# RATES OF MOVEMENT AND TIMING OF MIGRATIONS OF STEELHEAD TROUT TO AND WITHIN THE SKEENA RIVER, 1988

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# ABSTRACT

Summer-run steelhead (*Oncorhychus mykiss*) returning to the Skeena River system were radio-tagged to determine their rates of movement through commercial salmon fisheries near the river mouth. The run timing of individual spawning populations was also investigated as were riverine migrations through sport fisheries on the mainstem Skeena. Steelhead (n=140) were collected using a commercial seine vessel and either radio-tagged (n=55) or spaghetti tagged (n=80). Radio-tagged steelhead were monitored from aircraft or with stationary receivers as they entered freshwater. Additional data were obtained by examining the date and location of capture of tagged fish intercepted by the commercial fleet. The net rate of travel (km/day) towards the Skeena River was calculated from the times and distances between tagging and recapture locations. Only 39 (70.9% of total) radio-tagged steelhead were eventually accounted for of which 6 were reported caught in the commercial fishery. The average rate of travel from points of tagging to the river was approximately 8 km/day. It was estimated that steelhead took 12 days to migrate through the entire commercial fishing area. Travel through the river mouth where the highest gillnet catches of steelhead occur, took 2 - 3 days. Rates of movement in the Skeena mainstem averaged 10.4 km/day for the area downstream of the Zymoetz River, and 20.2 km/day between the Zymoetz River and Bulkley River. Individual fish travelled as quickly as 32.0 km/day in the upper Skeena River beyond its confluence with the Bulkley. The study failed to outline differences in the run timing of separate stocks within the Skeena River drainage, largely because of limited sample sizes and the fact nearly all radio tags were disbursed over a two day period.

# ACKNOWLEDGEMENTS

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# INTRODUCTION

The Skeena River system provides some of the world's finest angling for wild, summer run steelhead trout (*Oncorhnchus mykiss*) (Narver 1969, Billings 1989). However, returns of these fish are severely affected by gillnet and seine fisheries in and near the mouth of the Skeena (Oguss and Andrew 1977, Oguss and Evans 1978, Cox-Rogers 1985). Steelhead catches occur incidentally in these fisheries as a result of run timing overlaps with target stocks of sockeye (*O. nerka*) and pink (*O. gorbuscha*) salmon on which the commercial fishery focuses.

The problem of steelhead interceptions in these fisheries has been reviewed by the Ministry of Environment (M.O.E.) and the Department of Fisheries and Oceans (D.F.O.) since the mid-1970's. Models to assess impacts of the commercial fishery and test alternate harvesting strategies have been developed (Lapoint and Staley 1987) but require information on steelhead movements to function effectively. The migration rate of steelhead through the commercial fishery is a key variable in developing models and alternative harvest strategies.

Further complications in stock management and modelling have arisen because steelhead associated with each tributary may arrive at the Skeena River mouth at distinctly different times. Variations in the dates of arrival to the Skeena by stocks destined for individual tributaries were examined by radio-tagging adult steelhead in the Skeena River mainstem near tidewater (Lough unpublished M.S. 1981). Cox-Rogers (1985) also investigated run timing by examining the scale patterns of each stock. However, stock-specific dates of entry were not well defined by either study.

Accordingly, radio telemetry and spaghetti-tagging studies were conducted during 1988 by M.O.E. in cooperation with D.F.O. The objectives were:

1. to determine rates of movement of adult steelhead through the commercial fishery toward the mouth of the Skeena River, and
2. to assess differences in dates of entry into the Skeena River by steelhead stocks migrating to individual tributaries ("run timing").

A secondary objective was to study the rates of movement of adult steelhead as they migrated up the Skeena River mainstem.

# METHODS

## STUDY AREA AND THE FISHERIES

The Skeena River, situated in west central British Columbia, is one of the largest drainages on the Pacific coast of North America. Originating in the Skeena Mountains, this system flows approximately 530 km south-west before reaching the Pacific Ocean near Prince Rupert (Fig. 1). Major tributaries include the Babine, Bulkley-Morice, Kispiox, Sustut and Zymoetz Rivers. Many tributaries of the Skeena River are glacial in origin, resulting in high, turbid conditions throughout much of the spring and summer. Autumn hydrographs are characterized by at least one high water resulting from rain on snow. The drainage area and some tributaries were previously described by Narver (1969), Whately (1977) and Whately et al (1978).

Canadian commercial seine and gillnet fisheries targeting on Skeena River salmon stocks (Milne 1955) operate during July and August along the coast from the Alaskan border south to Ogden Channel within D.F.O. Statistical Areas 3, 4 and 5 (Fig. 2). The majority of fishing and steelhead catches occur in Area 4 and in particular at the mouth of the Skeena, within Subareas 4-12 and 4-15 (D.F.O., data on file). The gillnet fleet normally concentrates within these inner subareas. Haysport presently marks the furthest inland point of operations by the commercial fleet. A gillnet ‘test fishery’ at Tyee, approximately 6 km up the Skeena River from Haysport has been operated by D.F.O. since the mid-1950’s to estimate numbers of fish escaping the commercial fleet (Jantz et al. 1987).

Sport fisheries are well developed and increasing in popularity on the Skeena system. Highest use takes place on the Bulkley, lower Morice, Kispiox and Zymoetz Rivers, where better road access is found. Angling on the mainstem Skeena, particularly downstream of the Zymoetz has also expanded vastly over the past 10 years (Billings 1989). Guiding of anglers and tourism associated with the sport fishery are important to the economies of Terrace, Hazelton, Smithers, Houston and other settlements in the drainage.

Native Indians in the Skeena Valley operate net and gaff fisheries for both steelhead and salmon. Netting is concentrated on the Skeena itself near Kitwanga, Kitseguecla and Hazelton, while gaffing is confined to Moricetown on the Bulkley River(Fig. 1). A gillnet fishery also occurs at the river mouth just prior to the commercial fishing season and has been increasing in intensity in recent years. These fisheries are poorly understood but have been described in part by Morrell et al. (unpublished M.S. 1985) and Lough (unpublished M.S. 1988).

