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PRINCE WILLIAM SOUND HERRING SPAWN DEPOSITION SURVEY MANUAL

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By

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INTRODUCTION

The Alaska Department of Fish and Game has used underwater spawn deposition surveys from 1988 to the present as a basis for estimating the spawning biomass of Pacific herring (*Clupea harengus pallasi*) in Prince William Sound. The department's goal is to provide a more precise stock assessment tool aiding in the management of the herring fisheries in the Sound. Historically, estimates of spawn biomass were based on aerial surveys. Underwater ground surveys have improved the precision of estimates compared to aerial survey methods that tended to underestimate the biomass, exhibited a wide variation in reliability due to differences in surveyors and weather, and for which confidence intervals could not be estimated.

Adoption of underwater spawn deposition surveys in Prince William Sound was based on research in British Columbia and southeastern Alaska which demonstrated the shortcomings of above water survey techniques. In 1983 and 1984, Jackson and Randall conducted feasibility studies of implementing underwater survey methods for the Sound. They concluded that the technique could be utilized successfully in Prince William Sound. Funding constraints prevented the ADF&G from using diver surveys until 1988 when underwater surveys were conducted in all major herring spawning areas in the Sound. This method provides the current basis for managing the Sound's herring stocks.

The potential for adverse impacts from the 1989 EXXON Valdez oil spill provided additional motivation for more accurate monitoring of herring abundance and the health of Prince William Sound's herring population. As a result, sampling or the number of transects conducted during the spawn deposition survey was increased in 1989 to the present.

The intensity of fishing efforts and the economic value of the various herring fisheries, along with the damage assessment studies, demand precise management techniques to insure the viability of the industry and survival of the stocks.

Five fisheries target Prince William Sound's herring population: sac roe seine, sac roe gillnet, natural spawn on kelp, pound kelp, and the bait/food fishery. Guideline harvest levels are based on a fixed exploitation rate of 20% of the estimated stock biomass. Commercial harvests have ranged from 4,000 to over 15,000 tons since 1978 with ranges in the total exvessel value of 1 to 12.5 million dollars.

GENERAL OBJECTIVES AND METHODOLOGY

The objective of the spawn deposition survey is to backcalculate the biomass of the spawning population from estimates of the total number of eggs deposited on the spawning grounds, dividing by estimates of average fecundity, and multiplying by average weight and sex ratio estimates of the spawning population.

The overall biomass estimator is:

$$B = T \cdot B' \div (1 - R)$$

where:

B	=	Estimated spawning biomass in tonnes
T	=	Estimated total number of eggs (billions) deposited in an area
B′	=	Estimated tonnes of spawning biomass required to produce one billion eggs
R	=	Estimated proportion of eggs disappearing from the study area from the time of spawning to the time of the survey

The value of T is derived from underwater spawn deposition surveys in which diver estimates of egg quantities are subsequently adjusted for individual diver and vegetation type effects.

B' is calculated from average fecundity, average weight, and sex ratio of the herring population as determined from catch sampling programs.

Based on egg loss studies in southeastern Alaska, an egg loss of 10% is assigned to the variable R. Egg loss studies conducted in Prince William Sound in 1990 and 1991 may result in a recalculation of this multiplier.

Biomass estimates are calculated separately for each of the five major spawning areas in Prince William Sound. Figure 1 delineates the five major areas which include the Southeast, Northeast, North Shore, Naked Island and Montague Island Areas.

To estimate the total number of herring eggs deposited in the Sound, two person dive teams conduct systematic underwater sampling along randomly selected transects perpendicular to the shoreline. The transects are located within areas where milt has been previously sighted by aerial surveys.

Following a compass course perpendicular to the shore, the lead diver measures 5 meter intervals by pacing 1 meter arm spans along the course. Every 5 meters, the diver randomly places a 0.1 m^2 quadrat, estimates the number of herring eggs on the vegetation or other substrate within the quadrat, and communicates that estimate to the second diver. The reference standard used is that 40,000

Prince William Sound Herring Grounds by Area

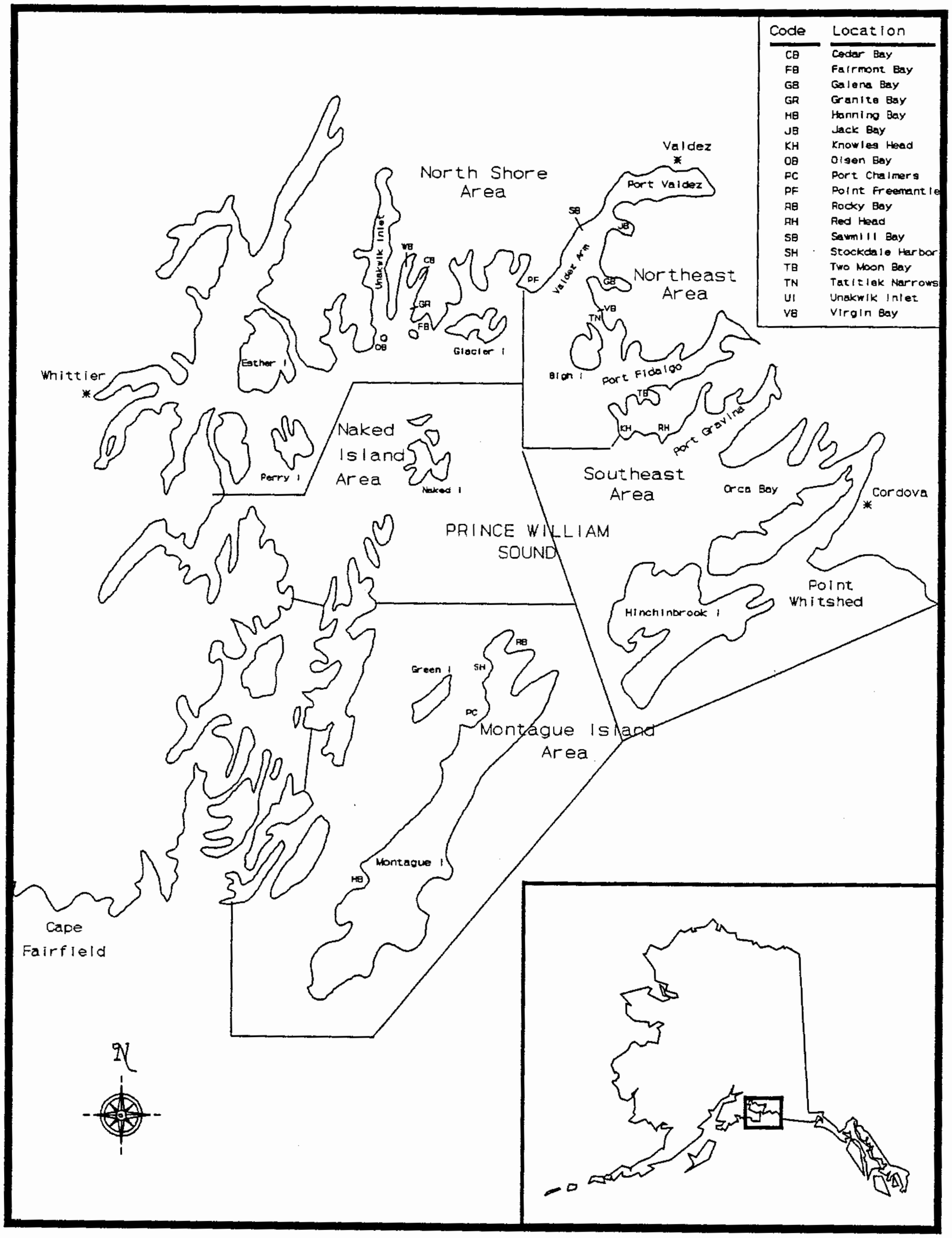


Figure 1. Delineation of the five major herring spawning grounds in Prince William Sound; the North Shore, Southeast, Northeast, Naked Island and Montague Island Areas.

eggs in one layer uniformly covers the 0.1 m^2 quadrat area. Two egg layers covering the quadrat is 80,000 eggs, 3 layers is 120,000 eggs, and so on.

The second diver records the vegetation type, vegetative percent cover, substrate type, depth, distance from the start of the transect and the estimated number of eggs in the quadrat as given by the lead diver.

