MEMORANDUM

TO:	Council, SSC and AP Members	
FROM:	Clarence G. Pautzke Executive Director	
DATE:	November 20, 1995	
SUBJECT:	Individual Bycatch Quotas/Comprehensive Rationalization	

ESTIMATED TIME
2 HOURS

ACTION REQUIRED

Review analytical outline for Plan Amendment and provide further direction to analysts.

BACKGROUND

At the June 1995 meeting the Council approved development of an IFQ management alternative for the BSAI pollock fisheries. Because of the relationship of those fisheries to other BSAI groundfish fisheries, the proposal included development of IBQs for all non-pollock groundfish fisheries in the BSAI. In September the Council also received a proposal from United Catcher Boats (UCB) to develop a similar program using vessel bycatch accounts (VBAs). At that meeting the Council identified IBQs, or some form of individual vessel accountability, as a high priority item for staff attention.

Also at the September meeting, staff recommended that the IBQ program be developed separately from the BSAI pollock IFQ program, due to the complex, and perhaps contentious, nature of both of these proposals. If approved, both programs could be implemented simultaneously. In developing an analytical outline for this program, staff has borrowed from the UCB proposal in fleshing out some of the elements and options. Item C-4(a) in your notebooks provides that analytical outline and will be presented by NMFS analysts working on this proposal. The original UCB proposal from September is included as Appendix A to the analytical outline. Our intent is to have an initial analysis available for review in April, with a final decision possible by June.

AGENDA C-4(a)
DECEMBER 1995

ANALYTICAL OUTLINE
FOR THE EVALUATION OF A VESSEL BYCATCH ACCOUNT PROGRAM

Prepared by Joe Terry

Socioeconomic Assessment Task
Resource Ecology and Fisheries Management Division
Alaska Fisheries Science Center
National Marine Fisheries Service
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INTRODUCTION

In response to concerns about the levels of bycatch in the Bering Sea/Aleutian Islands area (BSAI) and Gulf of Alaska (GOA) groundfish fisheries, the North Pacific Fishery Management Council (Council) has recommended and the Secretary of Commerce has approved and implemented a variety of management actions that were intended to help control the bycatch of Pacific halibut, crab, Pacific herring, and Pacific salmon in the groundfish fisheries. Recently, the bycatch of groundfish in the groundfish fisheries and the bycatch of crab in the BSAI crab fisheries have also received increased attention. Of the 34 amendments to the BSAI groundfish fishery management plan (FMP) that have been considered by the NPFMC since 1982, 13 addressed primarily bycatch issues and 9 additional amendments addressed some aspect of bycatch management. Although many of the management measures that have been taken to control bycatch in the BSAI groundfish fishery have decreased bycatch, the three-part bycatch problem remains. The problem is as follows:

1. The levels of bycatch of prohibited species and groundfish species are unnecessarily high.

2. The cost of controlling bycatch is unnecessarily high.

3. The distribution of the cost of bycatch is highly inequitable.

The lack of bycatch accountability by individual fishing vessels has been identified as the principal source of the problem and over the last few years there has been increased interest in management measures that would increase individual accountability. The most recent example is the vessel bycatch account program (VBAP) proposed by United Catch Boats (UCB). In September, the Council asked staff to prepare by the December 1995 meeting an analytical outline for developing and evaluating a VBAP proposal.

This report was prepared in response to that request. The report identifies the issues to be addressed in developing a VBAP, presents an initial set of alternatives for such a program, provides information concerning the nature and source of the three-part bycatch problem, and describes the types of analyses that would be conducted to assist in the development and evaluation of such a program. Two Alaska Fisheries Science Center processed reports were prepared in anticipation of further Council consideration of VBAPs to address the three-part bycatch problem. They are: 1) Using economic incentives in environmental management: The case for marketable permits for pollution control, and 2) Community development quota (CDQ) and open access pollock fisheries in the eastern Bering Sea: A comparison of groundfish utilization and prohibited species bycatch. Copies of both processed reports were reproduced by Council staff for the December 1995 meeting.

The UCB proposal is used as a starting point in this report for several reasons: 1) it was presented to the Council; 2) it is reported to have widespread support within the fishing industry; and 3) to date, it is the most complete proposal. The UCB VBAP proposal that was submitted to the Council June 8, 1995 is included in Appendix A.

The term "vessel bycatch account" is taken from the UCB proposal. It is one of several terms that could be used to describe a program in which each fishing vessel is held individually accountable for its own bycatch by establishing prohibited species catch (PSC) allowances at the vessel level. Currently, the PSC allowances are at the fishery level with fisheries defined by gear group and target species.

ISSUES

The three principal issues to be addressed are as follows:

1. the problems being addressed and the objectives of a VBAP proposal;

2. the technical feasibility and cost of adequate monitoring and enforcement; and

3. the alternatives for the elements of a VBAP including the allocation rules for vessel bycatch accounts (VBAs), transferability, VBA species, the retention of VBA species, restrictions on the ownership and use of VBAs, the inclusion of small vessels with limited or no observer coverage, the retention of other bycatch management measures, and sources of funding for VBAP costs.

Problems and Objectives

As noted above, bycatch in the BSAI groundfish fishery is a three-part problem in that the levels of bycatch of prohibited species and groundfish species are unnecessarily high, the cost of controlling bycatch is unnecessarily high, and the distribution of the cost of bycatch is highly inequitable. Each part of this problem is discussed briefly in this section. A more complete discussion of the nature and source of the bycatch problem is presented in Appendix B. Although the following discussion of the problem of bycatch is applicable to the bycatch of all species in all groundfish fisheries, the VBAP alternatives identified in this paper are limited to the bycatch of prohibited species in the BSAI trawl fisheries.

High levels of bycatch Because individual fishing vessels do not pay the full cost of using fish as bycatch, they tend to take too much bycatch from the perspectives of both society and the fishing industry as a whole.

High bycatch control costs The PSC limits for the BSAI trawl fisheries have resulted in lower levels of bycatch for some prohibited species than would have otherwise occurred, but often at the cost of a significant reductions in trawl catch, employment, and earnings. Typically, reducing groundfish catch is a high cost method of reducing bycatch but it is a method that is used because, when fishermen are not held accountable individually for their bycatch, individual fishermen do not have a sufficient incentive to use lower cost methods. In some cases, the losses to trawlers have been offset at least partially by increased catch, employment, and earnings by fixed gear fishermen who were able to catch groundfish that would have been taken by trawlers in the absence of the PSC limit induced closures of trawl fisheries. This has been the case in the cod trawl fishery in recent years.

Inequitable distribution of bycatch costs The cost of bycatch includes bycatch impact costs which are the foregone net earnings of fishermen who target on the species taken as prohibited species bycatch in the groundfish fishery. It also includes bycatch control costs which are the cost borne by groundfish fishermen as the result of efforts to control bycatch. The bycatch control costs include increased harvesting costs and decreased earnings. In the absence of individual accountability for bycatch, the groundfish fishermen who do more to control their bycatch tend to have higher bycatch control costs. Conversely, those who do the least to control their bycatch and are, therefore, most responsible for the PSC limit induced closures of trawl fisheries tend to have the lowest bycatch control costs. This is generally thought to be an inequitable distribution of bycatch costs.

Given these three aspects of the bycatch problem, the objectives of a VBAP would be as follows:

1. Decrease the bycatch of prohibited species.

2. Decrease the cost of the controlling bycatch and specifically increase the ability of the groundfish fleet to take the groundfish TACs without exceeding the PSC limits.

3. Produce a more equitable distribution of bycatch costs.

Adequate Monitoring and Enforcement

In the absence of adequate monitoring and enforcement, there would not be accountability at the vessel level and the three objectives would not be met. A combination of interdependent technical sampling, legal, enforcement, and cost issues need to be addressed to determine whether adequate monitoring and enforcement are feasible. Four elements required for an effective VBAP monitoring system were identified in a NMFS discussion paper presented to the Council in September (Agenda C-3(c), Monitoring individual vessel performance). They are:

1. the development of observer sampling procedures to estimate the total catch of each species [and perhaps halibut discard mortality rates] for individual vessels;

2. standards for timely and accurate transmission of data between vessels or processors and NMFS;

3. the identification of additional observer coverage requirements; and

4. funding for additional staff required to administer, monitor, and enforce VBAs.

Three additional requirements are:

1. the development of an adequate compliance monitoring program;

2. the identification of changes in vessel and processing plant operating practices that increase the effectiveness of the sampling procedures and the compliance monitoring program; and

3. meeting the above requirements at a cost that is not prohibitive.

NMFS has initiated three separate efforts to address the monitoring and enforcement issues. First, a contract was awarded to a consultant who will conduct a comprehensive review of observer sampling procedures. Second, a working group consisting of Alaska Region, Alaska Fisheries Science Center, Enforcement, and General Counsel staff has been established to: 1) identify the compliance monitoring requirements of proposed individual vessel monitoring programs, 2) identify the specific reasons why the existing observer program will not meet those requirements, and 3) identify alternative methods for meeting those requirements. Third, additional methods for providing information concerning the monitoring and enforcement issues are being explored.

The NMFS efforts to address the monitoring and enforcement issues are not expected to be completed until late 1996. Therefore, given the tentative schedule that includes final Council action by June 1996, these critical issues will not be addressed fully in either the draft EA/RIR that is expected to be reviewed by the Council in April 1996 or the revised EA/RIR that would be available prior to final action by the Council in June 1996. Although this is not the optimal situation, it is similar to the situation last June in which the Council took final action on expanding the CDQ program to all BSAI FMP groundfish and crab species without addressing the individual vessel monitoring systems that would be required to implement effectively the expanded CDQ program. The Secretarial review of the expanded CDQ program or any VBAP recommended by the Council would be expected to be delayed until an adequate monitoring system is identified and analyzed in a final EA/RIR.

Alternatives for the Elements of the VBAP

The alternatives to be considered are the status quo and various VBAP alternatives. Although an ITQ program for all groundfish and prohibited species is technically an alternative to a VBAP, it is probably not a feasible alternative at this time. Therefore, an ITQ program will not be included as an explicit alternative.

The UCB VBAP proposal contains a number of elements and several alternatives for most of the elements. The UCB proposal was the starting point for the elements and alternatives outlined below. The outline is intended to define but not justify or evaluate any of the alternatives. Many of the elements are linked. For those elements, the relevant alternatives are also linked. Therefore in some cases, the choice of an alternative for one element is expected to reduce the number of relevant alternatives for some other elements. For some individual elements, not all of the alternatives are mutually exclusive, in which case, a combination of alternatives could be selected.

1. VBA Species

1.1 Excluding salmon, all species for which there are currently PSC limits (i.e., halibut, red king crab, Tanner crab (bairdi), and herring)

2. Total VBAs

2.1 Current PSC limits

2.2 Flexible PSC limits equal to a set percentage of the biomass estimate (floating caps)

2.3 Scheduled reductions from current PSC limits

3. Allocation of VBAs

3.1 Annual allocation of VBAs issued to individual groundfish operations prior to the start of each fishing year based on a formula that would be specified in the FMPs or regulations.

3.1.1 Allocation by

a. fishery (e.g., bottom trawl pollock, cod, rock sole, etc) and/or a group of fisheries with the option to exempt the pelagic pollock fishery

b. one allocation for all BSAI bottom trawl fisheries and exempt the pelagic pollock fishery

3.1.2 Factors included in the formula

a. three year, rolling average of a vessel's catch

b. vessel size categories

c. both a and b

3.2 One time allocation of entitlements to receive VBAs annually (similar to the one time allocation of quota share with the halibut and sablefish IFQ program) Each operation would have an annual VBA which would be a percentage of the total PSC limit or allowance. The terms "ongoing VBA" and "annual VBA" would be the counterparts of QS and IFQ in the IFQ program.

3.3 Ongoing or annual VBAs could be sold by the government, either at a set price or at auction (Magnuson Act amendment required)

3.3.1 Require individuals to purchase 25% of their allocated VBAs (with the exception of halibut VBAs that could be purchased from halibut QS or IFQ owners, this would require a Magnuson Act amendment)

3.4 Require all annual halibut VBAs to be purchased from halibut IFQ owners

4. <u>Transferability of VBAs</u>

4.1 Fully transferable VBAs

4.1.1 among all trawl fisheries

4.1.2 within the fishery for which they were issued

4.1.3 to halibut fishermen who can use them as IFQs (halibut VBAs only)

4.2 Nontransferable VBAs (what you get is what you use)

4.2.1 no exceptions

4.2.2 specified hardship exceptions

4.2.3 transferable to halibut fishermen who can use them as IFQs (halibut VBAs only)

4.3 VBAs could be "pooled" by a group of vessels

5. <u>Retention of VBA Species</u>

5.1 Retention not allowed (status quo)

5.2 Retention allowed but with forfeiture at time of landing

5.3 Retention requires but with forfeiture at time of landing

5.4 Careful return to sea within a set time period, then retained until counted

6. Monitoring of a VBA Program

The following are only examples of monitoring alternatives. A more definitive list of alternatives will be one of the products of NMFS efforts to determine if an adequate monitoring program is feasible and, if it is, to identify alternatives for a feasible monitoring program.

6.1 Observer data from current year could be used

6.2 Sampling design of existing Observer Program and vessel operating procedures may need change

6.2.1 require whole haul sampling (do away with basket sampling)

6.2.2 require daily reporting rather than weekly

6.2.3 specify fishing vessel or processing plant operating conditions and procedures required to allow observer to provide adequate estimates

6.3 Require retention of VBA species but with forfeiture at time of landing

6.4 Estimate of discard mortality rate for halibut bycatch

6.4.1 estimate by vessel

6.4.2 estimate by fishery

7. Current Time/Area/Cap Closures

7.1 Retained (status quo)

7.2 Eliminated

8. PSC Allowances by Fishery

8.1 Retained (status quo)

8.2 Eliminated

9. Seasonal Apportionment of PSC Allowances

9.1 Retained (status quo)

9.2 Eliminated

10. VBAP Participants

10.1 Only trawl fishing vessels with 100% observer coverage

10.2 All trawl fishing vessels during the time there is at-sea observer coverage

10.3 All trawl fishing vessels (apply an average rate of observed vessels to vessels during period they have no observers)

11. Balancing VBAs and Estimated PSC

11.1 The VBA on a vessel at the beginning of a trip must be adequate to cover its PSC during a trip

11.2 A vessel would have up to 30 days after the end of a trip to acquire sufficient VBAs to cover the PSC of the trip

11.3 There would be an annual reconciliation of VBAs and PSCs by vessel (or pool)

12. Underages and Overages

12.1 An overage of up to 10% would result only in a comparable reduction in the VBA for the next year

12.2 An underage of up to 10% would be compensated for with a comparable increase in the VBA for the next year

13. PSC Limit Induced Fishery Closures

13.1 Individual vessels would be held accountable for their bycatch of VBA species but a fishery would not be closed when a PSC allowance or limit was reached for a fleet (similar to sablefish and halibut IFQ program)

13.2 The VBAs for a species could be set below its PSC limit to provide a reserve or buffer

14. Appeals

13.1 Allow for an in-port accounting immediately after a vessel uses its entire VBA

13.2 Establish an industry appeals committee to review all contested bycatch accountings within a specified period of time

15. Funding

15.1 All additional observer coverage costs would be paid for directly by the vessels (i.e, pay as you go)

15.2 A VBA fee would be used to cover the cost of administering and enforcing the VBAP (this would require a Magnuson Act amendment)

16. VBA Ownership and Use Restrictions

16.1 Restrictions on the persons who can own and use VBAs

16.2 No restrictions on the persons who can own and use VBAs

16.3 Restrictions on the quantity of VBAs that can be owned or used by a person or used on a vessel

16.4 No restrictions on the quantity of VBAs that can be owned or used by a person or used on a vessel

17. Adjusting TACs below ABCs to Stay within the 2 million mt OY Cap

17.1 The current process would continue to be used

17.2 The halibut PSC limit would be set annually to limit the total catch in the bottom trawl fisheries but the catch of each TAC species would be limited by its ABC and the willingness of fishermen to use their VBAs to catch that species.

18. Monitoring and Enforcement

As noted above, the monitoring and enforcement elements will be critical in determining whether a VBAP can meet its objectives and do so at an acceptable cost. The monitoring and enforcement elements and alternatives are expected to be develop by late 1996. It would be premature and potentially counterproductive to present specific elements and alternatives now.

19. Other Elements

19.1 Include no other elements

19.2 Add some of the elements for the IFQ program that is being considered for the BSAI pollock fishery

ANALYSIS

Until viable alternatives have been identified for the monitoring and enforcement systems for the VBAP, the analysis will be limited to the other elements of the program. A VBAP would allow significant changes in the operations of the trawl fisheries. Those changes would affect both the magnitude and the distribution of net benefits from the BSAI groundfish fishery. The actual differences in bycatch performance among vessels operating in a specific trawl fishery probably provide the best but yet limited information on how the fishery would change and the effects of those changes on net benefits and their distribution.

A combination of qualitative and quantitative analyses can provide a basis for formulating expectations concerning the potential effects of a VBAP and the different effects of various alternatives. Qualitative analysis can identify the nature of potential effects. The theoretical framework of the nature and source of the bycatch problem that is presented in Appendix B will be the basis for much of the qualitative analysis.

The linear programming model initially developed for the Alaska Fisheries Science Center by Doug Larson and Brett House provides a systematic method for using actual differences in bycatch performance among vessels to estimate some of the effects of a VBAP. The model uses weekly catch, bycatch, product value, and cost data by fishing vessel to estimate the optimal distribution of effort among vessels for various halibut PSC limits. The constraints can be varied to estimate both the short-term and long-term adjustments that would be made if vessels were individually held accountable for their bycatch. The model would have to be expanded to include data for the vessels that deliver fish to on-shore processors and the input data sets would have to be updated. Providing improved estimates of harvesting and processing costs is expected to be difficult.

The bycatch model that has been used in the analysis of many bycatch management measures provides an alternative but potentially less effective method for estimating the effects of a VBAP. The principal disadvantage of the bycatch model are that it provides very limited estimates of how the behavior of fishermen would change and it was designed to estimate the effects of changes in bycatch constraints on a fishery as a whole rather than changes in constraints on individual fishermen.

Accurate projections of the effects of a VBAP on the cost of bycatch are alone not sufficient to select among the alternatives that will be considered because the objectives include both decreasing the cost of bycatch and producing a more equitable distribution of the cost of bycatch. Value judgements are required both to define and value an improvement in the distribution of bycatch costs. Therefore, a unique index of the relative merits of the various alternatives can not be developed.

The change in the distribution of net benefits is particularly difficult to project because it will be heavily dependent on the ability of various fishing operations to respond to the opportunities provided by a VBAP and information on the ability to respond is not readily available.

The two aforementioned Alaska Fisheries Science Center processed reports will be used as a basis for both the quantitative and qualitative analysis of the VBAP alternatives.

APPENDIX A

DRAFT VESSEL BYCATCH ACCOUNT PROGRAM (VBAP) PROPOSAL SUBMITTED TO THE COUNCIL BY UNITED CATCHER BOATS

Groundfish Plan Amendment Proposal
North Pacific Fishery Management Council

RE: Vessel Bycatch Accounting Program (VBA)

Submitted By:
United Catcher Boats
1900 W. Emerson, Suite 212
Seattle, WA 98119
206-282-2599

Date: August 15, 1995

Fishery Management Plan: BSAI Groundfish FMP

Nature of Proposal

This proposal would establish a new bycatch management program for the BSAI trawl fisheries. The program is based on an allocation of PSC (halibut, *bairdi* and red king crab) to individual vessels. Once a vessel's PSC allotment is reached, it not longer would be allowed to fish in the directed fishery, unless it obtained additional bycatch.

What follows is a broad outline of the various options to consider in analyzing our proposal.

1. Allocation of VBAs
   - 1.1 Annual allocation of VBAs issued to individual groundfish operations prior to the start of each fishing year based on a formula that would be specified in the FMPs or regulations.
     - 1.1.1 Allocation by
       - a. specific species (directed fishery) and/or a group of species
       - b. one allocation for all BSAI bottom trawl fisheries
         - 1. Exempt MW pollock
     - 1.1.2 Factors included in the formula
       - a. Three year, rolling average of an individual's catch
       - b. Vessel size categories
   - 1.2 One time allocation of VBAs, or ongoing right, similar to a quota share. Each operation would have an annual 'Vessel Bycatch Account' as determined by a percentage of the allowed PSC.
   - 1.3 VBAs could be sold by the government, either at a set price or at auction
     - 1.3.1 Require individuals to purchase 25% of their allocated VBAs - (Would require a Magnuson Act amendment)

2. Transferability of VBAs
   - 2.1 VBAs could be fully transferable
     - 2.1.1 restricted or unrestricted to a fishery

2.2 VBAs not allowed to be transferred, what you get is what you use
2.3 VBAs could be "pooled" by a group of vessels

3. Retention of Bycatch (PSCs under a VBA program)
   3.1 Retention not allowed
   3.2 Retention allowed, with forfeiture at time of landing
       - to address issues of sampling error (accuracy) and observer 'cop' role
   3.3 Careful return to sea within a set time period, then retained until counted

4. Monitoring of a VBA Program
   4.1 Observer data from current year could be used
   4.2 Sampling design of existing Observer Program may need change
       - require whole haul sampling, do away with basket sampling?
       - require daily reporting rather than weekly
   4.3 Requiring retention of VBA species may be necessary to have adequate monitoring

5. Species to be considered for a VBA Program
   5.1 Halibut, Red King crab, tanner crab (*bairdi*) and herring

6. Total VBAs could be:
   6.1 limited to the current PSC limits
   6.2 Set allowable PSC limit to a set percentage of the biomass estimate (floating cap)
   6.3 option to allow Council to 'ratchet down' PSC limit

7. Current Time/Area/Cap Closures could be:
   7.1 retained
   7.2 eliminated

8. Current PSC allowances to separate fisheries could be:
   8.1 retained
   8.2 eliminated

9. Coverage. A VBA program could apply to:
   9.1 only groundfish operations with 100% observer coverage
   9.2 all groundfish operations during the time there is at-sea observer coverage
       - apply an average rate of observed vessels to vessels with less than 100% coverage
   9.3 Vessels that are moratorium/license limitation qualified

10. Enforcement
    10.1 Need for limiting the issues that are challengeable and
    10.2 Placing the burden of proof on the fishing operation
        - Pursue a system of 'Implied Consent'

11. Appeals
    11.1 Allow for an in-port accounting immediately after a vessel uses its entire VBA
    11.2 Establish an industry appeals committee to review all contested bycatch accountings within a specified period of time

12. Administration
    12.1 Accounting of bycatch by use of the observer program data

Need of the Plan Amendment

The current method of bycatch management (PSC caps, time/area closures, VIP violations) is broken and does not achieve its stated objective. Under the present system, there is a race for the PSC species along with the race for the directed fishery species, resulting in not achieving OY, poor use of PSCs and providing the opportunity for a few "bad actors" to prematurely close fisheries.

Objectives of the Proposal

A VBA bycatch management system will achieve the following objectives:

1. Effective incentive. Establish a bycatch management system that effectively provides individual vessels the incentive to minimize their bycatch rates. Establish a system that serves as a deterrent to high bycatch rates.

2. Individual Accountability. Provide for a system that holds vessels individually accountable for their use of bycatch.

3. Achievement of Optimum Yield. Establish a bycatch system that allows for the fleet to harvest up to OY annually.

4. Optimal use of bycatch. Establish a bycatch management system that maximizes the achievement of catching the TAC, with the minimal amount of PSC.

Are There Other Alternatives

Yes, the Council could move toward an ITQ system of management for the trawl and crab fisheries within which the bycatch species could be bundled and allocated to individual vessels.

Who Wins, Who Loses

If the harvest of OY is viewed as a benefit, then the public benefits when the TACs which cannot be harvested due to PSC time/area closures are harvested under a better bycatch management system. Fishermen who fish "clean" benefit by having the opportunity to fish for the entire TAC. Fishermen who fish "dirty" will lose by being excluded from fisheries in which they used up their allotted PSC amounts.

Supportive Data

NMFS observer data, NMFS catch records, and NPFMC bycatch analyses for previous amendments

UNITED CATCHER BOATS
UCB
Washington · Oregon · California · Alaska

Brent C. Paine
Executive Director

Steve Hugh
Technical Dir

June 8, 1995

Mr. Richard B. Lauber, Chairman
North Pacific Fishery Management Council
P.O. Box 103136
Anchorage, Alaska 99501

Re: Vessel Bycatch Account Program

Dear Rick,

Attached is an outline of a proposal a number of industry people have been developing as an alternative to the current method of bycatch management in the North Pacific. We submit it to the Council for discussion purposes and also request the Council task its and NMFS's staff to begin an analysis of this proposal.

We believe that if the Council is intent on recommending a license limitation program for our groundfish and crab fisheries at the June Council meeting, then in order to address one of the major issues originally posed by the Committee of the Whole, that of better management of bycatch, the Council should also recommend analysis of our proposal. Simply put, license limitation does not change the management of bycatch in the North Pacific. Thus it does not address current problem of premature closures of various fisheries because of a few individual vessels' extremely high bycatch rates.

The Vessel Bycatch Account Program (VBAP) proposal grew out of our frustration due to the closures to various Bering Sea fisheries due to attainment of PSC well before attainment of the TAC. The most recent example of this is this years' Zone 1 closure to P. cod trawl fishing due to *bairdi* PSC as well as a total BSAI closure to P. cod trawling with over 30,000 mt of fish left on the table!

Looking at the vessel by vessel PSC data provided by NMFS, we find again and again that a few bad actors' fishing behavior accounting for very high amounts of PSC. Their actions, given the current regulatory framework of time/area closures triggered by a PSC cap, cause the whole fleet, good and bad actors alike, to suffer. We are tired of being impacted by others' actions.

1900 W. Emerson Pl., Suite 212, Fishermen's Terminal • Seattle, WA 98199 • Tel. (206) 282-2599 • Fax (206) 282-2
Branch Office: 1300 Connecticut Avenue N.W. - Suite 600 • Washington D.C. 20036

The Current Vessel Incentive Program, after a four year period, just isn't providing the incentive to get individual operators to stay under the established bycatch rate standards. We have testified previously to the Council as to why this is so.

Our proposal focuses on 'real-time' incentives, similar to the original "penalty box" proposal introduced years ago by Captain Barry Fisher. It makes individuals accountable for their own actions, and keeps the effects of their actions at the individual level, thereby allowing the 'clean' actors to receive a benefit for their attempts at fishing with low bycatch rates, allows for a system of achieving OY, and lastly, optimizes the use of PSC.

Please review the attached proposal. It has gained widespread endorsement among the fishing community.

Sincerely,

Brent Paine
Executive Director

Steve Hughes
Technical Advisor

Options and Issues of a
VESSEL BYCATCH ACCOUNTING PROGRAM
Prepared by United Catcher Boats Association

I. Principles of a VBA Program

1. Effective incentive. Establish a bycatch management system that effectively provides individual vessels the incentive to minimize their bycatch rates. Establish a system that serves as a deterrent to high bycatch rates.

2. Individual Accountability. Provide for a system that holds vessels individually accountable for their use of bycatch.

3. Achievement of Optimum Yield. Establish a bycatch system that allows for the fleet to harvest up to OY annually.

4. Optimal use of bycatch. Establish a bycatch management system that maximizes the achievement of catching the TAC, with the minimal amount of PSC.

5. Transferability. To fully achieve OY, VBAs need to be tradable.

6. Pooling. Allow for small groups of vessels to work together to maximize their use of their allocated VBAs.

II. VBA Program Options

1. Allocation of VBAs
   - 1.1 Annual allocation of VBAs issued to individual groundfish operations prior to the start of each fishing year based on a formula that would be specified in the FMPs or regulations.
     - 1.1.1 Allocation by
       - a. specific species (directed fishery) and/or a group of species
       - b. one allocation for all BSAI bottom trawl fisheries
         - 1. Exempt MW pollock
     - 1.1.2 Factors included in the formula
       - a. Three year, rolling average of an individual's catch
       - b. Vessel size categories
   - 1.2 One time allocation of VBAs, or ongoing right, similar to a quota share. Each operation would have an annual 'Vessel Bycatch Account' as determined by a percentage of the allowed PSC.
   - 1.3 VBAs could be sold by the government, either at a set price or at auction
     - 1.3.1 Require individuals to purchase 25% of their allocated VBAs - (Would require a Magnuson Act amendment)

2. Transferability of VBAs
   2.1 VBAs could be fully transferable
      2.1.1 restricted or unrestricted to a fishery
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5. Species to be considered for a VBA Program
   5.1 Halibut, Red King crab, tanner crab (*bairdi*) and herring

6. Total VBAs could be:
   6.1 limited to the current PSC limits
   6.2 Set allowable PSC limit to a set percentage of the biomass estimate (floating cap)
   6.3 option to allow Council to 'ratchet down' PSC limit

7. Current Time/Area/Cap Closures could be:
   7.1 retained
   7.2 eliminated

8. Current PSC allowances to separate fisheries could be:
   8.1 retained
   8.2 eliminated

9. Coverage. A VBA program could apply to:
   9.1 only groundfish operations with 100% observer coverage
   9.2 all groundfish operations during the time there is at-sea observer coverage
      - apply an average rate of observed vessels to vessels with less than 100% coverage
   9.3 Vessels that are moratorium/license limitation qualified

10. Enforcement
    10.1 Need for limiting the issues that are challengeable and
    10.2 Placing the burden of proof on the fishing operation
        - Pursue a system of 'Impied Consent'

11. Appeals
    11.1 Allow for an in-port accounting immediately after a vessel uses its entire VBA
    11.2 Establish an industry appeals committee to review all contested bycatch accountings within a specified period of time

12. Administration
    12.1 Accounting of bycatch by use of the observer program data

III. Key Issues to be Resolved for VBA Programs

Technical/Legal Issues

1. A key issue with any program that holds vessels individually accountable for their estimated bycatch is our ability to use observer data for such a program for all vessels without incurring unacceptably high monitoring, enforcement, and legal costs. Can the observer program provide adequate estimates of absolute bycatch or bycatch mortality by operation for a fishing year as a whole for vessels with 100% observer coverage? Such estimates would be extrapolations from sampled hauls. Which of the following may help?

    A. Use the lower bound of the confidence interval rather that the point estimate of bycatch as the estimate of each vessel's bycatch.

    B. Use estimates for the year as a whole rather than for a week or month.

    C. Have the regulations say what will happen on the basis of estimated bycatch as opposed to actual bycatch and have the method of estimation specified clearly.

    D. Have a backup method for estimating bycatch for a vessel when some of the observer data/methods are not adequate.

    E. Have an industry advisory body to assist with appeals.

    F. Use the concept of implied consent as part of the permit process to have people accept being held accountable based on a specified estimation procedure.

G. Use previous year's data for a vessel to estimate its bycatch rate and let the vessel use current year data to demonstrate it is doing better.

H. Use some other method to establish assumed bycatch rate and let the vessel use current year data to demonstrate it is doing better.

I. Each vessels with less than 100% coverage could have the option of having 100% observer coverage, although perhaps at its own expense.

J. Provide observers with better tools (notebook Pcs, data and communication softwear, calibrated bins, electronic scales).

2. If the procedures for estimating bycatch are specified clearly, is there a limited time during which the procedures can be challenged, after which the only legal challenge is whether the procedures were followed?

3. Can a vessel with less than 100% observer coverage be held accountable for its bycatch or bycatch mortality based on the best available estimate of its bycatch? The considerations listed for item 1 also apply to this question. Does it matter if each vessel has the option of having 100% observer coverage, although perhaps at its own expense?

4. Are there specific legal problems for any of the VBA options listed above?

5. Given the current "Research Plan" regulations governing the observer program, how will additional costs, if necessary, be covered?

Policy/Equity Issues

1. Should vessels be exempted from the VBA program when they do not have observer coverage?

2. Will the size of the PSC limits be addressed?

3. What will be the basis for allocating VBAs?

Implementation Issues

1. What additional monitoring/administration systems and resources are required by an VBA program?

2. What changes in the observer program are required by an VBA program?

3. How long will it take to implement an VBA program?

4. What changes to the Magnuson Act would be requires to allow NMFS to collect funds from the sale of annual VBAs to then be used to fund the VBA program? Can NMFS establish a dedicated fund?

5

APPENDIX B

THE NATURE AND SOURCE OF THE BYCATCH PROBLEM: AN ANALYTICAL FRAMEWORK

This appendix presents a conceptual framework that can be used to understand the nature and source of the bycatch problem and to evaluate alternative management measures to control bycatch.

The Nature and Sources of the Bycatch Problem

The nature and source of the bycatch problem are explained by the answers to the following five questions;

1. What is bycatch?

2. Why does bycatch occur?

3. When is bycatch a problem?

4. What is the appropriate level of bycatch?

5. Why are there currently excessive levels of bycatch?

What is bycatch?

Bycatch, or more specifically bycatch mortality, is a consumptive use of living marine resources which includes most of the components of total fishing mortality. The components of total fishing mortality include: 1) the retained catch of the targeted species; 2) the retained catch of non-targeted species; 3) the discarded catch that does not survive; 4) mortality resulting from lost fishing gear (i.e., ghost fishing); and 5) mortality resulting from other direct interactions between fish and fishermen, fishing vessels, or fishing gear. Often, it is difficult to obtain good estimates for the amount of retained catch and it is even more difficult to generate good estimates for the other components of fishing mortality. In addition, it is often difficult to differentiate between targeted and non-targeted species.

Bycatch mortality clearly includes the discarded catch that does not survive and excludes the retained catch of the targeted species. Although there is no general agreement concerning whether bycatch mortality should include the other three components of fishing mortality listed above, they are included as bycatch in this report. Therefore, bycatch mortality is defined as the total fishing mortality excluding that accounted for directly by the retained catch of the targeted species. The components of fishing mortality included in this definition of bycatch are byproducts of efforts to catch specific fish that will be retained. That is, the objective of fishermen is to catch and retain specific groups of fish defined by species, size, quality, sex, or usability, but in doing so they also inflict fishing mortality on other groups of fish.

With a narrower definition of bycatch, bycatch could be reduced without decreasing the fishing mortality not accounted for by the retained catch of the targeted species. That is, one of the byproduct components of fishing mortality might simply be replaced by another. The distinction is made between bycatch and bycatch mortality because not all of the former results in fishing mortality. This distinction is important in that it identifies reductions in the handling or discard mortality rates as a potential method of reducing discards as a source of fishing mortality. This distinction is made for the halibut bycatch limits that are used in the BSAI area and GOA groundfish fisheries. The limits, which are in terms of estimated bycatch mortality, have resulted in effective efforts to decrease both incidental catch rates and discard mortality rates. From here on, bycatch mortality will be referred to simply as bycatch.

Why does bycatch occur?

Bycatch occurs because fishing methods are not perfectly selective and because fishermen often have a sufficient incentive to catch more fish than will be retained. Although some methods of fishing are more selective than others, there are few examples of methods that are perfectly selective for species, size, quality, or sex. An incentive exists to catch more fish than will be retained if the fisherman's cost of the additional catch is less than the expected benefit and the latter depends on the probability that the catch will be retained.

When is bycatch a problem?

When fish are taken as bycatch in a specific fishing operation and fishery, other uses of those fish are precluded. The alternative uses of fish include: 1) retained target catch by that fishing operation; 2) catch and bycatch in the same commercial fishery but by another fishing operation; 3) catch and bycatch in another commercial fishery; 4) catch and bycatch in subsistence and recreational fisheries; and 5) contributions to the stock and other components of the ecosystem.

The value to the Nation of a specific use of fish is determined by the net benefit of that use and the distribution of the net benefit. The net benefit of a use is the difference between the value of the outputs from that use and the value of all the inputs associated with that use. The inputs used in a commercial fishery include fish taken as target catch and bycatch; other living marine resources; the fishing vessels, gear, and bait used in harvesting; the plants or vessels, equipment, and materials used for processing; the fuel and labor used throughout the production process; and all the inputs used to manage the commercial fishery. The cost of each input should be measured in terms of its opportunity cost which is its value in its highest valued alternative use.

Bycatch is a problem if it precludes higher valued uses of fish and if the cost of reducing bycatch is significant. If the former condition is not met, there is not a better use of the fish taken as bycatch; therefore, the bycatch is not excessive and there is not a problem. If the latter condition is not met and if higher-valued uses exist, the solution to the problem is trivial, all bycatch would be eliminated at an insignificant cost.

What is the appropriate level of bycatch?

Basically, it makes sense to reduce bycatch in a cost-effective manner to the level at which further reductions would increase costs more than benefits. Both costs and benefits should be defined broadly from the Nation's perspective to include those that accrue to direct and indirect participants in the fishery as well as to other members of society. Those who harvest or process fish, those who provide support services to the harvesting and processing sectors of the fishing industry, and consumers of the fishery products are examples of direct and indirect participants in the fishery and of other members of society, respectively. "Cost-effective" refers to the lowest cost method of achieving a given reduction in the level of bycatch.

