Purpose

- Introduce a trial transferable effort credit scheme for purse seine vessels fishing tropical tunas in the Eastern Pacific Ocean that are on the Regional Vessel Register established by IATTC Resolution C-02-03.
- Obtain feed-back on ways to improve.

Main Points…(1)

- 1. Develop a plan of action or “road map” for capacity reduction in the EPO.
- 2. To provide not answers, but a starting point for ongoing, systematic discussion and analysis of capacity.
- 3. Break combined issues up into individual pieces and individually address them in phased,
- 4. Cannot reduce capacity until change current incentives
  - Current incentives increase capacity

Main Points...(2)

- 5. Transferable effort credit scheme to change incentives.
- 6. Effort not catch due to monitoring, control, surveillance, enforcement, and costs.
- 7. Trial (pilot) scheme for 3 years to reduce risk & costs and to learn.
  - Then either revert to current closed season or improve scheme.

Main Points…(3)

- 8. If continue with scheme, then shift to capacity reduction
  - Option: Individual CPC buyback & CPC keeps released days
  - Option: IATTC-wide buyback
- 9. If continue with scheme, address small fish.
- 10. If continue with scheme, address pending capacity claims.
  - Systematic capacity transfer following ISSF Capacity Workshop Barcelona 2014
  - Develop options as go forward

Organization

- 1. Introduction
- 2. Formal Definitions and Details of the Scheme
- 3. Allocation of Proportional Allowable Effort Shares and Allowable Effort
- 4. Vessel Buybacks
- 5. Main Points Recap
- ----------
- Annex 1: Empirical Analysis Transferable Effort Credit Scheme
- Annex 2: Individual CPC Vessel Buybacks

1. Introduction

New Alternatives for Capacity Management

Short Version with Basics

Longer Version with Details Available

Capacity Reduction

- Many different proposals to reduce capacity
- Have yet to reduce capacity
- Try a different approach
- Rather than directly address capacity itself, ”step sideways” for a different angle to reduce capacity

Incentives and Capacity Reduction

- Cannot reduce capacity until change current incentives
- Current incentives increase capacity and effort
- Capacity reduction and current incentives work at cross purposes

Proposed Plan of Action to Reduce Capacity

- First change incentives away from those increasing capacity.
- Then reduce capacity through vessel buybacks
  - Individual CPC or IATTC-wide buybacks
  - Individual CPC keeps released effort
- Then address small fish

Proposed Plan of Action to Reduce Capacity

- Proposed transferable vessel day credit scheme is:
  - An annual individual vessel limit for days
  - Supplemented with option to compensate excess-use of days by one vessel with under-use of days (i.e. credits) by another vessel obtained through exchange.

Proposed Scheme Reduces Capacity

- Scheme reduces capacity because:
  - Companies face weaker or no incentives to increase capacity in “race-to-fish”
  - Companies will consolidate days upon fewer vessels to increase profits
- If scheme becomes permanent, then reduce capacity in next phase

Proposed Scheme is 3-Year Trial

- Trial and simplified design minimize risk and uncertainty
- 3-Year period consistent with current 3-Year IATTC Resolutions
- Allows complete reversibility to current management
- Allows learning about nature of program, strengths and weaknesses
- Retains fundamental industry structure and operating patterns
  - No capacity permanently lost due to scheme design
- Some economic benefits that are sacrificed during the trial can be gained should the scheme become permanent.

Evaluate Scheme After 3 Years

- Options after 3 years:
- (1) Continue as is
- (2) Continue but with design improvements and additional features
  - Can begin buybacks to reduce capacity
- (3) Revert to existing management through seasonal closures with minimal cost and disruption to industry.
- During the initial 3-year trial period:
  - Maintain the status quo regarding pending capacity claims
  - No registered capacity is lost unless the capacity is voluntarily withdrawn.

Basics of Scheme

- Class 4-5-6 Vessels
- Under the current program, every vessel must be in port for 72 contiguous days for one of two periods during the year.
  - Each vessel gets to fish for up to 293 days each year, but for one of two prescribed contiguous periods.
- Under scheme, each vessel gets to fish its allocated days
  - Vessels can fish any time and days are not necessarily contiguous.

Benefits of Scheme: Without Transferability

- Benefits as Vessels Use Their Days More Flexibly and Effectively
  - Increase in gross revenue: about 9% on average per vessel
  - Increase in gross operating profit: about 20% average per vessel
- Even greater profit increases in multi-vessel companies from consolidating days on vessels
- More even flow of fish to processors throughout year

Potential Issues with Scheme

- Effort will become more effective over time
- Days from reactivated and new vessels increase effort, requiring reduced days from existing vessels
- Underlying biological dynamics could be significantly negative or positive to calculated revenue and profit over time
- TAE could change
  - Could decline if vessels become more efficient over time

2. Formal Definitions and Details of the Scheme

Day

- *Any calendar day, or part of a calendar day, in a Management Year during with a purse seine vessel is in the waters under the jurisdiction of the IATTC outside of a port*.
- A day is a day-at-sea.
- A day is a whole calendar day

Total Allowable Effort (TAE)

- Total nominal days for a Management Year.
- Defined in terms of fishing mortality at FMSY
  - MSY basis is current fishing mortality at age.
- TAE is defined on basis of the most “vulnerable” of yellowfin, bigeye, or skipjack.

CPC’s Proportional Allowable Effort Share (PAES)

- CPC’s proportion (share) of Total Allowable Effort
- Denominated in days at sea.
- Allocated for three years to CPCs
  - Current IATTC resolution cycle

A CPC's Allowable Effort (AE) in Days for Each Management Year

- Given by multiplying TAE by the CPC's PAES.
- CPCs in turn allocate their CPC Allowable Effort for each Management Year to eligible vessels of Classes 4-5-6
- Forms vessel Allowable Effort for that Management Year.

Credits

- Unused portion of a vessel's Allowable Effort during a Management Year.
- Created *gratis* when the vessel uses a number of days below the vessel's allocated limit of days.
- A credit receiver only needs credits to offset the days exceeding its Allowable Effort.
- Only transferred within same vessel size class
- Can be transferred within a CPC to other vessels within the same company or to other companies and across vessels of different CPCs as agreed by those CPCs.

Credits and Continued Fishing

- Each vessel must cease fishing in a Management Year when its Allowable Effort is met
  - unless it obtains **credits** from another vessel within that same Management Year.

3. Allocation of Proportional Allowable Effort Shares and Allowable Effort

Eligibility for PAES

- Only members and cooperating non-members of the IATTC.

Vessel Eligibility

- Purse seine vessels active on the Regional Vessel Register and Classes 4-5-6.
- Classes 1-2-3 vessels on the Regional Vessel Register are exempt.
- Vessels cannot start operating in the Management Year without a previous allocation of Allowable Effort
- Definitions of active and inactive vessels remain the same as under Resolution C-02-03

Vessel Allocation Based Upon Two Categories

- (1) Vessels that are currently on the RVR active in terms of days
- (2) Vessels currently inactive on the RVR.
- Inactive vessels can be activated following Resolution C-02-03.
- Reactivated vessels in a Management Year receive the number of days prorated according to number of remaining days in that Management Year.
- No allocation to sunk vessels.
- Always allocated to vessels through their CPCs.

Active Vessels' Allocation of Allowable Effort: Option 1

- Based on each vessel's number of days averaged over the previous three years prior to the beginning of a Management Year, regardless of Flag State.

Size Class	2014-2016 Average Days per Vessel
Class 4	241
Class 5	240
Class 6 No DML	230
Class 6 DML	238

Active Vessels' Allocation of Allowable Effort: Option 1

- Active vessels with less than three years of days are allocated days based upon their existing average.
  - For example, an active vessel with two years of days would receive an allocation averaged over those two years.

Active Vessels' Allocation of Allowable Effort: Option 2

- Even division of days for each vessel each year
- Example: 365 - 72 closure days = 293 days for each vessel
- If total allocated days > TAE, then equally reduce days from each vessel until total fleet days = TAE.

Active Vessels' Allocation of Allowable Effort: Option 3

- Days per m^3 of registered well capacity.
  - Average of all other eligible vessels in that size class active on RVR.
- If total allocated days > TAE, then equally reduce days from each vessel until total fleet days = TAE.
- Current average days per m^3

Class	2014-2016 Avg Days/cm3
Class 4	0.96
Class 5	0.65
Class 6 No DML	0.26
Class 6 DML	0.19

Active Vessels' Allocation of Allowable Effort: Option 4

- Hybrid or combination of first three options.
- Example:

  70% average three years of days + 30% day/m^3 capacity

Active Vessels' Allocation of Allowable Effort: Option 4

- Based on each vessel's number of days averaged over the largest previous X out of Y years prior to the beginning of a Management Year, regardless of Flag State.
- Examples:
  - Best 3 out of 4 prior years
  - Best 3 out of 5 prior years
  - Best 2 out of 4 prior years

United States Distant-Water Purse Seine Fleet Allocation: Option 1…(1)

- Paragraph 12 of Resolution C-02-03 allows for maximum 32 US vessels to make one trip to the EPO each year (here Management Year upon commencement of the VDS) not to exceed 90 days (consistent with C-02-03).
- Allocated X days of AE (the number of days to be determined) each Management Year, never to exceed 90 days.
- Allocated AE cannot be transferred between vessels or carried forward or backward in a Management Year.
- No more than 32 eligible vessels can hold AE during a Management Year (consistent with C-02-03).

