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Strategies and rationale for fishery subsidy reform

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ABSTRACT

Subsidies can directly support unsustainable fishing practices that harm both ecosystems and long-term social and economic benefits. Global fishery subsidies are substantial, yet their impacts on fishing dynamics are specific to given regions or fisheries at local scales. Subsidies thus have markedly different effects when applied to artisanal versus industrial, or managed versus open-access conditions, as shown for Mexican fisheries. Subsidy reform strategies are critically assessed, drawing on a review of over 30 case studies worldwide to determine patterns in their usefulness and conditions for implementation. Strategies with best relative results are reorienting subsidies away from capacity-enhancement, and/or conditioning them on specific sustainable performance metrics. Decoupling subsidies from fishing (e.g. providing direct aid to fishers) has unpredictable and unclear results, whereas buyback programs tend to have poor outcomes. Eliminating subsidies is perhaps the simplest strategy, but is the most difficult to implement from a social and political perspective. Key factors for any policy to succeed are clear short- and long-term goals; creative design; transparent implementation; and strong socio-political will.

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1. Introduction

A fishery subsidy, according to the World Bank definition, is a "financial contribution from the public sector that grants private benefits to the fishery sector" [1]. Subsidies can thus be used to fund various programs and activities, such as management, research, regulation, infrastructure, tax exemptions, fuel, vessel purchases or direct supplements to income. Globally, an estimated US$38 billion (2014 USD) in subsidies are granted to the fishery sector [2]. Of this total, around 60% are capacity-enhancing ("bad"), 30% beneficial ("good") and 10% ambiguous ("ugly") [3]. It is thus widely accepted that global subsidies mostly contribute to overfishing, resulting in an annual loss of US$55 (2014 USD) billion in potential benefits if fisheries operated at economically-optimal levels [1].

The public sector has limited resources, so conferring subsidies to fisheries (or other private sectors) should form part of a plan toward final goals. Traditionally, there are two reasons for introducing a subsidy [4]. The first is to provide incentives for a sector to take actions that may not otherwise have occurred in the same way. For example, when large-scale fishery subsidies were introduced in many developing countries during the 1970s, a main goal was to accelerate industry growth, which was undoubtedly achieved [5,6]. The second motivation for introducing a subsidy is to address distributional and social equity issues. In this case, the nation adopts subsidies that artificially increase income for workers in a sector to raise their living conditions to an 'acceptable' level. More recently, strategies aimed at environmental conservation are increasingly funded by governments (i.e. beneficial subsidies) at various scales, and funding from non-government organizations—though not subsidies in the strict definition—has become a crucial form of support [7].

Given that most global fisheries reached their ecological limits to production some years ago [5], it would seem that the only defensible reason, aside from purely political motivations, to continue capacity-enhancing fishery subsidies is poverty reduction. However, economic benefits from fishing—unlike, for example, the manufacturing sector—depend directly on ecosystem quality, and fishing, by definition, has (however slight) negative consequences on the ecosystem. Therefore, continuing to subsidize fishing effort on an already overexploited ecosystem will only damage it more, continually diminishing its long-term productivity (e.g., [4,8,9]). In this way, attempts to reduce current

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poverty levels through effort-enhancing subsidies will only ensure that there is even more serious poverty in the not too distant future. In anticipating these impacts, it is useful to first contextualize the economic performance of key fisheries to better appreciate their current ecological status and socioeconomic benefits, including public investments.

This study aims to inform discussion on subsidy reforms for applied fishery management, and offers a critical review of potential strategies that have been proposed or applied to address this issue [10]. Each is discussed at length below, and include (i) eliminating subsidies; (ii) decoupling subsidies (direct supplements to income instead of fishing effort); (iii) reorienting subsidies towards better management and technology; (iv) conditioning subsidies on fishery performance; and (v) substituting subsidies for vessel buybacks. To provide a more applied context to this review, we present Mexico as a typical developing country with an array of distinct fisheries. There is a clear need to rethink and reshape the goals and strategies for fishery subsidies in many settings [11], yet changes require a recognition of specific contexts for particular fisheries. Although the following analysis is certainly critical, the intent is to present the benefits and limitations of each strategy objectively and with the final goal of informing stakeholders to promote constructive dialogue. This framework can help provide a more objective picture of fishery performance, and identify priority issues of concern.

2. Providing context to fishery subsidies: Mexico

Just as fishery subsidy dynamics vary across global regions and countries [3], within-country fisheries can be impacted by subsidies in different ways. Mexico is a medium development Latin American country with temperate and tropical coasts on the Pacific and Atlantic Oceans. In 2012, Mexican fishery landings were reported at 1.2 million tonnes (*t*) [12] (though recent estimates suggest the total including unreported and illegal catch could be almost double the official reports [6]). Total landed value is reported at US$829 million [12], with an economic impact of close to US$1.4 billion [13]. Total fisheries employment is difficult to assess, as in many developing countries, but is estimated at between 155–750 thousand people [6,14,15].

Currently, Mexico allocates a budget of around US$254 million per year on the fishery and aquaculture sector [14,16]. Aside from funding for research and management, most expenditure (65%) is on capacity-enhancing subsidies [17], including fuel (US$73 million), infrastructure development (US$60 million) and fishing equipment (US$33 million) [12]. Despite an incomplete estimate of total subsidies, which should include the tax breaks conferred to national fishing fleets, the percentage of bad subsidies out of total fisheries investment in Mexico ranks as the worst in Latin America (based on data in Ref. [3]).

Below are very brief summaries of key Mexican fisheries selected as examples of differing economic dynamics (sardine, abalone-lobster, shrimp, squid, and artisanal finfish fisheries; tuna fisheries are also important but we focus primarily on coastal water fishing). An outlook of revenue, costs and subsidies are provided to emphasize these fisheries' status in economic terms (Table 1). Due to available data, these statistics were usually derived from representative production units (vessels) as reported in the literature.

2.1. Sardine

The largest fishery in Mexico by catch volume, sardine (and associated small pelagic fishes) is mainly fished inside the Gulf of California (where it is MSC certified) and the Pacific coast of the Baja California Peninsula. Abundance is highly variable, though ecological mechanisms are relatively well-understood and provide some room for predictions [18,19]. This fishery is fully industrialized, with relatively small purse-seine vessels feeding parent processing plants. Firms are mostly vertically-integrated, with most catch turned into low-price fishmeal for animal feed, and a much smaller portion canned for human consumption (domestic and export) [20]. Fuel subsidies are a small source of revenue compared to landed value of the catch, though this seems to be the end of a period of historically-high abundance.