The marginal benefit and marginal cost curves in Figure 1 present graphically the concept of the optimum level of bycatch. The marginal benefit and cost curves, respectively, depict the benefit and cost of reducing bycatch by one unit for a given level of bycatch. For example, when the level of bycatch is 5,000 units, the marginal cost is about $15 and the marginal benefit is about $4. One unit would be one fish if bycatch is measured in the number of fish taken as bycatch or one unit would be 1 metric ton if bycatch is measured in metric tons. For the groundfish fisheries, salmon and crab bycatch is measured in numbers of salmon and crab, respectively, but halibut, herring, and groundfish bycatch is measured by weight, usually in metric tons or kilograms.

The following two definitions can be used to ensure that each change in benefits and costs is accounted for in either the marginal benefit or marginal cost curve but not in both. First, marginal benefit equals the sum of the increases in benefits and the decreases in costs of a reduction in bycatch. Second, marginal cost equals the sum of the increases in costs and decreases in benefits of a reduction in bycatch. Other definitions can be used to assure that all benefits and costs are accounted for once, but only once, without changing the conclusions presented below.

Given these two definitions, marginal benefit includes the decrease in the total opportunity cost of using fish as bycatch, the decrease in the cost of sorting the catch, and any other decrease in fishing costs. Marginal cost includes the increase in fishing costs and the decrease in benefits from any reduction in retained catch.

The marginal benefit is expected to increase, but not necessarily steadily, as bycatch increases. At very low levels of bycatch, most of the fishing mortality of the species taken as bycatch is accounted for by other uses and the value of some of the other uses probably are quite low; therefore, the opportunity cost of bycatch and the marginal benefit of reducing bycatch are low. However, at very high levels of bycatch, much of the fishing mortality is accounted for by bycatch and the lower valued uses would have been eliminated; therefore, the opportunity cost of bycatch and the marginal benefit of reducing bycatch are high.

The opposite trend is expected for marginal cost; that is, marginal cost is expect to decrease, but again not necessarily steadily, as bycatch increases. When there are high levels of bycatch and little has been done to control bycatch, there are probably some simple and low-cost actions that can be taken to reduce bycatch. However, eventually, increasingly difficult and costly methods would be necessary and often very costly methods would be required to eliminate the last few units of bycatch.

If the marginal benefit and cost curves include all the benefits and costs to the Nation, the optimum level of bycatch, in terms of total net benefits, is the level at which marginal cost and marginal benefit are equal. In the hypothetical example depicted in Figure 1, marginal cost and marginal benefit both equal $10 when bycatch equals 10,000 units. At lower levels of bycatch, the marginal cost of reducing bycatch is greater than $10 and the marginal benefit is less than $10; therefore, reducing bycatch below 10,000 units would decrease net benefit. However, at higher levels of bycatch, the marginal cost is less than $10 and the marginal benefit is greater than $10; therefore, net benefit would be increased by decreasing bycatch.

The implications of not using cost-effective methods of controlling bycatch are depicted in Figure 2. Curves MC1 and MC2 in Figure 2, respectively, are the marginal cost curves when cost-effective methods are and are not used. In this example, the optimum level of bycatch is 10,000 units when the cost-effective methods are used, but it is 15,000 units when they are not used.

<u>Why are there currently excessive levels of bycatch?</u>

A common response to this question is that greed or lack of concern by the fishermen results in excessive bycatch. Perhaps a more productive response is that excessive bycatch is but one symptom of flawed fisheries management which substantially reduces the net benefits generated by the commercial fisheries.

More specifically, excessive bycatch is the result of the following set of circumstances: 1) the level of bycatch and the methods used to reduce bycatch are determined by individual fishermen in response to a variety of incentives and constraints that reflect the economic, social, regulatory, biological, and physical environments in which they operate; 2) an individual fisherman will tend to control bycatch to the point at which further changes would increase his cost more than his benefit; 3) a fisherman will define cost-effective methods of reducing bycatch in terms of the costs he pays; 4) the fisherman's benefit from reducing his bycatch is less than society's; and 5) in an open-access fishery for which there is a quota, the fisherman's cost of reducing his bycatch is greater than society's. These circumstances result in an individual fisherman making inadequate and non-cost-effective efforts to control bycatch. Basically, due to the existence of external benefits and costs, individual fishermen receive the wrong signals or incentives and make the wrong decisions from society's perspective as well as from the perspective of the fishermen as a group. There are external benefits (costs) when there are differences between the benefits (costs) to the fisherman and to society as a whole associated with an action taken by a fisherman.

This set of circumstances and the results are depicted by curves MBF, MBS, MCF and MCS in Figure 3, which are, respectively, the marginal benefit curves for a fisherman and for society at large including the fisherman and the corresponding marginal cost curves. In this case, the marginal cost and benefit are for a one unit reduction in bycatch by a specific fisherman or fishing operation.

The MBS curve includes the reduction in the opportunity cost of using fish as bycatch and the decrease in sorting costs for the fisherman. However, because the fisherman does not pay the opportunity cost of the bycatch, the MBF curve includes principally the reduction in sorting cost. That is, because the opportunity cost of bycatch is an external cost, the MBS curve is above the MBF curve.

In an open-access fishery with a catch quota, the MCF curve is above the MCS curve due to the external cost caused by the race for fish. This externality exists because, although the cost to the fisherman includes a reduction in his catch if his attempts to reduce bycatch decrease his rate of harvest relative to that of the rest of the fleet, the reduction in the fisherman's catch is not a cost to society. For the fleet as a whole, there is a redistribution of catch among fishermen, not a reduction in catch. This externality also results in a fisherman selecting methods to control bycatch that are not cost-effective from society's perspective. The externality does this by creating a bias in favor of methods that do not decrease a fisherman's catch. As a result of non-cost-effective methods being used by fishermen to reduce bycatch, the MCS curve is higher than it would otherwise be.

From the fisherman's perspective, it makes sense to control bycatch to the point at which the MBF and MCF curves intersect. For the hypothetical example depicted in Figure 3, the MBF and MCF curves intersect when bycatch for this one fishing operation is about 285 units. However, the MBS and MCS curves intersect when bycatch is 150 units. Therefore, in this example, the optimum level to the fisherman exceeds the optimum level to society by 135 units and it is the optimum level to the fisherman that determines what bycatch will be. In addition, the fisherman's use of non-cost-effective methods to decrease bycatch results in the MCS curve being unnecessarily high. Therefore, had cost-effective methods been used, the optimum level of bycatch for this fisherman from society's perspective would have been less than 150 units.

Conclusions

The conceptual framework presented above addressed the source and nature of the bycatch problem. This framework can be used to evaluate alternative bycatch management measures even when accurate estimates and projections of all costs and benefits are not feasible. Such an evaluation considers the expected effects of a management measure on the external benefits and costs that result in fishermen making the wrong decisions concerning bycatch from society's perspective.

Based on this conceptual framework, the following conclusions were reached: 1) for society, the optimum level of bycatch is not zero unless the benefit of eliminating the last unit of bycatch equals or exceeds the cost; 2) individual fishermen make the wrong decisions concerning bycatch because they do not pay individually the opportunity cost of using fish as bycatch and because the race for fish in an open-access fishery distorts their choice of methods to reduce bycatch; 3) the contribution of the commercial fisheries to the well-being of the Nation is decreased further by focussing on a narrow set of alternative uses and ignoring the importance of the distribution of fishing mortality among other uses; 4) physical measures of bycatch are of limited use in comparing the magnitude of the bycatch problem among fisheries because neither the benefit nor the cost of reducing bycatch is the same for all species or even for all fish of the same species; 5) bycatch is a multi-species problem because actions to decrease the bycatch of one species can increase or decrease the bycatch of other species and because the bycatch of one species can affect the status of other species through predator, prey, or other biological interactions; and 6) it is highly unlikely that the use of management measures that limit the choices of fishermen rather than eliminate the externalities will result in cost-effective reductions in bycatch to the optimum levels.

Management measures that eliminate or decrease the externalities that are the source of the bycatch problem have several potential advantages. Often these measures have lower information requirements for fishery management decision-makers and, in fact, provide information that is required by fishery management decision-makers. These measures also provide increased incentives for fishermen to use their knowledge and ingenuity to decrease bycatch effectively and efficiently. These measures tend to encourage technological improvements. Finally, these measures can decrease the need for ongoing regulatory changes when fishery conditions and optimum levels of bycatch change. Unfortunately, enforcement and transaction costs may be substantially greater for a management measure that effectively eliminates the external benefit of reducing bycatch than for a measure that limits the bycatch choices of fishermen.

A careful evaluation of the tradeoffs between these two types of measures is required to identify the appropriate mix of bycatch management measures. In making such an evaluation, it should be recognized that the bycatch problem and many other management problems have a common source and, therefore, the benefit of reducing the bycatch problem could include the benefit of reducing several other management problem. The common sources of these problems is that individual fishermen do not pay the opportunity cost of the fish and other living marine resources they use. In evaluating alternative bycatch management measures, it is also important to recognize that, in the fishery management decision-making process, the effects on the distribution of net benefits can be at least as important as the effects on the magnitude of net benefits. However, failure to take advantage of the conclusions drawn from this conceptual model can result in unnecessarily high costs to some groups to provide a given increase in benefits to another group.

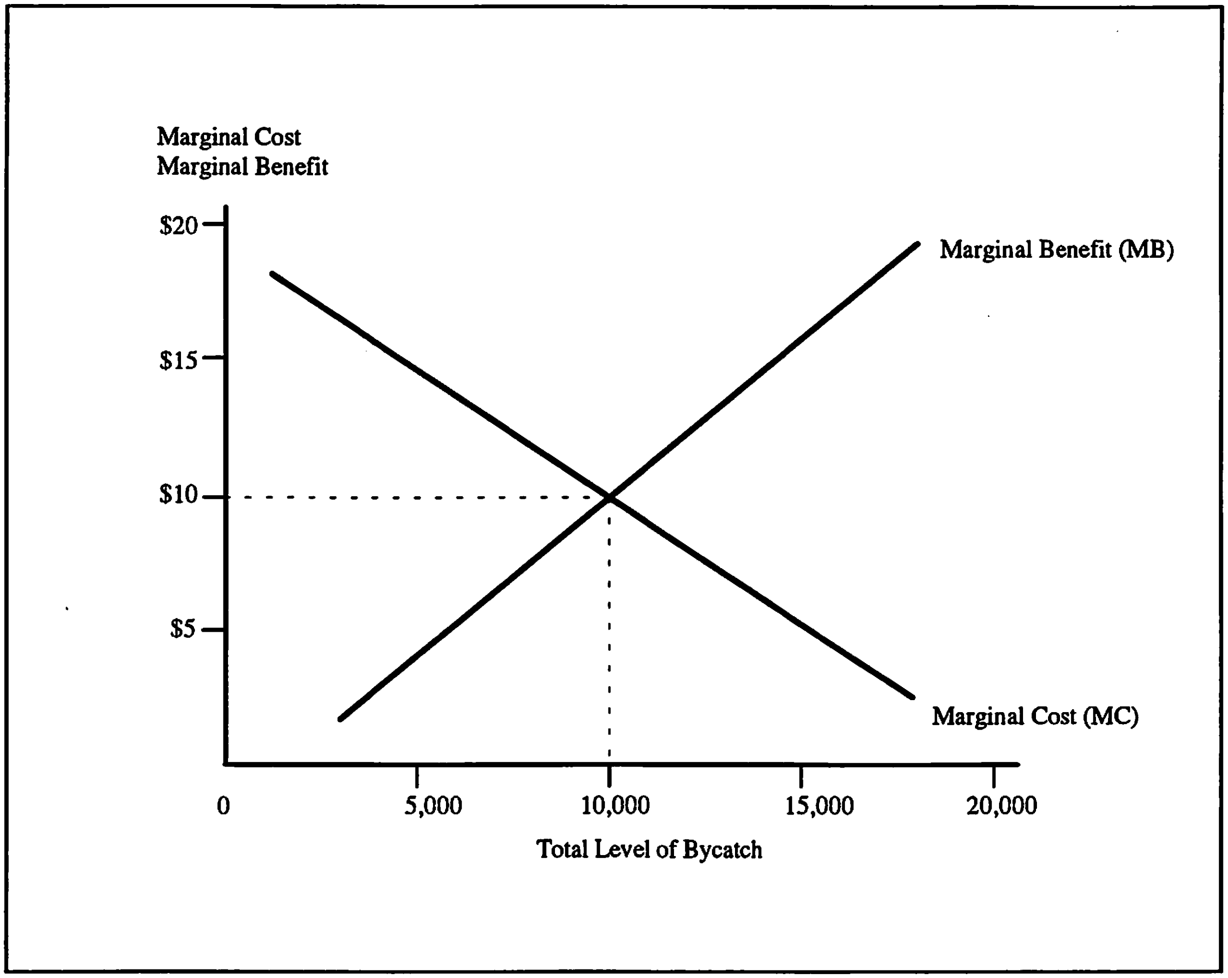

Figure 1. The marginal benefit and marginal cost of reducing bycatch and the optimum level of bycatch.

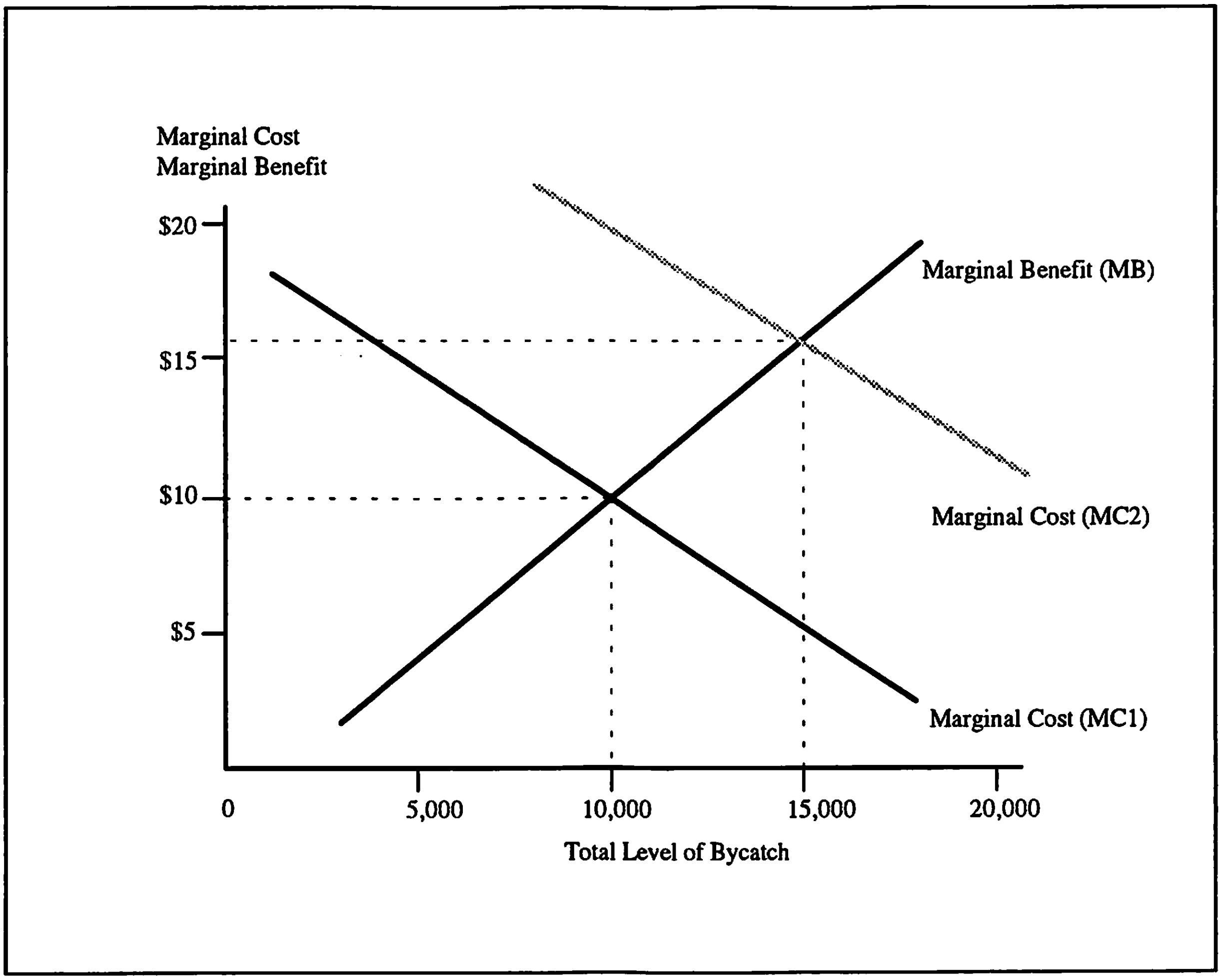

Figure 2. The marginal benefit, marginal cost of reducing bycatch with cost-effective methods (MC1), marginal cost of reducing bycatch without cost-effective methods (MC2), and the optimum levels of bycatch with and without cost-effective methods of reducing bycatch.

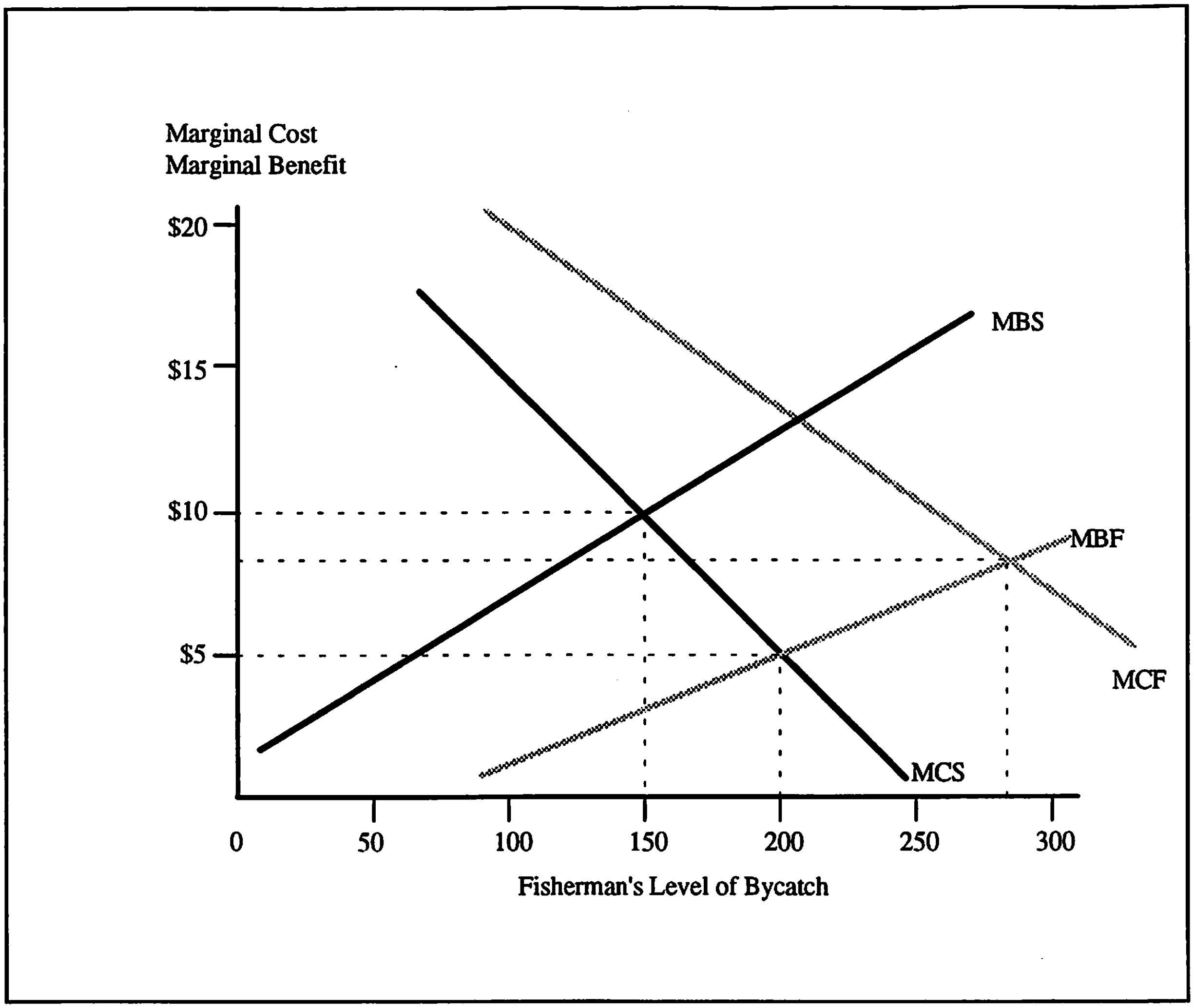

Figure 3. The marginal benefit to the fisherman (MBF), marginal benefit to society including the fisherman (MBS), marginal cost to the fisherman (MCF), marginal cost to society (MCS) of reducing bycatch, and the optimum levels of bycatch, respectively, for the fisherman and for society.

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Supplemental

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AFSC PROCESSED REPORT 95-07

Community Development Quota (CDQ) and Open Access Pollock Fisheries in the Eastern Bering Sea: A Comparison of Groundfish Utilization and Prohibited Species Bycatch

November 1995

COMMUNITY DEVELOPMENT QUOTA (CDQ) AND OPEN ACCESS POLLOCK FISHERIES IN THE EASTERN BERING SEA: A COMPARISON OF GROUNDFISH UTILIZATION AND PROHIBITED SPECIES BYCATCH

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CONTENTS

LIST OF TABLES v

LIST OF FIGURES vi

INTRODUCTION 1

THE COMMUNITY DEVELOPMENT QUOTA PROGRAM 2

CDQ Program Overview 2

Profile of the CDQ Fleet 3

HYPOTHESIZED DIFFERENCES BETWEEN CDQ AND
OPEN ACCESS FISHERIES. 4

The Nature and Sources of the Bycatch Problem 4

What is bycatch? 4
Why does bycatch occur? 4
When is bycatch a problem? 5
What is the appropriate level of bycatch? 5
Why are there currently excessive levels of bycatch? 7

Hypotheses 8

Pollock discards 8
The bycatch and discards of other species 9
Catch per unit of effort 9
The implicit qualification 9

Measures of Performance 10

DATA SOURCES AND LIMITATIONS 11

Databases Used in this Analysis 11

Report Scope 11

Limitations on the Comparison Between Open Access Fisheries 12

COMPARISONS OF GROUNDFISH DISCARDS AND PROHIBITED SPECIES BYCATCH 14

Discards of Pollock and Other Groundfish Species 14

Pollock discards 14
Pacific cod discards 15
Other groundfish species discards 15
Non-pollock total catch 16

Prohibited Species Bycatch 16

Pacific halibut 17
Pacific herring 17
Chinook salmon 17
Other salmon 18
Red king crab 18
Other king crab 18
C. bairdi Tanner crab 18
Other Tanner crab 19

COMPARISONS OF PRODUCTIVITY 19

Overview of Production in the CDQ and Open Access Fisheries 19

Product Values per Metric Ton of Pollock Landed 19

Product values by vessel and fishery 20
CDQ versus open access fisheries 20

Other Possible Differences Between the CDQ and Open Access Product Values . . 22

Catch per Unit of Effort 23

CONCLUSIONS 23

LIST OF TABLES

Table 1. Groundfish discard and prohibited species bycatch for vessels participating in the 1993 CDQ fishery.

Table 2. Groundfish discard and prohibited species bycatch for vessels participating in the 1994 CDQ fishery.

Table 3. Round weight equivalent of primary product fish meal production (expressed as a percentage of total pollock catch).

Table 4. CDQ discard and bycatch rates expressed as a percentage of open access discard and bycatch rates.

Table 5. Product value per metric ton of pollock catch, and breakdown of primary products for vessels participating in the 1993 CDQ fishery.

Table 6. Product value per metric ton of pollock catch, and breakdown of primary products for vessels participating in the 1994 CDQ fishery.

LIST OF FIGURES

Fig. 1. The marginal benefit and marginal cost of reducing bycatch and the optimum level of bycatch.

Fig. 2. The marginal benefit, marginal cost of reducing bycatch with cost-effective methods (MC1), marginal cost of reducing bycatch without cost-effective methods (MC2), and the optimum levels of bycatch with and without cost-effective methods of reducing bycatch.

Fig. 3. The marginal benefit to the fisherman (MBF), marginal benefit to society including the fisherman (MBS), marginal cost to the fisherman (MCF), marginal cost to society (MCS) of reducing bycatch, and the optimum levels of bycatch, respectively, for the fisherman and for society.

Fig. 4. Pollock discard rates in the 1993 CDQ fleet by vessel, fishery and season (expressed as a percentage of pollock catch).

Fig. 5. Pollock discard rates in the 1994 CDQ fleet by vessel, fishery and season (expressed as a percentage of pollock catch).

Fig. 6. Pollock discard rates in the CDQ fleet expressed as a percentage of pollock catch.

Fig. 7. Pacific cod discard rates in the CDQ fleet expressed as a percentage of Pacific cod catch.

Fig. 8. "Other" groundfish species (not pollock or Pacific cod) discard rates in the CDQ fleet expressed as a percentage of "other" groundfish catch.

Fig. 9. Percentage of total groundfish catch in the CDQ fleet consisting of species other than pollock.

Fig. 10. Pacific halibut bycatch rates in the CDQ fleet by fishery, year and season.

Fig. 11. Pacific herring bycatch rates in the CDQ fleet by fishery, year and season.

Fig. 12. Chinook salmon bycatch rates in the CDQ fleet by fishery, year and season.

Fig. 13. "Other" salmon bycatch rates in the CDQ fleet by fishery, year and season.

Fig. 14. Red king crab bycatch rates in the CDQ fleet by fishery, year and season.

Fig. 15. "Other" king crab bycatch rates in the CDQ fleet by fishery, year and season.

Fig. 16. *C. bairdi* bycatch rates in the CDQ fleet by fishery, year and season.

Fig. 17. "Other" Tanner crab bycatch rates in the CDQ fleet by fishery, year and season.

Fig. 18. Primary products expressed as a percentage of total primary product tonnage for vessels that participated the 1993 and 1994 CDQ fisheries.

Fig. 19. Individual product values expressed as a percentage of total production value for vessels that participated in the 1993 and 1994 CDQ fisheries.

Fig. 20. Total value of products produced per metric ton of pollock catch in the 1993 CDQ fleet by vessel, fishery and season.

Fig. 21. Total value of products produced per metric ton of pollock catch in the 1994 CDQ fleet by vessel, fishery and season.

Fig. 22. Product values per metric ton of pollock catch by product type, year and fishery for vessels that participated in the 1993 and 1994 CDQ fisheries.

Fig. 23. Value of products produced per metric ton of pollock catch in the 1993 CDQ fishery expressed as a percentage of the value of products produced per metric ton of pollock catch in the 1993 open access fishery by vessel and season.

Fig. 24. Value of products produced per metric ton of pollock catch in the 1994 CDQ fishery expressed as a percentage of the value of products produced per metric ton of pollock catch in the 1994 open access fishery by vessel and season.

Fig. 25. Pollock catch per hour of fishing effort for vessels that participated in the 1993 CDQ fishery.

Fig. 26. Pollock catch per hour of fishing effort for vessels that participated in the 1994 CDQ fishery.

Fig. 27. Average pollock catch per hour by fishery for vessels that participated in the 1993 and 1994 CDQ fisheries.

INTRODUCTION

The Community Development Quota (CDQ) Program, which began in 1992, allocates 7.5% of the Bering Sea/Aleutian Islands (BSAI) pollock total allowable catch (TAC) to six groups of Alaskan Native communities located primarily along the Bering Sea coast. Typically, each CDQ group has entered into a partnership with an existing fishing company to harvest and process its share of the CDQ. With respect to the incentives provided to fishermen, there are two important differences between the CDQ pollock fishery and the open access pollock fishery. First, each fishing company participating in the CDQ pollock fishery pays for the right to harvest a given amount of pollock. Second, each such company is relatively free to choose when and how to harvest that amount of pollock. It has been suggested that such differences would result in a more efficient use of resources in the pollock fishery and could be particularly effective in addressing the problems of discards and catch utilization in the groundfish fisheries. Since all vessels that participate in the CDQ pollock fishery also participate in the BSAI open access pollock fishery, the CDQ program provides an excellent opportunity to examine how these two characteristics of the CDQ fishery affect the performance of individual vessels.

The purpose of this report is to examine the different economic incentives present in these two pollock fisheries, and to develop and test several hypotheses as to the expected differences in vessel performance under both types of systems. Due to limitations in the data, this analysis is restricted to the offshore (catcher processor and mother ship) sector of the CDQ fleet which has been responsible for harvesting over 95% of the CDQ catch. Because the purpose of this analysis was to examine the differences in individual vessel performance in the CDQ and open access fisheries, this analysis was further restricted to those vessels that participated in both the CDQ and open access fisheries. Therefore, no comparison was made between the CDQ fishery and the open access pollock fishery as a whole.

National Marine Fisheries Service (NMFS) observer and weekly production report data were used to compare the performance of vessels in the CDQ pollock fishery to the performance of those same vessels in the open access pollock fishery. Among the measures of performance examined were: groundfish discard rates, prohibited species bycatch rates, product value per unit of catch, and pollock catch per unit of fishing effort (CPUE). The results of this comparison indicate that pollock and other groundfish species discard rates are lower when vessels operate in the CDQ fishery. In the area of prohibited species bycatch, the comparison between the CDQ and open access fisheries, as expected, is less conclusive. CDQ vessels produced higher king crab and Tanner crab bycatch rates in the open access fishery, while in the CDQ fishery those same vessels produced higher Pacific herring bycatch rates. Vessel bycatch rates for Pacific halibut and Pacific salmon in the open access and CDQ fisheries were roughly comparable.

The final two measures of performance compared the relative productivity of vessels in each fishery. The first measure of productivity compared the value of products in dollars per metric ton of pollock catch. During the 1993 and 1994 "A" seasons and the 1993 "B" season, vessels in the CDQ fishery produced substantially higher product values per metric ton (t) of pollock than those same vessels produced in the open access fishery. However, during the

1994 "B" season, the average value per metric ton of pollock catch was basically the same in the CDQ and open access pollock fisheries. The second measure of productivity compared pollock catch per hour of fishing effort. In the open access fishery, vessels harvest significantly more pollock per hour than in the CDQ fishery.

THE COMMUNITY DEVELOPMENT QUOTA PROGRAM

CDQ Program Overview

The CDQ Program for the BSAI pollock fishery was established by Amendment 18 to the BSAI groundfish fishery management plan. Amendment 18 apportioned the pollock total allowable catch (TAC) between the inshore and offshore processing sectors and reserved 7.5% of the pollock TAC for a CDQ fishery. The CDQ program was implemented in late 1992 and is now expected to be extended through the end of 1998. The implementing regulations for Amendment 18 identified the coastal communities in Western Alaska that were eligible to receive CDQs, and established the process to be used to apportion pollock CDQs among groups of eligible communities. The initial CDQ pollock fishery occurred in December of 1992.

Under the CDQ program, six community development associations (CDQ groups) representing 56 predominantly Alaskan Native communities have received CDQ allocations. Each CDQ group decided to enter into partnerships with existing fishing companies to harvest and process its CDQ, and each group selected its industry partner(s) through a bidding process. The industry bids contained different mixes of payments, training, employment opportunities, and assistance with other regional fishing ventures. CDQ groups and industry partners typically agreed either to a specific price per metric ton for CDQ pollock or to a base price plus some form of profit sharing. One CDQ group has extended the partnership further by investing in vessels owned by its industry partner. In limited instances, CDQ shares have been resold on the open market to vessels that have no partnership agreement with a CDQ group.

The Bering Sea CDQ fishery, like the Bering Sea open access pollock fishery, is divided up into "A" (roe) and "B" (non-roe) seasons. In both 1993 and 1994, CDQ groups were allowed to harvest 45% of their CDQ during the "A" season, and the remaining 55% at any time during the rest of the year. Vessels participating in the CDQ fishery typically begin CDQ fishing immediately after the open access "A" and "B" seasons close or before the 15 August start of the open access "B" season. Although vessels are free to conduct CDQ fishing operations while the open access pollock fishery is open, with few exceptions, CDQ vessels have chosen instead to participate in the open access pollock fishery and conduct CDQ fishing only when the open access pollock fishery is closed.

Due to the increased importance of accurate estimates of total pollock catch by vessel in the CDQ fishery, more intensive catch monitoring has occurred in the CDQ fishery. During the 1993 season, some CDQ partnerships voluntarily agreed to provide two observers on each vessel in an effort to improve total catch monitoring. CDQ participants or harvesters have also worked with NMFS to develop improved methods of measuring total catch such as calibrated bins and on-board flow scales. NMFS has increased the sampling and total catch measurement requirements for vessels participating in CDQ fisheries. In June 1994, NMFS required that vessels maintain two NMFS-certified observers while conducting CDQ fishing operations, and in August 1994, NMFS required all CDQ vessels to provide either on-board scales or certified bins to improve total catch estimates.

Profile of the CDQ Fleet

During 1993, 13 catcher processors, 1 shore plant and 1 mothership participated in the CDQ fishery. The offshore sector was responsible for harvesting almost 100% of the CDQ total. In the offshore sector, 11 vessels fished in both the "A" and "B" season open access, and "A" and "B" season CDQ fisheries. The remaining three vessels participated in only one of the two CDQ seasons.

During 1994, 17 catcher processors, 3 shore plants and 1 mother ship participated in the CDQ fishery. The offshore sector was responsible for harvesting 91.6% of the CDQ total. In the offshore sector, 12 vessels fished in both the "A" and "B" season open access, and "A" and "B" season CDQ fisheries. The remaining seven vessels participated in only one of the two open access or CDQ seasons.

While both bottom trawl and pelagic trawl gear were used during the 1993 and 1994 CDQ fisheries, most fishing was done with pelagic trawl gear. According to NMFS target data (which is based on catch composition data not actual gear type observations) 93% of the 1993 CDQ total was considered pelagic trawl target. In 1994, 89% of the CDQ total was considered pelagic trawl target.

For the purposes of this analysis, vessels participating in the CDQ fisheries are grouped according to their predominant primary product. In 1993, six vessels produced surimi as their predominant primary product in both CDQ and open access fisheries, six vessels produced fillets as their predominant primary product during both CDQ and open access fisheries, and two vessels produced surimi as their predominant primary product during open access fishing operations and fillets as their predominant primary product during CDQ fishing operations. In 1994, eight vessels produced surimi as their predominant primary product, nine vessels produced fillets as their predominant primary product, and one vessel produced surimi as its predominant primary product in the open access fishery and fillets as its predominant primary product in the CDQ fishery.[1]

[1] Some vessels produce both surimi and fillets at the same time. For the purposes of this analysis, vessels are categorized as surimi or fillet vessels according to which type of product represents the greatest production during a particular fishery on the basis of product tonnage (Tables 3-4).

HYPOTHESIZED DIFFERENCES BETWEEN CDQ AND OPEN ACCESS FISHERIES

As noted above, there are two potentially important characteristics of the CDQ pollock fishery in terms of the incentives provided to fishermen. It has been suggested that these two characteristics may be very useful in solving the groundfish bycatch and catch utilization problems in the groundfish fisheries. The nature and sources of these problems are discussed and used to develop hypotheses concerning expected differences between the open access and CDQ pollock fisheries.

The Nature and Sources of the Bycatch Problem

The nature and source of the bycatch problem are explained by the answers to the following five questions;

1. What is bycatch?
2. Why does bycatch occur?
3. When is bycatch a problem?
4. What is the appropriate level of bycatch?
5. Why are there currently excessive levels of bycatch?

What is bycatch?

In this report, bycatch is defined as total fishing mortality excluding that accounted for directly by the retained catch of target species. Therefore, in the pollock fishery, bycatch includes the discarded catch of all species and the retained catch of groundfish species other than pollock.

Why does bycatch occur?

Bycatch occurs because fishing methods are not perfectly selective and because fishermen often have a sufficient incentive to catch more fish than will be retained. Although some methods of fishing are more selective than others, there are few examples of methods that are perfectly selective for species, size, quality, or sex. An incentive exists to catch more fish than will be retained if the fisherman's cost of the additional catch is less than the expected benefit and the latter depends on the probability that the catch will be retained.

When is bycatch a problem?

When fish are taken as bycatch in a specific fishing operation and fishery, other uses of those fish are precluded. The alternative uses of fish include: 1) retained target catch by that fishing operation, 2) catch and bycatch in the same commercial fishery but by another fishing operation, 3) catch and bycatch in another commercial fishery, 4) catch and bycatch in subsistence and recreational fisheries, and 5) contributions to the stock and other components of the ecosystem.

The value to the Nation of a specific use for fish is determined by the net benefit of that use and the distribution of the net benefit. The net benefit of a use is the difference between the value of the outputs from that use and the value of all the inputs associated with that use. The inputs used in a commercial fishery include fish taken as target catch and bycatch; other living marine resources; the fishing vessels, gear, and bait used in harvesting; the plants or vessels, equipment, and materials used for processing; the fuel and labor used throughout the production process; and all the inputs used to manage the commercial fishery. The cost of each input should be measured in terms of its opportunity cost which is its value in its highest valued alternative use.

