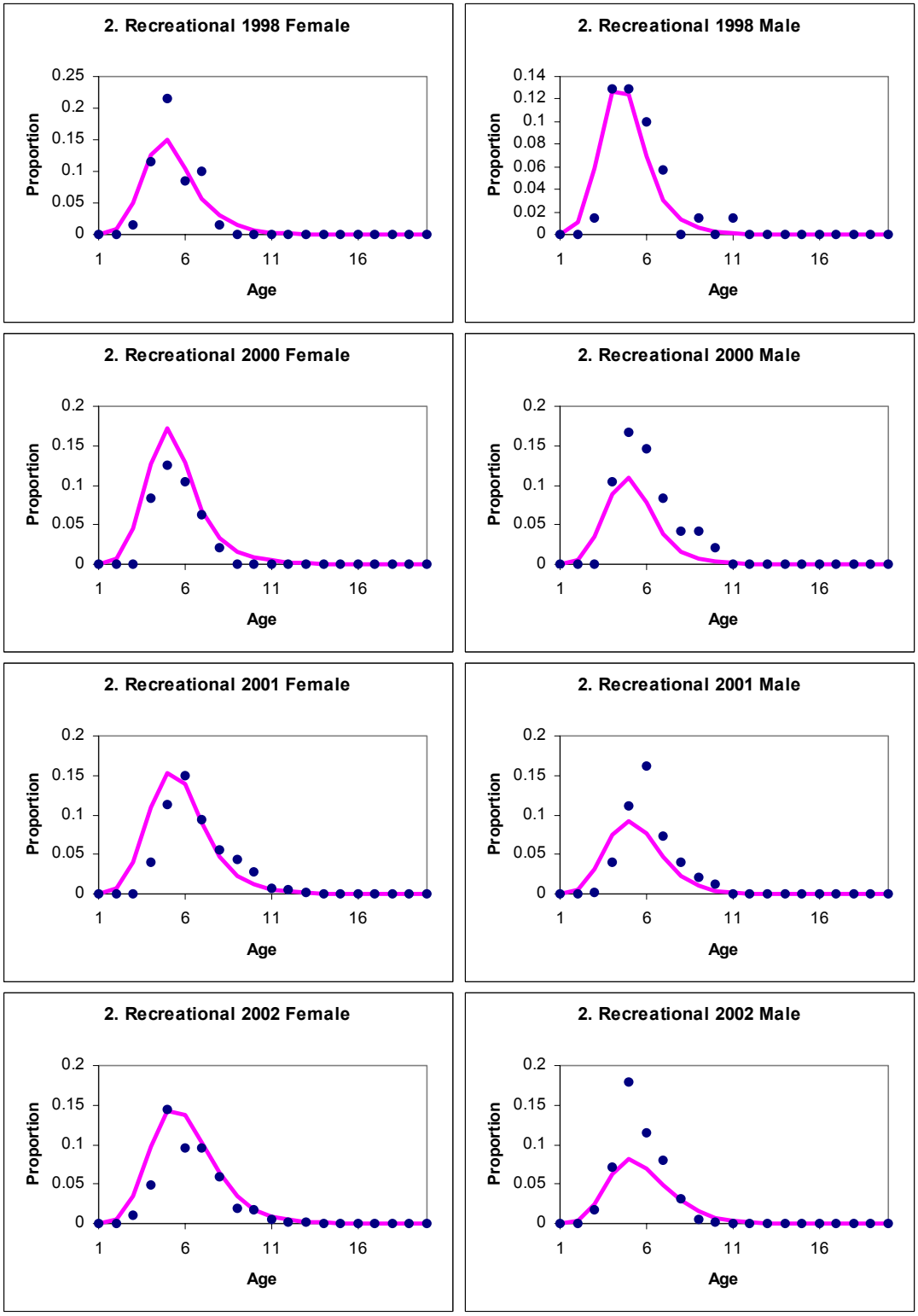


Figure 16. Coleraine output for the southern area (LCS) base model: Model fits to NMFS trawl survey catch-at-age.

