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

PART I

Transferable Day Credit Scheme

NOAA Fisheries Southwest Fisheries Science Report to the Inter-American Tropical Tuna Commission

1. Introduction

1.1. Organization

This U.S. NOAA Fisheries Southwest Fisheries Science Report to the Inter-American Tropical Tuna Commission (IATTC) develops a pilot Transferable Day Credit Scheme (hereafter Scheme) to address overcapacity in the tropical tuna purse seine fishery in the Eastern Pacific Ocean conserved and managed by the IATTC. The scientific results and conclusions, as well as any views or opinions expressed herein, are those of the author and do not necessarily reflect the views of U.S. NOAA Fisheries or the U.S. Department of Commerce.

The report is organized into two parts:

I. The pilot Transferable Day Credit Scheme
II. Initial Allocation of Proportional Allowable Effort Shares

Part I, the pilot Transferable Day Credit Scheme, develops the Scheme. As much as possible, vocabulary and terms are used consistent with the Parties to the Nauru Agreement Vessel Day Scheme.

Part II, the Initial Allocation of Proportional Allowable Effort Shares (PAES), develops four allocation formula for PAES and empirically analyzes the allocation of PAES to Contracting Parties to the Convention (CPCs) and subsequently by CPCs to their eligible vessels and the impact of each of the four PAES allocation formulae for the fishery's economic efficiency and equity. The result of Part II is two preferred PAES options based upon economic efficiency, equity (both *ex ante* in design and *ex post* in distributive impact), and fairness.

Annex I summarizes the key economic analyses of the 2018 Northern Economics and Research Reports. The main findings would change in magnitude to some degree but the overall results and key messages would remain the same.

Annex II summarizes different workshops and documents on overcapacity in tropical tuna purse seine fisheries by the Food and Agriculture Organization of the United Nations, the Inter-American Tropical Tuna Commission, and the International Seafood Sustainability Foundation.

The Scheme builds off of existing IATTC resolutions and workshops listed in Part I's Annex II.

This Report builds off of a 2018 Research Report, "Plan of Action for the Management of Fleet Capacity in the IATTC[1]" and a 2018 Northern Economics Report, "Alternatives to Address Excess Capacity in the Eastern Pacific Purse Seine Tuna Fishery."[2]

1.2. Purpose of the Scheme

The Scheme introduces flexibility in fishing throughout the year by eliminating the 72-day closure but with the total days of all vessels equal to the Total Allowable Effort (TAE). The TAE, determined by the IATTC Secretariat, ensures that the Scheme meets biological sustainability for yellowfin, bigeye, and skipjack tunas. Other limits to fishing that are required to achieve overall ecosystem sustainability and conservation of biodiversity, such as bycatch, are retained. The "correlito" can remain in place for conservation purposes should the Commission so elect.

The Scheme addresses overcapacity both: (1) directly, by introducing an incentive-based approach to conserving and managing the fishery that realigns the incentives from "race to fish" and "race to invest" to incentives more closely aligned with economic efficiency in the fishery, and (2) indirectly by setting the stage for vessel buybacks to be successful. The next two paragraphs discuss this realignment of incentives in greater detail.

This incentive-based Scheme alters the incentives of CPCs and their vessels, and hence their behavior and decision-making, away from the "race to fish" and "race to invest" that exist under the limited entry and overall capacity limit introduced by Resolution C-02-03. The Scheme realigns the underlying incentives of CPCs and vessels to more positive and long-term behavior, decision-making, and self-interest. These realigned incentives are now more consistent with collective interest at both the level of CPCs and vessels in fishing operations and toward no longer competing for a share of the available resource before another party can take it. Without secure access to the common resource, vessels compete wastefully with each other for a share of the resource. Under the Scheme, economic efficiency should increase so that vessel profits increase and economic rent to the fishery, as a whole, increases.

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[1] Available at: https://www.iattc.org/GetAttachment/4c6668bf-081d-4d85-875a-cd3be2c43167/A.%20Plan%20of%20Action%20for%20the%20Management%20of%20Fleet%20Capacity%20in%20the%20IATTC%20–%20Report%20of%20the%20consultant%20Summary

[2] Report to the Inter-American Tropical Tuna Commission by Northern Economics, "Alternatives to Address Excess Capacity in the Eastern Pacific Tuna Fishery", April 2018. Report presented during the 19th meeting of the Working Group on Fleet Capacity on May 13, 2018, under item 4.2. of the provisional agenda. Available at: https://www.fao.org/fileadmin/user_upload/common_oceans/docs/EPO_PS_CapacityReport.pdf

Realigning incentives then sets the stage for capacity reduction by either the IATTC collectively or by individual CPCs. The Northern Economics consultant's report clearly shows that vessel buyback programs can effectively remove excess fishing capacity. Vessel buybacks, without first altering incentives away from "race to fish" and "race to invest" toward more economically viable fishing effort, lead to increased investment and fishing as profits rise following the buyback. That is, altering the incentives is a fundamental precondition for successful vessel buybacks and fleet capacity reduction. The Scheme on its own contributes to removing capacity by allowing multi-vessel companies to reduce or eliminate the activity of less profitable vessels (and hence capacity).

The Scheme is a credit system and not a property rights system as discussed below.

1.3. How the Scheme Works in Brief

The Transferable Day Credit Scheme works as follows. The existing annual 72-day closure for the entire fishery is terminated to allow year-round fishing and is replaced by the Scheme. Days are allocated in the form of Party Allowable Effort Shares (PAES), which are shares or proportions of the TAE allocated to each eligible vessel through its CPC. Each vessel's PAES is then multiplied by the TAE to give the vessel its Party Allowable Effort (PAE), i.e. days, for the Management Year. Changes in the TAE then automatically lead to changes in each holder's PAE (days) that can be applied in each time period. Rounding up or down in the number of PAE (days) each year for each vessel may be required to create a whole number of PAE (days) should the product of the individual vessel's PAES (share of TAE) and the TAE create a non-integer number. A rounding rule to create a whole number would be required. Summing each individual vessel's PAE (number of days) should not exceed the TAE except perhaps for a small margin that could arise due to accommodating fractional PAES.

Transferable vessel day credits are an individual vessel limit for days supplemented with the option to compensate the excess-use of days for one vessel by under-use of days (credits) for another vessel. Such a cap-and-trade system is not rights-based management, since a property right is not created and allocated. Instead, the Scheme is a credit system (which is defined and explained below). The program transforms the current direct regulation using the 72-day time-area closure to incentive-based regulation.

The Dolphin Mortality Limit (DML) in the AIDCP is a credit program. DMLs are comparable to the limits allocated to vessels in the Transferable Day Credit Scheme. Transfers of unused DMLs each year from one vessel to another is a credit comparable to the credits in the proposed Transferable Day Credit Scheme.

The Transferable Day Credit Scheme provides flexibility and lowers costs for vessels and companies to fish throughout the year whenever they choose subject to the TAE of the total number of days at sea for all the vessel in the purse seine fishery. Such flexibility in fishing throughout the year also favors processors that can rely upon a more even supply of landings

throughout the year.