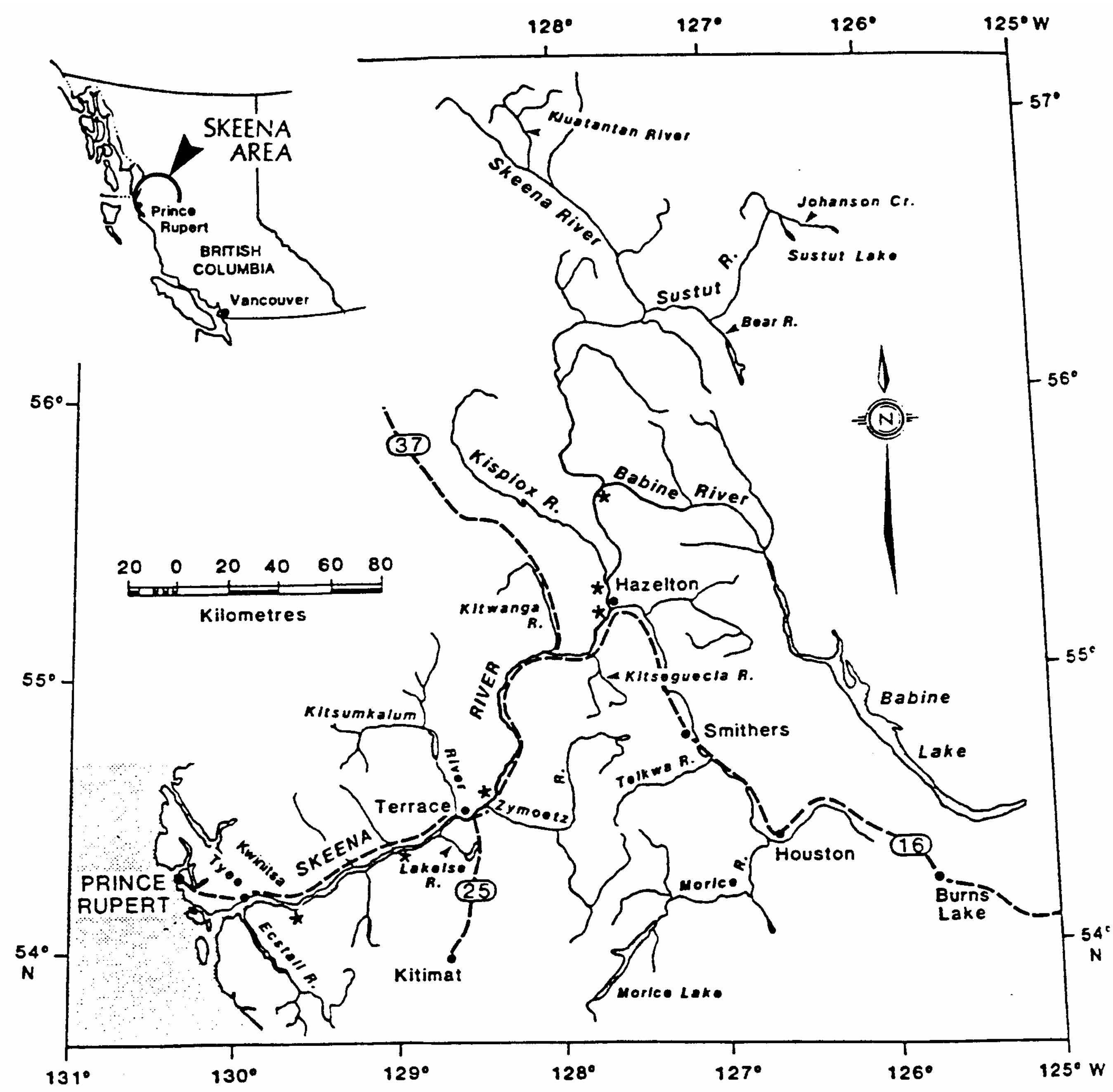



Figure 1. Map of the Skeena River system showing the B.C. coast and important geographic reference points (*denotes stationary scanner locations used in the present study).

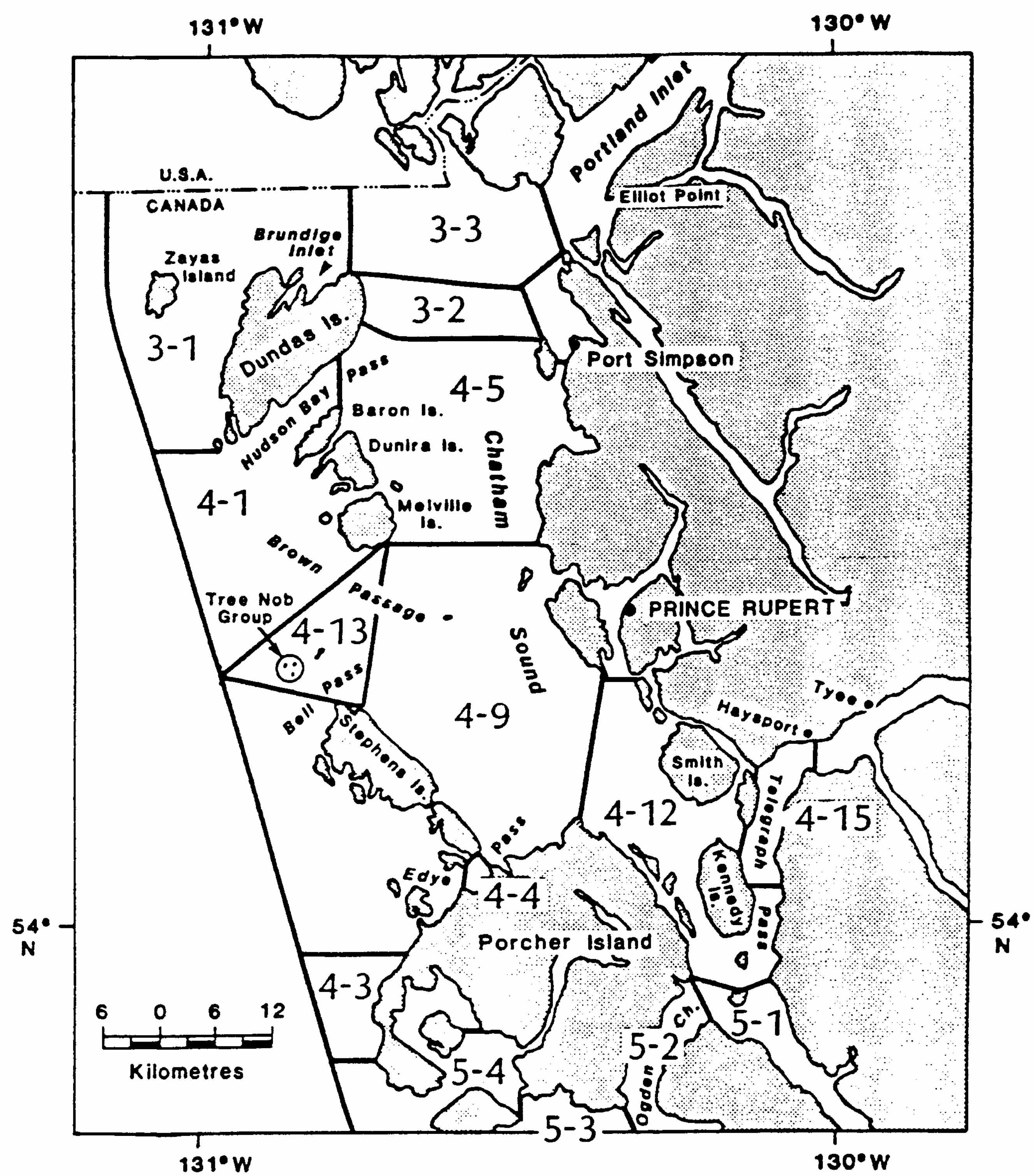



Figure 2. D.F.O. Statistical Areas 3, 4 and 5 and their positions relative to important geographic reference points and the inner boundary of the commercial fishery at Haysport on the lower Skeena River.

## FISH COLLECTION AND TAGGING

Fish were obtained with a licensed commercial seine vessel using conventional gear and methods (Quinn???? See Ward????). Seining was undertaken in Areas 3 and 5 at locations nearest the Skeena mouth and on the outer boundaries of Area 4 (Fig. 2). Seining locations were generally chosen by the vessel operator and were most often located at traditional beach tie-offs (i.e. points of land to which one end of the net is tied during seining operations). A total of 23 different seine sites within 6 general geographic areas were used (Table 1). Distances over water from these sites to the inner boundary of the commercial fishery at the Skeena mouth (Haysport) ranged between 20 and 100 km.

Greatest sampling effort occurred in Area 4, particularly along the north side of Porcher Island, from Alice Island through Edye Passage and west to Rod Island (Table 2). Fishing locations changed as experience improved estimation of where the best steelhead catches might occur. However seine sites were also selected on the basis of weather conditions; south easterly winds forced much fishing effort to sheltered areas such as the north side of Dundas Island, particularly during the early stages of the project.