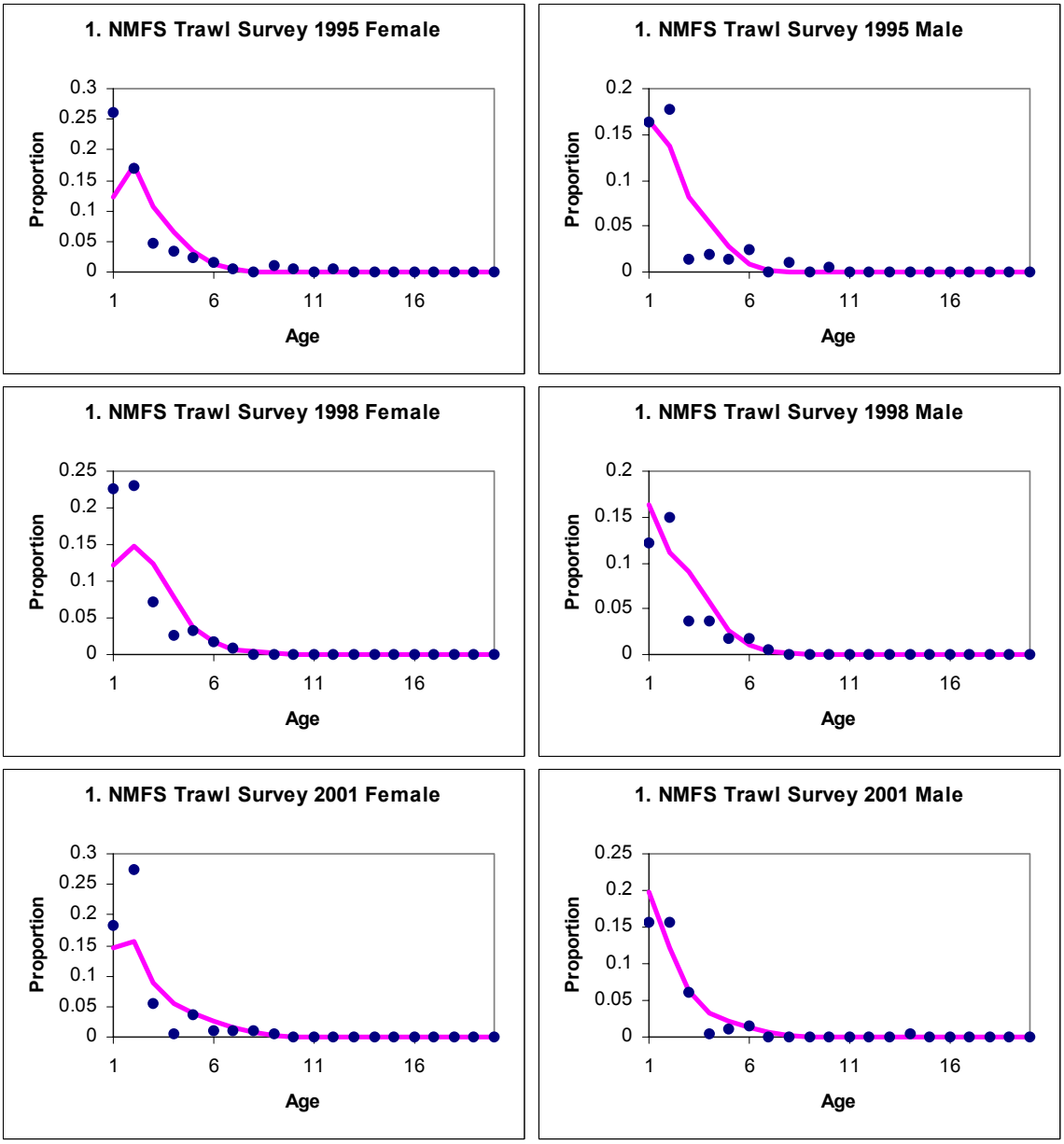
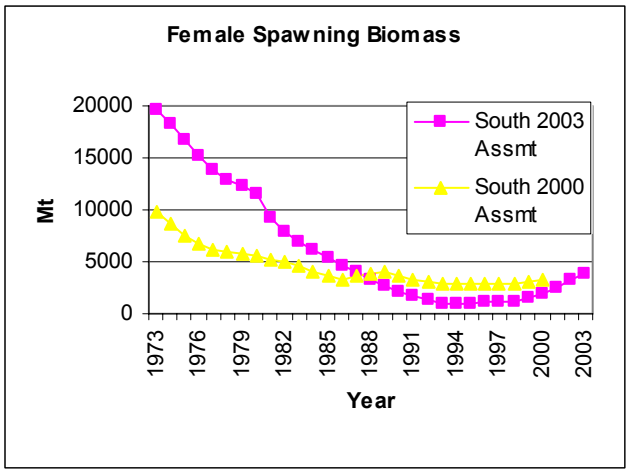


Figure 17. Coleraine output for the southern area (LCS) base model: Historical analysis comparing spawning biomass estimates from the 2003 base model with spawning biomass estimates from the 2000 base model.



