Plan of Action for the Management of Fleet Capacity in the IATTC

by

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The report and its results are intended to inform the conservation and management of the Eastern Pacific Ocean purse seine fishery for tropical tunas. The report does not represent the “last word”. Instead the report is intended to provide suggestions, empirical analysis, and inform on the experience from other fisheries, environmental regulation, and the academic and grey literatures, including the theories of economics, games, and international environmental agreements. The results and recommendations are intended to provide a starting point for the IATTC's deliberations and further analysis, and these deliberations and future events create a dynamic situation that will evolve over time and require further analysis, consultation, and consideration.

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Broad recommendations and principles for the Plan of Action.

- *Capacity reduction in an international fishery is fundamentally an issue in changing behavior and decision-making of both Contracting Parties to the Convention and vessels, not a solution to a technical fisheries management problem or a technological solution*

- Maintain and build upon the current capacity management program and allocation introduced through the 2005 *Plan of Action for the Regional Management of Tuna Fishing Capacity,* Resolution C-00-06 *Resolution on Fleet Capacity,* Resolution C-02-03, and "El Corralito"
- Without an effective plan of action to reduce capacity, time-area closures will become increasingly longer and costly to Contracting Parties to the Convention (CPCs), vessels, processors, and shore-side employment. The latter is not only a consequence of the continuous increment of fishing effort, but also because of future oceanographic conditions in the Eastern Pacific Ocean that are expected to support lower biological productivity and stocks.
- The contract's Terms of Reference only considers alternatives to reduce capacity. However, extensive consultations with CPCs, vessels owners and representatives, and other stakeholders, as well as the long record of IATTC discussion, led to extending the plan of action to address policies focused on small bigeye and yellowfin tunas, or more broadly catch that is not in line with IATTC objectives. Not including this issue in the overall roadmap would create counter-productive and conflicting CPC interests and incentives.
- The report, its approach, and its recommendations should be viewed as not an answer or a final conclusion, but as the starting point for an informed discussion to begin discussing a Plan of Action and to develop a set of principles and options.
- Evaluating the benefits and costs of a plan of action to reduce capacity must compare the plan of action to both the alternative of no agreement that includes an expected lengthening of the time-area closure and the alternative of the fleet operating at its optimal size.
- Break up the broad problem of managing the fishery into individual pieces that can be successfully addressed step-by-step in a phased approach. In this specific case (as per the contract), the issue is addressing capacity.
- Narrow the scope of the capacity problem to what all parties, both CPCs and vessels, can agree upon, even if not the very best policy outcome that is theoretically possible,
- Create an aggregate gain that allows all parties to benefit through compensation mechanisms,

- Ensure that no party loses, and in fact that all parties gain,
- A CPC's expected net benefits must exceed the cost of no agreement,
- Recognize that capacity reduction is an investment program for the remaining vessels and a disinvestment program for exiting vessels, and that the size, distribution, and certainty of future benefits and costs are central for investing vessels buying back the disinvesting vessels,
- Select alternatives that reduce uncertainty and increase clarity over the size of future net benefits and their distribution among CPCs and vessels,
- Select alternatives that are comparatively simple, practical, and inexpensive to implement (including monitoring, control, surveillance, and enforcement costs)
- Select alternatives that facilitate compliance, and build in enforcement right from the beginning,
- Consider "small steps" of direct regulation:
    - document existing vessels that are unavailable before replacement,
    - remove capacity from the Regional Vessel Register whenever capacity is reassigned to a different vessel,
    - freeze capacity immediately,
    - limit increase in the replacement size for vessels,
    - stricter *force majeure*,
    - simplified onboard electronic monitoring system for set and possibly species identification, change the observer program to align with use of on-board monitoring systems, and
    - Vessel Monitoring Systems, either centralized through the IATTC or decentralized through CPCs to the IATTC.
- The current IATTC direct regulation of time-area closure under the Tragedy of the Commons creates counter-productive incentives of "race-to-fish" and over-investment at the vessel level and does not increase cooperation at the CPC level, and may even incentivize declining CPC cooperation as the time-area closure increases in the future.
- Recognize that behavior and decision-making in an international fishery must be addressed at two levels: CPC and vessel. Therefore economic incentives must be realigned away from "race-to-fish" and overinvestment under direct regulation and Tragedy of the Commons at both levels to reduce capacity.
- Create incentives aligning CPC and vessel behavior and decision-making with IATTC objectives.
- To increase cooperative CPC behavior and decision-making, it is recommended to accept all outstanding CPC capacity requests deemed reasonable and legitimate by the IATTC. Paradoxically, increasing capacity allows reaching agreement on a plan of action to reduce capacity. Conditions placed upon accepted capacity claims, such as their activation only as part of an implemented comprehensive plan of action and freezing capacity thereafter or not allowing transfers of newly granted capacity and/or requiring attaching the granted

capacity to an actual vessel of the CPC that is not transferable, insure that capacity is not simply and solely increased.

- Use more decentralized and incentive-based approaches than the IATTC's centralized direct regulation under the Tragedy of the Commons,
- Enlist vessel and CPC incentives and realign them from "race-to-fish" and over-investment due to direct regulation and the Tragedy of the Commons to greater CPC and vessel cooperation and profitability through incentive-based policy,
- Recognize that capacity cannot be effectively reduced when facing incentives for "race-to-fish" and to over-invest under direct regulation and the Tragedy of the Commons and that buybacks under these conditions are ineffective. That is, buybacks are premature prior to changing incentives of both CPCs and vessels, so that buybacks should only be implemented after introducing incentive-based policy that realigns CPC and vessel incentives from "race-to-fish" and over-invest to IATTC objectives.
- Select incentive-based policy that increases certainty over future benefits and costs and incentives for capacity reduction (disinvestment), including vessel buybacks, and investment by remaining vessels through financing the buyback
- Adopt an intermediate policy approach of incentive-based policy and buybacks that is not property rights, which in turn are not currently feasible.
- Effort-based rather than catch-based incentive-based management is recommended for several reasons:[1]
    - It is a direct extension of the current effort and fishing mortality management approach,
    - It is simpler, easier, and less expensive to implement
        - Requires Vessel Monitoring Systems that are already in place at the CPC and vessel level and can be readily extended to the IATTC level
        - Does not require independent plant inspectors for landings, more extensive species identification, improved and more extensive data collection, or more frequent and complicated stock assessments,
    - Less risk and uncertainty in calculating Total Allowable Effort than Total Allowable Catch and gives automatic feedback with respect to abundance
    - Can readily and at low cost revert to current direct regulation through time-area closures if deemed an ineffective approach,
    - Provides a phased approach that can eventually be converted to catch-based management if so desired as a natural extension.

[1] See: (i) Appendix XX of this Report, (ii) Squires, D., M. Maunder, R. Allen, P. Andersen, K. Astorkiza, G. Caballero, R. Clarke, H. Ellefsen, P. Guillotreau, J. Hampton, R. Hanneson, E. Havice, M. Helvey, S. Herrick, Jr., K. Hoydan, V. Maharaj, R. Metzner, I. Mosqueira, A. Parma, I. Prieto-Bowen, V. Restrepo, S. Sidique, S. Steinsham, E. Thunberg, I. del Valle, and N. Vestergaard. 2017. "Rights-Based Management by Fishing Effort." *Fish and Fisheries* 18(3): 440-465, and (iii) Squires, D., M. Maunder, N. Vestergaard, V. Restrepo, R. Metzner, S. Herrick, R. Hannesson, I. del Valle, and P. Anderson, editors. 2016. *Effort Rights in Fisheries Management: General Principles and Case Studies from Around the World. 2016. FAO Fisheries and Aquaculture Proceedings P34*. Rome: Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/3/a-i5744e.pdf

- Nonetheless, effort-based management in comparison to catch-based management faces several limitations, most importantly:
    - "Effort creep" whereby incentives are to increase effort and productivity (fishing power) in order to increase catch and whereby effective effort increases over time due to technological progress,
        - Hence, effort-based management requires additional limits on other types of capital that impact fishing mortality
    - Catch approach creates stronger incentives to reduce capacity, effort, and costs,
    - Catch approach directly addresses species composition and size rather than indirect approach of effort.

- Develop an individual transferable days credit program based upon the current capacity management program of Resolution C-02-03, including its allocation of capacity and/or use historical days (that itself reflects the capacity allocation) as the basis for allocation.
- This incentive-based program of individual transferable days credits should:
    - be based upon days at sea rather than days fishing or days with sets to create the simplest, cheapest, and most enforceable program
    - allocates days-at-sea limits to individual vessels and unused days form credits that can be bought and sold, internally reallocated among vessels among multi-vessel companies, and possibly carried forward to the following year,
    - creates incentives to change behavior and decision-making away from race-to-fish and over-investment from direct regulation and Tragedy of the Commons,
    - not be a property right, but simply a limit made flexible,
    - allow vessels to flexibly adjust production to adapt to tightening limits on days at sea until meaningful capacity reduction is achieved,
    - builds upon Resolution C-02-03 on capacity, "El Corralito", and the current limited days and fishing mortality approach but make it flexible for vessels and processors,
    - insures that no CPC or vessel loses and in fact gains in net benefits,
    - provides future net benefits that are enjoyed within one year and are highly certain, i.e. increases expected operating profits in a short period of time,
    - establishes the foundation for capacity reduction through a subsequent vessel buyback,
    - be low cost and relatively simple to implement and enforce (VMS is the major commitment and expense),
    - be based upon the Regional Vessel Register
    - be based upon a hard limit on capacity, but

    - allow for the entry of new capacity/vessels[2]
- An alternative to the individual transferable days credit program is an individual transferable catch credit program for bigeye and yellowfin that also provides an incentive-based policy that:
    - Allocates catch limits for bigeye and yellowfin to individual vessels and unused catch limits form credits that can be bought and sold and possibly carried forward to the following year.
    - Creates stronger incentives to reduce capacity. However, catch limits also require a more comprehensive and costly program of monitoring, control, surveillance, as well as, presents a greater departure and bigger step than an individual transferable days credit program.
    - Has even stronger program requirements than a simpler individual transferable catch credit program in which catch is not differentiated by size but only by species.
- The fundamental ways to remove capacity are: (i) bankruptcy and exit; (ii) voluntary exit while financially solvent; (iii) rights-based management whereby one vessel buys the quota of another vessel and the selling vessel exits; and (iv) vessel buybacks, either mandatory or voluntary.
- Voluntary buybacks are the only feasible constructive IATTC-wide option in this fishery.
    - However, IATTC-wide voluntary buybacks should be introduced after the individual transferable days credit program is up and running and changes incentives away from race-to-fish and over-investment and creates the certainty over future expected benefits and costs through stable conditions and allocation required for a successful buyback program,
- Consider an alternative of allocating national TACs or TAEs that perhaps is conditional upon a national plan of action to reduce capacity.
    - National allocations of TACs or TAEs without a national plan of action to reduce capacity maintain the incentives of "race-to-fish" and over-investment from direct regulation and Tragedy of the Commons.
    - Voluntary or involuntary buybacks are an option in this basic alternative of this report, national allocation of TACs or TAE coupled with national plans of action to reduce capacity.
- Consider alternatives that promote greater flexibility and create positive incentives to reduce capacity through reduction of closure days for those CPCs that unilaterally decide to introduce a program whose objective is reduce capacity. This can be with a national allocation of TAC or TAE tied to a national

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[2] For details, see Inter-American Tropical Tuna Commission - Scientific Advisory Committee. 2011. "Evaluation of a Total Allowable Catch System for the Purse-Sine and Longlne Tuna Fisheries in the Eastern Pacific Ocean," Document IATTC-82-INF A. Available at: http://www.iattc.org/Meetings/Meetings2011/Jun/_English/IATTC-82-INF-A-Evaluation-of-TAC-program.pdf

plan of action to reduce capacity or through an allocation of days to individual vessels

- In the same vein of the previous recommendation, consider as an additional alternative suitable to either program (i.e. individual transferable days credits or national allocation of TACs or TAEs), the implementation of an additional credit program of rewarding days for capacity reduction. This credit program can extend across CPCs in which one CPC (or its vessels) purchase and reduce capacity in one CPC to earn the credit reward-days.
- Address the issue of small bigeye and yellowfin tuna in a phased approach after introducing an incentive-based policy (individual transferable days credit program) through a combination of direct regulation with technology standards and incentive-based policy. Potential options include:
    - annual vessel limits on the harvests of small bigeye and yellowfin tunas (performance standards),
    - limits on net depth (size) or area fished (technology standards),
    - processor size standards (performance standards),
    - in days credit program, potentially include reduced IATTC-wide time-area closure for small fish or limit number of days that can be used in certain months
    - increased price discrimination by vessel size (a voluntary tax levied on small fish and an incentive-based approach), and
    - individual transferable quotas for catch by fish size (incentive-based regulation)

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Capacity reduction in an international fishery is fundamentally an issue in changing behavior and decision-making of both Contracting Parties to the Convention and vessels, not a solution to a technical fisheries management problem or a technological solution.[3]

1. Introduction

1.1. Purpose of the Report

This report was prepared to satisfy the contract to the IATTC, entitled "Action Plan for Fleet Capacity Management in the IATTC". The Directorate General for Maritime Affairs and Fisheries of the Commission of the European Union funded the contract. Dr. Dale Squires directed the development and writing of the report.

In this report, "capacity" is understood to mean cubic meters of well capacity as defined by IATTC Resolution C2-03 and as recommended by the 2005 *Plan of Action for the Regional Management of Tuna Fishing Capacity*. Various distinctions of capacity, such as active, inactive, etc. are understood to follow the definitions given in IATTC DOCUMENT CAP-20-01 (2018), Utilization of Vessel Capacity Under Resolutions C-02-03, C-12-06, C-12-08 And C-15 -02 (Updated as of 30 June 2018).[4]

The Terms of Reference for this report only consider alternatives to reduce capacity. However, extensive consultations with CPCs, vessels owners and representatives, and other stakeholders, as well as the long record of IATTC discussion, led to extending the plan of action to address policies focused on small bigeye and yellowfin tunas. Not including this issue in the overall roadmap would create counter-productive and conflicting CPC interests and incentives.

The report builds upon: (1) IATTC's Resolution C-00-06, *Resolution on Fleet Capacity,* and 2005 *Plan of Action for the Regional Management of Tuna Fishing Capacity,* 2016 *Elements for Implementing a Fleet Capacity Management Plan in the IATTC*, and numerous IATTC Resolutions, reports, and analyses (see References), (2) the framework of the FAO International Plan of Action for the Management of Fishing Capacity and the FAO Code of Conduct for Responsible Fisheries, as envisaged by Article 2(d) of the Code,

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[3] See also Campling, L., E. Havice, and P. Howard. 2012. 'The Political Economy and Ecology of Capture Fisheries: Market Dynamics, Resource Access and Relations of Exploitation and Resistance', *Journal of Agrarian Change*, 12(2-3): 177-203 and Jentoft, S., 2007. 'In the Power of Power: The Understated Aspect of Fisheries and Coastal Management'. *Human Organization*, 66 (4): 426–37

[4] https://www.iattc.org/Meetings/Meetings2018/IATTC-93/PDFs/Docs/_English/CAP-20-01-EN_Review-of-changes-in-the-utilization-of-fleet-capacity-in-the-EPO.pdf

(3) two recent consultancies: Northern Economics “Alternatives to Address Excess Capacity in the Eastern Pacific Purse Seine Tuna Fishery” and Bucaram “Cost Benefit and Financial Analyses of Quota Managed Options for Bigeye and Yellowfin Tunas in the Eastern Pacific Ocean”, (4) the IATTC’s Cartagena and Mexico City buyback workshops, (5) numerous workshops by FAO, US NOAA Fisheries, IATTC, World Bank, WWF, Government of Ecuador, and the International Seafood Sustainability Foundation, (6) the PNA Vessel Day Schemes for purse seine vessels and for longline vessels, (7) global experience in fisheries, with incentive-based management in industries with issues in pollution, climate, energy, water, mining, and terrestrial conservation, and industrial regulation and industrial organization across all industries, (8) an extensive academic literature on fisheries, the environment, resource management, industrial organization, and regulation of industries of all types, and (9), site visits to numerous CPCs and consultations with the purse seine industry. Appendix XXX provides references to all of these sources.

