GREAT LAKES FISHERY COMMISSION

Project Completion Report[1]

Methods used to capture lampreys, *Geotria australis*, in New Zealand

by:

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Introduction

Geotria australis is one of some 40 species of lamprey in the world, is the only member of the lamprey family Geotridae, is one of four species found in the Southern hemisphere and is the only species of lamprey found in New Zealand (Potter et al. 1986). Lamprey were important as food for Maori for centuries and European immigrants to New Zealand occasionally sought lamprey to eat. Today, for all practical purposes, lampreys are still important to Maori as food (McDowall 1990) and lamprey capture has been confined to Maori by law (under clause 61 of the Fisheries Act, 1963, which restricts the taking of fish by permit). Consequently, lamprey capture today, 1996, in New Zealand is confined by permit to scientific purposes and use as food by Maori (allowed and no permit is required under the Treaty of Waitangi, 1840).

This report summarizes the biology of *Geotria australis*, describes methods of lamprey capture, describes the physical characteristics of rivers and streams in which the methods are used, details the sites at which various gears are fished and, where possible, summarizes information on success or catchability of adult lampreys.

Biology

Geotria australis is found in Chile, Argentina, western Australia, South Australia, western Victoria, the west coast of Tasmania, the Chatham Islands and New Zealand (McDowall 1990). It is widely distributed in New Zealand but lampreys are most common in streams and rivers of the west coast of both islands, the southern tip of the North Island, the Banks Peninsula and the southern coast of the South Island (Todd and Kelso 1993).

Because the lamprey is a diadromous species, it occurs in the sea and as far upstream in freshwaters as it is able to swim. The distribution of lampreys at sea is poorly known but, from the observations of Potter et al. (1979), they must travel great distances. Potter et al. (1979) found lampreys in albatross stomachs at South Georgia Island in the southern Atlantic almost 2000 km away from the nearest freshwater population. Admittedly, the albatrosses may have flown some distance since capturing lamprey; however, lamprey were present in large numbers in stomachs, were present in stomachs over several summer months and often appeared recently ingested.

In freshwaters, adults and larva were captured in all types of streams but most (31% of sites where lamprey have been collected in New Zealand) were caught in small, <10m wide, single channel tributaries (Todd and Kelso 1993). Generally though, lampreys at various life stages were common in a broad range of freshwater habitats and channel arrangements, were captured from all substrates from mud to bedrock and were found from the sea to headwater stream reaches.

Adult lampreys entered a New Zealand stream in mid-winter, early August, and were assumed to move upstream more or less en masse because 1) adults were collected only immediately above the tidal limit in August in an electrofishing survey conducted in August, from the estuary to headwaters (3 years of data), 2) adults were caught irregularly in fyke nets with nets placed downstream capturing lampreys first (August) and nets placed upstream only later (September and October), and 3) adults with radio transmitters travelled at a greater rate (87.8m day^{-1}) early in the upstream migration and did not move at all in November (Kelso and Glova 1993). In south-western Australia, Potter et al. (1983) captured adults in fyke nets in the estuary of the Donnelly River in July and August and assumed, too, that these were lampreys recently committed to a spawning stream. Todd (1979) suggested that adult lampreys may enter New Zealand freshwaters between late May and October but I am uncertain of his source material. "Large" numbers of adult lampreys have been seen or caught in New Zealand in autumn (Best 1929), winter (Todd and Kelso 1993; Kelso and Glova 1993), late spring (Dendy and Olliver 1901; Tweed 1987) and early summer (Todd 1981) but no information on lamprey maturity was provided by these authors. From the above, it appears that adult lampreys enter or are found in streams used for spawning from late autumn to early summer and it may be that, as Maskell (1929) noted, entry into streams may vary by latitude, by stream size and by stream type.

Kelso and Glova (1993) speculated, because adult lampreys had not spawned in Pigeon Bay Stream, Banks Peninsula, by the end of November, that lampreys spawned under cover of the boulders which were the final upstream resting places. By back calculating from larval lamprey growth rates, Kelso and Todd (1993) suggested that spawning probably occcurs from late November through December and emergence of larvae from spawning gravels occurs at 9.63 mm in January. Maskell (1929) also found small (1.1 cm) larvae in streams of the North Island during January. In Australia, Potter and Hilliard (1986) found larvae 10-13 mm long in December and concluded that lampreys spawned in early November.

As the male lamprey matures, its oral disc increases in size and a flabby pouch develops ventrally, immediately below the eyes. The reasons for the change in the sucking disc and the function of the gular pouch are not known. McDowall (1990) suggested that there may be benefit to lampreys for lifting stones from the stream bed for nest building. Maskell (1929), on the other hand, suggested that changes to the female head region are less pronounced than in male lampreys and stated that nest building has rarely been seen (Kelso and Glova (1993) suggested that *Geotria* may be cryptic spawners), and suggested that the gular pouch may simply evolve as a result of loose folds evolving from oral disc expansion. Whether the gular pouch aids nest building or is a non-functional accommodation of changes of the oral disc, the changes to the oral disc permits strong attachment to surfaces and enables maintenance of position by both sexes in areas of high water velocity. It is likely that it is the recent entrants, which move aggressively upstream early in the spawning run, to streams that are prone to capture.

Efforts in the 1980s by Maori and the New Zealand government to revive historic Maori culture may result in a return to exploitation of some endemic New Zealand fishes such as the lamprey or torrent fish (*Cheimarrichthys fosteri*). The Freshwater Fisheries Section of the Ministry of Agriculture and Fisheries (now the National Institute of Water and Atmospheric Research) attempted to document in the late 1980s locations of lamprey traps or weirs but were unsuccessful because Maori <u>hapu</u> were unwilling to pass information to "outsiders" (P.R.Todd, Ministry of Agriculture and Fisheries, Marine Fisheries Division, Private Bag, Nelson, New Zealand, personal communication). This reluctance to transfer traditional knowledge continues today (P.R.Todd, personal communication; R.M. McDowall, personal communication; J.T.Ross, Algoma University, Sault Ste. Marie, Ontario, personal communication; Kelso, personal experience). Consequently, this report is constrained and, in particular 1) does not document the full range of sites at which lampreys are captured, 2) likely does not present the full range in variations of trap and weir configurations, and 3) does not adequately reflect success in capturing lampreys (in part because upstream migration was essentially complete February-March, 1996, the period available to summarize capture methods of lampreys in New Zealand).

