SURVEY PROTOCOL FOR AQUATIC MOLLUSK SPECIES:

Preliminary Inventory & Presence/Absence Sampling

Version 3.1 — July 2008

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I. INTRODUCTION

The objective of this protocol is to provide standard survey methodology that can be used by field personnel to determine **presence/absence** for aquatic mollusk species, i.e., to determine what aquatic mollusk species are present in a selected body of water with a reasonable level of confidence, and to document species locations and habitats in a consistent format. This methodology can be used prior to project design on federal lands to collect information about what species are present and may be affected by such projects. It can also be used during general inventories of aquatic mollusks for watershed analysis or other efforts to determine distribution or habitat associations. Specific information for surveying in three major habitat types is described where appropriate. Following this protocol will assure consistent, standardized surveys in order to have comparable and credible survey effort and data quality standards, and to assist in future protocol refinement.

This Aquatic Mollusk Survey Protocol Version 3.1 is a revised protocol for use by USDA Region 6 Forest Service (FS) and the Oregon/Washington USDI Bureau of Land Management (BLM). It is specifically intended for use by FS and BLM wildlife and fish biologists conducting surveys for Special Status aquatic mollusk species. Surveys for FS and BLM Special Status species are not required, but if such surveys are conducted this protocol should be used to ensure consistent data collection. This protocol replaces the earlier version of Aquatic Mollusk Survey Protocol for federal lands in the Pacific Northwest, Version 2.0 and includes new information and different methodology.

The appendices contain important information used in conjunction with this protocol. Useful information about permit requirements, equipment, recommended surveyor background and training, and additional safety considerations are presented in Appendix A. Appendix B contains additional sources of aquatic mollusk and sampling information. Appendix C provides federal management status in Oregon and Washington and habitat information for Special Status species. Suggested survey and observation data forms and information about required data collection and data management are contained in Appendix D.

A. Goals and survey designs

Before planning or implementing any survey, it is important to determine what the objectives of the survey are and what type of information is needed from the survey in order to design a feasible sampling method which will provide the best results. There are basically three levels of investigation (Strayer and Smith 2003).

The most basic type of survey is a cursory visit, or incidental observation. This can be as simple as picking up a shell on the shore or observing it in the water and recording the location and date. Generally, there is no standard methodology for this type of search. They usually involve wading, or observing from shore, fishing boats or rafts. Preliminary visits to visually locate populations of mollusks are the first step in understanding distribution and occurrence, and are essential for designing more in-depth, future studies. Incidental observations will be of limited use in documenting abundance, but are of great use in locating and documenting where species occur. This information can be used for determining the distribution and range of a species or to identify habitats to investigate further. At the local scale, preliminary visits to a study area can be used to identify areas or habitats used by mollusks, in order to stratify more intensive sampling and increase the probability of detections or to increase the statistical power of quantitative sampling.

The second level of survey is used to determine occupancy or presence/absence. This is the most common type of survey, generally used to determine what species are present in a project area or to inventory various habitats. Section II.A. of this protocol contains a description of a presence/absence methodology in which area-constrained surveys are used. This method can be used in situations such as pre-project evaluations to determine what species are present in an area that may be affected by a proposed project or for inventory sampling to clarify distribution patterns of aquatic mollusk species. Rough approximations of the relative abundance of species or age classes can be documented, but results from this type of survey only apply to the sampled area and cannot be extrapolated out to larger areas.

Freshwater mollusks can be small, elusive, and clustered, which can make them difficult to detect. Detectability refers to the comparison of the observed presence to the actual presence, and is a variable that changes with observer, species and environment. Absence cannot be entirely determined with a presence/absence survey, but a minimum search effort (based on the proportion of the survey area represented by each habitat type) is required to achieve a reasonable degree of confidence that a species will be detected if present in the survey area. The flexible design of this type of survey allows the investigator to tailor the search effort such as with longer and more thorough searches depending on the probability of detection of the target species. Statistical measurements of detectability require repeated sampling, which is not covered in this survey protocol. For more information about detectability in occupancy surveys see Thompson et al. (2004) and for designing occupancy surveys to measure detectability see MacKenzie et al. (2005).

The third level of survey is used to obtain a statistically valid estimation of abundance for a given population. This type of survey methodology is not described in this protocol. If the goal is to gather population density information, to monitor demographic trends over time or to compare different populations and habitats, then a quantitative statistical approach, tailored to the physical site and expected density of individuals, is needed for valid results. Results from this type of random sampling can be extrapolated out to represent an estimate of population densities over a much larger area. A separate monitoring protocol is needed to describe the methodology for quantitative, statistically valid surveys using transects, grids and random quadrat samples, which can provide accurate estimates of population density, age class structure and trends. This type of survey is necessary in order to compare before- and-after data, or to compare data between populations or over time. Several websites are included in the Internet References (Appendix B) that provide examples of this type of protocol for aquatic mollusk species.

B. Species Identification, Range and Habitat Associations

This protocol applies to all aquatic mollusk species in the Pacific Northwest. Since there are literally hundreds of species, it is not feasible to provide detailed information on identification, range and habitat associations for all potential target species in this document. However, information on current Sensitive species and former Survey and Manage species within the Northwest Forest Plan area can be found in Appendix C. In this appendix, Table 1 summarizes the major habitat types used by these species and their current management status. A more detailed description of habitat associations for selected species follows this table. Additional information on habitat assosications, ranges, and species descriptions for Sensitive species can be found in Conservation Assessments, species fact sheets (species accounts), a field guide to Survey and Manage aquatic mollusks (Frest and Johanns 1999), and other conservation tools provided on the Interagency Special Status Species Program website **[http://www.fs.fed.us/r6/sfpnw/issssp]** and on the internal Federal mollusk information exchange website **[http://web.or.blm.gov/mollusks]**. Many other species of aquatic mollusks may occur in the Pacific Northwest and new, taxonomically undescribed species are frequently encountered. The Pacific Northwest Native Freshwater Mussel Workgroup has published a field guide for mussels and their website **[http://www.fws.gov/columbiariver/musselwg.htm]** also contains a variety of information on this group of aquatic mollusks. Sources such as Burch (1982a) provide identification keys and illustrations for many species. Refer to the internet reference section of this document for other sources of information on aquatic mollusks.

Before beginning a survey for aquatic mollusks, it is helpful to determine in advance which mollusk species may be potentially present within the survey area, based on available range descriptions and habitat associations. Little is known about habitat preferences or environmental tolerances for most aquatic mollusk species. When considering potential impacts, it is wise to recognize that seemingly minor changes to aquatic systems can affect their delicate balances and functioning, and may have adverse impacts to aquatic mollusks.

Identification of specimens can be very difficult for aquatic mollusk species. Subtle differences in shell shape or body pigmentation are sometimes used to distinguish between related species. Many species are very small and may only be identified after proper relaxation and preservation allowing effective examination of their internal anatomy, usually requiring an expert malacologist familiar with these taxa. In some cases molecular DNA analysis may be needed for a final identification. For these reasons, it is a requirement of the FS/BLM Interagency Special Status/Sensitive Species Program for vouchers of potential target species to be collected during surveys for later positive identification. Links to several Powerpoint presentations and webpages are available on the information exchange website, which provide an introduction to the various families of aquatic mollusks in the Northwest and give illustrations of many species. Proper collection and preservation of specimens with appropriate tissue quality for dissection can also be difficult and time consuming. Basic instructions on how to prepare mollusk voucher specimens is presented on the ISSSSP web site **[http://www.fs.fed.us/r6/sfpnw/issssp/inventories/identification.shtml]**.

II. SURVEY DESIGN

A. Qualitative Presence/Absence Surveys

1. Types of surveys

a. Pre-disturbance surveys for effects analysis

It is important to know the reason for a survey before it is undertaken. For federal biologists, it is often necessary to evaluate the effects of a proposed activity on aquatic mollusks. Knowing which species are present in a project area is the first step in such an evaluation and is one of the most common reasons for doing presence/absence surveys. Knowing what types of actions may adversely affect those species can help a biologist to decide the scope and type of surveys that are necessary.

In general, adverse impacts to aquatic species may result from: 1) disturbance of aquatic or riparian substrate that could result in direct mortality to mollusks from exposure or crushing, or result in increased sedimentation and/or turbidity; 2) alteration of large woody debris quantity or quality in stream channels; 3) alteration of streamside vegetation which could result in elevated water temperature or changes in the recruitment of litter to the aquatic system; 4) changes in hydrology resulting from dams, ground water withdrawals, removal of trees and vegetation, or surface water diversions (including irrigation, road construction and development of water storage facilities) which may affect water flow patterns, temperature or water table levels. Such changes may affect aquatic mollusks directly by altering water quality or secondarily by altering riparian and aquatic vegetation communities; 5) increases in soil compaction affecting run-off rates and recharge of aquifers (activities of this type may occur at large distances from the survey area); 6) chemical poisoning from herbicides, pesticides, acid mine drainage or other toxic substances; and 7) introduction of exotic plant or animal species.

Timber harvesting activities within riparian areas including thinnings, salvage and regeneration harvests may have potential adverse impacts, as may prescribed burning. Other activities such as grazing, fish habitat improvement projects, culvert replacement, groundwater withdrawals or spring development projects, recreational developments, quarry expansions, dredging and bridge or road construction may also have potentially adverse effects. Federal lands outside of or at a distance from project areas may also be surveyed if: 1) they could be adversely affected by the proposed activity (for example upslope diversion of water from a spring run may affect the volume and quality of water downstream for some distance); and 2) the area provides suitable habitat for sensitive species.

Examples of some activities that may **not** have adverse effects include: 1) routine road and facility maintenance with no new impacts; 2) road closures; 3) precommercial thinning with no or limited removal of hardwood vegetation such as alder or big-leaf maple along riparian corridors; 4) mechanical noxious weed treatments; and 6) reforestation activities on recently harvested sites. The scale of the proposed activity is also important to consider when determining potential adverse effects.

b. General Inventories

Another common reason to conduct surveys for aquatic mollusks is to gain an overview of the occurrence and distribution of selected fauna in a particular region by conducting a general inventory. Select your target species or genera ahead of time. Attempts to document all aquatic species in all habitats are not only impractical, but frustrating. Changing your search image during a survey can result in overlooking many cryptic and rare species. In general, surveys in many small inventory areas, focusing on a limited number of target species or a single habitat type will yield better results than a few large-scale, all-species surveys, which have the potential to miss many small, isolated populations.

The design of a basic presence/absence inventory should maximize the chances of locating new populations. For aquatic mollusks, the scale of the inventory is critical. The scale of an inventory should be based on the dispersal ability of the target species. For most aquatic species in the Northwest, patterns of distribution are poorly understood. Many species of small snails are endemic, restricted to an extremely localized area, perhaps a single spring, while other species such as bivalves are widely distributed across the Northwest. Focusing survey efforts in a few small areas near known sites for species with restricted dispersal abilities will result in better chances of detecting them. On the other hand, distributing surveys across several areas within the best habitats in a watershed will increase the probability of detecting species such as mussels that are dispersed by wide-ranging fish.

Many occupied sites of spring-dwelling species are believed to be relicts of populations that were historically more widely distributed. These relict populations may have become isolated (perhaps long enough to undergo speciation) due to the dry climate at the end of the Pleistocene Epoch, geological uplifting and extensive diversions of surface and ground water resulting from more recent human activities. Sites that have persisted have had continuously flowing water for centuries. Aerial dispersal of live snails or egg masses by agents such as waterfowl and flying insects is well documented (Rees 1965), however, prosobranch (gill-bearing) snails require well-oxygenated flowing water to survive. It is therefore considered extremely unlikely that such species could disperse from one watershed to another by aerial means. The historical drainage patterns of areas with known sites, therefore, are one of the best indicators of potential currently occupied habitats for this group of species. Current watershed boundaries may be used as surrogates for these historical boundaries. When determining the most likely places to locate a particular species, occurrence of known sites within a watershed is a better guideline than an arbitrarily defined linear distance, because opportunities for dispersal and gene flow are generally restricted to areas with continuously connected surface water.

