

CHAPTER 2

Taking Stock: Assessment of Salmon Runs on the North and Central Coasts of BC

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Misty MacDuffee sampling chinook and coho fry in a tributary of the Ecstall River. At 85,000 hectares, the Ecstall is the largest unlogged watershed on the North coast. It supports nine species of salmonids which spawn up to 96 km upstream and in more than one dozen of the watershed's tributaries and lakes.

APPROACH AND METHODS

The long term survival of salmon depends on maintaining genetic diversity, which in turn depends on adequate numbers of salmon returning to natal spawning grounds. DFO's ability to assess and manage for genetic diversity and nutrient returns were evaluated by posing 3 questions:

- Is escapement adequately monitored?
- Has DFO met its own target escapements?
- Are these escapement targets adequate to sustain ecosystem and predator requirements?

Answers to these questions will reveal DFO's successes or failure in managing for genetic diversity and nutrient returns.

The most practical way to assess fishery managers' understanding of salmon diversity is to review DFO's own database on salmon presence and trends in river systems. Such information reflects the level of on-the-ground field knowledge of metapopulations and demes. We analyze and discuss the database that contains enumerations of salmon returning to their natal streams, namely DFO's *salmon escapement database system* (SEDS). Although there are limitations to the SEDS (discussed below), there are no alternative databases for the type of assessment attempted here.

The Salmon Escapement Database System (SEDS)

DFO attempts to enumerate salmon annually, an enormous undertaking given the size and geography of the north and central coasts, and the multiple species and river systems. Coho, for example, are elusive and can stay in a given river over a long period of time. The size and depth of larger systems and the turbid nature of glacially fed rivers makes observation of fish complicated. Methods used to count fish include permanent fences, observation/visual estimations (creek-walks), fish wheels, aerial counts and swims by divers.

Escapement enumeration is an important tool used by DFO in the assessment of salmon returns and in determining harvest yields (PFRCC 1999). While DFO also uses other data to make management decisions, escapement data remain the backbone of salmon management.

While the escapement database is important, it has limitations. Knowledge of particular systems and species ranges from extensive to virtually absent. Creek-walker reports exist for some systems as far back as the turn of the century; however, these records are not in the SEDS. The present database contains escapement estimates for anadromous salmon from the 1950s to the present.

Assessment of salmon enumeration

The fact that the database starts in 1950 is unfortunate, because activities such as commercial fishing, logging and watershed development were already extensive by then. Adverse weather, changes in personnel, and inconsistent methodology can all lead to misrepresentation of the real trends in escapement, and may mask the effects of other influences such as logging and land use, over-fishing, climatic and natural variations. When enumeration data are inconsistent and incomplete, their value for precise management and assessment purposes is limited. As a result, the escapement database cannot be viewed as a truly accurate representation of salmon trends in coastal rivers and streams. However, it embodies the only collection of enumeration data on individual river runs.

Our analysis covers SEDS data from stream and river systems with DFO watershed codes in the central and north coasts (Fisheries Management Areas 3-10). The total number of systems that historically supported each species of salmon was determined using the DFO BC16 reports that catalogue spawning streams and escapements. The number so derived can only be viewed as an estimate; the actual number may be lower due to population extirpation or higher due to absence of some smaller systems and tributaries.

To evaluate the SEDS, we first analysed the database for known records of stream enumerations. In some cases this was straightforward; however, for many systems the data were too incomplete or vague even to answer the question “does a certain salmon run still exist?” Numbers and abbreviation codes used in the absence of data did not always indicate whether or not fish were present. For example, coding such as “UNKNOWN” can mean: stream not inspected, not inspected for species indicated, or fish present but none estimated (L. Godbout pers. com., DFO). Hence it was concluded that *all numbers* indicated a known presence of salmon, and that codes like NONE OBSERVED, UNKNOWN, NONE RECORDED, and NOT INSPECTED simply meant an absence of knowledge about the presence of salmon.

Once this first division was made, all systems with a *known presence* of salmon were broken down into two categories: *reliable data* and *unreliable data*. The category ‘reliable data’ was based on DFO’s list of indicator (also called ‘key’) streams which, for the most part, have been routinely enumerated. The term *Indicator Streams* is used throughout this report for systems with reliable data

that can be used for trend analysis. Based on these groupings, runs were placed into three categories:

1. **No knowledge:** there are no data on escapement
2. **Non-indicator systems:** enumeration is unreliable (for reasons noted previously) but the presence of salmon can be confirmed
3. **Indicator systems:** systems classified by DFO as indicator streams. These systems have been consistently enumerated and have data considered reliable for trends over time.

These three classifications were applied to each species in the SEDS for Fisheries Management areas 3-10.

Assessment of abundance

An important requirement for healthy salmon populations is adequate numbers of spawners to sustain the metapopulation structure and provide biomass and nutrients to the freshwater and terrestrial ecosystem. To undertake this analysis of abundance, a reliable database is required. The most reliable enumeration data on the north and central coasts come from the three systems with permanent counting fences (Plate-2-1), namely Meziadin River (Area 3), Babine River (Area 4), and Long Lake (Area 10). Even with the fences, confidence in the data varies considerably with species, ranging from very good for sockeye to very poor for coho (D. Peacock, pers. com., DFO). For the purpose of this report we expanded our sample beyond this limited number of systems to include the indicator/key streams without counting fences.

While the confidence in data from indicator streams is not as high as for fence counts, indicator streams have been routinely assessed and represent rough trends in run abundance. To review the status of salmon returns in indicator streams, we compared the escapement figures for each ten-year period since 1950 (and since 1930 where data were available) with the Management Target Escapements (MTE) established by DFO. MTE's are DFO's stream specific targets for spawning fish, based largely on professional judgment of habitat capacity and the number of fish needed to adequately seed spawning grounds. While the validity of these spawner targets can be questioned both from a productivity and ecosystem perspective, they provide a convenient and objective way to evaluate whether salmon escapements have been managed successfully to achieve baseline targets on a stream-by-stream basis.

In some of these indicator systems, DFO's enumeration visits lapsed during the 1990s. We therefore excluded data sets with less than 50% of the escapement data present over the 10-year period and classed the system as

Assessment of freshwater nutrient deficit

“unknown”. The status of all indicator runs was therefore assessed according to 4 categories:

1. **Meets Target:** 80% or more of the spawner target was met
2. **Depressed:** 40%-79% of the spawner target was met
3. **Very Depressed:** <40% of the spawner target was met
4. **Unknown:** unable to determine an average because less than 50% of the data were available.

The average escapement figures were converted into total nitrogen and phosphorous by wet weight based on the method described in Gresh and co-workers (2000). The average weights for each species for British Columbia (Table 2-1) were multiplied by the nutrient content of salmon carcasses: 3.03% nitrogen and 0.35% phosphorous (Larkin and Slaney 1997). This figure was then subtracted from the returning nutrients existing under the spawner target (used as a baseline) to determine whether a nutrient deficit exists today.

	Chinook	Coho	Sockeye	Chum	Pink
Current Weight	6.04	2.52	2.55	4.63	1.43

TABLE 2-1 Average weights (kg) of BC Pacific salmon used to determine nutrients returns. Adapted from Gresh and et al. (2000).

RESULTS: Assessment of stream enumeration records

The following graphs represent DFO's records of salmon stream enumeration on the north and central coasts. It is important to remember that this section evaluates the extent of DFO's on-the-ground knowledge of returning salmon. *The graphs do not represent trends in abundance; they represent trends in the number of enumeration visits.* Actual abundance of fish is evaluated in the following section ('assessment of abundance').

The north coast includes Fisheries Management Area 3 (Nass region), Area 4 (Skeena region) and Area 5 (Grenville/Principe). The central coast includes Fisheries Management Area 6 (Butedale), Area 7 (Bella Bella), Area 8 (Bella Coola), Area 9 (Rivers Inlet) and Area 10 (Smith Inlet).

PLATE 2-I

The counting fence at Long Lake in Smith Inlet (Area 10) is one of three permanent fences on the north and central coasts. This method of enumeration provides the most accurate escapement data.

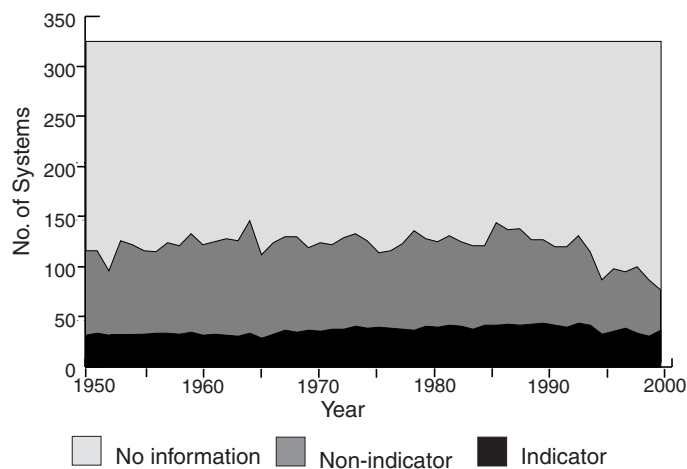


Sockeye

Sockeye enumeration

There are 320 sockeye systems on the north and central coasts that have been identified by DFO. Figure 2-1 shows the categories of enumeration records in these systems between 1950 and 1999. Escapement data considered reliable by DFO exist for 12% of these systems which are classed as indicator streams. A cutback in enumeration of sockeye has occurred primarily in the non-indicator streams. Generally, enumeration visits to sockeye streams began declining in the mid-1980s. A breakdown of the results for the north and central coasts follows.

FIGURE 2-1
Sockeye
enumeration
records for the
north and central
coasts.



North coast

On the north coast, monitoring of indicator systems has stayed relatively constant. These indicator systems comprise 10% of the sockeye river systems on the north coast.

AREA 3 (*Nass*) has the fewest sockeye systems ($n=28$), 5 of which are indicator streams. Since 1993, 4 indicator systems have been enumerated. Enumeration visits to non-indicator systems peaked in 1977 ($n=6$). Since then, there has been a gradual decline to 0. No enumeration of the non-indicator streams was done from 1993-1999.

AREA 4 (*Skeena*) has the most sockeye systems on the north coast ($n=111$), 9 of which are indicator streams. Enumeration of the indicator systems has remained consistent. Enumeration visits to the non-indicator systems received the greatest effort on the north coast (peak was 43 non-indicator systems in 1978). However, between 1987 and 1999 visitations declined to 14 systems.

Sockeye

AREA 5 (*Grenville/Principe*) contains 41 sockeye systems, 4 of which are indicator streams. Over the last decade an average of 3 of these indicator systems were enumerated. Enumeration visits to non-indicator systems peaked in 1968 (n=18). Since then, enumeration has declined. Five non-indicator systems were visited in 1999.

Central coast

There are 140 sockeye systems on the central coast, 35% of which (n=50) have enumeration records. Enumeration visits to indicator systems have stayed relatively constant over the last 50 years. Enumeration of about 31 non-indicator systems began to decline in the mid-1980s. Twelve systems were being enumerated by the end of the 1990s.

AREA 6 (*Butedale*) has 60 sockeye systems, 2 of which are indicator streams. Enumeration of non-indicator systems peaked in 1986 at 23. This declined to 8 systems by 1999.

AREA 7 (*Bella Bella*) has 34 sockeye systems, with no indicator streams. Up to 16 systems were enumerated until 1989. Stream visitations fell to 4 systems by 1999.

AREA 8 (*Bella Coola*) has 23 sockeye systems, 6 of which are indicator systems. Enumeration of the 6 indicator systems was constant up until the mid-1990s, but an average of only 3 indicator systems were enumerated since 1995. Very little enumeration of the non-indicator systems was done prior to the 1970s. Since then, an average of 3 systems have been visited; however, no stream enumeration was done in 1999.

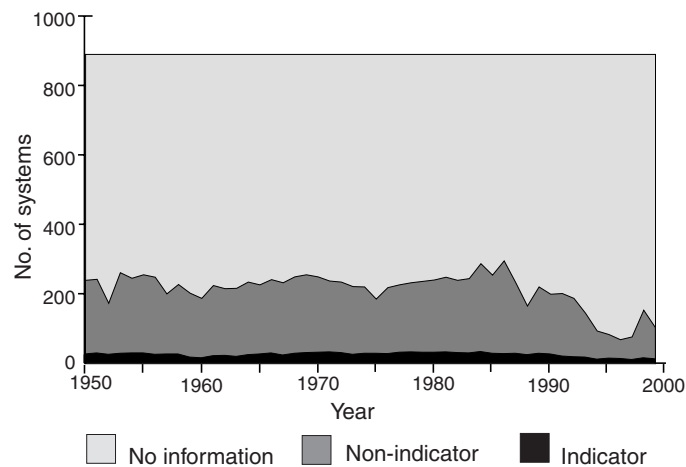
AREAS 9 AND 10 (*Rivers and Smith Inlets*) contain 16% (n=23) of the sockeye systems on the central coast but comprise 64% of DFO's reliable knowledge of sockeye escapements. Thus, there is a heavy weighting of indicator systems in these 2 areas. They have been enumerated consistently over time.