Appendix II. Coastwide Lingcod Rebuilding Analysis

Assessment of Lingcod for the Pacific Fishery Management Council in 2003

Coastwide Lingcod Rebuilding Analysis

October, 2003

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History

In 1997, an assessment of lingcod prepared for the PFMC found that female spawning biomass estimates were below 25% of the unfished biomass level for the northern portion of the stock (Jagielo et al. 1997). An analysis was subsequently prepared which indicated that rebuilding to the $B_{40\%}$ level was possible within 10 years at F=0 (Jagielo 1999). Based on the analysis for the northern area, a 10 year rebuilding plan was implemented by PFMC for the entire West Coast (Washington-Oregon-California). The rebuilding plan began in 1999 and set the target date of the start of 2009 for achieving the $B_{40\%}$ spawning stock size.

Subsequently, a coastwide assessment for lingcod was completed in 2000 (Jagielo et al. 2000). The 2000 assessment provided separate estimates of spawning stock biomass for the northern (LCN: US-Vancouver and Columbia) and southern (LCS: Monterey, Eureka, Conception) areas. An updated rebuilding analysis was conducted with the 2000 stock assessment model results using the SSC default rebuilding analysis software (Punt 2001).

Recently, an updated lingcod stock assessment was conducted in 2003 (Jagielo et al. 2003) which provided new, separate estimates of spawning stock biomass for the northern (LCN) and southern (LCS) areas. The present rebuilding analysis utilizes information from the 2003 stock assessment and conforms to the SSC Terms of Reference for Groundfish Rebuilding Plans. This analysis provides new coastwide rebuilding trajectories that provide for lingcod rebuilding within the time frame originally established by PFMC in 1999.

Data and Parameters

This analysis uses the most recent version of the SSC Default Rebuilding Analysis software (Punt 2003). Six rebuilding analysis projections were produced using separate sets of information derived from the 2003 stock assessment (Jagielo et al. 2003). The six rebuilding analysis input files were: 1) a pooled, coastwide asymptotic fishery selectivity model; 2) a pooled, coastwide domed fishery selectivity model, 3) separate northern and southern area asymptotic fishery selectivity models, and 4) separate northern and southern area domed fishery selectivity models. Data inputs for each rebuilding analysis projection included: 1) spawning output by age (the product of the weight-at-age and % maturity-at-age vectors); 2) sex-specific natural mortality; 3) age specific weight (kg), selectivity, and numbers of fish for the year 2002; and 4) vectors of annual recruitment (age 1 fish) and spawning biomass estimates (1973-2002). Age specific data were input for ages 1-20+, with 20+ serving as an accumulator age. The age composition for the beginning year of the rebuilding program (T_{min}) was derived from the 2003 stock assessment model estimates of the 1999 age composition. The population projection was configured to begin in 2002 with rebuilding occurring by the start of 2009 (year 10 from the original rebuilding start year of 1999). Catches were pre-specified for 2002 and 2003, and were derived from the projections for the years 2004-2008. Estimates of B_0 were computed using random draws from recruitments estimated for 1973-2002.

It should be noted that the Coleraine estimate of depletion from the 2003 stock assessment (Jagielo et al. 2003) can differ from the estimate obtained from the rebuilding

analysis presented here, because the rebuilding analysis computes B_0 using the average of recruitments from 1973-2002, while Coleraine uses the estimate of R_0 obtained in the model according to the formula provided in Hilborn et al.(2000). Additionally, the depletion values reported for Coleraine are with reference to 2003 spawning biomass, while those reported in the rebuilding analysis are with reference to 2002 spawning biomass.

Management Reference Points

Comparison of the spawning stock estimates for 2002 with the estimates of virgin spawning stock size under the asymptotic model assumption indicate that the recent coastwide spawning population size is approximately 25% of virgin levels (Table 1). Under the domed model assumption, the estimate of depletion was similar at 24%. By contrast, the model estimates of F_{45} differed between the asymptotic ($F_{45} = 0.12$) vs. domed ($F_{45} = 0.18$) cases, indicating higher productivity under the domed fishery selectivity assumption. Consequently, projected yields under the domed model assumption tend to be higher than under the asymptotic model assumption (Table 2).

When compared to the domed fishery selectivity model, the asymptotic fishery selection model is generally more consistent with the assumptions made in the previous lingcod stock assessment (Jagielo et al. 2000) and rebuilding analysis (Jagielo and Hastie 2000). (In the 2000 lingcod assessment, all fisheries were assumed to be asymptotic, with the exception for male fishery selectivity in the northern area, which was allowed to be dome shaped.) Estimates of F_{45} for the 2003 asymptotic model (0.12-north; 0.12-south) are similar to the estimates of F_{45} from the 2000 assessment, with a slightly higher value for the south (0.12-north; 0.14-south).

