

The Origins of New Zealand's Chinook Salmon, *Oncorhynchus tshawytscha*

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Introduction

New Zealand's acclimatized stocks of anadromous chinook salmon, *Oncorhynchus tshawytscha*, are one of very few unequivocally successful transplants of any anadromous Pacific salmon, and the only one of long standing (Childerhose and Trim, 1979). This lack of success is in spite of attempts to establish various salmon species in many areas, that date back to the era when salmonids were being shipped to many and diverse parts of the world prior to about the 1930's, including such unlikely places as Brazil, Hawaii, Mexico, and Nicaragua (McDowall, 1988). Early attempts to establish anadromous pink and coho salmon, *O. gorbuscha* and *O. kisutch*, respectively, in northeastern North America seem ultimately to have failed, despite initial signs of success (Lear, 1980). Pink salmon, transplanted to western Arctic

Russia, spread further into Scandinavia, but were only briefly successful there (Berg, 1977; Bakshtansky, 1980). Transplants of various species of *Oncorhynchus* to Chile generated some adult returns from smolts released to sea, though these do not seem to have persisted (Zamorano, 1991). By com-

parison, the New Zealand situation is quite unequivocal and of long-standing clarity: Chinook salmon have been established as self-supporting, anadromous populations, primarily in rivers along the east coast of New Zealand's South Island, since about 1905 (McDowall, 1990; Fig. 1).

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ABSTRACT—Chinook salmon, *Oncorhynchus tshawytscha*, are well established as anadromous and landlocked runs in New Zealand. Ova introductions during the 1870's (probably from the McCloud River, California, U.S.A.), failed to generate anadromous stocks, but further introductions of fall-run salmon ova from hatcheries in California's Sacramento River basin in the early 1900's were successful and formed the basis for existing runs. The first batch of ova in the 1900's consignments originated from Battle Creek, a Sacramento River tributary, but the explicit source of later batches is not known. It seems likely that the successful runs stem from the second batch (1903 brood year—1904 consignment in New Zealand), probably augmented by returns from later importations.

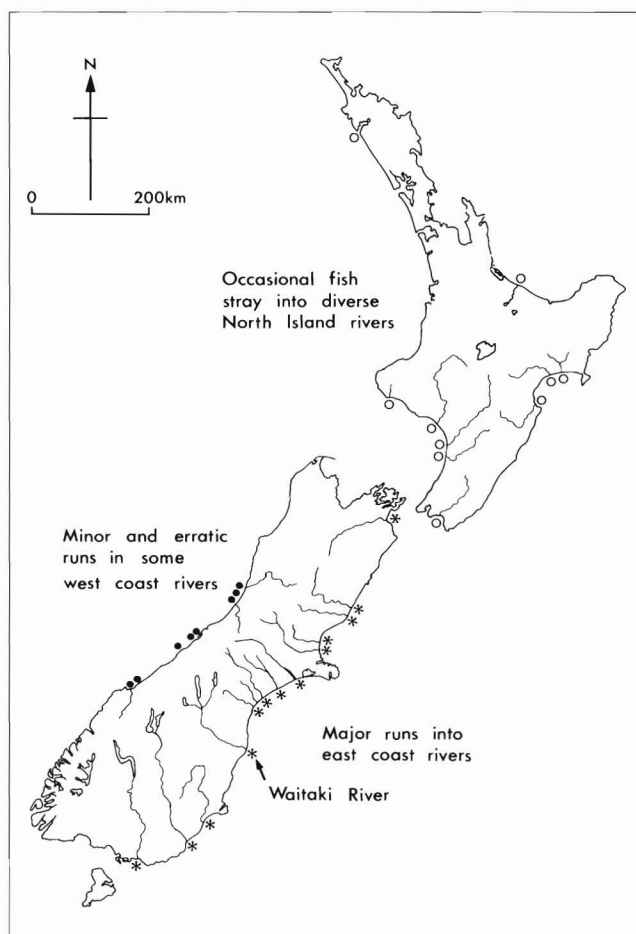


Figure 1. — Distribution of anadromous chinook salmon in New Zealand, showing broad presence along the east coast of the South Island, intermittent and minor runs on the west coast, and occasional stragglers appearing more widely throughout New Zealand.

