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METHODS FOR ECONOMIC ANALYSES

1 INTRODUCTION

This document provides a discussion of various economic methods that would be used in analyzing the economic impacts of the alternatives included in Amendment 15 to the Sea Scallop FMP. Economic analyses will address the potential impacts of these measures corresponding to the three broad objectives of this Amendment as follows:

1. Identify and implement appropriate ACLs and AMs for various components of the scallop fishery.
2. Consider addressing capacity in the limited access scallop fishery and improve overall economic performance while considering impacts on various fisheries and fishing communities.
3. Consider measures to adjust several aspects of the overall program to make the scallop management plan more effective.

The specific measures corresponding to these objectives are currently in the process of development; therefore, the economic methods include a broad discussion of various models that could be used in the assessment of short- and the long-term impacts of these measures on national economic benefits, vessel profits, crew shares, and employment. The analyses and the production, price and cost models presented in the following sections are based on preliminary estimates and will be revised using the latest available data and refined econometric techniques as Amendment 15 is further developed.

1.1 ANALYSIS OF ANNUAL CATCH LIMITS AND ACCOUNTABILITY MESAURES

Amendment 15 measures will change the process of managing the scallop fishery by setting annual ACLs instead of determining effort levels consistent with the target fishing mortality rate. The economic impact of the proposed management measures will be evaluated by comparing the present value of the short-term and long-term net national economic benefits with the benefits of the status quo management. Net national benefits are measured as the sum of benefits that accrue to the harvesters (producer surplus) and to the consumers (consumer surplus). Producer surplus for a particular fishery shows the net benefits to harvesters, including vessel owners and the crew, and is measured by the difference between total revenue and operating costs. Consumer surplus for a particular fishery is the net benefit that consumers gain from consuming fish based on the price they would be willing to pay for them. The economic model used in estimating the national economic benefits, including price and cost models and equations that define producer and consumer surpluses and national benefits, is presented in Section 2. In addition to the impacts on national benefits, the economic impacts of the proposed measures on the individual vessels (small business entities) of the scallop fleet will be also be analyzed in accordance with the requirements of the Regulatory Flexibility Act.

The economic benefits of the proposed measures will depend on the difference of annual ACTs from the landing streams that would be projected to materialize without the change in management process, i.e., under the status quo scenario. Under the present system, DAS and the access area trip allocations are determined from the levels of landings corresponding to the target F levels, which is 20% of $F_{threshold}$ (or F_{max}). The new system may result in a similar landings stream if, for example, ACT is set at the status quo fishing mortality target level. According to this procedure, OFL > ABC = ACL > ACT and OFL corresponds to the $F_{threshold}$ and ACT corresponds to the F_{target}, which is equal to 80% of OFL. The difference between OFL and ACL (or ABC) is due to the biological uncertainty, and the difference between ACL and ACT arises from the management uncertainty. Assuming a 10% biological uncertainty and a 10% management uncertainty, or any combination of buffers between OFL and ACT adding up to 20%, could result in an ACT level that equals the projected yield corresponding to F_{target} under the status quo management. In this case, there would be no change in economic benefits from the status quo levels except for the impacts of AMs on revenues and costs, as will be discussed below.

Any change in annual scallop catch from the status quo levels due to the new management measures will have an impact on economic benefits and thus will need to be assessed. A short and long-term assessment of the net economic benefits of the ACLs would require a biological projection of landings both under the new management systems and for status quo. A cost/benefit analysis of the proposed buffers between OFL, ACL and ACT and the landings streams corresponding to these specifications could then be conducted quantitatively using the economic model described in Section??. The specifics of the approach in estimating costs and benefits can be summarized here as follows:

1) The biological model output provides short and long-term projections for scallop landings by market size category, and landings per day-at-sea (LPUE) for all areas, as well as separately for open and access areas. Total fleet DAS-used is then estimated for each year by dividing the open area projections for landings with the LPUE for these areas. Trip allocations are obtained from the access area projections at the given possession limit (18,000 lb.).

2) The economic model estimates ex-vessel prices for scallops by market size category using the price model specified in Section 2.1 and the biological projection of landings by market category obtained from Step 1. Total fleet revenue is estimated for each year at these ex-vessel prices. The price model estimates annual average scallop ex-vessel price by market category as a function of meat count, average price of all scallop imports, per capita personal disposable income, total annual landings of scallop minus exports, percent share of landings by market category in total landings, and a dummy variable as a proxy for price premium for Under 10 count scallops. The specifics and preliminary empirical estimates for the model are presented in

3) Total variable fishing costs for the scallop fleet (excluding the crew shares) is estimated using the cost function presented in Section 2.3. The trip costs per day-at-sea is postulated to be a function of vessel crew size, vessel size in gross tons, fuel

prices, trip length, and average LPUE for the fleet. The variable cost per day-at-sea is estimated for an average vessel in the scallop fleet and then multiplied with the total DAS-used projected from the biological model to derive estimates for the scallop fleet as a whole.

4) The producer surplus is defined as the area above the supply curve and below the price line of the corresponding firm and industry. Using a straightforward approximation of this area, producer surplus is estimated as the excess of total revenue over the total variable costs derived in steps 2 and 3 above.

5) Consumer surplus measures the area below the demand curve and above the equilibrium price. For simplicity, consumer surplus is estimated by approximating the demand curve between the intercept and the estimated price with a linear line as shown in Section 2.6.

6) Total economic benefits are estimated as a sum of present value of producer and consumer surpluses, and its value net of status quo is employed to measure the impact of the management alternatives on the national economy (Section 2.8)

7) The gross profits per vessel are estimated as the boat share (after paying crew shares) minus the fixed expenses such as maintenance, repairs and insurance (hull and liability). Because the data on fixed costs do not include other costs such as loan payments, transportation costs, office expenses, professional fees and accounting, dock fees, however, the profit estimates would be an overestimate of actual profits. The adjustments to these estimates using the results of other studies on overhead expenses (Section 2.5)

8) Crew income is determined by a lay system which splits gross revenue between the owner and crew. Trip expenses such as fuel, food, ice, oil, and water are paid from the crew share. Boat owner pays for repairs, insurance, and the mortgage of the vessel. According to a study done by Daniel Georgianna and Debra Shrader (2, 2005), crew shares dropped from 59% in 1993 to 55% in 2002. The analysis will take into account the possible changes in the lay system since then in conjunction with the social impact analysis. The impacts on employment will be analyzed both in terms of the number of crew and crew × days-at-sea.

The economic analysis will also include a discussion of trade-offs in costs and economic benefits of various measures that could reduce management uncertainty. These include changes to the fishing year, conversion of open area DAS allocation to trips, or changes in the overfishing definition (Section 1.2).

It is expected that the current monitoring techniques including the daily monitoring of catch in access areas and yearly estimates of catch in the open areas will continue to be used for monitoring ACLs. Amendment 15 will include sub-ACLs for the limited access and general category limited access vessels and develop accountability measures for each sub-ACL such that one fishery cannot shut the other down. Both the biological projections and the economic analysis will also need to take into account ACL under another FMP that may be set for the scallop fishery, such as yellowtail flounder ACL under the multispecies FMP. These analyses could be largely qualitative, however, unless new measures change the yellowtail quota for the scallop fishery and the impact of this change on scallop landings could be quantified. There could also be an increase in administrative burden because the new management system will include an elaborate process in order to determine if ACLs were exceeded, or if the buffers for biological and management uncertainty and AM measures should be adjusted.

Amendment 15 will include accountability measures (AM) that would be triggered if the scallop fishery exceeds its ACL. These measures are in the process of development and could include in-season measures or adjustments in the next fishing year. AMs could include limits on the number DAS that can be used per season (same year adjustment), hard TAC for open areas (same year adjustment), DAS adjustment (same season or following season), and catch per DAS limit (in season). AM measures related to the yellowtail quota could include reduced possession limit for all access area trips for all vessels year, reduced number of total general category trips, and restricted fishing in YT stock area the following year, leasing of groundfish DAS for vessels that want to fish in yellowtail areas and so on. The economic analysis of these options would include the impacts on the costs due to the reduced flexibility in fishing decisions about when to fish (in case of seasonal limits on DAS-used) or increase in trip length if catch per DAS was limited or possession limits are lowered. Some measures such as hard TAC for open areas could possibly lead to derby fishing and could have negative impacts on prices. The monthly price model presented in Section 2.2 could be used to analyze the impacts of seasonal adjustments or hard TACs on prices.

1.2 MEASURES TO ADJUST SPECIFIC ASPECTS OF FMP TO MAKE OVERALL PROGRAM MORE EFFECTIVE

Amendment 15 proposed measures include adjustments to the overfishing definition, modifications to the limited access general category program, revision of the EFH closed areas if Phase II to the Habitat Omnibus Amendment is delayed, improvements to the research set-aside program, and changing the fishing year.