Rebuilding Projections

Rebuilding projection inputs and outputs are reported for the coastwide asymptotic fishery selectivity model in Tables 3-4 and Figures 1-3. The same information for the domed fishery selectivity model is provided in Tables 5-6 and Figures 4-6. Population projections were conducted using the "recruits" in lieu of the "recruits-per-spawner" option provided by Punt (2003), which was consistent with the previous analysis (Jagielo and Hastie 2001). The basis for this choice was the lack of a credible spawner-recruit relationship for lingcod. Recruitments for the projections were randomly drawn from the values estimated from the most recent years (1986-2002) in the assessment (Jagielo et al. 2000)(Figure 2-asymptotic; Figure 5-domed).

Performance of alternative rebuilding policies

The projected coastwide yields for 2004-2008 under both the asymptotic and domed fishery selectivity assumptions are constrained by the ABC rule, for values of $P < 0.6$ (Table ES2). Coastwide ABC yield for 2004-2008 ranges from 1,820 mt to 2,053 mt for the asymptotic fishery selection model, compared to 2,141 mt to 2,123 mt for the domed fishery selectivity model.

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Table 1. Management reference points derived from the 2003 lingcod stock assessment (Jagielo et al. 2003). Alternative models included the assumption of asymptotic vs. domed fishery selectivity. Under each assumption, rebuilding projection input files were constructed for 1) coastwide (northern and southern model data pooled) and 2) northern and southern area model data separately.

	Asymptotic Fishery Selectivity			Domed Fishery Selectivity		
	Coastwide	Northern	Southern	Coastwide	Northern	Southern
FMSY proxy	0.121	0.124	0.122	0.184	0.165	0.190
FMSY SPR / SPR(F=0)	0.45	0.45	0.45	0.45	0.45	0.45
Virgin SPR	12.41	13.27	11.20	11.77	13.27	11.20
Virgin Spawning Output (mt)	36967	19434	16969	37115	19518	18848
Target Spawning Output (mt)	14787	7774	6788	14846	7807	7539
Current (2002) Spawning Output (mt)	9160	5410	3751	8931	5679	3253
Depletion ($SpBio_{2002}/SpBio_{Virgin}$)	0.25	0.28	0.22	0.24	0.29	0.17
Spawning Output (ydecl) (mt)	4203	2226	1972	4077	2464	1608

Table 2. Projected yield (mt) under model assumptions of asymptotic vs. domed fishery selectivity. Yields are shown for probability of recovery values ranging from P=0.5 to P=0.9, and for the 40-10 and ABC rules.

Model	Year	P= .5	P= .6	P= .7	P= .8	P= .9	Yr=Tmid	F=0	40-10 Rule	ABC Rule
Coastwide Asymptotic	**2004**	1843	1799	1750	1693	1631	1767	0	1429	1820
	2005	1947	1906	1859	1805	1744	1875	0	1753	1926
	2006	2006	1968	1924	1873	1816	1939	0	1970	1986
	2007	2043	2008	1967	1920	1866	1981	0	2085	2025
	2008	2069	2037	1999	1955	1904	2012	0	2102	2053
North Asymptotic	**2004**	1342	1328	1305	1285	1255	1339	0	1050	1109
	2005	1359	1346	1326	1309	1281	1356	0	1156	1149
	2006	1354	1343	1326	1311	1287	1352	0	1174	1168
	2007	1331	1322	1307	1294	1273	1330	0	1172	1168
	2008	1312	1304	1291	1279	1261	1311	0	1170	1166
South Asymptotic	**2004**	686	660	626	594	547	650	0	492	759
	2005	752	725	692	659	610	715	0	664	823
	2006	794	768	736	704	655	759	0	800	862
	2007	830	805	774	742	694	796	0	898	894
	2008	859	836	805	775	728	827	0	961	920
Coastwide Domed	**2004**	2058	2009	1962	1905	1838	2032	0	1616	2041
	2005	2135	2089	2045	1992	1930	2111	0	1966	2118
	2006	2138	2098	2058	2010	1953	2117	0	2137	2124
	2007	2139	2102	2066	2022	1969	2120	0	2182	2126
	2008	2135	2101	2067	2025	1976	2117	0	2167	2123
North Domed	**2004**	1512	1496	1478	1462	1440	1509	0	1164	1185
	2005	1477	1464	1449	1435	1416	1475	0	1198	1195
	2006	1438	1427	1414	1403	1387	1436	0	1194	1192
	2007	1376	1366	1355	1346	1332	1374	0	1165	1163
	2008	1339	1330	1320	1312	1300	1337	0	1148	1146
South Domed	**2004**	600	571	538	502	455	603	0	421	803
	2005	658	629	595	557	509	661	0	618	858
	2006	687	659	626	588	540	690	0	764	877
	2007	711	683	650	613	564	714	0	860	893
	2008	736	708	676	639	589	738	0	924	911

Table 3. Coastwide asymptotic fishery selectivity model rebuilding analysis: Input values.