A total of 140 steelhead were landed over the course of the project for an average of 1.6 fish per set (Tables 2, 3). “Beach” sets, in which one end of the net is fixed to shore while the other is towed by the vessel, were most commonly applied and yielded the nearly all of the catch. Sets in which the net was not fixed to shore (“open” sets) were also capable of producing steelhead but were used less frequently since the charter vessel operator felt they were less effective.

A1though steelhead were present in catches from July 21 to September 1, a dramatic peak occurred on August 4 and 5 (Table 3). Catches took place in all six general geographic areas except the northwest side of Stephens Island where none were observed in 13 sets. The north side of Porcher Island produced most of the catch; 109 (77.9% of project total) steelhead were taken in that area. The vast majority of the catch on north Porcher and for the project as a whole occurred during August 4 and 5 when 84 steelhead were landed. During that two day period, as many as 43 steelhead were caught in one set while the average catch per set was 9.3.

The seine net was pursed and held along side the vessel in a confined bag after each set. The catch could usually be inspected without injury under these conditions. Depending on the extent of the catch and whether or not the fish were to be retained, either estimates or exact counts of each species were noted.

TABLE 1. Locations of seine sites used for the capture of steelhead in studies of their movements to and in the Skeena River.

| Geographic Location | Seine Sites | D.F.O. Subarea | Distance to Haysport (km)[1] |
| --- | --- | --- | --- |
| N. Side Dundas Isl. | Boat Harbour | 3-1 | 100.0 |
| | White Is. | 3-1 | 97.5 |
| | Goose Bay | 3-1 | 95.0 |
| | Brundige | 3-1 | 92.5 |
| | S. Holiday Is. | 3-2 | 87.0 |
| Port Simpson | Elliot(“Eli”)Pt. | 3-7,8 | 95.0 |
| | N. Hogan Is. | 3-7 | 89.0 |
| | Maskelyne Is. | 3-3,4 | 86.0 |
| | Haida Bay | 3-4 | 85.0 |
| | Birnie Is. | 3-4 | 82.5 |
| Hudson Bay Passage | Prince Leboo Is. | 4-1 | 80.0 |
| N.W. side Stephens Isl. | Bell Pass Is.7 | 4-13 | 76.0 |
| | Bell Pass is.37 | 4-13 | 72.5 |
| | China Is. | 4-2 | 57.5 |
| N. side Porcher Isl. | Rod Is. | 4-2 | 53.5 |
| | Edwin Pt. | 4-2,4 | 45.0 |
| | Goble Pt. | 4-9 | 42.5 |
| | Alice Is. | 4-9 | 37.5 |
| Ogden Channel | Alpha Bay | 5-2 | 39.5 |
| | Swede Bay | 5-2 | 35.0 |
| | Oona Pt. | 4-12,5-2 | 28.0 |
| | Gibson Is. | 5-12 | 7.5 |
| | Kennedy Is. | 4-12 | 20.0 |

1. Distances calculated by taking shortest possible measurement over water from point of seining to inner boundary of commercial fishing area (Haysport).

TABLE 2. Area summary of seining effort and steelhead radio-tagged, spaghetti-tagged, recaptured or released untagged during radio telemetry studies of steelhead movements to and in the Skeena River.

| | | | Steelhead | | | | | |
|---|---|---|---|---|---|---|---|---|
| Location | Seine Type | Sets No. | Radio Tagged | Spaghetti Tagged | Recapture Of Tag | Released Untagged | Total | Number per Set |
| N. Porcher Is. | Open | 4 | 13 | 0 | 1 | 0 | 14 | 3.5 |
| | Beach | 30 | 28 | 63 | 1 | 3 | 95 | 3.2 |
| | Combined | 34 | 41 | 63 | 2 | 3 | 109 | 3.2 |
| N.W. Stephens Is. | Open | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Beach | 9 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Combined | 13 | 0 | 0 | 0 | 0 | 0 | 0 |
| N. Dundas Is. | Beach | 20 | 7 | 3 | 0 | 0 | 10 | 0.5 |
| Hudson Bay Pass | Beach | 3 | 2 | 0 | 0 | 0 | 2 | 0.7 |
| Port Simpson | Beach | 2 | 3 | 4 | 0 | 0 | 7 | 0.7 |
| Ogden Channel | Beach | 2 | 2 | 10 | 0 | 0 | 2 | 0.7 |
| All | Open | 8 | 13 | 0 | 1 | 0 | 14 | 1.8 |
| | Beach | 81 | 42 | 80 | 1 | 3 | 126 | 1.6 |
| | Combined | 89 | 55 | 80 | 2 | 3 | 140 | 1.6 |

Steelhead were usually removed from the catch with a dip net and placed immediately in a water filled plastic tub for tagging. In instances where larger sets were made, however, not all steelhead were detected before the catch was brailed onto the deck or pulled up over the stern ramp.

All undamaged fish were tagged and released immediately. Time of tagging was noted to the nearest 5 minutes. Radio-tags were implanted orally into the stomach by means of a thin fiberglass tube through which the antenna was inserted (Lirette and Hooton 1988). Antennae were left protruding from the mouth. Two numbered spaghetti tags were then attached at the base of the dorsal fin and the fork length noted. To minimize potential affects on migration, no anaesthetic was used during any of these procedures.

Since it was unclear how many fish might be obtained for radio-tagging, virtually all uninjured steelhead were equipped with transmitters during the early stages of the project. As more fish became available than were required to meet radio-tagging objectives, portions of the

TABLE 3. Weekly summary of seiner effort and steelhead radio-tagged, spaghetti-tagged, recaptured or released during radio telemetry studies of steelhead movements to and in the Skeena River.

| Date | Number of Sets | Steelhead Radio Tagged | Spaghetti Tagged | Recapture Of Tag | Released Untagged | Total | Number per Set |
|---|---|---|---|---|---|---|---|
| July 15 | 7 | 0 | 0 | 0 | 0 | 0 | 0.0 |
| July 21-22 | 11 | 4 | 1 | 0 | 0 | 5 | 0.5 |
| July 28-29 | 13 | 6 | 0 | 0 | 0 | 6 | 0.5 |
| August 4-5 | 9 | 37 | 43 | 2 | 2 | 84 | 9.3 |
| August 10-12 | 16 | 3 | 10 | 0 | 0 | 13 | 0.8 |
| August 18-19 | 10 | 2 | 14 | 0 | 0 | 16 | 1.6 |
| August 25 | 6 | 3 | 9 | 0 | 1 | 13 | 2.2 |
| Aug 30-Sept 1 | 17 | 0 | 3 | 0 | 0 | 3 | 0.2 |

catch were marked only with a single spaghetti tag. Exceptionally small or large fish were sometimes selected preferentially for radio-tagging to increase the return of information on a number of Skeena River stocks.

## EQUIPMENT AND MIGRATION MONITORING

Transmitters and receivers were supplied by Lotek Engineering (Aurora, Ont). Transmitters were encased in resin and coated in paraffin to form cylindrical packages ranging from 18 X 40 mm to 22 X 70 mm. Tags were designed for esophageal implantation and were tapered toward the posterior end to reduce the chances of regurgitation (Lirette and Hooton 1988). A 280 mm whip antennae protruded from the anterior end of the tags. Tags were designed for a minimum operational life of 11 months. A total of 50 transmitters utilizing 25 different frequencies between 151.005 and 151.245 MHz were employed. We used two tags per frequency and distinguished individual tags by differing the pulse rates (60 vs. 90 pulses per minute).