Methods of Capture

Introduction

Traditional knowledge of Maori periodically has been shared (see bibliography prepared separately). Maori retain sites and methods of capture within familial and iwi (tribal groups) and traditional places of lamprey capture (mahinga kai or places where food is produced or procured (Evison 1993)) are passed down among generations. No sharing of mahinga kai occurs. Methods, too, appear to be unique to Maori and perhaps iwi in that methods exploit either "resting places" of migrating lampreys or lamprey travel patterns. Because mahinga kai and methods are extremely important to Maori and are subject to current negotiation for settlement under the Treaty of Waitangi, I therefore was not expected by New Zealanders to be successful in accessing people, information or sites. However, perhaps because I was a North American (and no threat to treaty negotiations) and because I brought some (limited) knowledge of lamprey from elsewhere, sharing (with constraints) by Maori occurred.

Manual Collection of Lampreys

At the Mataura Falls in Southland (Fig.1), poles are placed in holes and crevices in rocks along the falls and adjacent to the falls and fishers reach out and remove lampreys which were attached to the face of the falls. This fishery (see Bibliography) was first mentioned by Europeans in the early 1800s and continues today although the "quality" of the fish deteriorated with the urban and industrial development that occurred at the turn of the century. Lampreys also are gathered by hand from wet rock faces at the base of the Niagara Falls (Fig. 2) on the Waikawa River. Todd (1981) stated that, during a shutdown of the Manapouri Generating Station, 600-700 lampreys were removed from concrete surfaces at the tailrace by hand by power station workers (Maori) for eating. In the Cooper's Drain near Christchurch (a low lying area with periodic connection to the sea), lamprey attach to the surface of a culvert (Fig. 3) and can be removed at night by hand with the aid of a flashlight (Kelso, personal observation). Up to 70 lampreys have been removed (reported in 1983 and 1992) in 0.5 h. The Tentburn Stream, which drains a salmon hatchery, has been modified and provides dam faces and side walls (Fig. 4) to which lamprey attach. Lamprey are removed, almost annually, from these surfaces by hand by hatchery workers, Maori and NIWA scientific staff between September and December. Up to 200 lampreys have been removed by hand in 1 night and up to 60 lampreys have been removed in 0.7 h in December, 1995. Many (or perhaps most) of these surfaces where lampreys attach are known only to Maori and the location of these are known to few (Downes 1918; Best 1929; P.R. Todd, Ministry of Agriculture and Fisheries, Nelson, New Zealand, personal communication; A.D.Tweed, Westland Fish and Game Council, Greymouth, New Zealand, personal communication).

The total number of lampreys captured by hand are, or course, unknown. In other districts of New Zealand, Maori state, when asked, that "We do not catch lampreys this way." Perhaps these attachment locations are unique to site characteristics found in only a few locations? McDowall (1990) stated that Maori knowledgeable in removing lamprey from these attachment locations reported catching several thousand in a single night's fishing. Maori fisheries (hand removal) currently are known to occur at the Mataura Falls (Mataura River), Opurere Falls (Pomahaka River), on the Orawia River (Southland), at the Niagara Falls (Waikawa River) and perhaps on the Clutha River. Fisheries also exist at Cooper's Drain and the Tentburn channel. Stream widths vary from 1.5 m to 150 m and minimum summer discharge varies from 0.3 to ≈300 $m^3 \cdot sec^{-1}$. With the exception of Tentburn Stream, lamprey progress upstream from these attachment locations to spawn.

Questions for GLFC: 1) Do *Petromyzon marinus* attach as do *G. australis* to surfaces at falls, barriers or in areas of high water velocity? Divers have seen sea lampreys attached to the dam face in the St. Mary's River but is this a common behavior?
2) Would a "smooth" surface at an upstream barrier, natural or man-made, serve as an attachment surface from which *Petromyzon marinus* might be manually removed (at night?)?

Fyke Nets

Fyke nets with and without wings (Fig. 5) constructed usually of 20 mm stretched measure mesh are commonly used for sampling fish (McDowall 1990) and are used extensively in the eel fishery of New Zealand (Jellyman and Todd 1982). Fyke nets (0.4, 0.5, 0.7 and 1.2

m (only used in Lake Ellesmere) deep) set in streams commonly are used to capture adult lampreys (New Zealand Freshwater Fisheries Data Base; Kelso and Glova 1993) and fyke nets set in lakes and streams for eel capture yield substantial numbers of lampreys particularly in Lake Ellesmere (D.Jellyman, National Institute of Water and Atmospheric Research, Christchurch, New Zealand) some 30 km south of Christchurch.

Incidental catches of lamprey in the eel fishery can be large. In Lake Ellesmere, eel fishers consistently catch 2-3 lampreys per lift and during the 2 month fishing season (managed by permit) 0.5 to 1.2 Tonnes of lamprey can be caught by one fisher using 5-8 nets (quota is 15T of eels) (C.Smith, eel fisher, Leeston, Canterbury, New Zealand, personal communication). Traditional fisheries for lampreys in at least Taranaki, North Island have been replaced by fyke nets fished specifically for lampreys. Elsewhere, Maori use fyke nets for both eels and lampreys. Nightly catches in rivers in Taranaki can range up to 200 lampreys per night.

Note to GLFC: The fyke nets used in New Zealand are similar to those used by Canadian and U.S. lamprey control agents. The mixed success of nets used in New Zealand rivers seems to parallel that seen from applications of fyke nets in Great Lakes streams (Kelso, personal observation).

Lamprey Weirs (Utu piharau)

Best (1929) stated that the fact that the lamprey travels near river banks to avoid swifter mid-stream current when ascending streams led Maori to erect weirs near the banks only. [This conventional wisdom of lamprey movement may result simply from the fact that it is easier to capture lampreys, or build weirs, near stream banks!?] Regardless of the reason, descriptions of lamprey weirs apply only to weir systems extending from shore and extending no more than 20% of the rivers maximum width (Best 1924; Best 1929; Todd 1979). Only weirs in the Wanganui River are known to exist and no written record or verbal account suggests that weirs have been built or are used today in other large New Zealand rivers.