Bycatch is a problem if it precludes higher valued uses of fish and other living marine resources and if the cost of reducing bycatch is significant. If the former condition is not met, there is not a better use of the fish taken as bycatch; therefore, the bycatch is not excessive and there is not a problem. If the latter condition is not met and if higher-valued uses exist, the solution to the problem is trivial, all bycatch would be eliminated at an insignificant cost.

What is the appropriate level of bycatch?

Basically, it makes sense to reduce bycatch in a cost-effective manner to the level at which further reductions would increase costs more than benefits. Both costs and benefits should be defined broadly from the Nation's perspective to include those that accrue to direct and indirect participants in the fishery as well as to other members of society. Those who harvest or process fish, those who provide support services to the harvesting and processing sectors of the fishing industry, and consumers of the fishery products are examples of direct and indirect participants in the fishery and of other members of society, respectively. "Cost-effective" refers to the lowest cost method of achieving a given reduction in the level of bycatch.

The marginal benefit and marginal cost curves in Figure 1 present graphically the concept of the optimum level of bycatch. The marginal benefit and cost curves, respectively, depict the benefit and cost of reducing bycatch by one unit for a given level of bycatch. For example, when the level of bycatch is 5,000 units, the marginal cost is about $15 and the marginal benefit is about $4. One unit would be one fish if bycatch is measured in the number of fish taken as bycatch or one unit would be 1 t if bycatch is measured in metric tons. For the groundfish fisheries, salmon and crab bycatch is measured in numbers of salmon and crab, respectively, but halibut, herring, and groundfish bycatch is measured by weight, usually in metric tons or kilograms.

The following two definitions can be used to ensure that each change in benefits and costs is accounted for in either the marginal benefit or marginal cost curve but not in both. First, marginal benefit equals the sum of the increases in benefits and the decreases in costs of a reduction in bycatch. Second, marginal cost equals the sum of the increases in costs and decreases in benefits of a reduction in bycatch. Other definitions can be used to assure that all benefits and costs are accounted for once, but only once, without changing the conclusions presented below.

Given these two definitions, marginal benefit includes the decrease in the total opportunity cost of using fish as bycatch, the decrease in the cost of sorting the catch, and any other decrease in fishing costs. Marginal cost includes the increase in fishing costs and the decrease in benefits from any reduction in retained catch.

The marginal benefit is expected to increase, but not necessarily steadily, as bycatch increases. At very low levels of bycatch, most of the fishing mortality of the species taken as bycatch is accounted for by other uses and the value of some of the other uses probably are quite low; therefore, the opportunity cost of bycatch and the marginal benefit of reducing bycatch are low. However, at very high levels of bycatch, much of the fishing mortality is accounted for by bycatch and the lower valued uses would have been eliminated; therefore, the opportunity cost of bycatch and the marginal benefit of reducing bycatch are high. Consider, for example, pollock bycatch (i.e., discards) in the pollock fishery. When it is very low, the per unit opportunity cost of pollock bycatch is low because much of the discarded pollock would be accounted for by damaged, contaminated, and diseased fish that are of limited value in the production of fishery products. However, at high levels of pollock bycatch, a substantially larger percent of the discards would be accounted for by fish that are discarded because 1) they are not of the optimum size for processing, 2) catch exceeded processing capacity, and 3) catch in the last tow of a trip exceeded the amount that is retained due to storage capacity, safety, or product quality imposed trip limits. The opportunity cost per unit of discard for such fish would be much higher.

The opposite trend is expected for marginal cost; that is, marginal cost is expect to decrease as bycatch increases, but again not necessarily steadily. When there are high levels of bycatch and little has been done to control bycatch, there are probably some simple and low-cost actions that can be taken to reduce bycatch. However, eventually, increasingly difficult and costly methods would be necessary and often very costly methods would be required to eliminate the last few units of bycatch. In the pollock fishery, fishermen might only have to implement low-cost measures such as reducing their catch to match their factory's processing capacities or have to make a smaller last tow to stay within a trip limit. When vessels already have low discard rates, they may be required to initiate more costly measures to reduce discards such as slowing factory lines, processing low-value products, or converting to more selective fishing gear or techniques.

If the marginal benefit and cost curves include all the benefits and costs to the Nation, the optimum level of bycatch, in terms of total net benefits, is the level at which marginal cost and marginal benefit are equal. In the hypothetical example depicted in Figure 1, marginal cost and marginal benefit both equal $10 when bycatch equals 10,000 units. At lower levels of bycatch, the marginal cost of reducing bycatch is greater than $10 and the marginal benefit is less than $10; therefore, reducing bycatch below 10,000 units would decrease net benefit. However, at higher levels of bycatch, the marginal cost is less than $10 and the marginal benefit is greater than $10; therefore, net benefit would be increased by decreasing bycatch.

The implications of not using cost-effective methods of controlling bycatch are depicted in Figure 2. Curves MC1 and MC2 in Figure 2, respectively, are the marginal cost curves when cost-effective methods are and are not used. In this example, the optimum level of bycatch is 10,000 units when the cost-effective methods are used, but it is 15,000 units when they are not used.

Why are there currently excessive levels of bycatch?

A common response to this question is that the greed or lack of concern by the fishermen results in excessive bycatch. Perhaps a more productive response is that excessive bycatch is but one symptom of flawed fisheries management which substantially reduces the net benefits generated by the commercial fisheries.

More specifically, excessive bycatch is the result of the following set of circumstances: 1) the level of bycatch and the methods used to reduce bycatch are determined by individual fishermen in response to a variety of incentives and constraints that reflect the economic, social, regulatory, biological, and physical environments in which they operate; 2) an individual fisherman will tend to control bycatch to the point at which further reductions would increase his cost more than his benefit; 3) a fisherman will define cost-effective methods of reducing bycatch in terms of the costs he pays; 4) the fisherman's benefit from reducing his bycatch is less than society's; and 5) in an open access fishery for which there is a quota, the fisherman's cost of reducing his bycatch is greater than society's. These circumstances result in an individual fisherman making inadequate and non-cost-effective efforts to control bycatch. Basically, due to the existence of external benefits and costs, individual fishermen receive the wrong signals or incentives and make the wrong decisions from society's perspective, as well as from the perspective of the fishermen as a group. There are external benefits (costs) when there are differences between the benefits (costs) to the fisherman and to society as a whole as the result of an action taken by a fisherman.

This set of circumstances and the results are depicted by curves MBF, MBS, MCF, and MCS in Figure 3, which are, respectively, the marginal benefit curves for a fisherman and for society at large including the fisherman and the corresponding marginal cost curves. In this case, the marginal cost and benefit are for a one unit reduction in bycatch by a specific fisherman or fishing operation.

The MBS curve includes the reduction in the opportunity cost of using fish as bycatch and the decrease in sorting costs for the fisherman. However, because the fisherman does not pay the opportunity cost of the bycatch, the MBF curve includes principally the reduction in sorting cost. That is, because the opportunity cost of bycatch is an external cost, the MBS curve is above the MBF curve.

In an open access fishery with a catch quota, the MCF curve is above the MCS curve due to the external cost caused by the race for fish. This externality exists because, although the cost to the fisherman includes a reduction in his catch if his attempts to reduce bycatch decrease his rate of harvest relative to that of the rest of the fleet, the reduction in the fisherman's catch is not a cost to society. For the fleet as a whole, there is a redistribution of catch among fishermen, not a reduction in catch. This externality also results in a fisherman selecting methods to control bycatch that are not cost-effective from society's perspective. The externality does this by creating a bias in favor of methods that do not decrease a fisherman's catch. As a result of non-cost-effective methods being used by fishermen to reduce bycatch, the MCS curve is higher than it would otherwise be.

From the fisherman's perspective, it makes sense to control bycatch to the point at which the MBF and MCF curves intersect. For the hypothetical example depicted in Figure 3, the MBF and MCF curves intersect when bycatch for this one fishing operation is about 285 units. However, the MBS and MCS curves intersect when bycatch is 150 units. Therefore, in this example, the optimum level to the fisherman exceeds the optimum level to society by 135 units and it is the optimum level to the fisherman that determines what bycatch will be. In addition, the fisherman's use of non-cost-effective methods to decrease bycatch results in the MCS curve being unnecessarily high. Therefore, had cost-effective methods been used, the optimum level of bycatch for this fisherman from society's perspective would have been less than 150 units.

Hypotheses

The concepts of the marginal cost and benefit of decreasing bycatch and the optimum level of bycatch can be used as the basis for hypotheses concerning the effects of the two aforementioned characteristics of the CDQ fishery with respect to the discards of pollock and other groundfish and the bycatch of prohibited species.

Pollock discards

First, the MBF curve for pollock shifts up when a fisherman has to pay for the pollock that he catches. Second, the MCF curve for pollock shifts down because a fisherman's pollock catch is not decreased when he takes more time to either reduce the catch or increase the retention of pollock that would have otherwise been discarded. Therefore, the two characteristics of the CDQ fishery are expected to result in decreased catch of pollock that normally would be discarded and increased retention and more effective use of the pollock catch that does occur.

Therefore, the first two hypotheses are as follows:

Hypothesis 1: Pollock discard rates are lower in the CDQ fishery.

Hypothesis 2: Product value per metric ton of pollock catch is higher in the CDQ fishery.

In the case of the "A" season (roe) fishery, it is recognized that, although the catch of a CDQ vessel is not reduced if it reduces its rate of harvest, the value of its catch would be reduced because pollock roe is at the optimum stage of maturity for a relatively short period of time. Therefore, the opportunity cost of time for a vessel may not differ substantially in the CDQ and open access roe fisheries.

The bycatch and discards of other species

After pollock, which accounts for over 90% of the groundfish discards in the pelagic pollock fishery, Pacific cod is the dominant discard species in the pollock fishery. The CDQ vessels do not pay for the cod they harvest. Therefore, the MBF curve for cod is not higher in the CDQ fishery, but the MCF curve for cod is lower for the same reason why it is lower for pollock. Therefore the next hypothesis is as follows:

Hypothesis 3: Pacific cod discard rates are lower in the CDQ fishery.

With respect to the benefit and cost of decreasing the bycatch of prohibited species, the MCF curve is expected to be lower in the CDQ fishery because vessels are less constrained by time and area. The MBF curve is not expected to change unless the CDQ groups provide incentives to decrease bycatch. If the MCF curve continues to be above the MBF curve, the downward shift of the MCF curve alone would not be expected to change the level of bycatch. Therefore, the final hypothesis is as follows:

Hypothesis 4: The levels of prohibited species bycatch will not differ between the CDQ and open access pollock fisheries.

Catch per unit of effort

A comparison was also made of the pollock catch per hour of trawling. However, no hypothesis was developed concerning the expected difference between the CDQ and open access pollock fisheries. The comparison is presented principally to provide information concerning the presence of factors, other than the two aforementioned characteristics of the CDQ pollock fishery, that may influence the performance of each fishery.

The implicit qualification

For each of the hypotheses listed above, there is an implicit qualifier. To make it explicit, the following could be added at either the beginning or the end of each hypothesis: "as the result of the two characteristics of the CDQ fishery and everything else being constant". Because everything else was not constant, the tests of the hypotheses can not be definitive. That is, the comparisons of vessel performance for the CDQ and open access pollock fisheries may support a hypothesis concerning the effects of the two characteristics of the CDQ fishery because there were other factors that caused the expected differences in performance. Similarly, a hypothesis may appear to be refuted because some other difference between the fisheries more than offset the expected effects of the two characteristics of the CDQ fishery. Therefore, in the absence of strict controls or adjustments for other factors, the comparisons of the two fisheries are only suggestive concerning the validity of the four hypotheses listed above.

Measures of Performance

The above hypotheses were tested by comparing the individual performance of vessels that participated in both the CDQ and open access pollock fisheries. In addition, aggregate comparisons of performance were made for groups of vessels that participated in both fisheries. The comparisons were made separately for the "A" (roe) and "B" (non-roe) seasons and for 1993 and 1994. The measures of performance used are as follows:

1. pollock discard rate (pollock discards/pollock catch);
2. percent of pollock used for meal and oil only;
3. Pacific cod discard rate (cod discards/cod catch);
4. other groundfish discard rate (groundfish discards other than pollock and cod/groundfish catch other than pollock and cod);
5. non-pollock groundfish bycatch rate (non-pollock groundfish catch/total groundfish catch);
6. bycatch rates for halibut, herring, crab, and salmon;
7. pollock wholesale product value per metric ton of pollock catch; and
8. CPUE (pollock catch per hour of tow duration).

DATA SOURCES AND LIMITATIONS

Databases Used in this Analysis

The two primary sources of data used in this report are the NMFS weekly observer reports and the NMFS weekly production reports. In both the open access and CDQ pollock fisheries, observers make weekly reports of total catch, discards, prohibited species bycatch, and fishing effort. In the CDQ fishery, observers also provide NMFS with daily estimates of total pollock catch. In both the CDQ and open access fisheries, all processors must keep daily records of catch, discards and factory production and must make weekly production reports to NMFS. For management purposes, NMFS combines these two sources of data to produce a third database, known as the blend database, which is considered the "official" record of groundfish catch.

NMFS uses the blend estimates of catch for in-season management of the open access groundfish fisheries. However, in the CDQ fishery, NMFS uses only observer estimates to manage the fishery, and the daily observer reports are considered the "official" record of CDQ pollock catch. Because CDQ vessels must now carry two observers, and install either scales or certified bins for calculating catch estimates, observer estimates are considered to be the most reliable record of CDQ fishing operations. For this reason, the weekly observer database, rather than the blend database, is the primary source of groundfish catch and discards estimates used in this report. However, there is one instance where differing estimates of pollock catch significantly affect a measure of performance used in the analysis, it is the measure of product value per unit of pollock catch. For comparison purposes, this measure of performance was calculated separately using all three estimates of pollock catch.

Weekly observer reports are also the sole source of prohibited species bycatch information used in this report. In fact, observer estimates of prohibited species bycatch rates are the only source used for management purposes by NMFS. In addition, processor weekly production reports are the sole source of product information, and the Alaska Department of Fish and Game/National Marine Fisheries Service annual groundfish processor survey is the sole source of wholesale price data used in this report. Because the 1994 product price survey has not yet been completed, 1993 survey prices were used to estimate product values for both 1993 and 1994.

Report Scope

For most of 1993, the observer and weekly production report databases do not distinguish between CDQ and open access fishing activity. Therefore, information on the timing of the open access "A" and "B" seasons, the daily observer CDQ reports, and the week of each observation were used to differentiate between CDQ and open access fishery observations. Observations that occurred during a week in which a processor participated in both the CDQ and open access fisheries were dropped for 1993 because it was not possible to differentiate between CDQ and open access fishery activities for those processor weeks. The observations that were excluded from this analysis were primarily in the reporting weeks ending 27 February, 21 August, and 25 September, which are the weeks that correspond to the "A" season open access closure, the "B" season open access opening, and the "B" season open access closure, respectively. In 1994, both databases included separate records for CDQ and open access fishery activity; and it was therefore not necessary to exclude any 1994 observations from this analysis.

This analysis was also restricted to 1993 and 1994 when most "A" and "B" season CDQ fishing operations, respectively, were conducted immediately following the "A" and "B" season open access fisheries or just prior to the opening of the open access "B" season. Fishing under the CDQ program began in December 1992. However, data from the 1992 CDQ fishery were not included in this analysis. Because of the time gap between the 1992 open access and 1992 CDQ fisheries, it was felt that discard, bycatch, and production information from those two fisheries may not be directly comparable.

This analysis was further restricted to the offshore processing sector which accounted for over 95% of the CDQ catch during 1993-94. Comparisons between the CDQ and open access fisheries are most easily made in the offshore sector because observer and weekly production reports for the same vessel and report week can be compared directly. It is more difficult to make meaningful comparisons between CDQ and open access fishing operations in the inshore sector because each processing plant receives deliveries from a group of vessels that changes throughout the year. Some vessels in the inshore sector are below the 100% observer coverage size limit of 125 feet. As a result, there is less complete observer data for the inshore sector.

Limitations on the Comparison Between Open Access Fisheries

There are three principal reasons why the comparisons of the various measures of fishing performance between the CDQ and open access fisheries provide only a limited test of the hypotheses developed in this paper. First, there are a variety of factors that may explain differences in performance between the CDQ and open access fisheries; therefore, it is not possible to know with certainty what differences in the nature of these two fisheries caused any apparent difference in performance. Second, the comparisons are made using estimates of performance; therefore, apparent differences in performance may be due to measurement errors rather than real differences. Third, because participation in the CDQ pollock fishery is on a part-time and potentially short-term basis, some of the changes in fishing and processing strategies that would occur with a permanent program that included the two characteristics of the CDQ fishery are not economically feasible under the current CDQ program.

Two examples of other factors that complicate the comparison are temporal and regulatory differences between the open access and CDQ fisheries. The fact that the "A" and "B" season CDQ fisheries, respectively, occur primarily after the "A" and "B" season open access fisheries or prior to the "B" season open access fishery may either contribute to or partially offset the effects of the two characteristics of the CDQ fishery that were identified above. For example, industry sources suggested that in 1993 the roe season did not peak until after the closure of the open access fishery. Consequently, CDQ vessels may have had access to pollock with both a higher quantity and quality of roe.

Similarly, the fact that factory trawlers can operate in the catcher vessel operating area (CVOA)[2] during the CDQ "B" season but not during the open access "B" season may explain some of the differences in performance between the "B" season CDQ and "B" season open access fisheries. Industry sources have suggested that vessels fishing inside the CVOA were able to catch a higher percentage of large pollock than vessels fishing outside the CVOA. Because both weekly observer reports and weekly processor reports are made by NMFS reporting area, and because the CVOA crosses multiple report area boundaries, it was not possible in this report to isolate the vessel performance effects of fishing inside or outside the CVOA.

The quality of the data used in generating the estimates of performance can also confound the comparisons. The following discussions of the estimates of discard rates and product value provide two examples of this problem. Because the principal objective of the observers is to estimate total catch, species composition, and prohibited species bycatch rather than to track the disposition of catch, the estimation methods used concentrate on providing good estimates of catch and bycatch at the expense of better estimates of groundfish discards.[3] The disparity between the quality of the estimates of catch and discards is thought to be greatest for individual observations. Therefore, estimated differences in discard rates among processors may be due more to estimation errors than to actual differences in discard rates.

The industry-wide average wholesale product prices were used to calculate the product values used in this report. As such, these are very rough estimates of the value of products produced by an individual vessel during the CDQ and open access pollock fisheries. Accurate prices by

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[2]The CVOA is an area of the Bering Sea intended to be within easy traversing distance to processors in Dutch Harbor and Akutan. The CVOA is the area bounded by the Aleutian Islands, 56° N latitude, 172° W longitude and 163° W longitude. This area includes all of NMFS reporting area 519 and portions of reporting areas 509, 517 and 518.

[3]The 1995 NMFS Groundfish Observer Manual includes the following instructions to observers related to the calculation discards: "There is no clear scientific way for observers to arrive at the percent retained by species group figure because of the variability in discarding that occurs on vessels, and the many different places discard takes place. Recognizing these limitations, we want observers to make an approximation based on what they see happening on their particular vessel. Because this is an approximation, corresponding time and effort given to obtaining it should be minimized and complex mathematical approaches to this task avoided....In most instances, this estimate will only be a visual approximation based on the observer's best judgment and observations of what is going on in the factory. For this figure, it is acceptable to make your best guess." (pgs. 6-16).

product type, period, and processor would be needed to eliminate this problem. In the case of pollock roe, prices would be needed for a number of very short periods or product weight and price data would be required by grade. Despite these limitations and complications, there are sufficient observations for the comparisons that are presented below to provide useful information concerning some of the potential short-run effects of having fishermen pay for the fish they harvest and of allowing fishermen to determine when and how to catch fish. The long-run effects of these changes in the incentives for fishermen would be expected to be substantially greater because the ability to respond to the change in incentives is limited in the short run. For example, changes in the type of vessel and processing equipment used are much more limited in the short run.

COMPARISONS OF GROUNDFISH DISCARDS AND PROHIBITED SPECIES BYCATCH

Discards of Pollock and Other Groundfish Species

Mean discard rates for pollock and other groundfish species were calculated using weekly observer estimates of groundfish catch and discards. Pollock discard rates were calculated as a percentage of the total pollock catch; Pacific cod discard rates were calculated as a percentage of the total Pacific cod catch; "other" groundfish species discard rates were calculated as a percentage of "other" groundfish catch.[4] Since pollock is the only groundfish species of interest to most vessels participating in both open access and CDQ pollock fisheries, the percentage of non-pollock groundfish in the total catch was also measured to provide an estimate of the level of groundfish bycatch. Discard and bycatch rates for each species were estimated by vessel, fishery, and season (Tables 1 and 2). Individual vessels were assigned random codes to preserve confidentiality and were grouped according to primary product (surimi or fillets) based upon which product type represented the greatest product tonnage on an annual basis.

Pollock discards

With respect to pollock discards, two trends are evident. First, due in part to a decrease in the relative abundance of smaller pollock, discard rates for both the CDQ and open access fisheries declined from 1993 to 1994 (Figs. 4, 5 and 6). Second, with the exception of the 1993 "B" season, pollock discard rates were consistently lower during CDQ fisheries than the same season open access fishery. It should be noted that over 80% of the total pollock discards during 1993 CDQ fisheries were made by just 2 vessels (vessels P and R in Table 1 and Fig. 4). Those same 2 vessels were responsible for 50% of the pollock discards made by CDQ vessels in open access fishing operations. Many of the vessels participating in the CDQ

[4]For the purposes of this report, "other" groundfish species refers to all groundfish species other than pollock or cod. This should not be confused with the "other" groundfish reporting category used by NMFS in some observer and weekly production reports.

fishery discarded less than 1% of their total catch in both CDQ and open access fisheries (Figs. 4 and 5). When both years are combined, 5 vessels had lower pollock discard rates in the open access fishery, 13 vessels had lower pollock discard rates in the CDQ fishery, and 1 vessel had no reported pollock discards in either fishery. These results tend to support Hypothesis 1.

It has been suggested that because fish meal is such a low-value product, whole pollock processed into fish meal (as a primary product) should be considered underutilized in a similar category to discards. Eight vessels reported processing some whole pollock into fish meal as a primary product at some time during 1993 and 1994. When each year and season is examined separately, there are seven instances when a vessel processed a greater percentage of the pollock catch into fish meal as a primary product in the open access fishery and two instances when a vessel processed a greater percentage of the pollock catch into fish meal as a primary product in the CDQ fishery (Table 3). This may indicate a greater tendency among those vessels with fish meal capacity to process whole fish into fish meal during open access fisheries as compared with CDQ fisheries. These results also tend to support Hypothesis 1.

Pacific cod discards

Pacific cod is the only other groundfish species of commercial interest taken in significant quantities during CDQ and open access pollock fishing operations. The aggregate cod discard rate over both years was 87.3% in the open access fishery and 53.0% in the CDQ fishery (Fig. 7). Industry sources suggest that several vessels (particularly the smaller fillet vessels) may have combined CDQ pollock fishing and open access cod fishing during the 1993 and 1994 "A" seasons which could account for the higher cod utilization rate during those seasons. Five vessels had lower cod discard rates in the open access fishery, 10 vessels had lower cod discard rates in the CDQ fishery, and 4 vessels discarded 100% of their cod catch in both fisheries. These results tend to support Hypothesis 3.

Other groundfish species discards

Most vessels participating in the CDQ and open access pollock fisheries discarded virtually all other groundfish species (Fig. 8). These species include rock sole, yellowfin sole, arrowtooth flounder, Pacific ocean perch and assorted other rockfish. Because bycatch rates for these other groundfish species were insignificant (between zero and 1%) for all vessels and fisheries examined, these other groundfish species were grouped together to simplify our analysis. Vessels participating in the CDQ fishery exhibited slightly lower rates of other groundfish species discards at 93.6% versus 98.6% over both years. One vessel had lower discard rates in the open access fishery, 8 vessels had lower discard rates in the CDQ fishery, and 10 vessels discarded 100% of other groundfish species in both fisheries.

Non-pollock total catch

Since most vessels examined in this analysis only utilize pollock, all other groundfish species may be considered bycatch. A comparison of the level of non-pollock groundfish catch in both the CDQ and open access fisheries provides a measure of how "clean" each fishery is with respect to groundfish bycatch. However, such a comparison did not uncover any consistent difference between CDQ and open access fisheries (Fig. 9). In addition, this comparison may be further distorted by the fact that at least one vessel reportedly combined CDQ pollock fishing with open access cod fishing during the 1993 and 1994 "A" seasons. The aggregate non-pollock catch rate over both years was 2.2% in the open access fishery and 2.6% in the CDQ fishery. Eight vessels had lower average rates of non-pollock groundfish catch in the open access fishery, and 11 vessels had lower average rates of non-pollock groundfish catch in the CDQ fishery.

Prohibited Species Bycatch

The mean bycatch rates of prohibited species in the CDQ and open access pollock fisheries were estimated using weekly observer estimates. The rates were estimated by vessel, season, and fishery for those vessels that participated in the 1993 and 1994 CDQ fisheries (Tables 1 and 2). Bycatch rates for Pacific halibut and Pacific herring were calculated as the average kilograms of bycatch per metric ton of groundfish. Bycatch rates for Pacific salmon, king crab and Tanner crab were calculated as the average number of individuals caught per metric ton of groundfish. The rates for Pacific salmon were calculated for chinook salmon and other salmon; other salmon include chum, coho, sockeye, pink salmon, and steelhead.[5] The rates for crab species were calculated for *C. bairdi* Tanner crab and red king crab (the only two crab species for which there are bycatch limits), and for other Tanner crab and other king crab. Other Tanner crab include *C. opilio, C. angulatus, C. tanneri,* and the *C. bairdi* X *C. opilio* hybrid. Other king crab include blue king crab, golden (brown) king crab and cousei king crab.

With the exception of Pacific herring, *C. bairdi* Tanner crab, and other Tanner crab, there does not appear to be significant differences between prohibited species bycatch rates in the CDQ fisheries compared with open access fisheries over both years and seasons. Mean CDQ bycatch rates were expressed as a percentage of mean open access bycatch rates to determine the extent to which bycatch rates were higher or lower in the CDQ fishery (Table 4). However, because bycatch rates approach zero within the CDQ fleet for some species, fisheries, or seasons, comparisons of this nature tend to exaggerate the differences between two rates. Finally, it should be emphasized that the open access figures in this comparison

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5 Observer estimates for all groundfish fisheries in the BSAI and Gulf of Alaska indicate that chum salmon account for about 99% of the "other" salmon group. See Narita, R., M. Guttormsen, J. Gharrett, G. Tromble, and J. Berger. 1994. Summary of observer sampling of domestic groundfish fisheries in the northeast Pacific Ocean and eastern Bering Sea, 1991. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-48, 540 p.

include only those vessels that participated in the CDQ fishery and do not reflect prohibited species bycatch rates of the open access fleet as a whole.

These results tend to suggest that the differences in the times of year and areas in which the open access and CDQ fisheries are conducted may be more responsible for the differences in prohibited species bycatch rates than any changes in vessel behavior resulting from different economic incentives in the open access and CDQ fisheries. This may be especially true for the bycatch of salmon and herring which traditionally fluctuate on a seasonal and geographical basis. The differences in fishing areas are expected to be a factor particularly during the "B" season when open access vessels are excluded from the CVOA but CDQ vessels are allowed to fish within it. These results tend to support Hypothesis 3, but also indicate that the two characteristics of the CDQ fishery are clearly not the only factors causing differences in performance between the CDQ and open access pollock fisheries.

Pacific halibut

Bycatch rates for Pacific halibut varied significantly from a high of 1.65 kg/t in the 1993 "A" open access fishery to a low of 0.09 kg/t in the 1993 "B" open access fishery. In both the CDQ and open access fisheries, halibut bycatch rates declined from 1993 to 1994. In addition, the aggregate halibut bycatch rates for both years and seasons were nearly identical at 0.77 kg/t in the CDQ fishery and 0.76 kg/t in the open access fishery (Fig. 10). Over both years, 8 vessels had lower average halibut bycatch rates in the open access fishery and 11 vessels had lower average halibut bycatch rates in the CDQ fishery.

Pacific herring

In the case of Pacific herring, vessels exhibited significantly higher bycatch rates during both the 1993 and 1994 "B" season CDQ fisheries (Fig. 11). This may be due either to the timing of the "B" season CDQ fishery or to the fact that many vessels participating in the "B" season fishery fished within the CVOA during CDQ operations but were excluded from the CVOA during open access operations. Most vessels experienced their highest herring bycatch rates in the 1994 "B" season CDQ fishery (Table 2). The aggregate herring bycatch rate for both years was 0.36 kg/t in the open access fishery and 1.06 kg/t in the CDQ fishery. Over both years, 9 vessels had lower average herring bycatch rates in the open access fishery, 9 vessels had lower herring bycatch rates in the CDQ fishery and 1 vessel had no reported herring bycatch in either fishery.

Chinook salmon

Bycatch rates of chinook salmon in the CDQ and open access fisheries are strikingly similar when both years and seasons are combined (Fig. 12). The aggregate bycatch rate for chinook salmon over both years was 0.025 individuals/t in the open access fishery and 0.022 individuals/t in the CDQ fishery. Four vessels had lower chinook salmon bycatch rates in the open access fishery, 14 vessels had lower chinook salmon rates in the CDQ fishery, and 1 vessel had no reported chinook salmon bycatch in either fishery.

Other salmon

In general, bycatch rates were higher for other salmon as compared with chinook salmon. However, bycatch rates for both chinook salmon and other salmon declined from 1993 to 1994 in both the open access and CDQ fisheries (Figs. 12 and 13). The aggregate bycatch rate for other salmon over both years was 0.097 individuals/t in the open access fishery and 0.113 individuals/t in the CDQ fishery. Seven vessels had lower average other salmon bycatch rates in the open access fishery, 10 vessels had lower other salmon bycatch rates in the CDQ fishery, and 1 vessel had no reported other salmon bycatch in either fishery.

Red king crab

The red king crab bycatch rate was highest in the 1993 "A" open access fishery at 0.054 individuals/t In all other cases, the red king crab bycatch rate was extremely low at less than 0.01 individuals/t (Fig. 14). The aggregate bycatch rate for red king crab over both years was 0.012 individuals/t in the open access fishery and 0.002 individuals/t in the CDQ fishery. Five vessels had lower average red king crab bycatch rates in the open access fishery, 4 vessels had lower average red king crab bycatch rates in the CDQ fishery and 10 vessels had no reported red king crab bycatch in either fishery.

Other king crab

Bycatch levels of other king crab are not significant in either the CDQ or open access fisheries (Fig. 15). Observer reports estimate only 2 individuals were caught during the entire 1993 CDQ fishery and 234 individuals were caught during the entire 1994 CDQ fishery (229 individuals were attributed to just 2 vessels). In fact, 13 vessels had no reported bycatch of other king crab in either fishery, 4 vessels had higher other king crab bycatch rates in open access fishery, and 2 vessels had higher other king crab bycatch rates in the CDQ fishery.

C. bairdi Tanner crab

Vessels participating in the open access fishery exhibited significantly higher *C. bairdi* bycatch rates, especially during the "A" season (Fig. 16). *C. bairdi* bycatch rates were highest in the 1993 "A" open access fishery at 1.52 individuals/t. The aggregate bycatch rate for *C. bairdi* over both years was 0.47 individuals/t in the open access fishery and 0.12 individuals/t in the CDQ fishery. Five vessels had lower average *C. bairdi* bycatch rates in the open access fishery and 14 vessels had lower *C. bairdi* bycatch rates in the CDQ fishery.

Other Tanner crab

Vessels participating in the open access fishery exhibited significantly higher other Tanner crab bycatch rates. Other Tanner crab bycatch rates were highest in the 1994 "B" open access fishery at 1.64 individuals/t (Fig. 17). The aggregate bycatch rate for other Tanner crab over both years was 0.61 individuals/t in the open access fishery and 0.07 individuals/t in the CDQ fishery. Five vessels had lower average other Tanner crab bycatch rates in the open access fishery, 13 vessels had lower average other Tanner crab bycatch rates in the CDQ fishery, and 1 vessel had no reported other Tanner crab bycatch in either fishery.

COMPARISONS OF PRODUCTIVITY

Overview of Production in the CDQ and Open Access Fisheries

For the CDQ fleet, fillets and surimi are the two primary products that represent the bulk of primary product production. During both years and seasons, vessels consistently increased fillet production and decreased surimi production during CDQ fishing operations. In 1994, many vessels also began to process a new product, deep skin fillets, in place of the traditional skinless, ribless pollock fillet (Fig. 18). When the total value of all products is considered, roe represented over 50% of total product value during the 1993 "A" season and over 40% of total product value during the 1994 "A" season in both the CDQ and open access fisheries (Fig. 19).[6]

Product Values per Metric Ton of Pollock Landed

NMFS weekly production reports were used to compare the value of pollock products generated per metric ton of pollock catch in the CDQ and open access fisheries. Product values per metric ton were calculated by dividing the total value of pollock products produced in a given week by the estimates of total catch of pollock for that week. Product price information from the 1993 cooperative Alaska Department of Fish and Game (ADF&G)/NMFS annual groundfish processor survey was used to calculate the total value of products produced in a given week. Consequently, these figures represent an estimate of the value of products produced by an individual vessel and not the actual wholesale prices received by that vessel. The following prices were used: fillets, no skin or ribs, $0.86/lb.; deep skin fillets, $1.41/lb.; surimi, $0.76/lb.; roe, $5.56/lb.; minced fish, $0.40/lb.; fish meal, $0.23/lb.; and fish oil, $0.10/lb.

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[6] Although roe represents the most valuable product harvested during the CDQ fishery, it is always reported as an ancillary product in pollock fisheries. All vessels processing roe during the CDQ "A" season list either surimi or fillets as their primary product and roe as an ancillary product in their weekly production reports.

Product values by vessel and fishery

Tables 5 and 6 display total pollock product values per metric ton of pollock catch and the breakdown of primary products for vessels participating in the 1993 and 1994 CDQ fisheries. Because inconsistencies exist between the observer, blend, and weekly production report databases, product values per metric ton were calculated separately using pollock tonnage totals obtained from each of three databases. One significant source of discrepancy between the observer and weekly processor databases is the lag time between when fish are caught and processed. For example, fish caught at the end of a week will be attributed to that week's catch tonnage in the observer database. However, because those fish may not be processed for 24 to 48 hours, they may be attributed to the following week's production total. Consequently, the observer and weekly production databases may not be directly comparable on a week-by-week basis (but should be in closer agreement on a season-by-season basis).

Figures 20 and 21 display the average value of products per metric ton for each vessel participating in the 1993 and 1994 CDQ fishery, and Figure 22 displays the CDQ fleet average product values by fishery, season, and product type. For all three figures, observer data was the source of total pollock catch. Most vessels generated at least twice the value of pollock products per metric ton of pollock caught during the "A" (roe) season as compared with the "B" (non-roe) season. This difference in product value per metric ton is due largely to the high value of pollock roe which is produced as an ancillary product by all vessels during the "A" season (Fig. 22).

CDQ versus open access fisheries

The comparison between the CDQ and open access fisheries is made first using weekly observer data as the source of total pollock catch. That is followed by similar comparisons using blend data and then weekly production data as the source of total pollock catch.

During the "A" season, most vessels generated significantly higher product values per metric ton during the CDQ fishery as opposed to the open access fishery. In 1993, nine vessels had higher product values per metric ton of pollock catch in the "A" season CDQ fishery and two vessels had higher product values in the "A" season open access fishery (Fig. 23). In 1994, eight vessels had higher product values per metric ton of pollock catch in the "A" season CDQ fishery and, five vessels had higher product values in the "A" season open access fishery (Fig. 24). For all vessels combined in the 1993 "A" season, the estimate was $557 in the open access fishery compared with $677 for the CDQ fishery. The comparable estimates for 1994 are $687 and $749, respectively.

During the 1993 "B" season, average product value per metric ton of pollock catch was substantially greater for the CDQ fishery. Although five vessels had higher product values per metric ton of pollock catch in the CDQ fishery, six vessels had higher values in the open access fishery (Fig. 23). In 1994, the average product value was basically the same in the CDQ and open access pollock fisheries. Although eight vessels had higher product values per metric ton of pollock catch in the CDQ fishery, five vessels had higher values in the open access fishery (Fig. 24). For all vessels combined in the 1993 "B" season, the estimate was $339 in the open access fishery compared with $439 for the CDQ fishery. The comparable estimates for 1994 are $529 and $532, respectively.

One factor may account for much of the higher average value for the CDQ fishery during the "A" season. Industry sources have suggested that the peak of the 1993 roe season did not occur until after the closure of the "A" season offshore pollock fishery.[7] Vessels participating in the "A" season CDQ fishery may have had the advantage of fishing when the quantity of pollock roe was at the peak. Because one industry-wide average price for roe was used throughout this analysis, only differences in the total quantity of roe produced, not differences in the quality of roe between CDQ and open access fisheries are accounted for. Much of the increase in production per metric ton during the "A" season CDQ fishery is attributable to higher roe production, however production of other products such as surimi and fillets also increased during the CDQ fishery (Fig. 22). These results based on weekly observer estimates of total pollock catch tend to support Hypothesis 2.

