United States Department of the Interior

FISH AND WILDLIFE SERVICE

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MEMORANDUM

June 18, 2004

To: ARD Fisheries, Region 1
Fisheries Supervisor, AFR
Assistant Fisheries Supervisor, AFR

From: Project Leader, Idaho FRO
Aquatic Invasive Species Coordinator, Region 1 Fisheries

Subject: Risk Assessment and Risk Management Recommendations for New Zealand mudsnail introduction from Hagerman NFH steelhead releases

Introduction

The New Zealand mudsnail (NZMS), *Potamopyrgus antipodarum* is classified as an aquatic nuisance species by the Aquatic Nuisance Species Task Force, which is co-chaired by the U.S. Fish and Wildlife Service (Service). In the fall of 2002, well established colonies of NZMS were discovered in several springs that supply Hagerman NFH's production water.

Current policy of the Department of the Interior (Executive Order #13112, Invasive Species) and the U.S. Fish and Wildlife Service requires that programs "*. . . not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions*." There is a potential for the spread of the NZMS into new sites in the Clearwater and Salmon rivers through the distribution of steelhead smolts from Hagerman NFH. This report was prepared to assess the risk of spreading NZMS into currently unoccupied habitat in those basins from Hagerman NFH steelhead releases and develop management recommendations to minimize that risk.

NZMS Biology

NZMS are parthenogenetic, bear live young, and have high reproductive rates, ranging from 20-120 embryos per female (Richards 2002a; Winterbourn 1970 in Richards *et al*. 2004). NZMS can bear young at any time of the year in spring habitats of the western USA but most often reproduce in the summer and autumn (Richards 2002a). In optimum habitat their densities will approach 750,000/m^2. They are small, with a maximum size of 5-6 mm in the western U.S. They can close off their shell opening with a hard operculum which, in addition to conferring resistance to desiccation and chemical treatments, may allow them to pass unharmed through the digestive system of a fish and to be transported to new sites by humans or birds (Richards 2002b).

All NZMS in the Western U.S. are descendents of one clone from the North Island of New Zealand or Australia. These monoclonal populations, which possess no genetic diversity, seem to exhibit a phenotypic plasticity which enhances their capacity to spread across habitats (Dybdahl 2003). They have life-history traits that vary with diverse temperature regimes allowing the potential for high population growth in a wide variety of conditions.

The NZMS is classified as a scraper/grazer; it is a generalist feeder, a grazing herbivore and detritivore (Haynes and Taylor 1984 in Kerans and Cada 2002).

Idaho Distribution

The NZMS was first discovered in the Snake River, Idaho in 1987 (Richards 2002c), but no one knows when it first entered the U.S, the Snake River basin, or the springs at Hagerman NFH. In Idaho, NZMS are widespread in the Hagerman Valley, Snake River, and Snake River reservoirs, but are absent from Brownlee Reservoir (Shinn 2002). Although numerous sites have been surveyed in Northern Idaho, the only recorded finding occurred in 2001 when a single NZMS was collected in Kalispell Creek. Up to date locations of NZMS positive sites in Idaho and other western states is available at http://www2.montana.edu/nzms/

In the Clearwater Basin the Service sampled 14 sites in the South Fork Clearwater River (Burge 2003a) in addition to more than 50 sites sampled throughout the Clearwater basin by Dr. Gustafson of Montana State University. To date, no NZMS have been found in the Clearwater basin. Note that there is no standardized, nationally-accepted sampling protocol for NZMS surveys, therefore there are no methods for establishing statistical confidence regarding absence determinations.

The Service also sampled 34 sites in the Salmon River basin (Burge 2003b) to add to Dr. Gustafson's 55 survey sites. NZMS were found at 6 locations in the Salmon River basin (**Figure 1**). The Service found a few NZMS approximately 50 miles below the Pahsimeroi River in the main Salmon River at Tower Rock Recreational Site. A moderate to abundant population is known to occupy the mouth of the Pahsimeroi River and Pahsimeroi Hatchery, and the Service found a moderate number of snails approximately 2 miles above the Hatchery in the Pahsimeroi River. Last September moderate numbers of NZMS were found in the main Salmon River below the Pahsimeroi, however they could not be relocated on a recent trip in April, 2004. Most significantly, an abundant population was discovered approximately 40 miles above the Pahsimeroi in Squaw Pond. Squaw Creek Steelhead Pond is a man-made, earthen pond adjacent to Squaw Creek, approximately 1 km upstream from its confluence with the Salmon River (Osborne and Rhine 2000). It is used by Idaho Department of Fish and Game (IDFG) as an acclimation and release site for steelhead smolts from Magic Valley Hatchery. The pond is also used as a fish-out pond for rainbows stocked from Nampa Hatchery. Both Nampa and Magic Valley hatcheries are infected with NZMS, to varying degrees. The pond is drained early each fall after steelhead are released, but when full, the pond supports a healthy growth of algae. When surveyed in September, 2003 the pond was already drained although ground water maintained a small pool and outflow channel. NZMS were observed on the substrate and within the algal mats remaining in the pool. In April, 2004 the pond was recently refilled, the flow in the outflow channel was increased, and pools had been created in the channel to provide a release site for steelhead smolts. Although NZMS were abundant in the outflow channel prior to refilling the pond (Fred Partridge, pers. comm.) we only observed them in a small side channel below the recently created pools. The increased flow had obviously flushed snails in the main outflow channel downstream.