Some of these measures, such as adjustments to the overfishing definition and the revision of EFH closed areas could have impacts differential impacts on the annual scallop landings, thus on prices, costs and revenues. A cost/benefit analysis as outlined in Section 1.1 above could be used to estimate economic impacts quantitatively if biological model could project scallop landings streams for these alternatives and for the no action. If such projections cannot be done or are not deemed necessary to demonstrate the impacts, economic analysis could include a qualitative discussion of benefits and costs. The modified overfishing definition is designed to maximize scallop yield and increase flexibility for setting annual fishing mortality targets to meet area rotation objectives. If these objectives are materialized, this measure could increase landings and revenues and reduce costs for the scallop fishery resulting in higher producer, consumer and net national benefits. The revision of EFH areas is expected to have positive economic impacts as well because some EFH areas that are not consistent with the Amendment 13 (to the Groundfish FMP) measures could be provided access for the scallop vessels.

On the other hand, the measures that would modify or eliminate possession limit for the general category vessels, change the maximum quota per vessel restriction (for example, from 2% to 2.5%) of the total general category allocation or measures that would improve research set-aside program are not expected to change the scallop landings (at least, not directly). An increase in the general category possession limit is expected to reduce fishing costs and increase profits for these vessels as some scenario analyses with different possession limits could be used to demonstrate the economic impacts. Changes in the maximum quota will provide more flexibility to vessels to adjust their harvest levels to changes in the scallop resource conditions and will have positive impacts on profits. On the other hand, consolidation of quota could have some negative impacts on some communities which would be addressed by the social impact analysis. In summary, economic analysis of these measures would include either a qualitative discussion of impacts (as in the RSA program) or assessment of impacts on vessel costs and profits using some scenario analyses.

Changing the start of the fishing year will reduce the time lag between the fishing year and the time when the survey data becomes available reducing the scientific uncertainty because results from the latest surveys can be incorporated. Therefore this measure could lead to a reduction in the buffer between OFL and ACL and benefit the scallop fishery as whole with positive impacts on net national benefits which could be analyzed again using the approach outlined in Section 1.1 depending on the availability of biological projections of scallop yield corresponding to smaller buffer for the scientific uncertainty. However, the change in the fishing year would also require a change in the business plans of the scallop fishermen and could create some risks if plans do not materialize due to unforeseen conditions. Presently, the fishing year begins at a time when meat-weight of scallops begins to increase and a higher yield per unit effort could be obtained from scallop fishing (March). If the fishing year starts later, fishermen will need to reserve part of their day-at-sea allocations until next year with an increased uncertainty regarding the resource and market conditions that could prevail at that time. These impacts could be analyzed by examining the seasonal/monthly distribution of effort and by discussing the factors that would impact costs, revenues and profits when period of decision making changes in accordance with the change in the fishing year.

1.3 MEASURES TO ADDRESS EXCESS CAPACITY IN THE LIMITED ACCESS FISHERY

Amendment 15 alternatives include permit stacking and DAS and access area trip leasing in order to address excess capacity in the sea scallop fishery. Capacity could be defined in several ways relative to the technical efficiency or taking into account the costs of production, economic aspects, or social constraints. From a technical perspective, capacity may be defined as the maximum output that could be obtained by the fixed inputs (vessel this case), using the variable factors of production, such as DAS and crew size when the availability of these factors are not restricted. Capacity in the fisheries would also vary with the level of resource biomass and could be evaluated in relation to the sustainable scallop harvest.

A historical examination of the trends in terms of the number of vessels, DAS-used, and vessel characteristics of full-time limited access vessels that participated in the sea scallop fishery since 1994 indicates the existence of excess capacity in the fishery from a technical efficiency perspective at the current scallop stock harvest and biomass levels.

Table 1 shows that there has been a steady decline in the DAS-used per full-time limited access vessel since 1994 due to the effort-reduction and area-rotation policies implemented by the various Scallop Amendments and Frameworks. The DAS-allocation per full-time vessel declined from 204 days-at-sea in 1994 (Amendment 4) to less than 110 days-at-sea (Framework 18) for the 2006-2007 fishing years. As a result, average DAS-used declined from 161 days in 1994 to 95 days in 2007, while at the same time the number of full-time vessels participating in the fishery increased from about 210 in 1994 to 315 vessels in 2007. The reduction in effort was even greater, from an average of 180 days in 1994 to 93 days in 2007, for 124 relatively larger vessels that fished every year during the last 14 years from 1994 to 2007 (

Table 1). If there were no restrictions on effort, it is evident that most vessels would use more DAS than they did in the past when DAS allocations were higher, rather than operating two or more vessels with smaller DAS allocations and incurring overhead costs such as insurance for each vessel. This would reduce the costs per pound of scallops and increase profits per vessel. The fact that a smaller number of vessels could harvest the same amount of scallops at a given level of scallop biomass by using more days-at-sea than they are currently allocated is indicative of excess technical capacity in the scallop fishery.

Table 1. Vessel size, DAS-used and LPUE by years fished by full-time limited access vessels

FISHYEAR	Years Fished	Number of vessels	Average GRT	Average HP	Average DAS-used	Average LPUE
1994	14 years	86	143	727	135	591
	Less than 14 Years	124	168	899	180	519
1994 Total		210	158	829	161	543
1999	14 years	92	141	706	88	917
	Less than 14 Years	124	168	905	109	994
1999 Total		216	157	820	100	963
2003	14 years	155	136	678	105	1,588
	Less than 14 Years	124	167	905	117	1,867
2003 Total		279	150	779	110	1,713
2004	14 years	171	135	690	95	1,941
	Less than 14 Years	124	167	904	97	2,371
2004 Total		295	149	780	96	2,124
2005	14 years	188	133	702	77	1,775
	Less than 14 Years	124	166	907	83	2,004
2005 Total		312	146	783	79	1,866
2006	14 years	190	133	709	78	1,804
	Less than 14 Years	124	166	907	86	2,087
2006 Total		314	146	787	81	1,918
2007	14 years	191	134	716	97	1,602
	Less than 14 Years	124	166	907	93	1,884
2007 Total		315	147	791	95	1,714

*Excluding outliers and LPUE data <400 lb.

1.3.1 Adjustment of DAS for the permit stacking and open area DAS leasing options:

Although permit stacking and leasing alternatives will provide flexibility of the vessels to adjust their effort to changes in the scallop biomass and/or in management measures, they could lead to an increase in fishing effort if DAS is transferred from a small vessel to a larger vessel with higher fishing power. This could increase the capacity and the scallop fishing mortality. As a result, it would be necessary to reduce DAS and/or trip allocations for all vessels to counteract such an increase in fishing mortality to the disadvantage of the vessels that were not involved in permit stacking or DAS leasing. Amendment 15 includes fishing power adjustment alternatives in order to prevent an increase in fishing mortality as a result of effort transfers. This section describes the methods used in examining the factors that impact the fishing power, analyze the potential impacts of DAS consolidation, and discuss methods for adjusting DAS to prevent an increase in fishing mortality.

The historical data on LPUE's for the full-time limited access fleet by vessel gross tonnage and horsepower indicate that average open area trip landings and LPUE is higher and the trip length is longer for the group of vessels with a higher gross tonnage and horsepower compared to the smaller vessels (Table 2 to 4).[1] Thus, if a transfer of DAS took place from small full-time scallop boats to the larger boats either through permit stacking or DAS leasing, the scallop landings, mortality, and the capacity in the fishery could in fact increase.

Since scallop landings per day-at-sea varies from vessel to vessel according to the vessel characteristics among other factors, DAS from one vessel must be adjusted for other vessel's fishing power to prevent fishing mortality from increasing when DAS's are consolidated or transferred. In other words, DAS must be adjusted with relative landings per DAS (LPUE). An adjustment factor in relative LPUE's is expressed as follows:

A_{ij}= LPUE $_i$/LPUE$_j$ where

LPUE $_i$= Landings per DAS for vessel 'I';

LPUE $_j$= Landings per DAS for vessel 'J';

Table 2. Average open area scallop trip landings per full-time vessel by GRT and HP groups (in pounds)

GRT Group	Horse Power Group	2002	2003	2004	2005	2006	2007*	Average 2002-2007
<50	200-599	5643	9242	8122	2636	6521	5555	6478
50-99	200-599	9550	10581	11931	8092	8506	7189	9331
	600-850	13304	10253	11095	13405	12359	12297	12224
100-149	200-599	14268	13470	13973	14613	11091	10896	13203
	600-850	17282	17123	19178	18500	15967	16253	17351
	851-999	20066	19510	18999	16039	19004	15902	17935
	>=1000	21973	19822	26358	28301	18827	18049	21916
>=150	200-599	18166	16984	21144	19600	15913	13240	17519
	600-850	18604	18724	20454	21059	17027	15453	18575
	851-999	19736	20613	22771	26236	19154	16754	20787
	>=1000	24134	23563	28230	30762	24812	18585	24920

[1] These Tables show preliminary groupings of vessels for the purposes of exposition. Additional analyses will be conducted with the scallop fleet divided into more (or less) groups with different ranges of horsepower and vessel characteristics.