Table 1
Economic performance indicators by fishery in Mexico. All values are in 2014 USD millions. Catch, revenue and employment are from official statistics [12,14]. Cost, profit, and subsidies are calculated based on representative production units (as cited). Economic impact calculated assuming a 1.72 multiplier on revenue [13]. NA= Data not available.

Fishery	Catch (t '000)	USD millions					Jobs
		Revenue	Cost	Profit	Subsidies	Economic impact	
Abalone-Lobster[a]	2.7	31	28	3	0.4	53	2200
Sardine[a]	721	46	32	14	3.5	79	730
Shrimp[b]	39	145	170	−25	41	250	7350
Squid[c]	23	7	5	3	4.5	12	3000
Tuna	96	72	NA	NA	9.1[d]	124	1970
Artisanal finfish[e]	313	452	NA	NA	13.4[d]	781	144,500

[a] [27].
[b] [25].
[c] [30].
[d] [32].
[e] [6].

2.2. Abalone–lobster

Abalone and lobster fisheries in Mexico take place mainly on the Pacific coast of the Baja California Peninsula, where well-established territorial use rights fishing (TURF) schemes grant fishing access to specific communities. Fishing methods are artisanal (small boats and divers with hand-held gear), yet post-harvest processing and marketing are advanced and well-organized (including MSC certification), with most products exported to high-price markets [21,22]. These are limited-access fisheries, and though illegal catch occurs [23], this arguably is less of an issue relative to other Mexican fisheries. Fuel subsidies represent a small fraction of revenue for this economically-efficient fishery, raising the question of why they are conferred at all.

2.3. Shrimp

The most valuable fishery in Mexico in terms of revenue, several species of shrimp are fished along both Pacific and Atlantic coasts, though data for this exercise is for the industrial shrimp fisheries in the Gulf of California. There are legal limits on fleet size and gear types, as well as spatial and temporal closures; however, there are significant issues with monitoring and enforcement [6]. Industrial vessels in the Mexican Pacific use either single or paired bottom-trawl gear, with well-documented bycatch issues [24]. Most landings are chilled and packaged for export; prices can be variable, particularly with the current growth of shrimp aquaculture in the region and globally [25,26]. This fleet is known to be overcapitalized, with many individual vessels operating at a loss, mitigated into a net profit only after factoring in fuel and tax subsidies [25,27].

2.4. Squid

The jumbo squid (*Dosidicus gigas*) fishery in the Gulf of California is somewhat hindered by variability in squid abundance, but can be an important windfall supplement for fishing income [28,29]. It is carried out by either artisanal or larger industrial vessels, though both use variations on the same type of jig gear. Due to its high abundance when present, squid prices are generally quite low, requiring high-volume catches for profitability; fuel subsidies represent 3–6% of profits depending on the vessel type [30]. There is little post-harvest processing, and the meat is usually preserved and packaged for sale and/or export, or sold fresh locally, at a low price [30]. Most vessels in this fishery are not squid-specific, though they will exclusively target squid during periods of high abundance. The fishery operates at a small profit, further boosted by fuel subsidies.

2.5. Artisanal "finfish" fishery

In Mexico, this refers to the extensive fleets of small coastal vessels (~8 m length, open-deck, outboard engine, 2–4 fishers) that catch any available species of finfishes ("*escama*") and invertebrates [31]. Almost any type of fishing gear can be deployed from these vessels, with minimal conversion needed. There is little-to-no oversight of this sector, though it is important as an employment source (~145 thousand direct jobs) (Table 1). Efforts are being undertaken to generate representative economic analyses (M. Ramírez-Rodríguez, G. Ponce-Díaz, pers. comm.), but fishers can currently access yearly fuel subsidies and periodic programs offering new outboard motors.

2.6. Summary typology of Mexican fisheries

It is evident that fisheries, in Mexico and elsewhere, perform quite differently depending on ecological characteristics and regional contexts. It is worth noting that, for most economic analyses used as source material for the above fishery summaries (except shrimp), tax-breaks were not included in subsidy totals. This speaks to an overarching theme in efforts for subsidy reform, the need for increased transparency in the application of subsidies. Nevertheless, even this type of simple analysis presents an enhanced overview to aid in applied policy design. Three distinct types of fisheries are thus identified here using the Mexican case, but they arguably match up well with fishery sectors in most developing (and many developed) countries. This classification is nevertheless only developed as a general typology of fishery-subsidy contexts, a useful exercise to consider when focusing on other regions that may have their own distinct dynamics, and therefore their own issues and potential solutions.

One, some high-value benthic fisheries like the abalone–lobster fishery on the Pacific coast of the Baja California Peninsula are well-managed and incorporate key aspects of desirable fishery governance [33], including community-led management, access rights, effort and catch monitoring and control, and integrated added-value processing and marketing. As expected, these fisheries have been relatively sustainable and currently enjoy economic benefits captured in the form of increased labor wages for license holders [27]. Current subsidies to this sector are appropriately low (Table 1), and should probably be directed only for ongoing research and enforcement of current policies and to combat illegal fishing.

Two, most industrialized fisheries, including those targeting shrimp and sardine in Mexico, are currently engaging in economic overfishing (Table 1). Even when fishing effort may be ecologically sustainable, potential economic profits are dissipated through inefficiencies. Current subsidy programs focused on effort enhancement are only worsening the situation. In the case of profitable fisheries, including sardine and squid (and likely tuna), the goal for further subsidies is unclear. However, the industrial fleet is relatively small, and firms appear to be open to cooperation with reforms in exchange for increased access rights, which can be beneficial given the right circumstances [34]. This sector is therefore likely a good candidate for new and creative strategies to re-incentivize fishing to the benefit of economic and ecological sustainability.

