（様式３）

学　位　論　文　内　容　の　要　旨

博士の専攻分野の名称：　博　　士（食資源学）　　氏名　Jeeratorn Yuttharax

学　位　論　文　題　名

Ecological implications of trash fish harvests in tropical trawl fisheries: A case study in the Gulf of Thailand

（熱帯トロール漁業におけるトラッシュフィッシュ漁獲の生態学的影響: タイランド湾を事例として）

I. Introduction

Aquatic foods play a vital role in global food security, nutrition, and livelihoods, while the rapid expansion of aquaculture has intensified demand for fishmeal and fish oil. In tropical Asia, this demand is primarily met through trash fish (TF), comprising low-value or small-sized fish and invertebrates primarily derived from trawl fisheries. TF has long been criticized for its potential to cause growth overfishing and ecosystem degradation, particularly through the removal of juveniles and low-trophic-level organisms. However, empirical evidence linking TF exploitation to stock collapse or trophic deterioration remains limited, especially in highly diverse tropical multispecies systems where bycatch is broadly utilized rather than discarded.

This thesis examines TF dynamics in the Gulf of Thailand (GoT), addressing three knowledge gaps: decades of TF exploitation, ecosystem-scale implications for fish stocks and marine food webs, and the role of density-dependent regulation during early life stages. By integrating long-term fisheries statistics, landing surveys, trophic indicators, and biological datasets, this research provides the first ecosystem-level evaluation of the TF roles of tropical trawl fisheries in the GoT.

II. Trash fish component in tropical trawl fisheries of the Gulf of Thailand

Long-term analyses of trawl fisheries in the GoT from 1971 to 2023 demonstrate that TF supply has not expanded proportionally with the rapid growth of aquaculture and feed. TF peaked in 1987, then declined and stabilized (<60% of trawl catch since 2007), indicating that TF availability has been constrained by ecological limits, fleet reduction, and structural changes in utilization rather than driven by market demand alone.

Across 2016–2023, trawlers landed 525 taxa, with >75% appearing in TF catches, spanning a broad trophic range from 2.0–4.5. Importantly, 68.6% of taxa were shared between consumable fish (CF) and TF, demonstrating that TF is not a distinct ecological group but largely overlaps with resources used for human consumption. This overlap reflects the non-selective nature of trawl gears rather than targeted exploitation of low-value species.

Catch composition further reveals that dominant TF families and taxa have remained remarkably stable over the past five decades, despite major changes in management, markets, and fleet structure. This persistence indicates that TF supply reflects the underlying ecosystem structure rather than short-term economic incentives.

Length-frequency and selectivity analyses showed that CF and TF have overlapping retention sizes, with smaller individuals more likely to be classified as TF due to post-harvest sorting and freshness loss rather than gear-driven separation, and not due to deliberate targeting of juveniles or low-value fish.

III. Ecological implications on fish stocks and marine food webs

Standardized CPUE analysis for 2016–2023 revealed a mean trawl CPUE of 30.99 $kg \cdot h^{-1}$, with comparable values between CF (30.32 $kg \cdot h^{-1}$) and TF (31.72 $kg \cdot h^{-1}$). Temporal variation in CPUE was primarily explained by gear type and vessel size, whereas catch group (CF vs. TF) had no significant effect after accounting for operational factors. This indicates that TF harvesting does not exert an independent signal of stock depletion beyond overall fishing pressure.

Mean trophic level (MTL) trends showed no directional decline. Recent MTL values were significantly higher than during historically depressed periods (1970s–1990s), suggesting a shift from a classic 'fishing down' toward a more 'balanced exploitation' pattern. Under this regime, fishing pressure is distributed across multiple trophic levels rather than being concentrated on high-trophic predators, allowing the overall ecosystem structure to persist despite ongoing TF harvesting. Although lower MTLs than CF characterized TF catches, the trophic structure of total trawl landings remained relatively stable, indicating that TF utilization has not resulted in additional trophic erosion of the GoT ecosystem.

IV. Estimation of density-dependent attributes of trash fish populations

Density-dependent survival analyses of 25 dominant TF-associated taxa revealed strong evidence of compensatory mortality during early life stages. Eleven taxa exhibited statistically significant density-dependent regulation ($p < 0.001$), whereby higher juvenile abundance was associated with increased natural mortality prior to recruitment. Faster-growing species showed clearer compensatory responses, consistent with theoretical expectations for short-lived tropical taxa.

These results highlight that juvenile removals through trawl fisheries do not necessarily translate linearly into recruitment losses. Instead, density-dependent processes redistribute mortality within cohorts, thereby buffering population-level impacts of early-life harvesting and highlighting key internal stabilizing mechanisms in tropical multispecies systems.

V. Conclusions

Overall, this thesis demonstrates that TF exploitation has not triggered detectable stock collapse or trophic degradation in the GoT. Instead, TF harvests reflect a system regulated by compensatory density-dependent mortality, multispecies interactions, and balanced exploitation. Focusing on management implications, the presence of compensatory density-dependent mortality suggests that conventional management approaches, which assume fixed natural mortality, may overstate the risks associated with TF harvesting. When spawning biomass exceeds critical thresholds (approximately 30–40% of unfished spawning biomass, as suggested by the Spawning Potential Ratio theory), additional increases in biomass do not proportionally enhance recruitment. Under such conditions, moderate pre-recruit removals may have limited long-term impact on stock productivity.

Accordingly, this thesis argues that TF should be recognized as an explicitly managed fisheries output, rather than treated as incidental waste. Incorporating density-dependent processes into assessment frameworks, improving size-based governance, and strengthening monitoring of TF catches would enable management to better align with the ecological realities of tropical trawl fisheries. Such an approach offers a pathway to enhance governance, sustain aquaculture feed supply, and support resilient tropical trawl ecosystems.