Supplementary Evidence Tables for "Deep Learning Object Detection for Maritime Security: A Critical Review of Task Evidence, Benchmark Comparability and Deployment Constraints"

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Abstract

This document provides the study-level evidence that supports the quantitative synthesis of the main article: reported benchmark results (Table S1), evaluation protocols (Table S2), communication-aware methods (Table S3), sensing-modality trade-offs (Table S4), the corpus-level evidence profile (Table S5), representative datasets (Table S6) and application–platform mappings (Table S7). Reported values are given as stated in the source studies and are not harmonized into a performance ranking.

Table S1: Numerical results reported in the abstracts of primary studies on common maritime benchmarks. Values are taken as stated by the authors, using their metric names; "IoU n.s." means that the abstract does not state the IoU threshold, and "n.r." means not reported in the abstract. Rows use different dataset versions, splits, input sizes, training schedules, and hardware, so values must not be compared across rows; see the reported-results synthesis in the main article. GFLOPs: giga floating-point operations; MOTA: multi-object tracking accuracy; IDF1: identification F1 score; param.: parameters.

Dataset	Study	Metric	Value (%)	Speed, hardware, size	Note
SAR: SSDD	DSP-YOLO (Huang and Shang 2024)	mAP_{50}	99.0	2.59 M param.	
	SSC-YOLO (Hoang-Ngoc et al. 2025)	mAP_{50} / $mAP_{50:95}$	98.8 / 72.0	n.r.	
	FFC-YOLO (Zhang and Huang 2025)	mAP_{50}	98.5	n.r.	
	FSP-YOLO (Wang et al. 2026a)	mAP_{50}	98.3	118.2 FPS (RTX 3090); 2.2 M param.	
	LD-YOLO (Niu et al. 2026b)	AP_{50} / $AP_{50:95}$	98.2 / 73.1	n.r.	
	LGNet (Chen et al. 2025)	mAP_{50} / $mAP_{50:95}$	97.9 / 71.9	135.4 FPS (Huawei Atlas edge board); 0.74 M param.	second value labelled "mAP@95" in source
	DSSA-RT-DETR (Bu et al. 2026)	mAP_{50} / $mAP_{50:95}$	97.55 / 72.65	13.5 M param.; 46.5 GFLOPs	
	LightSAR-Net (Fang et al. 2025)	mAP_{50}	97.1	n.r.	
	Small-ship detector (Fan et al. 2024)	AP_{50}	96.8	n.r.	
	YOLOBiEMA (John and Guan 2025)	$mAP_{50:95}$	73.2	n.r.	

Dataset	Study	Metric	Value (%)	Speed, hardware, size	Note
	YOLO-SARDet (Wei and Cai 2026)	$AP_{50:95}$	72.5	n.r.	
	LPDNet (Zhao et al. 2023)	AP (IoU n.s.)	97.14	24.7 FPS (hardware n.r.); 5.1 M param.	
	SSANet (Cheng et al. 2026)	mAP (IoU n.s.)	98.40	n.r.	SSDD+ variant
	AMANet (Ma et al. 2024)	AP (IoU n.s.)	74.20	n.r.	
	AMTNet (Venkata et al. 2025)	Accuracy	94.60	138.5 FPS (hardware n.r.)	
SAR: HRSID	YOLOv8-SARship (He and Huang 2024)	mAP_{50} / $AP_{50:95}$	95.9 / 68.5	123.6 FPS (hardware n.r.)	+0.7 / +0.3 over YOLOv8n
	YOLOv8-ResAttNet (Liu et al. 2025)	mAP_{50}	95.2	n.r.	
	Multi-scale fusion net (Cao and Sui 2025)	mAP_{50} / $mAP_{50:95}$	93.1 / 69.2	n.r.	
	FRA-YOLO (Pan 2026)	mAP_{50} / $mAP_{50:95}$	92.9 / 71.4	n.r.	
	Improved VFNet (Ning et al. 2025)	AP_{50} / AP_{75}	92.3 / 80.0	n.r.	+0.9 / +1.2 over baseline
	DSSA-RT-DETR (Bu et al. 2026)	mAP_{50} / $mAP_{50:95}$	90.95 / 65.83	13.5 M param.	
	SSC-YOLO (Hoang-Ngoc et al. 2025)	mAP_{50} / $mAP_{50:95}$	89.5 / 62.9	n.r.	
	RTMDet-based (Zhang et al. 2024)	AP_{50}	85.6	n.r.	oriented boxes
SAR: LS-SSDD	Enhanced YOLO (Guan et al. 2025)	AP_{50}	77.2	n.r.	small ships
	Transformer-based (Garaiman and Radoi 2025)	AP (IoU n.s.)	77.62	n.r.	

