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WESTERN ASSOCIATION OF FISH & WILDLIFE AGENCIES

Wild Sheep Initiative

WILD SHEEP CAPTURE & HANDLING GUIDELINES

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CHAPTER 1

INTRODUCTION & PRE-CAPTURE PLANNING

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Introduction and Pre-Capture Planning

The capture of wildlife has its roots in providing nutrients for human consumption, whether through the domestication of wild animals or for more immediate use as a source of protein (Drew 2020). Over the millennia, methods of capturing wildlife have evolved in terms of their utility and efficacy. Recent history has seen massive improvements in capture and handling techniques, especially for wildlife conservation or wildlife research. Such has been the case with North American wild sheep (*Ovis canadensis*, *Ovis dalli*).

Capture and handling of wild sheep for any purpose requires extensive planning, is labor-intensive, and extremely costly (Bleich 1990). Some wildlife agencies have developed "in house" guidelines or recommendations for the capture, handling, sampling, treatment, or translocation of wildlife in general (e.g., Jessup and Clark 1980, 1982; Jessup et al. 1986), and some agencies eventually developed guidelines for wild sheep (e.g., George et al. 2008, WGFD 2022). With minor exceptions (e.g., Wilson et al. 1975, Remington and Fuller 1989), however, few recommendations specific to the capture of North American wild sheep were available. With this realization and at the urging of wild sheep biologists from throughout North America, Foster (2005) developed and published a set of guidelines to address that shortcoming. Those recommendations have been in use for more than 20 years. The concept and initial draft of these revised guidelines were initiated in 2019 by the then current Chair of the WAFWA Wild Sheep Working Group (now the Wild Sheep Initiative), who assigned two wildlife veterinarians to create the framework and sections necessary to build on and update Foster's (2005) document.

The earliest recorded captures of wild sheep for purposes of conservation, of which we are aware, occurred in California during the first few years of the 20th Century (Bleich et al. in press). Those efforts provided specimens for exhibition, agricultural experiments (e.g., breeding), and ultimately were terminated with the first translocation of desert bighorn sheep recorded. It is noteworthy that specially modified leghold traps were used to catch those animals (Bleich et al. in press). Since then, many methods have been used to capture bighorn sheep and their northern congeners, among which have been leg snares, corral traps, rocket-nets, drop-nets, drive-nets that depended on ground crews or aircraft to move animals into them, chemical immobilization from the ground or aircraft, and the use of net-guns fired from an aircraft (Coggins 1999, Jessup et al. 2014). Other methods, including the use of a net-gun from the ground, throw-nets, or hand capture, also have seen limited use (Heimer et al. 1980, Silvy et al. 2020a).

The physiological effects, survival rates, and efficacy of several capture methods have been evaluated over an extensive period of time (Kock et al. 1987a, 1987b, 1987c; Jessup et al. 1988; Wagler et al. 2022). In addition, Foster (2005) included substantial information germane to the translocation of bighorn sheep, among which were regulations and associated requirements regarding movement of wild sheep across an international border at that time, and readers are reminded of the necessary planning and permitting that may or may not be required due to recent changes. Foster (2005) also provided substantial details on the use of drive-nets to capture wild sheep, but this technique has not been used widely during recent years. Additionally, there have been numerous improvements in pharmaceuticals and the use of combinations of immobilizing agents to capture or medicate wild sheep, and a separate chapter herein addresses that methodology. Moreover, separate

chapters in this document provide detailed guidelines on the use of the drop-net and net-gun, respectively, and these account for the vast majority of wild sheep capture techniques in use today.

This document consists of a series of 8 separate contributions prepared by experienced personnel, and each addresses a specific aspect of handling, caring for, capturing, marking, or translocating North American wild sheep. The chapters are presented in the order in which activities generally occur. Following this introduction, the authors of Chapter 2 describe the set-up and management of a wildlife capture operation with an emphasis on the use of a basecamp for animal processing, the personnel that must be involved therewith, and provide numerous guidelines or suggestions to ensure success. The following chapter, Health and Veterinary Care of Wild Sheep, addresses the aspects of animal care and welfare that are of great concern, and provides valuable guidance to those involved in capture or translocation activities. Chapter 4 provides suggestions for methods of collaring or otherwise marking wild sheep that have been captured for a specific purpose, details on technologies and applications that currently are available, and recommendations for proper fitment and application of various methods to ensure the best return on the method selected.

Currently, three methods are the primary techniques used to capture wild sheep. These involve the use of the net-gun, drop-net, and the use of chemical immobilization. Each of these is the subject of a separate chapter that consists of guidelines and recommendations specific to the particular method. Aspects of the ecology among life stages of North American wild sheep increasingly are becoming subjects of interest (Blum et al. 2023), and methods of capturing and handling neonates, or otherwise very young wild sheep, are addressed specifically in Chapter 8. Technology used to investigate aspects of different age classes of wild animals has evolved substantially since publication of the original guidelines (Foster 2005), and the evolution of collaring and marking methods that have become available and the guidelines for applying collars and various other markers to juveniles of various ages are provided in detail by the authors of that chapter. The handling, transport, and release of animals—whether for research or translocation—are addressed in Chapter 9, in which the authors present guidelines and recommendations intended to maximize the probability of project success and the greatest possible benefit to the conservation or management of wild sheep.

Aspects of each of the chapters have been discussed by other authors in earlier publications, and many of those have appeared in the various editions of The Wildlife Society Techniques Manual, which has been published and updated over many decades. The eighth edition (Silvy 2020) recently appeared, and among the various chapters is information specific to the capture and handling of wild animals (Silvy et al. 2020a), chemical immobilization (Drew 2020), wildlife health and disease surveillance (Peterson and Ferro 2020), marking techniques (Silvy et al. (2020b), and radiotelemetry and remote monitoring (Silvy and Catanach 2020). Other material contained in Silvy (2020) and are not addressed specifically in these guidelines, but that remain germane to the capture and handling of wildlife, include ethics (Peterson et al. 2020), communications and outreach (Jacobson et al. 2020), and adaptive management (Organ et al. 2020). At some point, one or more of these topics is likely to require attention, but may or may not directly affect the outcome of capture, handling, or translocation operations.

Despite the availability of the general information that is included in the aforementioned publications, the wisdom and guidance provided in the opening paragraphs of the earlier version of the Wild Sheep

Capture Guidelines remain applicable and are emphasized and included herein. Foster (2005) maintained that preparation for any capture event should begin months in advance, and we certainly concur. He also noted the need for prior permission and permits to carry out any such operation, whether from the land management agency, or another state or national jurisdiction in which the capture event is intended to occur, noting that permissions to capture or clearances to release animals being translocated may take several months to several years to negotiate. After such approvals have been secured, the users of these guidelines should review the following activities and, where applicable, they should be applied. We concur with Foster's (2005) recommendation that one individual should be assigned to these tasks; further, that individual should be the person in charge of the operation and its implementation. A common moniker for that individual historically has been “Capture Boss”, a title that carries with it the overall responsibility for implementation of the capture event and is used in that context throughout these guidelines.

Foster (2005) recommended the Capture Boss initiate and oversee all essential tasks, the timely completion of which will facilitate the technical aspects of the capture event or translocation. Many of these tasks can be challenging or time-consuming, but are essential, and the success of any such project is dependent on proper preparation and planning. Preparation for the capture should include a “capture plan” developed at least several months prior to the event.

This plan should outline all aspects of the event, among which are:

- A detailed explanation of the need and objectives for the captures
- The targeted number, age, and sex of sheep to be captured
- An assessment of disease status (see “Chapter 3: Health and Veterinary Care of Wild Sheep”), to include:
    - A compilation of historic herd health and disease status information
    - The disease tests or samples needed and that are to be collected
    - Contacting the labs you will use to determine if they require any special handling of samples; for example, which samples to ship quickly and which can be stored
    - Ensuring all proper sample and processing equipment (e.g., portable centrifuge) and supplies including special media are available
    - Availability of sample storage requirements (e.g., frozen, refrigerated, room temperature) for warm or frigid weather to keep samples at their appropriate temperature
    - Advance preparation of shipping boxes and labels if samples need to be shipped right away (especially if they cannot be frozen)
    - On new capture sites, a full complement of tests on each adult sheep is recommended. On capture sites that have a recent sampling history for herd health, less testing (50%) may be adequate for collection of herd health data.
    - Assembly of Sample Kits
        - Preparation of kits should occur prior to the day of capture.
        - Sampling will be smoother, quicker, and have less likelihood of missing a sample if all sampling supplies are pre-placed in a separate bag for each animal.
        - When possible, pre-label all tubes and sample containers and label the bag with a unique identification number for each animal.
        - Ear tags can be included in the sample bag for ease of application.
- A detailed explanation of capture or release dates and times.

- Plan capture events for the time of the year when least apt to disrupt annual life events and when weather is most suitable at the planned location
- A description of capture and release methods and locations including directions and maps
  - Identify and secure required permits for capture, transport and release
  - Prepare the capture contract (if necessary), select a capture contractor, secure funding, and order radio collars
  - If the capture site is in another state or nation, permission to capture must be received before any planning starts
  - Select release sites and the number, sex, and age of sheep to be released at each site
  - Determine ear tag color, type, and size to be used at each release site. Color should be different than colors used on previous releases in the same area in case the sheep do not stay where they are released.
  - Determine collar needs. Order radio collars with frequencies assigned to each release site. Make sure frequencies do not overlap with other radio-marked species in the area.
- A list of key personnel and roles including contact information for each (cell phone number and email address).
  - Assign a wildlife veterinarian to assist with the capture, transport, and release and to be the lead on health and welfare aspects.
  - If the agency implementing the capture does not have a wildlife veterinarian on staff, develop a personal service contract with a private-practice veterinarian.
  - The veterinarian selected should have experience with large ruminants, and preferably with wild sheep.
- Establish base camp operations and logistic needs
- Determine method(s) of communication with capture crew, especially for helicopter captures
- Establish animal handling and processing procedures including health and welfare considerations in consultation with the project veterinarian
  - Determine method of euthanasia if and when it is necessary
- Prepare data recording and forms to be used
- Address ways to ensure human and animal safety
  - Strive for efficiency and minimum handling time. Train if necessary and assign duties of personnel well in advance, and be certain instructions are followed. Keep in mind there will often be more people present than there are tasks, and don't let the desires of all those willing helpers compromise the health of the sheep.
  - The best place for a captured sheep during any operation is in the transport vehicle, away from people. It is easy to get carried away with sampling, treatments, or handling, so review each planned activity prior to the event and ensure it is essential; unnecessary activities will only compromise the health of captured individuals.
- Review and address hazard considerations and the need for environmental compliance, such as captures in wilderness.
- Establish policy and rules to accommodate media, volunteers, and NGOs.

A further, albeit also essential, part of any capture or translocation operation that involves transport of wild animals across international or jurisdictional borders is compliance with all import and export permits, health certifications, and potentially other regulations affecting the movement of wildlife. Requirements for importation of sheep from Mexico or Canada may not be complex, but also may

change with time so start the permit process early by making phone calls and working on permit logistics at least 6 months ahead of time. Before starting the permitting process, decide which Port of Entry will be used, because it will be a factor in determining some of the permits needed. Establish a knowledgeable contact within the wildlife agency managing the source herd to help with their export requirements. Laws and regulations change on an irregular basis, and an unanticipated shift in a regulation or the enactment of a new law or regulation for which the Capture Boss is not prepared can delay or even prevent an otherwise well-planned capture from occurring. Despite the attention to detail and information provided by Foster (2005), project proponents must be aware of all regulations and permitting details, and we encourage close coordination with federal, and provincial or state veterinary personnel in each jurisdiction to ensure compliance.

The intent of the action-specific guidelines in each chapter is to help ensure the safety of the sheep and the capture crew, and we are optimistic that this document will be successful in doing so. These guidelines reflect a great deal of information that has changed in technology, methods, pathology, and bureaucracy during the past twenty years, and represent the first revision to Foster's (2005) effort to assemble then current information and recommendations into a single, usable, and useful document.

Additional summaries and reviews of material addressed in these guidelines are available, and users are referred to those earlier reports for background information or additional details. Some of those summaries are dated, but represent historical accounts of the use of immobilizing agents (Woodbury 1996, Kreeger 1999), the evolution and application of a variety of capture methods (Clover 1954, Beasom et al. 1980, Autenreith et al. 1981, Barrett et al. 1982, Krausman et al. 1985, Jessup et al. 2014) or release techniques (Thompson et al. 2001), use and safety of helicopters in wildlife capture work (Autenreith et al. 1981, Barrett et al. 1982, Jessup 1982, Bleich 1983), the use and utility of marks, collars, and telemetry (White and Garrott 1990, Millspaugh and Marzluff 2001), and other aspects associated with the conservation of wild sheep. Readers are encouraged to explore that history, as well as to keep pace with current advances and developments, and to apply information, as appropriate, in the best interest of conservation. Wild sheep deserve no less.

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CHAPTER 2

BASE CAMP OPERATIONS

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Wild Sheep Capture Base Camp of Operations

An established base camp is a critically important aspect of successful wild sheep capture operations, and it helps to ensure project success and animal and human safety. When well planned, organized, and prepared, the base camp serves a wide range of roles for the capture and improves operations for all capture methods. This chapter provides an overview of capture base camp set-up, needs, and operation. Many of the activities and processes (e.g., collaring and marking, sampling, animal handling, etc.) addressed here are covered in greater detail elsewhere in these guidelines.

Coordination and Planning

A primary function, and benefit, of the base camp is to provide coordination and communication during the capture event. All information contained in the Capture Plan, developed well in advance, is put into action from the base camp.

- Coordination with land managers or landowners is essential.
  - Clear and agree on operation dates and specific locations well in advance.
  - Clearly map sensitive areas or timeframes that need to be avoided.
- Active and early communication ensures consistency during the capture.
  - Include all involved personnel: capture crews, veterinarians, animal handling personnel, agency staff, local law enforcement, volunteers, NGO participants, dignitaries, media, and staff from receiving agencies if moving animals between jurisdictions.
  - Include all relevant information:
    - Operation dates
    - Nearest accommodations and travel time to base camp
    - Specific location(s) with coordinates (latitude, longitude)
    - Maps to the base camp site(s)
    - Preferred types of vehicles (e.g., 4x4) or vehicle restrictions (e.g., trailer length)
    - Anticipated environmental conditions
- Coordination with researchers reduces the opportunity for processing disruption.
  - Additional objectives
  - Additional procedures or activities (e.g. ultrasonography)
    - Include estimated additional time required.
  - Additional samples and methodology
    - Include any additional equipment or supplies needed.
- Coordination with agency and public media relations staff is critically important to minimize disruptions.
  - Establish clear ground rules and limitations.
  - Identify areas and actions that are off limits.
  - Predetermine potential interviewers and interviewees.

Base Camp Site Selection

Selection of a base camp location(s) depends on a number of factors, specific objectives of the capture, and on capture method. Two considerations inherent to all base camp operations are (1) the safety of all personnel involved and (2) minimizing stress and injury to the animals being captured. Prior to final selection of base camp locations, all potential sites should be visited by the Capture

Boss, the local biologist, and land manager or landowner. During the site visit, the following considerations can be validated. An example of a typical base camp layout is depicted in Figure 2.1.

- Consider the distance between the capture area (where the animals are) and base camp.
  - For helicopter captures or for trapping operations that require aerial transport of animals to or from a work area (remote drop-net sites or remote established traps), ferry distance from capture area to base camp should be minimized (< 6 miles between capture area and base camp, but no more than 8 miles) to increase aerial capture efficiency and reduce stress on animals. Multiple base camp locations can be used to minimize transport distances.
  - For drop-net operations or established trap sites with vehicle access, animals are typically worked at the capture site. The distance from the capture site (e.g., the net or trap) to the animal processing area should be minimized. Processing activity should be shielded from the capture site.
    - Improves trapping success.
    - Requires large enough staging area to support sufficient people and vehicles.
    - Reduces time to animals and time animals are in net or trap.
- Considerations for vehicle and trailer access to site:
  - Ensure access route has substrate appropriate for size and weight of vehicles.
  - Consider effects of temperature changes on road conditions during the day.
    - Frozen ground may allow early access, thawed ground may inhibit exit.
  - Ensure sufficient space to accommodate several vehicles and allow vehicles that are pulling trailers to make full circle turns.
    - Parking area should be separated from the animal handling area, animal drop zone, and helicopter landing zone.
  - For drop-net operations, ensure there is vehicle access to the drop-net site.
    - This eases net set-up and expedites transfer of animals in transport situations.
- Considerations for the helicopter landing zone (LZ):
  - The LZ is specifically reserved for refueling the helicopter, equipment resupply, and for capture crew. Typically, only the Capture Boss or Base Camp Lead is allowed in the LZ.
  - LZ should have a level, solid substrate as the landing surface, and solid access for the fuel truck.
  - Requires sufficient space to safely land the helicopter.
  - Ensure LZ is clear of power lines and trees.
  - Low grass/forb vegetation is preferred.
  - Ensure LZ is clear of structures and debris, with no loose items around structures.
  - In dry locations or during summer captures it is advisable to water LZs for dust control if possible.
  - Consider prevailing and forecasted wind direction.
  - LZ should be at least 100 yards from the area designated for animal processing or loading.
  - Alternate fueling locations may be used when space or fuel truck access is limited.
- The animal drop zone (DZ) is the area where animals are delivered to base camp for processing, and if animals are being transported back to the capture area via helicopter it is where animals are staged for loading.
  - DZ should have a level, solid substrate free of tripping hazards for animal handling crews.
  - Requires sufficient space for placement of multiple animals

  - Ensure the DZ is clear of power lines and trees.
  - Low grass or forb vegetation is preferred.
  - Ensure DZ is clear of structures and debris, with no loose items around structures.
  - Consider prevailing and forecasted wind direction.
- The animal processing area is the focal part of the entire base camp. This is where all the sampling, marking, and monitoring occurs for each animal.
  - Processing area should have adequate space for the maximum potential number of animals anticipated to be delivered by the capture crew in a single trip.
  - Substrate should be solid and free of tripping hazards for animal handling crews.
  - All equipment (tarps, tables, stretchers, tools, veterinary supplies, etc.) should be adequately secured to withstand exposure to helicopter rotor wash.
- It is important to select alternative base camp sites for all capture locations should inclement weather or ground conditions prevent use of the preferred base camps. All of the above considerations should be evaluated for each alternative location.

Sampling, Collaring and Marking, and Data Management

Wildlife capture operations may be conducted for a variety of reasons. Typical objectives for a wild sheep capture include disease sampling, health monitoring, collaring to evaluate movements and habitat use, or translocation. The viability of any biological samples collected, and the reliability of any animal collaring and marking activity are dependent on an efficient and functional base camp operation.

Samples, Storage, Processing, Shipping

- Ensure all personnel collecting biological (e.g., blood draws, fecal samples, tissues), disease (e.g., swabbing), or health monitoring (e.g., ultrasonography) samples are adequately trained in the proper technique(s).
- Pre-prepared and pre-labeled sampling kits for each individual should be centrally located and easily accessible or be distributed to animal processors by an independent party.
  - Each kit should contain all necessary equipment and supplies (e.g., swabs, syringes, punches, vials, etc.) to collect all required samples for an individual animal.
- All samples should be processed by, or at the end of each day.
  - Spin blood each day with a portable centrifuge during multi-day captures.
- Plan for and centrally locate sample storage equipment to maintain viability of samples.
  - Use racks for blood tubes where possible.
  - Compressed nitrogen is best for freezing samples, but a portable freezer will be necessary to keep samples frozen.
  - Prepare for both warm and frigid weather to ensure samples are maintained at appropriate temperatures.
    - Use ice chests and ice to maintain refrigerated samples.
    - Use ice chests and handwarmers for ambient or room temperature requirements.
  - Consider and meet the requirements for maintaining special storage media.
- Prepare shipping boxes and labels prior to capture if samples need to be shipped right away, but especially if they cannot be frozen.

Collars, Animal Tags, etc.

- Ensure all personnel tagging sheep are clear on application and placement of tags, and that information is recorded correctly.
  - On animal ear
    - Left or right ear
    - Forward or rearward facing
  - On the collar
  - Always have extra tags, buttons, and appropriate applicators for each type of tag
- One primary person should oversee collar preparation.
  - Clearly write the ID number and frequency on the outside of each collar's banding material for data recording.
  - Clearly identify ram, ewe, adult, subadult, and juvenile collars.
  - Test GPS collars in advance for data acquisition, storage, transmission, and satellite. access in the area where they will be deployed.
  - Confirm VHF signals are being transmitted by using appropriate receivers.
  - Activate all collars 1-2 days prior to capture.
  - Always have extra attachment hardware and nut drivers for each tag type and brand of collar being deployed.
- Ensure all personnel attaching collars are trained in collar deployment; refer to "Chapter 4: Collaring and Marking Wild Sheep" for these guidelines.
  - Identify proper collar fit by animal age and sex.
  - Always adjust and trim the collar to ensure the best possible fit.

Data Collection and Management

It is vitally important that data are recorded accurately and efficiently to maximize capture objectives. Failure to properly collect and record data compromises the purpose of the capture operation. Simple actions can ensure data are not lost or compromised during base camp operations, but depend on whether one person (e.g., the Capture Boss, or the Data Coordinator) oversees all data recording, or data are collected by animal handling teams and are consolidated by a data coordinator.

Data Coordinator

One person (Data Coordinator) coordinating data collection and consolidation

- Data Coordinator must be organized and capable of keeping track of multiple animals.
- Typically uses one central data sheet containing columns for all data and samples being recorded and collected, and checks boxes for any required vaccinations and identifying marks to be applied.
- Moves among all animals brought to the base camp to record data and verify appropriate samples are collected.
- Records and reminds teams to take a minimum of 1 heart rate and 1 respiration rate for each animal, and multiple body temperatures if actions are taken to lower body temperature.
- Notifies a veterinarian of any health-related issues.
- Answers data recording questions.
- Receives information on the animals from the processing team.

- Confirms with team members that all medications have been administered, samples taken, examinations conducted, and collars and ear tags have been attached.
- Records injuries or abnormalities.
- Records any emergency treatment(s).
- Gives final approval for sheep to be moved to the transport vehicle or be released once all data are recorded for that animal.

Animal Handling Team for Recording Data

- One individual from each animal handling team is assigned to record data for the animal being processed.
- Records and reminds team members to take minimum of 1 heart rate and 1 respiration rate of each animal and multiple body temperatures if actions are taken to lower body temperature.
- Notifies a veterinarian of any health-related issues.
- Records all information on the animal using the data card or data sheet specific to the animal.
- Confirms with team members that all medications have been given, samples taken, examinations conducted, and collars and ear tags have been attached.
- Records injuries or abnormalities.
- Records any emergency treatment(s).
- Gives final approval for sheep to be moved to the transport vehicle or be released once all data are recorded for that animal.
- Provides completed data card or data sheet to Data Coordinator.
- All datasheets should be checked against the samples taken to ensure there were no mistakes and that all samples are accounted for and properly stored.

Pre-Capture Meeting, Daily Briefing

A pre-capture meeting is essential prior to any capture activity. The pre-capture meeting provides an opportunity to conduct a “verbal dry run” of all the processes and safety precautions and ensures everyone involved is aware of all expectations. It is essential that all participants, including the helicopter capture crew, ground crew (agency personnel and volunteers), veterinarians, researchers, transport staff, and media representatives are present. The pre-capture meeting should be held the night immediately before a capture effort begins.

- All information is directed by the Capture Boss.
- Agenda items to be covered include:
  - General overview of goals and objectives
  - General overview of planned operations
  - Travel departure times and meeting locations
  - Helicopter safety protocol
  - Animal welfare and care
  - Overview of hazards and potential emergency responses
  - Assignment of individual roles and duties
  - Discussion of sampling, vaccinating, marking, and collaring protocols
  - Description of base camp set up to include locations of the LZ, work stations, transport vehicles, veterinary supplies, parking area, etc.
  - Overview of base camp rules

    - Discussion with media to ensure understanding of the “dos and don’ts”, the primary contact(s) for questions and direction, and arrangements for potential interviews
- Daily briefings should be conducted each morning prior to beginning activities, to include
    - Brief reminders regarding safety and emergency actions
    - Personnel changes and role assignments
    - Any protocol or objective changes

Key Personnel

Operation of a base camp for a helicopter or drop-net capture requires personnel with a variety of talents and skills. Success of the entire operation is dependent on effective communication among all participants, efficient conduct of activities by individuals with assigned duties, and stringent adherence to safety protocols for people and animals. As noted earlier, identification of capture crews and base camp staff typically is done well in advance.

Capture Boss

One person is selected as the Capture Boss well in advance to ensure consistency from pre-capture preparation through base camp operations during the capture. The Capture Boss is the lead for all operations involved.

- The Capture Boss oversees the entire operation and has no other specific assignment.
- Issues, concerns, and non-medical problems arising during operations are taken to the Capture Boss, who will make a decision after consultation with experienced staff.
- Responsibilities include
    - Communication and coordination with base camp personnel.
    - For aerial captures, maintain communication with all pilots (helicopter capture ships, spotter planes) and aviation authorities.
        - The Capture Boss may assign an individual specifically to monitor radio communication with any aircraft associated with the capture.
        - Handheld or base camp vehicle FM radios are preferred.
        - Ensure all pilots and base camp use the correct radio frequency.
        - Develop contingencies for loss of reception (e.g., cell phone, InReach, radio tower repeater system, flight following).
        - Constant communication of next actions to take and complete.
    - Ensure all necessary equipment and supplies are collected and available at the base camp (Appendix 2.1).
    - Inform local law enforcement of the capture event and associated activities.
    - Direct capture crew to capture areas preferably using geographic coordinates or map polygons on helicopter GPS.
    - Identify target animals for each search area.
    - Identify appropriate transport and release processes and ensure all transport equipment is available and in proper working order.
    - Assign base camp duties.
    - Coordinate with media personnel.
    - Coordinate travel accommodations.
    - Identify basecamp location(s) and set up.
    - Implement safety protocol.

- Conduct pre-capture meeting
- Constantly critique capture processes and identify potential for improvements
- Periodically meets with key personnel to assess and redirect operations when necessary

In addition to the Capture Boss and Data Coordinator, other key personnel include:

Lead Wildlife Veterinarian

The lead wildlife veterinarian is responsible for animal health and care, sampling protocols, euthanasia of injured animals, and the storage and shipment of samples.

- Responsibilities include:
  - Secure all medications, treatment supplies and materials, and disease sampling supplies.
  - Ensure all samples are properly stored, shipped, and delivered to appropriate labs.
  - Direct and conduct emergency treatments of stressed or injured animals.
  - Oversee other veterinarians present.
  - Oversee use of all pharmaceuticals.
  - Oversee vital signs data collection (temperature, pulse, respiration, body condition, etc.).
  - Train personnel administering treatments and collecting samples.
  - Supervise activities of other wildlife health professionals that are present.
  - Advise the Capture Boss on health-related issues, processes, and procedures.
  - Serve as final decision authority on all animal medical related issues.
  - Euthanize injured animals.
  - Complete any required health certificates.
  - Conduct or assist with specialized medical sampling procedures (e.g., ultrasonography for pregnancy or body condition).
  - Encourage and accommodate students or trainees at base camp to help train future professionals.

Animal Handling and Processing Personnel:

The largest group of people at a base camp operation are those tasked with handling and processing captured animals.

- For aerial captures a key individual is the **Drop Zone (DZ) Attendant.**
  - Responsible for any activities conducted under the helicopter (releasing animals from sling, unhooking capture bags from sling, etc.).
  - Must wear appropriate safety gear (high-viz vest, hard hat, etc.)
  - Assist with animal handling as necessary.
- For drop-net operations an equivalent task is **Trap Site Attendant.**
  - Maintains communication with Capture Boss and animal handling teams.
  - Releases the drop-net when appropriate animals are under the net.
  - Assists with untangling animals and animal handling as necessary.
- **Animal Handlers** and processors make up the bulk of the necessary personnel.
  - For aerial captures, 4 teams of 3 people each are preferred, but sufficient personnel need to be available in the event more than 4 sheep are brought in at one time.
  - For drop-net captures, the number of teams needed is a function of the anticipated number of animals to be captured at any one time. It is best to have more teams available than are needed so all animals are processed efficiently and safely.

    - Each team is responsible for moving one sheep from the DZ to the processing area during a helicopter capture, or from the net to the processing area for drop-net captures.
    - Each team completes processing the animal they moved per the planned protocol and assists with animal positioning for any specialized procedures (e.g., ultrasound).
    - After confirmation that all actions have been completed and all data have been recorded, the animal handlers carry the animal to the transport vehicle and load it, or to the appropriate release spot and release it.
- Unless otherwise directed, each team stays with its animal through the processing, loading, or release **Additional Staff** may be needed depending on research needs and specific tasks to help the operation run smoothly (cooling animals, nasal oxygen, etc.).
- The total number of staff on site should be limited to only those necessary. This will vary, however, based on factors such as capture method, media presence, volunteer management, and research needs.

The Basic Base Camp Process

Base camps are established primarily for the purpose of providing a safe and efficient area to process animals.

- For aerial captures, animals are delivered to the DZ on a long-line below the helicopter and lowered to the ground by the pilot. Only the designated DZ attendant is allowed in the DZ while the helicopter is in the area.
- After the helicopter clears the DZ, 3-person teams approach the animals, unhook sling cable connecting multiple animal bags, and carry animals to processing area. The number of teams should match the number of animals brought in.
- For drop-net captures, handling teams approach the net, untangle the animal, and carry animals to processing area. The number of teams should match the number of animals under the net.
- For the safety of the sheep and the handlers, a 3-person team is required to handle the animal. For carrying the animal, one person secures the head and horns (do not use the horns as handles), one supports the front half and one supports the back half. If available, hard or soft stretchers may be preferred when carrying animals because they are easier to lift and manage while moving across irregular terrain.
- Once in the processing area, teams place their animal in a sternal position (preferred) or on its right side on a table, tarp, or directly on the ground. Animals should not be completely rolled over. The sling-bag is undone, the animal is removed and the bag is placed out of the way to the side if sheep will be released at base camp. If the animal will be slung back to the mountain the sling-bag may be left under animal.
- The person holding the head should maintain control throughout processing, being certain to not obstruct the nose and mouth, to ensure the horns do not harm anyone. The team should communicate using low voices. Only people with a role in processing the animal should be near the animal.
- The team should immediately and quickly assess vital information (rectal temperature, respiration, heart rate) and, if necessary, cool the animal down.
- All team members should assess the portion of the animal visible to them for abrasions, lacerations, parasites, and other injuries, applying appropriate treatment if necessary. Special focus on the eyes and ears is important.

- The team ages and identifies the sex of the animal, either collects all desired samples (blood, fecal, nasal swabs, etc.) and measurements (ultrasound, BCI, etc.) or allows designated capture team members to collect desired samples and measurements.
- After all samples and measurements are collected and recorded, the collar or tags, or both, are attached to the animal.
- After checking with the designated data recorder and confirming that all samples and data were collected and recorded correctly, the animal is carried to the transport vehicles or DZ for loading, or to the designated release area for release near the base camp. Two experienced wildlife professionals should remove the hobbles and blindfold. Ensure the path of release for the animal is clear of boulders, obstacles, or other dangers.
- For animals being transported back to the capture location by helicopter, resecure the animal in the sling-bag and ensure sling bag straps and buckles are properly attached in the correct position under the body and legs. Independent checks of sling-bags by an experienced individual should occur prior to hooking the animal to the long line.

General Base Camp Rules

With any field activity, and especially those involving animals, there are inherent risks. With capture operations using a base camp and potentially large numbers of people, these risks can be elevated. Thus, the primary concerns during capture are human and animal safety, in that order. However, education on where the risks are and following simple rules of base camp etiquette can reduce or mitigate these risks.

- Identify the key danger areas: the LZ Heli-pad, DZ, and transport trailer or crate loading area.
- Only designated personnel are allowed to approach the helicopter to communicate with the pilot and capture crew, and only approaching the front of the aircraft; never from the rear.
- Observers (including media representatives) must remain outside the perimeter of the processing stations unless they have a specific task. The paths between the LZ and the processing stations, the processing stations and the transport vehicles, the processing stations and the release area, and the processing stations and the DZ must remain clear at all times.
- All personnel handling sheep must wear exam gloves and change them between animals to reduce the risk of pathogen transfer among animals.
- All personnel should be clearly informed the risks of the capture operation.
- All personnel should know where medical equipment and supplies are located.
- All personnel should be made aware of the nearest medical facility, facility contact information (communication via cell phone, satellite phone, or other satellite communication devices), and directions to get there.
- Emergency contact information (e.g., names and phone numbers) should be made readily available.
- After completing all assigned tasks, move outside the processing station to reduce congestion.
- Keep voices low and minimize unnecessary conversation around the animals. **Do not shout information to the data recorder or yell for equipment you need.**
- People must keep to their assigned responsibilities unless reassigned by the Capture Boss.
- No dogs at the basecamp except those involved with related research operations. Research dogs are not to be near sheep, including those in transport vehicles.

- Sanitation and Decontamination Procedures – (see “Chapter 3: Health and Veterinary Care of Wild Sheep”)

Media and Public Management

Allowing media and cinematographers to document captures and base camp operations can be a great opportunity to share our incredible story of wild sheep conservation. However, the mission of completing the project goals and maintaining human and animal safety and welfare must come first. Thus, simple rules of conduct for members of the media are important.

- Determine if this particular base camp will be appropriate and lend itself well to media coverage or public involvement.
- Assign a knowledgeable staff member to oversee media personnel and activities, answer questions, and direct coverage to improve messaging and videography.
- Do not compromise capture or basecamp operational efficiency or safety to accommodate media or public involvement.
- Schedule interviews in advance and ensure they do not conflict with activities.
- Drones are not allowed in the capture area unless approved by the Capture Boss, and then only under strict guidelines:
    - Drones may only be flown within relevant FAA regulations for the area.
    - Drones may only be flown in the area with Capture Boss, helicopter capture crew, and landowner concurrence.
    - Drones may only be used in designated areas that are clearly outside any area potentially used by aircraft during the active capture period. This includes LZs, DZs, and any potential capture area.
    - Use of drones by media (public and contracted), ***if permitted by the Capture Boss***, must be under the immediate supervision of the onsite Media Coordinator.
- Encourage the use of remote cameras such as capture crew’s GoPro devices.
- Manage the number of public citizens allowed at the base camp. Ensure adequate agency staff is on hand to direct and supervise them.

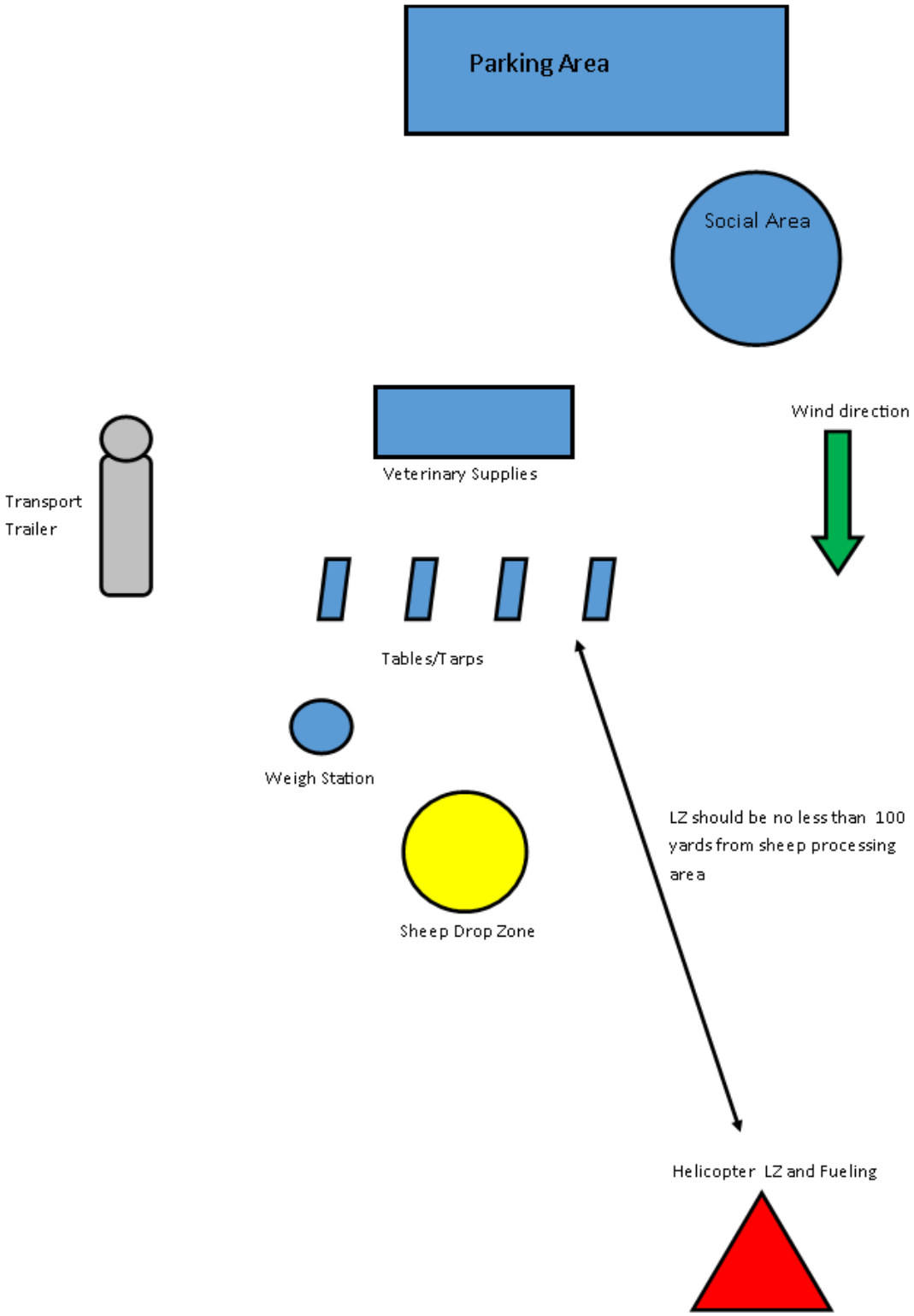
Other Considerations

Because larger base camp operations are inherently complicated and come with multiple levels of risk, there are a number of other considerations to consider.