Lingcod Coastwide-Asymptotic STAR Panel Final	
Created with Version 2.7b (August 2003)	
Directory	D:\
File Name	res.csv
Inputs	
Number of simulations	1000
Maximum age-class	20
Future recruits generated	from historical recruitments
Projections based on	constant fishing mortality
Economic discount rate	0.1
Defn of recovery	In or before year y
Policy after recovery	No change
Number of fleets	4
Parameter vectors	Best Estimates
Outputs	
FMSY proxy	0.12
FMSY SPR / SPR(F=0)	0.45
Virgin SPR	12.41
Generation time (yrs)	13
Minimum Rebuild Time (from ydecl)	5
Maximum Rebuild Time (from yinit)	13
Selected rebuild time (yrs)	5
Year for rebuild	2009
Virgin Spawning Output (mt)	36967
Target Spawning Output (mt)	14787
Current Spawning Output - 2002 (mt)	9160
Spawning Output (ydecl) (mt)	4203
Prob (<0.4B0) in ydecl	1
Prob (<0.25 B0) in ydecl	1
Tmin - calculation	
Year with age data (Yinit-Tmin)	1999
First zero-catch year (ydecl)	1999
Number of projected catches	0
Tmin	2004
Tmax - calculation	
Year with age data (yinit)	2002
First OY year	2004
Number of projected catches	2

Table 4. Coastwide asymptotic fishery selectivity model rebuilding analysis: Output values and recruitments used to compute B_0.

	Summary table							40-10 Rule	ABC Rule
Fishing rate	0.1225	0.1195	0.116	0.1121	0.1077	0.1172	0	0	0
OY	1842.8	1799.5	1749.7	1693.2	1630.6	1766.7	0	1429.4	1820.3
Prob to rebuild by Tmax	50.0	60.0	70.0	80.1	90.0	66.7	100.0	79.4	55.7
Median time to rebuild (yrs)	5	4.4	3.8	3.5	3.1	4	1.4	3	4.7
Prob overfished after rebuild	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Median time to rebuild (yrs)	2009.0	2008.4	2007.8	2007.5	2007.1	2008.0	2005.4	2007.0	2008.7
Probability above current spawning outptut in 100 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100
Probability above current spawning outptut in 200 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100
Probability below 0.01B0 in 100 years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Probability below 0.01B0 in 200 years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0

Recruitments (Number of age 1 fish in thousands)	Year	Recruitment
	1972	2839
	1973	2807
	1974	3152
	1975	3107
	1976	3168
	1977	3093
	1978	3462
	1979	4180
	1980	3268
	1981	3002
	1982	2348
	1983	2978
	1984	3848
	1985	5837
	1986	3333
	1987	2349
	1988	2550
	1989	2777
	1990	2976
	1991	3126
	1992	1690
	1993	2372
	1994	2437
	1995	2661
	1996	2317
	1997	2107
	1998	2901
	1999	2517
	2000	3195
	2001	2999

Highlighted values are used to compute B0

Figure 1. Coastwide asymptotic fishery selectivity model rebuilding analysis: Net spawning output and distribution of virgin biomass simulations (mt).

