

Reducing Chinook Salmon Bycatch with Individual Tradable Encounter Credits (ITEC) and The Legacy Market-Incentive Program

How Legacy Allocations and Trading of
ITEC satisfy the C-2 Motion PPA
requirements for an Inter-Cooperative
Agreement

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ICA requirements to participate in the
68,392 hard cap scenario
(as specified in the PPA)

1. An ICA must provide *incentive(s)* for each vessel to avoid salmon bycatch under any condition of pollock and salmon *abundance* in all years.
2. Incentive measures must include rewards for salmon bycatch avoidance and/or penalties for failure to avoid salmon bycatch *at the individual vessel level.*

ICA requirements to participate in the
68,392 hard cap scenario
(as specified in the PPA)

3. The ICA must specify how those incentives are expected to promote reductions in actual individual vessel bycatch rates relative to what would have occurred in the absence of the incentive program. Incentive measures must promote salmon savings in any condition of pollock and salmon abundance, and *influence operational decisions at bycatch levels below the hard cap.*

Summary of the C-2 Motion PPA Incentive Requirements

- 1) Provide incentives at the individual vessel level.
- 2) Reward vessels that successfully avoid Chinook and/or penalize vessels that fail to avoid chinook.
- 3) Incentivize vessels to avoid Chinook bycatch at all levels of abundance in all years.
- 4) Incentives must influence fishing decisions at levels below the hard cap.

Background: Why Hardcaps Need C-2

Are fixed hardcaps alone sufficient for managing bycatch?

1. The key problem is that chinook encounters are highly variable from year to year.
2. A fixed hardcap penalizes the Pollock industry most when the Chinook populations are likely to be most abundant. It does not protect Chinook when they are least abundant (i.e., when Chinook salmon populations are most vulnerable). Thus a hardcap alone without an incentive plan is a bad solution for everyone.
3. Thus, an incentive plan as in C-2 is required

Background: How Big Should Incentives be?

Q: How to scale Incentives?

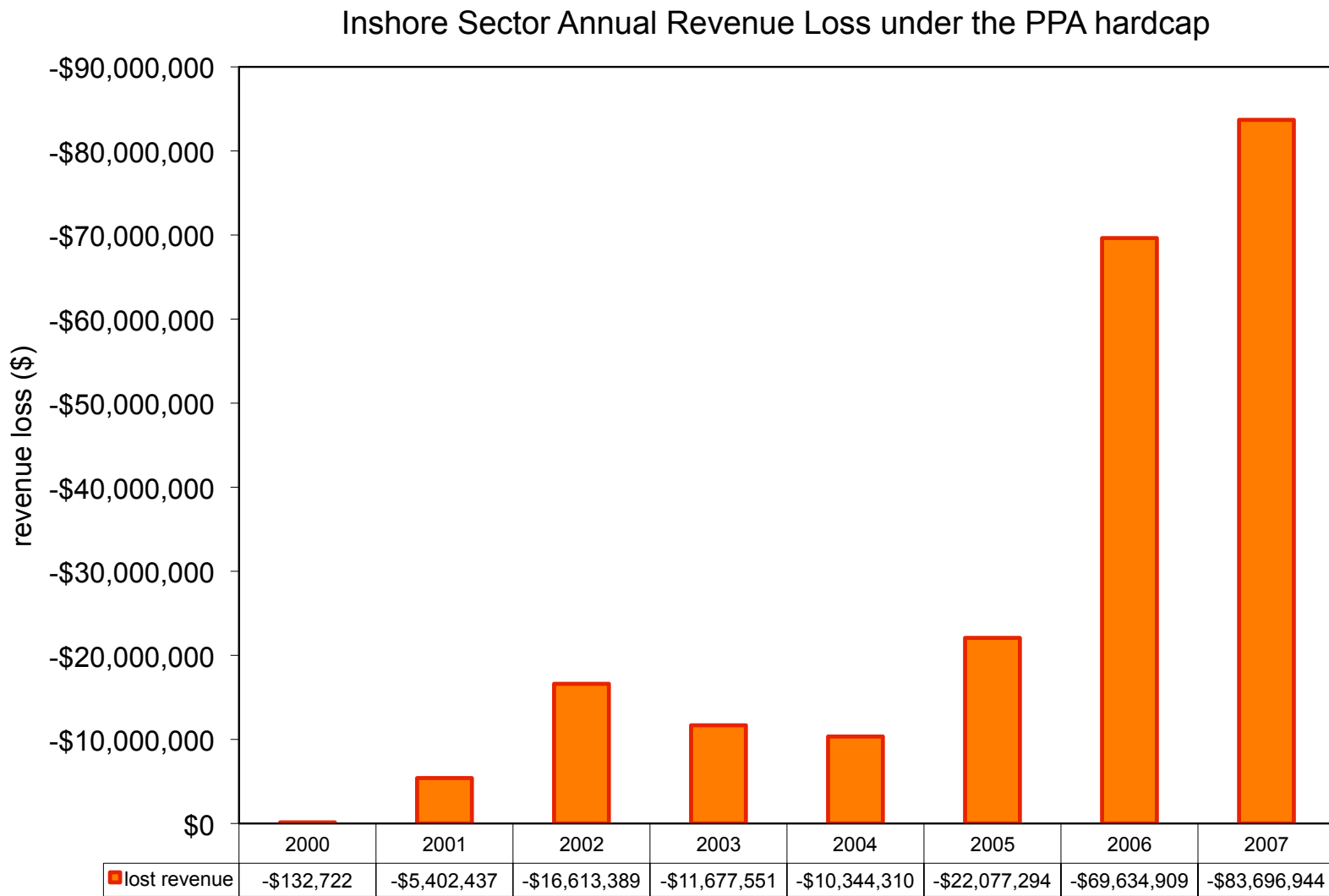
A: By the real costs of bycatch to the industry

Background: Cost of bycatch to the Pollock Industry

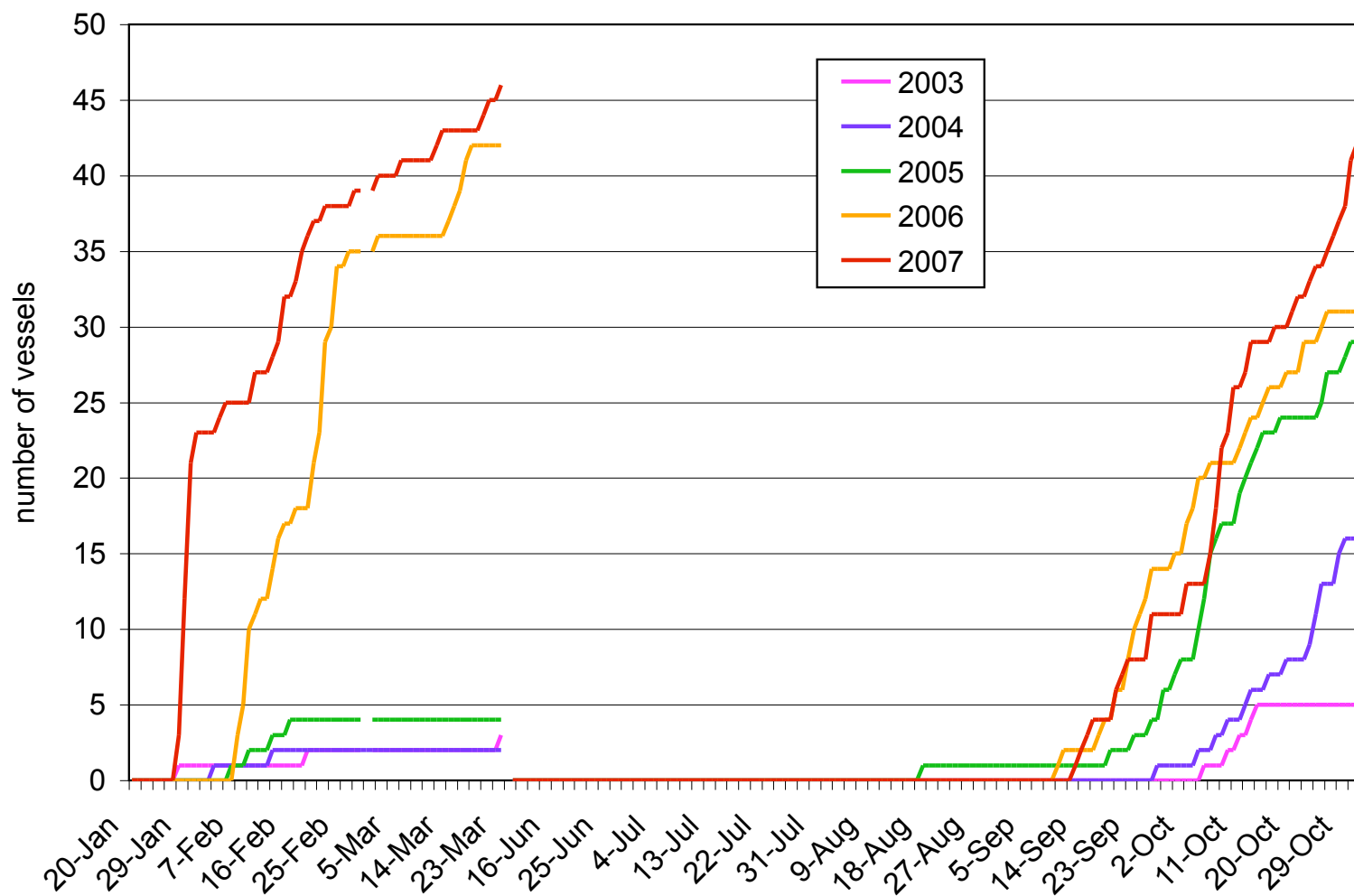
What is the TRUE COST of chinook bycatch to the pollock industry under the PPA hardcap of 68,392?