- For personal hygiene and minimization of local impacts, portable toilet facilities should be provided at the basecamp where feasible.
- Develop and discuss at the pre-capture meeting, and during briefings, contingencies and emergency procedures for dealing with human and animal injury.
- Consider and continuously evaluate animal handling times and make adjustments as necessary to minimize stress on animals.
- All animal handlers should be aware of health metrics that determine if animals are releasable or need further veterinary attention.
- Use of shade structures during hot weather, or having a warming capability if during cold weather, can help with animal welfare issues.
- Plan ahead to address the legal disposition of carcasses if mortalities occur (e.g., donation for food, ceremonial purposes, deposition in landfills, etc.).

- The Capture Boss must be willing to stop operations when an issue arises.
- Conduct a debrief before breaking down base camp.

Figure 2.1. Base Camp Site Map- A general schematic of basecamp layout emphasizing wind direction and location of the helicopter landing or drop zone.



Appendix 2.1. Supplies and Equipment List

- Tables, tarps, stretchers for carrying animals
- Weigh Scale and Hanger
- Shade Cover
- Clipboards and pens/pencils
- Hand-held radios and/or vehicle radios to communicate with helicopter and crew members
- Sampling and Animal Care
    - Fans, ice chest with towels in ice bath, water jugs, water sprayers
    - Oxygen with nasal cannula (1 per table)
    - Fluids, extension sets, IV catheters
    - Banamine
    - Antibiotic (e.g., Exceed, Draxxin)
    - Sedative if needed (e.g., midazolam)
    - Disposable gloves
    - Thermometers with lube
    - Stethoscopes
    - Ultrasound
    - Syringes and needles or vacutainer sheaths and vacutainer needles. Sharps container
    - Container with dilute chlorhexidine if using vacutainers
    - Blood tubes (minimum serum separator and EDTA)
    - Nasal swabs (sterile 2 pack) and M. ovi media
    - Pharyngeal swab (Sterile single swab) with TSB media and applicator tools
    - Ear notcher if doing BVDV testing
    - Rubbing alcohol
    - Gauze
    - Whirl Pak bags for ear notches and hair
    - Container with alcohol for ectoparasites
    - Forceps may be useful for removing ectoparasites
    - Extra hobbles and blindfolds
    - Ice chests with cold packs or ice for samples
    - Medication and veterinary supply kits
- Human Safety and Hygiene
    - Complete first aid kit
    - Reversals for any drugs used.
    - Defibrillator
    - Backboard
    - Satellite communication (e.g., inReach) if out of cell phone range
    - Portable toilet(s)

WILD SHEEP CAPTURE & HANDLING GUIDELINES

WAFWA
WESTERN ASSOCIATION OF FISH & WILDLIFE AGENCIES

Wild Sheep Initiative

CHAPTER 3

HEALTH & VETERINARY CARE OF WILD SHEEP

LAST UPDATED: JUNE 2024

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Health and Veterinary Care

This chapter provides recommendations for health and disease monitoring of wild sheep populations. Also included are considerations for individual animal handling and care, and procedures associated with sample collection. Additionally, suggested treatments for common injuries and conditions are provided. It is recommended that staff performing medical treatments and procedures receive training from a veterinarian, certified veterinary technician, or a trained and experienced biologist or wildlife health specialist.

Notes on Animal Welfare

Animal welfare is defined as the protection of animal health and well-being. For any wildlife capture we must understand that we are putting individual animals at risk, and it is our duty to ensure that we do everything practical to limit mortalities, injuries, pain, and stress among animals that are handled. Aside from ethical obligations, it is extremely expensive to capture, sample, or move animals, and adherence to animal welfare concerns helps protect this investment. Appropriate capture methods, handling techniques, treatment of illness or injury, and processing efficiency each increase the likelihood of a successful operation.

Disease and Health Assessments

Purpose

Disease, chiefly contagious pneumonia, has a substantial impact on wild sheep populations. Translocation of animals from populations in the absence of a clear understanding of their health status has the potential to be unsuccessful and could introduce disease(s) into naïve populations. In 2015, the Wildlife Health Committee of the Western Association of Fish and Wildlife Agencies developed guidelines for assessing wild sheep populations for pneumonia risk, and that document served as the basis for these recommendations. The disease status of bighorn sheep populations serving as sources of translocation stock should be assessed prior to implementing any restoration or introduction effort. Disease profiles should be developed, and a risk analysis regarding the disease and health impacts of any translocation should be developed—and fully evaluated—for the source population and potential effects on, or challenges to, the target population (e.g., the release site, if an augmentation). The potential for impacts to nearby, extant populations also must be addressed in any risk analysis.

Pre-capture Planning and Evaluation

Assessing Herd Performance

- Recruitment rate or population trend can indicate the potential for disease concerns.
- Low lamb:ewe ratios may be indicative of an ongoing disease but could also occur as a result of poor range conditions, or the presence of other stressors.
- One or more missing age cohorts suggest the occurrence of a prior disease event.
- Annual surveys of priority populations will provide a more accurate assessment of demographic performance and facilitate detection of disease events.

Routine Surveillance for Respiratory Pathogens

- Samples collected from living or dead animals are key to determining the presence of pathogens.
- The pathogen currently of greatest concern is *Mycoplasma ovipneumoniae* (Movi), which plays a substantial role in epizootic respiratory disease. Serology is the best method for determining the presence of the organism in a population. If exposure to Movi is detected, genomic characterization via Polymerase Chain Reaction (PCR) of samples, either lung tissues or swabs of the nasal cavity or tracheal bifurcation, and strain-typing is recommended. Swabs may be placed in dry cryovials or in trypticase soy broth (TSB) or brain-heart infusion broth (BHI) with 10% glycerin and then frozen until shipment to a diagnostic laboratory or saved for future testing.
- Pasteurellaceae also play a role in epizootic respiratory disease, have been implicated as initiators of disease events in the absence of Movi. *Mannheimia haemolytica* has been diagnosed or implicated in two recent die-offs in Wyoming.
- Aerobic culture of swabs of the tonsillar crypt, and nasal cavity and lung tissue, should be collected. Swabs may be placed in media described above or plated to media in the field and incubated at 37° C until submitted to a diagnostic laboratory for identification. Swabs should not be placed in dry cryovials. Positive cultures should be followed by PCR testing for the leukotoxin A gene.
- Additionally, the occurrence of respiratory viruses within a population can impact susceptibility and response to bacterial infections. Therefore, serological testing for respiratory syncytial virus, infectious bovine rhinotracheitis, bovine viral diarrhea virus, and parainfluenza virus 3 is advised.

Routine Surveillance for Additional Pathogens of Concern

- Bovine viral diarrhea virus (BVDV) has been implicated in a disease event in Nevada. Serology and PCR on blood or tissues may be used to detect exposure and persistently infected individuals, respectively. In cattle and other species, infection with BVDV causes suppression of the immune system.
- Routine surveillance for bluetongue and epizootic hemorrhagic disease (EHD) may be beneficial in some areas. Cross-strain immunity is not necessarily protective and even in endemic areas, immunity can wax and wane with changes in rainfall. New strains may be introduced through the movement of cattle or vectors. Vaccination may be beneficial when translocating animals from areas with low prevalence to areas with high prevalence.
- Contagious ecthyma has been linked to some population declines. Serology may be performed to detect exposure to the virus. Asymptomatic carriers may occur with this virus.
- External parasites: *Psoroptes* mites, winter ticks, or exotic ticks and lice have been implicated in some population declines. Bighorn sheep should be examined for the presence of external parasites that are more numerous or differ in appearance from the usual parasites, and specimens should be collected and speciated. If occurrence is correlated with poor herd performance, management options should be investigated.
- Sinus tumor appears to be a type of neoplasia present in some populations associated with the occurrence of certain respiratory pathogens. The occurrence of sinus tumors can complicate the epidemiology of Movi and persistence of respiratory disease within a population. The occurrence of sinus tumor within a population can be determined through

radiography or postmortem examination of natural mortalities, hunter-harvested animals, or animals removed as part of a test and cull strategy.

Outbreak Detection and Investigation

- Determine whether or not the population has a history consistent with outbreaks of disease.
- If multiple mortalities or symptomatic animals have been or are detected in a population, collect nasal and tracheal swabs from carcasses, even if not fresh; perform necropsies in the field or lab on fresh animals (see necropsy section); consider euthanizing and testing symptomatic animals.
- At a minimum, diagnostic testing should include aerobic and anaerobic culture, Movi PCR and strain-typing, and histological examination. Should Movi or bacterial pneumonia not be identified, PCR examination for other viral pathogens, for example respiratory syncytial virus (RSV), bovine viral diarrhea (BVDV), epizootic hemorrhagic disease (EHD), bluetongue (BT), infectious bovine rhinotracheitis (IBR), and parainfluenza-3 (PI-3) should be implemented.
- Additional viral, bacterial, or toxicological investigation also may be necessary, and metagenomic analyses may be desirable in some cases.

Equipment and Supplies

Capture and handling equipment will vary by capture method, whether field or central-place processing is involved, locational accessibility, and potentially other factors.

Animal processing equipment and supplies necessary for most capture methods

(See Appendix 3.1 for a Complete List)

- Animal handling equipment
  - Blindfolds
  - Hobbles
  - Stretchers
- Animal assessment
  - Stethoscope
  - Thermometer
  - Sampling equipment and supplies
  - Mouth gags and lights
  - Sample kits with blood tubes
  - Syringes
  - Swabs
  - Cooler for samples
- Animal treatment
  - Supplies for cooling – ice packs, towels, rubbing alcohol
  - IV fluids
  - Catheters
  - Wound care supplies – disinfectant, antibiotic ointment, gauze
  - Skin stapler
- Animal identification
  - Eartags

- Collars
- Data recording supplies
- Tablet or iPad
- Handling forms

Disinfection of Tools and Equipment

Infectious disease is the primary cause of poor performance among populations of bighorn sheep. Thus, it is critically important to include biosecurity measures in all wild sheep handling protocols but, especially, when working back-to-back among populations (including other species such mountain goats or aoudads), and when operations are performed at a central processing area (e.g., a base camp). Not every situation will dictate this level of caution, however. For example, if only a single animal is being captured, it may be more practical to return to the office to disinfect equipment.

- Good practices include the use of broad-spectrum commercial disinfectants and careful adherence to instructions for dilution, contact time, and effects of temperature. Among these are:
  - Trifectant
  - Rescue
  - Cavicide
  - Virkon
- Disinfect any equipment that has been in close contact with animals (nets, blindfolds, mouth gags) before using in another population. If working with several herds within a short timeframe, ideally capture and handle the cleanest herd(s) before moving to any potentially less clean.
- Wear disposable gloves and change them when moving among animals.
- Never reuse disposable equipment such as needles, catheters, etc.
- Any medical equipment that contacts blood, feces, or the mucus membrane of an animal, such as eartag applicators, thermometers, or nasal cannulas must be cleaned and disinfected between animals.
- Clean organic debris from equipment prior to disinfection.
- Use an appropriate disinfectant for the equipment (e.g., while bleach is a great disinfectant, it can damage some equipment or materials).
- Rubbing alcohol on gauze works great for electronic equipment, such as thermometers and ultrasound probes that cannot be submerged or may be sensitive to caustic disinfectants.
- Use a fast-acting disinfectant when needed, because some may take too long to work; read and follow the manufacturer's instructions.
- Equipment with many crevices (e.g., eartag applicators) is better disinfected if they are submerged, and diluted chlorhexidine works well for this.
- In a situation where hiking in to capture an animal is required, small containers or Ziploc bags of alcohol- and chlorhexidine-soaked gauze work well for most equipment.
- All equipment that touches the animal including nets, sling bags, blindfolds, hobbles, etc. must be cleaned and disinfected between herds.
- Large Volume Disinfection Processes

- Between captures of different herds, it is necessary to disinfect large quantities or volume of hobbles, blindfolds, nets, and anything that contacts respiratory or eye secretions, or other bodily fluids.
- A broad-spectrum disinfectant (e.g., trifectant) is better than bleach, which weakens fabrics or other materials.
- Pressurized sprayers of 1–2 gallons (4–8 L) in volume with an appropriate disinfectant solution can be used for blindfolds and hobbles to ensure sterilization.
- Soak sling bags, nets, and similar equipment in a disinfectant solution in a large basin or sink for the time specified on the label of the product.
- Do not reuse disinfectant solutions; dispose of used solution(s) before moving within, between, or among populations.
- Consider using a 'clothesline' or rack on which to hang and dry equipment.

Examination, Animal Processing, and Sample Collection

Examination:

Animal positioning

- Position anesthetized animals ONLY in sternal recumbency.
- Position the animal in sternal recumbency—or on the animal's right side only if they are NOT anesthetized—to encourage proper eructation (belching).
- Carry animals only in sternal recumbency with the head elevated.
- Ensure the animal is in the correct position throughout examination and processing.

Vital Rates and Body Condition

- Temperature, pulse, and respiration are to be determined and recorded approximately every 5 to 10 minutes (Table 3.1).
  - If rectal temperature is above 104° F (>40° C), begin emergency cooling immediately.
- Mucous membrane color is pink when normal, but bluish in color when the animal is oxygen deficient (note: oral membranes are pigmented in bighorn sheep).
- Normal capillary refill time is ≤2 seconds.
- Fully examine all limbs, neck, head, and spine for fractures or dislocations. Make sure to turn the animal over briefly to check the underside. Thoroughly examine the animal; the use of hobbles can make ligament ruptures or dislocations difficult to detect.
- Examine the entire skin along the whole body to check for wounds and treat, as necessary.
- Examine the ears carefully to check for parasites and injuries.
- Examine the eyes for injuries or debris; be careful because animals may flinch when the blindfold is removed.
- Determine a body condition score either by palpation of key landmarks or use one of the recently developed quantitative methods with or without ultrasound (Stephenson et al. 2020) – see Appendix 3.2.

Lambs – handling concerns

- Heart rate tends to be higher than in adults.
- Temperature is more volatile (goes up quickly, comes down quickly) than in adults, so be cautious with cooling.

- Be gentle
- Be sure to use appropriately sized equipment; the lamb's small mouth may preclude getting oral swabs.
- Check references regarding expansion collars, consult researchers that have used them before, and refer to “Chapter 8: Capture and Handling of Neonates” for these guidelines.

Table 3.1. Vital signs and rates for bighorn sheep under normal, stressed, and extreme conditions.

	Resting	Expected with Handling	Intervention	Extreme
Temperature °F (°C)[a]	101-103.5 (38-39)	≥102 (≥39)	≥104 (≥40.0)	≥107 (≥41.5)
Heart Rate (bpm)[b]	60-120	140-160	≥160 sustained	≥160 sustained
Respiratory Rate (rpm)[c]	15-35	40-70	≥70 sustained	≥70 sustained

[a] degrees Fahrenheit (degrees Celsius) [b] beats per minute [c] respirations per minute

Animal Processing

Processing strategy will vary substantially between that for a base camp operation and that of a helicopter crew working alone in a remote location. Regardless of location, the highest priorities of any capture and processing effort are always human and animal safety.

Steps for Animal Processing:

- Appropriately position the animal, and check for life-threatening injuries or illness. Rapid treatment can be important but, in some cases, it will be better to halt processing and release the animal immediately.
- Monitor vital signs and use available resources as needed to lower body temperature.
- When multiple personnel are present, one person should initiate needed treatment(s) while others process the animal.
- In basecamp operations, carry animals from the helicopter drop zone (or from the drop net) in their sling bags or on stretchers to the processing area. One person must be designated to support the head.
- Collar fitting, collar installation, placement of eartags, and placement of a vaginal implant transmitter are implemented only after blood has been collected and are undertaken when it is most efficient to do so. Do not apply an eartag while someone is drawing blood. Refer to “Chapter 4: Collaring and Marking Wild Sheep” for these guidelines.
- When necessary, administer drugs to mitigate capture stress or capture myopathy, and address concerns regarding disease or parasite transmission.
- Verify that each objective has been accomplished and each sample has been collected before the animal is released or placed in the trailer or transport vehicle. This process will be simplified if datasheets or capture apps tailored for each capture event have been prepared in advance.

General Animal Processing Tips:

- Pre-label all sample containers prior to the day of capture or place them in pre-labeled bags.
- Keep ambient noise to a minimum and speak softly.
- Wear gloves and change them before processing a different animal.
- Blindfold and hobble every animal at the site of capture.

- When done, determine body weight on the way to the processing area from the drop zone or drop net. Be sure to include a notation of whether the recorded weight includes items such as the transport bag, hobbles, or net. Weigh and record the tare of each of these items ahead of time and subtract the tare to provide the corrected weight of the animal.
- In a base camp, place animals on a table to reduce human fatigue and facilitate processing; when using tables, orient animals so that they are not facing each other.
- Warn those individuals responsible for restraining the animal before eartagging, needle application, or any other procedure during which the animal needs to be immobile and not allowed to move. As a further reminder, do not apply eartag(s) while someone is drawing blood.
- Assign specific personnel to the task of collecting samples and minimize pain and stress, but maximize efficiency while samples are being obtained.
- Do not restrain animals longer than needed to complete processing and data collection unless it is being treated for an injury or other serious condition.
- Do not place an animal in the trailer, transport box, or release it until it is stable unless the stress of handling and treatment appears to be contributing to the issue.
- For fractious animals and animals with temperatures that will not decrease, 5-10 mg of midazolam IV may facilitate handling and reduce stress induced hyperthermia.

Samples to Collect

Every opportunity to put your hands on an animal is an opportunity to take samples that will serve to better understand individual or population health. Details of collection, handling, processing, and shipment of samples are provided in Appendix 3.4. At a minimum, samples should include:

- Serum
- Whole blood (placed in ethylenediamine tetraacetic acid (EDTA) tube
- Nasal swabs
- Pharyngeal/tonsillar swabs

Other samples to be considered are:

- Whole blood (for trace mineral analyses)
- Ectoparasites (in ethanol or frozen)
- Hair
- Ear notch (for BVDV)
- Feces
- Other samples requested by collaborators or other researchers, such as blood for RNA.

Specific Animal Sampling Tips:

- Nasal swabs: Insert the swab up to 4 in (10 cm) and gently rotate the swab 3-4 times; both nostrils should be swabbed with a single swab; remove and place in the cryovial. Break the stick portion off about 1 in (2.5 cm) from the tip of the swab so that it will fit in the cryovial. Be certain the tube has been labeled properly. Vigorously swish in a mycoplasma enrichment media vial (TSB or BHI with 10% glycerin or similar, see above and Appendix 3.1) to separate the organisms from the swab and suspend them in the media.
- Tonsillar swabs: Direct an assistant (with gloves) to hold the mouth open with a mouth speculum. Use either a penlight attached to a swab holder, or a lighted laryngoscope and a

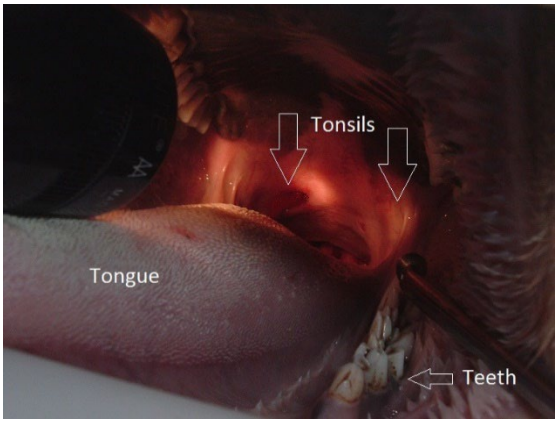


Figure 3.1. Hold the mouth open with a speculum and using a paint stick, rubber spatula or laryngoscope, depress the tongue to swab the tonsillar crypts.

swab holder. Depress the tongue so the tonsillar crypt is visualized and depress the swab into the tonsillar crypt while taking care to avoid the teeth and tongue (Figure 3.1). Place the swab in a cryovial with TSB or BHI and 10% glycerin, and ensure the vial is properly labeled.

- Blood: It is easiest to collect from the jugular vein, but it also can be collected from the lateral saphenous (back leg) or cephalic (front leg) veins. Appropriate choices are usually 18 or 20 G needles and 20 cc syringes or vacutainers; disinfect vacutainer adapters between animals.
- The amount of blood to collect and tubes to use will depend on the testing being done. At a minimum 20 cc of blood distributed into 2 serum separator tubes of 8 cc each and the remainder in an EDTA tube is recommended. A trace mineral tube may also be desired.
- Wipe or spray the collection location with alcohol to help visualize the vein and limit contamination. Loosen the plunger in the syringe slightly before starting. Insert the needle at an angle of about 30 degrees and with the bevel up. Once blood is observed in the hub of the syringe, flatten the trajectory to thread the vein, and gently pull back on the plunger to fill the syringe. Hold the syringe by the plunger end so grip does not have to be adjusted once the vein has been accessed. Post draw, hold off the stick-site for at least 30 seconds to lessen the probability of hematoma.
- After filling the tubes, samples should be kept cold but not frozen until the serum or plasma has been removed. In some cases, for example a remote location accessed by a rough dirt road, centrifuging the serum tubes on site and removing the serum to cryovials is recommended. This is to prevent hemolysis (breakdown of the red blood cells) as a result of agitation.
- Take ear notches for BVDV using a specified ear notcher that has been disinfected between animals, and then rinsed thoroughly with clean water. Alternatively, use a biopsy punch (available from veterinary supply companies, 0.15-0.25 in (4-6 mm). Place the tissue in a cryovial. Be sure to avoid major veins in the ear. Whole blood in EDTA may also be appropriate, but check with the lab to confirm sample type and amount needed.
- Feces are collected directly from the rectum using a lubed and gloved finger. Feces are the last samples to be collected because that activity can alter body temperature readings. Use only nitrogen-free lubricant, or measures of diet quality may be affected.

Animal Release

With any release, the following are essential considerations.

- The state of animal health, including effects of sedation.

- Release-site terrain and its proximity to escape terrain.
- Always ensure the anticipated path of travel is free of potential hazards like ditches, boulders, or fences.
- Consider distance the animal must travel to return to the capture site vs. the logistics associated with transporting the animal back to its capture location.
- Always pull the blindfold off the animal and shade the eyes for 5-10 seconds before the hobbles are completely removed; this will allow the animal to get orientated to the terrain.
- If using chemical immobilization, do not reverse the animal until all personnel are out of the way and the animal is in a safe location that is clear of hazards. Ideally, one person will be assigned to remain with and monitor the animal to ensure it avoids injury.

For translocations, the following are essential considerations:

- Avoid releasing animals at dusk or after dark; it is preferable to hold them in a trailer overnight rather than release them after nightfall.
- Release animals as one (or as several) group(s), rather than as individuals. This is especially important for ewes with lambs.

Transport Considerations

- In a transport trailer, place rams 2 years-of-age and older in a partitioned compartment or on a separate deck in order to separate them from ewes, yearlings, and lambs.
- Regardless of whether a transport trailer or specialized crates are used, each animal should have at least 16 ft^2 (1.5 m^2) of floor space so that they are all able to lie down without crowding.
- Use appropriate bedding to help prevent pressure sores and muscle damage which can occur if animals are lying on a hard surface for a pronged period especially if tissues are already compromised by subclinical capture myopathy. Bedding will also help soak up feces and urine. Rubber mats covered with straw, wood chips or shavings, or shredded paper often works well. Deep bedding is needed if there are no mats, especially on long trips.
- If hay or straw is used, ensure that it is certified as weed-free, and use only sources that have not been grazed by or exposed to livestock.
- All trailers or transport vehicles must be thoroughly cleaned and disinfected following, and again prior to, each translocation. All gaps that are so large that bighorn sheep may get their horns stuck must be securely blocked.
- Provide adequate ventilation appropriate for ambient conditions. Worry less about sheep being able to see outside. Maximum ventilation will be required with warm ambient temperatures.
- Ideally, sheep should not be held for more than one night.
- If sheep are to be held longer than 36 hours, provide water and good quality, weed-free grass, hay, or alfalfa that has not been grazed previously by domestic livestock.
- In hot weather, ensure good ventilation and place the trailer or transport truck in the shade; consider placing ice blocks in rubber water basins secured to the wall of the transport trailer.
- If animals are to be held overnight, or for long transports, neuroleptics of the appropriate length of action for the required transport may be used. For fractious or stressed animals moved short distances, short acting neuroleptics or sedatives may be useful, and are described below in a separate section.

- If it is necessary to treat or handle animals prior to release, it may be preferable to do so in the trailer rather than remove them. In any case, the animal being tended to must be blindfolded and hobbled, or otherwise physically restrained.

Medical Treatment

Animals may require treatment for complications associated with capture. The earlier some of these are addressed, the more likely the conditions can be reversed. However, field treatment may not be successful. The time necessary for treatment should be balanced with the costs and stress of holding the animal longer before release. While these guidelines will provide suggestions for when treatment should be initiated and potential outcomes, individual experience will come into play.

Complications can include:

- external or internal injuries;
- shock, hypothermia, or hyperthermia;
- acute or subacute clinical or subclinical muscle damage or myopathy;
- bloat; or
- a combination of these conditions.

Clinical signs potentially requiring treatment include:

- elevated (hyperthermia) or low (hypothermia) body temperature;
- increased or decreased heart rate;
- increased or decreased respiratory rate, with varying depth of respiration;
- increased capillary refill time, and pale or blue mucous membranes;
- lacerations; and
- fractures.

Other clinical signs are dependent on the body system involved. Emergency treatments and medications are to be provided with the goal of stabilizing animals and, ideally, under the direction and supervision of a licensed veterinarian. Before administration of any drug or vaccination, withdrawal times and the potential for harvest must be considered. All animals that have received drugs must be marked with a “Do not consume” tag.

Routine Treatments

Treatments can involve the use of sedatives, mineral or vitamin supplements, oxygen, paraciticides, antibiotics, or vaccines. The need for treatment, and administration thereof, is discussed in greater detail, below. For simplicity, we consider only treatments for conditions most apt to be encountered during, or associated with, capture events.

Hyperthermia

- Hyperthermia (heat stress) can occur as a result of prolonged chase times and individual animal response to capture. Placing limits on chase times for an individual animal, or on a group of animals that may be encountered later in the day, is the best way to decrease the likelihood of hyperthermia.
- Hyperthermia occurs at body temperatures >104° F (40° C) and is the most common complication encountered during capture events.

- Capture personnel should take a rectal temperature immediately and relay this information to those responsible for receiving and processing the animal.
- If an animal has a rectal temperature in excess of 106°F (41°C) at time of capture, consider releasing the animal rather than transporting it to a base station unless cooling measures can be taken in the field prior to loading.
- A mixture of isopropyl alcohol (0.5 gal or 2 L) and water (4.75 gal or 18 L) applied to the animal may increase the rate of evaporative cooling. Aerial capture crews should be equipped with such a mixture to soak the ventral surface of the animal before it is transported to a base camp.
- Cooling can be accomplished by using a steady stream of cold water, being sure to get the water down through the coat to the skin and placing cold towels or ice packs in the groin, inguinal, and axillary areas.
- Oxygen, administered nasally at 2–6 L/min will assist with cooling, and also help to reverse hypoxemia.
- A nonsteroidal anti-inflammatory, such as Meloxicam, Flunixin Meglumine, or Ketoprofen can be administered to reduce muscle inflammation.
- Midazolam can be administered to reduce excitement and aid in cooling.
- Administration of cool intravenous fluids (0.25–0.5 gal (1–2 L) of a balanced electrolyte solution, such as Normasol or Plasmalyte pH 7.4) will help cool the animal and correct hypovolemia associated with hyperthermia; continue until rectal temperature stabilizes at <104° F (40° C).
- Once rectal temperature drops below 104° F (40° C) active cooling should be stopped to prevent hypothermia, but continued monitoring is essential to ensure body temperature does not rise during additional handling.
- Cooling procedures should consider the ambient temperature and should be implemented cautiously when that temperature is less than 40° F (4.5° C).
- Extra caution should be taken with young animals, and those in poor body condition, as body temperature in these groups may change rapidly with the application of the above methods.
- Enemas have not been shown to be effective at reducing body temperature.

Abrasions

- Abrasions are the most common injury observed and involve the removal of one or more layers of epidermis. They often are accompanied by bruising of underlying tissues.
- Clean the abrasion(s) with a disinfectant and apply an antibiotic spray or powder.
- Consider giving an nonsteroidal anti-inflammatory drug (NSAID) such as Flunixin Meglumine or Meloxicam if extensive abrasion has occurred.

Bloat

- Ruminants that are physically or chemically restrained may not be able to eructate (belch) or dispel rumen gases. This may cause rumen distension, and result in extreme pressure on the diaphragm, lungs, or abdomen, and can lead to suffocation or shock if not corrected.
- Correct body positioning (e.g., sternal recumbency), with the neck elevated and the head pointing downwards will help prevent bloat but, in cases where the abdomen is enlarged, gentle pressure on the rumen and rocking the animal could help remove gas.

- A stomach tube, passed through a speculum in the mouth and into the esophagus and the rumen, should decompress the abdomen. Prior experience in this procedure is vital for proper placement of these items.
- Animals experiencing severe bloat while under anesthesia should be reversed immediately and placed in sternal recumbency.

Broken Horn

- The horn consists of a bony core surrounded by a keratin sheath. The bony core occupies $^1/_4$ to $^1/_3$ of the length of the horn and varies the age and sex of the animal.
- Do not use the horn(s) as "handles" when carrying or processing animals, as the horn sheath can become detached from the horn core. Grasping the **base** of the horn for restraint on an already subdued animal is appropriate to minimize head movement and protect personnel.
- Broken horns involving the bony core often occur because the horn core has been weakened as a result of sinusitis or prior injury.
- Control bleeding, if any, with direct pressure.
- Trim or file any sharp points, or loose pieces, from the horn.
- If broken at the base but still attached, no treatment is needed.
- If the horn core is broken at the base and the sinus is exposed, euthanasia may be indicated.

Lacerations

- Clean with an appropriate disinfectant solution such as chlorhexidine or betadine and remove dirt and debris.
- If less than 1.5 in (3 cm) in length on the body, or 0.5 in (1.5 cm) on a limb, apply an antibiotic ointment, spray, or powder.
- If greater than 1.5 in (3 cm) on the body or 0.5 in (1.5 cm) on a limb, consider suturing closed, leaving the most dependent 0.5 in open for drainage, especially on the trunk and proximal areas of limbs.
- Control bleeding with direct pressure. If direct pressure does not resolve the issue, use suture material to ligate the vessel. In most cases, the amount of hemorrhage will not reach the critical threshold of 17 oz (0.5 L) (10% of the blood volume).

Fractures

- Fractures of the foot bones may heal without treatment and not impair mobility to any great extent.
- Fractures of long bones may heal without treatment, but likely will result in an extended period of compromised mobility, pain, or both. Some agencies have successfully amputated the distal portion of a rear leg when a fracture has occurred, but any such surgery necessitates the presence of appropriate personnel and equipment and takes a substantial amount of time. Those resources are unlikely to be available during a capture event and, in situations of this type, euthanasia is probably the best option.

Capture Myopathy

- Capture myopathy is a non-infectious disease in which muscle damage results from stress and extreme physical exertion. It typically is associated with prolonged, or short but

intensive, pursuit during capture, extended struggling during restraint, and can develop during the transportation of animals.

- Capture myopathy is most apt to occur following extended pursuit times; a limit on pursuit time is the most effective way to decrease the likelihood of occurrence.
- The potential for capture myopathy is evidenced in the form of elevated body temperature, rapid pulse, pale mucus membranes, shock, and other evidence of 'stress'. Capture myopathy can be difficult to confirm, and treatment best involves efforts to return the animal to normal physiological status, correcting acid/base disturbances, and reducing inflammation of muscles.
- Administration of supplemental oxygen, balanced electrolytes with or without sodium bicarbonate, non-steroidal medications (e.g., flunixin meglumine), and efforts to cool body temperature can be helpful in combatting or decreasing the debilitating effect of capture myopathy.

Utility and Use of Drugs During Capture Events

Sedatives

Drug	Length of Action	Notes
Azaperone	6−8 hours	Non-reversible “A” in BAM*.
Midazolam (tranquilizer)	< 2 hours	May cause more recumbency than desired when the animal is in the trailer.
Haloperidol	8−18 hours, 72 hours (sustained release)	Doses are different for regular and sustained release (SR), make sure you know which you are using.
Zuclopenthixol	3−4 days or 21 days (depot form)	Combination with a short-acting drug may be needed during the “loading” period. Rarely used outside of captive situations.
BAM*	1−3 hours	O_2 level will drop, oxygen supplementation advised; heart rate (HR) and blood pressure (BP) will be low. Repeat, the antagonists, atipamezole and naltrexone if not up in 15 min

BAM = combination of butorphanol, azaperone, medetomidine

- Aerial capture crews can use 5−10 mg midazolam immediately after capture to help reduce struggling and associated overheating.
- Depending on the time of an anticipated release, an injection (0.2 mg/kg) of haloperidol or azaperone may be used to calm animals during transport to the release location.
- A veterinarian or other qualified individual must be consulted when considering the need for, or type of, sedation.
- BAM - Dose varies 1.2–1.5 cc ewe, or yearling; 1.5-1.7 cc ram; can top off with 0.1 cc IV if needed; repeat atipamezole and naltrexone if not up in 15 min.

Oxygen

Supplemental oxygen can help moderate physiological stress incurred during capture. Oxygen administered via a nasal cannula at a rate of 2–6 L/min can be very beneficial and is advised in critical care or emergency situations. A pulse oximeter (goal is >90% saturation), or mucous membrane color (pinkish as compared to bluish) may be used to monitor oxygen levels.

Anthelmintics

Prior knowledge of the parasites present in herds or metapopulations can help ensure that the appropriate anthelmintics are administered. Translocated animals with reduced parasite loads may prevent transmission to naïve animals and provide translocated animals an advantage in novel habitat. Consider administration of a broad-spectrum anthelmintic, such as doramectin, for all translocations because it is nearly impossible to be aware of all parasites that may be present. Injectable preparations having an extended length of action (e.g., eprinomectin) that are effective against ectoparasites and endoparasites and have larvicidal action are preferred.

Selenium-Vitamin E

Injectable combinations of selenium and vitamin E are frequently given as prophylaxis for capture myopathy and may supplement low selenium levels that characterize many wild sheep ranges. There is, however, no evidence that treatment at the time of capture is beneficial or protective, because selenium products (e.g., BoSE, MuSE) do not contain enough vitamin E to be helpful. Thus, an additional vitamin E product should be given, and may help stabilize cell membranes and provide some benefit in cases of mild capture myopathy.

Antibiotics

There is substantial and valid concern about the evolution of antibiotic resistant bacteria in human and veterinary medicine. The use of antibiotics as prophylaxis for wildlife is controversial and is not supported by some wildlife veterinarians. For example, a disruption of healthy gut flora in healthy animals may be more detrimental than a bacterial infection resulting from a capture-related injury. It is essential that this topic be discussed prior to the capture event, and that treatment protocols are agreed upon. Long-acting penicillin or oxytetracycline are sometimes used to treat capture-related injuries. There are, however, more suitable, and longer-acting therapeutics to prevent or treat respiratory disease caused by Pastuerellaceae and *Mycoplasma* spp. in stressed cattle during and following transport; among these are tulathromycin (Draxxin) and ceftiofur (Excede). Efficacy trials for some products have been conducted in domestic sheep and goats and may serve to extrapolate doses to wild sheep.

Vaccination

Clostridial Bacterin

- Post-capture clostridial bacterial infections of muscle tissue (e.g., blackleg) have occurred in some sheep following translocation. Clostridial bacteria typically release strong toxins when anaerobic conditions suitable for growth occur. Clostridial bacterins are given to domestic ruminants to prevent diseases such as tetanus, blackleg, and gastrointestinal overgrowth. Vaccination protocols suggest they generally are ineffective in animals experiencing stress, and it is necessary to inject with a booster after 3–4 weeks to gain full protection. For these reasons, clostridial bacterins rarely are used during capture events.

Bluetongue/Epizootic Hemorrhagic Disease Vaccination

- Bluetongue and epizootic hemorrhagic disease viruses are transmitted by a flying gnat (*Culicoides* spp.) or other insect vector. Prevalence of these viruses is dependent upon environmental conditions that affect vector biology such as temperature and precipitation. Prevalence may vary dramatically across a state. When considering translocation across a prevalence gradient, vaccination for EHD and BTV may improve survival. The vaccine is available from Newport Labs (https://newportlabs.com/ Worthington, MN). Use of the vaccine may require approval from the State Animal Health Veterinarian.