Four weirs were fished in the Wanganui River in 1995 and four weirs will be fished in 1996 (3 at Pipiriki and one at Jerusalem (Hiruhirama)). The weir described by Best (1929) still exists at the same location at Hiruhirama but is now constructed of different materials. The weir described by Todd (1979) was destroyed by flood in 1994, rebuilt and destroyed in 1995 and is under construction in 1996. I was permitted to inspect 2 weirs at Pipiriki. Access to 2 weirs (Jerusalem and one at Pipiriki) was denied.

Historically, weirs were constructed (Fig. 6) of poles driven into the stream bottom as in the construction of a picket fence (Best 1929). The upstream face of the weir was covered by palm fronds (*Rhopalostylis sapida*) or flax (*Phormium sp.*) leaves. The trap (hinaki, Fig. 7) was inserted in slots and at the end of the weir on the downstream side and was woven from kiekie (*Freycinetia baueriona*) roots or supplejack (*Ripogonum scandens*). The two weirs

I inspected were inexpensively constructed of steel rails (railway surplus) imbedded in concrete, poured when the river flow was low, pipe and corrugated sheet metal (Fig. 8 & 9). The two weirs I was allowed to visit have been at these locations for an unknown number of generations and was constructed of these materials only some 15-20 yrs ago. The traps were constructed of supplejack, keikie root and wire mesh (Fig. 10).

According to weir operators, weirs today are shorter (7.8 m and 4.4 m from shore to farthest projection) than former weirs (up to 15 m) but at most blocked 15% of river width (less today). Shorter weirs accommodate boat traffic (extensive today) and apparently have less likelihood of being washed away in flood conditions. Weirs are constructed at a angle from the river bottom to deflect large debris over the top when rivers are in flood. Weirs in current use are not rebuilt each year whereas historic weirs were constructed each summer during low flow.

I measured water velocity in the opening and at the end of the weir that was intact (Fig. 9). Water velocity in the opening was 1.88 $m \cdot sec^{-1}$ (N=8, s.d=0.21) and at 0.2 m from the end of the weir velocity was 2.09 (n-7, s.d=0.07). Weir operators stated that lampreys travelling upstream collected in the nearshore eddy (low velocity area) downstream of the weir then were forced back into the trap (hinaki) as they tried to negotiate the weir and the high water velocities in the slot opening and at the end. Note that the traps were fished at the water surface! Note, too, that weirs can be operated only in a range of discharges (too low and the weir is high and dry; too high and water flows over the top! Weirs, however, could be constructed to operate at all water levels).

It is impossible to provide any estimate of efficiency or proportion of the migrating population captured by weirs in the Wanganui River. Tradition and the method of construction ensures that only some portion of the migrating poulation is captured. While the weir is operating, the first (unknown number) and last (unknown number) of lamprey captures are returned to the river upstream of the weir. The reason from these releases is unknown but accepted as part of the "responsibility" of operating the weir (I assume that this is a conservation measure to ensure future stocks although tohunga (wise men of the iwi) told me that the practice was convention in Maori religion). Weirs are constructed such that they are operable only during a range in discharge; therefore, if lampreys are migrating upstream in high flows, none will be captured as the weir is inaccessible and inoperable. Nightly catches, however, ranged up to 1000 lampreys per night with up to one week of captures between 300-600 for up to 1 week in 1995. Virtually no other fish species, with the exception of an occassional inanga (<20) are caught.

Notes to GLFC: 1) No more information on design or efficiency will be forthcoming. I was fortunate to gain access to the site (other Maori are typically refused information and access).

2) Would a trial facility by of value? A test facility could be ecoonomically constructed as the Maori have done.

3) Because the construction and operation of the N.Z. weirs is so steeped in Maori culture, it is difficult to guess how much of the design is tradtional vs functional.

4) The weir design assumes that lampreys travel near the river bank. Telemetry (Wolf R., Pancake R.) indicates that *P. marinus* also travel near banks.

Coffin Weirs

Stone coffin-shaped weirs have been used in the Waitara River, Taranaki Region, of the North Island. One such weir (Fig. 11) is in current use. A mat of flax (today, feed sacks may be used) is placed between the rock coffin walls and is removed at night (or early morning) and the lampreys sequestered in the mat are removed. I assume that high velocities are created in the openings between rocks in the wall and, after passing through the wall, lampreys "rest" in the mats. Catches in these weirs (whakaparu piharau) range up to 30 to 40 lampreys in one night. Historically, these weirs were constructed in the Waitara, Waiaua and Mangamahoe Rivers (Aila Taylor, Maori tohunga and Taranaki Regional Council member, personal communication) but today only one weir is in use and fyke nets (catches up to 200 lampreys in 1 set) are most commonly used. (Note here too, fyke nets have been set at sites where families have fished for hundreds of years). The three rivers in which the whakaparu piharau are known to have been used are 30-40 m wide and, reportedly, some 0.75-1.5 m deep when the weir is installed.

Note to GLFC: My guess is that these coffin weirs offer far less efficient operation that the weirs used in the Wanganui River.

Acknowledgements

Addresses for those with direct site access are provided should further contact be required.

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Aila Taylor
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New Zealand

Graeme Davidson (Tentburn Salmon Hatchery), Clem Smith (eel fisher, Lake Ellesmere), Murray Thacker (Maori and Colonial Historical Society, Okain's Bay), Dave Houston, Murray Nielsen and Wayne Hutchinson (Department of Conservation in Oamaru, Invercargill and Wanganui, respectively) all were helpful or directed me to the right people or place.