Three, there remains a large and mostly unregulated artisanal sector (Table 1) that is also responsible for many coastal fish stock declines. Combined with limited governance, questionable design and implementation of subsidies have contributed to poor living conditions for fishers and their families, as well as ongoing ecosystem degradation. The size of the sector makes it a larger contributor to coastal employment than the more visible industrial fisheries (Table 1), yet open-access conditions have dissipated potential economic profits. Socio-political constraints will likely preclude any drastic changes in policy in the short-term, but it is imperative that the most negative subsidies to this sector be redirected and that a foundation begins to be laid for future positive actions, both in an ecological and social sense. This can and should include investments in monitoring, as well as subsidy programs to promote economic alternatives with a view to the long-term, which has been historically lacking [35].

3. Subsidy reform strategies

This section reviews and discusses potential strategies for subsidy reform that should be openly discussed, understood, and applied in ways that acknowledge local contexts, yet strive to look beyond current conditions and towards better alternatives. These strategies have been discussed in the literature, and/or emerged from dialogue between various stakeholders, including industry and government representatives, academics and non-governmental organizations, addressing a general proposal to reform public expenditure on fisheries [8,10,36]. Discussion is further strengthened with case studies where subsidy reform strategies have been applied, shown in Fig. 1. For the full list of case study references, see Appendix A. Note that the analysis below is framed within the assumption that, given low management capacity and unrestricted fishing access, competition between fishers will inevitably lead to overfishing, driving economic profits (or 'resource rents') to zero and decreasing fish abundance and catch [37]. Further increases in fishing effort, such as those following from profit-enhancing subsidies, will only lead to more serious overexploitation and loss of potential future benefits [3].

3.1. Elimination of subsidies

It is the most socially and politically-difficult strategy, yet the simplest option would be to completely eliminate subsidies to the fishery sector. In Mexico, for example, this would provide an instant yearly savings of US$180 million of public funds, though it would undoubtedly create serious short-term socio-political stress. In the mid- to long-term, it is likely that initial fishing profit "losses" from subsidy elimination would be more than offset by gains in fishery catch as overexploited populations recovered [38]. However, without strict enforcement to prevent new fishing effort to be drawn in by a newly profitable fishery, overall gains would be quickly dissipated once more [8].

This highlights two important issues to keep in mind when designing management strategies, or reforming current ones. First, the "fishing industry" must be defined and regulated to prevent new entrants from reaping potential gains in management

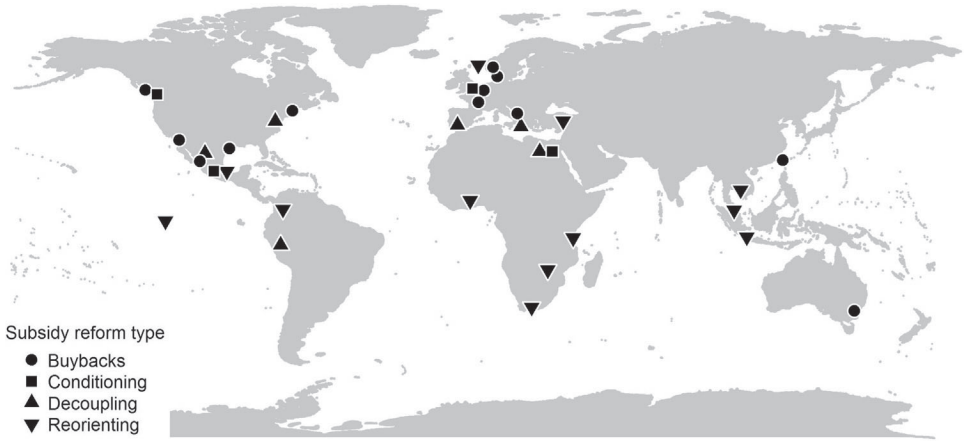

Fig. 1. Subsidy reform strategies (not exclusive to fisheries) with available case study information reviewed in this study. Figure only notes implementations, not outcomes; references are in Appendix A.

improvements. Second, and following from the previous point, any management strategy will have tradeoffs, but it is vitally important to consider who benefits and who bears the costs [39].

3.2. Decoupling subsidies from fishing effort

A decoupled subsidy is a transfer of income to subsidy beneficiaries without any conditions or specific uses, the key point being that payments are not linked directly to increases in fishing effort. In practical terms, decoupled subsidies can be granted as a yearly lump-sum payment to participants in a fishery (or other industry) in order to aid in poverty alleviation, without directly contributing to increased effort or production.

Decoupled subsidy programs are most common in agricultural policy, where international trade agreements constrain nations' ability to apply production-enhancing subsidies. A study of US income support programs for agriculture found that these payments indeed did not result in incentives for re-investment in farm inputs (the counterpart to fishing effort), and promoted savings and spending by beneficiaries [40]. One unresolved issue in that program was the large portion of overall payments captured by land owners from farmers on lands with increasing rental prices, similar to the relationship between fishing equipment creditors and many fishers in developing countries. In southern Spain, income support programs for agriculture have been ongoing since the mid-1980s [41]. The initial goals of the program may have been largely political, but results indicate a relatively stable amount of recipients of these benefits, with a sharp increase of female farmers in the overall gender ratio, and a rise in the mean age of recipients. This is an indication of successful labor mobility out of the sector, yet there is also some evidence that farmers may be "gaming" the system, with an increased number of younger recipients claiming that they have worked in farming for the legal minimum of days required for eligibility in the program.

Pure income support is not the only form of decoupled subsidy. For example, an EU plan is using a form of decoupled subsidy to fishers that redirects fishing vessels and effort toward environmental clean-up of floating debris [42]. Under this scheme, fishers would literally be paid to fish for plastic. In this particular type of subsidy, the public would gain from improved environmental conditions, former fishers employed for clean-up would be compensated commensurately, and fishers remaining in the fishery would benefit from reduced competition.

In Mexico, a decoupled subsidy program for agricultural communities directed money transfers to mothers specifically aimed at, and conditioned on, child school enrollment [43]. This form of subsidy is interesting in that, though families are receiving income in the short-term, the true payoffs would be expected in the long-term through the diversification of employment opportunities and increased earning power of their better-(formally) educated children. Similar subsidies include the incorporation of fishers and their families into social security systems, which has been historically difficult due to the variable nature of fishing income, but is already being done at sites around the world, including Latin America [44].