Respiratory viruses (Infectious bovine rhinotracheitis, bovine viral diarrhea, parainfluenza 3 and bovine respiratory syncytial virus).

- The prevalence of and exposure to these viruses may vary geographically and among bighorn populations. In some populations, some of these viruses have been implicated in respiratory disease and pneumonia disease events. The vaccines are typically available only as a group and are sometimes combined with “a bacterins” for *M. haemolytica* and *Haemophilus somnus*. Vaccination with the killed viral product appears to be safe and may prevent clinical disease. Vaccination with the products containing the “bacterins” may be associated with vaccine reactions.

Treating Capture-Related Conditions

Intravenous or Subcutaneous Fluids

Balanced electrolyte solutions (e.g., Plasmalyte; see protocol and previous suggestions) given subcutaneously or intravenously are used to reduce acidosis and reverse the dehydration brought about by shock, hyperthermia, or other capture-related stressors. Administration of cool intravenous fluids (0.25–0.5 gal (1–2 L) of a balanced electrolyte solution such as Normasol or Plasmalyte, pH 7.4 will further cool the animal and correct hypovolemia associated with hyperthermia.

- A sterile IV administration kit and a catheter (14–16 G) placed in the lateral saphenous or cephalic vein can be used to quickly administer fluids. There generally is little to no response from the sheep when the catheter is placed.

Non-Steroidal Anti-Inflammatory (NSAID)

Various products (e.g., meloxicam, ketoprofen, flunixin meglumine) are commonly used in domestic livestock to reduce inflammation, swelling associated with trauma, or as a potent analgesic (pain reliever). These NSAIDs can be routinely used on animals that are stressed by hyperthermia, musculoskeletal injuries, or other trauma. Depending on the drug, they are given subcutaneously, intramuscularly, or intravenously.

Dexamethasone

This steroid is used to treat individuals diagnosed with acute shock or demonstrating signs of severe capture stress. It may be protective and assist in maintaining normal respiration and heart rate and blood sugar levels and may improve general well-being. Dexamethasone should be used with caution and can cause abortion if given in the last trimester of pregnancy.

Euthanasia

Euthanasia may be necessary because an animal has an injury and is in significant pain, or for other welfare concerns; it may also be part of a lethal sampling protocol, or necessary in response to a disease outbreak. Thus, the reason for euthanasia may dictate the method used. A discussion of methods, necessary equipment or drugs, and the care and disposition of samples, and animal remains must be part of the capture-planning process.

Gunshot

- Use of a captive-bolt gun, placed directly above the forehead, is the preferred method, but a small caliber (e.g., 22 caliber, long rifle) cartridge also can be used.
- Do not use hollow point or soft point bullets, because they may not penetrate the skull.
- Hold the firearm 2-3 ft (0.6-0.9 m) away from and perpendicular to the skull.
- Placement of gunshot:
  - Head
    - At the 'X' formed by lines drawn from one ear to the opposite eye, aiming down the neck; this location will have a minimal effect on the frontal sinuses.
    - On a line from the poll (the bony prominence between the ears) aimed downward toward the back of the throat
    - Behind one ear and aimed at the opposite eye
  - Heart
    - Just behind the elbow and directly into the thorax.

Drugs

- Euthanasia solution, usually a barbiturate or combination of barbiturate and another drug, can be used for an intravenous injection. Following death, animal remains must be buried deeply, incinerated, or deposited in an appropriate landfill to prevent secondary poisoning of scavenging birds or mammals.
- Intravenous injection of other drugs, such as potassium chloride, should be used only on anesthetized animals.

Confirmation That Death Has Occurred

- Following chemical euthanasia, there will be some degree of involuntary movement of the limbs, muscle twitching, or a short period of agonal breathing. These are reflexes only, and do not infer or indicate consciousness.
- Lack of a heartbeat, absence of voluntary respiration, lack of corneal reflex, and eyes that will not close indicate that death has occurred.
- If gunshot is used, the animal will collapse immediately, and it will not attempt to right itself.

Necropsy

Training for Personnel

- In order to become proficient, personnel must observe and participate in a necropsy, and then collect samples. Such training can be quite challenging during actual capture events,

and it likely is most efficient for various agencies to provide periodic necropsy training. Readers are referred to Appendix 3.5 for additional details and guidance.

Sample Collection

- The objective of necropsy is to systematically examine and document the condition of an animal, and to collect a suite of samples for additional testing. Using a necropsy form that has been prepared ahead of time, and a camera, will expedite this procedure.
- Most investigators do not collect enough material, and sometimes do not collect the correct specimen(s).
- Investigators must describe all tissues collected, including what they perceive as appearing 'normal', and those that do not appear 'normal'.
- Tissue samples must be kept cold but, if necessary to preserve them, may be frozen. Fresh samples are better than frozen, but frozen is better than rotten or otherwise not usable. If it will be more than 3 days before tissues can be examined, freeze them.
- Investigators must follow basic necropsy protocols, and must be certain to collect the following samples:
  - Lung tissue from each of the lobes of both lungs;
  - Nasal, tonsillar, and distal tracheal swabs;
  - The entire head; and
  - Other tissues as dictated by local conditions, or according to protocols established for a specific capture event.

Appendix 3.1. Sampling Supplies and Necessary Equipment

Sampling kits for each animal with syringes, blood tubes, swabs, and cryovials for the swabs can be assembled for helicopter or darting events. Sampling kits can also be useful in base camp operations, but syringes and needles, or vacutainer holders and needles, can be left out of these. Always pre-label the tubes, and as a back-up identification system, write the eartag number, collar frequency, or other means of identification, on the sample bag. Necessary equipment is listed below.

Animal Handling

- Blindfolds and hobbles
- Stretchers or sling bags with which to move animals
- Tables or tarps upon which to place animals
- Shade shelter(s), if needed

Animal sampling and treatment

- Thermometer
- Stethoscope
- Assorted syringes and needles
- Vacutainer holders and needles
- Blood collection tubes, usually serum separator (red and gray top), and EDTA (purple top)
- Swabs
- Cryovials with and without media (TSB with 10% glycerol)
- Swab holder with light
- Laryngoscope or paint sticks to depress tongue
- Mouth gag or speculum
- Adequate sources of water and buckets or ice for cooling animals
- Ear notcher or biopsy punches if doing BVDV testing
- Containers with ethanol for ectoparasites
- Whirl-Pak bags
- Screw cap tubes, 15 mL, and 50 mL
- Disposable latex or nitrile gloves
- Camera (for photographing abnormalities)
- Balanced electrolyte solution - ideally something that can be administered either subcutaneously or intravenously, such as Normosol R or Plasmalyte
- 16–18 G catheters and IV administration lines
- Oxygen, nasal cannulas, and administration tubing
- Sterile surgical packs, gloves, and suture material from 5-0 to 0
- Surgical stapler
- Bandage material
- Parasiticides
- Method for euthanasia
- Antibacterial ointment, spray, solution, and scrub
- Necropsy kit

- Antibiotic, non-steroidal anti-inflammatory, and other drugs (see Appendix 3.3)
- Sharps containers
- Paper towels
- Cloth towels

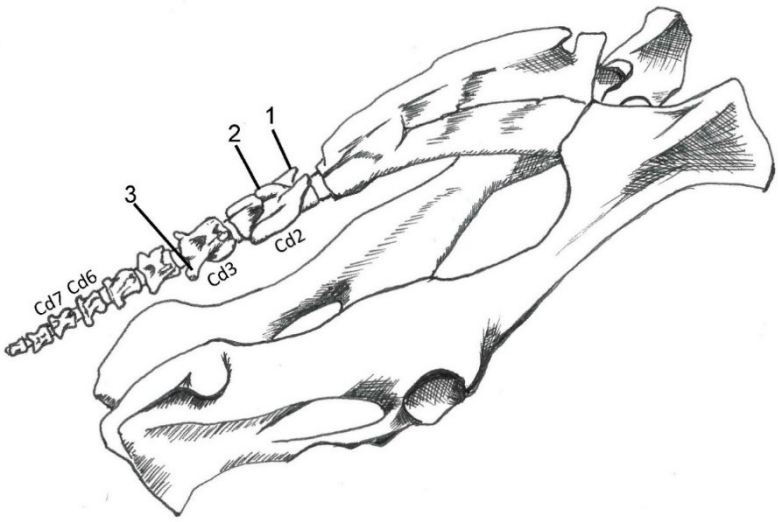
Sample handling and processing

- Tube racks
- Ice chest and ice, or 12 V refrigerator
- Centrifuge if processing blood in field and generator and extension cord
- Datasheets
- Permanent markers
- Bacterial plates (if beginning culture process in field)
- Incubator for field culture

Appendix 3.2. Body Condition Scoring Guide

Body condition scoring is a means of assessing the nutritional status of an animal and transforming a subjective assessment into a numerical value that can be useful when describing the overall health of an individual or general status of a population. There are many methods and scales available. Some have been correlated with total body fat. The simplest method involves palpating certain bony landmarks for the amount of subcutaneous fat. The more technically challenging incorporates the use of an ultrasound machine to measure the subcutaneous fat long with the palpation of certain landmarks. Included here are the reference, figure, and table for one method that has been carefully evaluated.

Stephenson, T. R., D. W. German, E. F. Cassirer, D. P. Walsh, M. E. Blum, M. Cox, K. M. Stewart, and K. L. Monteith. 2020. Linking population performance to nutritional condition in an alpine ungulate. Journal of Mammalogy 101:1244–1256.



Score	Sacro-sciatic ligament[1]	Caudal vertebrae (Cd2-3) cranial to tail	Caudal vertebrae (Cd6-7; tail)
6	0” (0 cm)	Vertebrae are not detectable[2]	Detectable with much fat
5	1/8” (0.3 cm)	Vertebrae barely detectable	Detectable with some fat
4	1/4” (0.6 cm)	Cranial articular processes are detectable	Individually palpable but fleshed
3	1/2” (1.3cm)	Cranial articular and dorsal spinous processes are detectable	Individually palpable but not fleshed
2	3/4” (1.9 cm)	Cranial articular and spinous processes are individually palpable[3]; transverse processes are detectable	Individually palpable with obvious joint space
1	1” (2.5 cm)	Cranial articular, spinous, and transverse processes (Cd3) are individually palpable	Not fleshed over bone but minimal flesh in joint space
0.5	1 1/8” (2.8 cm)	Cranial articular, spinous, and transverse processes (Cd3) are emaciated[4]	Emaciated bone and joint space

[1] Extent to which index finger may be inserted on caudal side of ligament, adjacent to caudal vertebrae (“pelvis score”)
[2] Detectable = vertebral process can be detected but is fleshed
[3] Palpable = vertebral process can be fully palpated but is fleshed
[4] Emaciated = anatomical features of the bone are completely palpable, not fleshed, with only skin over bone

Appendix 3.3. Drugs

This is a list of commonly used drugs. There may be additional drugs used by some agencies and new drugs may be developed in the near future.

Drug	Trade Name	Dose	Purpose
Atipamezole		2X the volume of BAM	Antagonist for BAM*
BAM*		1.2–1.5 cc/animal	Tranquilizer
Ceftiofur	Excede	6–7 mg/kg	Antibiotic
Doramectin	Dectomax	0.2–0.4 mg/kg	Parasiticide
Flunixin meglumine	Banamine	0.5–1.0 mg/kg	Anti-inflammatory, analgesia
Haloperidol		10–15 mg/animal	Tranquilizer
Ivermectin	Ivomec	0.2–0.4 mg/kg	Parasiticide
Midazolam		5–10 mg/animal	Tranquilizer
Moxidectin	Cydectin	0.2–0.4 mg/kg	Parasiticide
Naltrexone		0.5 cc/animal	Antagonist for BAM*
Oxytetracycline	LA 200	20 mg/kg	Antibiotic
Vitamin E-Selenium	Bo-Se	2.5 cc/45kg	For deficiency, may cause abortion

*BAM = combination of butorphanol, azaperone, medetomidine

Appendix 3.4. Sample Collection Details

Sample Collection

To increase handling and sampling efficiency, the role of each team member should be clearly defined prior to initiating the capture event.

Blood Collection

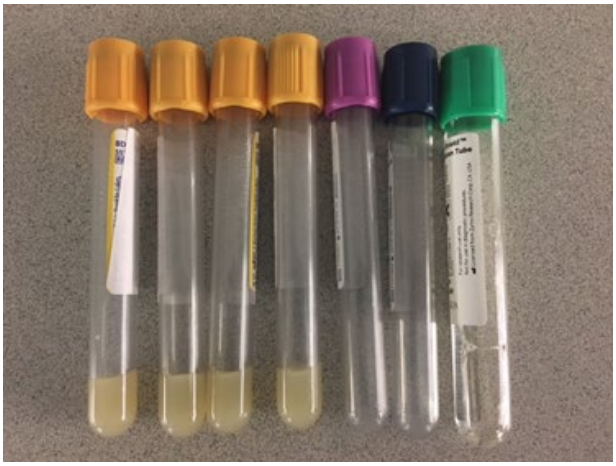
- Blood is the most important sample to collect from each animal.
- Training and experience are required to collect blood. The most experienced team member should oversee blood collection by new staff and should take blood when handling times are limited.
- The quality of data obtained from blood samples will be compromised by improper collection, handling, processing, and storage.
- Head control and proper positioning (head and neck not bent or twisted) are especially important if taking blood samples from the jugular vein (Figure 3.2). Other veins may also be used for blood collection (see below).
- Each kit has all supplies and blood tubes for completing the collection.
- Ensure the blood collection tubes are at 18–25ºC prior to use. NOTE: all blood tubes should be kept at this temperature to avoid temperature shock to the blood cells. If the tubes are removed from the sample bag and placed in your pocket prior to sampling temperature shock can be avoided.
- Blood is collected with needle and syringe or directly into the tube using a sleeve and special needle from the jugular vein, the cephalic vein (front leg), or the saphenous vein (hind leg).

Figure 3.2. Location for blood sampling from the jugular vein. (Source: CDFW)

- The vein must be held off by a hand on the neck below the vein access point, or by tourniquet on the leg above the vein access point (between the access point and the heart) to build up pressure and locate the vein.
- Hold the needle with the bevel up and insert carefully above the vein and puncture the vein. Once the vein is punctured, blood is seen in the needle hub and the blood can then be pulled into the syringe. Slowly pull until enough blood is collected to fill all tubes. With vacutainers, the tube will fill automatically.

Blood Transfer to Sample Collection Tubes

The blood collection tubes are in the kit in a BUNDLE with an elastic band. They contain a variety of fluids or compounds and are all under negative pressure.



Yellow tops are for serum separation, purple tops (EDTA) are for whole blood, royal blue tops are for trace mineral, and green tops (heparin) are also for whole blood.

- To prevent hemolysis (the rupture of red blood cells turning serum pink or red), do not squirt or force blood into collection tubes. Instead, once the syringe is full, insert the needle through the end and negative pressure will passively draw the blood from the needle and syringe into the collection tube.
- If the vacuum has been compromised, remove the cap and blood can be gently and slowly injected along the sides of the tube.
- Gently roll or turn all tubes immediately after collection to ensure the blood and contents are well mixed. This is especially important for purple and green tops.
- Once filled, handle blood tubes with care. Place upright in a cooler to protect from shaking, rough handling, direct sunlight, freezing, and heat.

Skin Biopsy (for population genetics, BVDV testing)

- Use the 0.25 in (6 mm) biopsy punch to place holes for each eartag. Use the same punch for both ears if two tags are used.
- Avoid large blood vessels in the ear, and target between the two cartilage ridges inside the ear flap. Please refer to “Chapter 4: Collaring and Marking Wild Sheep” for additional details.
- The punch blade is very sharp. Use an old piece of radio collar belt or folded paper placed on the back of the ear to protect your fingers.
- Transfer each ear biopsy into the SMALLER PAPER ENVELOPE provided in the kit or to a cryovial with desiccant beads.
- Record the number of biopsies collected.
- Air dry (in the envelope) at room temperature.

- Ensure biopsy sample envelope is labelled with: animal ID, herd, species, body site of sample collection, and date.
- Store skin biopsies at room temperature in desiccant, protected from heat, light, and moisture.
- Dispose of used punches in a crush-proof, puncture-proof sharps container.

Nasal swab (for bacterial culture and *M. ovipneumoniae* testing)

- Insert each swab into both nasal passages close to the wall between nostrils if possible, approximately 1-2 in (3-5 cm) (e.g., no further than the distance between the nose and the eye). Twirl swab.
- Place the swab back in the appropriate media vial or empty cryovial, breaking the stick off so that it will fit in the tube.
- Label the tube with pre-printed labels with WHL ID and 'NASAL SWAB'.

Ear swab (for *Psoroptes* detection)

- Insert a separate swab into each ear. Do not force the swab further than it will go with gentle pressure.
- Put swabs together in one sterile labelled cryovial.

Feces (for intestinal parasites, population genetics, or dietary quality)

- Using the glove provided, use 2 or 3 fingers to collect 5–10 fecal pellets per animal (or from the ground or snow).
- If collecting from the rectum, be careful to prevent tissue damage.
- For population genetics and parasite testing
  - Place pellets in the Whirl-Pak (NO ZIPLOCS) provided, remove as much air as possible and avoid crushing pellets.
  - Fold the bag down 4 times and fold the tabs to the center, sealing the bag
  - Store the fecal sample on ice or refrigerated (4°C) if for intestinal parasites or
  - Store frozen if for population genetics (minimum -20ºC); AVOID FREEZING, THAWING, or REFREEZING.
- If feces are being collected to estimate diet quality do NOT place in plastic bags but in paper bags, and air dry.

External Parasites

- Collect a sample of any external parasites (e.g., different life stages if present) if noted.
- In the field, ectoparasites can be temporarily placed in any small container if well sealed.
- Back at the lab, transfer specimens into cryovial(s) or screw-top specimen containers with 70% ETOH (Ratio of 10-parts ethanol:1-part parasite).
- Label containers with WLH ID, herd or study area, species, parasite type, body location recovered, and date.
- Store 70% ETOH at room temperature, protected from heat and light.

Appendix 3.5. Bighorn Sheep Field Necropsy Manual

Background

Vital information can be gained by examining the carcasses of wildlife even when the cause of death is apparent, such as by gunshot or vehicular trauma. Wildlife biologists and wildlife managers can provide the wildlife health program with the information needed by performing field necropsies following a consistent necropsy protocol. This involves a systematic examination of the entire carcass, documentation of findings with words and pictures, and collection of samples. This protocol should provide the information needed but participation in a field necropsy course will enhance the information gathered by the field personnel.

- When is it important to get an animal into necropsy? If there are unusual signs, like bleeding from orifices without signs of trauma, multiple deaths (>3 mid-sized to large animals) in a small area, any bighorn sheep known to be dead <24 hrs.
- When is it too late to worry about it? Anything dead more than 48 hours unless in the dead of winter with temperatures in at or below 40° F (4° C) at night.
- What should be frozen and what should be refrigerated? All tissues can be frozen. Blood and culture tubes should be refrigerated. While freezing causes artifacts when processed for histology, it is better than allowing the tissues to autolyze. Fixed tissues (in formalin, alcohol, or other preservatives) should not be frozen; refrigeration is ok but not usually necessary.

Equipment Needed:

Protective clothing

- Rubber gloves
- Rubber boots or plastic foot protectors
- Rubber or plastic apron (a large garbage bag will work)
- Coveralls
- Mask
- Goggles or face shield

Necropsy documentation

- Camera
- Necropsy report form

Necropsy equipment

- Sharp knife (plus sharpening stone)
- Scissors (small and large)
- Forceps
- String
- Hack saw or bone saw
- Small and large shears
- Scalpels
- Plastic ruler or measuring tape
- Ziploc or Whirl-Pak bags
- Rigid plastic containers with screw on lids
- Sterile vials or blood tubes
- Sterile syringes and needles (20 G)
- Sterile swabs in transport tubes
- Cryovials with and without media
- Labeling tape or tags
- Permanent markers, and pencil
- Ice and coolers
- Absorptive packing materials
- Sealing tape
- 10% buffered formalin (see Appendix 3.1 for formulation)
- 70% ethyl alcohol for parasites
- Chlorhexidine solution
- Pail and brush
- Disinfectant
- Soap
- Bleach

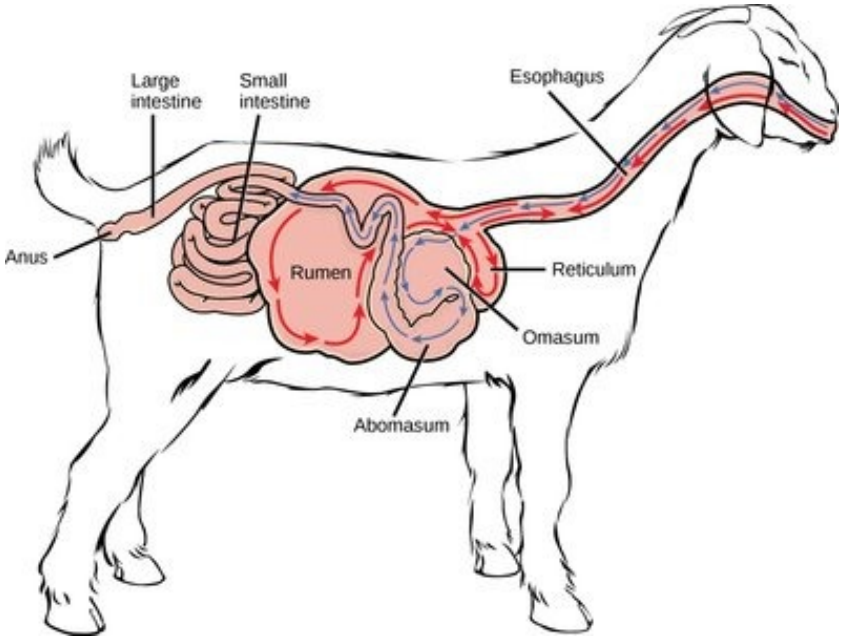
Safety Precautions

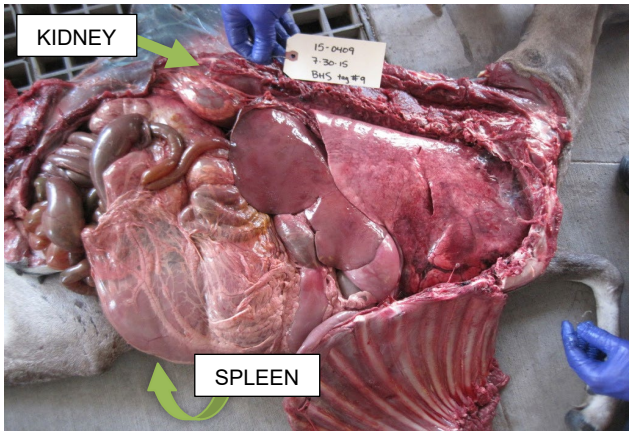
- Animals carry diseases that can infect people and often this cannot be determined without laboratory testing. Protect yourself by wearing protective gear.
- Anthrax causes bleeding from the mouth, nose, and anus. Carnivores will have a swollen head and neck. Ruminants will have a large, tarry, dark spleen. If you find this, then stop the necropsy and call a veterinarian
- Do not use any method which results in the dispersion of droplets of blood or fluids.
- Minimize exposure of other wildlife to disease by burying the carcass as soon as possible.

Getting Started

- Fill out the first part of the necropsy report form.
- Label sample bags, containers, blood tubes, and swabs with the following:
  - Date,
  - Species
  - Sex
  - Approximate age
  - Tissue identification
  - Person taking sample and
  - Animal ID (if tagged)
- Make a card with the same information and include it in each photograph.

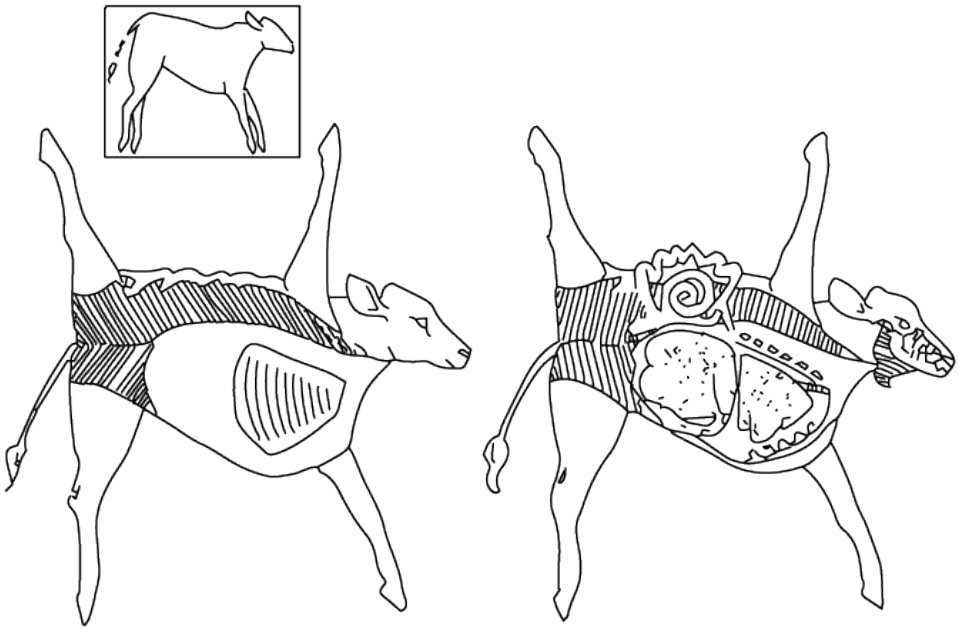
Ungulate Anatomy





The Necropsy

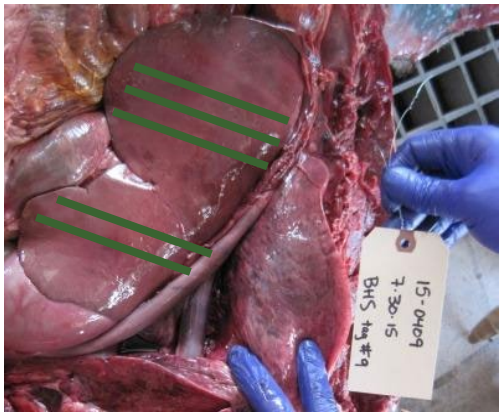
- Environmental evaluation
  - Take water samples.
  - Look for suspicious substances.
  - Examine evidence.
- External exam
  - Look for signs of trauma.
  - Look for external parasites.
  - Note general body and coat condition.
  - Take 2 or 3 pictures (left, right, front).
  - Take nasal swabs.



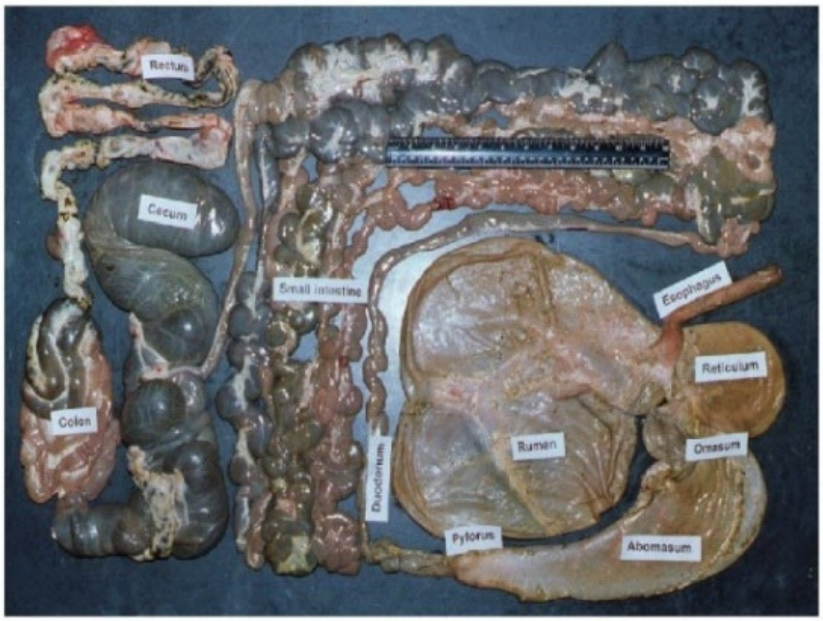
- Internal exam—most large animals
  - Lay the animal on the left side.
  - Lift the right rear leg and cut through the hip joint; lift the right front leg and cut into the axilla (armpit).
  - Connect the two incisions by cutting through the hide and removing it from the chest and abdominal wall.
  - Carefully, make an incision in the abdominal wall from the genitalia to the chest. Remove the ribs from the right side of the abdomen. Take a picture.
  - Expose the trachea and esophagus in the neck.

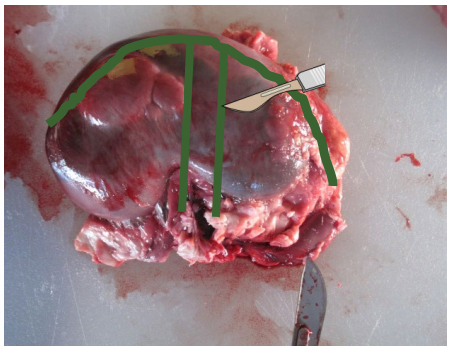
  - Examine the thoracic cavity.
    - Remove the trachea, heart, and lungs from the body.
    - Open the trachea along the soft membrane from where you cut it until you reach the lungs.
    - Take samples of the lung - 3 each from right and left sides, cranial, middle, and caudal lobes, take some from lung margin and some from near large airways.
    - Collect the distal trachea.
    - Take samples of the heart approximately 4 in^2 (25 cm^2).
    - Place samples in separate labeled Ziploc or Whirl-Pak bags.
    - Examine the inner rib cage.
    - Describe abnormalities in terms of discoloration, fibrin, adhesions, and consolidation (see pictures at end).

- Take samples from the liver, spleen, kidneys, and any unusual looking tissues. Place samples in separate labeled Ziploc or Whirl-Pak bags.



- Liver (pictured above left) – Make several slices through the lobes looking for hidden lesions; collect 0.2 in (0.5 cm) thick samples for formalin and 1 in^2 (6 cm^2) for examination as fresh.
- Spleen (pictured above right) – found on the left side of the rumen; make several slices looking for hidden lesions; collect samples as you did for the liver.
- Gastro intestinal tract – Large rumen filled with grass and ingesta, may be somewhat dry in desert species; smaller reticulum is pocket in front, omasum is round with flat sections inside, abomasum looks like stomach; followed by intestine – duodenum, small intestine, cecum, colon, and rectum. It is not often rewarding, but samples should be collected when diarrhea and other abnormalities are detected.
- Kidneys – Slice in half longitudinally; collect samples 0.2 in (0.5 cm) thick from the half section.





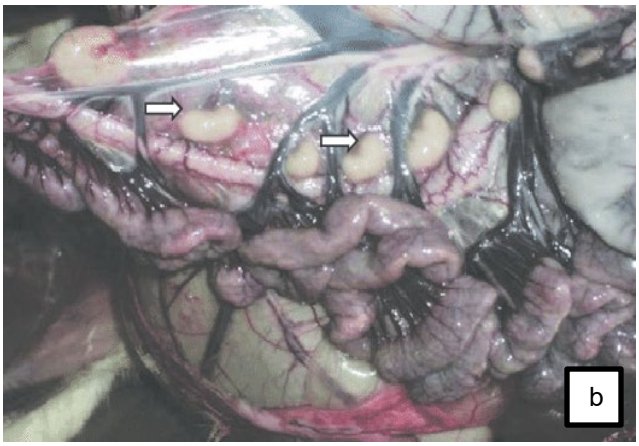
- Urinary bladder – Open and look for mineral deposits, thickening, roughening of inner surface.

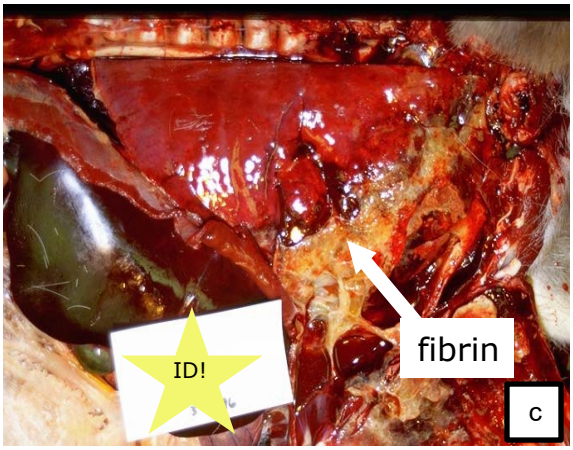
- Take several samples of intestine. Use string to close off each end of a 2-3 in (5-8 cm) section. Place samples in labeled Ziploc or Whirl-Pak bags.
- Open the intestinal tract and look for ulcers, worms—stomach, intestines, colon. Take additional samples of abnormalities or parasites.
- **Note: if you have formalin containers – collect a second set of the same tissue samples, tissues must be no more than 0.25 in (6 cm) thick and need only be 1 in (2.5 cm) in diameter. Keep the volume of tissue in any one container less than $^{1}/_{8}$ the volume of the formalin.**

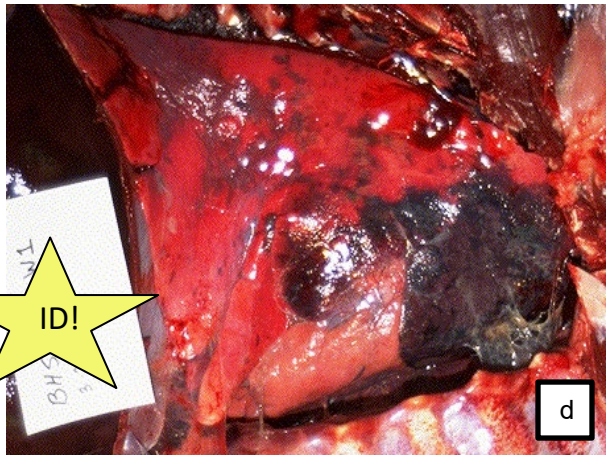
Ship the Samples

- Place the samples in a second Ziploc bag (more than one sample can go in each second bag).
- Place in the cooler with blue ice. If you have to, use wet ice and double bag it. Water will ruin the samples. If you don't have a cooler, place the ice and samples in a large garbage bag.
- Keep samples cold or frozen.

Pictures of Abnormalities







Figures a-e: a) Contagious ecthyma in a young ram; b) enlarged mesenteric lymph nodes; c) fibrin creating adhesions in pleural space; d) consolidated right cranial lobe and fibrin in a case of pneumonia; e) thickened urinary bladder with small stones

WILD SHEEP CAPTURE & HANDLING GUIDELINES

WAFWA
WESTERN ASSOCIATION OF FISH & WILDLIFE AGENCIES

Wild Sheep Initiative

CHAPTER 4

COLLARING & MARKING WILD SHEEP

LAST UPDATED: JUNE 2024

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Wild Sheep Collaring and Marking

Purpose and Need

Even before the efforts to restore bighorn sheep populations were well underway, wildlife managers were marking wildlife to learn about habitat use, survival rates, or behavior. As technology advanced, binoculars and ear tags were replaced with very high frequency (VHF) telemetry collars and, later, with collars incorporating Geographic Positioning System (GPS) technology and remote cameras. The questions to be asked, however, have remained critically important when determining collaring and marking options.

Objectives can range widely, and some marking approaches can fulfill multiple objectives if careful consideration is given during project planning. In the past, VHF collars offered biologists triangulated data points or opportunities to locate individual animals from aircraft, and data acquisition was limited by staff resources or the degree to which the landscape was accessible. Today, satellite-based GPS collars offer location and activity data that are conveniently transmitted to investigators. Along with changes in technology, so have the objectives many biologists build into their study designs. Datasets extending across multiple years are extremely valuable, and the ability to investigate survival, movements, and habitat use under a variety of environmental conditions or to monitor translocated animals for an extended period all are highly desirable. Each project or study design will require specific forethought and planning, and the number and type of telemetry devices available will vary widely (Appendix 4.1).

Collar Features and Monitoring

Technological advances have enabled wildlife managers to track wildlife, essentially in real-time, and have gone far beyond transmitting a VHF signal that allows a researcher to locate an animal from the ground or from the air. Some of these capabilities include collar-to-collar communication, proximity sensors, geo-fencing, and solar-charged batteries. Nevertheless, standard VHF collars remain useful and are suitable for some projects or purposes. It is strongly recommended that all collars, regardless of design, incorporate a drop-off mechanism that allows the collar to separate from the animal after a predetermined length of time, or allows the investigator to drop the collar at a time of the investigator's choosing.