Given these considerations, the following guidelines can be used in designing **general inventory** surveys:

1) If a known site for a target species or group of species is documented within a fifth-field Hydrologic Unit Code (HUC) watershed (generally ranging from 20,000-200,000 acres in size) it is likely that other populations of these species may also occur. Inventories for these species should focus on the best, most pristine habitats, closest to known sites. Use sub-watershed boundaries to break down inventory areas into smaller, manageable survey areas. Habitats within these smaller areas can then be surveyed with different intensities based on their quality and proximity to existing sites. For spring-dwelling species, include all springs identified on USGS maps, as these are generally the biggest perennial springs. Smaller springs may be included as practical.

2) If a known site is documented in a fifth-field HUC watershed that is immediately adjacent to a watershed that you wish to inventory, and if both watersheds are within the same sub-basin (i.e., fourth-field HUC watershed ranging in size from 128,000 acres to 640,000 acres), it is still possible, but less likely that small species with limited dispersal may occur. Inventory surveys should cover at least 50% of the identified springs, streams or lakes in these watersheds for the presence of target species, again focusing on the largest and best habitats, in order to have a reasonable expectation of detecting target species.

3) In watersheds where no target species locations have been documented within the fourth-field sub-basin, survey areas should be dispersed throughout the watershed as much as possible to insure broad coverage and should be focused on specific habitat types used by target species. Sample designs may range from random sampling to sampling high quality habitat with easy access.

4) For mussels, larger order rivers and streams should generally be targeted first and then smaller streams. Mussel distribution is mainly a reflection of the range of their fish host. Maps of many fish species' ranges are available through state fisheries departments and federal agencies. Breaking down large watersheds into smaller representative units for inventory is recommended. Barriers such as dams and waterfalls can provide useful divisions of riparian systems, and further breakdown of inventory areas into stream reaches or segments makes correlations with hydrologic and water quality data easier.

2. <u>Where to look</u>

a. Defining survey and sample areas

A **survey area** is a geographically defined area in which 1) impacts are possible, and/or 2) occurrence, distribution or abundance is being studied. The survey area generally represents the extent of a population of interacting individuals to which the resulting data applies.

The local resource specialist should identify the boundary of the survey area around a project or the extent of a designated watershed, stream reach or segment being inventoried. If negative impacts on stream and river-dwelling mollusks are expected to result from proposed activities, the survey area may include waters both downstream (up to 400 m) and upstream (up to 100 m) from the project site. These distances are very general, but have been shown from previous field work to include most types of habitat alteration or adverse effects (Piette 2005). The distance may be adjusted (up or down) after taking into consideration landscape features like gradient, vegetative cover, and the amount and type of disturbance anticipated. The survey area may be further refined to include only those portions of the aquatic landscape within a designated area that contain suitable habitat for a target species.

S**ample areas** are smaller areas within a survey area where an actual search takes place. Sample areas are selected to represent a subset of the habitats found in a survey area, and their size and shape is dependent on the distribution of habitat present in the survey area. Generally, at least 1/3 of the total amount of each habitat type in a survey area should be included in sample areas. Previous surveys in waters of the Pacific Northwest have shown that this intensity of searching will detect the presence of most species in most situations (Sada 2006, Duncan 2006). For example, a survey area in a spring or stream may include several substrate types, such as cobbles, gravel, mud, submerged wood, and aquatic vegetation, and these may each be present in several different levels of current velocity, such as pools, glides and riffles. Sample areas would be located in each of these habitat types. All major habitat types should be sampled, with the total area sampled in each habitat type proportional to its availability within the survey area. Sample areas should be dispersed throughout the survey area as much as feasible to insure the best coverage and increase the potential for detection of all species present. Preliminary visits to survey areas may be necessary in order to locate places which appear to provide a good representation of the available substrates and habitats and have safe access. Sample areas are then selected to represent these different habitat types.

The boundaries of sample areas are defined by the extent of each habitat type (e.g. a rock shelf, cobble bed, or patch of aquatic vegetation). Each sample area can be identified by a number for referencing locations of specimens found. If habitat preference is known for a target species, high-quality habitats can be targeted to maximize detection probability. Sample areas should not include locations with sensitive fish breeding sites (redds), summer holding pools for salmonids, or places where there are any hazardous conditions present.

Surveying a minimum of 1/3 of each habitat type has been found by the author to provide a reasonable degree of confidence that a species will be detected if present in a survey area. Survey intensity can always be increased. Where there are other known sites for a target species in the same watershed and threats are expected, when looking for cryptic species, or when searching complex habitat types, more intensive sampling may be desired in order to increase the chances of detecting occurrences. This can be in the form of either more sample areas or more search time at each sample area.

A pre-project evaluation of habitat or a review of the range and the proximity of documented sites can help determine which species to expect. Locations of documented sites and habitat preferences can be determined by reference to species observation databases (e.g. Oregon/Washington BLM's GeoBOB and ARIMS databases, Forest Service NRIS Wildlife or NRIS Water, National Heritage Information System databases, and the Streamnet Mussel database) and to any additional occurrence information available. If the target species is cryptic, present in small age classes, or known to be otherwise not obvious due to behavior or habitat conditions, more search time per sample area is recommended. If the target species is known to be rare or lives in small isolated colonies, detection improves with the addition of more sample areas, or by allowing surveyors to inspect important habitat components in more detail or search interesting sites that might fall outside of designated sample areas. If maximizing detection of a single target species is desired, preliminary stratification of the available habitat may be done by individuals who are familiar with the species' preferences, and the best habitat searched first or searched more intensely. If examination of habitat associations is an objective, an equal number (and area) of samples should be in each habitat category defined.

Springs – Inventories should include every spring within the survey area that appears on a 7.5 minute USGS quadrangle map having perennial flow. Springs bearing names on maps should receive special attention since they most likely have perennial flow. Try to sample every spring in a nasmode (spring complex) since some species may be restricted to one or a small group of sites having similar appearing habitat. Any unmapped perennial springs or seeps with suitable habitat discovered during visits to the survey area may also be included. Be sure to consider spring-influenced portions of streams also, as some species occupy these areas as well as the spring run itself. Each spring is unique in its source, size, substrate, etc., so before beginning the survey, the spring should be assessed visually to determine the number of different habitats and their relative availability. In many cases, the highest flows and coldest water, and therefore the highest numbers of mollusks, are found in the headwaters of the spring. Concentrating sample areas in the headwater reaches is recommended when surveying for springsnails (Family Hydrobiidae), however a few samples farther downstream may locate other species.

Rivers and streams – All major aquatic habitat types with differing current velocities present in lentic habitats, such as riffles, pools and glides, should be sampled in proportion to the amount of each in the survey area. Access and safety may limit the choices of sample areas available to a surveyor. Within each habitat type, major substrate types (cobble, boulder, sand, silt, or clumps of aquatic vegetation) should be represented and sampled proportionally. Sample areas parallel to shore are commonly used. In some cases, it may be sufficient to limit sample areas to near-shore habitats, especially when target species are known to prefer shallow water. Differences in shading, water temperature or gradient offer other options for stratifying the locations of sample areas. Avoid sampling in areas where sensitive fish species are breeding or holding over in pools.

Large rivers in the northwest can present many hazards, especially where high current velocities and submerged rocks are present. Confine sampling to portions of the river that provide safe conditions, preferably near shore. Never risk the safety of surveyors in order to sample dangerous habitats. Please refer to Section II.A.3 as well as Appendix A for more detailed descriptions of safety hazards and required safety procedures in different habitat types.

Lakes and ponds – Since lotic habitats tend to be stratified spatially, based on water depth as well as substrate type, it is important to include representative sample areas at several distances from shore, in different depths and substrates, in order to maximize detection of all species present. Transects perpendicular to shore may be used, or habitat types may be defined based on substrate and surveys limited to those areas. Include representative portions of all sides of the lake or pond, as prevailing wind, sunlight or currents may create different conditions in different portions of the lake. Consider locating sample areas near the inlet as well as the outlet areas where water flow may be stronger. Look for subsurface springs and other areas where water quality may be higher. These can sometimes be recognized by a difference in aquatic vegetation or water temperature and clarity. In large lakes, it may not be feasible to adequately survey deep water areas. In such cases, limiting sample areas to those habitats represented within a certain distance from shore may be sufficient to detect most species.

Swimming and diving in large lakes can be dangerous. Underwater hazards such as drowned trees and snags are possible, as well as discarded fishing gear. Collisions with boats or other motorized vehicles also present unique hazards for divers in lakes with recreational use. Areas with heavy use from motorized watercraft and fishing should be avoided. Refer to Section II.A.3 and Appendix A for more detailed descriptions of safety hazards and required safety procedures.

3. How to look - Sampling Procedures

Surveys using this protocol for presence/absence are area-constrained surveys that vary in search time in proportion to the amount and complexity of habitat searched. Details of search techniques for three major habitat types are given in the following sections. All surveyors should be conscious of the potential for harming delicate aquatic ecosystems, especially small springs that may contain very rare, endemic species. When searching substrates, attempt to minimize the disturbance caused and always replace substrates and specimens removed for examination to their original locations. Do not wear insect repellant, sunblock or other skin creams that may wash off into the water. To avoid spreading noxious species, thoroughly clean and disinfect all equipment, including boots and sampling gear, rinsing well before entering any aquatic environments. Several methods can be used to kill living organisms on field gear, including chemical sprays, drying and freezing, which do not harm equipment and clothing. More information can be found on this subject by doing a websearch for the New Zealand mud snail, *Potamopyrgus antipodarum*, or the Protect Your Waters website **[http://www.protectyourwaters.net]**. Other resources for information regarding methods to guard against the spread of a variety of aquatic invasive species can be found at the FS Intermountain Region's Aquatic Invasive Species website **[http://www.fs.fed.us/r4/resources/aquatic/index.shtml]** or the US Fish & Wildlife Service's Western Regional Panel on Aquatic Nuisance Species website **[http://www.fws.gov/answest/aboutus.htm]**.

a. Springs

Most small water bodies may be thoroughly examined from shore or by wading. Bright sunny days during seasons of low flow provide the best conditions for good visibility. Do not attempt a survey if there is high turbidity or recent disturbance causing visibility to be restricted. When implementing a survey of a spring or nasmode, first find the headwaters, then determine approximately how far down from the headwaters there is enough flow to provide suitable habitat for the target species. Most springsnails require cold (less than 65°F), flowing water - so once the water flow goes intermittent or starts pooling and warming up, the habitat quality decreases rapidly.

After determining the extent of the survey area and the major habitat types available, start at the lower end of the reach to be searched and methodically work towards the headwaters of the spring. Work slowly, trying to disturb the substrate as little as possible. Search time will vary, depending on the amount of habitat in the survey area. A minimum of 30 minutes is typically needed to adequately search even the smallest spring. Search for mollusks visually by looking on the tops and sides of rocks, on submerged wood and vegetation, and underneath banks, removing substrates to good light for examination with a hand lens occasionally. Remember that aquatic mollusks are almost always fully submerged. In most cases, if a population is present they will be easy to see because most species tend to form colonies where they occur and are not generally found as single individuals. Isolated shells can be found, however, and can serve as indicators of the presence of a species in the vicinity.

Field crews have reported that working in teams where each surveyor is responsible for searching a particular habitat type works well because it enables a surveyor to focus on a particular search image and method. For example, one person might examine the available down woody debris in the water, while another could search cobble and rock surfaces and a third could sift fine mud sediments. Having designated persons available as recorders and specimen handlers has proven to be an efficient way to keep track of species located by a team of searchers. The recorders and specimen handlers can also watch for upcoming hazards and warn the searchers who tend to be focusing on their immediate surroundings.

If you visually confirm that mollusks are present, move on to collection. If not, then begin a more systematic search to determine their presence by targeting a subset of the best habitats and removing samples of substrate to a white bucket or tray for closer examination. Use a hand lens if necessary to see small species or individuals. For spring reaches of 800 meters length or less, select at least 10 examples of each habitat type to search systematically, spaced fairly evenly along the spring, making sure to search all substrate types. For smaller springs sample every 10 feet until the spring ends.

