Oregon Fish and Wildlife Commission

Date: October 22, 1999

EXHIBIT B

SUBJECT	Developmental Fisheries Program
PRINCIPAL STAFF PERSON	Jim Golden and Jean McCrae **PHONE:** 541-867-4741
COMMISSION ACTION REQUESTED	The Commission will review the Developmental Fishery Program for 1999 and consider regulation changes in the harvest program for some fish species as recommended by the Developmental Fishery Board.
DOCUMENTS INCLUDED	1. Agenda Item Summary 2. Hearing Notice and Fiscal Impact Statement 3. Executive Summary 4. Staff Report 5. Draft Administrative Rules 6. Written Comments
RELATED STATUTES	ORS 506.109, 506.119, 506.129, and 506.450 through 506.465
RELATED RULES	OAR Chapter 635, Division 006

Read and Approved by:

Division Chief Redacted for Privacy **Date** 9/22/99

Attorney General Redacted for Privacy **Date** 9/30/99

Director Redacted for Privacy **Date** 10-5-99

Agenda Item Summary

BACKGROUND

This item is a review of the Developmental Fishery Program for 1999 that summarizes permits and landing activities; and research and management activities of the program. Also included are proposed rule changes in the harvest program for some developmental fishery species.

PUBLIC INVOLVEMENT

The Developmental Fishery Board held their regular meeting on June 10, 1999. A subsequent conference call of the Board was held on September 3, 1999. These meetings were "public meetings" and subject to the Oregon Public Meetings Law.

ISSUE 1 **Definitions in the Developmental Fisheries Species List**

ANALYSIS

The Developmental Fishery Board considered and, subsequently recommended, adjustments to the definition of species listed in Category A of the Developmental Fisheries Species List and addition of a definition for "actively managed."

OPTIONS and STAFF RECOMMENDATION

See Outline of Staff Report attached.

ISSUE 2 **Permit for brine shrimp cysts.**

ANALYSIS

The Developmental Fishery Board recommends removing the permit to harvest brine shrimp cysts.

OPTIONS and STAFF RECOMMENDATION

See Outline of Staff Report attached.

ISSUE 3	**Permit for spot prawns.**
ANALYSIS	The Developmental Fishery Board recommends that renewal requirements for spot prawns include an alternative of one landing of 1,000 pounds.
OPTIONS and STAFF RECOMMENDATION	See Outline of Staff Report attached.

ISSUE 4	**Listing of flat abalone.**
ANALYSIS	The Developmental Fishery Board recommends that flat abalone be listed in Category A and that a harvest program be added for that species.
OPTIONS and STAFF RECOMMENDATION	See Outline of Staff Report attached.

ISSUE 5	**Preference Point System.**
ANALYSIS	The Developmental Fishery Board is recommending that persons who put together proposals for adding new species to the developmental species list should be given priority for one of the permits.
OPTIONS and STAFF RECOMMENDATION	See Outline of Staff Report attached.

DRAFT MOTION	I move to adopt changes to OAR Division 006 to amend the harvest program for some developmental fishery species; to adjust harvest programs for brine shrimp and spot prawns; and to amend the preference point system as proposed by staff (with the following changes.....).
EFFECTIVE DATE	December 1, 1999

Secretary of State

NOTICE OF PROPOSED RULEMAKING HEARING*

A Statement of Need and Fiscal Impact accompanies this form.

Oregon Department of Fish and Wildlife (ODFW) - Fish Division	635
Agency and Division	Administrative Rules Chapter Number
Jennell Hoehne	(503) 872-5272, Ext. 5447
Rules Coordinator	Telephone
2501 SW First Avenue; P. O. Box 59; Portland, OR 97207	
Address	

Hearing Date	Time	Location	Hearings Officer
10-22-99	8:00 AM	The Seafood School, Duncan Law Seafood Consumer Center 2021 Marine Drive, Astoria, Oregon 97103	

Are auxiliary aids for persons with disabilities available upon advance request? Yes X No

RULEMAKING ACTION

ADOPT:
Secure approval of rule numbers with the Administrative Rules Unit prior to filing.

AMEND: OAR Chapter 635, Division 006

REPEAL:

Renumber: Secure approval of rule numbers with the Administrative Rules Unit prior to filing.

Amend and Renumber: Secure approval of rule numbers with the Administrative Rules Unit prior to filing.

506.109 and 506.119
Stat. Auth.: ORS

Other Authority

506.129, and 506.450 through 506.465
Stats. Implemented: ORS

RULE SUMMARY

Amendment of rules relating to the harvest program for some developmental fishery species.

10-22-99
Last Day for Public Comment

Redacted for Privacy
Authorized Signer and Date

9-15-99

*The *Oregon Bulletin* is published on the 1st of each month and updates the rule text found in the Oregon Administrative Rules Compilation. Notice forms must be submitted to the Administrative Rules Unit, Oregon State Archives, 800 Summer Street NE, Salem, Oregon 97310 by 5:00 pm on the 15th day of the preceding month unless this deadline falls on a Saturday, Sunday or legal holiday when Notice forms are accepted until 5:00 pm on the preceding workday.

Secretary of State

STATEMENT OF NEED AND FISCAL IMPACT

A Notice of Proposed Rulemaking Hearing or a Notice of Proposed Rulemaking accompanies this form.

Oregon Department of Fish and Wildlife - Fish Division — 635

Agency and Division — Administrative Rules Chapter Number

In the Matter of amendment of	)	Statutory Authority,
OAR Chapter 635, Division 006	)	Statutes Implemented,
relating to Developmental Fisheries	)	Statement of Need,
Program	)	Principal Documents Relied Upon,
	)	Statement of Fiscal Impact

Statutory Authority: ORS 506.109 and 506.119

Other Authority:

Statutes Implemented: ORS 506.129 and 506.450 through 506.465

Need for the Rule(s):

The rules are needed to adopt regulation changes in the harvest program for some developmental fishery species recommended by the Developmental Fishery Board.

Documents Relied Upon:

a. Staff Report for Oregon Fish and Wildlife Commission Meeting of October 22, 1999.

The above documents are available for public inspection in the Department of Fish and Wildlife, Fish Division, Third Floor, 2501 SW 1st Avenue, Portland, Oregon, between 8:00 a.m. and 4:30 p.m., on normal working days, Monday through Friday.

Fiscal and Economic Impact: See attached.

Administrative Rule Advisory Committee consulted?: Developmental Fishery Board

If not, why?:

Redacted for Privacy

Authorized Signer and Date — 9-15-99

Economic Impact Statement for the October 22, 1999 Hearing in the Matter of the Amendment of Rules Relating to the Developmental Fisheries Program

Fiscal and economic impact: The proposed rules will affect state agencies, units of local government and the public, respectively, as discussed below:

a. The only state agency which should be affected by adoption of these rules is the Oregon Department of Fish and Wildlife. No significant changes from the current legislatively approved levels of the department's operations or expenditures are expected as a result of the adoption of these rules.

b. No units of local government are expected to be affected by these rules. No significant changes from the current levels of any local agencies' operations or expenditures are expected as a result of the adoption of these rules.

c. The public could be affected by the adoption of these rules: The existing statute and rules require adoption of a list of developmental fisheries species, and the establishment or maintenance of limited entry harvest systems for the associated developmental fisheries. For this hearing, ODFW staff proposes six issues be considered.

(1) Adjust the definition of species in category A to include species managed under a federal plan, but not actively managed off Oregon under the federal plan. This would allow the continuation of fisheries for squid, anchovies and sardines as underutilized species under developmental category A status. Adoption of the staff recommendation would preclude discontinuation of current state harvest programs. Therefore, adoption of this amendment is expected to have a neutral to positive economic impact compared to the status quo, which would require management under the provisions of federal plans.

(2) Change the membership of the Permit Review Board for developmental permits and expand circumstances for considering permit renewal requirement waivers. If adopted this change is not expected to have any negative economic consequences.

(3) Discontinue the permit to harvest brine shrimp cysts. Because the conditions of Lake Abert have not been favorable for harvesting cysts, and are not projected to be favorable in the foreseeable future, staff recommends discontinuation of this permit. Therefore, we expect no negative economic impact if the amendment is adopted, because there is a very low probability that the permit could be utilized in an economically viable way.

(4) Add an alternative way to meet the permit renewal requirement for the spot prawn fishery. Presently, the renewal requirement for spot prawn permits is five landings of at least 100 pounds each. The proposal is to also allow one landing of at least 1000 pounds to meet the renewal requirement. If adopted this would probably have a positive economic effect because harvesters would not have to incur the costs of taking additional trips to meet the requirement for five landings.

(5) Add flat abalone to the developmental species list in category A. Staff does not favor this proposal because of a lack of sufficient information to meet the requirements of statewide planning goal 19. However, some potential harvesters and board members think that adoption of the proposal to issue one permit would offer an additional opportunity for several divers who have been adversely affected by reduced harvests in the sea urchin fishery. The economic impact of adoption of the proposal is unclear, because of uncertainty about the long term effects on abalone populations and because of potential offsetting effects on sport dive harvest and activity.

(6) Grant a preference point to a person who makes a proposal to add a species to the list of developmental fisheries. In the determination of who receives harvest permits for a new developmental species, the proposed amendment would essentially favor a person who went to the effort to explore the economic potential for harvest of the species. If

adopted this would probably tend to encourage public involvement in the development of new fisheries, because it would increase the probability that one who proposed a new fishery would be able to recoup the cost of exploring the economic potential for the fishery. In aggregate, the preference given to one individual would probably not affect the aggregate economic contribution of the fishery. The distribution of benefits could be affected, so particular individuals might be disadvantaged by the granting of the preference point to the person who initially proposed the new fishery.

Overall, the developmental fisheries rules are expected to produce positive economic effects for the public and small business both in the short run and in the long run. Rules relating to limited entry can be viewed as imposing additional costs (in the form of permit fees) on harvesters in the short run, and potentially excluding some harvesters who might not apply for limited entry permits soon enough. However, in the long run, implementation of the rules are expected to yield positive economic effects by controlling the development of fisheries, so the fisheries are sustainable in the long run. This is intended to help prevent the typical cycle in fisheries of boom (as a virgin fish stock is fished down to maximum sustainable yield levels) and bust (when the stock becomes incapable of sustaining yields at the initial exploitation level).

The rules are believed to be fully compatible with legislative direction on the goals of fish and wildlife management in Oregon.

Most businesses affected by these rules are believed to be "small business."

Developmental Fisheries Program
Staff Report

Prepared for Oregon Fish and Wildlife Commission
October 22, 1999 Astoria, Oregon

Summary of Staff Report

ODFW staff is providing a review of the Developmental Fishery Program for 1999 and asking the Commission to adopt regulation changes in the harvest program for some developmental fishery species recommended by the Developmental Fishery Board.

Key elements and conclusions from the staff report are:

- One hundred and twenty-six permits for the harvest of developmental fishery species have been issued in 1999, through August. Most landings of developmental fishery species have been as bycatch in other fisheries.

- ODFW staff completed a progress report on brine shrimp research conducted at Lake Abert, participated in the planning process of a federal management plan for migratory species (which includes swordfish), participated in a workshop and PFMC team meeting on pelagic species, collected samples from the sardine fishery, and participated in a sablefish research cruise (collecting data on bycatch species such as Tanner crab).

- The Developmental Fishery Board considered changes to the definition of species in category A and discussed procedures to waive renewal requirements. They also considered requests to discontinue the brine shrimp cyst permit, adjust the renewal requirements for spot prawns, remove spot prawns from the species list, and add flat abalone to the species list.

- The ODFW staff and Board recommend: adjusting the definition of species in category A; adjusting the harvest programs for brine shrimp and spot prawns; and granting a preference point to an applicant who makes a proposal to add a new species to the list.

- The Developmental Fishery Board recommends, but ODFW staff opposes, adding abalone to category A of the species list.

Outline of Staff Report

- ***Issue 1.***

Adjust the definition of category A of the developmental species list.

Option A (*preferred*) The Board and staff recommend the Commission adopt rules adjusting the definition of species in category A to allow for species under a federal management plan but not actively managed off Oregon under the federal plan and add a definition for "actively managed".

Option B: No action: status quo, no species under a federal management plan would be listed under category A.

- ***Issue 2.***

Discontinue the permit for brine shrimp cysts.

Option A: (*preferred*) The Board and staff recommend the Commission adopt rules removing the permit that allows harvest of brine shrimp cysts.

Option B: No action: status quo, one permit available for harvesting brine shrimp cysts.

- ***Issue 3.***

Add an alternative of one landing of 1000 pounds to renewal requirements for spot prawns.

Option A: (*preferred*) The Board and staff recommend the Commission adopt rules changing the renewal requirements of spot prawns to include an alternative of one landing of 1000 pounds.

Option B: No action: status quo, renewal requirements are 5 landing of 100 pounds.

- *Issue 4.*
  Add flat abalone to the species list in category A.

Option A The Board recommends the Commission adopt rules to add flat abalone to the developmental species list in category A and add a harvest program.

Option B: *(preferred)* Staff recommends no action: status quo, flat abalone are not on the developmental species list.

- *Issue 5.*
  Grant one preference point to person who makes proposal to add a species to the species list.

Option A: *(preferred)* The Board and staff recommend the Commission allow granting one preference point to persons who make the initial proposal (which is accepted) to add a species to the species list.

Option B: No action: status quo, no preference point available.

I. Introduction

The public hearing on October 22 is the annual review of the ODFW Developmental Fisheries Program. At the hearing, staff will: 1) describe the activities of the Developmental Fisheries Program in 1999; and 2) recommend changes to: the definition of category A species; the harvest programs for some developmental fishery species; and the preference point system.

II. Annual Report of Developmental Fisheries Activities

Permits

ODFW staff has issued 126 permits for the harvest of developmental fisheries species through August 1999 (Table 1). Of the more than 195 permits issued in 1998, 36 were renewed for 1999 (similar to last year). The permits for two fisheries (bay clams and spot prawns) were issued through a lottery. All available permits were issued for four fisheries (spot prawns, coonstripe & sidestripe shrimp, bay clams, and brine shrimp cysts).