Table 3. Annual average of open LPUE per full-time vessel by GRT and HP groups

GRT Group	Horse Power Group	2002	2003	2004	2005	2006	2007*	Average 2002-2007
<50	200-599	1025	1307	1250	763	1226	818	1080
50-99	200-599	1326	1349	1624	1338	1127	882	1281
	600-850	1732	1584	1866	2008	1503	1319	1631
100-149	200-599	1623	1631	1957	1812	1300	1172	1611
	600-850	1826	1884	2330	2245	1669	1495	1901
	851-999	1724	2020	2267	1992	1765	1698	1874
	>=1000	1856	1876	2333	2497	1751	1765	1988
>=150	200-599	1892	1831	2206	2227	1625	1410	1868
	600-850	1846	1930	2401	2328	1709	1475	1952
	851-999	1844	1924	2391	2453	2071	1538	2023
	>=1000	2002	2026	2542	2668	2181	1653	2173

* Preliminary numbers

Table 4. Average open area trip length per full-time vessel by GRT and HP groups

GRT Group	Horse Power Group	2002	2003	2004	2005	2006	2007*	Average 2002-2007
<50	200-599	5	6	5	3	5	7	5
50-99	200-599	7	8	7	6	7	8	7
	600-850	8	6	6	7	9	10	8
100-149	200-599	9	8	7	8	9	9	8
	600-850	9	9	8	8	9	11	9
	851-999	11	9	8	8	11	10	10
	>=1000	12	11	11	11	10	10	11
>=150	200-599	10	9	10	9	9	9	9
	600-850	10	10	9	9	10	10	10
	851-999	11	11	10	11	9	11	10
	>=1000	12	12	11	11	11	12	11

An adjustment formula could be developed by either using ratios of LPUE's of different vessels based on the historical data for a specific period of time or by using estimates of LPUE's corrected for factors that affect the catch rates. In general, DAS adjustments based on LPUE's obtained from the empirical data may not reflect accurately the differences in the fishing power of the vessels. For example, Table 5 shows that LPUE ratios for the different HP groups were not constant during the period from 1994 to 2007. Until the 1999 fishing year, there was little difference in the average LPUE of the vessels in different HP groups since the low stock abundance restricted catches per day-at-sea for all vessels, but at higher levels of biomass the vessels with higher HP and GRT, in general, were able to catch more than the smaller vessels within a given unit of time. In addition to changes in the scallop stock abundance, DAS-used, crew size, ring size, dredge size and area fished could affect the difference in the LPUE's of vessels with different HP or other characteristics. These factors could be taken into account by using a technical production model that takes into account the influence of these factors. The model coefficients could in turn be used to correct LPUE's of various vessels for factors that affect the catch rates.

Table 5. LPUE by fishing year and horsepower from all areas (full-time dredges, excluding small dredges)

FISHYEAR	Data	Horse power				Fleet LPUE
		<600	600-825	850-970	>=1000	
1994	LPUE (lb./DAS)	424	417	379	471	423
	Number of vessels	37	37	58	53	185
1995	LPUE (lb./DAS)	441	457	438	510	464
	Number of vessels	37	38	57	56	188
1996	LPUE (lb./DAS)	398	409	459	599	475
	Number of vessels	36	39	59	52	186
1997	LPUE (lb./DAS)	325	352	404	569	420
	Number of vessels	36	38	58	48	180
1998	LPUE (lb./DAS)	366	370	394	491	409
	Number of vessels	37	38	60	50	185
1999	LPUE (lb./DAS)	719	916	971	1,134	949
	Number of vessels	41	44	61	53	199
2000	LPUE (lb./DAS)	1,274	1,456	1,558	1,712	1,516
	Number of vessels	44	47	65	56	212
2001	LPUE (lb./DAS)	1,488	1,611	1,702	1,816	1,667
	Number of vessels	43	51	66	57	217
2002	LPUE (lb./DAS)	1,463	1,671	1,717	1,928	1,707
	Number of vessels	45	54	64	59	222
2003	LPUE (lb./DAS)	1,692	1,711	1,749	1,933	1,776
	Number of vessels	48	59	62	64	233
2004	LPUE (lb./DAS)	2,017	2,180	2,203	2,445	2,228
	Number of vessels	45	62	63	68	238
2005	LPUE (lb./DAS)	1,699	1,860	2,053	2,392	2,024
	Number of vessels	45	64	66	68	243
2006	LPUE (lb./DAS)	1,726	1,905	2,016	2,335	2,019
	Number of vessels	46	68	65	68	247
2007	LPUE (lb./DAS)	1,554	1,717	1,817	1,963	1,785
	Number of vessels	43	72	66	69	250

For this purpose, a simple Cobb-Douglas technical production model is estimated using a subset of the DAS database, which was matched to the trip records in the dealer database excluding a few outlier records. About half of the DAS records had a corresponding record in dealer database, which could be easily matched and constitute a good sample for the purpose of analyses presented here. Also, DAS data includes 317 full-time vessels that took open area trips in the 2006 fishing year, but there were matching records for 269 of these vessels in the dealer dataset.

The following annual production model estimates open area landings per full-time vessel by characteristics, crew size, scallop abundance, and DAS-used (Table 6):

Table 6. Open area production function estimates for full-time vessels

The GLM Procedure

Dependent Variable: lnscdealb

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	1162.129215	166.018459	3449.57	<.0001
Error	2024	97.409597	0.048127		
Corrected Total	2031	1259.538812			

R-Square	Coeff Var	Root MSE	lnscdealb Mean
0.922662	1.998578	0.219379	10.97677

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	-2.241897100	0.18940387	-11.84	<.0001
lndasused	1.059650054	0.00779201	135.99	<.0001
lnhp	0.200993409	0.01911449	10.52	<.0001
lngrt	0.063115328	0.02264920	2.79	0.0054
lncrew	0.059852214	0.02865585	2.09	0.0369
lnlpueop14	1.021732143	0.01897447	53.85	<.0001
lndregns	0.002178375	0.00612154	0.36	0.7220
DFT	-0.358015803	0.02027014	-17.66	<.0001

<u>**Variable Definitions and data sources**</u>

scdealb= Annual scallop landings per fishyear in pounds (source: dealer data)
dasused= Annual sum of DAS used by a vessel (source: DAS data)
HP= Horse power (source: permit data)
GRT = Gross Tonnage (source: permit data)
CREW = Number of crew (source: permit data)
Lpueop14= Average annual LPUE of the full-time vessels that fished in open areas every year (14 years) since 1994.

DREGNS = Dredge gear size * Number of dredges in use (source: permit data)
DFT = A dummy variable with value "1" for small dredge vessel, 0 otherwise.

The prefix **"ln"** indicates that logarithm of the variable is used as an explanatory factor.

The model presented above is a preliminary estimation and will be modified as more data becomes available using refined econometric techniques. In addition, the PDT will consider simplifying the model by eliminating some variables for which it is hard to get accurate data such as the crew size. Using this preliminary model, the adjustment factor (A_{ij}) for DAS exchanges between two vessels (vessel "i" and vessel "j") could be calculated as shown below through Equations 1 to 4:

(Equation-1)

$L_i = LPUE_i =$

$((-2.24\ (HP_i)^{0.20}(GRT_i)^{0.063}\ (DAS_i)^{1.05}\ (CREW_i)^{0.059}\ (DREGNS^i)^{\ 0.02}(LPUE)^{1.02}$

$/\ (DAS_i)$

(Equation-2)

$LPUE_i = ((-2.24\ (HP_i)^{0.20}\ (GRT_i)^{0.063}\ (CREW_i)^{0.059}\ (DREGNS)^{\ 0.02}\ (LPUE)^{1.02}\ )$
$(DAS_i)^{0.05}$

(Equation-3)

$A_{ij} = LPUE_{\ i}/LPUE_j$

(Equation-4)

$$A_{ij}=((HP_i)^{0.20}\ (GRT_i)^{0.063}\ (CREW_i)^{0.059}\ (DREGNS)^{\ 0.02}\ (DAS_i)^{0.05})\ /$$
$$((HP_j)^{0.20}\ (GRT_j)^{0.063}\ (CREWj)^{0.059}\ (DREGNS)^{\ 0.02}\ (DAS_j)^{0.05}$$

The adjustment factors could be determined for a group of vessels or for each transaction involving two vessels. For example, given the vessel characteristics below and for a transfer of 40 days from vessel B to vessel A and assuming both vessels used their allocations to the maximum, the adjustment factor could be calculated such that:

Vessel A: HP=844, GRT=157, Crew=7, Dredge size=143, number of dredges=2
Vessel B: HP=710, GRT=127, Crew=7, average dredge size=131 number of dredges=2

Adjustment factor for vessel A = $A_i = LPUE_{\text{vessel B}}/LPUE_A$

$$A_{\text{vessel A}} = ((710)^{0.20} (127)^{0.063} (7)^{0.059} (2*131)^{0.02} / ((844)^{0.20} (157)^{0.063} (7)^{0.059} (2*143)^{0.02} = 0.95$$

Therefore, vessel A could use only 96% of the 40 days it leases from vessel B, or about 38 days.