Coho

Coho enumeration

While more streams support coho than any other salmon species on the coast (n=891), knowledge of coho within these systems is the poorest for all species. Figure 2-2 shows the enumeration trend between 1950 and 1999. Overall, 23% of the coho systems were enumerated. Less than 4% (n=33) of the systems have reliable escapement data from indicator systems.

FIGURE 2-2
Coho enumeration records for the north and central coasts.



Cutbacks in coho enumeration have occurred widely. Eleven (33%) of coho indicator systems were visited in 1999, a 50% drop in visitation since 1990. Enumeration of non-indicator systems dropped even more dramatically, from 265 systems in 1986 to 52 systems by 1996, with an increase to 88 systems in 1999. A breakdown of results for the north and central coasts is as follows.

North coast

AREA 3 (*Nass*) has 138 coho systems, 14 of which are indicator streams. Prior to 1975 very few indicator systems were regularly enumerated. Enumeration visits increased to about 11 systems between 1975 and 1990 and then dropped to 5 systems in the 1990s. There has been an equal decline in visitations to non-indicator systems. Monitoring fell from an average of 26 to 2 systems since the mid-1980s, representing 1% of non-indicator coho systems in Area 3.

AREA 4 (*Skeena*) has the most coho systems on the north coast (n=321). Enumeration of 9 indicator streams was fairly consistent until the mid-1970s. By 1999, 6 indicator coho systems were being enumerated. An average of 58 non-indicator systems were visited until the 1990s, declining to 36 systems by the end of the decade (record low was 16 systems in 1996).

Coho

AREA 5 (*Grenville/Principe*) contains the fewest coho systems on the north coast (n=79) and has no indicator streams. Enumeration of the 79 non-indicator streams was as high as 49 systems until 1990, when a serious decline in visitations began. Since 1990, enumeration has been very poor, with no stream visits occurring in some years (1995 and 1996, average 1994-1999=2).

Central coast

Enumeration records for central coast coho are poor, due both to the small number of indicator streams and cutbacks in enumeration. By 1999, virtually no enumeration information was being collected on coho from indicator streams. There is a sharp decline in visits to non-indicator streams in the mid-1980's.

AREA 6 (*Butedale*) has the most coho systems on the central coast (n=184), 3 of which were enumerated as indicator streams until the early 1990s. Since then, enumeration has been inconsistent, with some years receiving no visits at all (1993, 1994, 1997, 1999). Enumeration of the non-indicator streams was fairly consistent between 1965 and 1985 with an average of 50 systems visited. Enumeration visits fluctuated downward from a high in 1986 (n= 90) to a low of 30 in 1999.

AREA 7 (*Bella Bella*) has 62 coho systems with no indicator streams. Enumeration of about 30 systems occurred until 1970, when visitations began to decline. By the mid-1990s, an average of 2 systems were being visited. There was a marginal improvement in 1999 with 10 systems visited.

AREA 8 (*Bella Coola*) has 57 coho systems, 5 of which are indicator streams. Enumeration of the indicator systems was fairly consistent until the early 1990s when it dropped to 1 system and then to none after 1995. Enumeration visits to non-indicator systems peaked in 1976 (n=16). There has been a gradual decline in enumeration to an average of 4 systems in the 1990s.

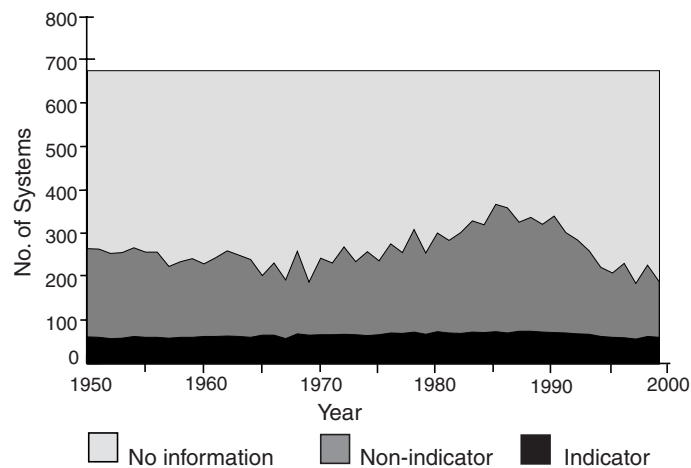
AREA 9 (*Rivers Inlet*) has 34 coho systems, with 1 indicator stream. This indicator system was enumerated until 1990 and has only been visited once between 1989-1999. Enumeration of the remaining systems peaked in 1986 (n=18). Since then, monitoring fell as low as 0 during the 1990s (1991, 1992, 1995-97). On average, 3% of the coho systems in area 9 were enumerated in the 1990s.

AREA 10 (*Smith Inlet*) has the fewest coho systems on the central coast (n=16), with only 1 indicator stream. This indicator system was enumerated only once (1993) between 1990-1999. Three non-indicator systems were enumerated until 1985. Since then, monitoring has dropped as low as 0 in several years. There were no systems visited in area 10 in 1991, 1992, and 1994-1997.

Pink

Pink enumeration

FIGURE 2-3
Pink enumeration records for the north and central coasts.



About 10% of pink systems have reliable enumeration records from indicator streams. Enumeration of non-indicator systems has declined, from a peak of 295 in 1985 to a low of 130 by 1999.

North coast

There are 342 pink systems on the north coast. Enumeration of 36 indicator streams stayed relatively constant until 1990. These indicator streams represent about 11% of all pink systems. Since 1990, enumeration of indicator streams on the north coast dropped by 26%. Generally, enumeration of indicator streams in areas 3 and 5 peaked during the 1980s and then declined slightly during the 1990s. Enumeration of indicator streams in Area 4 has stayed more consistent (n=8) since the 1950s. Enumeration of non-indicator systems peaked at 36% (n=123) of systems in the 1980's and declined to 11% by 1999 (n= 39).

Central coast

There are 332 pink systems on the central coast. Enumeration of 30 indicator streams has been consistent over time. These indicator streams represent 9% of the pink systems on the central coast.

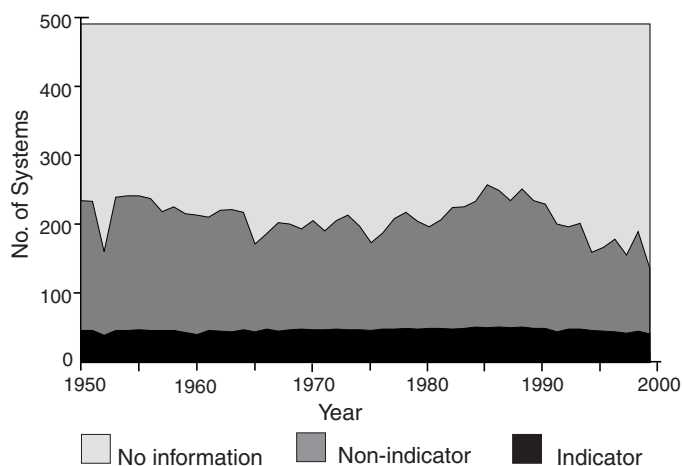
Enumeration of the 302 non-indicator streams fluctuated until the 1970s, peaked in the mid-1980s with visits reaching 52% (n=174). This declined through the 1990s (27% by 1999; n=91). Areas 6, 7 and 8, which have the highest number of pink systems, have had the most consistent enumeration (e.g. Area 6 peaked in the mid-1980s at 61%; n=97).

Chum

Chum enumeration

There are 492 chum systems in the north and central coasts that have been identified by DFO. Figure 2-4 shows the categories of chum enumeration records in these systems between 1950 and 1999. Chum enumeration is one of the most consistent for all salmon species at about 33%. Nevertheless, enumeration visits declined from 208 systems in 1985 to 96 systems by 1999. Enumeration of the indicator systems (10%) remained fairly constant between 1950 and 1999.

FIGURE 2-4
Chum enumeration records for the north and central coasts.



North coast

There are 173 chum systems on the north coast, 17 of which are indicator streams. Generally, enumeration of the indicator systems was consistent from 1950s to 1990, until a decline in monitoring began, falling from 17 systems in 1990 to 10 in 1999. Enumeration of non-indicator systems peaked at 44 systems in the late 1980s and declined to 11 in 1999.

AREA 3 (Nass) has 53 chum systems, 10 of which are indicator streams. Enumeration of the indicator systems fluctuated at around 9-10 systems until the late 1980s and then dropped to 7 or 8 systems during the 1990s. Enumeration of the non-indicator systems ranged between 9 and 14 systems until the early 1980s when a decline began. In 1999, only 2 (4%) of the non-indicator chum systems were enumerated.

AREA 4 (Skeena) has 59 chum systems, 4 of which are indicator systems. Enumeration of the indicator streams was sporadic prior to 1965. Enumeration of all indicator systems was consistent until the late 1990s. Declines in enumeration resulted in only 1 system visited in 1999. Enumeration of the non-indicator system in Area 4 fluctuated between 9-19

Chum

systems until the early 1990s, when visitations dropped to between 3 and 9 systems. Only 6% (n=3) of non-indicator systems were enumerated in 1999.

AREA 5 (*Grenville/Principe*) has 61 chum systems, 3 of which are indicator streams. Enumeration of the indicator systems was consistent until the 1990s, when visitations declined. In 1999, only 1 indicator chum system was visited. Enumeration of the non-indicator systems in Area 5 reached 50% (n=30) in the 1960s, then began to decline. Only 10% of systems (n=6) were visited in 1999.

Central coast

There are 319 chum systems on the central coast with Area 6 having the most streams (n=148) and the greatest enumeration effort. Enumeration of the 32 indicator systems in Areas 6-10 stayed fairly constant until the 1980s, and did not exhibit the pronounced decline in visitations that has occurred in all other species.

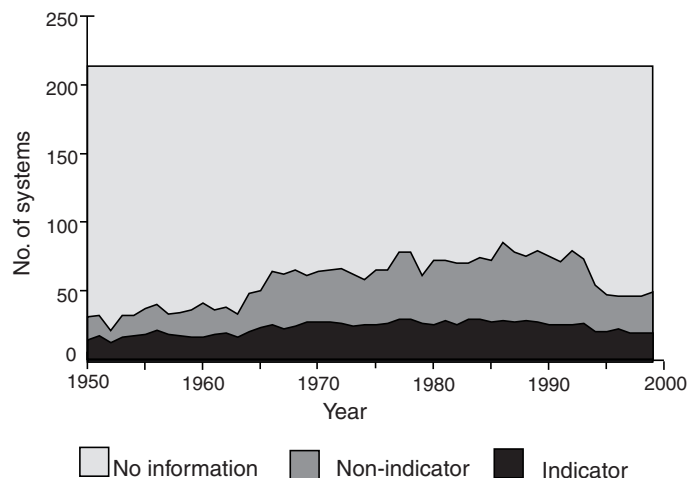
Enumeration of the non-indicator systems in Area 6 peaked in the 1950s (n=91) and 1980s (n=89) when about 30% of the systems were being visited. Enumeration in Areas 7, 8 and 9 fluctuated before peaking in the 1980s, when 40-50% of the chum systems were being visited. Visitation in all areas declined in the 1990s dropping to 25-30% of the non-indicator chum systems visited.

Chinook

Chinook enumeration

There are 215 chinook systems on the north and central coasts that have been identified by DFO. Figure 2-5 shows the categories of enumeration records for these systems between 1950 and 1999. Escapement data considered reliable by DFO exists for 13% of the systems. Enumeration visits in the non-indicator systems rose during the 1950s and 1960s to around 45 systems, then declined during the 1990s.

FIGURE 2-5
Chinook
enumeration
records for the
north and central
coasts.



North coast

AREA 3 has 44 chinook systems, 11 of which are indicator streams. Enumeration of the 11 indicator streams rose between 1950 to the 1980s, when visitations leveled at around 10. Visitations dropped to 4 systems by the end of the 1990s. Enumeration of the non-indicator systems was low during the 1950s and increased to 9 systems in the 1980s. Since the early 1990s, enumeration visits declined with very few systems visited in the late 1990s (n=2).

AREA 4 has the greatest number of chinook systems (n=103), 6 of which are indicator streams. Enumeration visits to these indicator streams has stayed consistent since the 1970s. Enumeration visits to non-indicator streams was initially poor, then rose steadily through the 1980s and 1990s to peak at 36 systems. Visitations then declined to 18 systems (1999).

AREA 5 has only 1 chinook system.

Central coast

There are 67 chinook systems on the central coast, 10 of which are indicator systems. Enumeration of the indicator streams has varied in different management areas.

Chinook

AREA 6 has 27 chinook systems with 4 indicator streams. Enumeration of Area 6 systems has been the most consistent, with indicator streams regularly visited since the 1950s. Enumeration of the non-indicator streams has fluctuated around 5 systems or 19%.

AREA 7 has 5 chinook systems but no indicator streams. The 5 streams received little enumeration prior to 1986. Only 2 systems were visited between 1986 and 1990. Only 1 system was visited between 1990 and 1995. There was no enumeration information gathered on chinook escapement in Area 7 in 1998-99.

AREA 8 has 18 chinook systems, 2 of which are indicator systems. The monitoring of the 2 indicator systems has stayed fairly consistent. Very little monitoring of the 16 non-indicator systems occurred prior to 1980. Between 1980 and 1992, an average of 3 non-indicator systems was being visited. From 1992 to 1997 only 1 system was visited and, since 1997, no non-indicator streams were visited.