Landings

Landings of developmental fisheries species through August 1999 are summarized in Table 2. The majority of the landings of developmental species were taken as bycatch in other fisheries.

There was an increase in landings for hagfish and sardines for 1999. The landing fees for species in all categories have generated approximately $11,709 into the developmental fisheries fund in 1999, through August.

Research

Ocean clams

There has been no activity with the experimental ocean clam dredge in 1999 because of oil contamination from the M/V New Carissa in the harvest area explored last year. The permit holder is planning to try again next year.

Brine shrimp

See appendix A for a progress report on activities on brine shrimp at Lake Abert.

Sablefish bycatch

Staff participated in a research cruise on sablefish, collecting size and sex composition data on bycatch of Tanner crab.

Sardines

Samples were collected from the landings of sardines and will be analyzed for size, sex, maturity, and age. Staff rode along on a vessel to observe bycatch. The only bycatch observed was one salmon, one blue shark, and approximately 25 pounds of mackerel.

Pacific Fishery Management Council Activity

The Pacific Fisheries Management Council (Council) has decided to develop a management plan for highly migratory species (which will include swordfish). Staff participated in writing a background paper on highly migratory species for the Council.

Staff also participated in Council plan development team meetings and a workshop on coastal pelagic species (which includes squid, sardines, and anchovies).

Developmental Fishery Board Activities

The Developmental Fishery Board held two meetings in 1999. At their meeting in June, the Board considered changes to the definition of species in category A and discussed procedures to waive renewal requirements. They also considered requests to discontinue the brine shrimp cyst permit, adjust the renewal requirements for spot prawns, and add flat abalone to the species list.

A spot prawn harvester also requested the Board consider removing spot prawns from the developmental species list and put it under a regular limited entry system. The request was tabled because creating another limited entry system would require going to the Legislature. The chair also mentioned concerns from the Council regarding the effects of prawn trawl gear on habitat. This winter, staff will conduct a review of the spot prawn fishery and develop options for future management for the Board to consider next spring.

The second meeting, in September, was a conference call to approve the wording of recommendations made at the June meeting.

Table 1. 1999 Developmental Fishery Permits (as of 9/1/99).

	Permits Allowed	Permits Issued	Renewals from 1998
Pacific hagfish	25	12	4
blue shark	10		
swordfish	10 other	6	2
	20 longline	4	
northern anchovy & Pacific herring	15	1	
Pacific sardine & Pacific saury	15	15*	
Pacific sandfish	10		
smelt	20		
Pacific pomfret	10		
slender sole	10		
box crab	25	3	
Oregon hair crab & scarlet king crab & grooved tanner crab	10	1	
spot shrimp	6 (3N/3S) trawl	6*	5
	10 (5N/5S) other	10*	
coonstriped shrimp & sidestripe shrimp	10	10*	1
cockle clams	5		1
bay clams	10 coastwide	10*	7
	5 south	5*	1
giant octopus	10	9	
California market squid	30 (15N/15S) trawl	18	12
other squid spp.	30 (15N/15S) other	8	2
fragile urchin	6 trawl		
	6 other		
sea cucumber	6 (3N/3S) trawl	1	
	10 (5N/5S) diver	1	
	10 (5N/5S) other		
marine snails	10	4	
brine shrimp	3 adults	1	1
	1 cysts	1*	1
	total	126	36

□* all available permits issued

□N/S -- permits issued geographically by home port, split at Hetecta Head, 50% N, 50% S

Table 2. Landings of developmental fisheries species, by category, through August, 1999

Category A	Pounds	Category B	Pounds	Category C	Pounds
Pacific hagfish	539,111	salmon shark	-	spiny dogfish	181,588
blue shark	608	black hagfish	-	soupfin shark	833
swordfish	-	Eelpouts	-	skate	909,222
northern anchovy	-	skilfish	-	American shad	201,947
Pacific herring	71,446	carp	-	Pacific cod	74,717
Pacific sardine	1,472,027	yellow perch	-	Pacific flatnose	-
Pacific saury	-	brown bullhead	-	Pacific grenadier	181,068
Pacific sandfish	-	northern squawfish	-	cabezon	48,073
smelt	11,148			sculpins	45
Pacific pomfret	-	euphausiids (krill)	-	kelp greenling	45,211
slender sole	-	Pacific sand crab	-	jack mackerel &	
		freshwater mussels	-	Pacific mackerel	1,367,761
box crab	75			greenstriped rockfish	
Oregon hair crab	-			redstripe rockfish	
scarlet king crab	-			shortbelly rockfish	
grooved tanner crab	-			sharpchin rockfish	
spot shrimp	16,695			splitnose rockfish	
coonstriped shrimp	893			Pacific sanddab	495,166
sidestripe shrimp	-			butter sole	968
butter clams	26,862			English sole	601,193
cockle clams	22,501			rex sole	424,087
gaper clams	1,412			rock sole	9,435
littleneck clams	2,115			sand sole	134,576
softshell clams	32			lemon sole	5,603
giant octopus	7,826			spotted ratfish	9
California market squid	2,209			wolf-eel	3,096
other squid spp.	-			walleye pollock	150
fragile urchin	-				
sea cucumber	7			red rock crab	381
marine snails	1			purple sea urchins	-
brine shrimp	33,800			crayfish	49,423
				grand total	6,907,320

III. Staff Analysis of Issues and Options - Recommendations

The following discusses staff recommendations. The full text of proposed rule changes is attached beginning on Page 13.

- ***Issue 1.***
  Adjust the definition of category A of the developmental species list.

Background of the definition of category A of the species list.

Presently, the definition of species in category A is: "Species in category "A" are underutilized, are not currently under another state or federal management plan, and have the potential to be economically viable".

Issue 1.

The Pacific Fishery Management Council recently adopted Amendment 8 to the Northern Anchovy Fishery Management Plan (FMP) which added squid, mackerel, and sardines to the plan and changed the name to the Coastal Pelagic Species Fishery Management Plan. Under this plan, only the fisheries for finfish south of 39° N (not squid) will be put under a limited entry system (actively managed status). Squid and finfish north of 39° N will have no specific federal regulations at this time (monitored status). The Council considers the existing Oregon and Washington regulations consistent with the FMP and prefers to rely on the state regulations in these areas. However, under the current definitions, squid, anchovies, and sardines would have to be moved to category C and the harvest programs discontinued because they are now under a federal management plan. Instead of moving the species to category C, the Board has recommended to continue listing these species under category A and adjust the definition to include species under a federal management plan but not actively managed off Oregon. A definition of "actively managed" would be included to be "federal management by harvest guideline or quota according to the provisions of a fishery management plan".

Option A: *(preferred)* The Board and staff recommend the Commission adopt rules adjusting the definition of species in category A to include species under a federal management plan but not actively managed off Oregon under the federal plan and adding a definition for "actively managed".

Option B: No action: status quo no species under a federal management plan would be listed under category A; squid, anchovies, and sardines would need to be reclassified under category C.

- ***Issue 2.***

Discontinue the permit for brine shrimp cysts.

Background of commercial brine shrimp fishery

See appendix A for a progress report on the commercial brine shrimp fishery at Lake Abert, Oregon.

Adult brine shrimp have been harvested in Oregon from Lake Abert since 1979. Under the present harvest program, three permits are available for harvest of adult brine shrimp and one permit is available for harvest of shrimp cysts. Closed periods have been established to protect nesting and migration seasons for bird populations. Both fisheries have an annual quota of 50,000 pounds per permit and harvest is also restricted to the south half of the lake to reduce disturbances to bird populations.

The harvest of adults has continued as in the past; one harvester, averaging 28,000 pounds annually. The other two adult permits have not been utilized. There has been no harvest of cysts due to a lack of harvestable cysts, due to water conditions.

From sampling in 1997, staff estimated the adult population of brine shrimp in October to be 1.9×10^{11}. If all three permit holders had taken their entire quota of 50,000 pounds each of adult shrimp, the commercial harvest would have accounted for approximately 1.8% of the total available biomass of shrimp (Appendix A).

Issue 2.

During 1997 and 1998, high percentages of empty shells were found in the floating "slicks" of cysts which means the viable cysts were not on the surface of the lake and therefore not available for harvesting. The lack of floating cysts may be due to the low salinities of the Lake. In the Great Salt Lake in Utah, as the salinity decreases, the cysts sink to the bottom of the lake. Staff believes the same thing happens at Lake Abert.

The permit holder estimated, the salinity would need to be above the 80-100 ppt range to provide enough floating cysts for a commercial harvest operation. If so, the level of the lake would need to drop to approximately the 4252 ft level to achieve these conditions; below the average level of the last 50 years. The level of the lake was below 4252 feet several years in the early 1990's, but in only four other years since 1953. Given the rise in water level in the last few years and the predicted future wet weather cycle, the number of years in the future the level of the lake will drop below 4252 will probably be few and far between. The Board recommends the permit for harvesting cysts be discontinued. The permit holder agrees with the recommendation.

Option A: (*preferred*)**:** The Board and staff recommend the Commission adopt rules removing the permit to harvest brine shrimp cysts.

Option B: No action: status quo, one permit available for harvesting brine shrimp cysts..

- ***Issue 3.***
  Add an alternative of one landing of 1000 pounds to renewal requirements for spot prawns.

Background of spot prawn renewal requirements.

Presently, the landing requirement for spot prawn permits is five landings of at least 100 pounds each. Many species on the species list have renewal requirements with two options; several small landing or one large landing (ie squid - 5 landings of 500 pounds or one landing of 5000 pounds).

Issue 3.

A prawn permit holder has requested to add a second option to the prawn renewal requirements as several of the vessels make multi-day trips with large landings but may not make at total of five landings. The Board recommends changing the spot prawn renewal requirements to: 5 landings of at least 100 pounds or one landing of at least 1000 pounds (underlined is new).

Option A: (*preferred*) The Board and staff recommend the Commission adopt rules changing the renewal requirements of spot prawns to include an alternative of one landing of 1000 pounds.

Option B: No action: status quo, renewal requirements are 5 landing of 100 pounds.

- ***Issue 4.***
  Add flat abalone to the species list in category A.

Background of Oregon abalone fisheries

Currently, commercial harvest of abalone is not allowed in Oregon. In 1996, the recreational bag limit was reduced from 3 to 1 abalone per day, with a yearly limit of 5. The minimum size limit for recreational harvest is 8 inches. This size limit precludes the harvest of the smaller flat abalone species.

Issue 4.

A commercial fisher presented a proposal to the Developmental Fishery Board to add flat abalone (*Haliotis walallensis*) to the species list. The applicant felt flat abalone are abundant on the southern Oregon coast, are of high quality, and could be sold in the live markets for optimum value. Because the sea urchin fishery is no longer a year round fishery, dive fishers need to diversify to survive. He believes a fishery for flat abalone would create a new source of revenue needed by divers and fish buyers. His proposal included 10 individual or 5 vessel permits, renewal requirements of 10 landings of at least 20 pounds each, and initial eligibility to current urchin permit holders.

Staff opposes the proposal to add flat abalone to the species list. Appendix B contains the life history summary and effects of evaluation for flat abalone. Basic life history of abalone is fairly well known; however, here is very little information specifically on flat abalone. Flat abalone have a fairly wide distribution, but abundance is sparse. The difficulty in distinguishing flat abalone

from small red abalone may result is some incidental harvest of small red abalone. Abalone are a very high value product. A high degree of interest has led to a great deal of illegal harvest activities in other abalone fisheries. Fisheries in other areas have shown that abalone populations can be easily over exploited. There may be concerns with having a commercial harvest but not allowing a sport harvest for this species. Staff has limited resources to conduct research on, or monitor, a new offshore dive fishery.

At the Developmental Fishery Board meeting, one member of the public objected to the proposal because he felt it would be too easy to strip an area clean of abalone. He also felt the south coast sport dive interests would also object to the proposal.

The Board felt the lack of information warranted issuing one permit in order to gather additional information. They adopted a recommendation to include flat abalone on the species with the following harvest program.

Harvest Program

A. Number of permits.

The Developmental Fisheries Board recommends issuing one permit to harvest flat abalone. The permit would be issued to the vessel with no more than two divers allowed on the vessel.

B. Renewal requirements.

The Developmental Fisheries Board recommends an annual renewal requirements of 10 landings of at least 20 pounds each.

C. Other stipulations.

Other stipulations recommended by the Developmental Fisheries Board include: an annual harvest quota of 3,000 pounds; a 4.5 in minimum size limit; a harvest season of May through Oct.; no harvest from depths less than 10 ft from MLLW; no undersized abalone brought ashore or aboard any vessel; and harvest done only by hand or abalone iron.

Option A: The Board recommends the Commission adopt rules to add flat abalone to the developmental species list in category A and add a harvest program.

Option B: *(preferred)* Staff recommend no action: status quo, flat abalone is not on the developmental species list.

- ***Issue 5.***

Grant one preference point to person who makes proposal to add a species to the species list.

Issue 5.

During the discussions to add flat abalone to the developmental species list, the Board realized that a person making a new proposal could not be guaranteed to get a permit if there was enough interest where the permits would go to a lottery. The Board felt if a person went to the time and effort to explore new markets, new gear types, etc. and worked to put together a proposal, they should be given a priority for one of the first permits. The Board recommends granting one preference point to the person who makes a proposal (if approved) to add a species to the species list.

Option A: *(preferred)* The Board and staff recommend the Commission allow granting one preference point to persons who make the initial proposal (which is accepted) to add a species to the species list.

Option B: No action: status quo, no preference point available.

Oregon Administrative Rules

COMMERCIAL FISHERIES
DIVISION 006
COMMERCIAL GEAR; LICENSES, POUNDAGE FEES, RECORDS AND REPORTS

Developmental Fisheries Program

635-006-0810

Definitions

For the purposes of OAR's 635-006-0820 through 635-006-0950 the following definitions shall apply:

(1) "Actively managed" means federal management by harvest guideline or quota according to the provision of a fishery management plan.

[(1)] (2) "Board" means the Developmental Fisheries Board appointed by the Commission.

[(2)] (3) "Commission" means the Oregon Fish and Wildlife Commission.

[(3)] (4) "Department" means the Oregon Department of Fish and Wildlife.