The results are not substantially different when blend estimates of total pollock catch are used. During the 1993 "A" season, 10 out of 11 vessels generated higher, often substantially higher, product values per metric ton in the CDQ fishery (Table 5). In 1994, 10 vessels had higher product values per metric ton of pollock catch in the "A" season CDQ fishery and 5 vessels had higher product values in the "A" season open access fishery. For all vessels combined in the 1993 "A" season, the estimate was $559 in the open access fishery compared with $679 for the CDQ fishery. The comparable estimates for 1994 are $520 and $553, respectively.

During the "B" season, average product value per metric ton of pollock catch was higher during the 1993 CDQ fishery but lower during the 1994 CDQ fishery. In 1993, 9 of 12 vessels had higher product values in the CDQ fishery. In 1994, eight vessels had higher product values per metric ton of pollock catch in the "B" season CDQ fishery and five vessels had higher product values per metric ton of pollock catch in the "B" season open access fishery. For all vessels combined in the 1993 "B" season , the estimate was $339 in the open access fishery compared with $425 for the CDQ fishery. The comparable estimates for 1994 are $376 and $349, respectively. Therefore, when total pollock catch is based on the blend estimates, the results support Hypothesis 2.

The third comparison of product value per metric ton of pollock catch was made using weekly production reports as the source of total pollock catch. The results are not substantially different for this third source of catch data. During the "A" season, most vessels generated significantly higher product values per metric ton during the CDQ fishery as opposed to the open access fishery. In 1993, nine vessels had higher product values per

[7]For a discussion of the timing of the 1993 roe season see NMFS Alaska Region, "EA/RIR/IRFA for a regulatory amendment to change the Bering Sea and Aleutian Islands area pollock roe season start date (28 June, 1994).

metric ton of pollock catch in the "A" season CDQ fishery and two vessels had higher product values in the "A" season open access fishery (Table 5). In 1994, 11 vessels had higher product values per metric ton of pollock catch in the "A" season CDQ fishery, 2 vessels had higher product values in the "A" season open access fishery, and 2 vessels had the same values in the CDQ and open access fisheries (Table 6). For all vessels combined in the 1993 "A" season, the estimate was $659 in the open access fishery compared with $846 for the CDQ fishery. The comparable estimates for 1994 are $486 and $597, respectively.

During the "B" season the differences between the CDQ and open access fishery were similar to those with the other two measures of value per metric ton on pollock catch. In 1993, nine vessels had higher product values per metric ton of pollock catch in the "B" season CDQ fishery and three vessels had higher product values per metric ton of pollock catch in the "B" season open access fishery (Table 5). In 1994, five vessels had higher product values per metric ton of pollock catch in the "B" season CDQ fishery and eight vessels had higher product values per metric ton of pollock catch in the "B" season open access fishery (Table 6). For all vessels combined in the 1993 "B" season, the estimate was $303 in the open access fishery compared with $369 for the CDQ fishery. The comparable estimates for 1994 are $343 and $382, respectively. Therefore, the results also tend to support Hypothesis 2 when the comparisons of pollock product value per metric ton of pollock catch are made using the weekly production report estimates of total pollock catch.

Other Possible Differences Between the CDQ and Open Access Product Values

Industry sources suggest that there may be other differences in the value of products produced in the CDQ fishery as compared with the open access fishery. Vessels in the CDQ fishery may have some market advantages over vessels in open access fisheries. Some secondary processors have indicated that they prefer to purchase products from CDQ partnerships for several reasons. First, the CDQ fishery increases the ability of secondary processors to rely on a particular supplier because the CDQs allow vessels to guarantee that a certain quantity of fish will be harvested and delivered. Second, inventory costs are potentially lower for firms purchasing products produced in the CDQ fishery because they can inventory fish in the water requesting delivery only when products are needed. For some secondary processors, inventory and storage costs may be significant. At present, most vessels participating in the open access fishery make the majority of their deliveries during February/March and October/November at the end of the "A" and "B" season open access fisheries. Because vessels participating in the CDQ fishery are free to fish at any time, they may spread out their deliveries to the times when products are in highest demand.

Despite the possible market advantages inherent in the CDQ fishery, one secondary processor contacted during this study indicated that they do not pay any additional price for products caught in the CDQ fishery. This secondary processor also noted that they have neither looked for nor observed any differences in product quality between CDQ and open access fisheries.

Catch per Unit of Effort

Observer tow duration estimates were matched with observer pollock catch estimates to generate a measure of CPUE. Figures 25 and 26 display the average pollock catch per hour of tow duration for each vessel and fishery. Several observations can be made with respect to fishing effort. First, vessels which produced surimi as a primary product tended to catch more pollock per hour than vessels which produced fillets as a primary product. This difference may be due to differences in vessel size rather than type of product as vessels with surimi processing capacity tend to be larger in size. Second, vessels in the open access fishery tended to catch more pollock per hour of fishing effort than in the CDQ fishery (Fig. 27). Although catch per day or week would be expected to be higher in the open access fishery due to both characteristics of the CDQ fishery, the reason for the difference in CPUE between the CDQ and open access pollock fishery is not obvious.

CONCLUSIONS

The results of this comparison of the performance of vessels participating in both the open access and CDQ pollock fisheries offer support for the four hypotheses detailed previously. Pollock and other groundfish discard rates were lower in the CDQ fishery. For the "A" and "B" seasons for both years together, the pollock discard rate was 2% in the CDQ fishery compared with 4% in the open access fishery. With respect to prohibited species, the open access fishery produced higher king crab and Tanner crab bycatch rates while the CDQ fishery produced higher herring bycatch rates. Bycatch rates for halibut and salmon in the open access and CDQ fisheries were roughly comparable. The differences in prohibited species bycatch rates between the CDQ and open access fisheries suggest that the two characteristics of the CDQ fishery that are the basis for the hypotheses are not the only factors that result in differences in the performance of the CDQ and open access pollock fisheries. Differences in pollock product values generated per metric ton of pollock caught were substantial during the 1993 and 1994 "A" seasons and 1993 "B" season. In these three cases, CDQ vessels generated higher product values. During the 1994 "B" season, there was basically no differences in product values between the CDQ and open access fisheries.

One final point to emphasize is that all of the vessels participating in CDQ fisheries continue to conduct the bulk of their activity in open access fisheries, and consequently are still governed by the economics of open access fishing conditions. As a result, investments that might make economic sense for vessels participating exclusively under the two characteristics of the CDQ fishery may not make sense for vessels that harvest the preponderance of their fish in open access fisheries.

Because of the absence of strict controls or adjustments for the other factors listed previously, the comparisons presented in this paper are only suggestive of the differences in fishing under CDQ and open access conditions. Nevertheless, the results of this study suggest that conditions in a CDQ fishery support a more efficient utilization of resources in the pollock fishery and could be effective in addressing the problems of discards and bycatch in the groundfish fisheries off Alaska.

Table 1. Groundfish discard and prohibited species bycatch rates for vessels participating in the 1993 CDQ fishery.

						kg/metric ton		Individuals/metric ton				
Vessel and fishery	*Primary product*[1]	*Pollock disc rate*[2]	*Cod disc. rate*[3]	*Oth. target disc.rate*[4]	*Non-poll. total catch*[5]	*hal*	*herr*	*Chin*	*Osal*	*Redk*	*Btan*	*Otan*
					<u>*Surimi vessels*</u>							
Vessel A												
"A" open access	Surimi	0%	100%	100%	4%	1.41	-	0.11	-	-	0.45	0.19
"A" CDQ	Surimi	0%	100%	100%	1%	0.04	-	-	-	-	0.01	-
"B" open access	Surimi	2%	100%	100%	0%	-	3.95	0.00	0.95	-	-	-
"B" CDQ	Surimi	2%	100%	100%	0%	-	1.08	0.06	0.41	-	-	-
Vessel B												
"A" open access	Surimi	2%	100%	100%	1%	0.38	-	0.06	-	-	0.09	-
"A" CDQ	Surimi	0%	0%	100%	0%	-	-	-	-	-	-	-
"B" open access	Surimi	0%	59%	100%	0%	0.02	0.03	0.01	0.20	-	-	-
"B" CDQ	Surimi	0%	100%	100%	0%	0.02	0.07	0.04	0.05	-	-	-
Vessel D												
"B" open access	Surimi	0%	100%	100%	0%	0.25	0.30	0.01	0.18	-	-	-
"B" CDQ	Surimi	0%	100%	100%	0%	-	-	0.03	-	-	-	-
Vessel G												
"A" open access	Surimi	2%	100%	100%	0%	0.17	0.00	0.08	0.00	-	0.11	0.07
"A" CDQ	Surimi	0%	0%	100%	0%	-	-	0.01	-	-	-	-
"B" open access	Surimi	2%	100%	100%	1%	0.06	0.14	0.01	0.06	-	-	0.00
"B" CDQ	Surimi	0%	100%	100%	0%	0.11	0.41	0.03	0.46	-	-	-
Vessel H												
"A" open access	Surimi	1%	67%	100%	1%	0.76	-	0.01	0.00	-	0.18	0.05
"A" CDQ	Surimi	1%	10%	100%	0%	0.14	0.01	0.00	0.01	-	-	-
"B" open access	Surimi	0%	100%	100%	0%	0.02	0.02	0.01	0.47	-	-	-
"B" CDQ	Surimi	0%	100%	100%	0%	-	0.89	0.02	0.01	-	-	-
Vessel I												
"A" open access	Surimi	10%	99%	100%	6%	1.69	-	0.00	-	0.378	4.39	1.47
"A" CDQ	Fillets	4%	10%	100%	0%	-	-	-	-	-	0.26	-
Vessel K												
"B" open access	Surimi	0%	100%	97%	0%	-	0.01	0.10	0.07	-	-	0.00
"B" CDQ [6]	Surimi	0%	100%	100%	0%	-	1.72	0.04	0.22	-	-	-

Table 1. Cont.

Vessel and fishery	*Primary product*[1]	*Pollock disc rate*[2]	*Cod disc. rate*[3]	*Oth. target disc.rate*[4]	*Non-poll. total catch*[5]	*kg/metric ton* *hal*	*kg/metric ton* *herr*	*Individuals/metric ton* *Chin*	*Individuals/metric ton* *Osal*	*Individuals/metric ton* *Redk*	*Individuals/metric ton* *Btan*	*Individuals/metric ton* *Otan*
					Fillet vessels							
Vessel L												
"A" open access	Fillets	10%	77%	100%	9%	3.62	-	0.06	-	0.001	0.28	0.15
"A" CDQ	Fillets	1%	45%	99%	7%	2.61	0.03	0.01	0.54	-	0.06	-
"B" open access	Fillets	5%	100%	100%	0%	0.01	0.08	0.03	0.57	-	-	-
"B" CDQ	Fillets	2%	100%	100%	0%	-	35.49	0.06	0.21	-	-	-
Vessel M												
"A" open access	Fillets	5%	100%	100%	9%	4.68	-	0.22	-	-	0.46	0.00
"A" CDQ	Fillets	5%	98%	100%	3%	1.22	0.20	0.00	0.17	-	0.72	0.12
"B" open access	Fillets	0%	100%	100%	1%	0.02	0.08	0.02	0.37	-	-	-
"B" CDQ	Fillets	0%	100%	100%	0%	0.20	0.53	0.11	0.21	0.004	0.13	0.07
Vessel O												
"A" open access	Surimi	3%	82%	100%	6%	1.05	-	-	-	-	1.71	0.69
"A" CDQ	Fillets	0%	100%	100%	2%	0.77	0.08	0.01	0.47	-	0.09	0.01
"B" open access	Fillets	1%	93%	100%	0%	0.02	0.12	0.00	0.12	-	-	-
"B" CDQ	Fillets	0%	36%	100%	0%	0.09	-	0.01	0.05	-	-	-
Vessel P												
"A" open access	Fillets	34%	100%	100%	7%	1.45	-	-	-	-	2.58	3.35
"A" CDQ	Fillets	25%	100%	100%	11%	0.91	-	-	-	-	0.36	1.42
Vessel Q												
"A" open access	Fillets	9%	98%	100%	4%	0.99	-	0.01	-	-	2.98	2.22
"A" CDQ	Fillets	1%	9%	99%	0%	0.19	0.05	0.00	0.24	-	-	0.00
"B" open access	Fillets	0%	92%	100%	0%	0.02	0.05	0.00	0.16	-	-	-
"B" CDQ	Fillets	3%	100%	100%	1%	0.10	-	0.08	0.00	-	-	-
Vessel R												
"A" open access	Fillets	52%	100%	100%	11%	5.42	0.01	-	-	0.000	2.12	-
"A" CDQ	Fillets	38%	93%	100%	18%	4.63	0.08	0.00	-	0.027	1.58	2.07
"B" open access	Fillets	5%	100%	100%	1%	0.18	0.10	0.02	0.08	-	0.00	0.00
"B" CDQ	Fillets	22%	100%	100%	3%	0.42	-	0.38	0.01	-	-	-
Vessel S												
"B" open access	Fillets	11%	100%	100%	1%	0.17	0.03	0.00	0.09	-	0.00	-
"B" CDQ	Fillets	0%	100%	100%	11%	35.11	-	-	-	-	1.53	-

Table 1. Cont.

	Primary	Pollock	Cod	Oth. target	Non-poll.	kg/metric ton		Individuals/metric ton				
Vessel and fishery	*product*[1]	*disc rate*[2]	*disc. rate*[3]	*disc.rate*[4]	*total catch*[5]	*hal*	*herr*	*Chin*	*Osal*	*Redk*	*Btan*	*Otan*
Total												
"A" open access	-	10%	95%	100%	5%	1.65	0.00	0.04	0.00	0.054	1.52	0.75
"A" CDQ	-	4%	82%	100%	3%	0.90	0.06	0.01	0.20	0.002	0.24	0.22
"B" open access	-	3%	97%	100%	0%	0.09	0.48	0.02	0.26	-	0.00	0.00
"B" CDQ	-	1%	100%	100%	1%	1.64	1.41	0.06	0.13	0.001	0.10	0.02
Surimi vessels												
"A" open access	-	3%	98%	100%	3%	0.94	0.00	0.05	0.00	0.093	1.24	0.42
"A" CDQ	-	1%	86%	100%	0%	0.03	0.00	0.00	0.00	-	0.04	-
"B" open access	-	1%	94%	100%	0%	0.07	0.80	0.02	0.33	-	-	0.00
"B" CDQ	-	0%	100%	100%	0%	0.02	0.76	0.03	0.16	-	-	-
Fillet vessels												
"A" open access	-	20%	94%	100%	8%	2.63	0.00	0.03	-	0.000	1.90	1.21
"A" CDQ	-	6%	82%	100%	5%	1.32	0.08	0.01	0.29	0.002	0.34	0.32
"B" open access	-	6%	99%	100%	1%	0.11	0.07	0.01	0.15	-	0.00	0.00
"B" CDQ	-	2%	100%	100%	2%	3.18	2.02	0.09	0.10	0.002	0.19	0.03

[1]Primary product calculated as a percentage of all primary product tonnage for each vessel and fishery. Vessels are categorized as surimi or fillet according to which product represents the greatest production on an annual basis.
[2]Pollock discard rate expressed as a percentage of the total catch of pollock.
[3]Cod discard rate expressed as a percentage of total catch of cod.
[4]Other target species (non-pollock or cod) discard rate expressed as a percentage of other target species total catch.
[5]Non-pollock groundfish catch expressed as a percentage of the total groundfish catch.

Source: Weekly observer reports, National Marine Fisheries Service, Alaska Region, Juneau, AK.

Table 2. Groundfish discard and prohibited species bycatch rates for vessels participating in the 1994 CDQ fishery.

	Primary	*Pollock*	*Cod*	*Oth. target*	*Non-poll.*	*kg/metric ton*		*Individuals/metric ton*				
Vessel and fishery	*product*[1]	*disc rate*[2]	*disc. rate*[3]	*disc.rate*[4]	*total catch*[5]	*hal*	*herr*	*Chin*	*Osal*	*Redk*	*Btan*	*Otan*
Vessel A					Surimi vessels							
"A" open access	Surimi	17%	100%	100%	2%	0.00	-	0.069	0.000	-	-	-
"A" CDQ	Surimi	0%	100%	100%	2%	0.00	0.00	0.070	-	-	-	-
"B" open access	Surimi	1%	0%	100%	1%	0.03	0.05	0.011	0.611	-	-	-
"B" CDQ	Surimi	1%	100%	100%	1%	-	1.24	0.001	1.462	-	-	-
Vessel B												
"A" open access	Surimi	0%	61%	92%	1%	0.50	0.00	0.052	-	-	0.04	0.00
"A" CDQ	Surimi	1%	100%	93%	1%	0.23	-	0.019	-	-	-	0.01
"B" open access	Surimi	1%	77%	60%	0%	0.17	0.42	0.003	0.041	0.000	0.04	0.00
"B" CDQ	Surimi	13%	81%	35%	0%	0.10	5.44	0.001	0.244	-	-	-
Vessel D												
"B" open access	Surimi	3%	77%	61%	7%	3.81	0.24	-	0.036	-	0.83	1.22
"B" CDQ	Surimi	0%	100%	100%	4%	2.39	-	-	-	-	0.78	0.04
Vessel F												
"B" open access	Surimi	3%	92%	71%	2%	1.43	1.31	0.002	0.042	-	0.65	2.71
"B" CDQ	Surimi	0%	22%	100%	0%	-	0.01	-	0.135	-	-	0.01
Vessel H												
"A" open access	Surimi	0%	100%	100%	0%	0.16	0.00	0.039	0.000	-	0.00	0.00
"A" CDQ	Surimi	0%	100%	100%	1%	1.46	-	0.024	0.006	-	0.00	-
"B" open access	Surimi	0%	100%	100%	1%	0.03	1.46	0.002	0.012	-	0.00	-
"B" CDQ	Surimi	0%	100%	100%	1%	0.25	2.53	0.001	0.201	-	-	-
Vessel I												
"B" open access	Surimi	0%	100%	100%	3%	0.91	1.87	0.004	0.085	-	0.70	3.56
"B" CDQ	Surimi	0%	100%	100%	1%	0.07	4.14	0.000	0.052	-	1.83	0.00
Vessel K												
"A" open access	Surimi	1%	100%	100%	2%	1.54	0.00	0.054	-	-	0.01	0.01
"A" CDQ	Surimi	0%	100%	92%	2%	2.19	-	0.023	0.002	-	0.12	-
"B" open access	Surimi	4%	100%	98%	1%	0.02	3.98	0.004	0.030	-	0.03	0.00
"B" CDQ	Surimi	1%	100%	100%	0%	0.00	4.67	0.004	0.122	-	-	-
Vessel O												
"A" open access	Surimi	3%	100%	100%	1%	0.13	-	0.125	-	-	-	-
"A" CDQ	Surimi	1%	72%	100%	1%	0.45	-	0.008	-	0.002	0.04	-
"B" open access	Surimi	1%	93%	47%	2%	0.31	0.11	0.001	0.066	-	0.04	0.02
"B" CDQ	Surimi	0%	100%	100%	1%	0.07	0.29	-	0.003	-	-	-

Table 2. Cont.

Vessel and fishery	Primary product[1]	Pollock disc rate[2]	Cod disc. rate[3]	Oth. target disc.rate[4]	Non-poll. total catch[5]	kg/metric ton		Individuals/metric ton				
						hal	herr	Chin	Osal	Redk	Btan	Otan
					Fillet vessels							
Vessel C												
"A" open access	Fillets	0%	98%	100%	9%	3.92	0.00	0.005	-	-	1.25	0.02
"A" CDQ	Fillets	17%	1%	40%	22%	2.60	0.02	0.251	-	0.074	0.10	0.33
Vessel E												
"A" open access	Fillets	2%	100%	100%	5%	4.75	-	-	-	0.286	0.17	-
"A" CDQ	Fillets	0%	1%	41%	37%	2.54	-	-	-	-	0.46	0.09
Vessel J												
"A" open access	Surimi	0%	2%	100%	5%	2.33	0.00	0.008	-	-	1.20	0.10
"A" CDQ	Fillets	0%	0%	100%	39%	3.25	-	-	-	0.155	1.81	0.96
Vessel L												
"A" open access	Fillets	49%	100%	100%	4%	2.22	-	0.037	0.002	-	0.03	-
"A" CDQ	Fillets	1%	58%	42%	11%	3.88	0.00	0.020	-	-	0.14	-
"B" open access	Fillets	0%	100%	100%	2%	0.93	1.25	0.012	0.045	-	0.01	-
"B" CDQ	Fillets	1%	100%	100%	0%	0.04	9.84	0.016	0.032	-	0.00	-
Vessel M												
"A" open access	Fillets	3%	100%	100%	0%	-	0.00	0.052	0.002	-	-	-
"A" CDQ	Fillets	1%	100%	100%	0%	0.00	0.00	0.010	-	-	-	0.00
"B" open access	Fillets	0%	100%	100%	1%	0.23	2.72	0.144	0.155	-	-	0.00
"B" CDQ	Fillets	1%	97%	95%	1%	0.01	2.18	0.029	0.077	-	-	0.00
Vessel N												
"B" open access	Fillets	6%	100%	100%	7%	3.99	0.14	0.000	0.005	-	0.17	4.41
"B" CDQ	Fillets	0%	0%	100%	1%	1.13	-	-	-	-	-	-
Vessel P												
"A" open access	Fillets	0%	100%	100%	2%	0.62	-	0.014	-	-	0.03	-
"A" CDQ	Fillets	0%	100%	100%	7%	0.89	-	-	-	-	0.59	-
"B" open access	Fillets	0%	100%	85%	5%	3.09	0.42	0.001	0.106	-	4.15	10.48
"B" CDQ	Fillets	0%	98%	100%	1%	0.06	1.06	-	0.004	-	0.06	0.10
Vessel Q												
"A" open access	Fillets	1%	100%	100%	1%	0.00	0.00	0.042	-	-	-	-
"A" CDQ	Fillets	1%	2%	100%	1%	2.97	0.00	0.024	-	-	-	-
"B" open access	Fillets	6%	100%	100%	3%	0.23	1.41	0.008	0.054	-	0.02	0.15
"B" CDQ	Fillets	0%	100%	96%	3%	0.18	1.01	0.001	0.002	-	0.08	0.11

Table 2. Cont.

	Primary	Pollock	Cod	Oth. target	Non-poll.	kg/metric ton		Individuals/metric ton				
Vessel and fishery	*product*[1]	*disc rate*[2]	*disc. rate*[3]	*disc.rate*[4]	*total catch*[5]	*hal*	*herr*	*Chin*	*Osal*	*Redk*	*Btan*	*Otan*
Vessel R												
"A" open access	Fillets	10%	86%	100%	1%	0.34	-	0.022	-	-	0.01	-
"A" CDQ	Fillets	10%	46%	100%	4%	0.18	-	0.022	-	0.012	0.04	-
"B" open access	Fillets	2%	100%	100%	5%	2.64	0.37	0.007	0.126	0.000	5.29	7.82
"B" CDQ	Fillets	0%	100%	100%	6%	2.91	0.09	-	0.409	-	2.11	-
Vessel S												
"A" open access	Fillets	0%	100%	100%	0%	0.11	-	-	-	-	-	-
"A" CDQ	Fillets	0%	0%	100%	0%	-	-	-	-	-	-	-
Surimi Vessels												
"A" open access	-	3%	95%	100%	1%	0.28	0.00	0.06	0.011	-	0.00	0.00
"A" CDQ	-	0%	92%	39%	2%	0.54	0.00	0.03	0.004	0.001	0.02	0.00
"B" open access	-	2%	72%	91%	2%	0.73	0.82	0.00	0.117	0.000	0.25	0.75
"B" CDQ	-	2%	91%	98%	1%	0.09	2.31	0.00	0.198	-	0.05	0.00
Fillet vessels												
"A" open access	-	7%	74%	100%	3%	1.14	0.00	0.010	0.000	0.020	0.14	0.01
"A" CDQ	-	2%	19%	98%	8%	1.06	0.00	0.022	-	0.009	0.17	0.07
"B" open access	-	3%	95%	100%	4%	1.45	0.79	0.012	0.066	0.000	1.40	3.50
"B" CDQ	-	1%	95%	100%	1%	0.06	3.21	0.023	0.059	-	0.03	0.02
All Vessels												
"A" open access	-	4%	82%	100%	2%	0.59	0.00	0.042	0.007	0.007	0.05	0.00
"A" CDQ	-	1%	27%	86%	5%	0.81	0.00	0.023	0.002	0.005	0.10	0.04
"B" open access	-	2%	82%	96%	3%	0.97	0.81	0.006	0.101	0.000	0.62	1.64
"B" CDQ	-	2%	94%	99%	1%	0.07	2.78	0.012	0.126	-	0.04	0.01
Grand Total (1993-1994)												
open access	-	4%	87%	99%	2%	0.76	0.36	0.025	0.097	0.012	0.47	0.61
CDQ	-	2%	53%	94%	3%	0.77	1.06	0.022	0.113	0.002	0.12	0.07

[1]Primary product calculated as a percentage of all primary product tonnage for each vessel and fishery. Vessels are categorized as surimi or fillet according to which product represents the greatest production on an annual basis.
[2]Pollock discard rate expressed as a percentage of the total catch of pollock.
[3]Cod discard rate expressed as a percentage of total catch of cod.
[4]Other target species (non-pollock or cod) discard rate expressed as a percentage of other target species total catch.
[5]Non-pollock groundfish catch expressed as a percentage of the total groundfish catch.

Source: Weekly observer reports, National Marine Fisheries Service, Alaska Region, Juneau, AK.

Table 3. Round weight equivalent of primary product fish meal production (expressed as a percentage of total pollock catch).

	1993				*1994*			
	"A" season		*"B" season*		*"A" season*		*"B" season*	
vessel	*open access*	*CDQ*	*open access*	*CDQ*	*open access*	*CDQ*	*open access*	*CDQ*
Vessel A		0%						
Vessel B	18%	33%			1%	2%	5%	
Vessel C								
Vessel D			9%					
Vessel E					3%			
Vessel F							1%	1%
Vessel G								
Vessel H			9%		4%		3%	1%
Vessel I								
Vessel J					12%	5%		
Vessel K					11%			

Source: Weekly observer reports and weekly production reports, National Marine Fisheries Service, Alaska Region, Juneau AK.

Table 4. CDQ discard and bycatch rates expressed as a percentage of open access discard and bycatch rates.

Year and fishery	*Pollock disc rate*	*Cod disc rate*	*Oth. groundfish disc. rate*	*Non-pollock total catch*	*Halibut*	*Herring*
1993 "A"	42%	86%	100%	66%	55%	5659%
1993 "B"	25%	122%	100%	29%	182%	2518%
1994 "A"	32%	33%	86%	273%	138%	185%
1994 "B"	82%	114%	103%	34%	8%	343%
Total	50%	61%	95%	117%	101%	295%

Year and fishery	*Chinook*	*Oth. salmon*	*Red king*	*Bairdi Tanner*	*Other Tanner*
1993 "A"	13%	85771%	3%	16%	29%
1993 "B"	1241%	67%	57%	40%	7%
1994 "A"	55%	28%	67%	187%	964%
1994 "B"	207%	125%	0%	6%	1%
Total	91%	116%	16%	25%	12%

Source: Weekly observer reports, National Marine Fisheries Service, Alaska Region, Juneau AK.

Table 5. Product value per metric ton of pollock catch, and breakdown of primary products for vessels participating in the 1993 CDQ fishery.

Vessel and fishery	*Total product value / metric ton of pollock*[1] *Observer*	*Blend*	*Processor*	*Primary products (percent of primary product tons)* *Surimi*	*Fillets*	*Minced fish*	*Fish meal*
Vessel A							
"A" open access	$ 434	$ 555	$ 452	100%	-	-	-
"A" CDQ	$ 899	$ 792	$ 800	100%	-	-	0.3%
"B" open access	$ 329	$ 329	$ 250	100%	-	-	-
"B" CDQ	$ 294	$ 519	$ 251	100%	-	-	-
Vessel B							
"A" open access	$ 588	$ 588	$ 534	81%	0.0%	-	19%
"A" CDQ	$ 658	$ 658	$ 763	62%	-	-	38%
"B" open access	$ 231	$ 236	$ 263	97%	3%	0.2%	-
"B" CDQ	$ 280	$ 280	$ 273	91%	9%	-	-
Vessel D							
"B" open access	$ 297	$ 369	$ 281	71%	22%	-	8%
"B" CDQ	$ 352	$ 352	$ 288	100%	-	-	-
Vessel G							
"A" open access	$ 461	$ 520	$ 402	100%	-	-	-
"A" CDQ	$ 731	$ 731	$ 681	100%	-	-	-
"B" open access	$ 307	$ 385	$ 247	100%	-	-	-
"B" CDQ	$ 296	$ 435	$ 244	100%	-	-	-
Vessel H							
"A" open access	$ 540	$ 540	$ 535	100%	0%	-	-
"A" CDQ	$ 555	$ 598	$ 713	94%	6%	-	-
"B" open access	$ 282	$ 334	$ 234	92%	0%	-	8%
"B" CDQ	$ 255	$ 269	$ 252	100%	0%	-	-
Vessel I							
"A" open access	$ 525	$ 531	$ 623	75%	25%	-	-
"A" CDQ	$ 954	$ 894	$1,669	-	75%	25%	-
Vessel K							
"B" open access	$ 284	$ 284	$ 259	95%	5%	-	-
"B" CDQ	$ 313	$ 409	$ 260	97%	3%	-	-

Table 5. Cont.

Vessel and fishery	Total product value / metric ton of pollock[1] Observer	Blend	Processor	Primary products (percent of primary product tons) Surimi	Fillets	Minced fish	Fish meal
Vessel L							
"A" open access	$ 729	$ 729	$1,208	-	90%	10%	-
"A" CDQ	$ 642	$ 747	$1,001	-	80%	20%	-
"B" open access	$ 332	$ 452	$ 483	-	74%	26%	-
"B" CDQ	$ 325	$ 630	$ 488	-	100%	-	-
Vessel M							
"A" open access	$ 519	$ 543	$ 602	-	100%	-	-
"A" CDQ	$ 416	$ 416	$ 574	-	76%	24%	-
"B" open access	$ 322	$ 423	$ 434	-	75%	25%	-
"B" CDQ	$ 303	$ 486	$ 490	-	67%	33%	-
Vessel O							
"A" open access	$ 578	$ 580	$ 613	66%	34%	-	-
"A" CDQ	$ 619	$ 784	$ 841	23%	69%	8%	-
"B" open access	$ 343	$ 343	$ 306	49%	51%	-	-
"B" CDQ	$ 360	$ 553	$ 494		100%	-	-
Vessel P							
"A" open access	$ 322	$ 322	$ 807	-	76%	24%	-
"A" CDQ	$ 811	$ 811	$1,275	-	91%	9%	-
Vessel Q							
"A" open access	$ 394	$ 428	$ 567	-	58%	42%	-
"A" CDQ	$ 498	$ 556	$ 691	-	62%	38%	-
"B" open access	$ 435	$ 439	$ 457	-	83%	17%	-
"B" CDQ	$ 365	$ 473	$ 454	-	70%	30%	-
Vessel R							
"A" open access	$ 262	$ 277	$1,002	-	77%	23%	-
"A" CDQ	$ 643	$ 628	$1,453	-	84%	16%	-
"B" open access	$ 320	$ 318	$ 408	-	82%	18%	-
"B" CDQ	$ 258	$ 258	$ 404	-	76%	24%	-

Table 5. Cont.

Vessel and fishery	Total product value / metric ton of pollock[1]			Primary products (percent of primary product tons)			
	Observer	Blend	Processor	Surimi	Fillets	Minced fish	Fish meal
Vessel S							
"B" open access	$ 307	$ 312	$ 378	31%	64%	5%	-
"B" CDQ	$ 333	$ 333	$ 913	-	100%	-	-
Total							
"A" open access	$ 557	$ 559	$ 659	64%	27%	7%	2%
"A" CDQ	$ 677	$ 679	$ 846	25%	57%	17%	1%
"B" open access	$ 339	$ 339	$ 303	59%	34%	5%	2%
"B" CDQ	$ 439	$ 425	$ 369	35%	47%	18%	-

[1]Product values per metric ton are calculated separately using three sources of total pollock catch data; weekly observer reports, weekly processor reports, and the "best blend" combination of the two.

Source: Weekly observer reports, blend estimates, weekly production reports and 1993 wholesale price survey, NMFS Alaska Region, Juneau AK

Table 6. Product value per metric ton of pollock catch, and breakdown of primary products for vessels participating in the 1994 CDQ fishery.

	Total product value / metric ton of pollock[1]			*Primary products (percent of primary product tons)*			
Vessel and fishery	*Observer*	*Blend*	*Processor*	*Surimi*	*Fillets*	*Minced fish*	*Fish meal*
Vessel A							
"A" open access	$ 735	$ 563	$ 505	100%	-	-	-
"A" CDQ	$ 661	$ 661	$ 649	100%	-	-	-
"B" open access	$ 285	$ 283	$ 303	100%	-	-	-
"B" CDQ	$ 302	$ 267	$ 302	100%	-	-	-
Vessel B							
"A" open access	$ 625	$ 576	$ 462	97%	2%	-	1%
"A" CDQ	$ 437	$ 437	$ 462	95%	2%	-	3%
"B" open access	$ 263	$ 265	$ 306	86%	8%	-	6%
"B" CDQ	$ 290	$ 271	$ 321	92%	7%	1%	-
Vessel C							
"A" open access	$ 792	$ 561	$ 472	-	77%	23%	-
"A" CDQ	$ 668	$ 680	$ 598	-	68%	32%	-
Vessel D							
"A" open access	$ 484	$ 450	$ 425	84%	16%	-	-
"A" CDQ	$ 747	$ 747	$ 839	100%	-	-	-
"B" open access	$ 396	$ 387	$ 337	74%	26%	-	-
"B" CDQ	$ 398	$ 1,076	$ 318	89%	11%	-	-
Vessel E							
"A" open access	$ 813	$ 628	$ 585	45%	52%	-	3%
"A" CDQ	$ 1,115	$ 1,115	$ 880	47%	53%	-	-
Vessel F							
"B" open access	$ 344	$ 318	$ 327	99%	-	-	1%
"B" CDQ	$ -	$ 235	$ 310	100%	-	-	0%
Vessel H							
"A" open access	$ 341	$ 342	$ 461	93%	-	-	7%
"A" CDQ	$ 500	$ 475	$ 527	100%	-	-	-
"B" open access	$ 399	$ 290	$ 299	98%	-	-	2%
"B" CDQ	$ 319	$ 317	$ 304	99%	-	-	1%

Table 6. Cont.

Vessel and fishery	Total product value / metric ton of pollock[1] Observer	Blend	Processor	Primary products (percent of primary product tons) Surimi	Fillets	Minced fish	Fish meal
Vessel I							
"A" open access	$ 567	$ 546	$ 451	82%	18%	-	-
"A" CDQ	$ 847	$ 788	$ 989	100%	-	-	-
"B" open access	$ 410	$ 355	$ 312	77%	23%	-	-
"B" CDQ	$ 379	$ 379	$ 311	82%	18%	-	-
Vessel J							
"A" open access	$ 655	$ 505	$ 424	65%	26%	-	9%
"A" CDQ	$ 1,251	$ 790	$ 823	-	93%	-	7%
Vessel K							
"A" open access	$ 610	$ 388	$ 417	91%	1%	-	8%
"A" CDQ	$ 405	$ 381	$ 449	97%	3%	-	-
"B" open access	$ 307	$ 282	$ 310	99%	1%	-	-
"B" CDQ	$ 328	$ 314	$ 297	96%	4%	-	-
Vessel L							
"A" open access	$ 664	$ 662	$ 594	-	99%	1%	-
"A" CDQ	$ 647	$ 553	$ 782	-	95%	5%	-
"B" open access	$ 561	$ 497	$ 440	-	100%	0%	-
"B" CDQ	$ 570	$ 359	$ 457	-	100%	-	-
Vessel M							
"A" open access	$ 1,172	$ 709	$ 563	-	93%	7%	-
"A" CDQ	$ 818	$ 501	$ 565	-	80%	20%	-
"B" open access	$ 476	$ 397	$ 434	-	88%	12%	-
"B" CDQ	$ 587	$ 369	$ 431	-	91%	9%	-
Vessel N							
"B" open access	$ 385	$ 380	$ 364	-	72%	28%	-
"B" CDQ	$ 343	$ 343	$ 376	-	79%	21%	-
Vessel O							
"A" open access	$ 624	$ 596	$ 551	89%	11%	-	-
"A" CDQ	$ 739	$ 656	$ 589	86%	14%	-	-
"B" open access	$ 412	$ 383	$ 334	64%	36%	-	-
"B" CDQ	$ 598	$ 373	$ 415	20%	80%	-	-

Table 6. Cont.