Areas with fine substrate (such as muds, sands, or silts) are sampled by excavating small areas (0.25 m^2 or less) of bottom sediment to a depth of about 3-5 cm (1-2 in.). This can be done either by directly scooping out a sample of sediment using a dip net or sieve with an effective mesh size of 0.5 mm or smaller, or by using a D-net or Surber sampler, held firmly against the bottom immediately downstream from a search area to catch disturbed debris while using your fingers to gently loosen the substrate to dislodge hidden mollusks. Figure 1 illustrates a typical D-net used for aquatic invertebrate sampling. Most mollusks are usually near the top of the substrate, so there is generally no need to scoop deeply into it. Use a standard soil sieve or a 10” stainless steel flour sieve, with a sturdy stainless steel rim (not plastic) and wire mesh, found in the baking section of department stores. For added ease in sampling, these sieves can be attached to a pole to collect samples while standing. Use the sieve to sweep through the substrate, under vegetation and under banks. Try not to scoop up too much coarse substrate, sticks or vegetation, as these are hard to filter out.

The sample should be washed several times to remove as much mud, silt, and sand as possible. If the sample is placed in a bucket and the contents swirled and then decanted, most of the fines will be flushed out as well as detritus and vegetation while leaving the heavier snails at the bottom of the bucket with the coarser and heavier sediments. The sample can then be transferred into a shallow, white pan and inspected closely in bright light. Generally, a 1-2 cup (8-16 oz.; ~ ¼ - ½ liter) volume of sieved material from each such site is an adequate sample.

Figure 1. Typical D-net used for aquatic invertebrate sampling

b. Streams and rivers

Larger streams and rivers with deeper waters have too much turbulence to adequately search without getting in the water. Surveys in these waters require the use of a viewscope (Figure 2a), plexiglass-bottomed bucket, snorkel or SCUBA equipment in order to have good view of the bottom. Surveys in these habitats should always be conducted in teams of at least two people. In large rivers, an additional person should be available to monitor the swimmers and be prepared for any necessary rescue. When using snorkel or SCUBA equipment, ensure that all surveyors have been trained and are certified in the use of their equipment. Follow all agency aquatic safety policies when working in deep waters. If using a raft or other flotation device for access or holding equipment, be sure to use highly visible flags or other devices for informing others of the presence of swimmers, and ensure that all required training for the use of such craft is provided. When wading, wear felt-bottomed boots or other non-slip footwear, and use a staff or other support to prevent falling on slippery rocks or in fast currents. Where cold water temperatures are encountered, insulated dry-suits or wetsuits may be necessary in order to prevent hypothermia, which may affect a surveyor's ability to think and act wisely.

Access to river survey sites can be problematic. Segments of the river to be surveyed need to have both put-in and take-out access with no hazardous situations in between so that surveyors can swim or float downstream while surveying and not have to fight the current. Since only ½ to ¾ mile of river can be searched thoroughly during a typical 2-3 hour survey, this access issue may limit the number and location of potential survey areas.

When searching, swim or move the viewscope slowly, close enough to see the substrate on the bottom clearly. An inner tube works well to float a surveyor with mask and snorkel high enough in the water to view the bottom while minimizing disturbance of sediments and animals. The tube also provides a floatation device, transportation over shallow rapids and riffles, and an anchor for a drybag or other gear strapped to it. A simple tether attaching the tube to a foot allows a surveyor to swim free and trail the tube behind when not needed (Figure 2b). Work your way over the sample area, anchoring yourself with your hands if necessary to remain in position over a selected area. Search patterns during qualitative surveys are slow and deliberate. This protocol uses an area-constrained search method, with no minimum time requirement. As a rough guide, at least 10 minutes is needed to adequately search $10m^2$ of river or stream bottom. As the complexity of the substrate increases, search time will also increase. Searchers should stop occasionally in areas of loose or fine substrate and hand grab (short tactile searches sweeping the hands back and forth while sifting with the fingers through the substrate) to detect mollusks not visible at the substrate surface. Areas of mixed loose gravel should be fanned occasionally to detect mollusks hidden by sediment between the substrate. Searchers need to explore all types of habitats including banks and backwater areas to locate species that prefer these habitats. For safety, areas in deep or swift water should be avoided. Avoid disturbance to listed salmonids where there are active redds or where adults are holding over in pools in late summer. Refer to Appendix A for federal ESA regulations.

If several surveyors are working together, swimming in parallel allows surveyors to effectively cover a stream in a short time (Figure 2 c). Alternatively, each person can select a shoreline and begin quartering back and forth towards the center of the stream and back, beginning at a given starting point. In some cases, it is helpful to assign one person the shoreline area only, so that this more complex area receives sufficient coverage. Be sure to inspect all crevices under banks and surfaces of woody debris (Figure 2d).

Figure 2a

Figure 2b

Figure 2c

Figure 2d

Streambanks and beaches may also be examined for dead shells or midden piles, where species not found alive may be represented by dead shells. This technique has been especially valuable after a high water event, when the lighter, dead shells are floated together into drifts along sand bars at the high water line. For juvenile mussels, this may be the best way they can be detected, as they normally are deeply buried in sediments or in dense vegetation. Although the exact locations where these shells originated cannot be determined based on beached specimens, their presence does indicate occurrence upstream.

Visual examination of underwater wood or rocks may be augmented by removing them from the water. For example, when searching for species which typically are found under cobble substrates, a number of cobbles may be selected and examined from a defined sample area, and the results combined to represent the area covered by cobbles. Dense mollusk aggregations may be found in areas with moderate vegetation. These areas need to be carefully searched by hand grabbing to locate mussels hidden within the vegetation. Vegetation can also be retrieved with a net, placed in a bucket with water, and vigorously shaken to dislodge mollusks. The vegetation can then be removed from the water and re-examined to assure that no snails remain.

For closer inspection of sediments, gravel and aquatic vegetation in wadeable areas, surveyors can use the 10” collection sieve described above in the section on spring sampling, or a standard D-shaped net for a more thorough search. Placing the edge of the net firmly on the bottom of the stream downstream from a small area (< .25 m^2) to catch dislodged debris, gently loosen and examine the substrate in front of the net. Feel rocks, lift them up and feel or look at the undersides, scrape loose attached specimens and let them drift into the net. A small brush may be helpful in dislodging specimens. You can also run the net through the sediment, scrape it under the bank, and underneath any vegetation. Use the flow of the water to rinse disturbed specimens, sediments and debris into the net, then dump the sample into a large, white or clear plastic container with water and sift through the sample to look for mollusks. Repeat at least 2 times with fresh samples from each area. If you find specimens, move on to collection. If not, move upstream and examine a new area. It is recommended that at least 2 areas within each habitat type be sampled intensively in this manner. Generally, 1 to 2 cups (8-16 oz.; ~ ¼ - ½ liter) volume of sieved material from each such site is an adequate sample.

As collections are made during the search, record their locations using a GPS recorder, photographs of the sites or illustrate the sites using a wax pencil on an aerial photograph laminated with waterproof plastic. Underwater photographs provide a good visual record of conditions at a site and may even allow future identification of associated plants or fish species. Assign a specimen number to each collection and then enclose the specimen in a sealed container, such as a film can or plastic bag. These containers then can be placed in a mesh dive bag attached to a belt or tube and examined later, or they can be transferred to a processor on shore for identification and recording.

c. Lakes and large ponds

Surveys in lakes and ponds will generally require the use of snorkel or SCUBA equipment, depending on water depth and clarity. Surveys in these habitats should always be conducted in teams of at least two or more people. Preferably, an additional person should remain on shore or in a raft or boat nearby to monitor the swimmers and be prepared for any necessary rescue. When using snorkel or SCUBA equipment, ensure that all surveyors have been trained and are certified in the use of their equipment. If using a raft or other flotation device for access or holding equipment, be sure to use highly visible dive flags or other devices for informing others of the presence of swimmers, and ensure that all required training for the use of such craft is provided. Avoid surveying in seasons with algae blooms or high turbidity or when other swimmers or boaters are present. Beware of discarded fishing lines which may become entangled with gear or feet. Where cold water temperatures are encountered, insulated dry-suits or wetsuits may be necessary in order to prevent hypothermia which may affect a surveyor’s ability to think and act wisely. As in river surveys, at least 10 minutes is needed to adequately search $10m^2$ of the lake bottom. As the complexity of the substrate increases, search time will also increase.

In large lakes, it may not be feasible or safe to adequately survey deep water areas. In such cases, limiting sample areas to those habitats represented within shallow water near shore are sufficient to detect most species. If surveys of deeper waters are necessary, for instance if a complete inventory of a lake is required, a dredge can be used to collect benthic samples at designated intervals along a transect or grid pattern. This survey technique is somewhat destructive, however, and is not recommended for routine inventory surveys. Benthic dredge survey techniques have been described in other documents and are not part of this protocol. A list of links to internet websites with other protocols and search methods is provided at the end of the Reference section.

For presence/absence surveys, be sure to search areas at several distances from shore, in different depths and substrates, in order to maximize detection of all species present. Include representative portions of all sides of the lake or pond, as prevailing wind, sunlight or currents may create different conditions in different portions of the lake. Consider searching near the inlet as well as the outlet areas where water flow may be stronger. Look for subsurface springs and other areas where water quality may be higher. These can sometimes be recognized by a difference in aquatic vegetation or water temperature and clarity.

Many search patterns can be used in lotic environments, but transects parallel or perpendicular to the shore, evenly distributed within the available substrate types, may be the most efficient. It has been found that a length of rope, equal to the transect length and marked off in regular intervals with knots, anchored at the start of the transect and unfurled during the survey enables searchers to easily determine their relative position for documenting specimen locations, and also serves as a device to anchor the swimmer and assist in returning to shore safely. Use of an underwater slate to record observation locations based on the position in the transect is advised for SCUBA surveys (Figure 3). If a surface observer is present, GPS locations can be recorded also. Make collections during the search by recording the position on the slate, assigning a specimen number and then enclosing the numbered label with the specimen in a container, such as a film can or plastic bag. These containers then can be placed in a mesh dive bag attached to a belt and examined later.

Figure 3. Underwater writing slate made from opaque plexiglass used during mollusk collecting. Column headings include species name, number live, and location. A metric ruler can also be scribed onto the backside of slate for measurements.

III. VOUCHER COLLECTION

Collection of voucher specimens is **required** to document Special Status aquatic mollusk species located in the survey area and to assure correct species identification. Voucher specimens must be collected and sent to the regional FS/BLM taxa specialist for verification. The FS/BLM vouchering policy, guidelines for mollusk voucher collection, and the taxa specialist's address to mail voucher specimens to is provided on the Interagency Special Status / Sensitive Species Program website **[http://www.fs.fed.us/r6/sfpnw/issssp/inventories/identification.shtml]**.

All specimens should be clearly and individually labeled with at least the following information: date of collection, collector's name, GPS coordinates (location), unique specimen ID number, project name, and preliminary species identification.

As a rule of thumb, when species are detected during a survey, collect a representative specimen for every taxon (species or subspecies) that is or could be a Special Status taxon, and representative specimens of other taxa that are of interest. Good data quality requires at least one specimen per survey area. *If you are concerned about depleting the populations of very rare species:* Empty adult shells in good condition may be identified to species and are often more useful than live juveniles – and collecting an empty shell will not harm the population. If you only find one or two live animals and think the local population would be at risk from their removal, photographs are another option. Take several photographs (underwater digital if possible) up close and from different angles to capture all of the relevant features, and leave the animals where they are. It may be necessary to remove the animal from the water to obtain a clear photograph, and this will usually not harm an animal if done quickly. Small species may be placed in shallow pans of water for this purpose. It is possible to identify freshwater mussels to genus without removing them by close examination of their incurrent siphons (*Anodonta* has simple filaments extending like fingers that meet along the midline and serve to exclude coarse material from entering the filtering system. Filaments are bifid in *Gonidea* and arborescent in *Margaritifera*).

If you have visually identified more than one species in the survey area, make sure you have representatives of each. Err on the side of collecting more information*:* 1) If your survey area seems large, collect multiple specimens from different parts of the area, particularly if the survey area covers some variation in habitat. 2) If you find a species that is not an agency-listed Special Status Species, but you would still like an ID confirmation for your own curiosity or records, send it in also. 3) If you are not sure whether two specimens are the same species, send them both in – many look-alike species can live in the same area. For some species such as springsnails, to ensure that you have enough live adult males to identify the species, you may need a sample of at least 20-30 specimens.