These costs should be reflected in the penalties and rewards of the incentive system

Without additional incentives or ITEC trading the cost to industry of the PPA hardcap (68,392) is high



Vessels run out of credits under the 68,392 PPA hardcap even in low and moderate abundance years



Even in low encounter periods many vessels run out of credits under the PPA Hardcap

year	# of Inshore sector vessels that run out of credits
2003	11
2004	33
2005	37
2006	54
2007	56

Cost of Bycatch to Pollock Industry

1. The “real cost” of Chinook Salmon bycatch under a hardcap is the value of the forgone Pollock left unharvested.
2. These costs can be considerable.
3. A good incentive plan should reflect these real costs and not be based on penalties and rewards that are arbitrarily set (and easily nullified).

Components of the Recommended Market-Incentive Program

1. Legacy Allocation Component

- Reallocates ITEC annually from high bycatch vessels to cleaner vessels. Creates inter-annual accountability.

2. Transfer Component

- Regulates trading. Enhances allocation and trading incentives (penalties/rewards) during low encounter times.

(Buy-side Limit, Dynamic Salmon Savings)

Legacy Allocation

1. Sectors are given fixed seasonal allocations of ITEC as specified in the PPA.
2. ITEC are distributed to *individual vessels* via the coops according to a uniform ITEC allocation formula. This formula adjusts allocations to reward low bycatch and penalize high bycatch.
3. The ITEC allocation formula is designed to distinguish consistent good/bad behavior from random noise. (i.e. chance encounters)

Legacy Allocation (cont'd)

4. Vessels that run out of ITEC must stop fishing. They can resume fishing only after buying sufficient ITEC to cover expected fishing activity.
 - Efficient vessels with surplus credits can earn additional revenue by selling them.
 - Vessels with high bycatch rates may need to purchase additional credits from clean vessels (if they are willing to sell) when they run out.

Rewards and Penalties associated with Legacy Allocation (per C-2)

1. ITEC allocations are adjusted based on individual vessel bycatch performance:
 - vessels with low bycatch rates are rewarded with increased ITEC allocation.
 - vessels with high bycatch rates are penalized with decreased allocation.

Incentives associated with Legacy Allocation

1. The Legacy Allocation rewards (and punishes) consistent good/bad behavior.
 - Vessels need to continue to have lower-than-average bycatch to maintain the same level of increased ITEC allocation.
2. Increased ITEC allocation acts as insurance against running out of credits in moderate- and high-encounter years.
3. Some vessels run out of credits even in low-encounter years.

Even in low encounter periods many vessels run out of credits under the PPA Hardcap

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Uniform ITEC Allocation Formula:

determines proportional credits allotments

$$P_t = 1/3 + 1/3 P_{t-1} + 1/3 Q_{t-1}$$

The diagram illustrates the components of the ITEC allocation formula. Three arrows point from descriptive text below to specific terms in the equation above:

- An arrow points from "constant factor (pollock)" to the first $1/3$ term.
- An arrow points from "“legacy” component (bycatch track record)" to the P_{t-1} term.
- An arrow points from "bycatch function (penalty/reward)" to the Q_{t-1} term.

ITEC allocations are done pro-rata to pollock quota

How it works

The legacy allocation rule is designed to minimize the effect of chance encounters (bad luck) in any year putting more credits at the disposal of consistent good players.

- This creates incentive for consistent good performance.

- This reduces fleet bycatch cumulatively through time.

- Incentives are the same every year, from the start.

Legacy Incentive: Insurance

1. During years of moderate to high-encounter:
 - Many vessels run out of credits, so vessels may not be able to augment initial allocations through purchases.
 - High-bycatch vessels with reduced ITEC allocation will run out of credits sooner: unfished Pollock can represent a major loss in revenue.
 - Low-bycatch vessels with increased ITEC allocation can complete more of its Pollock harvest: the extra Pollock can represent a major gain in revenue.

Magnitude of Legacy Incentives

1. With extra legacy credits from fishing cleanly in 2003 and 2004, these vessels were able to capture significant additional revenue in 2005.

Vessel	2005 credits gained/lost	Net Gain/Loss due to Legacy Reallocation
L	0	\$0.00
W	11	\$53,223.77
R	24	\$116,146.40
B	9	\$43,554.90

Magnitude of Legacy Incentives

1. The costs of unfished Pollock under the PPA hard cap can be considerable for the Inshore sector.
2. Legacy Allocation redistributes ITEC to cleaner, more efficient vessels that can harvest more pollock for each ITEC.

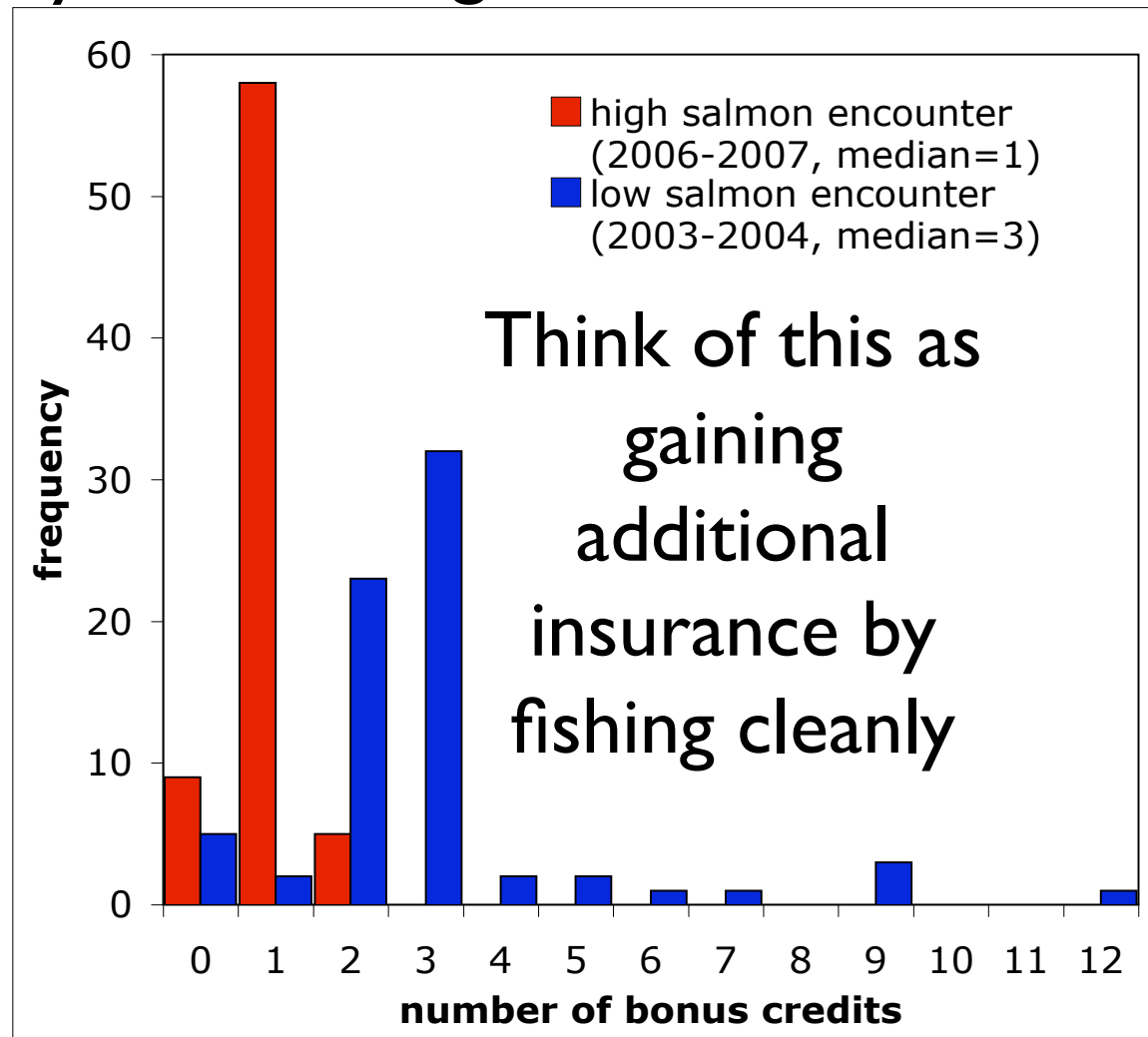
Vessel	2007 credits gained/lost	Net Gain/Loss due to Legacy Reallocation
L	(21)	(\$58,184.09)
W	17	\$47,101.41
R	35	\$96,973.49
B	(29)	(\$80,349.46)