Lotek SRX 400 receivers designed for scanning and long term data logging at unmanned stations were used throughout the study. Radio signals and their associated pulse rates were interpreted and stored by these receivers through built-in software and RAM. Data were off-loaded periodically in the field to a lap top IBM compatible computer. Recording stations consisted of an SRX 400 receiver connected to a 12 volt deep cycle battery within a weather proof, camouflaged container. A four element Yagi antenna fixed to aluminum conduit and fastened to a tree top was employed at each station. A total of six receiver stations were installed on the Skeena River banks between Kwinitsa and the mouth of the Babine River (Fig.1).

Data from fixed stations were supplemented with aerial monitoring using a helicopter (Bell 206) and occasionally a fixed wing aircraft (Cessna 206). We employed two SRX 400 receivers to allow the frequencies to be split and thereby reduce scan times. A three element Yagi antenna was attached to each receiver during helicopter work, while an "H" configuration was mounted on the strut of the fixed wing. Tracking from vehicles and boats was undertaken infrequently using similar systems. The times and positions of relocations were marked as accurately as possible on 1:250 000 map sheets.

Information on recaptures of tagged fish in both the tidal and inland fisheries was solicited throughout the study. Representatives from commercial, sport and Native fisheries were contacted as well as the media. Baseball hats bearing a special logo were offered as rewards to those who turned in tags or reported recaptures and releases of tagged fish.

## DATA ANALYSIS

Details of radio tagged fish movement in salt water could not be obtained due to radio signal attenuation (Solomon and Potter 1988). As a result, movements of tagged steelhead through the commercial fishery could only be assessed from recaptures by the fleet, recaptures by the test fishery at Tyee (Fig. 1), and monitoring radio tags as they entered the Skeena River. Net rates of movement toward the river were based on the length of time and shortest possible distance over water between the points of capture and relocation. Movements in the Skeena River were analyzed from 1:250 000 maps marked upstream in 1 km increments, using Haysport as km 0 (Fig. 1).

I assessed the run timing of individual steelhead stocks by first examining the late autumn - early winter locations of radio-tagged fish. After determining these destinations, I used the site of the test fishery at Tyee as a standardized point to determine dates of river entry. However, since most radio-tagged steelhead were first detected at a variety of locations other than Tyee (typically upstream), it was necessary to back-calculate the dates on which each fish passed by that point. Rates of travel through the commercial fishery were used in these calculations. For each fish, I divided the distance between Tyee and the first point of upstream relocation by the rate of travel to estimate the number of days it took to migrate that distance. This result was then subtracted from the date on which the fish was first relocated above Tyee to produce an estimate of the date when it passed that location.

# RESULTS AND DISCUSSION

## STEELHEAD CATCH DESCRIPTION

Of the 140 steelhead captured during the study, 55 were radio-tagged (Tables 2, 3, 4). Most of the remaining catch was spaghetti-tagged, with the exception of 3 fish released untagged and 2 recaptures of fish that had been tagged earlier. Although no steelhead appeared to die during seining or tagging operations, one fish hauled aboard with a large catch of salmon was not discovered for several minutes and likely did not survive. This fish was returned to the water untagged before its condition could be assessed.

Steelhead lengths ranged from 50.0 to 97.0 cm (Table 4). On average, males were slightly longer than females and radio-tagged fish were longer than those which were spaghetti-tagged. Most steelhead were in very bright condition, with only the occasional male showing slight indication of pink on the operculum. Several sea lice (*Lepeophtheirus* sp.) were present on most fish. Marks from recent encounters with gillnets were observed on 8 steelhead (5.7% of catch) and scars of other unknown origin on another 3 fish (2.1%).

## STATIONARY RECORDER PERFORMANCE

Difficulties with the stationary scanners/data loggers prevented complete assessment of the time of entry of radio-tagged fish into the lower Skeena River. Problems resulted partially from limitations in the sensitivity of the recording stations relative to the size of river. At the lowermost scanner (Kwinitsa), the river was well in excess of 300 m across and up to 4 m in depth. Although tests prior to tagging suggested radio tags in the deepest water on the far bank would be detected, follow-up aerial monitoring showed that fish occasionally passed undetected.

A further problem with the stationary scanners related to their inability to distinguish and screen signals generated by radio sources other than tags. This was not severe until the second week of August, when very powerful and persistent radio transmissions across a broad band of frequencies began on the lower Skeena River, particularly near Kwinitsa. The source of these transmissions was never determined even after considerable investigation, but it is possible that nearby highway and/or railway activity may have been involved. This was a large enough

TABLE 4. Numbers and lengths of male and female steelhead radio-tagged and spaghetti-tagged in Statistical Areas 3, 4 and 5 during radio telemetry studies of Skeena River stocks, 1988.

| | Tag Type | Sample[1] Size | Length (cm) Mean | St. Error | Min | Max |
|---|---|---|---|---|---|---|
| MALE | Radio | 14 | 82.3 | 2.80 | 55.0 - | 97.0 |
| | Spaghetti | 27 | 77.1 | 1.89 | 55.0 - | 92.5 |
| | Total | 41 | 78.9 | 1.59 | 55.0 - | 97.0 |
| FEMALE | Radio | 37 | 75.7 | 1.38 | 56.0 - | 91.5 |
| | Spaghetti | 46 | 74.8 | 1.12 | 50.0 - | 89.0 |
| | Total | 83 | 75.2 | 0.88 | 50.0 - | 91.5 |

1. Not all fish were sampled for length, hence sample sizes are smaller than the actual numbers tagged.

problem to eliminate stationary recorders as a tracking option on the lower Skeena River through most of the project. We therefore used aerial tracking extensively to provide a back up data source.

Recording stations were far more reliable in upriver locations and were the primary source of data above the outlet of the Zymoetz River (km 140). In those areas, I believe most erroneous records were generated by interference from passing vehicles and/or boats. McCleave et al. (1978) found that ignition of outboard motors caused the greatest electrical interference in their receiving system.

## SALTWATER MOVEMENTS

### *Radio Tag Disappearances*

Only 39 (70.9%) of the 55 steelhead fitted with radio tags were eventually accounted for, either in commercial fishery catches or upstream in the Skeena River. Several factors may have been involved in the disappearances of the remaining 16 radio-tagged fish. Transmitter regurgitation is fairly common in freshwater (Lirette and Hooton 1986, Spence unpublished M.S. 1981) and has also been observed with steelhead in saltwater immediately after tagging (T. Wilkinson, M.O.E., Williams Lake, pers. comm.). One transmitter malfunction was documented as a result of an angler recapture of a tagged fish; this tag almost certainly failed prior to entering the river. Movement of tags to other drainages, particularly the Nass River (140 km north of the mouth of the Skeena River), was a possible cause for the disappearance of fish tagged on the northern limits of the study area. Predation may also have contributed to tag disappearances, especially at the mouth of the Skeena where seals were numbering in the hundreds were observed during tracking flights. Although several tags were turned in by commercial fishermen some may not have reported tag recoveries.

*Rates of Movement*

Estimates of the net rate of movement of radio tags through the commercial fishery toward the river mouth (Fig. 3) were obtained using two sources of relocation data. Firstly, all fish initially relocated either below the upper limit of tidal influence on the Skeena (km 54) or through recaptures in the commercial fishery were analyzed. Secondly, only those steelhead relocated below km 10 or in the commercial fishery were examined.

Data from steelhead that were not relocated for the first time until they had passed the upper limit of tidal influence (km 54) were excluded because tagged fish accelerated as they ascended the river. Altogether data from relocations below km 10 were probably most accurate because they were salt water in origin, inclusion of data as far as the upper end of tidal influence (km 54) increased the sample size from 7 to 25.