Dispersal Pathways
The spread of NZMS into new systems is usually human caused with the most common dispersal methods being hatchery transplants, contaminated fishing equipment, boats, and trailers (Richards 2002c). Other possible vectors of introduction could include wading anglers moving between sites, rafters and kayakers floating between river access points, fishery biologists sampling various sites, etc. Additionally, waterfowl (Lassen 1978 in Richards 2002a), fish and discarded aquarium plants and pets are other possible vectors. The pattern of NZMS invasion involves geographic jumps, which supports the theory of introduction to new sites from various vectors; if it were dispersing primarily under its own volition one would expect to see a smooth and steady invasion front.

However, NZMS can move upstream under their own volition, unless other factors limit their spread (Dybdahl 2002). It is a relatively fast snail with an estimated substrate cruising speed of >1 meter/hour (Richards 2002a).

The potential for NZMS introduction to the upper Salmon River is greater than in the South Fork Clearwater River. The upper Salmon is typically used by wading anglers (Tom Curet pers. comm.) that are more likely to carry NZMS in the laces of their wading boots, whereas South Fork Clearwater anglers are mostly bank fishermen that seldom get in the water. Also an angler unknowingly transporting NZMS from the lower Salmon River would have a shorter travel time to the upper Salmon River than to the Clearwater River. The longer travel to the upper Clearwater River from a NZMS positive site would provide a longer duration for desiccation, which is one of the preferred methods for control of NZMS (Richards *et al*. 2004). Additionally because of the recreation aspect of the Stanley basin the upper Salmon River is used more heavily by rafters and floaters than the upper Clearwater basin. Recreationalists also do day float trips downstream from Stanley, but it is unlikely they get far enough downstream and into areas known to have NZMS, then unknowingly transport them back upstream.

NZMS have no natural predators in North America, whereas in New Zealand several native fish species frequently eat them (Richards 2002a). They have been found in catchable size rainbow trout at Hagerman State Hatchery, (IDFG data) and in whitefish stomachs (Cada 2003). Dwyer (2001) force fed NZMS to rainbow trout and observed an 85% survival rate after 2.5 hours in the trout, he also predicted some survival out to about 5 hours. Food passage time for trout is variable ranging from 6 or 8 hours up to 24 hours, and is affected by temperature, fish size, and other factors. So given these factors, a possible scenario could be for a fish to ingest a live snail prior to loading into a distribution truck and either passing a live snail in the tank during transport or in the stream after release. Either way the snail could be introduced into that water body and potentially start a population via cloning.

Currently Hagerman NFH is releasing steelhead into the Salmon River at several locations above and below the farthest known upstream infestation at Squaw Creek Steelhead Pond. Although NZMS can move upstream volitionally as noted earlier, any point in the main stem Salmon River downstream of Squaw Creek is particularly susceptible to invasion from that population. When the pond is drained in early fall, algae mats carrying NZMS are likely flushed downstream. It is interesting to note, however, that no NZMS were observed in Squaw Creek above the mouth or in the Salmon River directly below Squaw Creek. Lower Squaw Creek appeared to be suitable habitat and supported an abundant population of native *Physa* snails. Current Hagerman NFH stocking sites in the upper Salmon basin upstream of Squaw Creek include the Yankee Fork tributary and Sawtooth Hatchery. They also release steelhead into East Fork Salmon River and the Little Salmon River drainage, a tributary to the lower Salmon River (**Figure 1**). All of these sites have been used by Hagerman and other IDFG hatcheries as fish release sites for the past 10-15 years.

Potential Establishment

NZMS were initially found in the Hagerman Valley in 1987 by Dr. Peter Bowler (Richards 2002c). Hagerman NFH has been releasing steelhead into the Salmon River basin since 1978. We do not know exactly when NZMS colonized the springs at Hagerman, however based on the size of the population we can surmise that it was before they were first discovered in the fall of 2002. Nampa and Magic Valley Hatcheries, which are also infected to varying degrees with NZMS, also release fish into the Salmon River basin.

Recent releases from Hagerman NFH into the South Fork Clearwater River occurred in Newsome Creek and American River from 2001 to 2003 (Magic Valley Hatchery in 2000). There was a Hagerman NFH release into the Clearwater River in 1989, but the presence of NZMS at Hagerman NFH at that time is unknown. Hagerman NFH is the only station infected with NZMS that is programmed to release fish into the South Fork Clearwater River.