Legacy Allocation during years of low salmon encounter

1. Reducing bycatch during low-encounter years has a larger effect on increasing ITEC allocation. Thus, incentives to reduce bycatch are stronger during low encounter times.
2. Reducing bycatch by 10 salmon in 2006 (a high encounter year) increases ITEC allocation by an average of 1.11 credits in 2007.
3. Reducing bycatch by 10 salmon in 2003 (a low encounter year) increases ITEC allocation by an average of 2.84 credits in 2004.

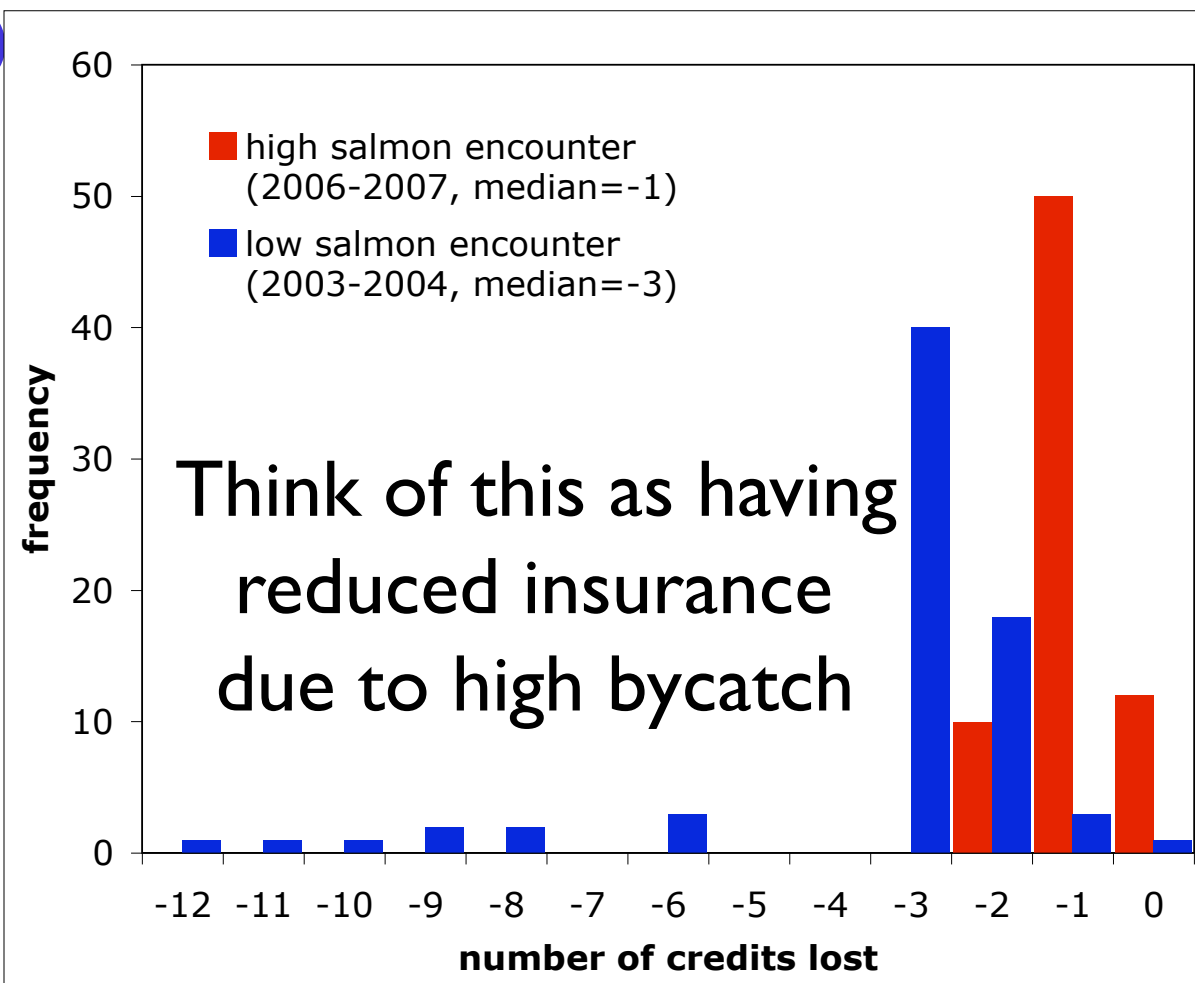
- Legacy Program

Individual Vessel Incentives - Rewards: There is more reward incentive to avoid bycatch during low chinook salmon encounter years (blue).



• Legacy Program

Individual Vessel Incentives - Penalties: Every vessel's future allocation of ITEC is at risk of being reduced if their relative performance is poor. This penalty is greater during low salmon encounter years (blue)



Legacy Allocation during years of low salmon encounter

4. Therefore, the incentive to reduce bycatch is roughly 3x higher during low-encounter years
5. Increased ITEC allocation can be worth up to ~\$7k/credit in Pollock revenue.

Summary: Legacy ITEC Reallocation

1. Legacy Allocation redistributes credits towards more efficient vessels with low bycatch that can maximize Pollock harvest with respect to salmon bycatch.
 - This increases the amount of Pollock that can be harvested in years in which the fleet runs against the hardcap (2005, 6, 7).
 - This provides incentive for vessels to reduce bycatch in low and moderate encounter years in order to maintain (or increase) ITEC allocation to avoid foregoing Pollock.