[(4)] (5) "Developed fishery" means a fishery where the level of participation, catch, and effort indicate the fishery has approached optimum sustained yield and/or there is sufficient biological information, information on harvest methods, gear types, and markets to develop a long-term management plan for the species.

[(5)] (6) "Developmental fisheries species" means food fish species adopted by the Commission to be managed under the Developmental Fisheries Program.

[(6)] (7) "Director" means the Director of the Oregon Department of Fish and Wildlife.

[(7)] (8) "Maximum sustainable yield" (MSY) means an estimate of the largest average annual catch or yield that can be taken over a significant period of time from each stock under prevailing ecological and environmental conditions.

[(8)] (9) "Underutilized species" means a food fish species that is not presently harvested in significant quantities due to poor markets or inadequate gear development or may be caught but not utilized due to poor markets.

[(9)] (10) "Optimum sustained yield" (OSY) means the desired catch level of a fishery that will provide the greatest overall benefit to the state taking into account economic, social, and ecological considerations that will maintain a level of population that insures the long-term productivity of the stock and does not impair its ability to sustain itself into the future.

(10) "Overfishing" means a level or rate of fishing mortality that jeopardizes the long-term capacity of a stock or stock complex to produce MSY.

Stat. Auth.: ORS 506.109, 506.119 and 506.450 through 506.465

Stats. Implemented: ORS

Hist.: Adopted 10-22-99, ef. upon filing

635-006-0830

Listing as a Developmental Fisheries Species

To list a food fish species as a Developmental Fisheries Species, the Commission shall determine the species is underutilized. If the Commission determines the species is underutilized it shall:

(1) Consider existing catch history, biological data, market information.

(2) Consider any known or potential conflicts including competing uses or gears, existing rules, state or federal management plans or policies, or impacts on other species.

(3) Place each species into one of three categories of the list according to the following criteria:

(a) Species in category "A" are underutilized, are not currently **actively managed off Oregon** under another state or federal management plan, and have the potential to be economically viable. Species in category "A" shall have

permit and gear limitations established by the Commission annually;

(b) Species in category "B" are underutilized, are not currently under another state or federal management plan, and have not shown the potential to be a viable fishery. A species so designated may be upgraded to the "A" category, upon application to the Board and approval by the Commission during the annual review;

(c) Species in category "C" are underutilized and are currently under another state or federal management plan already establishing permit and/or gear limitations.

Stat. Auth.: ORS 506.109, 506.119 and 506.450 through 506.465

Stats. Implemented: ORS

Hist.: Adopted 10-22-99, ef. upon filing

635-006-0850

Developmental Fisheries Species List

(1) The Developmental Fisheries [Species List, Category "A," is] **species, permit and gear restrictions, and landing requirements for renewal of Category A permits are** as follows:

(a) FISH

(A) Pacific hagfish (*Eptatretus stouti)* fishery has a qualifying and annual renewal requirement of five landings. There are 25 permits for harvest of which there are no trawl permits;

(B) Blue shark (*Prionace glauca)* fishery has a qualifying and annual renewal requirement of either five landings consisting of at least 500 pounds each landing or one landing consisting of at least 5000 pounds. There are 10 permits for harvest of which there are no high seas drift net permits and no large mesh gill net permits. No permit is needed for hand lines or hand harvest. Experimental gear permits may be required;

(C) Swordfish (*Xiphias gladius)* fishery has a qualifying and annual renewal requirement of either five landings consisting of at least 500 pounds each landing or one landing consisting of at least 5000 pounds. Permits are valid for and renewal requirements are calculated from February 1 through January 31 of the following year. There are 20 permits for harvest by floating longline and 10 permits for harvest by other gear. Specially adapted drift/gill net may be permitted. Experimental gear permits may be required. Five single-delivery permits will be issued to those who applied by annual filing date, but did not receive a Developmental Fishery Permit. Gill net gear must conform to California gear restrictions;

(D) Northern anchovy (*Engraulis mordax)* and Pacific herring (*Clupea pallasi)* fishery has a qualifying and annual renewal requirement of either five landings consisting of at least 500 pounds each landing or one landing consisting of at least 5000 pounds. There are 15 permits for ocean harvest. Specially adapted small mesh drift/gill net may be permitted. No permit is needed for hand lines or hand harvest. Experimental gear permits may be required;

(E) Pacific sardine (*Sardinops sagax)* and Pacific saury (*Cololabis saira)* fishery has a qualifying and annual renewal requirement of either five landings consisting of at least 500 pounds each landing or one landing consisting of at least 5000 pounds. There are 15 permits for ocean harvest. Specially adapted small mesh drift/gill net may be permitted. Experimental gear permits may be required;

(F) Pacific sandfish (*Trichodon trichodon)* fishery has a qualifying and annual renewal requirement of five landings. There are 10 permits for harvest of which there are no dredging permits and no trawl permits, however, limited numbers of experimental gear permits may be issued for trawl harvest. Permits are area specific. Experimental gear permits may be required. No permit is needed for hand lines or hand harvest;

(G) Eulachon (*Thaleichthys pacificus),* whitebait smelt (*Allosmerus elongatus),* uight smelt (*Spirinchus starksi*), longfin smelt (*Spirinchus thaleichthys*) and surf smelt

(*Hypomesus pretiosus*) fishery has a qualifying and annual renewal requirement of five landings consisting of at least 100 pounds each landing. There are 20 permits for ocean harvest of which there are no trawl permits, however, limited numbers of experimental gear permits may be issued for trawl harvest. Specially adapted small mesh drift/gill net may be permitted. No permit is needed for hand lines or hand harvest. Experimental gear permits may be required;

(H) Pacific pomfret (*Brama japonica*) fishery has a qualifying and annual renewal requirement of five landings consisting of at least 100 pounds each landing. There are 10 permits for harvest. Experimental gear permits may be required;

(I) Slender sole (*Eopsetta exilis)* fishery has a qualifying and annual renewal requirement of five landings consisting of at least 100 pounds each landing. There are 10 permits for harvest. Experimental gear permits may be required.

(b) INVERTEBRATES

(A) Box crab (*Lopholithodes foraminatus)* fishery has a qualifying and annual renewal requirement of five landings consisting of at least 100 pounds each landing. There are 25 permits for harvest with pots only;

(B) Grooved tanner crab (*Chionoecetes tanneri*), Oregon hair crab (*Paralomis mulitspina*) and scarlet king crab (*Lithodes couesi*) fishery has a qualifying and annual renewal requirement of five landings consisting of at least 100 pounds each landing. There are 10 permits for harvest with pots only;

(C) Spot prawn (*Pandalus platyceros)* fishery has a qualifying and annual renewal requirement of five landings consisting of at least 100 pounds (round weight) each landing **or one landing consisting of at least 1000 pounds**. There are six permits for harvest by trawl gear and 10 permits for harvest by other gear. Permits are area specific. Experimental gear permits may be required. Permits are issued geographically, split at Heceta Head with 50 percent issued north and 50 percent issued south of Heceta Head, until after the date of the lottery;

(D) Coonstripe shrimp (*Pandalus danae*) and sidestripe shrimp (*Pandalopsis dispar*) fishery has a qualifying and annual renewal requirement of five landings consisting of at least 100 pounds (round weight) each landing. There are 10 permits for harvest by pot gear;

(E) Ocean cockle clams (*Clinocardium nuttallii*) fishery has a qualifying and annual renewal requirement of five landings consisting of at least 100 pounds each landing. There are five permits for ocean harvest only. No permit is needed for hand lines or hand harvest. Experimental gear permits may be required;

(F) Bay clams including cockle clams (*Clinocardium nuttallii*), butter clams (*Saxidonus giganteus),* gaper clams (*Tresus capas, nuttallii),* native littleneck clams (*Protothaca stamines),* and softshell clams (*Mya arenaria*) fishery has no qualifying and annual renewal requirements for intertidal hand harvest, an unlimited number of permits, and a $25 permit fee. There are 11 permits (individual or vessel) for subtidal dive harvest, effective March 18, 1997-December 31, 1997, and 10 permits thereafter for statewide harvest and five permits for harvest south of Heceta Head. Qualifying requirements are either five landings consisting of at least 200 pounds each landing or an annual total of 2500 pounds for one calendar year during the qualifying period of January 1, 1990 through October 16, 1995. Annual renewal requirements are either five landings consisting of at least 100 pounds each landing or an annual total of 2500 pounds;

(G) Giant octopus (*Octopus dofleini)* fishery has a qualifying and annual renewal requirement of five landings consisting of at least 100 pounds each landing. There are 10 permits for harvest using octopus pots only;

(H) California market squid (*Loligo opalescens)* and other squid (several species) fishery has a qualifying and annual renewal requirement of either five landings consisting of at least 500 pounds each landing or one

landing consisting of at least 5000 pounds. There are 30 permits for harvest using trawl gear and 30 permits for harvest using other gear types. Experimental gear permits may be required. Permits are issued geographically, split at Heceta Head with 50 percent issued north and 50 percent issued south of Heceta Head, until after the date of the lottery;

(I) Fragile urchin (*Allocentrotus fragilis*) fishery has a qualifying and annual renewal requirement of five landings consisting of at least 500 pounds each landing. There are six permits for harvest using trawl gear and six permits for harvest using other gear. Experimental gear permits may be required. Permits are issued geographically, split at Heceta Head with 50 percent issued north and 50 percent issued south of Heceta Head;

(J) Sea cucumber (*Parastichopus* spp.) fishery has a qualifying and annual renewal requirement of five landings consisting of at least 100 pounds each landing. There are six permits for harvest using trawl gear, 10 permits for havest by diver, and 10 permits for harvest by other gear. Experimental gear permits may be required. Permits are issued geographically, split at Heceta Head with 50 percent issued north and 50 percent issued south of Heceta Head, until after the date of the lottery;

(K) Marine snails (various species) fishery has a qualifying and annual renewal requirement of five landings consisting of at least 100 pounds each landing. There are 10 permits for subtidal harvest only;

(L) Brine shrimp (*Artemia* spp.) fishery has a qualifying and annual renewal requirement of at least 5000 pounds landed. There are three permits to harvest adults [and one permit to harvest eggs. Applicants for the egg permit must have prior experience harvesting brine shrimp.] ;

(M) Flat Abalone (*Haliotis walallensis*) fishery has an annual renewal requirement of at least 10 landings of at least 20 pounds each landing. There is one permit for subtidal harvest with dive gear.

(2) The Developmental Fisheries Species List, Category "B," is as follows:

(a) FISH

(A) Salmon shark (*Lamna ditropis)*;

(B) Carp (*Cyprinus carpio)*;

(C) Black hagfish (*Eptatretus deani)*;

(D) Yellow perch (*Perca flavescens)*;

(E) Eelpouts (family Zoarcidae);

(F) Brown bullhead (*Ameiurus nebulosus)*;

(G) Skilfish (*Erilepis zonifer)*;

(H) Northern squawfish (*Ptychocheilus oregonensis).*

(b) INVERTEBRATES

(A) Euphausids (krill) (family Euphausidae);

(B) Pacific sand crab (*Emerita analoga*);

(C) Freshwater mussels (families Margaritifera, Anodonta, Gonidea, and Corbicula).

(3) The Developmental Fisheries Species List, Category "C," is as follows:

(a) FISH

(A) Spiny dogfish (*Squalus acanthias)*;

(B) Soupfin shark (*Galeorhinus zyopterus)*;

(C) Skate (family Rajidae);

(D) American shad (*Alosa sapidissima)*;

(E) Pacific cod (*Gadus macrocephalus)*;

(F) Pacific flatnose (*Antimora microlepis)*;

(G) Pacific grenadier (*Coryphaenoides acrolepis)*;

(H) Cabezon (*Scorpaenichthys marmoratus)*;

(I) Sculpins (family Cottidae);

(J) Kelp greenling (*Hexagrammos decagrammus)*;

(K) Jack mackerel (*Trachurus symmetricus)*;

(L) Chub (Pacific) mackerel (*Scomber japonicus)*;

(M) Greenstriped rockfish (*Sebastes elongatus)*;

(N) Redstripe rockfish (*Sebastes proriger)*;

(O) Shortbelly rockfish (*Sebastes jordani)*;

(P) Sharpchin rockfish (*Sebastes zacentrus)*;

(Q) Splitnose rockfish (*Sebastes diploproa)*;

(R) Pacific sanddab (*Citharichthys sordidus)*;

(S) Butter sole (*Pleuronectes isolepis)*;

(T) English sole (*Pleuronectes vetulus)*;

(U) Rex sole (*Errex zechirus)*;

(V) Rock sole (*Pleuronectes bilineatus)*;

(W) Sand sole (*Psettichthys melanostictus)*;

(X) Curlfin (lemon) sole (*Pleuronichthys decurrens)*;

(Y) Spotted ratfish (*Hydrolagus colliei)*;

(Z) Wolf-eel (*Anarrhichthys ocellatus)*;

(AA) Walleye pollock (*Theragra chalcogramma)*.

(b) INVERTEBRATES

(A) Red rock crab (*Cancer productus)*;

(B) Purple sea urchins (*Strongylocentrotus purpuratus)*;

(C) Crayfish (*Pacifastacus leniusculus)*.

Stat. Auth.: ORS 506.119

Stats. Implemented: ORS 506.109, 506.129 and 506.450 through 506.465

Hist.: Adopted 10-22-99, ef. upon filing

635-006-0915

Preference Point System

(1) Valid applicants who did not receive a permit during the lottery shall receive one preference point applicable to subsequent permit lotteries for the species gear category **(listed in OAR 635-006-0850)** for which points were accrued, except as excluded in section [(4)] (5) of this rule.

(2) Persons who submit the initial proposal to add a species to the Developmental Fisheries Species list (OAR 635-006-0850) shall be granted one preference point applicable to the first permit lottery for the new permit category.

[(2)] (3) Applicants shall accrue no more than one preference point per species gear category per year.

[(3)] (4) Applicants successful in obtaining a permit shall have zero preference points when they next apply for a new permit in that species gear category.

[(4)] (5) Applicants will forfeit preference points accumulated for a species gear category when they do not apply for that species gear category for two consecutive years.

[(5)] (6) Department records are final to determine accrued preference points for permit applicants.