Vessel and fishery	Total product value / metric ton of pollock[1] Observer	Blend	Processor	Primary products (percent of primary product tons) Surimi	Fillets	Minced fish	Fish meal
Vessel P							
"A" open access	$ 623	$ 508	$ 499	-	84%	16%	-
"A" CDQ	$ 566	$ 566	$ 591	-	73%	27%	-
Vessel Q							
"A" open access	$ 806	$ 581	$ 485	-	79%	21%	-
"A" CDQ	$ 424	$ 423	$ 485	-	62%	38%	-
"B" open access	$ 307	$ 307	$ 323	-	75%	25%	-
"B" CDQ	$ 309	$ 288	$ 308	-	66%	34%	-
Vessel R							
"A" open access	$ 512	$ 512	$ 511	-	79%	21%	-
"A" CDQ	$ 582	$ 582	$ 567	-	68%	32%	-
"B" open access	$ 373	$ 373	$ 359	-	69%	31%	-
"B" CDQ	$ 305	$ 254	$ 321	-	65%	35%	-
Vessel S							
"A" open access	$ 661	$ 614	$ 528	81%	19%	-	-
"A" CDQ	$ 838	$ 838	$ 805	100%	-	-	-
Total							
"A" open access	$ 687	$ 520	$ 486	61%	32%	5%	2%
"A" CDQ	$ 749	$ 553	$ 597	46%	42%	12%	0%
"B" open access	$ 529	$ 376	$ 343	62%	31%	7%	1%
"B" CDQ	$ 532	$ 349	$ 382	32%	60%	8%	0%

[1]Product values per metric ton are calculated separately using three sources of total pollock catch data; weekly observer reports, weekly processor reports, and the "best blend" combination of the two.

Source: Weekly observer reports, blend estimates, weekly production reports and 1993 wholesale price survey, NMFS Alaska Region, Juneau AK

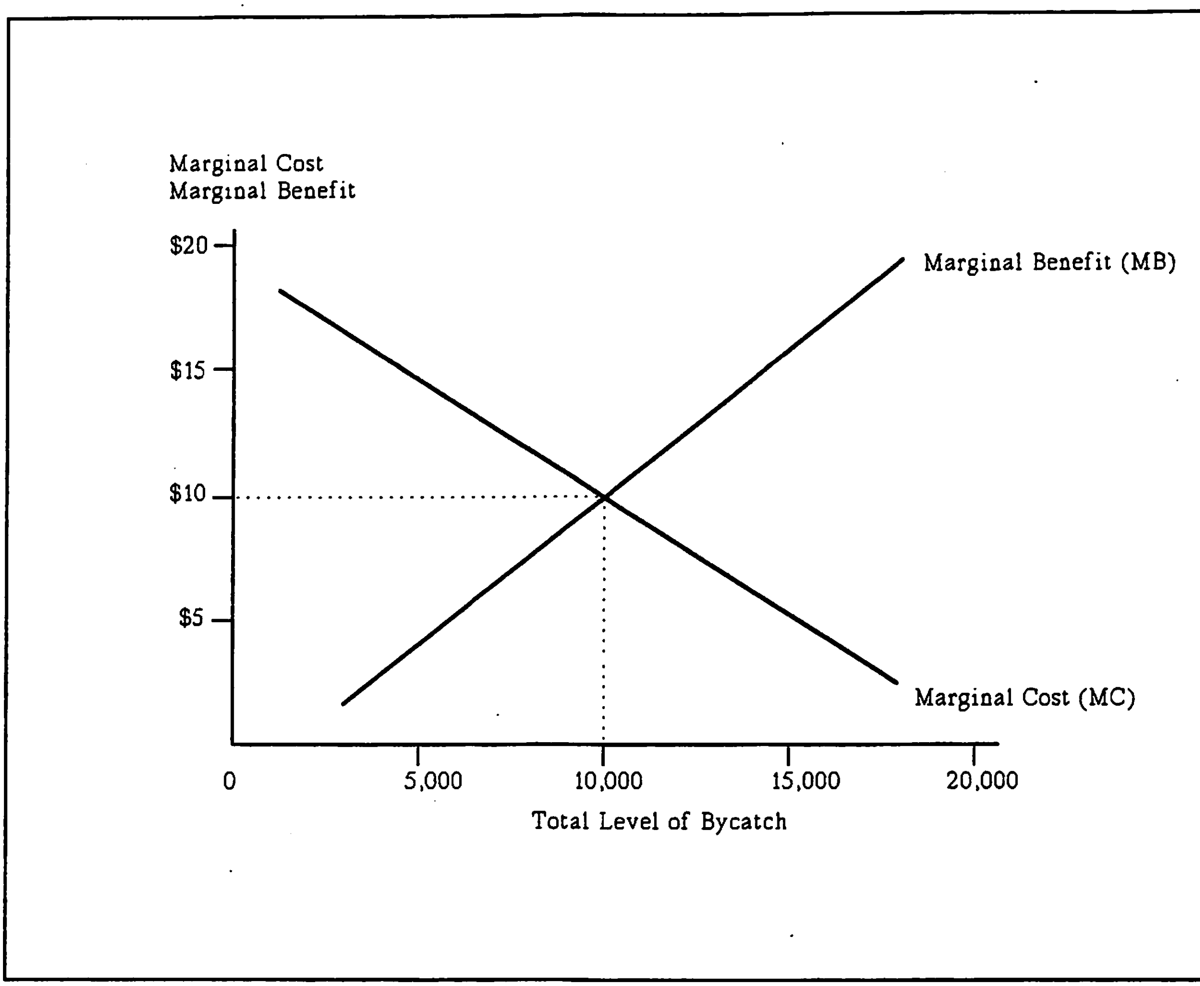

Figure 1. The marginal benefit and marginal cost of reducing bycatch and the optimum level of bycatch.

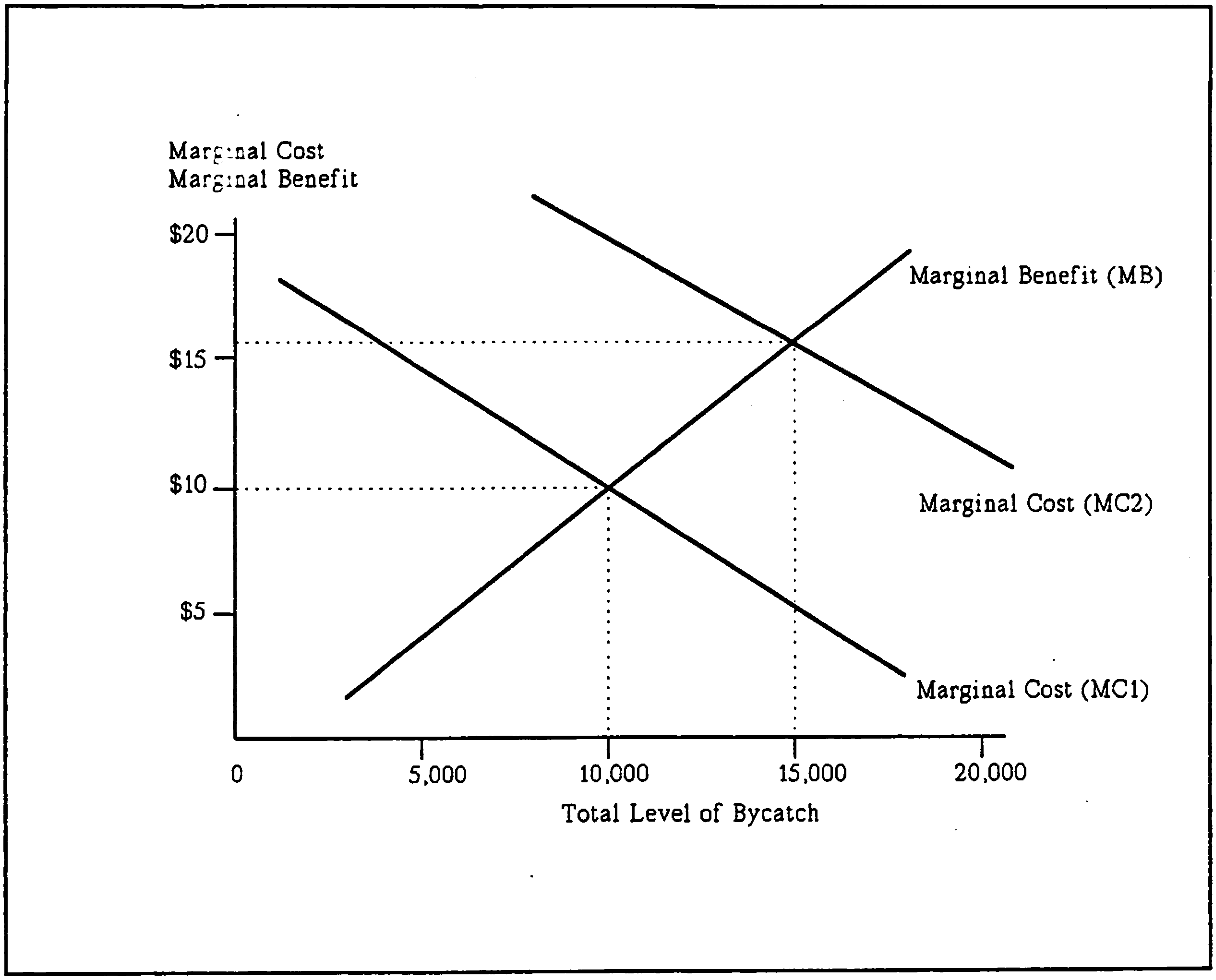

Figure 2. The marginal benefit, marginal cost of reducing bycatch with cost-effective methods (MC1), marginal cost of reducing bycatch without cost-effective methods (MC2), and the optimum levels of bycatch with and without cost-effective methods of reducing bycatch.

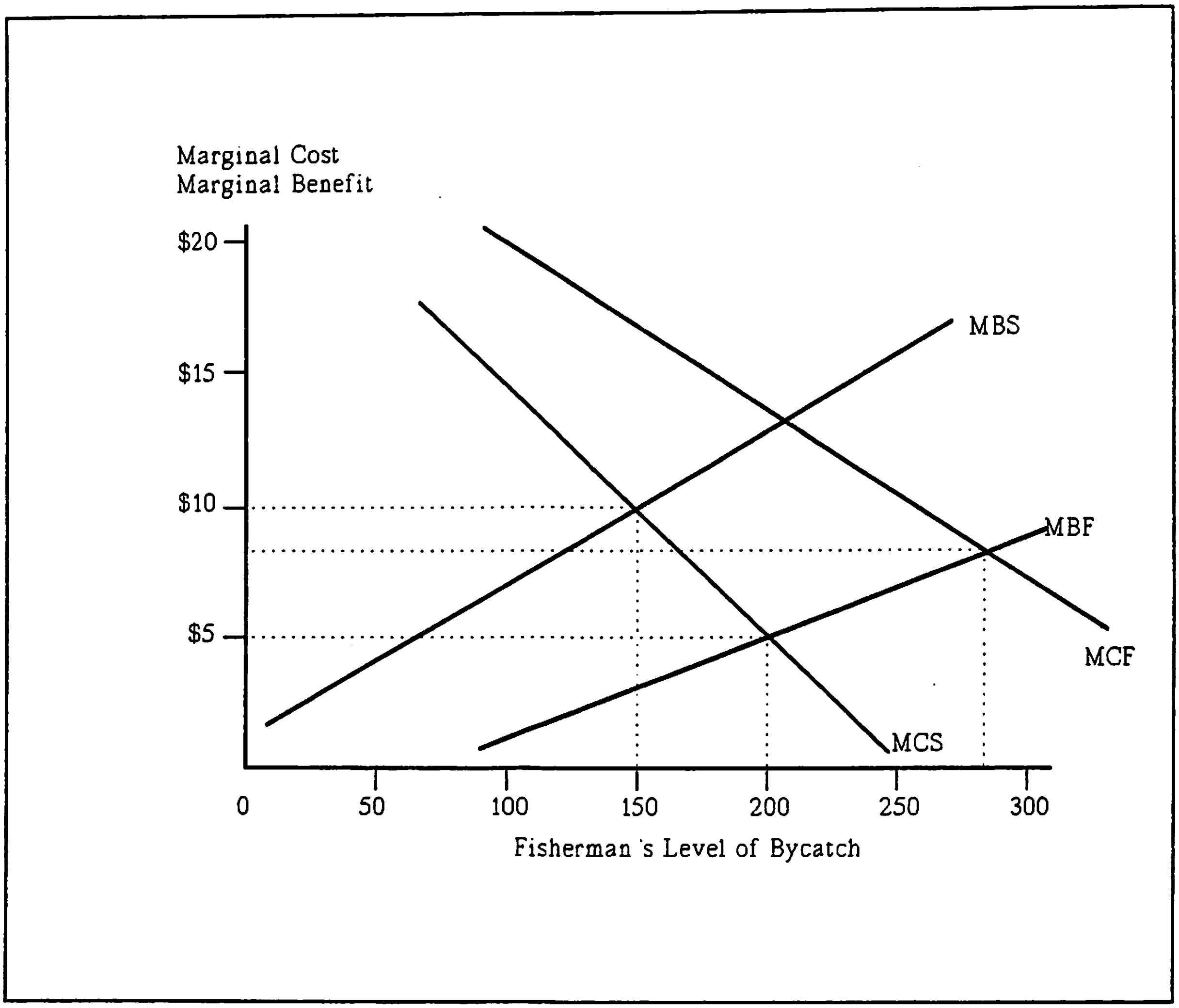

Figure 3. The marginal benefit to the fisherman (MBF), marginal benefit to society including the fisherman (MBS), marginal cost to the fisherman (MCF), marginal cost to society (MCS) of reducing bycatch, and the optimum levels of bycatch, respectively, for the fisherman and for society.

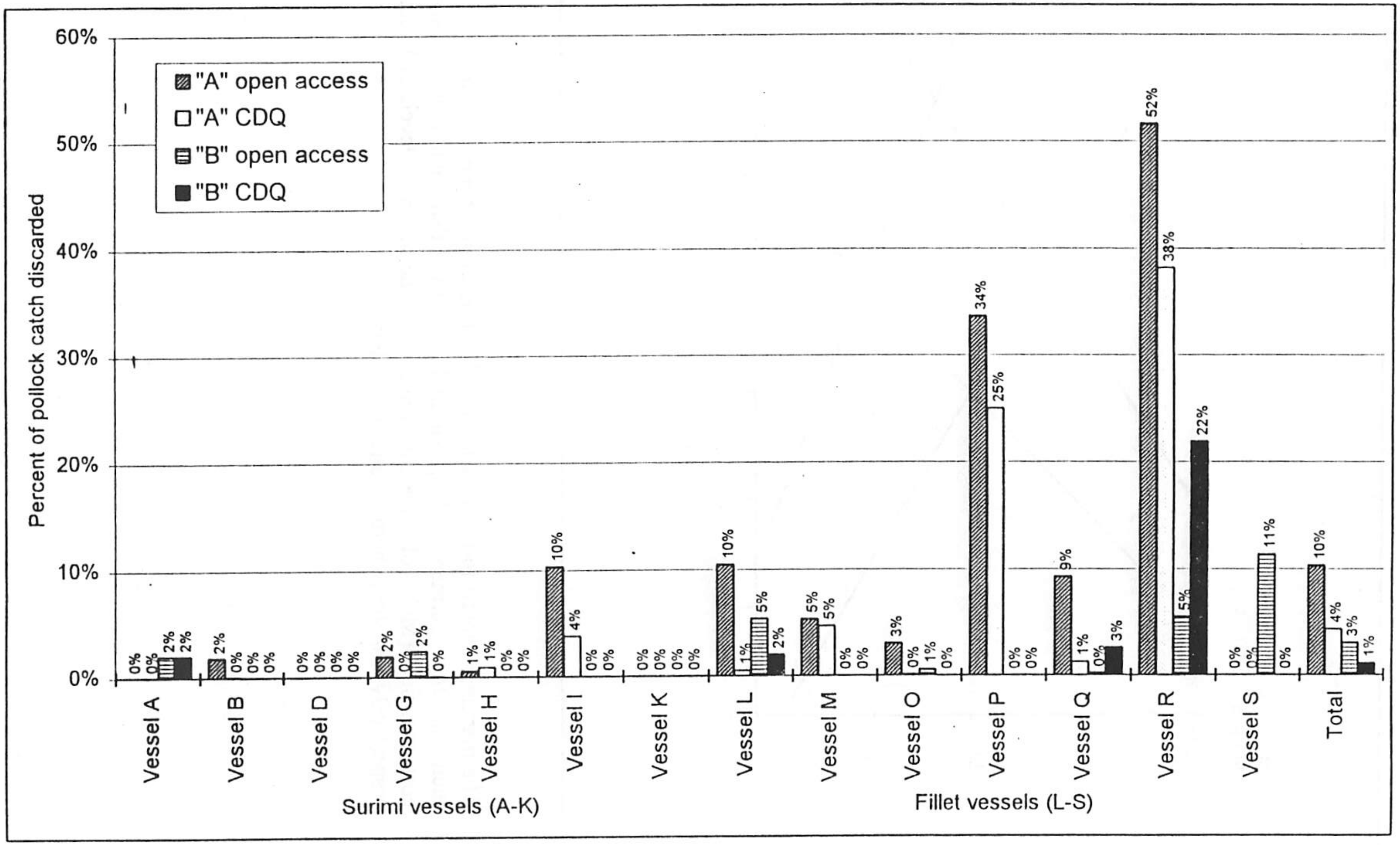

Figure 4. Pollock discard rates in the 1993 CDQ fleet by vessel, fishery and season (expressed as a percentage of pollock catch).

Source: Weekly observer reports, National Marine Fisheries Service, Alaska Region, Juneau, AK.

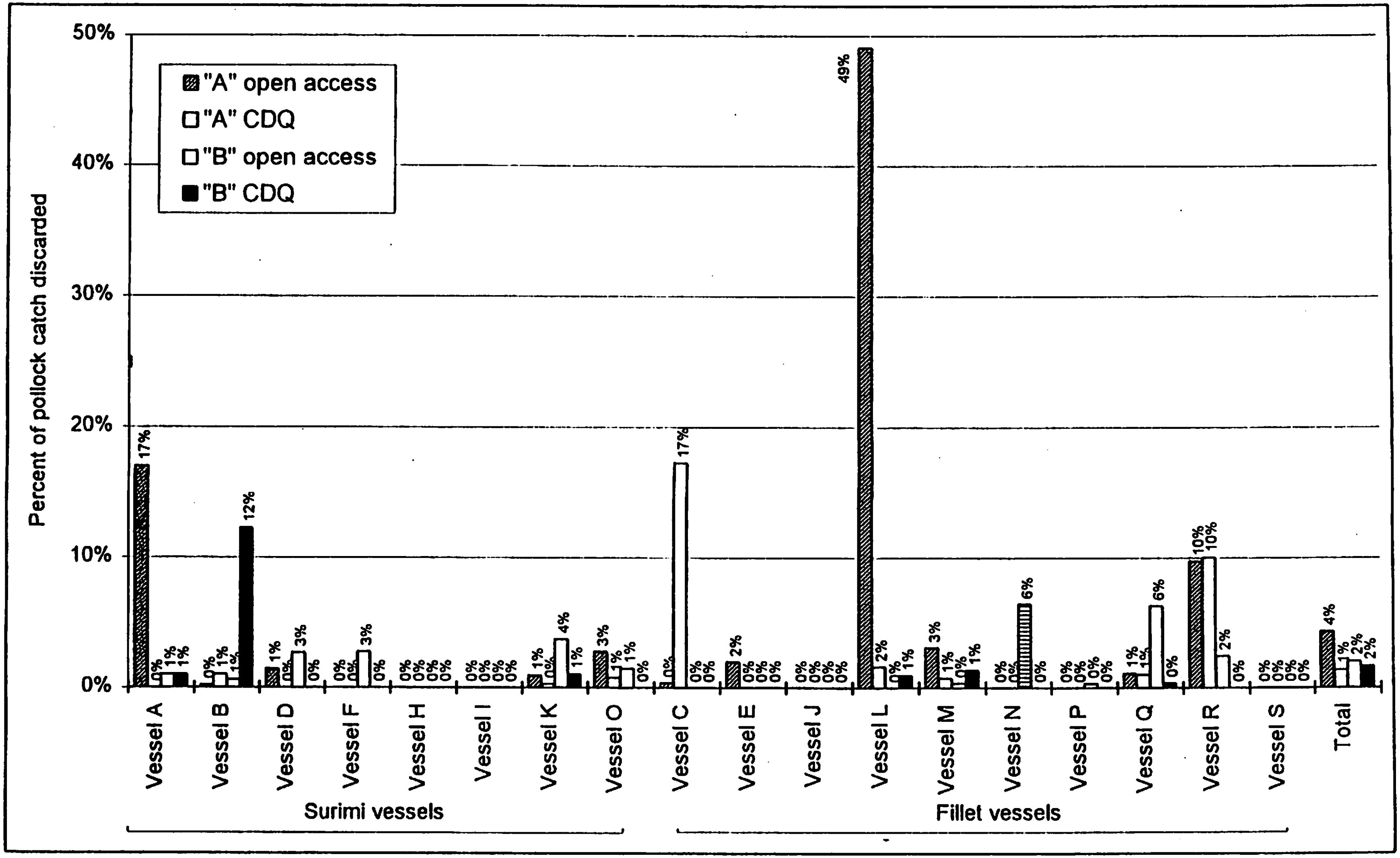

Figure 5. Pollock discard rates in the 1994 CDQ fleet by vessel, fishery and season (expressed as a percentage of pollock catch).

Source: Weekly observer reports, National Marine Fisheries Service, Alaska Region, Juneau, AK.

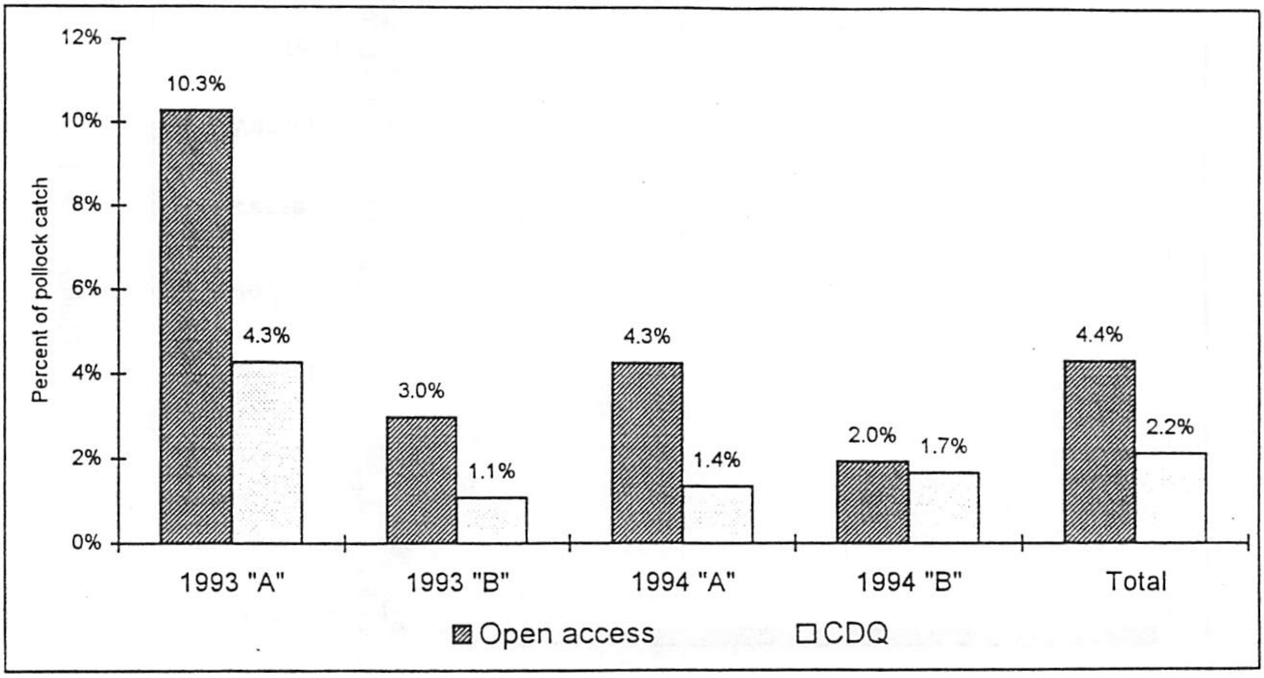

Figure 6. Pollock discard rates in the CDQ fleet expressed as a percentage of total pollock catch.

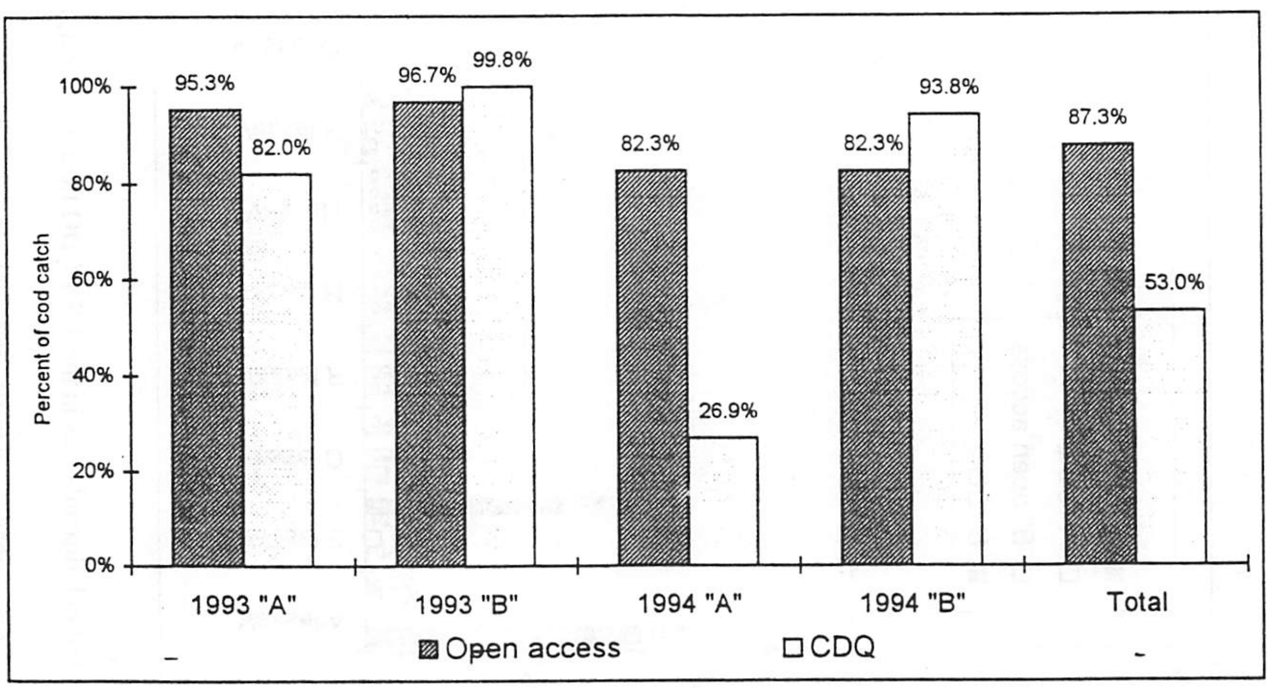

Figure 7. Pacific cod discard rates in the CDQ fleet expressed as a percentage of Pacific cod catch.

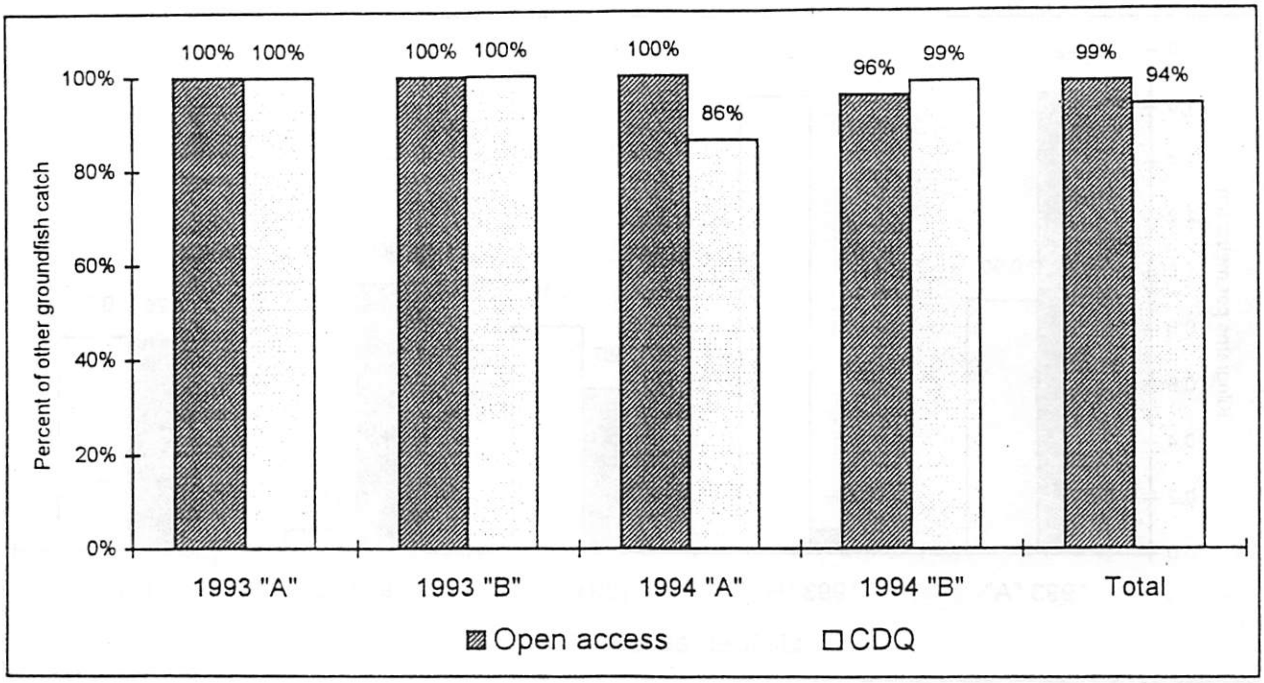

Figure 8. Other groundfish species (not pollock or cod) discard rates in the CDQ fleet expressed as a percentage of the total catch of other groundfish.

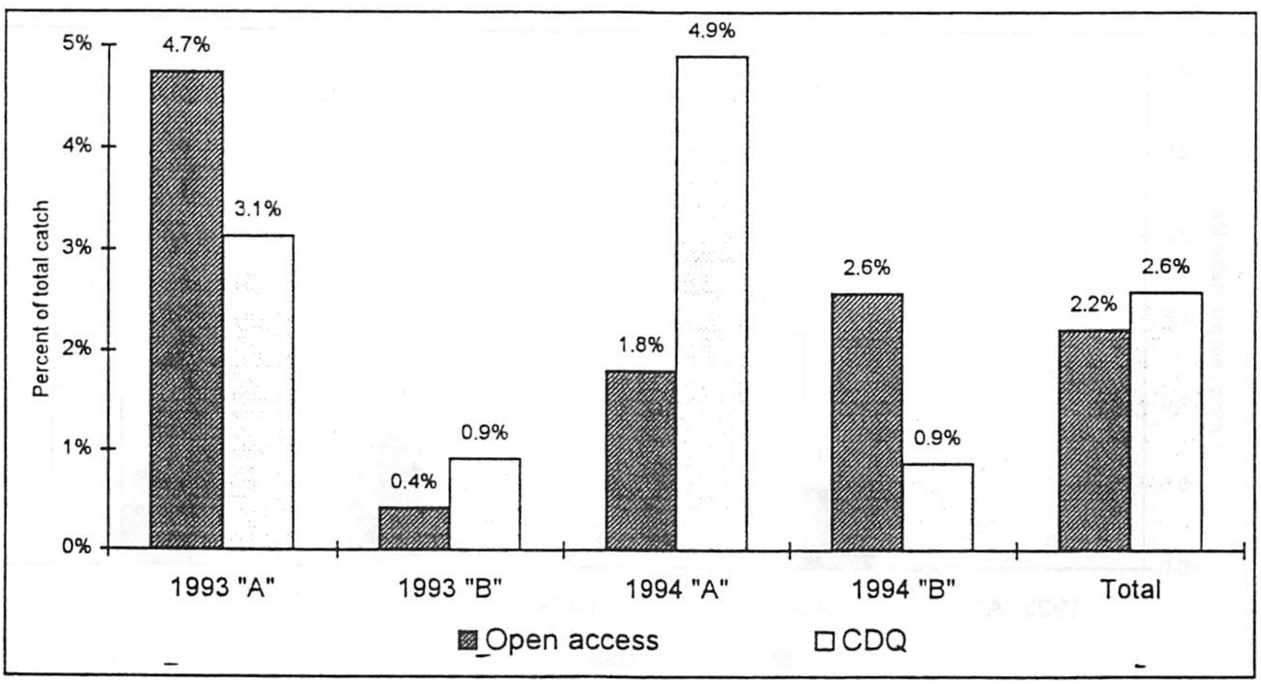

Figure 9. Percentage of total groundfish catch in the CDQ fleet consisting of species other than pollock.

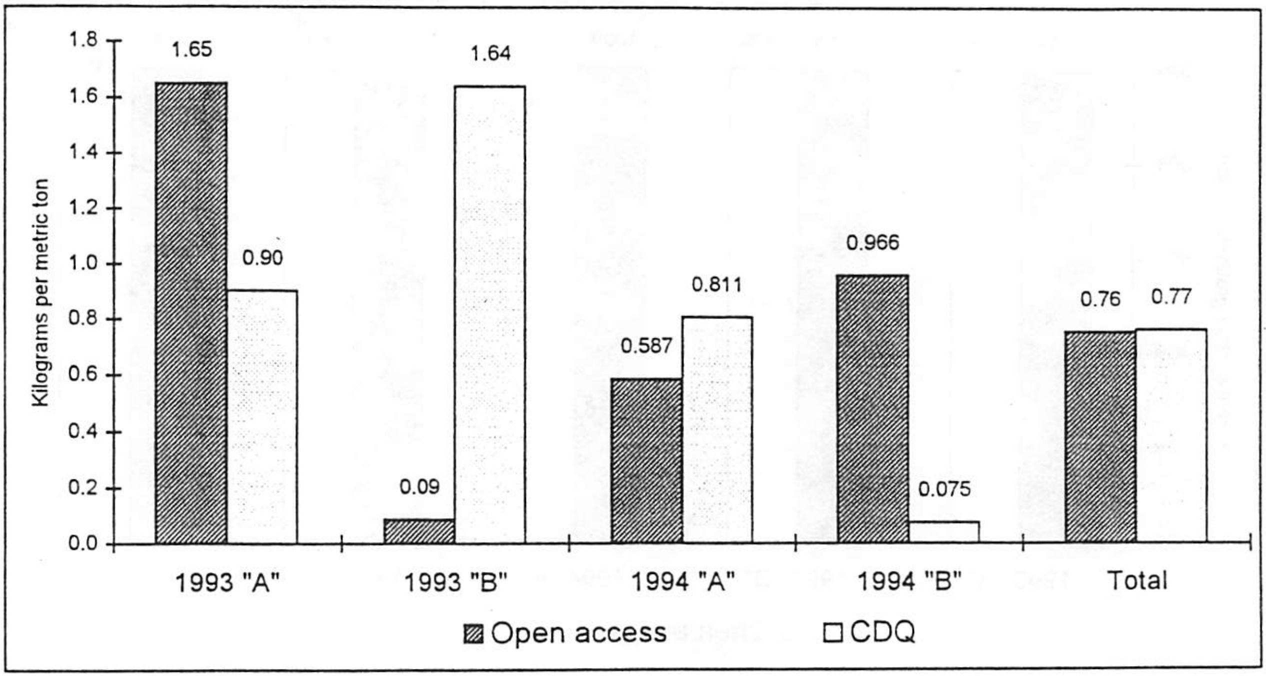

Figure 10. Pacific halibut bycatch rates in the CDQ fleet by fishery, year and season.