United States Distant-Water Purse Seine Fleet Allocation: Option 1…(2)

- Initially allocated AE is a maximum. If TAE declines in a Management Year, the allocated AE proportionately declines.
  - Treats these vessels on an equal basis as all other eligible vessels in the VDS.
- If TAE increases in a Management Year, allocated AE proportionately increases on an equal basis as all other eligible vessels, but cannot exceed 90 days.
- Any credits within a Management Year cannot be transferred and are cancelled at the end of that Management Year.
- US vessels active in RVR receive AE equal to their average days over the most recent three years.
  - Or options discussed previously

United States Distant-Water Purse Seine Fleet Allocation: Option 2

- Maintain paragraph 12 in C-02-03
  - Do not reduce any of the days from 90 days.
  - No more than 32 eligible vessels can hold AE during a Management Year.
- Unused days from the 90 days not placed into a credit system for others to use to reduce fishing pressure
  - As opposed to crediting out days that haven’t been used.

4. Vessel Buybacks

Two Options After Adopt Transferable Effort Scheme

- Adopting transferable effort scheme:
  - Improves incentives
  - Removes some capacity through consolidating days on fewer vessels in multi-vessel companies
- Then, two basic options for voluntary buybacks:
- 1. IATTC-wide (see Annex 2)
- 2. Individual CPC

Individual CPC Buybacks…(1)

- Voluntary and CPC-specific
- If adopt transferable effort credit scheme (with improvements), then create longer-term allocation of PAES
  - May require specific agreement on security of this allocation
  - Although should be stable

Individual CPC Buybacks…(2)

- CPCs retain released PAES by buyback
  - Creates de facto long-term, stable, and secure allocation of PAES to CPCs (much like capacity scheme).
- Northern Economics analysis showed that always profitable for remaining vessels that bought out exiting vessels.
- Because released catch to remaining vessels increased profitability.
- More details in Annex 2.

Individual CPC Buybacks…(3)

Table ES-6. Estimated Results of a Pilot Single-Country Buyback Program for the Pseudo-Ecuador Fleet

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	$1M Minimum Bid	$2M Minimum Bid	$3M Minimum Bid	Minimum Bid Varies by m^3	Variable Min. & Weight by EPO DAS	Variable Min. & Inverse Weighting
Active Vessels Remaining (from 116)	97	98	97	96	92	98
Capacity (m^3) Remaining (from 96,568)	68,749	66,248	64,742	69,003	67,000	69,576
Annual Pilot Program Cost*	$4,834,014	$7,009,823	$9,311,312	$8,375,398	$12,363,811	$8,257,180
Average Payment per Remaining Vessel	$49,835	$71,529	$95,993	$87,244	$134,389	$84,257
NOR Gains per Vessel Less Average Fee	$325,172	$309,190	$280,824	$297,944	$271,711	$304,978

Note: Estimated pilot program cost include only the compensation paid to vessel owners.

Source: Northern Economics

Individual CPC Buybacks…(4)

Table ES-7. Estimated Results of a Pilot Single-Country Buyback Program for the Pseudo-Mexico Fleet

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	$1M Minimum Bid	$2M Minimum Bid	$3M Minimum Bid	Minimum Bid Varies by m^3	Variable Min. & Weight by EPO DAS	Variable Min. & Inverse Weighting
Active Vessels Remaining (from 50)	40	41	42	42	41	42
Capacity (m^3) Remaining (from 61,925)	48,335	48,155	49,101	49,446	48,727	50,436
Annual Pilot Program Cost*	$1,531,096	$2,544,899	$3,213,091	$3,523,794	$3,878,892	$3,480,848
Average Payment per Remaining Vessel	$38,277	$62,071	$76,502	$83,900	$94,607	$82,877
Repayment fee per m^3 of remaining capacity	$31.68	$52.85	$65.44	$71.27	$79.60	$69.02
NOR Gains per Vessel Less Average Fee	$88,956	$43,706	$19,793	$9,825	($553)	$38,930

Note: Estimated pilot program costs include only the compensation paid to vessel owners.

Source: Northern Economics

5. Main Points Recap

Main Points Recap…(1)

- 1. Develop a plan of action or “road map” for capacity reduction in the EPO
- 2. To provide not answers, but a starting point for ongoing, systematic discussion and

  analysis of capacity.
- 3. Break combined issues up into individual pieces and individually address them in phased,
- 4. Cannot reduce capacity until change current incentives
  - Current incentives increase capacity

Main Points...(2)

- 5. Transferable effort credit scheme to change incentives.
- 6. Effort not catch due to monitoring, control, surveillance, enforcement, and costs.
- 7. Trial (pilot) scheme for 3 years to reduce risk & costs and to learn.
  - Then either revert to current closed season or improve scheme.

Main Points…(3)

- 8. If continue with scheme, then shift to capacity reduction
  - Option: Individual CPC buyback & CPC keeps released days
  - Option: IATTC-wide buyback
- 9. If continue with scheme, address small fish.
- 10. If continue with scheme, address pending capacity claims.
  - System capacity transfer following ISSF Capacity Workshop Barcelona 2014

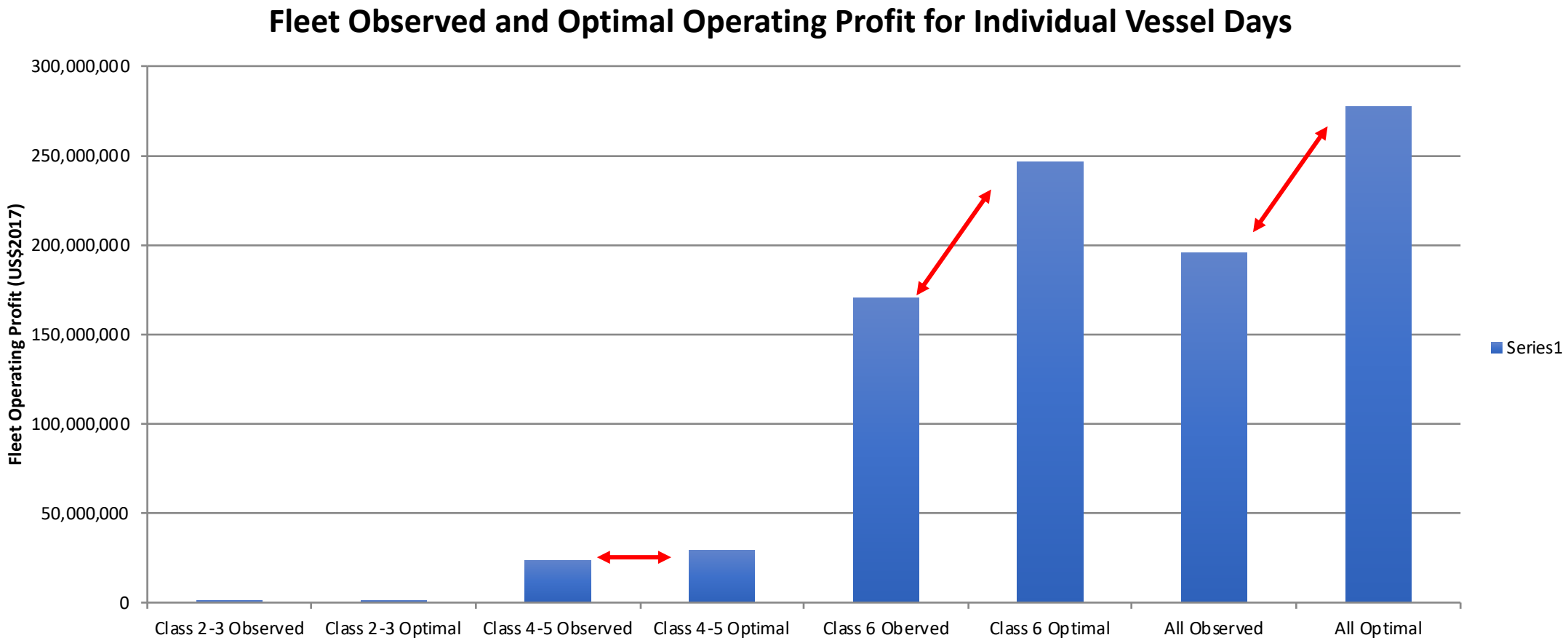
Thanks!.....Questions?