Periodically both divers estimate the eggs on the vegetation within the quadrat. They then collect the vegetation and eggs for use in calibrating diver estimates. The collected samples are preserved in Gilson's solution for later processing.

In the laboratory, the Gilson's solution is drained from each sample which is then placed in a potassium hydroxide solution. The kelp dissolves, is strained, and the eggs are then soaked in a 1.0 Normal saline solution for 24 hours to standardize their volumetric displacement. The average displacement of randomly selected 1000 egg subsamples is used to determine a standard reference displacement. The total volume of eggs in the sample divided by the standard reference volume yields the total number of eggs in
thousands of eggs. Refer to the Prince William Sound Herring Laboratory Operational Manual for detailed laboratory sample processing methods.

Divers' field estimates can then be employed to produce calibration curves. One calibration curve is produced for each of four major kelp types for each diver and has the diver estimate as a dependent variable versus the actual laboratory egg count.

DETAILED METHODS FOR SPAWN DEPOSITION SURVEY

Aerial survey

Before the diving phase of the herring spawn deposition program, several preliminary steps must occur. Beginning around the 1st of April, observers attempt to make daily flights throughout the portions of Prince William Sound where herring have historically spawned. The observers pencil in on maps the areas where herring milt is seen along the shoreline (Figure 2). Copies of the maps are given to the dive teams in order to plan transect locations. Spawn mileage is delineated within each of the five major spawning areas (Figure 1).

Figure 2. Aerial survey spawn map example.

Transect Allocation

The number of 0.1 mile segments in the miles of unsurveyed shoreline where spawning was observed is determined. Using a random number generator or table, a predetermined number of transect locations based on approximately 2 - 4 transects per mile, are selected within each spawning area randomly without replacement from among the 0.1 mile segments.

Beginning at one end of the spawned areas, the selected transects are marked and numbered by measuring to the appropriate 0.1 mile segments proceeding in one direction along the shoreline. A map measuring wheel or small paper scale divided into 0.1 mile increments can be used to mark the transect locations on USGS quad maps (Figure 3).

Transect locations and enough topographic detail should be traced onto a mylar sheet to enable the dive teams to locate the transects in the field (Figure 4). The original quad maps should not be taken into the field where they may be lost since the maps will be used to locate additional transects on successive days of spawning.

Conducting underwater surveys at mapped transects

Teams consisting of two divers and a tender perform the diving portion of the spawn deposition surveys. The roles and duties of the various members described in the duty checklist, enable the team to effectively complete the surveys.

Selecting transect locations in the field

Before choosing the dive transect location, the survey team should verify the presence of spawn as shown on the aerial survey maps. The team travels along the shore and visually or by grappling determines if spawn is present.

When spawn is found, the dive skiff approaches the shoreline, and while about 1/4 mile offshore, the team members select the starting point of a transect by referring to the map tracing with transect locations. The transects should be located as closely as possible to the mapped locations but without introducing bias by referring to subtidal vegetation or shoreline features. Once selected do not deviate from the point on the shore.

Figure 3. Transect location map.

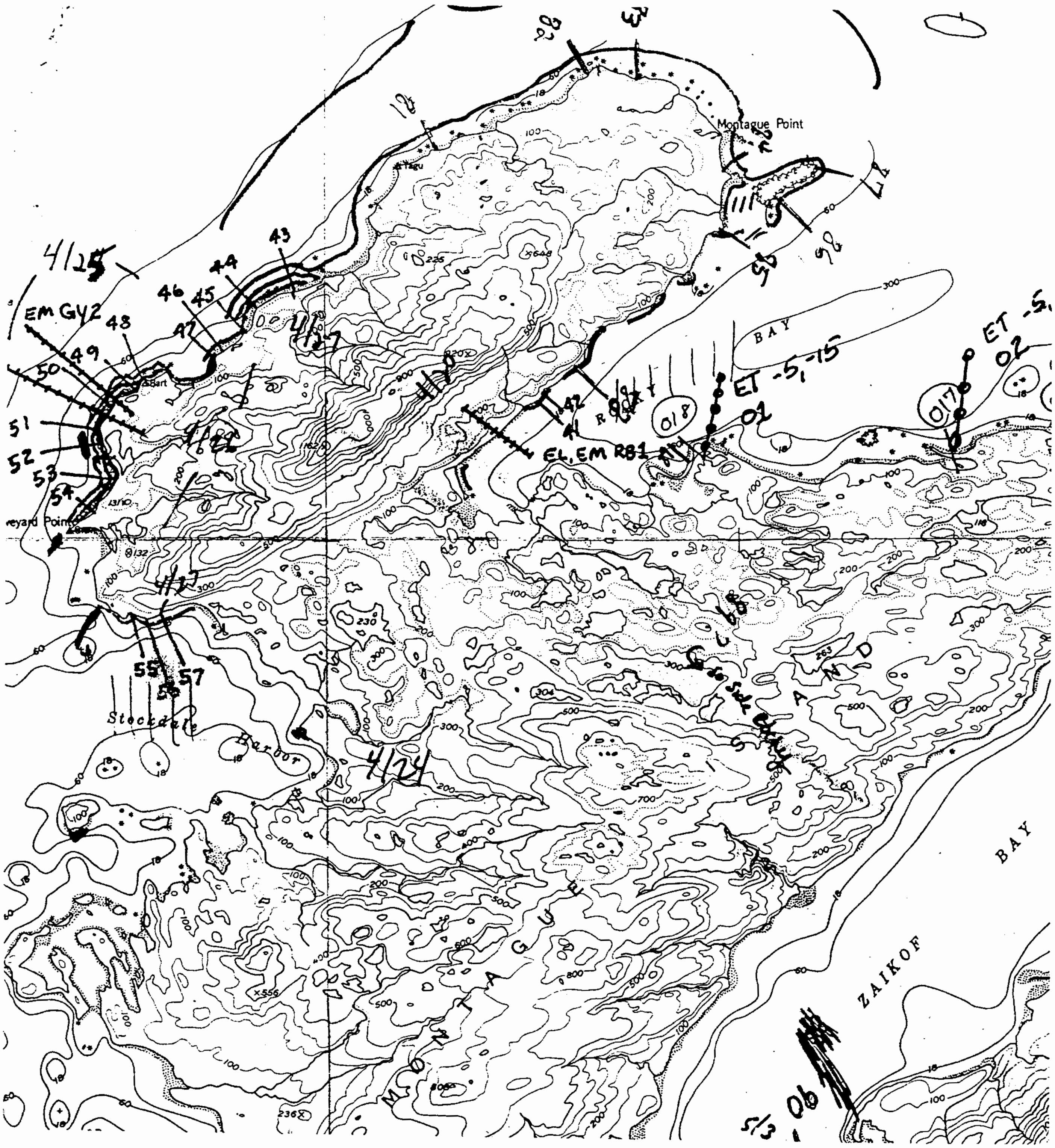
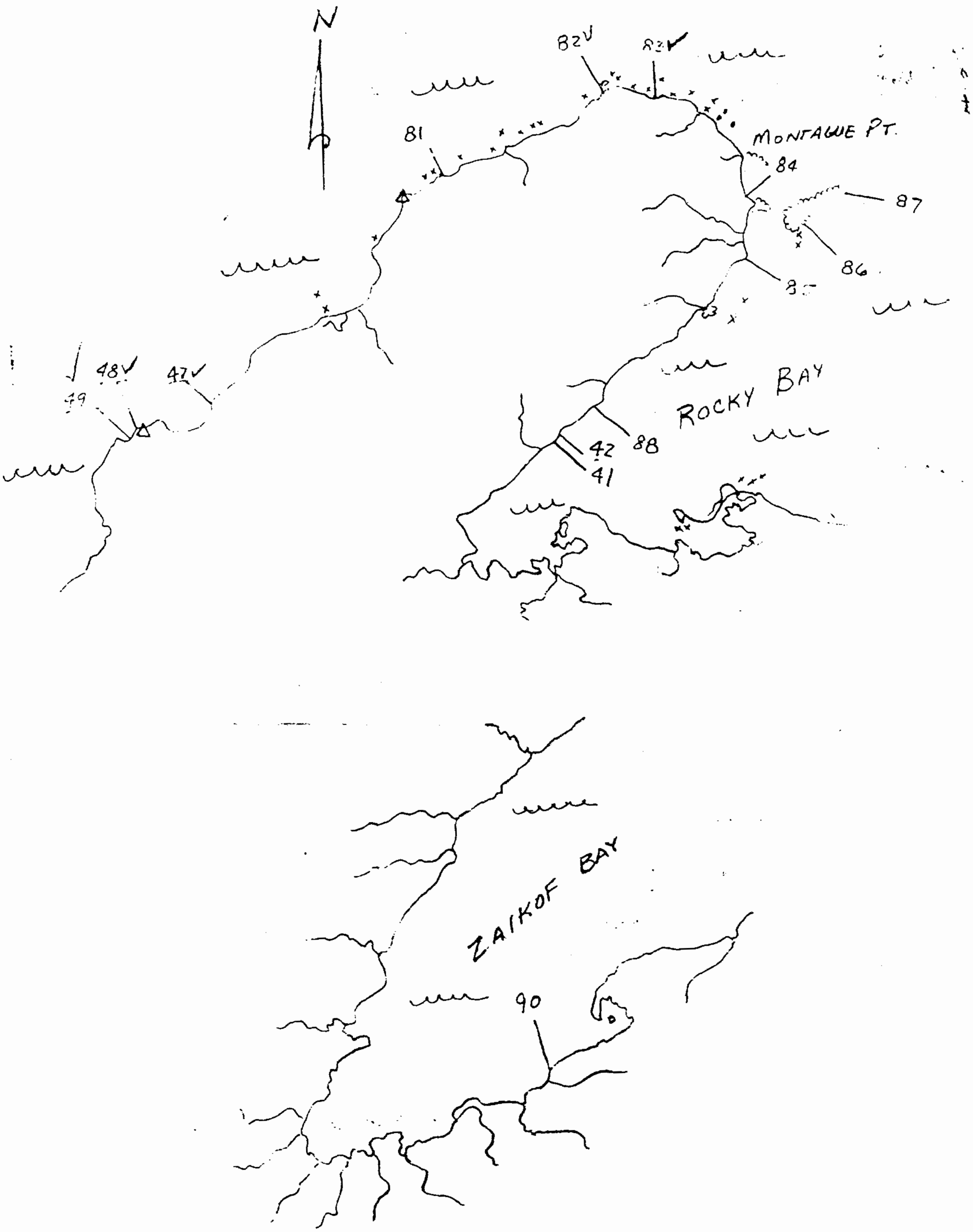