Preparation of live aquatic snail specimens for identification requires a relaxation process (see mollusk guidelines at **[http://www.fs.fed.us/r6/sfpnw/issssp/inventories/identification.shtml]**). In general, mollusks should be promptly separated from sediment and debris or else relaxation may not be successful. Fill a shallow, white plastic container with clear water and rinse each cleaned sample into it. Pick out as much remaining debris as possible and decant the dirty water. Last, pour remaining mollusks into a glass sample jar with a screw top, and fill to the top with fresh, cold water. Specimen jars should then be placed in a cooler with ice for transportation to the office for processing as soon as possible. Relaxation overnight should be done in a quiet location, free from loud noises or vibration for the process to be successful. Proper preservation of freshwater mussels requires cutting the adductor muscles (both anterior and posterior) so that the valves gap and preservative can reach the tissues. This is particularly important if genetic material is desired, otherwise they will "clam up" and tissues may decay. Make sure to label the sample with date, location, and surveyor name at a minimum, and GPS coordinates if possible. Recording this information on Rite-in-the-rain paper with pencil and placing the paper directly into the sample jar works very well.

Shell vouchers are sufficient for identification of many mollusk species, remembering that large, adult specimens are necessary for most positive IDs. Living snail specimens should be kept alive in a cooler on ice or in an ice bath and relaxed as soon as possible, generally within 4-5 hours of collection. Never release living gastropods at locations other than from where they were collected. Washington State requires scientific collection permits for all mollusks and specimens collected must eventually be donated to a museum. Oregon requires a collection permit for live freshwater mussels. Refer to Appendix A for details and contact information.

A. Shipping

When shipping mollusk specimens, make sure they are well-padded and tightly sealed, especially if they are in alcohol or in glass containers. Mark the outside with "Fragile", etc. as appropriate. There may be restrictions on sending containers with alcohol, since it is flammable, depending on the method of shipment. Be aware of labeling or packaging requirements. The US Postal Service has more information in "Publication 52 - Hazardous, Restricted, and Perishable Mail" at their website **[http://pe.usps.gov/text/pub52/welcome.htm]**. For short-term storage of preserved specimens, excess alcohol may be poured off and specimens packed with cotton saturated with alcohol. All specimens will be verified by specialists within a few weeks and identification information returned to the sender. Vouchers of FS/BLM Special Status Species will be curated and sent to the Oregon State Arthropod Collection at Oregon State University, unless the provider requests the specimen be returned. Send all specimens for identification to the interagency regional coordinator for mollusk identifications. Call before shipping to make sure they can be received. Priority mail, FedEx, or similar methods are recommended.

IV. TIMING OF SURVEYS

A. Time of Year

Sampling can occur in most <u>small perennial springs and spring habitats</u> during the entire year, but are best conducted in early- to mid-summer. For aquatic species that are semalparous (i.e. lay eggs once at maturity and die) like *Fluminicola* spp., surveys should be avoided during periods of population turnover. When a major portion of the population is dying off or most of the individuals present are immature, it may be difficult to collect enough specimens or mature individuals for identification. This period is poorly defined for all species, but as a general rule, avoid sampling in the spring. In areas with heavy grazing or other activities that have disturbed soft substrates, late summer surveys may not provide adequate results due to poor visibility from heavy siltation, which can cover surfaces to which snails may be attached.

Surveys of <u>streams and river habitats</u> should be avoided in the spring until water levels have receded and turbidity is reduced to a visibility level that makes surveys feasible. This also reduces the risk to surveyors from falling and dangerous currents. Sampling for mollusks inhabiting <u>lentic (i.e.non-flowing) habitats</u> may be restricted during the winter months in colder areas because of ice cover. Many lake-dwelling species remain buried in sediments during the cold months also, making detectibility difficult, if not impossible. For safety considerations, avoid surveys in all habitats during seasons with cold water temperatures which may cause hypothermia and affect the surveyor's ability to think and act wisely.

B. Time of Day

Time of day is generally not critical for aquatic surveys. Aquatic mollusks are generally active during all daylight hours and should be apparent to surveyors at any time during the day when ample light is available (avoid dawn and dusk). The angle of the sun may affect the visibility underwater, and is best at near vertical. Plan the visit to make use of the best available light at each site. Visual surveys will be most successful if not undertaken on overcast or rainy days. Some mussel and gastropod species have been known to migrate vertically within a water body on a daily or seasonal cycle, however, and movement patterns or habitat associations documented at a given time of day may be important to recognize.

C. Number of Visits

A single visit to a site should be adequate in most cases. A second visit may be necessary if weather conditions, turbidity, or high water hinder initial survey efforts.

D. Duration of Visits

Duration of surveys will vary by habitat condition at the sample area. However, a minimally adequate survey can be assumed when at least 1/3 of the area represented by each major habitat type within the survey area and all suitable microhabitat sites in identified sample areas have been well covered in the search. As a minimum, 30 minutes should be spent searching even the smallest spring. At least 10 minutes is needed to adequately search $10m^2$ of river or stream bottom. As the complexity of the substrate increases, search time will also increase. Additional time will be required to assess the habitat types available, to designate sample areas, collect vouchers and to record data.

V. DATA COLLECTION

Data collection must include general information about the survey, spatial data detailing the survey area, and observation forms when a target species is suspected to be located along with the voucher collection information. Survey forms should be completed in the field, regardless of whether a target species was detected. Accurate maps of survey areas should accompany survey forms. Whenever possible, digital photos of survey and sample areas should accompany the form to document site conditions. BLM and FS survey data, observation data, and collection data must be entered into the OR/WA BLM GeoBOB database or the Forest Service NRIS Aquatic Surveys database in a timely manner.

Instructions for data collection and suggested field forms used with GeoBOB are presented in Appendix D. The GeoBOB form has been modified to accommodate additional aquatic habitat data fields, such as stream width and current velocity that can be entered into an Excel spreadsheet and “linked” to a GeoBOB record using the GeoBOB Link Document tool. Digital photos or entire field forms in electronic media can also be "linked" to survey or observation records to illustrate the survey area or population condition. Contact the GeoBOB Team for instructions to use the Link Document tool.

FS data must be entered into the NRIS Aquatic Surveys database. FS data may be collected using the Region 6 Stream Inventory Handbook’s Aquatic Biota field form (USDA Forest Service 2008, pp. 61-65) [http://www.fs.fed.us/r6/water/fhr/sida/handbook/Stream-Inv-2008.pdf]. Collecting additional habitat and environment data such as shown on the Aquatic GeoBOB form is recommended to provide a more thorough understanding of the areas surveyed and where species occur.

VI. Glossary
(Arnold 1965)

adnate (adj.) Barely attached to or in contact with; refers generally to contact of last whorl with preceding one. In contrast, see **appressed**.

alate (adj.) wing-shaped.

angular, **angulate** (adj.) Having an angle (or having the tendency to form an angle), rather than a round contour.

anoxic (adj.) Without oxygen.

aperture (n.). The opening or "mouth" of a snail shell through which the body protrudes when the snail is active.

appressed (adj.) Well-attached to or clearly in contact with; refers generally to contact of last whorl with preceding one. In contrast, see **adnate**.

basal (adj., n.) That part of shell peristome opposite the apex; a tooth or lamella located in that portion of the shell aperture. As regards the natural life position, the base is the anterior end. When held with the apex directed upward, the base is the bottom of the shell.

basal crescent (n.) Depressed area of, or immediately adjacent to, columella, often crescent - or wedge-shaped, generally with closely spaced prominent growth lines or striae. Used in regard to shells of Hydrobiidae and related freshwater snail families.

broadly conic (adj.) Shell conic, as wide or wider than high.

collabral (adj.). Parallel to the lip of a snail shell. Said of shell sculpture such as ridges or ribs. Sometimes called "transverse". Some older literature uses the term "axial," but this is less appropriate because sculpture rarely runs parallel to the axis of the shell.

columella (n.) The internal column around which the whorls revolve; the axis of a spiral shell; especially the exposed expression of this structure on the last whorl. The adjective is **columellar**.

compressed (adj.). Appearing flattened; relatively plane as opposed to convex. Usually said of the whorls of a shell, the body whorl, or the base of the shell.

conic or **conical** (adj.). Having approximately the shape of a cone, i.e., tapering evenly from a wide, circular base to a point. Said of the shell. See Dindal fig.9.6h. A **broadly conic** shell is as wide or wider than high; a **narrowly conic** shell is markedly higher than wide.

crenocole (n.) An organism living only in spring environments; a spring dweller.

crenophile (n.) An organism that prefers spring environments but may be found in similar type habitats.

crenulated (adj.). Notched or scalloped in outline.

crescentic (adj.). Having the shape of a crescent moon. Generally said of the shape of an aperture (q.v.) or of a lamella (q.v.) that, rather than being straight, curves through a shallow arc.

deflected (adj.). Bent downward from the preceding trajectory of growth, as in the terminal part of the last whorl of some snail shells.

depressed (adj.). Flattened dorso-ventrally or from apex to base. Said of the shell. (see Dindal 1990, fig. 9.5d.) Sometimes used in combination with other adjectives describing shell shape; e.g., a depressed-globose shell is one that is somewhat flatter than globe-shaped.

depressed conic (adj.) Conic shell depressed dorso-ventrally or postero-anteriorily; more specifically, with an apical angle of about 100° (see Burch 1989, fig. 5e).

detritus (n.) Decaying organic material of plant or animal origin.

disjunct (adj.) Refers to whorls or portion of shell not in contact with preceding whorls (portion of shell); detached; loosely coiled shell, wholly or in part, with the whorls not touching one another.

elongate conic (adj.) Conic spire with an apical angle of about 30° (see Burch 1989, figs. 4a, 5b).

epipelic (adj.) On the surface of mud (referring to the microscopic algae, fungi, bacteria and organic particles that occur there and serve as food for grazing snails).

eutrophication (n.) Enrichment of bodies of water, primarily caused by sewage and runoff from fertilized agricultural land.

excentric (adj.) Not placed in the center; refers most often to the nucleus of an operculum.

external genital pore (n.). The hole by which the reproductive system reaches the exterior of the animal. In most mollusks it is located on the right side of the body, posterior to and slightly below the right ocular tentacle.

globose (adj.) Shaped like a sphere, *i.e.* with equal width and height and broadly rounded sides (see Burch 1989, fig. 4c).

globosely conic (adj.) Conic spire with an apical angle of about 70° (see Burch, 1989, fig. 5d).

heliciform (adj.) See **helicoid**.

helicoid (adj.). In the form of a low three-dimensional spiral; with a somewhat depressed spire and whorls that increase regularly in diameter. Also (and less frequently) called "heliciform"

hypoxic (adj.) With reduced levels of dissolved oxygen.

imperforate (adj.). Having no umbilicus. Said of a snail shell in which the inner sides of the coiled whorls are pressed together, leaving no central cavity along the shell axis; or, if the whorls are not pressed together and a cavity is formed, then in adult shells its opening is completely covered by callus or the reflected columellar lip of the aperture.

inflated (adj.). Appearing swollen; strongly convex as opposed to flattened. Usually said of the whorls of a shell, the body whorl, or the base of the shell.

lamella (n., plural "lamellae"). A calcareous plate, blade, "tooth," or scale-like structure on the shell of a snail. Most commonly used to refer to structures of this shape that project into the aperture (see Dindal fig. 9.49), and sometimes restricted to such structures occurring on the parietal (q.v.) and columellar sides of the aperture, those on the outer sides of the aperture being called "folds" or "plicae" (see Dindal 1990, figs. 9.47, 9.49).

lamellar (adj.). Plate-like, blade-like, or scale-like (i.e., as opposed to more broadly rounded). Generally said of ribbing or other sculptural features of the shell..

lentic (adj.) Pertaining to lakes and ponds, standing water habitats.

lenticular (adj.). Having the shape, in lateral view, of the cross-section of a convex lens, i.e., broadly convex above and below, angulate at the sides. See, for example, Dindal 1990, fig. 9.169c.

limnocrene (n.) A spring pool, with or without outlet; generally used for larger pools.

lineolate (adj.) Marked with minute lines.

lirate (adj.) Ornamented with sharp, raised threads, marked with parallel grooves or ridges; having thread-like sculpture (**lira**, pl. **lirae**).

littoral zone (n.) The near shore, relatively shallow area in lakes or ponds.

macrophyte (n.) Larger aquatic plants that may constitute submerged or emergent vegetation.

maculate (adj.) Having irregular-shaped spots of contrasting color.