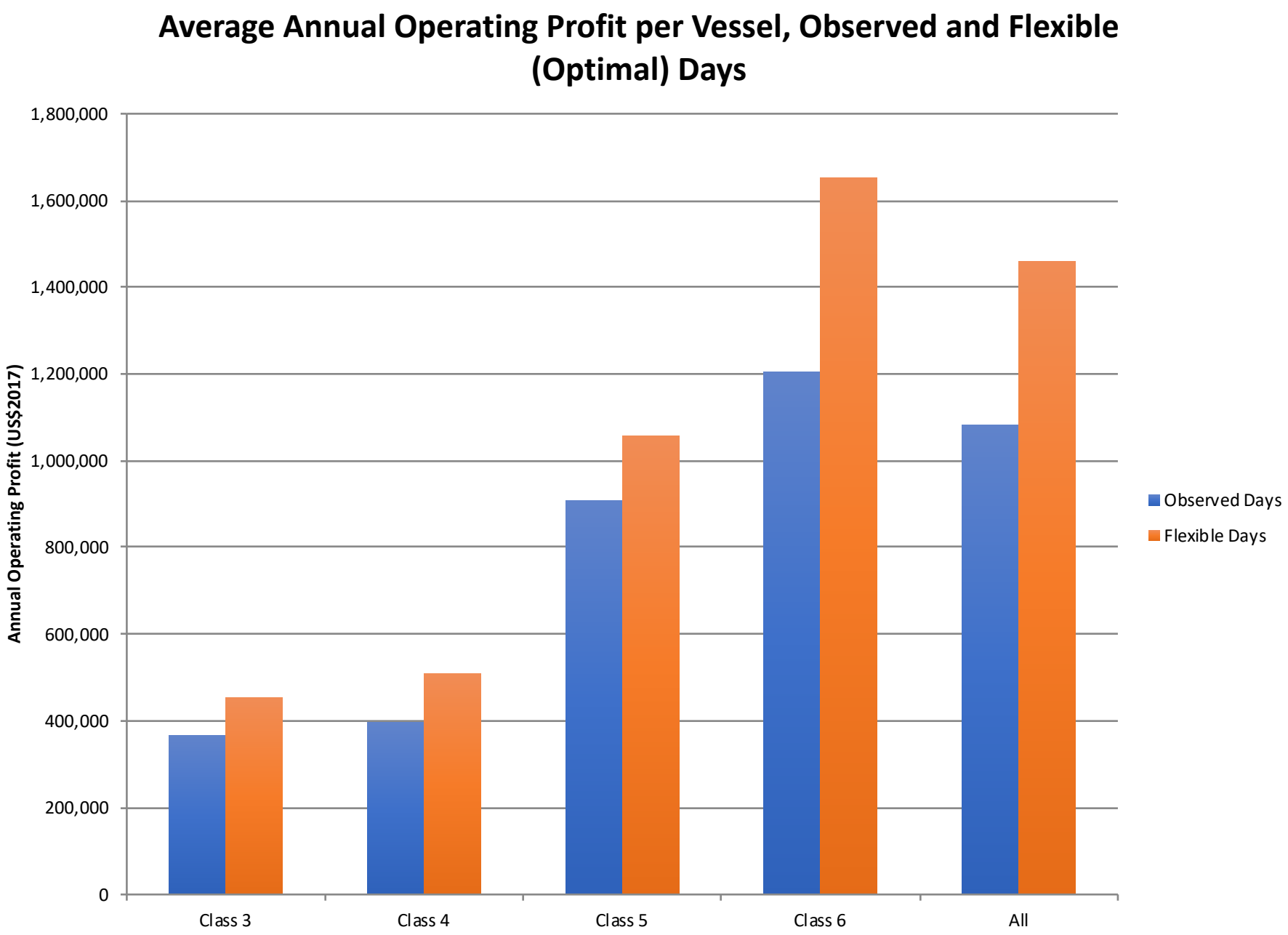
- Any options to add to the capacity scheme?
- Any suggestions to improve the scheme?

Annex 1: Empirical Analysis Transferable Effort Credit Scheme

Conditional upon existing purse seine fleet structure (existing vessel numbers and capacity by size class and DML/non-DML)

Total Fleet Observed and Optimal Operating Profit per Year, Average 2014-2016 (US$2017)




Average Annual Operating Profit per Vessel, Observed and Flexible (Optimal) Days
Annual Operating Profit (US$2017)
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
Class 3
Class 4
Class 5
Class 6
All
Observed Days
Flexible Days

Example of Gain in Operating Profits: Class 6, 10-Vessel Company Consolidating Days on 8 Efficient Vessels

	Original Vessels (10)	New Vessels (8)
Capacity (m^3)		
Mean per Vessel	1,133	1,024
Total	11,328	8,190
Days		
Mean per Vessel	210	263
Total	2,104	2,104
Operating Profit (US$2017)		
Mean per Vessel	1,075,531	1,899,144
Total	10,755,305	15,113,155
Operating Profit per Day		
Mean per Vessel		7,406

Note: Averaged over 3 years, 2014-2016. Profit gains only from days consolidation, not from operating more efficiently.

Operating profits increase
Due to:
(1) Increased efficiency per vessel as use days more efficiently
(2) No negative operating profits from 2 vessels that no longer fish
No fixed costs would further increase profits

Example of Gain in Operating Profits: Class 6, 5-Vessel Company Consolidating Days on 4 Efficient Vessels

	Original Vessels (10)	New Vessels (8)
Capacity (m^3)		
Mean per Vessel	1,848	1,805
Total	9,238	7,219
Mean Days per Year		
Mean per Vessel per Year	192	240
Mean Total per Year	959	959
Mean Operating Profit per Year (US$2017)		
Mean per Vessel per Year	1,662,398	2,635,352
Mean Total per Year	8,311,992	10,541,408
Mean Operating Profit per Day		
Mean per Vessel	10,286	11,928

Note: Averaged over 3 years, 2014-2016. Profit gains only from days

Example of Gain in Operating Profits: Class 6, 5-Vessel Company Consolidating Days on 4 Efficient Vessels

	Original Vessels (10)	New Vessels (8)
Capacity (m^3)		
Mean per Vessel	902	962
Total	4,511	3,849
Mean Days per Year		
Mean per Vessel per Year	207	258
Mean Total per Year	1,034	1,034
Mean Operating Profit per Year (US$2017)		
Mean per Vessel per Year	1,062,836	1,485,349
Mean Total per Year	5,314,181	5,941,396
Mean Operating Profit per Day		
Mean per Vessel	4,929	5,643

Note: Averaged over 3 years, 2014-2016. Profit gains only from days consolidation, not from operating more efficiently through flexible days.

Example of Gain in Operating Profits: 4 Vessels, 2 Class 5, 2 Class 6

	Original Vessels (10)	New Vessels (8)
Capacity (m^3)		
Mean per Vessel	443	443
Total	1,772	1,772
Mean Days per Year		
Mean per Vessel per Year	226	226
Mean Total per Year	903	903
Mean Operating Profit per Year (US$2017)		
Mean per Vessel per Year	1,566,813	1,710,468
Mean Total per Year	6,267,251	6,841,872
Mean Operating Profit per Day		
Mean per Vessel	7,140	7,361

Note: Averaged over 3 years, 2014-2016. Profit gains only from days consolidation, not from operating more efficiently through flexible days.

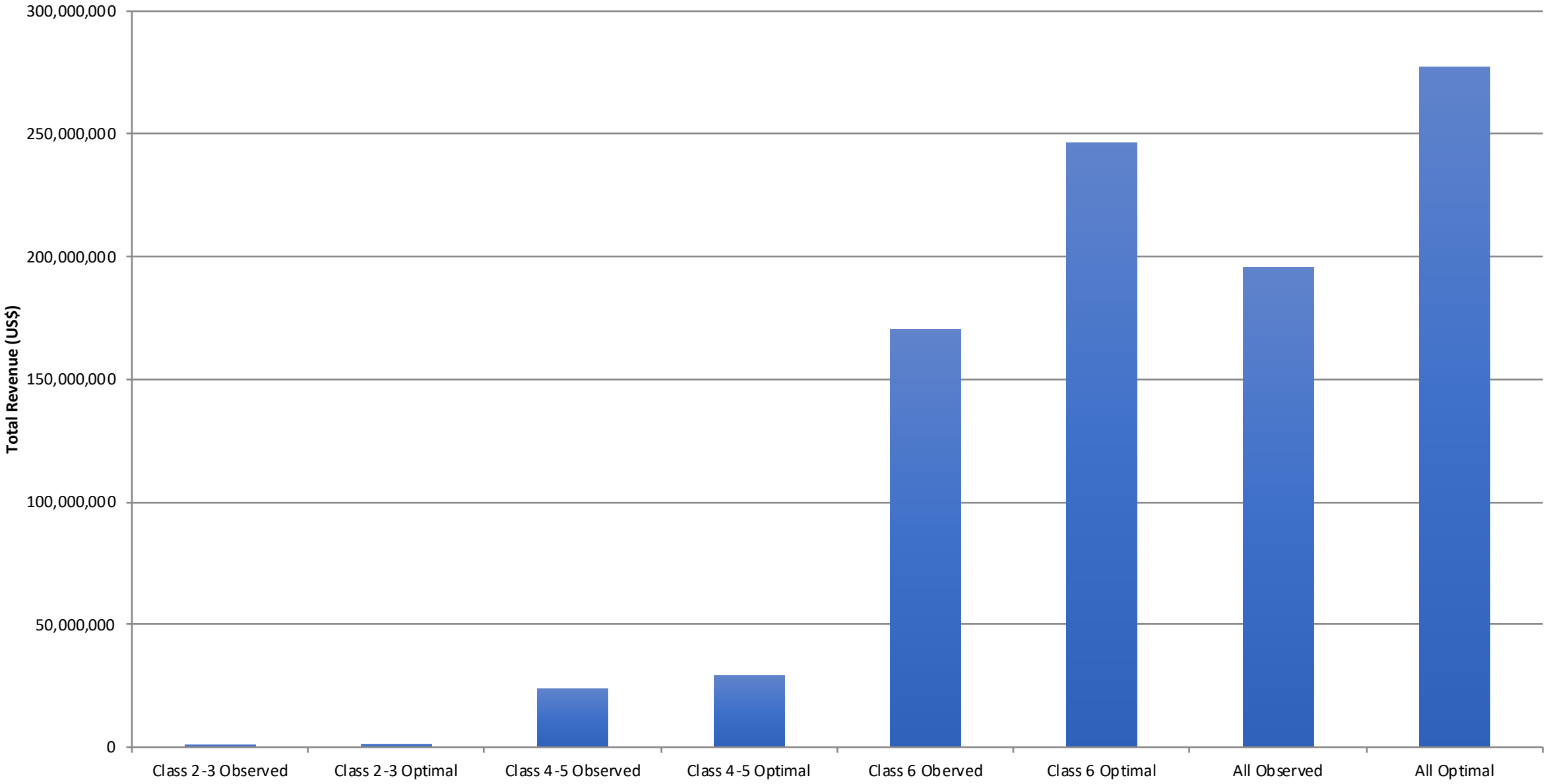
Example of Gain in Operating Profits: 8 Class Vessels, DML, Retire 2 Vessels with Negative Operating Profit, and Likely Sell 80 Days Credits (Not valued)