List of Figures

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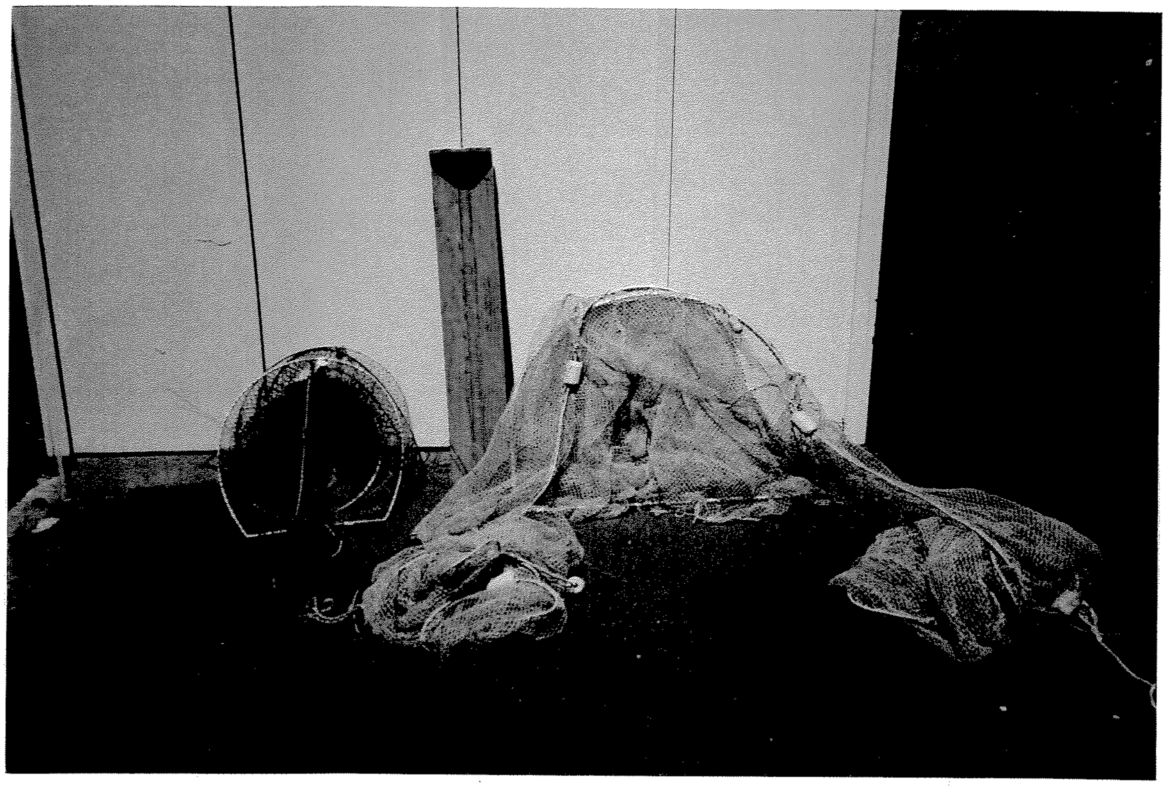