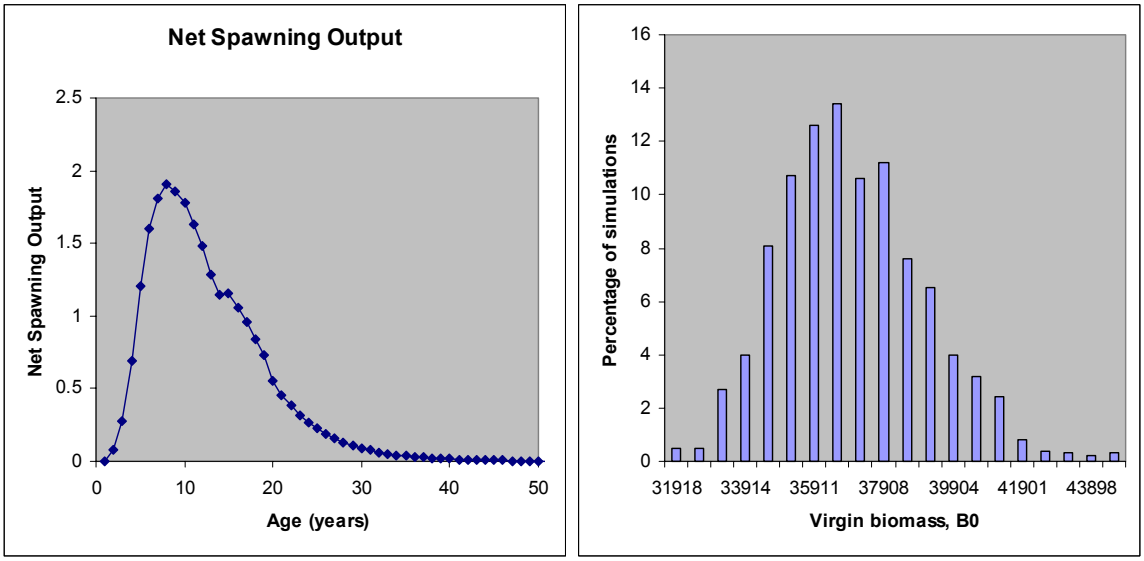

Figure 2. Coastwide asymptotic fishery selectivity model rebuilding analysis: Recruitments used for rebuilding projections (number of age 1 fish in thousands) (left) and distribution of years to rebuild (right).

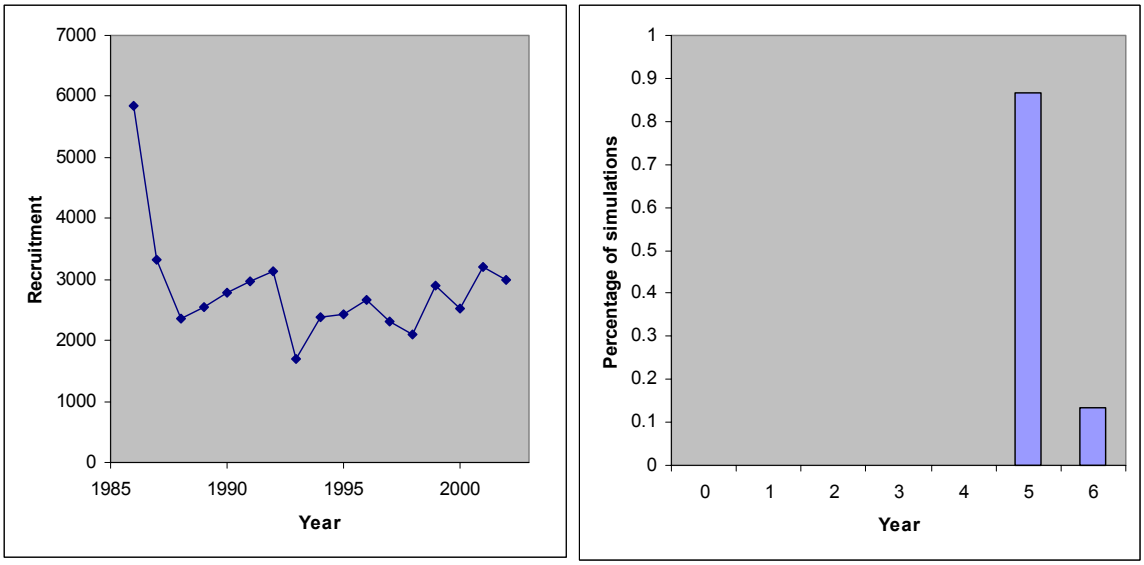

Figure 3. Coastwide asymptotic fishery selectivity model rebuilding analysis: Rebuilding trajectories showing probability above target (left) and catch (mt) (right) at selected P values.