	Original Vessels (10)	New Vessels (8)
Capacity (m^3)		
Mean per Vessel	1,293	1,339
Total	10,343	9,373
Mean Days per Year		
Mean per Vessel per Year	225	285
Mean Total per Year	1,803	1,803
Mean Operating Profit per Year (US$2017)		
Mean per Vessel per Year	676,069	1,102,238+mean credit revenue per vessel
Mean Total per Year	3,452,087	5,511,189+total credit revenue
Mean Operating Profit per Day		
Mean per Vessel	2,298	3,877

Operating profits increase
Due to:
(1) Increased efficiency per vessel as use days more efficiently
(2) No negative operating profits from 2 vessels that no longer fish
No fixed costs would further increase profits.
Additional profit from credits sold, which is not valued here.

Total Fleet Observed and Optimal Total Revenue per Year without Transferability, Average 2014-2016 (US$2017)

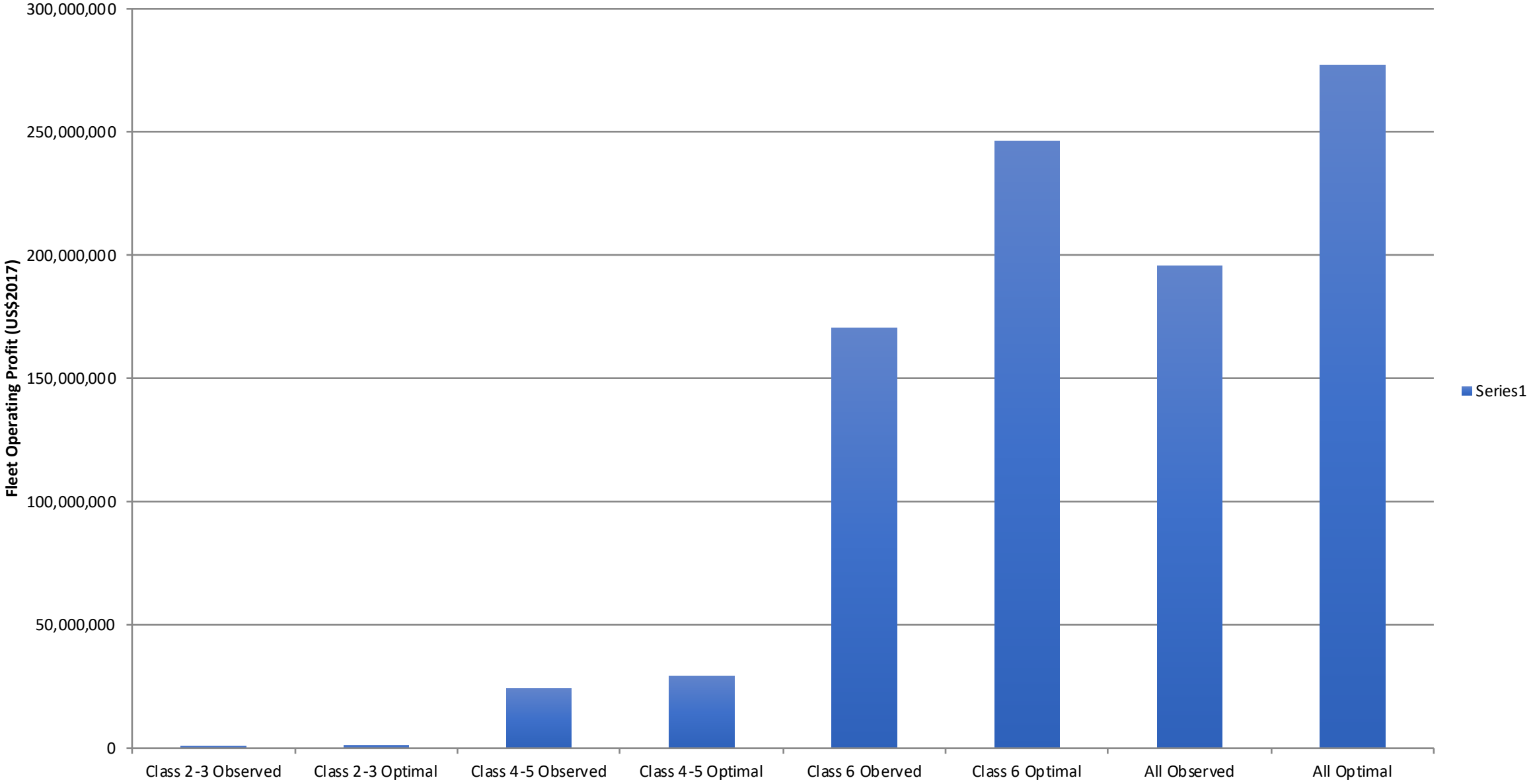
Category of Vessels	Total Fleet Revenue per Year (US$2017)
All Vessels	
Observed Days	965,430,748
Efficient Days (Giving Capacity Catch)	1,058,262,005
Increase (%)	9.62%
Class 2-3 Vessels	
Observed Days	5,051,437
Efficient Days (Giving Capacity Catch)	5,295,785
Increase (%)	4.84%
Class 4-5 Vessels	
Observed Days	74,181,848
Efficient Days (Giving Capacity Catch)	79,581,650
Increase (%)	7.28%
Class 6 Vessels	
Observed Days	886,197,462
Efficient Days (Giving Capacity Catch)	973,384,571
Increase (%)	9.84%
Source: IATTC data.	
Notes: Existing structure and number of vessels in fleet for observed. Average over 2014-2016. Inflation-free US$2017. Vessel days > 100. Historical days allocation averaged over 2014-2016. No transferability. Constant prices (no changes in price due to changes in timing and quantity of landings). Calculated using mean values from IATTC data for vessels > 100 days and observed capacity and number of vessels reported in Table 13. Data Envelopment Analysis (Shrader and Squires 2013, 2018). Convex frontier aggregated over all vessel size classes.	


Fleet Observed and Optimal Total Revenue for Individual Vessel Days
Total Revenue (US$)
300,000,000
250,000,000
200,000,000
150,000,000
100,000,000
50,000,000
0
Class 2-3 Observed
Class 2-3 Optimal
Class 4-5 Observed
Class 4-5 Optimal
Class 6 Oberved
Class 6 Optimal
All Observed
All Optimal

Total Fleet Observed and Optimal Operating Profit per Vessel per Year without Transferability, Average 2014-2016 (US$2017)

Category of Vessels	Total Fleet Operating Profit per Year (US$2017)
All Vessels	
Observed Days	195,709,400
Efficient Days (Capacity Catch)	277,195,811
Class 2-3 Vessels	
Observed Days	1,203,869
Efficient Days (Capacity Catch)	1,448,218
Class 4=5 Vessels	
Observed Days	24,061,509
Efficient Days (Capacity Catch)	29,463,552
Class 6 Vessels	
Observed Days	170,444,022
Efficient Days (Capacity Catch)	246,284,040
Source: IATTC data.	
Notes: Existing structure and number of vessels in fleet for observed fleet averaged over 2014-2016. Inflation-free US$2017. Vessel days > 100. Historical days allocation 2014-2016. No transferability. Constant prices (no changes in price due to changes in timing and quantity of landings). Calculated using mean values from IATTC data for vessels > 100 days and observed capacity and number of vessels reported in Table 13. Data Envelopment Analysis (Shrader and Squires 2013, 2018). Convex frontier aggregated over all vessel size classes.	