1.2. What is the Fundamental Issue and Why?

Under the Tragedy of the Commons, vessels (and even CPCs) have every incentive to compete for the largest possible share of a limited catch, therefore leading to a “race for fish” and a continuous investment in fishing capacity (and other forms of capital and new technology) to compete with other vessels and catch the largest share of the catch before the total catch or effort limit is reached.

The result is levels of fleet capacity and other forms of capital that exceed the optimal that is needed to capture the catch or effort target (fishing mortality corresponding to MSY, modified by any control rules), a situation referred to as over-capacity.[5] Over-capacity results in economic waste and inefficiency as each vessel catches fewer fish but continues to invest in vessels to catch these fish. Such “race-to-fish” behavior and

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[5] See the FAO International Plan of Action for the Management of Fishing Capacity. Rome, FAO. Available at: http://www.fao.org/docrep/006/X3170E/x3170e04.htm, Report of the FAO Technical Working Group on the Management of Fishing Capacity. La Jolla, United States of America, 15-18 April 1998. FAO Fisheries Report No. 586 Available at: http://www.fao.org/docrep/006/x0488e/x0488e00.htm, Kirkley, J.E., and D.E. Squires 1999a. Measuring Capacity and Capacity Utilization in Fisheries. In: D. Greboval (ed.). *Managing Fishing Capacity: Selected Papers on Underlying Concepts and Issues*. FAO Fisheries Technical Paper 386. Rome: Food and Agricultural Organization of the United Nations, http://www.fao.org/docrep/003/X2250E/x2250e05.htm#CHAPTER%203%20MEASURING%20CAPACITY%20AND%20CAPACITY%20UTILIZATION%20IN%20FISHERIES%20(James%20Kirkley1%20and%20Dale%20Squires2), Allen, R., J. Joseph, and D. Squires, editors. 2010. *Conservation and Management of Pacific Tunas*. Ames, Iowa: Wiley-Blackwell Publishing, 392 pages, and Squires, D., R. Allen, and V. Restreppo. 2014. *Rights-Based Management in International Tuna Fisheries*. FAO Fisheries and Aquaculture Technical Paper No. 571. Rome: Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/docrep/018/i2742e/i2742e.pdf, Joseph, J., D. Squires, W. Bayliff, and T. Groves. 2007. “Requirements and Alternatives for the Limitation of Fishing Capacity in Tuna Purse-Seine Fleets.” *FAO Fisheries Proceeding 8*. Rome: Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/3/a-a1338e.pdf

unnecessary investment results in vessels fishing at times and in ways that increase costs and erode fishery-wide profits. Racing behavior and unnecessary investment also cause shrinking fishing seasons, as currently witnessed by the IATTC, lead to landing fish at times that do not always fetch the highest price due to concentrated landings on the market. This behavior might well enable and incentivize violations of catch restrictions and create pressures to increase the sustainable catch or effort limits, thereby threatening sustainability. A formal Total Allowable Catch or Effort, whether fishery-wide or allocated to CPCs, does not alter these perverse incentives, and may in fact worsen the overcapacity issue, since such limits increase the potential value of additional productive capital and racing behavior.[6]

It is necessary to emphasize that economic incentives in an international fishery work at two levels, the CPC and the vessel. An effective plan of action to manage capacity addresses both levels of behavior and decision-making through altering economic incentives. Because Regional Fisheries Management Organizations are based upon voluntary multilateral cooperation and are self-enforcing, CPC behavior and decision-making to achieve this cooperation must also be addressed. Realigned economic incentives at the CPC level can increase this cooperation.[7]

In sum, the current “race-to-fish” of the Tragedy of the Commons and centralized direct regulation incentivize the current behavior and decision-making of CPCs and vessels for both over-investment and timing and amount of fishing activities. Under these perverse incentives, vessels race against each other for the largest share of the catch and over-invest before the total catch or effort limit is reached. The result is shortening seasons, eroding profits, and disruptions in the timing of fish supply to processors.

Many options exist to regulate capacity. Direct regulation[8] of the fishery, such as: (i)

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[6] Allen, R., J. Joseph, and D. Squires, editors. 2010. *Conservation and Management of Pacific Tunas*. Ames, Iowa: Wiley-Blackwell Publishing, 392 pages and Squires, D., R. Allen, and V. Restreppo. 2014. *Rights-Based Management in International Tuna Fisheries*. FAO Fisheries and Aquaculture Technical Paper No. 571. Rome: Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/docrep/018/i2742e/i2742e.pdf. Grafton, R.Q., R. Arnason, T.Bjørndal, D. Campbell, H. Campbell, C. W. Clark, R. Connor, D. Dupont, R. Hannesson, R. Hilborn, J. Kirkley, T. Kompas, D. Lane, G. Munro, S. Pascoe, D. Squires, S. Steinshamn, B. Turris, Q. Weninger. 2006. “Incentive-Based Approaches to Sustainable Fisheries.” *Canadian Journal of Fisheries and Aquatic Sciences* 63(3): 699-710. https://doi.org/10.1139/f05-247. OECD (2006). *Using Market Mechanisms to Manage Fisheries: Smoothing the Path*. Paris: Organization for Economic Cooperation and Development. Available at: http://www.oecd.org/agriculture/agricultural-policies/39318632.pdf

[7] Barrett, S. 2003. *Environment and Statecraft: The Strategy of Environmental Treaty-Making*. Oxford: Oxford University Press, Barrett, S. 2005. “The Theory of International Environmental Agreements.” Chapter 28 in K.-G. Mäler and J. Vincent, editors, *Handbook of Environmental Economics*, Vol. 3. Elsevier Science, pages 1458-15122, and Barrett, S. 2016. “Coordination vs. Voluntarism and Enforcement in Sustaining International Environmental Cooperation.” *Proceedings of the National Academy of Sciences* 113(51): 14515-1452.

[8] Direct regulation, sometimes called command-and-control regulation, occurs when a government or regulatory body such as the IATTC directly controls an activity through compulsory restrictions of the

time-area closures, (ii) limits on effort or catch, or (iii) limits on the types of technology employed/methods of fishing. These direct regulation policies are expected to not alter these perverse incentives, and in fact can make them worse. In fact, direct regulation, by not realigning incentives away from “race-to-fish” and continuous investment, raises costs and erodes profits.

Limited entry, such as the IATTC’s Resolution C-02-03, is a necessary place to start. This type of policy, however, is insufficient by itself, since limited entry simply limits the number of vessels and even their size (capacity) but does not eliminate the perverse incentives for the “race-to-fish” and over-investment and thereby increase investment in unregulated forms of capital, such as the use of more advanced and efficient types of fishing technologies and methods.[9] Thus, if perverse incentives remain to increase capacity to catch more fish, fishers will find innovative methods to increase “actual fishing capacity” within existing regulations[10].

On the other hand, incentive-based approaches (sometimes called market-based) change vessel (and CPC) incentives away from the “race-to-fish” and over-investment to increase capacity. Instead, with exclusive use of days or catch vessels make their own, economically rational decisions on the appropriate level of fishing capacity (versus investment to expand capacity) and timing of fishing activities (versus the “race to fish”).[11] As a result, incentive-based approaches create more controlled exploitation,

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choices facing vessels, i.e. they are left with no choice but to comply. Regulatory requirements tend to be less flexible than incentive-based instruments, as they do not allow vessels the freedom to determine the least costly way of meeting their objectives Direct regulations include performance standards (directly setting outcomes such as a quota on fish caught or a global Total Allowable Catch/Effort or national allocation of Total Allowable Catch/Effort), process standards (directly controlling the production process such as a quota on effort or a time-area closure), or technology standards (specifying technology such as the back-down procedure or FAD design and methods of operation such as no sundown sets or setting on whale sharks).Direct regulation is often wasteful, costly, and ineffective because it fails to harness the natural self-interest of CPCs and vessels and the decentralized information that vessels hold and the regulator (IATTC) does not that incentive-based approaches otherwise do. See OECD. 2006. *Using Market Mechanisms to Manage Fisheries: Smoothing the Path*. Paris: Organization for Economic Cooperation and Development. Available at: http://www.oecd.org/agriculture/agricultural-policies/39318632.pdf and Grafton, R.Q., R. Arnason, T.Bjørndal, D. Campbell, H. Campbell, C. W. Clark, R. Connor, D. Dupont, R. Hannesson, R. Hilborn, J. Kirkley, T. Kompas, D. Lane, G. Munro, S. Pascoe, D. Squires, S. Steinshamn, B. Turris, Q. Weninger. 2006. “Incentive-Based Approaches to Sustainable Fisheries.” *Canadian Journal of Fisheries and Aquatic Sciences* 63(3): 699-710. https://doi.org/10.1139/f05-247.

[8] An individual transferable catch or effort quota as a form of rights-based management automatically and inherently addresses the over-capacity as the industry self-rationalizes.

[9] See Hallman, B., S. Barrett, R. Clarke, J. Joseph, and D. Squires. 2010. “Limited Access in Transnational Tuna Fisheries.” Chapter 12 in R. Allen, J. Joseph, and D. Squires (eds) *Conservation and Management of Transnational Tuna Fisheries*. Ames, Iowa: Wiley-Blackwell, pp. 195-211.

[10] Including all potentially eligible vessels to reach an agreement on limited entry can increase capacity by including vessels that might not otherwise always fish or hold a license. By including all potentially eligible vessels, all parties gain, or at least do not lose, by borrowing potential profits from the future.

[11] Grafton, R.Q., R. Arnason, T.Bjørndal, D. Campbell, H. Campbell, C. W. Clark, R. Connor, D. Dupont, R. Hannesson, R. Hilborn, J. Kirkley, T. Kompas, D. Lane, G. Munro, S. Pascoe, D. Squires, S. Steinshamn, B.

higher profits, safer fishing practices, improved product condition, and improved seasonal availability of the product – with benefits for both processors and consumers.[12] Incentive-based approaches will necessarily be accompanied by some forms of direct regulation, such as technology standards on gear and equipment design (such as floating aggregator device design or the Medina panel), limits on some forms of capital (such as floating aggregator devices, and operating standards (such as the backdown procedure), and time-area closures for strict biological reasons (such as spawning areas). Moreover, fisheries management is increasingly a hybrid of catch and effort approaches, some of which are incentive-based and others direct regulation.

Capacity reduction is fundamentally an investment problem, whereby remaining vessels make investment decisions to finance vessel exit – disinvestment by exiting vessels. In turn, investment decisions require reasonable levels of certainty over the vessel's expected future benefits and costs. Hence, capacity reduction requires greater certainty over current and future expected benefits and costs to incentivize the investment and disinvestment decisions that are inherent to capacity reduction. Shifting from direct regulation and Tragedy of the Commons' perverse incentives to economic incentive-based management increases certainty over future expected benefits. In addition, by lowering the risk premium, increased certainty can also reduce the otherwise higher time discount rate that lowers the present value of expected future benefits and reduces the present value of the pay-off to capacity reduction.

In conclusion, rights-based management, such as individual transferable quotas for catch or effort, by providing secure and exclusive allocations of catch or effort realign the incentives from over-invest and "race to fish" and thereby align the behavior and decision-making of CPCs and individual vessels with the socio-economic-ecological objectives of the IATTC. Rights-based management also inherently reduces capacity as the most profitable vessels purchase the rights of the least profitable vessels and the latter exit the fishery.

Turris, Q. Weninger. 2006. "Incentive-Based Approaches to Sustainable Fisheries." *Canadian Journal of Fisheries and Aquatic Sciences* 63(3): 699-710. https://doi.org/10.1139/f05-247. Allen, R., J. Joseph, and D. Squires, editors. 2010. *Conservation and Management of Pacific Tunas*. Ames, Iowa: Wiley-Blackwell Publishing, 392 pages. Allen, R. 2010. *International Management of Tuna Fisheries: Arrangements, Challenges and a Way Forward*. FAO Fisheries and Aquaculture Technical Paper No. 536. Rome, FAO. 45 pp. Available at: http://www.fao.org/docrep/012/i1453e/i1453e00.pdf

[12] Grafton, R.Q., R. Arnason, T.Bjørndal, D. Campbell, H. Campbell, C. W. Clark, R. Connor, D. Dupont, R. Hannesson, R. Hilborn, J. Kirkley, T. Kompas, D. Lane, G. Munro, S. Pascoe, D. Squires, S. Steinshamn, B. Turris, Q. Weninger. 2006. "Incentive-Based Approaches to Sustainable Fisheries." *Canadian Journal of Fisheries and Aquatic Sciences* 63(3): 699-710. https://doi.org/10.1139/f05-247. L. Ridgeway and C.C. Schmidt. 2010. "Economic Instruments in OECD Fisheries: Issues and Implementation." Chapter 23 in R.Q. Grafton, R. Hilborn, D. Squires, M. Tait, and M. Williams. 2010. *Handbook of Fisheries Conservation and Management*. Oxford: Oxford University Press, pages 310- 323 and OECD. 2006. *Using Market Mechanisms to Manage Fisheries: Smoothing the Path*. Paris: Organization for Economic Cooperation and Development. Available at: http://www.oecd.org/agriculture/agricultural-policies/39318632.pdf

However, there are numerous practical difficulties in the adoption of rights-based management in an international fishery.[13] These difficulties most importantly stem from the issue of who holds and exercises sovereign rights, and the duration of these rights, to a shared migratory international resource when there are multiple jurisdictions (i.e. EEZs and the high seas, multiple Flag States). This issue of who owns and exercises sovereign rights, aggravated by the duration of these rights, is compounded by: conceptions and legal definitions of property that vary by Flag State. Further complicating the issue is Flag State heterogeneous goals and objectives, levels of economic development, and perceptions of the problem, costs, and benefits. Moreover the property rights are held in common through a multilateral cooperative political institution (that is voluntary and self-enforcing). Multiple Flag States, with all of these inherent differences, agreeing on the fundamental nature of property rights and their allocation is no easy task. The presence of multiple rights (Flag State and vessel/capacity/quota typically held by firms) and the potential for free entry under international law further compound the inherent complexity and difficulty of the issue.

An additional factor besides the nature of property is uncertainty over the size and distribution of future expected benefits and the costs of implementation among Flag states and vessels.[14] The greater the uncertainty associated with cost and benefit calculations, the lower the expected returns. Expected future benefits tend to be much more uncertain than the costs of implementation that are typically realized immediately and are known with greater certainty. Expected future benefits also tend to be highly time discounted, especially in an industry characterized by considerable risk through volatility in prices and catches. Parties also tend to give more weight to avoiding certain and more immediate costs than gaining future benefits, and even more so future benefits that are uncertain and highly discounted.

Adopting rights-based management in even the far simpler setting of national fisheries, much less in international fisheries, has proven difficult. For that reason, many national fisheries turn to an intermediate policy to conserve and to manage fisheries as well as to reduce capacity. This intermediate policy is buybacks of fishing vessels, permits, or both. Buybacks, however, by increasing profits in the short run, can paradoxically increase the incentives to "race-to-fish" and invest to increase capacity by the remaining vessels.[15]

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[13] On issues with property in fisheries, see Campling, L. and E. Havice. 2014. "The Problem of Property in Industrial Fisheries." *Journal of Peasant Studies*, 41(5): 707-727.

[14] For further discussion, see Libecap, G. 2007. "Open-Access Losses and Delay in the Assignment of Property Rights." National Bureau of Economic Research Working Paper 13642. National Bureau of Economic Research, Washington, D.C. Available at: http://www.nber.org/papers/w13642 and Libecap, G. 2014. "Addressing Global Environmental Externalities: Transaction Costs Considerations." *Journal of Economic Literature* 52(2): 424-479. Available as a National Bureau of Economic Research Working Paper 19501 (2013) at: http://www.nber.org/papers/w19501.pdf

[15] See Squires, D., J. Joseph, and T. Groves. 2010. "Buybacks in Transnational Fisheries." Chapter 11 in R. Allen, J. Joseph, and D. Squires, editors, *Conservation and Management of Transnational Tuna Fisheries*. Wiley-Blackwell Publishing, pages 181-194, Squires, D. 2010. "Fisheries Buybacks: A Review and

For this reason, incentive-based approaches are a necessary first step before buybacks can be implemented.