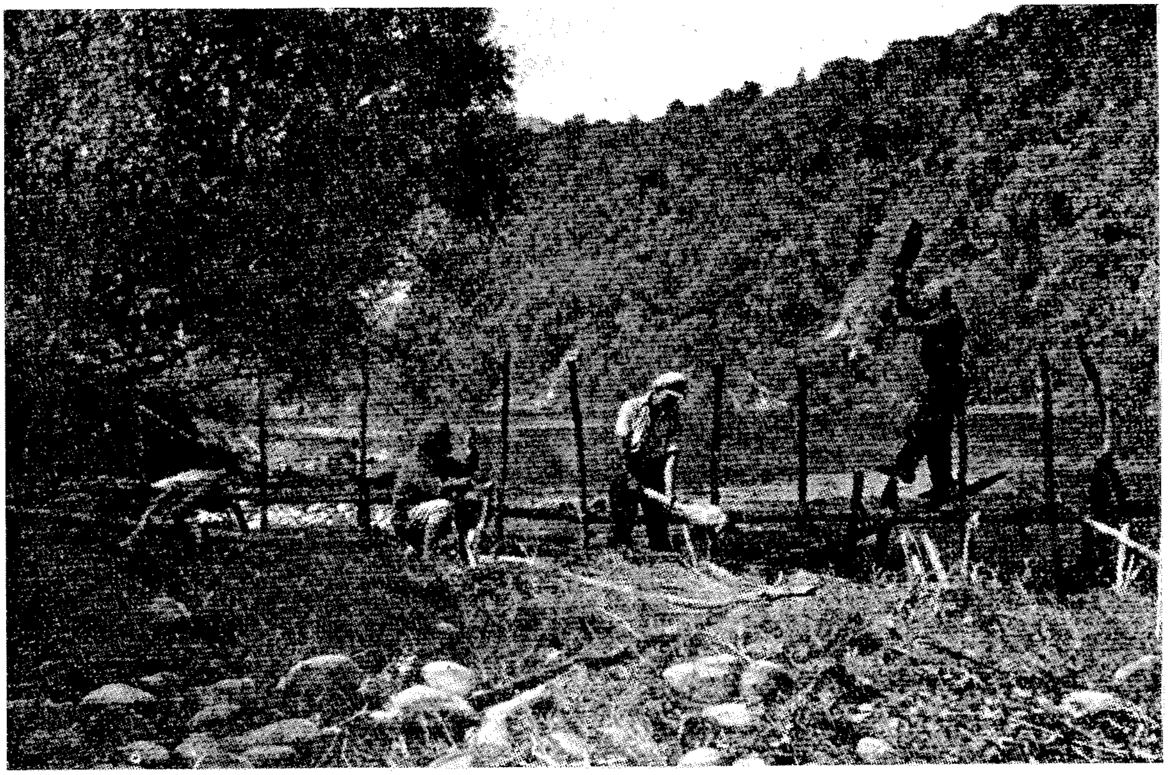

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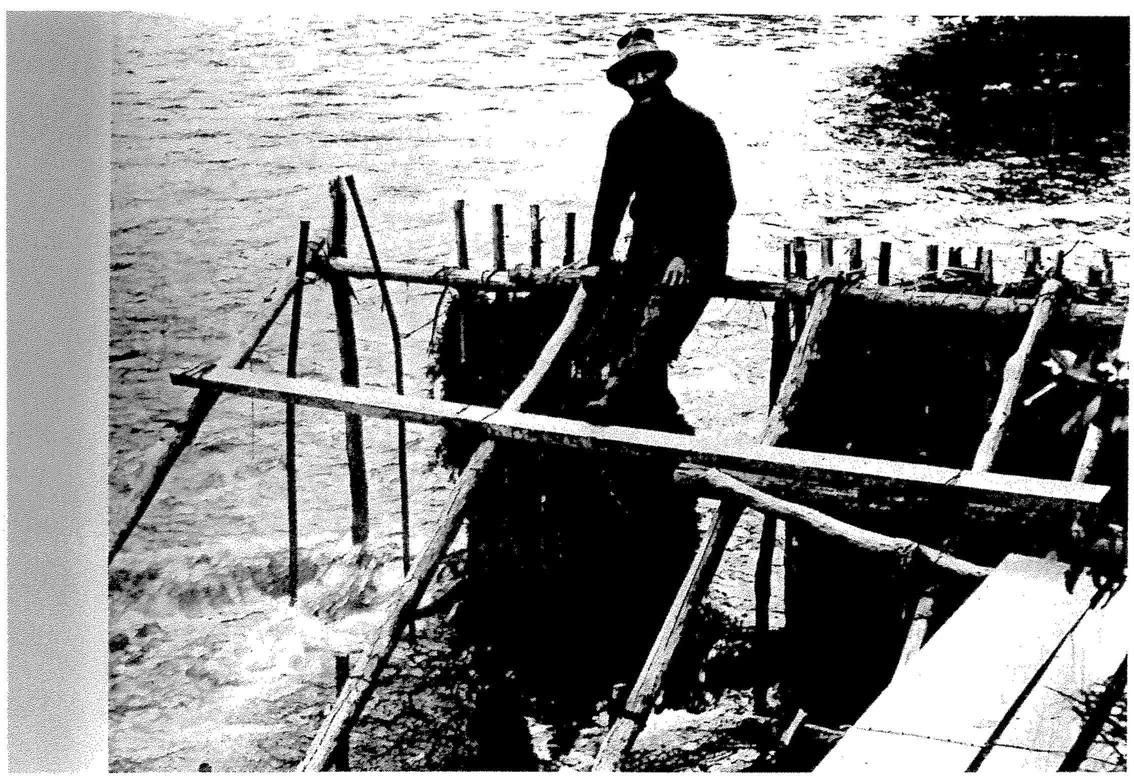

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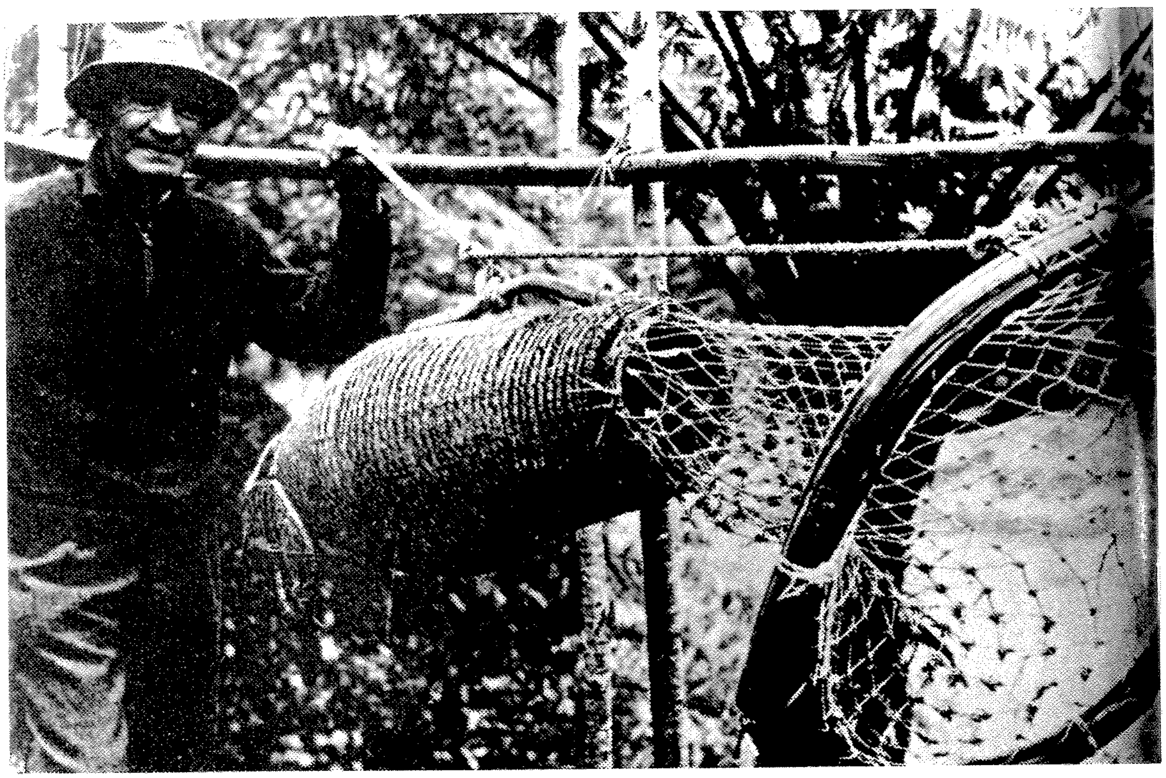