Fleet Observed and Optimal Operating Profit for Individual Vessel Days, Existing Fleet Average 2014-2016

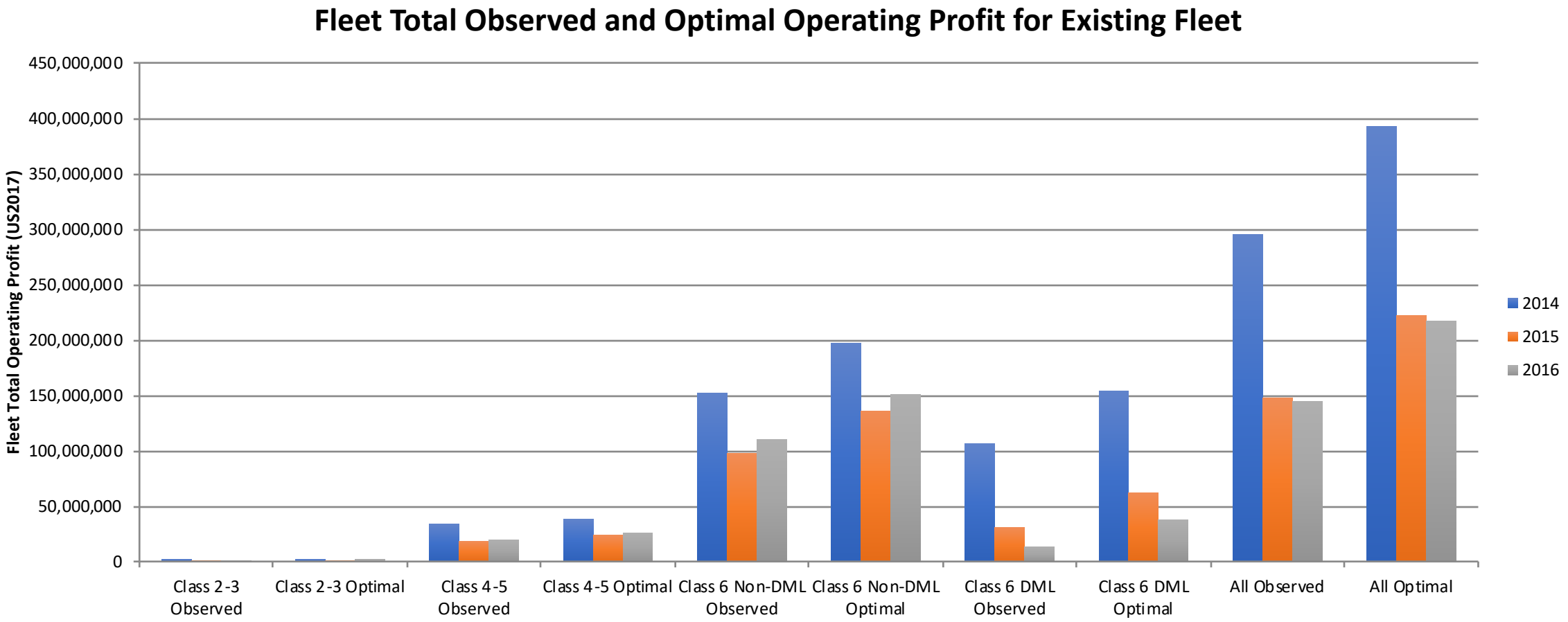


Total Operating Profit of Observed and Efficient Fleet Conditional upon Existing Capacity and Fleet Configuration (US$2017)

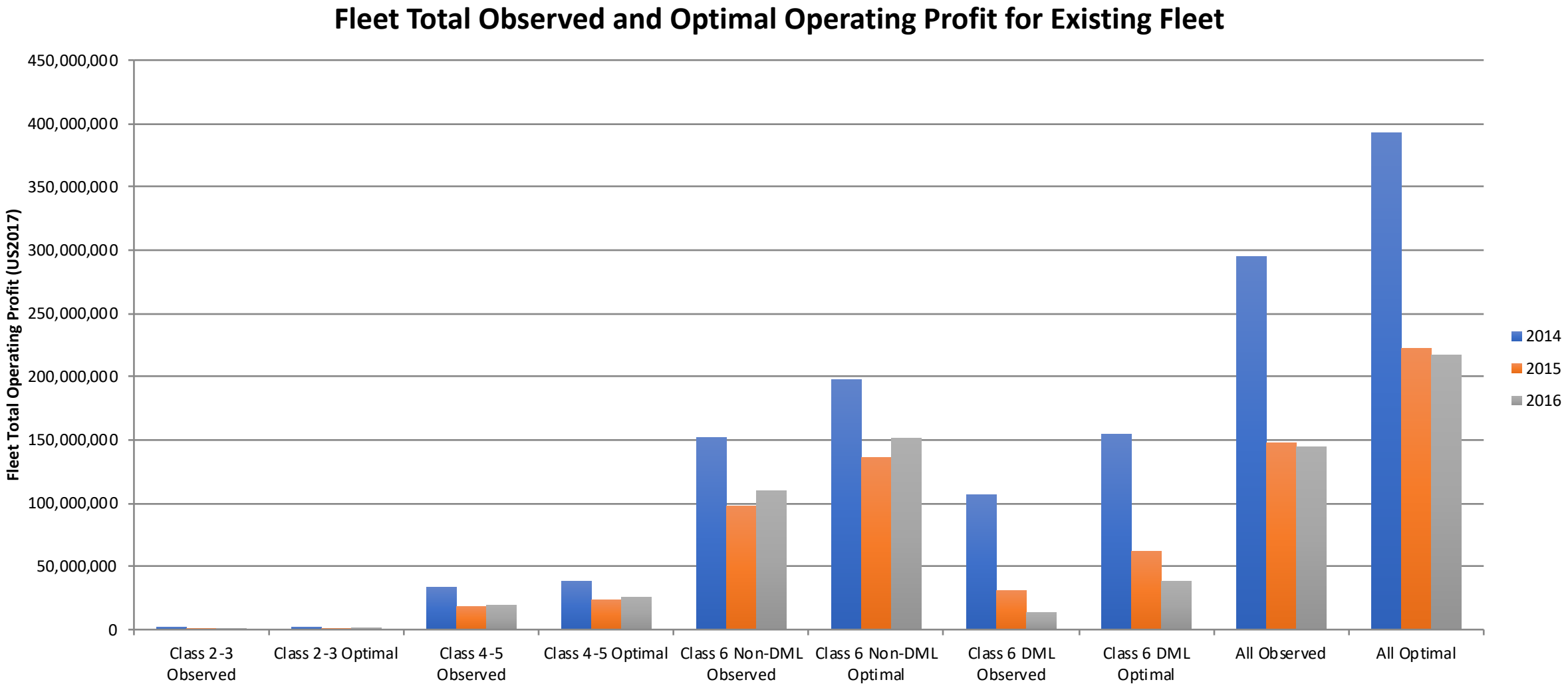
Year	Class 2-3		Class 4-5		Class 6 Non-DML		Class 6 DML		Total	
	Observed	Optimal	Observed	Optimal	Observed	Optimal	Observed	Optimal	Observed	Optimal
2014	2,453,650	2,453,650	33,861,225	38,531,300	151,814,223	197,287,596	106,861,102	154,190,192	294,990,200	392,462,738
2015	183,845	183,845	18,564,265	23,704,122	97,692,672	135,962,904	31,375,344	62,156,458	147,816,126	222,007,329
2016	974,113	1,707,160	19,759,036	26,155,235	109,837,728	151,086,312	13,750,998	38,168,658	144,321,875	217,117,365

Source: IATTC data and Data Envelopment Analysis (Shrader and Squires 2013, 2018). Convex frontier aggregated over all vessel size classes. Inflation-free US$2017.

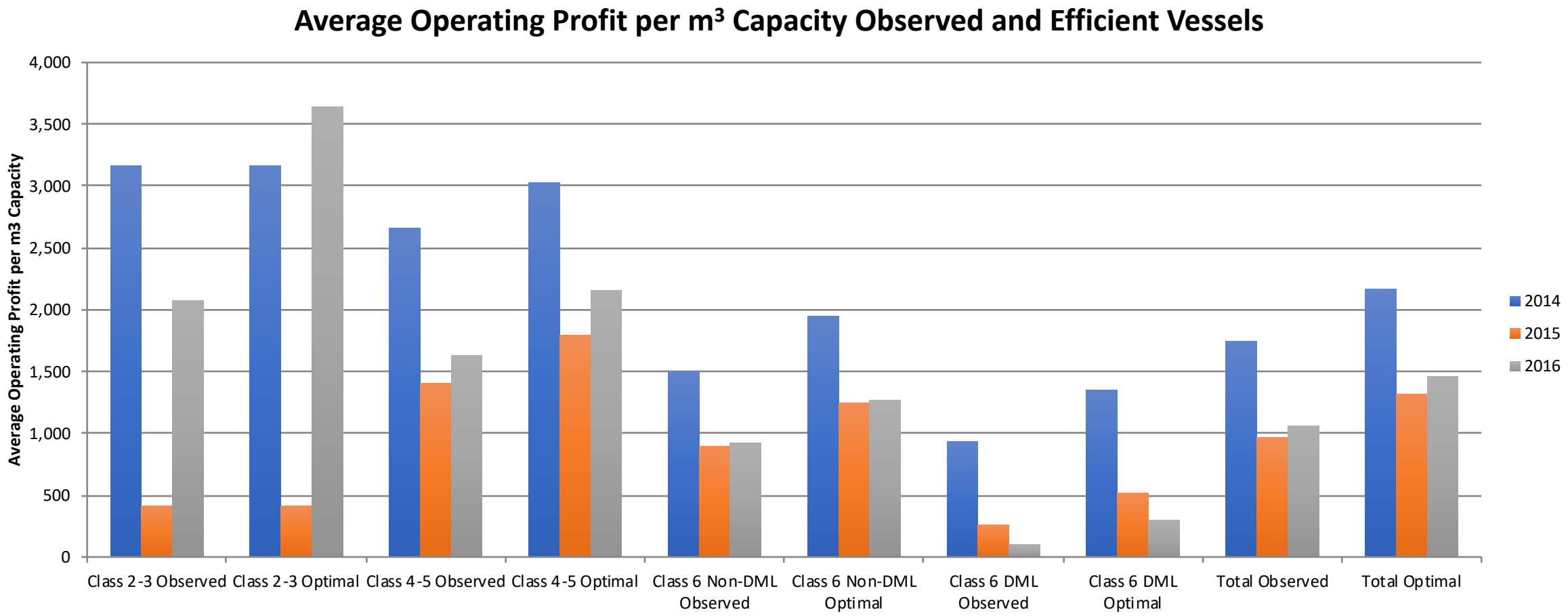
Total Operating Profit of Observed and Efficient Fleet Conditional upon Existing Capacity and Fleet Configuration (US$2017)