[(6)] (7) Each applicant's preference point accrual record will be jointly linked to his or her social security number or tax ID number and vessel document number. Preference point applicants shall use the same social security number or tax ID number and vessel document number each time they apply for a permit.

[(7)] (8) Applicants will receive no preference points when their application is not received by the appropriate application date.

Stat. Auth.: ORS 506.109 and 506.119

Stats. Implemented: ORS 506.129 and 506.450 through 506.465

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APPENDIX A. Progress report on brine shrimp research

Developmental Fisheries Progress Report: Brine Shrimp

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April, 1999

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ABSTRACT

In 1996, ODFW received numerous inquiries about harvesting brine shrimp cysts from Lake Abert; much of the interest coming from the expanding cyst fishery on the Great Salt Lake in Utah. Because of the potential increase in harvest activities, the fishery was placed under the developmental fishery project which allowed a limit to the number of permits issued and an opportunity to collect information needed for a management plan.

A review of the basic life history and ecology of Lake Abert was conducted. Brine shrimp can be found in salt lakes and brine ponds through out the world. They thrive in extreme environmental conditions such as high salinity and temperature, where predators cannot survive. Brine shrimp are filter-feeders, ingesting organic detritus and microscopic algae and bacteria. Due to the absence of predators and competitors, *Artemia* densities are mostly controlled by food limitations.

Lake Abert is a large closed-basin, saline/alkaline lake located in south-central Oregon. At high levels, Lake Abert covers over 64 square miles, is about 16 miles long and 6 miles wide, and has a maximum depth of more than 15 feet. The size of the lake varies considerably depending on its surface elevation, which varies with climatic changes. The Chewaucan River and precipitation are the two most important sources of water for Lake Abert. The dissolved-solid content of the lake fluctuates considerably, but generally ranges from 20,000 to 80,000 ppm, and has reached as high as 115,000 ppm. Because the lake is a unique ecosystem, the Bureau of Land Management has designated the area as an Area of Critical Environmental Concern.

Previous studies conducted on birds, brine shrimp, and other invertebrates of Lake Abert were summarized. In 1981-82, the brine shrimp biomass was calculated to be approximately 7.0 X 10^6 kg with a peak in abundance in midsummer. Fragments of mats made up of algae and diatoms break loose and form floating algae spheres which were actively sought after by feeding brine shrimp. In 1983-84, 14 species of benthic macroinvertebrates were collected at Lake Abert with the alkali fly usually being the most numerous. Lake Abert is an inland staging and stopover point for fall migrants in the Pacific Flyway. Large numbers of water-dependent birds rest and feed at the lake before continuing in their southward migration. Seven species of water-dependent birds were studied at Lake Abert in 1982-83 during the fall migration to determine their diets and foraging strategies. In addition to fall migrations, 33 species of waterfowl and shorebirds passed through Lake Abert in large numbers in the spring in 1988-89.

The Great Salt Lake in Utah supplies approximately 80% of the worlds supply of brine shrimp cysts. The maximum harvest was over 14 million pounds in 1995-96. The harvest methods have become very high tech, very expensive, and very competitive.

Adult brine shrimp have been harvested in Oregon from Lake Abert 1979. Under the developmental fisheries program, a limited number of permits to harvest brine shrimp were

allowed, with separate harvest programs for the adult and cyst fisheries. Closed periods were established to protect nesting and migration seasons for bird populations. Harvest for both fisheries was also restricted to the south half of the lake to reduce disturbances to bird populations. The harvest of adults has continued as in the past. There has been no harvest of cysts due to a lack of harvestable cysts, probably due to water conditions.

A pilot sampling project was conducted to determine what levels of monitoring and sampling would be needed to develop a management plan for commercial harvest of cyst and adult brine shrimp from Lake Abert. The estimated population of adult brine shrimp in October 1997, was estimated to be 1.9×10^{11}. If all three permit holders had taken their entire quota of 50,000 pounds of adult shrimp each, the commercial harvest would have accounted for approximately 1.8% of the total available biomass of shrimp. High percentages of empty shells were found in the floating "slicks" of cysts which means the viable cysts were not on the surface of the lake and therefore not available for harvesting. The lack of floating cysts may be due to the low salinities of the Lake. Given the wet weather patterns in Oregon in the last few years and predictions for the near future, it may be some time before the lake will be at the level and salinities necessary to produce harvestable amounts of cysts.

A much more detailed, multi-year study would be needed to provide complete sustainable yield information. A major gap in information is what happens in the lake at high salinities. Recommendations for future management include to continue present adult permits and discontinue the cyst permit.

INTRODUCTION

Since the early 1980's, adult brine shrimp (*Artemia salina)* have been harvested from Lake Abert, Oregon and sold for aquarium fish food. In 1996, ODFW received numerous inquiries about harvesting brine shrimp cysts from Lake Abert; much of the interest coming from the expanding cyst fishery on the Great Salt Lake in Utah. Because of the potential increase in harvest activities, the fishery was placed under the Developmental Fishery Project which allowed a limit to the number of permits issued and an opportunity to collect information needed for a management plan. Basic life history information for brine shrimp is fairly well known; however, ecology in natural systems is less well known.

The goals of this project were to develop a management plan and monitoring program for commercial harvest of brine shrimp cysts and adults from Lake Abert, Oregon. The specific objectives of this report were to:

1. Review the basic life history of brine shrimp;
2. Review the available information on brine shrimp and ecology of Lake Abert;
3. Review commercial fisheries in other areas and management of commercial harvest in Oregon;
4. Conduct a pilot sampling project to determine what level of monitoring and sampling would be needed to develop a management plan for commercial harvest of cysts and adult brine shrimp at Lake Abert, Oregon;
5. Make recommendations for future harvest and monitoring.

LIFE HISTORY OF BRINE SHRIMP

Ecology

Brine shrimp can be found in salt lakes and brine ponds through out the world (Sorgeloos, 1980; Sorgeloos, et al., 1986). They thrive in extreme environmental conditions such as high salinity and temperature, where predators cannot survive (Sorgeloos, et al., 1986).

Temperature thresholds are different for different strains of *Artemia* (Persoone and Sorgeloos, 1980). In general, brine shrimp can survive in temperatures between 6° C and 40° C, with the optimum in the range of 25° C to 30° C. The dehydrated cysts tolerate a much wider temperature range, which never occurs in nature: absolute zero (-273° C) to almost 100° C (Persoone and Sorgeloos, 1980).

Brine shrimp have been found in supersaturated brines at salinities as high as 340°/$_{oo}$ (Persoone and Sorgeloos, 1980; Sorgeloos, 1980). The lower salinity limit in which *Artemia* is found in nature, is in most cases a function of the presence of predators (Persoone and Sorgeloos, 1980). *Artemia* can survive in seawater or brackish water, but have no defenses against predation (Sorgeloos, et al., 1986). As a general rule, lower salinity limits vary from place to place depending on the upper salinity tolerance level of local predators (Persoone and Sorgeloos, 1980).

Reproduction and growth

Brine shrimp have the ability to reproduce by two different methods depending on environmental conditions. Under favorable conditions, fertilized eggs can develop directly into free-swimming nauplii (Sorgeloos, 1980). Under extreme environmental conditions (high salinity, low oxygen levels), eggs are surrounded by a thick shell and deposited as cysts which will remain inactive as long as they are kept dry or under anaerobic conditions; they will start to develop when the salinity drops below a certain threshold. At salinities above this threshold, cysts will not hatch because they cannot hydrate enough (Sorgeloos, 1980). The salinity threshold at which cysts will hydrate is different for different strains of *Artemia* (Persoone and Sorgeloos, 1980). When the conditions are right for hatching, within a matter of hours (Sorgeloos, 1980; Sorgeloos, et al., 1986), the cysts hatch into nauplii which grow to adults in a few weeks (Persoone and Sorgeloos, 1980).

Adult animals reach 8-10 mm long (Sorgeloos, 1980). Under optimal conditions, brine shrimp can live for several months and reproduce at a rate of up to 300 nauplii or cysts every 4 days (Sorgeloos, et al., 1986). Cysts can survive for years and only have to be incubated for 24 hours in seawater to produce larvae (Sorgeloos, 1980).

Food

Brine shrimp are filter-feeders, ingesting organic detritus and microscopic algae and bacteria (Persoone and Sorgeloos, 1980; Sorgeloos, et al., 1986). In many areas, the presence of

high numbers of shrimp often coincides with blooms of microscopic algae (Persoone and Sorgeloos, 1980).

Artemia can be subject to serious predation in situations where the predator can withstand the harsh environmental conditions . Numerous fish and crustacean species and some insects regularly prey on brine shrimp. One group of animals which is not so limited by the salinity barrier is birds. *Artemia* can be an important part of the diet of several species of waterfowl, gulls, avocets, and flamingos (Persoone and Sorgeloos, 1980).

Population

Due to the absence of predators and competitors, *Artemia* densities are mostly controlled by food limitations (Sorgeloos, et al., 1986).

The principal method of dispersion of *Artemia* is transportation of cysts by wind and waterfowl, as well as deliberate inoculation by humans into solar salt works (Persoone and Sorgeloos, 1980; Sorgeloos, et al., 1986).

ECOLOGY OF LAKE ABERT

Description

Lake Abert is a large closed-basin, saline/alkaline lake located in south-central Oregon, approximately 25 miles north of Lakeview. Unless otherwise cited, the following description was taken from Phillips and Van Denburgh (1971). At high levels, Lake Abert covers over 64 square miles, is about 16 miles long and 6 miles wide, and has a maximum depth of more than 15 feet. The size of the lake varies considerably depending on its surface elevation, which varies with climatic changes. Recent historic (last 100 years) high levels of about 4,262 feet above sea level were recorded in the mid 1980's (Figure 1). During several years in the early 1930's the lake was completely dry. During Pleistocene times, a larger lake occupied the deep Abert basin, where shoreline deposits were left more than 200 feet above the present-day lake bed.

Within one mile of the east edge of the lake is Abert Rim, a fault-scarp ridge which rises 1,500 to 2,200 feet above the lake. West of the lake, the surface of a tilted fault block slopes more gently to Goglan Buttes. To the north, mud flats merge into hilly terrain. At the southern end, the Chewaucan River, the lake's principal tributary, enters into the lake.

The Chewaucan River and precipitation are the two most important sources of water for Lake Abert. There are many springs that emerge along the shore on all sides of the lake, however, most of them make no material contribution to the water supply of the lake. Water loss from the lake is only through evaporation.

The dissolved-solid content of the lake fluctuates considerably, but generally ranges from 20,000 to 80,000 ppm, and has reached as high as 115,000 ppm (Keister, 1992). The three most

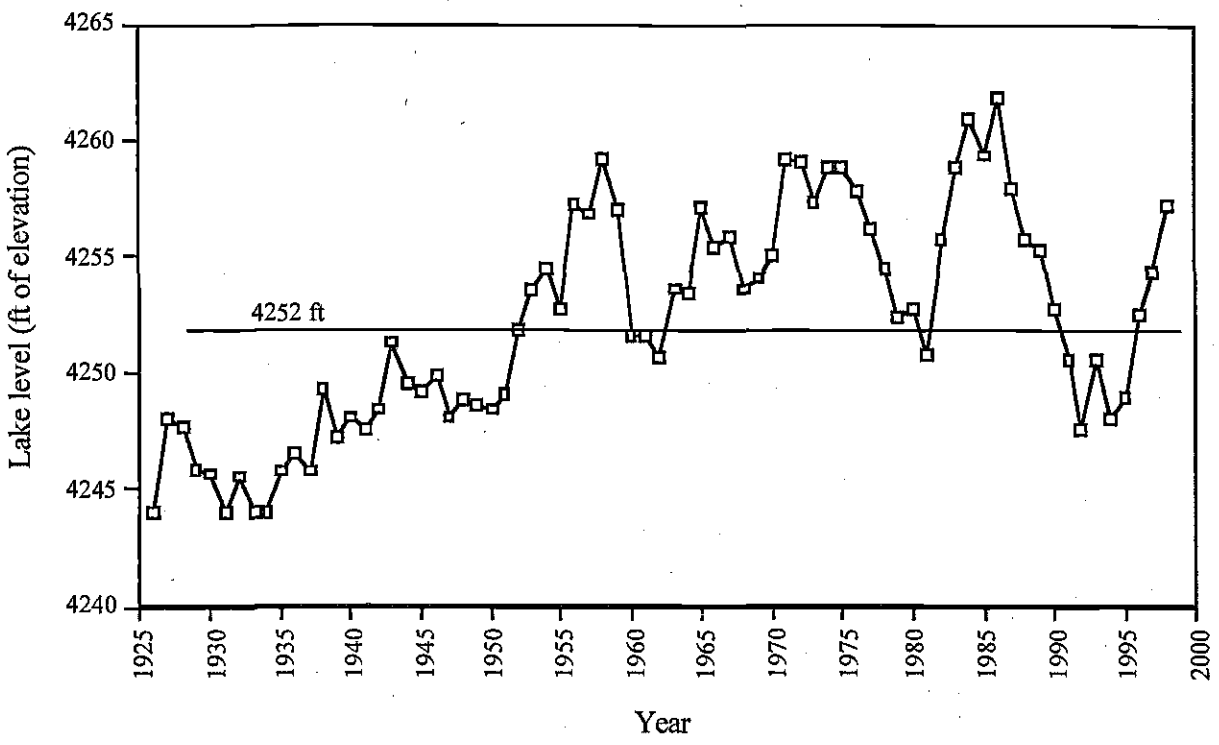

Figure 1. Water level of Lake Abert, Oregon, 1926-1998. 1926-1990 data from Keister, (1922). 1990-1996 data from Lakeview Watermaster, Oregon Water Resources Department. 1997-1998 data from personal observation. Lake levels were those taken as close as possible to October each year. Data are listed in Appendix A.

abundant dissolved constituents, sodium, carbonate, and chloride, make up about 90% of the dissolved solids. Except at near-dryness stage, the relation between dissolved-solids concentration and lake level is almost constant for Lake Abert over periods of several years. The only way the lake can lose salts is through precipitation of salts or through removal by wind in dry years (Van Denburgh, 1975).