Credits, denominated in units of homogenous 24-hour days, are created *gratis* when the vessel reduces days (at sea) below the required level in a certifiable and verifiable way. The credit or unused portion of the vessel's annual days allocation for that year are not transferrable forward to either the following year or the previous year (to cover catch beyond the previous year's limits). A credit buyer or receiver only needs credits to offset catch that exceeds the buyer's catch quota or limit.

The unused portion of a vessel's annual days, called a credit, can be transferred within a CPC Flag State to other vessels within the same company or to other companies and even across vessels of different CPC Flag States following the same or similar procedures to those used to manage capacity under Resolution C-02-03. Days allocated to individual vessels within the same multi-vessel company can be pooled and reallocated as required by the company to maximize expected catch, revenue, or profit as the company sees fit and to reduce uncertainty. Vessels will no longer have to "race to fish" during the open period under the current day closure system.

Credit transfer creates a price, either explicitly in the credit market or implicitly when transferred within a multi-vessel company or informally between vessels of different companies outside of the credit market. Even when credits are not actually transferred, this price values the non-transferred credits by creating an opportunity cost, i.e. the economic value of what the vessel would receive should the vessel actually transfer the credit. This explicit or implicit price sets the basis for incentive-based management. This price creates a cost to which an individual responds by altering its behavior and decision-making.

If the TAE is tightened over time, a multi-vessel company can internally reallocate PAES and PAE among the company's vessels, with the possibility that a vessel could cease fishing. In contrast, a single-vessel company or a company with a limited number of vessels may have to enter the credit market to purchase additional days or to sell days and reduce its fishing if the TAE is sufficiently reduced. As discussed in greater detail below, the Scheme is a pilot or trial in which vessel exit is not part of the Scheme.

Some portion of the TAE, such as five percent, can be retained as a reserve for new entrants or activation of inactive capacity. An open question remains as how and when unused days from this reserve are to be released and distributed toward the end of the year. This reserve, without a clear and well-defined allocation rule of integer-valued days to each vessel, creates a potential "race-to-fish" incentive that may favor some vessels over others.

Vessels that fish longer than their allocated days and fail to obtain credit days from other vessels should face a penalty. The simplest and most direct penalty is a fixed fine of a reduced number of days the vessel is allocated the following year. The size of this type of penalty remains to be determined. This implies a one-to-one relationship between a days' overage this year and a day allocated the following year, i.e. there is no: allowance for foregone growth of the fish stocks; accounting for discounting future catches, costs, revenues, and profits that can incentivize using days beyond the quota and not obtaining credit days; any disincentive created by a larger than directly proportional fine in the following year.

Days at sea (24 hours per day) are the proposed unit of effort because they are the simplest and least costly to monitor and control (they are already reported to the IATTC). Portions of days at

sea as the unit of effort, such as time actually spent fishing as fractions of a day, open up questions of definitions of fishing, difficulties in monitoring portions of days, etc. Days at sea, whether the vessel is in transit, searching for fish, or actually fishing, provide a single homogenous unit of effort. Experience with the Parties to the Nauru Agreement's (PNA) Vessel Day Scheme (VDS) illustrates the uncertainty and greater cost that would accrue to the IATTC for monitoring, control, and surveillance and enforcement that can otherwise be established. Similar issues arise if sets form the unit of effort. Days at sea can be readily monitored by Vessel Monitoring Systems (VMS), whereas more complicated units of effort, such as time actually spent fishing or number of sets, are more difficult to measure by VMS and may require on-board observers. In addition, using on-board observers to monitor effort shifts their role from a scientific function to include an enforcement function, which in turn raises additional complicating issues.

The Scheme is a pilot or trial of three years, the number of years in an IATTC Resolution cycle. The pilot Scheme intention is to reduce risk and uncertainty, learn from limitations that arise in order to either revise the Scheme or return to the current 72-day closure, and to maintain the current industry structure (e.g. number and type of vessels, capacity, etc.).

The Scheme is built around effort (days) rather than catch due first and foremost to issues of monitoring, surveillance, control, compliance, enforcement, and costs.[3] As a general rule, a catch-based scheme creates stronger incentives to reduce capacity and end the "race to fish" and "race to invest", but is difficult to apply in an international tuna fishery. Such considerations led the PNA to adopt an effort-based Vessel Day Scheme (as indicated by the original consultant's report to the PNA). An effort-based scheme can eventually lead to a catch-based scheme should the IATTC so decide. That is, an effort-based scheme does not preclude the IATTC from a future catch-based scheme, and indeed a number of effort-based schemes have eventually transitioned to catch-based schemes as experience is gained.

Details about the Scheme comprise the rest of Part I. Much of the balance of Part I is written in terms of "bullets" to keep the presentation short and to the point.

1.4. Costs of Closure and Excess Capacity

See Annex I.

2. Definitions

[3] The early consultant's report through Brad Wiley estimated the annual cost of tracking landings for a catch-based approach. "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."

2.1. Days

- Definition: *Any calendar day, or part of a calendar day, in a Management Year during with a purse seine vessel is in the waters under the jurisdiction of the IATTC outside of a port*
  - i.e. days-at-sea.
- Time spent by a vessel within a port of a Contracting Party to the Convention (CPC) shall not be considered a day unless part of the day was spent out of the port, other than a direct port-to-port transit without any fishing activity.
- Potential exemptions include *force majeure* for certified vessel breakdowns and for emergencies involving the health and safety of the crew or the safety of a vessel or when a vessel is solely in transit from one port to another or from or to a fishing area outside of the EPO.
- When vessels transit from one port to another follow the similar procedure adopted in conservation resolutions, last one is C-17-02.

2.2. Total Allowable Effort (TAE) and Days

- Defined in terms of fishing mortality at FMSY.
- MSY basis
  - Current fishing mortality at age
- Which species?
  - For most “vulnerable” of yellowfin, bigeye, or skipjack
- Phased approach to potentially distinguish between different types of sets or optimizing yield.

2.3. Credits

- *Credits* or *credit-days*, denominated in units of days, are created *gratis* when the vessel uses a number of days below the vessel’s allocated limit of days in a certifiable way and reported to, and registered with, the IATTC Secretariat.
- The unused portion of a vessel’s annual days (PAE), called a *credit*, can be transferred within a CPC to other vessels within the same company or to other companies and even across vessels of different CPCs as agreed by those CPCs.
- A credit receiver only needs credits to offset days exceeding its limit.
- PAE (days limit) allocated to individual vessels within the same multi-vessel company can be pooled and reallocated as required by the company to maximize expected catch, revenue, or profit as the company sees fit and to reduce uncertainty.
- Credits transferred within a company from one vessel to another must still be reported to the Director.
- A vessel may not agree to transfer to other vessels more than a fraction of its PAE.
  - 75% or some other minimum?

    - The intent of this provision is to ensure continued eligibility in the Scheme. Vessels may request days only to maintain eligibility.
- An unresolved issue is whether or not there is a maximum limit to accumulated days per vessel.
- As discussed elsewhere, credits cannot be transferred forward to another Management Year or backwards to a previous Management Year to retroactively compensate for days that exceed the allocated limit (PAE).

