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FIXED COSTS AND JOINT COST ALLOCATION IN THE MANAGEMENT OF PACIFIC WHITING - A WORKSHOP REPORT -

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U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

NOAA Technical Memorandum NMFS

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and Peyton Young for suggestions when gathering
the cost allocation literature.

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U.S. DEPARTMENT OF COMMERCE
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1. Introduction

This report gives background information and summarizes conclusions from a workshop held at the Southwest Fisheries Science Center, in La Jolla, CA during November 15-16, 1995. The report also reflects subsequent discussion of these issues.

The workshop's purpose was to decide how to treat fixed costs and how to allocate fixed and variable costs in benefit-cost analyses of options for allocating the harvest of Pacific whiting (*Merluccius productus*) in the Pacific coast groundfish fishery. The Southwest Fisheries Science Center and Northwest Region of the National Marine Fisheries Service (NMFS) and Pacific Fishery Management Council (Council) sponsored the workshop. Participants included economists and fishery biologists from four universities, the Council, NMFS and the fishing industry (Appendix A). Background materials (Appendix B) were distributed in advance of the workshop. Appendix C provides a game-theoretic discussion of joint and common cost allocation.

1.1. Background

With a US catch during 1994 of about 233,000 metric tons (mt) and an ex-vessel value of $16 million, the Pacific whiting fishery is the largest and highest value groundfish fishery managed by the Council.[3] The whiting fishery is the most recent groundfish fishery to be fully utilized by domestic interests and is the Council's only fishery for which there has been intense competition between on-shore and at-sea processors. The on-shore component of the whiting fishery includes onshore processors and catcher boats that deliver to them. The at-sea component includes factory trawlers, factory vessels and catcher boats. Catcher boats may participate in both the on-shore and at-sea components of the fishery.

In response to competition for whiting, the Secretary of Commerce, in consultation with the Council, limits the amount of the Pacific whiting harvest guideline (HG) that is available to at-sea processors. The current allocation regulations expire at the end of 1996. The Council and NMFS will therefore revisit the allocation of Pacific whiting between on-shore and at-sea processors during 1996.

Previous economic analyses of whiting allocation options did not include the cost of physical capital (i.e., fishing vessels, processing plants, and other equipment). In addition, other costs assumed to be fixed in the short run were also excluded. An important question addressed at the workshop was whether a more inclusive treatment of costs was feasible in the economic

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[3] Pacific Fishery Management Council. 1995. Status of the Pacific coast groundfish fishery through 1995 and recommended acceptable biological catches for 1996 (with appendices). Pacific Fishery Management Council, Portland, OR.

analysis of new options for allocating whiting in the fishery.

Allocation decisions and analyses are conducted in a highly charged political atmosphere. Contention about whiting allocation in 1996 will likely be exacerbated by a treaty right claim that would grant a portion of the whiting HG to the Makah Indian tribe. In addition, factory trawler owners spent approximately $15 million since the last whiting allocation decision to purchase groundfish limited entry permits so that they could participate in the whiting fishery.

2. Organization of the Workshop

The focus of the workshop was the treatment of harvesting and processing costs (especially fixed, joint, and common costs) in the economic analysis of the Pacific whiting allocation. These issues were addressed by discussion of a list of questions (see below). Where possible, consensus recommendations on technical points were developed and analysts were provided with guidance about how the economic analysis should be conducted. The following questions were considered:

1. What types of economic analyses should be conducted?

2. What are the relevant costs? In particular, should the cost of physical capital, and other costs fixed in the short run, be included in analyses of whiting allocation options?

3. How should costs be measured and forecasted?

4. What is the opportunity cost of capital?

5. When and how should joint costs be allocated between the whiting fishery and other uses of the relevant inputs?

6. What are the relevant external costs and how should they be estimated?

Although the focus of the workshop was the whiting allocation, a broader discussion of cost issues was encouraged. This was done to increase the contribution of the workshop to work in other fisheries.

2.1. Constraints

A number of constraints were important in focussing the discussion of cost issues. These included: 1) the nature of alternatives to be considered by Council (e.g. the magnitude of the change in the allocation regulations and the duration of the new regulations; 2) expected changes in the whiting Harvest

Guideline while proposed allocation options would be in force; 3) likely allocation to Makah Indians; 4) the necessity for fair, unbiased, and theoretically defensible analysis; 5) tradeoffs between simplicity and complexity in the analysis; 6) availability and quality of data; and 7) time and resources available.

3. Definition of Terms

Several terms were defined during the workshop to facilitate discussions and analyses. The terms and the agreed definitions are given below.

Fixed costs are those costs which are invariant with respect to output in the short run and are independent of the scale of production.[4] Fixed costs include any set-up costs. Fixed costs also include costs that are shared among different outputs and costs that are product-specific. Over the long run, costs which are deemed to be fixed in the short run are variable, except in the extreme case in which the rate of depreciation with respect to a piece of capital is zero.

Examples of fixed costs are the costs of having a fishing vessel and processing plant ready to operate. The time horizon is critical in determining whether a cost is a fixed cost. As the time horizon lengthens, fewer costs are fixed costs. For example, given enough time, a fishing vessel or processing plant could be sold, in which case the costs of having a vessel or plant ready to operate are not fixed costs to the fish harvesting or processing firm. Even if the vessel or plant could not be sold, each would eventually depreciate to zero over the long run.

Sunk costs are closely related to fixed costs. The essential characteristic of a sunk cost is that some productive activities are not easily converted into other productive uses.[5] Sunk costs

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[4] J. Tirole, The Theory of Industrial Organization. Cambridge, Mass: MIT Press, 1989, p. 307.

[5] W. Sharkey, The Theory of Natural Monopoly. Cambridge: Cambridge University Press, 1982, p. 37 states that a sunk cost is the difference between the *ex ante* opportunity cost and the value that could be recovered *ex post* after a commitment to a given project has been made. See also Tirole, pp. 307-308 and K. Kohli, Economic Analysis of Investment Projects: A Practical Approach. Oxford University Press, 1993, p. 43.

Baumol, Panzar, and Willig. 1982. Contestable Markets and The Theory of Industry Structure. New York: Harcourt, Brace, Jovanovich, Inc. (pp. 280-281) state that sunk costs are costs (in some short or intermediate run) that cannot be eliminated by

are not recoverable, nor salvageable, and hence have zero opportunity cost.