Decoupling of subsidy amounts currently destined to marine diesel and artisanal gasoline have been proposed as a potential option for Mexican policy. Most subsidies to Mexican fisheries are likely contributing to excess capacity and subsequent continuation of overfishing, yet these fuel subsidies are the worst in terms of long-term industry sustainability and usefulness of public funds. In contrast, for example, subsidies on fishing infrastructure such as port or road construction and improvement might very well be beneficial for other sectors including tourism, commerce and basic transportation. If only the funds currently used for fuel subsidies, that exclusively increase fishing effort, or all effort-enhancing subsidies were decoupled from effort and instead applied as income supplements, each fisher in Mexico would receive an average of US$470-$1160 per year (assuming the official estimate of 155,000 total fishers). Individual totals could be assigned depending on fuel usage rates, a common current method for granting fuel subsidies to individual fishers.

One key benefit of this strategy is that, in an overfished system, effort reductions through the re-direction of effort-enhancing subsidies would lead to increased overall catch and revenue in the mid- to long-term. This again assumes that fishing effort can be effectively regulated to prevent new entrants. While this may seem like an unrealistic assumption in many countries, the absence of this characteristic of basic governance should also preclude the use of many types of subsidies in the first place, if the goal is to achieve a sustainable industry. This assumption being met, decoupling of subsidies from fishing effort and directing them towards income supplementation would help ease the short-term losses from effort reduction while natural populations could recover to higher abundances.

3.3. Reorienting subsidies to management and technological improvements

A fishery operating closer to biological optimum levels causes less environmental impacts and would likely result in higher economic benefits, reducing the need for further subsidies.

Following from this, subsidies can be reoriented into investments to transition to environmentally and economically-sustainable fisheries that do not require ongoing government supports [45].

For example, after many years of serious overfishing that led to dwindling profits, subsidies by several European nations have been reoriented into improvements in research and management design that, coupled with reductions in overall fishing effort, have led to marked improvements in fish populations and industry profits [46]. In other cases, regional fisheries management organizations (RFMOs) have decided to address joint issues of concern by partnering with government and non-government organizations to subsidize research into solutions. Clear examples are the development of fishing gear to reduce bycatch of sea turtles and marine mammals in high-seas tuna fisheries, which would otherwise be forced to contend with legal restrictions on international sale and trade [47].

Reoriented subsidies should also recognize future development of industries. In the case of Eastern Africa, the negative impacts of overfishing and the growing aquaculture sector, which often share the same ecosystem, have been identified and addressed by developing these industries jointly, rather than in a vacuum [48]. This includes investing in research and planning for integrated multi-species aquaculture and fisheries sites, and aquaculture of herbivorous fishes and low-impact, high-value species such as seaweeds or pearl oysters. In South Africa, subsidies were reoriented heavily toward enforcement of fishing policies, particularly around relaxed abalone harvest regulations following the end of Apartheid [49]. One particularly successful initiative was the creation of a temporary Environmental Court specifically to attend to legal matters related to environmental (mainly fisheries) issues, recognizing that fisheries are important for coastal communities, yet the general legal system has many other priorities to contend with [49]. A series of convictions of illegal fishing firms and individuals followed, though concurrent policies are needed to increase incentives for voluntary compliance [49].

In the case of Mexico, for example, there is a clear disparity between negative effort-enhancing and potentially-positive subsidies. Out of the total national budget for fisheries and aquaculture, only 15% is destined towards research, monitoring or enforcement (see Section 2). Nevertheless, in many cases including Mexico the mechanisms and institutions already exist to make good use of increased public funds for research geared toward improvements to environmentally-damaging fishing practices [50], while mitigating short-term economic performance and improving future outlooks [51].

The key to successful subsidy reorienting is to work with industry to identify the best places for investment. This does not imply that the state should cede ultimate authority over public resources, but rather that fishers' and fishing firms' knowledge be incorporated into policy design that seeks to ensure sustainability, yet acknowledges gaps in "official" knowledge [52]. For example, if there are warranted restrictions on gear types or spatial/temporal fishery closures to protect certain stocks, finding out more about the species' natural life histories could allow for a refinement of regulations. In Alaska, concerns about sea lion populations led to restrictions on fisheries thought to be competing for available food. After a series of environmental and physiological studies, it is now evident that competition with fisheries is not the main cause of sea lion declines [53]. Other research that would likely benefit both the environment and fisheries includes strategies to reduce bycatch and habitat damage, development and enforcement of optimal fishing quotas, redesign of marketing strategies, and identification of natural climate patterns and their effect on population abundance [35].

Benefits from reorienting subsidies towards management and technology may require some time to grow, particularly when ecosystems are already heavily overexploited. It goes without saying that to achieve any benefits there must be an investment in enforcement of policies at least as large as that for developing them. This will require some enhancement of resources available to those tasked with monitoring and enforcement, but also increased political will and patience. As with all of the reform strategies discussed here, reorienting subsidies need not be the only strategy applied, but should be combined with others to address these types of potential hindrances.

3.4. Conditioning subsidies on fishery performance

Under this scheme, fisheries would gain the right to particular subsidy types and amounts depending on specific performance criteria designed to incentivize good management. Thus, conditioning of increased profits from public funds on diminishing environmental impact would result in higher overall benefits in the mid- to long-term.

The key problem with fisheries subsidies at the global level, aside from theoretical economic qualms with the use of subsidies in general, is that they most often lack an accompanying strategy and goals for long-term industry profitability and self-sustainability. As a case in point, the current objective of fishery subsidies in Mexico (slightly paraphrased from Ref. [17]) is to increase capitalization on equipment and infrastructure to allow fisheries to carry out their activities. In other words, the current official goal of public investment in the national fishing industry is to keep fishing. Indeed, this seems to be a widespread "goal" around the world [54].

Currently, programs for monitoring of fishery subsidies are focused on ensuring that granted funds have been used in accordance with the approved request [17]. For example, if a subsidy was granted with the objective of purchasing a new engine, it is only confirmed that the engine has been purchased and installed for use. This is one more example of the urgent need to re-formulate the objectives and final goals for providing fishery subsidies.

One example of conditioned payments are those offered by organizations such as the Marine Stewardship Council or Ocean Wise to particular fisheries that meet their criteria of sustainability [55,56]. In this case, support may be provided for ongoing evaluation of fishery performance, but is generally focused on consumer promotion and access to restricted markets. These supports in particular cannot strictly be defined as subsidies as they are not derived from public funds, but there is no reason why a state could not design subsidy schemes that are similarly conditioned on performance criteria. This type of partnership is already occurring in the Mexican forestry sector, where communities largely self-manage their forest land with government and international aid for training, industry development and marketing conditioned on sustainable logging practices [57].