Collar Types

VHF collars transmit a radio signal to a receiver used by the investigator. Technological advances have greatly improved monitoring and tracking capabilities, but VHF-only collars can be used only to locate animals or monitor for mortalities. They can also serve as visual markers and may be useful for inadequately funded or less elaborate projects. The cost per collar is inexpensive relative to more advanced technology, and battery life generally is lengthy. Nevertheless, they are labor intensive and require that the investigator observe the collared animal to determine its location accurately. In remote or expansive areas aerial telemetry is necessary when VHF-only collars are deployed. Although accuracy was not affected by elevation above ground level (AGL), terrain features and AGL in combination have been shown to significantly affect precision of the estimated location. In addition:

- Deflection of the signal can occur because of topographic features, and is known as 'bounce', making it difficult for investigators on the ground to ascertain the direction from which the signal originates.
- The potential for 'bounce' (e.g., signal deflection) likely is exacerbated by absolute distance from the animal.
- VHF collars transmit the signal on a unique frequency assigned to the collar.
- The radio frequency on which the collar is designed to transmit can change with time, or 'drift' away from its designed frequency.
- When 2 or more collars are near each other and their unique frequencies are inadequately separated from each other, signals from both collars may be received simultaneously and be detected as a “double beep”. This is known as 'bleed-over'.
- GPS store-onboard collars collect geographic coordinates at predetermined times of the day and store that information in the collar’s ‘memory’. These collars also transmit a separate VHF signal so that investigators can locate and retrieve the collar.
    - They are available at a reasonable price.
    - Battery life is affected by the rate of attempts to determine locations.
    - VHF ‘active’ periods can be adjusted so that signal broadcasting is not constant, and this can extend battery life.
    - It sometimes is difficult for the unit to acquire a fix if the animal is not in an area with a clear view of the sky.
    - The collar must be retrieved before data can be downloaded.
- GPS collars with communication capability collect and store geographic coordinates onboard, but also communicate with satellite networks, such as Iridium, Globalstar, or Argos and allow points to be uploaded for viewing by the investigator. These collars also transmit a separate VHF signal so that investigators can locate and retrieve the collar.
    - They are the most expensive of all units.
    - VHF ‘active’ periods can be adjusted so that signal broadcasting is not constant, and this can extend battery life.
    - Battery life is affected by the rate of attempts to determine locations and communicate with the satellite network.
    - Satellite communications may be interrupted and can be sporadic.
    - Subscription or data fees are required to retrieve the data transmitted from the satellite.

Collar Material

Collar neck-band material must be durable but pliable and not contribute to abrasions, hair loss, lacerations, or bone damage. Typical bands are about 2 in (50 mm) wide and 3/32 in (2 mm) thick. Many different types of material are available, and we recommend manufacturers be contacted for samples to evaluate.

For situations in which either growth or seasonal variation in neck circumference is anticipated, investigators will need to consider including sections that either expand or decompose, and thereby are designed to allow an increase in collar circumference.

Shape and Fit

If data acquired from collared individuals are to be meaningful, it is essential that marking devices do not influence outcomes (White and Garrott, 1990). Collars and marking devices can affect subjects in multiple ways (Murray and Fuller 2000; Withey et al. 2001), including changes in behavior, foraging ecology, energy balance, body condition, reproduction, recruitment, and survival. Ultimately, all of these can impact reproductive success, which has serious implications for individual study animals (Bleich et al. 2003), and can lead to biased research results (White and Garrott 1990). Thus, it is essential that investigators ensure that telemetry collars or other methods of marking animals do not in some way compromise study animals.

Similar concerns have provided cautions regarding the potential of such effects to further affect animal welfare, public opinion, or future opportunities to conduct meaningful research (Bleich et al. 1990, McMahon et al. 2012). Multiple authors (Bleich et al. 1990, Torres 2023, Massing et al. 2024) have provided information regarding the morphology or body weight of North American wild sheep, and others have emphasized the importance of proper fitting collars in the context of injuries or collar design (Bleich et al. 1990, Bleich and Pierce 1999, Krausman et al. 2004). Information available in the literature, our personal experiences, and data presented herein (Appendix 4.2, Appendix 4.3), form the basis of the recommendations included in this section. These guidelines are presented to help ensure the best possible outcomes in terms of animal welfare, the acquisition of meaningful and unbiased information, and for the future of wildlife research.

Shape

Do not deploy round collars on wild sheep; use pre-shaped oval or tear-drop collars to better conform to the natural shape of the neck (Figure 4.1).

Proper fit

It is essential to recognize and accommodate all lifecycle events that may affect neck circumference.

- There is an increase in body size, including neck circumference, from young to maturity.
- There is a difference in pelage length or density between summer and winter.
- Weight loss and gain occur between seasons.
- Ewes that experience a full-term pregnancy and those that lose a fetus early may differ substantially in weight gain or loss and, hence, neck circumference.
- There may be limited neck swelling of rams during rut activity. Time of year and associated biological variables (e.g., winter vs summer coat, weight gain or loss due to seasonal changes, and increased movements, etc.) are critically important factors when considering proper collar fit.
- Be cognizant of all these factors and then fit the collar snugly (Figure 4.1). Neck circumference changes throughout the year; keeping this in mind, investigators should ensure the best possible collar fit on a year-round basis.
- Most manufacturers offer antenna options, and the design selected will affect the options available to alter the collar material to ensure proper fit.

Figure 4.1. Proper collar shape and fit.

Collars with an expansion section

We should strive to have expansion sections on both ram and ewe collars to decrease the potential for complications with respect to collar fit. Expansion collars are being used to help compensate for varying neck sizes of an individual animal, as well as to mitigate neck-size variance depending on where the collar is placed on the neck (e.g., placing the collar high on neck closer to animal's head vs lower on the neck and closer to the body). Various designs are available, as follow:

- Magnets in a protective durable sheath
- Bungee cord in a protective durable sheath
- Spring cables in a protective durable sheath
- Collar pleats created with thread of a specific breaking strength for use on neonates

Collars without an expansion section

Please review the above factors and variables that cause seasonal and annual variation in neck size to ensure the best possible collar fit on a year-round basis. Also, be sure to consider the following points.

- Winter captures – with full pelage and ewes likely pregnant, the neck will likely be its largest size of the year, so it needs to be fitted very tight, with the winter coat visibly compressed under the collar but not impinging on the throat. For rams, if during the rut, it should be tight with winter coat compressed under the collar; if after the rut, the collar should be snug and barely able to be rotate around the neck with minimal compression of the winter coat.
- Summer captures – unfortunately, the collar will need to be loose on the neck of an animal that has shed its winter coat. How loose it should be will vary with body condition, but the collar must be able to rotate freely around the animal's neck.

Neck circumference by subspecies

Variation in neck circumference occurs between species, among subspecies, among populations, and among individuals on an annual basis (Appendix 4.2). Properly fitting collars are essential, and it is important to know the age range, sex, and subspecies prior to ordering collars. Project biologists should consider that individual neck circumference can vary from 1 in (25 mm) to >3 in (76 mm) depending on sex, season, or the individual across time. Some personnel have found it helpful to pre-mark collars with the appropriate minimum, median, and maximum circumferences to help handlers fit the collar based on an estimate of the changes in neck size that likely will occur.

Collar Weight to Body Weight Ratio

The weight of the entire collar should not exceed 1% of the animal's average body weight over the course of a year. The reader is referred to Appendix 4.3 for information on variation in body weight among North American wild sheep.

Neonate Collaring

When collaring neonates, remember that the lamb will undergo rapid growth and this must be a consideration. The reader is referred to "Chapter 8: Capture and Handling of Neonates" in these guidelines, which addresses this issue in detail.

Satellite Platform

Project personnel should always endeavour to develop budgets that ensure the best outcome for the wildlife, and to ensure collection of the correct data. The Iridium-based satellite platform provides 2-way communication for changing duty cycles, and some manufacturers provide options that allow investigators to alter the drop-off date, change virtual or geofence geometry, and make modifications to the duty cycle, along with other options. Other platforms currently allow data only to be retrieved from the collar. Regardless of the platform, neither incoming nor outgoing communication can occur if satellite coverage is not available.

Batteries

C- and D-Cell Lithium Batteries

Investigators must consider the pros and cons of meeting or accommodating the following constraint:

- Most manufacturers can offer an estimate of battery life that considers broadcast and data upload schedules and environmental realities, so informed decisions on battery size are possible in the context of project objectives. For example, a 2 D-cell Iridium GPS collar with a 2-hr VHF and upload schedule and a location fix-rate at 4-hrs may last 3-4 years; a similarly programmed 2 D-cell Iridium GPS collar with a 1-hr fix rate can last 2 years, and with a 2-hr fix rate may last up to 3 years. Battery life of collars powered by C-cell batteries will be correspondingly less than that of collars utilizing D-cell batteries.

Solar-charged Batteries

- Solar charging technology currently provides up to 5 years of battery life for GPS collars and dramatically reduces overall collar weight.
- Availability of adequate sunlight is critically important and is affected by vegetative cover, topography, and geography.
- When considering solar technology, think about animal wear and tear on the collar. For

example, rams are typically 'rougher' on collar hardware, which may affect solar panels.

Waypoint Fix Rate and Duty Cycle (e.g., the rate at which fixes are acquired or data are transmitted)

Considerations

- Type of behaviors or activities or management approach that is of interest
- How often the particular event or action occurs
- Objectives of the project or monitoring effort
- The reality of being able to effectively respond to a mortality signal or other events that require action, such as a contact with domestic sheep or to perform a necropsy
- Terrain features or canopy closure that can reduce probability of obtaining successful fixes
- Battery life adequate to extend data collection across the study

Current GPS collar technology provides for a multitude of duty cycles. Take the time to evaluate the duty cycles that will best fit the objectives of the project on a daily, weekly, monthly, seasonal, annual, or other basis. All manufacturers can accommodate highly variable duty cycles. As examples, a separate duty cycle can be programmed for an individual animal based on breeding season, physiological demands to maintain water balance, parturition period, winter constraints, periods of anticipated disturbance, or other factors.

Options for programming are widely available and must be properly programmed prior to deployment. In some designs, it is possible to change settings remotely if the need arises.

Other Special Sensors (that are available as options)

Cameras

- User-programable video clips
- Various levels of resolution
- Specific positioning on the collar and angle of view
- Variable amounts of memory and storage

Proximity Sensors

- Can provide mobile communication between animals via collar-to-collar contact when animals come within a predetermined distance of each other.

Geofence

- Can be programmed to send alerts when an animal moves in or out of a predefined geographic area, to switch to a different fix rate, or to change the upload duty cycle.

Activity Loggers and Accelerometers

- Can be incorporated into a collar or be attached as a peripheral unit
- Can have dedicated storage and battery power, or piggyback on the collar hardware. In the latter case, consider impacts that the added demands of data collection, storage, and transmission will have on battery life.
- Some manufacturers offer download via Ultra High Frequency (UHF) transmission that may reduce demands for data storage and power for uploads.

Environmental or Animal Body Temperature Sensors

Vaginally Implanted Transmitters (VITs)

- These are designed to notify investigators when parturition has occurred, but also provide internal body temperature and the ambient temperature when expelled.
- Maternal condition, pregnancy status, and general health must be ascertained prior to determining if VIT deployment is appropriate; do not place a VIT in a non-pregnant animal.
- Use only sterile equipment and lubricant to reduce the probability of bacterial infection.
- Exercise care to prevent damage to the vagina or vaginal canal.
- VITs should be of the appropriate size and have pliable wings just stiff enough to prevent premature expulsion, and the antenna should not protrude beyond the vulva.
- The reader is referred to “Chapter 8: Capture and Handling of Neonates” in these guidelines for additional details.

MITs (Mortality Implanted Transmitters)

- These are designed to monitor internal abdominal temperature. If value rises above a set threshold, it will trigger a message to Iridium satellites notifying the investigator of a spike in temperature, which could indicate an infection, disease outbreak, or other affliction and notify the investigator of a potentially dying animal, thereby allowing for investigation of a fresh carcass to better assess cause of mortality.

Release or Drop-off Mechanism

Wild sheep are long-lived animals with normally high adult survival rates; therefore, all collars should be equipped with a release mechanism. It is not unusual for ewes to live well into their teens, and a radio collar with a battery life of only 3–5 years but left on a sheep very likely creates an unnecessary hardship on that individual. Several types of release or drop-off mechanisms are available:

- Manual options including powder charge, mechanical, or electromagnetic
- Internal timer or clock that is preset for a specific time period or to a specific date
- Radio or satellite control
    - Must be within a specific distance to send signal releasing the collar, or the release mechanism is activated via the collar manufacturer’s satellite interface. Forethought should go into the timing of the release communications to maximize the ease of collar recovery activities (e.g., plan releases to activate when sheep are likely using gentler terrain).

Other considerations:

- Use of a back-up system, such as cotton or similar material, that eventually will wear through and release the collar is encouraged and can be considered a viable release or drop-off mechanism.
- Release mechanisms add weight to the collar.

Some biologists attach a separate VHF collar in addition to the GPS collar for animals that are part of longitudinal studies. This can be valuable if the animal cannot be captured before the GPS collar fails, if the release mechanism malfunctions, or if the battery dies prematurely. In these situations, the VHF collar allows the animal to be located and recaptured. It is necessary that the combined width of both collars be as narrow as possible, and that the combined weight of the collars does not adversely affect the individual. Whenever two collars are placed on an animal, both collars should incorporate drop-off

mechanisms.

Collar Attachment

The collaring process often creates a bottleneck when processing animals. Extra nuts, stud plates, and nut drivers should always be available during capture operations. Investigators must ensure that collars are properly oriented when they are attached. For example, activity loggers or cameras are direction-specific, and solar chargers must be on the dorsal side of the animal.

Data Viewing

Currently, most collar manufacturers have a web-portal on which to view locations and data on a Google Earth platform or website. This allows project personnel the ability to download files (e.g., kml files) of collar waypoints, and data in text or to Excel-compatible software. Some investigators have contracted with vendors to create unique web portals to meet specific project needs. Additional administrative time is required of all staff when an agency deploys collars from multiple companies. Complications include different operating platforms and website processes for registering collar identifications, programming, downloading, viewing, messaging, or organizing data.

Data Management, Collar Communication, and Downloads

It is critically important to develop a database repository to track collar status involving:

- Available and deployed VHF frequencies within geographic areas for consideration during future collar orders or placement. Additionally, some jurisdictions may require the registration of VHF frequencies with federal regulators, when working across jurisdictional boundaries, or across other applications (e.g., voice-radio communications) to avoid frequency overlap. Proximity to urban centers or military installations where radio communications could be affected by specific VHF frequencies need to be considered.
- The real-time status of a collar (e.g., inactive, active, on mortality, failed, and fate of the animal)
- Attributes associated with each collared animal, including the species, sex, age, manufacturer, model, collar ID, animal ID, collar length or circumference, date deployed, anticipated battery life, duty cycle, uplink cycle, and date the collar is set to be released from the animal
- A relational database including coordinate data and other important collar and animal attributes, which is linked to the other collar attribute tables, capture records, or health data

Collar Bid Process

- Bid and Procurement Process: Select a vendor based on collar specifications that will benefit the project and welfare of the study animals (shape, weight, material, etc.) and not just price. Collar components and specifications should be clearly listed on the bid and on the contract. Warranty language to account for collar failures should be included in the bid and contract process.
- Failure rate remains critically important and must be a consideration during solicitation of bids. There must be a willingness to pay more for better quality and a reduction in failure rates.
- Encourage multi-year procurement agreements to reduce time spent annually on the bid process, and to lock-in collar and satellite data costs.
- All-inclusive packages (e.g., collar, drop-off, pre-paid airtime services and fees, and other amenities) are sometimes offered by collar manufacturers at lower costs.

Collar Company Communication and Feedback

- Until such time that a collective communication tool and platform are developed that enable sharing of information, experiences, successes, and failures, it is recommended that project personnel create and share year-end 'lessons learned' documents. These can be a simple 1-page file note, but they will help others identify and consider challenges associated with product performance or delivery, and animal welfare issues.
- Share copies of year-end project reports or other suitable information with the collar manufacturer, and identify the problems experienced and recommendations to address these in the future. This feedback loop will help both the manufacturer and project personnel implement better solutions to collar infrastructure or design issues.

Visual Markers

Structured or casual observations of project animals by the public or staff often can encourage support and enhance data acquisition. For these reasons, the ability to identify individuals from a distance using a visual marker can facilitate:

- Mark-resight population estimates
- Individual identification within a group of collared or unmarked animals
- Recognition of individual animals in the absence of network or data connectivity, or the need for specialized equipment
- Acquisition of useful information in non-intrusive or non-disruptive ways
- Recognition by the public where it is important to retain a particular individual or individuals throughout a project (e.g., do not harvest protections), or that animals remain undisturbed (e.g., please avoid disturbance) in a specific study area

Types of visual markings include:

Ear Tags

It is essential that the tag is appropriate for the individual animal, and it must be understood how placement of the ear tag may impact an individual's well-being. Ear tags that are too large cause structural damage to the ear, interfere with ear function and thereby impact that individual, and may generate public concern about handling efforts or animal welfare. Moreover, the type or placement of the tag may predispose individuals to predation if they cause the study animal to behave differently than other conspecifics that may be nearby.

Ear tag size and weight can also influence placement, which may not align with the generally recommended placement illustrated in Figure 4.3. However, size, weight and placement of an ear tag must avoid the upper and lower vein ribs and arterial rib and not interfere with ear functionality.

Types of Ear Tags

- Allflex ear tags are available in multiple colors and alpha-numeric series, and allow individual animals to be identified from a distance.
- Rototags are small. If the animal or a carcass is in hand, they provide a way to identify individuals in wildlife health datasets.
- Call Before you Consume (CBC) tags are used to alert hunters that a harvested animal may still have sedatives or other drugs not yet metabolized in muscle or tissue.

- GPS ear tags are an emerging technology. These are small transmitters attached to an ear and collect location data just as collars do. However, they don't store data on the ear tag itself. Data are uploaded via satellite connection.

Tag Application

Ear-tagging must be done properly to keep the animal from losing the tag or developing an infection. We recommend maximizing sampling opportunity and reducing injury when using biopsy tools to collect tissue samples by installing the ear tag in the biopsy sample hole to negate the need for a second puncture. Before starting, make sure you have the proper ear tags and tag applicator. Steps for ear-tagging an animal are in order below.

- **Secure the animal -** Properly secure the animal to limit the animal's head movement during the tagging process.
- **Disinfect** - Proper hygiene will help prevent infections. Use rubbing alcohol or disinfectant to clean the applicator between animals.
- **Place the tag properly in the ear** - Tags should be placed in the middle third of the ear between the arterial rib and lower vein rib (Figures 4.2 and 4.3). Tags positioned toward the end of the ear place undo leverage on the ear and are prone to rip out. Tags placed too close to the base of the ear could cause pinching or necrosis and could interfere with hearing.
- **Prepare and properly position the tag and applicator -** Place each half of the tag (stud and tag button) onto the applicator. The stud must be completely onto the applicator pin and the tag button must be under the opposite clip. Make sure the applicator pin is not bent or broken. Make sure the applicator is aligned before tagging the animal by closing the applicator to the point where the two halves meet. Be certain that handlers are aware of which side the number should face. If ground observations are anticipated, the number should face forward; if there is greater need to identify the animal during helicopter surveys, the number should face the rear of the animal.
- **Tagging -** Firmly and quickly close the applicator and release it. Inspect the tag to verify it is correctly and securely fastened. Ensure the tag information is recorded (number, color, and which ear) correctly. The marking process often causes a bottleneck in handling captured animals. Ensure extra ear tag studs and ear tag pliers are available.

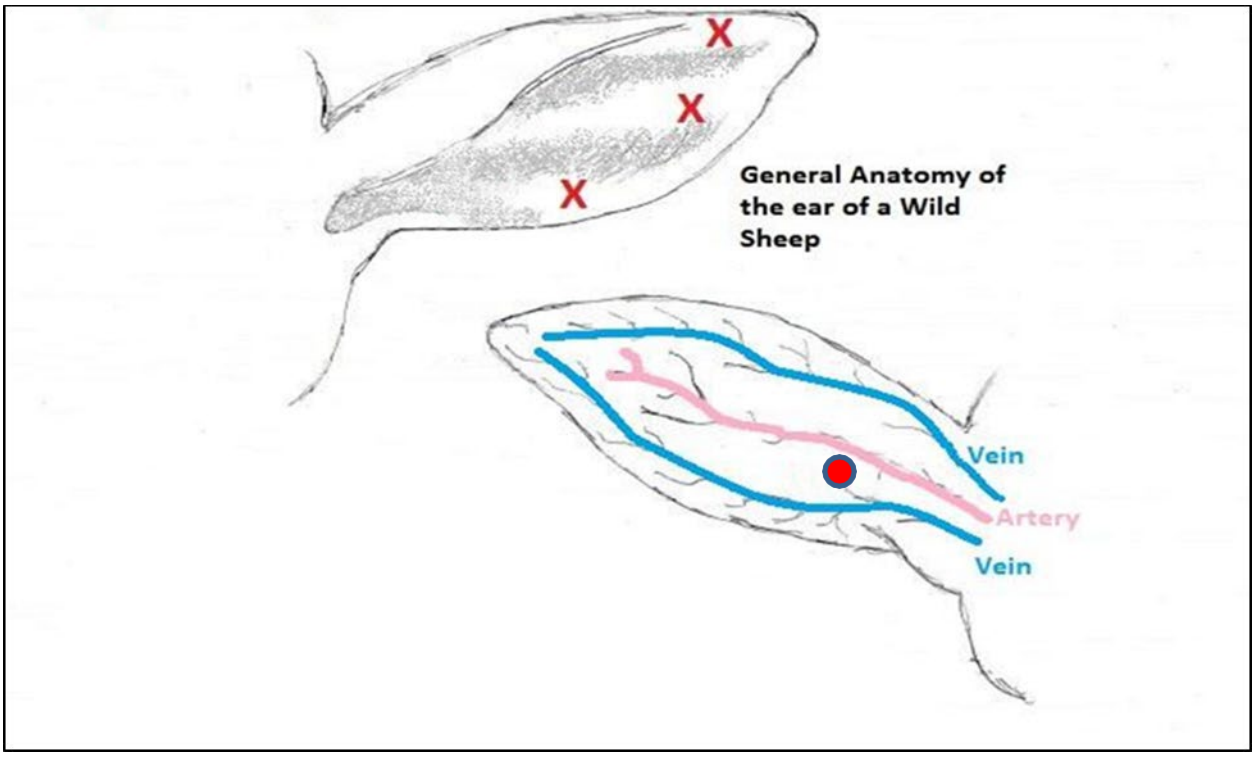

Figure 4.2. Schematic diagram of the anatomy of the ear of a North American wild sheep. The location in the ear at which the tag should be placed is shown by the red dot, and examples of locations where the tag should not be placed are indicated by a red X. Select a location between the main vessels that are prominent on the back of the ear, and away from the edge of the ear but not blocking the ear canal.

Figure 4.3. Proper ear-tag size relative to size of the animal.

Collar Tag or Collar Sleeve

Attaching a tag to the collar material (instead of the ear) or installing a colored or numbered fabric sleeve over the neck band is a technique that can be used if the objective is to not have a permanent mark on the animal once the collar releases (Figure 4.4). There are options to use the holes already punched in the collar material, or create new holes, and collar sleeves or Allflex tags can be placed on the collars prior to animal capture and collar installation.

Figure 4.4. Identification (ear tag) attached to collar band to avoid a permanent mark on the animal.

Paint Mark or Flagging

Paint on the pelage of the rump, or plastic flagging around a horn or neck, is used only for temporary identification and can help prevent animals from being recaptured by aerial net-gun crews.

Collar Labelling and Identification

Using a custom combination of colors, symbols, or alpha-numeric marks for identifying animals can provide valuable supplementary information, especially during aerial or ground surveys employing mark-resight population estimators. Using a permanent marker to write the collar identification on the external circumference of the collar's neck band also supports identification from a distance or post-release observations. If resightings will be made from an aircraft, place marks on the top of collars and large enough for clear identification. If resightings are apt to be from ground positions, marks should be placed on both sides of the collar.

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Appendix 4.1. Research objectives and suggested collaring considerations and metrics

Objective	Types of analysis	Number of Animals	Duration	Fix rate	Device
Distribution or home range mapping	Descriptive	Intermediate and distributed widely within a herd	≥3 years	2 per day	Iridium GPS collar
Habitat use or selection	Resource selection functions (RSFs), Step selection analyses (SSAs)	Many and distributed widely within a herd	≥3 years	3-4 per day unless spatial autocorrelation is problematic	Iridium GPS collar; peripherals may include activity loggers or accelerometers
Connectivity/herd mixing/foray/risk-of-contact	Home range overlap or association networks	Intermediate but stratified over space and sex age	≥3 years	4-6 fixes per day or 1-4 hr fix rates for fine scale movement	Iridium GPS collar; may use geo-fencing or proximity sensor technology
Movement dynamics	Step-selection functions/SSAs, Brownian bridges, Hidden Markov models	Few to intermediate	Specific to research question	4 per day or 1-4 hr fix rates for fine scale movement	Iridium GPS collar + peripherals
Adult survival	Cox proportional hazard models; capture-history-based models	Intermediate to many	many years or many animals	1-2 per day	Iridium GPS collar with programmed mortality sensor
Cause-specific mortality (adults and juveniles)	Known-fate or hazard models	Intermediate to many	many years or many animals	at least 6 fixes per day,	Iridium GPS collar with programmed mortality sensor and transmitter
Cause-specific mortality (lambs)	Known-fate models, hazard models			High	VITs followed by lamb collars
Parturition date and lambing site	Cluster or Descriptive	Intermediate	≥2 years	fixes near parturition period need to be at a 1-2hr fix rate (minimum of 12 fixes per day)	Ewe collars or paired ewe collar-VIT systems
Juvenile survival (point estimate)		Few adult collars per social group	1 year	4-6 per day	Iridium GPS collar for adult ewes and lamb collars
Juvenile survival (trend)	Multi-year lamb:ewe ratios; Poisson point process models; hazard models	Intermediate	at least 3 years	2-4 per day	Iridium GPS collar for adult ewes

Appendix 4.2. Neck circumferences by taxon and sex to help with proper fitting of collars

Most of the minimum and maximum neck measurements were taken on adult animals during standard fall and winter capture periods except for a few Nevada desert bighorn ewes in late June 2022 and Nevada California bighorn ewes in late August 2021 and 2022 with summer coats.

Taxon	Sex	Min (in)	Mid (in)	Max (in)	Min (mm)	Mid (mm)	Max (mm)	N	Reference
Desert bighorn	**ewe**	11	14	16.5	279	356	419	190	NV, Mike Cox, 2011-2022 captures
Desert bighorn	**ram**	14	17.5	20.5	356	445	521	78	NV, Mike Cox, 2010-2022 captures
California bighorn	**ewe**	11.8	14	17.5	298	356	445	163	NV, Mike Cox, 2012-2014, 2018-2022 captures
California bighorn	**ewe**	14	15.5	17	356	394	432		BC, Bill Jex
California bighorn	**ram**	14.6	17.1	21	371	434	533	32	NV, Mike Cox, 2018-2022 captures
California bighorn	**ram**	15	17.5	20	381	445	508		BC, Bill Jex
Rocky Mtn bighorn	**ewe**	13.3	16.0	21.0	338	406	533	84	MT, Emily Almberg, 2020-2022 captures
Rocky Mtn bighorn	**ewe**	13.4	14.8	17.7	340	376	450	28	CO, Mark Fisher, captures 2020-2022
Rocky Mtn bighorn	**ewe**	16.5	18.3	20.1	420	465	510		BC, Bill Jex, Jan. 2021 capture
Rocky Mtn bighorn	**ram**	15	19	23	381	483	584	23	MT, Emily Almberg, 2021-2022 captures
Rocky Mtn bighorn	**ram**	16.4	20.5	25.8	415	521	655	33	CO, Mark Fisher, captures 2020-2022
Rocky Mtn bighorn	**ram**	17	20.5	25.0	432	521	635		BC, Bill Jex, Jan. 2021 capture
Dall's thinhorn	**ewe**	14.5	16	18	368	406	457	4	AK, Tom Lohuis
Dall's thinhorn	**ram**	21	23	25	533	584	635	12	AK, Tom Lohuis
Stone’s thinhorn	**ewe**	13.0	15.7	18.3	330	400	465	100	BC, Bill Jex, 2017-2020 & 2022, Cassiar, Dome Mtn, and Williston herds
Stone’s thinhorn	**ewe**	13.4	16.3	19.7	340	414	500	100	BC, Bill Jex, 2006-07, Sulphur/8 Mile herds
Stone’s thinhorn	**ram**	16.1	18.3	20.5	410	465	520	20	BC, Bill Jex, 2006-07, Sulphur/8 Mile herds
Stone’s thinhorn	**ram**	18.5	21.3	22.0	470	540	560	12	BC, Bill Jex, 1999-2004, Williston herds

Appendix 4.3. Average body weights of adult animals by subspecies and sex

The collar should not exceed 1% of the animal's body weight, and the corresponding collar weight is listed. Most of the weights were taken on adult animals during standard fall and winter captures except for a few desert and California bighorn ewes captured in June and August, respectively.

Taxon	Sex	Average body weight (lbs)	Average body weight (kg)	% body weight	Collar weight (grams)	Reference	Sample size
Desert bighorn	**ewe**	114	51.7	1.0%	517	NV	596
Desert bighorn	**ram**	150	68.0	1.0%	680	NV	150
California bighorn	**ewe**	128	58.1	1.0%	581	NV	219
California bighorn	**ram**	167	75.7	1.0%	757	NV	42
Rocky Mtn bighorn	**ewe**	146	66.2	1.0%	662	NV	37
Rocky Mtn bighorn	**ram**	212	96.2	1.0%	962	NV	11
Stone's thinhorn	**ewe**	122	55.5	1.0%	555	BC	>15
Stone's thinhorn	**ewe**	125	56.5	1.0%	565	BC	19
Stone's thinhorn	**ram**	174	79	1.0%	790	BC	3

WILD SHEEP CAPTURE & HANDLING GUIDELINES

WAFWA
WESTERN ASSOCIATION OF FISH & WILDLIFE AGENCIES

Wild Sheep Initiative

CHAPTER 5

CAPTURING WILD SHEEP WITH A NET-GUN

LAST UPDATED: JUNE 2024

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Wild Sheep Helicopter Net-gun Capture

The net-gun was developed in New Zealand to capture free-ranging ungulates, primarily by shooting the net-gun from a helicopter (Krausman et al. 1985, Kock et al. 1987). Implementation of this capture technique generally involves 3 jobs: pilot, gunner, and mugger (see descriptions below). Modifications can include additional aircraft or additional personnel. The Net-gun Capture Working Group is comprised of individuals that have worked extensively in all 3 jobs and have been involved directly in many aerial capture events. This chapter contains extensive information in a bulleted format that addresses the details and aspects of helicopter net-gun capture of wild sheep, with additional background material included in several appendices. Wildlife biologists and wildlife health professionals must understand the inherent dangers involved in helicopter net-gun work. Human safety is the number one priority, and all participants in helicopter net-gun captures must keep that in mind. Common errors, mistakes, and accidents that have occurred during net-gun captures are described in Appendix 5.1.

Solicitation and Contracting Net-gun Crew

Having an open, honest, and respectful relationship among agency staff and helicopter net-gun companies is a precursor to successful net-gun capture operations. Though long-term friendships develop between agency biologists and capture-crew members, it is critically important that such relationships be put aside when evaluating vendors. Human and animal safety are of the highest priority in this process, and open and honest dialog is essential.

Bid Process

Project Overview

The overall project goal is the effective, efficient, and humane animal capture with the utmost focus on human safety and the safety and well-being of animals. Various broad objectives that are associated with aerial capture work include disease surveillance, deployment of telemetry devices, translocations, specific research or management projects, and locating and capturing specific individuals, among others.

Description and Scope of Work Expectations

- Scheduling
- Aircraft and crew requirements
- Protocols for sanitizing capture gear and other equipment
- Aerial transport capability and transport bag requirements
- Onboard equipment to load search polygons and waypoint or tracklog collection
- Communication with ground crew
- Online flight path tracking application
- Terrain and elevation of capture work

Company Profile

Be sure to request background information and any past contract issues or accidents and obtain referrals.

Staff Resumes and Qualifications

- The pilot should have at least 1,500 hours of aerial capture experience, and a greater amount is preferred. We suggest experience involve the annual capture of at least 500 animals per year, and that the majority of capture experience was gained in mountainous terrain.
- The gunner should have at least 3 years of experience, and a greater amount is preferred. We suggest the experience was obtained while capturing at least 500 big game animals per year, with the majority of that experience obtained while capturing mountain ungulates.
- We suggest the mugger have at least 2 years of experience.

Company References

It is helpful if vendors provide references from wildlife agency clients for whom they recently have worked, and that can attest to the vendor's strengths, abilities, and safety records, and to express any concerns about specific issues.

Vendor Cost Rates and Pricing Guidelines

All capture and related services should be spelled out in a cost schedule.

Invoicing and Payment Process

Jurisdictions should provide prospective vendors with any unique or specific requirements when creating or submitting invoices (e.g., receipts required for travel, due dates, options for electronic payments, or the company’s business license).

Vendor Questions of Agency

Allow vendors to pose questions about the bid process or to clarify any special requirements involved in soliciting their services. Some, if not most, jurisdictions may require that any such question and response be shared with other potential vendors.

The Proposal and Cost Schedule Submission Should Include

A Technical Proposal consisting of:

- Company profile, staff resumes, references
- Air Carrier Certificate
- Operating Certificate – rotorcraft external-load operations
- Certificate of Insurance – aircraft(s) covered, liability coverages, and limits

A Cost Schedule addressing:

- Hourly charge for low-density animal capture
- Cost per animal for capture in high density populations
- Helicopter ferry rate
- High-elevation surcharge
- Any charge per animal in addition to the aircraft cost per capture flight hour
- Immobilization, set-up, or positioning costs from worksite to worksite between jurisdictions, including the fuel truck and crew
- Daily crew travel (per diem and lodging) expenses
- Daily fuel truck expense and mileage rate
- Daily weather delay or standby daily charges for aircraft and crew
- Other potential costs, including biological sampling, sanitizing gear, costs for transporting animals back to capture site, or excess transport distance

The Bid Opening, Evaluation, Scoring, and Selection Process Should Involve

- Staff with broad experience gained while managing or participating in capture operations
- An evaluation of scores submitted separately by each member of the group
- Recognition that human safety and animal welfare are the primary considerations, but that experience and talent also are important
- Double-checking references

Preparation of The Contract

Be aware that each agency has different contracting rules and regulations, but consider the following:

- If permitted by your agency, attempt to develop a contract with more than one vendor due to high demand for net-gun services, and especially during peak capture seasons.
- Suggest the contract extend for at least 2 years, but with a "back out" option if service is not as advertised.
- Be as liberal as possible in identifying future capture work and the overall amount of the contract to lessen the need for burdensome amendments.
- Be open to allowing vendors to amend billing rates in light of continuing increases in fuel costs.
- If the work will be conducted on U.S. National Park Service lands or involve a federally listed species there may be a requirement to follow the Aerial Capture, Eradication, and Tagging Animals (ACETA) Operations Plan (https://www.nps.gov/subjects/aviation/upload/ACETA-operations-plan-2017.pdf).

The Cost Basis for Invoicing Dictates the Overall Capture Approach

Capture companies generally charge for their services on (1) a fixed rate per animal; (2) an hourly rate; or (3) a hybrid model that combines per animal and hourly rates. Before entering into any agreement for services, it is imperative that the contracting agency and the contractor understand and agree upon how billing for capture time is to be recorded and invoiced.

Per Animal Rate

This cost basis is a scheduled cost per animal as agreed upon in the capture company's cost schedule. Charging per animal is to the contractor's advantage in high density wild sheep herds. This practice encourages speed, but potentially promotes netting multiple animals in single nets and other time-saving practices that may not meet animal care and welfare stipulations.

Hourly Rate

Low density wild sheep herds are best suited for charging by the hour, or the company risks ‘losing money’ because of high fuel costs or maintenance needs. Typically, 5 animals captured in 1 hour at a per animal rate allows the crew to 'break even'. When charging by the hour, the crew is less inclined to capture multiple animals in a single net. The crew could also increase chase time with the few animals they find while trying to capture the target number, which adds undo stress and increases the chance of capture myopathy. Placing a strict limit on chase time, which we recommend does not exceed 2 minutes, and requiring the contractor to adhere to that limit is essential.

Hybrid Rate Model

Most capture companies use this model to accommodate variability in population densities and capture objectives. The company will charge on a per animal basis until the capture rate drops below some threshold of animals captured/hour, and then shift to an hourly rate.

Crew Member Roles and Responsibilities

Pilot

- There are few more dangerous jobs than those involving the aerial net-gunning of wildlife. For the safety of both crew and wild sheep, it is essential to have an experienced pilot. Communication among the pilot, other crew, and the Capture Boss is essential, and the method of communicating must be reliable. Topics of discussion that frequently require attention involve capture goals or information on local geography or animal distribution, but also information on animals captured, progress, or decisions literally made 'on the fly' to facilitate the mission.
- Situational awareness and attention to detail are essential. The pilot must continuously watch for danger to the aircraft including powerlines, trees, snags, rock walls, birds, other aircraft, loose equipment inside the helicopter, etc.
- The pilot makes the ultimate decision on animal welfare when pursuing animals for capture and adheres strictly to the established maximum chase time.

Gunner

- The gunner must have extensive experience in helicopter net-gunning and the use of the exact model gun used in the capture operation.
- The gunner must maintain the net-gun in the ‘unlocked’ or ‘unbolted’ position until just prior to firing.
- Situations often arise in which the gunner must double as a mugger and, therefore, must have the skills and ability to serve as both.
- It is imperative that gunners do not get airsick.
- Gunners must be able to distinguish young rams from adult ewes.
- Situational awareness and attention to detail are essential. The gunner must continuously watch for danger to the aircraft including powerlines, trees, snags, rock walls, birds, other aircraft, loose equipment inside the helicopter, etc., and advise the pilot of any such issue.
- The gunner is responsible for netting the animal in a location where there is a high likelihood it will not injure itself and can safely be restrained, processed, and released, or slung back to the base camp.