Joint costs are production costs incurred by the firm when two or more outputs are jointly produced. Joint costs and joint production can arise from either an interdependent production process or the presence of allocatable fixed factors.[6] Jointness occurs because a firm finds it less costly to incur costs relating to two or more cost objects than to incur costs individually for each.

For example, the annual cost of having a vessel or plant ready to participate in the whiting fishery and other fisheries is a joint cost. Joint costs can occur when the cost of an input is a fixed cost and when that input is used to produce multiple outputs either concurrently or consecutively. In the case of concurrent outputs, a variable cost can be a joint cost.

Common costs result when multiple products are produced together although they could be produced separately.[7] Common costs occur if the costs for two (or more) outputs contain a fixed element common to both. Common costs apply to a setting in which production costs are defined on a single intermediate product or service which is used by two or more users. Common production is undertaken due to cost savings related to economies of scale. Joint and common costs are often used interchangeably, but joint products and costs may be distinguished on technological grounds and common costs may be distinguished on organizational and institutional grounds. Common costs in the whiting and pollock

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total cessation of production. As such, once committed, sunk costs are no longer a portion of the opportunity cost of production.

For the authoritative discussion of irreversible investment and sunk costs in the optimal exploitation of renewable resource stocks, see C. Clark, F. Clarke, and G. Munro, "The Optimal Exploitation of Renewable Resource Stocks: Problems of Irreversible Investment," Econometrica, Vol. 47, No. 1, January, 1979, pp. 25-47.

[6] For further discussion, see Baumol, Panzar, and Willig op cit.; Sharkey op cit., page 38; G. Biddle and R. Steinberg, "Allocations of Joint and Common Costs," Journal of Accounting Research, Vol. 3, 1984, pp. 1-45; J.C. Loughlin, "The Efficiency and Equity of Cost Allocation Methods for Multipurpose Water Projects," Water Resources Research, Vol. 13, No. 1, 1977, pp. 99-105; H.P. Young, ed., "Cost Allocation," Chapter 34 in R.J. Aumann and S. Hart, Handbook of Game Theory, Vol. II, Amsterdam: Elsevier, 1994.

[7] See Biddle and Steinber op cit., pp. 4-5.

fisheries could refer to marketing or other home office services shared by both fisheries. These costs are common to both fisheries but are not technologically part of the harvest process.

Opportunity cost is defined as the foregone value of resources used in their best alternative use; a currently available alternative that is sacrificed.[8] For example, if the most a fisher could earn from another endeavor is $20 per hour, the opportunity cost of his or her labor services as a fisher is $20 per hour.

Externalities occur when the actions of one person or firm directly affect the welfare of another person or firm.[9] An external cost occurs when the action diminishes the welfare of the affected person or firm and an external benefit occurs when the action enhances the welfare of the affected person or firm. In both cases, there is no compensation. The externality drives a wedge between private and social costs or benefits.

Physical capital is the plant and equipment that are used to produce goods and services. In a commercial fishery, they include vessels, plants, and the equipment of both. The services of physical capital, which are provided over time, are important inputs in harvesting and processing fish. In this report, capital refers to physical capital.

Malleable capital is that capital for which there is an opportunity to sell or use for another purpose the capital over the time period of consideration. Non-malleable capital refers to the existence of constraints upon the disinvestment of capital assets utilized in production or exploiting a natural resource stock. Perfectly non-malleable capital has no alternative uses (the resale price is zero) and a depreciation rate identically equal to zero. Quasi-malleable capital also has no alternative uses (and a resale price of zero) but a positive depreciation rate.[10] In sum, the opportunity cost of perfectly non-malleable or quasi-malleable capital is zero and hence it is a sunk cost.

Stand-alone cost is the cost of producing a particular good or set of goods and services with production of the other goods and

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[8] R.L. Miller, Intermediate Micro-Economics: Theory, Issues, and Applications. New York: McGraw-Hill, 1978, p. 216.

[9] A. Mas-Colell, M.S. Whinston, and J.R. Green, Microeconomic Theory. New York: Oxford University Press, 1995, p. 350.

[10] See Clark, Clarke, and Munro op cit., p. 25. These authors use the concept of quasi-malleable capital.

services at a zero level.[11]

4. Summary of Discussion and Decisions

This section is organized in the same order as the questions addressed at the meeting (see above).

4.1. Types of analyses

Four types of economic analyses were discussed: (1) cost-benefit analysis; (2) financial analysis; (3) regional economic impact analysis; and (4) the economic components of a social impact analysis. Cost-benefit analysis attempts to identify the differences among alternatives in terms of net benefits to the nation. In doing so it may also identify, but not necessarily quantify, differences in the distribution of net benefits. Managers consider both the magnitude and distribution of net benefits in choosing preferred alternatives. Cost-benefit and financial analyses differ principally in terms of the accounting stance taken. Costs and benefits to the nation as a whole are used for cost-benefit analysis, whereas the costs and benefits of individual firms are used in financial analysis. Regional economic impact analysis attempts to identify the levels of economic activity by region associated with each alternative. The levels of economic activity are measured in terms of income, expenditures, and employment; therefore, they are not measures of the net benefit of an alternative to either a region or the nation. The economic component of a social impact analysis could include information from the other three types of economic analyses.

There was general agreement that, although the cost-benefit analysis was of principal importance, a financial analysis would provide information that would be useful in determining the preferred alternative and should be provided. It was agreed that regional impact and social impact analyses were outside the scope of the workshop.

4.2. What Are the Relevant Costs?

Identification of the relevant costs is an important component of either cost-benefit or financial analysis. As described above, the previous whiting allocation analyses excluded fixed costs, including the cost of capital.

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[11] Formally, $C(S,0)$ and $C(0,S')$ are stand-alone costs for outputs S and S' in the cost function $C(S,S')$, where S and S' represent two distinct sets of outputs and $C(\cdot)$ denotes the cost of producing the collection of goods. Tirole op cit., p. 20. See also Sharkey op cit., p. 41 and Baumol, Panzar, and Willig op cit., p. 71.