3.5. Substitution of ongoing subsidies for buyback schemes

Buybacks, as the name implies, involve the purchase using public funds of fishing vessels, gear, and/or permits from fishers in order to reduce excess capacity in a fishery. This is often identified as an attractive strategy, particularly from an industry and short-term political standpoint, but has been largely counterproductive for addressing either economic or ecological concerns [58].

In terms of reducing excess fishing capacity, the use of this strategy as a principal management tool has proven to be wholly ineffective. In addition to new vessels simply coming back into the fishery, the key reason why buybacks are generally unsuccessful is the weak correlation between vessel numbers (and, to a point, size), and fishing capacity. For example, schemes undertaken as

part of the European Union plans for fishery management restructuring were successful in reducing nominal fishing capacity (defined there as fleet kW and gross tonnage) by 25% over twenty years of successive buybacks. Fishing mortality continued to rise regardless, and some fisheries are now heavily overexploited to the point that total shut-downs may be necessary to recover populations [59].

The same results have occurred in a range of settings, from Norway to Canada to Taiwan [60–62]. In all of these cases, the overwhelming majority of boats retired were small and/or in poor condition, and only marginal contributors to overall fishing capacity. Furthermore, a lack of regulations on true fishing capacity, including technology and gear, resulted in funds from buybacks being re-invested on remaining fleet capacity, with a net negative effect on sustainability. All things being equal, reductions in fishing mortality that lead to increases in fish abundance and potential yield will increase profits for those remaining in the fishery (Fig. 1). If fishing mortality cannot be regulated, these new profits act as an incentive for increased effort until rent is again dissipated ([37]; Fig. 1). Effective fishing capacity regulation is therefore a pre-condition for buybacks to have any positive result [8].

A second, and perhaps more pervasive negative effect of buybacks in the long-term, is the signal to the fishing industry that potential losses stemming from overcapitalization and subsequent overexploitation will be mitigated with public funds [63]. Indeed, it can be demonstrated that buyback schemes anticipated by the industry will act like a subsidy to current fleet investment [8]. This lowering of investment risk thus acts as a strong incentive for capital investments in fishing capacity that otherwise would be avoided by established fishing firms or new investors. Logically, each subsequent round of buybacks would further reinforce these perverse incentives in a negative-feedback loop.

Though buybacks, as discussed above, are not an effective principal strategy for reducing fishing capacity, they have been proposed as a practical tool for facilitating the implementation of new management policies [64]. In particular, once catch limits are set and enforceable, and effective controls on fishing effort can be guaranteed, it has been argued that vessel and permit buybacks can help ease the transition from pure input-output controls into rights-based management. Examples are given by Norway, Australia and Italy (see Appendix A). It must, of course, be stressed that all cases met the conditions vital for buybacks to be of any benefit, that is, prior effective control mechanisms for both illegal fishing effort and on total fishing mortality [58].

Another key point is that, when capacity reductions will benefit fishers through stock recovery and increased economic efficiency [65], there is no need for "compensation" in the form of buybacks. This is particularly true for industrialized fisheries where firms own multiple vessels. The history of rights-based management schemes is that they can in fact result in increased income to vessel owners. It is simply perverse that the industry should have to be "bribed" into moving to a management scheme that will benefit it economically. An argument could be made for the use of buyback funds for fishers who must leave a fishery so that others may profit, but these cases would warrant a formal plan for investment in human capital (e.g. education, re-training) and not lump sums that could be easily used to re-enter the fishery.

4. Opportunities for fishery management

Patterns of strategy usefulness in terms of meeting self-defined objectives can be readily seen (Fig. 2) despite the relatively small sample size of available literature. These patterns align well with economic theory, where strategies with high firm acceptance (and subsequent easier implementation) but low expected benefits for resource management, such as buyback schemes, have been implemented more often and performed poorly for resource management. On the other hand, strategies that are potentially much more useful but more difficult to implement have not been used as much. The underlying reality is that resource managers must cope with the short-term incentives of private firms and communities, as much as longer-term ecological needs and other resource-specific goals that are often their official mandate.

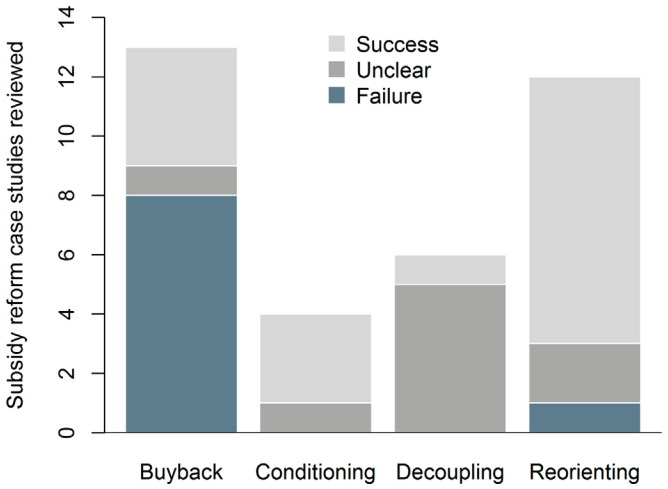

Fig. 2. Outcomes by subsidy reform type, as defined by case-study authors (whenever possible) or inferred from available information.

The analysis provided here focuses on the outcomes of subsidy reform strategies implemented around the world (Fig. 1). This implies many different contexts for implementation, and indeed quite different triggering factors for the decision to enact reforms. Though most fisheries worldwide could likely benefit from subsidy reforms to increase efficiency and reduce their environmental impacts, specific contexts warrant specific reform strategies and timelines [45]. Depending on the economic nature of the fishery and the status of the targeted natural populations, gradual approaches may be more beneficial than drastic ones. If drastic measures are indeed taken, which may be inevitable in cases of industry crisis (as likely exist in some Mexican and developing country fisheries), public reaction must be anticipated, integrated and managed by firm and transparent institutions in order to avoid shocks to social stability [36,66].