1.3.2 Limitations of the Fishing Power Adjustment method and further need for analysis

During the scallop committee meetings, many participants from the fishing industry expressed concern that the fishing power adjustment formula that is derived from the technical production model may not accurately account for the actual fishing power of the vessels. It was stated that the model does not take into account some important factors, such as the propeller and wheel size, which may be tweaked to increase LPUE of a small HP vessel. Unfortunately, the data on these engineering factors are not collected. Nevertheless, further analysis could be done to address these concerns as follows:

1) The technical production model will be estimated for two different time periods, 1999-2002 and 2003-2007, as an example, to examine if the coefficients of HP and other vessel characteristics are significantly different and indicate any increase in the relative LPUE of the vessels with smaller HP as a result of technological advancements in engine design and efficiency.
2) The data will be analyzed in more detail to inspect the range of LPUE for vessels with very similar HP and GRT characteristics.
3) The technical production model will be estimated by including a primary port (or state) of fishing to see if the fishing power formula changes significantly by location.
4) Finally, there is a need for expert information on the engineering aspects of vessels. This includes an assessment of the constraints placed on the fishing power of a vessel by the vessel and engine size such as HP and GRT that are included in the production model. In other words, it should be assessed to determine the extent to which the fishing power of a vessel could be increased by holding the HP and GRT constant but by changing other characteristics which are not measured in the model.

1.3.3 Economic Impacts of the Permit Stacking and DAS Leasing Options

Assuming that the adjustments will be effective in keeping the fishing mortality constant, there will be no change in landings and prices as a result of effort transfers and no impacts on the consumer benefits and the total fleet revenue. The permit stacking and leasing alternatives will have impacts, however, on the total DAS-used, the fishing costs, producer surplus, vessel profits, crew incomes, and employment. These impacts would be estimated using the economic model presented in Section 2, including trip and fixed cost equations, lay-system and definitions for producer surplus, profits, and in the case of employment, in conjunction with the social impact analysis. The multiplier impacts of these measures on regional incomes and employment could be estimated if the IMPLAN model could be developed for the Sea Scallop Fishery in time for this Amendment. The economic analysis would also include a discussion of distributional impacts on vessels and ports as DAS is moved from one vessel to another with a different homeport, the potential impact on prices through price fixing, and impacts on monitoring and transaction costs. Finally, the methods are discussed in relation to the DAS leasing options, but a similar method could be applied for access area leasing and permit stacking options, except that in the case of access area leasing there would be no need for adjustment for fishing power since trips have possession limits.

Since it will be uncertain how many vessels will take advantage of the permit stacking and various leasing options, the economic cost benefit analysis will be conducted by some scenario analyses with consolidation of fishing effort. These scenarios will take into account the constraints that are placed on the number of permits that could be stacked and on the ownership restrictions as a proportion of total effort or permits in the sea scallop fishery.

A rough estimate of the number of full-time vessels that could harvest scallops (in million pounds) corresponding to a range of sustainable or annual yield, LPUE, and annual DAS-used is provided in Table 7. For example, the shaded row in the last block of the Table shows a scenario corresponding to more or less of the level of landings (about 60.5 million lb.) and an average LPUE of 1800 lb. for larger vessels for the 2007 fishing year. By either permit stacking or leasing effort, if some vessels could increase their effort to180 day --in terms of DAS-used in the open and access areas --for example, then 185 full-time equivalent vessels could harvest the same amount of scallops that are currently landed by about 330 full-time equivalent vessels. Permit stacking, DAS, and access area trip leasing options include limits to the number of permits stacked to 2 permits and may limit the DAS leasing to double of the DAS allocation per vessel. These restrictions will be taken into account in the economic analysis. The economic impacts on the vessel profits, crew incomes, employment, fishing costs, and overall producer surplus for the scallop fishery could be then analyzed using some scenario analyses similar to the ones shown in Table 7 assuming that the number of active vessels in the fishery will be equal to the maximum number of vessels that could land scallops corresponding to a range of sustainable yield or level of ACT. This Table implicitly assumes that there is no increase in fishing power, i.e., transfer of effort is adjusted according to the fishing power formula

Table 7. Estimated number of vessels with DAS-used, LPUE and ACL

Sustainable yield/Annual harvest	DAS-used per full-time vessels		
	160	180	200
	LPUE	2300	
30	82	72	65
40	109	97	87
50	136	121	109
60	163	145	130
70	190	169	152
	LPUE	2000	
30	94	83	75
40	125	111	100
50	156	139	125
60	188	167	150
70	219	194	175
	LPUE	1800	
30	104	93	83
40	139	123	111
50	174	154	139
60	**208**	**185**	**167**
70	243	216	194

It must be cautioned, however, that this is a straightforward scenario analysis and is not intended to estimate a technically efficient level of DAS-used for the scallop fleet. There are several models which estimated technical inefficiency in the sea scallop fishery by data envelopment (DEA) and stochastic production frontier (SPF) models (John Walden (2006) and Jim Kirkley et al. (2004). The findings of these models will be discussed in the analysis of the Amendment 15 alternatives that address excess capacity.

Another limitation of this type of empirical analysis is that it is based on a constant crew size and it doesn't take into account the differences in the fishing power and costs of production of different vessels. It assumes that all vessels could gain either leasing DAS to or from other vessels. In fact, a vessel would lease DAS or trips to another vessel only if the expected gain from leasing, that is, the value of lease exceeds the revenue it could obtain by fishing DAS itself net of trip, labor, and other operating costs.

A scenario analysis that would take into account the differences in the fishing power and operating costs of the vessels could be developed by using the simulation techniques and by estimating revenue per DAS net of trip and labor costs for each vessel and conducting various scenarios analyses with effort transfers from vessels with a smaller revenue per day-at-sea to vessels with a higher daily net return. This analysis would use the technical production model to estimate landings and trip and fixed cost functions to estimate costs for each group.

A more sophisticated approach would be to use mathematical optimization techniques and GAMS software to simulate a DAS or access area trip leasing market. The objective of the model would be to maximize total industry profits subject to constraints on maximum DAS-use, on DAS transfers, or permit stacking, and subject to ACT by open and access areas. This model will include the production model, the costs equations and fishing power adjustment factors for transfers from a small to a larger vessel, and a lease price per DAS. As a first step, in order to keep the model small, the scallop vessels will be stratified into various groups according to their HP and GRT. A similar approach was used in the economic analysis of the leasing options for Multispecies Amendment 13. As it was pointed out in those analyses, this type of a model does not take into account the differences in the areas fished, where vessels land their fish, the transaction costs and other fisheries in which a vessel can participate. Even though this model would not represent an actual leasing market, it could still be employed to show the optimum level of leasing activity that could occur under some conditions and to estimate the direction of the DAS transfers from one group of vessels to another identified by their HP or GRT. It would also show the economic impacts in terms of changes in fishing costs, producer surplus, crew shares, profits and employment.

The actual economic costs and benefits will differ from the levels estimated using these methods since the transactions costs of combining effort or permits on fewer vessels are assumed to be zero. In addition, the economic and social impact analyses will examine the impacts of the permit stacking, DAS and access area leasing options on employment, prices, ports and communities. The distributional and social impacts of consolidation of the fishing activity in fewer boats through either permit-stacking or DAS will be discussed using the relevant literature on this subject.[2]

[2] Although Amendment 15 does not include ITQs, some literature related to ITQs could provide insight on the distributional and community impacts of permit-stacking or leasing alternatives. For example, David M. McEvoya et.al (2007) showed that ITQs could have a negative impact on fishermen's welfare when processors have market power and the cap on aggregate harvest is binding. Bonnie May (2004) addressed some of the undesirable social costs and how some of these costs could be mitigated by different ITQ systems.

2 ESTIMATION OF PRICES, COSTS, PROFITS AND NATIONAL BENEFITS

The economic model includes an ex-vessel price equation, a cost function and a set of equations describing the consumer and producer surpluses. The ex-vessel price equation is used in the simulation of the ex-vessel prices, revenues, and consumer surplus along with the landings and average meat count from biological projections. The cost function is used for projecting harvest costs and thereby for estimating the producer benefits as measured by the producer surplus. The set of equations also includes the definition of the consumer surplus, producer surplus, profits to vessels, and total economic benefits.

2.1 ESTIMATION OF ANNUAL EX-VESSEL PRICES

Fish prices constitute one of the important channels through which fishery management actions affect fishing revenues, vessel profits, consumer surplus, and net economic benefits for the nation. The degree of change in ex-vessel price in response to a change in variables affected by management, i.e., scallop landings and meat count, is estimated by a price model, which also takes into account other important determinants of price, such as disposable income of consumers and price of imports.