AREA 9 has 14 chinook systems, 2 of which are indicator streams. Enumeration of the 2 indicator streams fluctuated between 1 and 2 since the 1950s. Very few of the 12 non-indicator systems were visited prior to 1965. Between 1965 and 1990 an average 4 systems were visited. Since then, monitoring has fluctuated between 1 and 5 systems, dropping to 0 in the 1990s.

AREA 10 has only 3 systems that support chinook. Enumeration of the 2 indicator systems has fluctuated over the past 50 years.

SUMMARY

Between 1950 and 1999 approximately 30% of the north and central coasts' salmon systems were enumerated. Of this 30%, 20% are non-indicator systems with data considered too unreliable (by DFO) to represent trends over time. Over the past fifty years, reliable data on trends in abundance exist for only 10% of the north and central coasts salmon systems.

There has been a 47% decline in enumeration of salmon streams between 1985-1999 (Table 2-2). This reduction varies widely between species and management areas.

There has been a 47% decline in enumeration of salmon streams between 1985-1999 (Table 2-2). This reduction varies widely between species and management areas. Coho on the central coast has had the greatest reduction in enumeration within both indicator and non-indicator systems (100% and 67% respectively). As such, the status of coho escapement on the central coast is simply unknown. Overall, coho enumeration can only be described as scanty, with reliable data being collected from only 2% of coho systems. Chum on the north coast have had the second largest decrease in enumeration with a reduction of 41% in indicator systems and 73% in non-indicator systems. The reduction in enumeration effort between 1985 and 1999 is shown in Table 2-2. The status of enumeration in 1999 for each species by area is shown in Table 2-3.

TABLE 2-2
The reduction in stream visitation between 1985 and 1999 in indicator and non-indicator systems on the central and north coasts.

Declines in visitations on the North Coast				Declines in visitations on the Central Coast			N and C Total Reduction (%) in visits
Species	Indicator	Non-indicator	Total	Indicator	Non-indicator	Total	
Sockeye	9%	54%	41%	14%	75%	55%	48%
Coho	35%	50%	48%	100%	67%	70%	60%
Pink	26%	68%	57%	6%	48%	41%	48%
Chum	41%	73%	64%	6%	49%	42%	47%
Chinook	31%	30%	30%	27%	37%	33%	32%

The areas with the most information on escapement are Areas 3, 4, 9 and 10. Areas 6, 7 and 8 on the central coast and Area 5 on the north coast have been poorly enumerated. Sockeye, coho and chinook have received the least effort within these areas. Area 7 (Bella Bella) has very poor representations for indicator systems and has the lowest level of enumerations.

TABLE 2-3
Summary of
stream visitation
in Management
Areas 3-10
between
1990-1999.

Area	Species	# of systems	# of indicator systems	Average # indicator systems enumerated 1990-99	Average # non-indicator systems enumerated 1990-99	Percentage of systems visited 1990-99
3	Sockeye	28	5	5	1	26
3	Coho	138	14	6	5	9
3	Pink	95	14	14	16	32
3	Chum	53	10	8	6	25
3	Chinook	44	11	7	3	23
4	Sockeye	111	9	9	26	38
4	Coho	321	9	7	39	14
4	Pink	163	8	8	34	26
4	Chum	59	4	4	9	22
4	Chinook	103	6	6	25	30
5	Sockeye	41	4	3	7	20
5	Coho	79	0	0	10	13
5	Pink	84	14	11	18	35
5	Chum	61	3	2	10	20
5	Chinook	1	0	0	0	0
6	Sockeye	60	2	1	12	22
6	Coho	184	3	1	40	22
6	Pink	148	10	10	62	46
6	Chum	158	7	7	59	45
6	Chinook	27	4	3	5	30
7	Sockeye	34	0	0	7	21
7	Coho	62	0	0	13	21
7	Pink	69	12	11	23	49
7	Chum	80	11	10	27	46
7	Chinook	5	0	0	1	20
8	Sockeye	23	6	4	3	30
8	Coho	57	5	1	4	7
8	Pink	61	3	3	21	39
8	Chum	58	6	6	19	43
8	Chinook	18	2	2	2	22
9	Sockeye	18	12	11	0	67
9	Coho	34	1	0	1	3
9	Pink	35	3	3	8	34
9	Chum	22	5	5	6	50
9	Chinook	14	2	2	2	29
10	Sockeye	5	2	2	0	40
10	Coho	16	1	0	1	6
10	Pink	9	3	2	0	22
10	Chum	11	4	4	0	36
10	Chinook	3	2	1	0	33

RESULTS: Assessment of abundance

Appendix I summarizes the following information for indicator systems in the north and central coasts by species for 1950-1999 (in some cases from 1930-1999):

- Name of system
- DFO's Management Target Escapement goal (MTE) or "spawner target"
- average escapement achieved for each decade
- percent of spawner target achieved
- last year spawner target was achieved
- status of the run by species for each decade
- N and P nutrient deficit since 1990

While DFO's *indicator streams* were selected for their consistent enumeration effort, the previous section identified lapsed visitations to many of these systems since 1985. Hence, indicator systems with enumeration visits that dropped more than 50% over a 10-year period were classed as 'unknown'. This inconsistency in the number of systems is apparent in many graphs.

Sockeye

Abundance of sockeye salmon

There are 320 systems on the north and central coasts that historically supported sockeye. Forty of these systems are considered indicator streams (by DFO) with reliable escapement data. Figure 2-6 shows the distribution of these systems over Management Areas 3-10. DFO’s choice of indicator systems is biased toward areas with more important commercial fishing zones and runs. This gives rise to information gaps in run diversity and abundance in other areas. Based on average escapement for the 40 indicator sockeye systems from 1990-99, 20 systems are classed as *very depressed*, 9 as *depressed*, 8 as *meeting targets* and 3 as *unknown* (Figure 2-7).

FIGURE 2-6
Distribution of sockeye systems showing indicator and non-indicator systems by area.

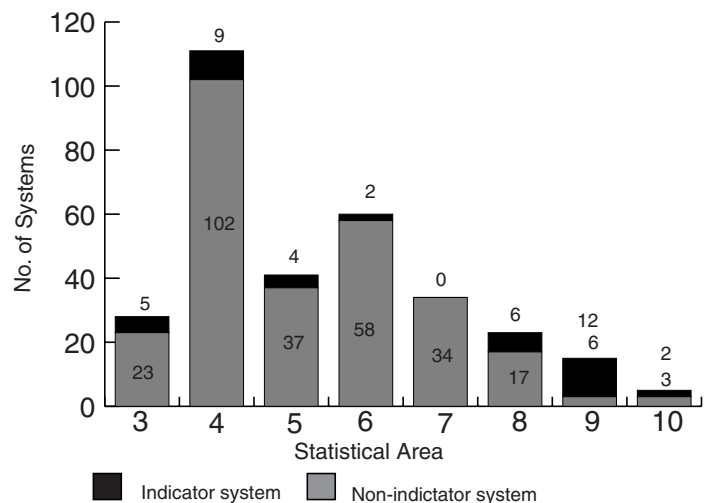
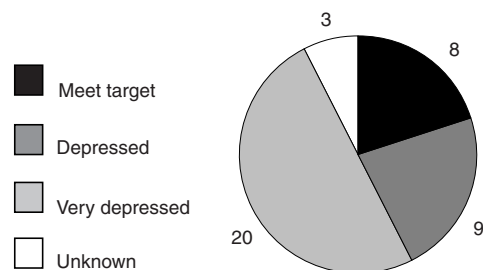


FIGURE 2-7
Status of sockeye systems on the north and central coasts, 1990-1999.



Sockeye

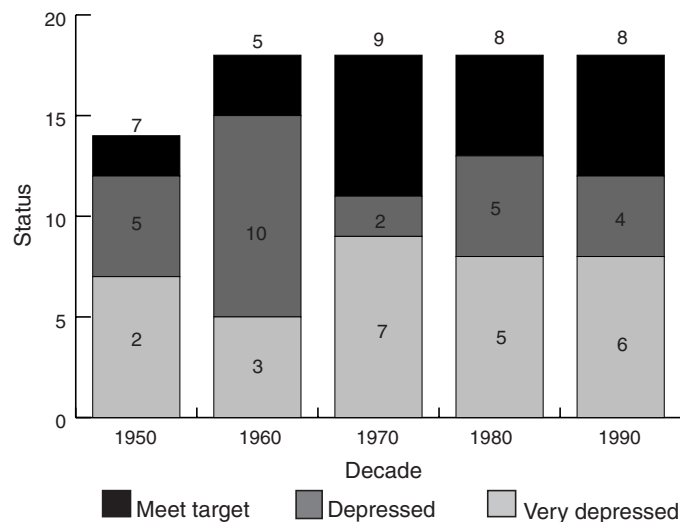
North coast

Eighteen of the sockeye indicator systems are on the north coast. Between 1990-99, 6 systems were classed as *very depressed*, 4 as *depressed* and 8 as *meeting targets*. 56% of sockeye systems are thus currently classed as *depressed* or *very depressed*. When these results are compared to the status of systems in the 1980s,

- 13 systems are unchanged (7 *meeting targets*, 2 *depressed*, 4 *very depressed*)
- 2 systems improved, and
- 3 systems deteriorated.

Figure 2-8 shows the status of these indicator systems since 1950 (also Appendix I, Table 1). Although the number of systems meeting their spawner targets has remained fairly constant, there has been an increase in the number of *very depressed* systems since the 1970s, especially in Areas 3 and 4. While Area 4 shows the highest number of systems *meeting targets*, this is largely driven by the spawning channels in the Babine Lake Development Project (BLDP). Area 5 shows an increase in *depressed* systems over the last 2 decades.

FIGURE 2-8
Changes in the
status of sockeye
indicator systems
on the north coast
from 1950-1999.



Sockeye

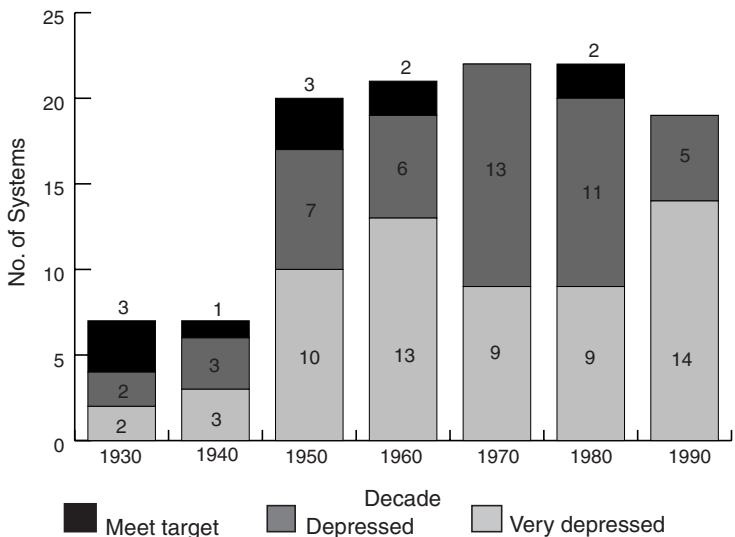
Central coast

There are 22 indicator sockeye systems on the central coast. For the 1990-99 period, 14 systems are classed as *very depressed*, 5 as *depressed*, none as *meeting targets* and 3 as *unknown*. When the *unknown* systems are excluded, all of the sockeye systems on the central coast are classed as *depressed* or *very depressed* in the 1990s. The 3 *unknown* systems appear to be remnant runs of fewer than 100 fish. When these results are compared to the status of systems in the 1980s,

- 9 systems are unchanged (3 *depressed*, 6 *very depressed*)
- no systems have improved
- 10 have deteriorated, and
- 3 have become *unknown*.

Figure 2-9 shows changes in central coast sockeye escapement over time (data prior to 1950 are available for Areas 6 and 8 only). Overall, very few systems have been achieving their spawner targets. Over the last 3 decades, the only 2 systems to reach their spawner targets were Smokehouse and Canoe Creek in Area 10. Since the 1930s, there has been an overall decline in the status of these systems (Appendix I, Table 1). 100% of sockeye systems on the central coast were classed as *depressed* or *very depressed* during the 1990s.

FIGURE 2-9
Changes in the
status of sockeye
indicator systems
on the central
coast from
1930-1999.