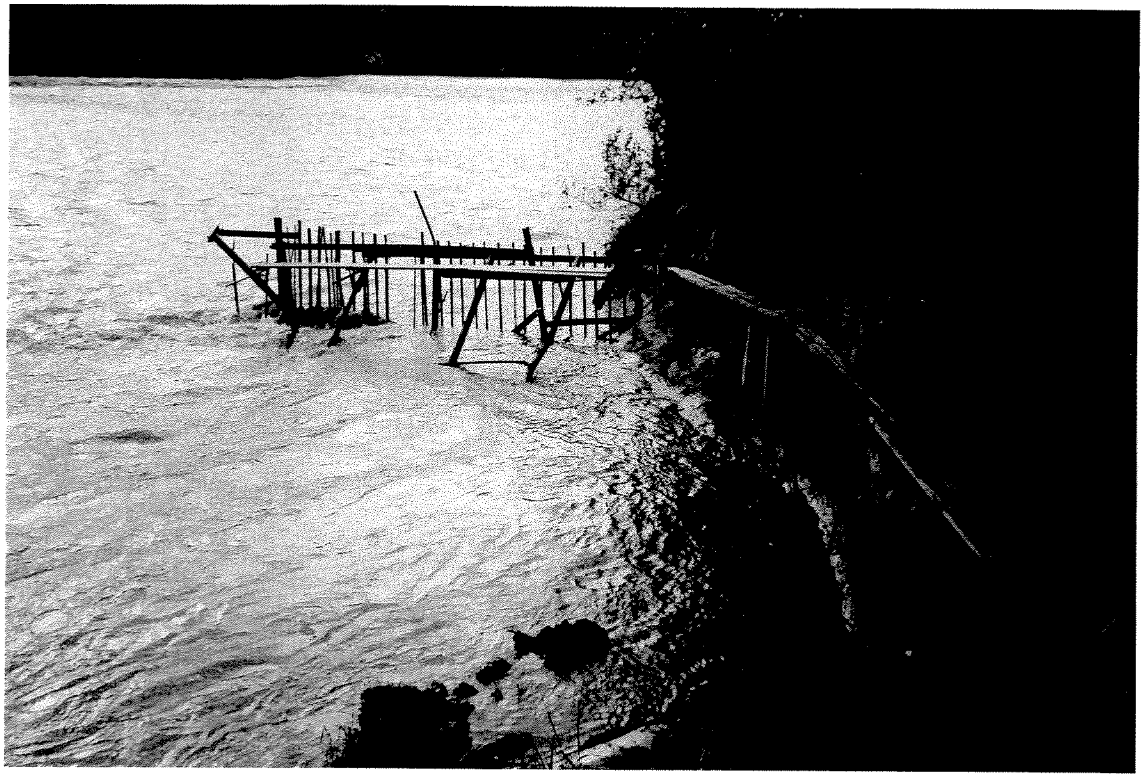

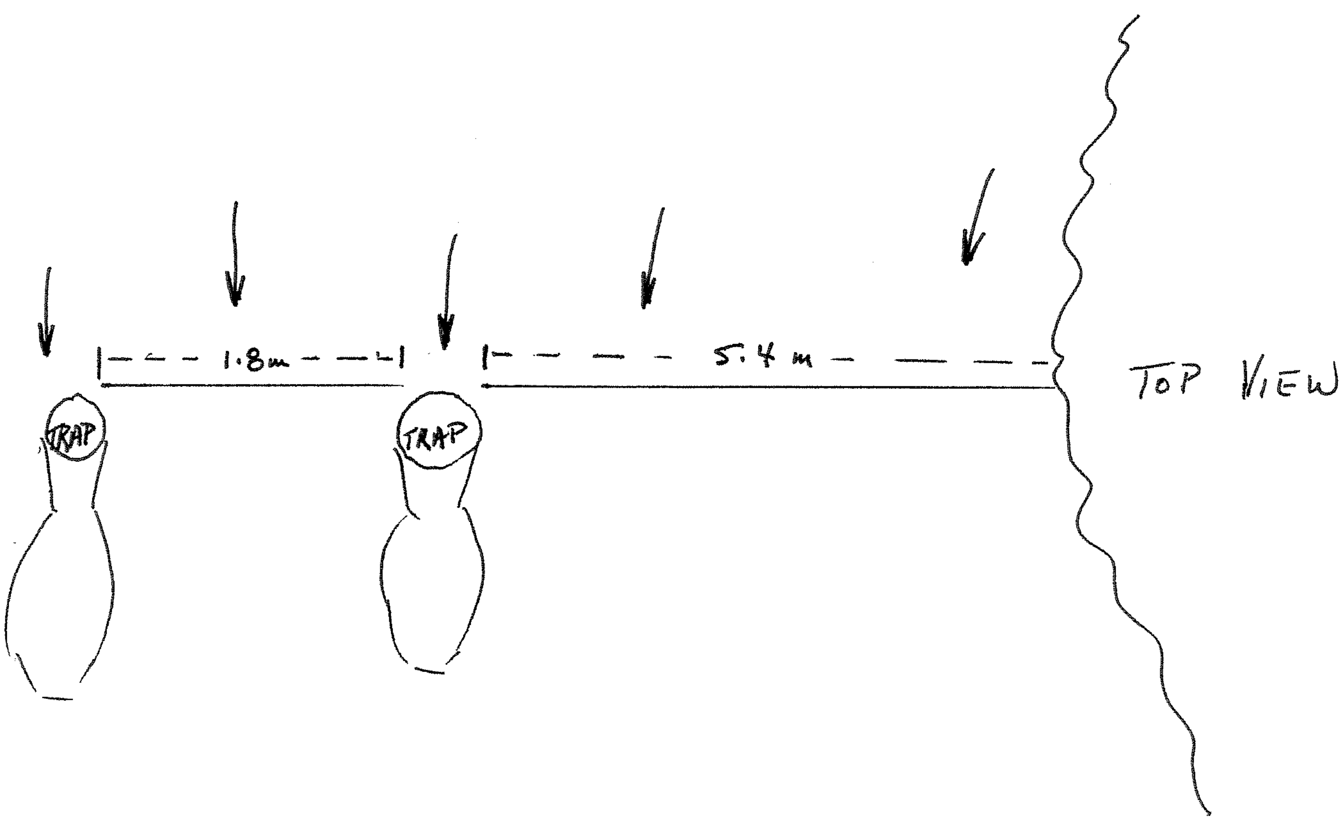
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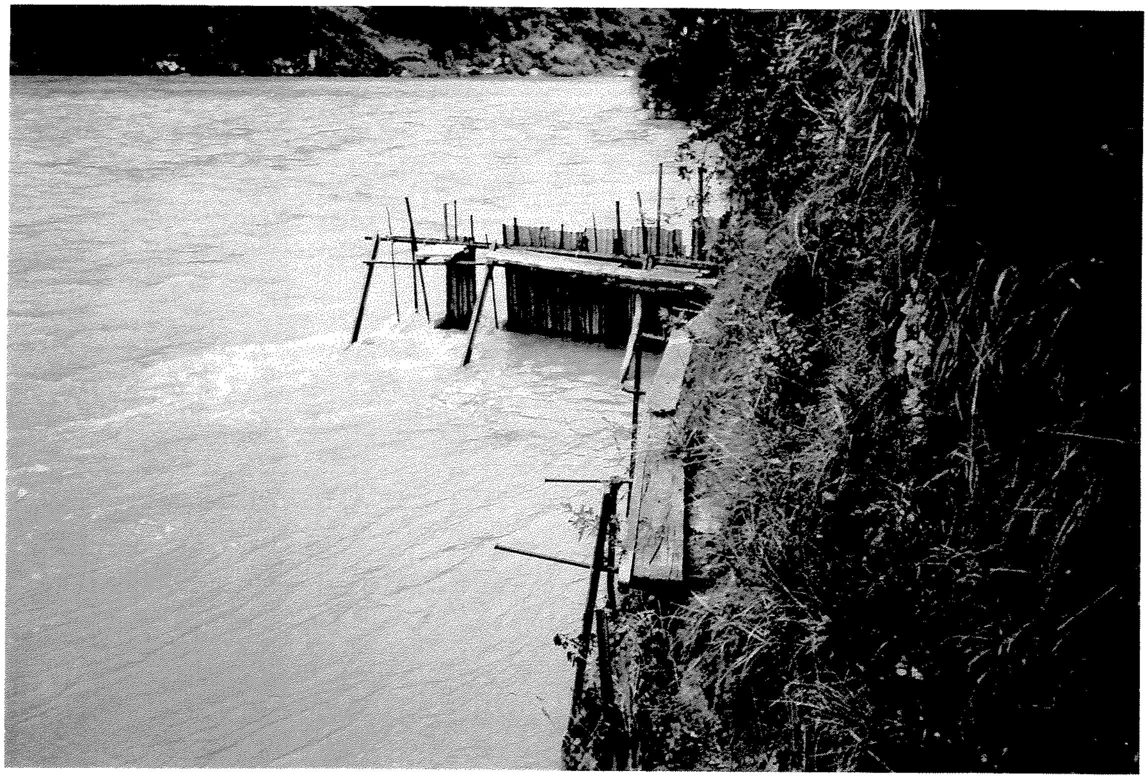