Mugger

- The mugger must have the speed, strength, and agility to run down partially netted individuals, lift animals to safety, and muscle animals into transport bags (ewes can weigh >180 lbs (80 kg) and rams can weigh >250 lbs (113 kg).
- It is imperative that muggers do not get airsick.

- Situational awareness and attention to detail are essential. The mugger must continuously watch for danger to the aircraft including power-line wires, trees, snags, rock walls, birds, other aircraft, loose equipment inside the helicopter, etc., and advise the pilot of any such issue.
- The mugger often is tasked with collecting biological samples or measurements and must have the skills to obtain blood from a venous puncture, obtain nasal swabs, and collect parasites, feces, and other information requested, including estimates of body condition.
- The mugger must be trained in, and familiar with, the proper fit and placement of radio-collars.

Fuel truck driver, Airframe & Powerplant Mechanic (A&P) or Aircraft Maintenance Engineer (AME in Canada)

Capture companies often use an A&P or AME as their fuel truck driver, and a mechanic thereby is available to work on the helicopter in the field. This lessens the probability of delays associated with having to bring a licensed individual from another location to address unexpected mechanical issues. Some drivers are also trained to serve as muggers.

Extra Crew Member

It is desirable to have an additional person available to work as a backup gunner, an additional mugger, or as the fuel truck driver. The added expense of a second gunner can be offset by an increase in efficiency. Rotating this individual into the capture team is important during long days or multi-day captures when crew fatigue can become a factor that increases the risk of mistakes or injuries. When not busy with other responsibilities, an 'extra' person can also disentangle nets, pack nets, and complete other tasks upon which the capture crew is dependent.

Additional Helicopter (up to 3 have been used simultaneously)

When multiple helicopters are used, very clear rules must be followed to maintain separation and safe operation. An additional crew in a second helicopter can be used to handle, sample, or prepare animals captured by the capture crew in the 'chase ship', and this strategy has several benefits.

- It reduces weight in the 'chase ship' or ‘capture crew helicopter’ by including only the pilot and gunner, with the mugger(s) or additional personnel in a second helicopter, which logically can be referred to as the 'hook ship' or ‘handling crew helicopter’.
- It can increase the speed of capture and handling operations because time searching for target animals occurs while processing of the most recently captured animal is ongoing.
- This strategy can eliminate the need for a base camp (wildlife health specialists can be shuttled into the field and assist with or perform more detailed processing or sampling efforts). This method may be especially useful when capturing wild sheep in remote, roadless locations.
- It improves response time in the event of injury or mechanical issues, especially in remote locations.
- In some situations, and while capture operations continued, a third helicopter has been used to transport animals from the capture site to the release location a great distance away.

Timing of Helicopter Captures

Wild sheep helicopter captures have been conducted during most months. There is no consensus among biologists or veterinarians regarding the benefit or detriment of summer versus winter pelage,

nor is there a strict cut-off in time of capture relative to stage of gestation. There is, however, increasing interest in conducting summer captures. Higher summer temperatures are offset by thinner summer pelage that allows animals to dissipate heat more efficiently, but also create issues related to the presence of young lambs. Managers or researchers must ensure lambs are apt to have been weaned before such captures are conducted.

Factors and Considerations in Capture Timing

- Don't disrupt the breeding season.
- We suggest not capturing females during the first trimester of gestation when the newly implanted embryo is most vulnerable.
- Consider not capturing females in the third trimester even though fetal stability increases as pregnancy approaches full term.
- Consider lamb size, mobility, dependence on its mother, and other ewes in the group as they relate to the outcome if the lamb becomes separated from its mother.
- Consider capturing adult animals when in their summer pelage while keeping in mind the potential for the presence of dependent offspring.
- Consider ambient temperature relative to seasonal pelage.
- Avoid capturing animals during open hunting seasons.

Suggestions for Timing of Capture Events

Desert Bighorn

Most helicopter capture work for desert bighorn sheep occurs between mid-October and early-December but summer captures, when desert bighorn have thin summer coats, have been highly successful. Summer desert sheep captures can occur on days with afternoon temperatures above 100° F (38° C), but morning temperatures generally are below 80° F (21° C), and capture attempts can be terminated as ambient temperatures rise, or management of body temperature becomes problematic.

New Mexico

Desert bighorn sheep have been captured for nearly 40 years in the Red Rock facility and generally from late October to early December. This is outside the highest summer temperatures and 1–2 months prior to the earliest date of parturition. A helicopter capture of desert bighorn lambs resulted in all collared lambs successfully reuniting with their dams.

Arizona

Arizona has captured desert bighorn sheep year-round but does not attempt captures from groups containing young lambs. Pregnant desert bighorn sheep can be present any month of the year, but this has generally been of less concern than has been the presence of young lambs.

Nevada

Nevada conducts desert bighorn captures from October to early January, and lamb drop in the Great Basin occurs in late March. Summer net-gun captures were initiated in June 2023 in the Mojave Desert; helicopter chase time was strictly limited, and shade and ventilation were provided at the processing area and trailer to minimize problems with hyperthermia.

- The capture window was 5:30 – 9:15 am based on animal body temperatures and air temperature at 5:45 am was 88° F (38° C).
- Of 32 animals captured, the average low rectal temperature was 101.4° F (38.6° C).

- The average high rectal temperature was 103.4° F (39.7° C).
- The average last temperature before being placed in a trailer was 101.9° F (38.8° C).
- Only 3 animals became hyperthermic and required intervention in the form of IV fluids.

California Bighorn

Nevada conducted summer helicopter captures for California bighorn sheep in August 2021 and 2022. Shade and ventilation were provided at the processing area to minimize problems with hyperthermia.

- The capture window was 6:00 am to 1:00 pm.
- Of 44 animals, the average low rectal temperature was 103.0° F (39.4° C).
- The average high rectal temperature was 104.2° F (40.1° C).
- The average temperature prior to release was 103.6° F (39.8° C).

Rocky Mountain Bighorn

Most helicopter capture work for Rocky Mountain bighorn sheep or thinhorn sheep is conducted from November to March.

Thinhorn Sheep

Thinhorn sheep generally are captured at temperatures below freezing, and the risk of increased body temperature occurs when ambient temperatures exceed 40° F (4° C).

Phases of the Capture

Chase

This is the precursor to the actual capture and is the period when animals generate elevated temperatures that put them at risk of hyperthermia and capture myopathy. There are two components to the chase.

- **Hazing or Herding** is when an individual or group is moved, often at slow speed, towards terrain conducive to implement the capture.
- **Chase Leading to the Shot** is when animals are generally running at full speed under the helicopter prior to the shot; it is during this phase that chase time must be accurately measured and the attempt terminated if a shot is unsuccessful. Chase time should be limited to 2 minutes, as emphasized earlier in these guidelines. If animals are running at full speed during the hazing and herding phase, be sure to count that as part of the chase time leading to the shot.
- The definition of chase is not entirely ‘science-based’ and includes elements of ‘art’ and ‘experience' to gauge the total chase time. Assessing the potential for severe stress and negative impacts to the individual should be viewed as a continuum, with termination of the chase time occurring before 2 minutes if in the best interest of the animal.
- The capture crew should not pursue the same animal or group twice in 1 day, and should also be cognizant of fatigue (extreme panting, tongue hanging out, etc.) during the chase leading to the shot.
- To lessen the risk of capture myopathy, fatigued animals should NOT be pursued.

The Shot

- The shot does not occur until the pilot has put the gunner in position for a high probability of success. The chamber of the gun is not closed, and the shot is not taken until the animal is in the proper position.
- Mortalities associated with the shot often include a broken neck, one or more legs, or the jaw; mortal internal and muscular injuries can occur from strikes associated with the weights attached to the net. Mortalities and injuries can be reduced by targeting single animals, animals that are not moving, animals on flatter terrain or distant from rocks and boulders, and animals that are turned uphill and thereby slowed in their effort to escape just prior to the shot.
- "Flock-shooting" (two wild sheep under the net) should be avoided; there may be certain situations, however, that warrant netting multiple wild sheep simultaneously. For example, some projects have focused on capturing all the individuals in a social group or even an entire population, but there is a heightened risk of capture myopathy or injury associated with additional or repeated chases. Such situations may appear to warrant a 'flock-shot' but the tradeoffs must be considered.

Extracting the animal from the net

- This can be the most time-consuming portion of the capture event. About 95% of the time the mugger can complete this without assistance. Use of an appropriately sized net and of the appropriate mesh are important considerations (see Equipment Section for dimensions).
- Wild sheep on steep terrain while they are hobbled for processing or awaiting helicopter transport must be secured with a rope to a fixed object.
- In rare situations it may be necessary to cut the net to avoid death or injury to the animal or the mugger, but the net otherwise should not be cut.

Cooling the Animal (please see "Chapter 3: Animal Health and Veterinary Care of Wild Sheep")

- Hyperthermia can occur as a result of prolonged chase times and individual animal response to capture. Placing limits on chase times for an individual animal, or on a group of animals that may be encountered later in the day, is the best way to decrease the likelihood of hyperthermia.
- Hyperthermia occurs at body temperatures >104° F (40° C) and is the most common complication encountered during capture events.
- Capture personnel should take a rectal temperature immediately (this can be done prior to removing the animal from the net), and relay this information to those responsible for receiving and processing the animal.
- If an animal has a rectal temperature in excess of 106° F (41° C) at time of capture, consider releasing the animal rather than transporting it to a base station unless cooling measures can be taken in the field prior to loading.
- A mixture of isopropyl alcohol (0.5 gal [2 L]) and water (4.75 gal [18 L]) applied to the animal may increase the rate of evaporative cooling. Aerial capture crews should be equipped with such a mixture to soak the ventral surface of the animal before it is transported to a base camp.

- Cooling can be accomplished by using a steady stream of cold water, being sure to get the water down through the coat to the skin, and cold towels or ice packs in the groin, inguinal, and axillary areas.
- Administration of midazolam to stressed animals will reduce excitement and aid in cooling.

Slinging Animals

- Animals should be placed in the bag in an upright position (e.g., rump down), which allows cooling during the flight.
- Long-lines may incorporate an electronic release that is controlled by the pilot, or a length of high-quality rope that can be attached to the belly-hook on the helicopter but can be disconnected from the load by a ground crew. The pilot also has the option of releasing that rope from the aircraft's external hook.
- Short-lines may be carried by the gunner or mugger, and a series of short-lines can be coupled to create a longer line. The short-line can be attached to the aircraft by the ground crew but, in many cases, the pilot will land following a successful capture, attach a short-line to the aircraft, and hover while the crew attaches the transport bag(s) to the short-line.

Release

- In some instances, animals will be transported back to the capture site or another location for release, and is most apt to occur when base camps are used to process animals. When this occurs, retaining the animal in a restrained state, hobbled and blind-folded and possibly sedated, should follow advice from wildlife health personnel. Staff responsible for release must be adequately trained to ensure that restraint equipment is completely removed and any sedation reversed, thus preventing injuries during or as a result of release.
- Where animals are processed in the field at the capture site, release can be straightforward. Care must be taken, however, to point the animal in a safe and preferred direction, and personnel must be cleared from that escape path so that directional deflections or injuries to the animal or personnel are avoided.

Capture and Post-Capture Mortality Rates

WAFWA agencies have provided data on morbidity and mortality during wild sheep helicopter net-gun captures; these data pertain both to the capture itself and post-capture follow up.

- Mortality directly related to capture events ranged from 0.2% to 2.4% and could be attributed to the level of capture crew experience, terrain, weather, season of capture, guidelines provided by agency (e.g., chase time limits), revisions to handling practices, and other factors (Appendix 5.2).
- Mortality also occurs post-release due to capture myopathy or unknown causes. Post-capture mortality varied from 0.2% to 1.8%, but this is likely an underestimate because agencies used different time criteria to assess mortality directly related to the capture event.
- Among jurisdictions, capture and post-capture mortality rates ranged from 1.8% to 3.2% (Appendix 5.2). In New Mexico, the mortality rate was markedly greater during a single event and was attributed to animals being in poor condition and to excessive body temperatures (Rominger et al. 2017). Readers are referred to additional literature regarding net-gun captures (Kock et al. 1987, Wagler et al. 2022).

Equipment

Hobbles

- Hobbles can be made from several different materials. The current and preferred material for hobbles is Biothane. It is made of polyester and polyvinyl chloride (PVC), is more durable and lighter than leather, and is resistant to mold, is waterproof, and non-absorbent when chemically cleaned.
- Suggested dimensions for wild sheep hobbles are 3/4 in (1.9 cm) wide and 50 in (127 cm) long.
- Always hobble the back leg to front leg because the animal can get away if hobbled front-to-front or back-to-back).
- Always put the buckle behind the legs with <1in (2.5 cm) of hobble exposed and behind the dew claw, and then wrap the tail of the hobble back to the buckle. All members of the capture crew or processing crew should be skilled at this procedure.

Blindfolds

- This essential tool should be applied as soon as possible, as it immediately reduces stress to wild animals. It can be applied before hobbling or extracting the animal from the net.
- Ensure the blindfold is properly sized and covers both eyes fully, but that it doesn't hang over the nose and interfere with breathing.
- Synthetic material that does not soak up water is preferred.
- Prior to releasing the animal, crews must ensure that the blindfold is not pinned or secured in place by the radiocollar or snagged on part of an ear tag. It MUST be unclipped, untied, or the velcro attachments released BEFORE removing the hobbles so the blindfold can easily be held and pulled away by hand, or will simply fall off when the animal is freed. Refer to Appendix 5.3 for additional guidance.

Sling Bag

- Transport wild sheep upright in transport bags, rather than upside down by hobbled legs.
- Transport bags with buckles or clips allow more rapid loading and removal than bags with eyelets laced together with a rope.
- Use a transport bag that allows hobbled legs to hang outside, allows animals to breathe more freely while in a "sitting" position, and thereby reduces potential for capture myopathy (Figure 5.1, Figure 5.2).
    - Use a loose top strap under animal's neck to prevent choking and use a strap to support the head and horns of mature rams in an upright position while in the bag.

Figure 5.1. Photo showing proper upright positioning of wild sheep being slung in transport bags that allow hobbled legs to hang out to allow animals to breathe more freely in a “sitting” position.

Figure 5.2. These 2 bighorn ewes are appropriately placed in transport bags with legs extending outside of the bag, and with straps and buckles that properly distribute weight and secure the animal during aerial transport.

Net-Guns

- If space in the helicopter allows, it is useful to have 2 guns or multiple loaded net cannisters to permit quick follow-up shots; additionally, if one gun malfunctions a back-up gun is immediately available.
- A pistol-grip enhances the agility necessary for the various shot angles that will be encountered, especially in aircraft with smaller cabins.
- Several manufacturers provide net-guns with different features and positive and negative attributes, depending on personal preferences.
- Regardless of the system used, a basic maintenance kit should be available to perform repairs in the field.

Canisters

The number of canisters and nets available during capture operation should be no less than 12 for single-ship operations. If separate chase-ships and hook-ships are used, having 24 cannisters and nets available is recommended, and will reduce delays and save money.

Nets

- The size best suited for wild sheep is 12 ft × 12 ft (3.7 m × 3.7 m) with 7 in (18 cm) mesh. For large rams, 15 ft × 15 ft (4.6 m × 4.6 m) nets are desirable.
- Use 1 in(2.54 cm) wide masking tape to retain nets in canisters.

Key Sampling and Processing Supplies

- Sampling kits from agency
- Sharpies
- Thermometer
- Cloth tape measure
- Cutter to trim excess collar material
- Ear-tag applicator(s) designed for the tag(s) being used
- Camera for taking photos of every animal that is captured

Processing Time

Helicopter net-gun companies are highly efficient and talented at processing captured animals. Most have processed thousands of animals representing many species, and not just wild sheep.

- Prior to initiating the capture project, agency personnel and capture crew will run through all the processes and sampling that are to be completed and exactly the data and information that are to be recorded.
- Make sure to review the data sheet with the capture crew so that all participants are clear on recording the proper information and in the proper format.
- Unless the welfare of the animal is compromised (e.g., it is hyperthermic), collecting the full suite of samples and accurately recording data are more important than the processing time.

Euthanasia

All capture teams must have a euthanasia protocol for severely injured animals. Animals should be sampled prior to being euthanized. See the Wildlife Health and Veterinary Care Chapter for euthanasia protocols and additional details.

Capture Gear Sanitation

All capture gear (gloves, hobbles, blindfolds, sling bags, nets, etc.) must be sanitized between capture events involving different populations or projects. See the Wildlife Health and Veterinary Care Chapter for a list of protocols and appropriate disinfectants or cleaning agents.

Agency versus Contract Capture Crew Pros and Cons

Some agencies have personnel that are qualified to conduct a net-gun capture if authorized by their administration to do so, but an agency crew may not be as efficient as a professional contractor. Nevertheless, such agency crews are not under the economic pressure to capture and process a high number of animals in a short time, and better handling practices may result. In some agencies, a new cohort of professionals is being trained to maintain in-house competency and to help ensure the best outcomes for wildlife. For smaller operations, or for emergency operations, the ability to field an agency crew is advantageous. Factors limiting any such operation are the immediate availability of an appropriate aircraft and an experienced pilot. Safety must remain the number one priority.

Helicopter Models

Various helicopter models have been used for net gun captures. All but the Robinson R44 are jet turbine helicopters. Aircraft that are used by many contractors include the MD500D or E, MD530, Bell 206B (Jet Ranger), Bell 206L-3 (Long-Ranger), Bell 407, AS350 (A-Star), and Robinson R44, and others. The rotor disc diameter and operational payload are important variables to consider in safely deploying and recovering crew members from capture sites, particularly at high elevations, in steep terrain, or in densely vegetated locations. All helicopters must be operated within their performance limitations. Consider fuel use, and deploying a fuel cache prior to the onset of capture efforts may be desirable, or even necessary, in remote locations or when using high fuel consumption helicopters. Contact the vendor with specific concerns about the model of helicopter to be used by the vendor or to determine the need for a fuel cache.

- Expense by model can vary substantially. Match the helicopter to your budget, the specific task, and needs. Consider the number of personnel, distances involved, altitude, temperature, and terrain in which the operation will occur.
- Seat position for the gunner may vary by helicopter model or pilot preference.
- The Bell 206L-3 has substantial capacity for safe hover-exits and hover-recoveries.
- The Bell 407 is substantially superior to the MD 500 in all measurable performance criteria, including payload, speed, and seating capacity.
- The AS-350 has more power, and greater speed and lift capacity than the MD-500.
- The MD-500 is more capable of allowing personnel recoveries in 'tight' places but is more dangerous when loading or off-loading in close terrain, and it is more vulnerable to blade strikes from net weights. Both of these issues are due to the proximity of the main rotor blades to the top of the aircraft, but the MD500 is a great aircraft for very experienced professional net-gun crews.

- Helicopters with a multiple-blade main rotor have a smaller diameter rotor disc relative to potential landing zones in dense vegetation or on hillsides.
- A larger payload helicopter such as the Bell 206L can carry more personnel and has a longer fuel cycle than the MD 500, both of which may be important considerations in remote settings and offer greater flexibility to the contracting agency.

Decision to Process in the Field vs. Base Camp

- If all that is required are simple biological samples and deploying a radio collar, processing ‘in the field’ is generally preferred. If the project requires substantial processing time (e.g., body condition determined with ultrasonography, pregnancy-testing, VIT insertion, extensive disease testing, etc.), transport to a base camp may be necessary. As described above, an alternative approach is to use a second helicopter to transport a mobile processing team that follows the chase ship or using the same helicopter to 'leapfrog’ the capture crew and the processing crew after an animal has been hobbled and blindfolded, thereby allowing the animals to be released at the location at which they were captured. If body temperatures are elevated, there are fewer options for cooling the animal when leapfrogging, so capture timing is also an important consideration.
- Animals brought to a base camp can be released either at that location or be transported back to where they were captured. Additional costs are incurred if animals are ferried back to capture locations for release.
- Some capture locations may be too remote to use a base camp, and this must be considered in the capture planning.
- Base camp requires an adequate number of experienced personnel to conduct the processing, but it allows the aerial crew to focus solely on capturing animals.

Repacking Nets

- There are multiple techniques for packing nets**;** if you are not the gunner or have not received net-packing instructions from the current gunner, do not attempt to repack nets. Processing crews can clean debris from nets, which will facilitate repacking of nets by personnel approved to do so.
- While removing debris from nets, it is good practice to check the integrity of weight connections on all four corners. Weights can break off during a shot, and rotor strikes have occurred as a result of such events. It is also important to check the end of the weights for burrs. If a suspected problem is detected, call it to the attention of a member of the capture crew for appropriate action or to obtain further direction.
- While removing debris from nets, check for holes and be certain that the net is repaired by appropriate personnel before it is placed back in use.

Tracking the Helicopter

- Real-time flight tracking technology in some format should be used to monitor the location of the aircraft and must be available to the agency and base camp crew.

Net-gun Capture Plan

- A written capture plan, sent to and to be read in detail by all participants prior to the pre-capture meeting, is imperative.

Pre-capture Meeting

- The Capture Boss should conduct this meeting with all participants, including the helicopter capture crew(s) and any media personnel expected to attend, the evening before the onset of the capture event. If scheduling conflicts arise, the meeting can be conducted on the first morning before the onset of activities. In any event, the meeting must occur prior to implementation of the capture operation, and the subjects covered must address all aspects of the mission.

Communication

- The Capture Boss, and at least 1 other person at the processing site, must have the ability to communicate directly with the helicopter pilot. This requires the use of hand-held radios on a dedicated frequency during the capture, or the ability of the helicopter to access the agency high-band frequency via permanent repeaters. The mugger and gunner should both have hand-held radios or wireless helicopter headsets so muggers, gunners, and pilots can be in constant communication during the pursuit and when outside of the helicopter.
- In areas without radio access to a permanent repeater (e.g., a dead area), deployment of a portable repeater can facilitate communications among the aircraft, crew, and base camp personnel.
- If the base camp is situated outside an area having cellular service, a satellite telephone must be available for emergency phone calls.
- The use of a satellite communication device that allows communication between users and devices, or communication via text message with cell phones or email with any email address, should be considered.

Use of Fixed-Wing Aircraft to Aid in Capture

- Having a fixed-wing aircraft ‘orbit’ above the capture helicopter can increase the success of a capture operation by allowing an observer or observers to keep track of animals in the group that evade capture during following the initial approach. The fixed-wing aircraft can then guide the chase ship to animals that are hiding or have moved a substantial distance. A fixed-wing observer may also observe and report animals that were not seen by the capture crew.
- When capturing animals to be re-collared or for other purposes, use of fixed-wing telemetry and an observer decreased chase times and reduced levels of physiological stress while simultaneously enhancing safety of the capture crew (Bleich et al. 2005).
- The fixed-wing pilot working in support of such an operation must also be experienced in mountain flying. The helicopter and fixed-wing pilots must maintain effective communication between each other at all times. The presence of a fixed-wing aircraft also provides an added layer of safety for the capture crew in case of an accident.

Accommodating a Media Helicopter or Drone

The use of drones or media helicopters must be approved by the Capture Boss and only under strict guidelines, which are detailed in the Base Camp Chapter. The Capture Boss, or designee, is responsible for managing any non-capture personnel present during the operation. With approval, GoPro devices can be used to generate capture footage.

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Appendix 5.1 Errors, Mistakes, and Accidents That Have Occurred During Net-Gun Captures

- **Pilot**
  - Rotor (main or tail) strike from unsecured objects or vegetation on the ground, or rocks or debris falling from a cliff face above the aircraft
  - Rotor strike of a rock wall or cliff face
  - Powerline collisions
  - Rotor strike involving capture personnel
  - Accidental release from a sling line, or because of equipment (hook or carabiner) failure
  - Pushing weather/wind conditions
  - Pressure to complete the job
  - Too involved in the work of the gunner or mugger, such as searching for tracks or animals; the first priority must be safe flying.
- **Gunner**
  - Net into main or tail rotor
  - Net into skids
  - Accidental discharge thru floor or bubble
  - Accidental discharge striking and killing pilot
  - Fail to crouch below main rotor or walk into tail rotor
  - Fail to inspect equipment including net weight attachments, etc.
  - Fail to unplug helmet upon exit
  - Any improper actions around the idling helicopter
  - Nets packed incorrectly
  - Items falling from the aircraft during flight
- **Mugger**
  - Allowing animal to fall or roll after being hobbled and placed in the transport bag
  - Broken neck or leg of animal during mugging
  - Improper placement of the animal in the transport bag
  - Allow the animal to escape, or to be released with blindfold or hobble still on
  - Fail to crouch below main rotor or walk into tail rotor
  - Fail to unplug helmet upon exit
  - Any improper actions around the idling helicopter
  - Items falling from the aircraft during flight

Appendix 5.2. Reports of capture-related mortalities of wild sheep from helicopter net-gun captures, 1984–2023.

State or Province	Taxon or Ecotype	Years	Total Capture Mortalities	Total Captured	Capture Mortality Rate	% Collared	Post Release Mortalities	Post-Release Mortality Rate	Total Mortality Rate	Comments
Alaska	Dall's	2009-2020	13	650	2.0%		1	0.2%	2.2%	Nearly all radiocollared
Arizona	Desert & Rocky Mtn	1984-2000	14	574	2.4%	47%	--	--	--	No data on post-release monitoring and mortality
Arizona	Desert & Rocky Mtn	2001-2018	12	867	1.4%	49%	--	--	--	No data on post-release monitoring and mortality
British Columbia	California & Rocky Mtn	2015-2022	3	598	0.5%	~80%	3	0.5%	1%	Collaring related to M.ovi infected herds.
British Columbia	Rocky Mtn	2004-2020	1	120	0.8%	100%	2	1.7%	2.5%	This is a subset of capture data
British Columbia	Thinhorn	2018-2022	0	80	0%	>90%	1	1.3%	1.3%	Mortality was in avalanche, but some injury may have occurred during capture.
California	Sierra Nevada	2001-2020	12	703	1.7%	>90%	6	0.9%	2.6%	Almost all radiocollared
California	Desert	2013-2018	2	381	0.5%		7	1.8%	2.4%	
California	Desert - Peninsular	1993-2018	7	504	1.4%	>90%	2	0.4%	1.8%	Nearly all radiocollared
Nevada[1]	Desert, California, Rocky Mtn	1986-1999	18	1205	1.5%	10%	15			If 100% collared, the total mortality rate may be 14.2%
Nevada[1]	Desert, California, Rocky Mtn	2000-2009	2	846	0.2%	9%	10			If 100% collared, the total mortality rate may be 13.7%
Nevada[1]	Desert, California, Rocky Mtn	2010-2016	9	1638	0.5%	43%	15			If 100% collared, the total mortality rate may be 2.7%
Nevada[1]	Desert, California, Rocky Mtn	2017-2023	14	970	1.4%	82%	17	1.8%	3.2%	If 100% collared, the total mortality rate may be 3.5%
New Mexico	Desert & Rocky Mtn	thru 2019	13	936	1.4%	>95%	10	1.1%	2.5%	Nearly 100% radiocollared

[1]Post-release capture-related mortalities included animals that died within 30 days of capture. Nevada split up its capture and mortality data into 4 separate time periods spanning from 1986 to 2023 to examine past vs. present rates associated with advancements in helicopter net-gun captures, enhanced awareness of animal welfare, vital-rate monitoring, increased collared animals, and improved capture and handling guidelines.

Appendix 5.3. Videos of Bighorn sheep being released

Video Clip 1. Release of a desert bighorn sheep ram.
https://drive.google.com/file/d/1SO1OQGzzqILQuzgNOs1Oa2SpJwmAFxIc/view?usp=sharing

Video Clip 2. Release of a California bighorn sheep ram.
https://drive.google.com/file/d/1EPd0sFGO-GufBwmUMU0Hij41m86t4sff/view?usp=sharing

WILD SHEEP CAPTURE & HANDLING GUIDELINES

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Wild Sheep Initiative

CHAPTER 6

CAPTURING WILD SHEEP WITH A DROP-NET

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Wild Sheep Drop-net Capture

Background

The drop-net is an effective method of capturing wild sheep and has been in widespread use across their range for many decades (Erickson 1970, Spraker 1977, Schmidt et al. 1978). This technique involves luring wild sheep under a net by habituating them to bait, usually consisting of alfalfa, fermented apple pulp, water, or salt (Rutherford and Schmidt 1973, Schmidt et al. 1978, Kock et al. 1987a, Heimer et al. 1980, Fisher and Humphreys 1999, Jessup et al. 2014).

Drop-nets have been effective in capturing wild sheep at elevations from near sea level to those approaching 13,000 ft (4,000 m) (Fisher and Humphreys 1999, Jessup et al. 2014, Bleich et al. 2019), and can be used under most weather conditions. Drop-nets are effective in targeting specific social groups, whole-herd medical treatments, or for translocations. Drop-net captures require detailed planning, however, because they involve large numbers of personnel (Bleich 1990). Like other methods, a decision to use the drop-net should be considered carefully if animals are in the third trimester of gestation or when neonates are present. Overall, drop-nets have an excellent safety record (Spraker 1977; Kock et al. 1987a, 1987b, 1987c).

Drop-nets remain an effective method for capturing wild sheep by wildlife managers in most jurisdictions, and cost per animal captured is much lower than commercial helicopter net-gun captures when considering contract expenses, and assuming that biologists' salaries are paid regardless of the method used. Moreover, many volunteers frequently participate in drop-net captures.

General Considerations

Drop-net operations usually catch 20-40 sheep at a time. If there is vehicular access to the trap site, animals can be processed on site as they are removed from the net, but that can be a time-consuming task. Despite the sometimes-slow process of extricating animals from the net, on-site processing will decrease the amount of time required to process animals, as they need not be transported to a central processing area. Assuming there is vehicular access and sheep can be processed completely on-site, it is more efficient to have sampling teams move from sheep to sheep rather than moving each animal to a tarp or table for processing. Animals to be released on-site can be freed immediately after processing, and animals that are to be translocated can be loaded directly into trailers or trucks or air-lifted to waiting transport vehicles as soon as processing has been completed. During winter, work should not occur when the temperature is less than 0°F (-18°C) or in excess of 50°F (10°C); during summer, ambient temperatures in excess of 100°F (38°C) may dictate postponement of a capture effort. Location, season, pelage condition, and other environmental or logistical variables will affect any such decision. Specialized capture equipment, among which are hobbles, blindfolds, and stretchers, is required to restrain and move animals after a net is dropped. Hobbles, blindfolds, and stretchers should be supplied at a rate of ≥1.5× the maximum number of sheep expected to be captured and distributed evenly among the assigned animal handlers.

Occasionally, it is possible to implement more than one drop of the net at the site on a given day. In those situations, it is advantageous to move animals immediately to a central processing area that is remote from the capture site. While animals are being transported or processed, the net can be

prepared for a second drop. In some cases, multiple drops on a single day have resulted in the successful capture of more than 50 animals.

Some drop-net captures occur in areas without vehicular access (e.g., wilderness areas) or that otherwise cannot be reached by wheeled vehicles. In these situations, sheep generally are cleared from the net, hobbled, blindfolded, and then transported via helicopter to a central base camp for processing. In such situations, it is essential that adequate clearance for ingress and egress by the aircraft are considered during site selection.

Commercially available drop-nets are approximately 90 ft (28 m) square, and are comprised of four, individual sections that are 45 ft (14 m) square that are fastened together with metal harness clips, or with brightly colored cordage that is readily visible and can be severed quickly with a knife. Separating the four sections from each other greatly facilitates removal of captured animals, decreases the potential for trap-related mortality, and increases trap mobility. The net is suspended by a center pole, 4 corner poles, and 4 support poles placed half-way between the corner poles (Figure 6.1). Each of these poles is anchored to posts or stakes driven into the ground, 55-gal (340-L) steel drums filled with rocks (Figure 6.2), or expansion bolts drilled into large rocks or boulders. The center pole must be secured to prevent it from falling over when the net is dropped, and the corners of the net must be tied off to the anchors to prevent the net from 'balling up' when it is dropped. Electronic devices have been developed and currently are used to trigger the drop of the net. Post-capture cleanup and disinfection of the net and other equipment must be implemented following use of the net.

Advantages

- This method has a good safety record (Spraker 1977; Kock et al. 1987a, 1987b, 1987c).
- This method can capture up to 40 wild sheep at one time.
- It may not require aerial access.
- This is portable and can be set up by 2–4 people in less than 1 day.
- Participation of volunteers can generate community support for conservation.
- On a per animal basis, out-of-pocket costs currently are less than net-gun captures.
- It can be selective for social groups (e.g., matrilines) that may stay together after being translocated, and is less apt to result in separation of females and larger offspring.
- If necessary, non-target or excess animals can be released quickly.

Disadvantages

- Daily baiting is necessary until the day of the capture.
- Vehicular access usually is required.
- Requires many personnel on capture day
- Use of the drop-net requires many hobbles, blind folds, thermometers, transport stretchers, etc., but those items are one-time costs that are amortized over time.
- There is a large investment in the net, supports, and release mechanism.
- The trap-site must be a flat, large area, and free of obstructions.
- It is non-selective (but, see above regarding matrilines), but non-target animals can be released quickly.
- It is not an appropriate method to use if young < 2-months-of-age are present and their safety

cannot be assured, but any such decision is to be made by the Capture Boss.
- There is a large amount of planning, organization, and training involved.
- There is the potential to affect age structure or social structure of a population.
- Sanitation of the net, rigging, and other equipment can be time consuming.
- The presence of bait can attract deer or elk to the trap-site.

Planning and Personnel Needs

- Planning and coordination had best begin at least 6 months before the scheduled capture.
- Personnel assignments and responsibilities (Table 6.1) must be arranged well in advance of the anticipated capture event.
- Necessary permits or permissions, including agencies or landowners, must have been obtained in advance.
- It is necessary to notify and coordinate with interested non-governmental organizations that may provide personnel to assist with the capture operation.
- Use as many experienced handlers as possible, and pair any volunteers to work with them.
- Two to three handlers are necessary for each wild sheep anticipated to be captured.
- Additional personnel are needed to collect samples, collar or mark animals, and to record data.
- The capture objective may be 20–30 sheep for a full-sized drop-net; any operation that large will require 80–100 total personnel (Table 6.1).
- Do not plan to capture animals in the third trimester of gestation.
- Do not plan to capture animals during winter when ambient temperature is less than 0°F (-18°C) or more than 50°F (10°C)
- Do not plan to capture animals during summer when ambient temperature is 100°F (38°C) or greater.

Site Selection and Related Issues

- The site must be frequented by wild sheep; do not assume you can lure sheep to a location not already being used by the target population.
- The site must be reasonably level; slopes ≥20% are much too steep (Heimer et al. 1980).
- The site must be large enough to accommodate the net, rigging, vehicles, aircraft, and personnel associated with the capture event.
- Remove brush, rocks, cacti, or other hazards under the net and that could prevent the net from reaching the ground.
- Cover or cap ends or edges of the net rigging to prevent injury to sheep or handlers; consider protective wrapping of the t-posts and stakes.
- Remove mineral blocks used as bait prior to dropping the net (George et al. 2008).
- Remove any obstacles that could interfere with handlers transporting animals to the processing area or helicopter landing zone.
- Conceal animal handlers close enough (ideally within 300 ft (100 m)) to allow them to reach the net within 30 seconds of the drop.
- If a heavy net is used, a slight delay in reaching the net can be advantageous because it generally will be the largest animals (usually males) that remain standing.

Pre-baiting

- Pre-baiting is essential and can be labor intensive (Figure 6.2).
- In very remote areas, efficiency can be increased by assigning a single individual to remain on site to deliver bait daily for an extended period.
- Initially offer bait in small amounts; if bait remains after sheep depart, however, reduce the amount offered each day (George et al. 2008).
- Baiting must occur at the same time by the same individual, and in the same manner each day.
- Distribute the bait to ensure sheep are distributed evenly under the net, but also away from the edges (George et al. 2008).
- There is little need for silence; sheep quickly become conditioned to auditory and visual cues associated with baiting (Figure 6.2).
- Suitable baits include high-quality, weed-free alfalfa hay, apple pulp, salt, and mineral blocks.
- Pelleted alfalfa can be substituted once sheep are coming to the site on a regular basis.
- Hay obtained from fields upon which domestic sheep have grazed must be avoided.
- Apple pulp must not contain any foreign material.
- In general, bait can be provided daily in the amounts of 1 bale of hay and 55 lbs (25 kg) of apple pulp per 25 sheep (George et al. 2008).

Net Setup (Figures 6.1 to 6.3)

- The net can be erected several days to several weeks prior to the scheduled capture operation (George et al. 2008, Bleich et al. 2019).
- Use of the drop-net in legislated wilderness greatly complicates operations and requires federal agency action and approval (Bleich et al. 1999). Before a decision is made to use a drop-net to capture wild sheep, refer to Policies and Guidelines for Fish and Wildlife Management in National Forest and Bureau of Land Management Wilderness as amended June 2006 (Available at < https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd940187.pdf>. Accessed 1 August 2023). Be sure to recognize and comply with the stipulations in the Minimum Requirements Decisions Process Outline (Appendix A of the aforementioned document).
- Once it has been erected, the drop-net net must be secured so it is unlikely to fall as a result of wind, rain, or snow.
- Inclement weather dictates the net-tender be at the trap site continuously after the net is erected.
- Use metal harness clips or brightly colored cordage to fasten quarter-sections of the drop-net together.
- Harness clips can be difficult to unsnap when sheep are struggling to escape, but a knife can be used to sever the cordage and quickly separate the quarter sections.
- Anchor the corners of the net to the corner poles (George et al. 2008).
- Secure the center pole to keep it from falling over when the net is dropped; this is easily accomplished using a 16ft (5 m) length of schedule 40 steel pipe attached via a floor-flange to a sheet of plywood; a heavy metal stake driven into the ground over which the center pole is placed; or by securing the top of the center pole with ropes attached to the corner posts.