The time horizon for allocation options being considered is important because, as noted above, the number of inputs that are fixed, and therefore result in fixed costs, decreases as the time horizon is extended. Hence, if the new allocation was to be of limited duration, such as only one or two years, the cost of the existing capital might be a fixed cost, with perhaps a low opportunity cost or even treated as a sunk cost. Over a longer period, however, through either depreciation or an increased opportunity to transfer the existing capital to other uses, the cost of the existing capital is not fixed. In addition, over time the opportunity cost of either replacement or additional capital is its acquisition price. Thus, the cost of capital is a relevant cost if the time horizon for whiting allocation options is sufficiently long that capital is not a fixed input.

When there is a reasonable likelihood that a short-term policy may be continued over the long term, including results based on analysis of the policy over the long term can provide useful additional information. This will help avoid consideration of long-run policy effects that might follow from a series of short-term incremental decisions.[12]

The relevant costs may change if the emphasis is upon rankings or incremental differences of net benefits among policy alternatives without consideration of total net benefit values. In this case, if some costs do not vary among the alternatives and over the time period of consideration these costs are truly constant, then these costs do not affect the differences in net benefits among the alternatives, and their exclusion would then not impact rankings or incremental differences of net benefits.[13] The same conclusion holds if the comparison is in terms of net benefits per metric ton of whiting catch (average net benefits)

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[12] Subsequent to the workshop, one view was expressed that cost-benefit analyses should be "long-run". The time paths of aggregate costs and revenues for the affected firms should be estimated far enough into the future so that discounted differences in the future between alternatives become insignificant, even with the most extreme set of assumptions used in any sensitivity analysis. An allocation rule with a short-term duration should not be treated with a short-run analysis. All effects are relevant, regardless of whether the allocation period has elapsed. If this approach is used, the analysis can proceed without ever using or having to explain the concepts of "time horizon", "fixed costs," or "cost allocation."

[13] This approach is essentially a version of incremental net benefit analysis for mutually exclusive alternatives. Rather than comparing NPV for two mutually exclusive alternatives, the difference between the alternatives can calculated and NPV calculated for this difference.—For further discussion, see S. Curry and J. Weiss, Project Analysis in Developing Countries, New Work: St. Martin's Press, 1993, pp. 61-67.

between the two competing user groups (i.e. on-shore and at-sea processors), as was done in the previous analysis.

Policy makers and industry cannot evaluate the policy alternatives in terms of the total net benefit values, inclusive of all costs and benefits, without including total fixed costs or other costs that might not vary among alternatives. For example, while a policy may be the highest ranked among the alternatives, a negative or even positive but low net benefit value could suggest rethinking current policy and finding new policy alternatives with positive or higher net benefits.

An error can be introduced into measures of net benefits for the whiting fishery if the analysis ignores the spillover effects upon benefits and costs of other fisheries that are linked to the whiting fishery.[14] One type of spillover effect is the impact on markets of other inputs or outputs. These are called general equilibrium effects and would be analyzed by a general equilibrium model.[15]

A second type of spillover effect that can arise is due to a change in the allocation of joint and common costs between fisheries, and could be considered an accounting change as long as the overall capital stock and its costs devoted to the fisheries remains constant. For example, if the capital costs for onshore processing for whiting and the other species the whiting processors process is $1 million per year for each of the allocation alternatives considered and if the capital cost is allocated between the whiting fishery and other fisheries based on the proportion of time, product, or product value associated with whiting, the apportionment of that $1 million capital cost between the whiting fishery and other fisheries will vary by alternative even though the total capital cost remains the same. If with one whiting allocation alternative 70% of the capital

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[14] The workshop did not consider this or the spillover effect immediately following. These two spillover effects were added subsequently.

[15] In most instances, research has found negligible effects on decisions when general equilibrium analyses are not used. For further discussion, see Dreze, J. and N. Stern. 1987. "The Theory of Cost-Benefit Analysis." Chapter 14 in A.J. Auerbach and M. Feldstein (eds.), Handbook of Public Economics, Vol. II. Amsterdam: Elsevier Science Pub.; Dreze, J. and N. Stern. 1990. "Policy Reform, Shadow Prices, and Market Prices." Journal of Public Economics, Vol. 42, pp. 1-45; Squire, L. 1989. "Project Evaluation in Theory and Practice." Chapter 21 in H. Chenery and T.N. Srinivasan (eds.), Handbook of Development Economics, Vol. II. Amsterdam: Elsevier Science Pubs; Just, Hueth, and Schmitz op cit.; Chapter 21 in R. Zerbe, Jr. and D. Dively, Benefit-Cost Analysis: In Theory and Practice. Harper Colins, 1994; and Chapter 5 in P. Johansson, Cost-Benefit Analysis of Environmental Change. Cambridge, U.K.: Cambridge University Press, 1993.

cost is apportioned to the whiting fishery and if 80% of the capital cost is apportioned to the whiting fishery for an alternative that allocates more whiting to on-shore processors, the capital cost apportioned to the whiting fishery would increase from $700,000 to $800,000 (i.e., by $100,000) and the capital cost apportioned to the other fisheries would decrease from $300,000 to $200,000 (i.e., by $100,000). Therefore, if just the whiting fishery is considered and the capital cost is apportioned to the whiting fishery, and if the capital stock and its costs remain constant in both fisheries, then there is an apparent increase in capital cost for the on-shore sector of the whiting fishery of $100,000 when in fact, the capital cost for the on-shore processors that participate in the whiting fishery did not change at all because there was an exactly offsetting spillover effect for the other fisheries in which these processors participate. If the capital costs and their apportionments are constant among alternatives, the second type of spillover cost does not occur, and, therefore, is not a source of error.

Over the long run, all capital is malleable, except in the most extreme cases. The above accounting issue assumes that the aforementioned sum of capital costs is fixed over the long run and across policy alternatives, whereas capital can flow out of, as well as into, both fisheries combined. Costs of investment, reinvestment, or disinvestment might vary by policy alternative, so that reinvestment costs might be higher under open access and lower under some form of limited access. If, in the above example and over the long run, less capital is devoted to the offshore whiting fishery while more is devoted to the offshore pollock fishery, fewer resources are then devoted to offshore whiting fishery, and the costs attributable to this sector should reflect this fact. This allocation or re-allocation of capital and its costs can prove to be contrary to society's long-run interests if fishing firms are irrational and/or the management of the pollock fishery is flawed in that it encourages capitalization.