malleation (n.). A texture of the surface of a shell in which the surface bears numerous small, rounded dents, as if a sheet of metal had been beaten with a ball-peen hammer. The individual dents ("malleations") may be densely or sparsely distributed.

mantle (n.) A fleshy tunic; a membranous covering of a mollusk that secretes the shell from marginal glands and provides the periostracum; pallium.

meatus (n.). The opening of a duct; esp. the opening of the seminal duct in the verge (q.v.), which may be at the tip ("terminal") or slightly off the tip ("subterminal").

mucronate (adj.) Terminating abruptly in a short sharp point or spine.

multispiral (adj.) Refers to an **operculum** (*q.v.*) in which there are numerous, very slowly enlarging whorls, spirals, or coils.

nasmode (n.) Spring complex; area with a number of nearby springs originating from the same source.

neanic (adj.). Post-embryonic. Said of the whorls of a snail shell that develop after the snail hatches from its egg. Embryonic whorls (i.e., those at the apex of the shell that develop while the snail is within its egg) are often differently sculptured from the neanic whorls that follow them. See, for example, Dindal 1990, fig. 9.44, where the embryonic whorls of *Zoogenetes harpa* are smooth and unsculptured but the neanic whorls bear thin ribs.

neritiform (adj.) Shaped like *Nerita*; *i.e*. subglobose or hemispherical, with few, rapidly enlarging whorls, very reduced spire, and a heavily callused and expanded parietal apertural margin.

node (n.) A knob or swelling.

nomen nudum [pl. **nomina nuda**] (n.) A name first published without adequate description or otherwise defective according to International Commission on Zoological Nomenclature rules.

oligotrophic (adj.) Referring to a body of water with low nutrient content and low productivity, usually characterized by extremely clear water.

operculum (n.) The plate of exoskeletal material on the foot of a gastropod mollusk with which it closes off the entrance to the shell

ovate (adj.). Having the shape of the longitudinal section of a hen's egg, i.e., oblong and curvilinear, with one end narrower than the other.

palatal (adj., n.) Outer lip or tooth or lamella in this area; that portion of the lip between the parietal wall and the basal lip.

pallium (n.) The tissue next to the shell of mollusks.

parietal (adj.). Describing the wall of the shell aperture that represents the outer wall of the preceding whorl. See Dindal 1990, fig. 9.3. A **parietal lamella** is a tooth-like or blade-like calcareous structure borne on the parietal wall and projecting into the aperture. Pertaining to the inside wall of the shell aperture, *i.e*., that portion in contact with the preceding whorl. (A synonym is "parietal tooth," although it is better not to refer to shell structures as "teeth," to avoid confusion with the teeth of the radula.)

paucispiral (adj.) Refers to an **operculum** (q.v.) with relatively few whorls, spirals, or coils.
perilithon (n.) Organisms growing on the submerged portions of coarse rock substrates; composed of microscopic algae, protozoans, fungi, and bacteria.
periostracum (n.). The thin, proteinaceous outer layer of the shell.
periphery (n.). The edge of the shell as seen in outline; that part of the shell that is farthest away from the axis. Dindal 1990, fig. 9.7 shows various shapes of the periphery.
periphyton (n.) Organisms growing on the submerged portions of aquatic macrophytes; composed of microscopic algae, protozoans, fungi, and bacteria.
peristome (n.) The thickened rim or lip around the mouth; the lip or margin of the aperture of a spiral shell.
photophobic (adj.) Avoiding light.
plication (n.) A small fold or corrugation that affects the whole shell but does not thicken it.
pneumostome (n.) The opening to the pulmonary cavity, specifically in pulmonate snails.
protoconch (n.) That portion of the shell of a freshwater snails that is developed in the egg, prior to hatching; also termed embryonic whorls. Ornament and other morphological features of this portion of the shell often differ from those of later (post-embryonic) whorls (**teleoconch** or **neanic** (q.v.) whorls).
pseudobranch (n.) Vascularized lobe-shaped structure that serves a respiratory function in planorbid snails.
reflected (adj.) Turned back; refers to edge of **peristome** (*q.v.*) or lip.
retractive (adj.) Oriented opposite of the direction of coiling.
revolute (adj.) Rolled back; refers to edge of **peristome** (*q.v.*).
rheocrene (adj.) A flowing spring or spring run.
rugae (plural n.; singular "ruga" but rarely used). Convex, usually collabral (q.v.), undulations of the shell surface, roughening it but not rising to the prominence of ribs. In cross-section through the shell wall, rugae would appear simply as outward undulations of the shell, whereas ribs would show actual thickening of the shell material.
s.l. (adv.) *Sensu lato*, in the broad or wide sense; broadly or loosely speaking.
s.s. (adv.) *Sensu stricto*, in the strict sense; strictly speaking.
solid (adj.). Firm, substantial. Said of the composition of a snail shell, as opposed to thin or delicate.
somatic (adj.) Pertaining to the body tissue of an organism.
spiral (adj.). Winding, coiling, or circling around a central axis; winding around a fixed point and continually receding from it; the form of the shell of most snails. Generally said of shell sculptural features such as striae; the opposite of "collabral" (q.v.) or "transverse."
spire (n.) The whorl series of whorls of a spiral shell, excepting the last.
stenotherm (n.) Organism having narrow temperature tolerances.
striae (plural n.; singular "stria" but rarely used). A narrow superficial groove or fine furrow on the outer shell surface. See Dindal 1990, fig. 9.13. Properly, the term refers to a feature that is incised below the general shell surface, but it is also sometimes used for streaks or fine threadlike lines that are raised above the shell surface.
subangulate or **subangular** (adj.). Describing the periphery (q.v.) of a shell in which the top and bottom surfaces of the whorl come together to almost form an angle, but the actual profile is rounded. See Dindal 1990, fig. 9.191b, right-hand figure.

sulcus (n.). A relatively broad, shallow furrow on the surface of a shell.

suture (n.) The line of junction or seam along which two hard structures join; a continuous spiral line marking the junction of whorls in a gastropod shell.

trematode (n.) A flatworm, a Class within the Phylum Platyhelminthes. These are virtually all parasitic species and many are parasitic flukes with snails as intermediate hosts.

tumid (adj.). Appearing swollen; broad as opposed to slender. Usually said of the whorls of a shell, the body whorl, or the base of the shell.

umbilicus (n.). The central opening or cavity along the axis of a shell that is formed when the inner sides of the coiled whorls are not pressed together. See Dindal 1990, fig. 9.3. A shell with the umbilicus showing prominently in basal view is termed "umbilicate" (see Dindal 1990, fig. 9.10d).

varix (n.). A transverse or collabral (q.v.) thickening of the inner or outer wall of the shell. The term is usually restricted to a structure that occurs once or a few times during the growth of the shell, as opposed to regular, closely repeating ribbing or striation.

verge (n). In freshwater snails, particularly Hydrobiidas, the external expression of the male genital system, a protuberant copulatory structure, consisting of a penis with a vas deferens and sometimes with various other associated lobes, ducts, glands or some combination of the same. The seminal duct is enclosed within it, with the opening (the meatus) either terminal or subterminal.

VII. References

Includes references from both the Text and the Appendices; it does not include named species authorities.

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APPENDIX A – REQUIRED PERMITS, EQUIPMENT, SURVEYOR SKILLS, AND TRAINING

Federal Requirements

To simplify the permitting needs for watershed councils, environmental education organizations, and other like-minded groups that wish to sample macroinvertebrate communities, the OR DEQ and NOAA Fisheries have drafted guidelines to sampling macroinvertebrates, while avoiding incidental take of federally listed salmonids. For convenience, the guidelines have been included below. A federal 4-D permit is not necessary if the guidelines are followed.

Macroinvertebrate Sampling Guidelines for Federal and State Fish Permit Compliance
(guidelines agreed to by Oregon DEQ and NOAA Fisheries)

The following guidelines will be followed to avoid incidental take of federally listed salmonids and other fish species during macroinvertebrate sampling.

Know the areas where you will be sampling and the federally listed salmonids that may be present in those areas. Consult with the local fish biologist if you have any questions about what you may encounter.

1) Avoid salmonid spawning and incubation by:
   - Sampling season - July 1st to October 1st is the standard sampling period for macroinvertebrate sampling. Consult with local fish biologists when sampling outside this window.
   - Do not sample if spawning adults or redds are observed in study reaches. Consult with local fish biologist for more appropriate sampling period.

2) Use standard macroinvertebrate sampling gear. This includes D-frame kick net, kick screen, Surber sampler or Hess sampler.

3) Any small fish caught while sampling invertebrates will be immediately returned to the water. Stop sampling immediately if any salmonid eggs/fry are collected in net. If the salmonid you collected may be a federally listed species, do not enter the water again until you have discussed the sampling with the local biologist and the NOAA Fisheries.

4) Train staff and volunteers to be low impact and to identify and avoid any early redds, adults, or juvenile federally listed fish. Conduct training surveys in a location/time/manner where you are unlikely to encounter listed fish (e.g., above a natural barrier), especially adults/redds.

State Requirements

Washington Department of Fish and Wildlife requires a Scientific Collection Permit for all animals collected for study or display. Several people can collect under the same Collection Permit, but all names and birth dates must be listed as sub-permittees. As of 1997, a permit fee of $12.00 was charged. Up to 60 days or longer may be required for a collection permit to be issued in Washington, so an application should be submitted as soon as possible in January (or December of the previous year).

To apply for a Washington State Scientific Collection Permit, fill out the online form **[http://wdfw.wa.gov/scp/]** or write to Washington Department of Fish and Wildlife, Scientific Collection Permits, 600 Capitol Way North, Olympia, WA 98501-1091.

Neither Oregon nor California currently requires a collecting permit for mollusks.

Equipment

Equipment and supplies suggested for the surveys include:

- Contour maps, aerial photos of the area and GPS to locate the unit and record location of any target species found, the legal description, latitude and longitude or UTM, elevation and other physical site information;
- Field forms on waterproof paper and notebook or clipboard;
- A watch to record time spent on each sample area;
- Hand lens or hand-held magnifier (10x or more) for field identification of species;
- Rigid containers with labels on which to record specimen or collection numbers to be coordinated with information on field forms and notes (i.e., screw-top glass bottles or collection vials, clean film canisters and some larger containers) -- note: do not use new film canisters for live specimens, the residue may be toxic. Mesh dive bag may be useful for holding specimens while working underwater;
- Ice chest and ice if living specimens are to be collected for identification or species confirmation during hot weather;
- Menthol crystals for relaxing specimens prior to preservation;
- Plant keys, field guides or knowledge of plants of the area sufficient to describe aquatic plant communities and specific habitats;
- Thermometer to measure water temperature;
- Hip boots, with felt or hob nail bottoms for better traction on rock and boulder substrates if available;
- Nets or sieves with a mesh size of 0.5 mm (500 microns);
- A measuring tape 100 feet in length;
- Plastic bucket for depositing collected specimens or substrates that will be examined for the presence of mollusks;
- White plastic trays (at least 2” deep) for examination and separation of specimens.

Other useful items include:

- Underwater slate or counter for recording specimens;
- Clinometer or abney level for measuring stream and river gradients;
- A pocket knife or forceps are useful for reaching into rock crevices to dislodge specimens in the field;
- A strong staff and felt-soled shoes for walking in streams;
- A brush to scrub hard surfaces that are covered with filamentous algae and debris that obscures the view of surveyors;
- Digital (underwater if possible) camera to document the sample sites visually;
- Snorkel or SCUBA gear;
- Plexiglass viewscope or glass-bottomed bucket;
- Diver alert flags to warn others of surveyors in the water;
- Mesh dive bag;
- Inner tube for floating over shallow rivers;
- Dry bag for storage of GPS units and other items.

Surveyor Skills

Personnel who will be doing these surveys will need to display an ability to recognize target mollusk species. Training should be provided for individuals not already familiar with mollusk systematics. Familiarity with most gastropod taxa, at least to genera, should be a prerequisite for surveyors, so they will be able to: (1) recognize the many species they will encounter that are not one of the target species; and (2) recognize target species well enough to determine when a sufficient survey has been achieved (see "Duration of Visits").