Figure 4. Mylar tracing of transect locations for field work.



If spawn is seen on the intertidal and upland areas at the transect location, the divers mark the beginning of the transect at the waterline. A seaward compass course perpendicular to the shoreline is determined and then the divers walk inland along the reciprocal course to the limit of spawn. The team then turns and steps off 5 meter intervals along the compass course toward the shoreline.

Beginning at the end of the first 5 meter interval or station 1, a diver randomly drops the quadrat and estimates the number of eggs within it. To estimate egg numbers, the diver visually examines the area within the sample quadrat, observing the amount of surface area of vegetation and bottom substrate, the percent of the surface area covered by herring eggs, and the number of egg layers. The diver then visually integrates the number of egg layers and the percent of the surface covered by eggs to estimate the number of eggs in the quadrat, using the reference standard that 40,000 (40 K) eggs in one layer would uniformly cover the 0.1 m^2 quadrat surface.

The other diver records the estimate and other required data as well as the estimated height in feet above the waterline. It is important to note the time at which the survey begins so that elevation and depth measurements can later be corrected to a standard tidal datum (see appendix for sample data form).

When they reach the waterline, the divers should mark the end of the last 5 meter interval, noting the station number and depth "0", and don their gear. Beginning at the point of the last estimate, the divers swim offshore along the compass course.

The diver estimating should begin with his/her head over the last quadrat placement and begin hand pacing 5 meter intervals with one meter paces along the compass course. Halfway through the 5th meter pace, the diver extends the quadrat ahead and randomly places it along the course. The estimator conveys his/her estimate to the recorder by standard hand signals (for signals, see Appendix 2).

The second diver records the depth, vegetation, percent of coverage, substrate, the estimated number of eggs, and any pertinent comments. Refer to Appendix 1 for detailed instructions and an example of a completed data form.

To be sure that they have reached the limit of spawn, divers should swim 20 meters beyond the last sighting or until they are confident that no more spawn will be found. Herring eggs are rarely found below a depth of 30 feet.

Pacing standardization

To pace accurately and comfortably, a diver should become slightly negatively buoyant. Reaching comfortably ahead with one hand, the diver draws himself/herself along the bottom with the pacing hand passing under her/his body until it comes beneath the diver's stomach. With practice, the distance traveled is about one meter. The diver then reaches forward for the next pace.

In order to standardize their one meter long arm paces, divers should practice pacing during their pre-season check-out dives. While holding onto the end of a 5 m. length of line, one member of a two diver team should pace ahead. Her/his buddy holds the other end of the line stationary. The practice should be repeated until the pacing diver achieves a standard one meter pace and can regularly reach the end of the line in 5 paces. The divers then trade places. Accurate pacing is important to minimize errors in the length of transects and the overall width of spawn.

Divers should also familiarize themselves with the compasses attached to the quadrats and practice pacing along compass courses. Using a separate compass, the divers should take turns verifying the precision of each other's travel.

DETAILED METHOD FOR CALIBRATION SAMPLING

Description/Rationale

In order to calibrate diver egg quantity estimates, divers must periodically take kelp samples with spawn for later volumetric measurement in the laboratory. Individuals take 2 to 3 seasons of estimating to be considered ADF & G calibrated divers. Each diver should take and estimate 84 samples per year for three years until calibrated. Of these samples, 21 should be collected from each of the four kelp types: fucus (FUC), eelgrass (EEL), large brown kelp (LBK), and hair kelp (HRK). Seven of the 21 samples should be from low density spawn kelp (0 - 20K), seven from medium density (20K -80K), and seven from high density spawn (80K+).

Sampling from the various kelp types and densities will allow correction for the kelp and egg density effects on individual divers' estimates.

Sampling methodology

The lead diver selects a quadrat location to take a calibration sample. The diver examines the kelp and spawn within the quadrat and then, in the margin of the data form, records his/her estimate and initials while the other diver is looking at the sample. The second diver also records her/his estimate and initials.

When both divers have recorded their estimates, one diver carefully tears the kelp with spawn out of the quadrat and places it in a numbered mesh sample bag held open by the other diver. The divers should attempt to remove all of the egg covered kelp within the quadrat. More than one bag may be needed. If necessary, a knife can be used.

The sample bag numbers must be recorded beside the divers' estimates. The bags can be hung from the divers' wrists or on a belt clip.

If the sample is taken from a station along a transect, the number of eggs left in the quadrant after egg removal should be recorded on the data sheet to insure that the total egg number is recorded. The sample estimate and the "eggs left" estimate are added for the total (see Appendix 1).

Sample preservation

At camp, each calibration sample should be emptied into a nalgene zip-lock bag. Sample data tags must be filled-out and cut from the "Never-Tear Paper" Xerox sheets. The same information must also be printed on the nalgene bags. Refer to Appendix 6 for a sample of the tags and necessary data.

Gilson's solution is carefully poured from 5 gallon jerry jugs into the bags and should just cover the kelp samples. Refer to the SOPs in the appendix for precautions when handling Gilson's solution.

The bags with samples are zipped closed and placed without crushing in a numbered kelp bucket for storage and shipment.

After a week, the Gilson's can be decanted from the samples and reused at least 3 times as long as the solution is not excessively cloudy or contaminated with sediment. When no longer useable, the solution should be poured into a 5 gallon jerry jug labeled "Used Gilson's solution" and shipped to the office for correct disposal.

Before shipment, samples should be carefully drained of excess Gilson's and laid carefully in a kelp bucket with a lid.

For further details on collection, preservation, shipment, and processing of calibration samples, refer to pages 13 - 23 in the PWS Herring Laboratory Operational Manual.