New Zealand is widely known for its stocks of acclimatized salmonids, especially of brown trout, *Salmo trutta*, and rainbow trout, *O. mykiss*; less well known are its acclimatized stocks of Atlantic salmon, *Salmo salar*; brook char, *Salvelinus fontinalis*; lake trout, *S. namaycush*; and sockeye salmon, *O. nerka* (McDowall, 1990). The origins of stocks of these species have been of considerable interest and confusion—interest stimulated by a concern to understand the stock origins of the populations, and confusion generated by poor record keeping when the fish were transported around the globe between the 1860's and early 1900's. The origins of New Zealand's rainbow trout were clarified by Scott et al. (1978) and of the sockeye by Hardy (1983) and Scott (1984). However, the source of New Zealand's chinook salmon has not been reviewed since the fish were established in New Zealand in the early 1900's, and their explicit source remains a matter for speculation.

Questions relating to genetic and phenotypic differences among stocks of Pacific coast salmonids have generated much research interest in recent years. This is due partly to extensive hatchery releases, made either for enhancement or regeneration of heavily exploited anadromous salmonid runs, or to restore those damaged by habitat deterioration and river impoundment. There have also been widespread and massive releases to support recreational salmonid fisheries. In addition, there has been active interest in the evolution of Pacific salmon species and stocks.

Considerable concern has grown about these various hatchery releases. Often the fish are of different (and even unknown) genetic provenance from those already present in the receiving ecosystems, and sometimes they are of reduced genetic diversity as a result of many generations of hatchery rearing. There is legitimate concern that these hatchery introductions might disrupt fish stocks finely adapted to local habitat characteristics; there is concern to protect the genetic integrity of locally adapted stocks, sometimes recognized as local subspecies of more widely distributed polytypic species (Allendorf

and Leary, 1988; Behnke, 1992; Hilborn, 1992).

“Wild” trout and salmon have become something of a “clarion call” among those sensitized to the issue of protecting local stocks (White, 1992). This same concern is relevant to New Zealand's stocks of chinook. For many decades after their early 1900's establishment they were not interfered with, and hatchery releases into the rivers were minimal; however, with the development of enhancement technologies in western North America and the prospect of ocean ranching both for commercial purposes and to enhance recreational angling in New Zealand, extensive hatchery releases and transfers between catchments were undertaken during the 1970's and 1980's (McDowall, 1990). The concerns that apply to stocks in North America therefore have similar implications for the management of New Zealand's acclimatized chinook stocks. Even though these have not had millions of years of local selection to adapt them to the different conditions found in New Zealand rivers (as is true in North America), there is nevertheless evidence to suggest that fundamental life history parameters such as age and size at maturity, spawning season, and relative fecundity, differ among New Zealand river systems (Quinn and Unwin, 1993).

Among certain stocks at risk in North America have been the diverse chinook salmon stocks of the Pacific coast (McDonald, 1981; Nehlsen et al., 1991); because of the fragility of some of these stocks, the presence of acclimatized chinook salmon in New Zealand is of wider interest and their stock origins in North America of particular interest. In addition, the presence of these stocks in New Zealand for about 90 years provides a valuable opportunity to examine changes in allele frequencies during that period of isolation. For this reason alone, identification of the origins of New Zealand chinook stocks would be of interest. In particular, the stocks on the Sacramento River (Rutter, 1902) suffered severely from the construction of the Shasta Dam in 1943, which prevented salmon from reaching the many spawning tributaries

in the upper river, including Mill Creek, the McCloud River, and other waters where chinook salmon stocks spawned (Cope and Slater, 1957). These were waters where racks and hatcheries had operated in earlier years to provide salmon ova for release in many other areas, including New Zealand.

Early New Zealand Chinook Salmon Introductions

Initial introductions of chinook salmon to New Zealand took place in the 1870's. In 1875 the Hawkes Bay Acclimatisation Society obtained ova “through Dr. Spencer F. Baird, Chairman of the United States Fishery Commission” (Thomson, 1922). The ova, though originally destined for the town of Napier, began to hatch as they reached Auckland, and they were released into nearby rivers; none reached Napier. Further consignments were sent in 1876, 1877, and 1878, but contemporary New Zealand accounts do not state their explicit origins; the common assumption has been that they came from the Baird Hatchery on California's McCloud River, a tributary of the Sacramento.

