AN OPERATIONAL DIVE PLAN

FOR

IN-THE-WATER STELLER SEA LION CAPTURES

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CONTENTS

INTRODUCTION

The population of Steller sea lions *(Eumetopias jubatus)* in United States waters has declined by approximately 72% during the last 30 years from roughly 192,000 adults and juveniles (nonpups) in the 1960s to 53,000 nonpups today. This led to the listing of this species as "threatened" in 1990 and "endangered" over a portion of its range in 1997 under the provisions of the Endangered Species Act.

This Department in conjunction with the National Marine Fisheries Service (NMFS) and others has undertaken a large research project to attempt to determine the causes of this decline. Live-capturing sea lions for examination, sampling and instrument deployment is crucial to this research and the only known safe and efficient method of capturing some age classes during the winter requires the use of divers to both attract the animals and place buoyed capture lines upon them. The Department marine mammals program dive team is now making these captures.

DIVE PLAN: As per provisions of the Department *Manual For Scientific Diving Safety*, Section 2.21, Dive Plans, this is a dive plan for the work currently being done. This document describes the general nature of the project as it concerns diving, identifies potential diving hazards peculiar to this work and sets forth project specific protocols. Diving related procedures that must be followed and useful reference material describing diving injuries and other topics are included. The plan is applicable to repeated field projects and it is also appended with the specific dive-related details of the current work.

DIVE PLAN PROTOCOLS:

1. The specifics of this dive plan shall be updated for each field project.

2. The project supervisor, the vessel captain and all divers, dive masters and dive tenders shall read and become familiar with this dive plan and the current Department *Manual For Scientific Diving Safety.*

GENERAL WORK PLAN

The primary objective of this dive work is to provide live sea lion pups and juveniles for a wide variety of studies.

TIME OF YEAR: The current focus for this research is mostly upon the animals' late winter and early spring ecology. Field work, especially that requiring diving, is done primarily from November through April.

LOCATION: Virtually all of this field work occurs in remote locations. Diving is done anywhere along the Gulf of Alaska coast from Southeast through the central Aleutian Islands. It is done both near protected "inside" haulouts and near haulouts on the exposed "outside" coast.

ENVIRONMENTAL CONDITIONS: During the winter, air temperature along the Gulf of Alaska coast ranges from a mean daily minimum of about 15 F to a mean daily maximum of about 41 F. Water temperature ranges from about 36 F to 46 F except in deep protected bays which may freeze and where glacial ice accumulates. Storms are frequent although periods of settled weather can be expected.

LOGISTICS SUPPORT: Due to the remote locations, most of this work is vessel supported; often by Department or NOAA boats in the range of 70 to 120 feet in length. In addition to the usual accommodations, these boats generally have permanently installed dive compressors, heated dive lockers, outdoor hot-water showers, extensive first aid materials and other amenities for the divers. These vessels carry large skiffs for support of the actual diving and can provide sophisticated, high-powered communications in the event of an accident.

THE DIVING: Although the work of live-capturing Steller sea lions in the water is highly specialized, the diving involved is relatively basic; it involves only common SCUBA protocols and equipment and the use of dry suits.

Dives are generally made to an average depth of less than 22 feet for an average duration under 42 minutes. Usually not more than four dives are done per day. Physiological stresses upon divers are quite minimal.

CAPTURE EQUIPMENT: The sea lion capture equipment, at least that used underwater, is exceedingly simple; consisting of only a buoyed line, a bait container with herring and a forked stick. The capture line has a loop and locking device fashioned at one end and a buoy bag and trailer attached to the other. Nothing more is needed.

SEA LION CAPTURE S: Once sea lions are located at an in-the-water congregation point, a dive team then descends to about 20 to 30 feet with the capture equipment. Underwater visibility, bottom topography, kelp, current and surge greatly influence the ease of the work so the divers move slowly about until a suitable capture site is located often in the lee of a large boulder or ledge. The divers then settle to the bottom where a sea lions is lured close and a loop of the line is cinched around its body. As the animal swims away, one diver continues to tighten the loop and surfaces to alert the pickup skiff. This diver remains within visual contact of the diver just a few feet away on the bottom. If captures are to continue the surfaced diver is given another capture line while the submerged diver retains the interest of the animals?

OTHER DIVE WORK: During the course of capture projects, the opportunity is generally taken to explore the underwater topography near most of the sea lion haulouts and congregation points encountered. These dives are purely observational and entail no specialized equipment beyond that of the diving itself, but they may range down to nearly 100 feet depth. Although deep, the bottom times for these dives are usually quite short and the diving is slow and easy.

DIVING PROTOCOLS:

1. All diving for this project will be done strictly in accord with protocols established to optimize productivity and diver safety.

2. Provisions of this dive plan, as noted below, and the Department *Manual For Scientific Diving Safety* Section 2.00, Diving Regulations for Scuba (Open Circuit, Compressed Air), will be strictly followed.

3. Only one dive team at a time will be permitted working underwater.

4. At no time shall a dive team consist of less than two or more than three divers.

5. No sea lion captures shall be attempted deeper than 40 feet below the surface.

6. Diving shall not be done at a distance greater than two miles from the larger support vessel nor more than 300 yards from the tending skiff.

7. The dive team shall trail a small float while doing exploratory dives whenever environmental conditions or work protocols prevent the tenders from tracking the divers bubbles.

8. All diving shall be monitored by dive computer unless not possible, then the Navy No-Decompression Limits and Repetitive Group Designation Table for No-Decompression Air Dives shall be used.

9. At the end of all dives, divers shall continue wearing their masks and fins until they are aboard the dive skiff. This will enable the diver to better assist himself should something go wrong in the retrieval process.

10. Dive tenders shall maintain an active log while diving is in progress to include as a minimum: date, location, divers' names, tenders' names, beginning and ending dive times, beginning and ending tank pressures, and notes concerning the work accomplished and problems encountered.

11. Daily, after diving, debriefings shall be held among the divers and other interested or affected personnel to discuss various aspects of the capture work including potential safety problems.