RULES FOR RUNNING TRANSECTS

1) The objective of the transects is to randomly sample -without duplicating or overlapping sampled areas- the total miles of shoreline where herring eggs have been deposited (Figure 5).

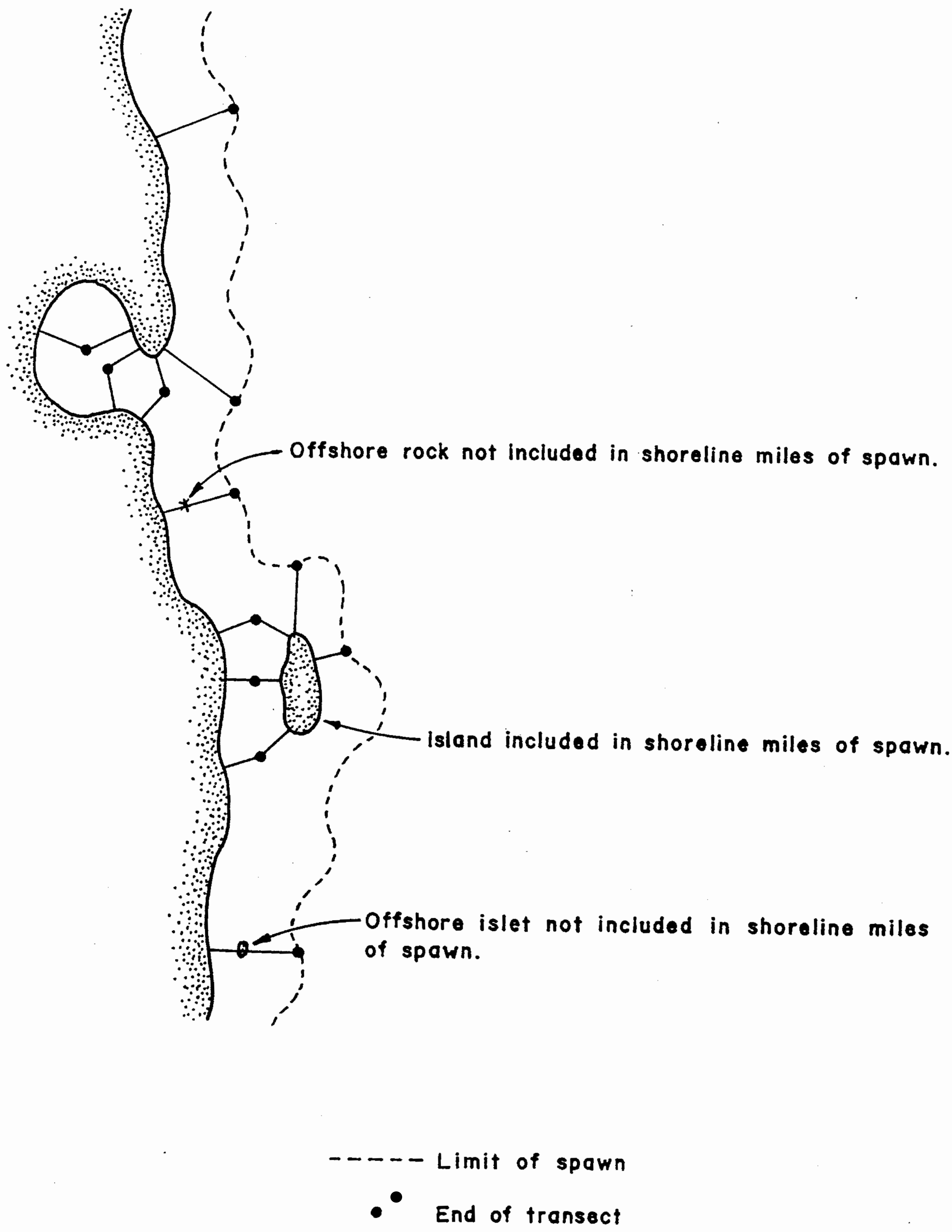
2) Transects are run perpendicular to the shoreline.

3) Run transects to the end of spawn or only to the point of intersection with another transect whichever occurs first. The tender should signal divers when they reach an intersection point (Figure 5).

4) Transects begin only from shorelines included in the total shoreline miles of spawn. An exposed rock or small islet not included in the total shoreline miles would be surveyed with a transect beginning from the adjacent shoreline.

Figure 5.

TYPICAL TRANSECT SITUATIONS



DUTY CHECKLIST

Before field surveys

General responsibilities

Team members should divide responsibilities for the following:

1) Filling tanks

2) Calibrating thermometers. This can be done by immersing the thermometers in a glass of water filled with ice for 5 minutes. The thermometers should read 32 $^{\circ}$F or 0 $^{\circ}$C. Any differences should be recorded on a piece of tape placed on the instruments.

3) Determining the transect locations and numbers and tracing these on the field map.

4) Collecting the necessary paperwork for the dive surveys.

Tender's responsibilities

The tender's job is to ensure that the divers are able to complete their tasks as efficiently and comfortably as possible. The tender should:

1) Make sure that the dive skiff is fueled-up.

2) Check the oil.

3) Warm up the motor.

4) Make sure that emergency and routine gear are in the boat and functional.

Skiff equipment list

1) Radio

2) Depth finder

3) Repair kit

4) Spare prop

5) Flares

6) First Aid kit

7) Anchor

8) Marker buoys

9) Lines

10) Tank suspension lines with caribiners

11) Spare oil

5) Prepare insulated containers of hot water to warm gloves, hoods, and hands.

6) Pack snacks and hot drinks.

7) Collect the paperwork and materials for the field surveys:

1) Data collection sheets (see Appendix 1).

2) Tender logs (see Appendix 4).

3) Dive tables (see Appendix 5).

4) Emergency SOPs (see Appendix 7).

5) Traced maps with transects.

6) Pencils

7) Clipboards

8) 0.1 m^2 quadrats

Divers' responsibilities

Divers are responsible for the direction and execution of the spawn deposition surveys and the safe condition of their dive gear.

Diver equipment list

1) Enough full tanks for the projected work (at least 2)
2) Regulator and console
3) Dry suit
4) Hood
5) Gloves
6) Mask
7) Fins
8) Knife
9) Back pack
10) Weight belt
11) Dive computer
12) Ankle weights
13) Sample bags

All diving equipment provided by ADF&G must be checked out by the person in charge of the gear storage bin.

Divers should keep track of and routinely maintain their personal equipment and gear assigned to them by the department. Any malfunctions should be reported to the team member in charge of repairing dive equipment.

Tender's responsibilities

1) Driving the dive skiff.

2) Helping the divers locate transect sites and assisting in skiff surveys of mapped areas of spawn.

3) Helping divers don and doff their gear.

4) Assisting divers when they enter and exit the water.

5) Taking depth readings on the fathometer when needed.

6) Keeping track of divers' location by watching their bubbles.

7) Taking and recording water temperatures.

8) Recording dive times of the divers on the tender log. In the event of a dive emergency requiring recompression, an accurate tender log will be essential for reconstructing the divers' dive profiles. The profiles will be used by the doctor and decompression chamber operator when treating the injured diver (see Appendix 4 for sample log).

9) Keeping track of the divers' dive groups and notifying divers if they are approaching decompression limits.

10) Signaling divers by revving the skiff motor. This could be to notify divers that they have reached the end of a transect, that they are nearing their decompression limits, or to alert them to the presence of sea lions.

Divers

The two divers will divide the tasks involved in conducting the deposition survey. One diver will orient the transect, pace, place the quadrat, and estimate the number of herring eggs within the quadrat.

The second diver will record the first diver's estimates as well as the data pertaining to substrate and vegetation types, depths, percent coverage, and calibration sample information.

After field surveys

Tender

1) Help divers remove dive equipment and other gear from skiff.

2) Make sure data sheets, logs and other paperwork is in order and dried.

3) Complete tender log.

4) Fill fuel tanks and top off oil.

5) Insure that the skiff is securely tied.

Divers

1) Stow their dive gear.

2) Record samples on kelp type and spawn density tally sheet.

3) Check data sheets for accuracy and legibility.

4) Complete diver logs (see appendix).

5) Label, preserve, and store samples.

