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From Fixed Boundaries to Fluid Stocks: Adaptive Legal Strategies for Shared Fisheries in the Western Mediterranean

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Abstract
This study examines the growing fragility of national fishing rights in the management of transboundary fish stocks within a context marked by ecological transformation and geopolitical uncertainty. It argues that traditional legal frameworks governing shared fisheries are increasingly inadequate in addressing

dynamic changes in stock distribution driven by climate variability, as well as persistent strategic competition among coastal states.
Adopting an interdisciplinary approach that combines principles of international fisheries law-particularly the United Nations Convention on the Law of the Sea (UNCLOS) and the UN Fish Stocks Agreement (UNFSA)-with insights from Game Theory, the study identifies three critical sources of governance instability: climate-induced shifts in fish stock distribution, unresolved maritime boundary delimitations, and the continued expansion of Illegal, Unreported, and Unregulated (IUU) fishing practices.
Focusing on the Western Mediterranean basin, with particular attention to small pelagic species and the institutional roles of General Fisheries Commission for the Mediterranean (GFCM) and International Commission for the Conservation of Atlantic Tunas (ICCAT), the analysis highlights the structural mismatch between static legal regimes and fluid ecological systems. The findings demonstrate that the resilience of national user rights is contingent upon the development of adaptive governance mechanisms that integrate real-time scientific data, flexible allocation arrangements, and incentive-based compliance tools.
The study concludes by proposing a forward-looking governance framework through which coastal states particularly those in the southern Mediterranean such as Algeria-can strengthen their maritime entitlements. This includes advancing maritime delimitation processes, enhancing participation in regional fisheries institutions, and adopting anticipatory, science-based policy instruments to ensure the sustainable and equitable management of shared marine resources in an increasingly volatile maritime environment.

Keywords: *Shared Fish Stocks, Adaptive Fisheries Governance, UNCLOS, National Fishing Rights, Western Mediterranean, Climate-Induced Stock Shifts, Game Theory*
IUU Fishing, Maritime Delimitation.

Résumé
Cette étude examine la fragilité croissante des droits de pêche nationaux dans la gestion des stocks halieutiques transfrontaliers, dans un contexte marqué par la transformation écologique et l'incertitude géopolitique. Elle soutient que les cadres juridiques traditionnels régissant les pêcheries partagées s'avèrent de plus en plus inadéquats pour faire face aux changements dynamiques dans la répartition des stocks, induits par la variabilité climatique, ainsi qu'à la concurrence stratégique persistante entre les États côtiers.

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Adoptant une approche interdisciplinaire qui combine les principes du droit international de la pêche – en particulier la Convention des Nations Unies sur le droit de la mer (CNUDM) et l'Accord des Nations Unies sur les stocks de poissons (UNFSA) – avec les enseignements de la théorie des jeux, l'étude identifie trois sources critiques d'instabilité de la gouvernance : les changements dans la répartition des stocks halieutiques induits par le climat, les délimitations maritimes non résolues et l'expansion continue des pratiques de pêche illicite, non déclarée et non réglementée (INN).

En se concentrant sur le bassin de la Méditerranée occidentale, avec une attention particulière portée aux petites espèces pélagiques et aux rôles institutionnels de la Commission générale des pêches pour la Méditerranée (CGPM) et de la Commission internationale pour la conservation des thonidés de l'Atlantique (CICTA), l'analyse met en évidence l'inadéquation structurelle entre des régimes juridiques statiques et des systèmes écologiques en constante évolution. Les résultats montrent que la pérennité des droits d'exploitation nationaux dépend de la mise en place de mécanismes de gouvernance adaptative intégrant des données scientifiques en temps réel, des modalités d'allocation souples et des outils de mise en conformité fondés sur des incitations.

L'étude conclut en proposant un cadre de gouvernance tourné vers l'avenir grâce auquel les États côtiers – en particulier ceux du sud de la Méditerranée, comme l'Algérie – peuvent renforcer leurs droits maritimes. Cela implique notamment de faire progresser les processus de délimitation maritime, de renforcer la participation aux institutions régionales de pêche et d'adopter des instruments politiques anticipatifs et fondés sur la science afin d'assurer une gestion durable et équitable des ressources marines partagées dans un environnement maritime de plus en plus instable.

Mots-clés *: stocks halieutiques partagés, gouvernance adaptative des pêches, CNUDM, droits de pêche nationaux, Méditerranée occidentale, déplacements de stocks induits par le climat, théorie des jeux*
pêche INN, délimitation maritime.