DIVE EQUIPMENT

Divers are equipped with a full complement of standard SCUBA equipment and inflatable shell dry-suits, Instead of the standard backpack, buoyancy compensating devices (BCs) are used to increase reserve buoyant capacity and provide redundancy in the buoyancy systems. This enhances a diver's ability to surface should entanglement with the equipment or a catastrophic suit failure occur. Only one item of common equipment, the snorkel, is sometimes not used. This lessens the possibility of a curious sea lion removing a diver's mask and also diminishes the possibility of entanglement with the capture line. Divers also carry adequate knives or other tools for self rescue.

Reserves of diving air and SCUBA regulators are carried aboard the tending skiff in order that a diver may be supported underwater should that be necessary due to entanglement or decompression needs.

Diving air is obtained daily from onboard dive compressors.

EQUIPMENT PROTOCOLS:

1. At the diver's discretion, snorkels may be omitted from the diver's equipment.

2. Prior to each field project, dive compressor maintenance records shall be reviewed and air intake ports shall be inspected to assure proper compressor configuration and servicing.

3. Dive cylinders shall be opened, visually inspected (informally) and cleaned as needed prior to each field project.

DIVING SAFETY CONSIDERATIONS

Working underwater, making sea lion captures, is unquestionably hazardous. There are all of the usual dangers of diving plus some unique hazards in doing the assigned work. It is often fast paced, physically demanding and distracting causing the divers to focus upon the animals and the capture process. In addition, there is some possibility of entanglement in the capture equipment and of a sea lion attack upon a diver.

Not all potential accidents, however, are equally likely to occur. Various combinations of dive depths, dive times and work performed lead to different injuries and illnesses. Due to sea lion capture dives being shallow and of short duration, some deeper water maladies such as oxygen toxicity and nitrogen narcosis are very unlikely. Decompression sickness, while possible, is also quite improbable for the dives, even if repetitive, are well within the no-decompression limits. Other injuries such as ear squeezes, sinus squeezes, suit squeezes and pulmonary edema are about as likely as during any other easy diving project. Lung overpressurization injuries, however, are slightly more likely due to the shallowness of the diving with consequent rapid pressure changes. Asphyxia also is slightly more likely due to the potential for the capture lines or the animals to dislodge the divers dive equipment.

APPENDIX 2 assesses the likelihood for this project of various diving and capture related illnesses and injuries

and will aid in accident management. Divers being attacked by sea lions, divers tangling in the capture equipment, lung overpressurization accidents and asphyxia are also detailed below. Each is briefly described and evaluated.

DIVING WITH STELLER SEA LIONS: No one knows with certainty the precise amount of risk involved in diving with Steller sea lions; no formal studies have been done. A large body of anecdotal information, however, indicates that while sea lions will readily approach divers and may appear intimidating, these interactions have always been reasonably benign. Reports do exist of divers feeling threatened, but no attack by a Steller sea lion upon a diver has ever been reported in the published literature (C. Rosen, ADF&G librarian, pers. com.). In addition, Department divers have logged many dives with sea lions for the purpose of assessing the safety of working underwater with these animals and to experiment with capture procedures. During these dives, numerous pups and juveniles have been hand captured. Although ritualized threat signals may have been seen, no overt aggression has been noted. At no time, including during captures, has a sea lion disrupted a divers primary work, that of the diving itself. The *NOAA Diving Manual* (October 1991), the bible of scientific and technical diving, states in reference to both seals and sea lions, "Their activity can be distracting or *even* frightening, but it is rarely dangerous. Large bull seals and sea lions, althoughaggressive on the above-water rocks of their breeding rookery, apparently do not constitute a serious threat under water."

Even without serious aggression, an overly inquisitive or playful sea lion may interfere with a diver's ability to continue diving. Sea lions, however, are reluctant to approach a diver on the surface, so ascending should tend to resolve any problems and at least make the situation immediately apparent to the dive tenders. The sea lion research staff does not assume that diving with these animals is perfectly safe, but the evidence indicates that the risks are minimal and manageable.

ENTANGLEMENT IN THE CAPTURE EQUIPMENT: The likelihood of a diver becoming seriously injured due to entangled in the capture equipment is minimal for, as mention earlier, the equipment consists simply of a buoyed line, a small bait container and a forked stick. Prior to initiating a capture, it is possible for a diver's gear to become snagged in the slack line, but this is very easily resolved. After the line has been placed on a sea lion and the animal swims off, sometimes quickly, the seriousness of entanglement may be slightly greater because the tension on the line will tend to tighten any wrap that may be around the diver's regulator hoses, tank valve, or other equipment. The diver may also be pulled through the water. Fortunately, snared sea lion pups and juveniles do not seem inclined to dive deeply, remain submerged more than momentarily or leave the area. While the tension on the line may be firm, the animals are not capable of pulling strongly while swimming and often allow the line to go slack. The diver can almost always pull slack in the line in order to disentangle. If this is too troublesome, the diver may then simply surface and inflate his suit and BC to create large positive buoyancy. His weight belt may also be dropped if needed. Assistance can then be quickly provided by the dive tenders. In practice, entanglements are quite easily resolved.

ASPHYXIA: Asphyxia, which in diving equates to near-drowning or drowning, results from the inability to continue breathing while underwater. This may be caused by physiological dive injury such as gas embolism or loss of the diver's air supply, perhaps from displacement of the second stage regulator. In making sea lion captures, this may result from making an improper ascent, from entanglement in the capture equipment or from jostling with the animals. If not handled appropriately, these problems may lead to cessation of breathing or to panic which causes the stricken diver to inhale water or experience a laryngeal spasm which, in turn, causes severe hypoxia. The shallow depths at which sea lion captures are made enable easy controlled emergency ascent to the surface and lessen the likelihood of asphyxia. Although the probability of asphyxia is slightly enhanced due to the nature of this work, it is not an inordinate hazard.