Water temperatures in the winter range from 0°C to 5°C with some ice formation near the entrance of the Chewaucan River (Conte and Conte, 1988). In the spring, the lake warms and forms a temporary thermocline which is broken down by wave action. The lake achieves an isothermal condition with nearly constant temperature (approximately 22°C) for several weeks at a time. Gradual cooling occurs in the autumn (Conte and Conte, 1988).

Management designations

Most of the land surrounding Lake Abert is owned by the Bureau of Land Management (BLM). A permit is need by the BLM for access to the lake for commercial harvest of brine shrimp. Because the lake is a unique ecosystem, the BLM has designated the area as an Area of Critical Environmental Concern (ACEC). This designation allows the BLM to establish a management plan for the area, including standards such as water quality, to protect significant

resources in the area. The BLM recognizes four important resource values or processes in the Lake Abert area that deserve special management attention: wildlife resources, cultural resources, scenic value, and ecological processes (Bureau of Land Management, 1996). The harvest of brine shrimp or cysts would not affect water quality and is therefore allowed in the ACEC.

Brine shrimp

In the early 1980's, Conte and Conte (1988) estimated the distribution, abundance, and biomass for brine shrimp in Lake Abert. The brine shrimp biomass was calculated to be approximately 7.0 X 10^6 kg with a peak in abundance in midsummer. They found no vertical stratification of shrimp between the surface and the bottom. However, horizontal distribution of shrimp was quite patchy. They estimated the annual commercial harvest in 1981 to 1983 (7,500 lb - 10,800 lb) to be approximately 0.05 % of the estimated shrimp biomass. They also estimated the maximum utilization of brine shrimp by shovelers and eared Grebes for a migratory period to be 1125 kg.

Boula (1985) found brine shrimp occurred frequently only in the diets of eared grebes (mostly adult shrimp), and shovelers (mostly cysts). Although low in frequency, adult brine shrimp were considered among the most preferred foods for ring-billed and California gulls. Low proportions of shrimp in diets of birds at Lake Abert may have reflected reduced levels of absolute availability during the time frame of the study.

Other invertebrates

Boula (1985) investigated what prey organism were available to migrating birds and documented patterns of use of prey species. Prey species included brine shrimp (*Artemia*), alkali fly (*Ephydra hians*), long-legged flies (*Hydrophprus plumberus*), amphipod (*Hyallela azteca*), waterflea (*Moina* sp.), and the beetle (*Hygrotus masculinus*). She found peak sample biomass of bird prey species in August and September. The alkali fly was the primary prey of birds at Lake Abert during autumn; alkali flies accounted for at least 65 % of the biomass consumed by each species except the northern shoveler.

Herbst (1988) collected 14 species of benthic macroinvertebrates at Lake Abert with the alkali fly usually being the most numerous. The two southernmost sites, closest to the Chewaucan River, had the greatest number of species. Species diversity declined the further north the sample site, i.e. farther from the river (the source of colonization) and more saline.

Algae

Conte and Conte (1988) found the dominant alga at Lake Abert was *Ctenocladus circinnatus*, a filamentous green alga which grew on the muddy bottom or on submerged rock near the shore. Large mats comprised of *Ctenocladus* zoospores, the diatoms *Navicula* and *Nitzschia* and the blue-green algae *Anabena* and *Oscillatoria* form on submerged mud flats. Fragments of these mats break loose and form floating algae spheres which were actively sought after by feeding brine shrimp.

Birds

Lake Abert is an inland staging and stopover point for fall migrants in the Pacific Flyway. Large numbers of water-dependent birds rest and feed at the lake before continuing in their southward migration (Boula, 1985). Morawski and Stern (1991, as cited in Keister, 1992) estimated about 1,300,000 use-days by shorebirds from July through September, 1991.

Boula (1985) studied seven species of water-dependent birds at Lake Abert during the fall migration to determine their diets and foraging strategies. Birds included in this investigation were the northern phalarope, Wilson's phalarope, American avocet, eared grebe, ring-billed gull, California gull, and northern shoveler. These species comprised the majority of all birds observed at the lake during both years of the study.

Peak numbers of Wilson's and northern phalaropes occurred in August. No Wilson's phalaropes were observed after mid-September. Northern phaloropes were observed as late as mid-October. The numbers of avocets peaked in mid-August one year and mid-July the next. Eared grebes peaked in early-August and numbers stayed relatively high throughout September and October. Some adult grebes observed early in June may have nested at the lake. Northern shovelers were the latest arrivals; with peak numbers at mid-October and early-September.

Although relative proportions varied, the alkali fly was the primary prey of birds at Lake Abert during the autumn. Alkali flies accounted for at least 65% of the biomass consumed by each species, except the northern shoveler. Brine shrimp occurred frequently only in the diets of eared grebes (35.5%, mostly adult shrimp), and shovelers (41.6%, mostly cysts). Although low in frequency, adult brine shrimp were considered among the most preferred foods for ring-billed and California gulls. Low proportions of shrimp in diets of birds at Lake Abert may have reflected reduced levels of absolute availability. Conte and Conte (1988) estimated the maximum utilization of brine shrimp by shovelers and eared Grebes for a migratory period to be 1,125 kg.

In addition to fall migrations, shorebirds pass through Lake Abert in large numbers in the spring (April & May). Kristensen, et al. (1991) observed 33 species of waterfowl and shorebirds using the lake edge habitat at the north end of the lake in 1988 and 1989, with 10 of these species as known breeders at Lake Abert (Table 1). Common spring migrants included western sandpipers, least sandpipers, dunlins, semipalmated plovers, red-necked phalaropes, and Wilson's phalaropes. Most breeders utilized the open playa or the adjacent saltgrass flats on the north lake edge. The most numerous breeder at Lake Abert was the American avocet, with an estimated 1,000 breeding birds in May. Approximately 100 pairs of western snowy plovers were observed with peak nesting between mid-May and mid-June. The breeding populations of snowy plovers at Lake Abert is the largest in Oregon (Page and Bruce, 1989 as cited in Kristensen, et al., 1991). The western snowy plover is listed as threatened in Oregon and is a federal "category 2" candidate species. There were an estimated 40 pairs of long-billed curlews nesting along the north end of the lake. Curlews are also a federal "category 2" candidate species (Kristensen, et al., 1991).

Table 1. Waterfowl and shore birds found in the lake edge habitat on the north shore of Lake Abert, with abundance greater than rare. * = known breeders at Lake Abert. (from Kristensen, et al., 1991).

Pied-billed Grebe	Canada Goose *	Black-bellied Plover	Franklin's Gull
Eared Grebe	Green-winged Teal	Snowy Plover *	Bonaparte's Gull
	Mallard *	Semipalmated Plover	Ring-billed Gull
White Pelican	Northern Pintail	Killdeer *	California Gull
	Blue-winged Teal	American Avocet *	Forster's Tern
	Cinnamon Teal *	Willet *	
	Northern Shoveler *	Marbled Godwit	
	Gadwall *	Western Sandpiper	
	American Wigeon	Least Sandpiper	
	Redhead	Dunlin	
	Lesser Scaup	Long-billed Dowitcher	
	Ruddy Duck	Wilson's Phalarope *	
		Red-necked Phalarope	

COMMERCIAL HARVESTING OF BRINE SHRIMP

Fisheries in other areas

The Great Salt Lake in Utah supplies approximately 80% of the worlds supply of brine shrimp cysts. The maximum harvest was over 14 million pounds in 1995-96 and the price has been as high as $25 per pound for cleaned cysts (Ross, 1996). The brine shrimp industry began on the Great Salt Lake in the 1950's when adult shrimp were harvested for aquarium fish food. In the 1970's the industry began harvesting cysts which are used in commercial aquaculture of shrimp, prawns, and some fish, primarily in SE Asia and South America (US Geological Survey, 1997; Ducey, 1998).

In 1996, the Utah Department of Wildlife Resources began a limited entry system for brine shrimp issuing 79 "certificates" for $10,000 each. The harvest methods have become very high tech, very expensive, and very competitive (Ducey, 1998). Spotter planes with high-tech communications are used to locate cysts; high powered vessels, oil-skimming equipment, rotary drums, and sump pumps are used to harvest the cysts (Ross, 1996; Ducey, 1998). Streaks of floating cysts are surrounded by the oil-skimming booms and then pumped into large woven bags that allow the water to drain (Allen, 1996; Ducey, 1998). The cysts are then washed, dried, packaged into one pound vacuum cans, and shipped around the world (Allen, 1996).

Oregon harvest & management

Adult brine shrimp have been harvested in Oregon from Lake Abert by one harvester since 1979. Annual landings in the last ten years have averaged over 28,000 lb (ODFW landing records). Conte and Conte (1988) estimated the annual commercial harvest in 1981 to 1983 (7,500 lb - 10,800 lb) to be approximately 0.05 percent of the estimated shrimp biomass.

Because of the expansion of the cyst fishery on the Great Salt Lake, in 1996, ODFW received numerous inquiries from harvesters looking for new harvest areas. The increased interest

in harvest of cysts from Lake Abert prompted ODFW to place the fishery under the developmental fishery program in 1997.

Under the developmental fisheries program, a limited number of permits were allowed, with separate harvest programs for the adult and cyst fisheries: three permits to harvest brine shrimp adults and one permit to harvest brine shrimp cysts. Closed periods were established to protect nesting and migration seasons for bird populations. Harvest of adults was allowed from May through August and harvest of cysts was allowed, initially, from January through March. The season for cysts was expanded, beginning in 1998, to include November through December. Harvest for both fisheries was also restricted to the south half of the lake to reduce disturbances to bird populations. The adult permits were limited to a maximum annual harvest of 50,000 lb per permit and the cyst permit was limited to a maximum annual harvest of 25,000 lb. Both permits had annual renewal requirements of 5,000 lb.

Since 1997, the harvest of adults by the harvester has continued. The other adult permits have been issued but not actively used. There has been no harvest of cysts due to a lack of harvestable cysts, probably due to water conditions.

PILOT SAMPLING PROJECT

The objectives of the pilot sampling project were to determine what levels of monitoring and sampling would be needed to develop a management plan for commercial harvest of cyst and adult brine shrimp from Lake Abert.

Methods

Sample stations were chosen based on the stations used in Conte and Conte (1988) to facilitate comparisons. The shoreline of the lake was digitized from US Geological Survey (USGS) quad maps (map number's 685, 686, 245, & 246). The latitude and longitude and UTM coordinates of the stations were calculated from the digitized map and entered into a handheld GPS to locate the stations on the lake (Figure 2 and Appendix B).

At each station, three samples of brine shrimp were taken using a 30 cm diameter, 120 μm plankton net, towed from near the bottom to the surface. The net was not placed directly on the bottom, but as close to the bottom as possible without disturbing the layer of fine sediment on the bottom which would otherwise plug the plankton net.

At each station, ph, temperature, and salinity data were also collected (Appendix C) using a hand held ph meter, a hand held thermometer and a refractometer. The water level of the lake was determined from a gaging station located on the east shore of the lake (Figure 2).

Figure 2. Map of Lake Abert showing sample stations (1-14), gaging station, and north/south dividing line.

Samples of brine shrimp were fixed in the field with 5% formalin and then transferred to 70% isopropyl alcohol a day or two later. Counts were made by either counting the entire sample (when the sample was small enough) or by subsampling from a grid sampler. Shrimp were distributed as evenly as possible over the grid sampler and subsamples were chosen by the roll of dice. Life stages were determined by microscopic examination and classified into nauplii, juveniles, and adult males and females following Heath (1924).

A number of samples of cysts were collected and analyzed for hatching rates. The samples were collected from "slicks" in the water or on the shore of the lake and sent to Avocet Artemia, Inc., in Salt Lake City, Utah for analysis.

Results and discussion

sampling conditions

We were able to sample all 14 stations on only two days. The weather and lake conditions were very unpredictable; some days the wind would not come up until late in the afternoon and on other days it would come up early in the morning and blow all day. For a more detailed, intense sampling program, personnel would need to be located much closer than Newport, 7 hours away. Because the weather was unpredictable, we focused the sampling on the south half of the lake (the commercial harvest area) and sampled the northern half when weather and time permitted. The October, 1998 samples were taken from the shore of the lake because we could not get on the lake at all.

water conditions

Table 2 summarizes the average salinity, temperature, ph, and lake level data. Individual station and sample data are listed in Appendix D. Average salinity ranged from a low of 37 $^{o}/_{oo}$ to a high of 51 $^{o}/_{oo}$. Average temperature ranged from 0.2° C in the winter to 23.1° C in the summer. Average ph ranged from 9.5 to 10.6. The temperature and ph data are incomplete due to equipment malfunctions. The lake level had been rising from a low in 1992, which was the lowest level since 1944 (Figure 1). Salinities and lake level were slightly lower than during the study by Conte and Conte (1988) where salinities were 54-80 $^{o}/_{oo}$ and lake level was above 4260 ft.

Table 2. Summary of water conditions at Lake Abert, 1997-1998.

Date	Stations sampled	Average salinity ($^{o}/_{oo}$)	Average temperature (^{o}C)	Average ph	Lake level (feet of elevation)
2/97	4	42	3.1	10.2	4,255.2
5/97	8	37	17.2	9.9	4,256.1
7/97	14	35	23.1	9.5	4,255.8
10/97	14	51	9.5	9.8	4,254.4
11/97	4(**)	60	3.7		
12/6/97	3(**)	62	3.7		
12/20/97	3(**)	62	0.2		
1/98	3(**)	59	3.8		
3/98	8	47	-	10.6	4,254.8
10/98	5 (*)	37	-		4,257.3

(*) Samples were not taken at established stations, see text

(**) Samples were taken by Avocet Artemia, Inc, Salt Lake City, Utah and not at established stations, see text

brine shrimp

The capture efficiency of the plankton net was not calculated. Another study using a similar net calculated a capture efficiency of 70% (Conte, Jellison et al., 1988). Therefore, estimates from this sampling could be considered low. Table 3 summarizes the estimated density data for brine shrimp during 1997-1998. Individual station and replicate count data are listed in Appendices E & F. The estimated population of brine shrimp was calculated by expanding the estimated average density to the volume of the lake. The volume of the lake was calculated from the lake level using the regression from Keister (1992). Densities were highest in late winter as nauplii were hatching. Over the spring and summer, densities decreased reaching the lowest levels in the fall.