- If space permits, use a full-size net even if the number of animals to be captured is small (George et al. 2008).
- Use a commercially available electromagnetic release mechanism to trigger the net (Gehr 2010).
- Be sure to trigger the net several times to ensure proper functionality prior to implementing the capture event (Foster 2005).

The Net Drop (Figure 6.4)

Some conditions will dictate that the scheduled operation be delayed, or even suspended for a day or two if certain conditions cannot be achieved. Paramount among these considerations and cautions are the following.

- Never drop the net on more than 40 wild sheep.
- Do not attempt to capture more than 8 sheep when using only a quarter of the full-size net.
- Do not drop the net if sheep are bunched tightly together.
- To the extent possible, do not drop net if small individuals are near mature males.
- Do not drop the net if neonates or young <2 months old are present; any such decision is situation-dependent, however, and rests with the Capture Boss.
- Animals can be hazed out from under the net to reduce the number subject to being captured.
- Early morning is the best time for drop-net captures because of cooler temperatures, and doing so allows more time to transport animals to release sites (George et al. 2008).

Removing Animals from the Net, Handling, and Processing

- Animals will bunch up and tangle in the net and they must be removed in the shortest possible time (Schmidt et al. 1978).
- Each sheep must be physically restrained, hobbled, and blindfolded.
- Do not lay or sit on animals and avoid compression of the animal’s chest or abdomen.
- Ensure that animals are not contorted in any way that could restrict airways or otherwise compromise an individual.
- Do not use the horns of females or young to as 'handles' to control or maneuver animals.
- Animals nearest the perimeter of the net should be extricated first.
- Work the net off the animals at their location under the net, rather than dragging individuals out from under the net.
- Immediately place extricated animals in a sternal position with their heads oriented uphill, and in a shaded area if available at the capture site.
- At least one animal handler shall remain with each restrained animal to ensure proper positioning and monitor its status.
- Ensure that adequate water is available—or use another method such as towels soaked in ice water—if it is necessary to cool animals; be sure to soak the pelage thoroughly and to the skin to facilitate heat transfer.
- Maximize heat transfer by cooling the axillary or inguinal regions of both sexes, the mammary gland of females, or the scrotum of males.
- Process each of the animals quickly and, ideally, within 45 minutes (George et al. 2008).
- Release any animal(s) showing evidence of distress immediately upon completion of processing; in some cases, it will be necessary to release individuals prior to completion of

processing.
- While handling animals, always speak in a hushed voice.
- Following extrication from the net, use a stretcher, litter, or tarp to move each animal to a nearby processing site, a vehicle, or to the location from which it will be airlifted to another location for processing (Foster 2005).
- Move animals that are to be released at the capture location away from the net, other restrained sheep and personnel, and vehicles. Place them uphill from the net and facing toward escape terrain (Foster 2005) and ensure they do not become entangled in the net upon release.

Clean-up, Disinfection, and Storage of Equipment

- After a capture event, implement appropriate cleaning and disinfection protocols of all equipment in the following order (Stull et al. 2018, CFSPH 2020).
  - Remove all grossly visible debris, including feces and vegetation.
  - Wash the net and associated materials (support ropes and poles) in detergent.
  - Thoroughly rinse the net and associated supporting materials to remove all detergents and allow the net and materials to dry thoroughly.
  - Select and apply an appropriate disinfectant for the recommended contact time.
  - Thoroughly rinse away and discard any disinfectant before again drying the net.
  - Store the net and associated materials together in a dry location out of direct sunlight.

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Table

Table 6.1. Personnel requirements for successful drop-net bighorn sheep capture operation. Ideally, processing teams remain together and move from animal to animal as processing of each is completed. The individual assigned to baiting the net is not included in this list but can be assigned as necessary.

Position Title	Number	Assignment or Responsibility
Capture Boss	1	Oversee and direct entire capture operation
Assistant Capture Boss	1	Advisor to Capture Boss; first-line consultant or advisor to capture staff
Communications Officer	1	Handles all radio communications on behalf of and following consultation with the Capture Boss
Bait Coordinator	1	Ensures bait is procured and provided daily; oversees set-up and testing of drop-net; helps decide when to trigger the net
Safety Officer	1	Human safety
Chief Veterinarian	1	Animal safety; advises Capture Boss
Trouble Shooters	4–6	Check net and animals for problems, separate the net, assist handlers
Animal Handlers	2/animal to be captured	Restrain (blindfold and hobble) and monitor animals
Watering Crew	2	Cool hyperthermic animals
Processing Crew	3–4 Crews	Obtains measurements, samples, attaches collars and tags, records data, ensures samples are handled properly
Sampling Team	2 Persons	Take blood, swabs, give meds
Collaring Team	2 Persons	Attach telemetry collar and other markings
Data Recorder	1 Person	Record all data, abnormalities, and treatments
Loading Supervisor (and crew)	1 (4)	Load animal in trailer or prepare and attach to long-line for aerial transport
Public Information Officer	1	Media contacts; manage media at central processing area

Figures

Figure 6.1. Erecting a drop-net in Alberta, Canada, showing the center pole (immediately to the right and behind the person in the orange vest) and 2 of the 4 poles placed at the corners that support the outer perimeter of the net.

Figure 6.2. Pre-baiting a drop-net with alfalfa hay. Note the 55-gallon (200 L) drums that have been filled with rocks and anchor support poles at the corners and sides of the net; note also that the area below the net has been cleared of large rocks and other obstacles, and that the sheep are well-conditioned to the presence of the net-tender.

Figure 6.3. Bighorn sheep in Montana beneath a drop-net net immediately before the net was dropped on them.

Figure 6.4. The moment the net was dropped on the same group (Figure 6.3) of bighorn sheep in Montana.

WILD SHEEP CAPTURE & HANDLING GUIDELINES

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Wild Sheep Initiative

CHAPTER 7

CAPTURING WILD SHEEP USING CHEMICAL IMMOBILIZATION

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Chemical Immobilization

Introduction

Chemical immobilization is an appropriate technique for capturing wild sheep in circumstances that allow a close approach. The remote delivery of drugs in darts can be an effective tool to selectively capture, mark, collar, or sample wild sheep in several field situations. Care must be taken, however, to avoid accidentally striking non-target animals or immobilizing individuals in unsafe terrain. When done correctly, and with the advancement of new drugs and technology, chemical immobilization is a safe and reliable method, and it can result in lower rates of injury or mortality that other methods of capturing wild sheep.

Wildlife professionals considering chemical immobilization must recognize that given the terrain conditions and unique responses to aerial pursuit, it can be difficult to immobilize wild sheep in field settings. It is recommended that wildlife professionals interested in this technique refer to Kreeger and Arnemo (2018) for information on capture protocols and human safety concerns; additional useful references include Woodbury (1996) and Jorgensen et al. (1990). Consultations with others experienced with chemical immobilization of wild sheep may also be helpful. The drugs and their combinations listed in this section are commonly used or frequently recommended for safe chemical immobilization, but it is not an exhaustive list. Refer to the appropriate references (Jorgensen et al. 1990, Woodbury 1996, Kreeger and Arnemo 2018), or consult with an attending veterinarian, for the most appropriate drug combinations available in your jurisdiction. Drugs used to immobilize wildlife are considered “off-label” uses, and veterinary oversight is required to prescribe, dispense, or report adverse reactions.

Rely on your personal experience and that of colleagues, including your attending veterinarian, when choosing drugs for immobilization. If a particular drug or drug combination proves to be efficient and safe, stay with that selection, but recognize that results are not always predictable or consistent in field settings. For example, appropriate dosages may be dependent on the season of the year, geographic area, or nutritional state of the animal. An animal that is highly stimulated or otherwise is stressed can be refractory to chemical immobilization, particularly when using alpha-2 agonists, such as xylazine or medetomidine. Following reversal, investigators are encouraged to monitor individual wild sheep for latent effects, and to consider a method of considering or incorporating those results during future capture efforts.

Chemical immobilization should be performed only by personnel having appropriate training and experience, and specific training and qualifications may be mandatory in some jurisdictions. Human safety and that of the target animal must be the utmost priorities at all times. An awareness of potential human safety risks is essential, and emergency care and response protocols must be established prior to any capture event involving immobilization drugs. Designating a coordinator to be responsible for contacting local health professionals prior to every capture event will help ensure they are prepared to respond in the event human safety is threatened.

Drug Combinations and Reversals

There are several different drugs, or drug combinations, that have been used to chemically immobilize wild sheep and they each have different characteristics, advantages, and disadvantages. Administering the proper drug dose is critically important to the effectiveness and efficiency of every capture. Drug dose refers to the specific quantity of drug administered while dosage is the amount of drug (mg/unit weight) and frequency at which the drug is administered to the target animal. The proper volume is usually determined by a calculation that includes an estimate of animal weight, the recommended dosage, and drug concentration. The following formula is used to calculate the appropriate volume of a particular drug (Kreeger and Arnemo 2002).

$$\text{Drug Volume (ml)} = \frac{\text{Estimated Body Weight (kg)} * \text{Recommended Dosage (mg/kg)}}{\text{Drug Concentration (mg/ml)}}$$

Induction times are often affected by dart placement, and placement in large muscle groups is paramount to avoiding extended induction times. Practitioners are advised to wait until the head is down before approaching immobilized animals, because spontaneous arousal is common and can occur prior to full induction.

- BAM (butorphanol, azaperone, medetomidine anesthesia combination)
  - With the development of the BAM drug combination (ZooPharm 2023a; Table 7.1), wildlife professionals have an effective drug for use on wild sheep (Wolff 2009, Smith et al. 2015, Butler et al. 2017, Grigg et al. 2017, Kreeger and Arnemo 2018).
  - Medetomidine, one of the drugs in the BAM cocktail, is an alpha-2 agonist and presents a high risk to humans.
  - This combination produces good analgesia, muscle relaxation, and reversibility, and is safe and low risk with smooth induction and smooth recovery in wild sheep.
  - BAM is reversed with intramuscular atipamezole and naltrexone (ZooPharm 2023a, 2023b). Table 7.1 provides information on recommended reversal doses.
  - Once the animal has been restrained (hobbled and blindfolded), partial reversal with ¼ to ½ of the recommended dosage of atipamezole can reduce risk of respiratory depression.
  - Hypoxemia is common with this combination and oxygen should be provided to sedated individuals by face mask or nasal cannula. Small oxygen tanks suitable for field use and weighing only 2 lbs (1 kg) are readily available.
  - Volumes can also be calculated for a range of body weights by qualified veterinary personnel. Drug concentrations are based on commercial BAM that contains 27.3 mg/ml butorphanol tartrate, 9.1 mg/ml azaperone tartrate, and 10.9 mg/ml medetomidine. Reversal agent recommendations are based on the commercial 25 mg/ml atipamezole and 50 mg/ml naltrexone. Consultation with an experienced veterinarian regarding body weight and seasonal effects prior to the capture event is recommended. For the purposes of these calculations, practitioners are reminded that 1 kg = 2.2 lbs.

Table 7.1. Recommended volume (ml) of BAM kit (ZooPharm 2023) for wild sheep relative to body weight.

Age	BAM	Atipamezole Reversal	Naltrexone Reversal
Lamb[a] (23 kg)	0.2-0.4	0.4-0.8	0.1-0.2
Ewe (45 kg)	1.0	2.0	0.5
Ram (68 kg)	1.5	3.0	0.75

- Thiafentanil
  - Thiafentanil has been utilized successfully to immobilize wild sheep.
  - It is slightly less potent than carfentanil or etorphine.
  - It has shorter induction and reversal times than BAM.
  - It is reversed with naltrexone.
  - This drug requires special Schedule II DEA registration in the United States and an Emergency Drug Release in Canada to comply with regulations. Local and jurisdictional regulations also may exist. Consult with a licensed veterinarian for specific regulations pertaining to this drug.
  - Using intranasal xylazine with thiafentanil has been observed to reduce mortalities in Dall's sheep captured with a net-gun, or that otherwise have been physically restrained (K. White and K. Beckmen, unpublished data).
- Xylazine
  - This drug is no longer widely used when compared to those listed above; however, it is still an option that may be considered. Be sure to seek veterinary guidance for proper usage.
- Other drug combinations have been used to immobilize wild sheep, including mixtures comprised of ketamine hydrochloride and xylazine hydrochloride, or mixtures of ketamine and medetomidine. Tiletamine hydrochloride has also been used. Consult with a compounding pharmacy for proper guidance and procedures.
- Etorphine (M99), which is reversed with diprenorphine (M50-50; use Naloxone for humans), may be another drug option in jurisdictions where thiafentanil is difficult to obtain or not available, but when a potent opioid is necessary to capture animals.
- Carfentanil is no longer commercially available.
- Telazol™ (tiletamine and zolazepam, Zoetis, Zoletil) is not recommended.
- Tolazoline is no longer the recommended reversal agent when alpha-2 agonists are used for captures because of the mixed receptors targeted by alpha-2 drugs and their potential side effects. Instead, atipamezole is the preferred reversal agent because it is more specific for the receptor targets than tolazoline, and it is a complete antagonist.

Other effective drug and drug combinations exist, but availability varies among jurisdictions. Licensed veterinarians, compounding pharmacies and agency protocols should be consulted for additional details regarding combinations.

Methods of Delivering Drugs

Helicopter or ground darting are the two methods for delivering chemical immobilizers to wild sheep. Each method has different advantages, disadvantages, and practical applications, depending on specificity of target animals, accessibility to sheep habitat, and the terrain they are utilizing. It is essential that several factors be considered when selecting capture methods to mitigate risks of injury or mortality. Indeed, animal body condition (depth of body fat) and thickness of pelage are related to seasonality, and ambient climatic conditions also warrant consideration. Although ground darting and helicopter darting are effective methods of drug delivery, it must be understood that mortalities have occurred with both methods (Table 7.2).

Ground Darting

- Never shoot at a moving animal.
- Either BAM or thiafentanil with xylazine, is recommended when a ground approach is feasible.
    - BAM can suppress respiratory function; administer ¼ dose or ½ dose of atipamezole (the reversal) as soon as animal is blindfolded and hobbled to alleviate side effects. It is also advised to administer oxygen when using this drug.
- Ketamine hydrochloride with xylazine hydrochloride can be used with ground darting.
- Ketamine-medetomidine with tiletamine hydrochloride can be used with ground darting.
- NalMed-A (a combination of nalbuphine HCl, medetomidine, and azaperone) can be used, but more research is needed to explore effects on wild sheep, and it has not been proven reliable in some locations. With the development or modified use of drugs, information gathered and procedures to share that information should be considered to enhance knowledge and provide additional guidance.

Helicopter Darting

BAM

- It has a good safety record and is suitable for helicopter darting of wild sheep where terrain and ambient conditions allow.
- The effective dosage is generally greater than recommended by manufacturers when a helicopter is used to deliver the drug.
- Consult those experienced with the use of BAM during the planning stage.
- Avoid unnecessary aerial harassment of animals following darting, as it may prolong time of induction, down time, or both.

Thiafentanil

- Can be used in combination with an alpha-2 agonist, like xylazine or medetomidine, for relaxation following immobilization.
- It has a good safety record for helicopter darting.
- Thiafentanil has a short induction time.
- If using with narcotics combined with xylazine or medetomidine, administer ¼ of reversal dose of atipamezole after the animal is restrained to mitigate side effects.

Midazolam

- This drug provides light sedation and muscle relaxation while the animal retains control over its limbs.
- Flumazenil is the reversal for midazolam (ZooPharm 2023b).

Capture Site Selection

Regardless of whether aerial or ground delivery is employed, careful consideration and evaluation of potential capture sites is essential to avoid unnecessary exposure of animals and capture crews to overly dangerous situations. Knowledge of animal behavioral responses and the terrain at capture sites are critically important when selecting appropriate capture microsites. Since there is a time lag between drug delivery and induction or immobilization, anticipation of potential hazards associated with locations animals can reach following drug delivery must be considered.

- Optimal capture locations are semi-open spaces with adequate distance from hazardous cover or terrain features, among which are cliffs, steep snowfields, ravines, boulders, and tall vegetation that may obscure visibility of an animal and delay it being located.
- There must be a safe, open place for the helicopter to land and allow personnel to reach the immobilized animal.
  - The pilot and crew must be prepared for a “toe-in” landing.
  - The crew may need to carefully approach the animal before full sedation and loss of muscle control to prevent hazardous falls or rolling downhill.
- Avoid areas of steep cliffs or exposure to steep terrain or limit it to one side of the capture site.
  - Position the helicopter between animal and any potential danger, such as a steep cliff.
  - Be alert to animals wanting to travel downhill, because they can move long distances in a short amount of time.

Ambient Weather

Considerations should be given to ambient temperature and wind speed.

Temperature

- Temperature trend can influence physiological condition of the animal and therefore dictates needed action; be proactive and treat early.
- If body temperature is steadily climbing, treat the animal for hyperthermia immediately.
- A body temperature of 104°F (40°C) is considered the threshold for enacting treatment for hyperthermia.
- Consider the animal's adaptations to extreme temperatures (e.g., summer or winter pelage; stage of molt) and climate in the context of the stressors associated with capture.
- Remember that time of day affects ambient temperature and humidity, and helicopter performance is a function of density altitude (e.g., change in air density despite constant elevation) and pay close attention to this metric.

Wind Speed

- Wind speed changes or any other extreme weather conditions may require immediate decisive action. For example, it may require personnel to consider changing locations, calling off the event entirely, or other immediate alterations to the original plan.

- Be familiar with wind resistance and its effects on performance of the dart projectile, and on animal behavior under differing wind conditions.

Projectile Delivery System

Delivery System

- Use the delivery system least likely to cause physical trauma to the animal.
- Use the projectile system with which the shooter is most familiar and proficient.
- The type of approach (helicopter vs ground) will affect the choice of the delivery system; gas-powered delivery is effective at shorter ranges; powder-charged systems are used more frequently in aerial captures; muzzle velocity can be altered, however, in powder-charged weapons when used for ground delivery.
    - Pneu-Dart or Dan-Inject Rifles use compressed CO_2 (Pneu-Dart 2023, Dan-Inject 2016) to propel the dart.
    - Pneu-Dart (2023) or Palmer (2023) both manufacture powder-charged rifles.
- Cartridge-powered guns are better suited for cold climates.

Table 7.2. Examples of capture methods and recent mortality rates for North American wild sheep.

State or Province	Species	Method	Mortality Rate	Drugs Used	Source	Complication
Alaska	Dall's sheep	Helicopter Net-gun	0.5% (1/200)	Net-gun + xylazine	ADFG[a]	parachute capture myopathy (1); result of double-netting
Alaska	Dall's sheep	Helicopter Net-gun	100% (3/3)	none	ADFG[a]	capture myopathy (3); prior to intranasal xylazine
Alberta	Bighorn sheep	Ground darting	1.1% (1/95)	BAM	AFW[b]	broken leg (1); not drug induced
Alberta	Bighorn Sheep	Helicopter darting	0% (0/18)	BAM	AFW[b]	none
British Columbia	Bighorn sheep	Ground, Helicopter darting	1.6% (2/126)	BAM	BCFWB[c]	undetermined (1), bad dart strike (1)
New Mexico	Bighorn sheep	Ground darting	10.6% (12/113)	carfentanil, BAM	NMDGF[d]	carfentanil (9), BAM (3)
South Dakota	Bighorn sheep	Ground darting	1.4% (6/438)	BAM	SDDGFP[e]	allergic reaction to antagonist (2), poor body condition (1), BAM overdose (1), undetermined (2)

[a]Alaska Department of Fish and Game. 2021. Mountain ungulate mortality rates. Unpublished data.
[b]Alberta Fish and Wildlife. 2021. Mountain ungulate mortality rates. Unpublished data.
[c]British Columbia Fish and Wildlife Branch. 2021. Mountain ungulate mortality rates. Unpublished data.
[d]New Mexico Department of Game and Fish. 2021. Mountain ungulate mortality rates. Unpublished data.
[e]South Dakota Game, Fish and Parks. 2021. Mountain ungulate mortality rates. Unpublished data.

Dart Selection

- Use 1 or 2 ml darts, as appropriate for the drug volume, with 1–1¼" (25–30 mm) needles having a ¼" (5 mm) metal barb. Barbed darts remain secured to the animal and allow for complete injection.
- Use a permanent marker to mark the position of the barb along the side of the dart to facilitate removal of the dart from the animal.
- Do not use gel points or barbless darts because they bounce out before delivering a full dose.
- Telemetry darts can be helpful when using drugs that have a lengthy induction time.
  - It is unsafe to leave any darts resulting from animal misses in the field.
  - Use a telemetry dart in situations where animals may evade visual detection after being darted, such as those that can move into densely vegetated areas.

Dart Placement

- Follow the manufacturer's recommendations and establish proper air pressure or power settings and ranges and record those data for each individual rifle.
  - Always be familiar with changes in dart impact as air pressure in CO_2-powered guns is altered with power-load settings.
  - When using powder-charged guns, changes in impact occur when different loads (low, medium, or high) in blank cartridges are used.
  - Be aware that impact increases or decreases with positioning of the dart in the barrel.
  - Placement of the dart down the barrel from the chamber will lessen impact relative to a dart placed closer to the chamber.
  - Fatalities or injuries can occur if the pressure setting is incorrect or distance to the target is incorrectly estimated.
  - Become proficient with the delivery method before attempting to use it to capture animals.
  - Use of a range finder to determine distance is recommended.
  - Attempt to place the dart into a large muscle group.
    - The primary muscle group is the lower portion of the hind quarter.
    - The secondary muscle group is the front shoulder.
  - Avoid large areas of accumulated body fat and less-muscled areas.
  - Good dart placement is critically important to rapid induction and reduced risk of complications.
  - Efficacy of BAM is sensitive to dart placement, and it is most effective in good muscle mass.
- Know the factors that affect or limit projectile accuracy.
  - Wind direction, air speed, ground speed, and rotor-wash all affect ballistic performance and accuracy of dart placement.
  - Extreme temperatures affect the performance of CO_2 powered rifles, but also affect proper dart placement in the barrel of a powder-charged rifle. Recall that impact and range of powder-charged rifles can be altered with use of different cartridge loads, position of the dart in the barrel, or both in combination.
  - Angle or slope of the terrain, and angle from which the projectile is fired toward the target all will affect efficacy and accuracy.
  - Vegetation height or density have the potential to impede or deflect darts.

- Always be familiar with the manufacturer's recommendations.

Induction

- Induction refers to the initial administration of sedative agents to bring about an adequate state of anesthesia.
- Partial induction may result for a variety of reasons:
  - Dart placement was inappropriate (e.g., into bone or connective tissue).
  - Equipment malfunctioned, or the dart bounced off the target, or partial injection resulted from dart failure whereupon the animal does not receive the full dose.
  - Body weight was underestimated, and an incorrect dose was delivered.
  - An expired, precipitated, or frozen drug was used.
  - Overexcitement or prolonged chase of the animal occurred; it is essential to track the variables associated with each pursuit (e.g., chase time, dart placement, time to sedation) and to have established limits on chase times prior to initiating any capture operation. In cases of inefficient or unsuccessful captures, an understanding of the variable(s) affecting that capture will be important learning outcomes that inform future success.
  - Partial induction may also result from continued stimulation of the animal during drug induction.
- Signs of partial induction include the following:
  - A period during which stumbling occurs and the animal does not lie down or gets up repeatedly for a period longer than the typical induction time.
  - The animal lowers the head but fails to become recumbent.
  - The animal continues to struggle or tries to escape after the typical induction time.
  - The animal attempts to rise in response to audio, physical or visual stimuli.
- Decisions to re-dose an animal or to wait for full induction must be made on a situational basis. Managers are advised of the following:
  - Any decision to re-dose is drug dependent.
  - After waiting the full recommended induction time, but the animal shows evidence of partial induction, investigators should consider giving the individual ½ dose of the primary immobilizing drug.
  - Decisions to re-dose are terrain dependent; in some settings it may be necessary to administer a second dose quickly if there is a potential for the animal to access hazardous terrain or an area where a second dose cannot be delivered. Backup darts should be pre-loaded and readily accessible for use in such circumstances.
  - An extra vial of the immobilizing drug and a suitable syringe and needle should be readily and safely available so it can be quickly handled and an animal re-injected without a dart and it is possible to do so.
  - Circumstances can dictate it is unsafe to continue to chase for a re-dart, and it may be better to let the animal recover on its own if it is only showing slight or no effects.
  - If the handling crew cannot reach the animal where it may go down, consider darting it with reversal drugs.

Dart removal

- Find the location of the barb by using the markings that were drawn onto the side of the dart. Use a clean, sharp knife or scalpel blade to make a cut over the barb and remove the dart.

Removing the dart by pulling it can result in significant trauma to vessels or ligaments, especially if dart placement was less than ideal.

- A skin wound open from ¼" (~0.5 cm) to ½" (~1 cm) will allow flushing and drainage of the wound and prevent premature closure, which can lead to abscessation.
- When using powder-charged darts (Pneu-Dart®, CapChur®), debridement to remove damaged tissues and hair is necessary. Air pressure injected darts (Daninject®) do not require wound debridement.
- To debride a dart wound, use a curve-tipped flushing syringe from which the plunger has been removed and fill it with diluted povidone-iodine solution or sterile saline to flush out debris.
    - Povidone-iodine (Betadine®) comes as a 10% solution. It is then diluted 1:100 in distilled water or saline for flushing and will have a 'weak tea' appearance. This is the least irritating and most effective antibacterial concentration. The most important thing is to remove the debris and have the wound open enough to heal. If freezing conditions exist, add an appropriate amount of propylene glycol to the mix, and warm the Betadine solution before heading out; a chemical heat pack placed next to the flush (or ointment) will help keep it flowing. Unscented, diluted, Nolvasan® solution is approved for use in animals or sterile saline for irrigation can be used, but DO NOT use Nolvasan-S.
- Replace the plunger in the syringe, and place tip of syringe in the wound and flush out debris or hair.
    - Use at least ½ oz (15 ml) of diluted solution.
    - Use sterile saline for irrigation if diluted iodine solution is unavailable.
- Remove any remaining hairs or debris with forceps or a hemostat.
- Instill Nolvasan® 1% ointment with the wide syringe tip.
    - Do Not use Panalog® or other oily substances not meant for deep wounds.
- Clean and disinfect the flushing syringe tips and a knife blade between use on different animals.
    - Do not put the syringe tip into the stock bottle of solution; instead, pour straight onto or into the syringe.
- Consider using antibiotics (IM or SQ [subcutaneous]) to assist with fighting infection of the dart wound.
- If the wound is hemorrhaging (not just superficial skin bleeding), cover it with a clean cloth or gauze and apply firm direct pressure for 5 minutes. Do not disturb the clot when gently peeling away the gauze. Only 'blot' a bleeding wound; never 'wipe' it, or you will remove the forming micro-clots. Do not flush or apply ointment in these cases.

Drug Withdrawal and Animal Consumption

Drug withdrawal time is the time needed after administration of a drug until it can be considered fit for human consumption to ensure that no significant drug residue remains. For some of the drugs used in wildlife chemical immobilization, drug withdrawal times are available for domestic species, but must be determined by the prescribing veterinarian under regulations (AMDUCA) for wildlife. Still, these may not be universally applicable and must be considered when planning the project.

Notification of the hunting public is strongly advised, and possibly legally required, if working with a harvestable population. Animals that have had any drugs administered, including antibiotics,

supplements, or dewormers, are not immediately fit for human consumption, and in some cases may never be acceptable for consumption.

- Mark all captured animals with visible ear tags or other appropriate markers to prevent consumption within 30 days of capture (or longer, depending on the drugs administered and the attending veterinarian's assignment of withdrawal time), and to avoid re-capture of the same animal as work continues.
- Carcasses of animals that die during or before withdrawal time can be toxic to scavenging animals. Following necropsy, and especially for animals that have been euthanized with barbiturates, or drugged with potent opiates such as thiafentanil, be sure to properly dispose of the carcass in accordance with local regulations.

Monitoring of Vital Signs

A veterinarian or other properly trained individual must regularly monitor vital signs and be prepared to administer treatment for shock. In addition to body temperature, respiration, and heart rate, monitoring of oxygen saturation is highly recommended.

Restrained animals will sometimes have body temperatures that exceed the minimum safe level for hyperthermia, and preventive measures must be taken immediately. Action should also be taken when the body temperature is trending up over time and a rapidly increasing rectal temperature indicates the need for immediate intervention. Prior to stopping a treatment, it is essential that the animal exhibit at least two declining temperature readings that are below the minimum value at which hyperthermia is recognized (104°F or 40°C).

Following capture, vital signs (Table 7.3) should be monitored so that proper treatment can be given at an early stage if an animal exhibits undesirable clinical signs (e.g., respiratory depression, hyperthermia, bloat, regurgitation). Excitation and continued handling will exacerbate these values, and higher ambient temperatures will aggravate them further.

- Frequent measurement of body temperature, heart rate, and respiratory rate is important.
- Check body temperature every five minutes and continually watch respiration rate.
- Certain drugs (especially medetomidine) will alter the blood pressure and peripheral perfusion; this can make pulse oximetry and capillary refill times misleading and must be considered.
- Take pulse (palpate femoral artery or use a stethoscope or hand over heart on left side) for six seconds and multiply by 10; if done for 15 seconds, multiply by 4.
- To assess blood pressure and evidence of shock, check gum color for capillary refill; <2 seconds and pink coloration indicates it is adequate, and bluish or gray indicates shock or respiratory arrest, and emergency treatment must be initiated immediately.
- Monitor SpO_2 (relative oxygen saturation) using a pulse oximeter. SpO_2 levels below 90% can become dangerous and require close monitoring.
- Provision of supplemental oxygen is recommended for all chemically immobilized animals.

Table 7.3. Expected ranges for temperature, heart, and respiration during resting when the animal is being handled, and levels of each at which intervention is necessary or becomes mandatory.

Metric	Expected Range		Level at Which Intervention is	
	Normal (Resting)	**During Handling**	**Necessary**	**Mandatory**
Temperature	101.0–103.5°F 38.3–39.7°C	102°–103.9°F 38.8°–40.0°C	104°F 40°C	>106°F >41°C
Heart Rate (beats per minute)	120–160	140–160	>160, sustained	>160, sustained
Respiration Rate (breaths per minute)	15–35	40–70	>70, sustained	>70, sustained

Emergency Treatments

Always use the capture method that has the least risk of injury or stress for the animal while still achieving study or management objectives. Reliance on treatments to compensate for an inappropriate capture method will increase the probability of complications and put animals and capture crew at unnecessary risk. Animals may require treatment for capture or post-capture complications, such as hyperthermia, shock, acute or subacute muscle damage or myopathy, trauma, or other conditions listed below. The earlier that treatment can be initiated, the more likely abnormal signs can be reversed, but field treatment often is not successful. Emergency treatments must attempt to stabilize animals and are best carried out under the direction or supervision of a licensed veterinarian. Oftentimes, it is best to immediately administer the reversal agent to an animal that exhibits a concerning level of respiratory or thermal stress (Table 7.3). These conditions are evidenced by the following:

- High (hyperthermic) or low (hypothermic) body temperature
- Drug-related complications, such as narcotic-induced hypoxia
- Increased or decreased heart rate outside rates typically resulting from capture
- Increased or decreased respiratory rate and varying depth of respiration
- Increased capillary refill time and pale or blue mucous membranes
- Other symptoms that are dependent on the body system involved.

Hyperthermia

Hyperthermia (body temperature rapidly increasing or 106°F (>41°C)) is the most common complication encountered during capture events. Treatment for hyperthermia should be initiated if temperature is >104°F (>40°C) or the temperature trend is steadily rising and anticipated to exceed 104°F (>40°C). Hyperthermia can cause physiological damage and can be fatal if left untreated. Adherence to the guidelines below will reduce physiological damage and fatalities caused by hyperthermia.

In some instances, the immobilizing drugs can cause hyperthermia. Drug-induced hyperthermia cannot be treated, and the animal must be reversed immediately. The risk of hyperthermia increases substantially with some capture methods, especially pursuit with an aircraft.

- Cool water, snow or rubbing alcohol rubbed into the coat may help reduce body temperature. These are most effective when applied to the neck, belly, axilla and groin, and to the mammary area.

    - Use this technique with caution in winter because drenching an animal's coat could result in development of hypothermia after the animal is released.
- Additional measures include creating shade, putting the animal in direct contact with cool ground, moving it onto snow or into a stream, and plucking the molting coat away.
- Mix 0.5 gal (~2 L) of isopropyl alcohol with 4.5 gal (~38 L) of water to increase the evaporative cooling effect of the solution.
- Give flunixin meglumine (Banamine; Merck Animal Health, USA) to help reduce high temperatures.
    - Administer Banamine at a rate of 1 ml/100 lbs (1 ml/45 kg) body weight.
    - Give IV or SQ only, because IM will cause tissue necrosis.
- Aerial capture crews must take a baseline temperature and apply water, or a mixture of water and isopropyl alcohol, and rub it thoroughly into the pelage so it is soaked to the skin if hyperthermia is indicated or anticipated.
- When animals are to be transported to base camp for processing, the capture crew must write the body temperature on the horn with a permanent marker and notify the pilot to relay information regarding an animal with a critically high body temperature so it will be treated immediately upon arrival.
- Administer IV fluids if available and it is appropriate to do so.

Human Safety and Accidental Exposure

Protocols and proper training must be in place for all personnel that will be handling immobilizing drugs, and every effort must be made to prevent accidental exposure.

- Be certain that all personnel responsible for animal capture or the handling of chemical immobilizing agents have completed a comprehensive training course before participating in captures.
    - Refresher courses are recommended to assist these personnel with information on updated procedures, methods, treatments, or pharmacology.
- Develop human safety protocols in conjunction with state or local veterinarians prior to capture events to ensure that correct information is available, and a proper plan of response is in place.
    - Consider protocols that include treatment in the field in the absence of immediately available medical assistance, on-site and in-transit treatments, and emergency room treatments and considerations.
- It is essential that all personnel work with at least one additional person when capturing wild animals because accidental exposure to drugs can occur in the field. The affected individual must stay calm and notify the other, who must immediately initiate the emergency care response protocol and ensure that professional medical assistance is sought and obtained.
- It is essential that Material Safety Data Sheets for each drug being used be readily available.
- For additional information, see the safety protocols and other considerations outlined in the Safe Capture Course developed by the Zoological Society of San Diego.

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WILD SHEEP CAPTURE & HANDLING GUIDELINES

WAFWA
WESTERN ASSOCIATION OF FISH & WILDLIFE AGENCIES

Wild Sheep Initiative

CHAPTER 8

CAPTURE & HANDLING OF NEONATES

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Capture and Handling of Wild Sheep Neonates

Background

Over the past decade, investigations involving neonatal wild sheep have become quite prevalent (Smith et al. 2014, Karsch et al. 2016, Grigg et al. 2017, Cain et al. 2019). These studies have provided useful information on demographic processes, cause-specific mortality, habitat selection, and timing of parturition, all of which may influence conservation decisions or increase efficacy of management actions. However, even with this increase, there have been no comprehensive guidelines that agency personnel could refer to when establishing capture protocols or designing investigations. This document provides agency personnel who propose to handle neonates with the guidelines to do so safely and efficiently and to increase the effectiveness of neonate-focused studies.

Not all investigations of neonate ecology or behavior will require handling to achieve the desired objectives. For example, delineation of critically important areas that warrant protection, resource selection by females during lamb-rearing, birth-site identification, timing of parturition, and some demographic studies can, under the right circumstances, be accomplished without handling neonates. Further, as unmanned aerial vehicle technology continues to progress, some study objectives may be accomplished without the need to handle those vulnerable individuals; exceptions will include the need to obtain morphometrics, place telemetry collars, investigate cause-specific mortality, or sample for pathogens or disease. Further, and depending on the study objectives and area(s) in which individuals can be observed with minimal effort, capture and handling of neonates may not be necessary. Conversely, in large areas or those having limited access, it may be necessary to capture and handle neonates, and monitor their status with telemetry.

Study Design

A defensible design that justifies handling of neonates must be developed to ensure the set of objectives are realistic and are apt to be achieved. This will help with structuring budgets, identifying necessary personnel, determining strategies, and developing an appropriate course of action. Prior to initiating any project that will involve handling of neonates, personnel must identify the specific hypotheses to be addressed, why it is essential to capture neonates, and the data necessary to achieve the management or research objectives.

Collar and VIT design

Communication to improve design is essential. It is critically important that project personnel actively communicate with the companies designing and creating the technology used in studies of neonates. Careful consideration must be given to the design of vaginal implant transmitters (VITs), adult collars, and neonate collars.