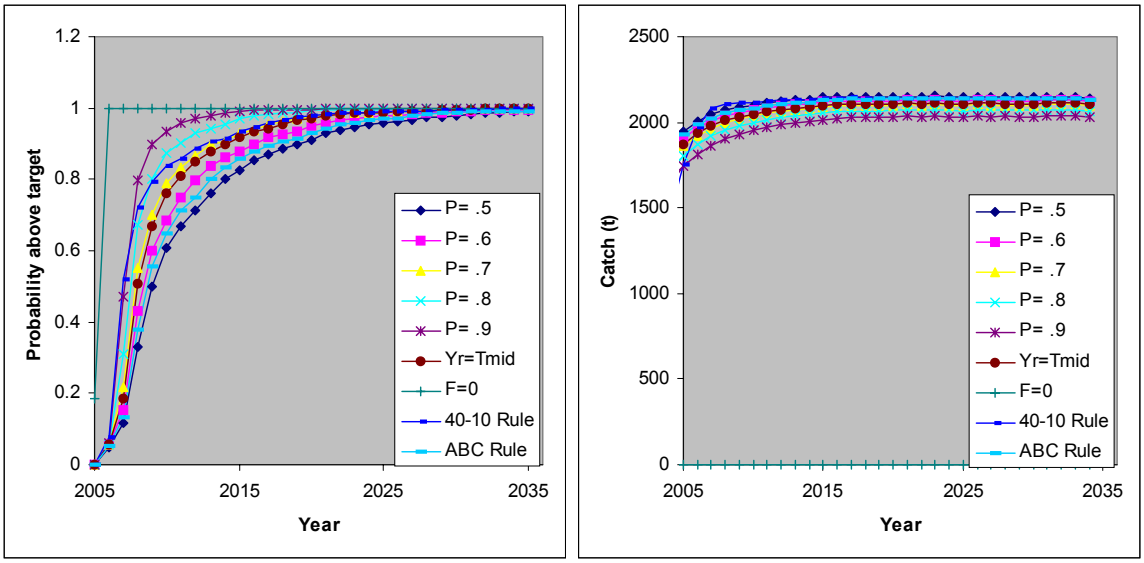

Table 5. Coastwide domed fishery selectivity model rebuilding analysis: Input values.

Lingcod Coastwide-Domed STAR Panel Final	
Created with Version 2.7b (August 2003)	
Directory	D:\
File Name	res.csv
Inputs	
Number of simulations	1000
Maximum age-class	20
Future recruits generated	from historical recruitments
Projections based on	constant fishing mortality
Economic discount rate	0.1
Defn of recovery	In or before year y
Policy after recovery	No change
Number of fleets	4
Parameter vectors	Best Estimates
Outputs	
FMSY proxy	0.18
FMSY SPR / SPR(F=0)	0.45
Virgin SPR	11.77
Generation time (yrs)	12
Minimum Rebuild Time (from ydecl)	6
Maximum Rebuild Time (from yinit)	13
Selected rebuild time (yrs)	5
Year for rebuild	2009
Virgin Spawning Output (mt)	37115
Target Spawning Output (mt)	14846
Current Spawning Output - 2002 (mt)	8931
Spawning Output (ydecl) (mt)	4077
Prob (<0.4B0) in ydecl	1
Prob (<0.25 B0) in ydecl	1
Tmin - calculation	
Year with age data (Yinit-Tmin)	1999
First zero-catch year (ydecl)	1999
Number of projected catches	0
Tmin	2005
Tmax - calculation	
Year with age data (yinit)	2002
First OY year	2004
Number of projected catches	2

Table 6. Coastwide domed fishery selectivity model rebuilding analysis: Output values and recruitments used to compute B_0.

	Summary table							40-10 Rule	ABC Rule
Fishing rate	0.1856	0.1809	0.1764	0.1709	0.1646	0.1831	0	0	0
OY	2058.2	2009.3	1961.7	1904.8	1838.3	2032.3	0	1615.9	2040.7
Prob to rebuild by Tmax	49.9	60.0	69.9	80.1	89.9	55.3	100.0	80.3	53.2
Median time to rebuild (yrs)	5	4	3.6	3	2.7	4.4	0.5	2.7	4.7
Prob overfished after rebuild	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Median time to rebuild (yrs)	2009.0	2008.0	2007.6	2007.0	2006.7	2008.4	2004.5	2006.7	2008.7
Probability above current spawning outptut in 100 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100
Probability above current spawning outptut in 200 years	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100	100
Probability below 0.01B0 in 100 years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0
Probability below 0.01B0 in 200 years	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0

Recruitments (Number of age 1 fish in thousands)	Year	Recruitment
	1972	3516
	1973	3359
	1974	3557
	1975	3967
	1976	4087
	1977	3490
	1978	3598
	1979	5104
	1980	3516
	1981	3015
	1982	2264
	1983	2935
	1984	3438
	1985	5505
	1986	3359
	1987	2554
	1988	2478
	1989	2568
	1990	2939
	1991	2991
	1992	1725
	1993	2646
	1994	2507
	1995	2719
	1996	2016
	1997	2289
	1998	2469
	1999	3437
	2000	3369
	2001	3201

Highlighted values are used to compute B0

Figure 4. Coastwide domed fishery selectivity model rebuilding analysis: Net spawning output and distribution of virgin biomass simulations (mt).