Belovsky (1996) noted a similar pattern within a year for brine shrimp in the Great Salt Lake in Utah: densities increasing rapidly in the spring and then declining over the summer. He suggests that this pattern occurs in the Great Salt Lake because the shrimp population is food-limited: within an individual year, "as the season progresses, the shrimp may reduce algal abundance by consumption and this effect is enhanced as the shrimp become larger which increases each individual's consumption.". He also noted that between years, the monthly algal abundance is statistically correlated with the average salinity of the lake for the year so that algal abundance is lowest at very low and very high salinities and the average brine shrimp density was positively correlated with the largest algal abundance in a year. "This indicates that brine shrimp populations tend to be food-limited" in The Great Salt Lake. It would be helpful to determine the salinity tolerances of the *Ctenocladus circinnatus*, algae to determine if Lake Abert brine shrimp may also be food-limited.

In a study at Lake Abert in 1981-1982, Conte and Conte (1988) made density, population, and biomass estimates of brine shrimp. "The total lake wide population of brine shrimp derived from the 14 collecting stations was estimated to be 3.4×10^{11} adults with an estimated biomass of 6.6×10^{6} kg." The salinities during Conte's study was above $80^{o}/_{oo}$ during the first year and dropped to less than $40^{o}/_{oo}$ in the second year after "the lake received large amounts of freshwater as a result of heavy spring inflows". The volume of the lake was calculated to be 675×10^{6} m^3 (it is not clear whether this volume was in 1981 or 1982 or at what time of year). This volume would convert to a level of above 4260 feet of elevation using the equations by Keister (1992).

From the present study's data, the estimated population of adult brine shrimp in October 1997, was 1.9×10^{11} (Table 3), a little over half that in Conte's study. Using Conte's conversion of adults per kg, the estimated biomass in October, 1997 would be 3.7×10^{6} kg or 8.2 million pounds. Only one permit holder harvested a minimal amount of shrimp in 1997, but if all three permit holders had taken their entire quota of 50,000 pounds each, the commercial harvest would have accounted for approximately 1.8% of the total available biomass of shrimp.

Variations in salinity of saline lakes can result in different species distribution, abundance, and composition (Herbst, 1988; Stevens, 1990). Herbst (1988) proposed a model suggesting

abundance of species in saline lakes reaches a maximum at salinities intermediate between the physiological limitation of high salinity and the ecological limitations imposed by a diverse community at low salinity. Multiple years of data are needed, especially at higher salinities, to determine what might be "typical" population levels. Personal observations by Keith Kruise (Oregon Desert Brine Shrimp Co. Portland, OR, personal communication) suggest 1997 was below average in its population of brine shrimp.

This study did not look at vertical distribution of shrimp, but did notice a large variation in density between stations (Table 4), as did Conte and Conte (1988). They found little vertical stratification of shrimp between the surface layer and the bottom, but quite a patch horizontal spatial distribution during periods of peak abundance. We used the estimates of inter-station variance (in the formula by Prepas, 1984) in order to determine the number of sampling station that would be needed for future monitoring. The formula used is: $n = s^2/D^2X^2$; where n = number of sampling stations; s^2 = population variance; D = size of the ratio of the standard error to the mean (in this case, 25%); and X = mean density of shrimp. The estimated number of sampling stations needed to produce a standard error estimate of 25% of the mean varied from 1 to 16 (Table 4). During summer and fall, when densities are lower, the eight sampling stations on the southern half of the lake would probably be adequate to document shrimp abundance. During late winter and spring, when densities are higher, more stations may be needed.

In the late winter samples, all brine shrimp in Lake Abert were in the nauplii stage (Table 5). Over the spring and summer, the shrimp matured to juveniles and then almost all were adults in the fall. In the fall samples, a few nauplii were again present, possibly indicating the beginning of a second cohort. The counts of nauplii in the fall samples may be slightly low. Large numbers of water fleas (*Moina* sp.) in the fall samples made it difficult to distinguish the nauplii. Initially in the spring, all adult shrimp appeared to be males (Table 5). By fall, the sex ratio was close to even. In the Great Salt Lake, Gliwicz, Wurtsbaugh et al. (1995) found the population of brine shrimp consisted of two generations; one was from rapidly-growing adults that hatched from over-wintering cysts and then were gone by early June. These adults produced a second generation which grew much more slowly and only a small proportion attained maturity, "suggesting that many were unable to find sufficient food... and died of starvation". Multiple generations have been also reported in other areas: two generations have been consistently observed in Mono Lake, CA; four and eight generations have been estimated in other California areas (Lenz and Browne, 1991). "Several factors, including temperature and length of growing season, are probably important in determining the number of generations per year" (Lenz and Browne, 1991). Again, multiple years of data are needed to determine if the "normal "pattern in Lake Abert is mainly just one cohort or if different water conditions would produce multiply cohorts.

Table 3. Estimated average density (m^3) and population of brine shrimp by date, on Lake Abert, 1997-1998.

Date	Estimated average density of brine shrimp (m^3)	Lake level (feet of elevation)	Lake volume (acre feet)	Estimated population of brine shrimp (10^{12})
2/97	44,462	4,255.2	282,250	15.5
5/97	8,801	4,256.1	315,712	3.4
7/97	2,477	4,255.8	304,405	0.8
10/97	670	4,254.4	255,422	0.2
3/98	77,753	4,254.8	269,611	22.8
10/98	-	4,257.3	362,481	-

Table 4. Average density (m^3), number of sampling stations, 95% confidence interval, coefficient of variation, and number of stations that would have been required to produce standard errors of 25% of the mean on each sampling date for brine shrimp from Lake Abert, 1997-1998.

Date	Average density (m^3)	Number of sample stations	95% confidence interval	Coefficient of variation	Estimated N for 25% SE
2/97	44,462	3	24,376	0.22	1
5/97	8,801	8	7,244	0.98	16
7/97	2,477	4	1,439	0.37	2
10/97	670	14	118	0.31	2
3/98	77,753	8	41,781	0.64	7

Table 5. Average percent by life stage (nauplii, juvenile, adult) and sex ratio of adults for brine shrimp from Lake Abert, 1997-1998. P = present, but less than 1%. Individual station and replicate data are listed in Appendices G and H.

Date	Average percent by life stage			Average percent of adults by gender	
	nauplii	juvenile	adult	males	females
2/97	100	0	0	-	-
5/97	5	95	P	100	0
7/97	P	93	7	66	34
10/97	3	P	97	52	48
3/98	100	0	0	-	-

brine shrimp cysts

During most trips to the lake from fall until spring, "slicks" of cysts could be seen on the lake surface or along the shore. However, no cysts could be located anywhere on the October, 1998 trip. The samples of cysts taken were not of a quantitative nature: we did not look at factors that affect the abundance of cysts. However, there are factors that seem to have an effect on the availability of cysts for harvest purposes. The hatching rates and percent of empty shells in the samples are summarized in Table 6. Almost all the cysts collected were empty shells.

Initially, the harvest season for cysts was set at January through March. When the high percent of empty shells was noted in the first samples in January, we speculated the shrimp had already hatched. The permit holder then requested the season be adjusted to open in November to be able to harvest the cysts before they hatch; the request was approved. However, continued samples of floating cysts, even in November and December, showed the same high percent of

empty shells. Stevens (1990) noted that as the salinity in the Great Salt Lake decreases, the hard winter eggs produced by the shrimp sink to the bottom of the lake. We believe the same thing happened at Lake Abert at the salinities present during 1997-1998. It is also possible, the shrimp in this lake produce cysts that sink as do the shrimp in Mono Lake, California (Persoone and Sorgeloos, 1980; Lenz and Browne, 1991).

The high percent of empty shells in the floating "slicks" of cysts means the viable cysts were not on the surface of the lake and therefore not available for harvesting. For a brine shrimp cyst harvesting and marketing endeavor to be successful, it would be necessary to have much higher yield of viable cysts: i.e., lower shell percentages (<10%) and higher hatching percentages (>70 and preferably 90%) (Brad Marden, Avocet Artemia, Inc. ., Salt Lake City, Utah, personal communication). Further investigations would be needed to determine if the shrimp from Lake Abert will produce floating cysts and the optimum salinity for an adequate supply of floating viable cysts for a commercial harvest operation.

Brad Marden (Avocet Artemia, Inc., Salt Lake City, Utah, personal communication) believes the salinity would need to be above the 80-100 ppt range for a large enough quantity of viable cysts to be available for commercial harvest. Since the salinity of the water is related to the lake level, the level of the lake would have to be below approximately 4252 feet of elevation to achieve salinities in the 80-100 ppt range (Keister, 1992); below the average level of the last 50 years. The level of the lake was below 4252 feet several years in the early 1990's (Figure 1), but in only four other years since 1953. The winter of 1998-99 continues a wet weather pattern: total precipitation for the water year (starting October 1, 1998) is 124% of average and streamflow forecast for the Chewaucan River for March through July, 1999 is 165% of average (NWCC, 1999). Taylor (1999) believes weather patterns indicate Oregon is entering a wet weather period which may last 20 years. Given the rise in water level in the last few years (Figure 1), it seems unlikely the level will drop below 4252 feet in the next few years.

Table 6. Percent of hatched cysts and empty shells in samples of cysts from Lake Abert, 1997-1998. Samples were analyzed by Avocet Artemia Inc., Salt Lake City, Utah.

Date	Cysts hatch %	Shell %
2/97	0.0	100.0
11/97	1.9	90.9
12/6/97	4.0	94.9
12/20/97	2.7	94.7
1/98	4.1	86.6
2/98	0.0	100.0
3/98	0.0	100.0
10/98	no cysts located	

RECOMMENDATIONS

Future studies

A much more detailed, multi-year study would be needed to provide complete sustainable yield information:

- If a more intense sampling program is undertaken in the future, personnel need to be located much closer than Newport.
- During summer and fall, when densities are lower, the eight sampling stations on the southern half of the lake would probably be adequate to document shrimp abundance.
- During late winter and spring, when densities are higher, more stations may be needed.
- Updated conversions of adults per kg are needed to estimate biomass.
- Both this study and the study by Conte and Conte (1988) occurred when the salinities were relatively low. A major gap in information is what happens in the lake at high salinities:
  - Are brine shrimp more abundant at higher salinities? What is the upper tolerance limits? At what salinities is the population at its highest level?
  - Is more than one cohort a season produced at higher salinities?
  - Are brine shrimp at Lake Abert food-limited? What are the salinity tolerances of the *Ctenocladus circinnatus*, algae?
- The present level and timing of harvest activity, basically only one permit during the summer, does not seem to cause any significant disturbance to bird populations. If there is an increase in activity, especially at other times of the year, additional information would be needed on the effects of harvest activity on bird populations.

Future management

adults

The main increase in interest in brine shrimp has been for cysts rather than adults; the additional permits for adult harvest have been issued but none were used. As long as the present level of interest for adults continues, the current level of permits appears to be sufficient to allow some turnover in permits but not an over harvest of shrimp.

cysts

If the salinity needs to be above the 80-100 ppt range to provide enough floating cysts for a commercial harvest operation, the level of the lake would need to drop to approximately the 4252 ft level to achieve these conditions; below the average level of the last 50 years. The level of the lake was below 4252 feet several years in the early 1990's, but in only four other years since 1953. Given the wet weather cycle and rise in water level in the last few years, it seems unlikely the level will drop below 4252 feet in the next few years. Therefore, we recommend the permit for cyst harvesting be discontinued.

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APPENDICES

Appendix A. Water level data for Lake Abert, Oregon, 1926-1998. The 1926-1990 data are from Keister, (1992). The 1990-1996 data are from Lakeview Watermaster, Oregon Water Resources Department. The 1997-1998 data are from personal observation. Lake levels were those taken as close as possible to October each year.

Year	Lake level (feet of elevation)	Year	Lake level (feet of elevation)	Year	Lake level (feet of elevation)
1926	4,244.0	1951	4,249.1	1976	4,257.8
1927	4,248.0	1952	4,251.9	1977	4,256.2
1928	4,247.7	1953	4,253.5	1978	4,254.5
1929	4,245.9	1954	4,254.5	1979	4,252.4
1930	4,245.7	1955	4,252.8	1980	4,252.7
1931	4,244.0	1956	4,257.3	1981	4,250.8
1932	4,245.6	1957	4,256.8	1982	4,255.7
1933	4,244.0	1958	4,259.1	1983	4,258.8
1934	4,244.0	1959	4,257.0	1984	4,260.9
1935	4,245.8	1960	4,251.7	1985	4,259.3
1936	4,246.6	1961	4,251.7	1986	4,261.7
1937	4,245.8	1962	4,250.6	1987	4,257.9
1938	4,249.3	1963	4,253.6	1988	4,255.7
1939	4,247.2	1964	4,253.4	1989	4,255.2
1940	4,248.1	1965	4,257.2	1990	4,252.7
1941	4,247.6	1966	4,255.4	1991	4,250.6
1942	4,248.4	1967	4,255.8	1992	4,247.6
1943	4,251.3	1968	4,253.6	1993	4,250.6
1944	4,249.6	1969	4,254.1	1994	4,248.0
1945	4,249.2	1970	4,255.1	1995	4,249.0
1946	4,249.9	1971	4,259.1	1996	4,252.5
1947	4,248.1	1972	4,259.1	1997	4,254.4
1948	4,248.9	1973	4,257.3	1998	4,257.3
1949	4,248.7	1974	4,258.8		
1950	4,248.4	1975	4,258.8		

Appendix B. UTM, latitude/longitude coordinates of sample stations, and north/south division line.