A history of California salmon hatcheries suggests that, at this early period, the Baird Hatchery was the only one in a position to provide ova for New Zealand (Leitritz, 1970). Their source is largely of academic interest, anyway. There is only slim evidence that even an occasional salmon from the 1870's releases may have returned to New Zealand rivers as adults, e.g. a few rather modest-sized fish, thought by some to be chinook salmon, were taken from rivers like the Waimakariri (3.6, 2.4, and 2.0 kg) and Waitaki (4.4 kg; Thomson, 1922), but there is as much likelihood that they were sea-run brown trout which abounded in such rivers and grew to this or greater size.

One early report claimed that a fish from a New Zealand river (1884) was identified as a California salmon by T. H. Bean, of the U.S. National Museum (N.Z. Marine Department, 1885) Unfortunately, this fish is no longer in the collections of the Museum. Thomson (1922) related several events reputed to involve specimens of *Oncorhynchus*

from New Zealand rivers. L. F. Ayson, who was responsible for the later, successful introductions of chinook salmon, and who was New Zealand's Chief Inspector of Fisheries from 1898, wrote that "apparently some fish caught in the Waitaki River have been identified as belonging to the Pacific Salmon or *Oncorhynchus* family," but he thought the evidence "far from compelling" (N.Z. Marine Department, 1899).

Whether or not any of these fish were chinook remains uncertain, and in terms of the present stocks of chinook salmon in New Zealand it is probably unimportant. What is very clear is that if chinook were still present in New Zealand by 1900, as a result of the 1870's importations, they were sparse indeed. Such runs, if any, were most likely restricted to rivers of Canterbury where stocks of chinook are now present, since there were never even hints of consistent runs in any other New Zealand rivers before 1900, nor have there been since, apart from some sparse and intermittent runs on the South Island's west coast (Fig. 1). There were certainly no fish running into any of these rivers in the late 1800's in numbers comparable with those that followed the early 1900's releases, and it can be concluded that even if there were a few salmon in these rivers, their genetic contribution to the stocks that developed rapidly in the early 1900's was probably minor.

Most commentators have considered the 1870's releases a failure. Certainly, the attitude of L. F. Ayson, who had major involvement in the early 1900's chinook releases, gave no support for any significant success following the 1870's releases. He obviously saw some glimmers of success in 1899, but he also proposed a series of further major importations, and probably would not have done so had he thought there were significant existing runs. Somewhat later he was even more definite and negative, thinking that "had any of these prolific fish survived from the spasmodic efforts to acclimatize them previous to 1900, they would have disclosed themselves long before the . . . importations in 1900" (N.Z. Marine Department, 1917). Thus, Ayson, on the basis of his contemporary knowledge and experience,

clearly thought that these 1870's introductions were probably a failure.

Ayson visited North America in 1899 and returned with offers of salmon ova, noting that supplies could be obtained from the Baird and Battle Creek Hatcheries and Canada's Fraser River; from his detailed description, it is clear that he visited Battle Creek, but apparently not Baird Hatchery (N.Z. Marine Department, 1899). When he returned to New Zealand, Ayson recommended that the American offer should be accepted, and he successfully promoted further major and repeated importations of Pacific salmon ova. The New Zealand Government approved construction of a hatchery on the Hakataramea River, a tributary of the Waitaki (Fig. 2).

The 1870's consignments of salmon ova to New Zealand, which were of spring-run stock (those that enter rivers from the sea during spring), had been liberated in small batches in many rivers. Ayson was critical of this practice and intended concentrating the forthcoming releases on one river system. He chose the Waitaki River partly because of its resemblance to western North American salmon rivers—and he knew the Waitaki well, having worked there earlier in his life. It was also partly because he surmised that north-flowing ocean currents sweeping past the Waitaki River mouth would disperse the

fish northwards, and help to establish runs in other South Island rivers north of the Waitaki. And so it soon proved.

Records of Early 1900's Importations

New Zealand records of how many consignments of chinook came to New Zealand are inconsistent, some listing four, others five. The New Zealand Marine Department, the agency responsible for the importations (1901–07), recorded that five consignments of chinook salmon ova were shipped, the available details being as follows (North American brood years are the previous year in all instances):

- 1) 1901–500,000 ova, arrived in New Zealand in early January;
- 2) 1904–300,000 ova, arrived in January; accompanied by G. H. Lambson;
- 3) 1905–300,000 ova, arrival date not given; accompanied by L. F. Ayson;
- 4) 1906–500,000 ova, arrival date not given; accompanied by L.F. Ayson;
- 5) 1907–500,000 ova, left the United States 8 February, arrived in New Zealand late February; accompanied by L. F. Ayson (N.Z. Marine Department, 1901–08)

These Marine Department records are consistent with data on ova handled by California hatcheries of the U.S. Fish



Figure 2. — The Hakataramea hatchery (probably ca. 1920's), built in the early 1900's to support the chinook salmon introduction program; it remained in operation until 1942.