Legacy Market-Incentive Program

2 Components:

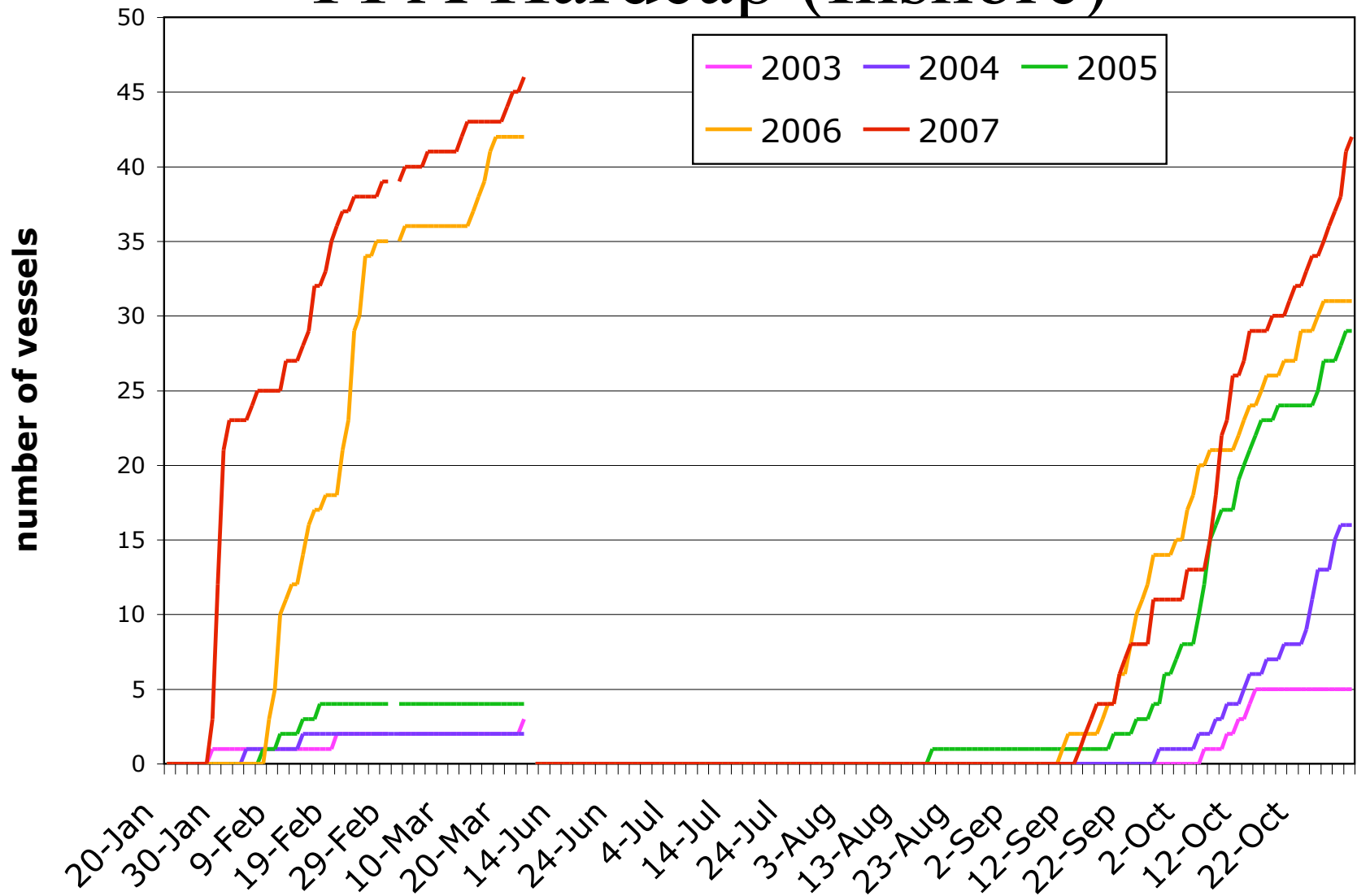
1. Legacy Allocations

2. Transfer Rules (trading rules)

Trading is Necessary Under the PPA hard cap

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Vessels Run Out of Credits Under the PPA Hardcap (Inshore)



Why have transfer rules?

During years of low salmon encounter, a high hard cap may result in an oversupply of ITEC for available for sale. This oversupply will tend to lower credit prices and diminish short-term trading incentives.

Solution:

Create transfer rules to prevent potential abuse, control supply, and strengthen the long-term incentives of Legacy Allocation.

Transfer Rules

1. Buy-Side Transfer Limit

- Vessels may only purchase a fixed fraction of their initial ITEC allocation. (prevents hoarding and abuse)

2. Dynamic Salmon Savings Rule

- Controls supply of ITEC by setting credits aside “Salmon Savings.”
- Adaptive to the level of salmon abundance.

Transfer Rules

1. Transfers occur between individual vessels (per C-2).
2. Transfer Rules amplify vessel-level incentives (per C-2).

Transfer Rules

- prevent abuse (hoarding) of abundant credits during low-encounter years
- increase short-term trading incentives (especially in low-encounter years) (C-2)
- increase the strength of long-term incentives created by Legacy Allocation (C-2)

Buy-Side Transfer Limit

1. Consider a limit of $\frac{1}{3}$: vessels may only purchase up to $\frac{1}{3}$ of their annual allocation.
2. A vessel that is allocated 300 credits for the year (for A and B seasons combined) can only purchase a total of 100 additional credits from other vessels willing to sell them.
3. Lease Provision: If the vessel then leases an amount of pollock equal to its original allocation (doubling the amount of pollock), the number of credits it may buy (if available) is also doubled to 200 credits.

Rewards and Penalties associated with Buy-Side Transfer Limits

1. The number of credits a vessel may buy moves in tandem with its ITEC allocation:
 - Vessels with low bycatch rates are rewarded with increased buy-side limits. (in addition to an increased ITEC allocation)
 - Similarly, vessels with high bycatch rates are penalized with decreased limits.

Dynamic Salmon Savings (DSS)

1. Adaptive to Chinook abundance and evens out the supply of saleable credits.
2. Limits the supply of ITEC during low encounter years (when salmon stocks are most vulnerable).
3. Does not hamper vessel's ability to use full ITEC allocation if needed.

Dynamic Salmon Savings (DSS)

1. When vessels finish fishing in the B season, some credits are “set aside or saved”.
2. The percentage of credits “saved” is the Salmon Savings Rate (SSR).
3. The SSR is computed such that the sector has enough credits to harvest the remaining pollock.
4. Prior to the determination of an SSR, credit transactions are governed by a Provisional Salmon Savings Rule (like tax withholding).

Provisional Salmon Savings Rule (PSSR)

1. Prior to finishing fishing, (and having credits retired) vessels may still transfer credits.
2. The appropriate number of credits are set aside to cover eventual retirement. (PSSR is similar to tax withholding)
3. This number (PSSR) is determined by the maximum SSR before the SSR has been calculated.
4. This rule prevents avoidance of Dynamic Salmon Savings by selling credits before they can be retired.

Provisional SSR Example

1. Suppose the maximum SSR is 40%.
2. Provisional SSR = maximum SSR = 40%.
3. Thus, if a vessel wishes to sell 60 credits before the SSR is set, it must set aside 40 ITEC in reserve.
4. If the SSR is set to 40%, all 40 reserve credits are retired.
5. If the SSR is less than 40%, some of the 40 reserve credits are returned.

Calculating a Salmon Savings Rate

1. The Salmon Savings Rate (SSR) is computed using an estimate of the number of credits needed to fish the Pollock allocation.
2. This estimate can be made accurately when $\frac{2}{3}$ of the B season Pollock allocation is caught (cf Sugihara 1994) .
3. The SSR corresponds to the number of credits that are not needed to finish fishing the Pollock allocation.

Calculating a Salmon Savings Rate

4. A maximum SSR provides an upper bound on the SSR. It is the “withholding maximum” that determines the Provisional Salmon Savings Rate. It should be set so that the resulting PSSR does not prohibit required credit transactions.
 - A maximum SSR set too high can make credits too expensive for vessels that need to buy ITEC before the SSR can be computed.

Calculating a Salmon Savings Rate

	A	B	C	D	E	F
2000	16-Sep	37001	254	7540	29461	79.6%
2001	11-Sep	31578	277	7770	23808	75.4%
2002	5-Sep	24955	1655	21550	3405	13.6%
2003	2-Sep	24318	256	7560	16758	68.9%
2004	31-Aug	25859	1890	23900	1959	7.6%
2005	29-Aug	21122	4142	46420	-25298	0.0%
2006	10-Sep	12182	3591	40910	-28728	0.0%
2007	2-Sep	14848	1465	19650	-4802	0.0%

A = date when 2/3 Pollock caught

B = sector credits remaining (including 100% carry-forward from A season)

C = bycatch caught (up to the date in A)