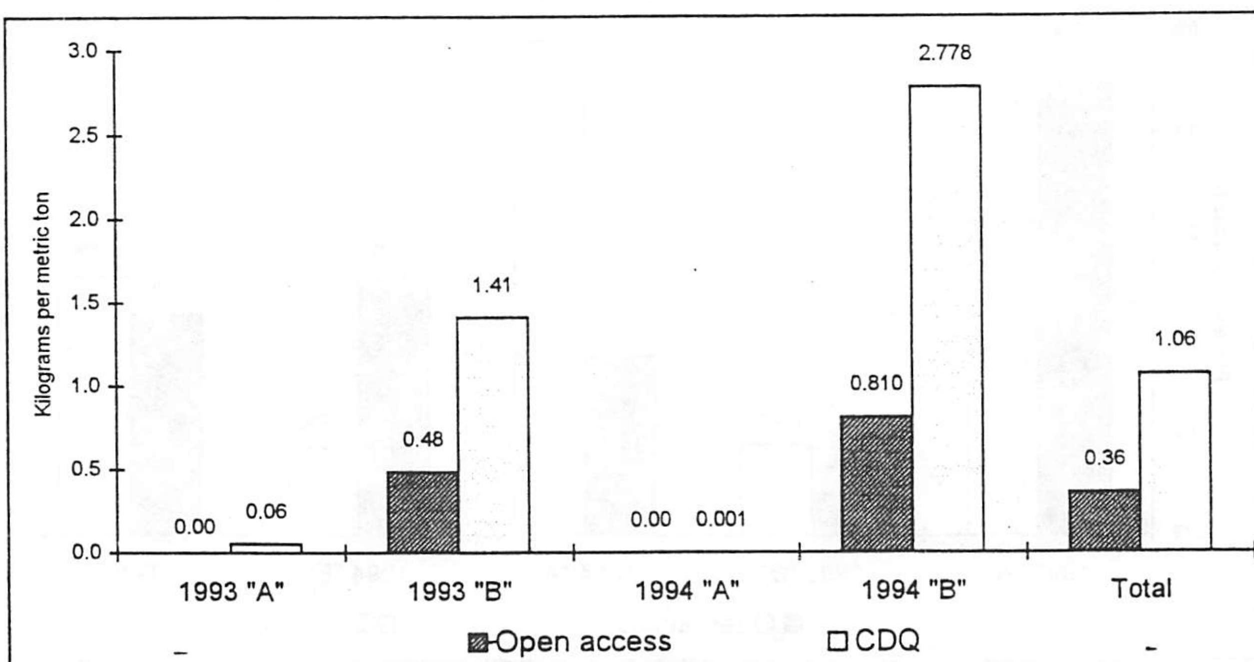

Figure 11. Pacific herring bycatch rates in the CDQ fleet by fishery, year and season.

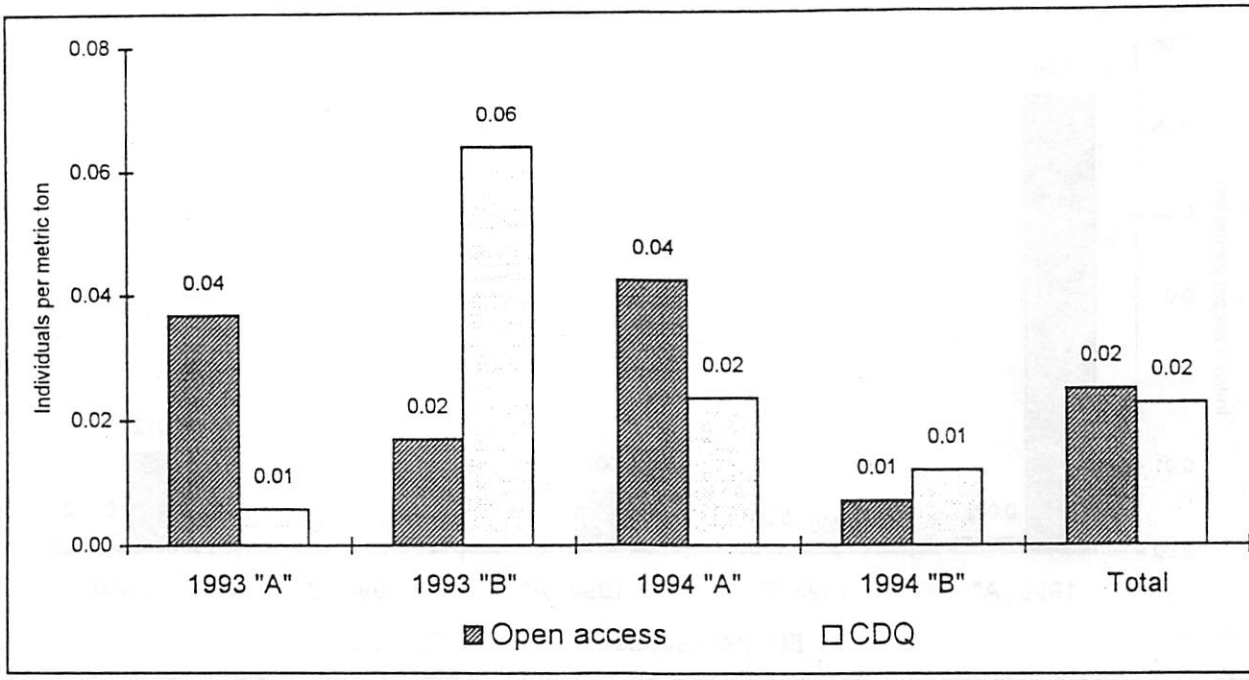

Figure 12. Chinook salmon bycatch rates in the CDQ fleet by fishery, year and season.

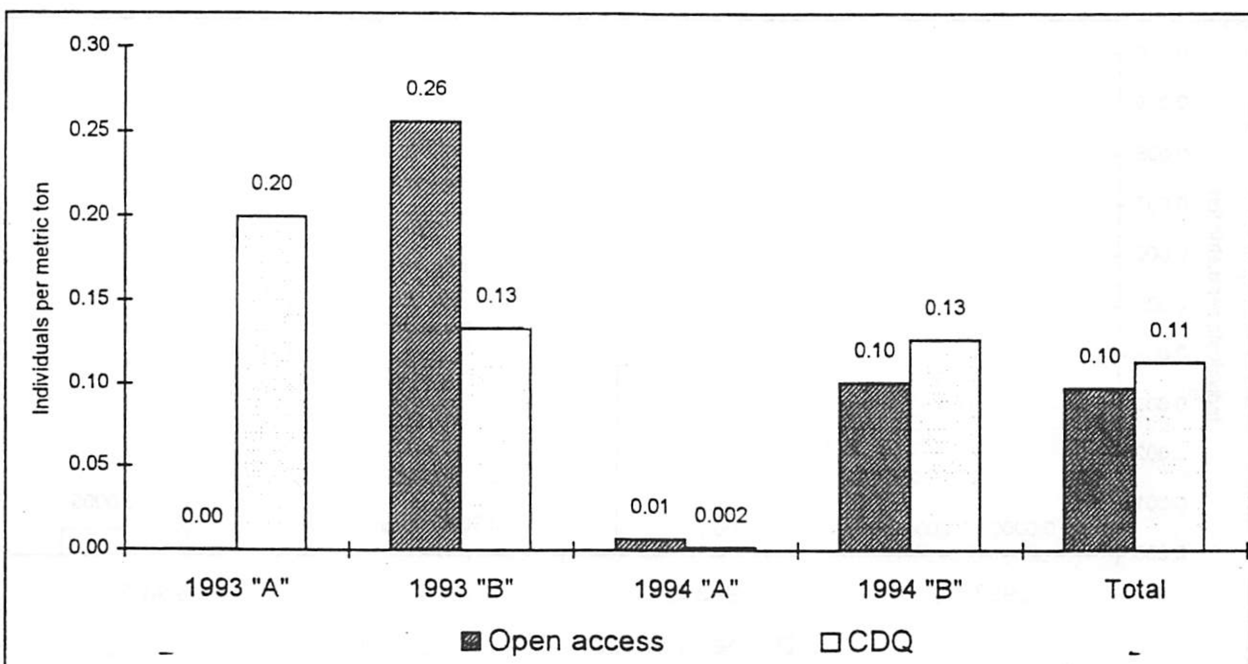

Figure 13. "Other" salmon bycatch rates in the CDQ fleet by fishery, year and season.

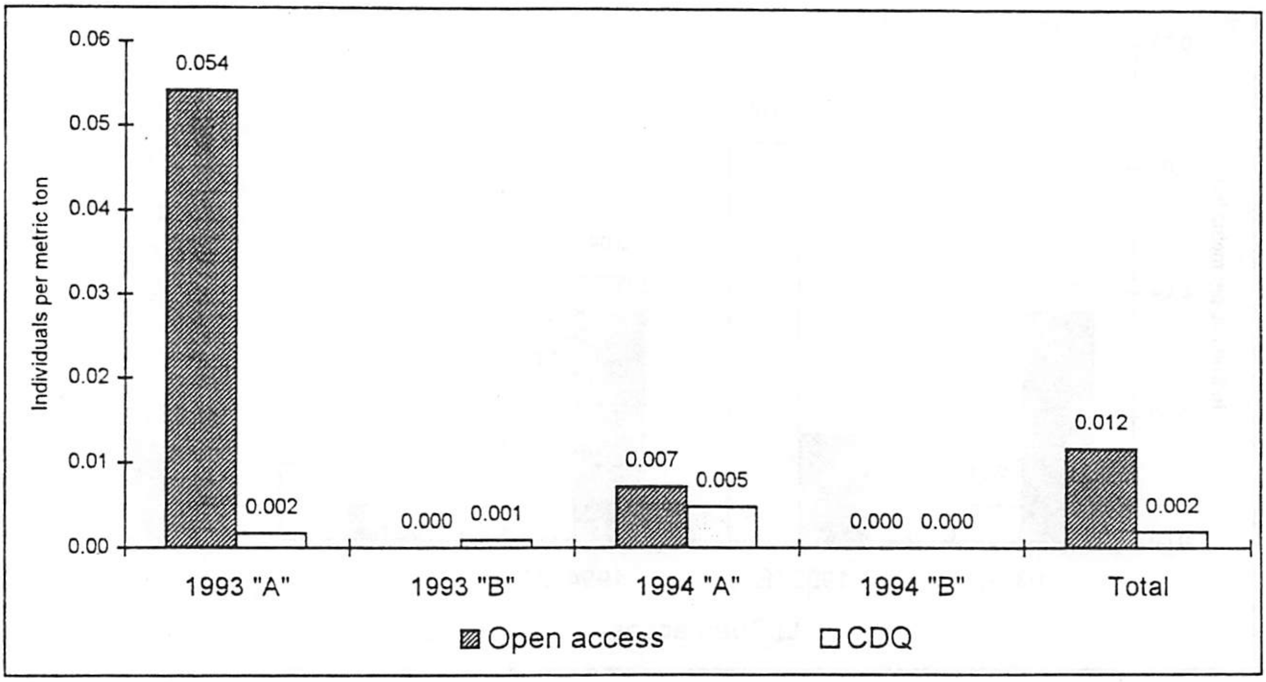

Figure 14. Red king crab bycatch rates in the CDQ fleet by fishery, year and season.

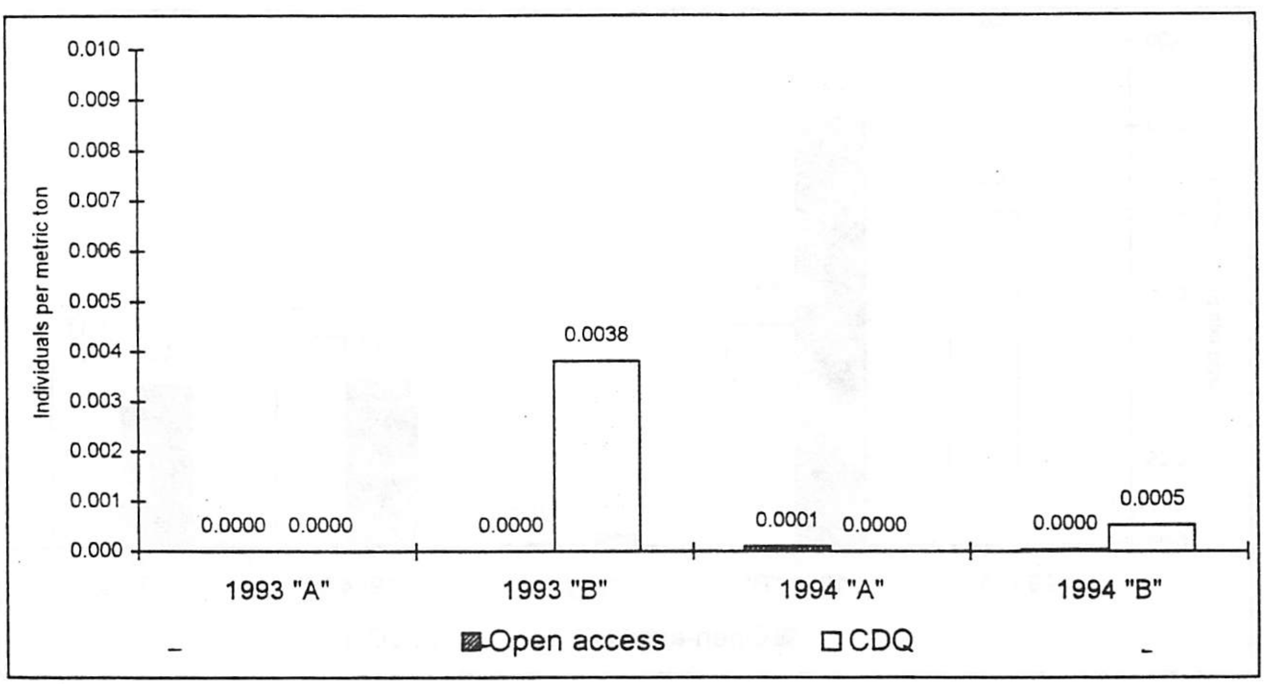

Figure 15. "Other" king crab bycatch rates in the CDQ fleet by fishery, year and season.

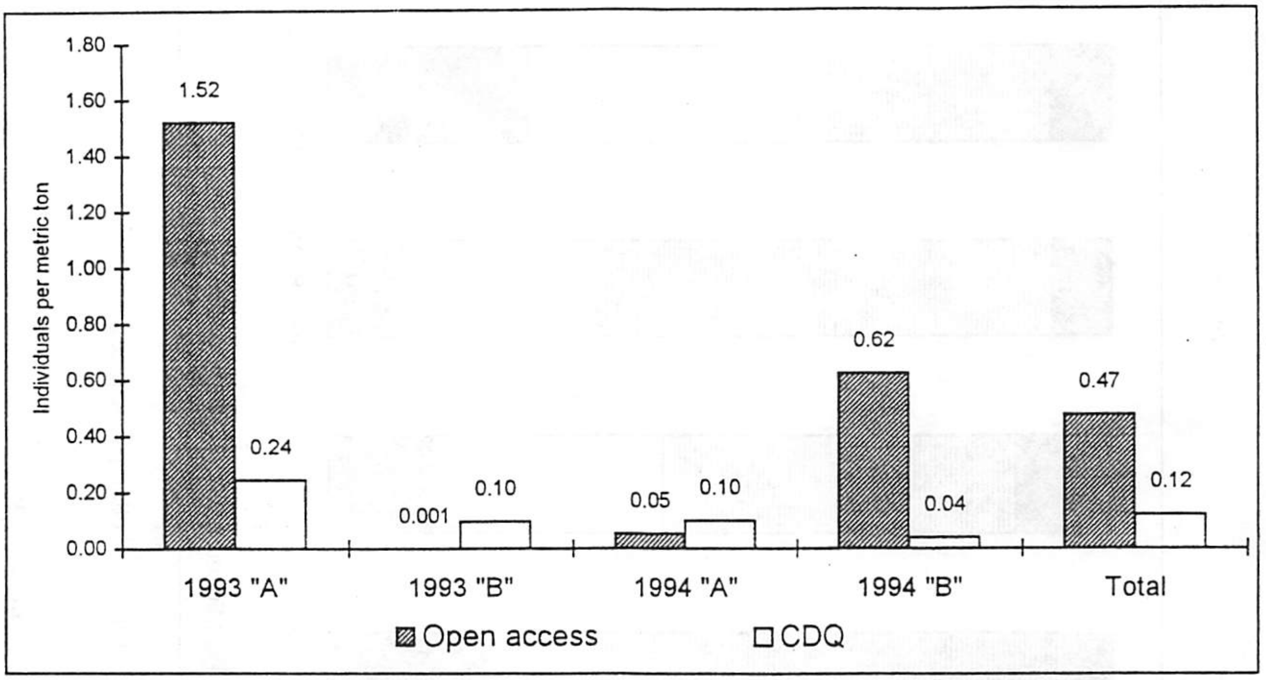

Figure 16. Bairdi Tanner crab bycatch rates in the CDQ fleet by fishery, year and season.

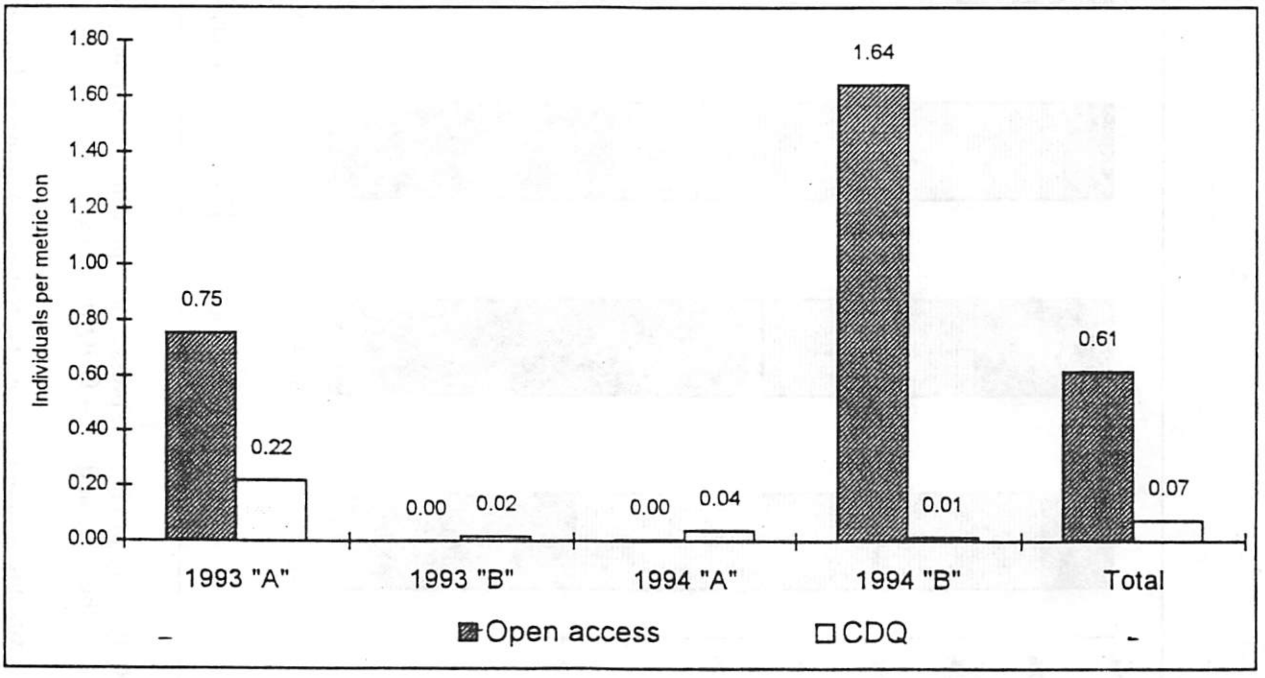

Figure 17. "Other" Tanner crab bycatch rates in the CDQ fleet by fishery, year and season.

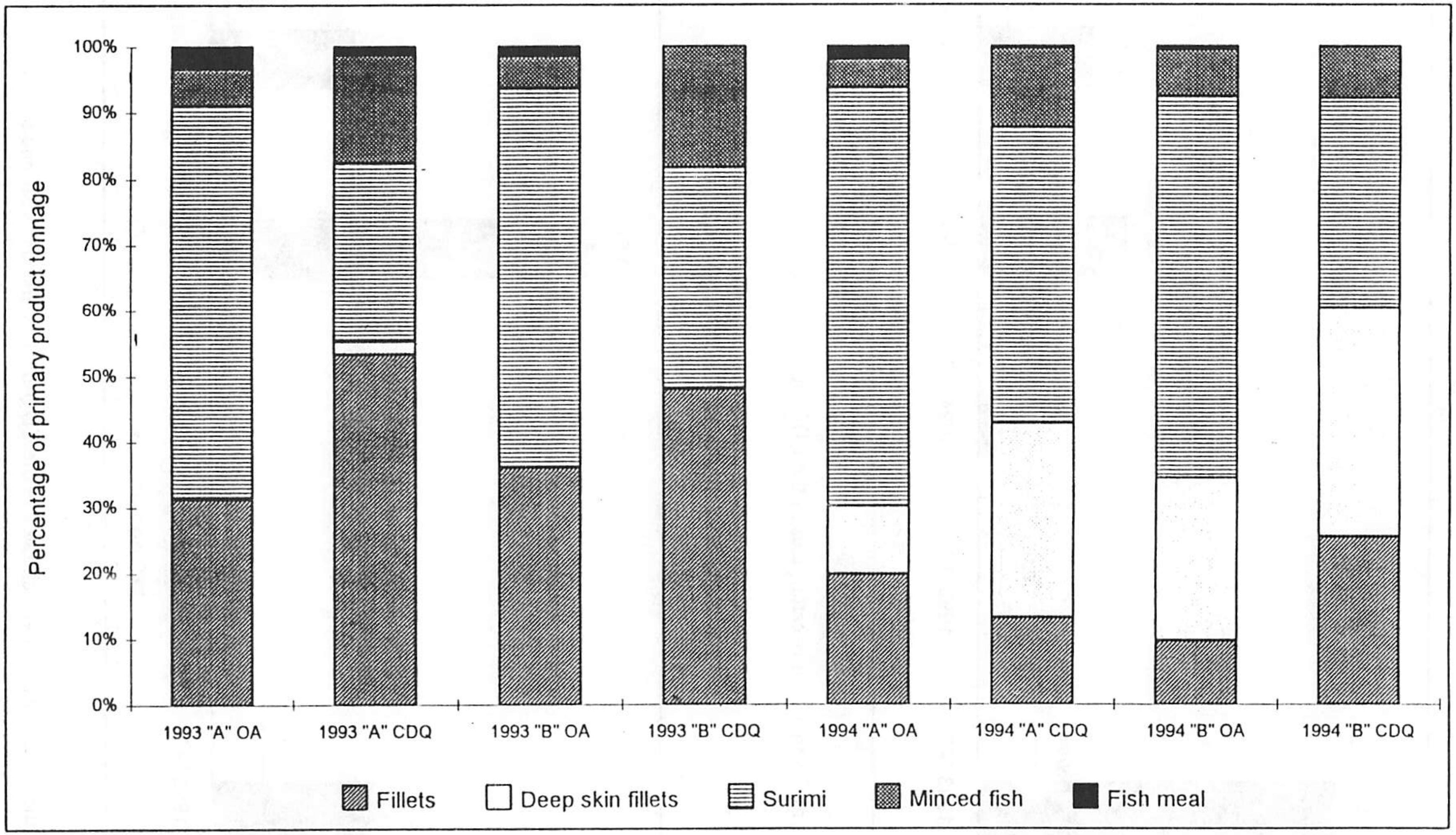

Figure 18. Primary products expressed as a percentage of total primary product tonnage for vessels that participated in the 1993 and 1994 CDQ fisheries.

Source: Weekly production reports, National Marine Fisheries Service, Alaska Region, Juneau AK.

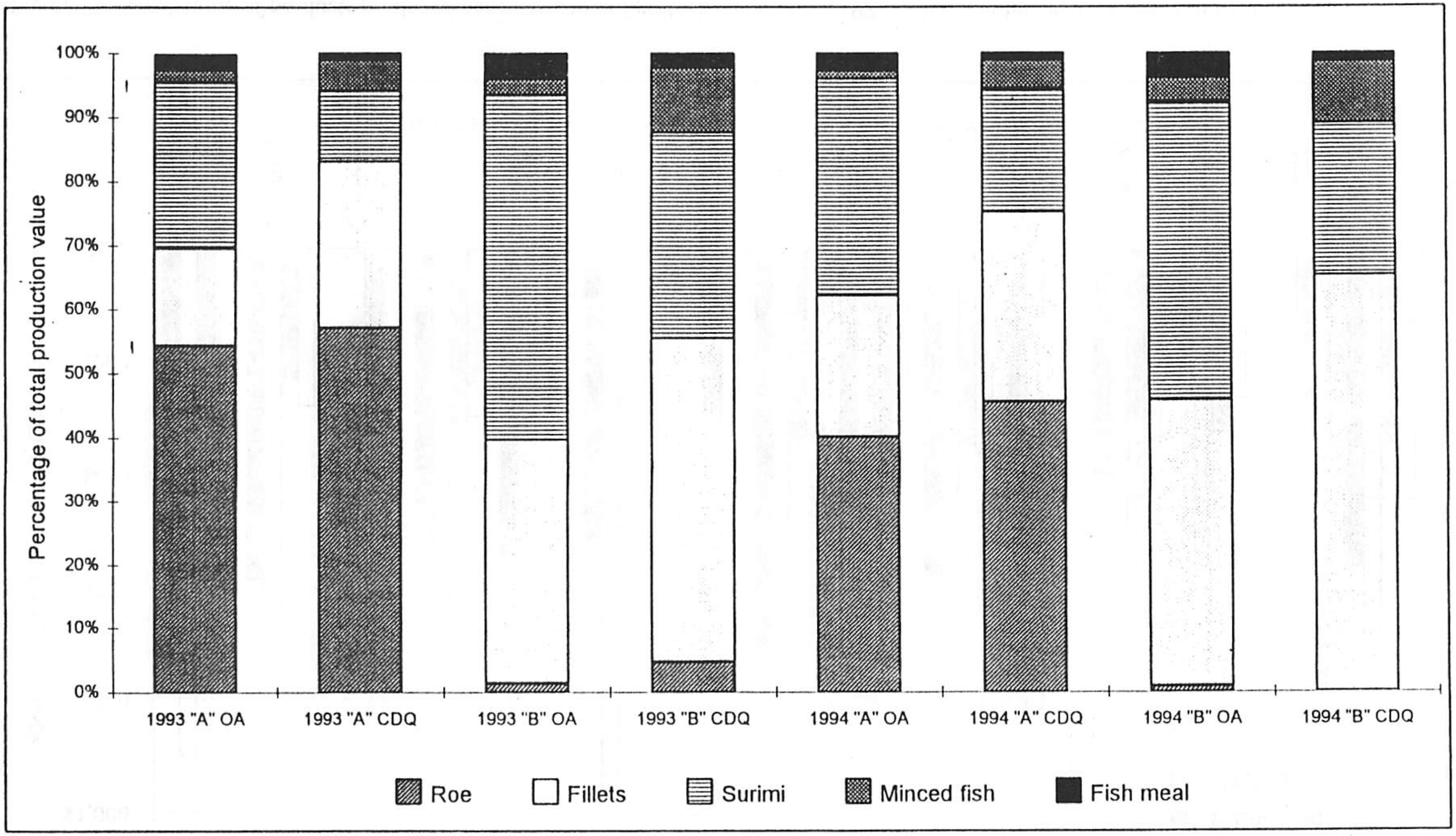

Figure 19. Individual product values expressed as a percentage of total production value for vessels that participated in the 1993 and 1994 CDQ fisheries.

Source: Weekly production reports and 1993 wholesale price survey, NMFS Alaska Region, Juneau, AK.

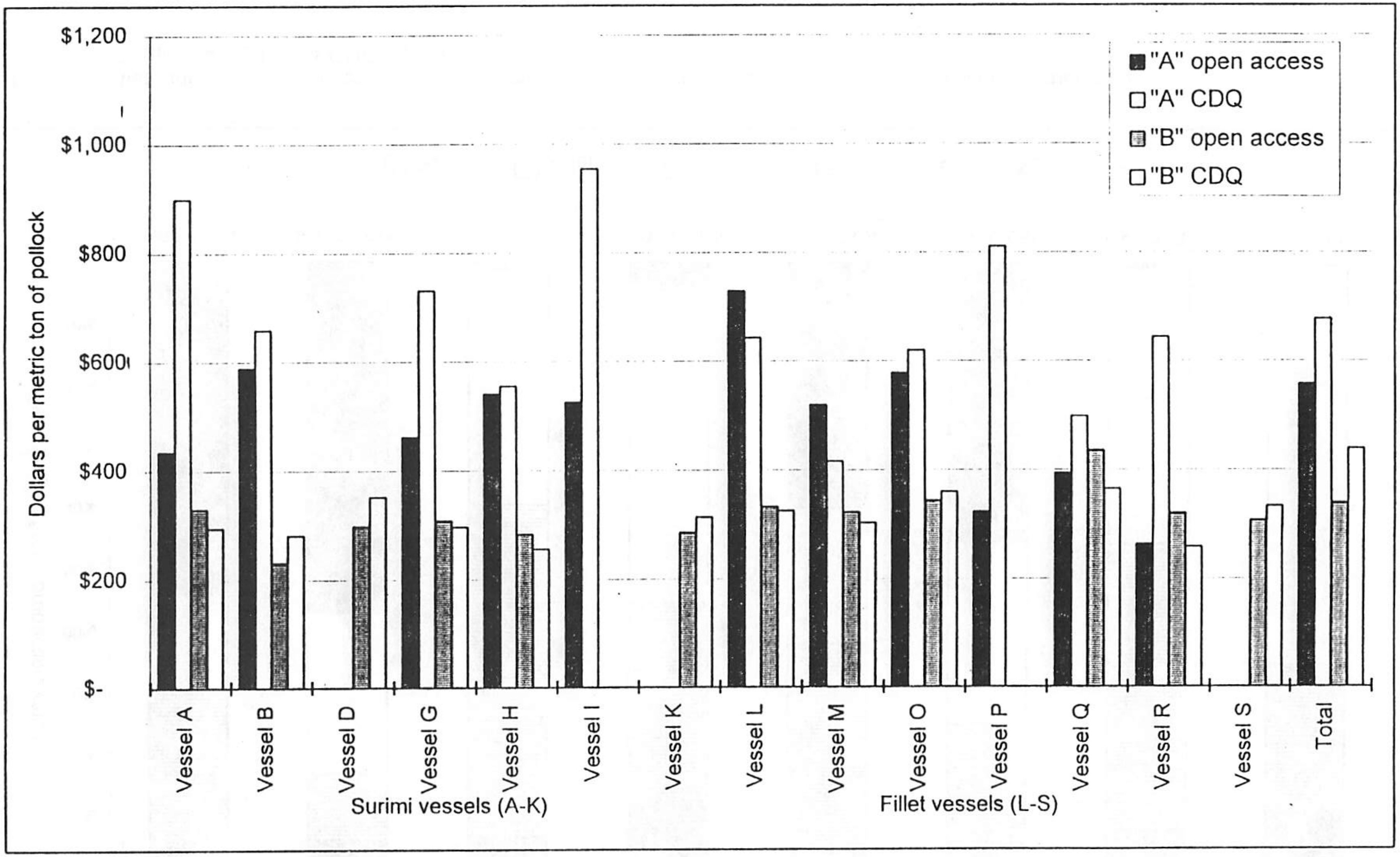

Figure 20. Total value of products produced per metric ton of pollock catch in the 1993 CDQ fleet by vessel, fishery and season.

Source: Weekly observer reports, weekly production reports and 1993 wholesale price survey, NMFS Alaska Region, Juneau, AK.

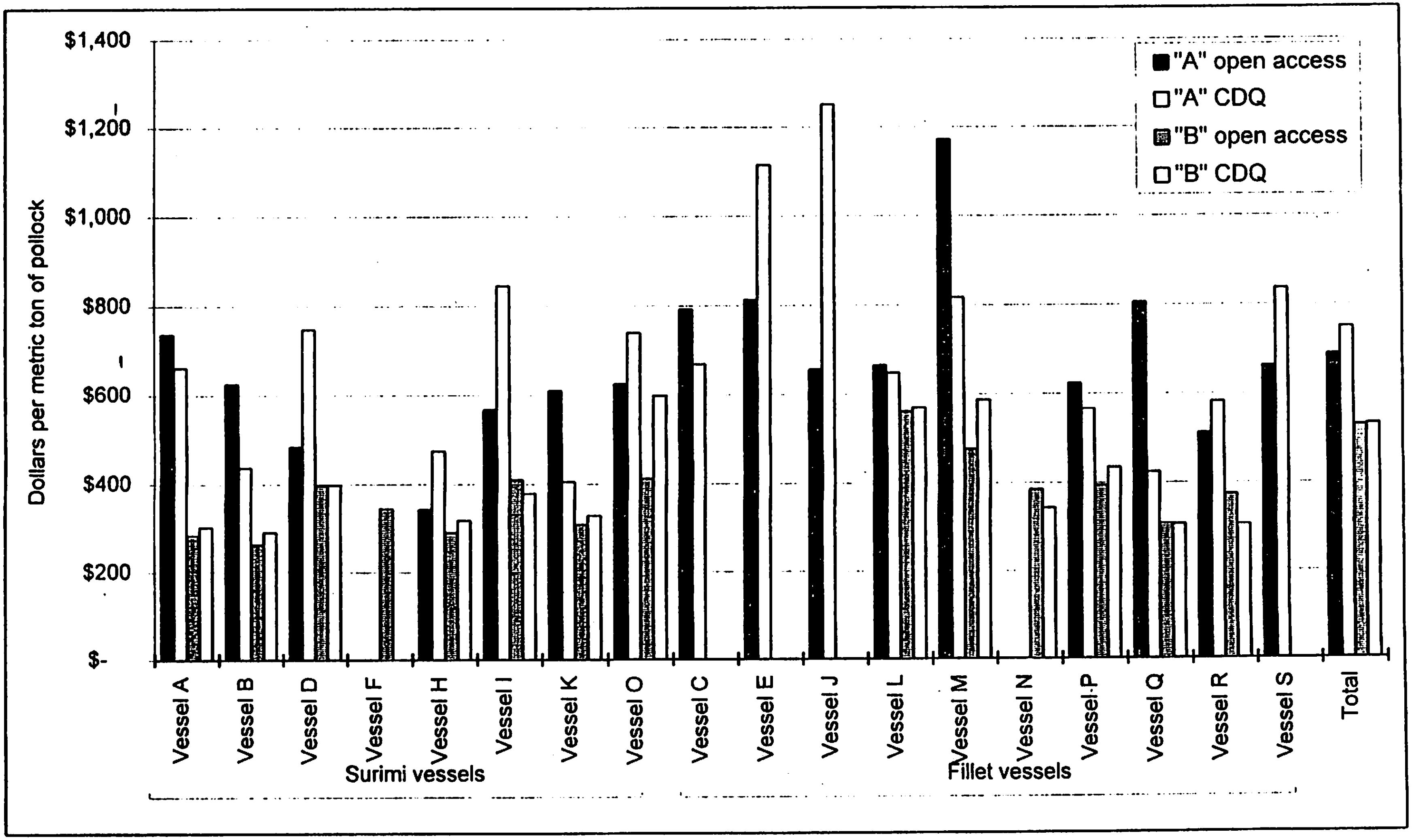

Figure 21. Total value of products produced per metric ton of pollock catch in the 1994 CDQ fleet by vessel, fishery and season.

Source: Weekly observer reports, weekly production reports and 1993 wholesale price survey, NMFS Alaska Region, Juneau, AK.

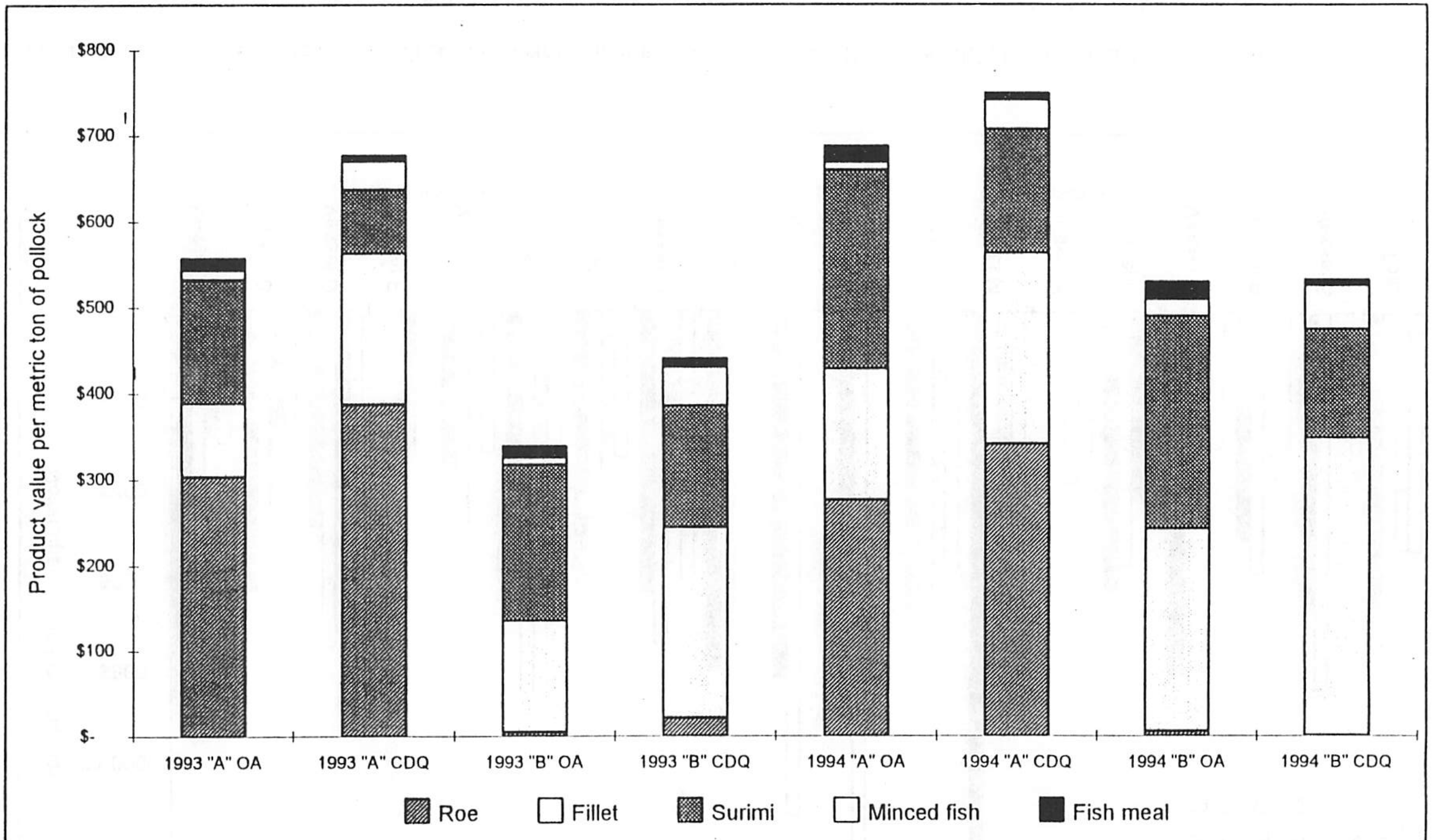

Figure 22. Product values per metric ton of pollock catch by product type, year and fishery for vessels that participated in the 1993 and 1994 CDQ fisheries.