General responsibilities

1) Fill tanks.

2) Perform any required equipment maintenance.

3) Count and list on the data sheets the total number of hits and total estimated eggs.

4) Determine and list latitude and longitude of each transect.

DIVE SAFETY AND ACCIDENT MANAGEMENT

Compressor safety

All divers should be checked-out on the safe operation and required maintenance of the dive compressor that they will use. Improper procedures when filling tanks could cause serious injuries to the compressor operator. A failure to perform routine maintenance could result in damage to the compressor and consequent expensive down-time for the spawn deposition project.

Compressor use checklist

1) Compressor operators should read the compressor instruction manual.

2) When reaching over the compressor to bleed moisture, extreme caution must be exercised to prevent hair or loose clothing from becoming entangled in the pulleys and belts.

3) Ear plugs or muffs should be worn while filling tanks.

4) The compressor oil level should be checked each time before filling tanks.

5) The compressor log must be filled out after each tank filling. This will insure that periodic maintenance is performed on schedule.

6) The air pressure should be bled off when the compressor is shut down after filling tanks.

7) If a tank is accidentally overfilled, it should be prominently labeled and set apart from the rest of the tanks. The tank should not be used until it is reinspected.

Sea lion interaction protocols

Though spawn deposition divers have not been injured by sea lions, these animals are potentially dangerous because of their size and speed. Divers should exercise caution when these marine mammals are around.

Spawn deposition survey dives should not be conducted until the water is free of milt and the spawning herring have left. Diving is usually possible within four to five days after the end of spawning.

If sea lions appear, divers should not panic but be alert to the animals' movements and behavior. They are generally curious and leave after a short time. If any sea lion seems to be acting aggressively or approaches too closely, the divers should surface and end the dive. The tender should mark the end of the interrupted transect with a marker buoy so that the dive can be completed later.

Dive accident protocols

The Department has established procedures for managing diving emergencies. In the event of a dive accident, use the **Dive Emergency Protocols, Prince William Sound**, the **Diving Accident Management Flow Chart**, and the **Underwater Accident Report Form** (Appedices 7, 9 and 10). Copies of these are included in the appendix, should be posted prominently in the dive shack, and should be carried on the dive skiff.

KELP IDENTIFICATION GUIDE AND CODING

Accurate identification of kelp types is important for several reasons. A diver's ability to identify the four broad categories of kelp used in the project (eelgrass, fucus, large brown kelp, hair kelp) is important because tendencies in diver estimates of egg quantities vary by kelp category. These categories provide one of the parameters by which diver estimates are calibrated and adjusted.

Kelp species identification along transects adds to the data base which may be used for future mapping of kelp habitat and distribution.

By comparing the density of herring egg deposition on the various kelp species, differences in the attractiveness of the species to spawning herring may be found. When quantified, these differences may be significant for management decisions in roe fisheries where the kelp substrate is impacted such as the wild kelp harvest.

Appendix 1. Sample Data Sheet

Fill in all required heading information: transect #, location , date, lead estimator and other divers, time in (beginning of dive time), time out (end of dive time), water temperature, comments. Keep accurate, legible, and complete notes.

Upland portion of transect #50 began 15 meters inland from the upland limit of spawn. Estimated elevations varied from +5 to +3 feet above waterlevel. Vegetation was fucus (FUC). Substrate was rock (RK).

Beginning at no. 3, each number represents a 5 m. paced interval between quadrat tosses. O.3K (300) eggs were estimated within the quadrat.

List the vegetation types in order from the type with the most egg coverage to the type with the least. FUC (fucus) had a greater egg density than HR (hair kelp).

The underwater portion of the transect began here. Depths are in feet.

2K of loose eggs (LE) fell within the quadrat.

Percentage of vegetation coverage (% COVR) is an estimate of the % of the quadrat covered by vegetation. This estimate will be useful later in studies to determine if vegetation coverage correlates with herring egg deposition density.

Substrate codes are SND (sand), MUD, GRV (gravel), RK (rock), COB (cobble), BOL (boulder). List substrate types in order of predominance.

Egg estimates are in thousands (K). If no eggs are found on vegetation, write 0 in the Quadrat column.

The transect ended at no. 39. The divers swam another 15 m. over rock (RK), sand (SD), and old elephant ear kelp (EE) to a final depth of 22'. No spawn was sighted.

Vegetation data may be used to produce a kelp habitat distribu map. Because of uncertainty regarding the genus, DES (Desmare was changed in the office to the more general category red hair l (RH). If in doubt about identification, use the four broad gro FUC (Fucus), EEL (Eel grass), LBK (Large brown kelp), HRK (l kelp).

TRANSECT #: 50 LEAD DIVER: BB OTHER DIVERS: KB

TION: N of Stockdale TIME IN: 1324

DATE: 5/6/91 OUT: 1403 TEMP: 42°F at-

H₂O

COMMENTS: OVC and raining - again

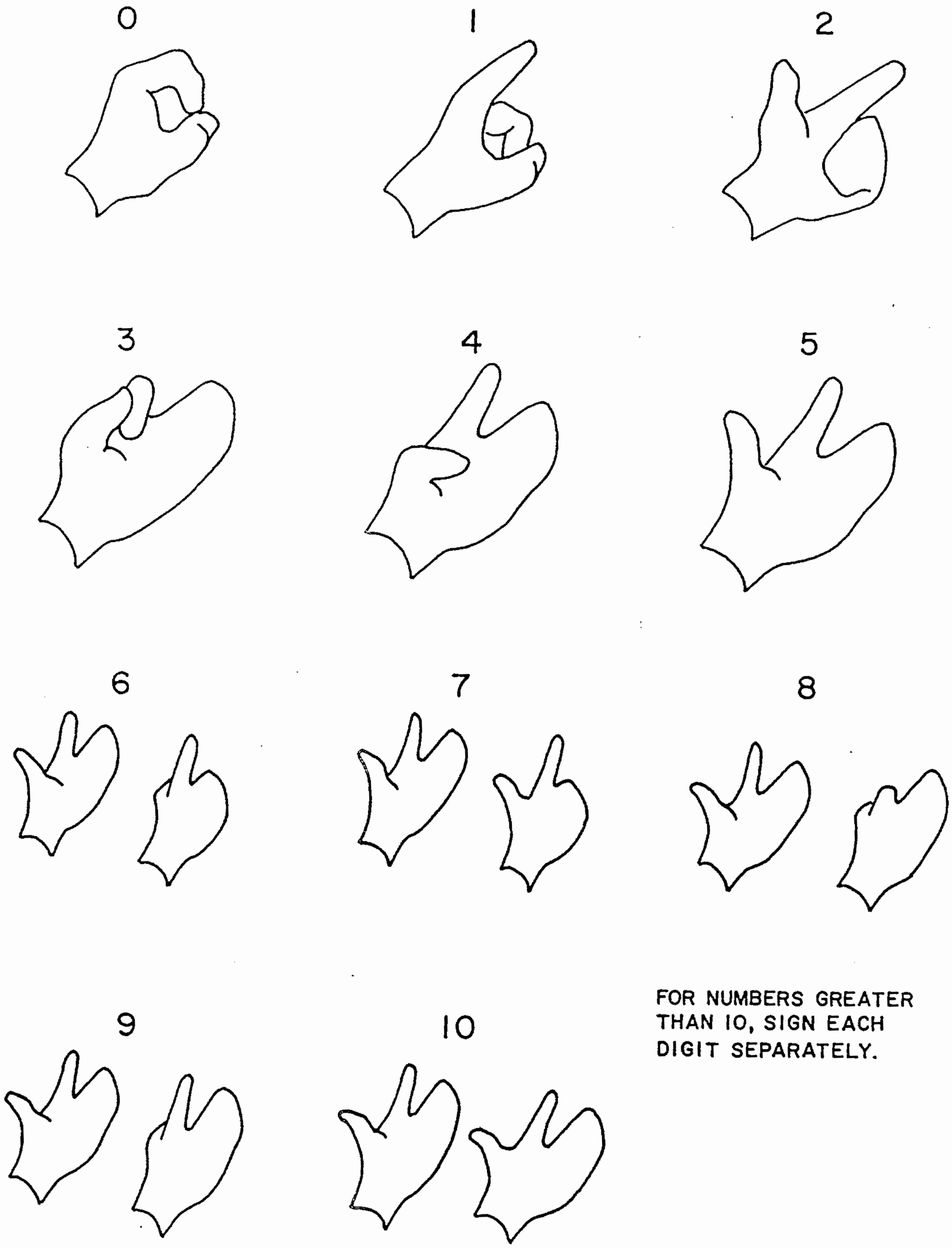
NO	FT DEPTH	VEGETATION	% COVR	SUBS TRAT	K EGGS QUADRAT	EGGS LEFT	BAG #	NO	DEPTH	VEGETATION	% COVR	SUBS TRAT	EGGS QUADRAT	EGGS LEFT	BAG #
1		15 m over		RK	w. sparse	FUC		26	7	COS, EE	50	RK	4		
2		from +5'		to +3'	No spawn			27	8	RK EE	60	"	22		
3	+3	FUC		RK	0.3			28	9	"	30	"	5		
4	+2	FUC, HR		"	4			29	10	EE	70	"	66		
5	+2	——		"	Ø			30	11	RH EE, COS	40	"	60	100	LE
6	+1	FUC	35	"	42			31	12	EE	100	"	8	160	"
7	+1	HR	50	"	5.2			32	13	"	"	"	50	2	"
8	+2	FUC	25	"	32			33	14	AG, EE	25	"	62		
9	0	HR	25	"	34.	2	LE	34	14	EE	100	"	6		
	1	FUC	10	"	7	2	"	35	15	COS	90	"	7		
11	1	HR, UL	80	"	140			36	16	AG, EE	25	"	5		
12	2	——		"	Ø	0.1	"	37	17	HR, EE	30	"	6		
13	2	HR	50	"	50			38	17	EE	100	"	Ø		
14	3	EG	100	"	320			39	18	"	"	"	Ø		
15	1	RK	60	"	60			40		15 m over	RK SD	to	22'		
16	2	HR	30	"	Ø	1	"	41		OLD EE			Ø		
17	2	UL	30	"	Ø	1	"	42							
18	3	"	10	"	Ø	0.2	"	43		HITS:		35			
19	3	UL, RL	70	"	6			44		CUM:		1,633.8			
20	4	RL	85	"	35			45							
21	4	HR, UL, AG	75	"	70			46							
22	5	UL, RL, COS	65	"	30	5	"	47							
23	6	RL, COS	70	"	7	5	"	48							
	6	UL, RL	60	"	137		"	49							
25	7	HR, EE	90	"	60	6	"	50							