There are several environmental factors that may prevent the colonization or limit the success of NZMS in the Upper Salmon and Clearwater rivers. Under higher water velocities (>.5 m/s) (Richards 2003; Lysne 2003) the long spiral shell of the NZMS causes it to wash away easily. While average water temperature of 7°C did not prevent survivorship, growth, or reproduction, optimum growth occurs at 19°C, so colder winter temperatures will slow population growth. Also, Dr. Gustafson (pers. comm.) theorized that ice formation and scouring may limit successful colonization. Recent observations suggest that the clone that has invaded the Western U.S. is a “river” clone and is unlikely to invade lakes or reservoirs in ecologically disruptive densities (Dybdahl 2002). Concerning the Snake River reservoir populations, Dybdahl (2002) suggested that they are not self-sustaining, but are maintained by immigration from riverine habitats, whereas the absence of NZMS from Brownlee Reservoir is possibly due to the large fluctuation zone and depths greater than 60 feet (Shinn 2002).

The South Fork Clearwater River has many of the features that would classify it as unsuitable habitat for widespread establishment of NZMS. However, there is always the possibility for a small population surviving in a pocket of suitable habitat. Given that possibility, a small colony could become the point of invasion, potentially seeding establishment of larger populations of NZMS in more suitable habitat downstream or a stepping stone to other waters.

While the upper Salmon River may also be unsuitable habitat, if a small colony was established upstream of Squaw Creek Steelhead Pond there is no increased risk of invasion into more suitable habitat downstream, due to the present occurrence of NZMS. Additionally there are other factors that add support to the theory of potentially unsuitable habitat in the upper Salmon River. The length of time that stocking into an area from infected facilities has been occurring must be considered. In the Salmon River, stocking from hatcheries has been occurring probably as long (greater than 20 yrs) as there have been NZMS in the facilities, whereas in the South Fork Clearwater River, stocking from Magic Valley Hatchery occurred in 2000 and from Hagerman NFH in 2001 to 2003. Also, the level (number of fish) of stocking in the Salmon River was much greater than in the Clearwater River. Approximately 900,000 steelhead are released annually into the upper Salmon River from Hagerman NFH, compared to 200,000 into the South Fork Clearwater River. While more than 20 years of large releases does not ensure that NZMS will not become established in the future, it does support the theory of low potential for establishment. Additionally, the lack of a contiguous population downstream of the two locations that currently have well established NZMS colonization in the Salmon River drainage help support the theory of unsuitable habitat. The Little Salmon River can also be grouped with the upper Salmon River regarding unsuitable habitat and the potential for downstream introduction of NZMS already present.

Water chemistry played a minor role (5%) in growth and reproductive rates, but may determine distribution (Dybdahl 2003). Hall *et al*. (2002) reported that NZMS production is highest in vegetated habitats, but cobble can also support high densities.

Schreiber *et al*. (2003) found that NZMS frequently occurred in sites draining catchments with multiple types of human activities (grazing, agriculture, towns). This is typical pattern for successful invaders (D'Antonio *et al*. 1999 in Schreiber *et al*. 2003). The pattern may not be related to disturbance, but to other factors. In its native habitat the NZMS occurs in higher densities in agricultural catchments than in forested catchments (Quinn and Hickey 1990 in Schreiber *et al*. 2003). These streams also have higher amounts of algae, which provide increased food resources, possibly leading to higher abundance of NZMS.

As a final note, adaptation and habitat change need to be considered when contemplating potential distribution of NZMS. Already endowed with phenotypic plasticity, genetic change in existing NZMS populations could lead to greater tolerance of habitats in Idaho that currently may not support establishment. Such genetic changes could be disseminated relatively rapidly given the snail's asexual method of reproduction. Similarly, future climate or habitat change as well as other broad-scale environmental changes could potentially transform isolated NZMS refugia into continuous and wide-ranging populations.

Potential Impacts

While the full impacts of NZMS in Western rivers are unknown, invasive species are usually assumed "guilty until proven innocent" because it may take years for impacts to show up and then it is too late for eradication. Like all aquatic nuisance species NZMS has the potential to cause serious impacts to native species, fisheries, and aquatic ecosystems.

It is interesting to note that algal biomass increases as the biomass of NZMS increases (Riley *et al*. 2002), possibly due to the stimulus of algae growth through nutrient enrichment from NZMS (Giannotti and McGlathery 2001 in Riley *et al*. 2002). The input of nitrogen may have increased the growth of algae to a rate faster than the snails could consume it.