Source: Weekly observer reports, weekly production reports and 1993 wholesale price survey, NMFS Alaska Region, Juneau, AK.

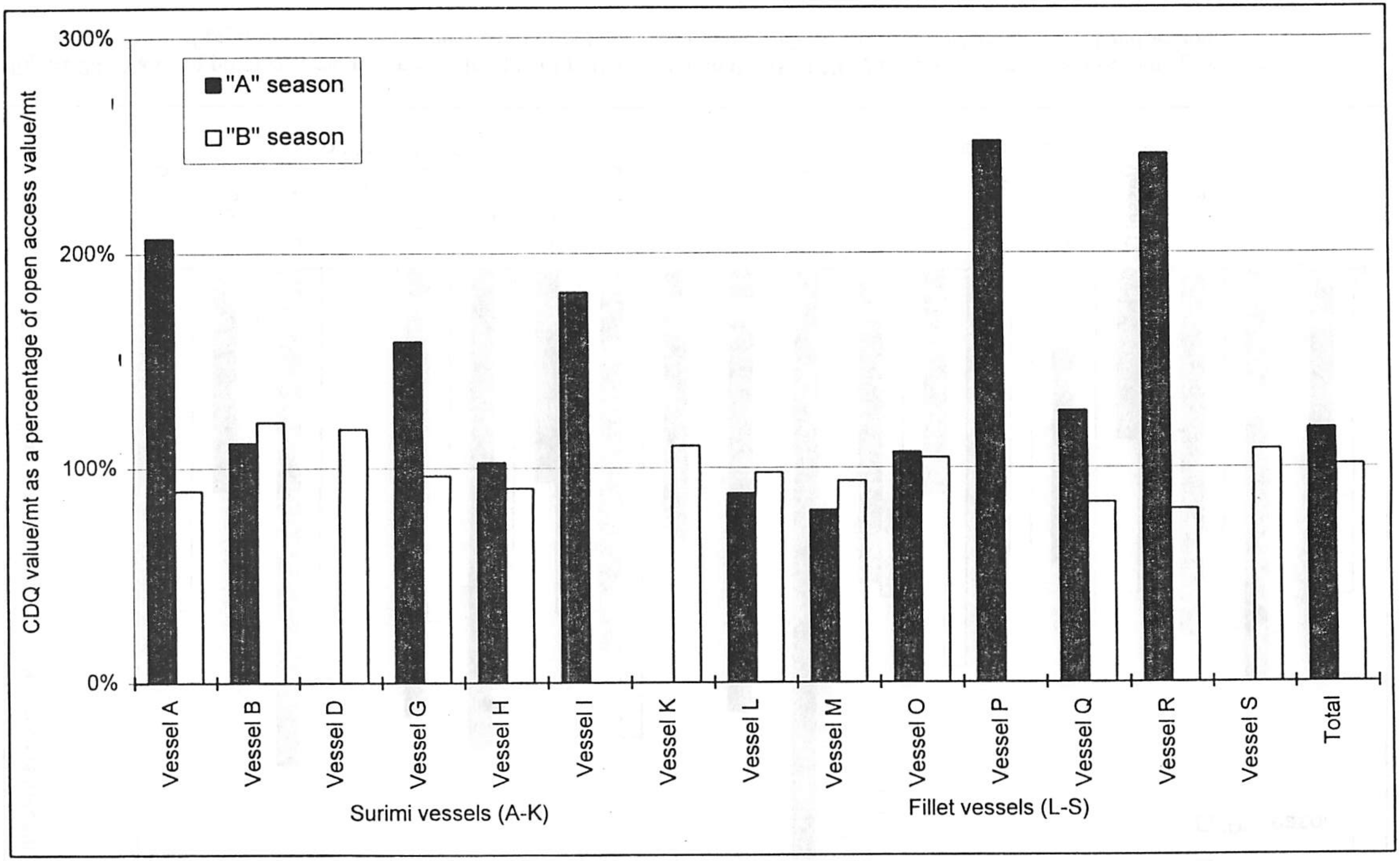

Figure 23. Value of products produced per metric ton of pollock catch in the 1993 CDQ fishery expressed as a percentage of the value of products produced per metric ton of pollock catch in the 1993 open access fishery by vessel and season.

Source: Weekly observer reports, weekly production reports and 1993 wholesale price survey, NMFS Alaska Region, Juneau, AK.

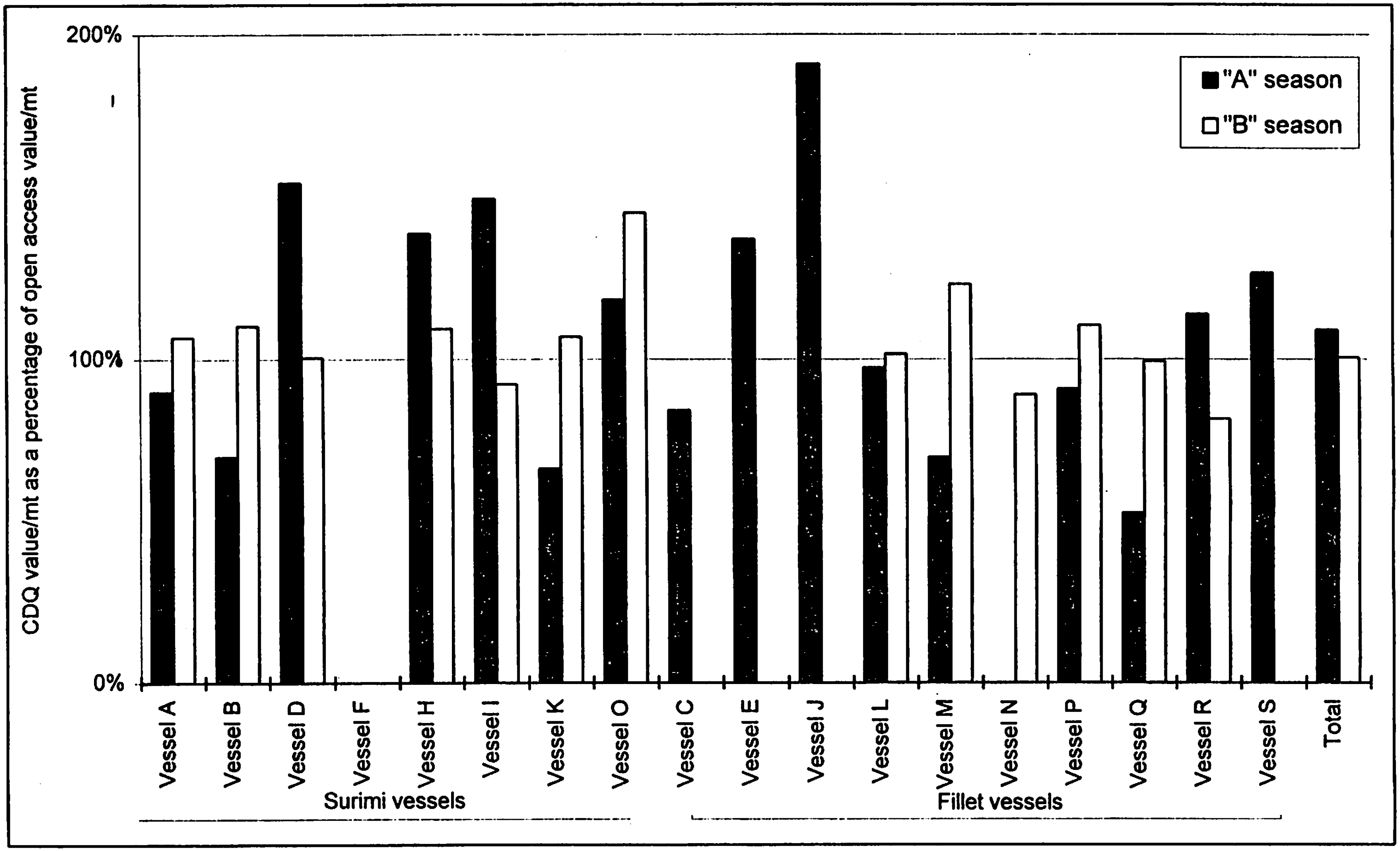

Figure 24. Value of products produced per metric ton of pollock catch in the 1994 CDQ fishery expressed as a percentage of the value of products produced per metric ton of pollock catch in the 1994 open access fishery by vessel and season.

Source: Weekly observer reports, weekly production reports and 1993 wholesale price survey, NMFS Alaska Region, Juneau, AK.

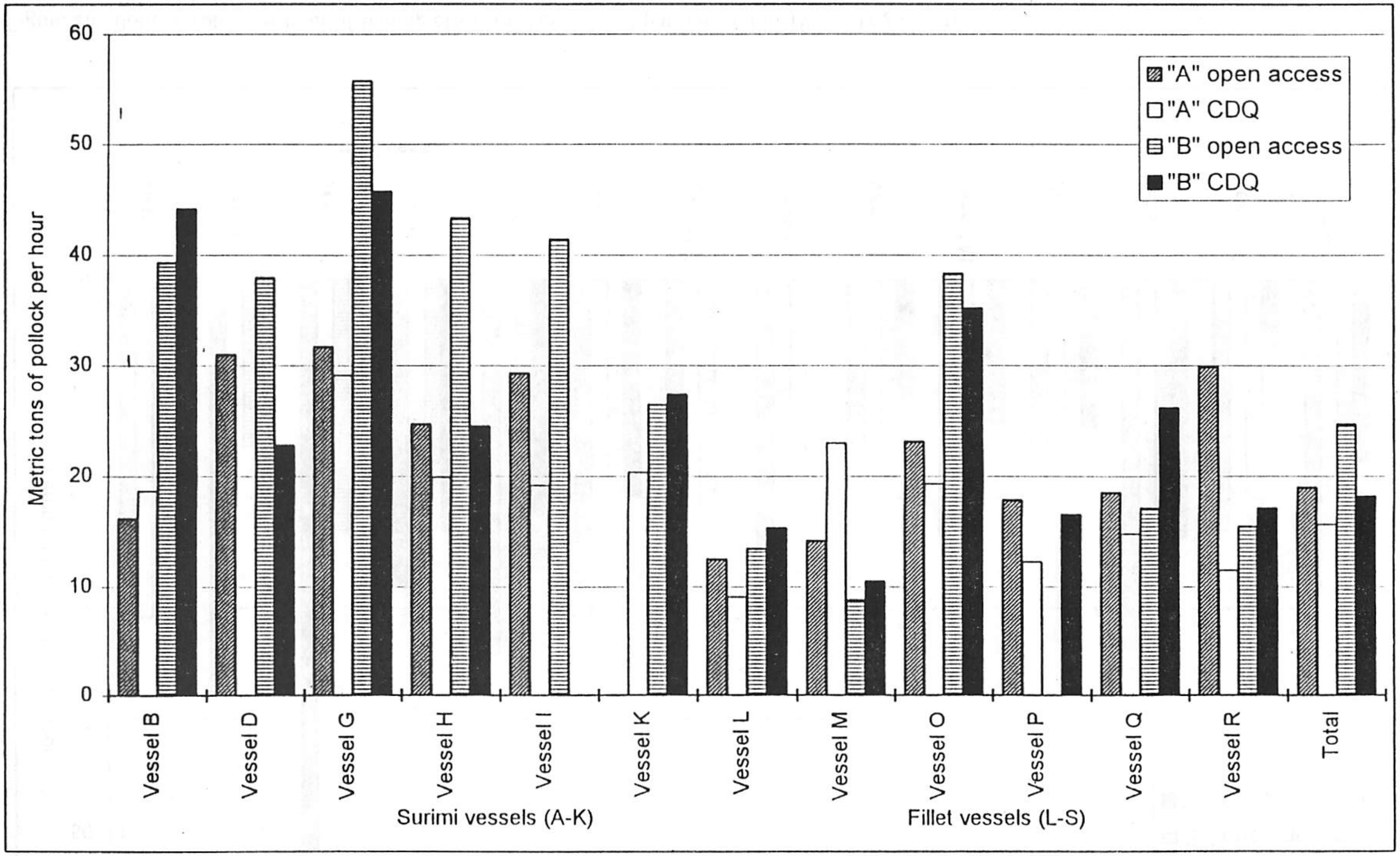

Figure 25. Pollock catch per hour of fishing effort for vessels that participated in 1993 CDQ fisheries.

Source: Weekly observer reports, NMFS Observer Program, Seattle WA.

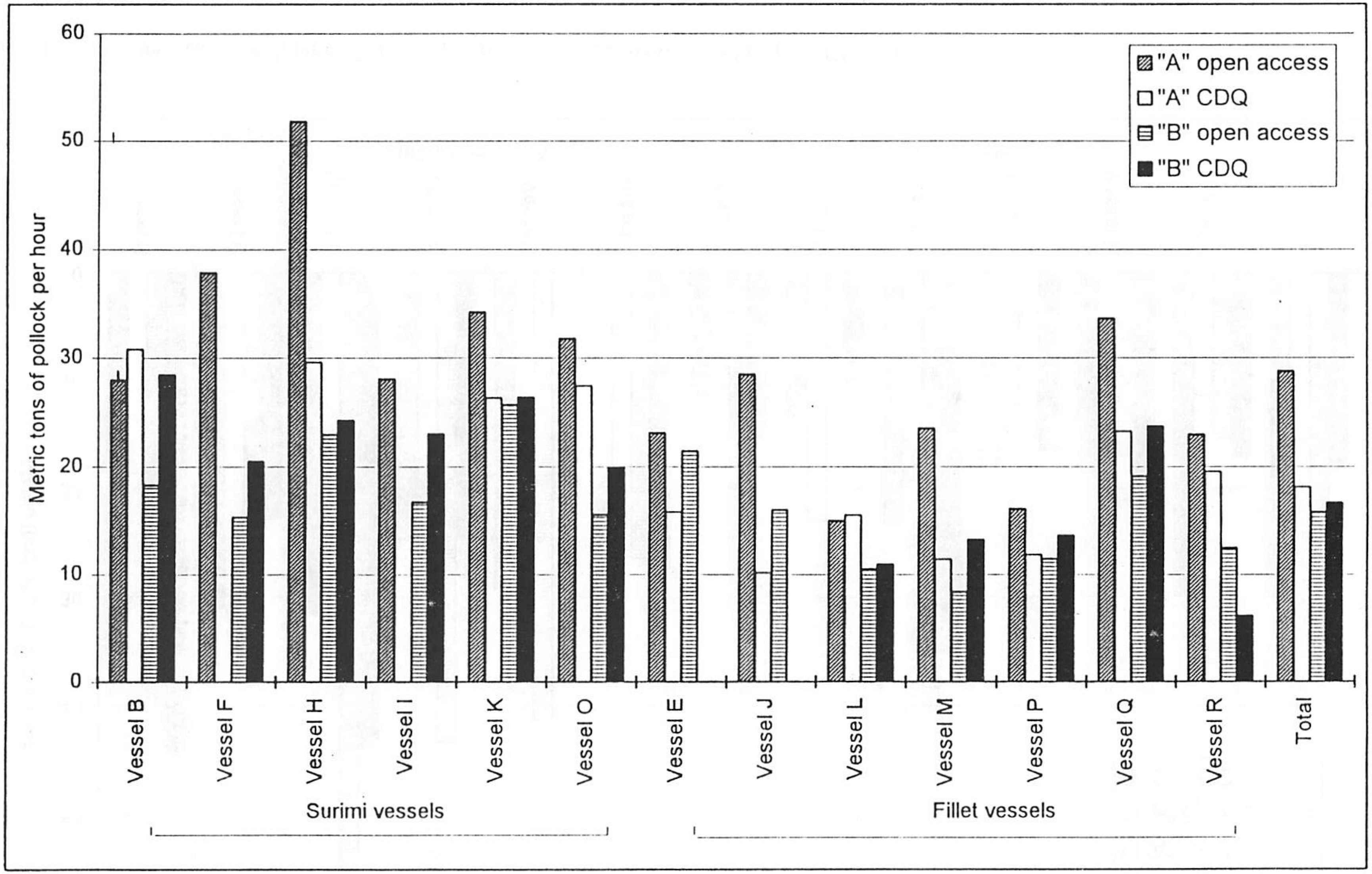

Figure 26. Pollock catch per hour of fishing effort for vessels that participated in 1994 CDQ fisheries.

Source: Weekly observer reports, NMFS Observer Program, Seattle WA.

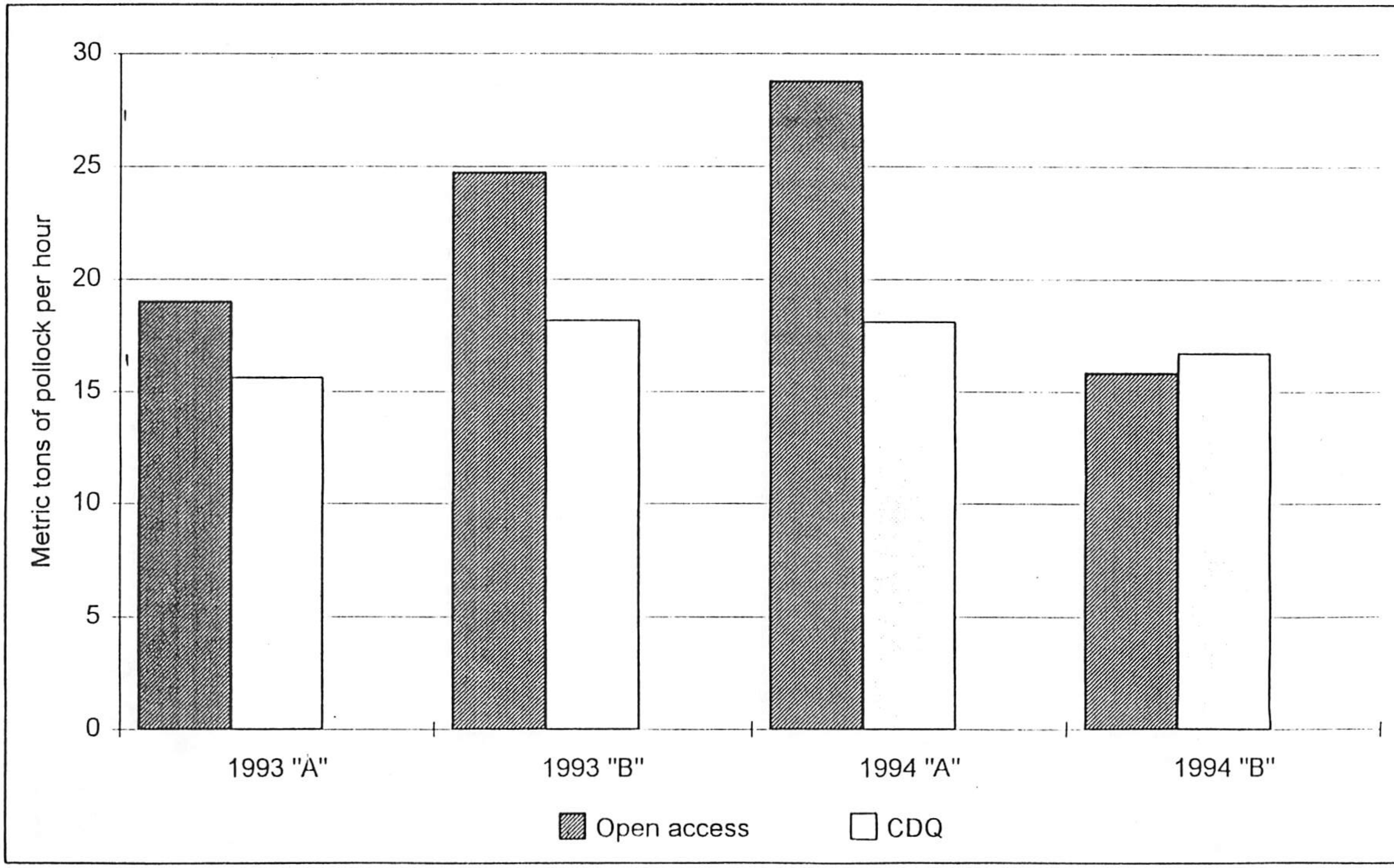

Figure 27. Average pollock catch per hour by fishery for vessels that participated in the 1993 and 1994 CDQ fisheries.

Source: Weekly observer reports, NMFS Observer Program, Seattle WA.

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Supplemental

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Using Economic Incentives in Environmental Management: The Case of Marketable Permits for Pollution Control

May 1995

USING ECONOMIC INCENTIVES IN ENVIRONMENTAL MANAGEMENT:

THE CASE OF MARKETABLE PERMITS FOR POLLUTION CONTROL

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May 23, 1995

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TABLE OF CONTENTS

1 INTRODUCTION 1
2 THEORETICAL BASIS FOR MARKETABLE PERMIT PROGRAMS 1
2.1 Effects on Economic Efficiency 2
2.2 Stimulus to Innovation and Technical Change 3
2.3 Effects on Environmental Protection 4
3 ATTRIBUTES OF MARKETABLE PERMIT SYSTEMS 4
3.1 Credits versus Allowances 5
3.2 Group Permits versus Individual Permits 5
3.3 Mass-Based Limits versus Rate-Based Limits 6
4 MARKETABLE PERMITS IN PRACTICE 6
4.1 Credit Systems 6
4.1.1 Emissions Trading Under the Clean Air Act: An Overview 6
4.1.2 Emissions Trading in Practice: The Los Angeles Basin Experience . . . 8
4.1.3 Lead Trading Program 9
4.1.4 Point/nonpoint Water Pollution Trading: Colorado and North Carolina Examples 10
4.2 Allowance Systems 12
4.2.1 The Acid Rain Allowance Program 12
4.2.2 Chlorofluorocarbon Production Allowance Trading 15
4.3 Rate-Based Averaging Programs 16
5 CRITERIA NECESSARY FOR THE SUCCESS OF TRADING PROGRAMS 16
5.1 Physical Context 16
5.2 Market Incentives 18
5.3 Trading Opportunity 19
5.4 Transaction Costs 19
5.5 Uncertainty and Risk 20
5.6 Legal, Institutional and Political Conditions 20
6 CONCLUSIONS 21
7 REFERENCES 22

1 INTRODUCTION

The use of individual transferable quotas for bycatch (IBQ) or target species (ITQ) has been proposed as a potential solution to the bycatch, discard and underutilization problem in the Gulf of Alaska (GOA) and Bering Sea/Aleutian Islands (BS/AI) groundfish fisheries. The objective of this report is to provide information that can be used to design and evaluate such programs by summarizing the nature and effectiveness of environmental protection programs that include the use of marketable rights.

A central tenet of organizational theory is that allocation and definition of property rights have important implications for market performance (Hahn and Hester 1989a). When ownership is not attached to a particular user, but rather to groups of unrelated users, the problem of the "commons" arises. That is to say, users of a common resource do not fully internalize the costs of resource depletion. A common result is that the resource is "overused" relative to what might have occurred with individual private ownership (Hardin 1968).

Many areas of environmental policy have been analyzed using the framework suggested by the problem of the "commons" including: pollution control, regional planning, wetland protection, and fisheries management. The most prolific area of research has been in the design of market-based solutions to pollution control. Economists frequently argue that environmental protection programs could be designed and operated more efficiently if the government were willing to define a system of marketable property rights. With marketable pollution rights, a given pollution objective can often be met at a lower cost making higher standards more acceptable to industry. In addition to economic efficiency, incentive-based approaches are thought to stimulate greater innovation and technical change.

2 THEORETICAL BASIS FOR MARKETABLE PERMIT PROGRAMS

In the past few years, marketable permit programs have moved from relatively obscurity to the fore as tools for environmental management. Most marketable permit programs to date have been developed for regulating air pollution. However, a small number of programs have also been used to control water pollution, urban sprawl and wetland loss. Marketable permit programs are typically implemented by regulatory agencies which issue permits to firms allowing some set level of impacts such as emissions or effluents. Individual firms are then allowed to trade (i.e., buy and sell) these permits. When control costs differ between firms, companies facing higher control costs will benefit by purchasing permits from firms able to reduce emissions for less than the offered price. As a result, reductions are made where they are least expensive while the overall emissions target is still achieved. In market-based systems, regulators do not attempt to determine the optimal pollution control technologies as these decisions are left up to the individual firms. Firms have incentives to develop and implement improved control technologies because they can realize savings either by selling any unused emissions permits or by having to purchase fewer emission permits (Teitz 1994).

While theoretically appealing, the success of marketable permits greatly depends on how they are implemented in a given setting. Marketable permits only succeed where firms face different control costs and where a market in permits develops. Transaction costs such as regulatory requirements and information costs impose market barriers and reduce cost savings. In addition, assuring the environmental effectiveness of permit trading requires accurate permit tracking, monitoring and enforcement. For a marketable permit program to be worthwhile as a matter of policy, the costs of developing, implementing and administering the system must be outweighed by actual savings in control costs. At the same time, the level and certainty of environmental protection must be maintained.

The United States has had over twenty years of experience with a variety of marketable permit systems. In 1974 the Environmental Protection Agency (EPA) began its first forays into market-based approaches to pollution control by designing limited emissions trading programs (Hahn and Hester 1989b). Since then, regulatory agencies have experimented with marketable permits in a wide range of settings including: air pollution, water pollution, solid waste, land use, and wetlands mitigation. The literature on the use of economic incentives for environmental protection is immense. Before examining the actual experience of specific trading programs, it is worthwhile to review the theoretical basis for marketable permits.

2.1 Effects on Economic Efficiency

Much of the literature on marketable permits is theoretical in nature. On a theoretical level, marketable permit programs are inherently more efficient than traditional command-and-control approaches. In other words, they are expected to achieve environmental goals at a lower cost. Some theoretical research on marketable permits simply attempts to provide a theoretical basis for permit systems without addressing a specific problem context. This research broadly defines the types of markets and permit systems that could increase the economic efficiency of environmental programs (Hahn and Hester 1989a). The overall conclusion emerging from this research is that marketable permits represent the most cost effective approach to achieving environmental objectives (Atkinson and Tietenburg 1982; Dales 1968; Hahn 1989a; Hahn 1989b; Hahn and Hester 1989a; Hahn and Stavins 1992; Montgomery 1972; Steidlmeier 1993; Tietenburg 1974; Wiley 1992).

A second body of applied theory evaluates the cost savings that could accrue under marketable permit systems in specific settings. Economists have performed numerous mathematical simulations comparing cost and environmental quality in a particular environmental context usually air or water pollution. EPA (1992) and Tietenburg (1985) reviewed the bulk of quantitative studies completed in the United States. Typically, the cost of a system of uniform standards is compared with an optimal system that could, in theory, be reached by using a system of marketable permits (Hahn and Hester 1989a). The conclusion of this body of research is that marketable permit systems could produce significant savings in pollution control costs, by up to 90 percent in some cases (Tietenburg 1985). No studies of marketable permits are known to exist that reach the opposite conclusion (EPA 1992).

In recent years, as actual trading programs have developed, empirical studies have attempted to explain the actual performance of environmental markets. Many of these studies have identified specific aspects of environmental problems that tend to facilitate or restrict permit trading. In a review of retrospective analyses of emission and effluent trading systems Atkinson and Tietenburg (1991) concluded that in all the marketable permit programs examined, actual cost savings fall well short of projections. In every case trades have been fewer and cost savings smaller than was predicted by economic modeling.

Economists cite numerous and varied reasons why many marketable permit programs have failed to live up to expectations. Coggins and Smith (1993) explored the welfare effects of emissions trading in the electrical utility industry where firms face multiple regulatory restraints. They concluded that marketable sulfur dioxide (SO_2) permits in the utility industry cannot be relied upon to guarantee either productive efficiency or economic efficiency because of interference in the market by state public utility commissions. Cason (1993) examined the seller incentives of EPA's emission allowance trading auction and concluded that the EPA's sealed bid/offer rules generate significantly biased price signals and reduce the efficiency of the allowance market. In the area of water pollution Letson (1992a) examined point source/nonpoint source water pollution trading programs and concluded that uncertainty about the effectiveness of nonpoint source control approaches has stifled trading.

The literature on pollution control also examines the distributive effects of different types of regulatory systems to society at large. The literature on air pollution policy suggests that uniform command-and-control strategies tend to be regressive. For example, Gianessi et al. (1979) demonstrated that uniform technology-based standards simply generated higher prices and transmitted the regulatory burden disproportionately to the poor.

2.2 Stimulus to Innovation and Technical Change

Most marketable permit programs are based on the quantity and composition of emissions rather than a uniform technical standard. Consequently, marketable permit programs are more likely to provide incentives for innovation and technical change than command-and-control approaches. When emissions are the only basis for determining compliance, a firm can minimize its compliance cost by reducing its emissions to the point where its marginal cost and marginal benefit of further reductions are equal and by developing and using lower cost methods of meeting the emissions standards. In command-and-control approaches, where technology-based standards are commonly used, firms may have little incentive to innovate. This is either because the technology itself, rather than the level of emissions, is often the standard or because other methods of meeting the emissions standard are not permitted. Some studies have even found that technology-based standards produce a negative incentive for firms to innovate (Dwyer 1992). With technology-based standards, regulators are often obligated to require the use of "best available technologies". Firms that develop new control technologies on their own often find their innovations have become the new "best available technology" and the basis for even tighter control standards.

Studies that have examined various incentives for technological change and innovation have found that pollution taxes provide the greatest stimulus to innovation with marketable permits providing an intermediate level of stimulus (EPA 1992). However, long-term changes in behavior, technology and investment are among the most difficult economic effects to document. For that reason, relatively little is known of the long-term effects on innovation that occur as a result of different pollution control systems (EPA 1992). The best available evidence suggests that existing environmental policies provide only mild stimulus for technological change and innovation (Cramer et al. 1990).

2.3 Effects on Environmental Protection

The literature comparing marketable permits with command-and-control approaches focuses almost exclusively on economic efficiency or the cost side of the comparison. However, to judge the worth of marketable permit programs as environmental policy, it is also necessary to compare the environmental effectiveness of such programs with traditional command-and-control approaches. Generally, marketable permit programs are designed to produce environmental effects that are comparable to a command-and-control alternative. However the environmental effectiveness of such programs may be better or worse depending on the details of market design.

Some trading programs require trading ratios in excess of one. In other words, more than one unit of emissions reduction is required for every extra unit allowed. Sometimes high trading ratios are required to account for uncertainty about the effectiveness of control methods. In other cases, the intent of high trading ratios is to produce additional decreases in total pollution compared to what would be achieved with command-and-control approaches.

On the other hand, it may be more common for marketable permits to provide somewhat less reduction in overall pollution than command-and-control based programs. Oats et al. (1989) found that uniform command-and-control approaches often result in "over-control" beyond a pollution standard, whereas trading-based approaches only just achieve the standard. This is because in most regulatory settings, some firms are able to reduce pollution to levels below what is required by regulation. With trading, those excess reductions are canceled by excess pollution from other sources.

3 ATTRIBUTES OF MARKETABLE PERMIT SYSTEMS

The design options for marketable permit systems range from small shifts in command-and-control approaches to free-wheeling pollution markets. However, all trading systems can be characterized in terms of a number of important attributes: (1) incentives may accrue either before or after the time of pollution; (2) permits may be assigned to either individuals or groups; and (3) standards may be based on either the mass or the rate of discharge.

3.1 Credits versus Allowances

Marketable permit programs can involve either credits or allowances. The difference between credits and allowances is the time at which the right accrues. Credits must first be earned by demonstrating reductions in pollution. Allowances are pollution rights which are issued before hand. A credit is created after pollution has occurred, when a firm emits less than its allowable limit. To earn credits, a polluter is required to show that its reduction in emissions is a surplus and meets other regulatory tests. Regulators grant credits when reductions are below the regulatory baseline. In a credit program, the regulatory agency usually certifies the creation of the credit at the end of a pre-designated accounting period. In a credit-based system regulators have two opportunities to regulate the creators of credits. The first is when the baseline and ground rules are established and the second is when the firm applies for credits (EPA 1992).

In an allowance system, trading involves future pollution. Firms are granted quasi-rights or allowances to emit pollution on an annual or some other calendar basis. Firms are "allowed" so many tons per year to pollute; if a firm does not need all of these "rights," it may sell them. Once the regulatory agency sets allowable limits for each firm, the firm can add to its limit or reduce it by trading in allowances. Regulatory agencies might track trades, but do not necessarily certify every trade before hand. Until the past few years, most marketable permit programs were credit systems, although allowance systems are becoming more common.

Allowance systems are generally considered a freer form of markets than credit systems. That is because the property right attached to pollution reductions under allowance systems is more secure. In some credit programs, where a regulatory agency must certify pollution reductions before credits are granted, some regulatory agencies have refused to issue credits because of changing regulations or other discretionary reasons. In other cases, where firms are guaranteed that a given level of reductions will earn a given level of credits, there may be little functional difference between allowances and credits (aside from differences in accounting procedures).

3.2 Group Permits versus Individual Permits

The group permit approach is most commonly used to control nonpoint sources of water pollution (Teitz 1994). The regulatory body establishes the maximum level of allowable discharge for a water body, but instead of issuing individual allowances, dischargers as a group, are held responsible for controlling pollution sources. In group permit systems, groups are free to distribute allowances among members in any manner they chose. With a group permit system, the group itself, rather than the regulatory body generally establishes the guidelines for trading.

3.3 Mass-Based Limits versus Rate-Based Limits

Programs to regulate pollution may be based on the total mass discharged, the rate of discharge, or both. Command-and-control regulations commonly limit the rate of emissions, but not the total amount (for example, federal automobile tailpipe standards). Some programs regulate both rate and mass at the same time. Ambient air quality programs frequently use rate-based restrictions to assure that emissions loading on any particular day (or under specific atmospheric conditions) do not exceed air quality standards. At the same time, air quality programs usually impose mass-based restrictions on an annual basis to meet regional air quality targets.

Trading systems have been designed to achieve both mass-based and rate-based limits. The distinction between the two is important because mass limits are a significantly different regulatory burden than rate limits. In fact, analysts have found that many of the most difficult problems associated with trading programs come from the limit itself rather than from allowing firms to adjust their limit through trading. Issues such as monitoring, baselines, and enforcement are all limit-related rather than trading-related. In many marketable permit programs, the allowance unit and total number of allowances are based on mass calculations, while the initial distribution of allowances among firms is based on a combination of rate and mass considerations.

4 MARKETABLE PERMITS IN PRACTICE

Theoretical analyses and empirical studies have produced a rough consensus about the conditions that may be necessary or beneficial for marketable permit programs to succeed. Nevertheless, it is difficult to evaluate whether or not permit trading is the optimal regulatory approach to a particular environmental problem at the theoretical level because the factors that influence success or failure vary tremendously in practice. To provide a realistic view of how marketable permit programs work in practice, this section examines a range of currently functioning trading systems.

4.1 Credit Systems

Until recently, most marketable permit programs have used credits rather than allowances. The EPA's emissions programs, the lead trading program, point source/nonpoint source water pollution trading, and transferable development rights programs are all examples of credit systems.