To estimate the total net benefit of any policy alternative, as opposed to the incremental difference in net benefits, all costs and benefits need to be considered. Therefore, joint and common costs would have to be apportioned among the whiting fishery and other fisheries in which the processors or harvesters are involved. However, when this is done, and when the capital stock is truly fixed (perfectly non-malleable) over the long run, the problem of counting the reapportionment of a cost as an increase or decrease in cost, as described above, occurs. If the information were available to estimate the total benefits and costs of all activities of the processors and vessels that participate in the whiting fishery, the problems associated with apportioning joint and common costs would be eliminated (since cost allocation is not required).

In summary, there are several alternative ways to specify relevant costs, depending upon the conditions at hand:

(1) In an ideal analysis, when costs vary in the long run and over different policy alternatives, all costs and benefits accounting for all spillover effects onto linked markets and all adjustments in related or linked fisheries would be accounted for, although this task may be prohibitively time consuming and expensive;

(2) When costs vary in the long run and over different policy alternatives, all costs and benefits in the whiting fishery can be included to evaluate total net benefits in only the whiting fishery but at the expense of neglecting changes in net benefits in other, related or linked fisheries and markets;[16]

(3) If joint, common, or other fixed costs do not vary among policy alternatives and over the length of the time period under consideration, then rankings or incremental differences in net benefits can be estimated without including those costs although the total net benefit of each alternative cannot be determined. One possibility in this case is to analyze the policy alternatives for incremental differences in net benefits to provide a choice among these alternatives, and then to also estimate the total net benefits of each alternative to determine if additional alternatives should be considered;

(4) If some joint and common costs remain fixed over the long run and do not also vary among the policy alternatives, if the allocation of these costs differs among policy alternatives, and if only the whiting fishery is analyzed in the cost-benefit analysis, then there can be an apparent change in these fixed costs and hence net benefits, when in fact no change has occurred;

(5) Most importantly, over the long run, fixed costs are expected malleable except in rather extreme cases, and any analysis, whether of total net benefits or incremental differences among policy alternatives, should reflect this and different rates of investment, reinvestment, disinvestment, and perhaps depreciation that may occur over the long run for different sectors and policy alternatives.

4.3. How Should Costs Be Measured and Forecasted?

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[16] Some spillover effects may be relatively small. If there is "minimal" change in allocated joint costs, and no change in output of pollock or other output of related fisheries, then there is minimal linkage, and the bias introduced by a single sector analysis would be minimal. However, "minimal" must be interpreted with respect to the other changes being considered. A small percentage change in the pollock fishery may be large compared to anything in the whiting fishery.

It is difficult to compare harvesting and processing costs for on-shore and at-sea fishery segments because data are scarce. It is even more difficult to estimate what these costs would be in the future, particularly if the allocation is changed.

There was general agreement concerning the following statements:

1) the industry is the principal source of cost information;

2) some cost information is available from other sources such as equipment suppliers and tax assessors;

3) the processor cost data used for the previous analysis is of limited use now due to the substantial learning that has occurred in the relatively young domestic whiting fishery;

4) the benefits of using a bioeconomic model to estimate biological costs can be limited by the lack of transparency of such models, the difficulty in correctly specifying such models, and the likelihood that the allocation alternatives to be considered will not result in substantial changes in the temporal or spatial distribution of the catch of whiting;

5) a straight-line depreciation schedule based on the expected useful life of capital should be used because it is more straightforward than other methods;[17]

6) market prices for inputs and outputs should be used when available;

7) the payment to labor can be used as a proxy for the opportunity cost of labor unless there is expected to be long-term excess supply of labor[18];

8) the relative importance of the export market, particularly for whiting surimi, the expectation that whiting product supply would not differ much among the

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[17] Subsequent to the workshop, one view was expressed that it is not necessary to estimate depreciation if there is a market price for existing capital (e.g., used vessels), or if there is a way of estimating its annual future value of production and expected life. If there is only replacement cost, age, and expected life, then it is necessary to depreciate the replacement cost. The discussion of footnote 22 provides further details.

[18] One view expressed subsequent to the workshop was that payments to labor may not be "arms length" transactions, especially on catcher vessels, where the skipper is often the owner, and other crew members may be family.

alternatives, and considerable substitution possibilities among fish types for surimi production probably are sufficient justifications for ignoring consumer surplus;[19]
9) a common understanding of what is to be included in each cost category is critical in collecting meaningful cost data;

10) the use of terms and classifications used by the industry, the use of more detailed questions (e.g., ask for variable cost information by category instead of aggregate variable cost), and pretesting of the data collection methods can help avoid problems with survey instruments;

11) double counting can occur when the value of the vessel and its equipment are estimated separately;

12) for additional or replacement capital, the purchase price is its cost, whereas adding the annual opportunity cost of capital services would result in double counting;

13) if existing capital is malleable, the capital services price, or rental value of capital, should be used as the cost of existing capital;

14) if existing capital is non-malleable (there is no opportunity to sell the capital and it is sunk), then the opportunity cost is zero;

15) due to the uncertainty concerning measuring and projecting costs, sensitivity analysis should be used to determine how robust the comparisons among alternatives are;

16) if the differences in costs among alternatives are a function of the other management measures that will be in place, assumptions will have to be made concerning the other management measures;

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[19] One view expressed subsequent to the workshop was that very small changes in the price of surimi, when multiplied across the entire market, may be a substantial change in consumer surplus when compared to other changes entering the cost-benefit comparison. If the change in total production of surimi from whiting is substantial relative to whiting, then the net change in consumer surplus from surimi and other whiting products may well be significant.

It was also subsequently noted that consumer surplus realized by trading partners does not directly benefit U.S. citizens, but that it is related to the U.S. trading position vis-a-vis those partners. If it can be estimated, perhaps it should be reported as a qualification of the net benefits of any alternative.