VITs

Designs

- VITs are similar in design to the controlled internal drug release (CIDR) technology being used in cattle. The wings are located at the opposite side of the very high frequency (VHF) or ultra-high frequency (UHF) antenna and must be pliable enough that they do not damage the

vaginal canal. Wings that are too pliable may increase the rate of premature expulsion, while wings that are overly stiff may cause tissue damage. Additionally, design should minimize the extent to which the antenna extends beyond the vulva. Ideally, the antenna will be exposed no more than 1 in (2.5 cm) and preferably less than 0.5 in (1.3 cm) beyond the vulva; this will minimize the chance that the female will be able to remove the VIT. Moreover, all edges of the VITs must be rounded and smooth to further limit the probability of injury to the vaginal canal.

Temperature Sensor

- Current technology primarily uses temperature sensors to identify expulsion events when temperatures fall below a pre-set threshold. Temperature sensors may not be fully effective in some environments because ambient temperature in warm climates may prevent expelled devices from 'switching on' and transmitting a signal indicating expulsion has occurred.

Multi-sensor Transmitters

- These VITs are preferred because they offer multiple avenues to detect expulsion events; sensor types include proximity, light, and activity sensors, and combinations thereof.
- Proximity sensors activate when a VIT is no longer detected via UHF communication with the female's GPS collar. If no connection is established within a pre-determined period, the GPS collar will transmit a signal and alert personnel that it can no longer locate the VIT, indicating that it may have been expelled.
- Light-sensing VITs are activated following expulsion and subsequent exposure to daylight and alter the VHF signal to indicate it has been expelled. Investigators should ensure that the light sensor is close to the wings of the VIT to reduce the chance of signals that falsely indicate expulsion has occurred. VITs that are not fully within the vaginal canal because the animal is nearing parturition, body position of the animal (e.g., laying down), or improperly placed within the vaginal canal may erroneously indicate the VIT has been expelled.
- Activity-sensing VITs employ technology that is similar to that in the tip-switches used in telemetry collars, and if a VIT is moving a signal is transmitted indicating that is the case. Upon expulsion, the VIT signal changes to indicate that the VIT has become stationary, and that birth likely has occurred.

Methods of detecting birth

- Temperature Detection: This is a standard approach to estimating the time that birth occurred and is associated with a VIT declining in temperature and dropping below some predetermined temperature threshold.
- False birth notifications are not uncommon, but usually are associated with Braxton Hicks contractions and during which VITs may begin to extend beyond the vulva and cool adequately to activate a birth notification.
- Activity Detection: This technology is similar to that used to detect a mortality event but is less reliable than other types of sensors because there is a lag between the birth and when cessation in movement is detected, rather than the near instantaneous notifications associated with temperature or light sensing VITs.
- Light Detection: In hot environments, a temperature-sensing VIT might not detect a change in temperature adequate to trigger a message that birth has occurred, because the VIT failed to cool below the necessary threshold.

  - If a light sensor is incorporated into a temperature-activated VIT, be reminded that the light sensor should be at the end closest to the wings, rather than near the antenna, to avoid false notifications.
- UHF Connection with the Female's Collar
  - This is the most advanced technology for monitoring VITs and is associated with a UHF connection between the VIT and the mother's collar. The VIT yields a notification that is transmitted to investigators via a satellite signal from the mother's collar.
  - This system is the most efficient and reliable for "real time" monitoring and detection of birth events, but false notifications also occur, and are not uncommon.

Alternatives to Using VITs

- Given the nursery behavior and the gregariousness of bighorn sheep, knowing with certainty that birth has occurred, or if and when a female's lamb has died, also may justify or necessitate capture and marking of lambs.
  - Unmanned Aerial Vehicles (UAVs): This technology is rapidly advancing in terms of flight time and quality of imagery captured. In the near future, UAVs may be used to confirm parturition events, detect mortalities of adults or neonates, and determine habitat attributes such as ruggedness, vegetative cover, habitat type, vegetation type, or vegetation quality.
  - There are many constraints on the use of UAVs, and it is essential that personnel familiarize themselves with these regulations.
  - A particularly important regulation dictates that UAVs be operated only within line-of-sight, but a waiver may be obtained in some circumstances.
  - Those operating UAVs must have the appropriate license(s) or permits to do so.
- Video Collars
  - Some collars incorporate video capabilities, thereby allowing images to be captured. This technology can be used to confirm parturition events, observe nursing behavior, and survival status of lambs (Kaczensky et al. 2019). Video quality and frequency of image capture are limited by battery life and must be considered before employing this technology.
- Direct Observation
  - Highly visible or readily accessible populations may best be investigated without the need to handle neonates, but application or utility is a function of objectives. Moreover, this technique is most apt to be useful in small study areas, or when populations are acclimated to the presence of humans.
  - If a large portion of the population can be observed multiple times per week, it may meet objectives without the need to handle neonates.
- Use of Movement Data to Identify Parturition Events. It is possible to identify parturition events through movement data gathered from pregnant females that have been fitted with GPS collars (DeMars et al. 2013, Severud et al. 2015, Cameron et al. 2018, Nicholson et al. 2019).
  - If only VITs are used to identify parturition events, investigators likely will be dependent on female movement data to detect the probable birth-site, and must then search location clusters for the VIT or other evidence that birth has occurred. This will result in a shorter battery life because fine movement data are typically needed to identify these sites.
  - Metrics associated with movement rate and multiple scales of first passage time (e.g., the time taken for an individual to reach a specific site for the first time; McKenzie et al. 2009), when combined with the extensive pre-partum movements often made by a female

seeking isolation just prior to giving birth, can help determine time and location of the birth. Geographic coordinates should be received at a rate of no less than 1/hour; fixes received at a lesser rate likely will be too coarse to identify the fine-scale shifts in movement often associated with birthing behavior.

Neonate Collars

Collar Fit

- Collars must fit snugly around the neonate's neck.
- Collars that are too loose may slip off or move excessively on the neck. Collars must fit animals appropriately, but collars that are slightly oversized and placed on individuals that are a bit small when captured can be adjusted in the field by using electrical tape to add an additional, temporary fold, compression, or 'pleat' to the neck band.
- In direct sunlight, electrical tape will break down quickly and fall off as the lamb's neck grows in circumference and creates pressure against the collar, thereby causing the specially created 'pleat' to open.

Pleat Size

- Neonate collar bands include a series of pleats that will break as the neck grows and, thereby, allow the collars to expand in circumference.
- Pleat size varies among collar manufacturers and must be a consideration. Shorter pleats are more likely to accommodate growth as it occurs and to retain a snug fit with weathering. In contrast, longer pleats will increase expansion in larger steps and, as a result, increase the possibility of collar loss.

Design

- Neonate collars must be neither bulky nor heavy.
- Researchers must consider the size of the box that contains the battery and transmitter. The housing (e.g., the box) containing the electronics must be rounded, and small enough to not cause discomfort or alter behavior of the animal.
- Collar weight must be considered because of its potential to influence mobility or activity of the neonate; collars weighing 40 g or less have been used successfully with no negative effects having been observed.
- Neonates grow rapidly and collar weight will become less important as the animal increases in age.

Band Material

- Collars are best constructed from material that will eventually break down and allow the collar to fall off; commonly used materials are elastic and cotton. Collar material will break down at different rates depending on the environmental conditions in which deployed.
    - Cotton will break down more rapidly in humid environments than it will in more arid climates.
- Stitching
    - Stitching must be of material that will break down when exposed to the elements. Cotton is commonly used for the stitching material that keeps the pleats intact.
    - Pleats should not be overly stitched, yet sufficiently to allow collar retention. Collar designs with greater than 2 bands of stitching per pleat are not recommended because it is more difficult for the collar to expand.
    - The strength of stitching must increase incrementally across the pleats to avoid all of them opening simultaneously, and the collar suddenly becoming too loose.
    - Multiple small pleats are better than a few large pleats, because they allow the collar to open up in small, rather than large, increments that can result in premature loss of the collar.

Logistics

Crew Size

- Crew size must be considered from safety, budgetary, and efficiency perspectives. Each study area presents its own set of challenges that may reduce or increase the most effective crew size.

Human Safety

- The primary consideration is human safety. Wild sheep occupy a range of topographic conditions from open meadows to high and rugged cliffs. The size of the crew should be determined based on knowledge of the area and the difficulty of the terrain.
    - Areas with more gentle terrain and reduced availability of escape terrain can be effectively navigated by a single individual.
    - As areas become increasingly dangerous (e.g., cliffs, steep slopes, etc.) and difficult to navigate, additional personnel are needed to ensure that handlers have help in the event of injury.

Spotters

- Spotters are useful when locating a female and her neonate, and in guiding the handler(s) into the area (Smith et al. 2014). The spotter is best located on a vantage point that provides a wide view of the area in which the animal of interest is thought to be located. Suitable areas typically are across a drainage from the suspected parturition site. Spotters must do their best to remain out of sight to limit the potential for alerting the female.

Handlers

- In some cases, the number of handlers has been linked to abandonment of neonates by post-parturient females (DelGiudice et al. 2018). Other investigators, however, have reported no such effect on rates of survival or abandonment of neonates among multiple species or subspecies of ungulates (M. E. Blum et al. unpublished data). As a result, the

number of persons present in the immediate area may not be a consideration beyond human safety or increased efficiency.

Capturing Older Offspring

- Older offspring are more difficult to capture than neonates. Lambs ≤2 days old can be captured and processed efficiently with only 2 handlers. Lambs that are >2 days old are more difficult to capture and likely will require more than 2 handlers to corral individuals that attempt to escape. Probability of success dramatically decreases, and is rare, when neonates are ≥ 3 days of age.

Timing of Captures

- Among populations, wild sheep can exhibit prolonged periods during which parturition occurs. Ranges over which parturition is likely to occur must be considered when developing a project budget and list of available personnel.
    - This may lead to differing climatic conditions that researchers will encounter, as well as length of time that personnel must be in the field.
    - Individuals working in areas in which animals exhibit a protracted birthing period may benefit by deploying collars on females that negate the need for personnel to be on the ground.
    - Designs that transmit notice of a VIT expulsion are valuable in populations characterized by less synchronous periods of parturition, but this technology is not error-free.

Terrain Considerations

- Wild sheep typically occupy precipitous terrain during parturition, and investigators must consider the equipment needed to capture neonates in those habitats. Some areas may necessitate technical climbing skills and the use of specialized equipment. The decision to capture lambs in such areas is up to the investigator in charge and there are considerable risks, both to study animals and personnel, with such efforts.

Prior Experience

- As emphasized previously, human safety is the number one priority during any capture event. Areas that are too dangerous to navigate safely, or that handlers are not comfortable traversing, are best avoided. Any such decision will be a function of the level of skill and experience of personnel involved. It is essential that these individuals are proficient in their ability to navigate precipitous terrain.

Equipment

- Handheld radio telemetry receiver
- Handheld GPS receiver
- Handheld nets (e.g., insect or bird-catching nets)
    - We are unaware of the use of handheld nets to capture neonatal sheep. These nets may be useful in some circumstances, but handlers need to consider the practicality of moving through precipitous terrain with a handheld net.
- Handheld or skid-mounted net-gun
    - We are unaware of the use of hand-held net-guns for capturing neonatal wild sheep from the ground. As with hand-held nets, the difficulty of carrying these devices

must be a consideration when moving through rugged habitat. These devices likely are unnecessary for capturing neonates ≤2 days old.
    - Skid-mounted net-guns have been used to capture Dall's sheep neonates (Scotton and Pletscher 1998); however, the researchers abandoned this method due to the difficulty of separating the female from the neonate. The authors mentioned that use of a hand-held net-gun likely would have increased capture success over skid-mounted net-guns because helicopter positioning would be less of a consideration.
    - If these devices are used, it is recommended to not capture adults and neonates in the same net in order to minimize the potential of injury to the neonate (Scotton and Pletscher 1998).
- Measuring tape
- Scale and weighing bag
- Disease sampling kits
- Blood-drawing kits
- PIT tags and applicator
- Leatherman or other multi-tools
- Binoculars and spotting scopes

Capture Techniques

Helicopter

Helicopters have been used to capture ungulates in a variety of ecosystems (Ballard et al. 1979, Barrett et al. 1982, Keech et al. 2000, Jacques et al. 2009, Webb et al. 2010, DelGiudice et al. 2015, Downs et al. 2018, Van de Kerk et al. 2020, Wagler et al. 2022). For Dall's sheep, helicopters have been used to access remote locations and to assist handlers by directing the neonate into more accessible locations and using the rotor wash to disorient neonates or mothers (Scotton and Pletscher 1998).

- It has been observed that golden eagles (*Aquila chrysaetos*) keyed in on helicopters, resulting in an increase in mortality among young Dall's sheep (T. Lohuis, Alaska Department of Fish and Game, personal communication). This potential must be considered if a decision is made to use a helicopter to capture neonates.
- Use of helicopters to capture neonates is not recommended given the safety concerns for crew members, increased chance of injury to neonates, and increased disturbance.

On the Ground

Remote Observers

- Remote observers may help locate the mother and neonate prior to the handling crew approaching the birth-site (Smith et al. 2014). Observers also may assist the handling crew by helping them remain undetected while navigating to the mother and neonate, or to notify the handlers of the behavior or movement by the pair.
- Remote observers may also allow biologists the opportunity to determine if a female reunites with her neonate, or to record behaviors observed during reunification.

Telemetry

- Regardless of VIT design, telemetry is essential to identify the location of females (and, ultimately, their offspring).
- Bighorn sheep neonates exhibit a following behavior and are more likely to be with the mother than are those of species that employ a "hiding" strategy. Nevertheless, use of telemetry to locate the mother will increase the likelihood of finding the neonate, as the dam and offspring may move away from the birth-site shortly after parturition.
- If the mother is spooked prior to the offspring being observed, it is useful to locate the birth-site and search the immediate area in a circular pattern.

Route Planning

- It is critically important for all personnel to remain out of sight for as long as possible.
- If using UHF-connection VIT technology, crews should use the location of the birth-site provided by the mother's collar and her GPS locations prior to parturition. This information can be used to plan routes that maximize the ability of handlers to avoid detection as they approach the target animal(s). Even with this technology, use of radio telemetry to locate the mother via her collar will be helpful to the handlers.
- Approaching females and neonates from above, where it is possible and safe to do so, is recommended. Approaching from above appears to elicit a more rapid flight response from females, which increases the likelihood that females leave their neonate behind instead of leading it into safer terrain (M. Blum, personal observation).
- Handlers must be cognizant of wind direction.
- Spooking the female and causing movement will allow her the opportunity to move the lamb out of the area before handlers can reach them.
- Handlers are best within 50 yards (~50 m) of the female before alerting her to their presence.
- When within 50 yards of the female, it is recommended that handlers allow the female to see them and make noise to cause the female to leave abruptly, resulting in the lamb bedding down and not attempting to follow the female.
- If a female detects the handlers and attempts to lead the neonate into escape terrain, approaching rapidly, with handler safety in mind, and loud noises may encourage the female to leave her offspring behind.

Handling Considerations

- Agencies invest substantial resources into captures, the datasets being collected are important for management of bighorn sheep, and handling crews must collect the data essential to each investigation.
- Bonding time has been described as a critically important consideration when handling neonates (Livezey 1990, Chitwood et al. 2015). To our knowledge, however, no research has linked either age at capture, or bonding time, to survival of neonates in bighorn sheep. Nevertheless, it is logical that an effect would occur at some threshold, but handling times ranging from 5 to 34 minutes have not produced evidence of a relationship with post-capture survival, or evidence of abandonment (M. Blum et al. unpublished data).

- Researchers must consider weather and time of day when capturing individuals, as these factors may influence safety of handlers, subject a neonate to harsh conditions, or cause it to become separated from its mother for an extended period.
- Gloves and scent control often have been used by investigators that have handled neonates (Gilbert et al. 2014, Heffelfinger et al. 2018, DelGiudice et al. 2018). These precautions, however, have not been linked to abandonment or survival rates.
- Use of sanitized equipment is always desirable, but it is essential when handling neonates in multiple populations because it will reduce the potential for capture crews to transmit pathogens between or among populations.
- Blindfolding, or placement of neonates in weighing bags, often is done to attempt to reduce struggling and stress to the captive lamb.

Data Collection

Adult Body Condition

- Female body condition can provide insight into female health and fat reserves prior to parturition. Neonate survival may be related to these metrics, and they may also influence habitat selection by adult females. Recent literature (Stephenson et al. 2020) has linked population performance to female body condition and described the methodology for collecting this information in bighorn sheep. For further information see “Chapter 3: Health and Veterinary Care of Wild Sheep”.

Additional Means of Identifying Individuals

- After collars drop off, continued ability to identify individuals is useful for monitoring survival. Additionally, this information may provide unanticipated details on movements within, between, or among mountain ranges. Passive Integrated Transponders (PITs) can be used to obtain additional information of this type.
    - Place PIT tags in an area that is unlikely to be consumed by predators or scavengers. Placement at the base of the skull or along the metatarsus are locations likely to increase probability of retrieval from dead individuals.
- Ear Tags
    - Ear tags are not commonly used in neonatal wild sheep but can be useful for individual identification if of the correct size.
    - Neonate ear tags should be substantially smaller and lighter than those commonly used to mark adults (e.g., standard cattle tags). Tags should not result in any noticeable drooping of the ears (Figure 8.1).
    - A tag in one ear should be sufficient for identification.
    - When applying tags, be sure to avoid arteries to minimize pain, and bleeding following application. The ideal location is in the middle one-third of the ear between the rises in auricular cartilage, which can be detected by feeling the protrusions that run along the ear with your fingers. Centering the tag in the ear also will reduce the likelihood of tag loss and will lessen discomfort to the study animal.

DNA

- Blood
  - FTA (Flinders Technology Associates) cards are easy to use and allow lengthy storage of samples.
- Saliva
  - FTA cards are also useful for collection and storage of saliva (Figure 8.2).
- Ear Notch
  - The tissue collected by notching the ear at the lateral margin (e.g., the lower edge of the ear). Following sampling, store the tissue sample in desiccant and at room temperature.

Pathogens

- To minimize stress and time spent handling the lamb, collect only a nasal swab for *Mycoplasma ovipneumoniae*. Rotate the same swab in each nostril and freeze the dried swab once you are out of the field.
- If a neonate dies during processing, or is recovered as a mortality shortly thereafter, swab both nostrils as described above. Use an additional, sterile nasal swab to swab the distal portion of the trachea, and store it separately as described above.
- Collect lung tissue for aerobic culture and histopathology, as described in "Chapter 3: Health and Veterinary Care of Wild Sheep".
- For *Pasteurella* bacteria, swab the tonsillar crypts (see "Chapter 3: Health and Veterinary Care of Wild Sheep" for details) and place the sample in dry cryovials, or in trypticase soy broth (TSB) or brain-heart infusion broth (BHIB) and 10% glycerin, and then freeze immediately.
- Ear notch (see above)
  - Useful for detection of bovine viral diarrhea (BVDV) virus
  - Samples should be stored in a plastic tube with nothing added and should be kept cold.

Age and Sex

- Age
  - Estimate the age of the lamb by referring to the date and time of VIT expulsion.
  - A number of equations that use hoof measurement to predict age of neonates are available but may be too imprecise for specific needs (Grovenburg et al. 2014).
- Sex
  - Examine the genitalia carefully to ascertain whether male or female.

Birth-sites

- Birth-sites often can be identified by the presence of the placenta, blood, ground disturbance, bed-site, or a VIT.
- Geographic coordinates for the birth-site may be useful in resource selection analyses.
- Cover measurements (e.g., measures of openness) may provide information useful in investigations of neonate survival or resource selection (Smith et al. 2015).

- Additional habitat features near the birth-site, including vegetation type or composition, topographic metrics, or availability of shade, may prove to be useful.
    - Topographic features (e.g., physical habitat attributes) can be collected on the ground or via remote sensing.
    - Information on environmental covariates must be gathered at the time of handling. Among these are wind speed, current precipitation, ambient temperature, and wind chill or heat index.
    - Vegetation measurements or some index to visual obstruction are most readily gathered by line-intercept transects or step-point transects at the desired location.
- Handling covariates include time spent in the area, handling time, whether gloves were used or not, number of personnel involved, age of the neonate at bonding with the female, and others as desired or deemed necessary.

Morphometric Measurements

- Specific measurements can be used to calculate body condition indices in neonates (Schulte-Hostedde et al. 2005, Heffelfinger et al. 2018). These often are linked to survival rates of neonates or juveniles and can be useful for that purpose.
    - Body weight is obtained by placing the young animal in a weighing bag and hanging from a spring scale (Figure 8.3).
    - Body length is measured from the tip of the nose to the base of the tail (Figure 8.4).
    - The metatarsus is measured by bending the hoof downward and determining the length from the point perpendicular to the hoof to the point of the calcaneus (e.g., heel Figure 8.5).
    - Chest girth is determined by measuring the circumference of the animal's body perpendicular to the spine and parallel to the distal ends of the scapulae (e.g., shoulders [Figure 8.6]).

Mortality Information

- Collect detailed information when investigating neonate mortalities. Use care, and do not make assumptions about the cause of death.
- Entire carcasses should be collected and sent to a laboratory for necropsy.
- Deaths must be investigated as quickly as possible, and preferably within 24 hours, to maximize the value of tissue samples.
- Be sure to collect evidence of predation or scavenging (Alt and Eckert 2017), among which are the following:
    - Tracks, scat, or drag marks;
    - Hair or feathers;
    - Presence of a cache, or evidence of caching behavior;
    - Details of carcass utilization or consumption;
    - Location at time of death; and
    - Multiple habitat attributes.

Release Techniques

Leave Site and Walk Away from the Lamb

Based on conversations with personnel that have captured or handled neonatal bighorn sheep, this is the most common method of release.

- After processing, place the neonate back in the birth-site, or at the location at which it originally was bedded or observed before it was pursued by the handlers.
- To discourage the neonate from fleeing, handlers should then move out of the area as quickly and quietly as possible.
- Placing the neonate in vegetation at or near the release site may reduce the likelihood of immediate flight.
- Do not pursue neonates that flee.
- If the female remains in sight during handling, facing the neonate toward the mother may encourage or speed unification.

Remain at Site and Encourage the Ewe and Lamb to Acknowledge One Another

- Monitor the ewe's location and behavior during lamb processing. If the female starts to leave the area, try to call her back by imitating a low-key, but high-pitched, 'lamb-bleat'.
- Hold the lamb with one hand under its chest with its head pointing toward the ewe, and its feet just touching the ground.
- Ideally, the lamb will bleat, and the female will respond, indicating each has acknowledged the other visually or audibly, or both. Release the lamb (e.g., push it forward toward the female, and back slowly away). Ideally, the female and lamb will converge, touch noses, and the mother will pause briefly to identify the lamb by touching her nose to the neonate's rear.

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Figures

Figure 8.1. Rocky Mountain bighorn sheep neonate with ear tag properly placed. Photo courtesy of Nebraska Game and Parks.

Figure 8.2. Desert bighorn sheep neonate with an FTA card in its mouth for DNA sampling. Photo courtesy of Nevada Department of Wildlife.

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WILD SHEEP CAPTURE & HANDLING GUIDELINES

WAFWA
WESTERN ASSOCIATION OF FISH & WILDLIFE AGENCIES

Wild Sheep Initiative

CHAPTER 9

TRANSLOCATION, RELEASE & MONITORING OF WILD SHEEP

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Wild Sheep Translocation, Release, and Monitoring

This chapter discusses the strategies and logistics associated with the translocation event itself, among which are habitat assessment, the translocation event (transport and release logistics), and post-project monitoring. The various methods of capturing and caring for wild sheep intended for translocation are discussed in detail elsewhere in the Capture Guidelines. Information in this chapter briefly addresses logistics and details that surround such work across the wide range of environments inhabited by North American wild sheep.

Translocation

Introductions, Reintroductions, and Augmentations

These terms have been adapted from long-standing documents (IUCN 1987) or a recent review (Hale and Koprowski 2018) and are used here in an effort to standardize terminologies associated with translocation events. Hale and Koprowski (2018) described these terms as the intended or unintended movement of an organism out of its native range, the intentional movement of an organism into native range from which it has been extirpated, and movement of members of a species to augment the number of individuals remaining in an original habitat, respectively.

In western North America, most translocations that have occurred involved the moving of wild sheep to what was considered by wildlife managers to be the most suitable and available habitat. Translocations should be carefully planned and evaluated to maximize efficient use of, and survivorship of, the source population(s) of wild sheep. It is essential that managers recognize that inadequate habitat, high rates of predation, disease, or a combination of these or others represent limiting factors that must be addressed prior to implementing translocations for the purposes of introduction, reintroduction, or augmentation. Lastly, and realizing it may not be a necessity for all translocation work, the implications of public access to translocated sheep and associated habitats should be strongly considered when choosing translocation sites.

Habitat Evaluation of Release locations

Habitat Suitability

For a translocation to be successful, wild sheep habitat must be sufficient in quantity and quality to meet the needs of the population on a year-round basis. Prior to any translocation, an on-site evaluation by wild sheep habitat experts is necessary, and it may be helpful to use a Geographic Information System (GIS) to evaluate those attributes associated with habitat quality (Table 9.1). Coordination among individuals conducting such evaluations will help ensure critically important considerations are not overlooked and maximize the probability of a successful management action. When adequate data exist, use of models to evaluate the degree to which proposed release locations provide the necessary habitat for wild sheep is recommended. Following a translocation, Resource Selection Functions (RSFs) can be developed to determine whether habitat selection or distribution of the translocated animals occurred as predicted.

Ultimately, managers and other proponents of the translocation project must consider habitat attributes in the context of other factors, including jurisdictional management goals and objectives, social interests, and political interests, among others. Quality of available habitat must be at the

forefront of these considerations to maximize wild sheep population performance. Further, monitoring these habitats post-release may provide insight into area needs, potential enhancement options, or future management priorities. Wild sheep habitat attributes and minimum area requirements (Table 9.1) should be considered as guiding parameters but will vary among locations and taxa.

Table 9.1. Physical habitat attributes, definitions, and minimum area requirements to be evaluated for proposed wild sheep translocation sites; these parameters and definitions of suitable habitat, winter range, lambing habitat, summer range, and escape terrain were gleaned from the literature for general guidance and do not fully represent all circumstances (Smith et al. 1991, Hengeveld et al. 2011, Johnson and Swift 2000, Singer et al. 2000a, Zeigenfuss et al. 2000, McKinney et al. 2003, Lowrey et al. 2020, Robinson et al. 2020, Enns et al. 2023). In addition to these metrics, the availability of migration corridors or routes, as well as other strategies necessary to provide access to suitable seasonal habitats, need to be considered.

Habitat Attribute	Definition	Minimum Area Requirement
Suitable Physical Habitat	Land areas with slopes ≥60% (escape terrain) and the contiguous land within 330 yd (300 m); land within 1,100 yd (1,000 m) if escape terrain is proximate on 2 sides, and lacking dense vegetation, human developments, or man-made or natural barriers.	Bighorn sheep; ≥53 mi^2 (≥137 km^2); >124 mi^2 (>320 km^2) Thinhorn sheep; 84 mi^2 (218 km^2; ewes); 147 mi^2 (381 km^2; rams)
Winter Range	Land areas defined as suitable habitat with southern (SE, S, SW) aspects (bighorns) and west/southwest aspects (thinhorns); and <10 in (25 cm) winter snowpack.	>4% of Suitable Habitat (bighorn and thinhorn)
Lambing Habitat	All suitable habitat in ≥5-ac (2-ha) patches with mid- to upper-slopes ≥60%; and within 1,100 yd (1,000 m) of water with southern, eastern, or western aspects.	Steep, rugged sites (~65% for thinhorns) with adequate solar radiation and near escape terrain (<¼ mi [400 m]). Approximately 4 mi^2 (10.3 km^2 for bighorns)
Summer Range	Suitable higher elevation habitat minus slopes >60% with sufficient availability of perennial grasses and forbs; and <10 mi (16 km; bighorns) or 6–9 mi (10–14 km; thinhorns) from other seasonal ranges.	32 mi^2 (83 km^2; bighorns) Thinhorn sheep: 34 mi^2 (88 km^2; ewes); 37 mi^2 (97 km^2; rams)
Escape Terrain	Areas with slopes ≥60% plus the contiguous land within 165 yd (150 m) with slopes of 32%–60%.	9 mi^2 (23 km^2) (bighorns) and general availability of escape terrain proximal to daily movements
Property Ownership	Property ownership to be mapped as private, USFS, BLM, National Park Service, state land, or other jurisdictional options.	>75% of all habitat types on lands that allow habitat improvements, public access, and other management actions are preferred.

In addition to physical habitat attributes (Table 9.1), other variables to be considered include, but are not limited to:

- Proximity to domestic sheep or goats
- Proximity to other wild sheep (genetic interchange, hybridization concerns, etc.)
- Predators and the potential to manage them if necessary (current or future)
- Forage quality and quantity
- Seasonal range requirements and adequate opportunities for migration
- Wilderness considerations
- Water availability
- Anthropogenic disturbances (current or future)
- Availability of mineral licks

Source Stock Considerations

Source stock simply refers to an established population of wild sheep (source population) to be used to introduce or reintroduce wild sheep into vacant habitat, or to augment an existing, but separate, wild herd (e.g., a recipient population). Like habitat evaluations, a number of variables associated with the source stock must be considered. This section briefly summarizes some important attributes to be considered when evaluating or selecting source stock.

Disease History

Source populations must have some level of health evaluation completed prior to moving any animals for translocation or supplementation. Do not move wild sheep from source populations or into recipient populations with ongoing or recent evidence of respiratory disease or other serious pathologies; moreover, wild sheep should not be moved into herds that recently have suffered disease outbreaks (Brewer et al. 2014, Jex et al. 2016). In all situations, those areas into which the translocation of wild sheep is being considered should be evaluated fully and carefully prior to any action. Where translocations proceed, adherence to animal treatment and equipment decontamination protocols consistent with the Animal Health and Capture and Handling sections of these guidelines is paramount to avoiding unintended movement of parasites, pathogens, or both into recipient populations or geographic areas.

Source Herd Demographic Characteristics

- Impacts to social structure and population dynamics should be considered prior to removals.
- Candidate source herds should have at least 10 years of meaningful demographic data that indicate satisfactory population levels and acceptable winter lamb:ewe ratios.
- The potential for a negative effect on sheep remaining in the source population must be a consideration. Removals are not recommended from herds that are >20% below management objective, that have post-weaning lamb ratios <20 lambs/100 ewes, or where most of a subpopulation could be removed, because viability of the source population is just as important, if not more so, than using it for translocation stock.
- Alternative approaches may be warranted in the selection of translocation stock based on the size of source herds, the intensity of monitoring, and the degree of conservation need or management objective (e.g., endangered species recovery vs. increasing hunting opportunity).
- In ranges where herds are large in size and knowledge of limiting factors is incomplete, source herds should not be reduced to fewer than 75 females (50–60 adult ewes) (Geist 1975, Smith et al. 1991, MTFWP 2010).

- Alternatively, when source stock is limited, conservation need is high, and demographic characteristics are well known, herds of 40 breeding ewes could be used as translocation stock. In such cases, the number of females removed on any single occasion should be fewer than 10. Rubin et al. (2002) noted that multiple small translocations may reduce the risk to source herds and also increase translocation success.
- Stage of gestation is an important consideration and capture or handling can affect the ability of a female to carry a fetus to term. Managers should be cognizant of the potential for capture to affect the integrity of pregnancies and caution should be considered when capturing in early or late gestation.
- Translocation of females during late gestation may help anchor them to their new environment, and selection of release sites in, or proximate to, birthing habitat is recommended.
- Summer captures should take place well after parturition and, ideally, after offspring are weaned to maximize survival of lambs that are translocated or have been orphaned during the process.
- Translocated animals may be more likely to exhibit group cohesion or maintain herd integrity when animals are from the same social group, and there could be an advantage to doing so.

Ecological Similarities Between Source Population Habitat and Release Site Habitat

- The importance of similarities between habitat occupied by a source population and the location to which wild sheep will be translocated has become widely recognized within recent decades (Whiting et al. 2023, and references therein).
- Strong consideration should be given to the use of source stock from an environmental setting similar to that at the intended release location. Whenever possible, use of source populations from habitat, terrain, and resource distribution (e.g., established migratory behavior to maximize probability of accessing summer and winter ranges, or water availability) similar to that in the release area is recommended.
- It is not recommended to move source animals to a release site that is a drier, less productive environment. However, releases of low-elevation desert bighorn sheep in higher-elevation and more productive habitats have been successful.
- In some situations, special considerations may dictate use of source stock genetically most similar to the animals that occupied the area prior to extirpation. For translocations, preference should be given to source populations that are best adapted to the habitat to which they are being translocated (Wiedmann and Sargeant 2014, Bleich et al. 2018).

Orienting Animals to Specific Resources

Historically, most translocations have occurred during winter because of accessibility to source stock and to help reduce physiological impacts (e.g., vital rates). More recently, summer capture and release efforts are proving to be successful and, in some locations, are more appropriate.

- Winter releases
    - Winter releases have proven to be successful, but sheep are often placed on winter range that forces them to familiarize themselves with their new surroundings during a physically demanding time of year (cold temperatures, snow, limited or low-quality vegetation, less access to water sources, etc.). Avoid translocating wild sheep during severe winters.

    - Placing individuals into high quality winter range where they can easily find basic resources and, in the case of augmentations, join sheep already present in that same location, is preferred.
- Summer releases
    - In southern environments, capturing and releasing animals during early summer may help them imprint on water sources and, thereby, enhance translocation success.
    - Careful consideration is warranted when capturing ewes with lambs-of-the-year. If captured accidentally, lactating ewes can be released. If the female was captured and a lamb was at heel and had been, or can be safely captured, the pair may be translocated together; special precautions to ensure injuries to lambs are prevented is an important consideration. In most circumstances the appropriate action will be to release the ewe to rejoin the lamb and select a different adult female for translocation.
    - Sheep can best acclimate to their new surroundings during the season(s) when forage is most abundant or of greatest quality and enhances the probability of survival going into the winter period.

Whether translocation work is completed during the winter or summer period, seasonal range availability and the translocated individuals' migratory behavior must be considered. Choosing source herds that have established migratory behaviors that potentially fit well into the receiving areas will help maximize herd performance over the long-term.

Free Ranging vs. Captive Source Populations

Under certain circumstances, using a captive source population may be more desirable when compared to a wild, free-ranging sheep herd, and some jurisdictions have relied on captive breeding facilities for sources of translocation stock. Captive populations may have an advantage because few wild, free-ranging populations are available from which to move animals, limited numbers of surplus sheep exist in accessible source populations, there is interest in the development of ‘disease free’ sheep for use as source stock, or for other reasons. The following warrant serious consideration prior to developing a captive source herd.

- The facility and habitat therein must be adequate in quality and scale to be able to sustain a genetically viable herd, and predators must be effectively excluded from the facility.
- Costs of maintaining a captive population extend beyond initial planning and construction, and include long-term expenditures associated with staffing, animal health and nutrition, habitat quality, and maintenance of infrastructure.
- Long-term population management goals and objectives, including the anticipated demand for surplus sheep for future translocations.
- Captive populations should be maintained under conditions that approximate the conditions in native habitat; release plans should include strategies to help the animals adapt to the new habitat.

Genetics

Genetics plays an integral role as a potential limiting factor in wild sheep conservation, management, and restoration. Understanding genetic structure of source and recipient herds is important when considering translocation opportunities (Garrott et al. 2021, Whiting et al. 2023). Using samples from four distinct populations, Garrott et al. (2021) concluded samples from 20–25 animals may be

adequate to address management concerns about genetic heterozygosity. Depending on source stock population characteristics, however, additional samples may be necessary to better understand genetic variability and its potential effect on long-term herd performance.

Luikart and Allendorf (1996) and Fitzsimmons et al. (1997) reported greater genetic variability in indigenous herds than in previously translocated herds, and Singer et al. (2000b) found greater translocation success rates associated with indigenous source stock. Singer et al. (2000b) further reported that mixing genetic stocks did not improve translocation success. Additionally, population connectivity, or animals received via augmentation, were more important predictors of genetic diversity than historic minimum counts or whether the population was native or restored (Garrott et al. 2021). Flesch et al. (2020) noted that augmentations were more successful in contributing to genetic diversity than natural connectivity in restored populations. Despite these findings, however, the risk of disease transmission among populations is enhanced by translocation (Whiting et al. 2023) and that risk may not outweigh anticipated benefits. Chapman et al. (2009) found a lesser effect of heterozygosity on life history, morphology, and physiology than predicted by contemporary theory.

Demographic Structure of Source Stock

- The number of individuals to be translocated should be considered in the context of the receiving population, but it will typically include 20–25 individuals with 2–3 rams/10 ewes, and success of some initial translocations may be enhanced if subsequent augmentations occur. Ultimately, many factors (e.g., source herd availability, fiscal and logistical constraints, herd performance over time, etc.) will determine if augmentation of an existing population or an initial reintroduction is desirable. Additionally, existing information (V. C. Bleich, unpublished data; Dekelaita et al. 2023), combined with newly available evidence (K. Manlove and L. Ricci, unpublished data), indicates that mature males are more likely to initiate forays or exhibit dispersal behavior than are behaviorally immature (e.g., young) males. Young and behaviorally immature males are apt to remain with female conspecifics (Geist 1971, Bleich et al. 1997) for extended periods than are mature males, and generally do not spatially segregate from females until they are ≥2-years-of-age, potentially decreasing the probability of dispersal or initiation of forays. Moreover, young males can be sexually mature at an early age (Turner 1976) and, in the absence of the behavioral dominance of mature males, can successfully achieve copulations during rut (Hogg 1984).