2.4. Management Year

- *Management Year* is the period of one year during which management measures hold.

2.5. Party Allowable Effort Share (PAES)

- *Party Allowable Effort Share* or *PAES* is the proportion or share of the Total Allowable Effort allocated to each eligible vessel through its CPC. Part II of this report develops and analyzes four different formulae for the *PAES*.

2.6. Party Allowable Effort (PAE)

- Number of days in a Management Year for each CPC and its eligible vessels. The steps to create PAE are:
    - Create TAE
    - Allocate PAES to eligible individual vessels through the CPCs.
    - Each vessel's PAE is then calculated as PAES * TAE
- Three-year allocation period
    - Consistent with current conservation and management resolution duration

2.7. Capacity

- Total capacity of vessel. The total well volume of a vessel, including the volume of any sealed wells.
- Active capacity. See Resolution C-02-03. The total well volume, in cubic meters, of vessels that are on the IATTC Regional Register and are authorized to fish in the EPO. May change status to inactive at any time during the year.

In summary:

- *Day*: Any calendar day, or part of a calendar day, in a Management Year during with a purse seine vessel is in the waters under the jurisdiction of the IATTC outside of a port. Days are not a fraction of a day (e.g. 18 hours rather than 24 hours).
- *Total Allowable Effort (TAE):* Total nominal days for a Management Year.
- *Proportional Allowable Effort Share (PAES):* Proportion (share) of the Total Allowable Effort for eligible individual vessels of a CPC.
- *Party Allowable Effort (PAE):* A vessel's PAE = PAES * TAE.
- *Allowable Effort (AE):* Allowed days in Management Year based upon PAES and TAE

- *Management Year*:
- *Credit*: Unused portion of a vessel's Allowable Effort during a Management Year.
- *Capacity*: m^3 of purse seine vessel well capacity for a vessel on the IATTC Regional Vessel Register.

3. Pilot Scheme

The Scheme is a pilot Scheme, or trial, of initial three-years duration with simplified design and limited features. This pilot allows learning about the Scheme and its strengths and weaknesses.

After three years, the pilot Scheme's performance is evaluated to make design changes or to revert back to existing features of 72-day time-area closure. No registered capacity is lost during the initial 3-year trial period of the scheme, except if voluntarily withdrawn.

Thus:

- No complete transfer of days between vessels (i.e. no vessels exit from the Scheme),
- No carry-forward of unused days (credits), etc.
- No carry-backward of unused days (credits) to retroactively cover a vessel's excess use of PAE (days)
- No granting of CPC capacity claims
- No addressing of small fish issues

The pilot or trial scheme minimizes risk in two ways:

1. The pilot feature facilitates learning about the benefits and costs of the Scheme. Then, if the IATTC does not like the Scheme, there is minimal cost and difficulty to revert back to current time-area closure. If the IATTC likes the scheme, the IATTC can then further develop the Scheme as the IATTC learns more about how the Scheme works and the Scheme's strengths and weaknesses.
2. Restrictions on the Scheme retain the fundamental current industry structure and operating patterns. This retention of industry structure and basic operating pattern facilitates learning about the Scheme precludes CPCs and vessels from making mistakes that they may later regret.

4. Build upon Resolution C-02-03

- The foundation is the Regional Vessel Register
- Every CPC has right to participate through its registered capacity
- Vessel-level registration (and allocation) is through CPCs and then to their vessels
- Even when vessels are part of a multi-vessel company, the registered capacity is linked to individual vessels
- A multi-vessel company could consolidate the allocated days limit and reallocate the limit (and subsequent credits) among its own vessels

- The Scheme recognizes two rights: the CPC Flag State right and the eligible vessel's capacity (from Resolution C-02-03) which in turn establishes the right to use days but does not establish a property right to days per se (including a specific number of days or specific Party Allowable Effort Share).
- The Scheme address issues of over-capacity but not fully, and leaves untouched the remaining CPC claims
- Over-capacity can be addressed through buybacks as elsewhere and in the Northern Economics report
- Granting pending CPC capacity claims would require assessing and reallocating PAES from existing eligible vessels

5. Limit and Credit System, Not Property Right

- Like DMLs, days (PAE) are limits, not a property right, and thereby no "guarantee" or right to a number of days as property
- Like unused DMLs (which are a credit), credits in this Scheme are not a property right
- The Scheme, building upon Resolution C-02-03, implicitly establishes the right to use days (but not a right to days or a specific number of days per se, nor are days a property right or entitlement)
- Unused days are credits that can be traded within a Management Year (more discussed elsewhere on credit transfers)
- *De jure*, PAES are not "permanent" (as with a property right), but instead exist for a more limited period of time.
- *De facto*, much like the capacity allocation inherent to Resolution C-02-03, the PAES allocation will stabilize within limits but will always be subject to change according to the IATTC, changes in resource and environmental conditions, etc.

6. PAES Allocation Issues

Part II of this Research Report develops the PAES allocation in detail. This section gives a brief overview.

6.1. Allocate to Which Vessel Size Classes?

- Classes 5-6
- Class 4

6.2. Allocate PAES for Trial 3-Year Period

- Matches current management resolutions.

6.3. Allocation Based Upon?

- Two Categories:

- 1. Eligible vessels are those vessels currently on the Regional Vessel Register and active in terms of days[4]
- 2. Ineligible vessels: vessels that are not on the Regional Vessel Register or that are on the Regional Vessel Register but are inactive (in terms of days).
  - There is a need for a rule of activation (which is same as C-02-03)
  - Reactivated vessels receive a number of days prorated according to the number of remaining days in the Management Year
  - No allocation to sunk vessels
  - CPCs with newly granted capacity that is directly tied to a vessel
- For active vessels, PAES are allocated to vessels through CPCs based on one of four formulae discussed in Part II.
  - New vessels receive days from vessels they replace on the Regional Vessel Register or based upon allocated days of the closest size of existing eligible vessels on a Flag CPC using the PAES allocation formula
  - CPCs with newly eligible vessels that currently do not have PAES and days (PAE) receive PAES and days based upon the average capacity of the closest size of existing eligible vessels of the full fleet.
    - An open question is whether or not these eligible vessels are distinguished by whether or not they hold DMLs.
- For reactivated vessels, PAES are allocated to vessels through their CPCs based on days per m^3 of well capacity
  - Based upon the average of all other eligible vessels in that size class that are active on the Regional Vessel Register
  - An open question is whether or not this average of eligible vessels is further distinguished by whether or not the recipient vessel holds a DML.

6.4. TAE Allocation Reserve

- Any portion of the TAE not allocated to vessels and held in a reserve for new vessels or other specified reasons.
- Can be released at some agreed upon time during the Management Year.
- Any unused days in the TAE allocation reserve in the last 30 days of the Management Year will be cancelled and cannot be carried forward to the next Management Year.
  - Implies that there is no carry-forward (transfer) of credits (unused days) from one Management Year to the next Management Year.

[4] Vessels authorized to fish. The vessels currently listed on the Regional Vessel Register as active pursuant to Resolution C-14-01.