Research by Kerans and Cada (2002) has shown that NZMS interferes with the foraging of baetid mayflies (about 25% reduction) which could reduce fecundity and success, potentially reducing population size. Conversely, when *Brachycentrus* (caddisfly genus) is wandering on rock surfaces, it can reduce the foraging of NZMS, impeding colonization and success of NZMS. While the interactions between *Brachycentrus* and NZMS may appear small, when integrated over long period of time they may cause significant shifts in assemblage. Hall *et al*. (2002) also measured native invertebrate production much lower than NZMS, suggesting that snails have out competed native invertebrates. This evidence is supported by Armitage's (1958, in Hall *et al*. 2002) measure of insect biomass in 1958 that was twice as high as insect biomass measure in the same riffle in 2002. Riley *et al*. (2002) observed that the growth rate of NZMS is enhanced by the presence of *Pyrgulopsis*, whose own growth was negatively affected by NZMS, at least within the treatment densities.

Richards (2003) looked at competition between NZMS and the threatened Bliss Rapid snail and found that both species were affected by intra- and interspecific competition, although the Bliss Rapids snail was more affected by NZMS than vice versa. He hypothesized that at lower densities NZMS could actually facilitate growth of the Bliss Rapids snail or that the Bliss Rapids snail may be a better competitor at some densities.

Loo (2003) reported on impacts of NZMS in Australia including snails emerging from drinking taps and clogging water pipes. However, she also showed a positive correlation with native macroinverebrate densities, possibly through providing fecal matter and other nutrients to the system.

It should be noted that although NZMS may initially show no, minimal, or positive effects to primary or secondary aquatic production, it may still have negative effects on native fauna through interactions not yet studied. At the high densities NZMS can potentially achieve, other macroinverebrates would be excluded just from a spatial prospective. Also at high densities, NZMS may spread into unoccupied habitat quicker because a population can grow at a faster rate when the density is increased. A potential nutritional impact to fish could also occur under high densities of NZMS whereby they exclude other invertebrates and thus become a significant part of a fish's diet. Under this scenario the snails may provide lower nutritional value, particularly if most pass through the gut undigested.

Another potential impact of NZMS is as a fish parasite vector. Staton (2003) notes that in New Zealand and Australia the mudsnail is host to at least 14 trematodes, which appear to also control them. To date none of these parasites has been found in NZMS in the Western US, but there is concern about the potential for NZMS to transmit parasites to salmonids. In Yellowstone National Park there are at least 10 trematode species that currently affect fish (Staton 2003).

Risk Mitigation
Hagerman NFH has developed a Hazard Analysis and Critical Control Point (HACCP) Plans for both steelhead and rainbow trout production. These Plans provide a structured method to identify risks and focus procedures on minimizing the unintended spread of species through natural resource pathways. These Plans include visual inspections in all springs, rearing units, and at all phases of the rearing cycle. To date, the presence of NZMS has been confirmed in all the open springs and spring ponds at Hagerman NFH; however, they are not found in the egg incubation water or the water source used for filling distribution trucks (**Figure 2**). They have not been observed in the inside rearing tanks or on raceway walls, however since a small number has been found in the head boxes and tailraces they have undoubtedly passed through the raceway (Kurt Schilling, pers. comm.). The raceways are also desiccated annually which contributes to the control of NZMS at the facility.

Fish are also checked for presence of snails in their stomach at several times during the rearing phase. To date, no live snails have been found in over 1,200 steelhead sampled annually and only recently (3/04) two empty NZMS shells were found in steelhead from the upper deck at Hagerman NFH (Kurt Schilling, pers. comm.) (**Figure 2**). Whether the shells were empty when ingested or live snails were digested is unknown, however the incidence of snail consumption by steelhead is very low.

The HACCP Plans call for specific measure to be taken to reduce the risk of transporting snails off station. These measures include; using a clean water source to fill the distribution truck, taking fish off feed 48 hours prior to transport, and sweeping raceway floors and walls 24 to 48 hours prior to transport. Hatchery staff utilize large mesh screens on the dewatering tower of the fish pump to allow any NZMS to fall back into the raceways rather that be loaded into the transport truck. Staff also conduct visual checks of transport trucks and fish pump water and any NZMS, if seen, would be physically removed (Kurt Schilling, pers. comm.).

Even by instituting all the steps outlined in the Hagerman NFH HACCP Plans, there is no way to guarantee that NZMS will not be transported off station during fish stocking. The only way to guarantee no possible introduction from Hagerman NFH would be to curtail stocking. While this would work in the South Fork Clearwater River since Hagerman NFH is the only infected hatchery stocking there, in the upper Salmon River this management action would be pointless unless matched by IDFG for their infected hatcheries.

The HACCP Plan calls also for surveys of current release sites for the presence/absence of NZMS. The Clearwater and Salmon rivers were surveyed and plans are in place to establish annual monitoring sites in the Clearwater and upper Salmon rivers to see if NZMS colonize these areas in future years.

Risk Assessment
A long list of unknowns (see Additional Research section below) makes it difficult to quantify the risk of NZMS spread by Hagerman NFH operations. For example, what are the odds that NZMS will survive if introduced into new sites like the Clearwater and if they survive, will they cause ecological problems? Eventually, many of these issues will be addressed in the ANS Task Force National NZMS Management and Control Plan and

assessed in the Hatchery-based NZMS Introduction Risk Assessment Model, both of which are currently under development.