LUNG OVERPRESSURIZATION: Lung overpressurization injuries are generally caused by over expansion and rupture of lung tissue which in diving is often caused by breath holding, coughing or sneezing while ascending. These injuries may also result from obstructive lung diseases such as asthma, bronchitis, emphysema, fibrosis and tuberculosis which sometimes trap air in the alveoli. As air or other breathing media escapes the lungs, it collects in or around the thoracic cavity causing pneumothorac, mediastinal emphysema or subcutaneous emphysema. These can cause lung collapse and pressure on the heart. A more serious condition, gas embolism, occurs when the

escaped **air** enters the venous system and causes blockages of the blood supply to the spine, heart or brain. The reduced blood flow can cause very severe injury and sometimes death. These injuries are most likely to occur while ascending at shallow depths where relative pressure changes are greater for every foot rise. Although the lungs can accommodate considerable expansion, breath holding from as little as 4 feet with full inflation can be fatal.

During sea lion captures, the distracting and sometimes fast paced nature of the work and the shallow depths make these injuries slightly more likely that during more routine diving. The only safeguard is for divers to be sufficiently trained, experienced and comfortable in the water so as to remain calm and make controlled ascents no matter what the circumstances.

DIVE SAFETY PROTOCOLS:

1. As a minimum, the tending skiff shall be equipped with functional two-way marine VHF radio communications equipment, an emergency oxygen kit and a backboard.

2. The support vessel shall maintain a continuous radio watch while skiffs are at work away from the boat. This will enable long range communications, first aid supplies, oxygen, additional dive tanks, other safety equipment and reference materials to be readily available.

3. The dive tender shall notify the support vessel via radio whenever divers enter and exit the water.

'4. At least one dive tender who is not the skiff driver shall be present in the dive skiff to assist the divers.

5. This dive plan shall be available on the bridge of the support vessel whenever dive operations are underway.

6. Divers shall remain awake and associate with other persons for at least one hour after exiting the water. This will allow them to be monitored for signs of dive related illness.

DIVING ACCIDENT MANAGEMENT

In the broad sense, diving accident management includes many things from accident prevention to caring for an injured diver. This recognizes that the very best way to deal with an accident is to prevent it. Short of that, accident management is a critical element in safeguarding the stricken diver. What happens between the accident and delivery to a medical facility can often have a significant impact on the diver's recovery. Many times permanent impairment may be prevented and even the diver's life may be saved in the field before qualified physicians or pant-medics become involved.

ACCIDENT AWARENESS: Remaining aware that diving accidents can occur ever during easy dives and having a working knowledge of the types of likely accidents leads divers to use safer diving practices. Knowing that asphyxia and embolism are potential hazards of shallow sea lion capture dives should encourage divers to avoid situations in which their air supply might be disrupted and to practice good breathing habits while ascending. Awareness also facilitates earlier recognition and better diagnosis of injuries. Knowing that decompression sickness is nearly impossible during sea lion captures, yet the likelihood of embolism is slightly enhanced enables better evaluation of symptoms.

MONITORING DIVERS: Monitoring divers for signs of injury and illness is often difficult. Persons hurt or sick

will tend to withdraw from social interaction and will often take to their bunks. Then too, ego or concerns about letting their fellow divers down sometimes causes even otherwise sensible divers to conceal or deny their problems. For those reasons, it is important for dive supervisors to monitor their divers closely especially for the first hour after diving and for divers to be honest about evaluating their condition.

ACCIDENT MANAGEMENT REGIMES: When a diving injury or illness is detected, it remains then to assess the type of accident management required. All diving illnesses and injuries can be categorized as those treatable by the stricken diver alone, those that require intervention of other field personnel or those that require transport to a medical facility. Minor medical conditions that remain evident after diving such as suit squeezes and sinus congestion generally require only self-treatment by the diver. Mild decompression sickness, mild carbon monoxide poisoning and hypothermia generally require assistance for oxygen administration, rewarming the patient and other procedures. Serious decompression sickness, embolisms, near drowning and pronounced carbon monoxide poisoning always require transport. APPENDIX 4 provides a useful flow diagram to assist in quickly determining the most appropriate management regime in order to simplify the decision making process and facilitate selecting appropriate treatments.

ACCIDENT MANAGEMENT PROTOCOLS:

1. The availability of hyperbaric chambers and their type shall be checked immediately prior to each field project.

2. As soon as possible, all diving injuries and illnesses shall be categorized as (I) treatable by the diver only, (II) treatable on-board with the assistance of other personnel or (HI) requiring emergency transportation to a medical facility. This will facilitate further accident management decisions.

3. For each stricken diver transported the following emergency contact shall be notified unless the diver denies permission.

Walt Cunningham: Susan Stanford, l-907-747-4900, Sitka, AK
Dennis McAllister: Ada McAllister, l-603-524-1473, Gilford, NH
Una Swain: Robert Small, l-907-248-5010, Anchorage, AK
Don Calkins: Janet Calkins, l-907-345-0334, Anchorage, AK

EMERGENCY ASSISTANCE

COMMUNICATIONS: In the event of a serious diving injury or illness, long distance communication is critical to obtaining medical advice and emergency evacuation of the patient. Due to this project's use of vessels, a variety of reliable, easily used radio systems are generally available. Direct contact can almost always be established from anywhere along the Gulf of Alaska coast, but if needed, relays through other vessels may be arranged. The primary contact for remote vessel operations and for this dive work is the United States Coast Guard. They will respond with emergency medical consultation, transportation and other assistance as required; Once contacted, they will periodically monitor the situation and generally make all further arrangements. If the Coast Guard is deemed not the appropriate rescue agency; perhaps because they are too far away or busy with another rescue, then contact can also be made with private medical consultants, commercial transportation companies, municipal emergency services, area hospitals, Department dive officers and others as needed. APPENDIX 8 lists telephone numbers and radio frequencies for a variety of emergency contacts.

TRANSPORTATION: The degree to which the victim of a serious diving accident recovers and avoids permanent impairment is often directly related to the rapidity in which sophisticated professional treatment is obtained. Since this type of care is generally unavailable in the field, emergency transportation may be required.

In truly remote areas, the Coast Guard should be the first contact. They are equipped and trained to respond to areas and under weather conditions where others cannot. In more traveled areas or when the work is being done close to a community with a well qualified medical facility, commercial air transportation or the use of the project's skiff or vessel may be more appropriate. To some degree, the stricken divers condition will determine the urgency of travel. Generally, however, when over two hours travel from professional help, the Coast Guard should be called.