Total number of quadrat tosses within the area with spawn.

Total of estimated quantities of eggs.

These totals are counted in the office.

Appendix 2. Diving hand signals



Appendix 3. CHEMICAL SOLUTIONS SAFETY INFORMATION

The processing of herring samples in the lab and in the field requires the use of various Chemical Solutions. These Solutions contain Chemicals that are considered hazardous materials and have specific hazardous warnings associated with them. Solutions that are utilized during the course of the Herring Spawn Deposition, field season include the following:

1) **Gilson's Solution**

2) **5% & 10% Formalin Buffered with Sodium Phosphate, Borate and/or Sea Water**

3) **Potassium Hydroxide (KOH)**

4) **1.0 Normal Buffered Saline Solution**

The most dangerous exposure to these chemicals occurs during recipe mixing. Precautionary measures should be taken at all times, but most of all during mixing to prevent skin contact and/or injury. Avoid inhalation of concentrated chemicals, mix in well ventilated area.

Precautionary Measures:

Protective Clothing...: Wear elbow length neoprene gloves, lab apron and eye protection.

Ventilation...: Where inadequate ventilation is present wear a cartridge respirator with an acid/organic filter. Whenever possible mix chemical recipes outside for minimal inhalation exposure.

Skin Contact...: Avoid contact with skin and clothing. If skin contact occurs immediately flush skin with soap and water.

GILSON'S SOLUTION

Gilson's Solution is a mixture of Formalin, Glacial Acetic Acid, Nitric Acid, Denatured Alcohol and water. *(Anhydrous Alcohol can be used in place if Denatured Alcohol, but is not recommended as it is classified as a severely Toxic Chemical. See Hazardous Material Data Sheet for Health Risk.)* Gilson's Solution is used in the field as a preservative for storing Herring Spawn Calibrations until processing. In the laboratory Gilson's acts as a preservative/decomposing agent for Herring Fecundities.

HEALTH HAZARDS

Hazardous warning labels and first aid procedures for each concentrated chemical are defined in Appendix IV. Hazardous warnings for each solution utilized are listed below.

Appendix 3. Page two of four.

Formalin:
When mixed Gilson's contains **2.13%** formalin or **.8%** formaldehyde. Formalin at 37% concentrate is 18 times greater than found in Gilson's and carries a "Severe" health rating. Formaldehyde is a proven carcinogenic and is absorbed through the skin. Avoid breathing vapors always wear protective clothing. Prudent Laboratory measures should be used at all times regardless of Solutions concentration.

Glacial Acetic Acid:
Gilson's contains Glacial Acetic Acid at approximately **1.9%** concentration. The Health rating for 90-100% Glacial Acetic Acid is listed as "Moderate". The concentrated state of Acetic Acid is 50 times greater than that found in Gilson's. Avoid skin contact may cause irritation and/or burns, is harmful if swallowed or inhaled, do not get in eyes. Glacial Acetic Acid is not a carcinogenic and is not absorbed through the skin. Use prudent laboratory procedures.

Nitric Acid:
The approximate concentration level of Nitric Acid in Gilson's is **1.6%**. The concentrated state of 70% Nitric Acid is 62 times greater than found in Gilson's Solution and carries a "Severe" health rating. Avoid contact with skin and eyes can cause severe irritation and/or burns, do not breathe vapors, use in well ventilated are. Always use Prudent Laboratory Procedures. Nitric Acid is a strong oxidizer and reacts with most metals to produce **Hydrogen Gas,** which can form an explosive mixture with air. Mix agent slowly with water as it will produce extreme heat when diluted with water.

Denatured Alcohol:
The concentration level of Denatured Alcohol in Gilson's is **6.7%.** At full concentration Denatured Alcohol is 95% and is similar to that of Grain Alcohol. Dilute alcohol poses minimal health risk. Concentrated levels however can cause skin irritation and if inhaled can irritate the mucous membrane. Wear gloves and work in a well ventilated area.

First Aid:
Upon skin contact flush exposed area with soap and water. Upon contact with eyes flush for at least 15 minutes seek medical advice. If solution is ingested **DO NOT INDUCE VOMITING,** dilute by giving water, milk or milk of magnesia and transport individual to medical facility immediately.

Disposal Methods For Gilson's:
Since formalin is listed as a hazardous waste Gilson's can only be disposed of through the City Sewer System in 1/2 gallon increments after being neutralize as defined by ADEC.

10% BUFFERED FORMALIN

Buffered formalin is a mixture of Borate, Sea Water and Formalin. Buffered Formalin is used to preserve tissue samples. Avoid breathing vapors and keep sample jars closed when not in use.

HEALTH HAZARDS

Always mix chemical solutions in a well ventilated area and avoid skin contact. Formalin is listed as a carcinogenic and in any concentration should be treated as such. Wear protective clothing and gloves and use prudent laboratory procedures.

Formalin:
10% Buffered Formalin contains less than **1.0%** hazardous components. One ml of this solutions contains 37mg of formaldehyde. Avoid skin contact always wear protective gloves.

First Aid:
If solution is ingested **DO NOT INDUCE VOMITING,** dilute or inactivate by giving milk, activated charcoal, or water. Seek medical attention immediately. If skin contact occurs wash area with soap and water.

POTASSIUM HYDROXIDE (KOH)

KOH is a mixture of Potassium Hydroxide Flakes and water. KOH is used in the lab as a decomposing agent. KOH when exposed to the skin has a soap like consistency however prolonged exposure causes irritation and cracking, wearing gloves is recommended.

HEALTH HAZARDS

Always mix KOH in a well ventilated area. Avoid breathing dust, add water to container prior to adding agent. Avoid skin contact as agent becomes hot when mix with water and may burn exposed areas.