In the interim, the following criteria have been developed to assess the risk of NZMS spread by hatchery release operations. A hatchery release will likely cause or promote the spread of NZMS if**:**

- Evidence of live or dead NZMS in any quantity has been found associated with water used in rearing or transport of subject fish, inside facilities that indicate availability for consumption by subject fish, or inside subject fish within the last 12 months, and;
- NZMS have not yet been found in the watershed of the tributary where the hatchery release is to occur.

Based on these criteria, and the information presented in this report regarding the snail's biology, current distribution data, existing control opportunities, and contamination history at the facility, the release of steelhead from Hagerman NFH at current stocking sites in the South Fork Clearwater River, upper Salmon River (including the West Fork and Yankee Fork), and Little Salmon River is likely to cause or promote the spread of NZMS in Idaho.

Risk Management Recommendations
The above risk assessment involves a conclusion about likely risk based on a scientific analysis of available information. The rest of this report addresses the decision of how to manage this risk. This decision considers the science-based conclusions of the risk assessment, but also needs to factor in scientific uncertainty, mitigating circumstances (e.g., additional sources of risk), and other consequences of the decision (ecological, political, socio-economic, etc.).

The following factors were compiled and prioritized to guide decision-making for Hagerman NFH operations that are likely to introduce or spread NZMS into the South Fork Clearwater River, Upper Salmon River, and Little Salmon River. These factors should be used to determine whether continued hatchery release operations are justifiable despite a risk assessment conclusion that the operation will likely cause or promote the spread of NZMS. Note that these factors need to be reevaluated to determine if they are appropriate for guiding decision-making for other Pacific Region Fisheries operations, and modified accordingly.

1) **Ongoing stocking by other parties** (i.e. any advantage from not stocking from a Service hatchery is negated by practices in the watershed by other parties)

2) **Potential introduction from other vectors** (i.e. type and level of human recreation, natural waterfowl or fish movement, etc.)

3) **Contamination abundance/history of infected water, facility, and/or fish**

4) **Effectiveness of HACCP plan or control measure implemented at the infected facility**

5) **Habitat suitability** (i.e. water velocity, mean water temperature, ice formation and scouring, vegetation, substrate, nutrient loading, food availability, natural or man-

caused habitat disruption, reservoir water level fluctuation, etc.), recognizing uncertainty due to potential changes in habitat quality or NZMS tolerance

6) **History of previous stocking for infected hatcheries** (i.e. number of fish and years, this may help support or refute a determination of habitat suitability)

7) **Contiguous NZMS populations downstream of established colonies** (this may help support or refute a determination of habitat suitability)

8) **Distance of nearest NZMS population**

9) **Public benefit of continuing the operation relative to the anticipated costs of resulting NZMS spread**

10) **Potential for development of a new invasion point or stepping stone population** (i.e. possibility of seeding unoccupied habitat downstream or an intermediate step for NZMS to reach a new water body)

11) **Natural resource benefit of continuing the operation relative to the anticipated risks of resulting NZMS spread**

12) **Potential for development of a 'significant' population** (i.e. marginal habitat, pockets or fragmented suitable habitat availability, well established native snail or macroinvertebrate populations, etc.) (significant could be defined as one that may impact listed species or reach densities high enough to displace native invertebrates through spatial factors)

13) **Potential for continued stocking from infected Service hatcheries to promote continued stocking from infected facilities by other parties**

14) **Potential for continued operation to compromise other Service invasive species programs even if biological risk is inconsequential**

The above factors were used to reach the following recommendations concerning Hagerman NFH releases:

1) **<u>South Fork Clearwater River</u>**: **We recommend that until more definitive data is available, no steelhead be released into the Clearwater basin from Hagerman NFH.** Currently there are no known NZMS in the Clearwater basin and stocking from Hagerman still has potential for introducing them. The South Fork Clearwater is not being stocked by any other infected hatcheries. There is low risk of introduction from other vectors since the Salmon and the lower Snake River are the closes known NZMS population. Habitat suitability would rank low in the upper Clearwater, but higher in the lower Clearwater. There is only 4 years of previous stocking from infected facilities. Since this program can be shifted to another facility the resource benefit will continue and there is no change to the sport fishery because this is a release of un-clipped steelhead.