4.1.1 Emissions Trading Under the Clean Air Act: An Overview

To date, the bulk of our experience with marketable permits had been with air pollution. The first limited efforts at creating marketable permits in the United States were emissions trading systems developed as part of EPA's ambient air quality programs. These programs emerged in the 1970s as policy recommendations by EPA to state and local clean air agencies to alleviate the costs of meeting some of the more expensive elements of the 1970 Clean Air Act. When Congress drafted the Clean Air Act, it gave no serious consideration to the magnitude and distribution of control costs. In addition, Congress prevented EPA from even considering costs when setting ambient air quality standards (Bleicher 1975). Congress felt that public health and the environment could not be compromised by concern for corporate profits and apparently had faith that ambitious air quality standards and short deadlines would force industry to develop the necessary control technologies (Bonine 1975). Congress' faith in technology produced a political and legal dilemma for the EPA. One element of the Act prohibited both construction of major new facilities and major modifications to existing ones in so-called "nonattainment" areas (Dwyer 1993). The Clean Air Act, if strictly enforced, effectively banned the construction of new manufacturing facilities in most urban areas due to the fact that major cities in 45 states failed to meet initial ambient air quality standards. EPA, as well as state and local regulatory agencies, were forced to confront head on, the conflicting political goals of environmental protection and economic development. To provide a way of allowing continued economic development in "nonattainment" areas, EPA developed four specific types of credit programs referred to as *netting, offsets, bubbles* and *banking.*

Netting was introduced in 1974 as EPA's first foray into market-based pollution programs. Netting allows an expanding facility to avoid strict standards for new operations to be applied on plant modifications by using internal trading (within the same plant) to keep total emissions below a pre-determined level. Under netting, new source of emissions would be allowed if emissions from other sources within the same plant are reduced proportionately. Because "insignificant" increases are allowed under netting, some environmental degradation may result (Hahn and Hester 1989a).

Offsets have been used since 1976 to allow continued economic development in "nonattainment" areas where the Clean Air Act prohibits all emissions increases. Under this policy, firms are able to build new facilities, or modify existing ones, so long as they employ strict pollution controls on the new source and offset all residual emissions by reducing emissions at other existing sources (Hahn and Hester 1989a). With offsets, exchanges may occur between different firms or different facilities within the same firm, while netting only applies to different discharge points within a single facility.

Bubbles were introduced in 1979. Under this policy, an existing facility is regulated on the basis of an imaginary bubble placed over the complex. Emissions levels from individual sources within the complex can be freely traded as long as total emissions do not increase. Most trades involve emissions within one plant but there have been a few multi-plant bubbles (Hahn and Hester 1989a). While netting and offsets only apply to new sources of pollution, bubbles apply to all sources of pollution within a plant or geographic area.

Banking, which was first allowed in 1979, provides a mechanism for firms to save emissions credits for future use. EPA established guidelines for banking programs but state or regional agencies must set up and administer the rules governing banking. Banking does not generally involve trading *per se*. Rather, it is usually applied to emissions from a single source over time (Hahn and Hester 1989a).

During the reauthorization of the Clean Air Act in 1977, Congress debated the more extensive use of economic incentives. Many legislators viewed them as politically risky and as an unwarranted delegation of the public interest to private actors. In the end, a modest offset program was formally authorized within the Act itself (Hahn 1989a)[1]. However, when the Clean Air Act was again amended in 1990, Congress authorized and in some cases mandated a much broader range of marketable permit programs to deal with specific problems such as urban smog and acid rain (Dwyer 1993).

4.1.2 Emissions Trading in Practice: The Los Angeles Basin Experience

While the Clean Air Act requires EPA to set ambient air quality standards, actual implementation is delegated to state and local agencies. In the late 1970s, local regulators in the South Coast Air Quality Management District (SCAQMD), which covers the Los Angeles basin, began to experiment with offset trades under guidance from EPA (Dwyer 1993). With SCAQMD taking the lead, many other California districts began to adopt rules governing offset trades. To date, however, the results of the offset program in the Los Angeles basin have been disappointing. In SCAQMD, which reportedly has the "most developed and well functioning" trading program in the nation, only a handful of firms complete offset trades with each other each year (Hahn and Hester 1989b). In addition, two thirds of the credits sold (by volume) have been in conjunction with firms closing their facilities. The extent to which these plant closings are attributable to pollution incentives rather than other factors has not been examined. While there have been a significant number of intra-firm offsets, producing considerable savings, no market in inter-firm permits has emerged (Dwyer 1993).

Analysts have attributed the lack of inter-firm offset trading to a number of factors. First, the offset program itself is designed to suppress demand. Most existing firms cannot buy offsets. Only those firms undergoing major modifications or construction of new facilities may purchase offsets. Expanding firms must first install the latest pollution control technologies regardless of the availability of less expensive offsets. SCAQMD regulations also create exemptions ("thresholds") for entire categories of small facilities and for modifications that result in relatively small emissions increases. As a result, few firms need to acquire offsets, demand is suppressed and the market is undeveloped (Dwyer 1993).

A second reason for the lack of offset markets is the tendency of existing firms to hoard their credits, thereby restricting supply. Most plant managers believe that they will need additional credits in the future to respond to new SCAQMD emission reductions or to accommodate future expansion plans. Firms also fear, with some justification, that if they reduce emissions, the District will simply lower their emissions limits and place restrictions on future increases. In addition, firms have found that the use of new technologies at one plant has, in some cases, been the basis for mandatory controls at other plants (Dwyer 1993). Additional market barriers include the transaction costs associated with locating a seller, undertaking appropriate engineering studies to quantify the emissions reductions, negotiating a price, and securing

[1] Prior to 1977, netting and offsets had emerged as EPA policy but were not mentioned in the Clean Air Act itself.

SCAQMD approval (Hahn and Hester 1989b).

For these reasons, the majority of trades have involved firms that have ceased operations and have no economic motive for withholding their credits from the market (Dwyer 1993). SCAQMD's regulations make it extremely difficult to create tradable credits by any other means than closing a plant. Given how strict the District's rules are, getting more emission reductions by over-controlling emissions is difficult. In addition, the fee SCAQMD charges for processing credits is so high (SCAQMD issues separate permits for individual pieces of equipment) that it is not cost effective for most companies with multiple permits to generate credits (NAPA 1994). However, by allowing firms that will cease operations to sell their credits, the probability that such permits will be allocated efficiently among existing and new operations is increased.

Despite the limited success of the offset program in the Los Angeles basin in generating a market, SCAQMD regulators, industry and environmentalists have shown a growing interest in the use of economic incentives. The 1990 Amendments to the Clean Air Act, which openly encouraged incentive based systems, were instrumental in encouraging the development of a new marketable permit system for the Los Angeles basin. In 1992, state and federal regulators, as well as representatives from industry, environmental groups and labor developed an ambitious program to replace the existing command-and-control structure with marketable permits for sulfur oxides, nitrogen oxides, and hydrocarbons (Dwyer 1993). This new emissions trading program, known as the Regional Clean Air Incentives Market (RECLAIM) began on January 1, 1994. This program establishes annual limits on the amount of air pollution a plant can emit. These limits are ratcheted down on an annual basis. Firms that are able to realize reductions in excess of their annual limits are granted credits which they can sell to firms that have difficulty meeting baseline requirements. While several thousand firms will eventually be regulated under RECLAIM, the current program affects only 387 plants in the Los Angeles basin (Bornstein 1994). Although the RECLAIM program has been heralded with great fanfare as a successful example of marketable permits, it is still too early to judge the effectiveness of the program. The first emissions credit auction was postponed until late 1994 to give firms more time to convert their emission reduction credits and develop compliance plans (Heinsohn and Karey 1994).

4.1.3 Lead Trading Program

The lead trading program, formally known as "inter-refinery averaging" was instituted by EPA as part of a regulatory program that mandated reductions in the amount of lead added to gasoline (Hahn and Hester 1989a). Although EPA began regulatory efforts to reduce lead in gasoline as early as 1974, trading in lead credits did not begin until 1982 when EPA imposed new, lower limits on lead content. The trading program was developed in response to concerns that some refineries, especially small ones, would have trouble meeting the new standards and would benefit from a program providing extra flexibility for a period of time. In 1985 EPA further reduced the amount of lead allowed in gasoline and specified that lead trading would end in 1986. Prior to 1985, unused lead credits expired at the end of every quarter. Beginning in 1985, refineries could "bank" credits for their own future use or sale to others. While the trading program ended in 1986, firms were allowed to use banked rights until the end of 1987 (Hahn and Hester 1989a).

Under the program that expired in 1986, rights to add specific quantities of lead to gasoline could be freely traded between refineries. EPA set national standards specifying the quantity of lead that could be added to gasoline. The quantity of rights to which a refiner was entitled was determined by the quantity of gasoline produced by that refiner and the current lead standard. Refineries that added less lead than was allowed could sell all excess lead credits in a one-to-one ratio. Refineries exceeding the lead standard were required to obtain lead credits in an amount equal to the excess. Transactions were reported to EPA at the end of each calendar quarter, and each refiner was required to have a net balance of lead credits greater than or equal to zero for the quarter (Hahn and Hester 1989a).

Trading of lead credits could be internal or external. In other words, refineries could use lead credits themselves by adding more lead to their gasoline at some point during the quarter than would otherwise have been allowed, or they could sell credits to another firm. The trading program was successful without compromising any of the environmental objectives of EPA's lead reduction program. Lead trading shifted the use of lead between refineries but it did not increase the total amount of lead that could be used. In is unlikely that trading resulted in greater overall use of lead by refineries. Because lead is the most cost-effective method of raising octane levels in gasoline, virtually the entire amount of lead permitted would have been used by refineries with or without a trading program.

Economists consider the lead trading program to be the most successful example of a marketable permit program to date (Hahn and Hester 1989a). The lead market itself was extremely active. During the programs existence, upwards of 60 percent of all refineries participated in either trading or banking. By the programs end, the percentage of lead credits banked or traded exceeded 50 percent of the total lead used (Hahn and Hester 1989a). Although EPA has not collected data on the actual cost savings realized by refineries as a result of lead trading, the agency estimated that lead banking alone could produce savings of as much as $225 million to refineries. Anecdotal evidence placed the combined savings of both trading and banking in the hundreds of millions of dollars (Hahn and Hester 1989a). Without trading in lead credits, two alternatives were likely: (1) the phase-down would have take longer or (2) there would have been a short-term contraction in the supply of gasoline and possible supply disruptions in some areas (EPA 1992).

4.1.4 Point/nonpoint Water Pollution Trading: Colorado and North Carolina Examples

Since 1972 the emphasis of national water quality programs has been the control and elimination of pollutants from point source discharges.[2] Although problems with some point

[2]Point source discharges are defined as coming out of a pipe from a single source such as factories or sewage treatment plants. Most point source discharges are regulated under the Clean Water Act through the National Pollutant Discharge Elimination System (NPDES) permit program. Nonpoint source pollution may be thought of as runoff from agricultural and urban areas where the identification of a single source is impossible. Fertilizer

source pollutants such as oxygen-demanding waste and bacteria have lessened, water quality has not improved commensurably because nonpoint source contributions are increasing as a share of the nation's water quality problem (EPA 1990). Centralized "command and control" programs have had difficulty regulating nonpoint sources which are decentralized and dependent on localized features such as land use patterns and agricultural practices (Leschine and Shigenaka 1988). For this reason, there is growing interest in marketable permits as a method of regulating nonpoint sources of water pollution.

Point/nonpoint source trading is one mechanism used for dealing with nonpoint source problems. Point/nonpoint source (PS/NPS) trading borrows the "bubble" or "offset" concepts from air pollution regulation and applies them to watershed management. A "bubble" (or "bowl" for a watershed) adds the discharge levels for all sources in the watershed and allows for adjustment of the levels of individual discharges as long as the total does not exceed the target aggregate level. PS/NPS trading has come to mean giving municipal treatment plants and industrial dischargers the option of reducing nonpoint source contributions rather than requiring further point source reductions (Letson 1992a). The advantage of PS/NPS trading is that it allows dischargers to pursue the most cost effective methods of water quality improvement. PS/NPS trading has the added advantage of drawing nonpoint sources into the regulatory scheme without the need to regulate them directly.

Programs at the Dillon and Cherry Creek Reservoirs in Colorado and a similar program for the Tar-Pamlico River basin in North Carolina are among the few examples of PS/NPS trading to date (Letson 1992a). Lake Dillon (Denver's source of drinking water) is an interesting example. By the early 1980's Lake Dillon's water quality was declining rapidly due to excessive nutrient loading. As is often the case, point source dischargers were required to carry much of the responsibility for cleanup. Surrounding towns had to consider adding expensive state-of-the-art wastewater treatment facilities or face moratoriums on new development. Studies showed, however, that the bulk of phosphorus coming into the lake originated from nonpoint sources. Much of the NPS phosphorus was attributable to runoff from golf courses, parking lots, construction sites and seepage from septic tanks. Consequently, the "Dillon Bubble" strategy was designed to allow growth in the basin while at the same time maintaining -- or even improving -- the water quality of Lake Dillon (Zander 1991).

An integral part of the Lake Dillon strategy was a plan for PS/NPS trading. Under the plan, wastewater treatment facilities were awarded 1 pound of PS phosphorus credit for the removal of 2 pounds of NPS phosphorus. In other words, treatment plants could finance NPS reductions in the community in leu of making PS reductions at the plant. Because many NPS controls are inexpensive low-tech approaches such as grass filter strips and detention ponds, municipalities found PS/NPS trading to be economically viable even at a 2:1 ratio. In the past few years, however, the operating efficiency of existing tertiary treatment facilities in the

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runoff from farms, golf courses and lawns; animal waste from farms and feedlots; oil runoff from highways; and silt from logging operations and construction sites are all examples of nonpoint source pollution. Until recently, most nonpoint sources of pollution have fallen outside the regulatory framework.

basin has greatly improved, reducing the need for phosphorus trading. While PS/NPS trades continue to be proposed, the program has changed somewhat to include NPS/NPS trading. As the area continues to grow, new development will likely produce new sources of phosphorus. To counter this increase, the plan allows developers to mitigate for newly created sources of phosphorus by reducing or eliminating "old" nonpoint sources (Zander 1991). This use of NPS/NPS trading is analogous to compensatory wetlands mitigation.

The Tar-Pamlico River PS/NPS trading program began in 1989, however it is still appears to be in the formative stages. Although trading is allowed in the program, no economically motivated trades have occurred to date for two primary reasons. First, the lack of a nutrient model means that regulators do not yet have accurate information about the basin's water quality dynamics. For this reason they are reluctant to promote trading. Second, most of the basins' point source dischargers have been able to meet mandated reductions with relatively inexpensive internal modifications which has reduced the demand for PS/NPS trading (Apogee Research 1992).

Despite the Tar-Pamlico experience, we may be reaching the point in many instances where NPS reductions are cheaper than further PS controls. Letson (1992) identifies two conditions that must exist for PS/NPS trading to be economically viable. First, inexpensive NPS reductions must exist that are similar in nature to the PS reductions they are to replace. Second, the uncertainties stemming from prediction, monitoring and control of nonpoint sources must not overwhelm potential savings. Several watershed studies produced for the EPA suggest that these conditions do exist in some watersheds.

A study of the Wicomico basin in Maryland showed significant potential savings. It was estimated that for one treatment plant, trading could provide savings of $64,000 in meeting a 25 percent reduction target and $245,000 in meeting a 75 percent reduction target (Industrial Economics 1987). Other case studies in the Great Lakes basin and Honey Creek watershed in Ohio indicate similar possible savings exist (Letson 1992a). Unfortunately there are no larger cost comparison studies that can provide insight into the demand for PS/NPS trading on the national level.

4.2 Allowance Systems

Marketable permit systems have not commonly used allowances, in part, because of a reluctance on the part of regulators to certify rights in advance of the polluting activity. To date, there have only been two examples of marketable permit programs using allowances in the United States: the acid rain program and the chlorofluorocarbon production trading program.

4.2.1 The Acid Rain Allowance Program

The most significant marketable permit program to emerge as a result of the 1990 Clean Air Act Amendments is the sulfur dioxide (SO_2) allowance trading market which was mandated by

Congress and designed to reduce acid rain in the Northeast. The SO_2 trading program was designed from the outset as a compromise to break the decade-long deadlock in Congress between Northeastern and Midwestern representatives over who should bear the cost of cleaning up the nation's acid rain problem (Fulton 1992). Under this program, total emissions of SO_2 from all electric utility power plants in the continental United States are capped and ratcheted downwards on an annual basis to meet the Clean Air Act's overall goal of halving SO_2 emissions nationwide by the year 2000. EPA issues annual emissions limits to each utility in the form of allowances. Utilities are then allowed to meet their emissions limits using any method they like the most common being a shift to low-sulfur coal mined mostly in the West, installing scrubbers, or purchasing additional allowances from other utilities. The acid rain program established a national market in SO_2 emission allowances allowing utilities from any part of the country to freely trade allowances without regard for the effects that the trade will have on the geographic distribution of air pollution or acid rain deposition. Phase I of the program affected 110 of the dirtiest coal-fired electric utilities which are all located in the eastern half of the country. Phase II, scheduled to begin in the later half of the decade will include all sizable sources of sulfur dioxide (Hausker 1992).

The SO_2 allowance trading program was designed to achieve two specific goals that Congress was unable to deal with in any other way. First the program was intended to spread the cost of acid rain reduction among utilities and ratepayers in a way that all regions of the country would find acceptable. Congress struggled for a decade with the distribution problem considering and rejecting such measures as federal subsidies and national utility taxes. By establishing marketable permits, Congress expected that utilities would decide among themselves how to distribute the cost (Fulton 1992). The second goal of the program was to lower the overall compliance costs of the acid rain provisions of the Clean Air Act. Initial projections estimated potential savings to the electric industry of at least $1.5 billion annually (Burtraw 1991) or 20 percent of the estimated $5 billion in annual compliance costs (Goldburg and Lave 1992). Much of this potential savings results from the wide disparity in compliance costs between power plants. Compliance is significantly cheaper for some plants due to the technology in use when they were constructed and the type of coal they were designed to burn.

In 1992 EPA selected the Chicago Board of Trade to conduct the public auction of SO_2 emissions allowances. The first public auction was held on March 29, 1993 and attended by approximately 100 electric utilities. This initial auction generated $21 million in trades and included a "spot auction" for 1995 allowances and an "advance auction" for the year 2000 (Bukro 1993). Utilities were also free to arrange private trades in allowances. Since 1992, a number of private trades have occurred including several between utilities and smelters. Most analysts, however, consider the level of trading, to date, to be disappointing and lower than originally projected (Torrens and Platt 1994).

The most significant reasons for the lack of SO_2 trading are related to the monopoly characteristics of the coal-fired electric utility industry rather than to the design of the market itself. The electric utility industry is, perhaps, as far removed from the competitive ideal as any industry in the United States. Most utilities hold at least some monopoly power in their output markets and are tightly regulated by state public utility commissions (PUCs) (Coggins and Smith 1993). The market barriers to trading in SO_2 allowances fall into three categories. First, utilities whose rate of return is tightly regulated may have little financial incentive to reduce pollution control costs that are traditionally passed on to consumers. In Pennsylvania, for example, state law requires the profits of allowance trading to be passed on to utility ratepayers which removes any incentive for utilities to play the market at all (Fulton 1992).

Second, PUCs have shown a willingness to overrule the decisions of utilities and reject allowance trades on the basis of regional environmental or economic issues. In New York, for example, the PUC has expressed an unwillingness to approve any trades between New York and Midwestern utilities that could increase SO_2 emissions in the Midwest -- the primary source of acid rain deposition in the Adirondacks. In Florida, PUC commissioners have indicated they will block out-of-state allowance trading all together to prevent any reductions in statewide power generating capacity and the loss of jobs that might occur if utilities chose to purchase cleaner generated electricity from utilities in other states (Fulton 1992).

Finally, Midwestern state legislatures have passed laws intended to protect the regions high-sulfur coal industry by requiring utilities to use the more costly scrubber option instead of switching to low-sulfur western coal. In Ohio, American Electric Power (AEP) estimated the capital costs of installing scrubbers would be $800 million while switching to low sulfur coal from the West would cost only $200 million. Other utilities throughout the region predicted similar savings which led economists to predict that the allowance trading system would encourage most utilities to switch fuel rather than installing more costly scrubbers. Indeed, much of the predicted savings from allowance trading is based on utilities choosing the less costly low-sulfur coal option over scrubbers. Nevertheless, AEP's proposal to switch to low-sulfur coal generated vehement opposition in the state legislature from the Ohio coal industry. Within months the legislature had passed a tax credit for Ohio coal burned in local powerplants, and the state PUC indicated that future rate increases might be jeopardized if AEP did not reconsider the scrubber option. Finally, AEP abandoned the low-sulfur option and asked the state to float $800 million in tax-exempt bonds to finance the scrubber option.

In Illinois the state legislature has taken the more drastic steps to protect the local coal industry. The Illinois legislature recently passed a law requiring the state's two largest utilities, Commonwealth Edison of Chicago and Illinois Power Co. of Decatur, to burn high-sulfur Illinois coal at the state's four largest powerplants. In essence, the state mandated that the utilities install scrubbers at the four powerplants and gave them advance permission to pass the cost likely to exceed $1 billion on to consumers around the state (Fulton 1992). Similar examples of state protectionism are emerging in Indiana, Kentucky, Pennsylvania, and West Virginia.

In some instances, state interference in utility decision-making might be expected to increase trading if trades are perceived to be more economical than the costly scrubber option. However trading has not appeared to increase as a result of state interference. This may be due to the "ratcheting" nature of the program in that allowances are decreased over time. Because all utilities will face increasingly stringent control requirements in the future, any current supply of surplus allowances is likely to evaporate in the future. For this reason, utilities can only consider allowance trading a short-term cost saving option rather than a permanent solution to their pollution reduction requirements. All utilities believe it necessary to move forward with new control technologies (whether low-sulfur coal or scrubbers) over the longer term (NAPA 1994).

These and other deliberate attempts by states to prevent utilities from taking advantage of market-based incentives represent a serious threat to the success of the acid rain allowance trading program. Economists now worry that, if enough states drive up the cost of compliance or interfere with the market, the expected cost savings will disappear (Fulton 1992). If environmental compliance costs are seen as excessive, consumers may be unwilling to finance additional environmental measures in the future. On the other hand, some of the sponsors of the program are less concerned with the lack of trading. They point out that the primary purpose of the acid rain allowance program was breaking the political deadlock between Northeastern and Midwestern states rather than cost savings. During the 1980s, states such as Illinois refused to accept the notion that they should bear the entire cost of installing scrubbers in order to protect their coal mining industries. They argued that Northeastern states, where acid rain is a large political issue, should share the costs of emissions reductions. Today however, faced with mandatory reductions in SO_2 emissions, Midwestern state legislatures have suddenly found the political will to transfer the costs of protectionism to local consumers (Fulton 1992).

4.2.2 Chlorofluorocarbon Production Allowance Trading

A second allowance program to emerge from the 1990 Clean Air Act Amendments was the chlorofluorocarbon production allowance trading program. In 1988 the United States ratified the Montreal Protocol on Substances that Deplete the Ozone Layer. The Montreal Protocol called for a cap on the production of chlorofluorocarbons at 1986 levels, with further reductions in 1993 and 1998. EPA issued initial regulations implementing the Montreal Protocol in 1988. Title VI of the 1990 Clean Air Act Amendments called for additional restrictions on chlorofluorocarbon production (EPA 1992).

In late 1991 EPA issued temporarily a final rule that (1) apportioned baseline chlorofluorocarbon production allowances, (2) provided for gradual reductions in allowances, and (3) permitted the transfer of allowances among firms (56 FR 49548-580). The only limit placed on trading was that during trades, the seller's remaining allowances are reduced by the amount transferred plus one percent of the amount transferred (EPA 1992). The chlorofluorocarbon allowance program is similar to the lead trading program in that both were designed to ease the short-term transition costs of a rigid reduction program.

Chlorofluorocarbon trading was welcomed by industry, and EPA considered it to be a relatively successful example of a trading program. Nevertheless, no detailed estimates of the cost savings produced by chlorofluorocarbon trading are currently available. EPA believed that one reason an incentive-based program was so readily accepted by both industry and the regulatory community was that the chlorofluorocarbon problem was being attacked for the first time. Unlike other areas of pollution control, incentive-based efforts were not undermined by an existing command-and-control regulatory framework (EPA 1992).

4.3 Rate-Based Averaging Programs

A final category of trading programs are those based solely on rate. Emissions averaging to control motor vehicle pollution is, perhaps, the best known example of rate-based trading. Title II of the Clean Air Act called for an emissions standard for nitrogen oxides that represented the maximum degree of reduction available with a goal of attaining a reduction of 75 percent in the "average of actually measured emissions" from heavy duty truck engines (EPA 1992). The emissions standard for particulates was set in a similar fashion. While vehicles and engines had to be certified on an individual engine basis, section 206(g) allowed manufacturers to comply through the payment of a non-conformance penalty sufficient to remove whatever competitive advantage they obtained from making high emitting engines. EPA's implementation of these requirements allowed manufacturers to comply by averaging together the emissions performance of all heavy duty truck engines they produce (EPA 1992). A similar proposal for averaging automobile emissions included in the Bush Administration's 1989 Clean Air Act reauthorization, failed to win Congressional approval.

Emissions averaging is also permitted under EPA's Emissions Trading Policy to meet industry-specific Reasonably Available Control Technology (RACT) standards (EPA 1992). For years EPA has allowed RACT requirements to be met through emission averaging. In 1980 EPA allowed can coating manufacturers to compute daily weighted average volatile organic compound (VOC) emissions in conjunction with a plant-wide emission limitation for satisfying RACT requirements (EPA 1992). This so-called "cross-line" averaging is also to other industrial sectors. However, little data is available on the extent to which "cross-line" occurs or the savings afforded to industry (EPA 1992).

5 CRITERIA NECESSARY FOR THE SUCCESS OF TRADING PROGRAMS

The experiences of existing programs and the theoretical literature on market design provide some general criteria necessary for successful permit trading programs. Success not only depends upon whether a trading program functions well once in place, but also upon whether the problem context allows a market to be developed, approved, and implemented. The following are a series of conditions which analysts have identified as either necessary or helpful for the establishment of a successful trading program.

5.1 Physical Context

For trading programs to be successful, the environmental problem must be physically amenable to a trading approach. In the case of pollution control, the harm must relate to the total mass loading of pollution to the environment and be independent of particular sources. Trading may not be appropriate where concentrations of pollutants in certain areas (hot spots) pose a concern since a reallocation of pollutant sources could exacerbate the problem. In addition, trading may not be appropriate where sensitivity to pollutants varies significantly within a proposed trading zone. In both of these cases, the reallocation of impacts through trading could defeat environmental protection goals.

In some instances, concerns about equity and market viability have taken precedence over concerns about the physical appropriateness of a trading zone. The acid rain program is an excellent example. Evidence suggested that SO_2 emissions from Midwestern utilities are most responsible for acid rain in the Northeast. Nevertheless, the trading program established a national market in allowances with no consideration of the environmental effects of trades between regions. Some analysts argued that SO_2 emissions from utilities in the Southeast (and parts of the Northeast) had little effect on the acid rain problem because prevailing winds carried most emissions out over the Atlantic where deposition is harmless.[3] They were concerned that allowance trading could cause large-scale shifts in emissions from the Southeast and Northeast to the Midwest exacerbating the acid rain in the Northeast (Hausker 1992). However, legislators felt that a national market was necessary to achieve an equitable distribution of control costs across all regions of the country. Legislators also rejected a multiple standards approach based on location (e.g., contribution to acid rain) on equity and competitiveness grounds.

Differences in the type of impact are a second reason the physical context of a problem is not always appropriate to trading. In the case of water pollution, PS and NPSs do not generally discharge the same pollutants limiting the number of problems to which trading could be applied. Water treatment point sources generally discharge bacteria and oxygen-demanding waste while nonpoint sources tend to contribute sedimentation and nutrient loading. Both sources are responsible to different degrees for different types of water quality problems.

Calculation of the net social benefit of the reduction of a given unit of pollutant is dependent on a wide range of factors including watershed dynamics, ambient pollutant levels, and risk assessment techniques. However any attempt to quantify and compare the social costs of different pollutants would be highly suspect. For this reason, all PS/NPS trading programs have dealt with exchanges in the reduction of a single nutrient -- usually phosphorus. Extension of PS/NPS trading programs beyond nutrient control is difficult because many pollutants, such as biochemical oxygen demand (BOD), are nonconservative (degradable). Current regulation of nonconservative pollutants such as BOD requires the staggering of discharges over time and location so that ambient levels of dissolved oxygen do not violate standards. Exchanges of nonconservative pollutants would require a different trading ratio for each pairing of dischargers affecting water quality at a specific location during a specific time period.

[3] Unlike fresh water, sea water has tremendous buffering capacity. Even small amounts of sea water are able to absorb tremendous quantities of acid without measurable increases in pH. For this reason, acid rain is of no concern in marine and estuarine settings.

Finally, the physical characteristics of the problem should be amenable to accurate monitoring. Ease of monitoring was one reason cited by the EPA for the success of the chlorofluorocarbon allowance program as one EPA manager explains:

> I think [incentive-based program approaches] are best designed to fit situations where you are attacking the problems for the first time. I think it's best in a situation where the physical characteristics of the problem allow you to keep track of that which you have permits for readily. The chlorofluorocarbon case was an ideal one because there were not very many manufacturers of chlorofluorocarbons, it's very easy for the government to control the inventory, to know where they came from, how many there were, where the plant was, and so forth (Cook 1988).

At the same time, difficulties in monitoring and defining baseline pollution levels is frequently cited as a significant obstacle to trading in EPA's offset program. Regulators have been reluctant to approve trades where actual baseline emissions information (defined by the historic pollution record of a source) is unavailable. One alternative approach is to use standardized baselines (defined by administrative requirements). However, regulators have been reluctant to use standardized baselines because they could allow firms to create "paper" trades, in which the differences in emissions between those allowed by regulation and those actually emitted by a source, differences which exist only on paper, could be traded against real increases in emissions elsewhere (Cook 1988).

5.2 Market Incentives

For a market to emerge, firms must have an incentive to trade. The principal incentive for trading is a difference, between firms, of the marginal costs of meeting environmental protection goals. If trading is to reduce control costs, there must be potential cost savings in a redistribution of reduction efforts among firms. Furthermore, the difference in marginal costs must be of sufficient magnitude to make trading worthwhile. Hahn and Hester (1989b) found that firms used bubbles only where there was potential for large cost savings (upwards of several million dollars per firm). Bubbles that would provide smaller savings were discouraged by the lengthy application process and the low likelihood of approval.

Lack of incentive may be the primary barrier to trading in the acid rain allowance program. Utilities, which are among the most heavily regulated industries in the United States, have found that most avenues to realize profit from trading are blocked at the state level. In some cases, state legislatures have removed the financial incentive for utilities to trade by requiring that all trading profits be returned to rate-payers. Other states prohibit any trades that could cause a loss of productive capacity within the state effectively banning out-of-state sale of allowances. Finally, many Midwestern states have mandated and subsidized costly and inefficient scrubber technologies to protect local coal industries, rather than allowing utilities to switch to low-sulfur western coal.

Theoretically, a trading system should also encourage firms to develop innovative technologies to exceed environmental standards because the costs of technological development can be recouped through permit sales. In practice, however, it appears that this incentive has had relatively little impact. In the SCAQMD, the lack of innovative technologies is probably due to factors such as uncertainty about market price and demand, as well as regulator's tendency to require implementation of any new technology as a technology based standard (Dwyer 1992).

5.3 Trading Opportunity

The incentive to trade must be accompanied by the opportunity to trade. The availability of excess tradable reductions is one key to the opportunity to trade. Lack of available permits due to hoarding and the failure of firms to exceed minimum standards were cited as frequent constraints on California's offset trading program (Dwyer 1992). Permit availability also depends on the technological ability of firms to reduce emissions to different levels. If there is just one possible control technology, which can reduce emissions only to a required level, then there will likely be no excess emissions reductions available to trade (Teitz 1994). In cases such as the SCAQMD, where environmental standards are ratcheted downwards, firms may face increasingly limited control options and the availability of excess permits is likely to decrease.

In addition to permit availability, there must be a sufficient number of market players and transactions to produce a clear price signal for a competitive market to function. The number of players is often determined by the geographic scope of the market, which in turn should be defined by the geographic area in which reductions can be traded without compromising environmental objectives. Finally, for cost-effective market prices to emerge, no player must be influential enough to exercise monopoly power (Tietenburg 1990). However, non-competitive markets may still provide savings over no markets at all. If trades occur at all under any conditions, then presumably, some cost savings are being realized through trading.

5.4 Transaction Costs

In cases where control costs can be reduced through trading, transaction costs will significantly influence the extent that these potential savings are realized through trading. While transaction costs exist in all markets, their magnitude can vary greatly according to market design. Examples of transaction costs include the costs of finding interested buyers and sellers, the costs of arranging deals, and the costs of regulatory requirements placed on trades. Regulatory costs include requirements -- sometimes mandated by statute -- for firms to conduct studies to quantify reductions or the amount of credits needed to offset certain activities, and the costs of gaining regulatory approval for trades. Dwyer (1993) cited excessive regulatory costs imposed by SCAQMD as one reason for the failure of the offset market in the Los Angeles basin. In contrast, Hahn and Hester (1989a) credited low regulatory and transaction costs as one reason for the success of the lead trading program. In the lead trading program EPA did not insist on pre-approving trades, but simply allowed refineries to report trades to the agency at the end of each quarter.

5.5 Uncertainty and Risk

Uncertainty and risk impose additional constraints to the development of permit markets. Uncertainty about the permanence of emissions credits and their value under new regulatory regimes produced a substantial disincentive to trade in the Los Angeles basin offset market. The fear that emission credits could be withdrawn or reduced at the discretion of regulators is frequently cited as a key reason for the failure of the offset market to develop (Hahn and Hester 1989b). In 1990 SCAQMD confirmed industry's fears of regulatory appropriation by discounting most banked credits by 80 percent (Dwyer 1993). As a rule, analysts suggest that property rights must attach to marketable permits for successful markets to emerge, a move SCAQMD and EPA have been unwilling to make.

Uncertainty about the effectiveness of control mechanisms often leads regulators to set high trading ratios to increase the chance that environmental goals will be met through trading. This has been the case in the Lake Dillon PS/NPS trading program where regulators set a 2:1 trading ratio to reflect difficulties in evaluating the success of NPS reductions. Tradeoffs between point and nonpoint sources involve a great deal of uncertainty. While the reasons for uncertainty are many, Letson (1992b) identifies two that stand out. First, limitations in predicting storm driven NPS loadings create difficulties in selecting trading ratios to appropriately substitute for continuous PS discharges. NPS loadings from storm events vary widely and are difficult to predict from ambient loading levels. Second, inadequate monitoring of both PS and NPS loadings adds fuzziness to the "bubble" by allowing dischargers to pollute without purchasing the right to do so. In the Lake Dillon program, both high trading ratios, and the uncertainties of linking specific NPS management actions with actual reductions, have tended to discourage trading.

5.6 Legal, Institutional and Political Conditions

Finally, legal, institutional and political conditions must be appropriate for a workable permit trading program to be developed, approved and implemented. At a minimum, the relevant statutory authority must explicitly or implicitly approve a market-based approach. In addition, some political constituency must support implementing marketable permits. To date, most trading programs appear to have been initiated by regulators, affected local groups, or Congress, often as a compromise intended to break political deadlock over expensive environmental programs (Teitz 1994). The support of regulatory agencies is especially critical when there is no explicit statutory for trading programs because only regulatory agencies are able to claim that implementing trading programs is within their mandate to exercise discretion (Teitz 1994).

The support of both the regulated industries and public interest or environmental groups is often critical to the success of trading programs. In the two most ambitious programs to date, RECLAIM-and the acid rain program, environmental groups were instrumental during the program design stage and lobbied for program approval (Dwyer 1993). If industry and environmental groups are to form active constituencies, both must view marketable permit programs as advancing their respective agendas. Both groups are most likely to advocate trading when they believe it is the best outcome they are likely to get (Hahn 1989a). Unfortunately this may become apparent only after advocacy groups have spent years battling each other to a standstill as happened with acid rain.

6 CONCLUSIONS

A wide range of marketable permit programs are currently active in the United States. Many levels of government have instituted incentive-based programs from individual towns to the Federal Government. Although it would be desirable to be able to summarize the cost savings from their use, the financial consequences to individual economic sectors, and the environmental effects of each of these programs, the available evidence provides significant information only on the cost savings. To date, over 20 quantitative comparative studies have been done, all of which indicate that marketable permits should be much more economically efficient than command-and-control approaches for controlling environmental pollution (EPA 1992). The differences in economic efficiency are potentially quite large. However, due principally to constraints placed on trading, many studies also conclude that the actual cost savings realized by current programs fall well short of the potential indicated by these comparisons.

Although incentive-based programs are being used increasingly, they are not always implemented with the sole objective of decreasing costs. Consequently, the cost savings have often fallen short of what would have been possible. Among the market-based trading systems with which there is experience, the lead trading program came closest to achieving the projected cost savings. Most other emission and effluent trading systems have been subject to severe regulatory constraints that have raised barriers to trading. As policy-makers begin to examine the use of marketable permits as a solution to other environmental management problems such as fisheries bycatch regulation, these results underscore the importance of assuring that unnecessary constraints are not imposed in future trading applications.

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