Therefore, this report recommends another intermediate policy, which is incentive-based, to change the incentives of vessels away from the "race to fish" and overinvestment. This intermediate, incentive-based policy to change vessel behavior and decision-making, which is based on individual vessel limits, is individual transferable credits. Credit systems are not property rights, but individual vessel limits from direct regulation made flexible[16]. Credit systems are similar to Dolphin Mortality Limits.[17]

Both buybacks and credit systems are intermediate policy instruments and thereby less economically efficient than rights-based management. However, they are more tractable than rights-based management in an international fishery (for the reasons outlined above) and improve welfare and net benefits compared to the existing direct regulation of time-area closure. They can be implemented as a phased, step-by-step approach that over time can transition to rights-based management should CPCs want to and the underlying conditions support. A phased approach allows learning how the system works, which in turn allows adaptation and refinement, before proceeding to the next step.

1.3. Recommendations and Alternatives

The primary recommendations of the report follows the recommendations from the IATTC's Resolution C-00-06 *Resolution on Fleet Capacity,* the 2005 *Plan of Action for the Regional Management of Tuna Fishing Capacity*, and the 2016 *Elements for Implementing a Fleet Capacity Management Plan in the IATTC* to manage fishing capacity by adopting a phased approach and by using economic incentives. Resolution C-00-06 states that the management of fishing capacity should encourage the efficient

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Guidelines." *Fish and Fisheries* 11(4): 366-387, Curtis, R. and D. Squires, editors. 2007. *Fisheries Buybacks.* Blackwell Publishing, 267 pages, and Squires, D., T. Groves, R. Grafton, R. Curtis, J. Joseph and R. Allen. 2010. "Fisheries Buybacks." Chapter 37 in R.Q. Grafton, R. Hilborn, D. Squires, M. Tait, and M. Williams, editors. 2010. *Handbook of Marine Fisheries Conservation and Management*. Oxford: Oxford University Press, pages 507-519

[16] A key distinction between rights-based management and a credit system (for either catch or effort) is that the right is owned and tradable, whether actually used all or in part. A credit from a limit only pertains to the unused portion of the limit and does not entail a right to the credit or limit or the residual catch/effort covered by the limit. Limits are not owned, do not confer a "right" to the full amount, and face a limited duration (length of time). Transferable credits from limits are complementary to direct regulation and not a substitute, whereas rights-based management is a clear-cut substitute for direct regulation. Appendix 13 discusses credit systems versus rights-based management.

[17] Credit systems grew out of direct regulation of pollution control to make quotas flexible for firms. See Nentjes, A. and E. Woerdman 2012. "Tradable Permits versus Tradable Credits: A Survey and Analysis." *International Review of Environmental and Resource Economics* 6: 1-78. They have been used in a few national fisheries, notably the Scottish cod fishery to address small and juvenile cod and the Scottish fishery for Norwegian lobsters in which small and juvenile cod form bycatch.

use of fishing capacity, allow the legitimate transfer of vessels among CPCs and all participants in these fisheries, and discourage entry of new vessels into the EPO if that leads to excess capacity. The 2005 *Plan of Action for the Regional Management of Tuna Fishing Capacity* also emphasizes the economic importance of the fleets targeting species covered by the Convention and the need to limit the size of these fleets to a level commensurate with economic viability should be considered in implementing the *Plan of Action for the Regional Management of Tuna Fishing Capacity*. This report builds upon Resolution C-02-03 and the Regional Vessel Register, and accepts the "corralito", and from Resolution C-13-01 and Resolution C-17-01/C-17-02, the requirement that all purse-seine vessels are required to land all tropical tunas caught, except fish considered unfit for human consumption for reasons other than size.

The first of the report's two most fundamental recommendations is to individually address the major conservation and management issues facing the IATTC, rather than addressing them all at once, the report recommends to approach the issues in a phased or step-by-step and adaptive approach. Narrowing the focus to policy approaches for which agreement can be reached may lead to a choice of policy that is not necessarily the absolute best to reduce capacity and address the other outstanding issues, but will be tractable and lead to an improvement. Once a good start has been made, further changes can be made.

The second of the report's two most fundamental recommendations is that capacity cannot be successfully addressed before first changing the behavior and decision-making of both CPCs and vessels through realigning economic incentives at two levels, both CPCs and vessels. That is, effective and durable capacity reduction cannot be achieved without creating an incentive structure that supports rather than counters capacity reduction and eliminates the perverse incentives of "race-to-fish" and over-investment from direct regulation and Tragedy of the Commons, and incentivizes the improved economic efficiency that underpins them.

Increased CPC cooperation can be achieved through granting existing unresolved capacity requests that the IATTC considers legitimate and responsible. All parties to an agreement must gain, and until unresolved requests deemed legitimate and responsible are granted, those parties with unfilled claims will consider themselves as losing from any plan of action. On the face of it, the granting parties appear to lose welfare by the additional capacity in the fishery. However, paradoxically, granting these requests to increase cooperation allows addressing the capacity problem, so that over a longer time period all parties gain in welfare through lower capacity and higher and more certain future net benefits. Granting unresolved capacity claims deemed legitimate and reasonable by the IATTC must be conditioned upon implementation of a meaningful plan of action on capacity, thereby creating an incentive to increase CPC cooperation.[18]

[18] See IATTC – Working Group on Capacity. 2013. CAP-14 INF A EU Working Paper on a Capacity Management Plan. Available from: https://www.iattc.org/Meetings/Meetings2013/Jun/_English/CAP-14-

Additional limitations on granted capacity are all possible, such as not allowing transfer to another CPC, requirement that a vessel be obtained for the capacity and actively fished within a limited period of time such as 18 months, and so forth.

After granting the unresolved capacity claims, the Regional Vessel Register has to be frozen and no new capacity granted. Procedures for new entrants into the fishery, relationships between active and operative capacity and inactive capacity and the Regional Vessel Register, transfers of capacity between new entrants and existing vessels, the relationship between days and the Regional Vessel Register are given in Inter-American Tropical Tuna Commission - Scientific Advisory Committee. 2011. "Evaluation of a Total Allowable Catch System for the Purse-Sine and Longlne Tuna Fisheries in the Eastern Pacific Ocean," Document IATTC-82-INF A.[19] Additional potential approaches and broad discussion, including experience in both tuna and high seas Regional Fisheries Management Organizations, is given in Andrew Serdy 2016, *The New Entrants Problem in International Fisheries Law*. Cambridge Studies in International and Comparative Law. Cambridge: Cambridge University Press. The issue of sovereign rights and the ability to use the days limit and transfer between CPCs can follow what has evolved through both custom and formal resolutions with capacity after the implementation of Resolution C-02-03. It is possible that while this comparable development for capacity can provide considerable guidance that a period of trial-and-error and learning may be required to further fine-tune the system. The Agreement on the International Dolphin Conservation Program and Dolphin Mortality Limits may also be able to provide guidance for refinement of program details.

Subsequently, capacity can be successfully reduced through a vessel buyback only after incentive-based management policies replace the current direct regulation and Tragedy of the Commons incentives (that produce both a "race-to-fish" activity and over-investment). Global historical experience shows that vessel buybacks under these conditions are otherwise likely to be ineffective and under a framework that incentivizes "race to fish" and over-invest in capacity and other forms of capital.[20] Realigning the

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INF-A-EU-Capacity-management-plan.pdf See also Action 4 in Martini, A. 2014. Towards a capacity management plan for the Eastern Pacific Ocean. *Technical Experts Workshop on the capacity of the tuna-fishing fleet in the eastern Pacific Ocean - 23-25 April 2014.* Cartagena de Indias, Colombia. Available from http://www.iattc.org/Meetings/Meetings2014/April/PDFs/6-Angela-Martini-Cartagena.pdf

[19] Available at: http://www.iattc.org/Meetings/Meetings2011/Jun/_English/IATTC-82-INF-A-Evaluation-of-TAC-program.pdf

[20] See Squires, D., J. Joseph, and T. Groves. 2010. "Buybacks in Transnational Fisheries." Chapter 11 in R. Allen, J. Joseph, and D. Squires, editors, *Conservation and Management of Transnational Tuna Fisheries*. Wiley-Blackwell Publishing, pages 181-194, Squires, D. 2010. "Fisheries Buybacks: A Review and Guidelines." *Fish and Fisheries* 11(4): 366-387, Curtis, R. and D. Squires, editors. 2007. *Fisheries Buybacks.* Blackwell Publishing, 267 pages, Squires, D., T. Groves, R. Grafton, R. Curtis, J. Joseph and R. Allen. 2010. "Fisheries Buybacks." Chapter 37 in R.Q. Grafton, R. Hilborn, D. Squires, M. Tait, and M. Williams, editors. 2010. *Handbook of Marine Fisheries Conservation and Management*. Oxford: Oxford University Press, pages 507-519, Graff-Zivin, J. and J. Mullins. 2015. "Vessel Buybacks in Fisheries: The Role of Auction and Financing Structures." *Marine Policy* 53: 188-197. Available at: https://iss-foundation.org/knowledge-

incentive structure also facilitates reducing the catch of small bigeye and yellowfin. Their catch can be reduced through direct regulation, but direct regulation is more difficult, wasteful, and costly because it fails to harness the natural self-interest of CPCs and vessels in ways that are beneficial to the IATTC that incentive-based approaches otherwise do.

Incentive-based approaches reinforce behavior and decision-making that enables CPCs and vessels to act in their self-interest in a way that also aligns their behavior and decision-making with the larger goals of the IATTC. Incentive-based policy removes perverse and counter-productive incentives associated with direct regulation and the Tragedy of the Commons and realigns short-term and long-term incentives so that they no longer conflict. Incentive-based approaches also utilize decentralized information that vessels hold but central regulators, such as the IATTC, do not. Incentive-based policy, by realigning CPC and vessel behavior, creates a gain in aggregate net benefits for the fishery, insures that all parties gain, and increases profitability and certainty in future benefits and costs that are foundational for vessel investment and hence capacity reduction through a vessel buyback. Similarly, incentive-based policy toward small and juvenile fish increases profitability and utilizes the information known by vessels but not by the central regulator more than under direct regulation.

The first of the two primary incentive-based approaches recommended by the report is to replace the direct regulation of the time-area closure by an individual transferable day credit program based upon Total Allowable Effort and allocating an annual limit of days at sea to individual vessels for their exclusive use. Any unused portion of the annual limit – the credit – can be transferred to another vessel and perhaps carried forward to the following year. Credit days exchange rates between different size classes, whether or not vessels set on dolphins or floating objects, etc. can all be established to account for the heterogeneity and variability of the impact upon fishing mortality of days by different set types and vessel size classes. Such a program makes flexible the current IATTC program to manage fishing mortality through effort, and specifically through the time-area closure. Because vessels have guaranteed and exclusive days for that year, they can freely choose when to fish, their trip length, and their trip frequency, while considering costs of production and tuna prices and making reasonable financial and business decisions. Information held by vessels but not the central regulator is enlisted and vessels are incentivized to experiment to increase profitability.

Section 5 of the main report provides a comprehensive and detailed program that can

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tools/reports/technical-reports/download-info/issf-technical-report-2013-07-vessel-buybacks-in-purse-seine-tuna-fisheries-the-role-of-auction-and-financing-structures/, Martell, S., C. Walters, and U.R. Sumaila. 2009. "Industry Funded License Reduction Good for Both Profits and Conservation." *Fish and Fisheries* 10: 1–12, and Teh, L., N. Horte, and R. Sumaila. 2017. "Having It All: Can Fisheries Buybacks Achieve Capacity, Economic, Ecological, and Social Objectives?" *Maritime Studies* 16(1): DOI 10.1186/s40152-016-0055-z provide a guideline for further development. This program builds upon the PNA Vessel Day Scheme[21], including use of similar language, Inter-American Tropical Tuna Commission - Scientific Advisory Committee. 2011. “Evaluation of a Total Allowable Catch System for the Purse-Sine and Longlne Tuna Fisheries in the Eastern Pacific Ocean,” Document IATTC-82-INF A,[22] and Serdy, A. 2016. *The New Entrants Problem in International Fisheries Law*. Cambridge Studies in International and Comparative Law. Cambridge: Cambridge University Press. Section 3.9 of the main body of this report provides estimates of the costs of a Vessel Monitoring System, the primary method of monitoring, control, and surveillance.

Eliminating the time-area closure and allowing vessels to fish throughout the year – subject to the Total Allowable Effort available to the fishery -- provides several benefits, including greater flexibility in operations, increased operating profit (measured in the main body of the report), and a smoother, year-round supply of fish to processors at more stable prices. Section 5, which details a stylized Vessel Day Scheme program, includes empirical estimates of the benefits; Section 1.5.2. summarizes the expected gains in total revenues and operating profit. Such a program also creates greater certainty over future expected benefits and costs. Increased certainty underpins rational vessel investments, where a vessel buyback entails remaining vessels investing in fleet reduction and greater days and catch from exiting vessels and the exiting vessels representing vessel disinvestment. A closure related to strictly biological reasons other than fishing mortality and capacity would be maintained as well the seasonal area closure of the area known as El Corralito.

A catch-based approach to manage the overall fishery could create stronger incentives to reduce capacity and lower costs and can more directly addresses small bigeye and yellowfin (depending upon the design). An individual transferable catch credit system for bigeye and yellowfin, rather than days, is also an incentive-based approach that can be considered. Nonetheless, both alternatives entail more comprehensive and costly monitoring, control, surveillance, and enforcement as well as represent a bigger departure from the current effort-based approach. In contrast, an individual transferable days credit program is simply the current system made flexible, and entails less risk and lower cost of monitoring, control, surveillance, and enforcement.[23] In fact, a transition back to the current system from an individual transferable days credit

[21] https://www.pnatuna.com/content/purse-seine-vds-text

[22] Available at: http://www.iattc.org/Meetings/Meetings2011/Jun/_English/IATTC-82-INF-A-Evaluation-of-TAC-program.pdf

[23] Effort –based (days) rather than catch-based was recommended in the WCPO for the PNA for very similar reasons. See Geen, G. 2000. Review of The Palau Arrangement for the management of yhe Western Pacific Purse Seine Fishery. Report by Fisheries Economics, Research 7 Management Pty Ltd to PNA and Asian Development Bank under Technical Assistance 5815 ‘Development of an international fisheries agreement for the conservation and management of the tuna resources in the western and central Pacific Ocean’.

program is inexpensive and straightforward.

For these reasons, the report recommends starting with an individual transferable days credit system. Many fisheries regulated through individual transferable quotas for effort (as rights-based management) have eventually transitioned to catch-based approaches as experience and knowledge are gained.[24] That is, starting with the smaller and more certain first step of an individual transferable days credit program that improves upon the current effort-based management does not preclude the more substantial, uncertain, and costly departure from the current system through an individual transferable catch credit program and can even lead to it over time if so desired.

Many fisheries conservation and management rights-based programs place limits on transferability and concentration of catch or effort holdings to insure social (here IATTC) objectives for the distribution and concentration of limits, benefits, employment, etc. To this end, the IATTC can place limits on the transferability of day (or catch) credits and the amount that can be held by individual vessels, companies, or even CPCs. Similarly, vessel buyback auctions (markets) can be designed to achieve social (e.g. vessel size) and/or economic (e.g. profitability or catch per unit of effort) objectives for the desired fleet composition along the desired lines.[25]

An alternative to the individual transferable day credit scheme is based upon national allocations of TAC or TAE. CPCs then develop capacity reduction plans of their own making. Voluntary pilot programs, whether by CPCs or private entities (e.g. companies) to reduce capacity in return for a reduced time-area closure (i.e. additional days), falls into this category since an allocation is implicit in this approach. An important issue that arises is whether to allow transfers among countries; discussions with stakeholders showed diverging views.