17) both the costs and benefits of whiting for on-shore or at-sea processors can be dependent on the length of the whiting fishery for that sector, and its length will depend on both the HG and its allocation;

18) when a theoretically sound approach has the appearance of introducing a bias, the use of that approach can undermine the credibility of the analysis unless the appearance problem can be eliminated;

19) given the limited resources that are available to conduct the analysis, it is necessary to identify information priorities and to be pragmatic;

20) insurance costs that depend on the number of operating days or crew size are not fixed costs;

21) projected, rather than historical, values should be used to estimate costs;

22) differences in which variable costs are paid by the crew can bias the comparisons;

23) sample size and response rates affect the confidence we have with data collected from the industry;

24) when the purpose of the cost collection exercise is clear, strategic decisions concerning which questions to answer and how to answer them are more likely to occur;

25) some secondary data are available to test for such a bias;

26) cost-benefit analyses using a standard accounting format of adding benefits and subtracting costs are linear models, and the accuracy of linear models generally declines the larger the change analyzed, but this potential bias is reduced to the extent that the cost-benefit analysis is only one of several factors (e.g. distribution effects) in the decision-making process;

27) vertical integration beyond primary processing can complicate cost comparisons; and

28) there are advantages in using data for individual firms as opposed to one stylized firm per sector but it would require more resources to do so.

4.4. What Is the Opportunity Cost of Capital?

The previous section included recommendations that: (1) the opportunity cost of capital be used as the cost for existing,

malleable capital in the whiting fishery; (2) a zero opportunity cost be used if existing capital is non-malleable (there is no opportunity to sell the capital and therefore it is sunk over the time period of consideration); and (3), the acquisition cost should be used for replacement and additional capital (new investment).

The most important issue for existing capital is the existence and value of alternative uses, i.e. its opportunity cost. There can be a once and for all transfer to another use or there can be temporary transfers to other uses. The sale value of the capital for a use other than in the whiting fishery provides a measure of the opportunity cost in terms of a permanent transfer. The foregone net earnings from an alternative use provides a measure of the private cost of the temporary or seasonal use of that capital in the whiting fishery.

For cost-benefit analysis, the net social benefits to the nation and not just those private benefits to the owners of the capital are of interest. Thus any costs external to the private firm, such as stock, congestion, or effluent, should be considered. The social opportunity cost of capital is the value of the net social benefit obtained by transferring the capital to its alternative use, where this net social benefit includes any external social cost. This means for example, that if the alternative use is in another overcapitalized fishery, the net earnings to the owner of the capital will exceed that of society and that the net earnings to society could be equal or less than zero. In that case, the social opportunity cost would be zero or negative. Therefore, if the alternative to participating in the whiting fishery on a seasonal basis is either seasonal participation in another overcapitalized domestic fishery or idleness, the opportunity cost of the temporary use of capital is not positive and could be assumed to equal zero.

If alternative seasonal uses are available, the social opportunity cost of capital in the whiting fishery varies according to these seasonal alternatives. Utilization data for the capital used in the whiting fishery can be used to determine if there are viable alternative uses. For example, if the factory trawlers that are used in the whiting fishery participate in the Alaska pollock fishery and are then idle during most of the rest of the year and if the pollock and whiting seasons do not coincide, the seasonal opportunity cost of participating in the whiting fishery is zero.

When used capital is acquired, particularly if for example one group of processors buys it from the other group (and not from outside of the nation), there is a transfer rather than the use of new resources to provide that capital. Although it may be correct theoretically to distinguish between the acquisition of

new and used equipment, doing so may be problematic.[20]

4.4.1. Capital Services Prices[21]

An existing durable input, such as vessel, plant, or equipment, has a positive social opportunity cost if the input is deemed malleable for the period of analysis and the alternative use of this input generates a positive net social benefit. The task then turns to pricing its flow of services.[22] The durable input is a stock which yields a flow of productive services in one or more subsequent periods. The question is: what fraction of the social opportunity cost should be charged to the current period and what fraction should be charged to future periods?

The related problem of interest payments should also be considered. Hence another question arises: how should interest payments be charged to the various capital inputs that the firm utilizes during the accounting period?

Capital services prices (P_K) for plant and equipment are

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[20] Along similar lines, one view was expressed subsequent to the workshop that if the alternative fishery is within the scope of the analysis, as it would be if the alternatives were, for example, Pacific whiting or Alaskan pollock for the catcher/processors, then it is not necessary to identify an opportunity cost for capital. If the catcher/processor allocation of whiting were increased, causing more participation in whiting by existing vessels, then an analysis which determined the change in output across both fisheries, and the change in inputs other than the preexisting vessels, would be complete without any estimate of the cost of the vessels, since that would be captured in the change in output of the alternative fishery.

[21] See pp. 191-195 of W.E. Diewert, "The Measurement of Productivity," Bulletin of Economic Research, Vol. 44, No. 3, July, 1992, pp. 163-198. See also Gittinger op cit., p. 257 when entering the rental value of land as a cost on a year-by-year basis. Gittinger also states that the annual rental value may be capitalized by dividing the rental value by an appropriate rate of interest stated in decimal terms and then entering this capitalized value in the first year of the project's cash flow.

[22] Subsequent to the meeting, one view was expressed that the point of calculating the year-by-year cost is to enter it into a discounted sum for the purpose of producing a single net present value for the alternative. If the type of data available for this purpose is the age of the capital equipment and its replacement value, then the use of a capital services price is the correct approach. However, if a market for the used capital items exists (e.g., a used vessel market), then the market price already represents an approximation of the private net present value, which may be inserted in the first period.

calculated:

$$P_K = P_B[i + \delta],$$

where P_B is the social opportunity cost value of the stock of plant and equipment (frequently the current market value, and not the historical or book value), i is an interest rate (e.g. Moody's long-term interest rate for bonds rated Baa is one candidate that incorporates some of the economic risk inherent in fishing), and δ is a depreciation rate (depreciation calculated from the straight-line method represents a viable approach).

When the property insurance premium rate (if the relevant capital stock component is insured) and combined and valorem property tax rate are considered, the capital services price may be calculated:

$$P_K = P_B[i + \delta + \tau],$$

where τ represents the property insurance premium rate and combined and valorem property tax rate that may be applicable.

When the inflation rate is not assumed zero, the interest rate i is then a nominal interest rate for the period and inflation must be explicitly considered. Let σ represent an *ex post* inflation rate for the asset over the period, so that $i - \sigma$ may be interpreted as a real interest rate. Then the capital services price may be calculated:

$$P_K = P_B[i - \sigma + \tau] + \delta P_B[1 + \sigma],$$

where the 'physical' depreciation rate δ is multiplied by $1 + \sigma$ to obtain the overall 'finanical'depreciation rate $\delta[1 + \sigma]$.

Conventional practice in fisheries economics has been to estimate the capital services price $P_K = P_B[i + \delta]$, where i represents a nominal interest rate and all values are adjusted for inflation to some base year.