D = predicted season bycatch + buffer

E = estimated surplus credits

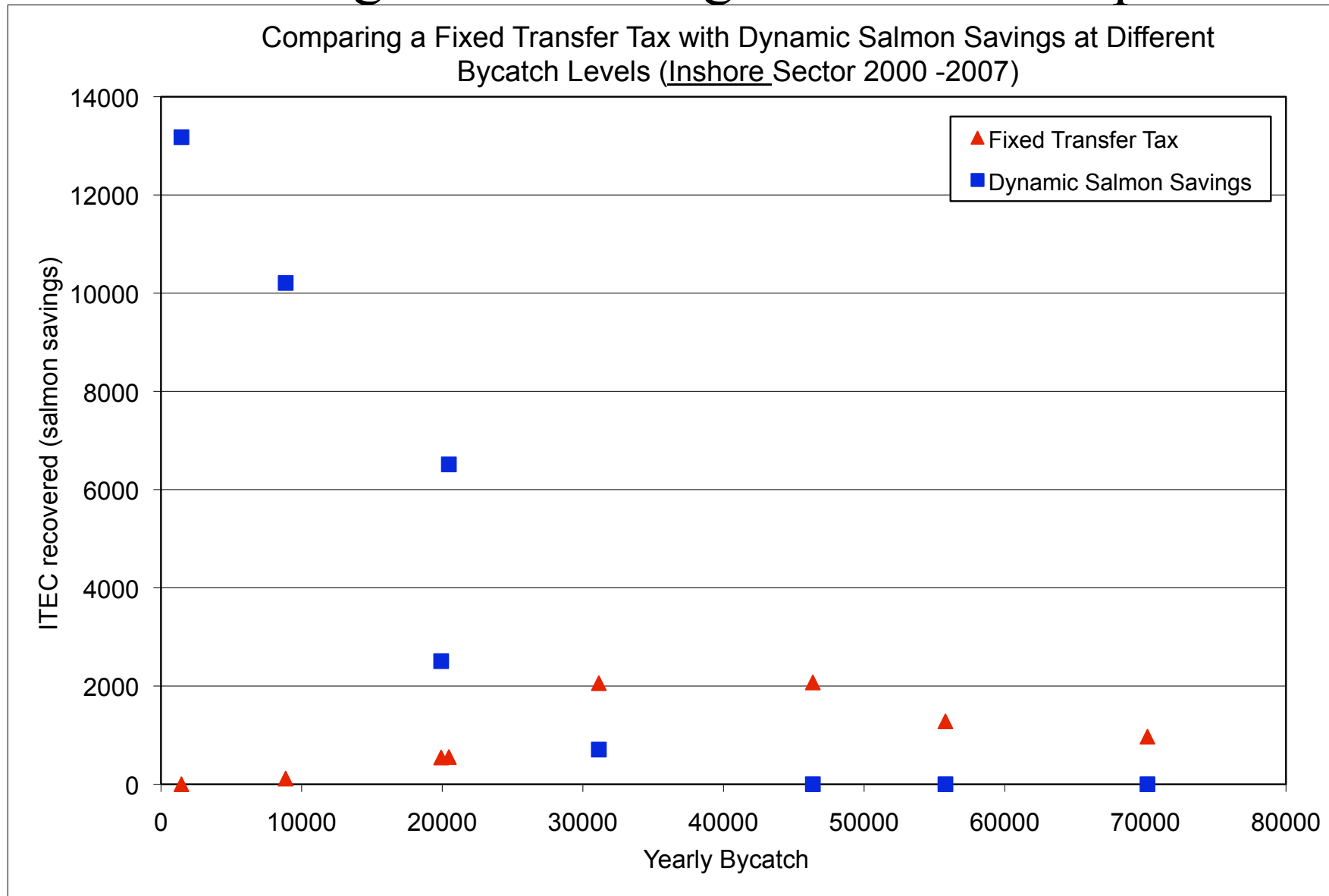
F = allowable salmon savings rate

Dynamic Salmon Savings during years of low salmon encounter

1. The effective supply of credits is reduced most strongly during years of low salmon encounter.
 - This increases the value of ITEC and strengthens short-term trading incentives.
 - Provisional Salmon Savings: withholding tax on A-season and early B-season sales.
2. During these times, large numbers of credits may be retired (equivalent to a lowered hard cap), without affecting the ability of the Pollock Industry to harvest its full pollock TAC.

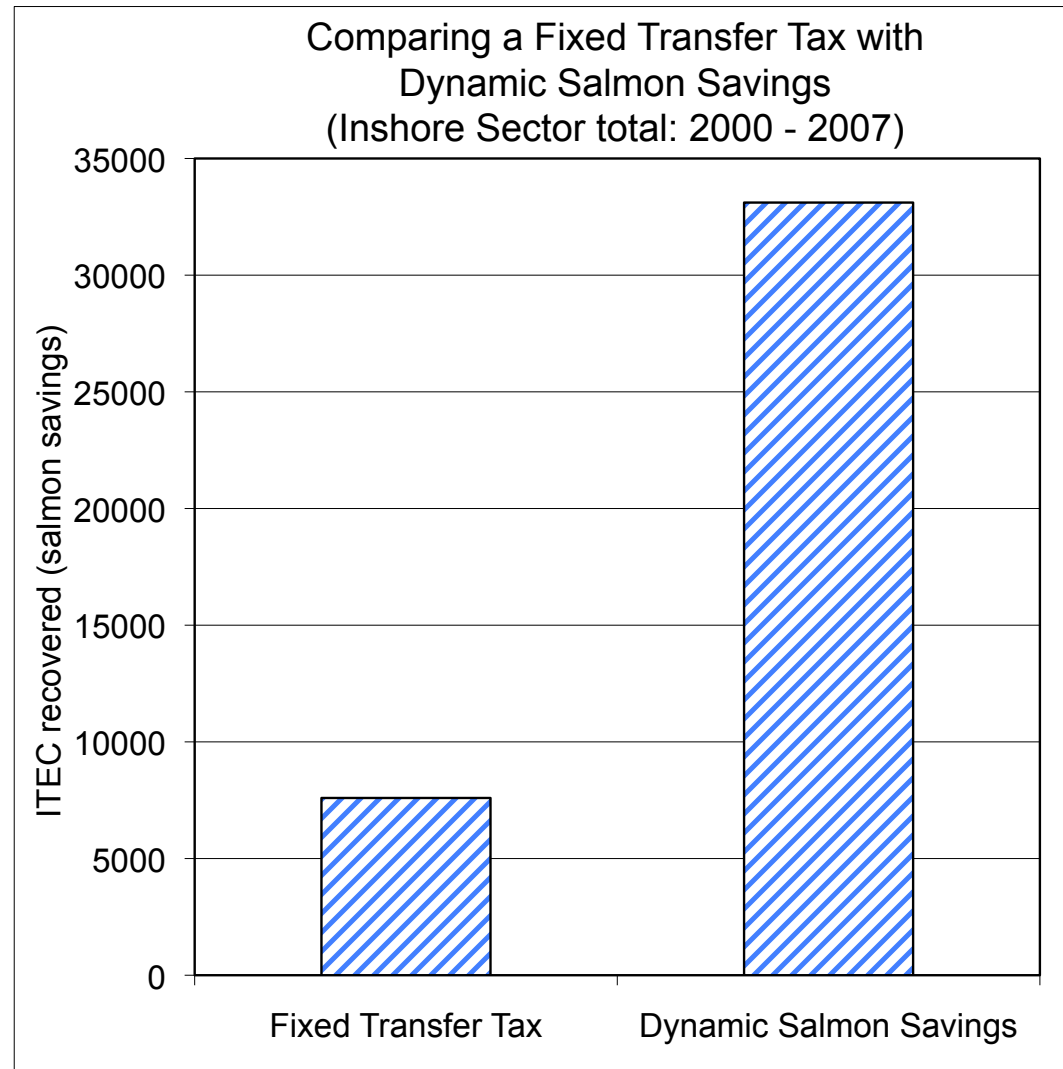
Dynamic Salmon Savings

More savings occur during low encounter periods



Dynamic Salmon Savings

1. Over an 8-year period, DSS “saved” over 4 times as many credits as a fixed transfer tax of 20%.
 - DSS: 33,111
 - Tax: 7,596



Rewards and Penalties associated with Dynamic Salmon Savings

1. The value of ITEC is increased by Dynamic Salmon Savings.
 - Efficient vessels with low bycatch rates are rewarded with additional revenue from selling more expensive credits.
 - Inefficient vessels with high bycatch rates are penalized by having to pay higher prices for ITEC.