KOH
In full concentration KOH is not identified as a carcinogenic nor is it absorbed through the skin. If inhaled however it can cause severe burns to the upper respiratory system and mucous membranes. The concentration level of Potassium Hydroxide found in a five gallon mixture of KOH is **6.8%.**

First Aid:
If substance is ingested **DO NOT INDUCE VOMITING,** give water, fruit juices, diluted vinegar or egg whites beaten with water. Seek medical attention immediately.

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1.0 NORMAL BUFFERED SALINE SOLUTION

Saline Solution is a combination of Salt, Baking Soda, Water and a dash of Formalin. Calibration eggs are soaked in Saline Solution to insure standardized volumetric displacement.

HEALTH HAZARDS

Always mix chemical solutions in a well ventilated area and wear protective clothing.

Formalin:

Buffered Saline Solution contains **2.5%** Formalin per five gallon mixture. Hazardous warnings for 37% formalin are outlined in (Appendix VII). The low concentration of formalin found Buffered Saline Solution poses little health risk however regular laboratory procedures apply.

First Aid:

If solution is ingested **DO NOT INDUCE VOMITING,** give milk, activated charcoal or water. Seek medial attention immediately.

Appendix 4. Sample tender log.

STATE OF ALASKA
TENDER LOG

TENDER'S NAME: B Haley

DATE: 5/6/91

LOCATION: N. of Stockdale

	TRANSECT# DIVE#	DIVERS	DOWN TIME START/STOP	TOTAL TIME DOWN	MAX DEPTH	GROUP LTR	SURFACE TIME HOUR/MIN
1	53	BB / KB	1015 / 1103	48	15	C	
2	52	KB / BB	1153 / 1227	34	25	D	50
3	50	BB / KB	1324 / 1403	39	22	E	57
4	Sample	KB / BB/BH	1815 / 1918	63	10	B	
5		/	/				
6		/	/				
7		/	/				
8		/	/				
9		/	/				
10		/	/				
11		/	/				
12		/	/				

Appendix 5. Dive Tables.

U.S. NAVY DIVE TABLES

PAGE 1: NO–DECOMPRESSION LIMITS AND REPETITIVE GROUP DESIGNATION TABLE FOR NO–DECOMPRESSION AIR DIVES

Depth (FEET)	No–decom–pression limits (MIN.)	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											

Appendix 5. Page two of two.

RESIDUAL NITROGEN TIMETABLE FOR REPETITIVE AIR DIVES

REPETITIVE GROUP AT THE BEGINNING OF THE SURFACE INTERVAL →→→
↓↓↓

Repetitive group at beginning →→→→→	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
A																10
																1200
B															10	211
															210	1200
C														10	140	250
														139	249	1200
D													10	110	239	549
													109	238	548	1200
E												10	55	158	323	633
												54	157	322	632	1200
F											10	46	130	229	358	706
											45	129	228	357	705	1200
G										10	41	116	200	259	426	736
										40	115	159	258	425	735	1200
H									10	37	107	142	224	321	450	800
									36	106	141	223	320	449	759	1200
I								10	34	100	130	203	245	344	513	822
								33	59	129	202	244	343	512	821	1200
J							10	32	55	120	148	221	305	403	541	841
							31	54	119	147	220	304	402	540	840	1200
K						10	29	50	112	136	204	239	322	420	549	859
						28	49	111	135	203	238	321	419	548	858	1200
L					10	27	46	105	126	150	220	254	337	436	603	913
					26	45	104	125	149	219	253	336	435	602	912	1200
M				10	26	43	100	119	140	206	235	309	353	450	619	929
				25	42	59	118	139	205	234	308	352	449	618	928	1200
N			10	25	40	55	112	131	154	219	248	323	405	504	633	944
			24	39	54	111	130	153	218	247	322	404	503	632	943	1200
O		10	24	37	52	108	125	144	205	230	300	334	418	517	645	955
		23	36	51	107	124	143	204	229	259	333	417	516	644	954	1200
	10	23	35	49	103	119	137	156	218	243	311	346	430	528	657	1006
	22	34	48	102	118	136	155	217	242	310	345	429	527	656	1005	1200
New group at end of interval →→→→→	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A

REPETITIVE DIVE DEPTH	Z	O	N	M	L	K	J	I	H	G	F	E	D	C	B	A
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	8	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

Appendix 6. Calibration sample labels.

Date: 5/6/91 Location: STOCKDALE	Date: Location:	Date: Location:
Bucket# 3 Bag# 18	Bucket# Bag#	Bucket# Bag#
Transect# 53	Transect#	Transect#
Depth: 22'	Depth:	Depth:
Diver #1 Est. KB 26K	Diver #1 Est.	Diver #1 Est.
Diver #2 Est. BH 30K	Diver #2 Est.	Diver #2 Est.
Substrate: LBK	Substrate:	Substrate:

Use a "Sharpie" extra-fine pen.

Calibration sample labels are placed in Nalgene Zip-lock bags with preserved kelp samples. The same information must be written on the front of the Zip-lock bags.

"Bag # 18" is the number of the mesh sample collection bag.

"Bucket # 3" is the number of one of the kelp buckets where samples are stored for decanting and shipment.

"KB" and "BH" are the initials of the divers whose egg quantity estimates were 26K and 30K respectively.

"LBK" is the group designation for large brown kelp.

Appendix 7. DIVE EMERGENCY PROTOCOLS, PRINCE WILLIAM SOUND

There are three chambers available in Anchorage at Martech International and one chamber in Valdez which is currently inoperable. If chamber use is needed, call:

Providence Hospital, 562-2211 or 261-3111 for emergencies only
or:

Humana Hospital, 258-EVAC for emergencies only.

For advice on dive accidents call DAN (Diver Accident Network) at:
(919) 684-8111. Use Evelyn Biggs' ID number: 000131562. A doctor is on the line 24 hours a day.

Procedures for dive accidents and transport from the field

1) STAY CALM.

2) Treat accident victim with an emphasis on oxygen delivery at 100% and fill out accident report form.

3) Call the U.S. Coast Guard on channel 16 VHF for transport or the Cordova Fish and Game office on 3230 or 2509 SSB to relay the need for a medivac plane from Cordova Air or Chitina Air. Have the air service call the Cordova Volunteer Fire Department to standby on 2509 SSB or 16 VHF to receive the accident report. They may be able to contact the chamber in Anchorage more easily and can reach Providence Hospital in Anchorage in case the medivac jet is needed. CVFD may also send an EMT with the medivac airplane.

4) Give as much clear information as possible including:

   a) What happened. Be thorough!

   b) Depth of dive

   c) Condition of patient out of water

   d) When symptoms occurred after dive

   e) Where you are located (exact location and make sure the answering party understands the location)

Appendix 7. Page two of two.

f) When the accident occurred (exact time)

g) How the accident occurred

h) What the diver's group letter was on the dive tables

Let the answering party know what you are doing to treat the victim and provide a medical history on the victim including:

a) Age

b) Sex

c) Past medical history

d) Medications the victim may have been taking

e) When the victim last ate

f) Sequence or trend of vitals if taken. Try to include:

1) Blood Pressure

2) Heart rate

3) Respirations

Do not get off the radio until you are clear that they are clear.

5) Send the tank, regulator, and dive buddy with the diver.

6) Send the dive accident report with the victim, but ensure that the buddy gets a copy for our records.

7) Stay with the victim until the medivac transport arrives. Go with the victim to provide details of the accident to the medical staff if the buddy is unavailable or may also have potential injuries.

8) Report the accident to the State Dive Board as soon as is practical.

Appendix 8. Sample dive log.

STATE OF ALASKA SCUBA DIVING LOG

DIVER NAME: KARL BECKER

DATE 5/6/91 DIVE NUMBER(S) 30-33

RECORDER/TENDER BETH HALEY TEAMLEADER BILL BECHTOL/KARL BECKER

PURPOSE OF DIVE: HERRING SPAWN DEPOSITION SURVEY

LOCATION/TRANSECT NUMBER(S): MONTAGUE IS. - N. OF STOCKDALE. T-53,52,50 & SAMPLE COLLECTION IN STOCKDALE HBR.