- Also implies no carry-backwards of credits (unused days) from one Management Year to the previous Management Year, for instance to cover overages.

- This reserve of days can be allocated in a number of ways, including:
  - following the PAES formula (proportionality),
  - equal amounts to all eligible vessels (equal division), to CPCs with some agreed-upon special circumstance such as reactivation from inactive to active,
  - to vessels that satisfy criteria in a credit-reward program (discussed below)
  - to US fleet as special feature of VDS (discussed next)

6.5. US Distant Water Purse Seine Fleet

- The US distant water purse seine fleet can be classified into at least four categories.
- First category is 32 US vessels under Paragraph 12 of Resolution C-02-03 that are currently allowed a single trip not to exceed 90 days. These vessels can be allowed:
  - the current single trip not to exceed 90 days
  - X days < 90 days and which cannot be transferred and no more than 32 vessels can hold days
  - The X days < 90 days are a maximum and if TAE falls these X days are proportionately reduced (so treated like everybody else)
  - If the TAE increases these days are proportionately increased according to the rest of the eligible vessels but cannot exceed 90 days.
  - Any unused days (credits) within a Management Year cannot be transferred and are cancelled.
- Second category is vessels that are active in Regional Vessel Register but the EPO is secondary (and serves as de facto “insurance” to fishing in the Western and Central Pacific Ocean).
  - Treat as everybody else (see Part II)
- Third category is vessels that are full-time in EPO and on the Regional Vessel Register.
  - Treat as everybody else (see Part II)
- Fourth category is vessels that do not fish in the EPO as of the beginning date of the Scheme (they are excluded from the program) but can apply like any new vessels.

7. Days

7.1. Heterogeneity of Days: Differential Impacts upon Fishing Mortality

Not all days are equal in their impact upon fishing mortality or recruitment. An individual transferable day credit program in principle should account for the different impacts of a day upon fishing mortality due to differences in average effective effort for each day. Effective effort varies by fishing strategy, vessel size, employed technology, and other factors. Options to address

heterogeneity of days by these and potentially other categories of effective effort are possible as discussed next.

7.2. Different Fishing Strategies

- Distinguish days solely on the basis of vessels holding a Dolphin Mortality Limit (DML) and those not holding a DML.
- Vessels setting on dolphins as their primary strategy also set upon unassociated schools and non-DML vessels setting on floating objects as their primary strategy also set upon unassociated schools.
- Such a simple distinction is also consistent with current IATTC distinctions and is the easiest and least costly to define and monitor.

7.3. Alternative to Fishing Strategy

- No distinction between DML and non-DML
- One pool of days
- Reason: administrative simplicity and costs, especially during pilot phase.
- Reason: transferability facilitates economic efficiency (but could be long-term impact if differential impact upon age classes and species)
- Biological: number of days depends upon stock that is most vulnerable

7.4. Transfers of DML and Non-DML Days

- Exchange rates for transfers of days between DML and non-DML vessels if we allow trade?
- Even if days are distinguished by fishing strategy, exchange rates from DML to non-DML creates an administrative burden and costly

7.5. Differences in Effective Effort and Days by Vessel Size Class

- Options:
- No transfer between size classes
- Days could also be distinguished by vessel size class.
  - Restrict to classes 5-6 and class 4; classes 1-3 unrestricted around year
- PNA VDSs for both purse seine and longline vessels make such a distinction.
- Exchange rate for transfers between vessel size classes.

7.6. Effort Creep

- The TAE can be reduced over time due to growing productivity (fishing power) of vessels, i.e. “effort creep”.
- When allocating days, different rates of effort creep can potentially be distinguished by:
  - Vessel size classes?
  - DML vs non-DML?

7.6. Recommendation

- Because the Scheme is a pilot or trial, this Report recommends that at least during the pilot phase days and their transfer not be distinguished by fishing strategy. Should the pilot Scheme be adopted, days and their transfer can be further distinguished following learning and further development of the Scheme.

8. Area-Based Management

- Control for:
- (1) variations in fishing mortality by species;
- (2) variation in size and age of fish caught that also vary by species; or
- (3) localized stock depletion.
- Spatial management is time-area closures for biological purposes. Such time-area closures are not part of allocating PAES / days by area, but are simply biological closure.
- Such closures remain to be determined and extend beyond the pilot Scheme developed in this Report.
- Such area-based management often forms a feature of effort-based management.
- Potential closure areas are given in Section 8 of Inter-American Tropical Tuna Commission. 2016. Document IATTC-90 INF-B, Alternative Management Measures for Tropical Tunas in the Eastern Pacific Ocean.
- https://www.iattc.org/Meetings/Meetings2016/IATTC-90-2/Pdfs/Docs/_English/IATTC-90-INF-B_Alternative-management-measures.pdf

9. Enforcement: Penalties and Fines

- One firm condition for the Scheme to effectively function is a firm obligation for any vessel to not exceed its PAE during a Management Year. Satisfaction of this requirement entails a strong, readily enforceable penalty for overages during a Management Year not covered by credits. Observable repeated patterns of behavior and decision-making particularly require penalty.
- A penalty creates a disincentive.
- Thus, if a vessel exceeds its PAE (no threshold) for a Management Year, that vessel's PAE for the following Management Year can be adjusted by a penalty if the vessel cannot find days to cover their overage during the Management Year.
    - Unless allow for retroactive covering of overages (discussed below)
- The size and nature of the penalty remain to be determined.
- The simplest and most direct penalty is a fixed fine of a reduced number of days the vessel is allocated the following Management Year. Such a penalty implies a one-to-one relationship (directly proportional) between a day overage this Management Year and a day allocated the following Management Year

- An alternative might be a differentiated penalty.
    - A step function creates a graduated penalty.
- Example: If the excess is less than X days, the penalty is the amount of the excess. If the excess is X days or more, the penalty is the amount of the excess plus a further penalty, such as an additional 20%, giving a total penalty of 120%.
- Such a graduating penalty incentivizes compliance but creates additional program complexity and costs.
- Vessels are given a limited period of time to obtain the necessary days from another source if the vessel does not have valid days at the end of the Management Year.
- The question is how much time?
- Retroactive balancing of days from a new Management Year to a previous one is disallowed. This creates a need to find days prior to the end of Management Year, not ex-post. Days must be balanced prior to start of new Management Year.
- Any vessel cannot start operating in the Management Year without a previous allocation of PAE, which shall be officially registered.
- Details to be determined (how, where, etc. to register).
- DMLs provide an example.
- Use of penalties and fines does not require the development of an adjudication process to assess whether in fact infringements have been committed.
- Information on day leaving harbor and returning makes this clear.
- VMS system also makes this clear, but is not needed for this purpose, since simpler and less costly information on days leaving and returning from harbor is available.

10. Administrative Features

10.1. Financing

- All CPCs shall contribute to the expenses necessary to achieve the objectives of this scheme, through the establishment and collection of vessel fees or some other method to financing the scheme, the level of which shall be determined by the Commission, without prejudice to other voluntary financial contributions.
- Rationale: Because all CPCs benefit from the Scheme, the potential reduction of capacity and its adverse effects, and consequently, the improved state of the stocks.
- Any vessel that is in arrears shall not be eligible to fish in a Management Year until that vessel's assessed contribution is paid in full.
- An open question is whether this payment is required prior to the Management Year or following X months after the beginning of the Management Year.