Each surveyor should have sufficient knowledge and experience to demonstrate skills in executing these survey methods and in finding and recognizing the target species. They should be trained for these abilities by person(s) knowledgeable of mollusk taxonomy and survey methods. If performing surveys where swimming or diving are involved, each surveyor should be trained in water safety and rescue. Safety vests and other floatation devices may be necessary when working in deep water. If SCUBA diving methods are required in deep waters, each diver must obtain certification from an official training center.

Training

At a minimum, training sessions should include one day in a classroom for instruction in recognition of mollusk taxonomic groups, Special Status species, survey methods, and handling and preserving specimens. This should be followed by a day of field training in survey methods and practical experience in recognizing the species. It is recommended that instructors follow-up this training by additional work with persons who will be implementing surveys, either during a third day in session, or within 30 days, in smaller groups at their home units.

Objectives of the training will be for the surveyors to be able to: (1) recognize examples of adults of most genera of snails that occur in their areas; (2) recognize the target species that might occur within their area and their preferred habitats; and (3) understand and be able to implement the survey protocol.

Safety Considerations

Working in aquatic environments presents a number of dangers and challenges that are not generally encountered by terrestrial field biologists. Before doing surveys in these waters, please consult your agency safety representative and handbook for required precautions and training. Specific hazards and recommended safety procedures used in the different habitat types are given in the text of this document. Below are some additional considerations included in federal agency safety handbooks:

- Correctly identify the water conditions (including hazards), weather, no more than 24 hours prior to the trip.
- Be aware of any storm or flash flood warnings, and scheduled water releases from dams.
- Contact appropriate authorities for water conditions.
- Ensure all persons have been fitted with the personal floatation device (PFD) prior to departing to site.
- Verify the swimming capability of all persons, and match experienced personnel with novices.
- A minimum of two people is recommended - never swim alone, use the Buddy-system. (Arrangements may include one person on shore, two in the water).
- Ensure that all persons have spare dry clothes stored in dry bag.
- Ensure that emergency communication plan, and emergency medical plan is discussed between survey coordinator , surveyors and base of operations.
- Always tell someone where you are going and what time you will return.
- Wear lug-sole boots or similar footgear with non-slip soles (i.e., felt on waders, etc.)
- Utilize the following equipment when appropriate: Rescue throw bags, z-drag lines, life-lines, boats, shore tenders.
- Follow Occupational Safety and Health Adminstration (OSHA) regulations for Commercial Diving operations.
- One member of the crew must have PADI/Red Cross Advanced Swimmers certification or equivalent.
- Cold water: Operating in 40-degree F water without approved cold water gear (dry suit) is prohibited.
- Water below 60 degrees F is dangerously cold, and may be fatal in deep water or swift moving streams.
- If the water temperature and air temperature do not add up to 100 degrees F, then wet or dry suits should be worn.

APPENDIX B – SOURCES OF ADDITIONAL INFORMATION

Internet Information Sources

Below are Internet links and Adobe .pdf versions of some other macroinvertebrate protocols that you may consider as more appropriate options for your goals and locality. The Oregon protocols are very similar to those of Washington and the Environmental Protection Agency. The protocols that are most significantly different are probably the California and the B-IBI (Benthic Index of Biological Integrity) field sampling protocols.

Since macroinvertebrate monitoring is a relatively young science, many of the protocols go through periodic changes, but have recently been settling into the current protocols. Though different than the other protocols, the B-IBI has been widely used across the nation, and particularly in the Puget Sound area, and has changed little in the last 10 years. Also included are less technical options for educators and the general public.

Simple protocols for use in educational sampling.

- B-IBI protocols have been used throughout the Northwest with particularly strong use in the Puget Sound area (website: http://www.cbr.washington.edu/salmonweb/ - then click B-IBI on the left)
- EPA Rapid Bioassessment Protocols for Streams and Wadeable Rivers (website: http://www.epa.gov/owow/monitoring/rbp/)
- EPA volunteer stream monitoring manual (website: http://www.epa.gov/volunteer/stream/)

State protocols

- Alaska Stream Team (websites: http://aquatic.uaa.alaska.edu/BiolMonitoringResources.htm)
- California *Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California*. 2007 (website: http://www.waterboards.ca.gov/swamp/docs/phab_sopr6.pdf)
- Idaho DEQ BURP (Beneficial Use Reconnaissance Program) Protocols (website:http://www.deq.state.id.us/water/data_reports/surface_water/monitoring/overview.cfm)
- Montana water quality monitoring standard operating procedures (website:http://www.deq.state.mt.us/wqinfo/QAProgram/) macroinvertebrate protocol section
- Washington Department of Ecology Sample Collection and Analysis Protocols (website: http://www.ecy.wa.gov/biblio/bioassessment.html)
- Nevada: Sada, D.W. and K.F. Pohlmann. 2006. U.S. National Park Service Mojave

Inventory and Monitoring Network Spring Survey Protocols: Level I and Level II. Draft. Desert Research Institute, Reno and Las Vegas, Nevada. 98 pp. (website:http://www.dri.edu/Home/Features/text/0705_protocols.htm)

National Protocols

- EPA-EMAP: Peck, D.V., A.T. Herlihy, B.H. Hill, R.M. Hughes, P.R. Kaufmann, D.J. Klemm, J. M. Lazorchak, F. H. McCormick, S.A. Peterson, P.L. Ringold, T.Magee, and M.R. Cappaert. 2006. Environmental Monitoring and Assessment Program-Surface Waters: Western Pilot Study field operations manual for wadeable streams. EPA/620/R-06/003. USEPA. Washington, DC. (website: http://www.epa.gov/wed/pages/publications/authored.htm)
- Western Center for Monitoring and Assessment of Freshwater Ecosystems: This Center at Utah State University, has close affiliations with the BLM / USU National Aquatic Monitoring Center. The field sampling protocol recommended by the lab that is the standard for many federal agency programs is: Hawkins, C.P., J. Ostermiller, M. Vinson, R.J. Stevenson, and J. Olsen. 2003. Stream algae, invertebrate, and environmental sampling associated with biological water quality assessments: field protocols. Department of Aquatic, Watershed, and Earth Resources, Utah State University, Logan, UT. (website:http://129.123.10.240/WMCPortal/downloads/USU_field_protocols_9Jun2003.pdf)

General information on species identification and management:

- Interagency Special Status Species Program webpage – Conservation Assessments and Species Profiles - (websites: http://www.fs.fed.us/r6/sfpnw/issssp)
- BLM Mollusk Information Exchange – contains many photographs, descriptions and learning tools for aquatic species, including sensitive species profiles with habitat associations and range information – (website: http://web.or.blm.gov/mollusks)
- Pacific Northwest Native Freshwater Mussel Workgroup – field guide to native species, other mussel info and links (website: http://www.fws.gov/columbiariver/musselwg.htm)
- University of California Berkeley photograph collection – hundreds of images of native and exotic mollusk species (website: http://calphotos.berkeley.edu/)
- Natural Heritage Information Center – contains species status and locations, as well as current agency status – (website: http://oregonstate.edu/ornhic/)
- A well-illustrated key to families of freshwater gastropods (snails) is Perez, K. E., S. A. Clark, and C. Lydeard. 2004. Showing your shells; a primer to freshwater gastropod identification. Freshwater gastropod identification workshop manual: 60 pp. (website: http://www.cofc.edu/~dillonr/FMCSGastropodID.pdf)

APPENDIX C – AQUATIC MOLLUSK SPECIES & THEIR HABITAT ASSOCIATIONS

Table 1. General habitat types used by Special Status Species of aquatic mollusks in OR/WA BLM and R6 Forest Service based on the January 2008 Special Status Species list. Includes former Survey and Manage aquatic mollusks within Oregon and Washington.

* = Species complex now considered solely as *Pyrgulopsis hendersoni* (Hershler and Liu 2004).

Family	Taxon	Federal Status					Habitat Types			
		R6 FS & OR/WA BLM				Former Survey & Manage				
		Sensitive		Strategic						
		OR-SEN	WA-SEN	OR-STR	WA-STR		River	Stream	Lake - Pond	Spring - Seep
Lymnaeidae										
	Fisherola nutalli	X	X				X			
	Lanx alta	X					X			
	Lanx klamathensis	X				X		X	X	X
	Lanx subrotundata	X					X			
Physidae										
	Physella columbiana			X	X		X	X		
Planorbidae										
	Helisoma newberryi	X					X		X	X
	Vorticifex effusus dalli			X					X	X
	Vorticifex effusus diagonalis	X						X	X	X
	Vorticifex klamathensis klamathensis			X				X	X	X
	Vorticifex klamathensis sinitsini			X					X	X
	Vorticifex neritoides			X	X					
Valvatidae										
	Valvata mergella				X			X	X	X
Hydrobiidae										
	Amnicola sp. nov. Washington duskysnail				X				X	
	Fluminicola fuscus	X	X				X			
	Fluminicola insolitus	X								X
	Fluminicola sp.nov. Crooked Creek			X				X		X
	Fluminicola sp.nov. Klamath			X			X	X	X	
	Fluminicola sp.nov. tall			X						X
	Fluminicola sp.nov. Keene Creek			X				X		X
	Fluminicola sp.nov Fredenburg					X		X		X

Family	Taxon	Federal Status					Habitat Types			
		R6 FS & OR/WA BLM				Former Survey & Manage				
		Sensitive		Strategic						
		OR-SEN	WA-SEN	OR-STR	WA-STR		River	Stream	Lake - Pond	Spring - Seep
Hydrobiidae (cont)	Fluminicola sp.nov. Klamath Rim	X				X				X
	Fluminicola sp.nov. nerite	X								X
	Fluminicola sp.nov. toothed			X						X
	Fluminicola sp.nov. diminutive			X						X
	Fluminicola sp.nov. Fall Creek			X				X		X
	Fluminicola sp.nov. casebeer			X						X
	Fluminicola sp.nov. Lake o' Woods			X						X
	Fluminicola sp.nov. tiger lily			X						X
	Fluminicola sp.nov. Lost River			X			X			X
	Fluminicola sp.nov. Metolius			X				X		X
	Fluminicola sp.nov. Odessa			X						X
	Fluminicola sp.nov. Ouxy Spring			X					X	X
	Fluminicola sp.nov. Wood River			X						X
	Fluminicola turbiniformis	X								X
	Colligyrus depressus			X						X
	Lyogyrus (Colligyrus) sp.nov. Columbia duskysnail	X	X			X		X		X
	Lyogyrus (Colligyrus) sp.nov. masked duskysnail		X			X			X	
	Pyrgulopsis archimedis	X							X	X
	Pyrgulopsis intermedia	X								X
	Pyrgulopsis robusta	X					X	X	X	X
	Pyrgulopsis sp.nov. Klamath Lake springsnail *			X					X	X
	Pyrgulopsis sp. nov. Lost River springsnail	X					X			X
	Pyrgulopsis sp.nov. Owyhee hot springsnail			X						X
Littorinidae										
	Littorina subrotundata (Algamorda newcombiana)	X	X				Salt marsh			
Pleuroceridae										
	Juga bulbosa			X			X	X		

Family	Taxon	Federal Status					Habitat Types			
		R6 FS & OR/WA BLM				Former Survey & Manage				
		Sensitive		Strategic						
		OR-SEN	WA-SEN	OR-STR	WA-STR		River	Stream	Lake - Pond	Spring - Seep
Pleuroceridae (cont)	Juga (J.) hemphilli dallesensis	X						X		X
	Juga (J.) hemphilli hemphillii	X	X					X		
	Juga (J.) hemphilli maupinensis	X						X		
	Juga (J) hemphilli sp. nov. Indian Ford			X				X		X
	Juga (J.) sp.nov. three-band			X	X			X		X
	Juga (O.) bulbosa			X			X	X		
	Juga (O.) sp.nov. basalt	X				X		X		X
	Juga (O.) sp.nov. Blue Mountains			X						X
	Juga (O.) sp.nov. brown			X	X			X		X
	Juga sp.nov. Opal Springs			X						X
Pomatiopsidae										
	Pomatiopsis binneyi	X								X
	Pomatiopsis californica	X								X
	Pomatiopsis chacei			X						X
Pelicipoda										
	Anodonta californiensis			X	X		X		X	
	Anodonta wahlametensis			X	X		X		X	
	Gonidea angulata	X	X				X	X		
	Pisidium ultramontanum	X							X	X

Habitat Associations for selected aquatic mollusk species including non-special status species in Oregon and Washington

NOTE: The taxonomies of several genera (especially *Anodonta* and *Juga*) are currently undergoing revision, based on recent genetic and anatomical analysis. The following information is necessarily brief and other information may be available.