Introduction

The governance of internationally shared fish stocks remains a central challenge in contemporary maritime law and fisheries management, yet its study continues to suffer from critical analytical gaps. Shared stocks—those that traverse exclusive economic zones (EEZs) of multiple states or span both EEZs and high seas—are crucial for global marine production and coastal economies. However, the current body of scholarship often assumes the effectiveness of existing legal instruments without critically quantifying how ecological variability, geopolitical instability, and enforcement weaknesses interact to undermine both cooperation and national user rights. This is particularly evident as climate change reshapes the distribution and dynamics of shared stocks, challenging the traditional "stability" of maritime boundaries and jurisdictional entitlements [1, 2]. While the United Nations Convention on the Law of the Sea (UNCLOS) and the UN Fish Stocks Agreement (UNFSA) establish foundational duties to cooperate, recent legal analyses in Ocean Development & International Law suggest that these mechanisms remain fragile. The implementation of these agreements by Regional Fisheries Management Organizations (RFMOs) often struggles with state-centric interests and the lack of robust compulsory dispute settlement mechanisms [3, 4]. Furthermore, while the Port State Measures Agreement (PSMA) was designed to curb illegal, unreported, and unregulated (IUU) fishing, its effectiveness is frequently hampered by uneven enforcement capacities and the complex legal nature of coastal state jurisdiction over straddling stocks

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[5, 6]. The intensifying impact of climate change further complicates this landscape, altering species distributions and challenging the static nature of existing governance regimes. Recent discourse highlights that the law of the sea must now transition from a "stationary" biophysical assumption to an adaptive framework capable of addressing "shifting" stocks that migrate across maritime boundaries [7, 8]. The fragmentation of legal instruments and the absence of integrated mechanisms to adapt to these changes further underscore a significant governance gap, where legal norms and ecological science remain insufficiently aligned [2, 9]. Against this backdrop, the present study offers a novel contribution by developing a conceptual framework that explicitly links ecological uncertainty, strategic state behavior, and institutional instability to the legal and economic security of national fishing entitlements. First, it critically evaluates the evolution and limitations of international fisheries law with a focus on UNCLOS and UNFSA. Second, it draws on strategic interaction theory to interrogate why states may deviate from cooperative management even when legal obligations exist. Third, it identifies key drivers of instability-including climate-driven stock redistribution and IUU fishing—and proposes governance mechanisms aimed at strengthening national user rights in dynamic environments. By situating the Western Mediterranean as a case study-where overlapping jurisdictional claims and migratory stocks exacerbate these challenges-this research bridges qualitative legal analysis with contemporary strategic insights, a perspective currently underrepresented in the literature [3, 5, 7].

1. The Legal Evolution of Fisheries: From Commons to Sovereignty

1.1. The Global Framework

1 Prior to 1982, international fisheries were governed under a dualistic regime characterized by absolute coastal sovereignty within territorial seas and the doctrine of "Freedom of the Seas" on the high seas, where living marine resources were treated as common pool resources (Res Communis). This traditional regime, however, proved inadequate in curbing resource depletion, prompting coastal states to seek extended jurisdiction and regulatory authority over marine living resources [3, 4, 10].

In response, the 1982 United Nations Convention on the Law of the Sea (UNCLOS) introduced the Exclusive Economic Zone (EEZ), granting coastal states sovereign-like rights over marine resources up to 200 nautical miles (Article 56). UNCLOS thus represents a constitutional milestone in the evolution of ocean governance, shifting the legal basis from open access towards state-regulated utilization of fisheries resources [3, 6]. Despite its foundational role, UNCLOS did not contain comprehensive, compulsory mechanisms to enforce effective cooperation in the management of straddling and highly migratory fish stocks (Articles 63–64). Recent scholarship in Ocean Development & International Law underscores that the "duty to cooperate" remains a procedural obligation often lacking substantive enforcement standards [11]. This led to critical implementation gaps, particularly where stocks migrate across fluid maritime boundaries [1, 4]. To operationalize these duties, the 1995 UN Fish Stocks Agreement (UNFSA) was adopted, codifying collective conservation measures through Regional Fisheries Management Organizations (RFMOs) [3, 4, 12]. However,

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effective compliance remains a persistent challenge. Competing economic incentives and the rise of IUU fishing continue to distort scientific assessments and undermine the legal security of national fishing entitlements [5, 6]. Furthermore, existing frameworks are increasingly strained by climate-induced shifts in species distribution, which challenge the "static" jurisdictional assumptions of UNCLOS and necessitate more adaptive, science-based governance models [1, 7, 8].

2. Strategic Interaction and Game Theory in Shared Fisheries

The exploitation of internationally shared fish stocks is inherently characterized by strategic interactions among states, where unilateral harvesting decisions by one party directly affect the resource available to others sharing the same stock [1, 13]. In this context, game-theoretic approaches-particularly variants of the Prisoner's Dilemma and common-pool resource games-provide critical insights into why states may prioritize short-term national gains over collective sustainability, even when international legal instruments prescribe a "duty to cooperate" [9, 10]. Without binding cooperative mechanisms, states are often incentivized to engage in a "race to harvest," resulting in stock depletion and rendering national user rights legally and economically vulnerable [4, 11]. Recent literature emphasizes that traditional game models must be adapted to capture contemporary drivers of instability, such as spatial shifts in stock distribution due to climate change and asymmetric enforcement capacities among coastal states [1, 5, 13].These drivers introduce layers of uncertainty that intensify