Given that there could be many variables that could affect the price of scallops, it is important to identify the objectives in price model selection for the purposes of cost-benefit analyses. These objectives (in addition to developing a price model with sound statistical properties) are as follows:

- To develop a price model that uses inputs of the biological model and available data. Since the biological model projects annual (rather than monthly) landings, the corresponding price model should be estimated in terms of annual values.
- To select a price model that will predict prices within a reasonable range without depending on too many assumptions about the exogenous variables. For example, the import price of scallops from Japan could impact domestic prices differently than the price of Chinese imports, but making this separation in a price model would require prediction about the future import prices from these countries. This in turn would complicate the model and increase the uncertainty regarding the future estimates of domestic scallop prices.

In the past SAFE reports and Scallop Amendment and Frameworks, the average ex-vessel price for scallops was estimated from an annual price model as a function of total landings, average meat count of scallops landed, disposable income of consumers, and average import prices. Collection of price data by market category of scallops since 1998, however, made it possible to improve the price model by taking into account the changes in the size composition of scallops. The composition of scallops changed significantly in the last ten years toward larger sizes as a result of effort-reduction measures, area closures, and an increase in ring sizes implemented by the Sea Scallop FMP. The share of

U10's increased to 27% in 2007 from 7% in 2000 and the share of count 11-20 scallops increased from 18% in 2000 to over 50% in 2007 (Table 8).

The scallop price by market category is affected by the relative abundance or supply of that size category relative to total scallop landings. Until the 2005 fishing year, U10 scallops had a significant price premium, but as their supply in landings increased, the difference in the annual average price of U10's and other size categories declined and in 2006, average price of U10s actually was lower than the price for other size categories (Table 9). The price model developed originally for Framework 18 captured these changes by estimating the prices by major meat count categories and including the relative share of each category in total supply of scallops as an explanatory variable.

Table 8. Composition of scallop landings by market category

Year	U10	11 to 20	21 to 30	Over 30	Unknown
2000	7%	18%	44%	20%	10%
2001	3%	24%	49%	11%	13%
2002	5%	15%	65%	4%	11%
2003	6%	21%	56%	3%	13%
2004	7%	41%	42%	2%	8%
2005	13%	57%	21%	2%	7%
2006	23%	52%	18%	1%	6%
2007*	27%	51%	13%	3%	5%

*Preliminary values

Table 9. Average annual price of scallops by market category (2006 prices)

Year	U10	11 to 20	21 to 30	Over 30	Unknown
2000	8.0	6.2	5.4	5.5	5.9
2001	6.6	4.3	4.0	4.3	4.2
2002	6.1	4.4	4.1	4.7	4.3
2003	5.2	4.4	4.4	4.8	4.3
2004	6.2	5.3	5.0	5.2	4.9
2005	8.0	7.9	7.7	7.6	7.7
2006	6.0	6.7	6.9	6.9	6.1
2007*	6.7	6.4	6.3	5.8	6.1

*Preliminary values

In addition to the changes in size composition and landings of scallops, other determinants of ex-vessel price include level of imports, import price of scallops, disposable income of seafood consumers, and the demand for U.S. scallops by other countries. The main substitutes of sea scallops are the imports from Canada, which are almost identical to the domestic product, and imports from other countries, which are generally smaller in size and less expensive than the domestic scallops. An exception is the Japanese imports, which have a price close to the Canadian imports and could be a close substitute for the domestic scallops as well.

The ex-vessel price model estimated below includes the price, rather than the quantity of imports as an explanatory variable, based on the assumption that the prices of imports are, in general, determined exogenously to the changes in domestic supply. This is equivalent to assuming that the U.S. market conditions have little impact on the import prices. An alternative model would estimate the price of imports according to world supply and demand for scallops, separating the impacts of Canadian and Japanese imports from other imports since U.S. and Canadian markets for scallops, being in proximity, are highly connected and Japanese scallops tend to be larger and closer in quality to the domestic scallops. The usefulness of such a simultaneous equation model is limited for our present purposes, however, since it would be almost impossible to predict how the landings, market demand, and other factors such as fishing costs or regulations in Canada or Japan and in other exporting countries to the U.S. would change in future years.

Since the average import price is equivalent to a weighted average of import prices from all countries weighted by their respective quantities, the import price variable takes into account the change in composition of imports from Canadian scallops to less expensive smaller scallops imported from other countries. This specification also prevents the problem of multi-colinearity among the explanatory variables, i.e., prices of imports from individual countries and domestic landings. In terms of prediction of future ex-vessel prices, this model only requires assignment of a value for the average price of imports, without assuming anything about the composition of imports, or the prices and the level of imports from individual countries. The economic impact analyses of the fishery management actions usually evaluate the impact on ex-vessel prices by holding the average price of imports constant. The sensitivity of the results affected by declining or increasing import prices could also be examined, however, using the price model presented in this section.

The price model presented below estimates annual average scallop ex-vessel price by market category (PEXMRKT) as a function of

- Meat count (MCOUNT)
- Average price of all scallop imports (PIMPORT)
- Per capita personal disposable income (PCDPI)
- Total annual landings of scallop minus exports (SCLAND-SCEXP)
- Percent share of landings by market category in total landings (PCTLAND)
- A dummy variable as a proxy for price premium for Under 10 count scallops (DU10).

Because the data on scallop landings and revenue by meat count categories were mainly collected since 1998 through the dealers' database, this analysis included the 1999-2005 period and five meat categories shown in Table 12. All the price variables were corrected for inflation and expressed in 2004 prices by deflating current levels by the consumer price index (CPI) for food. The ex-vessel prices are estimated in semi-log form to restrict the estimated price to positive values only as follows:

Log (PEXMRKT) = f(MCOUNT, PIMPORT, PCDPI, SCLAND-SCEXP, PCTLAND, DU10)

The coefficients of this model are shown in Table 11. The estimated model provided a good fit to the actual data for annual ex-vessel prices as Table 10 indicates. The F-test shows that the overall relation is statistically significant (P<0.0001), meaning that the explanatory variables as a whole have a significant influence on ex-vessel price. Adjusted R^2 indicates that changes in meat count, composition of landings by size of scallops, domestic landings net of exports, average price of all imports, disposable income, and price premium on under 10 count scallops explain 87 percent of the variation in ex-vessel prices by market category. Figure 1 and Table 12 also verify that the estimated values of ex-vessel prices closely track the actual values.

Table 10. Regression results for price model

Regression Statistics			
Multiple R	0.94		
R Square	0.89		
Adjusted R Square	0.87		
Standard Error	0.08		
Observations	35		
ANOVA			
	Degrees of Freedom	**Sum of Squares**	**Significance F**
Regression	6	1.54	P<0.0001
Residual	28	0.19	
Total	34	1.73	

Table 11. Coefficients of the Price Model

Variables	Coefficients	Standard Error	t Stat
INTERCEPT	-2.2597	0.7736	-2.9210
MCOUNT	-0.0049	0.0014	-3.3897
PIMPORT	0.0247	0.0678	0.3639
PCDPI	0.0478	0.0090	5.2981
SCLAND-SCEXP	-0.0251	0.0052	-4.8596
DU10	0.0649	0.0525	1.2352
PCTLAND	-0.3084	0.0843	-3.6565

All of coefficients of the explanatory variables have the expected sign, and they are statistically significant at least at the 5% level of significance, except for price of imports, and dummy variable for under-10 count scallops, which were kept in the model for theoretical reasons. There has been little change in import prices during the period of analysis (1999-2005) compared to other variables explaining price, which explains the low t-statistics for this variable. When the scallop price model included a longer time-series (1982 on) as presented in the SAFE 2000 report and later in Amendment 10, FEIS, the coefficient for the import price was statistically significant. The dummy variable, reflecting the price premium on under 10 count scallops, however, is statistically significant at the 22% level,.

In summary, these empirical results verify that the ex-vessel price of scallops is related inversely to the domestic supply, net of exports, and an increase as landings decrease or a decrease as landings increase. The price per pound of scallops is expected to increase as the meats per pound decrease. A negative sign for the meat count variable (MCOUNT) indicates that when other factors held constant, the price increased with the size of scallops. On the other hand, scallop price by market category is affected by the relative abundance or supply of that size category relative to total scallop landings. The negative sign for PCTLAND indicates that it is possible for smaller scallops to command a similar or even higher price in some circumstances if their supply declines to the scarcity levels in domestic markets. Positive sign and relatively high t-statistics for per capita income imply that an increase in the income of consumers will have a positive impact on the price of scallops for all market categories.

Overall, the model was successful in estimating average prices by market category during the 1998–2004 period, with a 3% difference at most from the actual price (Table 12). Similarly, predicted scallop price as an average of all market categories tracked very closely the actual annual price for scallops, with negligible differences from actual values in any single year. These numerical results should be interpreted with caution, however, since the analysis covers only 7 years of annual data from a period during which the scallop fishery underwent major changes in management policy including area closures, controlled access, and rotational area management. For Amendment 15 analyses, this price model will be updated using the most recent data for the period from 1999 to 2008.