***Anodonta californiensis,* California floater -** shallow muddy or sandy habitats in larger rivers, reservoirs, and lakes.

***Anodonta wahlemetensis,* Willamette floater –** slow-moving waters in muddy or sandy habitats in larger rivers, reservoirs, and lakes. Current understanding is name is a synonym for *A. nuttalliana*.

***Anodonta nuttalliana,* winged floater -** rivers and lakes in muddy or sandy bottoms, especially in low gradient, low elevation areas of coastal watersheds. The host fish species are unknown.

***Anodonta oregonensis,* Oregon floater** - low gradient and low elevation rivers, lakes, and reservoirs. They prefer shallow water in mud, sand, or fine gravel. They often share habitat with California floaters. Like other *Anodonta* species, they are likely long-term brooders that breed in late summer and spawn in the spring. Coho salmon may be a host.

***Colligyrus depressus,* Harney basin duskysnail -** small, cold rheocrines (spings and spring runs). Surrounding vegetation sage scrub. Photo of type locality in Hershler (1999).

***Colligyrus sp. nov*., Blue Mountains duskysnail -** very cold, clear springs and spring-fed small streams at moderate elevation, with swift flowing water, sand-gravel or cobble substrates. Associated vegetation includes *Rorippa* and aquatic bryophytes.

***Colligyrus sp. nov*., Klamath duskysnail - n**ear shore in lakes in areas with spring influence. Species appears photophobic, living only on the sides and undersides of bolders and cobbles. Macrophytes appear to be absent at known sites.

***Colligyrus sp. nov*., nodose duskysnail - s**prings and spring complexes draining directly into Klamath Lake, and rarely in spring-influenced outflow from the lake. Not found in isolated springs or spring pools away from the lake. Species appears photophobic, living only on the sides and undersides of bolders and cobbles. *Rorippa* present at some sites, but not all.

***Colligyrus sp. nov*., mare's egg duskysnail -** near shore in lakes in areas with spring influence, or in large, spring-influenced streams. Species appears photophobic, living on the sides and undersides of bolders and cobbles, and under large colonies of *Nostoc* (algae commonly called mare's eggs).

***Fisherola nuttali,* shortface lanx –**unpolluted rivers and large streams, in highly oxygenated, swift-flowing, cold water on stable boulder or bedrock substrates, often in the vicinity of rapids. Marcophytes and epiphytic algae generally rare to absent at sites for the species. Not found in locations with sediment or silt deposition.

***Fluminicola sp. nov*. 3, Klamath rim pebblesnail –** small, cold flows emanating from springs in shaded areas where it is a perilithon grazer and is possibly photophobic.

***Fluminicola sp. nov.* 1, Klamath pebblesnail –** areas with gravel-boulder substrates and flowing water. Like other *Fluminicola*, it prefers cold, oligotrophic water with high dissolved oxygen. It is found rarely in springs and avoids areas with dense macrophyte beds. It is believed to graze on perilithon (i.e. the algal and microbial film on the surface of stones).

***Fluminicola sp. nov.* 11, Fredenberg pebblesnail –** small, cold flows emanating from springs with cobble and gravel substrates. The species appears to feed on perilithon.

***Fluminicola sp. nov*. 2, tall pebblesnail –** an obligate spring dweller that may be photophobic. It occurs on pebbles and cobbles. Large (i.e. 5-30 cm diameter) cyanobacteria colonies of *Nostoc pruniforme*, locally known as mare's eggs, cover much of the bottom of the one spring with known populations of this species, and resemble green cobbles. Water temperature at the site is about 5^{o}C (41^{o}F).

***Fluminicola sp. nov*., casebeer pebblesnail –** large cold spring complex, mixed mud-gravel substrate.

***Fluminicola sp. nov*., Fall Creek pebblesnail –** large cold springs and outflows including medium-sized creeks, gravel-cobble substrate.

***Fluminicola sp. nov*., Keene Creek pebblesnail –** small to medium sized springs and spring-influenced creeks.

***Fluminicola sp. nov*.**, **tigerlily pebblesnail –** medium to large springs with cold, clear water commonly associated with bogs or marshes, on mud-cobble substrate in shallow water with moderate to swift flow.

***Fluminicola sp. nov*., Lake of the Woods pebblesnail –** small to large spring complexes, on mud-cobble substrate.

***Fluminicola sp. nov*., pinhead pebblesnail -** springs, no other information available.

***Fluminicola sp. nov*., toothed pebblesnail -** very large cold springs and their outflow, with exceptionally good water quality, gravel-boulder substrate.

***Fluminicola sp. nov*., nerite pebblesnail -** large cold springs and their outflow, with exceptionally good water quality, gravel-boulder substrate.

***Fluminicola sp. nov*., diminutive pebblesnail –** very large cold springs and their outflow, with very cold, clear water, gravel-boulder substrate.

Fluminicola insolitus, **Donner und Blitzen pebblesnail –** small, undisturbed cold springs and outflow.

***Gonidia angulata,* western ridged mussel** - streams of all sizes and are rarely found in lakes or reservoirs. They are found mainly in low to mid-elevation watersheds, and do not often inhabit high elevation headwater streams where western pearlshells are found. They often share habitat with the western pearlshell throughout much of the Pacific Northwest. They inhabit mud, sand, gravel, and cobble substrates. They are more tolerant of fine sediments than western pearlshells and occupy depositional habitats and banks. They can withstand moderate amounts of sedimentation, but are usually absent from habitats with highly unstable or very soft substrates. Cursory evidence suggests that western ridged mussels are more pollution-tolerant than other native mussels.

***Helisoma* (*Carinifex*) *newberryi* - Great Basin rams-horn -** "Larger lakes and slow rivers, including larger spring sources and spring-fed creeks. The snails characteristically burrow in soft mud and may be invisible even when abundant" (Taylor 1981). *Helisoma newberryi* were found in Screwdriver Creek, Shasta County, and Eagle Lake, Lassen County. Shells only were found in Screwdriver Creek, and it is possible those shells washed in from upstream, although the thin and delicate nature of *H. newberryi* shells suggests that they did not travel far. In Eagle Lake, only shells are commonly encountered in shallow waters close to shore. Live animals were only found by SCUBA diving in deeper water (e.g., > 10 feet). Although Taylor (1981) suggested that *H. newberryi* burrowed in soft mud and could possibly be 'invisible even when abundant,' in Eagle Lake live animals were commonly observed on top of the substrate (sand), but only in deeper water. Additional live *H. newberryi* were found at a site outside of the LNF, in Hat Creek, Shasta County.

***Juga (O.) bulbosa,* bulb juga – s**mall-medium streams, gravel-boulder riffles and edges of rapids in moderately swift current, in clear, cold water. Generally absent from areas with macrophytes and algae, or pools, mud and bare rock substrate.

***Juga (J.) hemphilli dallesensis,* Dalles juga –** large springs and small-medium streams, low elevations, stable gravel substrate, fast-flowing, highly-oxygenated, cold water.

***Juga (J.) hemphilli hemphilli,* barren juga –** small-medium streams, low elevations, in level-bottom, stable gravel substrate, with moderate velocity, highly-oxygenated, cold water.

***Juga (J.) hemphilli maupinensis,* purple-lipped juga –** large streams, low elevations, stable gravel substrate, riffles in cold water. More tolerant of silt and slack water than other JUHE subspecies.

***Juga (J.) sp. nov.*,three-band juga –** small to large springs and seeps or spring-fed streams, associated with talus or basalt bedrock substrates, also in sand or mud in slow and shallow water. Sites typically well-shaded.

***Juga (O.) sp. nov.*, basalt juga –** small springs and seeps or spring-fed streams, associated with talus or basalt bedrock substrates, shallow water or falls at low elevations.

***Juga sp. nov.*, Opal Springs juga (Crooked River Juga) –** small to medium cold springs and spring-runs, basalt bedrock substrates including cliff faces in spray zone, rarely on sand/cobble substrate.

***Lanx klamathensis*, scale lanx –** restricted to spring-influenced portions of large lakes and streams, or limnocrene springs. Occurs on boulder and cobble substrates in well-oxygenated, cold water. Populations in lakes limited to the vicinity of perennial spring input. Not found in areas with sediment or silt deposits, or in areas subject to hypoxia (low oxygen levels) due to temperature increases or organic decomposition.

***Lanx subrotunda*, rotund lanx -** unpolluted rivers and large streams at low to moderate elevations, in highly oxygenated, swift-flowing, cold water on stable cobble, boulder or bedrock substrates. Marcophytes and epiphytic algae generally rare to absent at sites for the species. Not found in pools or slow water locations with sediment or silt deposition, or in sites that are exposed during low water conditions.

***Lyogyrus (Colligyrus) sp. nov* ., masked or Washington duskysnail** - a kettle lake inhabitant and riparian associate. It lives in the littoral (i.e. near shore) zone of lentic ecosystems (lakes) on the surface of oxygenated mud substrates with aquatic macrophyte growth, submerged macrophytes or empty clam shells.

***Lyogyrus sp. nov*., Columbia duskysnail** - cold, well oxygenated springs and spring outflows on soft substrates in shallow, slow-flowing areas where it appears to feed on decaying organic particles). It prefers areas without macrophytes (macroscopic emergent and submerged aquatic plants), but may also occur in areas with *Rorippa (*water cress*)* and *Cicuta* (water hemlock).

***Margaritifera falcata,* western pearlshell** - cold clean streams and rivers that support trout and salmon populations. They can inhabit headwater streams less than a few feet wide, but are more common in larger streams and rivers. This species can even be found in some irrigation ditches in Oregon. Western pearlshells prefer cold clean streams and rivers that support trout and salmon populations. They can inhabit headwater streams less than a few feet wide, but are more common in larger streams and rivers. This species can even be found in some irrigation ditches in Oregon. Sand, gravel, and cobble are preferred substrates, especially in stable areas of the streambed. Large boulders help create these stable environments by anchoring the substrate and creating a refuge from strong currents on their downstream side. Banks are often favorable habitats because the current is slack and the substrates are more stable. Scientists in Montana found that when these mussels were covered with a substantial amount of fine sediment, they were unable to move to the surface and perished. In environments where host fish are abundant and human threats are minimal, western pearlshells can attain very high densities (>300 per square yard), often carpeting the stream bottom.

***Petrophysa sp. nov.*, hotspring physa -** thermophile, highly endemic to its type locale: a warm spring complex in open and dry sage scrub in the Owyhee River canyon. Found mostly in very shallow water in warm water springs and seeps, including cliff faces. Substrates include basalt bedrock to cobble, gravel and sand. It can be found in the same spring runs as *Pyrgulopsis sp. nov* (Owyhee hot-springsnail), but the latter is restricted to horizontal, stream-based habitat, while *Petrophysa sp. nov*. can be found on vertical substrates in more rapid flow conditions.

***Physella Columbiana*, rotund physa -** large rivers and streams, also occasionally lakes and ponds. Sites are typically in several feet of water, on or under gravel-boulder substrate. Found in some situations near Coeur d'Alene where other species are absent. Apparently more tolerant of heavy metals than other aquatic snails.

***Pisidium (Cyclocalyx) ultramontanum*, montane peaclam** - generally found on sand-gravel substrates in spring-influenced streams and lakes, occasionally in large spring pools. These sites are characterized by a high diversity of aquatic mollusks, some of which are restricted to these habitats (i.e. *Helisoma newberryi*, *Juga acutifilosa* and *Lanx klamathensis*). This species also occurs at sites with *Fluminicola* spp.

***Planorbella oregonensis*, lamb rams-horn (Borax Lake rams-horn)** - Borax Lake is a hot, thermal lake approximately 10 acres in size which occupies a depression in the center of a broad, shield-like mound (formed by geothermal discharges into surrounding marshlands over many centuries) which rises 10 meters above the desert floor. Lake depth averages 1-2 meters, except in the vicinity of the thermal vent, where the water temperature at 30 m depth has been recorded as 118 ^oC. Dissolved solid concentration is 1,600 mg/l and pH averages 7.5. High concentrations of heavy metals including arsenic, cadmium, cesium, copper, lead and mercury are present. *P. oregonensis* was commonly observed along the lake shore on hard substrates or on submerged vegetation. Single individuals were also found attached to benthic samplers at depths of 3 and 9 m. in the thermal vent.