2) **<u>Upper Salmon River (incl. the East Fork and Yankee Fork)</u>: We recommend that steelhead releases into the upper Salmon River continue as planned.** The upper Salmon River is negative for NZMS presence and there is the possibility of introduction from Hagerman releases. However, several factors were considered that we believe support the continuation of the program. The upper Salmon River is being stocked by other parties from facilities that are infected by NZMS. Therefore, ceasing Hagerman NFH releases in this area will not significantly reduce the chance for NZMS introduction. There is high risk of introduction from other vectors since there are established populations in the mid Salmon 40 miles downstream. However, even with existing NZMS populations in the basin, the potential for NZMS colonization in the upper Salmon River drainage appears low based on habitat suitability. This habitat determination is supported by the fact that there are no established populations in the mainstem Salmon River, either where long-term fish releases have taken place or below established NZMS populations in Squaw Creek or the Pahsimeroi River. Additionally, there is a long history of previous stocking from infected facilities into the upper Salmon River. Based on habitat and past history the potential for developing a significant colony or new stepping stone population is also low. If an isolated population became established in a pocket of suitable habitat in areas of the upper watershed, it is questionable that a colony would ever achieve density levels that cause ecological problems in these reaches.

3) **<u>Little Salmon River</u>: We recommend that steelhead releases into the Little Salmon River continue as planned.** The Little Salmon River is also negative for NZMS presence and there is still the potential for introduction from Hagerman. However, several factors were considered to support continuation of the program. Like the upper Salmon River the Little Salmon River is also being stocked by other parties from facilities that are infected by NZMS. Therefore, ceasing Hagerman NFH releases in this area will not significantly reduce the chance for NZMS introduction. There is some risk of introduction from other vectors since NZMS are established upstream in the mid Salmon, although they are ~150 miles upstream. While NZMS are not established in the Little Salmon the potential for NZMS colonization in river appears very low based on the high velocities found throughout the river. This determination is supported by no known NZMS in the Little Salmon, even though numerous years of stocking has taken place. The potential for developing a significant colony or new stepping stone population also appears to be low. Any NZMS introduced into the Little Salmon River are likely to be washed downstream into the main Salmon River, but that river is already subject to introduction from upstream.

4) **<u>Rainbow Trout Program</u>: For this year we recommend that the May releases continue as planned and that this assessment be expanded to include all rainbow stockings prior to releases planned for October.** The rainbows are scheduled for release in May and October, the 5” rainbows scheduled for May release are planned for stocking into the Snake River in three locations less than 20 miles above American Falls Reservoir. This reach of the Snake River is already colonized by NZMS, and therefore does not meet the risk assessment criteria for likely promotion or spread of NZMS. The long-term release of rainbow trout from Hagerman NFH needs further investigation. Release sites need to be surveyed for presence/absence of NZMS and habitat conditions. Releases into a lake or reservoir, especially those with a large annual fluctuation zone, would minimize risk of establishment, since any introduced mudsnails would probably

die annually. Also, the theory of these NZMS not being a lake clone needs further verification.

5) **We recommend that a similar analysis occur for other FWS Pacific Region Fisheries hatcheries and related operations that may be infected with NZMS.** Whenever possible, this analysis can be conducted in concert with HACCP planning for these facilities.

Additional Research

The Service is beginning development of a hatchery-based NZMS introduction risk assessment model that would be used when looking at releasing fish from an infected hatchery. Pertinent factors associated with hatchery activities, possible introduction from other vectors, and habitat suitability would be weighted, ranked, and summed to obtain a cumulative score for each category. Then the category scores would be added together to obtain a total risk score that would be relative to scores from other hatcheries or release sites. We are hoping to get input from biologists knowledgeable in the life history and requirements of the NZMS to assist with the development of this model. The model would have useful application not only in Idaho, but throughout the western U.S. as more hatcheries are likely to face NZMS problems in the future.

The following research questions need to be addressed so that future Service decisions regarding NZMS management can be based on more complete information. Priority tasks are indicated in bold type.

<u>General life history/ecology questions</u>

- Are certain habitats/environments less conducive for population establishment/build-up?

- How does water temperature or quality affect the snail's effectiveness in colonizing new habitats?

- What is the life span of the snail in the digestive system of steelhead, rainbow trout, and other salmonids?

- What is/are the most vulnerable life stage(s) of the snail?

<u>Dispersal/Distribution questions</u>

- What protocols and confidence limits should govern the accuracy of a negative survey finding?

- What is the most up-to-date distribution of NZMS?

- What are the ranges of natural dispersal rates/distances that have been documented for NZMS upstream and downstream from initial infestations, and what physical factors affect those rates and distances?

- How does this distribution align with fish hatchery location and stocking sites? In particular, what is the known distribution in the Salmon River basin and how thoroughly/recently has a survey been done there?

- Once NZMS occur in one tributary of a watershed, what is the likelihood that they will eventually occupy all reaches of the entire watershed that support their habitat needs?

- What is the abundance of viable NZMS in the digestive system of hatchery fish at Hagerman?