Station	UTM (mN)	UTM (mE)	Latitude	Longitude
1	4711717	726580	42° 31' 35.2"	120° 14' 28.9"
2	4712866	726633	42° 32' 05.9"	120° 14' 25.2"
3	4714471	728544	42° 32' 55.8"	120° 12' 29.2"
4	4714339	727372	42° 32' 52.8"	120° 13' 50.7"
5	4715936	725751	42° 33' 46.2"	120° 14' 59.4"
6	4716154	727612	42° 33' 51.3"	120° 13' 37.6"
7	4716148	729661	42° 33' 48.9"	120° 12' 07.8"
8	4718301	730315	42° 34' 57.9"	120° 11' 36.1"
9	4720706	724462	42° 36' 22.0"	120° 15' 49.1"
10	4722750	729779	42° 37' 22.6"	120° 11' 56.0"
11	4725613	730256	42° 38' 54.8"	120° 11' 28.0"
12	4725662	727202	42° 38' 59.6"	120° 13' 41.9"
13	4728537	731132	42° 40' 28.5"	120° 10' 45.3"
14	4721212	724810	42° 42' 01.9"	120° 15' 18.9"
north/south line	4722051		42° 37' 00.0"	

Appendix C. Summary of data and samples of brine shrimp and cysts collected from Lake Abert, 1997-1998. AA = Avocet Artemia Inc., Salt Lake City, Utah.

Date	Number of stations sampled	Data/samples collected						Samples collected by
		temp	salinity	ph	water level	shrimp	cysts	
2/97	4	x	x	x	x	x		ODFW
2/97							x	AA
5/97	8	x	x	x	x	x		ODFW
7/97	14	x	x	x	x	x		ODFW
10/97	14	x	x	x	x	x		ODFW
11/97	4(*)	x	x				x	AA
12/6/97	3(*)	x	x				x	AA
12/20/97	3(*)	x	x				x	AA
1/98	3(*)	x	x				x	AA
2/98	2(*)	x					x	AA
3/98	8(*)		x		x	x	x	ODFW
10/98	3(*)		x		x		(**)	ODFW

(*) Samples were not taken at established stations, see text
(**) looked for cysts but none were located

Appendix D. Bottom depth, salinity, temperature, and ph, by station, of Lake Abert during 1997 and 1998. * = equipment malfunctioned.

Date	2/28/97				5/22/97				7/11/97				10/15/97				3/12/98			
Station	Bottom depth (ft)	Salinity (ppt)	Temp (°C)	ph	Bottom depth (ft)	Salinity (ppt)	Temp (°C)	ph	Bottom depth (ft)	Salinity (ppt)	Temp (°C)	ph	Bottom depth (ft)	Salinity (ppt)	Temp (°C)	ph	Bottom depth (ft)	Salinity (ppt)	Temp (°C)	ph
1	6.5				6.4	36	17.7	10.0	6.1	38	23.2	9.7	4.1	52	*	9.9	4.8	44	*	*
2	8.5				8.9	38	17.2	10.0	8.7	35	22.5	9.6	7.2	52	*	9.9	7.7	43	*	*
3	9.5				10.0	34	15.8	10.0	7.4	35	21.5	9.6	6.3	50	*	10.1	8.6	47	*	*
4	11.5	42	3.1	10.2	11.2	38	17.5	9.9	11.2	32	22.5	9.5	10.0	50	*	11.2	10.4	47	*	*
5					8.5	39	17.1	9.9	8.3	35	22.5	9.4	7.0	51	9.3	9.9	7.0	48	*	*
6					11.9	39	17.4	9.9	11.8	35	22.8	9.4	10.8	51	9.2	9.7	10.7	48	*	*
7					10.6	36	17.4	9.9	10.5	33	22.6	9.4	9.1	51	9.4	9.5	9.3	47	*	*
8					10.5	38	17.7	9.9	10.5	34	22.9	9.5	9.1	50	9.8	9.4	9.1	48	*	*
9									8.7	37	24.1	9.6	7.2	50	9.7	9.4				
10									10.0	35	23.9	9.4	8.8	50	*	9.1				
11									9.0	34	24.0	9.5	7.9	50	*	9.6				
12									10.8	37	24.1	9.6	7.7	51	*	9.7				
13									7.7	35	23.2	9.6	6.4	51	*	9.4				
14									5.4	37	23.5	9.6	4.0	51	*	10.2				

Appendix E. Sample depth, count, volume, and estimated density (m^3) of brine shrimp from Lake Abert during 1997 and 1998.

Date		2/28/97				5/22/97				7/11/97			
Station	Replicate	Sample depth (ft)	Sample count	Sample volume (m^3)	Est. density (m^3)	Sample depth (ft)	Sample count	Sample volume (m^3)	Est. density (m^3)	Sample depth (ft)	Sample count	Sample volume (m^3)	Est. density (m^3)
1	1	6.5				5.0	2,905	0.108	26,967	5.0			
	2					5.0	1,154	0.108	10,712	5.0			
	3					5.0	1,592	0.108	14,778	5.0			
2	1	8.5	9,877	0.183	53,933	6.0	399	0.129	3,087	8.0	133	0.172	772
	2					6.0	887	0.129	6,862	8.0	190	0.172	1,102
	3					6.0	433	0.129	3,350	8.0	578	0.172	3,353
3	1	9.5	7,029	0.205	34,342	8.0	5,025	0.172	29,154	7.0			
	2					8.0	4,468	0.172	25,922	6.0			
	3					8.0	4,317	0.172	25,046	6.0			
4	1	11.5	11,177	0.248	45,111	9.0	1,038	0.194	5,353	10.0			
	2					9.0	522	0.194	2,692	10.0			
	3					9.0	395	0.194	2,037	10.0			
5	1					6.5	1,135	0.140	8,105	7.0			
	2					6.5	951	0.140	6,791	7.0			
	3					6.5	496	0.140	3,542	7.0			
6	1					10.0	455	0.215	2,112	11.0			
	2					10.0	226	0.215	1,049	11.0			
	3					10.0	584	0.215	2,711	11.0			
7	1					9.0	964	0.194	4,971	9.0			
	2					9.0	1,020	0.194	5,260	9.0			
	3					9.0	1,217	0.194	6,276	9.0			
8	1					9.0	611	0.194	3,151	9.0	338	0.194	1,743
	2					9.0	1,042	0.194	5,374	9.0			
	3					9.0	1,148	0.194	5,920	9.0			
9	1									7.0			
	2									7.0			
	3									7.0			
10	1									9.0			
	2									9.0			
	3									9.0			
11	1									8.0	620	0.172	3,597
	2									8.0			
	3									8.0			
12	1									9.0			
	2									9.0			
	3									9.0			
13	1									6.0	365	0.129	2,824
	2									6.0			
	3									6.0			
14	1									4.0			
	2									4.0			
	3									4.0			

Appendix E (con't). Sample depth, count, volume, and estimated density (m^3) of brine shrimp from Lake Abert during 1997 and 1998.

Date		10/15/97				3/12/98			
Station	Replicate	Sample depth (ft)	Sample count	Sample volume (m^3)	Est. density (m^3)	Sample depth (ft)	Sample count	Sample volume (m^3)	Est. density (m^3)
1	1	3.5	21	0.075	278	3.5	10,490	0.075	139,110
	2	3.5	30	0.075	398	3.5	8,446	0.075	112,004
	3	3.5	42	0.075	557	3.5	8,525	0.075	113,052
2	1	6.0	114	0.129	882	7.0	5,242	0.151	34,758
	2	6.0	108	0.129	835	7.0	4,586	0.151	30,408
	3	6.0	41	0.129	317	7.0	4,860	0.151	32,225
3	1	5.0	35	0.108	325	8.0	9,914	0.172	57,519
	2	5.0	55	0.108	511	8.0	11,009	0.172	63,872
	3	5.0	58	0.108	538	8.0	12,722	0.172	73,810
4	1	9.5	162	0.205	791	10.0	14,810	0.215	68,740
	2	9.5	128	0.205	625	10.0	18,756	0.215	87,055
	3	9.5	124	0.205	606	10.0	15,970	0.215	74,124
5	1	7.0	146	0.151	968	6.0	4,219	0.129	32,637
	2	7.0	64	0.151	424	6.0	3,550	0.129	27,462
	3	7.0	70	0.151	464	6.0	6,365	0.129	49,238
6	1	7.0	45	0.151	298	10.0	38,815	0.215	180,157
	2	9.5	86	0.205	420	10.0		0.215	
	3	10.0	91	0.215	422	10.0		0.215	
7	1	8.0	121	0.172	702	9.0	10,757	0.194	55,475
	2	8.0	64	0.172	371	9.0	10,210	0.194	52,654
	3	8.0	236	0.172	1,369	9.0	6,372	0.194	32,861
8	1	8.0	156	0.172	905	8.0	10,426	0.172	60,489
	2	8.0	190	0.172	1,102	8.0	11,894	0.172	69,006
	3	8.0	114	0.172	661	8.0	10,188	0.172	59,109
9	1	6.0	103	0.129	797				
	2	6.0	87	0.129	673				
	3	6.0	101	0.129	781				
10	1	7.5	90	0.162	557				
	2	7.5	96	0.162	594				
	3	7.5	91	0.162	563				
11	1	6.5	53	0.140	378				
	2	6.5	119	0.140	850				
	3	6.5	128	0.140	914				
12	1	6.0	109	0.129	843				
	2	6.0	102	0.129	789				
	3	6.0	197	0.129	1,524				
13	1	6.0	150	0.129	1,160				
	2	6.0	114	0.129	882				
	3	6.0	93	0.129	719				
14	1	3.0	29	0.065	449				
	2	3.0	34	0.065	526				
	3	3.0	23	0.065	356				

Appendix F. Estimated density of brine shrimp (m^3) of Lake Abert during 1997 and 1998. * = samples taken, but inadequately processed.

Date	Replictate	Station 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average
2/28/97	1		53,933	34,342	45,111											44,462
5/22/97	1	26,967	3,087	29,154	5,353	8,105	2,112	4,971	3,151							
	2	10,712	6,862	25,922	2,692	6,791	1,049	5,260	5,374							
	3	14,778	3,350	25,046	2,037	3,542	2,711	6,276	5,920							
	mean	17,486	4,433	26,708	3,361	6,146	1,957	5,503	4,815							8,801
7/11/97	1	*	772	*	*	*	*	*	1,743	*	*	3,597	*	2,824		
	2	*	1,102	*	*	*	*	*	*	*	*	*	*	*	*	
	3	*	3,353	*	*	*	*	*	*	*	*	*	*	*	*	
	mean		1,742						1,743			3,597		2,824		2,477
10/15/97	1	278	882	325	791	968	298	702	905	797	557	378	843	1,160	449	
	2	398	835	511	625	424	420	371	1,102	673	594	850	789	882	526	
	3	557	317	538	606	464	422	1,369	661	781	563	914	1,524	719	356	
	mean	411	678	458	674	619	380	814	890	750	571	714	1,052	920	444	670
3/12/98	1	139,111	34,758	57,519	68,740	32,637	180,157	55,475	60,489							
	2	112,005	30,408	63,872	87,055	27,462		52,654	69,006							
	3	113,052	32,225	73,810	74,124	49,238		32,861	59,109							
	mean	121,389	32,464	65,067	76,639	36,446	180,157	46,997	62,868							77,753

Appendix G. Percent of brine shrimp by life stage (n=nauplii, j=juvenile, a=adult) of Lake Abert during 1997 and 1998. P = present, but less than 1%. * = samples taken, but inadequately processed.

Date	Sub-sample	Station 1			2			3			4			5			6			7			8		
		n	j	a	n	j	a	n	j	a	n	j	a	n	j	a	n	j	a	n	j	a	n	j	a
2/28/97	1				100	0	0	100	0	0	100	0	0												
5/22/97	1	0	100	P	1	99	0	0	100	0	P	99	P	P	100	0	13	87	0	11	89	0	13	87	P
	2	0	100	P	P	100	0	0	100	0	9	91	0	P	100	0	13	87	0	10	90	0	11	89	0
	3	0	100	0	0	100	0	0	100	0	9	91	0	1	99	0	11	89	P	4	96	P	10	90	0
	mean	0	100	P	P	100	0	0	100	0	6	94	0	P	100	0	12	88	0	8	92	0	11	89	P
7/11/97	1		*		0	94	6		*			*			*			*			*		0	100	0
	2		*		0	94	6		*			*			*			*			*			*	
	3		*		P	91	9		*			*			*			*			*			*	
	mean				P	93	7																		
10/15/97	1	0	5	95	2	1	97	20	0	80	1	0	99	1	1	98	0	2	98	0	1	99	3	0	97
	2	0	3	97	2	1	97	4	0	96	2	0	98	6	0	94	0	0	100	2	0	98	1	0	99
	3	0	0	100	5	2	93	17	2	81	1	0	99	4	0	96	1	0	99	1	0	99	4	0	96
	mean	0	3	97	3	1	96	14	P	86	1	0	99	4	P	96	P	1	99	1	P	99	3	0	97
3/12/98	1	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0
	2	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0				100	0	0	100	0	0
	3	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0				100	0	0	100	0	0
	mean	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	0	0

Date	Sub-sample	Station 9			10			11			12			13			14			Average		
		n	j	a	n	j	a	n	j	a	n	j	a	n	j	a	n	j	a	n	j	a
2/28/97	1																			100	0	0
5/22/97	1																					
	2																					
	3																					
	mean																			5	95	P
7/11/97	1		*			*		0	92	8		*		0	89	11		*				
	2		*			*						*						*				
	3		*			*						*						*				
	mean																			P	93	7
10/15/97	1	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	7	0	93			
	2	0	0	100	0	0	100	0	0	100	0	0	100	0	0	100	4	0	96			
	3	0	0	100	1	0	99	0	0	100	0	0	100	3	0	97	6	0	94			
	mean	0	0	100	P	0	100	0	0	100	0	0	100	1	0	99	6	0	94	3	P	97
3/12/98	1																					
	2																					
	3																					
	mean																			100	0	0

Appendix H. Percent of adult brine shrimp by gender (m=male, f=female, n=number) from Lake Abert during 1997 and 1998. * = samples taken, but inadequately processed.