Using data up to km 54, minimum and maximum rates of movement were 3.7 km/day and 33.7 km/day respectively. Although the mean of these data was 10.3 km/day this was strongly influenced by two unusual fish which traveled in excess of 30 km/day. The remainder did not exceed 15 km/day and may best describe the typical migration. These fish moved at a mean rate of 8.3 km/day. Data from fish located below km 10 or in salt water did not contain “outliers” and averaged 7.5 km/day, with extremes varying between 4.4 and 12.7 km/day. Thus, both methods of analysis suggested an average net rate of travel of about 8 km/day through the fishery toward the mouth of the Skeena River.

At an average rate of 8 km/day steelhead would take about 12 days to travel from the top of Dundas Island, on the outside of the Area 4 fishery, to Haysport. Goble Point (north side Porcher Island) to Haysport would take about 5 days. The 15 to 20 km distance from outside to inside of Subarea 4-15 (the river mouth fishery and main source of steelhead

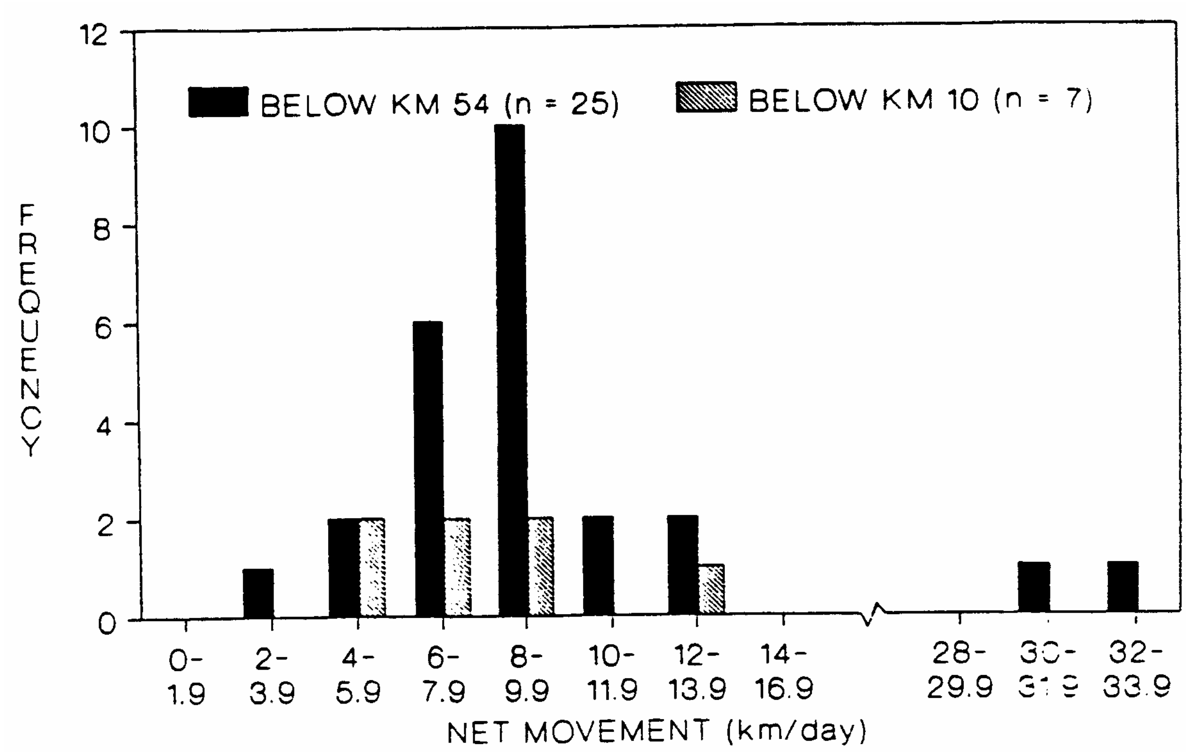



Fig. 3. Net rate of movement of radio-tagged steelhead toward the Skeena River from seining sites in D.F.O. Statistical Areas 3, 4 and 5, 1988.

commercial catch) would require about 2 to 2.5 days. Intensive commercial gillnetting in Subarea 4-15 would be reflected by poor catches at the Tyee test fishery about 2 days after the start of the fishery. In reality, test fishery catches follow this pattern very closely (Lough unpublished M.S. 1981).

The sample used to calculate rates of movement in salt water was limited to only 25 steelhead, even with the inclusion of relocation data up to km 54. Further fish could not be included in the analysis because they were not detected until they had migrated well beyond km 54. The sample was also reduced because specific capture location and time data were unavailable for some saltwater recaptures.

In using relocation data up to km 54 to generate a larger sample, I assumed that fish in salt water migrated at the same speed as fish in the tidal zone of the river (km 0 - 54). I was able to test this assumption by comparing the migration rates of steelhead in the tidal portion of the Skeena to those fish recaptured by the commercial fleet or relocated downstream of km 10. The opportunity for such a comparison was afforded by a total of 7 fish relocated more than once within the area of tidal influence. The rate of travel for those fish averaged 8.1 km/day and ranged between -2.6 and 14.0 km/day in comparison, the net rate of travel for the 7 fish relocated in salt water or downstream of km 10 averaged 7.5 km/day and ranged between 4.4 and 12.7 km/day.

Although the sample sizes were small and the data highly variable, similarities in the means suggested it was reasonable to include tidal river relocation data as part of the study of saltwater movements.

It is important to note that 80% of the data from the larger sample and 50% from the smaller group came from fish tagged off the north side of Porcher Island on August 4 and 5.
This concentration in time and space prevented any meaningful study of the effects of such factors as tidal conditions or location of tagging on migration rates. Movements of sockeye salmon near the mouth of the Skeena are influenced by tides (Groot et al. 1975) and it would not be unreasonable to suggest steelhead exhibit similar behaviour. The location of tagging might also have affected movements. For example, the progress of Atlantic salmon (*Salmo salar*) during spawning migrations slows significantly as fish approach the river (Laughton 1989, Heggberget et al. 1988, Westerberg 1982). Since patterns of this type could not be assessed in the present study, considerably more variation in movement probably exists than has been demonstrated.

It was shown clearly on two occasions that steelhead sometimes move downstream shortly after they enter the Skeena River. In one instance, a steelhead located by helicopter 7 km up the Skeena from the commercial fishing boundary was found dead in a packing plant in Prince Rupert 3 days later. Another appeared to remain upstream of the commercial fishing boundary and travelled only a short distance downstream before resuming an upstream migration. Five other similar cases have been documented from tagging undertaken at the Tyee test fishery (M.O.E., data on file).

*Recaptures*

A total of six radio-tagged steelhead were reportedly recaptured in the commercial fishery. All recaptures were by gillnetters, and showed that the fish had migrated toward the Skeena River since tagging. Four recaptures took place within Subarea 4-15 near the mouth of the Skeena, where gillnetting activity was most intense.

Of the six steelhead tagged only with spaghetti tags and later caught in the commercial fishery, two were recaptured in Subarea 4-15. A third fish was caught in Area 4 but information on the subarea was not documented. One steelhead spaghetti-tagged at Birnie Island was recaptured 4 days later and 20 km to northwest in Alaskan waters off Garnet Point. Other recaptures involved two fish tagged August 4 at Goble Point and then recaptured by the seiner during tagging operations the following day. Of the latter two fish, one was recaptured at the same location while the other had moved 10 km to the east.