Following from the above, one overarching policy strategy would be to establish parallel lines of dialogue with specific fishery sectors that may benefit from, and be agreeable to, particular subsidy reforms. Having a relatively strong economy with tangible alternative employment opportunities may help ease the transition into a more efficient and streamlined fishing industry, yet it must not be forgotten that fishing also provides direct access to food for many artisanal fishers. This social importance of fisheries makes trade-offs during management improvements more difficult, and there is a growing focus on this issue by institutions and organizations at local and global scales [67,68].

In one developing country case, Cambodia, a well-established, albeit rife with corruption, system of fishing access rights resulted in sustainable fisheries, yet gross inequalities among industrial and artisanal sectors. To address this issue and make resources available to the poorest fishers, the government instituted a sweeping reform, essentially reverting the fishery sector to open access by slashing regulations and enforcement. What followed was predictable, and a glaring evidence of poorly-designed policies. Resources are quickly being depleted, economic rents disappeared, corruption and illegal fishing practices have increased, and poverty was not in any way ameliorated [69]. There is some

empirical evidence that better governance contributes to better outcomes in marine management [70], yet even in highly developed regions large fishing firms with political clout can dramatically impact industry-specific governance and ecological outcomes (e.g., Europe; [71,72]. Many of the buyback schemes discussed here occurred in developed nations with relatively strong management schemes in place (Fig. 1), yet most subsidy reforms were ineffective (Fig. 2). Again, this supports the need for very clear and transparent goals for fishery performance, which should explicitly incorporate ecological and economic dynamics in addition to social needs [33].

5. Conclusions

Truly effective subsidies should address the root cause of industry issues, not the symptoms. For example, if participants in a non-profitable fishery agree that the core problem is one of overcapacity, any subsidy strategy should aim to reduce capacity in the short and long-term, not increase profits artificially. This is a logical principle, and others like it will undoubtedly emerge with increased and transparent discussions between government, industry, researchers and the general public. A key point here is that effective management makes ongoing subsidies unnecessary.

As this study shows, there are many potential subsidy reform strategies that can and likely should be used in various combinations for best results. Necessary for any of these policies to succeed are four key factors: clear short- and long-term goals; creative design; transparent implementation; and strong socio-political will. All of these can be likely fostered by open dialogue and co-management frameworks, and there currently appears to be a worldwide surge towards improved fishery management involving many stakeholder groups. With contributions from various sectors, it is evidently possible to design frameworks with positive, and sustainable, economic and ecological results.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http: //dx.doi.org/10.1016/j.marpol.2015.10.001.