Commission for the brood years 1900–06 (U.S. Commission of Fish and Fisheries, 1902, 1903; U.S. Bureau of Fisheries, 1904–07); Ayson (1910), in his slightly later review, also listed five consignments. However, Thomson (1922), in his very detailed, and usually authoritative, historical account of animal introductions to New Zealand, listed only four batches, omitting that which arrived in New Zealand in 1905; this account has wide acceptance. Perhaps coincidentally, noted U.S. ichthyologist Charles Gilbert, in a letter¹ to C. A. Vogelsang of the California Department of Fish and Game (12 March 1910) also wrote of just four consignments. It appears that both Thomson and Gilbert were wrong.

No totally contemporary publications in New Zealand state where any of these ova came from, apart from “United States”; however, Ayson (1910) shortly thereafter stated that the 1901 ova “were supplied by the United States Bureau of Fisheries, from its station at Baird, California, on the McCloud River [and] came over in charge of Mr G. H. Lambson, superintendent of the Baird Station.” However, the latter source was not recorded in the initial account of the importation (N.Z. Marine Department, 1901), an account which Ayson, himself, probably wrote.

Ayson’s (1910) statement that the 1901 batch came from Baird Hatchery is not as unambiguous as it seems, because ova were often shifted between the hatcheries on tributaries of the Sacramento River (Baird, Battle Creek, Mill Creek, etc.). In this regard, records of 1900 brood year ova handled by Battle Creek are quite explicit, stating that “3,079,660 [ova] were transferred to the Sisson hatchery of the California Commission and to Baird station, including 500,000 sent to New Zealand.” The 1901 consignment, thus definitely came originally from Battle Creek not Baird, and were from fall–run fish, as it was found impossible to get summer run chinook from Battle Creek, owing to its high water temperatures at that season (U.S. Commission of Fish and Fisheries, 1902). This is the last year in which

details of the source of ova were published by the Commission, and records of ova shipped from the Baird Station were largely lost in a fire at Baird in 1909. Consequently, there are apparently no surviving details of the explicit source of the four later New Zealand consignments, though they are likely to have come from the various hatcheries in the Sacramento River basin.

Returns From the Early 1900’s Releases

The first indication of the return of chinook salmon to New Zealand waters from the early 20th century releases was a report that “fish believed to be salmon have been caught at the mouth of the Waitaki River” (N.Z. Marine Department, 1905). In a report dated 9 December 1905, James Hector, a noted New Zealand naturalist, reported that a fish sent to him was “without doubt a young specimen of the genus *Oncorhynchus*” (N.Z. Marine Department, 1905), but it is not possible to determine from Hector’s account whether this fish was from a return in the “1905” run or a very early return from the “1906” run; either is possible.

It is probably not important. The fish itself, which Hector thought a “young specimen,” was only 522 mm long, and of particular note had “rudimentary testes.” Since 448 4-year-old chinook salmon had been reared at and released from the Hakataramea hatchery during 1904–05 (Thomson, 1922), the fish Hector examined was probably one of these. Fish of this small size with rudimentary testes certainly do not feature in the present chinook salmon runs in New Zealand rivers. Small “jacks” of this size are common enough in the runs, but are sexually mature, typically with well-developed testes. Given the hatchery rearing of fish to 4 years old before release, and the rudimentary state of the testes of this fish, it may never have been to sea. Nothing more conclusive can be drawn from this report of returns in 1905. Whether any truly sea–run fish were caught in 1905 is not known; any would have been from the 1901 consignment.

Charles Ayson, son of L. F. Ayson, also worked on the Waitaki salmon run,

and at the Government’s Hakataramea Hatchery, eventually assuming control of it. He may have been familiar with this early history. In a report evidently written in 1958, Charles Ayson (1959) asserted that the first fish to come back from the sea weighed 5.5 kg and was taken in the Hakataramea trap in May 1905. At this time it would have been 4.5 years old, if derived from the original 1901 release. However, dating this return was clearly controversial at the time, as Ayson (1959) added that: “Different dates have been given . . . as to the year of the first returned fish, but . . . 1905 is definitely correct.” This 1959 account of events in 1905 differs from others, including some that were much more contemporary (N.Z. Marine Department, 1906; Ayson, 1910; Thomson, 1922). Further, in the same 1959 report Ayson stated that in the early 1900’s “probably five million salmon eggs were imported,” and this figure, too differs greatly from other reports (mostly 2.1 million ova, though Davidson and Hutchings (1938) reported 1.6 million). This discrepancy casts further doubt on the accuracy of Charles Ayson’s account, which seems to be based entirely on memory, and was written 50 years after the event by an elderly man.