One radio-tagged steelhead was reportedly recaptured and subsequently released in the commercial fishery. This fish appeared to migrate normally after the encounter and was last located in an overwintering area in the Morice River. Two radio-tagged steelhead were also captured and released by the Tyee test fishery gillnetter but only one was eventually tracked into the river.

*Effects of Capture and Tagging*

The degree to which the stress associated with capture and tagging might affect fish survival or behaviour was a key consideration in the study. Although mortalities of radio-tagged steelhead could not be ruled out, there was evidence to suggest this was unlikely. Most fish appeared very strong and healthy following capture, even in circumstances where they were hauled over the stern roller of the seiner along with several hundred salmon. In one instance, a steelhead treated in this fashion was later recaptured and released by an angler on the lower Skeena, and then caught and released by yet another fisherman on the Bulkley River. Another spaghetti-tagged fish was recaptured by the seiner the following day, released and then again recaptured and killed by a gillnetter 5 days later. Numerous other recaptures during the project all point to a high probability of survival following tagging. McCleave et al. described the use of radio telemetry for studies of Atlantic salmon and reported no ill effects. Sonic tagging of steelhead, which is very much like radio tagging, revealed no evidence of mortalities as a result of capture and tagging under similar circumstances (Quinn and Rugerone unpublished M.S. 1988).

A clear indication of migration rates could not be obtained from fish bearing only spaghetti tags since recaptures were infrequent and poorly reported. Thus, a comparison with rates of movement of radio-tagged fish could not be undertaken to assess the effects of the radio tag itself. However, simultaneous tagging and sonic tracking experiments by Westerberg (1982) showed clearly that the transmitter per se did not affect Atlantic salmon migrations. Quinn and Rugerone (unpublished M.S. 1988) found the impacts of tagging stress affected migrations for only a few minutes. The effects of stress from handling and tagging on fish behaviour were therefore unlikely to have been a significant factor in the present study.

The results suggest that seining offers a means of fishing selectively if non-target species such as steelhead are released. However, even those fish hauled over the stern roller were released more quickly and treated with considerably more care than would be expected under standard commercial fishing conditions. Releasing steelhead from seine catches would only be effective if crews were extremely attentive. Very large catches, such as those typically found during pink salmon fisheries, would present difficulties since the fish are brailed directly from the pursed seine into the hold of the vessel.

*Freshwater Movements*

Movements were analyzed within three zones on the Skeena mainstem: from the limit of tidewater (km 54) to the Zymoetz River (km 126), between the Zymoetz and Bulkley Rivers (km 257), and from the Bulkley River to the Kispiox River (km 271).

The majority of radio-tagged fish passed through the area between km 54 and the stationary scanner near the mouth of the Zymoetz River between August 14 and 24. Upstream speeds averaged 10.4 km/day and ranged between less than 2 and nearly 20 km/day (Fig. 4). Upriver movements averaged 11.1 km/day during August 14 - 17 and were well distributed over a wide range of values (Fig. 5). Movements slowed to an average of 8.0 km/day between August 17 and 21 and tended to cluster between 4 and 10 km/day. A sharp increase in the rate of travel occurred from August 21 - 24, when all rates exceeded 10 km/day and the average climbed to 14.6 km/day.

Using the average of 10.4 km/day as a guide, steelhead would be expected to take about 10 days to travel the approximately 100 km long section of the Skeena River downstream of Terrace, where the majority of the bar fishery currently takes place. Averages and ranges in migration rates were similar to those noted by Lough (unpublished M.S. 1981) in an earlier telemetry study of Skeena River steelhead.

Rates of movement below the Zymoetz River appeared to be inversely related to river discharge. The hydrograph for the Skeena River mainstem at Usk (just upstream of the mouth of the Zymoetz River) showed a distinct decline from August 14 - 17 (Fig. 5), when migrations averaged 11.1 km/day. Upstream movements slowed as the hydrograph ascended between August 17 and 21. Conversely, a steep, continuous decline in discharge after August 21 corresponded to a sharp increase in travel rates. Heggberget et al. (1988) found similar behaviour with tagged Atlantic salmon.

Increased rates of movement were observed as migrations progressed up the Skeena (Fig. 4). The average speed of fish travelling between the Zymoetz and Bulkley scanners (20.2 km/day) was nearly double the average speed noted below the Zymoetz scanner (10.4 km/day). Individual rates ranged up to 26.2 km/day in the area between the Zymoetz and Bulkley. Extreme variations in rate of movement were evident as fish moved up the Skeena River beyond its confluence with the Bulkley. We observed rates as high as 32.0 km/day and as little as 1.5

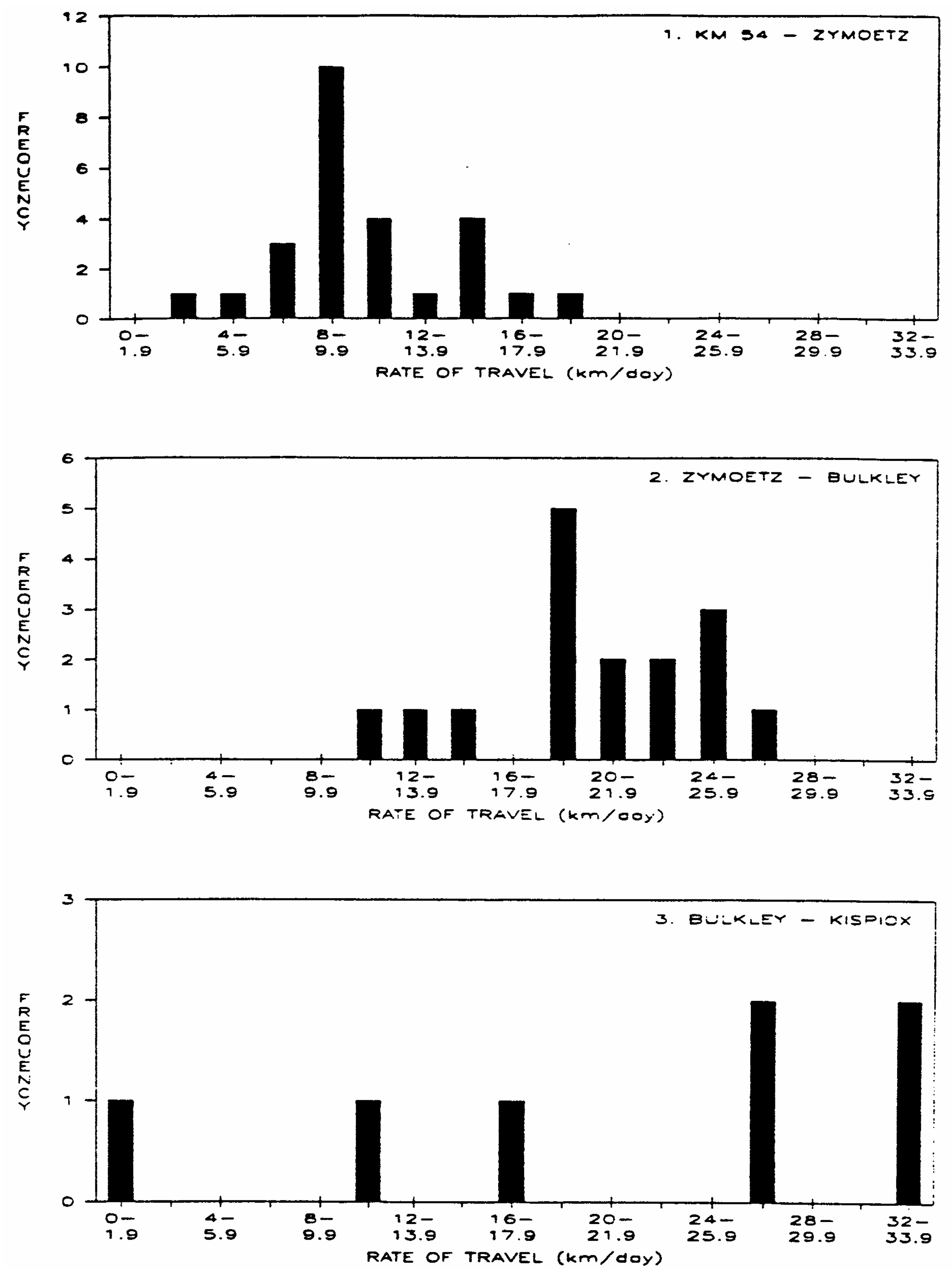



Fig. 4. Net rate of upstream travel of individual radio-tagged steelhead in 3 zones of the Skeena River, 1988. The zones of travel were (1) km 54 to Zymoetz River, (2) Zymoetz River to Bulkley River, and (3) Bulkley River to Kispiox River.