10.2. Administration

- The scheme will be administrated by the IATTC Secretariat.
- Additional resources will be required.
- The financing method remains to be determined.

10.3. Implementation at the National Level

- Each CPC shall adopt and report to the Commission the necessary measures to ensure the implementation of and compliance with this scheme including, as appropriate, the adoption of relevant laws and regulations.

10.4. Rights of States

- No provision of the program may be interpreted in such a way as to prejudice or undermine the sovereignty, sovereign rights, or jurisdiction exercised by a State in accordance with international law, as well as its position or views with regards to matters relating to the Law of the Sea.

10.5. Settlement of Disputes

- There is no need for a section on dispute settlement because dispute settlement is already covered by the Antigua Convention.

10.6. Monitoring, Control, and Surveillance

- The IATTC staff already monitors departures and returns of vessels.
- The CPCs should report in real time to the Secretariat the information on the departure and return of vessels under their jurisdiction.
- Vessels entering the EPO from the WCPO shall report in real time to the Secretariat their entry into the EPO.
- (The overlap area is EPO for some vessels and WCPO for others.)
- For verification purposes, any vessel in the EPO might be required to provide their VMS information to the Secretariat.

11. Transfer of Credit-Days

- Several limits to transferability are necessary:
    - From before: A vessel may not agree to transfer to other vessels more than a fraction of its PAE.
        - 75% or some other minimum?
        - A minimum retention ensures eligibility for the following Management Year.
    - From before: Should there be a maximum limit to accumulated days?
- ***11.1. Option*.** Carry-forward of credits (unused days) in years 1 and 2 of the 3 years?
    - If carried forward, one-to-one or only some discounted fraction of the days?
    - This report recommends no carry-forward of credits from one Management Year to the following Management Year, at least during the pilot phase. The intent is to keep the pilot phase simple and lowest possible cost, even at the expense of potential increases in efficiency.

- **11.2. Requirement***: Retroactive Transfer of Credit-Days within the Management Year*
- Allows one Party to purchase credit-days to cover its excess days from another Party that has not used all of its days, i.e. has credit-days to transfer.
- Clearing day overages (negative credits) through trade do not greatly differ in substance from trade within a Management Year.
- If yes, see next slide on length of time to clear.

- **11.3. Option***. Length of Time to Clear Overages of Days*
- Clearance of overages of days must be completed by the end of the Management Year.
- Note: after the Scheme is developed and CPCs and vessels learn, then they can further develop the Scheme by including additional features such as carry-forward, carry-backward, settlement beyond end of Management Year, etc. but not back to previous Management Year or to the following Management Year.

- **11.4. Additional issues and conditions arise**:
- (1) Temporary, annual credit transfers among Parties do not change their PAEs (each Party's allocated days from the TAE).
- Payment can be in-kind (e.g. future considerations of credit-days) or monetary.
- When credit-days are transferred between vessels of different CPCs, the rights and responsibilities of CPCs and their right over days and credit-days differs from capacity, which can be longer term, including permanent (see Resolution C-12-06).
- (2) Transfers do not interfere with the approved system for loans, concessions, charters of capacity.
- Relevant IATTC documents include the following:
- IATTC Resolution C-12-06 includes provisions for loans/concessions/charters https://www.iattc.org/PDFFiles/Resolutions/_English/C-12-06-Capacity-loans-and-chartering.pdf
- The RVR shows loans/concession in the note section here: https://www.iattc.org/VesselRegister/VesselList.aspx?List=AcPS&Lang=ENG
- The following IATTC document shows something similar in #5 https://www.iattc.org/Meetings/Meetings2018/CAP-19/_English/CAP-19-01-EN_Review-of-changes-in-the-utilization-of-fleet-capacity-in-the-EPO%20.pdf

12. New Entrants, Eligibility, and Allocation

- New entrants without relevant historical days and no current allocated PAES are allocated days on the basis of average days/m^3 capacity for that vessel category (DML/non-DML, size class)
- Options:
- All vessels with assigned capacity are entitled to request and receive PAE
- (1 Accommodate these vessels within the existing PAES allocation, either through existing members, voluntarily relinquishing limit, or through exchange, such as limit or credit markets, to new participants,

- (2) Set aside a portion of the TAE for future use by new members or the interests of coastal States, allowing them to rent limit days from the Commission,
    - Receive days on the basis of days/m^3 of capacity
- (3) Set aside and distinguish between the limit of a coastal CPC that can be fished in the marine waters of its jurisdiction and the limit of any CPC that can be fished on the high seas,
- (4) Require new distant-water entrants to rely upon transfer or trade of both capacity (and access to the Regional Vessel Register) and day limits to secure entry to the fishery
    - This option is consistent with Resolution C-02-03 and the Regional Vessel Register as the foundation for the Scheme.
- (5) Restrict the duration of limits so that some limits expire in each year and are therefore always available every year for reallocation in some manner,
- (6) Allow buybacks of existing capacity and hence any accompanying limits that are either reallocated or permanently expired to make room for expansion by others,
- (7) Equi-proportional reductions in limit days and the relinquished limit days are then transferred to the new entrants

13. Days Penalty-Reward System

13.1. Rationale

- The IATTC can supplement the Transferable Day Credit Scheme by a penalty-reward system, another type of credit program.
- Such a penalty-reward credit program is fully developed in: Squires, D., R. Lent, P.H. Dutton, L. Dagorn, L.T. Ballance. 2021. “Credit Systems for Bycatch and Biodiversity Conservation.” *Frontiers in Marine Science* doi: 10.3389/fmars.2021.613279. Available at: https://www.frontiersin.org/articles/10.3389/fmars.2021.613279/full
- A penalty-reward system explicitly penalizes or rewards (in-kind through credit-days) vessels that voluntarily satisfy regulatory goals.
- A penalty-reward credit program can create stronger and more targeted incentives to achieve regulatory goals.

13.2. Four Potential Applications

- 1.Compliance
- 2. Voluntary capacity reduction
- 3. Fish size

13.3. Reserve-Days

- First, when allocating days to each vessel, IATTC can retain some quantity of that vessel’s days in reserve (the “penalty”), which is explicitly designated as a reserve for that vessel, the ***reserve-days***.