The services prices (P_K) for land are calculated:

$$P_K = P_L[i],$$

where P_L is the current market value of the land upon which the plant and equipment are sited, i is an interest rate, and the depreciation rate δ is zero (since land is not depreciated). As with the capital services price, modifications could be made to this basic formula to account for inflation, taxes, and property insurance.

4.5. Cost Allocation

When and How Should Joint and Common Costs Be Allocated Between the Whiting Fishery and Other Uses of the Relevant Inputs?

Joint and common cost allocation is concerned with the distribution of these costs among the various purposes of a firm, policy, or project. These costs can be allocated among firms' divisions, products, and accounting periods. In a cost benefit analysis, joint and common costs should be allocated among the different benefits or outputs in some instances. The allocation problem can be acute for multipurpose projects or policies, or when multiproduct firms are involved and some of those outputs are subject to the policy (or regulation) and other outputs are not. There is no allocation problem when: (1) joint and common costs do not vary among policy alternatives over the long run, total net benefits are not desired, and only incremental differences are evaluated; (2) when the analyses are for all activities of all the fishing and processing firms involved in the whiting fishery without consideration of net benefits by joint product.[23]

In the context of the whiting allocation, examples of joint costs, requiring allocation among whiting and other outputs when fixed costs are considered, include the following: 1) the fixed cost of a factory trawler that is used in the whiting fishery and in the Alaska pollock fishery, 2) the fixed cost of an on-shore processing plant that is used to process fish both from the whiting fishery and from other fisheries, and 3) the fixed cost of a trawler that is used in the whiting fishery and in other fisheries. If the costs of operating in the whiting fishery and the other fisheries were "nonjoint", i.e. not from an interdependent production process or an allocatable fixed factor, they could be directly allocated. For example, the variable cost of fuel used during trawling is not a joint cost because the fuel used trawling for whiting is independent of the fuel used trawling for some other species. However, the cost of fuel used in testing fishing gear and electronics that will be used in both fisheries is a joint cost.

Variable costs are joint costs when multiple products are produced from an interdependent production process. For example, in a multispecies fishery, several species are caught in the same tow and the cost of the fuel used to make the tow is a joint cost

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[23] Another exception occurs when deciding whether to include a function in a project or policy in which an incremental analysis is employed. J. Loughlin, "The Efficiency and Equity of Cost Allocation Methods for Multipurpose Water Projects," Water Resources Research Vol. 13, No. 1, p. 99 states, "As long as the additional benefits from including the function are equal to or greater than the additional or separable costs of including the function, inclusion of the purpose is justified. The benefits of each purpose need only cover separable costs, since joint costs are sunk and need not be recouped. This eliminates the necessity for purpose benefits to cover a part of joint costs and therefore the need to allocate joint costs among functions in deciding purpose justification."

of catching all the species that are caught.

The problem is that a joint cost cannot be attributed to a single activity or product. This presents a problem for cost-benefit or financial analysis of the whiting allocation alternatives if it is necessary to apportion a joint cost between the whiting fishery and other activities. It is necessary to apportion a joint cost if the following two conditions are met: (1) it is a relevant cost for the whiting alternatives being considered and (2), the analyses are being done for the whiting fishery alone instead of for all the activities of all the fishing and processing firms involved in the whiting fishery.

The range of the alternatives to be considered and the ability of the analyst to estimate cost differentials by alternative will determine whether the first condition is met. The breadth of the analysis dictated by the problem in hand and selected by the analyst will determine whether the second condition is met.

When it is necessary to apportion joint costs, there are a variety of methods that can be used. Each paper cited in Appendix B evaluates cost allocation alternatives in the context of answering one of two questions. First, what is an equitable allocation of joint costs among groups of individuals that use the different joint products of an input or group of inputs? For example, the joint products of a dam include flood control, irrigation, and recreational opportunities. If those who benefit from these products of the dam are expected to pay for the dam on the basis of the cost of providing the services of the dam they use, the joint costs need to be apportioned among these services. In the case of whiting, a joint cost allocation for one sector of the whiting fishery that is perceived as "inequitable" to the other sectors will be perceived as a biased analysis in favor of that first sector. Second, with decentralized decision making in a firm, how should joint costs be allocated to individual decision making units to assure the efficient use of the services provided jointly?

Acceptable cost allocations must satisfy two eminently reasonable criteria, which can be termed: (1) the breakeven requirement and (2) the stand-alone cost test.[24,25] For sake of

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[24] Appendix C provides a theoretical basis, through a game-theoretic exposition, for the basis for joint and common cost allocation.

[25] Let $c(S)$ represent the joint cost function, S represent a subset of projects (products, services), and $x(S)$ be the charge to a purpose i. Then the stand-alone cost test requires for every subset S of purposes (including singletons) that $x(S) \leq c(S)$. Its rationale is that if cooperation among the parties is voluntary, then self-interest dictates that no participant -- or group of participants -- be charged more than their stand-alone (opportunity) cost. Otherwise there would be no incentive to

exposition, consider a multiproduct operation involving the production of two goods, A and B. The breakeven requirement is simply that the sum of costs allocated to A and B must equal the total cost of producing A and B together. The stand-alone cost test, or rule, is that the cost allocated to the production of A (B) must not exceed the cost of producing A (B) alone. If the breakeven requirement is met and the cost allocated to, say A, exceeds the cost of producing A alone, then the production of A will in effect be subsidizing the production of B, an outcome which will perceived as decidedly "inequitable".

There may a number of acceptable cost allocations. This leaves another question, namely which is the most equitable of the acceptable cost allocations.[26] For the whiting cost benefit analysis, the search for the single most equitable cost allocation, or cost allocation rule, could be futile. However, a tractable approach that can be deemed "reasonable" by all sectors in the whiting fishery should, unless rejected on other grounds, be considered as acceptable.

When deciding upon a joint cost allocation rule to be used in the cost-benefit analysis of different resource allocation alternatives, three basic conclusions were reached: (1) a cost allocation rule must be adopted that is the same for all sectors; (2) the cost allocation rule must be simple, and thus capable of being readily understood (invoking trust in the analysis), i.e. "transparent"; (3) the cost allocation rule must be equitable.