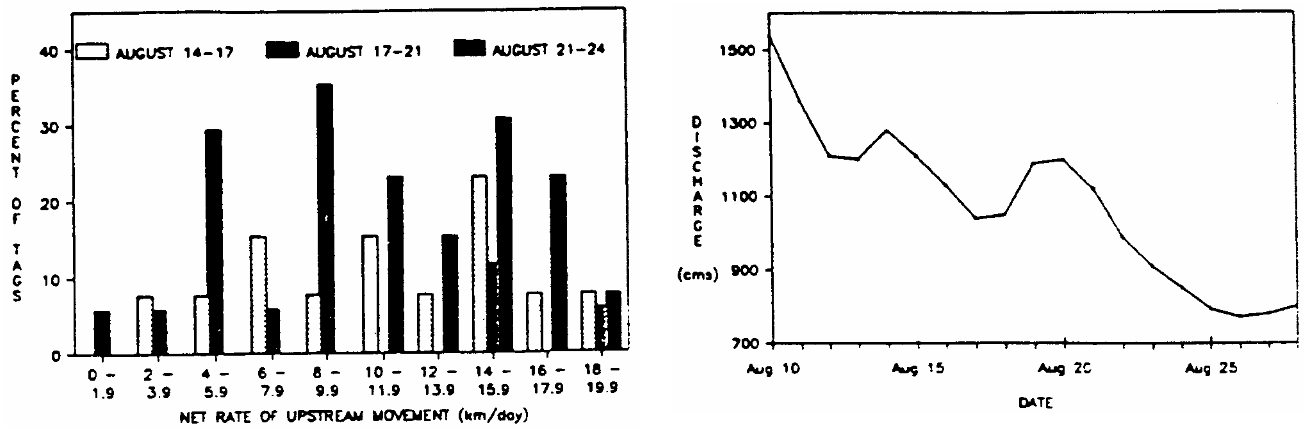



Fig. 5. Rates of movement of radio-tagged steelhead in the Skeena River between km 54 and the Zymoetz scanner during August, 1988, in comparison to discharges of the Skeena River at Usk (Water Survey of Canada, data on file).

km/day from the Bulkley to the Kispiox. The fastest rates were exhibited by fish eventually destined for tributaries upstream of the Babine River, suggesting that speed of migration and distance to natal stream are directly related. The slowest fish in this group were never relocated after passing the Kispiox scanner, but it would follow that those fish were destined for the Kispiox or some other tributary in that vicinity.

A total of four radio-tagged and nine spaghetti-tagged steelhead were eventually recaptured in freshwater. One of these recoveries was made by a Native food fisherman while the rest were reported by sport fishermen. Only two fish were killed; one by an angler and the other by the Native fisherman.

*Run Timing and Tag Destinations*

Radio-tagged steelhead destined for various parts of the Skeena drainage showed little variation in their average dates of arrival to the mouth of Skeena River (Table 5). For example, no difference was noted in the averages run timing of fish found in the Bulkley River in late fall versus those located in the Morice. Similarly, little difference was noted between the timings of Bulkley - Morice steelhead and fish destined for other parts of the Skeena. Differences indicated for the Kispiox and Skeena River above the Bulkley were a reflection of only two fish estimated to have passed Tyee on August 29.

The Skeena River between the Zymoetz and Bulkley has been broken into two components in Table 5 to reflect possible harvests in the Native food fishery. Three fish disappeared somewhere in this area and it was unclear if they were actually destined for tributaries in this part of the drainage (eg. Kitwanga, Kitseguecla) or were caught by Natives.

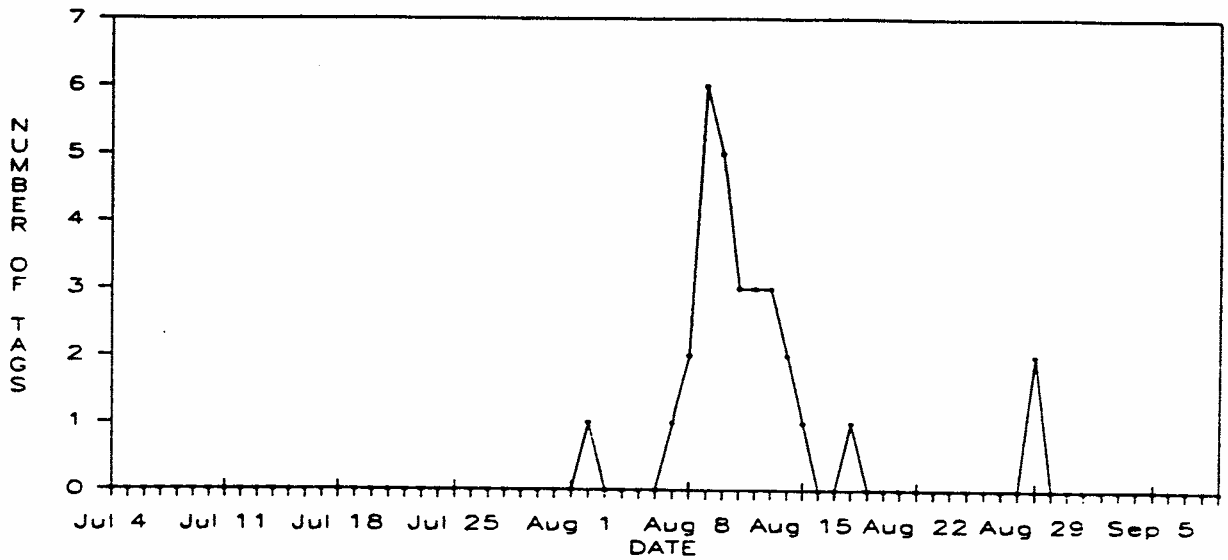
TABLE 5. Estimated dates on which radio-tagged steelhead passed by the Tyee test fishery and subsequent destinations of those fish within the Skeena drainage, 1988.

| Destination | N | Date Mean | Past Tyee Earliest | Latest |
|---|---|---|---|---|
| Bulkley – Morice | | | | |
| a. Combined | 12 | Aug 11 | Aug 2 | Aug 18 |
| b. Bulkley only | 6 | Aug 11 | Aug 8 | Aug 14 |
| c. Morice only | 5 | Aug 11 | Aug 2 | Aug 18 |
| d. Suskwa | 1 | Aug 10 | -- | -- |
| Kispiox | 2 | Aug 21 | Aug 13 | Aug 29 |
| Sustut and Skeena above Babine | 2 | Aug 9 | -- | -- |
| Skeena above Bulkley[1] | 5 | Aug 14 | Aug 9 | Aug 29 |
| Skeena between Zymoetz and Bulkley[2] | | | | |
| a. Verified alive | 3 | Aug 11 | Aug 8 | Aug 13 |
| b. Possible food fish kills | 3 | Aug 12 | Aug 8 | Aug 14 |
| Zymoetz – Clore | 3 | Aug 10 | Aug 10 | Aug 11 |
| All | 30 | Aug 12 | Aug 2 | Aug 29 |

1. Unknown if above or below Babine.
2. Including tributaries.

The observed narrow “window” of entry into the Skeena River was primarily a reflection of the timing of radio tag placement in salt water. Nearly 70% of all radio tags were placed in fish on August 4 and 5 on the north side of Porcher Island. These fish remained together as they entered the river but eventually dispersed into a variety of summer steelhead producing areas throughout the upper Skeena River drainage. Considerable overlap in stock run timings was therefore apparent. However, it is important to note that no radio-tagged fish were present amongst steelhead that passed Tyee in late July. Latter portions of the run were also poorly represented in the study. Stock specific differences in run timing would only have become evident if we had been able to tag more fish from either end of the run.