- When the vessel triggers a threshold for one or more criteria, the IATTC can reward the vessel with additional days drawn from that vessel's reserve-days, which forms a credit, and is termed ***reward-days***.
- Second, the reserve-days might not be vessel-specific and part of the vessel's own initial allocation of days, but instead constitute a common pool of days shared across all or some vessels.
- Third, penalties go to the reserve-days pool

13.4. Remaining Questions

- Should a vessel, which has exhausted its own reserve of reward-days, be allowed to purchase or otherwise obtain (e.g. through costless transfer from another vessel in the same multi-vessel company) unused reward-days from another vessel whether or not that vessel has used all of its initially allocated days?
    - If so, should a discount be applied?
- Open questions include how to dispose of or distribute:
    1. any unused reward-days balance for participating vessels;
    2. any reserve held back for new entrants;
    3. when to distribute; and
    4. for any reserve that is created as a common pool rather than reserve created from each vessel's allocation of days?
- With DMLs under the AIDCP, after April 1 of each year, any DML that the IATTC Director determines will not be utilized or which has otherwise been forfeited could be reallocated to the vessels. The Director could reallocate such additional days among qualified vessels, subject to any limitations and conditions adopted.
- Should this credit-reward program extend across CPCs in which one CPC (or its vessels) purchase and reduce capacity in one CPC to earn the credit (reward)?
- Reward-days under this program are distinguished from the days (PAE) initially allocated and not held in reserve. Transfer of the days initially allocated and not held in reserve is not prohibited and is indeed an integral part of the individual transferable days credit program.

14. Individual CPC Buybacks

- Voluntary and CPC-specific
- CPCs retain released days within the Management Year
- But potential contradiction to credit program in which days are not long-term allocation (property right)
- Implies cannot be permanent
- Sections 4.2.1. - 4.2.3. of the Northern Economics report quantitatively evaluates the gains in economic efficiency of vessel buyback program alternatives.

ANNEX 1. Costs of Closure and Excess Capacity

Annex 1 presents key summary economic analyses from the 2018 Northern Economics and Southwest Fisheries Science Center Research Reports on the Costs of Closure and Excess Capacity. An update of these analyses would change specific values but not the overall magnitudes and qualitative conclusions.

The Northern Economics Executive Summary is available here: http://iattc.ucsd.edu/meetings/meetings2018/sac-09/CAP-19/_English/CAP-19-INF-E(a)_Northern-Economics-Alternatives-to-Address-Excess-Capacity-in-the-EPO-PS-fishery-Executive-Summary.pdf

The Northern Economics Full Report is available here: https://www.fao.org/fileadmin/user_upload/common_oceans/docs/EPO_PS_CapacityReport.pdf

The Southwest Fisheries Science Center report is available here: https://web1.iattc.org/meetings/meetings2018/iattc-93/Docs/_Spanish/CAP-20_INF-A%20Plan%20de%20accion%20para%20la%20ordenacion%20de%20la%20capacidad%20de%20la%20flota%20en%20la%20CIAT–Informe%20del%20consultor%20resumen.pdf

Northern Economics (Section 3.4) estimated that excess capacity costs the EPO purse seine fleet due to the prior 62-day closure period an average of 11 percent of their net operating profit since 2010 or a total of over $256 million. Northern Economics estimated that the costs of the 72-day closure in place for 2018 would be approximately 28 percent higher than the costs of the 62-day closures in place through 2016.

The 2018 Southwest Fisheries Science Center Report estimated 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 2018 Report found 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.

The 2018 Report provided another way to measure the cost of over-capacity 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.

Table XX rom the 2018 Southwest Fisheries Science Center Report reports the optimal fleet size is

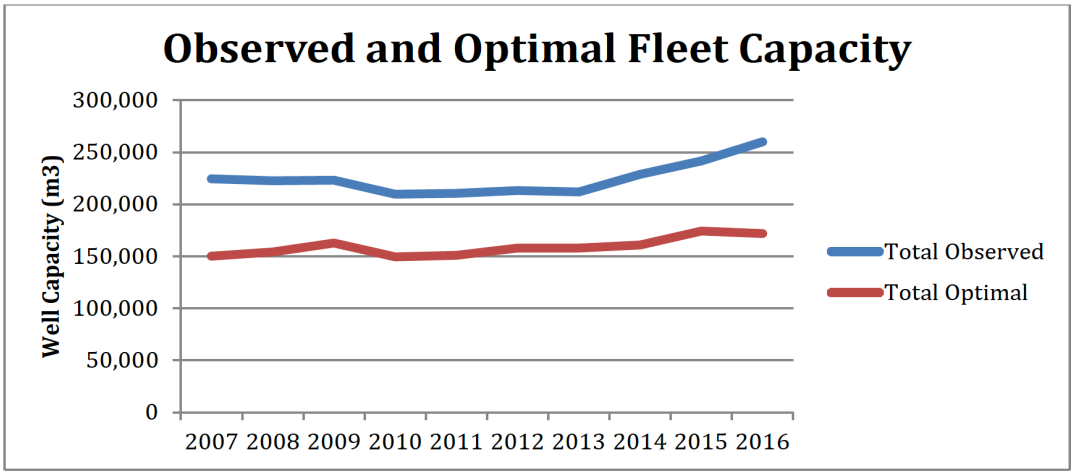
Table 12. Efficient Fleet Configuration: Well Capacity, 2007-2016

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 of the 2018 Report, 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 20. 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 show some variation in the efficient number of vessels, but a relatively stable fleet structure emerges.

Table 13. Efficient Number of Vessels by Size Class

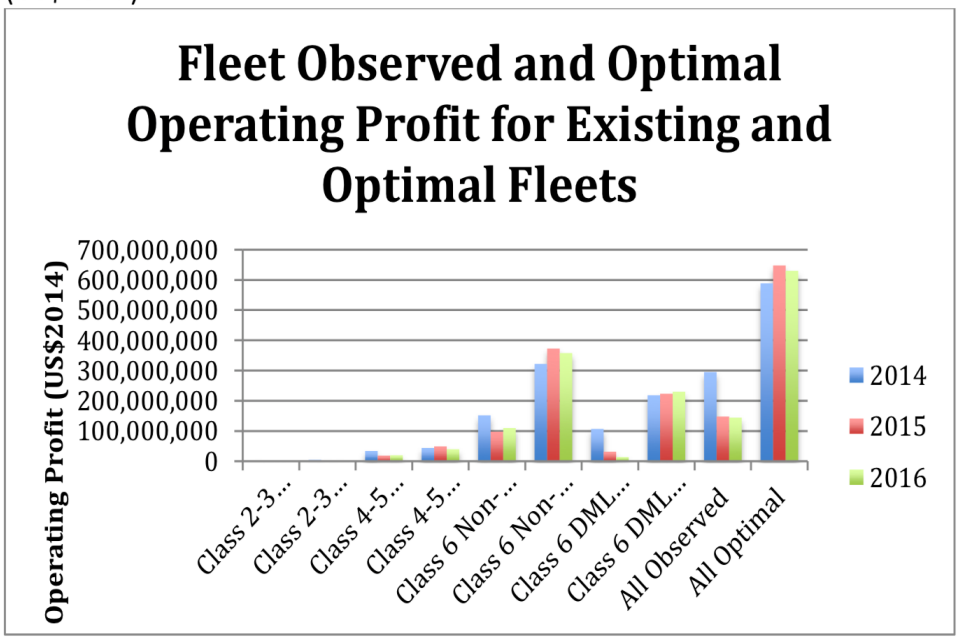
Year	Class 2-3	Class 4-5	Class 6 Non-DML	Class 6 DML	Class 6 Total	Total No. Vessels
2007	3	18	52	70	112	143
2008	3	18	58	67	125	146
2009	4	24	61	66	127	155
2010	2	25	52	61	113	140
2011	4	22	52	64	116	142
2012	2	25	59	64	123	150
2013	2	27	59	62	121	150
2014	1	25	62	63	125	151
2015	1	34	63	63	126	161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