The advantage of a national allocation coupled with national plans of action is that

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[24] Squires, D., M. Maunder, R. Allen, P. Andersen, K. Astorkiza, G. Caballero, R. Clarke, H. Ellefsen, P. Guillotreau, J. Hampton, R. Hanneson, E. Havice, M. Helvey, S. Herrick, Jr., K. Hoydan, V. Maharaj, R. Metzner, I. Mosqueira, A. Parma, I. Prieto-Bowen, V. Restrepo, S. Sidique, S. Steinsham, E. Thunberg, I. del Valle, and N. Vestergaard. 2017. "Rights-Based Management by Fishing Effort." *Fish and Fisheries* 18(3): 440-465. See also Squires, D., M. Maunder, N. Vestergaard, V. Restrepo, R. Metzner, S. Herrick, R. Hannesson, I. del Valle, and P. Anderson, editors. 2016. *Effort Rights in Fisheries Management: General Principles and Case Studies from Around the World. 2016. FAO Fisheries and Aquaculture Proceedings P34*. Rome: Food and Agriculture Organization of the United Nations. Available at: http://www.fao.org/3/a-i5744e.pdf

[25] For extensive discussions of buyback markets, see Squires, D. 2010. "Fisheries Buybacks: A Review and Guidelines." *Fish and Fisheries* 11(4): 366-387, Curtis, R. and D. Squires, editors. 2007. *Fisheries Buybacks.* Blackwell Publishing, 267 pages, and Graff-Zivin, J. and J. Mullins. 2015. "Vessel Buybacks in Fisheries: The Role of Auction and Financing Structures." *Marine Policy* 53: 188-197. Available at: https://iss-foundation.org/knowledge-tools/reports/technical-reports/download-info/issf-technical-report-2013-07-vessel-buybacks-in-purse-seine-tuna-fisheries-the-role-of-auction-and-financing-structures/

coordinated actions among CPCs is required rather than the more difficult formal cooperation, including enforcement, that would be required through an incentive-based approach based upon credits and an IATTC-wide buyback.[26] Coordination is easier. Coordination requires a pull: CPCs must believe that they will be better off if the coordinate. The positive incentive here that creates the individual CPC gain and the aggregate gain is that lower capacity reduces the length of the time-area closure. Coordination also requires a push: CPCs must understand that, if most other CPCs coordinate, those that do not will be worse off. This latter incentive is missing from national allocations.

The report recommends potentially supplementing the individual transferable day credit program by several credit or reward programs, which are incentive-based policy. One reward program addresses the small bigeye and yellowfin issue through issuing additional days to vessels that achieve certain performance standards on fish size. This also represents a phased approach after introducing incentive-based management into the fishery. This reward program for small fish would be complemented by technology standards through limits on the design, operations, and numbers of floating aggregator devices that also necessarily accompany an individual transferable days credit program. A days credit program accompanied by technology standards (net, gear, and operating requirements) and area management successfully addressed small and juvenile cod in the Scottish trawl fishery for cod and the cod bycatch in the fishery for Norwegian lobster (before the European Union full catch retention policy replaced the credit program).[27] An individual transferable catch credit program for bigeye and yellowfin catch, differentiated by size, or a non-transferable limit on bigeye and yellowfin, also differentiated by size, directly addresses this issue and creates stronger incentives. But a days credit program is recommended for the same reasons an effort-based days credit program is recommended over a catch-based credit program.

A second credit program rewards additional days to CPCs whose vessels unilaterally reduce fishing capacity. That is, should a CPC reduce the overall capacity of its flagged vessels, the CPC can retain the days that are released. Alternatively, a multi-vessel

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[26] See Barrett, S. 2016. "Coordination vs. Voluntarism and Enforcement in Sustaining International Environmental Cooperation." *Proceedings of the National Academy of Sciences* 113(51): 14515-1452.
[27] See Squires, D. and S.M. Garcia. In press. "Economic Efficiency and the Biodiversity Mitigation Hierarchy with a Focus on Marine and Fishery Issues." *Conservation Biology,* Fernandes, P.G., Coull, K, Davis C., Clark, P., Catarino, R., Bailey N., Fryer, R., and Pout A. 2011. "Observations of Discards in the Scottish Mixed Demersal Trawl Fishery." *ICES Journal of Marine Science* 68(8): 1734-1742., Holmes, S.J., Bailey, N., Campbell, N., Catarino, R., Barratt, K., Gibb, A., and Fernandes. P.G. 2011. "Using Fishery-Dependent Data to Inform the Development and Operation of a Co-Management Initiative to Reduce Cod Mortality and Cut Discards." *ICES Journal of Marine Science* 68(8): 1679-1688. Doi: 10.1093/icesims/fsr101, Scottish Government. 2011. "Scottish Government Conservation Credits Scheme: Scheme Rules." Versions 2.1 (11 May 2011). http://www.gov.scot/Topics/marine.Sea-Fisheries/17681/ccs, WWF Scotland. 2009. *The Scottish Conservation Credits Scheme: Moving Fisheries Management towards Conservation*, and Squires, D. and S.M. Garcia. Under review. *Fisheries Bycatch in Marine Ecosystems: Policy, Economic Instruments, and Technical Change* 636 pages.

company that retires the capacity of one or more vessels (whether permanently or temporary) retains the days that are released. Such companies can enjoy gains in efficiency and profitability as demonstrated in Section XXX. Two or more companies could also agree to share the days and profits by a released vessel. A related approach has been adopted with bycatch credits in the Alaskan Pollock fishery and with Pollock production in Alaska (American Fisheries Act), and with Pacific whiting (hake) off Oregon and Washington in the USA.[28]

The report also develops several options for small bigeye and yellowfin tuna. These options are both direct regulation and incentive-based. The direct regulation options include annual vessel limits on the harvests of small bigeye and yellowfin tunas (performance standards), limits on net depth (size) or area fished (technology standards), processor size standards, increased price discrimination by vessel size (a voluntary tax levied on small fish and an incentive-based approach), and individual transferable quotas for catch by fish size (incentive-based regulation).

In addition, several "small steps" of direct regulation are also proposed in the report. These small steps are direct regulation and include: document existing vessels that are unavailable before replacement; remove capacity from the Regional Vessel Register whenever capacity is reassigned to a different vessel; freeze capacity immediately, limit increase in the replacement size for vessels; stricter force majeure; simplified onboard electronic monitoring system for set and possibly species identification; change the observer program to align with use of on-board monitoring systems; and Vessel Monitoring Systems (either centralized through the IATTC or decentralized through CPCs to the IATTC).

The following table summarizes the policy options developed in this report.

Table 1. Policy Options Considered

Policy Options
I. Direct Regulation "Small Steps"
1. Document existing vessels that are unavailable before replacement
2. Remove capacity from the Regional Vessel Register whenever reassign capacity to a different vessel
3. Freeze capacity immediately
4. Limit increases in replacement size for vessels

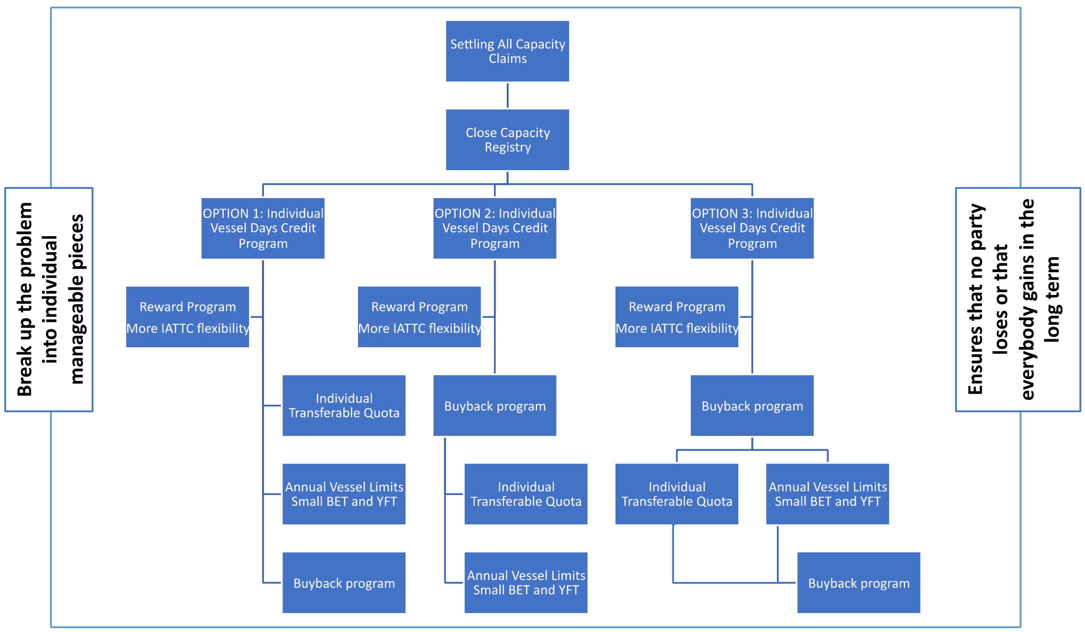
[28] For the bycatch credits, see Squires, D. and S.M. Garcia. Under review. *Fisheries Bycatch in Marine Ecosystems: Policy, Economic Instruments, and Technical Change* 636 pages. For the American Fisheries Act, see Felthoven, R.G. 2002 "Effects of the American Fisheries Act on Capacity, Utilization and Technical Efficiency." *Marine Resource Economics* 17(3): 181-205. Available at: https://doi.org/10.1086/mre.17.3.42629363

5. Stricter *force majeure*
6. Simplified onboard electronic monitoring (EM) system for set and possibly species identification
7. Change observer program to align with use of on-board monitoring systems
8. Increase shore-side plant inspectors
9. Introduce Vessel Monitoring System at IATTC level
II. Direct Regulation of Allocating TAC/TAE to Individual CPCs
III. Incentive-Based Options
1. Change CPC incentives by accepting pending capacity claims deemed reasonable and legitimate and perhaps conditional upon an implemented Plan of Action to Manage Fleet Capacity
2. Change economic incentives through an individual transferable day credit program
3. Option to allocate national Total Allowable Effort to CPCs as sum of their flag individual vessel allocations
4. Days penalty-reward credit program for:
4.1. Compliance
4.2. Voluntary capacity reduction at CPC level
5. Vessel buybacks
6. Rights-based management: Individual transferable quotas for catch
7. Small bigeye and yellowfin
7.1. Annual vessel limits on harvests of small bigeye and yellowfin (direct regulation)
7.2. Limit on net depth or area fished (direct regulation, technology standard)
7.3. Processor size standard (direct regulation)
7.4. In days credit program, reduced IATTC-wide time-area closure for small fish or limit number of days that can be used in certain months
7.5. Days penalty-and-reward credit system (incentive-based regulation)
7.6. Increased price discrimination by vessel size (voluntary tax levied on small fish)
7.7. Individual transferable quotas for catch by fish size (incentive-based regulation)

The following flowchart illustrates a phased approach that starts with the incentive-based approach based upon an individual transferable days credit program followed by vessel buybacks and policies to address small fish. This report estimates the expected empirical benefits of such an individual transferable days credit program and a vessel buyback, Chapter 5 provides a stylized Vessel Day Scheme, and Section 3.9 provides cost estimates for a Vessel Monitoring System, the primary means for monitoring, control, and surveillance.

As the flow chart shows, subsequent complementary policies can then be developed, including credit systems for capacity reduction and reducing the catch of small fish.

The report, its approach, and its recommendations should be viewed as not an answer or a final conclusion, but as the starting point for an informed discussion to begin discussing a Plan of Action based upon a Vessel Day Scheme and vessel buyback program.



1.4. Empirical Methods Used in this Report

The empirical analysis applied in this report uses the same IATTC data on catch and effort, the same Manta Ecuador ex-vessel prices for bigeye, skipjack, and yellowfin tunas, and many related analytical approaches as the reports by Northern Economics (2018) and Bucaram (2017) to provide consistency across reports. The empirical analysis augments the cost data for vessels setting on floating objects used by Northern Economics (2018) and Bucaram (2017) with additional observations from Ecuador for three different size classes. The empirical analysis replaces cost data used by Northern Economics (2018) and Bucaram (2017) for vessels setting on dolphins, which are no longer available due to issues in confidentiality and access, with cost data for a stylized U.S. vessel (representative of those U.S. purse seine vessels fishing in the Eastern Pacific Ocean), this could be considered as an adequate approximation since the Northern Economics report indicates very similar cost structures between the two countries fleets (even though US vessels set on floating objects rather than dolphins).

The empirical analysis also draws heavily from the many IATTC analyses. For instance, to analyze the current economic conditions of the fishery or economic impacts of alternative capacity management measures, this report uses a combination of: (1)

profitability and cash-flow analysis using standard financial techniques in Excel, (2) Data Envelopment Analysis (DEA)[29], and linear regression analysis. The DEA analysis updates the analysis on capacity in the EPO tuna purse seine fleet reported by Shrader and Squires (2013).

The main body of the report assumes basic familiarity with the purse seine capacity issue in the EPO, the different IATTC resolutions to manage capacity, methods of managing capacity, and the past ten years of fishery performance. The following section briefly summarizes the capacity issue and method of management. Appendix 1 reports in detail the past ten years of fishery performance and also provides additional empirical representation of the overcapacity issue. Appendix 2 summarizes the relevant IATTC resolutions on capacity and management.

Evaluating the benefits and costs of a plan of action to reduce capacity must compare the plan of action to the alternative of no agreement that includes an expected lengthening of the time-area closure. That is the business as usual scenario of the current and future lengthened time-area closures provides the counter-factual or "without" alternative by which to compare to the "with" of the proposed options. Thus, in this report we proceed to compare the net benefits of the current situation and a plan of action towards an optimal size fleet. The net benefits of an option form the "with" and the expected future time-area closures will form the "without" or counter-factual.

1.4. Organization of the Report

1. Introduction
1.1. Purpose of the Report
1.2. What is the Fundamental Issue and Why?
1.3. Recommendations and Alternatives
1.4. Organization of the Report

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[29] DEA is a linear programming technique to measure the relative performance of organizational units – here vessels – when there are multiple inputs (the vessel measured by its capacity and days at sea) and multiple outputs (catches of bigeye, skipjack, yellowfin, and other tunas and other fish). DEA compares the relative catch rates of vessels of similar sizes (measured by capacity) by first establishing which vessels have the highest catch rate (and thereby are the most efficient and fishing at full capacity) and then determining the relative performance of the other vessels of similar sizes but that are less efficient. Less efficient vessels can increase their catches to full capacity and efficiency by either becoming more skilled at fishing (finding fish given capacity and days, i.e. technical efficiency) or using their days more effectively through adjusting days at sea during a year, trip length in terms of days, or the frequency of trips during a year. This analysis assumes that fishing skill in finding fish is stable (e.g. probability of a successful set is constant over time), so that vessels reach full capacity (efficiency) by using their days throughout the year more effectively, given their vessel size (capacity). The empirical analysis can differ from Northern Economics due to differences in modeling, some data (especially costs), and selection and use or non-use of some observations that are extreme values.

2. The Purse Seine Capacity Issue in the Eastern Pacific Ocean
2.1. Purse Seine Capacity
2.1.1. History of Purse Seine Capacity
2.1.2. Current Purse Seine Capacity
2.2. Fishery Closures
2.3. Days at Sea
2.4. Economic Profitability
2.5. Tuna Markets, Responsiveness of Ex-Vessel Prices to Landings, and Targeting of Bigeye, Yellowfin, and Skipjack
2.6. Capacity Utilization and Technical Efficiency
2.7. Efficient Fleet Configuration: Well Capacity
2.8. Economic Costs of Time-Area Closures
2.8.1. Compared to current conditions
2.8.2. Compared to optimal fleet
3. "Small Steps" of Direct Regulation
3.1. Document existing vessels are unavailable before replacement
3.2. Remove capacity from the Regional Vessel Register whenever reassign capacity to a different vessel
3.3. Freeze capacity as immediate step
3.4. Limit increases in vessel size

- Not to increase capacity: freeze, immediate step
- Not to increase size of vessels, especially because efficiency is increasing
    - (We can go step further and recommend replacement of a vessel requires scrapping some capacity)

3.5. Stricter *force majeure*
3.6. Simplified onboard electronic monitoring (EM) system for set and possibly species identification
3.7. Change observer program to align with use of on-board monitoring systems
3.8. Increase shore-side plant inspectors
3.8.1. Current IATTC data collection programs
3.8.2. Cannery sampling and plant inspector program
3.9. Vessel Monitoring Systems
3.9.1. Centralized VMS Cost Estimate
4. Settling All Capacity Claims, New Entry, and Activate Inactive Capacity
4.1. Why Settle Outstanding Capacity Claims?
4.2. The Pending Capacity Claims
4.3. Should the Settled Capacity Claims be Conditional?
4.4. How to Address New CPC Capacity Requests?
5. Individual Transferable Vessel Days Credit Program
5.1. What is an Individual Transferable Vessel Day Credit Program?
5.2. Participation and Allocation
5.2.1. Eligibility for Participation
5.2.2. Allocate Nominal Days or Shares of Total Allowable Effort?
5.2.3.1. Alternatives to Allocate Party Allowable Effort Shares

[30] This section draws from the Northern Economics report, and is subject only to light editing for clarity and brevity.