Figure 1. Actual and predicted annual ex-vessel price

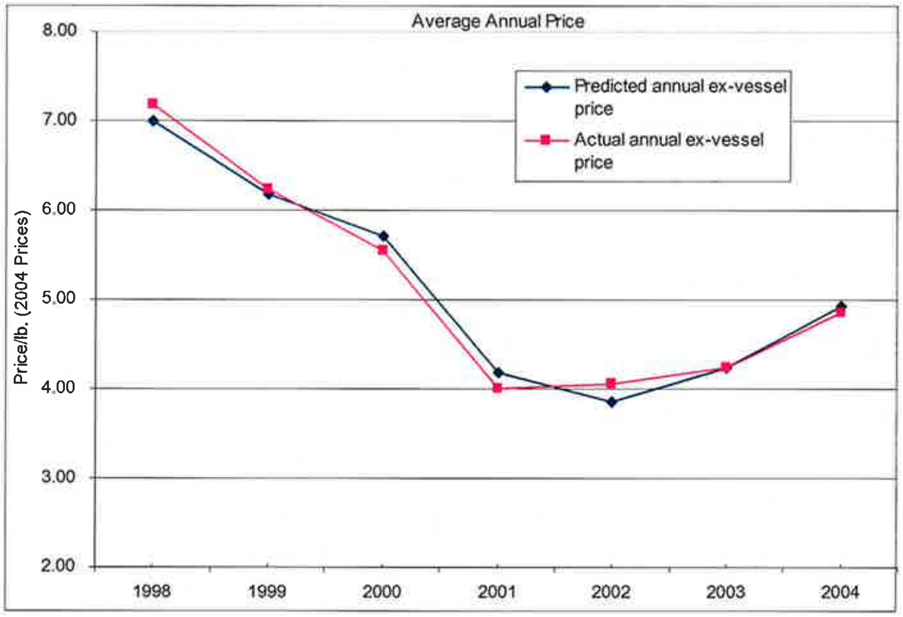


Table 12. Average predicted and actual ex-vessel price during 1998-2004

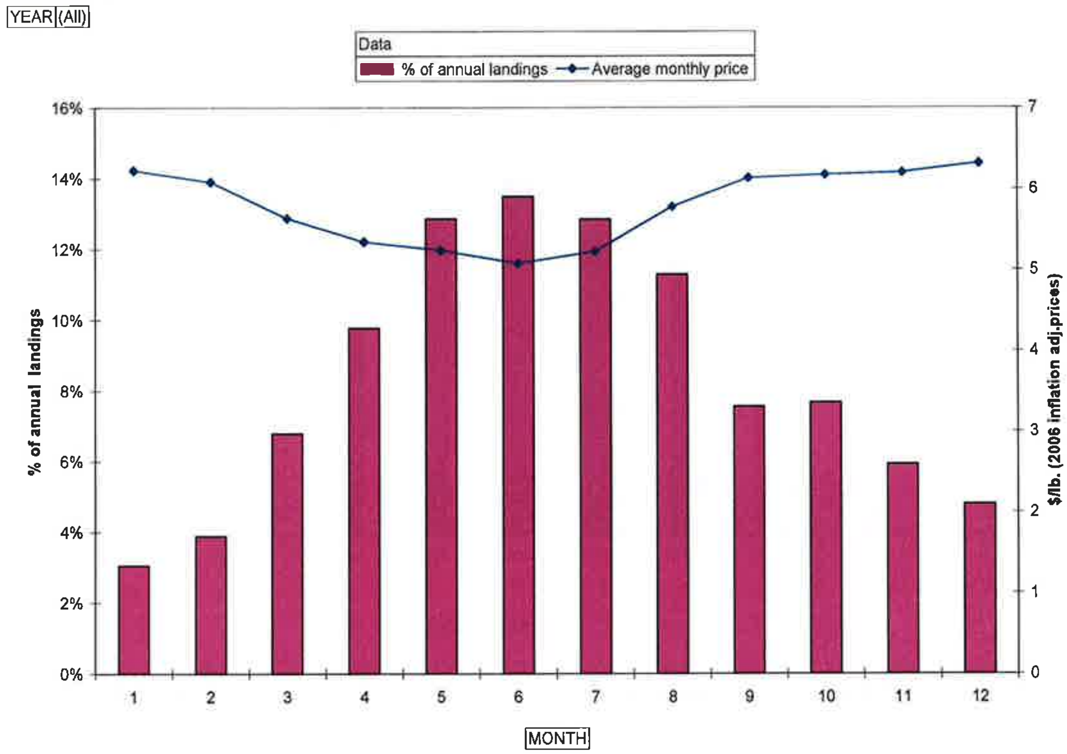
Market Size Category	Actual Price	Predicted Price	Percent Difference
Under 10 count	6.47	6.37	-1.6%
11-20 count	5.40	5.55	2.9%
21-30 count	5.08	4.93	-3.0%
31-40 count	5.17	5.21	0.8%
41 plus count	5.05	5.04	-0.3%

2.2 MONTHLY PRICE MODEL

In addition to the annual price model, the economic model includes a monthly price model developed to analyze the impacts of derby fishing and access area management. This model estimates ex-vessel prices by market size category using the monthly dealer data for 1999–2007 (up to September 2007) and takes into account the effect of the change in composition of landings, the changes in exports, import prices, and disposable income of consumers on monthly scallop prices.

In general, ex-vessel prices are lower during the months in early spring and summer as scallop landings increase during these months. Figure 2 shows this seasonal relationship between the seasonal composition of landings and the average price for scallops for the last 8 years. Scallop prices usually begin to decline from their high levels in January until the months of June to July, and then begin increasing as scallop landings decline in the fall and winter months.

Figure 2. Monthly composition of scallop landings and average ex-vessel price in 2006 inflation adjusted prices (1999-2006 average)



The monthly changes in prices differ from these average patterns, however, as a result of changes in landings and other factors that determine prices. Comparison of monthly data for 2006 and 2007 provide insight about these monthly patterns. For example, during June and July in 2006, the average price of scallops declined sharply as scallop landings that were mostly composed of larger scallops increased significantly during these months (Figure 3). In contrast, there was not a significant decline in ex-vessel prices in the summer of 2007, because landings were more or less evenly distributed from March to August compared to landings during these months in 2006 (Figure 4). During March of 2007, however, ex-vessel prices declined by more than 20% compared to the previous months, from about $7.96 per pound in February to about $6.12 per pound in March due to the large amount of landings from the Elephant Trunk area.

Figure 3. Scallop landings and ex-vessel price (in 2006 inflation adjusted prices) by month in 2006

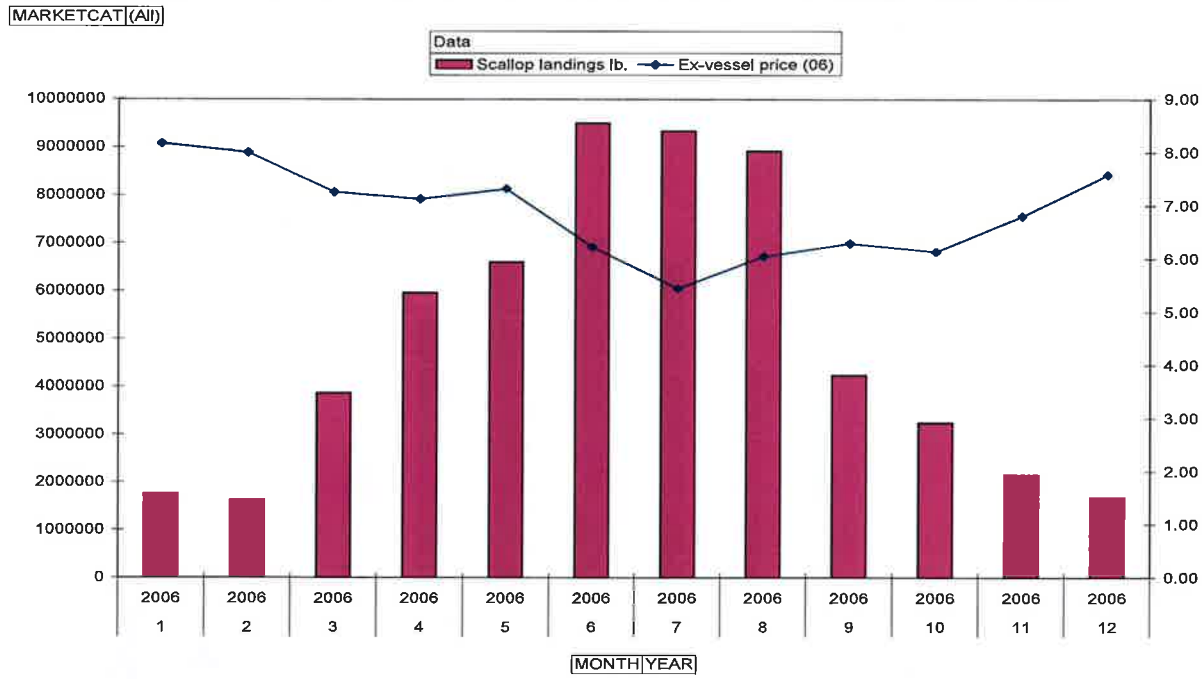


Figure 4. Scallop landings and ex-vessel price (in 2006 inflation adjusted prices) by month in 2007

These examples indicate that the rotational area management could have important impacts on prices, revenues, and the profits of fishermen. Even though larger scallops have a higher price, their prices also vary inversely with their share in the monthly scallop landings (Table 13). For example, in 2006 the *average* annual price of U10 scallops was lower than the average annual prices of smaller scallops because of the changes in the seasonal composition of scallops. Table 13 shows that until May 2006, when U10 scallops comprised less than 15% of the total supply, their price exceeded the prices of smaller scallops. During the months of June and July of 2007, however, landings of U10 scallops increased dramatically, comprising respectively 43% and 66% of the total scallop landings during these months. This influx of U10s reduced their price below the price of smaller scallops. After the month of August, however, U10's once again commanded a price premium as their supplies declined below 8% of the total scallop landings.