Incentives associated with Dynamic Salmon Savings

1. The supply of credits affects short-term trading incentives to avoid bycatch: an overabundance of credits can reduce the strength of these incentives during years of low encounter.
2. Dynamic Salmon Savings regulates the supply of credits so that the short-term trading incentives to avoid bycatch are maintained at all levels of abundance. (per C-2)

Overview of the Recommended Market-Incentive Program

1. Legacy Allocation Component (long-term)
 - reallocates ITEC based on bycatch performance
 - Promotes consistent good behavior and inter-annual accountability (track record).
2. Transfer Component (long- and short-term)
 - buy-side transfer limits
 - Dynamic Salmon Savings (DSS)
 - enhances allocation and trading incentives

Summary: C-2 Checklist (see Table)

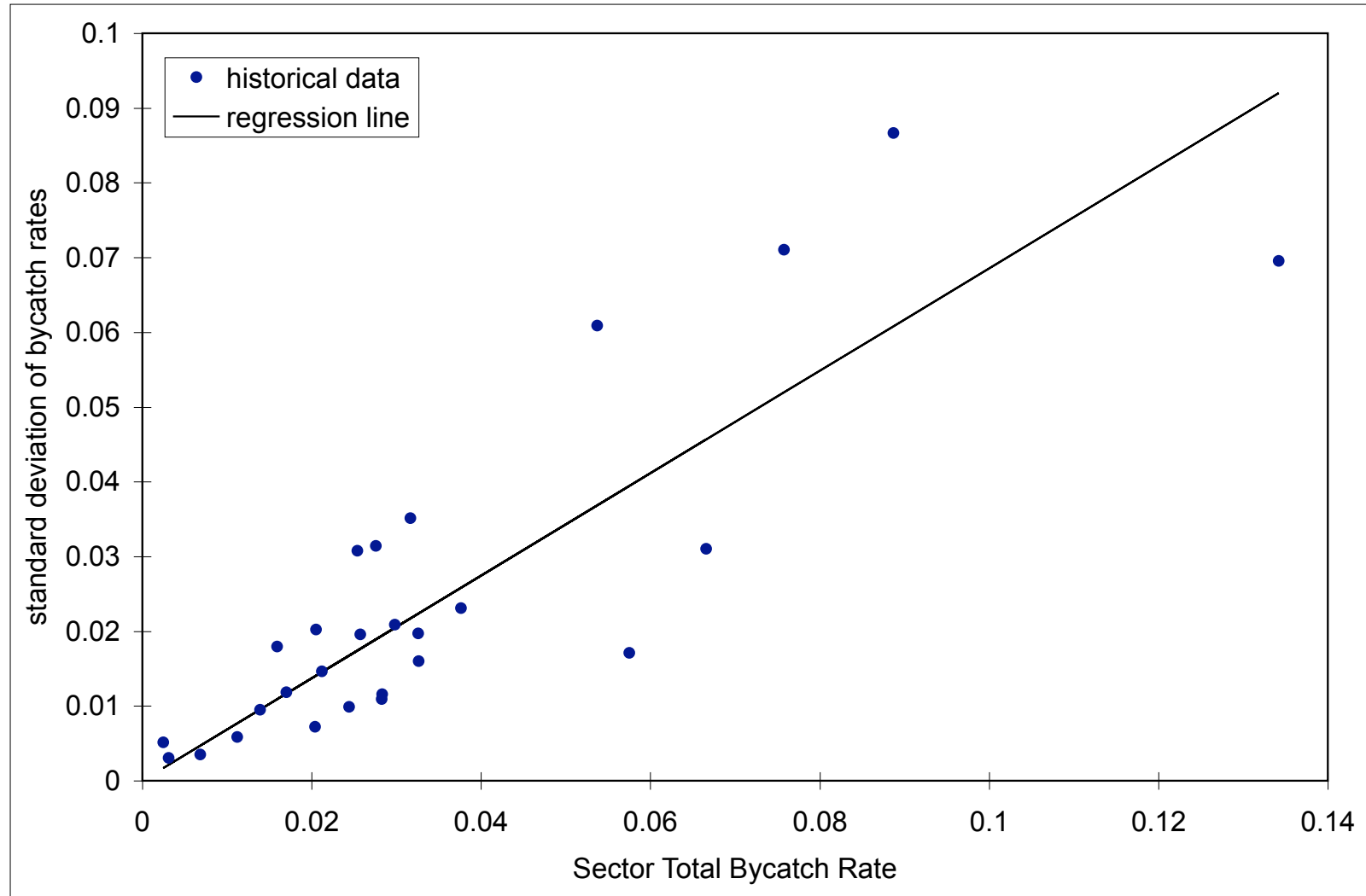
1. The Legacy Market-Incentive Program creates incentives for individual vessels.
2. Vessels are rewarded for low bycatch rates and penalized for high bycatch rates.
3. Vessels are incentivized to reduce bycatch in all years at all levels of salmon encounter.
 - These incentives are both short-term (trading) and long-term (cumulative insurance).
 - Both legacy and transfer components have a stronger effect during years of low salmon encounters.

END

Calculation of Modified Z-Scores

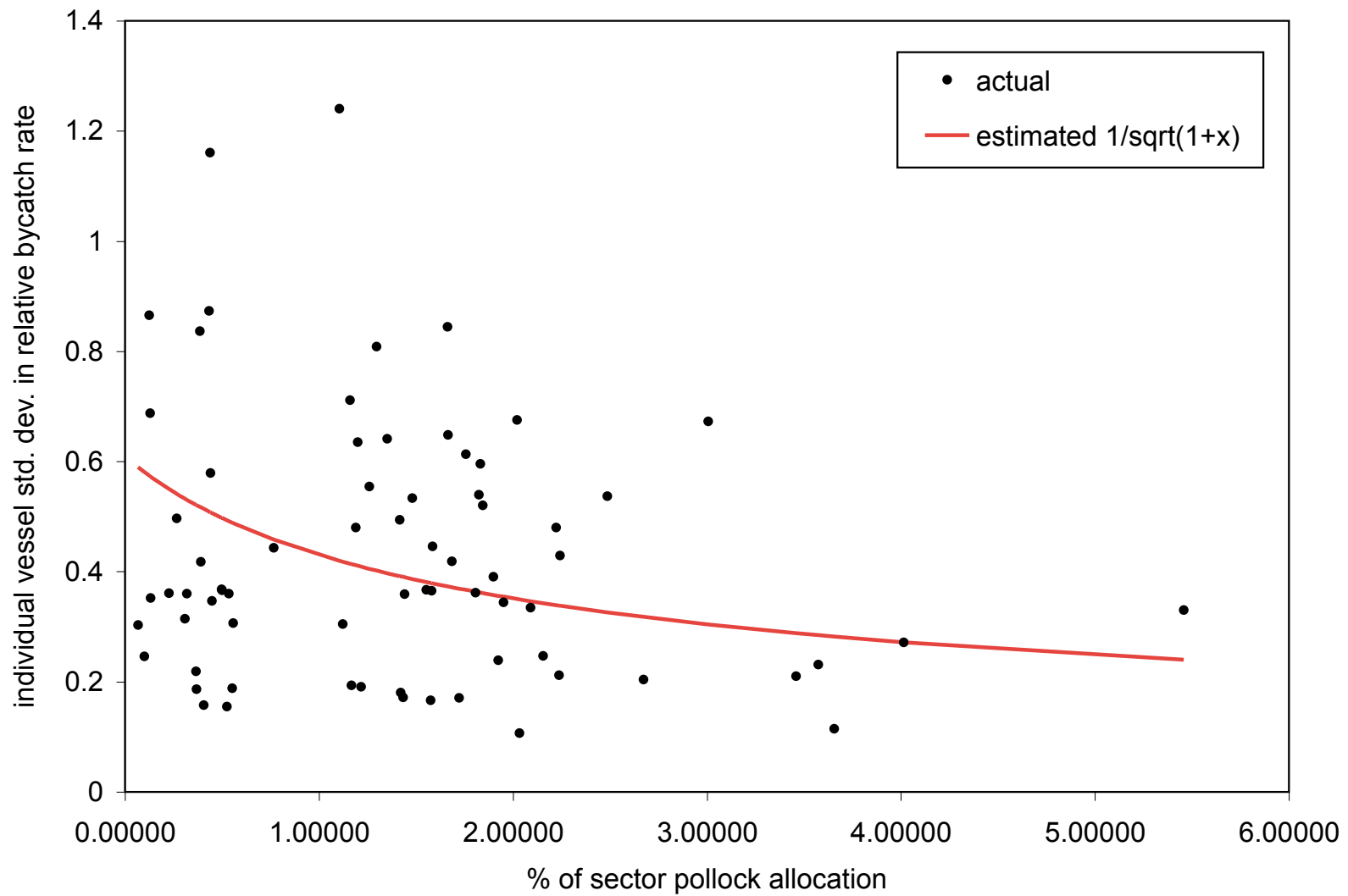
1. variance in bycatch rates is higher in years of high encounter:
 - Z-scores are computed using an estimated standard deviation based on historical data:
2. Smaller vessels experience more noise than larger vessels:
 - standard deviations are adjusted for vessel size
 - for companies owning multiple vessels, adjustments are done based on the total

Estimated Standard Deviation



Analysis by Karl Haflinger, Sea State Inc.