From the 2018 Report, 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)

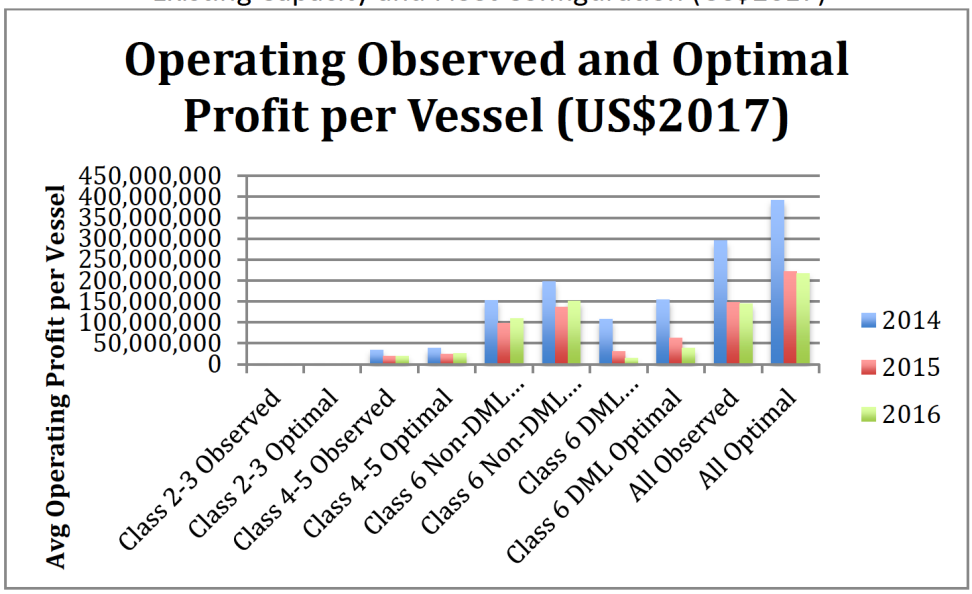
Figure 34. Fleet Observed and Optimal Operating Profit for Existing and Optimal Fleets (US$2017)



In the above Figure 34, the horizontal axis provides vessels group by several categories: capacity classes 2-3, 4-5, 6 Non-DML, and 6 with DML for observed and optimal fleets. Moving from left to right on the horizontal axis and in each category, e.g. Class 2-3, the first representation is for the observed Class 2-3 vessels and the second is for the optimal Class 2-3 vessels. The horizontal axis also provides all observed vessels and the group of optimal vessels that satisfies the optimal fleet capacity.

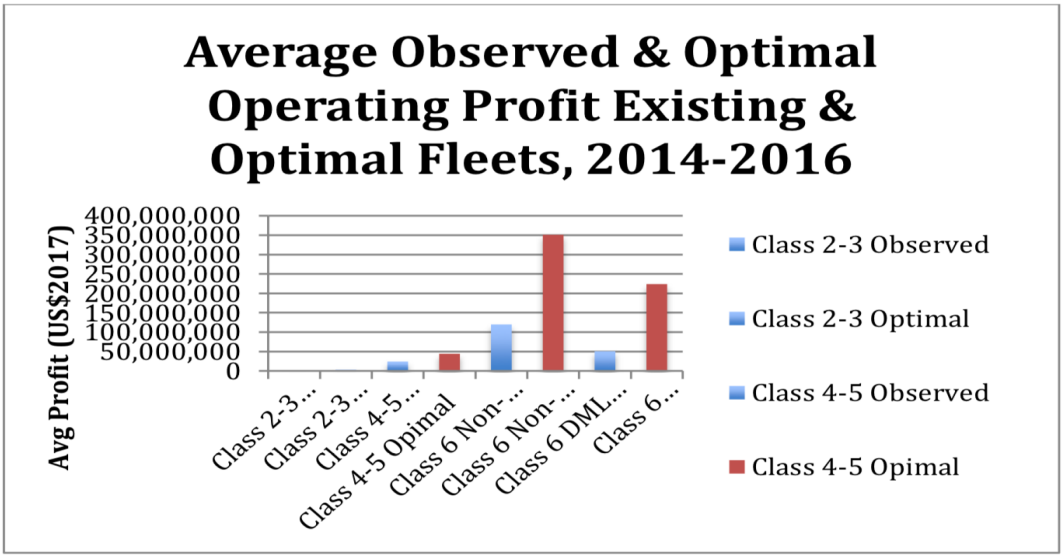
The following figure illustrates operating profit per vessel for both observed and efficient vessels, given the existing capacity and fleet structure (i.e. the fleet as it is, not the optimal fleet). (Efficient vessels are those that utilize their days most effectively.) Average operating profit per vessel varies by year and depends upon annual price and catch rates, 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 from the 2018 Report 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)



In the above Figure 38, the horizontal axis provides vessels group by several categories: capacity classes 2-3, 4-5, 6 Non-DML, and 6 with DML for observed and optimal fleets. Moving from left to right on the horizontal axis and in each category, e.g. Class 2-3, the first representation is for the observed Class 2-3 vessels and the second is for the optimal Class 2-3 vessels. The horizontal axis also provides all observed vessels and the group of optimal vessels that satisfies the optimal fleet 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 the 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.
The 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.

The following table from the 2018 Report 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)

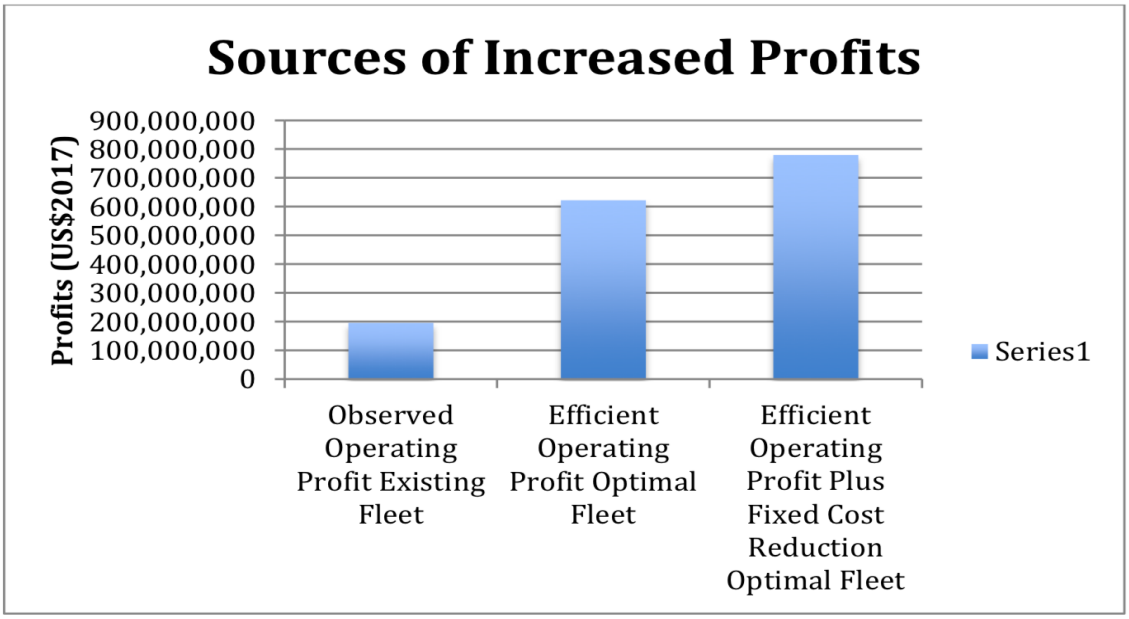
Year	Class 2-3		Class 4-5		Class 6 Non-DML		Class 6 DML		Total	
	Observed	Optimal	Observed	Optimal	Observed	Optimal	Observed	Optimal	Observed	Optimal
2014	2,341,205	1,549,727	38,441,080	25,436,062	208,580,994	138,009,825	234,878,877	175,068,648	484,242,157	340,064,261
2015	1,338,263	951,587	39,915,284	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 from the 2018 Report 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 from the 2018 Report 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: $PV = A/i$.			