MEDICAL CONSULTATION: When medical consultation only is required, perhaps for on-board treatment, and phone service is available, it can be obtained from the Northwest Diving Network in Seattle or from the Diving Accident Network (DAN) at Duke University. DAN consultations are available 24 hours a day. Be aware, however, that these services do not make diagnoses or practice medicine over the phone. They can only provide detailed diving illness and injury information.

HYPERBARIC CHAMBERS: The closest permanent hyperbaric chambers are available at Providence Hospital in Anchorage, at Bartlett Memorial Hospital in Juneau and at Virginia Mason Medical Center in Seattle. Other portable units may be available in the projects vicinity and in an extreme emergency it may be advisable to check on their whereabouts. Two commercial diving companies that carry portable units to their job sites are American Divers out of Anchorage and Alaska Diving Services out of Ketchikan.

AREA HOSPITALS WITHOUT HYPERBARIC CHAMBERS: Additional major area hospitals are in Cordova, Ketchikan, Kodiak, Petersburg, Seward and Sitka.

EMERGENCY PROTOCOLS:

1. Appropriate area phone books shall be carried aboard the support vessel.

2. Stricken divers with suspected asphyxia, embolism, type II decompression sickness or serious carbon monoxide poisoning shall be transported to an appropriate medical facility.

3. A stricken diver's equipment including his air supply shall be secured for later inspection if there is any reason to suspect it contributed to the accident. The tank pressure upon exiting the water, the position of the tank valve and the amount of weight the diver carried shall be noted.

4. The diver's tank and regulator set shall be transported with the stricken diver if there is any reason to suspect they contributed to the accident.

5. A stricken diver's recent dive history shall be recorded and accompany the diver upon evacuation.

6. The stricken divers buddy shall also accompany the diver if there is any reason to suspect he might suffer from a like affliction or be of diagnostic assistance.

PROJECT PERSONNEL

The following identifies the principal personnel involved with the Department's marine mammals research program diving activities. Any one may or may not be. involved with a particular field project.

PRINCIPAL INVESTIGATOR: Donald Calkins, an ADF&G marine mammals biologist based in Anchorage, is the principal investigator for the Department's Steller sea lion research project.

DIVE TEAM LEADER: Dennis McAllister, a marine mammals research technician based in Anchorage, is the dive team leader for this project. Dennis is also the Local Dive Safety Officer (LDSO) for the Division of Wildlife Conservation and a Department divemaster.

DIVE TEAM: The dive team for the Department's marine mammals program consists of Walt Cunningham, Working Diver, ADF&G, 295 dives, 160.7 hours, depth limit 100'; Dennis McAllister, Dive Master, ADF&G, 213 dives, 129.9 hours, depth limit 100'; Una Swain, Diver in Training, ADF&G, depth limit 30' and Don Calkins, Diver in Training, ADF&G, depth limit 30'.

DIVE TENDERS: Dive tenders for the Department's marine mammals program include all of the program divers plus David Van Den Bosch.

MEDICAL PERSONNEL: The Department's marine mammals program employs three veterinarians Bruce Heath, D.V.M., Terry Spraker D.V.M., Ph.D. and William Taylor, D.V.M.

APPENDIX 1

SPECIFIC FIELD PROJECT DETAILS

DATES:

LOCATION:

VESSEL: **VHF CALL SIGN:**
HOME PORT: **VESSEL MASTER**

PROJECT LEADER: **DIVE MASTER:**

DIVER
EMERGENCY CONTACT:
DIVER:
EMERGENCY CONTACT:
DIVER
EMERGENCY CONTACT:
DIVER:
EMERGENCY CONTACT:

DIVE TENDER:
DIVE TENDER:

MEDICAL PERSONNEL:

NUMBER OF DIVES:	**DEPTH:**	**DURATION:**	**FOR:**
NUMBER OF DIVES:	**DEPTH:**	**DURATION:**	**FOR:**

SUPPORT EQUIPMENT:

SPECIAL HAZARDS:

NEAREST HYPERBARIC CHAMBER:
ADDRESS: **PHONE:**

NEAREST MEDICAL FACILITY:
ADDRESS: **PHONE:**

MEDICAL CONSULTATION: **PHONE:**

EMERGENCY TRANSPORTATION: **PHONE:**
EMERGENCY TRANSPORTATION: **PHONE:**
EMERGENCY TRANSPORTATION: **PHONE:**

ADF&G DIVE CONTACT: **PHONE:**

APPENDIX 2

ASSESSMENT OF SPECIFIC DIVE ACCIDENT LIKELIHOOD

(A Diagnostic Aid For Accident Management: Assumes no more than 4 sea lion capture dives per day to an average maximm depth of 35 feet with a cumulative bottom time of less than 3 hours and sufficient surface intervals to achieve a Repetitive Group Designation no greater than "I" on the Navy tables. Also assumes using trained and practiced working divers).

DIVE INJURY OR ILLNESS	CAUSE OR CONTRIBUTING FACTOR	LIKELIHOOD WHILE CAPTURING SEA LIONS
High pressure nervous syndrome	Diving to depths in excess of 300 feet	Virtually impossible
Pulmonary oxygen toxicity	Breathing oxygen at high partial pressures (great depth over long duration)	Virtually impossible
Central nervous system (CNS) oxygen toxicity	Breathing oxygen at high partial pressures (great depth over long duration)	Virtually impossible
Inert gas narcosis (nitrogen)	Diving on air to depths generally greater that 100 feet	Virtually impossible
Thoracic squeeze	Breath-holding while descending	Possible, but very unlikely using SCUBA
Type II decompression sickness (CNS)	Exceeding the no-decompression limits without adequate stops	Possible, but very unlikely
Type I decompression sickness (pain only)	Exceeding the no-decompression limits without adequate stops	Possible, but unlikely
Carbon dioxide poisoning	Poor breathing practices (skip breathing)	Possible, but unlikely
Carbon monoxide poisoning	Breathing air contaminated with carbon monoxide	Possible, but unlikely with good compressor maintenance
Barotrauma (ear and sinus)	Failure to equalize properly	Average likelihood
Round window rupture	Improper equalizingon method	Average likelihood
Suit squeeze	Failure to add adequate air	Average likelihood
Mask squeeze	Failure to add adequate air	Average likelihood
Otitis externia (swimmers ear)	Altered Ph balance resulting in infection	Average likelihood
Pneumothorax	Lung overpressurization upon ascent (breath-holding or bronchial blockage)	Slightly more likely than average
Mediasternal emphysema	Lung overpressurization upon ascent (breath-holding or bronchial blockage)	Slightly more likely than average
Subcutaneous emphysema	Lung overpressurization upon ascent (breath-holding or bronchial blockage)	Slightly more likely than average
Air embolism	Lung overpressurization upon ascent (breath-holding or bronchial blockage)	Slightly more likely than average
Asphyxia (near drowning)	Loss of breathing air while diving (running out of air or loss of regulator)	Somewhat more likely than average