scenarios where non-cooperative equilibria emerge as the default outcome. In regions like the Western Mediterranean, where overlapping jurisdictions and migratory stocks are prevalent, defensive harvesting strategies often dominate in the absence of credible enforcement and binding dispute settlement agreements, reinforcing a zero-sum dynamic that undermines legal entitlements to sustainable exploitation [11, 14].To counteract these tendencies, modern strategic frameworks incorporate economic incentives and enforcement tools—including quota allocation rules and traceability technologies—demonstrating that coupling legal obligations with economic penalties can shift the strategic equilibrium towards cooperation [15, 16]. Such enhanced models suggest that when cooperative outcomes are tied to observable economic benefits, states have reduced incentives to defect, thereby strengthening the legal and economic value of national user rights. Furthermore, adaptive governance strategies that integrate real-time ecological data into strategic decision-making have shown potential to stabilize cooperative behavior, even under conditions of environmental variability and enforcement asymmetry [5, 17].

3. Sources of Instability in Shared Fisheries Management

3.1. Ecological and Climatic Instability

Climate change challenges the "stationary" assumptions of maritime law. As stocks shift across EEZs, historical quotas lose their legitimacy, undermining the legal certainty of agreements [1, 7]. In the Mediterranean, warming waters cause small pelagics to migrate beyond traditional jurisdictional reach, creating a "natural instability" where previously agreed frameworks become obsolete [4, 8].

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3.2. Geopolitical and Legal Instability

In semi-enclosed seas like the Western Mediterranean, unresolved maritime boundary delimitations exacerbate governance fragility [10, 11]. Unlike more institutionalized regimes, these areas face "legal fluidity" where fisheries access is often a hostage to broader diplomatic tensions and shifting alliances [6, 11]. National user rights thus become high-risk assets subject to unilateral reinterpretation [9, 11].

3.3. Behavioral Instability: IUU Fishing

IUU fishing erodes the normative foundation of UNCLOS and the principle of good faith [10, 12].When non-compliant actors harvest with impunity, the cooperative equilibria discussed in strategic models collapse, leaving compliant states at a competitive disadvantage [13, 14].

4. Case Studies from the Western Mediterranean

4.1. Shared Small Pelagic Stocks between Algeria and Neighboring States

In the Western Mediterranean, species like sardines and anchovies migrate across the EEZs of Algeria, Tunisia, Spain, and Italy. While UNCLOS mandates cooperation, empirical evidence suggests that national allocation schemes often prevail over cooperative quotas [3, 4]. This reflects a game-theoretic dynamic where short-term maximization undermines the long-term legal security of national user rights [6, 7].

4.2. Maritime Boundary Uncertainty and Fisheries Governance

Legal uncertainty over maritime boundary delimitation remains a core obstacle in the Western Mediterranean [8, 11]. Overlapping claims among North African and European states create a "legal fluidity" that weakens incentives for sustainable investment [9, 10, 11]. Confining fisheries access to diplomatic stability renders user rights inherently fragile [11, 12].

4.3. Regional Cooperation Mechanisms: Lessons from the GFCM and ICCAT

The GFCM and ICCAT offer pathways to operationalize cooperation through catch documentation and market-based compliance [13, 14, 15]. Algeria's success in securing Bluefin Tuna quotas under ICCAT demonstrates how regional frameworks can transform "zero-sum" conflicts into stable, legal entitlements [14, 15]. However, as noted in Ocean Development & International Law, the effectiveness of these RFMOs remains contingent on the political will of member states to enforce shared accountability [5, 9, 13].

5. Discussion and Conclusions

5.1. The Critical Nexus Between Regional Stability and National Entitlements

Experience from ICCAT and the GFCM demonstrates that the legal certainty of a fishing license issued by a coastal state—such as Algeria—is contingent upon the stability of the regional cooperative network [5, 13]. As underscored in Ocean Development & International Law, unresolved maritime boundaries and climate-induced shifts can

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transform secure national rights into legally fragile entitlements, undermining long-term planning [4, 15].

5.2. Strategic Interaction in the Mediterranean "Game"

In the absence of binding quota-sharing mechanisms, the "race to fish" remains a dominant strategy in the Western Mediterranean [7, 8]. Transitioning to a legally binding allocation system, grounded in principles of zonal attachment, is not only a biological necessity but a legal imperative to ensure equitable access [10, 16].

5.3. Combating Instability: Market-Based and Incentive Mechanisms

Technical regulations are insufficient if economic incentives for non-compliance persist [2, 11]. Integrating catch documentation and digital traceability transforms "zero-sum" dynamics into cooperative equilibria, sustaining the legal and economic value of national user rights [11, 12, 17].

5.4. Evolutionary Governance and Algeria's Strategic Path

Algeria's strategy rests on three pillars: Legal Consolidation (delimitation of boundaries), Scientific-Legal Diplomacy (GFCM integration), and Anticipatory Governance (incorporating climate dynamics) [1, 9, 13]. This integrated approach ensures that national user rights retain validity despite environmental and geopolitical volatility [13, 18].

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