References

[1] World Bank, The Sunken Billions. The economic justification for fisheries reform, The World Bank, Washington, D.C., 2009.
[2] U.R. Sumaila, V.W.Y. Lam, F. Le Manach, W. Swartz, D. Pauly, Global fisheries subsidies, European Parliament, Brussels, 2013.
[3] U.R. Sumaila, A.S. Khan, A.J. Dyck, R. Watson, G. Munro, P. Tydemers, et al., A bottom-up re-estimation of global fisheries subsidies, J. Bioecon. 12 (2010) 201–225, http://dx.doi.org/10.1007/s10818-010-9091-8.
[4] G.R. Munro, U.R. Sumaila, Subsidies and the sustainability of offshore fisheries: an economist's perspective, World Wildlife Fund, La Paz, Mexico (2012), p. 15.
[5] A. Espinoza-Tenorio, I. Espejel, M. Wolff, J. Alberto Zepeda-Domínguez, Contextual factors influencing sustainable fisheries in Mexico, Mar. Policy 35 (2011) 343–350, http://dx.doi.org/10.1016/j.marpol.2010.10.014.
[6] A.M. Cisneros-Montemayor, M.A. Cisneros-Mata, S. Harper, D. Pauly, Extent and implications of IUU catch in Mexico's marine fisheries, Mar. Policy 39 (2013) 283–288, http://dx.doi.org/10.1016/j.marpol.2012.12.003.
[7] A. Balmford, T. Whitten, Who should pay for tropical conservation, and how could the costs be met? Oryx 37 (2) (2003) 238–250, http://dx.doi.org/10.1017/S0030605303000413.
[8] C.W. Clark, G.R. Munro, U.R. Sumaila, Subsidies, buybacks, and sustainable fisheries, J. Environ. Econ. Manag. 50 (2005) 47–58, http://dx.doi.org/10.1016/j.jeem.2004.11.002.
[9] G.R. Munro, U.R. Sumaila, The impact of subsidies upon fisheries management and sustainability: the case of the North Atlantic, Fish Fish. 3 (2002) 233–250.
[10] C. Muñoz-Piña, C. Meza, Políticas para desacoplar subsidios a la pesca en México, WWF, México, 2013.
[11] WWF, Reforma en los subsidios a la pesca, Maximizar el valor de las inversiones gubernamentales al sector pesquero a través de la investigación científica y el diálogo abierto, WWF, México, 2011. ⟨http://subsidiospespesqueros.net/⟩.
[12] CONAPESCA, Anuario estadístico de acuacultura y pesca, SAGARPA, México, 2013. ⟨http://www.conapesca.sagarpa.gob.mx/wb/cona/anuario_2012_zip⟩.
[13] A.J. Dyck, U.R. Sumaila, Economic impact of ocean fish populations in the global fishery, J. Bioecon. 12 (2010) 227–243, http://dx.doi.org/10.1007/s10818-010-9088-3.
[14] J.A. Lara, A. Guevara-Sanginés, Apoyos al sector pesquero en México 2005–2011, WWF, México, 2012.
[15] L.C.L. Teh, U.R. Sumaila, Contribution of marine fisheries to worldwide employment: global marine fisheries employment, Fish Fish 14 (2013) 77–88, http://dx.doi.org/10.1111/j.1467-2979.2011.00450.x.
[16] CONAPESCA, Informe de rendición de cuentas de la Administración Pública Federal 2006–2012. Etapa 1-3, SAGARPA, México DF, 2012.
[17] DOF, Acuerdo por el que se dan a conocer las reglas de operación de los programas de la Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación, 2013.
[18] M.O. Nevárez-Martínez, E.A. Chávez, M.A. Cisneros-Mata, D. Lluch-Belda, Modeling of the Pacific *Sardinops caeruleus* fishery of the Gulf of California, Mexico, Fish. Res. 41 (1999) 273–283.
[19] M.A. Cisneros-Mata M.O. Nevárez-Martínez, M.G. Hamman, The rise and fall of the Pacific sardine, *Sardinops sagax* Girard, in the Gulf of California, México, California Cooperative Oceanic Fisheries Investigations Reports, vol. 36, pp. 136–143, 1995.
[20] M.O. Nevárez-Martínez, M.A. Martínez-Zavala, C.E. Cotero-Altamirano, M. L. Jacob-Cervantes, Y. Green-Ruiz, G. Gluyas-Millán, et al., Peces pelágicos menores, in: Instituto Nacional de la Pesca (Ed.), Sustentabilidad Pesca Responsab. En México Eval. Manejo, SAGARPA, México DF, 2006, pp. 263–302.
[21] P. Sierra-Rodríguez, M. Muciño-Díaz, J.L. Gutiérrez-González, J. Turrubiates-Morales, La pesquería del abulón, in: Instituto Nacional de Pesca (Ed.), Sustentabilidad Pesca Responsab. En México Eval. Manejo, SAGARPA, México DF, 2006, pp. 1–38.
[22] A. Vega-Velásquez, Langosta de la Península de Baja California, in: Instituto Nacional de la Pesca (Ed.), Sustentabilidad Pesca Responsab. En México Eval. Manejo, SAGARPA, México DF, 2006, pp. 155–2010.
[23] R.B. Reyes, O.A. Pombo, G.P. Díaz, Fishers' reasons for poaching abalone (haliotidae): a study in the Baja California Peninsula, Mexico, N. Am. J. Fish. Manag. 29 (2009) 237–244, http://dx.doi.org/10.1577/M06-032.1.
[24] J. López-Martínez, E. Herrera-Valdivia, J. Rodríguez-Romero, S. Hernández-Vázquez, Peces de la fauna de acompañamiento en la pesca industrial de camarón en el Golfo de California, México, Rev. Biol. Trop. 58 (2010) 925–942.
[25] L. Almendárez-Hernández, V. Hernández-Trejo, Subsidios en el Sector Pesquero de México, el Caso de la Pesquería de Camarón de Alta Mar Del Golfo de California, WWF, México, 2012.
[26] FAO, The State of World Fisheries and Aquaculture, FAO Fisheries and Aquaculture Department, Rome, 2012.
[27] Agroprospecta, Unidades representativas de producción acuícola y pesquera. Panorama económico 2008–2018, Universidad Autónoma Chapingo, Chapingo, México, 2010.
[28] S. Martínez-Aguilar, J.G. Díaz-Uribe, M.O. Nevárez-Martínez, Calamar gigante del Océano Pacífico, in: Instituto Nacional de la Pesca (Ed.), Sustentabilidad Pesca Responsab. En México Eval. Manejo, SAGARPA, México DF, 2006, pp. 63–86.
[29] E. Morales-Bojórquez, M.A. Cisneros-Mata, M.O. Nevárez-Martínez, A. Hernández-Herrera, Review of stock assessment and fishery biology of *Dosidicus gigas*in the Gulf of California, Mexico, Fish. Res. 54 (2001) 83–94.
[30] M. Ramírez-Rodríguez, L.C. Almendárez-Hernández, Subsidies in the jumbo squid fishery in the Gulf of California, Mexico, Mar. Policy 40 (2013) 117–123, http://dx.doi.org/10.1016/j.marpol.2013.01.005.
[31] J.A. Rodríguez-Valencia, M.A. Cisneros-Mata, Captura incidental de las flotas pesqueras ribereñas del Pacífico Mexicano, WWF, México, 2006 (accessed 22.10.13).
[32] V. Hernández-Trejo, Subsidios al sector pesquero en México. Un panorama general, WWF, México, La Paz, México, 2012, p. 7.
[33] N.L. Gutiérrez, R. Hilborn, O. Defeo, Leadership, social capital and incentives promote successful fisheries, Nature 470 (2011) 386–389, http://dx.doi.org/10.1038/nature09689.
[34] C. Costello, S.D. Gaines, J. Lynham, Can catch shares prevent fisheries collapse? Science 321 (2008) 1678–1681, http://dx.doi.org/10.1126/science.1159478.
[35] S.E. Lluch-Cota, E.A. Aragón-Noriega, F. Arreguín-Sánchez, D. Aurioles-