***Pomatiopsis binneyi*, robust walker – "**Perennial seeps and rivulets, where protected from seasonal flushing in rainy season."(Taylor, 1981) also "lives on shallow mud banks and marsh seepages leading into shallow streams."(Davis, 1967)

***Pomatiopsis californica*, pacific walker -**"Semiaquatic; the snails are characteristically found among wet leaf litter and vegetation beside flowing or standing water in shaded situations where humidity remians high."(Frest, 2000)

***Pomatiopsis chacei*, marsh walker –** "Shaded swampy areas and margins of seeps, springs, stable streams and similar areas with fresh water and persistent high humidity." (Frest 2000)

***Pyrgulopsis hendersoni (P. robusta)*, Harney Lake springsnail (Lake Abert or XL Ranch**

springsnail) - prefers small to large cold springs and pools, which may be quite shallow, with moderate flow. Also found in small rivers and streams as well as lake margins. Some sites are in moderately warm, thermal springs and pools. Although preferred substrate varies from sand to basalt cobbles, well-oxygenated soft sediments or mud can also support populations. These snails are primarily periphyton feeders, grazing on microscopic organisms on the surfaces of rocks and plants, but also may graze on larger aquatic macrophytes, especially *Rorippa* species.

***Pyrgulopsis sp. nov.* (*P.robusta*), Columbia springsnail -** the habitat of this taxon is somewhat different from other PYrgulopsis species: in the Columbia River, in relatively deep, constantly flowing water on rocky substrate, typically found on the clean undersides of cobbles. It is unknown if spring influences affect the species distribution within the river, or how far up tributaries this taxa occurs

***Pyrgulopsis intermedia,* Crooked Creek springsnail -** large, low-elevation cold springs, spring runs and spring-influenced streams. Can co-occur with *P. hendersoni* at some locations. Klamath Lake springsnail found on cobbles and boulders in spring-influenced portions of Klamath Lake.

***Pyrgulopsis sp. nov.,* Owyhee hot springsnail –** thermophile, mostly found in shallow water in small spring runs and seeps, including rock cliff faces. Sada spring database describes the Three Forks site as follows: large flow volume, elevation 3820 ft., depth 40 cm, width 100 cm., temp 33.8° C, dissolved oxygen 5.7 mg/l, pH 8.3, no vegetation, either on bank or in water, no silt, substrate 20% sand, 30% gravel, 50% cobble.

***Pyrgulopsis Archimedes,* Archimedes springsnail -** large springs outflows and spring-influenced sites near shore in Upper Klamath Lake. Prefers sites with gravel-boulder basalt and pumice substrates and few macrophytes. Grazes on sides and lower surfaces of larger stones.

***Pyrgulopsis sp. nov.,* Klamath springsnail –** large springs outflows and spring-influenced sites near shore in Upper Klamath Lake. Prefers sites with gravel-boulder basalt and pumice substrates and few macrophytes. Occurs with *P. archimedes* (above).

***Pyrgulopsis sp. nov.,* Lost River springsnail -** large, cold spring complexes, with slow-moderate flow or spring-influences sites in Lost River and Sprague River; mud and sand substrate mixed with few cobbles. Sites typically have abundant aquatic vegetation including *Rorippa,* with *Chara* in deep areas. Species appears to prefer mud substrate and is believed to be a detritivore.

***Vorticifex klamathensis sinitsini,* Sinitsin rams-horn** - large, cold springs with coarse substrates and rapid current velocities. It grazes on perilithon.

***Vorticifex neritoides,* nerite Rams-horn** - generally found in relatively deep rivers, in unpolluted, swift-flowing, highly oxygenated water on stable (boulder-gravel) substrate, such as in the vicinity of rapids or other unimpounded stretches.

APPENDIX D – DATA MANAGEMENT AND FIELD FORMS

This Appendix contains a suggested Survey Form and a Species Observation Form developed for use with the OR/WA BLM Geographic Biotic Observations (GeoBOB) database. These forms provide a permanent record of when and where surveys were conducted and where locations of special status species and other taxa were observed. The form is provided as a Microsoft Word document (separate attachment) so that it can be downloaded and easily used.

A survey form is to be completed for each visit to a survey area, even if no target species is found. Each survey record should be linked to a spatial polygon feature representing the survey area (not each sample area). If multiple visits are necessary to complete a survey, data for each visit should be recorded. The first "Survey" portion of this form describes the location of the survey area, indicated by start/end coordinates and an accompanying survey polygon, while the second "Visit" portion describes the conditions of the survey such as date, time and observers. The third portion of the form is a list of target species and whether the survey detected those species. Other, non-target species can also be listed in the "Inventory Observations" table, and entered as additional observations. If species identification is not known, record it to the nearest known taxon (e.g., Fluminicola #1; or, Snail #2, etc.). Record the same taxon information along with the survey area name or number, and the date on the specimen collection container so that the specimen can be referred back to the field notes or form. The fourth "Habitat/Environmental Conditions" portion of the survey form records information on aquatic habitat types and substrates. Good records of habitat characteristics are especially important since so little is known about these species and their ecology. Plant community data and microsite feature associations are the key to future management on the landscape scale.

For each location within the survey area at which a target species is found, the second form called the "Species Observation Form" should be completed as well. This form contains information about observations such as the precise coordinates where an animal is found, its abundance, condition and details about its reproductive status. For specimen collections, complete the collections portion of the form to indicate who identified the specimens, their collection number and where they are retained; verification and repository information may need to be added later. The Site portion of the form is used only when the survey area is repeatedly visited, such as would be the case with permanent monitoring plots.

Data Management

Complete the Survey and Species Observation Forms in the field, as the surveys are done. Both the BLM and FS now use the datum NAD 83. Attach copies of the maps and/or aerial photographs, on which the survey areas and sample areas are delineated, to the completed Survey Field Forms. Enter the survey, observation, and collection data into the corporate agency database and then file these documents as appropriate. All survey data (including negative surveys when no target species were found), observation data of target species, and collection data are required to be entered into the corporate databases for the OR/WA BLM and R6 Forest Service Interagency Special Status/Sensitive Species Program.

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(*Circle or check* appropriate option when a list is provided. **Bold** items are required fields. Gray highlighted fields are new for aquatic mollusks. *Key to codes on cheat sheet. See data dictionary for Field Name and List of Value definitions.)

SURVEY

Survey ID: ____________________ Admin Unit: ________________ Sub Admin: ____________________________
Survey area (ac):____________________________ Zone: __________ Datum: ______________
Start coordinates: UTM: __________________________, E _______________________N
End Coordinates: UTM: __________________________, E _______________________N
*__Location Accuracy__: _____________________ GPS model & software used: ________________________
Legal Description: T __________R __________ S _______¼_______ 1/16______ 1/64________ Meridian: W H D
Related documents / files: ____
Notes: ____
____

VISITS

Visit ID: _____________________ *__Survey Type__: ____
***Survey Method**: ____________________ Project Name: ______________________ Project Unit: _______________
*Protocol Name ____
Observers: ____
Contractor:____ Contractor Bid:_________________________________

Visit Start Date: _______ End Date: _________ **Date Accuracy**: Day, Exact, Hour, Month, Year
Military Start Time (HHMM): ______ Military End Time (HHMM): _____ Visit Length: ____________
Estimated Actual Sampled Area (acres) : ____
Notes:
____
____
____
____

TARGET SPECIES List all species that are the focus of the survey. Record Negative data in the GeoBOB Add_Obs table (use Inventory / Neg Obs button in Survey form). Positive data must also be recorded in Fauna_Obs tables.

Species Code	Scientific Name	Found (Y/N)

HABITAT/ENVIRONMENTAL CONDITIONS

LANDFORM : RIVER____ LAKE____ POND____ STREAM____ SPRING_____ SEEP ______

ELEVATION: ______; GRADIENT: _______; WETTED WIDTH: ______; CURRENT VELOCITY: _______________

% SUBSTRATE TYPE: BOULDER ______ , COBBLE ______, GRAVEL _______, SAND _______, SILT/MUD ________;

WATER TEMPERATURE: ______ C/F; AVE. WATER DEPTH ________________(M)

DESCRIPTION OF SITE AND OTHER COMMENTS:

____
____
____
____

INVENTORY OBSERVATONS

Create a list below of species (other than those on the target list) found during the survey. Indicate percent cover or abundance for each species, and the quantity. Enter data into GeoBOB Add_Obs table (use Inventory / Neg Obs button in Survey form). Macrophytes present may be entered as additional observations

Species Code	Scientific Name	% Cover	*Abundance	Quantity

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(*Circle* appropriate option when a list is provided, **Bold** items are required fields, highlighted fields are new for aquatic mollusks, *key to codes on cheat sheet. See GeoBOB data dictionary for Field Name and List of Value definitions.)

OBSERVATIONS

OBS ID: ____________________________ **SPECIES CODE**: _______________
SCIENTIFIC NAME: __________________________ COMMON NAME: _________________________________
UTM: _____________________ E, ___________________N ZONE: _____________ DATUM:______________
LAT: _______________ W, LONG:______________N GPS model & software used: _______________________
***OBSERVATION TYPE**: _________________________________ **DATE**: _________________________
DATE ACCURACY: Day, Exact, Hour, Month, Previous Year, Year
RELIABILITY: Excellent, Good, Fair, Poor, Unknown ***LOCATION ACCURACY**: ________________________
TOTAL QUANTITY: _______ QUANTITY ESTIMATED?**:** Y / N OCCUPIED AREA _____m^2 DENSITY ______$/m^2$
DISTRIBUTION: Clumpy, Linear, Scattered-Even , Scattered-Patchy
ABUNDANCE: Unknown, Abundant, Common, Uncommon, Rare
OBSERVERS:
____
Notes:
____
____
____

DETAIL OBS

QUANTITY: _______ GENDER: Female, Male, Neuter, Hermaph, Unknown *AGE: __________
*ACTIVITY: ___________ CONDITION: Dead, Excellent, Fair, Good, Injured, Live, Poor, Sick, Unknown
REPRO-STATUS: Non-repro, Repro, Unknown, N/A
NOTES: ____

HABITAT/ENVIRONMENTAL OBS

SUBSTRATE TYPE WHERE FOUND (select all types used by species at site):
BOULDER ________ , COBBLE ________, GRAVEL _________, SAND _________, SILT__________
WATER TEMPERATURE: _______ C/F; WATER DEPTH: ________________(m)
CURRENT VELOCITY: _________________

COLLECTIONS

COLLECTION ID: ____
COLLECTION TYPE: Voucher, Museum, Commercial, Photo, ID Tag, None, Other
DATE: ___________________**COLLECTOR**: ____
REPOSITORY: ______________________________________ IDENTIFIER: ___________________
Photo ID: ________________________
VERIFIER: ___________________________ Verification Date: _____________________________
VERIFIED SPECIES CODE: _________________________
COLLECTION NOTES:
____
____

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FAUNA SITES (enter data only if this site is visited repeatedly or is a monitoring site)

SITE ID: ______________________________ SITE NAME: _______________________________________
SITE ALT. ID: __________________ **SITE SPECIES CODE**: ____
ADMIN UNIT____________SUB-ADMIN UNIT_______***LOCATION ACCURACY**: __________
SITE STATUS: (locally): Extinct, Extirpated (sp. & habitat), Occupied, Undetected, Unknown, Unoccupied
TOTAL QUANTITY: ___________ QUANT. ESTIMATED?: Y / N AREA OCCUPIED (ac): _______________
VISIT TYPE: Incidental, Inventory, Treatment (specify in notes), Monitoring – Annual/ Fed. Listed, Monitoring – Grazing, Monitoring – Long-Term, Monitoring – Unspecified, Monitoring – Fire, Monitoring – Timber, Research, Revisit, Resurvey
DATE: ________________ **DATE ACCURACY: Day, Exact, Hour, Month, Previous Year, Year**
REVISIT NEEDED: Y / N REVISIT SCHEDULED DATE:
____

OBSERVERS:
____

NOTES:
____
____
____

PLEASE ATTACH MAPS of Observation or Site when helpful.