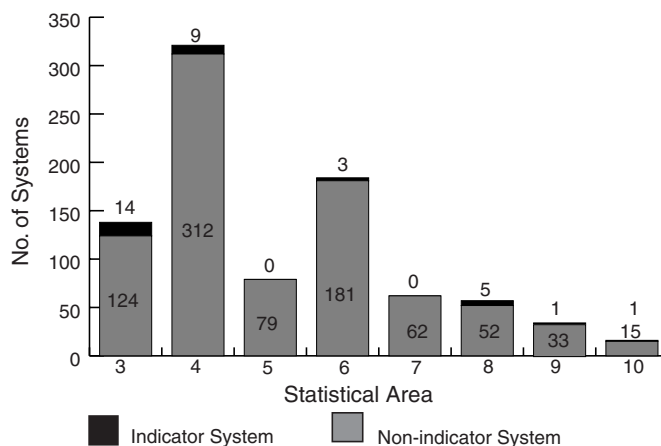


Coho

Abundance of coho salmon

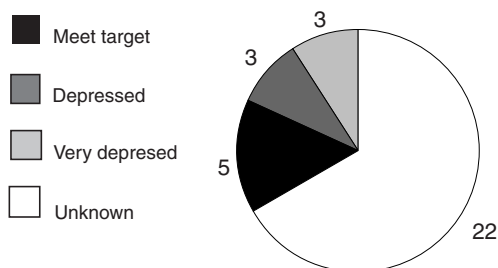
Coho enumeration on the north and central coasts is poor. Of all salmon species, coho are found in the greatest number of river systems, but have received the leastest enumeration effort. There are 891 coho systems, 33 of which are considered indicator streams. The majority of the indicator streams are on the north coast (n=23) with 10 on the central coast (Figure 2-10).

FIGURE 2-10
Distribution of
coho systems
showing indicator
and non-indicator
systems by area.



A review of the 1990s enumeration data of the 33 indicator systems shows 3 systems classed as *very depressed*, 3 as *depressed*, 5 as *meeting targets* and 22 as *unknown* (Figure 2-11). The 22 *unknown* are a result of reductions in enumeration. As a result, only 11 indicator systems have reliable escapement data for our analysis.

FIGURE 2-11
Status of coho
systems on the
north and central
coasts, 1990-1999.



Coho

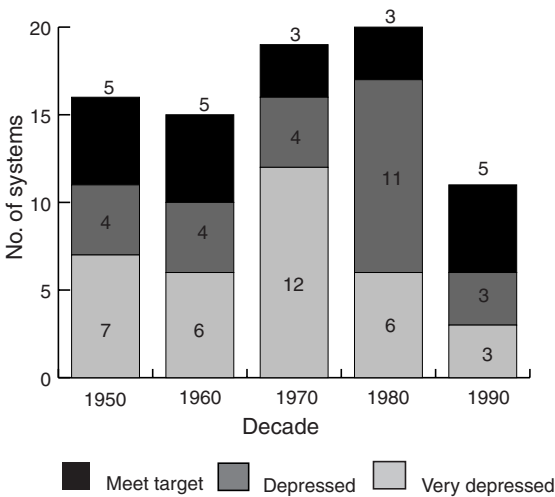
North coast

Of the 23 indicator systems on the north coast, 3 are classed as *very depressed*, 3 as *depressed*, 5 as *meeting targets* and 12 *unknown*. When the *unknown* systems are excluded, 54% of the north coast coho systems are classed as *critical* or *depressed*. When compared to the status of the systems in the 1980s,

- 8 systems are unchanged (1 *meeting targets*, 2 *depressed*, 2 *very depressed*, 3 *unknown*)
- 5 have improved
- 1 has deteriorated, and
- 9 have become *unknown*.

Figure 2-12 shows the change in status of north coast coho systems over time (Appendix I, Table 2). 1970 was the worst decade for coho escapement with the highest number of systems classed as *very depressed*. There was an improvement into the 1980s with 6 *very depressed* systems improving to *depressed*. It is difficult to interpret the trend into the 1990s as there was a 50% reduction in the number of systems visited. However, the Khutzeymateen River, Ensheshes River, Lachmach River, Ecstall River and Toboggan Creek have all shown improvement.

FIGURE 2-12
Changes in the
status of coho
indicator systems
on the north coast
from 1950-1999.

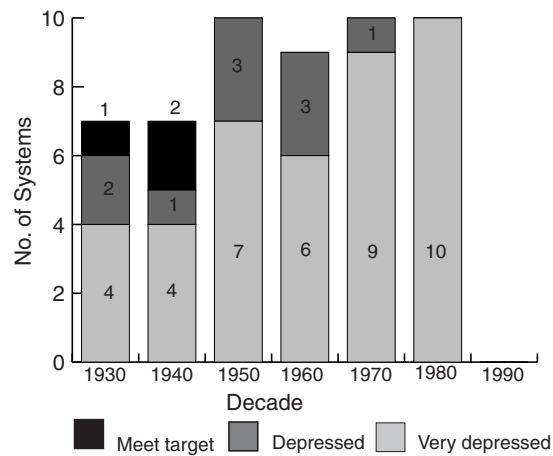


Coho

Central coast

On the central coast, the lack of data makes it impossible to draw conclusions about the current status of coho (Appendix I, Table 2). However, figure 2-13 shows 100% of indicator systems *very depressed* during the 1980s. Figure 2-13 shows the condition of these systems over time (data prior to 1950 available for Areas 6 and 8 only). There has been a failure to reach spawner targets since the 1940s with a growing increase in the number of systems classed as *very depressed*.

FIGURE 2-13
Changes in the
status of coho
indicator systems
on the central coast
from 1950-1999.

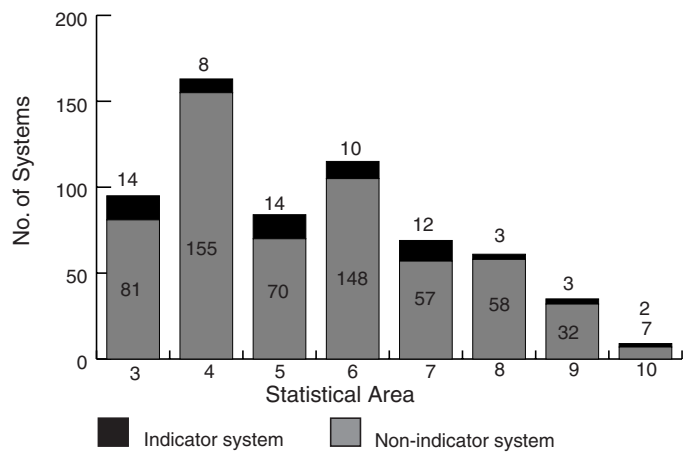


Pink

Abundance of pink salmon

The analysis of pink salmon abundance has been broken down into odd and even years. Even and odd year pink salmon are reproductively isolated and have developed into genetically distinct sub populations. Of the 674 pink systems on the north and central coasts, 66 are considered indicator streams. Figure 2-14 shows their distribution over the coast.

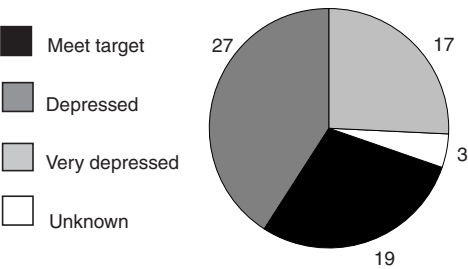
FIGURE 2-14
Distribution of pink systems showing indicator and non-indicator systems by area.



Even-year pink salmon

For 1990-99, 17 even-year pink systems on the north and central coasts are classed as *very depressed*, 27 as *depressed*, 19 as *meeting targets* and 3 as *unknown* (Figure 2-15).

FIGURE 2-15
Status of even-year pink systems on the north and central coasts.



Pink

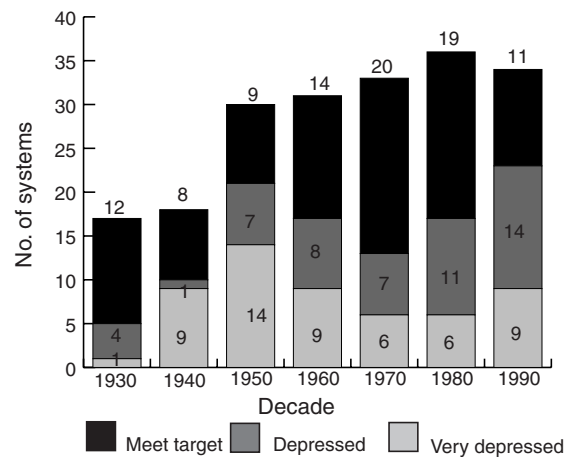
North coast

For 1990-99, 9 systems on the north coast were classed as *very depressed*, 14 as *depressed*, 11 as *meeting targets*, and 2 as *unknown*. 64% of the even-year runs in indicator systems on the north coast were thus classed as *depressed* or *very depressed* during this period (Appendix I, Table 3). When these results are compared to the status of the systems during the 1980s,

- 15 systems are unchanged (8 *meeting targets*, 4 *depressed*, 3 *very depressed*)
- 5 have improved
- 14 have deteriorated, and
- 2 systems have become *unknown*.

Figure 2-16 shows the status of even-year pink salmon in indicator systems on the north coast over time (data prior to 1950 available for Areas 3 and 5 only). The 1970s and 1980s were the best decades for even-year pink salmon escape-ment on the north coast. All areas (3-5) declined in status during the 1990s.

FIGURE 2-16
Changes in the
status of even-year
pink indicator
systems on the
north coast from
1930-1999.



Central coast

For 1990-99, indicator even-year pink salmon systems on the central coast (Appendix I, Table 4) were classed as 8 *very depressed*, 13 *depressed*, 8 *meeting targets* and 1 *unknown*. When the *unknown* system is removed, 72% of the indicator, even-year pink salmon runs on the central coast are currently classed as *depressed* or *very depressed*. When these results are compared to the previous decade,

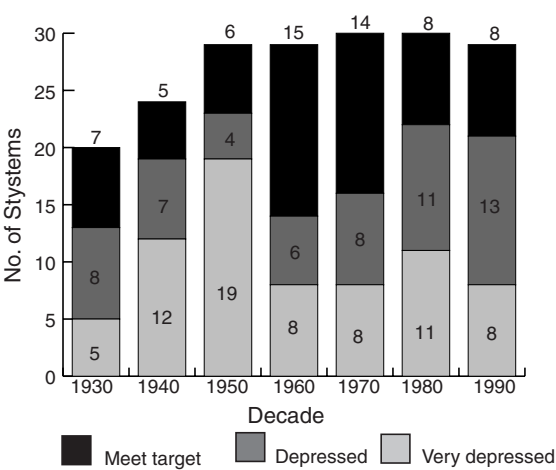
- 13 systems are unchanged (3 *meeting targets*, 6 *depressed*, 4 *very depressed*)
- 9 systems improved

Pink

- 7 systems deteriorated
- 1 system became *unknown*.

Figure 2-17 shows the status of indicator, even-year pink systems over time (data prior to 1950 is for Areas 6, 7 and 8). The 1950s were the worst decade for pink escapement with 19 systems classed as *very depressed*. The best years were the 1960s and 1970s; there has been a decline in even-year pink salmon returns over the last 2 decades.

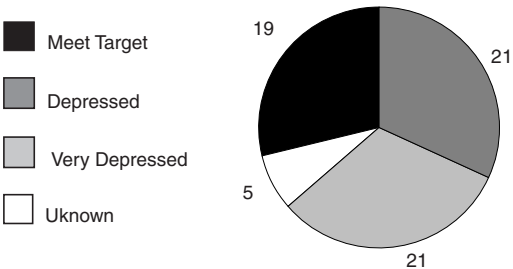
FIGURE 2-17
Changes in the status of even-year indicator systems on the central coast from 1930-1999.



Odd-year pink salmon

Results for 1990-99 show 21 systems *very depressed*, 21 *depressed*, 19 *meeting targets* and 5 *unknown* (Figure 2-18).

FIGURE 2-18
Status of odd-year pink systems on the north and central coasts, 1990-99.



Pink

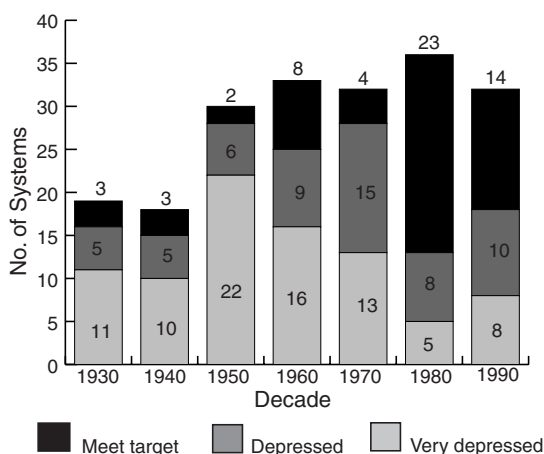
North coast

Results for the north coast in the 1990s show 8 systems classed as *very depressed*, 10 as *depressed*, 14 as *meeting targets*, and 4 *unknown*. When the *unknown* systems are excluded, 56% of odd-year runs in indicator pink systems on the north coast are currently classed as *depressed* or *very depressed*. This is a decline in their status from the 1980s, when 36% were classed as *depressed* or *very depressed*. When 1990 results are compared to the status of systems in the 1980s,

- 16 systems are unchanged (10 *meeting targets*, 3 *depressed* and 3 *very depressed*)
- 4 systems improved
- 12 systems deteriorated
- 4 systems became *unknown*.

Figure 2-19 shows the status of odd-year pink salmon in indicator streams on the north coast since 1930 (data prior to 1950 for Areas 3 and 5 only.) The odd-year pinks show a different trend than the even-year pinks, and are generally below their spawner targets. Between the 1930s and 1970s there are very few systems that were meeting their spawner targets (Appendix I, Table 5). There is a noticeable improvement in status through the 1980s and into the 1990s.