Control questions

- Are there any mechanical, physical, temporal or other barriers to prevent the spread of the snail? (e.g., would it be feasible or cost effective to use micro-screen drum filters or an electric field in the water intake as a barrier between the spring supply and the rearing area at Hagerman?)
- Are there any "chemical" controls known to eliminate NZMS that are non-lethal to fish (e.g., could fish be isolated in a holding tank and treated for a period of time prior to release)?
- How might various control methods affect native molluscs?
- What is the mesh size required to filter embryonic and/or adult snails from a water supply (e.g., Hagerman truck fill water is gravity fed through a 3-inch pipe at 200 gpm)?
- Is there any work on a species-specific biocide to control NZMS?
- Are there any "biological" controls that could be approved for use in the United States?

Other impact questions

- How do/might high NZMS densities affect listed species directly or through food web interactions (e.g., what are the food supply impacts to bull trout when NZMS densities exceed 100,000/sq. meter)?
- What is the risk of NZMS as a pathway/reservoir for new pathogens or parasites that would harm native species?

Distribution List

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Kurt Schilling, FWS
Ray Jones, FWS
Janna Brimmer, FWS
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Kendra Womack, FWS
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Christine Moffitt, U of I
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Tom Curet, IDFG
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Bill Hutchinson, IDFG
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Ed Larson, NPT
Lytle Denny, SBT

Figure 1. Clearwater and Salmon river drainages showing sites with New Zealand mudsnails and Hagerman NFH steelhead release sites.