The Tyee test fishery gillnetter on the lower Skeena River provides catch per hour (“test index”) information for each species every day throughout the commercial fishing season (Jantz et al. 1990). The average date of entry of radio-tagged fish into the Skeena (August 12) corresponded almost exactly with a peak test index value at the Tyee test fishery. However, on a day-to-day basis, backcalculated estimates of numbers of radio tags passing Tyee did not follow trends in catch (Fig. 6). The date of peak tag entry (August 9) corresponded with a low



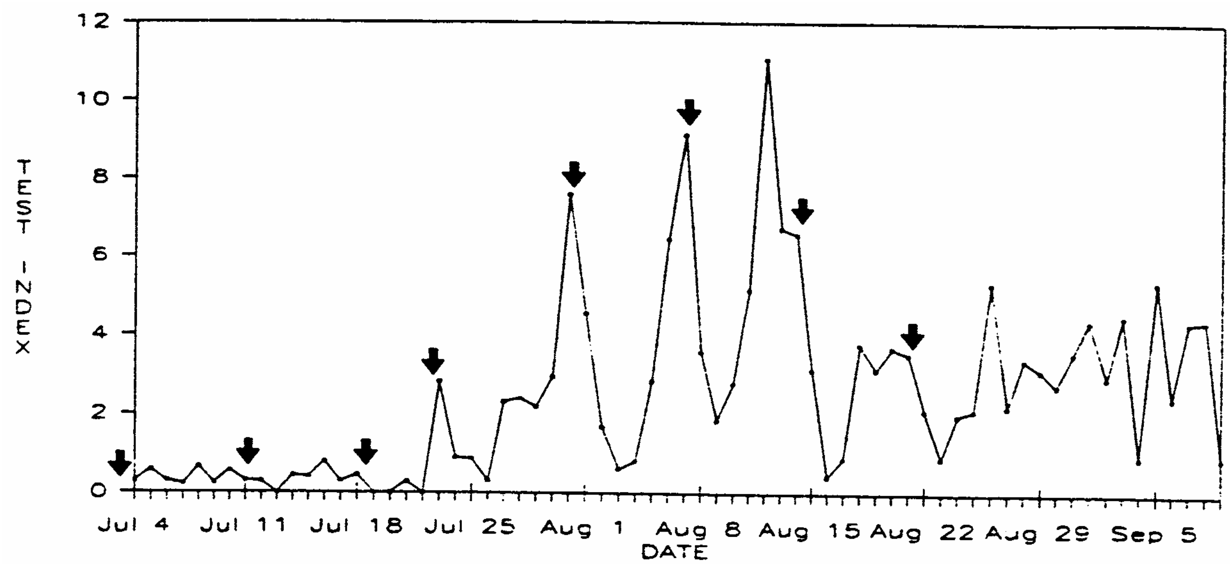




Fig. 6. Daily numbers of radio-tagged steelhead estimated to have passed by the Tyee test fishery site in 1988, contrasted with daily indices of steelhead escapement as determined from test fishery catches. Arrows indicate the start of openings in the Area 4 commercial fishery.

in the test index following a commercial opening in Statistical Area 4. This suggests that the large group of fish tagged on August 4 and 5 should have encountered high interceptions in the fishery. It is unclear whether this actually occurred or if back-calculated entry dates were erroneous. If back calculations were incorrect, the magnitude of the error would be in the order of 2 - 3 days.

Late season (September through winter) tracking flights were insufficient to clearly outline the destinations of radio-tagged steelhead. As a result, I could not thoroughly assess stock run timings. In addition, disappearances of fish and partitioning of the already limited sample into a number of tributaries led to extremely limited sample sizes by the time fish reached their natal streams. Early and late portions of the run were also poorly represented in the sample. These factors, combined with previously noted questions regarding the entry date backcalculation process, suggest a need for caution in viewing these results. Lough (unpublished MS. 1981) identified distinct differences in run timing between steelhead destined for various parts of the Skeena system using much larger sample sizes and more detailed tracking. Bulkley - Morice fish, for example, comprised the majority of the early portion of the run during the year in which that work was undertaken. Clearly, this aspect of the study will require further investigation before conclusions are drawn.

## CONCLUSIONS

1. Radio-tagged steelhead migrated through the commercial fishery toward the Skeena River at an average rate of approximately 8 km/day. Nearly 2 weeks were required for tagged fish to travel from the outermost boundaries of Area 4 to the inner boundary at the mouth of the Skeena River. Travel through the core of the gillnet fishery at the outlet of the Skeena River was estimated to have taken about 2 days.

2. Incorporation of migration rate data into existing modelling (Lapoint and Staley 1987) suggests that reductions in the incidental catch of steelhead will require extensive decreases in the duration of commercial openings from the current 4 day per week maximum.

3. Differences in the timing of individual stocks of steelhead through the commercial fishery at the mouth of the Skeena River were not detected, mainly due to limited sample sizes and compressed timing of tag placement.

4. Steelhead ascending the Skeena River mainstem migrated at rates averaging 10.4 km/day in the area downstream of the Skeena-Zymoetz confluence. Rates of travel appeared to be directly related to distance up the Skeena River mainstem and inversely related to river discharges.

## RECOMMENDATIONS

1. The reduction in commercial fishing effort needed to decrease harvest rates on non-target stocks would also likely reduce the harvest rate on target stocks far below acceptable levels. Other selective harvest strategies must be therefore be explored. The present study has shown that selective fishing is possible with seines. Another area which may hold some promise concerns the specifics of steelhead swimming behaviour. Sonic tagging conducted by Quinn and Rugerone (unpublished M.S. 1988) in Dean Channel indicated that steelhead tend to migrate near the top of the water column and that gillnet structures might be modified to allow passage of these fish. The potential to apply this commercial fisheries at the mouth of the Skeena River should be examined. It must be recognized, however, that only marginal improvements in overall management of the Skeena mixed stock fishery are likely to be found in the manipulation of traditional gillnet practices.

2. Harvest rates for individual Skeena River steelhead stocks depend on the degree to which their run timings overlap with those of sockeye and pink salmon. A clear understanding of differences in the run timing of each stock is therefore critical to effect proper management. This could be examined by radio tagging steelhead caught in the test fishery at Tyee. Spaghetti tagging of adults at Tyee has and will continue to provide useful information as tagged fish are caught by fishermen in tributary streams. Further adult spaghetti tagging in the tributaries will also yield such data when these fish are caught in the commercial fishery as repeat spawners.

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