FIGURE 2-19
Changes in the
status of odd-year
pink indicator
systems on the
north coast from
1930-1999.



Pink

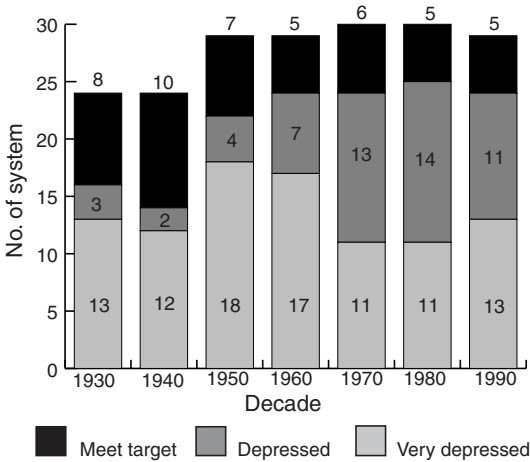
Central coast

Results for odd-year pink salmon on the central coast show 13 systems *very depressed*, 11 *depressed*, 5 *meeting targets* and 1 *unknown*. When the *unknown* system is excluded, 83% of odd-year pink runs on the central coast are classed as *depressed* or *very depressed* during the 1990s. When these results are compared to the 1980s,

- 17 systems are unchanged (2 *meeting targets*, 7 *depressed* and 8 *very depressed*)
- 5 systems improved
- 7 systems deteriorated
- 1 system became *unknown*.

Figure 2-20 shows the status of odd-year pinks on the central coast over time (Appendix I, Table 6). Again, the odd-year pinks show a different trend from even-year pinks, and are generally in poorer condition. Very few systems have been reaching their spawner targets since the 1950s.

FIGURE 2-20
Changes in the
status of odd-year
pink indicator
systems on the
central coast from
1930-1999.



Chum

Abundance of chum salmon

There are 492 chum systems on the north and central coasts, 49 of which are considered indicator streams. Figure 2-21 shows their distribution over the north and central coasts. Analysis of the 1990-99 average escapements for the indicator systems shows 28 systems were classed as *very depressed*, 10 as *depressed*, 8 as *meeting targets* and 3 as *unknown* (Figure 2-22).

FIGURE 2-21
Distribution of
chum systems
showing indicator
and non-indicator
systems by area.

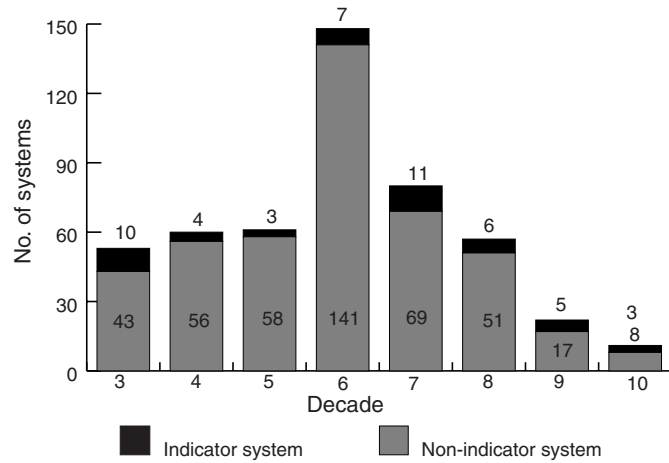
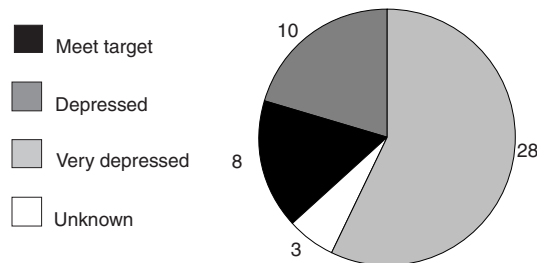


FIGURE 2-22
Status of chum
systems on the
north and central
coasts, 1990-99.



Chum

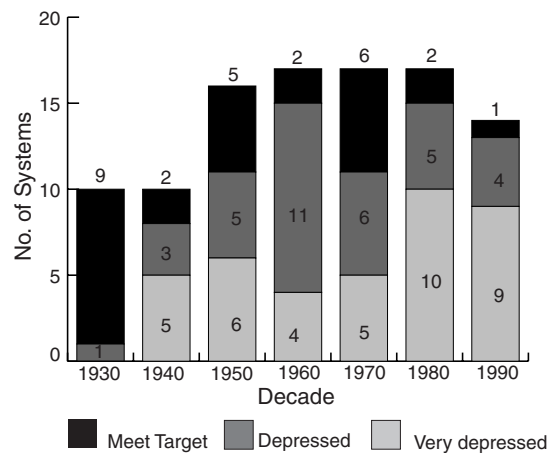
North coast

Results for the 17 indicator systems on the north coast shows 9 systems classed as *very depressed*, 4 *depressed*, 1 *meeting targets* and 3 *unknown*. When the unknown systems are excluded, 93% of north coast chum runs are classed as *depressed* or *very depressed* during the 1990s. When these results are compared to the 1980s,

- 8 systems were unchanged (1 *meeting targets*, 2 *depressed*, 5 *very depressed*)
- 2 systems improved
- 4 systems deteriorated
- 3 systems became *unknown*.

Figure 2-23 shows the status of indicator chum systems on the north coast over time (data prior to 1950 available for Areas 3 and 5 only). There was a large shift in systems *meeting targets* between 1930 and 1940. Between 1950 and the 1970s, the status of systems varied slightly (Appendix I, Table 7). There has been a decline in the health of all areas through the 1980s and 1990s.

FIGURE 2-23
Changes in the
status of chum
indicator systems
on the central
north from 1930-
1999.



Chum

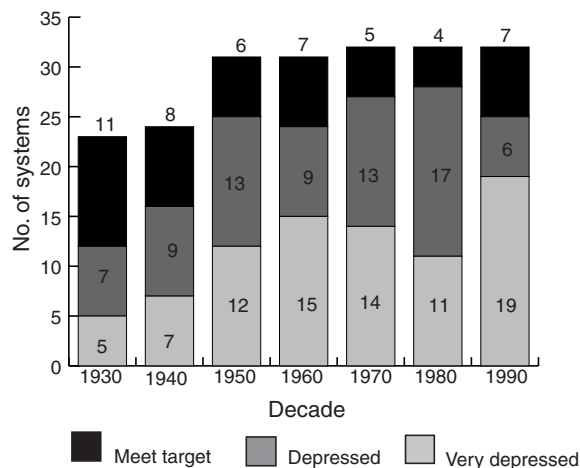
Central coast

Results for the 32 chum indicator systems on the central coast show 19 systems classed as *very depressed*, 6 *depressed*, and 7 as *meeting targets* during the 1990s. 81% of the central coast runs were classed as *depressed* or *very depressed* during the 1990's. Comparing these results to the 1980s,

- 16 systems are unchanged (3 *meeting targets*, 5 *depressed*, 8 *very depressed*)
- 5 systems improved in status
- 11 systems declined in status.

Figure 2-24 shows the status of chum indicator systems on the central coast over time (data from 1934 available for Areas 6, 7 and 8). Since the 1930s, the status of chum systems has been in decline, with Area 7 declining the most (Appendix I, Table 8). Areas 9 and 10 have been below their spawner targets since 1950 and all were *very depressed* by 1990. Many systems in Area 8 have been below their targets for decades, with only the Kimsquit and Bella Coola Rivers meeting their targets in the 1990s.

FIGURE 2-24
Changes in the
status of chum
indicator systems
on the central coast
from 1930-1999.



Chinook

Abundance of chinook salmon

There are 215 chinook systems on the north and central coasts. 27 of these systems are considered indicator systems with reliable escapement data. Figure 2-25 shows the distribution of indicator systems over the north and central coasts. Based on the 1990-99 average escapements for the indicator systems, 15 systems were classed as *very depressed*, 6 as *depressed*, 3 as *meeting targets* and 3 as *unknown* (Figure 2-26).

FIGURE 2-25
Distribution of chinook systems showing indicator and non-indicator systems by area.

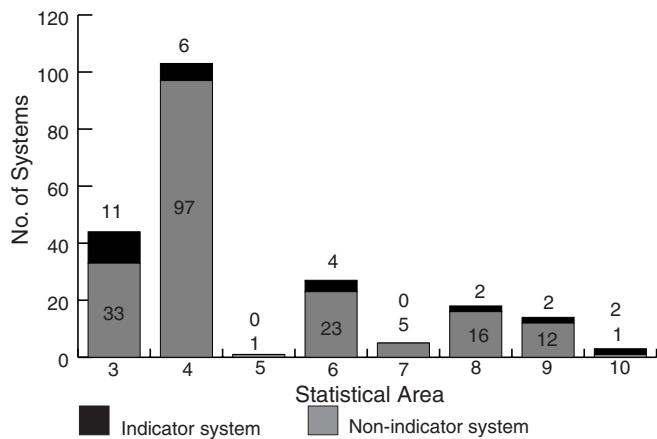
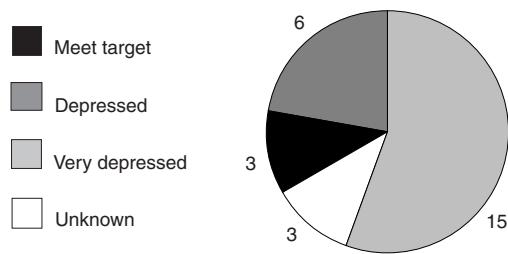


FIGURE 2-26
Status of chinook systems on the north and central coasts, 1990-99.



Chinook

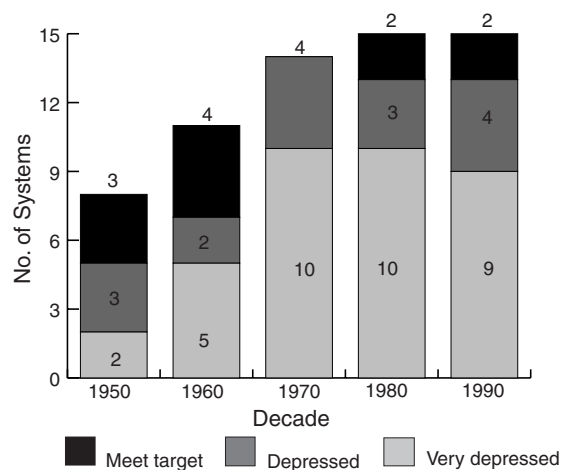
North coast

Results for the 17 indicator systems on north coast show 9 systems classed as *very depressed*, 4 as *depressed*, 2 as *meeting targets* and 2 as *unknown*. When the *unknown* systems are excluded, 87% of the indicator chinook systems on the north coast are classed as *depressed* or *very depressed* during the 1990s. When these results are compared to the 1980s,

- 14 systems are unchanged (1 *meeting targets*, 2 *depressed*, 9 *very depressed*, 2 *unknown*)
- 2 systems improved
- 1 system deteriorated.

Figure 2-27 shows the status of indicator chinook systems on the north coast over time. There is a sharp increase in the number of *very depressed* systems between the 1950s and the 1970s (Appendix I, Table 9). Marginal improvements occurred in the 1980s and 1990s with higher escapements in Lake Kitsumkalum, the Meziadin, Morice, and Bear Rivers.

FIGURE 2-27
Changes in the
status of chinook
indicator systems
on the north coast
from 1950-1999.



Chinook

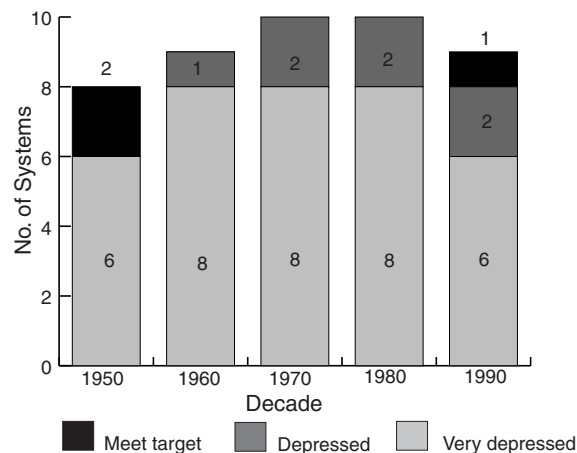
Central coast

The 10 indicator chinook systems on the central coast show 6 systems *very depressed*, 2 *depressed*, 1 *meeting targets* and 1 *unknown* during the 1990s. When the 1 *unknown* system is removed, 88% of the indicator systems are *depressed* or *very depressed* in the 1990s. This is a slight improvement over the 1980s when 100% of systems were classified as *depressed* or *very depressed*. Since the 1980s,

- 5 systems are unchanged (*very depressed*)
- 3 systems improved
- 1 system deteriorated
- 1 system became *unknown*.

Figure 2-28 shows the status of indicator chinook systems on the central coast since 1950. Chinook escapements have been well below targets for many decades (Appendix I, Table 9). The commercial catch of chinook on the central coast had a dramatic decline in the early 1970s. These declines in catch have not been reflected in recovery of chinook on the central coast. However during the 1990s the Kitmat, Bella Coola and Wannock Rivers have shown some improvement.