Many cost allocation rules do not satisfy the simplicity test. Two cost allocation rules that do, however, are (1) Separable Costs-Remaining Benefits Method (SCRB Method) and (2) Use of Facilities Method. The SCRB Method assigns to each function the separable costs of including the function in the multipurpose project plus a share of the joint or common costs. Joint or common costs are allocated on the basis of the remaining benefits accruing to each function. Separable costs are the difference between the costs of the multipurpose project with the purpose included and the cost without, and they are subtracted from justifiable costs to arrive at remaining benefits. Separable costs include not only the specific costs of including the purpose, but also the added costs of a change in the size or design of the multipurpose project from inclusion of the specific purpose under consideration.[27]

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agree to the proposed allocation. See Young (1994), p. 1199; Baumol, Panzar and Willig op cit., pp. 70, 351-352; and Sharkey op cit., p. 41.

[26] See Young (1994), Section 5.

[27] Loughlin op cit. In addition, Gittinger (p. 235) states that, "Separable cost is expenditure that could be avoided if one purpose were excluded from the project. It is possible to find that no portion of the joint cost is solely and clearly traceable

The Use of Facilities Method of cost allocation attempts to allocate joint or common costs in proportion to the relative use of the common facilities by each purpose. It thus distributes joint or common costs in proportion to physical criteria, such as fishing time, rather than benefits as in the SCRB Method.

The SCRB Method requires calculation of the stand-alone costs of each of the joint activities. While this may be feasible for the onshore processors, it may not be for the offshore catcher-processors. The joint activities for the at-sea sector consist of harvesting and processing pollock off Alaska and whiting off Washington and Oregon. The stand-alone costs might be calculatable for harvesting and processing of pollock, because most, if not all, of the vessels were acquired for the purpose. The stand-alone costs for harvesting and processing whiting are quite another matter, since the entry of the offshore catcher-processors came in a subsequent action that was not originally intended when the vessels were constructed. Any attempt to calculate the stand-alone costs for offshore harvesting and processing of whiting may then very well involve the use of highly arbitrary assumptions, which could not be readily supported.

The Use of Facilities Method appears to circumvent such problems and should appeal to all sectors as being "reasonable".[28] Therefore, the Use of Facilities Method for allocating joint costs, while certainly not free from criticisms, is the "least worst" of the alternatives. The Use of Facilities Method will: (1) provide acceptable solutions; (2) prove to be simple and readily comprehensible; and (3) be perceived as "reasonable" by all sectors involved.

Three approaches are possible when allocating joint costs with the Use of Facilities Method for the cost benefit analysis of Pacific whiting: (1) by time spent fishing for whiting and other species; (2) by the revenues received fishing for whiting and other species; and (3) by the quantity of landings for whiting and other species. It was agreed that all three approaches to the Use of Facilities Method should be used when

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to a particular purpose. In measuring the separable cost, each purpose should be treated as if it were the last increment added to a project that serves all the other multiple purposes; in this way favoring one purpose over another may be avoided."

[28] Loughlin (1977) objects to the Use of Facilities Method since, for the case which he is considering, it can lead to a particular activity being assigned a cost in excess of its stand alone cost. In other words, the Use of Facilities Method can lead to unacceptable solutions, i.e. solutions that do not satisfy breakeven requirement and the stand-alone cost test. However, it would be mathematically impossible for the Use of Facilities Method to lead to such an outcome for the at-sea sector and should not for the onshore sector as well.

joint and common cost allocation is required and sensitivity of the cost benefit results appraised.

4.5.1. Producer Surplus with Investment Over the Long Run[29]

Over the long run, a firm may adjust its stock of fixed factors. What does this adjustment in the stock of fixed factors do to measures of producer surplus, which is a short-run concept?

This adjustment in the stock of fixed factors shifts and/or rotates the marginal cost or short-run supply curves. The short-run producer surplus in turn changes. The net welfare gain is given by the sum of the changes in short-run producer surplus minus the investment cost.

4.6. What Are the Relevant External Costs and How Should They Be Estimated?

Several external costs were identified: (1) the opportunity cost for using whiting in the fishery (instead of elsewhere or later); (2) the opportunity cost of using other fish and marine mammals taken as bycatch in the whiting fishery; and (3) adverse environmental effects from processing whiting and waste disposal.

The full opportunity cost of using whiting as catch in the whiting fishery is not paid by fishermen, giving rise to an external cost. The external cost for catching whiting would probably not differ among alternative allocation options and could be ignored if the temporal distribution, spatial distribution and the level of whiting catch did not differ substantially.

The opportunity cost of using other groundfish, other fish, and other living marine resources as bycatch is an external cost. The principal bycatch species appear to be salmon and rockfish. The opportunity cost of using salmon or rockfish as bycatch is the highest valued alternative use of these fish. This would be measured as the willingness to pay for it in the next best use, and would include commercial market value (use value), consumer surplus for recreation use, and existence or preservation value and option value. However, the values of the uses that are actually precluded may provide the best measure of the cost of using these fish as bycatch. For example, if salmon bycatch is expected to principally decrease the salmon quota and catch in the commercial salmon fisheries, the gross value of the foregone salmon catch in the salmon fisheries would be an upper bound

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[29] This section was not discussed at the workshop but was added due to its relevance. The basic discussion draws from R. Just, D. Hueth, and A. Schmitz, Applied Welfare Economics and Public Policy. Englewood Cliffs, New Jersey: Prentice Hall, 1982, pp. 64-68. See also P. Johansson, An Introduction to Modern Welfare Economics. Cambridge, U.K.: Cambridge University Press, 1991, p. 58.

estimate of the cost of using salmon as bycatch in a whiting fishery.

The first step in calculating the foregone salmon value is to estimate the foregone catch per unit of bycatch. That will depend on a variety of factors, including the difference between the age of the salmon taken as bycatch and the age of salmon taken in the salmon fisheries, growth rates, natural mortality rates, and the spawner-recruit functions. If the differences in bycatch rates are not substantial between the two competing user groups, the use of a sophisticated and time consuming method of estimating foregone value probably is not justified. If the excluded uses include recreational catch, the change in the value of recreational catch ideally needs to be estimated. If the salmon species taken as bycatch include endangered species, the valuation process is more difficult. Perhaps quantifying the difference in bycatch levels among alternatives is the most that can be done given the time and resource constraints for the analysis.

It was noted that bycatch can be considered as either an input or an undesired output without affecting the outcome of the economic analysis. More complete salmon bycatch rate data for factory trawlers than for catcher vessels limits the comparisons of bycatch costs that can be made.