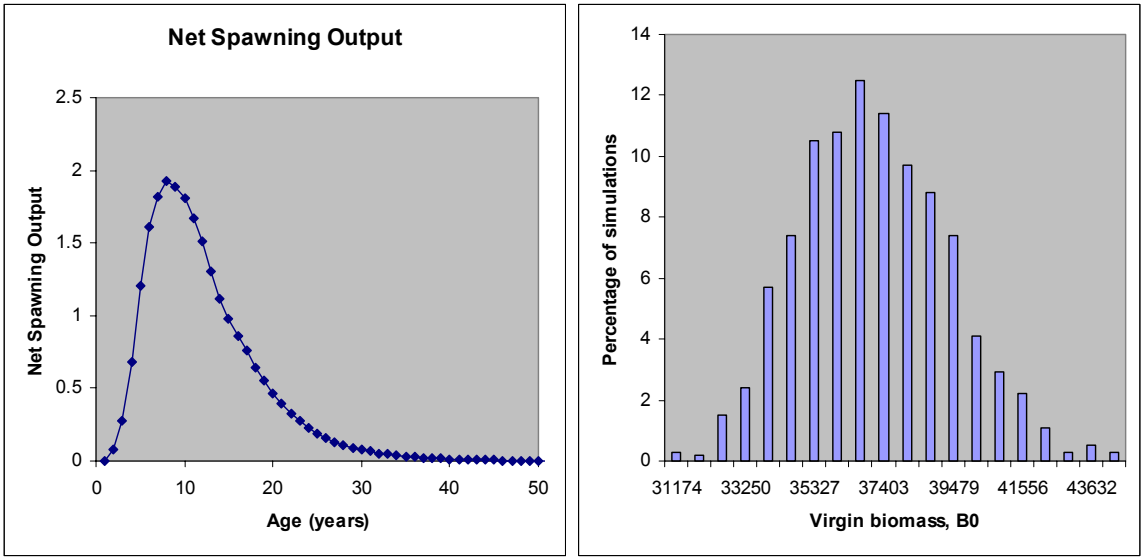

Figure 5. Coastwide domed fishery selectivity model rebuilding analysis: Recruitments used for rebuilding projections (number of age 1 fish in thousands) (left) and distribution of years to rebuild (right).

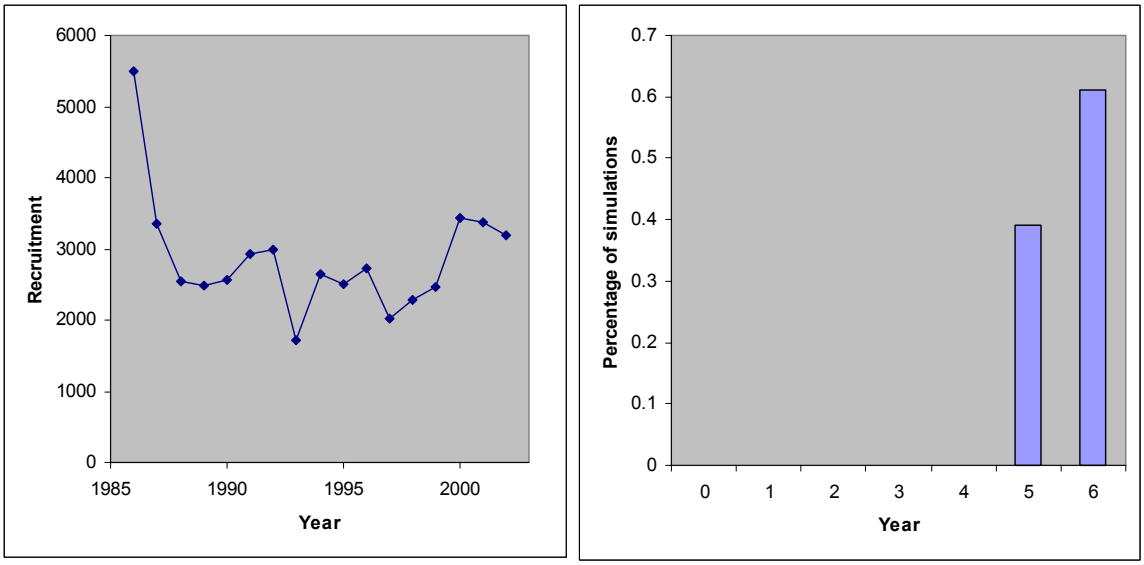

Figure 6. Coastwide domed fishery selectivity model rebuilding analysis: Rebuilding trajectories showing probability above target (left) and catch (mt) (right) at selected P values.