FIGURE 2-28
Changes in the
status of chinook
indicator systems
on the central
coast from 1950-
1999.



Preliminary data on the status of salmon runs in 2000 and 2001

The following is an overview of escapement status based on returns to indicator systems in 2000 and preliminary data from 2001. Because previous escapement data have been averaged by decade, comparisons with the first two years of this century should be made with caution. Where differences have been observed between the ability to meet spawner targets in the past and the situation in 2000 and 2001, these have been noted.

Sockeye

North coast

There is generally little change in sockeye returns in 2000 and 2001 compared with their situation in the 1990s. Of the 15 indicator systems sampled (out of 18), ten showed no change in their status from the averages of the 1990s (five *met targets*, five *depressed/very depressed*). Two systems (Kinkown Inlet and Morrison) showed improvement over the last decade and Southend Creek met its target for the first time since 1959. Lowe Inlet and Tsimtack had very poor returns in both years.

Central coast

Generally, there has been no marked change in sockeye returns to the central coast since the 1990s. All indicator systems remained *very depressed* in 2000 and all but one system were *very depressed* in 2001. Specifically,

RIVERS AND SMITH INLETS (Areas 9 and 10)

Some sockeye indicator systems have shown an increase in escapement over the devastating returns of 1999; however, returns are still not even within 5% of the target escapement.

BELLA COOLA (Area 8)

Preliminary results from 2001 show a decline in status compared to the averages of the 1990s. The Koeye and Namu remain *very depressed* with Koeye not even reaching 10% of its spawner target. The Bella Coola was the only system to improve slightly in status (*very depressed* to *depressed*) in 2001.

Coho

North coast

Sporadic sampling of coho indicator systems makes it difficult to assess their status, or change in status; however, a few systems show improvement. The Babine River met its spawner target for the first time since 1958, the Kwinamass met its target in 2000 for the first time since 1984 (not sampled in 2001), and the Meziadin River met its spawner target in 2001 for the first time since 1990. Another four systems (Toboggan, Khutzymateen Ensheshese, and Lachmack) showed no decline in their status from the 1990s (all met targets).

Six indicator systems remain below or seriously below their targets (Gitnadoix, Upper Zymoetz, Lakelse, Ecstall, Illiance and Kincolith). Eight coho indicator systems were not sampled and their status remains unknown.

Central coast

The minimal sampling of coho systems on the central coast means that the status of most indicator systems except the Bella Coola River remain unknown. The Bella Coola River, met its spawner target in 2001 for the first time since the 1950s. The recent monitoring of coho at the Docee River counting fence in Smith Inlet shows a steady increase in returns since 1998.

Chum

North coast

Chum continue to have poor escapements on the north coast. Only one system, the Stagoo, met its target in 2001. All other systems sampled were below or seriously below their targets; however, six of the 17 systems were not sampled.

Central coast

CHUM IN AREA 6 do not show much change in status. Five out of seven systems remain *very depressed*. The Kitimat River declined to very poor returns and only Arnoup Creek met its target in 2001. Giltoyees Creek was not sampled in either year and has not met its target since the 1930s.

CHUM IN AREAS 7 AND 8 (*Bella Bella and Bella Coola*) show minor change with 12 out of 16 systems maintaining their status of the 1990s (four systems met their targets in 2001, eight systems remained depressed/very depressed). Three systems improved in 2001 (Kainet, Echo and Roscoe Creeks) and the Kimsquit declined. Nameless Creek was not sampled in either year.

CHUM IN AREAS 9 AND 10 (*Rivers and Smith Inlets*) show poor escapements and limited sampling. Of eight indicator systems only one met its target in 2001 (Draney) and only one (Draney) was sampled in both years. All other systems that were sampled in 2000 or 2001 (Chuckwalla, Clyak, Macnair, Nekite, Takush and Walkum), were *very depressed*. The Wannock River was not sampled in either year.

Pink

North coast

EVEN YEAR (2000)

Compared to the average escapement of the 1990s, 2000 returns were very strong. Fifteen out of 23 systems sampled met their spawner targets easily, with many of these systems doubling or tripling their targets (n=7). Ten out of 12 systems classed as *depressed/very depressed* in the 1990s showed no change in 2000/2001. Two of the systems, Lakelse and Sam Bay, declined from previous strong returns. Ten pink indicator systems were not sampled.

ODD YEAR (2001)

Compared to the average escapements of the 1990s, returns in 2001 were very strong. Twenty-two out of 26 systems sampled met their spawner targets easily with many systems doubling and tripling their targets (n=12). Of the six systems classed as depressed, five did not change since the 1990s, and one system (the Kispiox) declined. Seven pink indicator systems were not sampled.

Central coast

EVEN YEAR (2000)

Several pink systems (n=9) on the central coast had very strong runs and showed improvement over the averages from the 1990s; however, most of this improvement occurred in Area 6. Overall, 15 out of 28 systems met their targets in 2000 compared to the averages of the 1990s, where only eight systems met their targets. Specifically,

AREA 6 had the strongest returns with eight out of 10 systems easily meeting their targets. Four of these (Kitkiata, Dala, Giltoyees and Quaál) more than doubled their spawner targets.

AREAS 7, 8, 9 AND 10 showed less change. Three systems (James Bay, Koeye and Johnston Creeks) showed improvement over the averages of the 1990s. However, fourteen out of 18 systems sampled showed no change in their status (ten *depressed/very depressed*, four *meeting targets*). The Kunsoot declined. Two indicator systems were not sampled.

ODD YEAR (2001)

Pink returns on the central coast in 2001 were very strong and 12 systems showed improvement over the averages of the 1990s. Seventeen systems met their escapement targets and 13 of these systems more than doubled their targets. Six systems remained depressed/very depressed. No systems declined. No sampling was done in six (out of 36) indicator systems.

Chinook

North coast

Inadequate sampling makes it difficult to assess chinook. On the north coast, only five of 17 systems were sampled in 2000 and 2001. Of these five systems, only the Kitsumkalum met its target in both years, an improvement over the average from the 1990s. The Kispiox met its target in 2001 (improved) and Morice in 2000 (no change). All other systems sampled remained *depressed/very depressed*.

Central coast

Only five out of 10 chinook indicator systems were sampled on the central coast. Only one system, the Bella Coola, met its spawner target in both years. All other systems remained *very depressed*.

TABLE 2-4
Summary of
returns to
indicator streams
on the north and
central coasts in
2000/2001

Species	# of systems	Meets target	Depressed	Very depressed	Not sampled
Sockeye	40	9 (23%)	1 (2%)	20 (50%)	10 (25%)
Coho	33	8 (24%)	1 (3 %)	5 (15%)	19 (58%)
Pink Even	66	29 (44%)	11 (17%)	14 (21%)	12 (18%)
Pink Odd	66	39 (59%)	7 (11%)	7 (11%)	13 (19%)
Chum	49	9 (18%)	5 (11%)	25 (51%)	10 (20%)
Chinook	27	4 (15%)	4 (15%)	5 (18%)	14 (52%)
Total	281	98 (35%)	29 (10%)	76 (27%)	78 (28%)
'Not sampled' removed	203	48%	14%	38%	

DISCUSSION

Gaps in our knowledge of salmon escapement

DFO's data show that efforts to enumerate sockeye, coho, pink and chum (1950-1999) on the north coast reached an all-time low in 1999. The same occurred with sockeye and coho on the central coast, with enumeration of chinook, pink and chum systems continuing a decline that began in the 1980s. The greatest reduction in enumeration effort occurred for coho on the central coast. Reliable data on coho escapement have been collected from only 2% of all coho systems. Sockeye have the second poorest enumeration record, followed by chinook, pink and chum.

Monitoring effort tends to be greater in larger commercial runs, hence many of the smaller systems and less commercially important regions suffer from lack of monitoring. For example, Areas 3 and 4 (north coast), and 9 and 10 (Rivers and Smith Inlets) received the greatest enumeration effort. Area 7 (Bella Bella) received the least amount of effort followed by Areas 5, 6 and 8. While this may serve the interests of commercial production, it overlooks the ecological role of salmon, as well as the importance of the smaller runs to the First Nations food fishery.

Many of the streams in the 'no information' category (where no monitoring has occurred) are small streams. Small streams store a significant percentage of the coast's gene pool and are critical for bears and other predators because salmon are easier to catch; their importance thus belies their size and production. Bergdahl (1995) stated that small streams have important consequences for wildlife and forest ecology, "such as social interactions, distribution, activity patterns and survivorship, and the conservation of biodiversity". Small runs in small streams are more vulnerable to extinction from a variety of causes, although it has been suggested that their evolutionary history has given small runs a greater ability to withstand changing environmental conditions (Bergdahl 1995). The loss of local spawning populations in small streams is argued to be the greatest threat to long term salmon conservation on the west coast (Walters 1995, Walters 1985).

The status of salmon runs on the north and central coasts

Conclusions based on the assessment of indicator streams must be drawn with caution. Because of the limitations with the escapement database, only 10% of the systems have data considered reliable by DFO. This sub-group tends to be biased toward larger, more productive runs, so to consider these systems representative of the coast-wide situation is unwise. Still, they represent the most reliable data available, and are the basis for the discussion that follows.

Table 2-4 presents a troubling picture of the health of salmon populations. When the *unknown* category is removed, only 25% of indicator runs on the north and central coast met their spawner targets. The spawner targets were determined by fishery biologists who walked the systems and estimated the number of spawners necessary to fully seed the available spawning grounds. The remaining 75% are classed as *depressed* or *very depressed*.

TABLE 2-5
Summary of the status of indicator streams on the north and central coasts for 1990-1999.

Species	No. of Systems	Meets Target (%)	Depressed (%)	Very Depressed (%)	Unknown (%)
Sockeye	40	20	22	50	8
Coho	33	15	9	9	67
Pink Even	66	29	40	26	5
Pink Odd	66	29	31	32	8
Chum	49	16	21	57	6
Chinook	27	11	22	56	11

Overall, our analysis suggests a disturbing failure to meet spawner targets in most indicator systems on the central and north coasts (Table 2-4). Clearly, these results represent a troubling picture of salmon populations on the coast, with some runs already collapsed. A continuing inability to meet spawner targets may only perpetuate declines in salmon abundance and productivity (Figure 2-31) with severe repercussions for future generations of salmon and the abundance and diversity of dependent organisms.

FIGURE 2-29
Nutrient returns for the 11 chum indicator systems in Area 7 from 1930-1999.

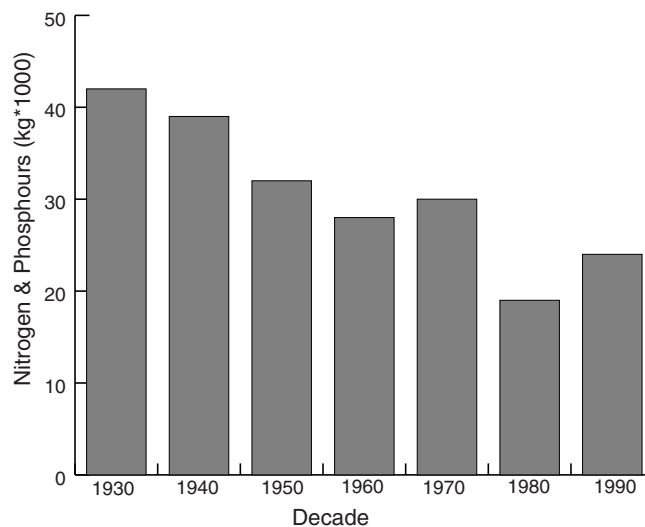


Figure 2-29 shows the decline in nutrients to 11 chum indicator systems in Area 7 that accompanies declines in returning spawners. This decline is substantial. Using 1930 as the baseline when most systems were meeting their target escapements (Table 1-7, Appendix I), the 1940-1990 period reflects a nutrient decline of 83,000 kilograms of phosphorous and nitrogen.

Status of sockeye salmon

Sockeye on the central and north coasts are classed as *depressed* or *very depressed* in 73% of the indicator systems. On the north coast, 8 out of 18 systems met their target escapements; however, 3 of these systems are artificially enhanced with spawning channels. When the enhanced systems and the runs with insufficient data are eliminated, 85% of the north and central coasts' sockeye runs are classified as *depressed* or *very depressed*.

The trend since 1950 on the north coast shows a shrinking middle ground between systems *meeting their targets* and those *very depressed*, especially in the Skeena (Area 4). The healthy systems include the spawning channels into Babine Lake. While the sockeye harvest in Areas 3 and 4 (Nass and Skeena) has increased since the spawning channels were constructed in the 1960s, this increase has come at a cost to the non-enhanced, wild runs. Wild sockeye runs have declined significantly over this period due to harvesting pressure from the Skeena's mixed stock fishery which targets the enhanced sockeye returning to the Babine River and has over-exploited the wild runs (Wood 2001; Walters 1995).

On the central coast, there are no sockeye runs in indicator streams meeting their target escapements. Certainly this situation reflects the collapse of the Rivers and Smith Inlet runs, but even removing these areas from the analysis does not improve the picture.