[31] The empirical analysis of this section draws from the Northern Economics report, and is subject only to light editing for clarity and brevity.

[32] Directly taken from Northern Economics with some editing for greater brevity.

1.5. Summary of the Key Empirical Analysis Results

This section briefly summarizes much of the empirical results developed in the report and the selected policy options from the Northern Economics report. The results can differ between the two reports due to different analytical methods and slightly different cost data.[33] Although the empirical results can differ, they fundamentally align. This report's economic values are calculated in inflation-free US$2017, i.e. the US dollar is valued in the prices of the year 2017.

1.5.1. Capacity Utilization and Technical Efficiency of the Existing Fleet

The average capacity utilization (CU), i.e. $CU = \frac{catch}{potential\ catch}$, for the entire fishery over 2014-2016 is 61%. This value indicates that purse seine vessels had a fishing capacity or potential catch that is 39% greater than their observed catch. In short, tuna purse seine vessels had the fishing capacity to catch substantially more of all species over 2014-2016 than they actually caught – there is excess fishing capacity across all vessel size classes with the possible exception of Class 3.

Capacity utilization less than 100% is due to either technical inefficiency (using the existing days, given capacity, not as efficiently as the most technically efficient vessels,

[33] As noted elsewhere, this report's results differ from Northern Economics through: (1) somewhat different sources for the costs of production (but definitions and calculations of revenue, cost, operating profit, catch, effort, and price data are the same); (2) this report using inflation-free prices in US$2017 and Northern Economics does not control for inflation (i.e. uses nominal prices); (3) Northern Economics values bluefin tuna using bluefin tuna prices and other species using skipjack prices and this report only considers catches and revenues from bigeye, yellowfin, and skipjack tunas; (4) allowing for more efficiency gains in cost savings by allowing for declining rather than constant unit costs of production with larger catches (economies of scale rather than constant returns to scale); (5) by choosing the exiting vessels to minimize the total fixed costs of capacity rather than solely on the basis of selecting vessels with the lowest operating profit (that is conditional upon capacity and excludes fixed costs); (6) by different modeling approaches that yield more efficient use of trips or days (this report by a best-practice frontier and Northern Economics by a "visual" increase in days through adjusting for trip length up to some maximum amount); (7) this report ordering and ranking optimal operating profit on the basis of m^3 rather than per vessel; and (8), by this report explicitly distinguishing between adjustment in days and technical efficiency (fishing skill) and explicitly keeping technical efficiency (fishing skill) constant. In both reports, the remaining vessels are those with the highest optimal operating profit. This report maintains purse seine yellowfin annual catch below MSY (from annual reports), bigeye annual catch below annual MSY less the annual amount allocated to the longline fleet, and skipjack below annual observed levels.

i.e. a lower catch per unit effort due to fishing skill) or not using their days as effectively to catch fish as the comparable best-practice vessels, given their existing capacity (and controlling for abundance and environmental conditions).

Average technical efficiency (TE) for the entire fishery is about 66%. This means that vessels could have used their eixisting days more efficiently to catch fish, giving a higher catch per unit effort, given their capacity, biomasses, states of the environment and technology, etc.

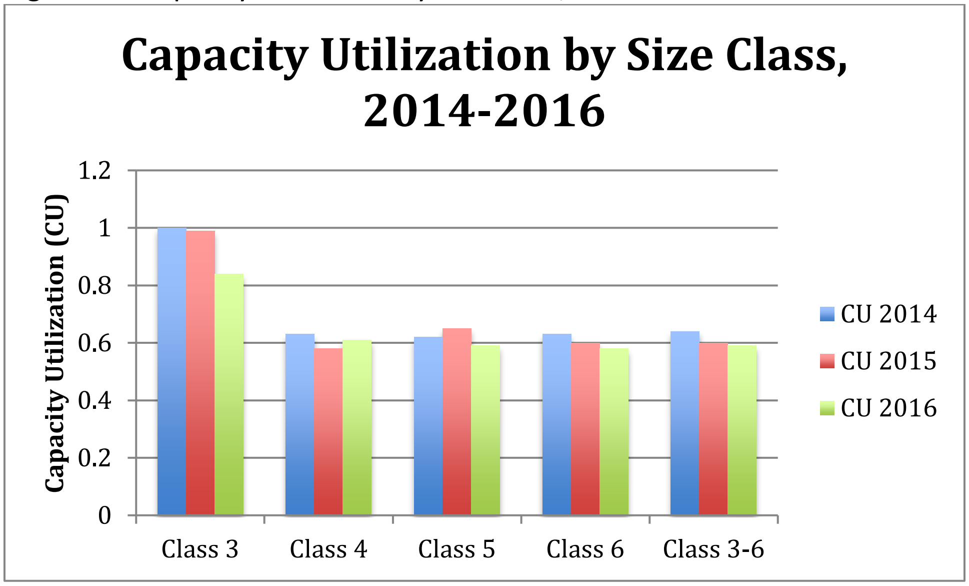
Consider next capacity utilization due entirely to not using days as effectively to catch fish as the best-practice vessels (i.e. CU without technical efficiency or CU purged of fishing skill). Such CU purged of technical efficiency is on average at 92% of full potential production. There is about 8% excess fishing capacity. This inefficiency in using days (e.g. inefficient trip length, trip frequency, time of the year) compared to best-practice vessels of comparable capacity is expected under the “race-to-fish” incentives under the Tragedy of the Commons and direct regulation. Class 6 vessels are slightly less technically efficient in using their days than the other size classes.

Table 10. Capacity Utilization and Technical Efficiency of Existing Fleet, 2014-2016

Vessel Size Class	2014	2015	2016	2014-2016 Average
Class 3				
CU	1.00	0.99	0.84	0.94
TE	1.00	0.99	1.00	1.00
CU no TE	1.00	1.00	0.84	0.95
Class 4				
CU	0.63	0.58	0.61	0.61
TE	0.65	0.63	0.67	0.65
CU no TE	0.95	0.93	0.91	0.93
Class 5				
CU	0.62	0.65	0.59	0.62
TE	0.65	0.68	0.63	0.66
CU no TE	0.94	0.93	0.93	0.93
Class 6 All				
CU	0.63	0.60	0.58	0.60
TE	0.70	0.65	0.63	0.66
CU no TE	0.91	0.91	0.92	0.91
Class 2-6				
CU	0.64	0.60	0.59	0.61
TE	0.69	0.65	0.64	0.66
CU no TE	0.91	0.92	0.91	0.92
Source: IATTC data.				
Note: Estimation by Data Envelopment Analysis, Johansen industry model, nonconvex aggregate frontier.				

Vessel with at least 100 days.

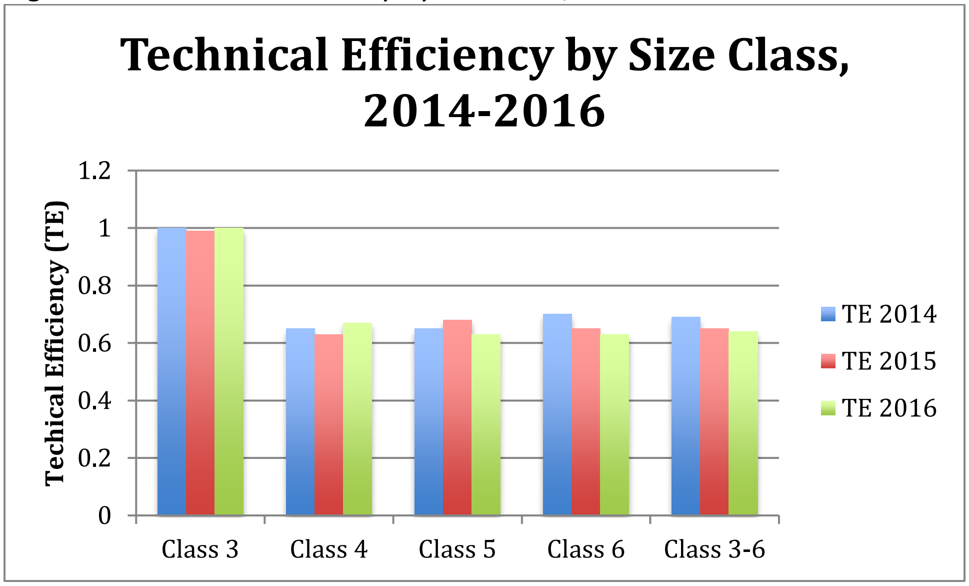
Figure 24. Capacity Utilization by Size Class, 2014-2016



Source: IATTC data.

Note: Capacity utilization (CU) comprised of both inefficient use of days and technical inefficiency (skipper skill). CU = 1 is full capacity utilization, 0 ≤ CU ≤ 1.

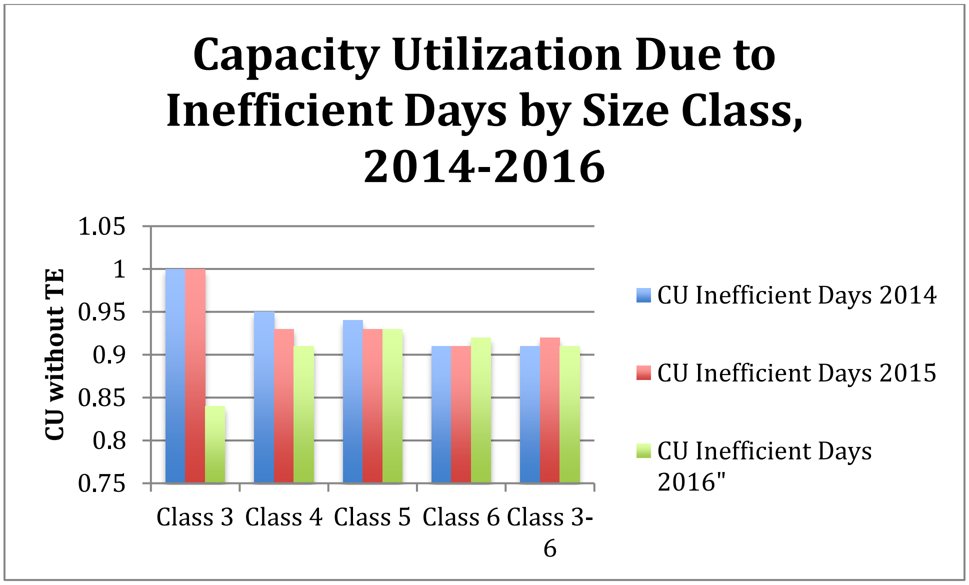
Figure 25. Technical Efficiency by Size Class, 2014-2016.



Source: IATTC data.

Note: Technical efficiency (TE) or skipper skill. TE = 1 is full technical efficiency, 0 ≤ TE ≤ 1.

Figure 26. Capacity Utilization Due to Inefficient Use of Days by Size Class, 2014-2016



Source: IATTC data.
Note: Capacity utilization (CU) due entirely to inefficient use of days and purged of technical inefficiency (inefficiency compared to best-practice vessels in catch per unit effort given capacity or skipper skill). CU = 1 is full capacity utilization, $0 \leq CU \leq 1$.

1.5.2. Estimated Economic Impacts from an Individual Days Credit Program without Transferability

This section discusses an incentive-based credit program based upon effort – days – that takes as given the existing purse seine fleet's number of vessels, their size classes, and capacity. The program is not intended to alter the permanent existing fleet capacity and structure, but to increase the flexibility of production and efficiency of existing vessels.

An individual transferable days credit program allocates days as a limit to individual vessels for their exclusive use within a year (or some multi-year period such as three years). When transferability is allowed, any unused days, called the credit, can be traded to another vessel or if the program allows, carried forward to another year. Days can be allocated to a vessel based upon the vessel's historical days, its capacity, or a combination of both. The total days allocated to the fleet forms the Total Allowable Effort and should conform to the target fishing mortality. Days exchanged between different sized vessels or methods of fishing or carried forward can be subject to exchange rates. Days allocated to a CPC can be differentiated by days that the CPC has exclusive use over for its Exclusive Economic Zone and to the high seas that all CPCs' vessels can fish.

In the absence of a time-area closure and year-round fishing, this program creates an increase in total revenue by allowing vessels to optimally adjust their days at sea (e.g. change trip frequency, trip length, or when the trip occurs). In the empirical analysis, tuna prices do not change as a result of changes in the timing and quantity of tuna landings throughout the year. The increases in economic efficiency and increases in total revenues and operating profits are maximum expected gains under the very best of conditions, and the actual expected gains will be positive but lower. Hence, the empirical analysis should be viewed as an upper bound or potential maximum, where the best-practice or most efficient vessels in the fleet determine this upper bound

Average total fleet revenue during 2014-2016 in US$2017 (value of US currency in 2017) prior to the individual transferable days credit program (with the existing fleet structure and vessel numbers) was $965,430,748 (average per vessel $4,035,529) and after the individual transferable days credit program (with the existing fleet structure and vessel numbers) was $1,058,262,005 (average per vessel $4,417,529) for an average gain in expected total fleet revenue of $92,831,258 (average per vessel $376,778) and an average gain of 9.62%.

The average observed operating profit per vessel during 2014-2016 in US$2017 prior to the program was ($1,082,337 per vessel) and after the program was (per vessel $1,459,115) for an average gain in expected fleet operating profit of XXX (average per vessel $376,778) and an average gain of about 42%.[34]

Table XXX 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 (Capacity Catch)	1,058,262,005
Increase (%)	9.62%
Class 2-3 Vessels	
Observed Days	5,051,437
Efficient Days (Capacity Catch)	5,295,785
Increase (%)	4.84%
Class 4-5 Vessels	
Observed Days	74,181,848
Efficient Days (Capacity Catch)	79,581,650
Increase (%)	7.28%
Class 6 Vessels	
Observed Days	886,197,462

[34] The change in operating profit is entirely due to a change in total revenue. In contrast to the percentage gain for total revenue, the base of reference (denominator in the calculation) is observed operating profit, which is a much smaller base than total revenue. Hence, the percentage change in operating profit is substantially higher than the percentage change in total revenue even though the change (numerator) is the same in both cases.

Efficient Days (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 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.	

Figure XXX Average Fleet Observed and Optimal Total Revenue for Individual Vessel Days, 2014-2016 (US$2017)

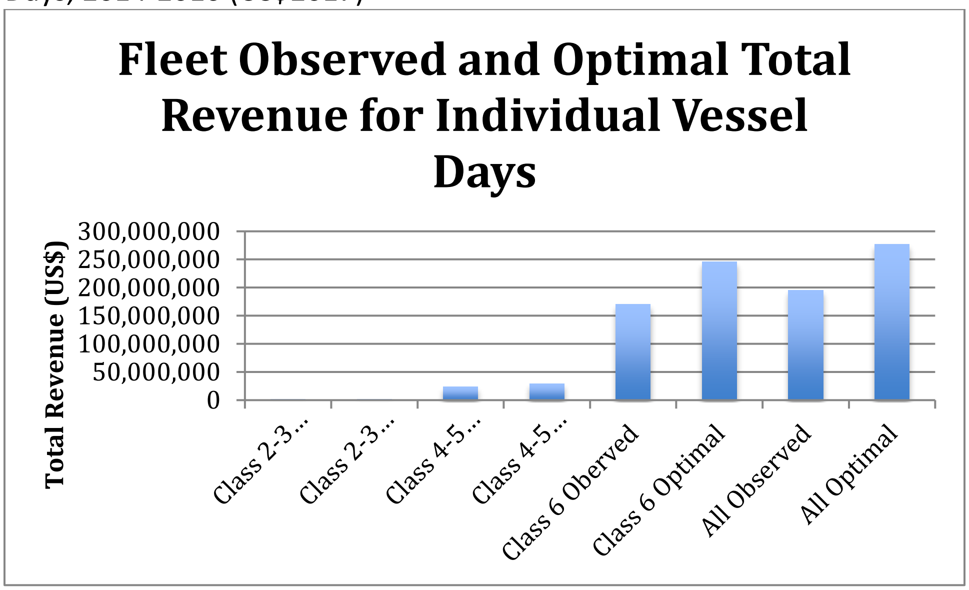


Table XXX Total Fleet Observed and Optimal Operating Profit per Year without Transferability, Average 2014-2016 (US$2017)

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.	