[35] The results are based upon the profits viewed as a constant annuity received over an infinite time horizon: $PPPP = AA/ii$, 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%.

*Economic Costs of Time-Area Closures (*from the 2018 Report)

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

Profits (US$2017)

- 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.

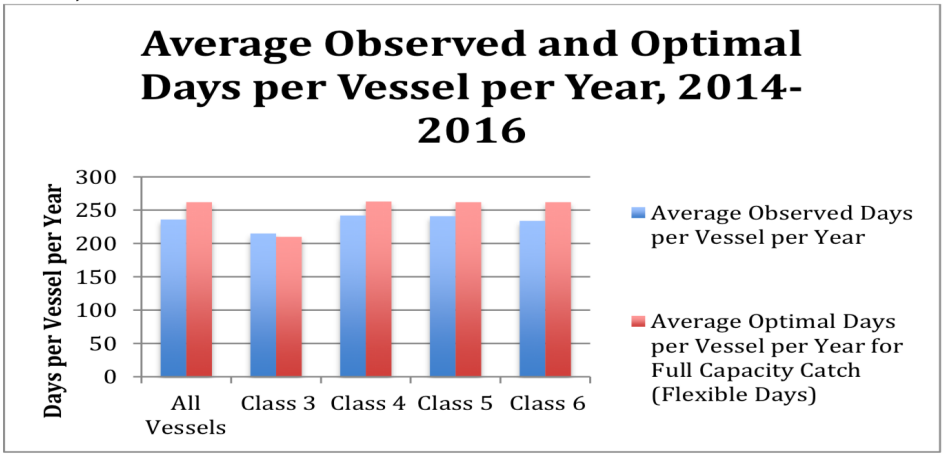
  Vessels, because of the time-area closure and limits on catches and excess capacity, do not fish their optimal number of days in a year and do not use their vessel, gear, and equipment (fixed inputs) optimally. For a vessel that aims to catch the maximum possible catch, the vessel's observed days can 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 from the 2018 Report 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



Economic Cost of Closure Compared to 62-Day Closure (from the 2018 Report)

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 from the 2018 Report (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				

Economics Costs of Closure Compared to No Closure from 2018 Report

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.

Economic Cost of Closure Compared to No Closure from 2018 Report

From the 2018 Report, 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).

ANNEX 2

Workshops on Tuna Fishing Capacity

- *Inter-American Tropical Tuna Commission*
    - Workshop Technical Experts Workshop on the Management of Capacity of the Tuna Fishing Fleet in the EPO. Cartagena, Colombia, 2014
    - Workshop on Fisheries Buybacks, Mexico City. Mexico, 2012
    - International Workshop on Global Tuna Demand, Fisheries Dynamics and Fisheries Management in the Eastern Pacific Ocean. Inter-American Tropical Tuna Commission. La Jolla, California, USA, 2010.

- Rights-Based Management and Buybacks in International Tuna Fisheries. Scripps Institution of Oceanography (workshop in collaboration with World Bank). La Jolla, California, USA, 2008
- Rights-Based Management and Buybacks in International Tuna Fisheries. Institute of the Americas (workshop in collaboration with World Bank). University of California San Diego, La Jolla, California, USA, 2008
- Workshop International Workshop on Global Tuna Demand, Fisheries Dynamics and Management in the Eastern Pacific Ocean, Inter-American Tropical Tuna Commission (workshop in collaboration with the International Seafood Sustainability Foundation), La Jolla, California USA, 2006

- *International Seafood Sustainability Foundation Workshops*
  - Workshop on Capacity Transfer. Barcelona, Spain, 2014
  - Workshop on Rights-Based Management in the Eastern Tropical Pacific Tuna Fishery. International Seafood Sustainability Foundation and Inter-American Tropical Tuna Commission. Guayaquil, Ecuador, 2011.
  - Kobe Taking Stocking Workshop. La Jolla, California, USA, 2011.
  - Workshop on Allocation in Global Tuna Fisheries. Cordoba, Spain, 2011.
  - Workshop on Global Tuna Demand. University of Nantes. Nantes, France, 2011.
  - Workshop on Allocation. International Seafood Sustainability Foundation. Napa California, USA, 2011.
  - Bellagio Conference on Sustainable Global Tuna Fisheries. Rockefeller Bellagio Conference Center. Bellagio, Italy, 2010.
- *Food and Agriculture Organization of the United Nations*
  - Workshop on Effort Rights-Based Management (in collaboration with NOAA, ISSF, University of Basque Country). Bilbao, Spain 2016.
  - Workshop. Methodological Workshop on the Management of Tuna Fishing Capacity: Stock Status, Data Envelopment Analysis, Industry Surveys and Management Options. La Jolla, California, USA, 8-12 May 2006.
  - Second meeting of Technical Advisory Committee on Global Tuna Purse Seine Capacity. Madrid, Spain, 2004.
  - First meeting of Technical Advisory Committee on Global Tuna Purse Seine Capacity. Rome, Italy, 2003 (Squires participant)
  - Technical Consultation to Measure Fishing Capacity. Mexico City, Mexico, 1999.
  - Technical Working Group on the Management of Fishing Capacity. La Jolla, California, 1998.

- *International Seafood Sustainability Foundation Bi-Annual Conferences*
    - Special Session on Global Tuna Fisheries. Aberdeen, Scotland, 2016.
    - Special Session on Global Tuna Fisheries. Montpelier, France, 2010.
- *Others*
    - European Commission. Ministerial Global Fishing Capacity Conference – Less Is More. Thessiloniki, Greece, 2014.
    - Government of Ecuador. On analyzing and designing fisheries buybacks. Guayaquil, Ecuador, 2012.
    - NOAA. Economics and Management of International Tuna Fisheries, Southwest Fisheries Science Center. La Jolla, California, USA. 2007.

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