Since the 1960s, 6 of the 8 indicator systems in Areas 6 and 8 (Area 7 has no indicator systems) have seen significant declines in sockeye returns. While the Bella Coola and Kimsquit Rivers (Area 8) have not declined to the same extent, neither system is meeting its spawner target. Despite fishing reductions in Areas 6 and 7 over the last 15 years (Rutherford and Wood 2000), escapement has not improved. This indicates that systems are not recovering and that fishing pressure, habitat loss and/or marine conditions continue to undermine the productivity of these runs.

Preliminary results from 2001 and 2000 show very minor changes in sockeye returns. Two indicator systems on the north coast did show some improvement over the last decade, but returns on the central coast remain very depressed.

The situation in Rivers Inlet is critical. Since the beginning of the century, total sockeye abundance in Rivers Inlet fluctuated around 1.5 million fish. This abundance declined through the 1980s and crashed in the late 1990s. Only 3600 sockeye spawners were counted in 1999. While there has been some slight increase in these returns in 2000 and 2001 (21,000 and 24,000 respectively) they are still not within 5% of the spawner targets. Table 1 in Appendix I shows indicator systems in Rivers Inlet well below their target escapements. While the productivity of Owikeno Lake is believed to be unchanged through 1996 (McKinnell et al. 1998), the continuing reduction in nutrient returns warrants further investigation.

The collapse of central coast sockeye also drives home the vital connection between salmon and surrounding wildlife. As a result of the disastrous 1999 returns to Rivers Inlet, 14 grizzly bears and 2 black bears were shot because their fall food supply failed to materialize and the bears were starving. Thus the implications of diminished salmon runs go far beyond the visible realities of fishery closures.

Very little is known about the many small runs of sockeye that contributed significantly to local First Nations fisheries and were once important to the commercial fishery. The status of these runs must be assessed.

The Rivers Inlet sockeye collapse

Rivers Inlet has a long history of resource-related activities on land and water. Between 1884 and 1974 the average annual sockeye harvest was around 1 million fish, with an escapement of about 0.5 million. Total abundance of Rivers Inlet sockeye has reached 2 and 3 million fish but not since the early 70s (Holtby, 2000). Between 1911 and 1937 a hatchery operated in the Owikeno watershed to supplement sockeye populations (and a small number of chinook). Until the 1960s, Rivers Inlet was fished almost exclusively by gillnetters whose numbers reached 1150. From the late 1960s onwards, there was increasing interception of Owikeno sockeye from seiners and gillnetters operating off Bella Bella (MacLeod 2000). According to Rivers Inlet fisheries officer Ron MacLeod, neither reductions in fishing days nor adjustments to fishing boundaries were sufficient to offset the advancements in gear technology. Declines in catch began in the 1970s, and declines in escapement began in the 1990s. Abrupt declines in marine survival during the 1990s are believed to be responsible for the record low escapements on the central coast in the late 1990s (McKinnell et al. 2001; Holtby et al. 2000; Rutherford and Wood, 2000; Wood C. pers. com., PBS). Rivers Inlet was closed to commercial fishing in 1996.



Logging of the Sheemahant watershed at the head of Owikeno Lake in Rivers Inlet. Many important sockeye systems in the lakes tributaries have been logged.

PHOTO: Jim Pojar

Clearcut logging began in the tributaries to Owikeno Lake in the late 1960s and continues today. Many important sockeye systems have been logged, some all the way to their headwaters. As the logging commenced, biological assessments being conducted in the lake and some rivers systems were curtailed, resulting in a loss of essential baseline information (MacLeod 2000). While it is likely that timber extraction has affected hydrology in the logged tributaries, discharge data exist only for the Wannock River, which drains Owikeno Lake. Although changes in spring and fall discharge of the Wannock River attributable to logging were considered negligible (Holtby et al. 2000), McKinnell and co-workers (1998) show a shift to lower annual discharges after 1977 that is similar to other coastal rivers. This phenomenon is attributed to the 1976/77 climate regime shift. How hydrologic changes in the tributaries have affected hydrology in the lake is unknown.

The Rivers Inlet seal population has increased significantly since lifting of the bounty in the 1960s; however, the degree of predation on salmon is unknown (MacLeod 2000). The role of predators such as mackerel that have moved into the Inlet under conditions of warmer water is also unknown. Predator-prey dynamics need to be properly understood before any predator control program is proposed.

The productivity of Owikeno Lake and its capacity to rear sockeye has never been well understood. The high turbidity in the lake (due to its glacially fed tributaries) means that light does not penetrate more than a few feet into the water column, an unproductive environment for fry and presumably one of the factors contributing to their emigration from the lake after only one year (Wood C. pers. com., PBS). Sockeye smolt leaving Owikeno Lake are the smallest on the coast and below the typical threshold size for sea adaptability (Wood C. pers. com., PBS). This is believed to make them more vulnerable to changes in salinity and predation in the estuarine environment of Rivers Inlet.

Interestingly, the high turbidity in Owikeno Lake should limit production of the lake to a greater degree than it actually appears to (Wood C. pers. com., PBS). Existing evidence suggests there has not been a decline in either productivity or fry abundance in Owikeno Lake (McKinnell et al. 1998). Hence, scientists at the Pacific Biological Station believe the survival problems began after the fry left the lake, and that the smolts died as a result of very poor survival in the early marine phase. Small smolt size, reduced freshwater discharge and changes in the marine environment could all play roles. The similar trend and collapse over the same time period in Smith Inlet sockeye (Area 10) and other sockeye populations in Area 8 (Bella Coola) reinforces the argument of adverse marine conditions (Rutherford and Wood 2000).

Even though evidence suggests that poor marine survival caused the dramatic collapse of sockeye returns to Rivers Inlet in the 1990s (McKinnell *et al* 2001; McKinnell *et al.* 1998; Holtby 2000; Wood C. pers. com., PBS), the lack of understanding of lake productivity and ecosystem dynamics means that the roles of fishing and industrial forestry in altering the function of the watershed are unknown. While we have little immediate control over climatic variability, we *can* provide optimal conditions for survival in key life stages and environments in which salmon must recover. This point is critical, as salmon must be protected from anthropogenic stresses if they are to recover under adverse marine conditions.

Recuperative measures for sockeye on the central coast

There are many gaps in knowledge that need to be addressed to improve our understanding of sockeye dynamics. Longterm records predating European contact need to be obtained from both Owikeno and Long Lakes (Rivers and Smith Inlets respectively). Analysis of sediment cores can provide a historical record of major trends in salmon abundance and nutrients over the last 300-400 years. It could also provide insights into lake productivity, the impacts of high exploitation rates on overall abundance/productivity and the influence of climate variation on abundance. Studies also need to be carried out on health of the estuarine ecosystem and the history of sockeye smolts once they reach the Wannock estuary and Rivers Inlet. Understanding these conditions and relationships will make recovery and management strategies more effective. However without further knowledge, fisheries management and recovery strategies must be conservative.

Every possible measure must be taken to protect the structure and function of the Owikeno and Long Lake watersheds. The Pacific Fisheries Resource Conservation Council (PFRCC 2000) has stated that the deferral of logging is an essential measure for habitat protection and the recovery of salmon productivity on the central coast. This means an end to industrial forestry practices in watersheds that provide freshwater spawning and/or rearing. In the marine phase, a continued moratorium on sport and commercial fishing of Rivers and Smith Inlet sockeye is imperative. In addition to Rivers and Smith Inlets, the status of sockeye indicator systems in Areas 6 and 8 are also of great concern. Until additional information shows that sockeye runs in Areas 6 through 8 are meeting target escapements, there should be no commercial or sport fishing of sockeye on the central coast and the food fishery should be undertaken with caution. Conservation objectives in the form of habitat protection and catch restrictions must be rigorously implemented and take priority over the fishery.

Status of coho, pink, chum and chinook salmon

It is virtually impossible to assess the status of coho with only 14 out of 891 systems reliably enumerated in the 1990s. Escapement information on the north coast during the 1990s is simply too limited to interpret. On the central coast, escapement tables show coho have been declining since the 1950s. All systems were critical in the 1980s and no indicator systems were enumerated in the 1990s. Coho catches on the central coast have declined since the mid-1970s (Appendix II, Figures 12-16). Poor enumeration data combined with high exploitation rates (which averaged 60% to 80%) caused extensive over-fishing of coho coastwide (PFRCC 1999). DFO implemented fisheries restrictions on coho in 1998. Preliminary data from 2001 and 2000 do show improvement in some systems. DFO attributes this increase in returns to fisheries restrictions and improved ocean survival that accompanied the 1998 ocean regime shift (PFRCC 2002). However poor sampling still makes it difficult to assess coho returns and status. Wild coho runs may also be affected by habitat changes in logged watersheds (Hicks, 2002 Chapter 3) and declining productivity in the headwater streams (Bilby et al. 1996). Better coho enumeration is imperative, and fishing this species should not be considered until adequate information on stock status is available.

Escapement tables for pink salmon suggest they are the healthiest species within the indicator stream systems. However, only 35% of even and odd year pinks were meeting their targets in the 1990s. Preliminary data from 2001 and 2000 show many pink systems with strong returns. Fifty-four percent met their targets in 2000 and 73% of pink systems met their targets in 2001. DFO attributes this improvement to increased marine survival.

Chum escapement tables show a disturbing picture with 75% of indicator systems classed as *depressed* or *very depressed*. Until recently, there has been little attention paid to suggestions that chum runs are declining. However, indicator chum systems on the north coast declined in escapement throughout the 1980s and 1990s, at a time when the harvest rates for Areas 3 and 4 were above average (Appendix II, Figures 33, 34). Only one chum system on the north coast was meeting its spawner target in the 1990s. Preliminary data from 2000 and 2001 show no change in this condition. Only one system met its spawner target in 2001. All others were below or seriously below their targets.

Chum systems on the central coast are also in very poor condition. All indicator chum systems in Areas 9 and 10 were *very depressed* in 1990, and the greatest decline in health occurred in Area 7. While catches have declined in Area 7 since the late 1970s, this has not aided the recovery of escapements by the 1990s. Preliminary data from 2001 show some improvement to a few

systems in Area 7, however most systems on the central coast continue to show very poor returns. Limited sampling in several areas also hinders an adequate assessment of improvement or declines in returning chum.

Difficulties in enumeration and unrealistic spawner targets in some systems may colour chinook numbers, so results must be interpreted cautiously. However, indicator systems suggest that 56% of chinook runs are *very depressed* and 22% are *depressed*. Escapement trends on the north coast show the 1970s as the worst decade for chinook. Despite significant declines in catch since the mid-1970s (Appendix II, Figures 41-43), only a few systems (Kitsumkalum, Morice and Bear Rivers) showed improvement in the 1980s and 1990s. The decline in escapements in the Tseax, Khutzemateen and Kwinamass watersheds are serious, because spawner targets for all of these systems were easily achieved in the 1960s. Poor sampling in 2000 and 2001 make it difficult to assess any changes, however available data suggests only one system (Kispiox) shows some improvement.

Chinook spawner targets for the few indicator systems on the central coast are also falling short. Commercial catches on the central coast have declined dramatically (Appendix II, Figures 44-48) since the 1970s but this has not relieved the pressure on chinook. Marginal improvements in escapement have occurred in the Kitimat and Wannock Rivers. The Bella Coola is the only indicator system that has met its spawner targets for chinook on the central coast, and this system has been enhanced by hatchery fish. The Bella Coola was the only system to meet its target in 2000 and in 2001.

Factors affecting salmon abundance

It is often difficult to isolate specific causes of depressed salmon runs. It can even be difficult to argue declines in abundance of wild salmon because catch statistics do not necessarily reflect these observations.

Since the inception of BC's Salmonid Enhancement Program (SEP) in the late 1970's, hatcheries and spawning channels have been augmenting natural spawning production with tens of millions (to hundreds of millions) of fry and smolts annually. This phenomenal output can mask run declines caused by habitat loss and over fishing, and contribute to the exaggerated notion that ocean climate presents the greatest threat to salmon survival.

Prior to the 1990's, hatchery output was premised on the belief that the ocean's potential for salmon production was limitless. It was not until the late 1980s when marine survival of many salmon stocks dropped significantly that this understanding was questioned. The decline in marine survival during the 1990s allowed scientists to observe the influence of the climate/ocean

environment on salmon productivity, largely by assessing the survival of hatchery released coho in the Strait of Georgia (Beamish et al., 1998).