Table 13. Composition of landings and ex-vessel price by market category in 2006

Data		Month												Total
	Market category	1	2	3	4	5	6	7	8	9	10	11	12	
% of Monthly landings	<=10 count	5%	5%	6%	10%	14%	43%	66%	16%	8%	6%	6%	5%	16%
	11-20 count	63%	75%	53%	56%	66%	49%	28%	78%	67%	51%	49%	37%	56%
	21-30 count	30%	19%	40%	34%	19%	8%	6%	6%	23%	42%	42%	52%	27%
	>30 count	2%	1%	1%	0%	1%	1%	0%	0%	1%	2%	3%	6%	2%
Price (in 2006 inflation adj. prices)	<=10 count	8.9	8.5	8.0	7.6	7.5	5.8	5.3	6.2	6.7	7.1	8.1	8.2	7.3
	11-20 count	8.2	8.0	7.4	7.1	7.4	6.5	5.6	6.0	6.2	6.2	6.8	7.9	6.9
	21-30 count	8.0	8.1	7.2	7.1	7.3	6.9	6.4	6.4	6.5	5.9	6.6	7.4	7.0
	>30 count	8.4	8.2	7.3	7.3	7.5	6.8	6.4	6.7	6.7	5.9	6.4	7.1	7.1

In addition to the changes in size composition and landings of scallops, other determinants of ex-vessel price include the level of imports, the import price of scallops, disposable income of seafood consumers, and the demand for U.S. scallops by other countries measured by the quantity of exports.

The price model presented below estimates annual average scallop ex-vessel price by market category (PEXMRKT) as a function of

- Meat count (MCOUNT)
- Average monthly price of all scallop imports (PIMPORT)
- Per capita monthly personal disposable income (PCDPI)
- Total monthly scallop landings (in million lb.)
- Total monthly exports (in million lb.)
- Percent share of landings by market category in total monthly landings (PCTLAND)
- A dummy variable for 2005 (D2005)
- Lagged ex-vessel price (PEXMRKT1)

Because relatively reliable data on scallop landings and revenue by meat count categories were mainly collected since 1999 through the dealers' database, this analysis includes the 1999-2007 period and four meat categories shown in Table 15. All the price variables are corrected for inflation and expressed in 2006 prices by deflating current levels by the consumer price index (CPI) for food. The ex-vessel prices are estimated in semi-log form to restrict the estimated price to positive values only as follows:

Log (PEXMRKT) = f(MCOUNT, PIMPORT, PCDPI, SCLAND, SCEXP, PCTLAND, D2005, PEXMRKT1)

The coefficients of this model are shown in Table 14. The estimated model provides a good fit to the actual data for annual ex-vessel prices as Figure 5 indicates. The F-test shows that the overall relation is statistically significant ($P<0.0001$), meaning that the explanatory variables as a whole have a significant influence on ex-vessel price. Adjusted R^2 indicates that changes in meat count, composition of landings by size of scallops, domestic landings net of exports, average price of all imports, disposable income, explain 88 percent of the variation in ex-vessel prices by market category. Figure 5 and Table 15 also verify that the estimated values of ex-vessel prices closely track the actual values.

Table 14. Estimates (GLM) for price model

Dependent Variable	LNPRICE
N	418
Multiple R	0.942
Squared Multiple R	0.887
Adjusted Squared Multiple R	0.885
Standard Error of Estimate	0.085

Analysis of Variance

Source	Type III SS	df	Mean Squares	F-ratio	p-value
Regression	23.179	8	2.897	400.832	0.000
Residual	2.956	409	0.007		

Regression Coefficients B = (X'X)$^{-1}$X'Y

Effect	Coefficient	Standard Error	Std. Coefficient	Tolerance	t	p-value
CONSTANT	0.707	0.128	0.000	.	5.521	0.000
PEXMRKT1	0.119	0.004	0.715	0.454	28.974	0.000
PIMPORT	0.039	0.005	0.142	0.712	7.219	0.000
MCOUNT	-0.002	0.000	-0.092	0.801	-4.951	0.000
PCTLAND	-0.099	0.019	-0.093	0.887	-5.253	0.000
PCDPI	0.003	0.001	0.075	0.259	2.296	0.022
SCLAND	-0.018	0.002	-0.164	0.570	-7.436	0.000
SCEXP	0.030	0.011	0.092	0.226	2.642	0.009
D2005ONLY	0.050	0.015	0.064	0.738	3.297	0.001

Figure 5. Estimated and predicted prices ex-vessel price of scallops

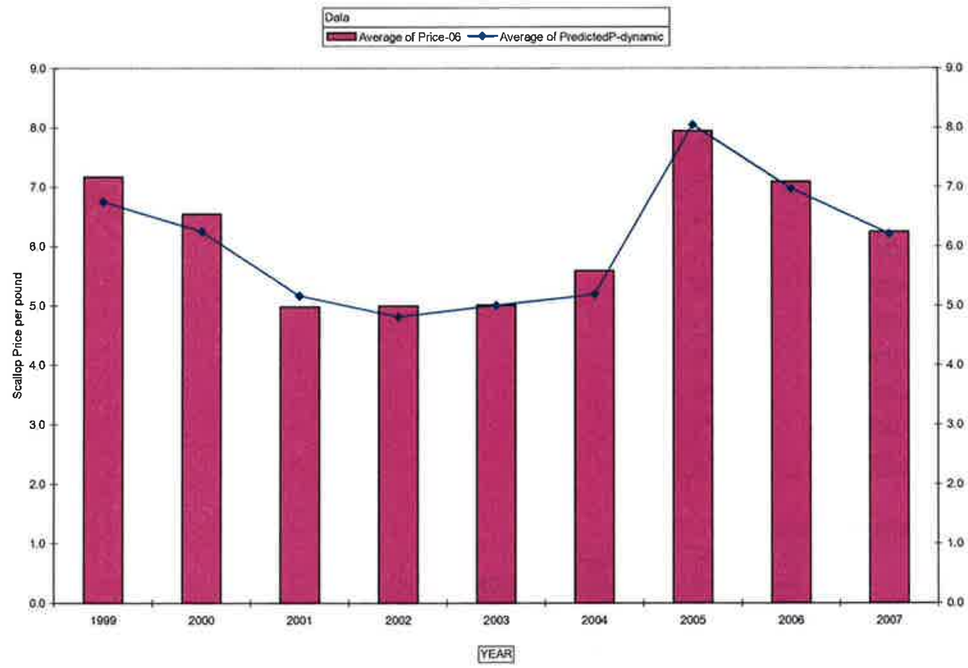


Table 15. Actual and predicted prices as an average of 1999-2007 monthly prices.

MARKETCAT	Price (06)	Predicted price (06)	% Difference of predicted from actual price
<=10 count	7.2	7.1	-1.4%
11-20 count	6.0	6.0	0.0%
21-30 count	5.8	5.6	-3.4%
>30 count	5.7	5.5	-3.5%
Grand Total	6.2	6.0	-1.4%

These numerical results should be interpreted with caution, however, since the analysis covers only 8 years of annual data from a period during which the scallop fishery underwent major changes in management policy including area closures, controlled access, and rotational area management.

A simulation model is constructed to analyze the impacts of the changes in the monthly composition of landings on annual prices. For example, Table 16 shows a rather extreme scenario when a major proportion of scallops (25%) are landed in March and April and the landings during the summer months are reduced by more than 50%. A simulation of prices based on the monthly price model indicates that the average annual price could have declined by as much as 9% (in 2005 for example) if such a shift in the seasonal composition of landings occurred. It must be cautioned, however, that the model assumes that the size composition of landings is independent of the amount of monthly landings --although the model could be used with different assumptions regarding the composition of scallops by market category for each month. It could be also possible to extend the model to include such changes in future research.