APPENDIX 3

SELECTED DIVE ILLNESS SIGNS AND SYMPTOMS

(This table is intended to be a handy reference to aid in identifying dive illnesses that both might occur during sea lion captures and are of a serious nature. These are conditions that generally require timely attention and evacuation to a medical facility. Types I and II decompression sickness, pneumothorax, mediastinal emphysema, subcutaneous emphysema, gas embolism and asphyxia are included. Type I decompression sickness probably would not require evacuation, but it is included in order to distinguish type II. And asphyxia is quite self-evident, but it is a serious dive illness that might also involve other significant problems. Less serious dive illnesses such as sinus squeeze and ear infection generally do not require rapid attention nor evacuation and their diagnosis and treatment are adequately detailed in other reference materials.)

DECOMPRESSION SICKNESS TYPE I (DCS-I): Nitrogen bubbles in tissues

- Usually require some time, maybe several hours (not over 48) to develop
- Deep, dull, localized, non-radiating pain in extremities (torso pain is DCS-II)
- Itchy skin
- Faint skin rashes (mottling or marbling is DCS-II)
- Slight tenderness of lymph nodes

DECOMPRESSION SICKNESS TYPE II (DCS-II): Nitrogen bubbles in tissues

- Severe cases develop within minutes of surfacing
- DCS-I symptoms may be present
- Moderate, radiating joint or torso pain
- Mottled or marbleized skin
- Painful, swollen lymph nodes
- Numbness, tingling and decreased sensation to touch
- Vertigo, dizziness and ringing in the ears
- Abnormal fatigue and weakness
- Difficulty walking, hearing or urinating
- Amnesia, incoordination, tremors and unusual behavior
- Chest pain, lung congestion, cough and rapid respirations
- Loss of consciousness. . . . . .death

PNEUMOTHORAX: Air in chest from ruptured lung

- Sharp pain in chest, shoulder or upper back aggravated by deep breathing
- Difficulty in breathing (shortness of breath)
- Shallow, rapid breathing
- Bending chest toward affected side
- General pallor (blue skin lips and nails)

TENSION PNEUMOTHORAX: Accumulating air in chest from ruptured lung

- All of above pneumothorax symptoms

Accumulating pressure in chest
Collapsed lung
Pressure on heart
Faintness

MEDIASTINAL EMPHYSEMA: Air in space between lungs from ruptured lung
Dull, mild to moderate pain or tightness behind breast bone
Difficulty in breathing (shortness of breath)
Sometimes radiating pain to shoulder, neck or back
Change of voice

SUBCUTANEOUS EMPHYSEMA: Air from mediastinum under skin of neck and face
Feeling of fullness around neck
Difficulty swallowing
Voice change
Inflated pouches under skin
Moving inflated skin produces crackling sound

ARTERIAL GAS EMBOLISM: Gas bubble obstruction of vessel from DCS or lung rupture
Symptoms almost always immediately upon surfacing
Dramatic, rapid onset (severe DCS takes at least a few minutes to develop)
Sensation of sudden thump in chest while surfacing
Dizziness or blurred vision
Large areas of numbness, prickling, weakness or paralysis
Loss of consciousness
Stoppage of breathing
Death

ASPHYXIA (NEAR-DROWNING): Water blockage of breathing air
Unconscious diver in the water

FACTORS TO REMEMBER:
1 Remember to consider the dive scenario and factor in the probability for any particular dive illness (APPENDIX 3) in searching for a diagnosis.
2. Remember that more than one dive illness may be present in a given case.
3. Remember that DCS II can cause an arterial gas embolism, but-not vice versa.
4. Remember that any rupture of lung tissue can lead to pneumothorax, mediastinal emphysema, subcutaneous emphysema, arterial gas embolism or any combination of these.
5. Remember that any diver that surfaces unconscious may have drowned, suffered an arterial gas embolism or both.