- Rams:
  - Mature rams are not ideal for use as source stock given the propensity to move and segregate from females in the release area, and potential lack of a genetic contribution to the establishment of a new herd.
  - Mature rams may present a greater risk of disease transmission when compared to young rams because of an increased propensity to initiate forays, which could result in commingling with domestic sheep bands or other disjunct wild sheep herds.
  - Young males are easier to handle than are mature males, and do not necessitate separation from females during holding and transport prior to being moved (Figure 9.1).
  - Depending on the goals or objectives of the translocation, moving rams may be desirable for a variety of reasons including breeding requirements, maintenance of a ‘natural’ sex

ratio within a source or recipient population, maintenance or improvement of genetic diversity, or for other reasons.

- Translocation of lambs is not recommended because they may be more susceptible to capture and transport related injuries and are apt to have lower survival rates than yearling or older animals. Additionally, lambs will not become part of a breeding population for a year or more following translocation, which can slow the population growth rate and, ultimately, reduce the return on the investment.

Figure 9.1. Translocation of young rams in a standard stock trailer with wood chip bedding.

Transportation to Release Site

Second only to the capture event, transporting the sheep is the most stressful part of any translocation effort. Thus, careful planning is necessary to minimize the potential for problems to develop with respect to equipment, logistics, and animal welfare during this phase of the translocation effort.

Limiting Stress Associated with Transportation

- Animals should be able to lie down prior to and during transportation. Trailers designed especially for transporting wild sheep, stock (horse) trailers, boxes for helicopter transport, and even railroad cars all have been used to contain animals, and surface area available to individual animals will vary with the method of transport. In any situation, however, the maximum density of sheep in a contained space (e.g., a box in the bed of a pickup truck, or a

trailer) should not exceed 10 per 40 square feet (3.7 square meters) of floor space (Foster 2005). See the Trailers and Transport Boxes section for further information.

- In most situations, sheep captured for translocation will be transported together, but keep in mind the following recommendations.
  - Separate mature rams (>3 yrs old or >½ curl) from younger males, adult females, and lambs.
  - Older males (>3 yrs old) need to be separated from younger rams, or confined to their own space, to limit the potential for fighting if being transported in a trailer. A limited number of young rams may be transported together if space is adequate (Figure 9.1).
  - Yearling rams can be placed with mature ewes.
- Prevent animals from piling into one end or a corner of the transport vehicle or transport box to minimize the potential for injury, overheating, or suffocation.

Animal Comfort

- Bedding should be provided during transport (Figure 9.1, Figure 9.2).
  - Bedding prevents pressure sores and reduces the potential for capture myopathy if animals lay down for a long time. Bedding also acts to absorb urine and sequester feces away from direct contact with the translocated animals.
  - Rubber mats covered with straw, wood shavings or chips, or shredded paper all work well (Figure 9.1, Figure 9.2), but some jurisdictions may have specific regulations and this must be a consideration during transportation planning.
  - Deep bedding is needed if there are no mats, especially on long trips.
  - Use only hay or straw that is certified weed-free and has not been grazed by domestic sheep or goats. Interjurisdictional transport may regulate use of specific hay or straw sources to lower risk of contamination with Chronic Wasting Disease prions.
  - All transport devices must be thoroughly cleaned and disinfected prior to each translocation event (refer to “Chapter 8: Capture and Handling Neonates” for these guidelines).
  - All windows and gaps large enough to partially entrap a sheep, or that may entice a sheep to jump through, must be blocked securely. Adequate ventilation must be a primary consideration.
  - More ventilation and space per animal will be required with warmer temperatures; large electric fans can be used to increase air movement.
  - Ice blocks can be placed in the transport trailer or transport box for additional cooling during warm weather.
  - With cold temperatures and longer transport times, more bedding may be needed.

Figure 9.2. Translocation of ewes in a double decker sheep trailer with wood shaving bedding.

Food and Water

- If sheep are to be held longer than 12 hours, water and good-quality weed-free grass hay, alfalfa, or both should be provided. Feed and bedding that has been grazed or used by domestic sheep or goats must not be used.

Treatment of Injuries

- In the case of injury or illness it can be preferrable to treat animals while inside the trailer rather than removing them. Sheep often calm down quickly during transport, and lambs, ewes, and young rams rarely challenge a person. The animal being treated should be blindfolded and potentially hobbled. Assistance of a spotter to help protect the person treating the animal is advised.
- Routine monitoring of sheep during transport is important and will decrease the potential for injuries to animals going unnoticed, or piling onto each other, and perhaps overheating or suffocating.

Overnight or Extended Transports

- Ideally, sheep will not be held for more than one night. When stopped during transport, place the transport vehicle in a safe, quiet, and secure location, and consider air exchange and wind direction and solar loading and temperatures.
- When crossing state or international boundaries, certificates of veterinary inspection will be required. Ensure that all requirements have been complied with ahead of time.
- Make arrangements with the lab doing any testing to ensure needed results are available as quickly as possible; doing so ahead of time will decrease transport and holding times.
- Transport trailers or transport boxes should be kept in the shade as necessary on sunny days.

Use of Sedatives

- If animals are held overnight or will incur lengthy transport times, use of long-acting neuroleptics may be considered. For fractious or stressed animals that are to be moved short distances, short-acting neuroleptics or sedatives may be useful.
- For further information, see “Chapter 3: Health and Veterinary Care of Wild Sheep”.

Transport Trailers, Boxes and Boats

Transport Trailers (Appendix 9.1)

Well-designed transport equipment is imperative to maintain the wellbeing of sheep during the translocation process. Over the years, such equipment has been developed or enhanced to meet the needs of safe and secure transportation of wildlife. Although modern stock trailers can be used to move large numbers of sheep simultaneously, trailers specially designed to transport wild sheep are recommended. If modern stock trailers are to be used, criteria described in this section are recommended.

Design

(based on the transport of 20 to 30 sheep at one time)

- Trailer length (main deck) should be no smaller than about 20 ft (6 m) in length and 7 ft (2.2 m) wide.
- Specifically designed sheep trailers can be compartmentalized into 4 or more similar-sized sections on each of the two decks. This will aid in mitigating the potential for overcrowding and provide the ability to separate sheep by sex or age classes, as necessary.
- For conventional stock trailers (e.g., a four-horse trailer) similar in size to the sheep trailer design (albeit a single level), approximately half the number of sheep can be transported with the assumption that at least one center divider is present in the trailer.
- Upper and lower sections should be 3.5–4.0 ft (1.0–1.2 m) from floor to ceiling (Figure 9.2, Figure 9.3.
- Door configurations that allow access to each section separately are important and will facilitate animal care or intervention if required during transport.
- Exterior doors (back of trailer and front compartments) may be swinging or sliding, depending on personal preference or trailer availability.
- Swinging or sliding dividers can be used to separate front and back sections (top and bottom). Sliding dividers may be less cumbersome inside, especially when handling sheep.

- Goose-neck or bumper-pull trailers both are functional options and may depend on the type of vehicle available (most trucks come adequately set up for bumper-pull trailers).
- Goose-neck trailers often have separate storage space in front of the trailer.
- If standard stock trailers are used, similar specifications should be followed, but capacity of sheep will be limited given lack of an upper compartment. In such cases, previous recommendations for maximum capacities should be followed.

Figure 9.3. Sheep transport trailer with upper and lower decks including swinging center dividers.

Ventilation

- Air flow openings must be available for all trailer compartments and must allow adequate ventilation; use of fans to aid in air circulation under certain circumstances, especially when the vehicle is stationary, is desirable.
- Any openings must be of appropriate size and location to prevent sheep legs, head, or horns from extending outside the unit or becoming caught. Side vents or openings running the length of trailers work well; these should have a width of not more than approximately 5 in (13 cm) and be located above the head-height of a standing sheep.
- Roof and front vents are optional but will improve air flow and enhance ventilation.
- Removable vent covers (burlap, perforated plexiglass, or other material) for venting is optional. Whatever material is used, coverings should always allow for air circulation. Trailers should be kept in shaded areas when stationary or not in active transport to prevent sheep from overheating.

Flooring and Bedding

(see Animal Comfort section for additional information)

- Rubber mats covered with straw, wood shavings or chips, or shredded paper are ideal (Figure 9.1, Figure 9.2).
- Deep bedding is needed if there are no mats, especially on long trips.
- Hay or straw must be certified weed-free and not harvested from areas that have been grazed by or exposed to domestic sheep or goats.

Monitoring Devices

- Remote cameras may be used to monitor sheep while inside the transport vehicle.
- Remote or standard thermometers mounted inside the trailer can be used to monitor temperature inside the transport vehicle.
- If the inside of the trailer is dark, sheep cannot be observed and ventilation may not be adequate. Openings above head level should not be blocked, assuming they are small enough so a sheep cannot jump through them or get horns, heads, or legs stuck.
- Interior lighting may be helpful under low light conditions. During daylight, natural light through ventilation systems generally provides light adequate to observe sheep.

Transport Boxes (Crates) (Appendix 9.2)

Designed to move individual or small numbers of sheep, transport boxes (crates) are often used to move sheep from the trailer closer to the intended release location. Depending on their size, these boxes can be moved via truck, flatbed trailer, or flown to a remote site via helicopter. Crates are designed more for short rather than lengthy transport and are most apt to be used when aerial transport of animals to the release location occurs. Crate designs can be variable, so specifications noted below and in Appendix 9.2 are included for general reference.

Sized to transport 1 to 6 sheep simultaneously

(depending on size of the crate)

- Small aluminum crates
  - 4 ft (1.2 m) L x 4 ft (1.2 m) H x 4 ft (1.2 m) W
  - Weight ≈260 lbs (118 kg)
  - Can carry ≤ 3 ewes (fewer if rams are being transported)
- Large aluminum crates
  - 8 ft (2.4 m) L x 4 ft (1.2 m) H x 8 ft (2.4 m) W
  - Weight ≈500 lbs (227 kg)
- Both large and small crates should incorporate a center gate to separate animals when it is desirable to do so.
- Aluminum construction is ideal because it provides strength and limits the weight.
- Attachment or mounting points are necessary on the top corners of the crate for external helicopter transport.
- There are up to three separate access doors of various sizes for loading and releasing animals.
- Access doors may be swinging or sliding, depending on personal preference.

- Multiple crates can be transported on a flatbed trailer.

Ventilation

- Air-flow openings must be available on at least three sides to provide ventilation, especially when the crate is stationary.
- Any openings must be of appropriate size and location to prevent sheep legs, head, or horns from becoming caught or incurring injury. Vents not more than about 5 inches (13 cm) wide should be located in the upper half of a crate.
- Transport crates should be kept in shaded areas when the transport vehicle and trailer are stationary to decrease the potential for sheep to become overheated.

Flooring and Bedding

(see Animal Comfort section for more information)

- Rubber mats covered with straw, wood shavings or chips, or shredded paper are ideal.
- Deep bedding is needed if there are no mats.
- Hay or straw must be certified weed-free and not previously exposed to, or grazed by, domestic sheep or goats.

Monitoring Devices

- Monitoring devices can be, and have been, used in crates (as previously described in the Trailer Section)

Boats

Although not often used, boats have been effective methods of transporting animals to release sites that are adjacent to water (rivers, lakes, or reservoirs).

Design

- Flat bottom jet-boats, airboats, or other similar types with adequate open deck space are necessary. If not a jet-boat or airboat, propeller clearance and running depth both are critically important considerations to avoid damage resulting from contact of the propeller with the river or lake bottom.
- Deck space should be large enough to carry more than one sheep at a time to maximize efficiency, but ambient conditions, load limits, or other limiting factors also must be considered; it is essential to comply with load limits. As long as conducted safely, the more animals that can be moved simultaneously, the better, since doing so may encourage group cohesion and reduce stress on individual animals.
- Boats must be powered adequately to ensure reasonable transport times when the boat is fully laden.
- The capture crew and boat captain need to calculate load weights to ensure boats are not overloaded and determine the most efficient means of movement (e.g., the number of trips or number of boats needed).

Ventilation

- Assuming sheep are only hobbled and blindfolded during the transport process (e.g., not put into enclosed containers or crates), ventilation typically is not a concern as long as transport times are minimal; however, consideration must still be given to sun exposure and solar heating to avoid heat stress.
- If animals are to be moved in crates, all previously described cautions regarding the use of those crates are to be followed.

Flooring and Bedding

- Like transport trailers and boxes, rubber mats that are relatively easy to sanitize are best. Other bedding materials, such as straw or wood shavings and both of which are subject to windy conditions, are not recommended.

Loading

Animal Handling and Placing Sheep into Transport Equipment

Experienced handlers will minimize risk of injury, both to the handlers and the sheep (Figure 9.4).

- Three individuals are adequate to handle or carry one hobbled sheep. One person should hold the head and horns while making sure the blindfold stays secure; one person should support the mid-section from the dorsal (spine) side; and one person should cradle the rear quarters.
- Sheep horns (male or female) should never be used as “handles”.
- Mistakes made by inexperienced handlers can result in injuries to animals and people, but a mix of experienced and novice handlers can provide a good training opportunity.
- Placing sheep into a transport device:
  - One person is responsible for opening and closing the access door while the team of three places the animal into the trailer or crate.
  - Once the sheep is in the trailer or crate, the blindfold can be removed and laid over the eyes of the sheep so the blindfold easily comes off when the animal is released.
  - One or two individuals unhobble the sheep while maintaining pressure on legs until all hobbles are removed.
  - A curtain (or something similar) can be used to provide a small area where unhobbling the sheep can take place while not being visible to sheep already in the trailer.
- Once the blindfold and hobbles are removed, lift the curtain so sheep can join other sheep and the individual at the access door can allow the handlers to exit.

Figure 9.4. Transporting a bighorn sheep using a customized tarp with built-in handles.

Release

The release is the culmination of a substantial amount of work and coordination. Wild sheep releases (whether reintroductions, introductions, or augmentations) often are of great interest to many parties; as such, it is important to make sure all aspects leading up to the release have been thoroughly considered and contingencies developed for aspects of the effort where they may be needed.

Media, General Public and Volunteers

Translocations are very popular and generate a lot of interest from volunteers and the media. There can be real value in this interest as it relates to expanding outreach and extension of information to the public; coordination with the media and other stakeholders is critically important.

- Delegating one individual to work with any media or public present to provide appropriate information, or to coordinate opportunities to obtain photos or video, but without compromising efficiency or safety is recommended. This person must be completely familiar with the objectives, techniques, and safety measures pertaining to the capture and release.
- Interested parties should be familiarized with the 'ground rules': where to watch from or stand, the need to stay out of the way, the need to keep quiet, etc., ahead of time. This applies to all phases of the translocation.
- If volunteers are playing an active role in the capture, transport, or release, all pertinent roles and safety measures need to be covered. Pairing an experienced individual with each volunteer is strongly recommended.
- Paperwork, which may be required by some agencies before volunteers can be involved, must be completed before their participation in the translocation occurs.

Release Site

- Select release sites that will provide translocated animals with the best opportunity to survive under a variety of anticipated and unanticipated conditions.
- Animals will often run hard after being released; the release site should be in an area free of hazards and near enough to water so they will be able to locate it easily.
- Avoid releasing animals into areas that may support high densities of predators or dense cover that will decrease opportunities for released animals to detect or evade predators. In some situations, removal of predators, such as mountain lions prior to the release will enhance success of the translocation.
- In environments with a harsh winter climate, do not carry out translocations when snowpack is extreme. Translocations implemented during years of below average snowpack will help ensure that animals can acquire adequate forage and explore their new environment without traveling through deep snow.
- With the assumption that sheep will become established on or near the release site, opportunities for future public access to this location is an important consideration (sheep viewing, hunting opportunity, motorized recreation), but may be dependent on jurisdictional goals and population or recovery objectives.

Access to Release Area

- The release site must be legally and readily accessible, and not be dependent on seasonally maintained or poor-quality roads; plan for the worst conditions (heavy rain, mud, drifted snow), and then avoid those roads.
- Always have a backup location planned in the event of vehicle breakdowns, an accident, or unanticipated access problems.
- Ensure that landowner (public or private) permission to access the release location has been received and is in place prior to the release, and that it includes alternative options as discussed above.

- Special equipment (e.g., snowplow, loader, or chainsaw) may be necessary to access the release site under unexpected conditions.
- Helicopter release sites should be selected and evaluated for appropriate landing zones in advance.

Type of Release

A hard release (Figure 9.5) is defined as releasing sheep as soon as possible following transport to limit holding time to a minimum and to reduce stress; this is the most common method in use. A soft release (Figure 9.6) is defined as one in which sheep are held for a period of time in some structure or facility (e.g., a pen or a corral) to allow the animals to acclimate, calm down, or imprint on the area to which they have been moved. Soft releases are used much less frequently than hard releases.

- Release animals ≥2 hours before total darkness so that they have time to familiarize themselves with their surroundings prior to nightfall. Holding animals overnight in a trailer is preferable to releasing them at night.
- Releasing animals during daylight hours provides managers an opportunity to observe animals as they disperse.
- Releasing animals as a group may help with group cohesion and decrease the potential for them to split up. This strategy is especially important for ewes with lambs.
- If inclement weather conditions at the release are severe enough to cause concern, try to release the sheep near areas where they can find protection from the elements.
- Survival rates and indices of group cohesion have been evaluated between hard and soft releases but with variable results, in part because of a lack of consistency among holding times and facility design (Berbach 1987, Thompson et al. 2001, Jessup et al. 2014, Bleich et al. 2019, Dailey et al. 2022). When aerial transport involves numerous flights to the release site, holding animals together in a pen until all have been delivered will allow them to be released simultaneously rather than as multiple small groups. When released upon arrival, members of every group (e.g., each crate load) released previously continue to scatter and move further from the point of release with each arrival of the helicopter (Thompson et al. 2001, Jessup et al. 2014, Bleich et al. 2019).

Figure 9.5. A hard release involves animals being released immediately upon arrival at the target location.

Figure 9.6. A soft release occurs when animals are translocated to the release location and held in a corral or other structure to allow the animals to acclimate or calm down or imprint on the area to which they have been moved. Soft releases are used much less frequently than hard releases.

Helicopter Transport

The easiest and most efficient releases involve ground transport to the pre-selected, highest quality release site, simply opening the door, and encouraging as many sheep as possible to exit together. Unfortunately, this is not always possible, or precludes the opportunity to release animals into the best habitat at a particular time of the year. Under any scenario, knowing sheep weight(s) is paramount to calculating the allowable load, and final decisions related to such (including terrain and weather) lie with the pilot or boat captain. The following four options (Foster 2005) are listed in no particular order.

- Option 1: Use a large helicopter, and hobble and blindfold animals; lay them on the floor of the helicopter for aerial transport. Twin-rotor Chinooks can haul greater numbers of sheep per load than lighter helicopters. Albeit expensive, dangerous, and labor intensive (personnel need to be in place for loading, unloading, and releasing sheep), this method can be efficient given the number of sheep that can be moved at one time. A Bell 212 can sling boxes loaded with animals under the helicopter. Additionally, animals can be released almost simultaneously without incurring multiple turnarounds of the helicopter.
- Option 2: Hobble and blindfold the sheep, place them in transport bags and haul them externally under a smaller helicopter (Figure 9.7). Smaller helicopters (Bell Jet Ranger, Bell Long Ranger, Hughes 500) can sling fewer sheep directly under the helicopter. Alternatively, some helicopters may be set up to haul small numbers of animals inside the helicopter (rear of the cockpit). Keep in mind that the weight that can be lifted changes with terrain, elevation, and weather, and remains a decision to be made by the pilot.
- Options 1 and 2 each require a crew with as many people as sheep to be released at any one time, and they must be stationed at the release site before any animals are transported. When sheep arrive, the crew should take all of them out of the helicopter or transport bags, remove hobbles and blindfolds as soon as possible, and release the animals simultaneously, or as close to a single group, as conditions permit.
- Option 3: Use transport boxes or crates that are transported externally by helicopter or hauled by truck to the release site. This option can be completed independently or in tandem depending on site logistics. The gross weight of the load (box and sheep within) will determine the type of aircraft to be used (a Bell 212 can transport large boxes, but maximum weight will vary with ambient conditions). Hobbles and blindfolds are removed from sheep after they have been placed in the box, as previously described. At least one person per box must be stationed at the release site prior to transport of the sheep.
- Option 4: Transport of animals by boat is uncommon but has been used in Hells Canyon to facilitate releases. A jet sled or other type of boat with open deck space is best. Sheep were hobbled and blindfolded in the transport vehicle then carried to the boat and placed on the deck in a sternal position, with at least one person per two sheep to maintain them in that position during transport. Boats must not be overloaded, and the number of trips necessary to complete the release must be determined by the captain and the size of the handling crew. Additional personnel must be available at the release to facilitate unloading, removing restraints, and release of the animals.

Figure 9.7. External transport of multiple sheep to the release location using a Hughes 500 helicopter.

Other options such as combinations of helicopter and truck transport may also be considered. Such options may include transport within individual crates that are moved on trucks (but do not involve a trailer) to or from the helicopter landing zone, and sheep then moved in crates to the release site inside a large helicopter. Ultimately, available equipment and resources will dictate practical options to be used in any transport effort. It always remains important, however, that the safety and welfare of the crew and the sheep are the highest priority.

Directing Animals During the Release

- Release sites that are close to 'escape terrain' (steep, rugged habitat) can support improved survival outcomes of the translocated animals.
- Facing animals, or the release crates, in either an uphill or downhill direction may encourage them to remain together rather than 'fan out' across a flat landscape.
- Having individuals flanking the back of the trailer, crate, or even behind animals that have been moved in transport bags may help direct them in the preferred direction. Burlap, which is available as long rolls in widths of 3–6 ft (1–2 m), can be held by personnel and used as 'wings' to encourage sheep to move in the preferred direction as they leave.

Post-Release Monitoring

Monitoring Strategy

A well planned and organized post-release monitoring strategy must be part of the translocation proposal and project. This includes routine visits to the release site and surrounding area to monitor sheep distribution and habitat use, demographic monitoring, mortality investigations, coordination and communication with public or private landowners, providing updates to other interested stakeholders, and predator management if necessary. Together, information such as this will help inform the initial and long-term success (or failure) of the translocation, and better inform future needs for translocations. Readers are referred to “Chapter 4: Collaring and Marking Wild Sheep” for guidance on collar types, monitoring protocols, marking animals, and other aspects of post-release monitoring.

Mortality Investigations

- It is highly recommended that all known mortalities of translocated sheep be investigated as soon as possible and preferably within 72 hours, to better inform post-release project delivery of goals and objectives, and the broader field of translocation work (Figure 9.8). GPS-type collars with properly programmed mortality sensors and associated notifications are paramount to better detect, locate, and understand mortality events or to identify a false mortality alert.
- Capture myopathy is a condition with marked morbidity and mortality that occurs from stress and physical exertion associated with the capture event. Capture-related deaths are defined differently among investigators or jurisdictions and often are attributed to a mortality within one week post capture or release, but this time frame may vary (Wagler et al. 2022).
- Translocated sheep are naïve to new surroundings so their propensity to wander, inability to find necessary resources, and vulnerability to predation are much greater than among indigenous sheep in the same area. Thus, an understanding of mortality events will help inform future management and planning decisions.
- Necropsy and sampling of dead sheep for various disease, pathogens, or injury-related concerns is important, albeit not always possible.

Demographic Monitoring

Monitoring of population size, composition, and demographic rates is important for reintroduced populations and helps explain project outcomes.

- Annual surveys or counts will inform the numeric success of a translocation.
- Lamb survival and recruitment success can also be determined using annual surveys or counts.
- Survival rates, sightability indices, and sightability correction factors all can be calculated using collared animals.
- Long-term monitoring of translocated populations is necessary to determine the degree to which population growth occurs in response to variation in weather patterns and levels of predation.

Figure 9.8. It is highly recommended that all known mortalities of translocated sheep be investigated as soon as possible and preferably within 72 hours, to better inform post-release project delivery of goals and objectives, and the broader field of translocation work.

Foray Management

Sheep translocated to a new area will wander and explore their new surroundings. Such movements to better understand their escape terrain, resources, routes to evade predators, key habitats, preferred lambing locations, etc., are important. However, there should be no tolerance for individuals or groups venturing into or through areas occupied by domestic sheep or goats on public or private land. Plans to respond to or manage such forays need to be defined and agreed upon in advance, and a commitment to carry out the agreed upon actions must be in place prior to any translocation.

- Proper communication before and after release will encourage timely reports of foray events.
- Foray events need to be dealt with in a committed and immediate fashion.
- Risk of contact modeling may help decide what constitutes or defines a foray event that triggers concern or subsequent action for every translocation project.
- Habitat Suitability or Resource Selection Function models may assist with identifying probable habitat use prior to translocation.
- GPS collars with geofence capabilities are an important tool that can be used in areas where foray events are of concern, or where other information on distribution and movements is of interest. Collars with geofence capabilities (e.g., creating a virtual geographic boundary, enabling software to trigger a response when a mobile device enters or leaves a particular area) may be of particular utility in some circumstances.

Habitat Use

Conducting pre-translocation habitat evaluation or habitat modeling is important and may help to understand potential seasonal habitat use. Post-translocation data will help define the efficacy of the initial habitat evaluation or habitat model and offer informed options for future management in the area, which may include additional translocations. Such data will also help the manager evaluate more specific use of habitat by sheep and potentially highlight previously unknown or unidentified issues that could impact sheep distributions (e.g., a new hiking or motorcycle trail adjacent to potential natal range) and support new management directives to mitigate those negative effects.

Predator Management

Like foray events, predator management must be a consideration and this may require additional, targeted pre-planning and public engagement or consultation. Introducing naïve sheep to a new landscape or to a novel predator can bode poorly for individual animals, with consequences for the establishment of a new wild sheep herd or augmentation of an existing population. In either case and as previously described, GPS collars with mortality sensors are paramount to better understand this issue.

- If predation is a concern, preemptive predator removal should be considered to help minimize mortality among the translocated animals. Proper communication with pertinent stakeholders and agency staff is essential.
- If predation becomes an issue after sheep are released and is a primary cause of mortality, options need to be in place to remove individuals of the offending species. Ideally, any such effort is short-term and implemented to help sheep get established, but long-term management also could be necessary. Transparent reporting on the need for action, actions taken, and outcomes of any actions will be important in maintaining broad political and public support of the initial project and subsequent translocation planning.

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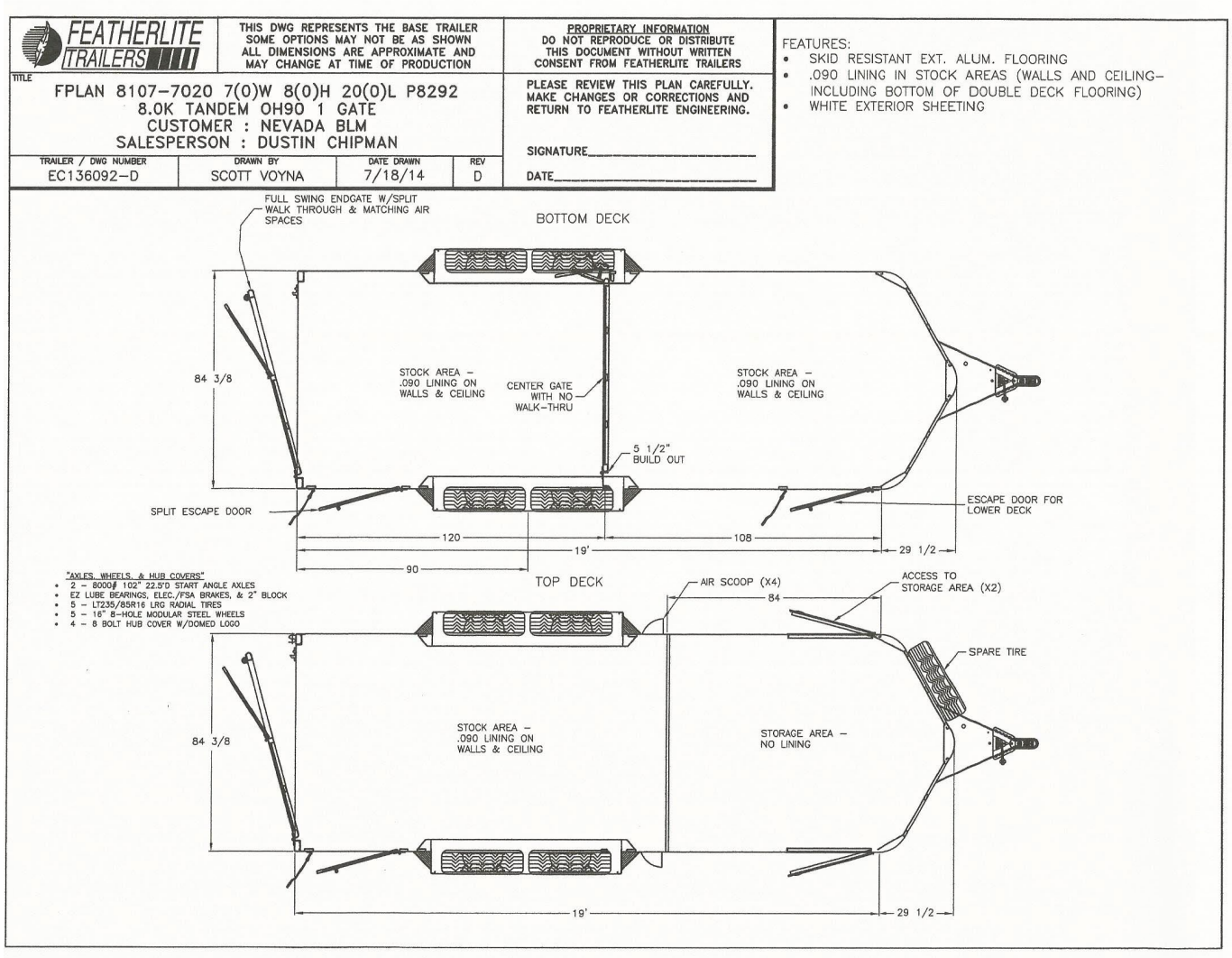
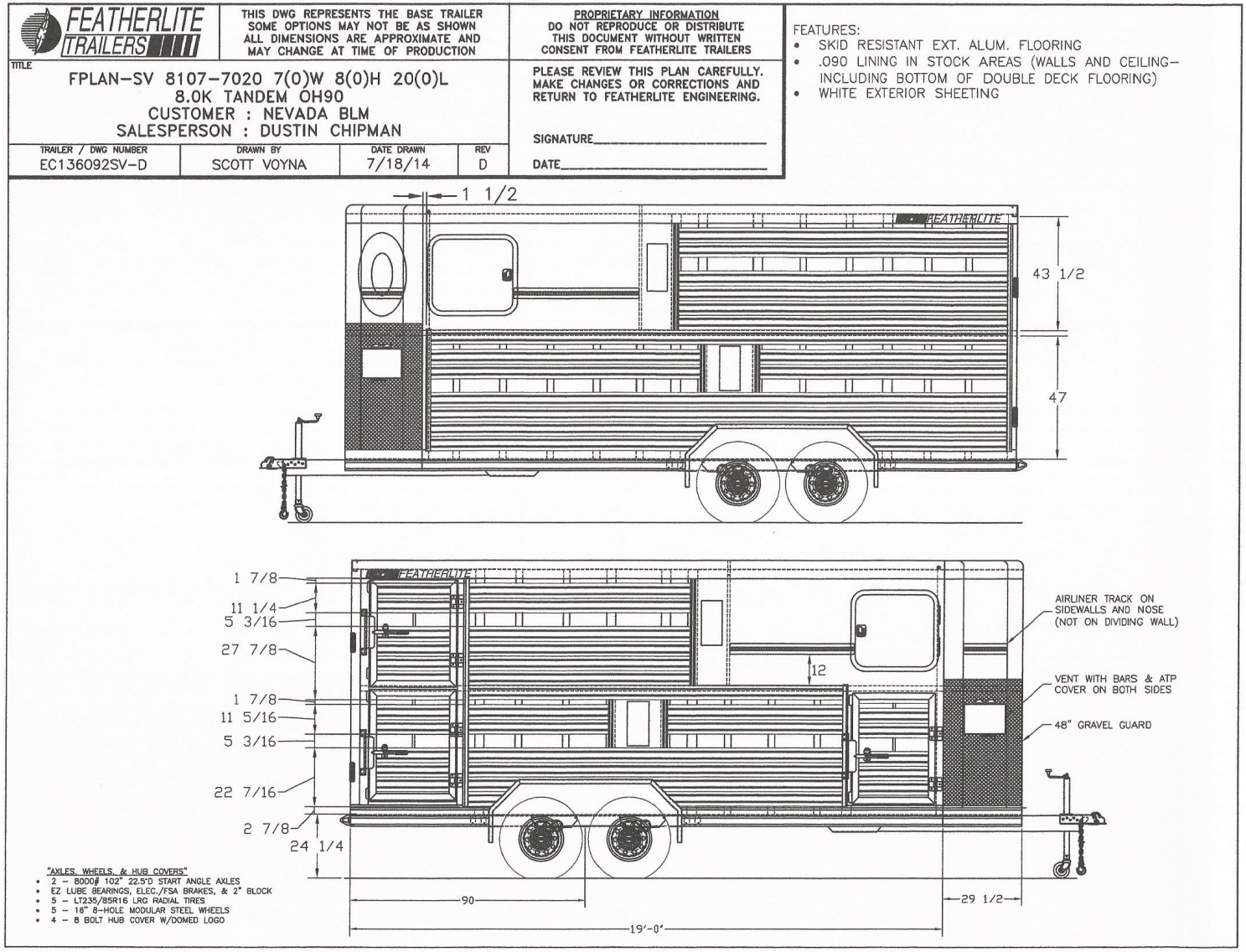
Appendix 9.1.

Wild Sheep Transport Trailer Specifications and Photo




FEATHERLITE TRAILERS
THIS DWG REPRESENTS THE BASE TRAILER
SOME OPTIONS MAY NOT BE AS SHOWN
ALL DIMENSIONS ARE APPROXIMATE AND
MAY CHANGE AT TIME OF PRODUCTION
PROPRIETARY INFORMATION
DO NOT REPRODUCE OR DISTRIBUTE
THIS DOCUMENT WITHOUT WRITTEN
CONSENT FROM FEATHERLITE TRAILERS
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8.0K TANDEM OH90
CUSTOMER : NEVADA BLM
SALESPERSON : DUSTIN CHIPMAN
PLEASE REVIEW THIS PLAN CAREFULLY.
MAKE CHANGES OR CORRECTIONS AND
RETURN TO FEATHERLITE ENGINEERING.
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SCOTT VOYNA
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FEATURES:
• SKID RESISTANT EXT. ALUM. FLOORING
• .090 LINING IN STOCK AREAS (WALLS AND CEILING- INCLUDING BOTTOM OF DOUBLE DECK FLOORING)
• WHITE EXTERIOR SHEETING
1 1/2
43 1/2
47
1 7/8
11 1/4
5 3/16
27 7/8
1 7/8
11 5/16
5 3/16
22 7/16
2 7/8
24 1/4
12
AIRLINER TRACK ON SIDEWALLS AND NOSE (NOT ON DIVIDING WALL)
VENT WITH BARS & ATP COVER ON BOTH SIDES
48" GRAVEL GUARD
90
29 1/2
19'-0"
"AXLES, WHEELS, & HUB COVERS"
• 2 - 8000# 102" 22.5"D START ANGLE AXLES
• EZ LUBE BEARINGS, ELEC./FSA BRAKES, & 2" BLOCK
• 5 - LT235/85R16 LRG RADIAL TIRES
• 5 - 16" 8-HOLE MODULAR STEEL WHEELS
• 4 - 8 BOLT HUB COVER W/DOMED LOGO

Wyoming Game and Fish Bighorn Sheep Trailer Specifications and Photos

Stock trailer custom made to the following specifications developed in cooperation with Wyoming Wild Sheep Foundation and Wyoming Game and Fish personnel. Built to transport 20-30 sheep.

- Goose neck stock trailer – Aluminum or Steel
- 20 ft. (6.1 m) "deck" length X 7.5 ft. (2.3 m) width
- 7 ft. (2.1 m) side walls
- Full height divider (stud stall) floor to ceiling with ability to move at 8' and 16' intervals. Additional sliding ½ width 3 ft. (0.9 m) door in the divider similar to that in the rear door.
- Ventilation on upper 1/3 of side walls covered with expanded metal and plexi-glass inserts (removable).
- Roof vents
- Full rear door with ½ door slider
- Side man door on front driver's side
- Goose neck storage with outside access doors
- Interior lights
- Outside lights – both sides and rear
- Two surveillance cameras (optional Bluetooth connection to cab of pickup) – one for the ram section and ewe/lamb section
- Rubber floor mats throughout
- 1/4" thick rubberized interior side walls – 3 ft. (0.9 m) height
- Minimum 16 inch (40.6 cm) load rated "E" or 10 ply rated tires.
- Torsion axles
- Brakes on both axles
- 2 spare tires mounted with tire changing ramp
- Truck bed-liner on front of trailer and inside wheel wells

Appendix 9.2.

Transport Crates Used to Sling Bighorn Sheep to Release Sites)

The crate manufacturer for these crates is Alum-Line, Inc. (800-446-1407, www.alum-line.com). Recommended specifications for these crates are provided in the transportation section of this chapter.