Table 16. Monthly composition of landings

Month	Simulation	Average for 1999-2006
1	3.05%	3.05%
2	3.89%	3.89%
3	25.00%	6.79%
4	25.00%	9.78%
5	10.00%	12.86%
6	5.00%	13.50%
7	5.00%	12.86%
8	5.00%	11.29%
9	5.00%	7.56%
10	5.00%	7.68%
11	5.00%	5.93%
12	3.06%	4.80%

Table 17. Change in annual prices

YEAR	SIMPRICE	Average of Predicted P-dynamic	Average of Annual land	% Change Price
1999	6.6	6.7	22.31	-1.2%
2000	6.0	6.1	32.24	-0.7%
2001	4.9	5.1	46.69	-4.4%
2002	4.5	4.7	52.67	-5.4%
2003	4.6	4.8	56.04	-3.6%
2004	4.7	5.1	64.19	-8.0%
2005	6.8	7.5	56.62	-9.4%
2006	6.3	6.5	58.94	-4.1%

2.3 ESTIMATION OF TRIP COSTS

Estimation of the trip costs for the entire fleet of vessels requires estimation of the costs for vessels for which there is no observer cost data. The annual trip costs per vessel are estimated using the multiple regression analysis shown in Table 18.

Data for variable costs, i.e., trip expenses include food, fuel, oil, ice, water and supplies. In addition, LPUE for the full-time fleet, including small dredges and scallop trawls, is included as an explanatory variable as a proxy for abundance. LPUE is the average annual scallop landings per DAS per full-time vessel excluding those vessels that have an average LPUE of less than 400 lb.

The trip costs per day-at-sea (TRPC06) is postulated to be a function of vessel crew size (CREW), vessel size in gross tons (GRT), fuel prices (FUELP), trip length (DA) and average LPUE for the fleet (LPUEFLT). This cost equation was assumed to take a double-logarithm form and estimated with data obtained from observer database. The empirical equation presented in Table 18 verifies the postulated hypothesis and has proper statistical properties.

Table 18. Trip costs per DAS regression coefficients

Ordinary Least Squares Estimation

Model	lntrpc06
Dependent Variable	lntrpc06

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	87.24592	17.44918	127.47	<.0001
Error	419	57.35736	0.136891		
Corrected Total	424	144.6033			

Root MSE	0.36999	R-Square	0.60335
Dependent Mean	6.74380	Adj R-Sq	0.59861
Coeff Var	5.48634		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	4.675419	0.492682	9.49	<.0001
lngrt	1	0.305071	0.051137	5.97	<.0001
lncrew	1	0.862284	0.086305	9.99	<.0001
lnfuelp	1	0.995525	0.066177	15.04	<.0001
lnLPUEFLT	1	-0.23771	0.059468	-4.00	<.0001
lnda	1	0.167628	0.031358	5.35	<.0001

Durbin-Watson	1.721726
Number of Observations	425
First-Order Autocorrelation	0.139033

2.4 ESTIMATION OF FIXED COSTS

The fixed costs include those expenses that are not usually related to the level of fishing activity or output. These are insurance, maintenance, license, repairs, office expenses, professional fees, dues, utility, interest, and dock expenses. The expenses on insurance, maintenance, repairs and replacement of engine, electrical and processing equipment, gear and other equipment are obtained from the observer data. Observer data does not include expenses in license, professional fees, dues, utility, interest and dock expenses. In the estimation of profits, allowance was made for these items using the results of a study conducted by Daniel Georgianna et.al (1999).

The expenses on insurance, maintenance, repairs and replacement of engine, electrical and processing equipment, gear and other equipment are estimated using the following equation and total fixed costs as a function of vessel HP, length and crew size (affects liability insurance, and another proxy for vessel size).

Table 19. Fixed cost equation

The SYSLIN Procedure
Ordinary Least Squares Estimation

Model	lnfixedc
Dependent Variable	lnfixedc06n

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	47.63714	15.87905	42.76	<.0001
Error	283	105.0846	0.371324		
Corrected Total	286	152.7218			

Root MSE	0.60936	R-Square	0.31192
Dependent Mean	11.58883	Adj R-Sq	0.30463
Coeff Var	5.25820		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.248892	1.001379	3.24	0.0013
lnhp	1	0.515738	0.127651	4.04	<.0001
lnlen	1	1.032715	0.320903	3.22	0.0014
lncrew	1	0.253544	0.113418	2.24	0.0262

Durbin-Watson	1.842343
Number of Observations	287
First-Order Autocorrelation	0.074984

2.5 GROSS PROFITS

As it is well known, the net income and profits could be calculated in various ways depending on the accounting conventions applied to gross receipts and costs. The gross profit estimates used in the economic analyses in the FSEIS simply show the difference of gross revenue over variable (including the crew shares) and fixed expenses rather than corresponding to a specific accounting procedure. It is in some ways similar to the net income estimated from cash-flow statements since depreciation charges are not subtracted from income because they are not out-of-pocket expenses.

Gross profits per vessel are estimated as the boat share (after paying crew shares) minus the fixed expenses such as maintenance, repairs and insurance (hull and liability). This may be an overestimate of the gross profits since estimated fixed costs do not include other costs such as loan payments, transportation costs, office expenses, professional fees and accounting, dock fees or taxes because these items are not included in the observer cost data. According to a study by Daniel Georgianna et.al (1999), these other costs excluding loan payments amounted to about $33,000 in 1997, or about 41,600 in 2006 prices for scallopers greater than 70 feet in length. According to the cost model, estimates for the same group of total fixed costs including insurance, maintenance and repairs averaged to $136,500 for the same year for the same group of vessels (i.e., in 1997, in terms of 2006 prices). Adding these other cost items ($41,600) would increase the total costs by about 30% to $178,100. In order to calculate the effect of other items on profits, adjusted profits are calculated for all vessels with the fixed costs adjusted upwards by 30%. This assumption has the limitation, however, that these cost items may not be 30% of the overall fixed costs for each vessel. There was no separate data on these cost items (office expenses, professional fees and accounting, dock fees or taxes) for the medium and small vessels, however. Therefore, values of adjusted profits should be interpreted with caution indicating, at the best, the level of profits if all other fixed costs were underestimated by 30%.

2.6 CONSUMER SURPLUS

Consumer surplus measures the area below the demand curve and above the equilibrium price. For simplicity, consumer surplus is estimated here by approximating the demand curve between the intercept and the estimated price with a linear line as follows:

CS= (PINT*SCLAN-EXPR*SCLAN)/2

$$PVCS = \sum_{t=2000}^{t=2008} (CS_t / (1+r)^t)$$

Where: r=Discount rate.

CS_t= Consumer surplus at year "t" in 1996 dollars.

PVCS= Present value of the consumer surplus in 1996 dollars.

EXPR= Ex-vessel price corresponding to landings for each policy option.
PINT=Price intercept i.e., estimated price when domestic landings are zero
SCLAN= Sea scallop landings for each policy option.

Although this method may overestimate consumer surplus slightly, it does not affect the ranking of alternatives in terms of highest consumer benefits or net economic benefits.

2.7 PRODUCER SURPLUS

The producer surplus (PS) is defined as the area above the supply curve and the below the price line of the corresponding firm and industry (Just, Hueth & Schmitz (JHS)-1982). The supply curve in the short-run coincides with the short-run MC above the minimum average variable cost (for a competitive industry). This area between price and the supply curve can then be approximated by various methods depending on the shapes of the MC and AVC cost curves. The economic analysis presented in this section used the most straightforward approximation and estimated PS as the excess of total revenue (TR) over the total variable costs (TVC). It was assumed that the number of vessels and the fixed inputs would stay constant over the time period of analysis. In other words, the fixed costs were not deducted from the producer surplus since the producer surplus is equal to profits plus the rent to the fixed inputs. Here fixed costs include various costs associated with a vessel such as depreciation, interest, insurance, half of the repairs (other half was included in the variable costs), office expenses and so on. It is assumed that these costs will not change from one scenario to another.

PS=EXPR*SCLAN- ΣOPC
ΣOPC = Sum of operating costs for the fleet.

$$PVPS = \sum_{t=2000}^{t=2008} (PS_t / (1+r)^t)$$

Where: r=Discount rate.
PS_t= Producer surplus at year "t" in 1996 dollars.
PVPS= Present value of the producer surplus in 1996 dollars.
SCALN= Sea scallop landings for each policy option.
EXPR= Price of scallops at the ex-vessel level corresponding to landings for each policy option in 1996 dollars.

Producer Surplus also equals to sum of rent to vessels and rent to labor. Therefore, rent to vessels can be estimated as:

RENTVES=PS – CREWSH

Rentves= Quasi rent to vessels
Crewsh= Crew Shares

2.8 TOTAL ECONOMIC BENEFITS

Total economic benefits (TOTBEN) is estimated as a sum of producer and consumer surpluses and its value net of status quo is employed to measure the impact of the management alternatives on the national economy.

TOTBEN=PS+CS

Present value of the total benefits= PVTOTBEN= PVPS+PVCS

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