APPENDIX 4

ACCIDENT MANAGEMENT FLOW DIAGRAM

MONITOR DIVERS AFTER DIVING

DIVER STRICKEN IN WATER

RESCUE DIVER FROM PERILOUS SITUATION

DIVER REPORTS ILLNESS OR INJURY (NON-EMERGENCY) OR BECOMES UNCONSCIOUS (EMERGENCY)ON BOARD VESSEL

QUICKLY ASSESS SITUATION AND ASSIGN MANAGEMENT REGIMES I, II or III

REGIME I	REGIME II	REGIME III
DIVER SELF-TREATS ONBOARD VESSEL (MASK SQUEEZE, SUIT SQUEEZE, SINUS SQUEEZE, MIDDLE EAR INFECTION, OTITIS EXTERNA, CONGESTION, MILD HYPOTHERMIA)	ASSIST DIVER WITH TREATMENT ONBOARD (TYPE I DECOMPRESSION SICKNESS,, MILD CARBON MONOXIDE POISONING, HYPOTHERMIA)	ASSIST DIVER FOR TRANSPORT (NEAR DROWNING, TYPE II DECOMPRESSION SICKNESS, SEVERE CARBON MONOXIDE POISONING, PNEUMOTHORAX, MEDIASTINAL EMPHYSEMA, SUBCUTANEOUS EMPHYSEMA, GAS EMBOLISM)
MONITOR DIVER	O2 or FIRST AID AS NEEDED	CPR, O2 or FIRST AID AS NEEDED
SITUATION RESOLVES / SITUATION WORSENS	REASSESS SITUATION USING REFERENCES AND MEDICAL CONSULTATION	REASSESS SITUATION USING REFERENCES AND MEDICAL CONSULTATION
REASSIGN REGIME II or III	CONSIDER REGIME I or III	CALL FOR TRANSPORT
	TREAT DIVER AS NEEDED	ADMINISTER EMERGENCY CARE
	MONITOR DIVER	PREPARE DIVER, BUDDY, EQUIPMENT AND INFORMATION FOR TRANSPORT
	SITUATION IMPROVES / SITUATION WORSENS	TRANSPORT DIVER
	REASSIGN TO REGIME III	PROVIDE INFORMATION DIRECTLY TO DOCTOR
		NOTIFY DIVER CONTACT IF PERMITTED
		NOTIFY ADF&G DSO

APPENDIX 5

SELECTED FIRST AND PROCEDURES FOR DIVE ILLNESSES SOME DOS AND DON'TS

(The following discussions are intended to provide a quick reference for some commonly asked diver first aid questions.)

HEIMLICH MANEUVER: The Heimlich maneuver which every first-aider knows for relieving choking, has now been demonstrated to be useful as a quick first response in near-drownings (where the victim is not breathing). It takes very little time to administer and it is often quite effective in expelling water from the trachea and possibly the lungs. In a large percentage of cases it also stimulates the person to breath, thus cardiopulmonary resuscitation (CPR.) is not needed. It is a safe procedure which when successfully employed can reduce the rescuer's and victim's exposure to disease transmission and lung damage that sometimes result from CPR The Heimlich maneuver can even be done fairly easily in the water and may save precious time in reviving the victim before they can be removed to a boat or the land. Every diver's buddy or tender should attempt the Heimlich maneuver at the earliest Possible moment in the event of any near-drowning;.

OXYGEN ADMINISTRATION: Oxygen administration is perhaps the most important first-aid procedure in treating any moderate to serious dive illness including near-drowning, decompression sickness, gas embolism, contaminated air poisoning and other sicknesses. Providing 100% oxygen improves tissue oxygenation when it has been compromised. Elevated levels of oxygen in the tissues reestablishes normal metabolic function, eases breathing, reduces swelling and produces a calming effect. A higher partial pressure of oxygen in the tissues also speeds the removal of nitrogen and other gasses associated with decompression sickness and gas embolism. Oxygen can be given for up to several hours although short breaks, perhaps 10 minutes out of every hour, should be taken. Always give 100% oxygen for dive illnesses.

TRENDELENBERG POSITION: The Trendelenberg position in which a stricken individual is placed laying on a steep incline on the person's left side with the head down is a procedure no longer recommended for the treatment of gas embolisms and decompression sickness. The supposed benefit of preventing gas bubbles from reaching the person's brain is now very much in doubt and the position may have serious side effects. It can lead to discomfort, restriction of the airway, cerebral edema and further embolization. The position is also very difficult to maintain on a moving boat or aircraft and may interfere with cardiopulmonary resuscitation, oxygen administration or other procedures. Instead, the stricken diver should be placed on a level surface on the back or side as needed and with the feet only slightly elevated if shock is suspected. Do not use the Trendelenbern Position.

REHYDRATION WITH FLUIDS: Unless a diving illness victims is unconscious or otherwise impaired, giving fluids, especially water and electrolyte balanced sports drinks, may be beneficial and should not cause harm. There is evidence to suggest that orally ingested fluids replenish intravascular volume, reverse hemoconcentration, raise blood pressure and increase

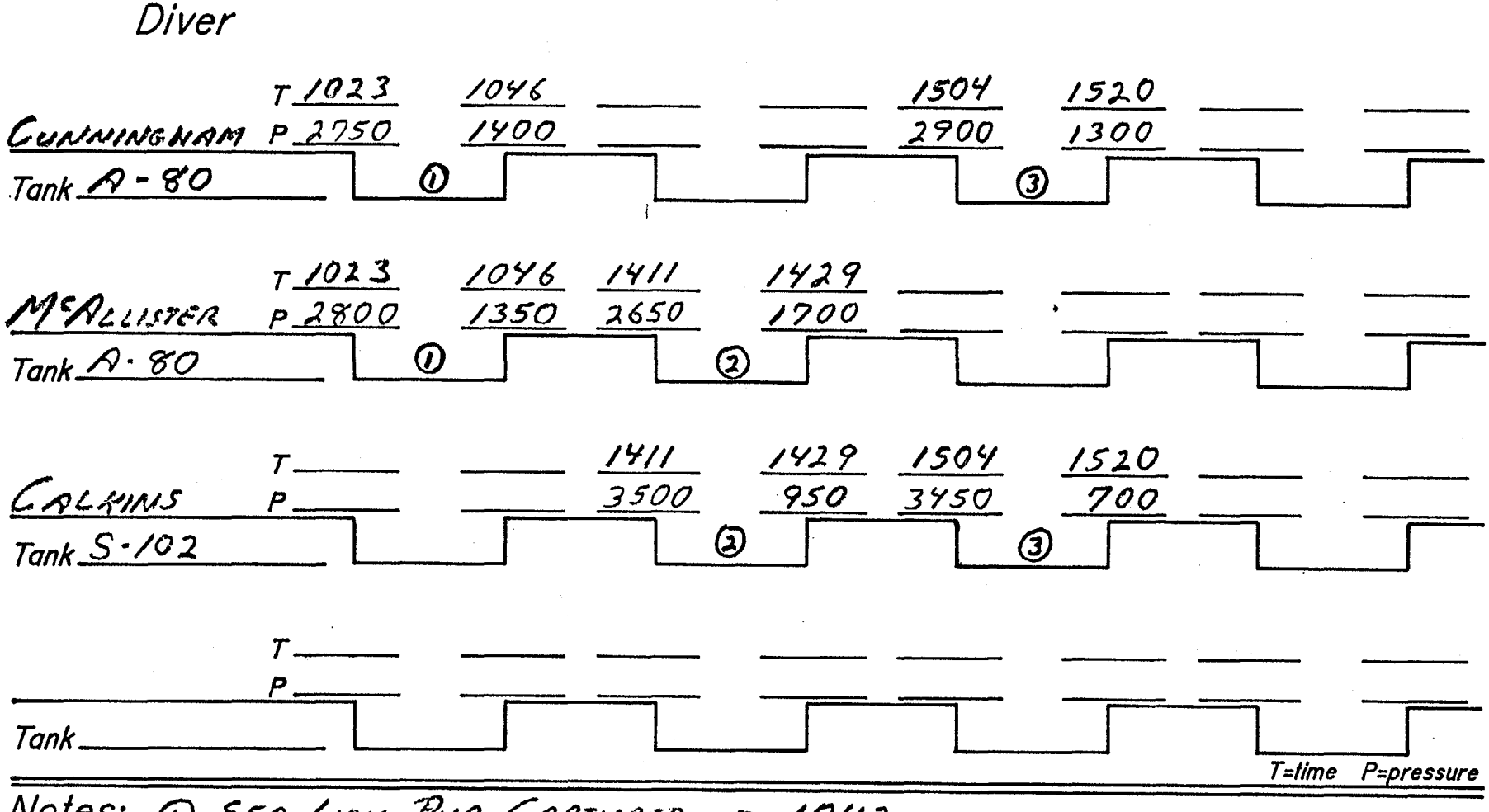
microcirculatory flow. There is further indirect indication that this may hasten the elimination of excess inert gasses in cases of decompression illness and gas embolism. If the stricken diver can tolerate fluids, give them.