Processing of whiting and the disposal of processing waste can cause air and water pollution. If there are thought to be substantial differences in these types of external costs among the alternatives to be considered, these external costs should be evaluated.

The additional harvesting and processing costs that have resulted from efforts to reduce all of these types of external costs should be considered.

5. Concluding Remarks

The most important conclusions for cost-benefit analysis arising from the meeting are presented below.

1. Inclusion of fixed cost information, even when the time period of analysis is confined to the short run, keeps the focus of policy makers on the long-term effects of policy alternatives.

2. When **existing** fixed inputs are nonmalleable, they have zero opportunity costs and their acquisition costs are sunk costs

3. An **existing** fixed input has a positive social opportunity cost, and thus positive fixed cost, if the input is deemed malleable for the period of analysis and the alternative use of this input generates a positive net social benefit. An existing fixed input can also have a zero or even negative social

opportunity cost.

4. **Existing** malleable fixed inputs are stocks with flows of capital services, whose costs are represented by capital services prices.

5. **Reinvestment or new investment is included at the time of occurrence and valued at its complete social opportunity cost.**

6. Joint and common costs can be allocated between the whiting fishery and other uses of the relevant input by a variety of approaches, but for the sake of tractability and transparency, the Use of Facilities Method was recommended.

7. There are three possibilities when allocating joint costs with the Use of Facilities Method for the cost-benefit analysis of Pacific whiting: (1) by time spent fishing for whiting and other species; (2) by the revenues received fishing for whiting and other species; and (3) by the quantity of landings for whiting and other species.

8. Over the long run, fixed costs are expected malleable except in rather extreme cases. Any analysis, whether of total net benefits or incremental differences among policy alternatives, should reflect this and any changes in these costs that may occur over the long run for different sectors and policy alternatives.

9. In an ideal analysis, when costs vary in the long run and over different policy alternatives, all costs and benefits accounting for all spillover effects onto linked markets and all adjustments in related or linked fisheries would be accounted for, although this task may be prohibitively time consuming and expensive;

10. If joint, common, or other costs do not vary among policy alternatives over the entire time period, then the rankings or incremental differences in net benefits for alternative policies under consideration can be estimated without including those costs and in this case the apportionment of joint and common costs can result in the appearance of a cost change when in fact only the apportionment of the cost changes.

11. Including all costs allows determining the total net benefit of each policy alternative and whether or not it provides a positive total net benefit to the nation and whether or not additional alternatives should be considered.

12. One possibility is to analyze the policy alternatives for incremental differences in net benefits to provide a choice among these alternatives, and then to also estimate the total net benefits of each alternative to determine if **net benefits are positive or if** additional alternatives should be considered.

13. Several external costs were identified: (1) the opportunity cost for using whiting in the fishery (instead of elsewhere or later); (2) the opportunity cost of using other fish and marine mammals taken as bycatch in the whiting fishery; and (3) adverse environmental effects from processing whiting and waste disposal.

14. Both financial and social cost-benefit analyses provide important and relevant information for the Council and industry.

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APPENDIX B: LITERATURE DISTRIBUTED PRIOR TO THE WORKSHOP

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APPENDIX C: COST ALLOCATION IN A GAME-THEORETIC CONTEXT

The cost allocation rules can be placed in a game theoretic discussion. The argument to be made on behalf of employing capital to produce multiple products, or services, rather than single products (services), is that the multiproduct operation will lead to cost savings. Consequently, the game, from which the cost allocation rules can be drawn, can be characterized as a "cost saving" cooperative game, in which the issue at hand is the division of the cost savings between and among the production activities.[30] Moreover, the "game" is the equivalent of a cooperative game with side payments, which simplifies matters to a considerable degree.[31]

The solution to the game, i.e. the cost allocations, which are acceptable, and thus constitute the "core" of the game, must satisfy two eminently reasonable criteria, which can be termed:[32] (1) the breakeven requirement and (2) the stand-alone cost test.[33] For sake of exposition, consider a multiproduct operation involving the production of two goods, A and B. The breakeven requirement is simply that the sum of costs allocated to A and B must equal the total cost of producing A and B together. The

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[30] In a cooperative game, groups and subgroups of individuals are assumed to be able to attain particular outcomes for themselves through binding cooperative agreements.

[31] To obtain a stable equilibrium solution to a cooperative game, a party that might otherwise lose receives a "side payment" from gainers to induce their cooperation. Thus side payments are transfer payments, whose existence can lead to an optimal cooperative solution.

[32] The core is the set of all solutions of a cost-sharing game. More specifically, the core of a cost-sharing game is the set of all allocations such that the stand-alone cost test is satisfied and that costs are allocated exactly. Equivalently, the set of all allocations can satisfy the incremental or marginal cost test and all costs can be allocated exactly. For further discussion, see Young (1994), pp. 1199-1200.

[33] Let $c(S)$ represent the joint cost function, S represent a subset of projects (products, services), and $x(S)$ be the charge to a purpose i. Then the stand-alone cost test requires for every subset S of purposes (including singletons) that $x(S) \leq c(S)$. Its rationale is that if cooperation among the parties is voluntary, then self-interest dictates that no participant -- or group of participants -- be charged more than their stand-alone (opportunity) cost. Otherwise there would be no incentive to agree to the proposed allocation. See Young (1994), p. 1199; Baumol, Panzar and Willig op cit., pp. 70, 351-352; and Sharkey op cit., p. 41.

stand-alone cost test, or rule, is that the cost allocated to the production of A (B) must not exceed the cost of producing A (B) alone. If the breakeven requirement is met and the cost allocated to, say A, exceeds the cost of producing A alone, then the production of A will in effect be subsidizing the production of B, an outcome which will perceived as decidedly "inequitable". The stand-alone costs, in effect, constitute the "threat point" in the cooperative game.

It would be unusual if it were not the case that there will be many solutions (perhaps infinite in number) to be found within the "core". This leaves another question, namely which is the most equitable of the core solutions.[34] For the whiting cost benefit analysis, the search for the single most equitable solution, or cost allocation rule, could be futile. However, a tractable approach that can be deemed "reasonable" by all sectors in the whiting fishery should, unless rejected on other grounds, be considered as acceptable.

[34] See Young (1994), Section 5.

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