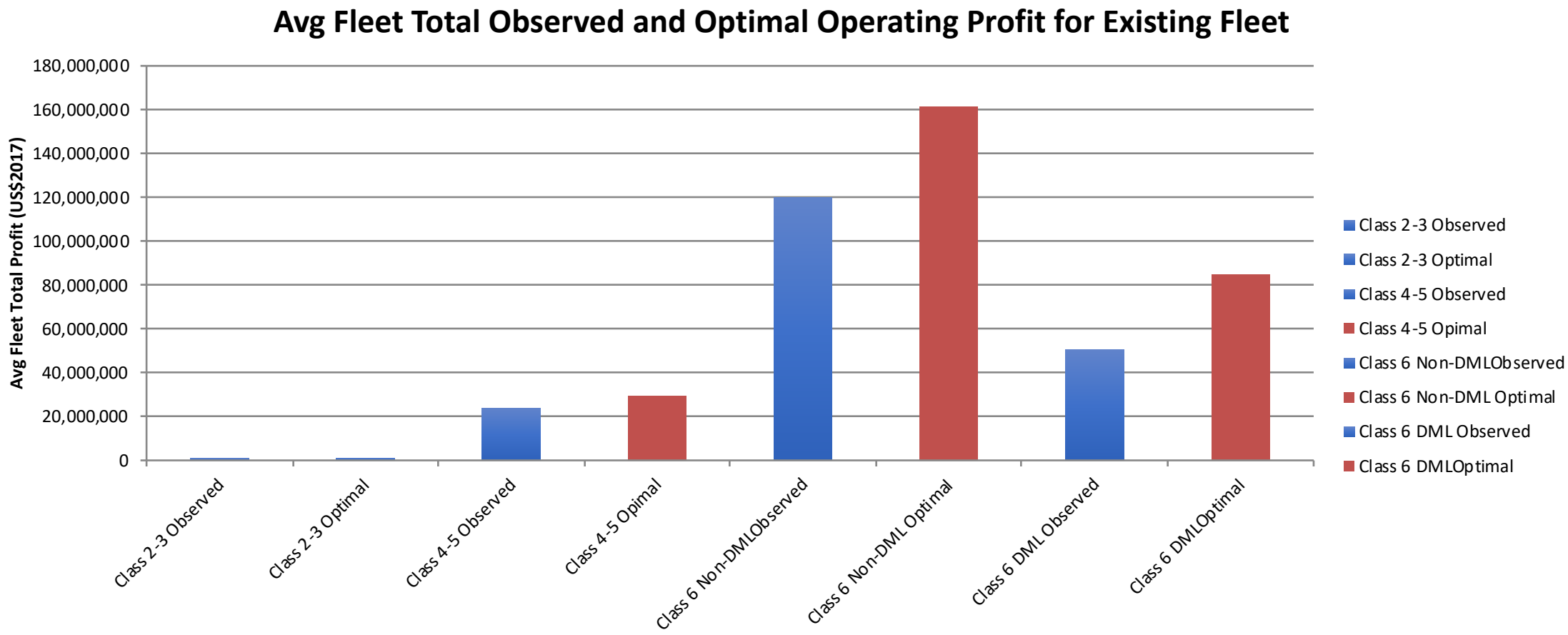
Average Operating Profit per Vessel-Day for Observed and Efficient Vessels Conditional upon Existing Capacity and Fleet Configuration (US$2017)



Average Operating Profit per m^3 Well Capacity for Observed and Efficient Vessels Conditional upon Existing Capacity and Fleet Configuration (US$2017)



Average Fleet Observed and Optimal Operating Profit Conditional upon Existing Capacity and Fleet Configuration (US$2017)



Optimal Efficient Fleet in Long Run

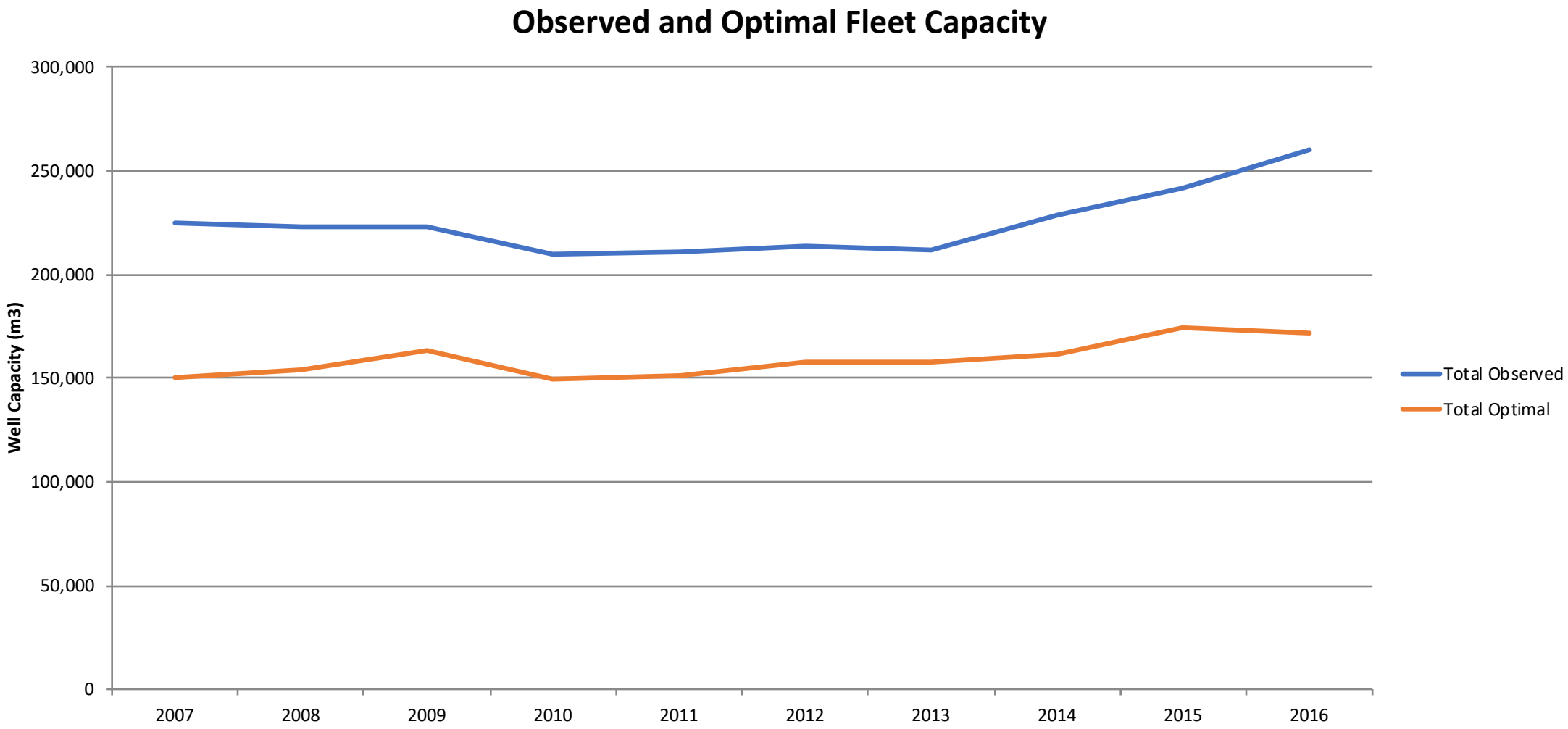
Conditional upon resource stocks, MSYs, prices, costs, state of environment

Efficient Fleet Configuration: Well Capacity, 2007-2016

Year	Class 2-3		Class 4-5		Class 6 Non-DML		Class 6 DML		Total	
	Observed	Optimal	Observed	Optimal	Observed	Optimal	Observed	Optimal	Observed	Optimal
2007	2,163	1,355	10,666	6,679	75,187	47,084	136,515	94,928	224,531	150,046
2008	1,687	1,092	10,884	7,048	87,837	56,878	122,174	89,263	222,582	154,282
2009	1,825	1,294	10,658	7,559	95,548	67,762	115,213	86,211	223,244	162,826
2010	1,321	920	10,865	7,567	86,367	60,151	111,106	80,805	209,659	149,443
2011	1,633	1,089	10,222	6,815	89,046	59,364	109,535	83,569	210,436	150,836
2012	1,384	994	11,040	7,926	91,200	65,472	109,571	83,483	213,195	157,873
2013	776	572	12,397	9,133	90,512	66,679	108,283	81,455	211,968	157,838
2014	775	513	12,725	8,420	101,277	67,011	114,046	85,005	228,823	160,948
2015	443	315	13,213	9,400	109,032	77,570	118,846	86,955	241,534	174,240
2016	469	294	12,137	7,604	118,872	74,473	128,514	89,554	259,992	171,925

Source: IATTC data and Data Envelopment Analysis (Johansen Industry Model) (Shrader and Squires 2013, 2018). Non-convex frontier aggregated over all vessel size classes.