GIVING DRUGS: Although it is tempting to give aspirin or other mild pain relievers for the aches and pains of decompression illness, it is generally thought not to be wise to do so. There may be some slight beneficial effect of anticoagulants in reducing platelet deposition (clotting) around bubbles, but this is very minor relative to the important loss of the diver medic's most telling indicator of decompression sickness; pain. If the natural progression of the condition is to be adequately monitored either aboard the vessel or in the recompression chamber, the pain symptom must not be masked. Do not give pain relievers for dive illnesses.

IN-THE-WATER RECOMPRESSION TREATMENTS: It is tempting with moderate cases of decompression sickness to place the stricken diver back in the water at some shallow depth. In theory this is sound and, in fact, it has been done successfully on a routine basis in some situations. To be practical, however, in-the-water recompression requires exceedingly close monitoring and specialized equipment. Generally surface supplied oxygen, intercoms and temperature controlled suits are needed. When attempting this procedure using SCUBA, it is caught with dangers including the inability to follow an appropriate treatment schedule, hypothermia, drowning and the possibility of other dive accidents. In-the-water recompression treatments should not be attempted unless specifically trained and equipped to do so.

Dive Tender's Record — Steller Sea Lion Project

Date: 3 FEB 97 Location: EAST BROTHER I Tender: VAN DEN BOSCH



Notes: ① SEA LION PUP CAPTURED AT 1042
② NO PUPS INTERESTED IN DIVERS
③ YEARLING CAPTURED AT 1517

Dive Log

							OR			
Required	Required	Required	Required	Required	Required	Required	Required	Required	Required	Optional
			(format = M / D	(ex. 1996)			ex: 0:34	(if applicable)		
			ex: 1/1)				(use a colon)			
Diver								Surface	Max	Depth
Last_Name	First_Name	Dive_No.	Date	Year	Time_In	Time_Out	Botton_Time	Interval	Depth	Category
		1								
		2								
		3								
		4								
		5								
		6								
		7								
		8								
		9								
		10								
		11								
		12								
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		17								
		18								
		19								
		20								
		21								
		22								
		23								
		24								
		25								
		26								
		27								

Dive Log

Required	**Required**	**Required**	**Required**	**Required**
		(if applicable)	**(if applicable)**	
			Dive	
Location	Buddy	Tender	Master	Work/Prof/Train

Required	**Optional**	**Required**	**Optional**	**Optional**	**Optional**
		(Air, NI,			
		NII, O)			
					Surface
Table/Computer	Day/Night	Gas	SAC	Vis	Conditions

Dive Log

Optional	**Required**	**Required**
		(if applicable)
Comments	Decompression	Project

No-Decompression Limits and Repetitive Group Designation Table for No-Decompression Air Dives

Depth (feet)	No-decompression limits (min)	Repetitive Group Designation														
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
10		60	120	210	300											
15		35	70	110	160	225	350									
20		25	50	75	100	135	180	240	325							
25		20	35	55	75	100	125	160	195	245	315					
30		15	30	45	60	75	95	120	145	170	205	250	310			
35	310	5	15	25	40	50	60	80	100	120	140	160	190	220	270	310
40	200	5	15	25	30	40	50	70	80	100	110	130	150	170	200	
50	100		10	15	25	30	40	50	60	70	80	90	100			
60	60		10	15	20	25	30	40	50	55	60					
70	50		5	10	15	20	30	35	40	45	50					
80	40		5	10	15	20	25	30	35	40						
90	30		5	10	12	15	20	25	30							
100	25		5	7	10	15	20	22	25							
110	20			5	10	13	15	20								
120	15			5	10	12	15									
130	10			5	8	10										
140	10			5	7	10										
150	5			5												
160	5				5											
170	5				5											
180	5				5											
190	5				5											

Source: US Navy (1985)

Residual Nitrogen Timetable
for Repetitive Air Dives

*Dives after surface intervals of more than 12 hours are not repetitive dives. Use actual bottom times in the Standard Air Decompression Tables to compute decompression for such dives. See section 14.6.2.3 for instructions in the use of this table.