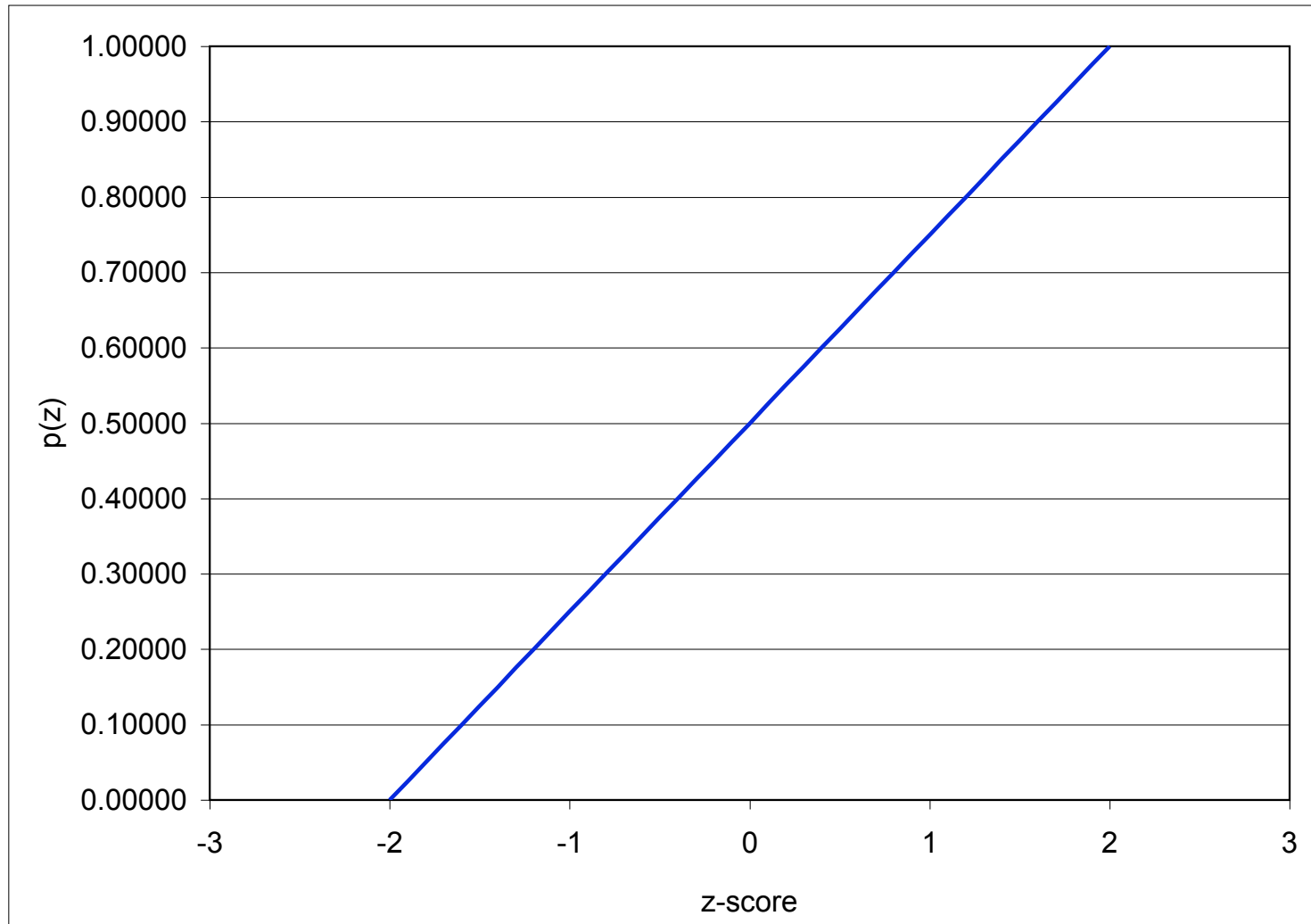
Effect of Vessel Size



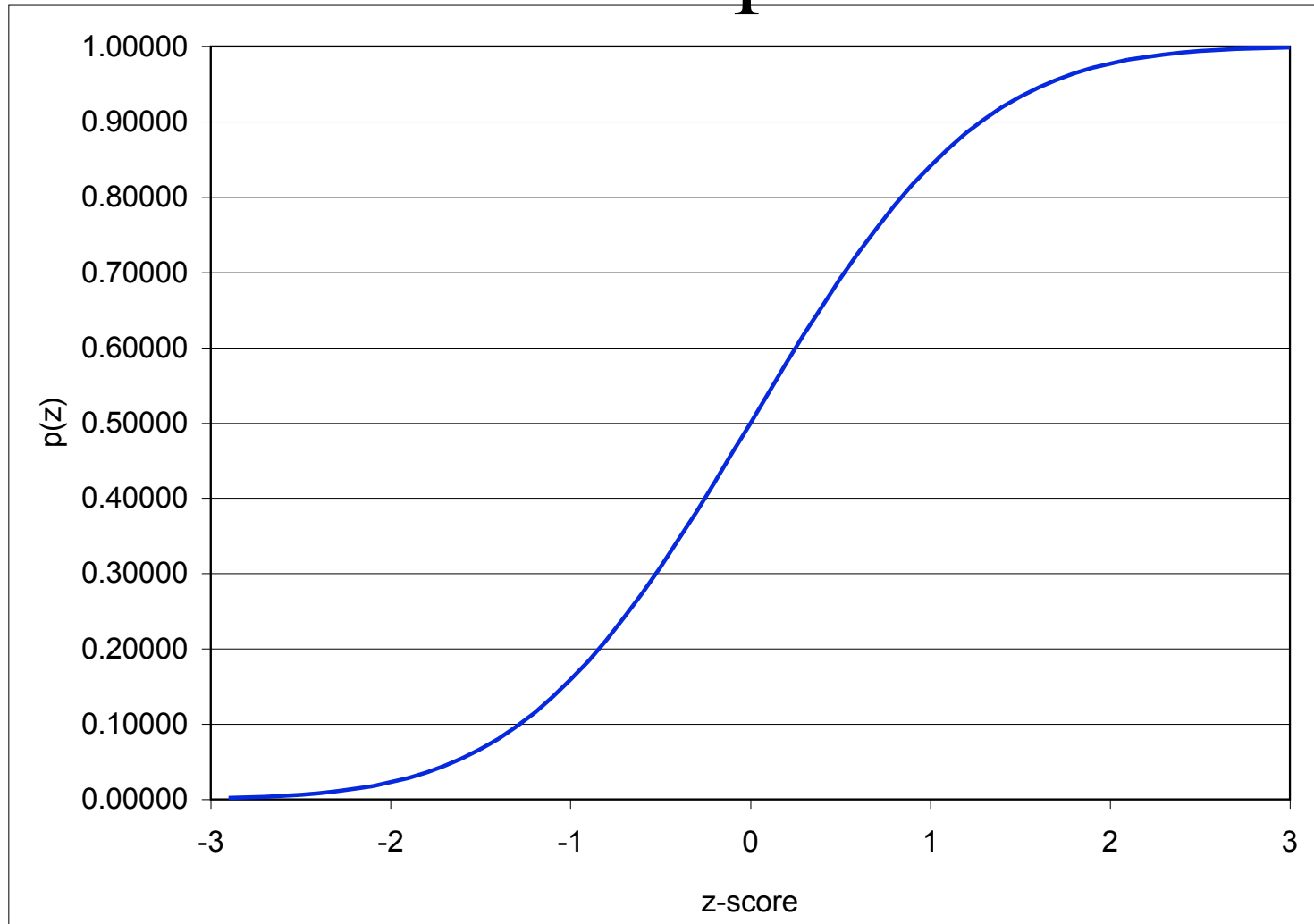
Scaling of Incentives

1. The penalty function affects the relative strength of Legacy Allocation incentives for vessels with various relative bycatch rates.
 - The relative strength of incentives is proportional to the slope of the penalty function.
2. The absolute strength of incentives is set by the bycatch function, Q , which scales the penalty function and the chosen constants for the allocation formula.