Figure XXX Average Fleet Observed and Optimal Operating Profit for Individual Vessel Days, 2014-2016 (US$2017)

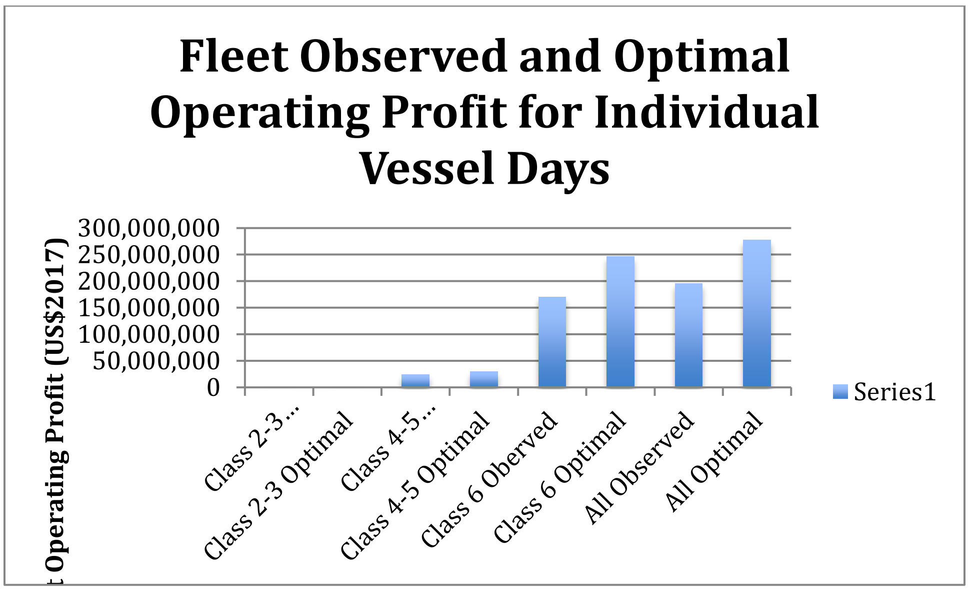
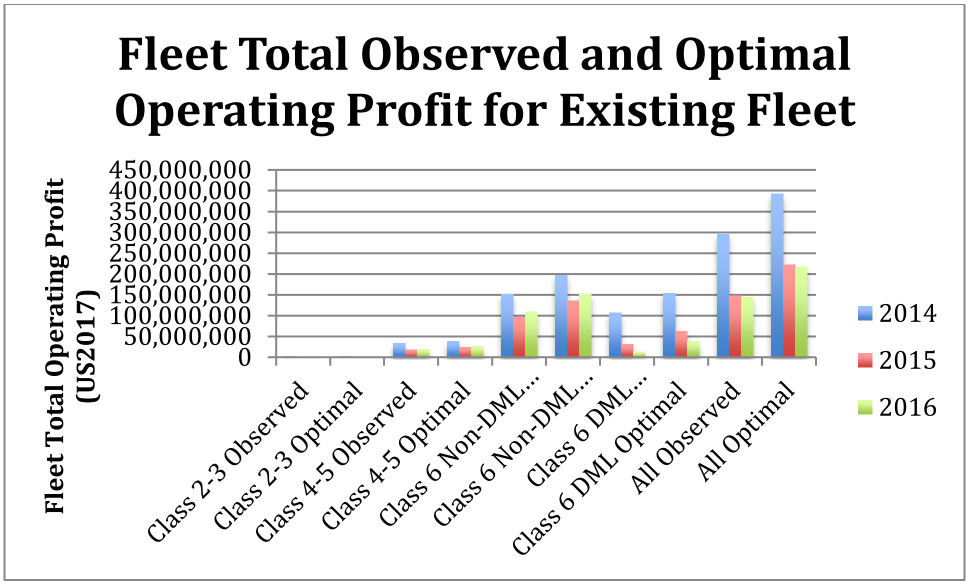


Table 17. Total Operating Profit of Observed and Efficient Fleet Conditional upon Existing Capacity and Fleet Configuration (US$2017)

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.



1.5.3. Estimated Economic Impacts from an Individual Days Credit Program with Transferability

This section again discusses an incentive-based credit program based upon effort – days – that takes as given the existing purse seine fleet's number of vessels, their size classes, and capacity. The program is not intended to alter the permanent existing fleet capacity and structure, but to increase the flexibility of production and efficiency of existing vessels.

This report does not calculate the optimum profit from an individual transferable days credit program that is fleet-wide. The most important gains from traded are anticipated to come from a multi-vessel company's consolidation of days from its most inefficient vessel(s), which then fishes either less or not at all, onto the most efficient vessels. The main body of the analysis provides several examples of the potential gains from trade for stylized multi-vessel companies.

1.5.4. Estimated Equilibrium Market Price of Transferable Days

Work in progress…..

1.5.5. Optimum Fleet Size

This section discusses obtaining the purse seine fleet that maximizes the potential catch (full capacity catch) and minimizes the fixed costs of capacity. The optimum fleet that is obtained gives optimum vessel numbers, size classes, and capacity for these objectives. The corresponding optimum operating profit that corresponds to this fleet can be contrasted with the existing operating profit to give the maximum potential gain in operating profit that is possible under an optimum fleet. The savings in fixed costs that are possible under the optimum fleet can be added to the optimum operating profit to give the total gains in economic benefits possible under an optimum fleet.

Purse seine capacity in the Eastern Pacific Ocean has been steadily increasing and now stands well above the target set by Resolution C-02-03 of 158,000 m^3, creating serous overcapacity. In 2013, Shrader and Squires (2013) estimated optimal capacity as 171,000 m^3 with 164 vessels of all size classes for vessels operating at full capacity, and with yellowfin and bigeye TACs and observed skipjack total catch in place, optimal capacity falls to 167,000 m^3. The current optimal capacity estimated in this report (an update of Shrader and Squires 2013) with yellowfin and bigeye TACs and observed skipjack total catch in place is 169,000 m^3 with 155 vessels of all size classes (average over 2014-2016), and in the Northern Economics Report (2018) is 195 vessels of all size classes with total capacity of 211,003 m^3. The decline in number of vessels from 164 vessels to 155 vessels could be due to vessels that are more efficient due to technological progress.

This optimum fleet size corresponds to the fleet size that would be reached by individual transferable quotas implemented and operating under textbook conditions or the fleet organized by an all-knowing "social planner". The Shrader and Squires (2013, 2018) approach gives a more economically efficient fleet than Northern Economics approach.

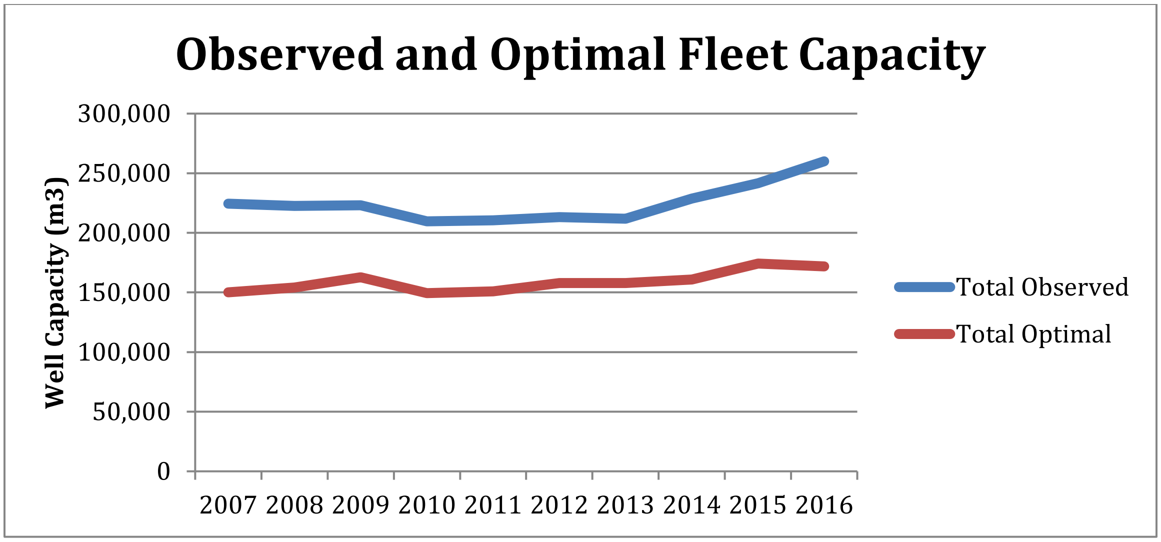
Table 12. Efficient Fleet Configuration: Well Capacity, 2007-2016

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.

The following figure, which is a summary of total fleet capacity from Table 12, shows the stubborn gap between optimal and observed active fleet capacity. This gap appears to be widening in recent years, perhaps due to technological change and accumulation of capital in the form of floating aggregator devices.

Figure 29. Observed and Optimal Fleet Capacity



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

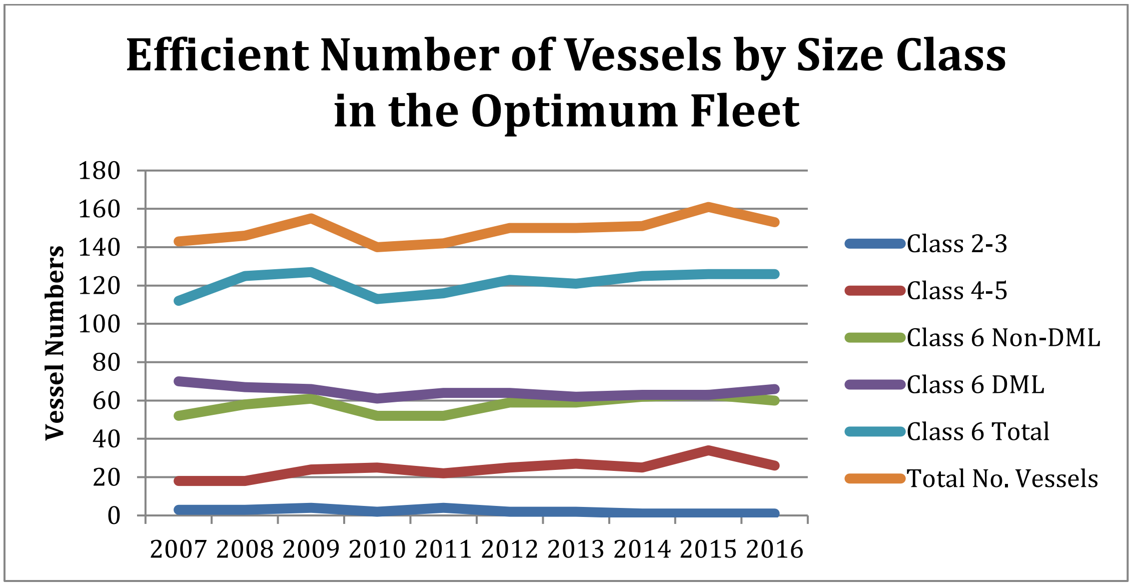
The following table and figure (illustrating the following table) show some variation in the efficiency number of vessels, but a relatively stable fleet structure emerges.

Table 13. 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.

Figure 30. Efficient Number of Vessels by Size Class in the Optimum Fleet



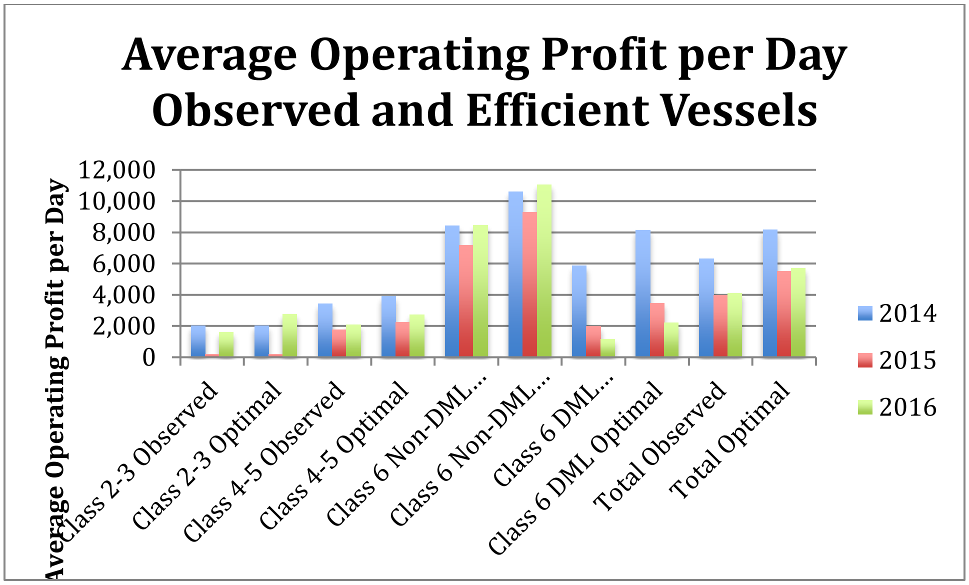
Source: IATTC data and Data Envelopment Analysis (Two-Stage Johansen Industry Model) (Shrader and Squires 2013, 2018). Non-convex frontier estimated by aggregate frontier defined over all vessel size classes.

1.5.6. Operating and Total Profit: Current and Optimum & Economic Costs of Over-Capacity

This report finds that the average total fleet observed operating profit for the existing fleet is $195,709,400, when averaged over 2014-2016, for the average existing capacity and fleet structure of 2014-2016 (and valued in US$2017).

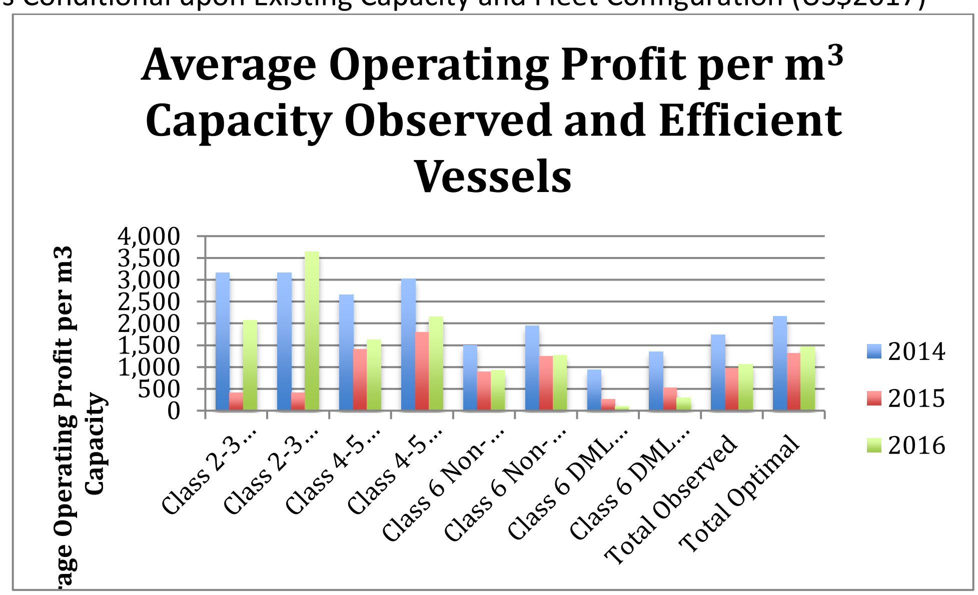
The following figure shows that the average operating profit per day for both observed and efficient vessels, given the existing capacity and fleet structure (i.e. the fleet as it is, not the optimal fleet). (Efficient vessels are those utilize their days most effectively, such as through an individual transferable day credit program.) Operating profit per day varies by year, most notably due to differences in prices and catch rates per day, with fuel prices providing a third but lesser factor. Operating profit per day also grows with vessel size, demonstrating economies of scale or increasing returns to scale when measured on a days basis.

Figure 32. Average Operating Profit per Vessel-Day for Observed and Efficient Vessels Conditional upon Existing Capacity and Fleet Configuration (US$2017)



The following figure illustrates operating profit per m^3 of well capacity for both observed and efficient vessels, given the existing capacity and fleet structure (i.e. the fleet as it is, not the optimal fleet). (Efficient vessels are those utilize their days most effectively.) Average operating profit per m^3 of well capacity varies by year and depends upon annual price and catch rates per m^3 per year, with fuel prices providing a third but lesser factor. On the basis of m^3 of well capacity, smaller vessels are more efficient.