Date	Sub-sample	Station 1			2			3			4			5			6			7			8		
		m	f	n	m	f	n	m	f	n	m	f	n	m	f	n	m	f	n	m	f	n	m	f	n
5/22/97	1	100	0	1							100	0	1										100		1
	2	100	0	1																					
	3																100		1	100		2			
	mean	100	0								100	0					100	0		100	0		100	0	
7/11/97	1		*		88	12	8		*			*			*			*			*			*	
	2		*		58	42	12		*			*			*			*			*			*	
	3		*		67	33	52		*			*			*			*			*			*	
	mean				71	29																			
10/15/97	1	35	65	20	58	42	111	50	50	28	52	48	161	62	38	143	57	43	44	48	52	120	56	44	152
	2	41	59	29	62	38	105	62	38	53	55	45	126	52	48	60	55	45	86	46	54	63	53	47	188
	3	45	55	42	61	39	38	52	48	47	55	45	123	43	57	67	49	51	90	49	51	234	63	37	109
	mean	40	60		60	40		55	45		54	46		52	48		54	46		48	52		57	43	

Date	Sub-sample	Station 9			10			11			12			13			14			Average	
		m	f	n	m	f	n	m	f	n	m	f	n	m	f	n	m	f	n	m	f
5/22/97	1																				
	2																				
	3																				
	mean																			100	0
7/11/97	1		*			*		64	36	47		*		62	38	39		*			
	2		*			*						*						*			
	3		*			*						*						*			
	mean							64	36					62	38					66	34
10/15/97	1	52	48	103	53	47	90	43	57	53	54	46	109	48	52	150	44	56	27		
	2	57	43	87	50	50	96	52	48	119	50	50	102	50	50	114	50	50	32		
	3	56	44	101	54	46	91	51	49	128	49	51	197	50	50	90	45	55	22		
	mean	55	45		52	48		49	51		51	49		49	51		46	54		52	48

APPENDIX B. Synopsis of information on flat abalone

Flat Abalone
Haliotis walallensis

(Note: there is little information in the literature specifically on the flat abalone species. Much of the following information is for abalone in general, unless flat abalone are specifically mentioned)

Ecology

Flat abalone occur from British Columbia southward into Baja California; but are sparsely distributed throughout its range (Cox, 1962; Mottet, 1978; Ebert and Houk, 1989; Hahn, 1989). Flat abalone are found along open coasts from intertidal to 17 m in northern California, to 20 m in central California, and at depths greater than 27 m in southern California (Cox, 1962; Mottet, 1978; Hahn, 1989). Abalone prefer high energy, open coastal environments with good water circulation (Karpov and Tegner, 1992). Flat abalone live on and under rocks with other species of abalone (Cox, 1962).

Depth and geographical distribution of abalone are best described by seawater temperature (Karpov and Tegner, 1992; Lindberg, 1992).

Life History

Reproduction

The spawning season of flat abalone is April, May, June (Hahn, 1989).

Abalone are broadcast spawners and release their sex products directly into the seawater, where fertilization takes place (Mottet, 1978). The sexes are separate (Cox, 1962; Mottet, 1978) and the sex ratio is usually one to one (Mottet, 1978).

At the biological minimum size when the gonads first ripen, the abalone may produce only a thousand eggs, but millions of eggs are likely in later years. There is usually a simple near-linear relationship between the number of mature eggs in the ovary and body weight (Mottet, 1978). Sexual maturity is reached at a small size, and fecundity, which increases exponentially with size, is high (Karpov and Tegner, 1992).

The spawning season appears to be affected by environmental differences and there is considerable variation even in the same species from one year to the next, and from one location to another (Mottet, 1978). Although the spawning season for the different species of Haliotis may vary according to their location, liberation of sex products is believed to depend upon the water's temperature (Cox, 1962).

After a relatively brief period (2-11 days) in the water column, the free-swimming larva settles to the bottom and assumes the creeping life-style of a post-larva (Mottet, 1978).

Flat abalone hybridizes with pink abalone, *H. corrugata* (Cox, 1962) and are capable of hybridizing with red abalone (Mottet, 1978; Hahn, 1989).

Growth

Most flat abalone are 7.5 to 12.5 cm in length (three to five inches) but can reach 17.5 cm (seven inches) (Cox, 1962; Mottet, 1978; Hahn, 1989).

Growth of abalone is quite slow, and it takes a minimum of 4 years (and often several years longer) for the abalone to grow to a moderate length of 10 cm (4 inches). Both male and female grow at the same rate (Mottet, 1978).

In at least some abalone species, food intake and corresponding growth correlate most strongly with the water temperature, and is slowed or stopped at higher or lower temperatures (Mottet, 1978). Growth during the first two years is believed to be fairly uniform among all species depending on the amount and kind of food available. Growth rates of adults are highly irregular and size is not directly related to age. Growth is directly dependent upon the availability of food (Cox, 1962).

The amount of meat in abalone with the same shell dimensions will vary depending on seasonal and environmental conditions (Mottet, 1978).

Food

Flat abalone feed by grazing on small attached algae (Cox, 1962). Abalone are almost entirely vegetarians, in locations where there is abundant drift or vegetation. Each abalone species shows definite preferences for certain types of seaweeds. Abalone may eat up to 39% of their weight in seaweed per day, but with better food species, 10-20% is more typical (Mottet, 1978).

Abalone, particularly when they are young, will eat other things besides seaweeds. Very small abalone less than a year old usually subsist on a diet of sessile diatoms and sometimes coralline algae. In fact, young abalone often grow very well in areas which are not suitable for adults (Mottet, 1978). During free-swimming stages, diet consists of pelagic plankton. As juveniles, they feed upon diatoms attached to the substrate (Cox, 1962).

The color of the shell can vary depending on the food eaten. The diets of pinto, flat, and threaded abalone probably contain greater amounts of diatomaceous and coralline algae than do the diets of the other species. This is suspected because the shells of these three species exhibit the typical mottling produced by this diet (Cox, 1962).

Most abalone are quite inactive and do not forage unless they are unable to catch sufficient drift algae (Mottet, 1978). California abalone feed primarily on algal drift; foraging on attached algae is rare. Specialization on drift algae puts abalone in competition with sea urchins. Sea urchin grazing has been reported to limit kelp and abalone distributions in many regions of California (Karpov and Tegner, 1992).

Predators

Predators includes sea otters, fishes (cabazon and sheepshead), crab, spiny lobster, octopuses, seastars, and gastropods (Cox, 1962; Karpov and Tegner, 1992). In some locations, predation is the major factor restricting abalone to certain habitats, limiting the size of the population and affecting feeding behavior. Most abalone predators hunt by sight. To reduce the probability of attack, abalone rarely move about except under the cover of darkness (Mottet, 1978).

Adult abalone, unless they have become dislodged from the substrate, are not ordinarily vulnerable to fish predation (Cox, 1962; Karpov and Tegner, 1992). Many species of fish will attack abalone which have become detached from the substrate due to storms or human activities, and a few are adept at knocking the abalone off the substrate (Mottet, 1978). If displaced and unable to right themselves quickly, the abalone usually fall victim to the always-present fish. Fish immediately swarm around upturned abalone and tear pieces from the foot (Cox, 1962). In one study, a third of the fish stomachs contained the shells of young *H. corrugata* and *H. wallalensis*. (Mottet, 1978).

The young of all species are restricted by predators to the undersides of rocks or to crevices where they are unlikely to be seen (Mottet, 1978). Small abalone are preyed upon by starfish but large abalone successfully resist the starfish attacks even though the starfish are larger (Cox, 1962). Though starfish are known to prey on abalone, there are no studies to indicate that they are a significant problem (Mottet, 1978).

Where urchin populations are next to abalone, there is competition for food and living space. Once sea urchins have gained a foothold, they seldom leave and they may be able to out-compete abalone for food (Cox, 1962; Mottet, 1978). Sea urchins are more intensive grazers than abalone and they crop the rocks almost completely bare (Cox, 1962).

In North America, sea otters are potentially the greatest source of danger to abalone population, and it is likely that sea otters and a commercial abalone fishery cannot coexist in the same area (Mottet, 1978).

Population

Flat abalone are generally not plentiful, but occasionally abundant in small areas (Cox, 1962). Abundance is highest where physical conditions allow good kelp growth and the substrate promotes trapping of drift kelp (Karpov and Tegner, 1992).

Estimates of the mortality rate of native abalone populations, made on different species in different locations by a variety of methods, vary considerably. Studies from southern and central California suggest that natural finite mortality rates are quite high. In central California, three methods resulted in finite mortality rate estimates of 0.3 to 1.0 for one population of red and flat abalone (Tegner and Butler, 1989).

A sport and commercial fishery for abalone usually results in many more mortalities than are revealed by fishing statistics. A serious problem is the wounds inflicted on under-sized abalone while they are being removed from the substrate. Bar cut abalone bleed profusely because abalone blood has no clotting mechanism. Sampling has shown that the percentage of legal-sized abalone which are cut varies greatly depending upon species, accessibility, weather conditions, and the experience of the collector. commercial divers cut 8-13% of their catch (Mottet, 1978).

Storms can be an important source of mortality and may limit abalone distribution in areas of greatest exposure (Karpov and Tegner, 1992).

In California, abalone stocks are in decline due to commercial harvest efficiency, increased market demand, sport fishery expansion, an expanding population of sea otters, pollution of mainland habitat, and loss of kelp populations. Management efforts to protect stocks through size limits and limits on the number of commercial abalone fishermen have been ineffective (Karpov and Tegner, 1992).

Harvest

After surveys for red abalone were conducted on the southern Oregon coast from 1958-1962, abundance of red abalone was deemed insufficient to support a commercial fishery and commercial harvest of all abalone was prohibited. Sport harvest is basically limited to the southern Oregon coast where a few red abalone can be found. Annual sport harvest is estimated to be less than 100 animals.

Management

Present Regulations

Commercial harvest of abalone is not allowed in Oregon. Sport harvest is limited to abalone greater than 8 inches in length. This size limit precludes the harvest of the smaller flat abalone species.

There is no commercial harvest of abalone in any west coast state or provence at this time. California closed the last commercial harvest of abalone in 1997, mostly due overfishing. Recreatoional harvest is also closed south of San Francisco because of overfishing and "withering syndrome" disease (Kashiwada, 1999). Washington has never allowed commercial harvest of abalone and they closed their recreational harvest in 1994 (Bradbury, 1999). Alaska has not opened their commercial fishery since 1995 due to low stock abundance (Larson, 1999)

In Canada, commercial harvest of abalone has not been allowed since 1990 because of poor stock conditions. Illegal harvests apparently continued after the closure of the legal fishery because of high abalone prices. Although stock reviews are ongoing, there is little chance it will be opened soon (Muse, 1998).

Suggestions for Future Management

There is very little information available on the flat abalone species. Any harvest should be restrictive until abundance, distribution, and other population parameters can be obtained.

Abalone are a very high value product. A high degree of interest has led to a great deal of illegal harvest activities in other fisheries.

A dive fishery should be restricted to conserve intertidal resources. Refugia to protect nursery areas may be beneficial.

A minimum size limit would insure a portion of the population has a chance to spawn before being harvested.

Most sessile (slow or non-moving) invertebrates need tight adult concentrations in order for successful egg fertilization to occur.

Effects Evaluation

Information is not sufficient to meet statewide planning Goal 19. Additional information is needed to determine short-term and long-term effects of harvest on flat abalone resources and on other resources. Flat abalone should be managed under the developing fisheries program with conservative numbers of permits and restrictions.

(1) Sustainability of developmental fisheries resources or incidental catch under proposed future harvest:

a. Flat abalone have a fairly wide distribution, but abundance is sparse.
b. Abundance, distribution, and life history data are limited.
c. Abalone have a relatively high fecundity.
d. There may be undocumented mortalities from injuries during harvest activities.
e. Fisheries in other areas have shown that abalone populations can be easily over exploited.

(2) Biological and ecological effects on critical marine habitats, other habitats and other species supported by those habitats:

a. Dive gear would have very little impact on the habitat or other species and little incidental catch.
b. The activity of turning over rocks while searching for abalone may have some impact on habitat.
c. Inability to distinguish flat abalone from small red abalone may result is some incidental harvest of red abalone.
d. There is potential for diving activities to cause disturbance to marine mammals and birds utilizing offshore rocky areas.
e. If sea urchins are able to move into areas from which abalone have been harvested, the urchins may out-compete the remaining abalone for food or keep the abalone population from reestablishing.

(3) Conformity and compatibility with existing uses such as commercial and recreational fishing, non-consumptive uses, public access, etc:

a. There is currently no commercial harvest of any species of abalone.
b. There is no recreational harvest of flat abalone due to size limits.
c. There may be concerns with having a commercial harvest but not allowing a sport harvest for this species.

(4) Ability of the Department and other agencies to monitor the fishery for needed data and compliance with rules and regulations:

a. Analysis of existing data, sampling and monitoring a new fishery would require additional staff resources.

(5) Recommendations for future fishery development including gear types and effort levels:

a. Information not sufficient to determine optimum effort levels.
b. Alternatives to harvesting wild stocks such as culturing flat abalone may exist and could be explored.

Program Objectives

(1) Develop scientific information on the stocks and life history of flat abalone.

a. Need opportunities for on-board, dockside, and/or research sampling.
b. Need recording of effort, location, and time on logbooks.

(2) Develop understanding of effects of harvest on local ecosystem.

a. Conduct literature review and analyze habitat studies.
b. Need research cruises with underwater video gear or using SCUBA methods to evaluate effects on ecosystem.

(3) Develop improved fishing practices and equipment to protect the local resources.

a. Need research cruises with underwater video gear, using SCUBA methods, and/or ride-along trips on harvest vessels.

(4) Identify and protect critical habitat and other important biological habitats for flat abalone or other affected resources.

a. Need research sampling to identify juvenile, spawning, and rearing areas.
b. Fisheries should be restricted to depths greater than 10 feet from MLLW to conserve resources.
c. Refugia may be very helpful.

(5) Report findings and research data during annual review.

Management Options

Board Recommendations

1. Permits - 1 (issued to a vessel)
2. Renewal requirements - 10 landings of 20 lb.
3. Other permit stipulations
   a. minimum size limit - 4.5 inches
   b. season quota - 3,000 pounds
   c. season - May through October
   d. harvest area - below 10 ft from MLLW
   e. gear - abalone irons only
   f. no more than two divers on vessel

Staff Recommendation

1. Status quo - species not on developmental species list; no commercial harvest of abalone.

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