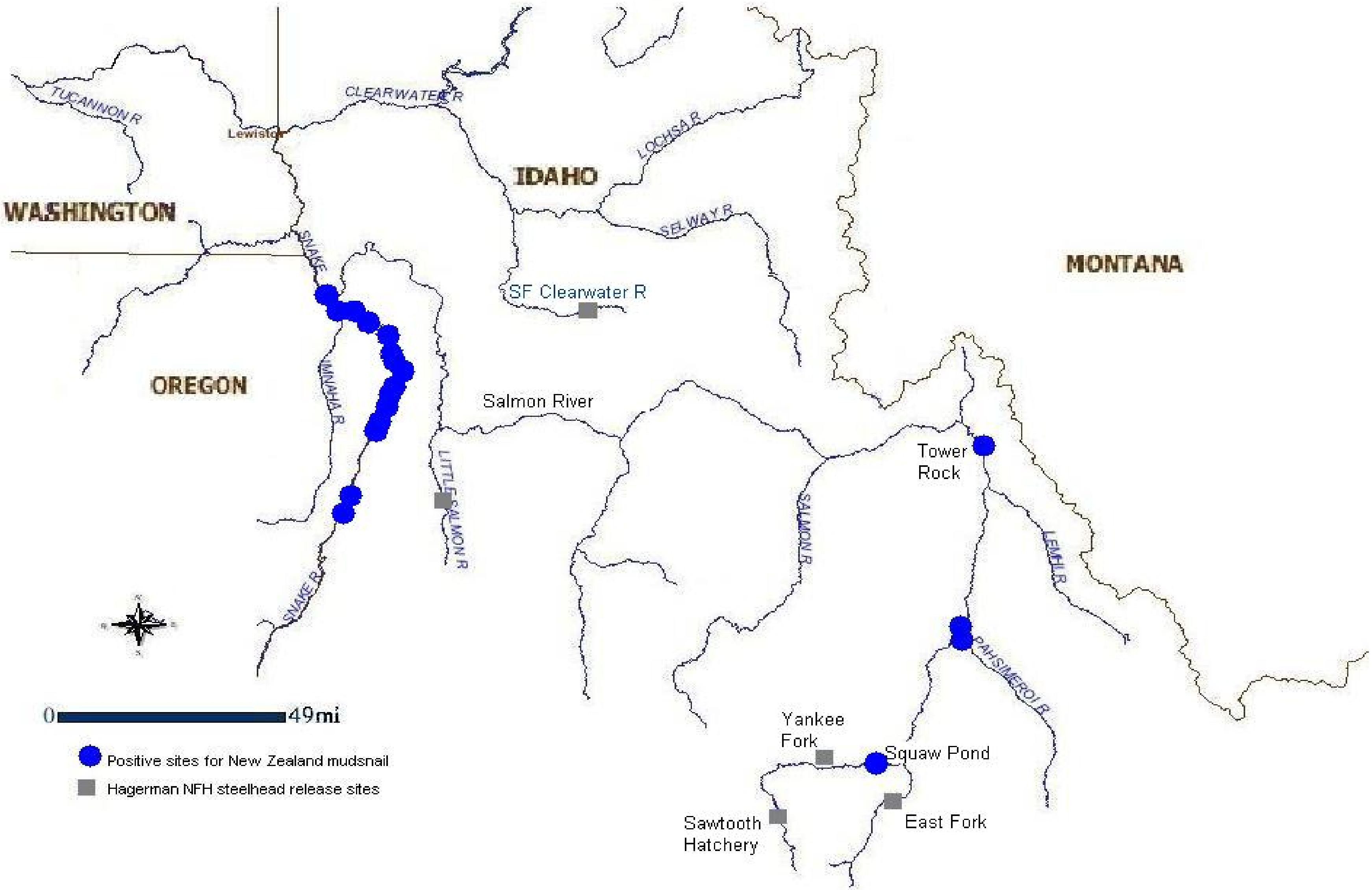
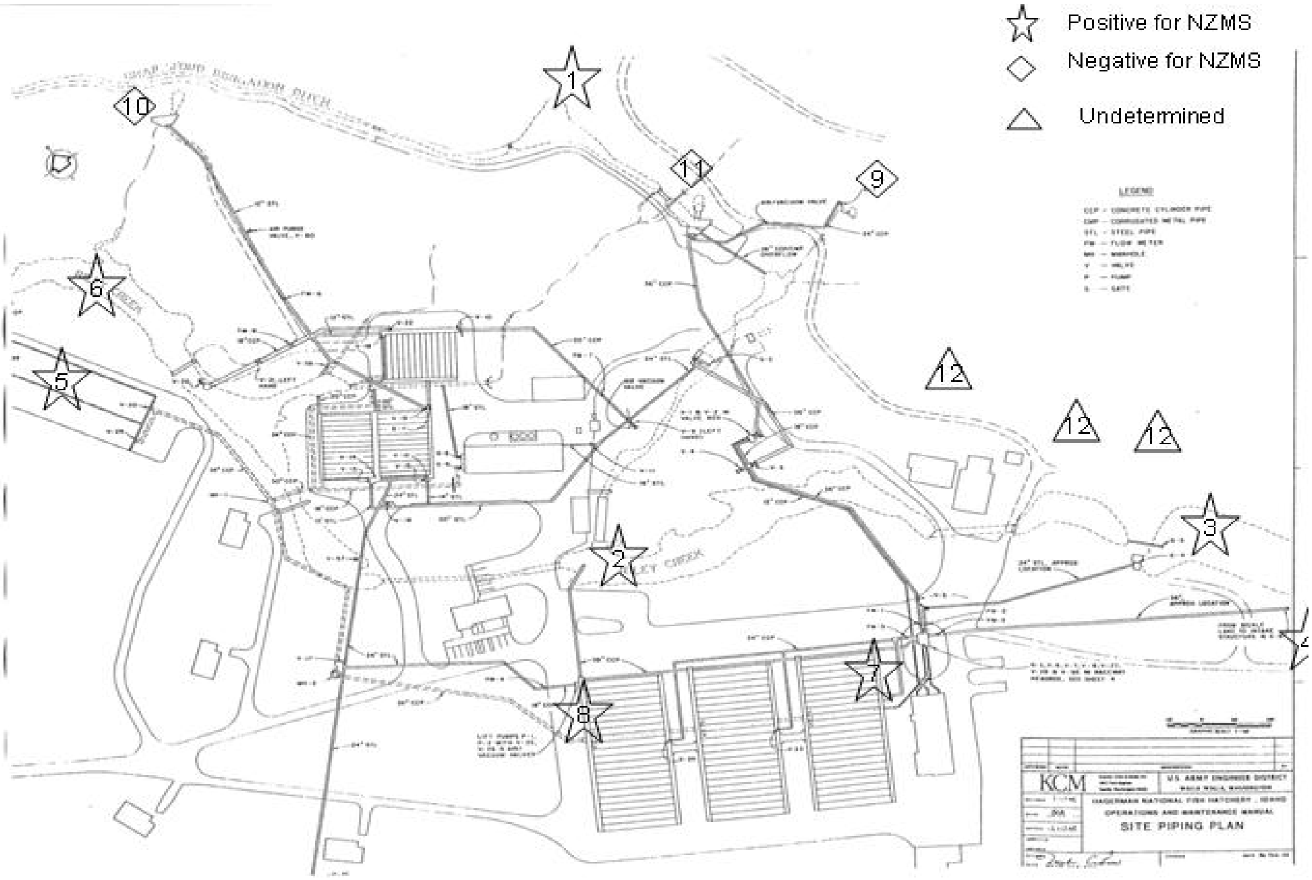


Figure 2. Hagerman NFH springs and facilities and status of sites surveyed for New Zealand mudsnails in 2003.



Positive NZMS Sites:

1. Len Lewis/Spring 16
2. Tailrace of Display Pond
3. Riley Lake/Spring
4. Bickel Lake/Spring (Not pictured in above drawing)
5. Off Line Sedimentation Ponds
6. Riley Creek (receiving waters)
7. Head box of upper deck of Steelhead raceways (very few)
8. Tailrace of lower deck of Steelhead raceways

Negative NZMS Sites:

9. Spring 13/14 (water source for incubation, and filling transport tankers)
10. Spring 17
11. Spring 15

Undetermined NZMS Status:

12. Springs 11/10/9/8 (Water rights held by FWS, but diverted to University of Idaho Hagerman Fish Culture Experiment Station). We suspect there are snails in the water below their facility.

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