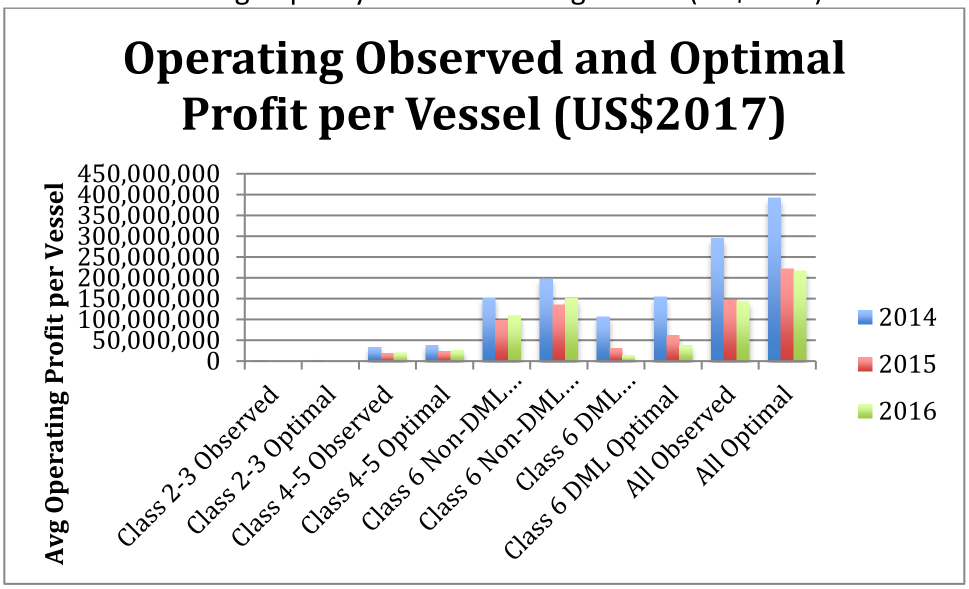
Figure 33. Average Operating Profit per m^3 Well Capacity for Observed and Efficient Vessels Conditional upon Existing Capacity and Fleet Configuration (US$2017)



The following figure illustrates operating profit per vessel for both observed and efficient vessels, given the existing capacity and fleet structure (i.e. the fleet as it is, not the optimal fleet). (Efficient vessels are those utilize their days most effectively.)

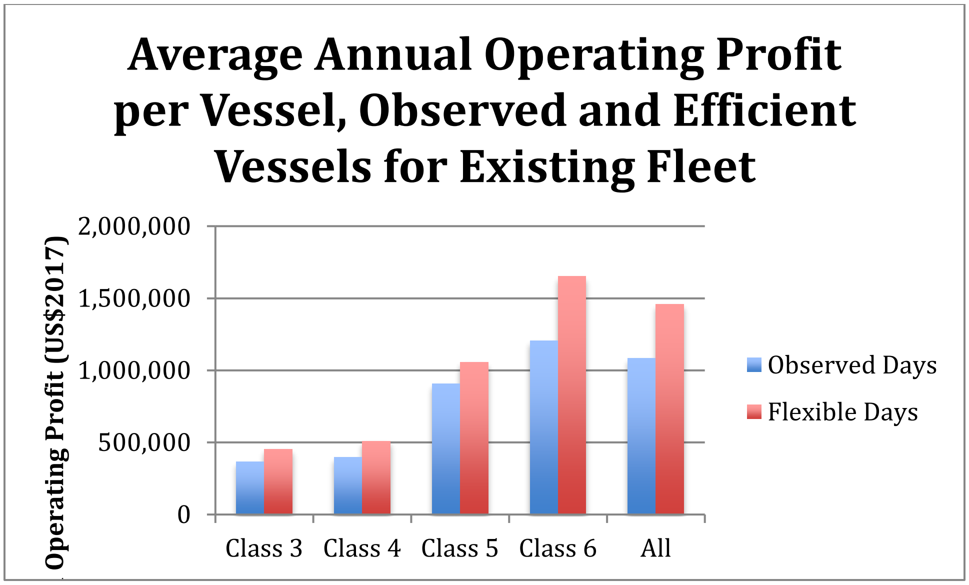
Average operating profit per vessel varies by year and depends upon annual price and catch rates per m^3 per year, with fuel prices providing a third but lesser factor. Larger vessels yield higher profits on a per vessel basis.

Figure 34. Average Observed and Optimal Operating Profit per Vessel Conditional upon Existing Capacity and Fleet Configuration (US$2017)



The following figure illustrates average operating profit per vessel, averaged over 2014-2016, for observed and efficient vessels, given the existing capacity and fleet configuration (i.e. the fleet as it is, not the optimal fleet). (Efficient vessels are those utilize their days most effectively, such as through an individual transferable day credit program.) As expected, the average operating profit per vessel increases with vessel size and allowing vessels to use their days more flexibly leads to gains in efficiency as measured by operating profit.

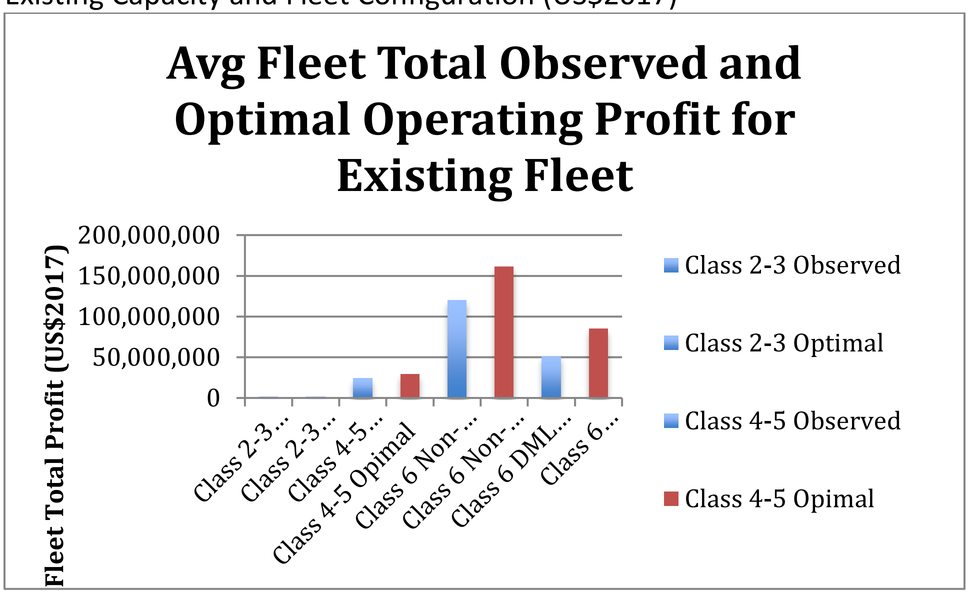
Figure XXX. Average Operating Profit per Vessel per Year Observed and Efficient Vessels, Conditional upon Existing Capacity and Fleet Configuration (US$2017



Source: IATTC data and Data Envelopment Analysis model, convex aggregate frontier (Shrader and Squires 2013, 2018).

The following figure depicts the fleet's observed and optimal operating profit for the given, existing capacity and fleet configuration averaged over 2014-2016. (Efficient vessels are those utilize their days most effectively, such as through an individual transferable day credit program.)

Figure 36. Average Fleet Observed and Optimal Operating Profit Conditional upon Existing Capacity and Fleet Configuration (US$2017)



Now the report turns to the optimal, efficient fleet and the economic performance and gains.

One measure of the economic cost of over-capacity is as follows. Allowing for perfectly transferable catch or effort quotas under textbook conditions gives the optimum operating profit of $622,224,817 for the optimum sized and structured fleet of 169,000 m^3 of capacity with 155 vessels of all size classes (average over 2014-2016). The optimum operating profit is for the most profitable remaining vessels (highest profit per m^3 capacity) where the remaining vessels are those that minimize the total fixed costs of the remaining capacity.

The difference between the optimum operating profit for the efficient fleet of $622,224,817 and the operating profit for the existing fleet of $195,709,400 represents a 218% increase in operating profit for the optimum sized and structured fleet (of 169,000 m^3 of capacity with 155 vessels of all size classes) compared to the existing capacity and fleet structure (averaged over 2014-2016). This is an economic cost of over-capacity.

This increase is due to two factors: vessels able to optimally fish through more efficiently using days and the remaining vessels (with the lowest fixed costs of capacity) having the highest optimal operating profit (the least profitable vessels in terms of optimal operating profit/m^3 drop out of the fleet). This increase requires perfect "textbook" conditions, and the actual increase would be less. Nonetheless, the optimal fleet under the optimal incentive-based policy is expected to yield a considerable increase in operating profit.

This 218% difference demonstrates the wide disparity in efficiency of vessels and number of less efficient vessels in the existing fleet and the maximum potential efficiency gains under incentive-based policy and optimum capacity reduction.

Another way to measure the cost of over-capacity is as follows. Additional efficiency gains would accrue through the reduction in fixed costs of the exiting vessels. The fixed costs (averaged over 2014-2016 in US$2017) decline by $157,486,859, a decline of 31%. This decline in fixed costs boosts the optimum profits in the fleet by the same amount, increasing the optimal fleet profit to $779,711,676 (= $622,224,817+$157,486,859), a 298% increase in profit from the observed operating profit of $195,709,400 for the existing fleet.

Northern Economics finds an increase in operating profit to $345,980,558, based upon a fleet of 211,000 m^3 of capacity with 195 vessels of all size classes, which is about 44% of the comparable value found in this report of $622,224,817. The Northern Economics value of $345,980,558 is a 169% increase in operating profit. The Northern Economics values are in nominal US$ that do not keep inflation constant.

The following table and the accompanying figure that illustrates the table provide the total fleet operating profit for the observed fleet (existing capacity, vessel numbers, and vessel size classes) and the optimum fleet. The results, provided for each year from

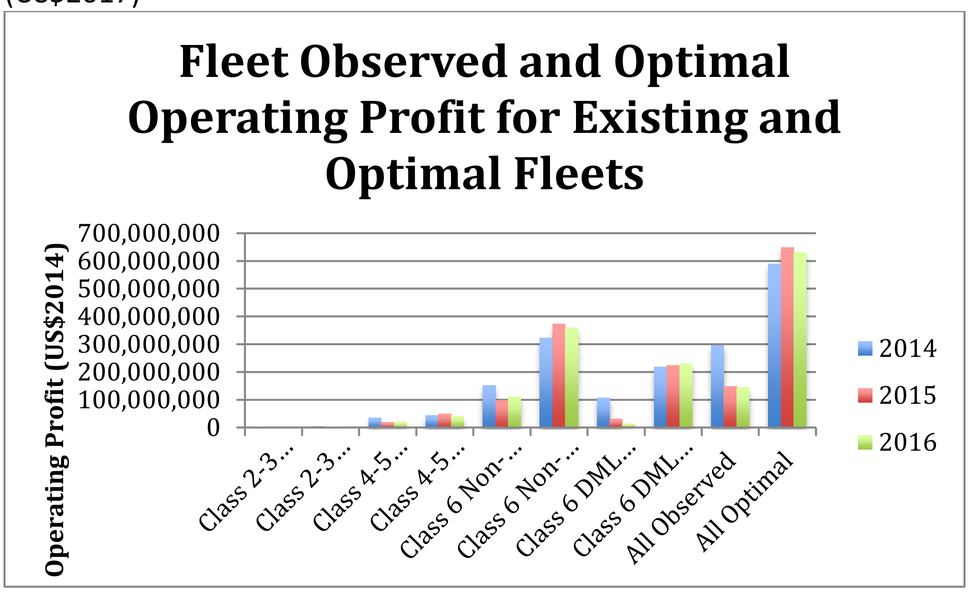
2014-2016, show year-to-year variation, a substantial difference between the observed operating profit of the existing fleet and the optimal operating profit of the optimal fleet, and greatest source of operating profits from Class 6 vessels.

Table 18. 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

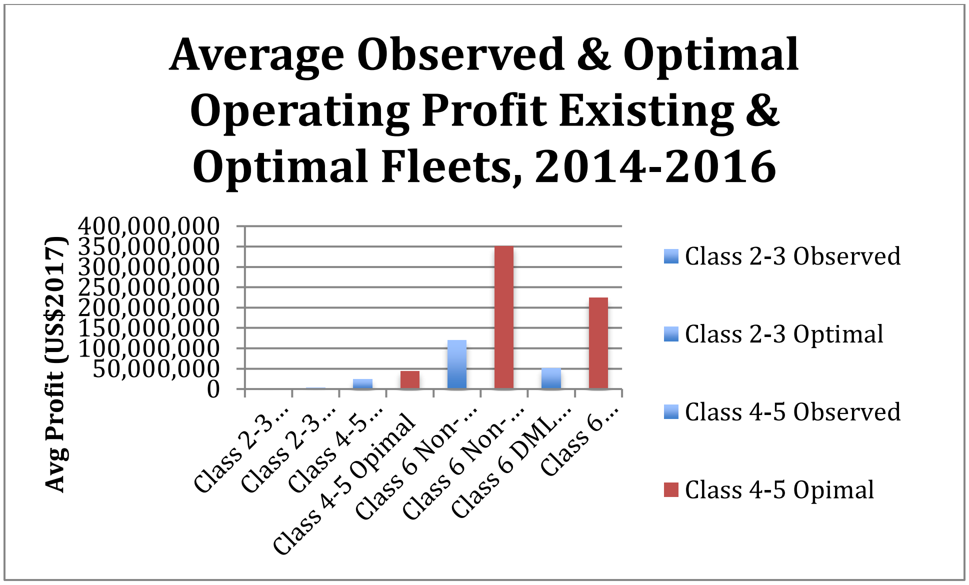
Source: IATTC data and two-stage Johansen Industry DEA model with MSY and catch constraints and conditional upon biomasses and sea surface temperatures and various production constraints (Shrader and Squires 2013, 2018. Non-convex frontier aggregated over all vessel size classes. Inflation-free US$2017. 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.

Figure 34. Fleet Observed and Optimal Operating Profit for Existing and Optimal Fleets (US$2017)



The following figure provides the average over 2014-2016 of the observed operating profit for the existing fleet and the optimal operating profit for the optimal fleet. The results show substantial difference in operating profit between the existing and optimal fleet and that Class 6 vessels provide the greatest source of operating profit and efficiency gains.

Figure 38. Average Observed and Optimal Operating Profit for Existing and Optimal Fleets, 2014-2016 (US$2017)



The following table summarizes the total fixed costs of the existing fleet (existing capacity and vessel numbers) and the optimal fleet (optimal capacity of 169,000 m^3 and 155 vessels from Shrader and Squires (2018)).

Table 19.Fixed Costs of Existing and Efficient Fleet (US$2017)

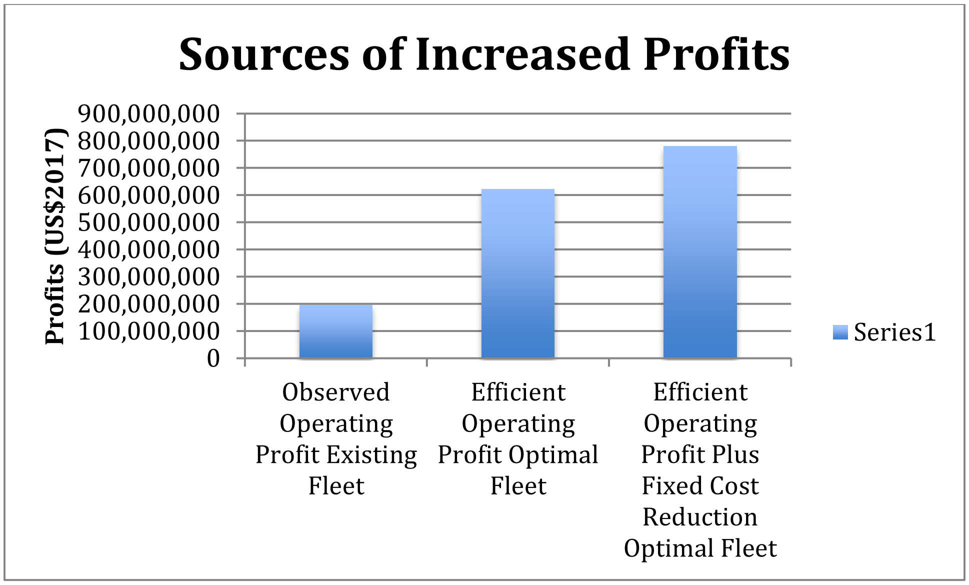
Year	Class 2-3		Class 4-5		Class 6 Non-DML		Class 6 DML		Total	
	Observed	Optimal	Observed	Optimal	Observed	Optimal	Observed	Optimal	Observed	Optimal
2014	2,341,205	1,549,727	38,441,080	25,436,062	208,580,994	138,009,825	234,878,877	175,068,648	484,242,157	340,064,261
2015	1,338,263	951,587	39,915,284	28,396,554	224,552,494	159,756,191	244,764,525	179,084,692	510,570,567	368,189,023
2016	1,416,807	888,148	36,664,785	22,971,000	244,818,073	153,377,888	264,675,868	184,437,359	547,575,532	361,674,394
2014-2016 Average	1,698,758	1,129,820	38,340,383	25,601,205	225,983,854	150,381,301	248,106,424	179,530,233	514,129,419	356,642,560

Source: Confidential cost data.
Note: Fixed costs comprised of

The following table summarizes the sources of increased profits for the purse seine fishery in $US2017 and using averages from 2014-2016. The two sources of increased profits are the optimal operating profit for the optimal fleet and this profit plus the fixed cost saving with the optimal fleet.