AIR TEMP ~45°F WATER TEMP: top ~40°F bottom

MAX. DEPTH (all dives) 25 COMMENTS: (substrate, visibility, species observed, other)

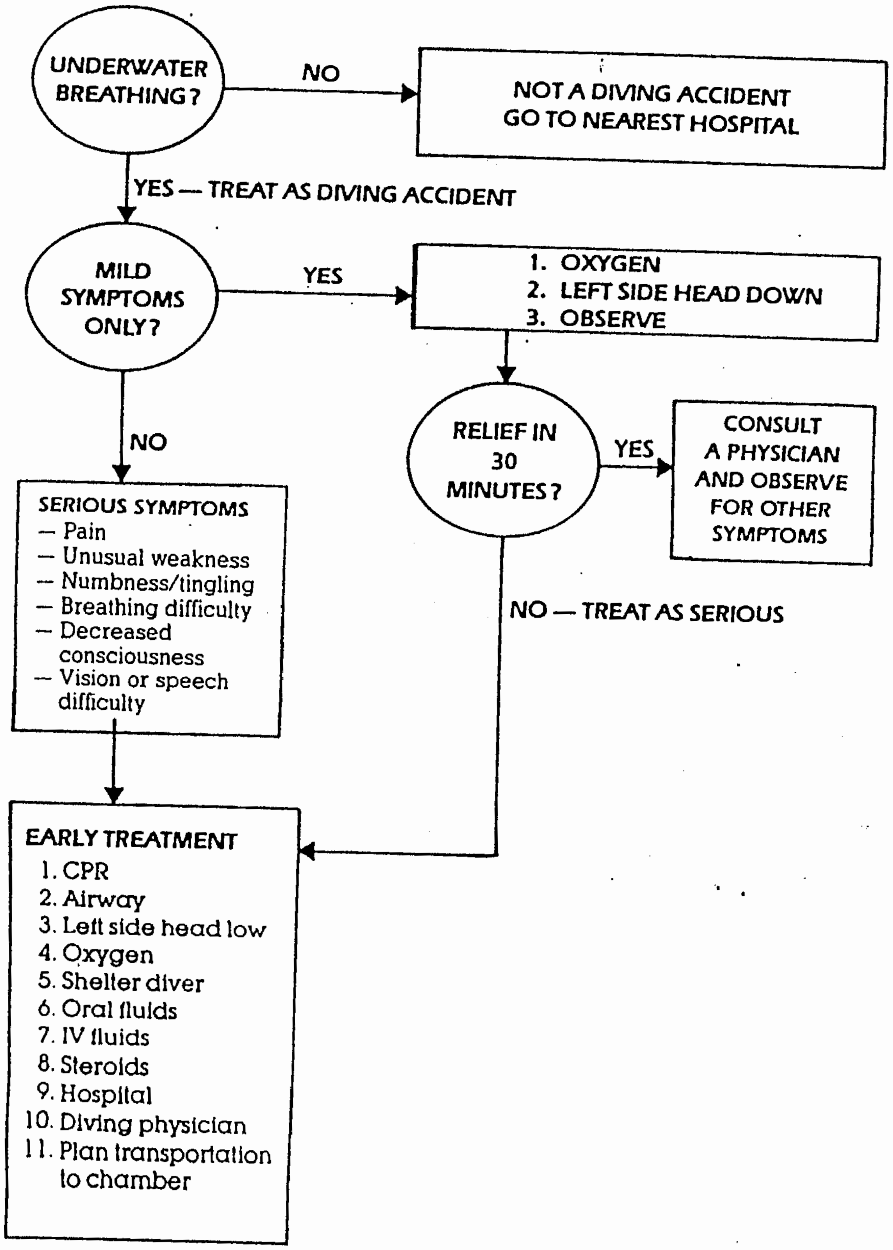
DIVE NO.	TIME: start	stop	MAX DEPTH	DIVERS	TOTAL TIME
1)	1015	1103	15	BB/KB	0:48
2)	1153	1227	25	KB/BB	0:34
3)	1324	1403	22	BB/KB	0:39
4)	1815	1918	10	KB/BB/BH	0:63
5)					
6)					
7)					
8)					

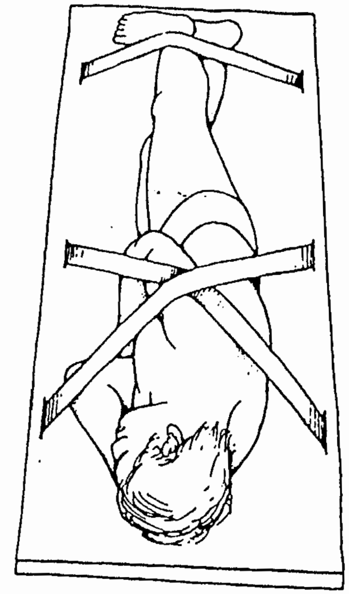
TOTAL DIVE TIME TODAY 3:04

FORWARD DIVE HOURS TO DATE 52:59

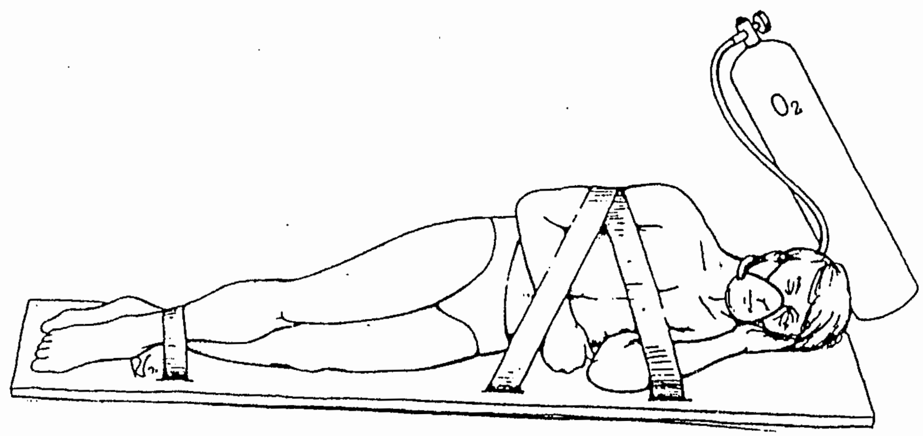
TOTAL DIVE HOURS 56:03

Appendix 9. Diving accident management flow chart.





LEFT-SIDE-HEAD-LOW DIVING ACCIDENT POSITION FOR BREATHING VICTIMS



MUST BE FLAT FOR CPR

Appendix 10. Underwater accident report form.

UNDERWATER ACCIDENT REPORT

FORWARD REPORT WITH PATIENT

VICTIM INFORMATION

Name of Victim ______________________ Sex _____ Age ____ Ht. _____ Wt. _____

Social Security No. ______________________ Known allergies, meds, or med. problems?

Occupation ______________________ ______________________

Address ______________________ ______________________

______________________ State __________ Marital Status __________

DESCRIPTION OF DIVES AND ACTIVITIES

Description of all dives within previous 12 hours including the accident dive

Max. Depth	Time Down	Surface Interval

Type of Diving (explain if necessary):

SCUBA _____ Hookah _______ Other? _______

Others in accident? (yes or no) __________

Separate report filed? (yes or no) __________

At the time of the incident,

Activities engaged in:		Buddy record:
Recreational	________	Diving solo
Comm./Res.	________	________
Under instruction	________	Buddy diving
Instructing	________	________
Cave/Ice Diving	________	Buddy distance
Spear Fishing	________	________
Photography	________	Two or more diving
Night Diving	________	________

Vessels Involved? (yes or no) __________

US Coast Guard called? (yes or no) __________

(Give details of name of captain, vessel, phone, etc. below)

WITNESSES

Next of Kin	Address	Phone	Relationship

WITNESS: Name ______________________ ON SITE PHYSICIAN/PARAMED.: Name __________

Address ______________________ Address ______________________

DETAILED DESCRIPTION OF ACCIDENT

DETAILED DESCRIPTION OF ACCIDENT AND TREATMENT

Describe how, what, where, and when; describe scene and events leading to accident; include first aid and resuscitation efforts administered; list any decompression or recompression treatment administered; list timed sequence of vitals taken if possible.