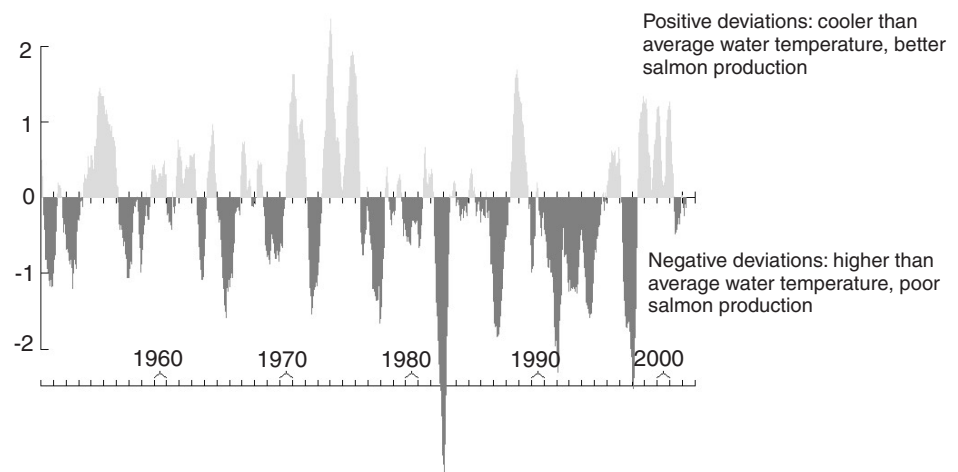
Climate indices such as the Southern Oscillation Index, the Aleutian Low Pressure Index, the Atmospheric Forcing Index and the Fraser River discharge, suggest that a regime shift occurred in 1989 which altered the marine ecosystem in a manner that was detrimental to fish production in general, but significantly to Georgia Strait coho (Beamish et al., 1998). While these regime shifts have occurred in the past (1925, 1947, 1977, PFRCC 2001) the impact on salmon survival has not been as clear and definite.

Were it not for salmon enhancement programs, run declines from fishing pressure and habitat loss would be evident through much lower salmon abundance. The consequence of these human impacts was masked by the SEP as long as the marine environment remained stable. When the 1989 regime shift occurred, salmon survival dropped significantly (survival rate on the south coast for hatchery coho was as low as 0.4%, hatchery chinook as low as 0.03% PFRCC 2001, Beamish et al 1998). Because poor marine survival was the rationale behind most catch restrictions, it left the impression that prior to this point, salmon stocks in British Columbia were healthy and well managed.

FIGURE 2-30
The Southern Oscillation Index shows negative and positive deviations associated with El Nino and La Nina events. Over the past 20 years, several major El Nino events have influenced salmon abundance in BC waters. The movement of warmer surface water northward (El Nino) correlates with decreased ocean productivity (as nutrients are prevented from reaching the surface) and hence poor salmon production.

Source: Institute of Ocean Sciences, 2002

Southern Oscillation Index 1950-2002



How should genetic diversity be conserved?

It was not until 1967 that the Federal Fisheries Act contained a clear statement of purpose on conserving and protecting fish and fish habitat (PFRCC 1999). However, neither a clear definition of conservation nor a policy directive on how conservation relates to salmon management were implemented. Hence no emphasis was placed on the importance of conserving genetic diversity and population abundance until the New Directions initiative 30 years later. During this time period (1968-1998) the known decline in salmon populations such as non-Babine Skeena sockeye, Skeena coho and Fraser coho, were seen by society/DFO as acceptable tradeoffs to sustain high fishing pressures (Wood C. pers. com., PBS). The recognition that this is no longer an acceptable practice is now being reflected in new policy development.

In October 1998, the Fisheries Minister (then David Anderson) released the *New Direction for Canada's Pacific Salmon Fisheries* (DFO 1998). The first five principles identify conservation and sustainable use as the department's first priority:

- "Conservation of Pacific salmon stocks is the primary objective and will take precedence in managing the resource."
- "A precautionary approach to fisheries management will continue to be adopted."
- "Continue to work toward a net gain in productive capacity for salmon habitat in British Columbia. Our goal is to ensure that natural salmon habitat is maintained to support naturally reproducing populations of salmon."
- "An ecological approach will guide fisheries and oceans management in the future. An ecosystem approach involves understanding and providing for the complex interactions between the different species and requires a move away from the current single species management."
- "The long term productivity of the resource will not be compromised because of short term factors or considerations – tradeoffs between current harvest benefits and long term stock will be resolved in favour of the long term."

Policies like the *New Direction* and the *Wild Salmon Policy* (DFO 2000) recognize the importance of genetic diversity in wild salmon conservation and are critical steps toward a new era of fisheries management. However, there are some fundamental concepts within these initiatives that, to be implemented effectively, will require strong political will. These include: allocation of salmon to non-human predators (Principle Four), stopping habitat destruction

(Principle Three), reforming fisheries models (Principle Four), reducing fishing pressure (Principle Five), and prioritizing conservation of wild salmon diversity over production initiatives such as hatcheries, sea ranching and enhancement projects (Principle One). We do not feel these challenges are insurmountable, but recognize that considerable political will, and public support are needed for their success.

While recognition of the enumeration problem is not new, there is no plan in place to repair or restore the salmon enumeration program. Sound conservation strategies cannot be developed if baseline information is lacking. Given the financial and logistic difficulties in gathering good enumeration data implementing a better enumeration program is no simple undertaking; what, therefore, is the most effective way to conserve, monitor and manage salmon so that genetic diversity at the deme level is ensured?

The *Wild Salmon Policy* (DFO 2000) identified a need to implement conservation policies based on biologically sound Conservation Units. For this to work, a core monitoring site would be required within each identified Conservation Unit to produce reliable information on productivity, escapement, recruitment and ocean survival. Based on information from these core sites, indexes would be developed to monitor a network of peripheral sites. Abundance trends within these systems would be monitored to confirm the inferences from the core sites. If disparities are apparent, full assessments would have to be undertaken. If the size of the Conservation Unit was found to be too large, it would be reduced accordingly.

While DFO has proposed a greater monitoring effort such as that described, it needs to ensure that all classes of runs (including smaller and less productive ones) are included in sampling. Conservation Units should be based on the differences within and between species, productivity, run sizes, run times, and the physical environment. This will require an initial increase in the number of system/runs visited so that baseline data can be gathered and all units fairly assessed.

New stewardship models

A comprehensive monitoring program should include non-governmental stewardship groups to complement DFO surveys, suggest inferences, and test assumptions about stratification of sampling. Such groups should be drawn from both native and non-native communities. Stewardship programs could be co-ordinated through DFO's Science Branch to ensure personnel are fully trained and continually assessed to ensure the highest scientific standards and

quality of work. Such programs would require funding on a time scale that encourages dedication and expertise.

As one example, an initiative on the Saanich Peninsula involving First Nations, non-government groups and the Institute of Ocean Sciences is revealing the potential for community partnerships to change conventional approaches to integrate marine, freshwater and land management. The Peninsula Streams Program started with a small commitment to support four Tseycum First Nation women taking introductory courses in aquatic stewardship. This evolved into a science mentorship program with the Institute of Ocean Sciences that includes continuing education, training and employment for aquatic assessments, stewardship and outreach. The program has since expanded to other bands and has resulted in a broadened involvement from the community and local First Nations in marine and freshwater issues and a heightened awareness of First Nations traditional knowledge on the part of scientists and decision makers. As well as collecting the data necessary for resource conservation and management, the program is building dedication and awareness within the native and non-native community.

Active community involvement is critical in incorporating salmon considerations into all levels of municipal planning and in addressing the multitude of jurisdictional challenges that society faces in its efforts to manage salmon from an ecosystem perspective. DFO must recognize that it can't accomplish its goals without strong community involvement.

A precautionary approach to fisheries management

The global declines in fish stocks have caused many scientists and resource managers to lose confidence in conventional fisheries models. The Precautionary Approach entails an explicit recognition of the uncertainties implicit in fisheries management. Broader interpretations of the Precautionary Approach encompass a shift in focus from *resource yield* to the maintenance of *ecosystem structure and function* (Weeks and Berkeley 2000). Weeks and Berkeley conclude that old fisheries models are unable to meet new mandates due to:

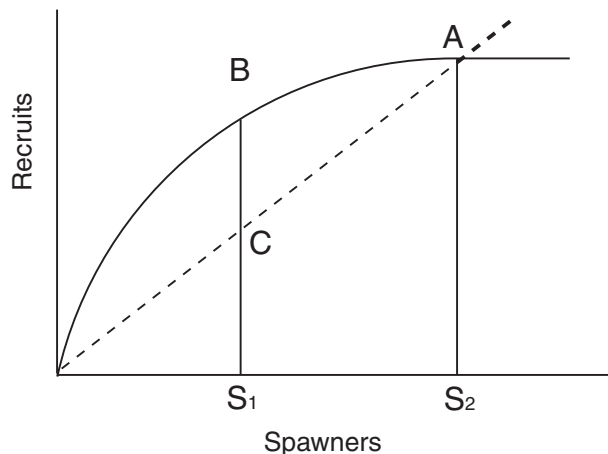
- imperfect understanding of complex ecological systems
- overly optimistic assumptions of resource productivity
- conflicting objectives
- a management approach that poorly balances short term and long term risks, and
- an institutional and legal context that makes change difficult and time consuming

Many of these limitations are true for the MSY models that have guided salmon management in BC. Harvest levels under the MSY policy are determined from a relationship between spawning salmon (spawners) and the number of offspring the spawners produce (recruits). Fundamental to the MSY model is the assumption that the “spawner-recruit” curve is determined primarily by density-dependent interactions. There are, however, factors that influence the survival and productivity of salmon (such as the delivery of marine derived nutrients and long term processes) that are not detectable within single generations and are not captured in these single generation spawner-recruitment curves.

Cederholm and co-workers (2000) show the potential difference in Marine Derived Nutrient returns in un-fished conditions and under the MSY model. In an undisturbed system, Point A in Figure 2-31 shows the number of spawners whose carcasses would decompose in the stream to provide nutrients to support the next generation of juveniles.

FIGURE 2-31
A typical Ricker spawner-recruit curve showing the MSY level as the point where the difference between the spawner-recruitment curve and the replacement line is the greatest (B-C). Point A is the natural carrying capacity/equilibrium of returning adults without harvest.

Source: Cederholm et al. 2000.



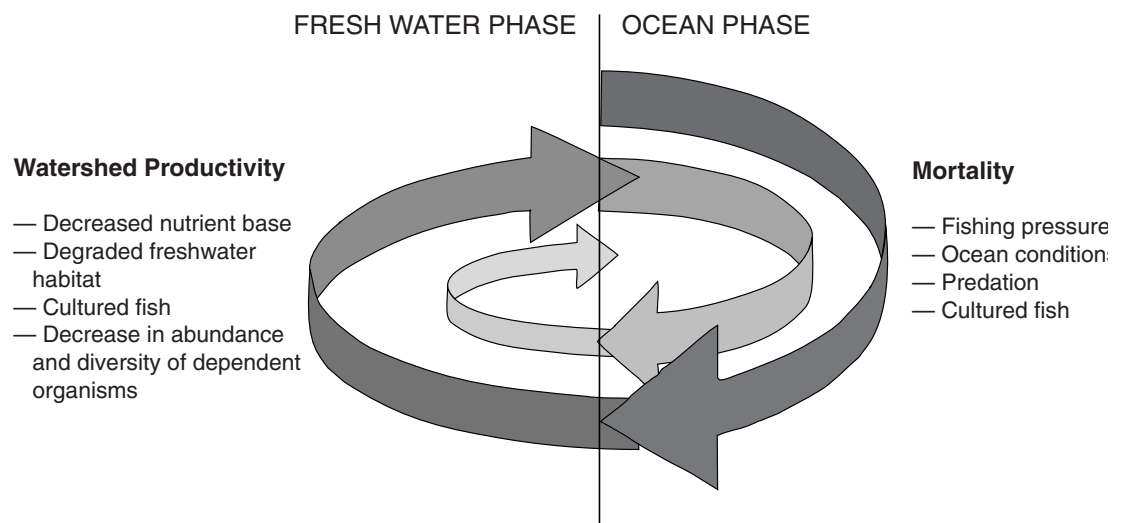
Harvesting the population to the MSY level (B) would reduce the number of spawners, and associated nutrients, from point S_2 to S_1 . This level of spawners represents a reduction of about a half the number of adult spawners (can be higher in more productive runs) allowed to return to the stream, prompting a corresponding decrease in the amount of marine derived nutrients.

Extraction of the ‘surplus’ fish reduces the carcasses and nutrient returns. This in turn can correspond to reduced productivity within the freshwater environment, smaller fry size, and ultimately reduced survival in the marine environment. Decreased survival means fewer returns of spawners, which further depletes the nutrient capital and further depresses survival.

Both from a sustainable fisheries approach and an ecosystem perspective, the level of exploitation that has been allowed over the last century cannot be sustained. Higher escapement must be achieved by lowering the exploitation rates. Conventional models that focus on MSY without considering long-term sustainability, predator and ecosystem needs, or the protection of genetic diversity must be revised. Two fundamental shifts in fisheries management must occur to meet sustainability and ecological objectives and conserve genetic diversity:

- First, harvest levels must be significantly reduced to achieve higher numbers of returning salmon and address predator needs
- Second, protecting genetic diversity means that the mixed-stock fishery must be replaced with selective and terminal river fisheries

FIGURE 2-32
The negative feed back loop of declining abundance (line represents abundance). This is a simplification of natural oscillations, as well as the extent of individual influences on abundance.



Escapement targets must also include a buffer to allow for unknown and unpredictable sources of mortality. This combination of measures offers the best chance of protecting wild salmon production and diversity, and restoring nutrient requirements to the food web. A growing body of evidence suggests that hatcheries, enhancement programs (Chapter 4) and fish farms (Chapter 5) will only compound the stresses facing wild salmon, thus undermining their recovery. Such technical approaches to fish production also require extensive (and expensive) human intervention that comes at an ever-increasing cost to society and the ecosystem.

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