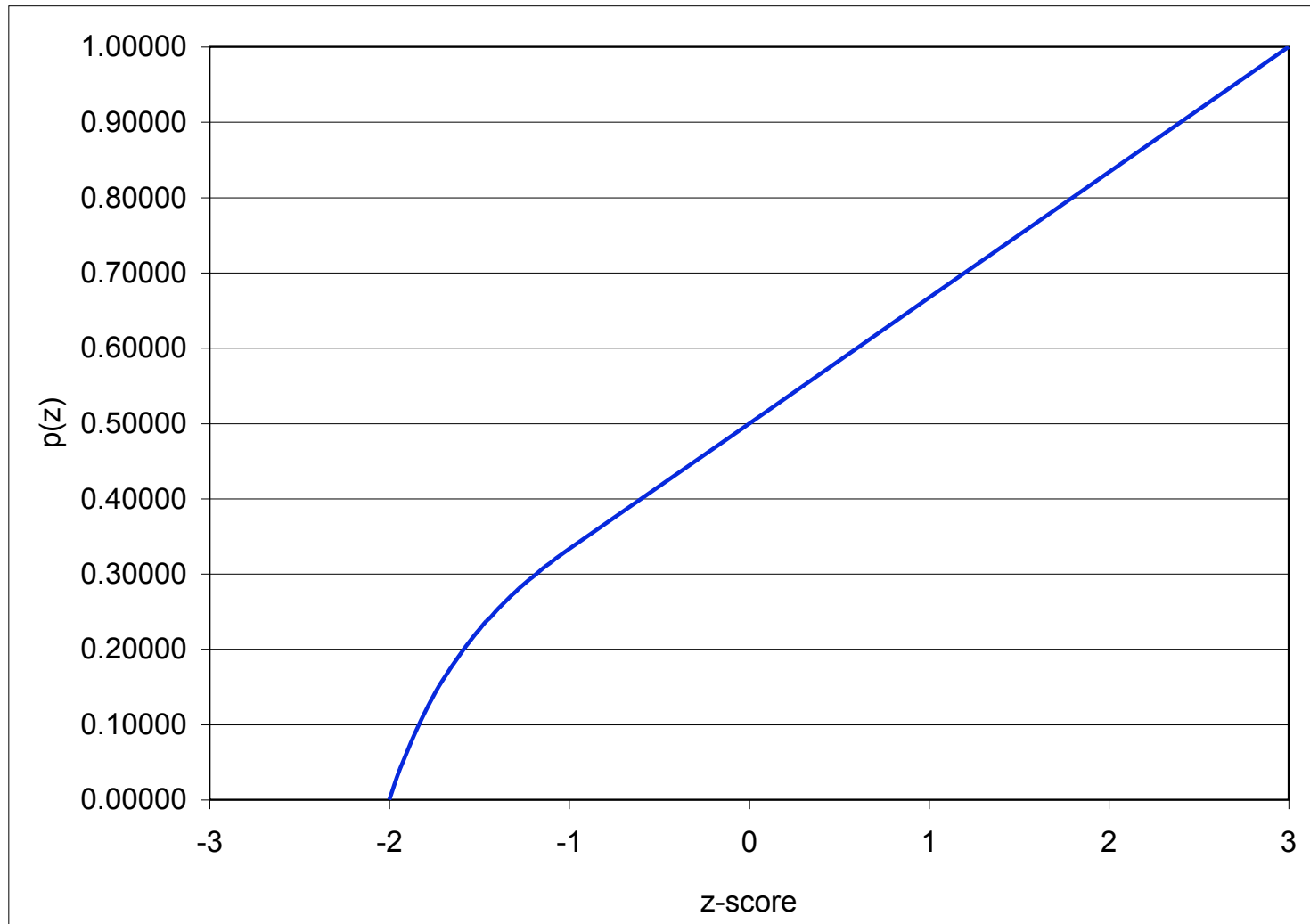
Actual Penalty Function: linear



Alternate Penalty Function 1: cumulative p-values



Alternate Penalty Function 2: curvilinear



A Fixed Transfer Tax

1. A Fixed Transfer Tax would impose a fixed tax, say 20%, on all credit transfers.
2. Issues:
 - transfers are rare in low-encounter years:
the tax is ineffective at these times
 - transfers are common in moderate- and high-encounter years:
the tax “retires” credits when they are most needed

Dynamic Salmon Savings (DSS)

1. DSS lowers the effective credit supply in low abundance years (when salmon stocks are most vulnerable).
2. It does not lower the effective credit supply in high-encounter years (when Pollock fishing is credit-limited.)
3. A provisional rule regulates transfers before a Salmon Savings Rate is set.

Credit transfers across sectors

1. Sectors with Dynamic Salmon Savings (DSS) may sell credits to any other sector.
2. Sectors without DSS may buy credits from any other sector.
3. A sector with DSS cannot buy credits from a sector without DSS.

Dynamic Salmon Savings

1. When vessels finish fishing in the B season, some credits are “retired”.
2. The percentage of credits “retired” is the Salmon Savings Rate (SSR).
3. The SSR is computed such that the sector has enough credits to harvest the remaining Pollock.
4. Prior to the determination of an SSR, credit transactions are governed by a Provisional Salmon Savings Rule.

Provisional Salmon Savings Rule

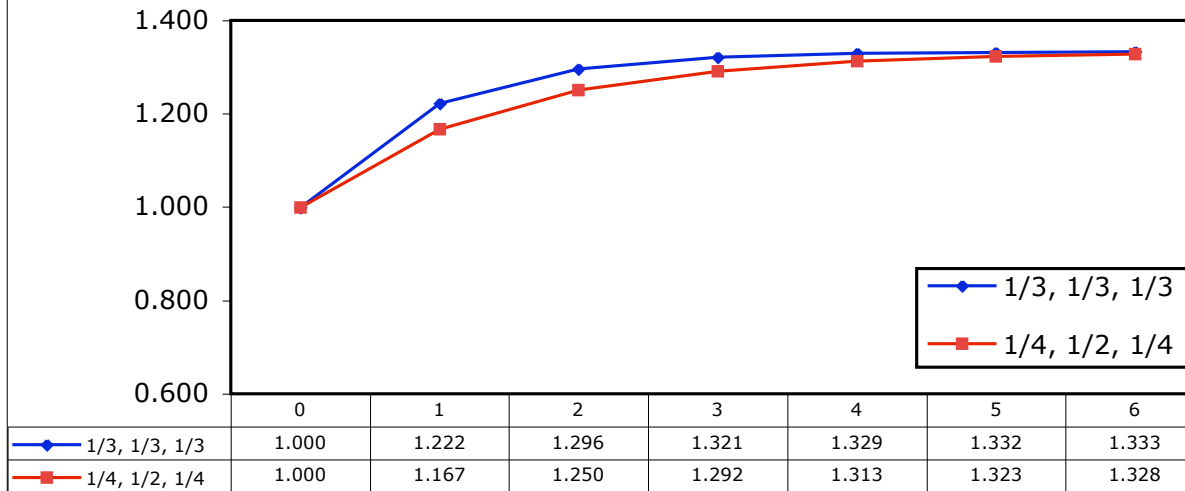
1. Prior to finishing fishing, (and having credits retired) vessels may still transfer credits.
2. The appropriate number of credits are set aside to cover eventual retirement. (This calculation is similar to tax withholding.)
3. This number (the provisional SSR) is determined by the maximum SSR.
4. This rule prevents avoidance of Dynamic Salmon Savings by selling credits before they can be retired.

Incentives associated with Buy-Side Transfer Limits

1. Vessels are limited in the number of credits they can buy.
2. There is uncertainty in the number of credits needed to finish fishing Pollock.
3. The costs of unfished Pollock can be high
4. Thus, vessels are incentivized to minimize bycatch so as to not run out of available ITEC.
(initial allocation + purchase limit)

Legacy Program

Convergence to upper bound



Convergence to lower bound