Gamboa, J. Jesús Bautista-Romero, R.C. Brusca, et al., The Gulf of California: review of ecosystem status and sustainability challenges, Prog. Oceanogr. 73 (2007) 1–26, http://dx.doi.org/10.1016/j.pocean.2007.01.013.
[36] D. Pearce, D. Finck von Finckenstein, Advancing subsidy reforms: towards a viable policy alternative, UNDP, Nairobi (1999), p. 19.
[37] C.W. Clark, The worldwide crisis in fisheries. Economic models and human behavior, Cambridge University Press, Cambridge, 2006.
[38] U.R. Sumaila, Intergenerational cost–benefit analysis and marine ecosystem restoration, Fish Fish. 5 (2004) 329–343.
[39] M.E. Lam, D. Pauly, Who is right to fish? Evolving a social contract for ethical fisheries, Ecol. Soc. 15 (2010) 16.
[40] USDA, Decoupled Payments: Household Income Transfers in Contemporary U. S. Agriculture, U.S. Department of Agriculture, Washington, D.C, 2003.
[41] R. Román-Collado, Cambios en el perfil del beneficiario del subsidio agrario (1984–2001), Rev. Minist. Trab. Asun. Soc. 51 (2002) 139–155.
[42] The Guardian, EU unveils plans to pay fishermen to catch plastic, 2011. ⟨http://www.theguardian.com/environment/2011/may/04/eu-fishermen-catch-plastic⟩.
[43] P.T. Schultz, School subsidies for the poor: evaluating the Mexican Progresa poverty program, J. Dev. Econ. 74 (2004) 199–250, http://dx.doi.org/10.1016/j.jdeveco.2003.12.009.
[44] E. Galán-Rodas, Seguro social del pescador artesanal: herramienta de inclusión social y ciudadanía, Rev. Cuerpo Méd. HNAAA 6 (2013) 6–7.
[45] U.R. Sumaila, How to make progress in disciplining overfishing subsidies, ICES J. Mar. Sci. 70 (2012) 251–258, http://dx.doi.org/10.1093/icesjms/fss173.
[46] O. Flaaten, P. Wallis, Government financial transfers to fishing industries in OECD countries, in: Conference Proceedings, Corvallis, U.S.A., 2000, pp. 1–11.
[47] H. Gjertsen, M. Hall, D. Squires, Incentives to address bycatch issues, in: R. Allen, J. Joseph, D. Squires (Eds.), Conservation and Management of Transnational Tuna Fisheries., Wiley-Blackwell, Oxford, 2010, pp. 225–248.
[48] P. Rönnbäck, I. Bryceson, N. Kautsky, Coastal aquaculture development in Eastern Africa and the Western Indian Ocean: prospects and problems for food security and local economies, AMBIO J. Hum. Environ. 31 (2002) 537–542, http://dx.doi.org/10.1579/0044-7447-31.7.537.
[49] M. Hauck, M. Kroese, Fisheries compliance in South Africa: a decade of challenges and reform 1994–2004, Mar. Policy 30 (2006) 74–83, http://dx.doi.org/10.1016/j.marpol.2005.06.007.
[50] G. Ponce-Díaz, F. Arreguín-Sánchez, A. Díaz-de León, P. Álvarez-Torres, Promotion and management of marine fisheries in Mexico, in: G. Winter (Ed.), Sustainable Fisheries Law Competition Analysis, IUCN, in collaboration with IUCN Environmental Law Centre, Bonn, Germany, Gland, Switzerland, 2009, pp. 233–251.
[51] A. Hernandez, W. Kempton, Changes in fisheries management in Mexico: effects of increasing scientific input and public participation, Ocean Coast. Manag. 46 (2003) 507–526, http://dx.doi.org/10.1016/S0964-5691(03)00032-2.
[52] S. Jentoft, Fisheries co-management as empowerment, Mar. Policy 29 (2005) 1–7, http://dx.doi.org/10.1016/j.marpol.2004.01.003.
[53] A.W. Trites, C.P. Donnelly, The decline of Steller sea lions Eumetopias jubatus in Alaska: a review of the nutritional stress hypothesis, Mammal Rev. 33 (2003) 3–28.
[54] T. Markus, Towards sustainable fisheries subsidies: entering a new round of reform under the Common Fisheries Policy, Mar. Policy 34 (2010) 1117–1124, http://dx.doi.org/10.1016/j.marpol.2010.03.011.
[55] MSC, Global impacts summary report 2013. Monitoring and evaluation, Marine Stewardship Council, 2013. ⟨http://www.msc.org/documents/environmental-benefits/global-impacts/msc-global-impacts-summary-report/⟩.
[56] Ocean Wise, Vancouver Aquarium's Ocean Wise Program, 2013. ⟨http://www.oceanwise.ca⟩.
[57] D. Klooster, O. Masera, Community forest management in Mexico: carbon mitigation and biodiversity conservation through rural development, Glob. Environ. Chang. 10 (2000) 259–272.
[58] R. Curtis, D. Squires (Eds.), Fisheries Buybacks, Blackwell Publishing, Ames, U.S.A, 2007.
[59] J.C. Cueff, A case study of fishing vessel capacity management public buyout schemes: Community experience through the Multi-Annual Guidance Programmes and ways forward, in: R. Curtis, D. Squires (Eds.), Fisheries Buybacks, Blackwell Publishing, Ames, U.S.A., 2007, pp. 75–80.
[60] R. Hannesson, Buyback programs for fishing vessels in Norway, in: R. Curtis, D. Squires (Eds.), Fisheries Buybacks, Blackwell Publishing, Ames, U.S.A., 2007, pp. 177–190.
[61] R.Q. Grafton, H.W. Nelson, The effects of buyback programs in the British Columbia salmon fishery, in: R. Curtis, D. Squires (Eds.), Fisheries Buybacks, Blackwell Publishing, Ames, U.S.A., 2007, pp. 191–202.
[62] J. Chin-Hua, Sun, Effectiveness of vessel buyback programs on the offshore fishery in Taiwan, in: R. Curtis, D. Squires (Eds.), Fisheries Buybacks, Blackwell Publishing, Ames, U.S.A., 2007, pp. 203–214.
[63] R. Hannesson, Do buyback programs make sense?, in: R. Curtis, D. Squires (Eds.), Fisheries Buybacks, Blackwell Publishing, Ames, U.S.A., 2007, pp. 55–66.
[64] D. Squires, Fisheries buybacks: a review and guidelines: a review of fisheries buybacks, Fish Fish. 11 (2010) 366–387, http://dx.doi.org/10.1111/j.1467-2979.2010.00365.x.
[65] U.R. Sumaila, W. Cheung, A. Dyck, K. Gueye, L. Huang, V. Lam, et al., Benefits of rebuilding global marine fisheries outweigh costs, PLoS One 7 (2012) e40542, http://dx.doi.org/10.1371/journal.pone.0040542.
[66] T. Gutner, The political economy of food subsidy reform: the case of Egypt, Food Policy 27 (2002) 455–476, http://dx.doi.org/10.1016/S0306-9192(02)00049-0.
[67] A. Espinoza-Tenorio, I. Espejel, M. Wolff, Capacity building to achieve sustainable fisheries management in Mexico, Ocean Coast. Manag. 54 (2011) 731–741, http://dx.doi.org/10.1016/j.ocecoaman.2011.07.001.
[68] U.T. Srinivasan, W.W.L. Cheung, R. Watson, U.R. Sumaila, Food security implications of global marine catch losses due to overfishing, J. Bioecon. 12 (2010) 183–200, http://dx.doi.org/10.1007/s10818-010-9090-9.
[69] B.D. Ratner, Community management by decree? Lessons from cambodia's fisheries reform, Soc. Nat. Resour. 19 (2006) 79–86, http://dx.doi.org/10.1080/08941920500323344.
[70] T. Pitcher, D. Kalikoski, G. Pramod, K. Short, Not honouring the code, Nature 457 (2009) 658–659.
[71] S. Khalilian, R. Froese, A. Proelss, T. Requate, Designed for failure: a critique of the Common Fisheries Policy of the European Union, Mar. Policy 34 (2010) 1178–1182, http://dx.doi.org/10.1016/j.marpol.2010.04.001.
[72] V.M. Kaczynski, D.L. Fluharty, European policies in West Africa: who benefits from fisheries agreements? Mar. Policy 26 (2002) 75–93.

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