Table 20. Sources of Increased Profits (US$2017)

Existing Fleet	Optimal Fleet	
Observed Operating Profit	Efficient Operating Profit	Efficient Operating Profit Plus Fixed Cost Reduction
195,709,400	622,224,817	779,711,676



The following table gives the existing and optimal wealth of the fishery, based upon the existing and optimal fleet structures, using discount rates of 5%, 10%, and 15%, and valued in US$2017.[35] The results show that the existing wealth in the fishery could be substantially increased up to $5billion - $15billion depending upon the discount rate. Wealth can be increased about four to five times when considering both the optimal operating profit and the fixed cost savings of the optimal fleet.

Table 21. 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: $PV = A/i$.			

1.5.7. Economic Costs of Time-Area Closures

The history of the time-area closures is as follows:

[35] The results are based upon the profits viewed as a constant annuity received over an infinite time horizon: $PV = A/i$, where *PV* denotes present value, *A* denotes the constant annuity received each time period, and *i* denotes the discount rate. As a point of comparison, the August 2018 Moody's long-term corporate bond rate for AAA rated securities is 3.88% and the long-term historical average is 6.81%.

- The first closures were established in 2002 with the closure of the entire fleet during the month of December.
- In 2003-2008, the closed season was extended to 42 days, and in 2009 the closed season was extended to 59 days.
- From 2010 to 2017, the closing period was set at 62 days, but in 2018 it was extended to 72 days.
- Beginning in 2009, small vessels in Classes 1–3 were exempted from the closure periods, while Class 4 vessels were authorized to take one trip no longer than 30 days during the closure period.

There are several basic ways to measure the economic costs of closure depending upon the point of comparison (the benchmark or counter-factual). Economic cost is the foregone operating profit, where the operating profit could be observed or optimal. One way is to compare the cost of the 72-day and 100-day closures to the existing fleet under the 62-day closure over 2014-2016, using only the observed foregone operating profits. A second way is to compare the cost of the closure, in terms of observed operating profit, to the fishery that would have occurred without the closure.

Vessels, because of the time-area closure and limits on catches and excess capacity, do not fish their optimal number of days in a year and do not use their vessel, gear, and equipment (fixed inputs) optimally. For a vessel that aims to catch the maximum possible catch, the vessel's observed days can be compared to the number of days it would use if it used its vessel, gear, and equipment efficiently and used the same number of days as the vessels that catch the most fish in the range of vessels matched to the same capacity (i.e. best-practice vessels) given their method of setting (floating objects, dolphins, unassociated).

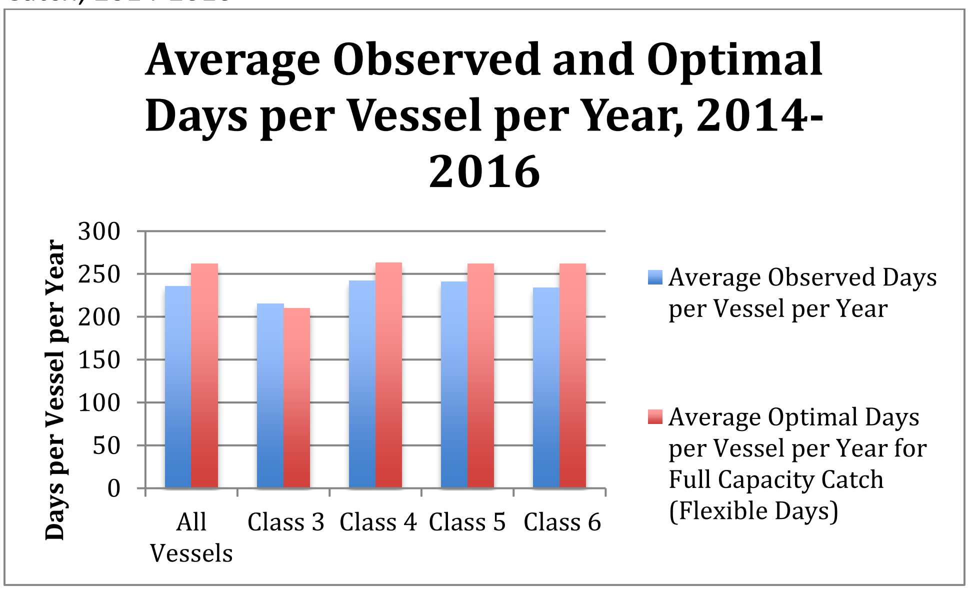
The following table and figure show the difference between the average observed days per vessel per year over 2014-2016 for all size classes and the average optimal days per vessel per year for the full capacity catch given the existing fleet structure (size and number of vessels) and capacity and catch rates. The difference between observed and optimal days for all vessels is about 11% for all vessels with the largest difference for the Class 6 vessels. The results also show that the Class 3 vessels currently use too many days and that these Class 3 vessels should reduce their days by about 5 days per vessel per year or a 2.33% reduction.

Table 22. Average Observed and Optimal Days per Vessel per Year for Full Capacity Catch, 2014-2016, for the Existing Fleet

Category of Vessels	Average Observed Days per Vessel per Year	Average Optimal Days per Vessel per Year for Full Capacity Catch (Flexible Days)	Difference in Days (%)

All Vessels	236	262	11.02
Class 3	215	210	-2.33
Class 4	242	263	8.68
Class 5	241	262	8.71
Class 6	234	262	11.97
Source: IATTC data.			
Note: 2014-2016 average. Vessels > 100 days. Data Envelopment Analysis, first stage, convex aggregate best-practice frontier in Shrader and Squires (2013,2018). Existing fleet and constant prices.			

Figure XXXX. Average Observed and Optimal Days per Vessel per Year for Full Capacity Catch, 2014-2016



1.5.7.1. Economic Cost of Closure Compared to 62-Day Closure

The economic cost of the current 72-day closure, in terms of observed operating profit and the current fleet capacity and structure (i.e. not the optimal fleet, but the observed fleet), can be evaluated by finding the number of vessels that would be impacted by an additional 10 days of closure, calculate the number of days they would not be able to fish under the 72-day closure, and estimate the corresponding loss in observed operating profit. Because of the limited increase in number of days of closure, the analysis assumes that vessels do not substantially alter their operating behavior, such as the number of days in port in between trips, period for vessel maintenance and repair, etc. The analysis also assumes that landings prices do not change.

The 72-day closure to be implemented in 2018 would impact Class 5-6 vessels over 2014-2016 as depicted in the following table. Vessels are assumed to not change their fishing patterns and the fleet structure is assumed unchanged. Impacted vessels are those for which the increase in 10 days of closure from 62 days to 72 days would limit their days at sea. Only a very small number of vessels and days are impacted by the increase in 10 days. The average foregone operating profit for the fleet over 2014-2016 would be $905,725, which represents 0.51% of the average operating profit for the fleet. For almost all vessels, an additional 10 days of closure does not impact them (assuming their fishing patterns remained constant).

Table 24. Class 5-6 Vessels Impacted by 72-Day Closure Compared to Actual 2014-2016 Days with 62-Day Closure

Year	Number of Impacted Class 5-6 Vessels	Number of Impacted Class 5-6 Vessel Days	Total Foregone Operating Profit Class 5-6 Vessels (US$2017)	Foregone as Percent of Observed Operating Profit
2014	9	200	949,214	0.32%
2015	8	157	1,437,858	0.97%
2016	9	109	330,103	0.23%
Average	8.67	155	905,725	0.51%
Source: IATTC data				

A 100-day closure would have a larger impact upon Class 5-6 vessels compared to their actual days over 2014-2016 as depicted in the following table (which assumes no changes in operating behavior and fleet structure). The average foregone operating profit over 2014-2016 would be $4,351,393, which represents 2.48% of the average operating profit for the fleet. Compared to their 2014-2016 days, most vessels are not impacted by a 100-day closure, assuming their fishing behavior does not change.

Table 25. Class 5-6 Vessels Impacted by 100-Day Closure Compared to Actual 2014-2016 Days with 62-Day Closure

Year	Number of Impacted Class 5-6 Vessels	Number of Impacted Class 5-6 Vessel Days	Total Foregone Operating Profit Class 5-6 Vessels (US$2017)	Foregone as Percent of Observed Operating Profit
2014	110	6,214	4,411,672	1.50%
2015	101	5,632	3,141,114	2.13%
2016	140	7,393	5,501,394	3.81%
Average	117	6,413	4,351,393	2.48%
Source: IATTC data				

1.5.7.2. *Economics Costs of Closure Compared to No Closure*

The impact of the 62-day closure upon Class 5-6 vessels compared to what they could have achieved without a closure at all is evaluated as follows, under the unchanged vessel behavior of direct regulation (i.e. without allowing for efficient vessel behavior). Class 5-6 vessel days over 2014-2016 are compared to the optimal number of days given by the DEA model[36], and the difference represents the number of days that the 62-day closure reduced the optimal days that vessels would ideally spend at sea when they are aiming for full capacity catch. The current observed operating profit per observed day then multiplies this difference between optimal and observed days. The increased catches added to the existing catches of bigeye and yellowfin do not exceed the bigeye MSY (less the allocation to longliners) and the yellowfin MSY for each of the years 2014-2016.

Table XX. Impact of 62-Day Closure upon Class 5-6 Vessels if They Could Have Fished the Optimal Number of Days (US$2017)

Year	Number of Impacted Class 5-6 Vessels	Increase in Days (Optimal Days – Observed Days) Class 5-6	Foregone Operating Profit by Not Fishing Optimal Days Class 5-6	Foregone as Percent of Observed Operating Profit Class 5-6
2014	110	6,214	51,548,569	17.47%
2015	101	5,632	43,734,647	29.59%
2016	140	7,393	32,168,585	22.29%
Average	117	6,413	42,483,934	23.12%

Source: IATTC data.

Note: Data Envelopment Analysis (Shrader and Squires 2013, 2018). Convex frontier aggregated over all vessel size classes. Inflation-free US$2017. Vessels > 100 days. Constant prices.

[36] The DEA model provides the optimal number of days for a vessel for each year, given their capacity, biomasses, environmental conditions, and state of technology, under the behavioral assumption that vessels strive to maximize their catch.

1.5.7.3. Economic Cost of Closure Compared to No Closure

The economic cost of the current 72-day time area closure, given the current fleet capacity and structure (i.e. not the optimal fleet, but the observed fleet) can be evaluated by comparing the observed days with the optimal days at sea if a vessel was not limited by the closure for the existing fleet (capacity, vessel numbers, vessel size classes, methods of setting).

1.5.8. National Allocation of Total Allowable Catch or Total Allowable Effort

National allocation of TACs or TAEs without accompanying incentive-based policy does not alter the individual vessel's incentives from direct regulation and the Tragedy of the Commons to "race-to-fish" and over-invest in capital. The presence of IATTC-wide direct regulation, such as limits on floating aggregator devices and the IATTC time-area closure, or national direct regulation, does not alter the perverse incentives. These perverse incentives can lead to a rapid closure of the national fishery.

National allocation of TACs or TAE, while used in SPRFMO, ICCAT, and NAFO, does not solve the over-capacity problem. National allocations simply individualize the responsibility for the over-capacity problem to the individual CPCs and do not alter the impacts of vessels upon all other vessels in the entire fishery due to the perverse incentives and absence of exclusive use.

National allocation of TACs or TAE do, however, offer the potential for coordinated actions among CPCs rather than the consensus-driven full cooperation among CPCs. In that regard, they offer the potential for improvements in economic welfare, even if the potential improvements are smaller than the full cooperation required for an IATTC-wide program such as individual transferable days credits.

National allocation of TACs or TAE should leave current operating profit largely unchanged unless the "race-to-fish" incentives are substantially altered.

1.5.9. National Allocation of Days and Individual CPC Buybacks in Return for Vessel Days[37]

Northern Economics analyzed individual CPC buybacks in return for vessel days through a reduced time-area closure. The two CPCs are modeled after Ecuador and Mexico. Such a program, which can be a pilot program, implicitly allocates days to individual CPCs, creating a national TAE for those CPCs.

[37] This analysis is summarized from the Northern Economics report.

Northern Economics' empirical results indicate that a national buyback would remove about 30 vessels, which is approximately 35 percent of the number of vessels that would need to be removed under the fleet-wide buyback, even though the two synthetic "Pseudo-Fleets" comprise over 65 percent of the entire 271 vessels on the Regional Vessel Register. The reason so few vessels need to be removed is primarily because no latent vessels required removal.

A second key Northern Economics finding is differences in the estimated costs of the two (synthetic) single-CPC programs and a fleet-wide program. If measured in terms of annual repayment fees per m^3 that would be charged to the remaining fleet, the Pseudo-Ecuador fleet would pay $144/$m^3$, while the Pseudo-Mexico fleet would pay $66/$m^3$ under their program. The annual fee per m3 under one of the fleet-wide buyback scenarios would be $171/$m^3$. The cost differences are due to differences in production patterns between the Pseudo-Ecuador and Pseudo-Mexico fleets and the entire purse seine fleet.

A third key finding is that remaining vessels, which finance the buyback, 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.

Source: Northern Economics

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 m³	Variable Min. & Weight by EPO DAS	Variable Min. & Inverse Weighting
Active Vessels Remaining (from 50)	40	41	42	42	41	42
Capacity (m³) 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 m³ 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

1.5.10. Annual Limits on Bigeye and Yellowfin Catch[38]

Annual vessel limits are imposed on the catch of small bigeye and yellowfin tunas to limit the catch by a small number of vessels that catch large quantities of small bigeye and yellowfin relative to the rest of the fleet. This direct regulation represents a uniform production standard that applies equally to all vessels. Small bigeye and yellowfin are defined as all fish less than 15kg, the bigeye and yellowfin vessel limits would be set at limits that eliminate closure days, plant inspectors determined when vessel limits are reached, and vessels reaching their limit of either species must stop fishing for the balance of the year.

1.5.11. Centralized VMS Cost Estimate

The IATTC provide the following cost analysis for a centralized VMS System. [39] Appendix XXX provides a detailed explanation.

Low-end estimate: VMS operation contracted out ($130k), an annual operating costs equivalent to that of SPRFMO's ($67k), 1 full-time VMS staff at IATTC HQ ($65k), CPCs or their vessels paying for air time, no AIS data, and including the initial contracting and training costs provided by SPRFMO, but not the cost of continuous IT development contracting ($30.5k).

1st year cost, including operation- $292,500
Yearly operational cost in subsequent years- $132,000

High-end estimate: Centralized VMS setup ($360k), 4 full-time VMS staff at IATTC HQ ($260k), air time services for 284 vessels at the rate paid by FFA ($135.75k), AIS data

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[38] This analysis is summarized from the Northern Economics report.
[39] The author is grateful to the IATTC and in particular Brad Wiley for conducting this analysis.

included ($50k), initial contracting and training costs similar to SPRFMO ($30.5k), and contracted IT services for continuous development of system and capabilities ($70k).

1st year cost, including operation- $906,250
Yearly operational cost in subsequent years- $515,750

1.5.12. Cannery Sampling and Plant Inspector Program[40]

Acknowledging the large amounts of uncertainty associated with the following estimate, the total first year expenses to establish a monitoring program for deliveries to processing facilities would cost an estimated $1,892,000. The estimated annual cost for the included parameters would be approximately $1,149,400.

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[40] The author is grateful to the IATTC and in particular to Brad Wiley for conducting this analysis.