L. F. Ayson reported numerous fish caught by anglers during the 1906 season (N.Z. Marine Department, 1907), and Hector was again sent specimens for study. One was a ripe female of 7.3 kg, and then three more fish, a male 635 mm and 2.7 kg (spent), a female 559 mm and 2 kg (spent), and a male 432 mm and 0.7 kg (ripe). Hector considered that the two larger of this trio of fish were 4-year-olds and the smaller one a 3-year-old; if these ages were correct, these fish were only a fraction of the size of chinook salmon of these ages in modern runs in New Zealand (Flain, 1982; McDowall, 1990), and it implies that they, too, may have been hatchery–reared for some time before release; they, too, may never have been to sea, or have done so only briefly before returning to the Waitaki River—scarcely evidence of the foundations of an anadromous salmon run.

The 7.3 kg fish therefore assumes greater significance. Judging by current

¹ Letter in possession of Mark R. Jennings, 1830 Sharon Ave., Davis, Calif. 95616.

growth rates of chinook in New Zealand (Flain, 1982; Quinn and Unwin, 1993), a 7.3 kg fish would be either 3 or 4 years old. This fish is therefore probably the first captured chinook salmon that went to sea and returned as a mature, prespawning adult. There were evidently others in the river that year, as there were newspaper reports of a few salmon spawning in the Hakataramea River at that time, April–May (fall–winter) 1906.

During 1907 there was a modest run of salmon into the Waitaki. Though most of the run was over before the rivers were inspected, 30,000 ova were obtained from fish in the 1907 run into the Hakataramea (N.Z. Marine Department, 1908), and Ayson (1910) wrote later of “quite a run of salmon up the Waitaki River [which] spawned in several of its main tributary rivers. In the Hakataramea between 300 and 400 salmon had spawned naturally in the 3 kilometres of river before it joins the Waitaki.” A similar run was reported in 1908, though the fish were “on average . . . considerably heavier.” These events confirm the initiation of a run in 1906–07 of chinook salmon into the Waitaki that resulted from the 1901–07 releases, and which became the progenitor of runs into other rivers along the east coast of New Zealand’s South Island.

In a few years, salmon spread naturally north along the coast of the South Island, just as L. F. Ayson had hoped, establishing anadromous runs in the Rangitata, Opihi, Ashburton, Rakaia, Waimakariri, Hurunui, and Waiau Rivers; these runs persist today (McDowall, 1990) (Fig. 1).

The Source of the New Zealand Chinook Salmon Runs

Several questions surround the origin of the fish that did return to New Zealand rivers from about 1906 onwards:

- 1) Which release did they originate from?
- 2) What river did the original stock come from?
- 3) How do the New Zealand runs compare with the source stocks with regard to their seasonal occurrence and age structure?

Though it might seem that the primary question to discuss would be the second of those listed above, identification of the source population depends on establishing which New Zealand releases produced the returns.

As noted above, the key fish in all this discussion appears to be the 7.3 kg fish examined by Hector in June 1906 since this was the first almost certainly anadromous salmon known to have returned, and was presumably representative of the first “run” from the early 1900’s introductions. This fish could have been derived from the 1901 (1900 California brood year) importation, in which case it would have been about 5.5 years old. Or it could have been from the 1904 (1903 brood year) importation, which would have made it about 2.5 years old. Ayson’s comment that the more abundant fish that returned in 1907 were larger may suggest that these were from the same brood year as the 1906 return, but a year older, i.e. fish that were “considerably heavier” than 7.3 kg and either 6.5 or 3.5 years old. There is no way of being certain which of these ages is correct, but it seems probable, on the basis of the ages and sizes of chinook salmon that now return to New Zealand rivers (Flain, 1982; Quinn and Unwin, 1993), and in the apparent absence of runs into the Waitaki/Hakataramea Rivers in 1903, 1904, and 1905, that the lower age is correct—that there was a small return of a few fish in 1906, probably including the 7.3 kg fish, 2.5 years old, and from the 1904 release, rather than 5.5 years old and from the 1901 release. If that is so, the more abundant, larger fish reported in 1907 could have been 3.5 years old, also from that 1904 release, quite probably with some smaller, 2.5 year old fish from the 1905 releases.