Repetitive group at the beginning of the surface interval

															A	0:10 12:00*
														B	0:10 2:10	2:11 12:00*
													C	0:10 1:39	1:40 2:49	2:50 12:00*
												D	0:10 1:09	1:10 2:38	2:39 5:48	5:49 12:00*
											E	0:10 0:54	0:55 1:57	1:58 3:22	3:23 6:32	6:33 12:00*
										F	0:10 0:45	0:46 1:29	1:30 2:28	2:29 3:57	3:58 7:05	7:06 12:00*
									G	0:10 0:40	0:41 1:15	1:16 1:59	2:00 2:58	2:59 4:25	4:26 7:35	7:36 12:00*
								H	0:10 0:36	0:37 1:06	1:07 1:41	1:42 2:23	2:24 3:20	3:21 4:49	4:50 7:59	8:00 12:00*
							I	0:10 0:33	0:34 0:59	1:00 1:29	1:30 2:02	2:03 2:44	2:45 3:43	3:44 5:12	5:13 8:21	8:22 12:00*
							J	0:10 0:31	0:32 0:54	0:55 1:19	1:20 1:47	1:48 2:20	2:21 3:04	3:05 4:02	4:03 5:40	5:41 8:40	8:41 12:00*
						K	0:10 0:28	0:29 0:49	0:50 1:11	1:12 1:35	1:36 2:03	2:04 2:38	2:39 3:21	3:22 4:19	4:20 5:48	5:49 8:58	8:59 12:00*
					L	0:10 0:26	0:27 0:45	0:46 1:04	1:05 1:25	1:26 1:49	1:50 2:19	2:20 2:53	2:54 3:36	3:37 4:35	4:36 6:02	6:03 9:12	9:13 12:00*
				M	0:10 0:25	0:26 0:42	0:43 0:59	1:00 1:18	1:19 1:39	1:40 2:05	2:06 2:34	2:35 3:08	3:09 3:52	3:53 4:49	4:50 6:18	6:19 9:28	9:29 12:00*
			N	0:10 0:24	0:25 0:39	0:40 0:54	0:55 1:11	1:12 1:30	1:31 1:53	1:54 2:18	2:19 2:47	2:48 3:22	3:23 4:04	4:05 5:03	5:04 6:32	6:33 9:43	9:44 12:00*
		O	0:10 0:23	0:24 0:36	0:37 0:51	0:52 1:07	1:08 1:24	1:25 1:43	1:44 2:04	2:05 2:29	2:30 2:59	3:00 3:33	3:34 4:17	4:18 5:16	5:17 6:44	6:45 9:54	9:55 12:00*
		0:10 0:22	0:23 0:34	0:35 0:48	0:49 1:02	1:03 1:18	1:19 1:36	1:37 1:55	1:56 2:17	2:18 2:42	2:43 3:10	3:11 3:45	3:46 4:29	4:30 5:27	5:28 6:56	6:57 10:05	10:06 12:00*
NEW → GROUP DESIGNATION		Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A

REPETITIVE DIVE DEPTH																	
40	257	241	213	187	161	138	116	101	87	73	61	49	37	25	17	7
50	169	160	142	124	111	99	87	76	66	56	47	38	29	21	13	6
60	122	117	107	97	88	79	70	61	52	44	36	30	24	17	11	5
70	100	96	87	80	72	64	57	50	43	37	31	26	20	15	9	4
80	84	80	73	68	61	54	48	43	38	32	28	23	18	13	8	4
90	73	70	64	58	53	47	43	38	33	29	24	20	16	11	7	3
100	64	62	57	52	48	43	38	34	30	26	22	18	14	10	7	3
110	57	55	51	47	42	38	34	31	27	24	20	16	13	10	6	3
120	52	50	46	43	39	35	32	28	25	21	18	15	12	9	6	3
130	46	44	40	38	35	31	28	25	22	19	16	13	11	8	6	3
140	42	40	38	35	32	29	26	23	20	18	15	12	10	7	5	2
150	40	38	35	32	30	27	24	22	19	17	14	12	9	7	5	2
160	37	36	33	31	28	26	23	20	18	16	13	11	9	6	4	2
170	35	34	31	29	26	24	22	19	17	15	13	10	8	6	4	2
180	32	31	29	27	25	22	20	18	16	14	12	10	8	6	4	2
190	31	30	28	26	24	21	19	17	15	13	11	10	8	6	4	2

RESIDUAL NITROGEN TIMES (MINUTES)

Adapted from US Navy (1985)

APPENDIX 8

EMERGENCY CONTACTS

EMERGENCY TRANSPORTATION:

Marine VHF channel 16, United States Coast Guard (USCG)
Single side band 2182 and 4125 (Kodiak), USCG
l-800-478-5555, USCG general emergency contact number
I-907-463-2000, USCG command center Juneau
l-907-487-5888, USCG command center Kodiak
l-907-27 l-6700, USCG Anchorage
l-907-261-3070, Lifeguard Air Ambulance, Learjet, Anchorage (to Seattle)
l-907-586-2611, Bartlett Memorial Hospital transport, Citation, Juneau (to Seattle)
l-800-426-0333, Alaska Airlines, general reservation number

HYPERBARIC CHAMBERS:

l-907-562-2211, Providence Hospital, Anchorage
l-907-586-2611, Bartlett Memorial Hospital, Juneau
l-206-583-6433, Virginia Mason Medical Center, Seattle
l-907-562-5420, American Divers, Anchorage
l-907-225-3667, Alaska Diving Services, Ketchikan

AREA HOSPITALS (without hyperbaric chambers):

l-907-424-8000, Cordova
l-907-225-5171, Ketchikan
l-907-486-3281, Kodiak
l-907-772-4291, Petersburg
l-907-224-5205, Seward
l-907-747-3241, Sitka

MEDICAL CONSULTATION:

l-206-624-1144, Northwest Diving Network, Seattle
l-919-684-8111, Diving Accident Network (DAN), Duke University

STATE TROOPERS:

l-907-465-4000, Juneau
l-907-225-5188, Ketchikan
l-907-747-6611, Sitka
l-907-772-3100, Petersburg
l-907-785-3393, Kake, Municipal Police

ADF&G DIVE OFFICERS:

l-907-465-4250, l-907-789-69820, Scott Marshall, Dept. Dive Officer, Juneau
l-907-465-4244, 1-907-789-7105(H), Marc Pritchett, Dive Board member, Juneau