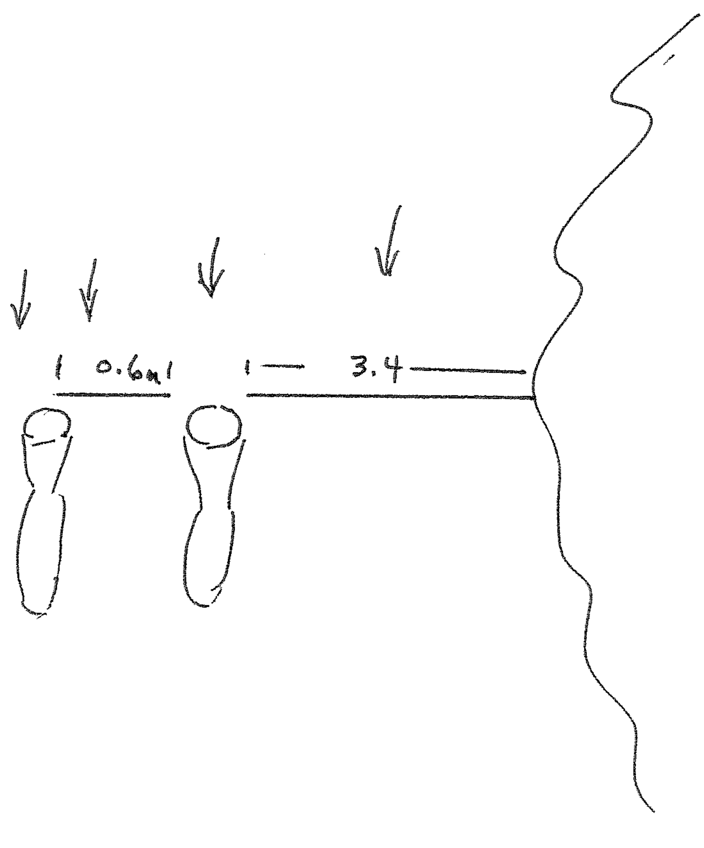
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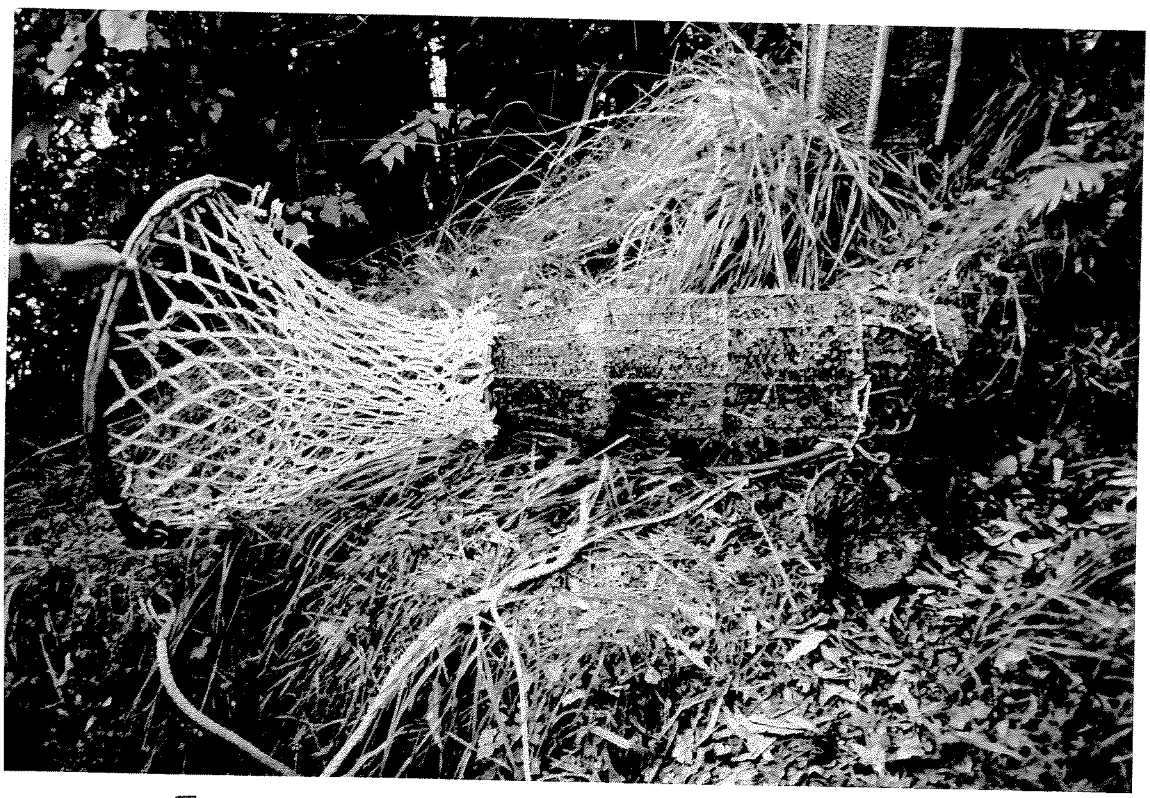