With the knowledge of some natural spawning by additional fish returning in 1906, observed natural spawning from the 1907 returns to the Waitaki, plus additional importations and releases of California stocks in 1906 and 1907, it is obvious that there is no way of distinguishing the sources of any returns after 1907, whether from natural reproduction, or from one or other of the releases derived from imported ova.

There is no hint of any salmon returning in 1902, 1903, or 1904, so the likelihood of a return of fish from the 1901 release seems slim; an unobserved run into a small river like the Hakataramea (3.5 m³/second median flow) seems unlikely, with workers busy on the river rearing salmon at the hatchery and with keen anticipation of a return of fish from earlier releases. With releases made from the production of a consignment of 500,000 ova, returns from this batch could have been prolific. Although there will never be any certainty, this fragmentary evidence leaves us with the probability that the first returns were from the 1904 release, and that this release, either alone, or probably with augmentation from the 1906 and 1907 releases, formed the source of New Zealand’s chinook salmon runs. Because the origin of the 1904, 1906, and 1907 importations is not explicitly documented, all that can be said is that they came from the Sacramento River drainage system.

As L. F. Ayson (Fig. 3) recounted, initial returns to New Zealand rivers took place in the autumn and early winter, equating with a fall run of chinook salmon in California. This return timing could have occurred because the parent stock in California were fall–run fish, or it could have been because the fish were ready to return to fresh water after 2.5 or 3.5 years at sea, as they would have been if they were spring–run fish. If maturation in chinook salmon is triggered by changes in day length, the former scenario is more likely.

Records of the ova taken at the various hatcheries on the Sacramento River indicate that the ova sent to New Zealand in the period 1901–07 were fall run fish. New Zealand runs, today, are also chiefly in the fall: Some fish begin to return to rivers from November (mid–spring) onwards, continuing through December and early January (summer). However, these early immigrants form a continuum with the main run, which builds up from late January and through February and March (fall), with spawning occurring from April until June (McDowall, 1990; Quinn and Unwin, 1993). No studies have yet been under-



Figure 3. — Lake Ayson (right), as an elderly man, shown with two assistants, holding adult chinook salmon taken at a trap in the upper reaches of the Waitaki River.

taken to determine whether the early, November–December (spring) fish in any way comprise a stock distinct from the main run of fish in February–March. On the face of it, New Zealand seems to have a “fall run” of chinook salmon, like those from which it was derived.

The age structure of the runs in most New Zealand rivers is as follows: Three-year-olds predominate in any brood year; 4-year-olds may be second in abundance, but sometimes 2-year-olds are more common; there are very few 5-year-olds, and no 6-year-olds or older (Flain, 1982). Pack and Jellyman (1988) recorded salmon up to 6 years old in the Clutha River, but these fish had reared for several years in inland lakes before emigrating to sea. Quinn and Unwin (1993) concluded that the New

Zealand stocks of chinook grow more rapidly than the American counterparts, up to an age of 3–4 years, but mature earlier; earlier maturation may be a result of this more rapid early growth.

In this regard the New Zealand stocks differ from those in California, in which 4-year-olds predominate, with some fish 6 years or even older (Gilbert, 1914; Flain, 1982). The younger age structure in New Zealand dates back at least as early as the 1920’s, as scale samples sent to Charles Gilbert, the noted early 1900’s American fisheries biologist, were aged and showed that the New Zealand fish were already returning at a younger age than those from which they were derived in California (N.Z. Marine Department, 1927). Further scale samples examined in New Zea-

land from 1928 onward confirmed this view (Finlay, N.d.), and this difference remains.

Conclusion

New Zealand’s stocks of anadromous chinook salmon are probably derived from the second of five consignments of ova in the early 1900’s. These came from an undetermined tributary and hatchery on the Sacramento River, were taken to New Zealand in 1903, reaching there early in 1904; the first consignment (1900 brood year, reaching New Zealand in early 1901), which is known to have come from Battle Creek, a Sacramento tributary, may have failed to produce returns, though there could have been a small and unnoticed return from this consignment. The explicit

source in the Sacramento River of the later shipments cannot now be determined.

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