Observed and Optimal Fleet Capacity

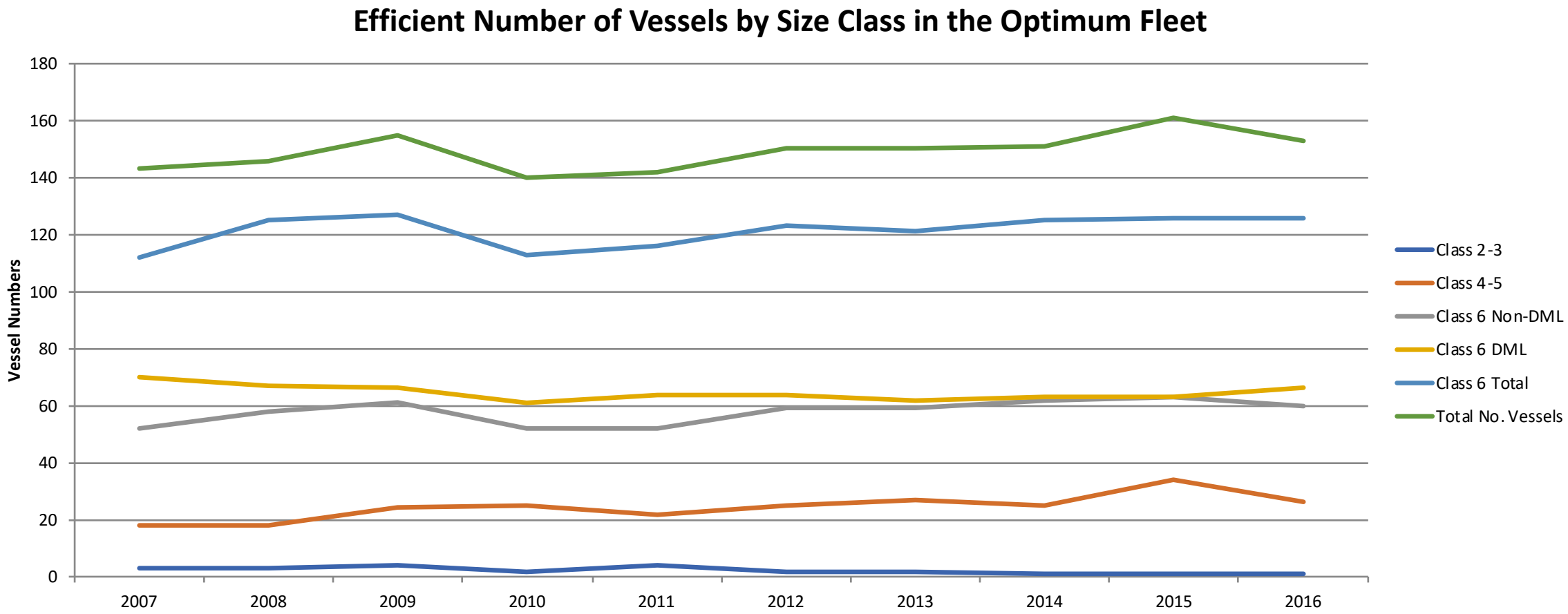


Efficient Number of Vessels by Size Class

Year	Class 2-3	Class 4-5	Class 6 Non-DML	Class 6 DML	Class 6 Total	Total No. Vessels
2007	3	18	52	70	112	143
2008	3	18	58	67	125	146
2009	4	24	61	66	127	155
2010	2	25	52	61	113	140
2011	4	22	52	64	116	142
2012	2	25	59	64	123	150
2013	2	27	59	62	121	150
2014	1	25	62	63	125	151
2015	1	34	63	63	126	161
2016	1	26	60	66	126	153

Source: IATTC data and Data Envelopment Analysis (Two-Stage Johansen Industry Model) Shrader and Squires 2013, 2018). Non-convex frontier estimated by aggregate frontier defined over all vessel size classes.

Efficient Number of Vessels by Size Class in the Optimum Fleet

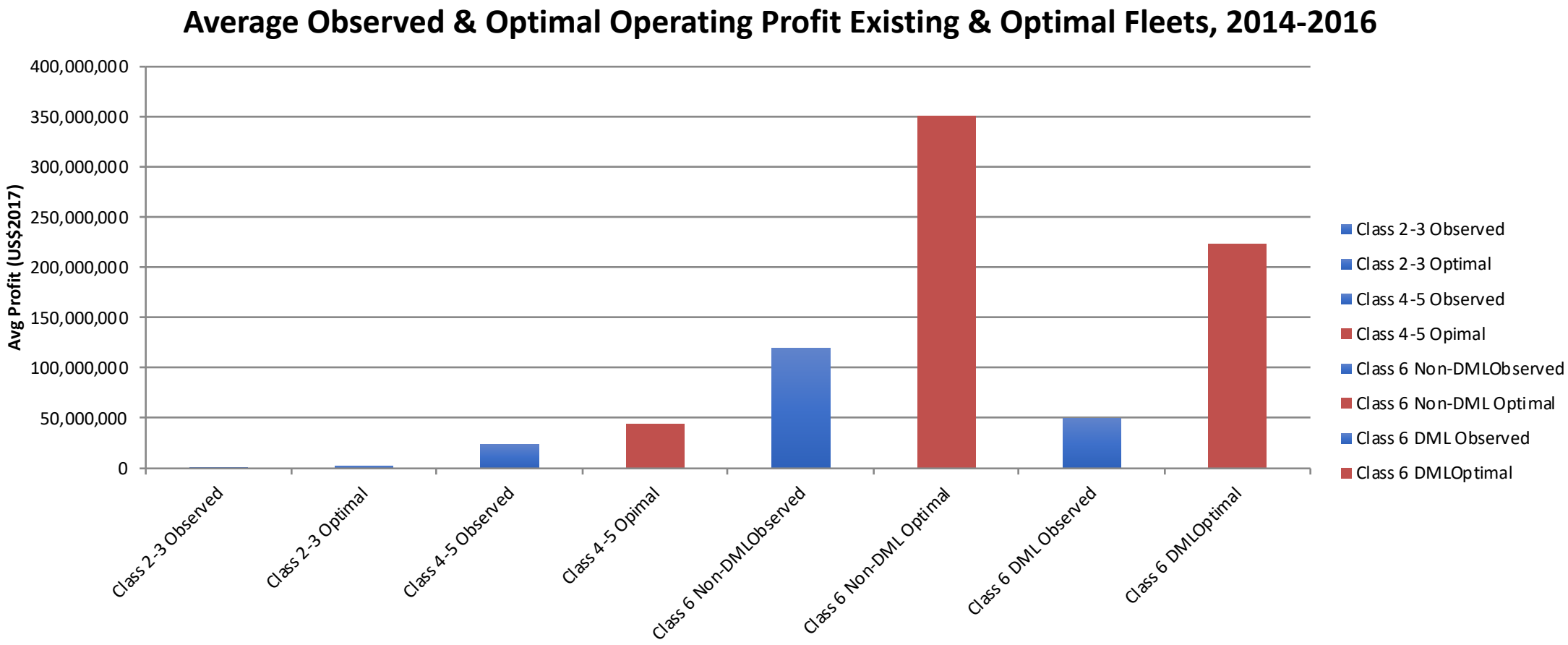


Total Operating Profit of Observed and Efficient Fleet under Observed and Efficient Levels of Capacity and Fleet Configuration (US$2017)