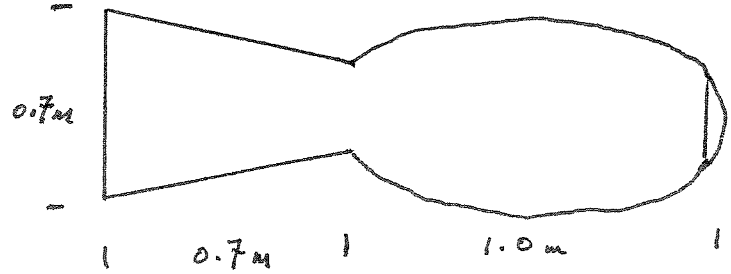
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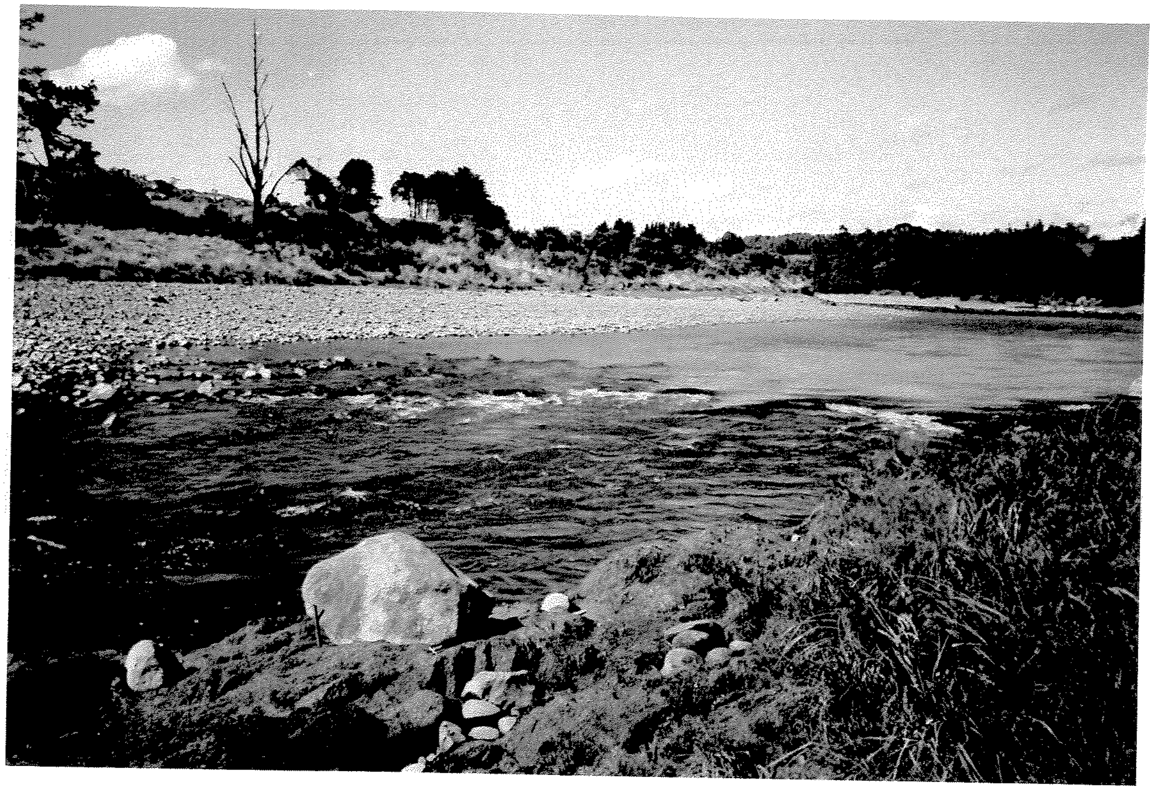

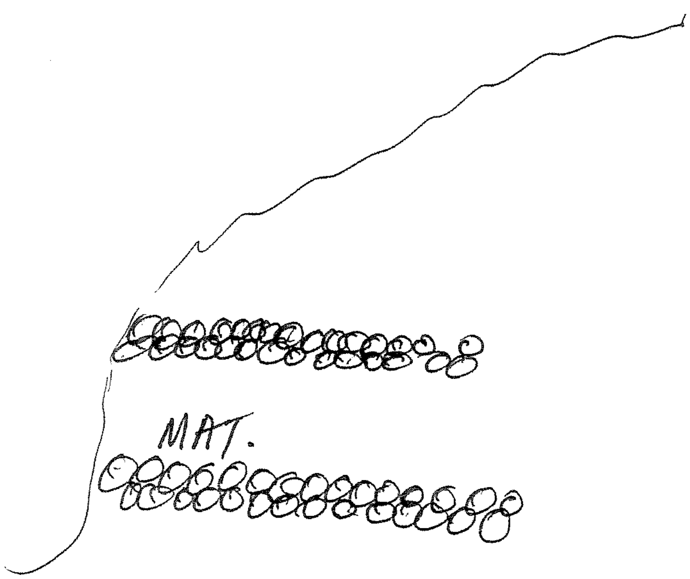
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