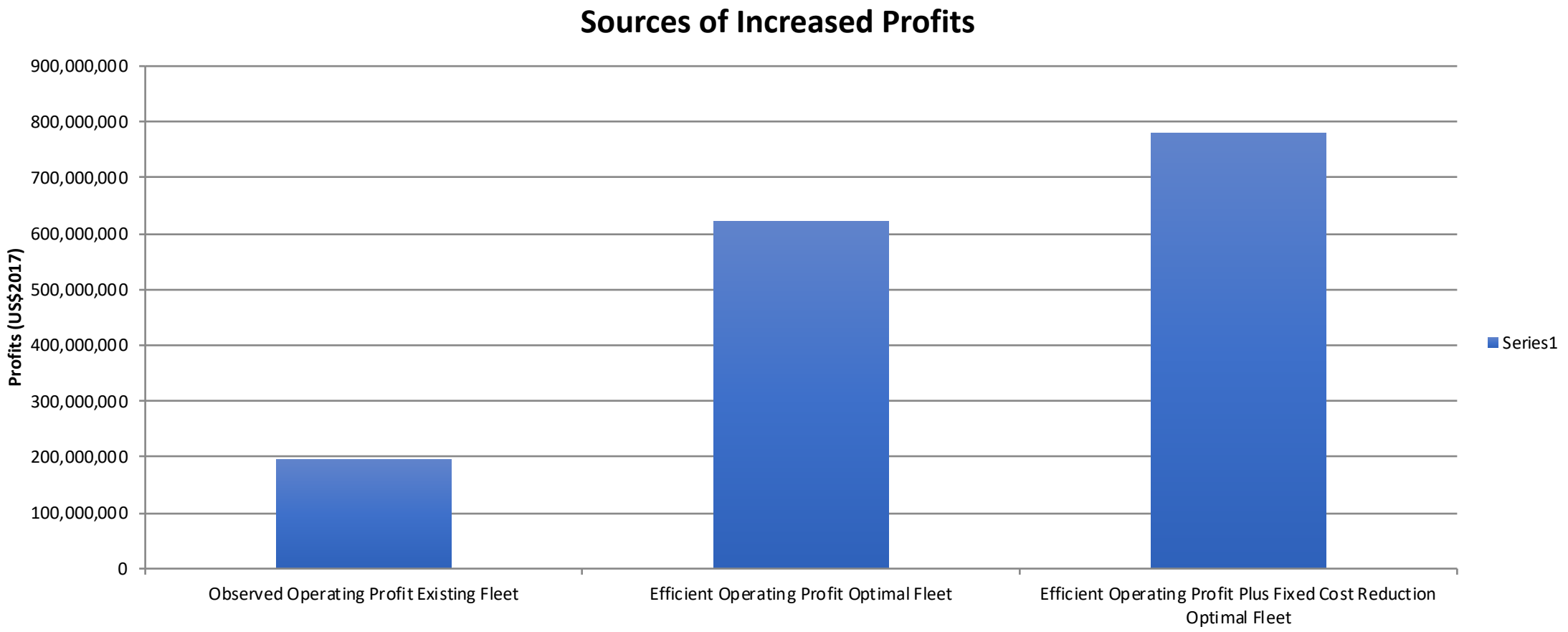
Year	Class 2-3		Class 4-5		Class 6 Non-DML		Class 6 DML		Total	
	Observed	Optimal	Observed	Optimal	Observed	Optimal	Observed	Optimal	Observed	Optimal
2014	2,453,650	4,456,431	33,861,225	43,910,300	151,814,223	322,054,866	106,861,102	218,292,840	294,990,200	588,714,437
2015	183,845	2,736,405	18,564,265	49,021,000	97,692,672	372,801,420	31,375,344	223,300,440	147,816,126	647,859,265
2016	974,113	2,553,978	19,759,036	39,654,860	109,837,728	357,917,238	13,750,998	229,974,672	144,321,875	630,100,748
2014-2016 Average	1,203,869	3,248,938	24,061,509	44,195,387	119,781,541	350,924,508	50,662,481	223,855,984	195,709,400	622,224,817

Source: IATTC data and two-stage Johansen Industry DEA model with MSY and catch constraints and conditional upon biomasses and sea surface temperatures and various production constraints (Shrader and Squires 2013, 2018. Non-convex frontier aggregated over all vessel size classes. Inflation-free US$2017. Difference between observed and optimal due to retaining vessels with the lowest fixed costs and highest optimal operating profit/m^3 of capacity and less efficient vessels exiting the fleet.

Average Observed and Optimal Operating Profit for Existing and Optimal Fleets, 2014-2016 (US$2017)



Sources of Increased Profits for Long-Run Efficient Fleet



Wealth of Present Value of Fleet (US$2017)

Discount Rate	Existing Fleet	Optimal Fleet	
	Observed Operating Profit	Efficient Operating Profit	Efficient Operating Profit Plus Fixed Cost Reduction
5%	3,914,188,007	12,444,496,340	15,594,233,520
10%	1,957,094,003	6,222,248,170	7,797,116,760
15%	1,304,729,336	4,148,165,447	5,198,077,840

Note: Present value (PV) of an annuity A at discount rate i over an infinite time horizon: $PV = A/i$.

IATTC-Wide Vessel Buybacks

Northern Economics

Results

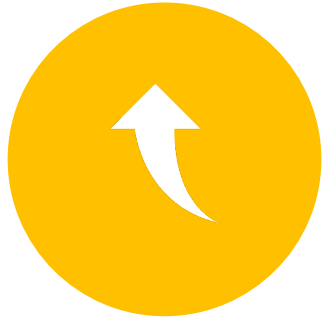
Buybacks are disinvestment by exiting vessels and investment in buying out vessels by remaining vessels

Investments require increase in future profitability and greater certainty over these increases for remaining vessels

REVERSE AUCTION

VESSELS SUBMIT BID OF $/M^3 CAPACITY

SELECT LOWEST BID, THEN NEXT LOWEST BID, ETC. UNTIL BUDGET EXHAUSTED



FINANCED BY TAX ON VESSEL LANDINGS

Northern Economics obtained different results depending upon assumptions

But always profitable for remaining vessels that bought out exiting vessels

Because released catch to remaining vessels increased profitability

Multiple scenarios that eliminate closure

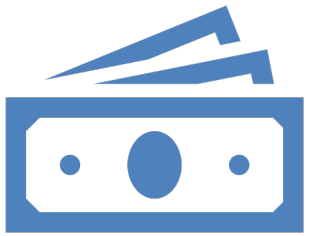
Average total cost of $223 million

Average annual fleet-wide payment from remaining vessels of $26.2 million

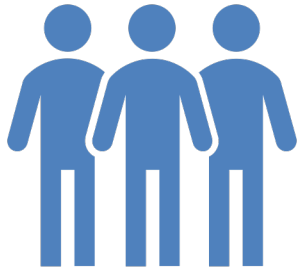
Average fee of expected returns is 3.1%

Average fee per m^3 of remaining capacity of $\$148.1/m^3$

- Average expected gains in operating profit of remaining vessels:
    1. Setting on floating objects: $312,270
    2. Setting on dolphins: $192,492



Flag State capacity right assumed without economic value



Considerable uncertainty over this right

The legal right over the capacity belongs to the flag state then negotiations and policies should consider this characteristic.

National Allocations of TAE to Individual CPCs for Buybacks

Northern Economics

Results

- Without accompanying shift to incentive-based policy, incentives of direct regulation and Tragedy of Commons remains.

- Pilot or experimental national programs require either explicit or implicit national allocations of PAES.
- Explicit allocation gives greater stability and hence security.

CPCs voluntarily remove capacity through buybacks in return for PAES through reduced time-area closure

Synthetic buybacks for Ecuador and Mexico

Remove about 30 vessels

- Approximately 35 percent of the number of vessels that would need to be removed under the fleet-wide buyback
- Due to no latent capacity otherwise found for fleet

$144/m^3$ for Ecuador buyback

$66/m^3$ for Mexico buyback

$171/m^3$ for fleet-wide buyback

1

Remaining vessels in pseudo-Ecuador and pseudo-Mexico finance the buyback

2

Remaining vessels increase their profits through additional days and catch even after paying the buyback levy.

Table ES-6. Estimated Results of a Pilot Single-Country Buyback Program for the Pseudo-Ecuador Fleet

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	$1M Minimum Bid	$2M Minimum Bid	$3M Minimum Bid	Minimum Bid Varies by m^3	Variable Min. & Weight by EPO DAS	Variable Min. & Inverse Weighting
Active Vessels Remaining (from 116)	97	98	97	96	92	98
Capacity (m^3) Remaining (from 96,568)	68,749	66,248	64,742	69,003	67,000	69,576
Annual Pilot Program Cost*	$4,834,014	$7,009,823	$9,311,312	$8,375,398	$12,363,811	$8,257,180
Average Payment per Remaining Vessel	$49,835	$71,529	$95,993	$87,244	$134,389	$84,257
NOR Gains per Vessel Less Average Fee	$325,172	$309,190	$280,824	$297,944	$271,711	$304,978

Note: Estimated pilot program cost include only the compensation paid to vessel owners.

Table ES-7. Estimated Results of a Pilot Single-Country Buyback Program for the Pseudo-Mexico Fleet

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
	$1M Minimum Bid	$2M Minimum Bid	$3M Minimum Bid	Minimum Bid Varies by m^3	Variable Min. & Weight by EPO DAS	Variable Min. & Inverse Weighting
Active Vessels Remaining (from 50)	40	41	42	42	41	42
Capacity (m^3) Remaining (from 61,925)	48,335	48,155	49,101	49,446	48,727	50,436
Annual Pilot Program Cost*	$1,531,096	$2,544,899	$3,213,091	$3,523,794	$3,878,892	$3,480,848
Average Payment per Remaining Vessel	$38,277	$62,071	$76,502	$83,900	$94,607	$82,877
Repayment fee per m^3 of remaining capacity	$31.68	$52.85	$65.44	$71.27	$79.60	$69.02
NOR Gains per Vessel Less Average Fee	$88,956	$43,706	$19,793	$9,825	($553)	$38,930

Note: Estimated pilot program costs include only the compensation paid to vessel owners.