Dataset	Study	Metric	Value (%)	Speed, hardware, size	Note
UAV: SeaDronesSee	FX-DETR (Feng et al. 2025)	mAP_{50}	80.5	28.8 GFLOPs	
	TCLS-YOLOv11n (Lu et al. 2026)	mAP_{50}	78.2	1.78 M param.	
	TPS-YOLOv8n (Wang et al. 2025)	mAP_{50}	78.1	n.r.	
	SeaLSOD-YOLO (Ruan et al. 2026b)	mAP_{50} / $mAP_{50:95}$	77.0 / 44.9	256 FPS (hardware n.r.)	
	M-YOLO (Liang et al. 2026)	mAP_{50}	73.3	n.r.	version 2
	FGS-YOLO (Zhang et al. 2026a)	AP_{50} / $mAP_{50:95}$	73.0 / 41.0	468 FPS (hardware n.r.); 9.8 GFLOPs	version 2
	Improved YOLO (Wang 2026)	mAP_{50}	68.5	n.r.	
	YOLOv8-sea (Yang et al. 2025)	mAP_{50} / $mAP_{50:95}$	56.9 / 31.9	n.r.	version 2; +0.5 / +0.2 over YOLOv8n
Optical: SeaShips	YOLOv8-IPAN (Liang and Han 2025)	mAP_{50}	99.0	n.r.	
	SKAN-YOLO (Geng et al. 2025)	mAP_{50}	98.9	n.r.	extended version
	OZRWD-YOLOv11 (Kumar et al. 2026)	mAP_{50}	97.1	n.r.	
	YOLO11-pico-CoT (Wungow et al. 2025)	mAP_{50} / $mAP_{50:95}$	96.4 / 71.4	3.97 FPS (hardware n.r.); 1.7 M param.	
	SPD-PPA YOLOv8 (Chen 2026)	mAP_{50}	93.9	142 FPS (hardware n.r.)	
	VSTF-Net (Peng et al. 2026)	mAP_{50} / $mAP_{50:95}$	89.2 / 56.2	n.r.	enhanced version

Dataset	Study	Metric	Value (%)	Speed, hardware, size	Note
Optical: other	C-YOLO (Cai and Zhou 2026)	mAP_{50} / $mAP_{50:95}$	79.7 / 55.2	119 FPS (hardware n.r.); 76.75 M param.	SeaShips 7000
	Marine-YOLO (WSODD) (Ruan et al. 2026a)	mAP_{50} / $mAP_{50:95}$	76.7 / 44.1	4.2 M param.; 13.3 GFLOPs	+3.5 / +1.3 over YOLOv11n
	HFPNet (NWPU VHR-10) (Chen et al. 2023a)	mAP_{50}	95.46	n.r.	after image enhancement
	Rotated detector (HRSC2016) (Zhang 2026)	mAP_{50}	90.5	n.r.	+1.3 over baseline
Infrared: ISDD	DGG-YOLO (Niu et al. 2026a)	mAP_{50}	94.0	n.r.	
	IRSD-Net (Sun and Lian 2025)	mAP_{50}	92.5	714.3 FPS (hardware n.r.)	
	IRS-DETR (Tang and Ji 2025)	AP_{50}	91.7	n.r.	
Marine radar	YOLO with radar attention (Cen et al. 2025)	mAP_{50} / $mAP_{50:95}$	88.7 / 64.3	92 FPS (hardware n.r.)	4,237 own radar images
	Pre-processing + YOLO (Külcü 2026)	mAP_{50}	95.8	n.r.	350 simulated frames; best model with P2 layer
Tracking: SMD	MOMT (Niu et al. 2024)	MOTA / IDF1	46.0 / 66.7	44.6 FPS (hardware n.r.)	
Rescue (own data)	R-DET (Wang et al. 2026b)	mAP_{50}	84.1	63.2 FPS (RTX 2080 SUPER) 14.5 M param.	Marine Rescue-8K

Table S2 Evaluation protocols of open-access primary studies from Supplementary Table S1, extracted from their full texts. "Official" means that the study states that it follows the split released with the dataset. Only one of the 19 studies reports repeated training runs with standard deviations (Zhang 2026); none reports confidence intervals. "n.r." means not reported in the text.

Study	Benchmark	Split (train : val : test)	Input size	Hardware for training and speed
LPDNet (Zhao et al. 2023)	SSDD	Random 7 : 1 : 2 (stated as 7:2:1 train : test : val)	416 to 800	NVIDIA Tesla K80
LGNet (Chen et al. 2025)	SSDD	Official 928 : 232	640 × 640	RTX 2080 Ti (681 FPS at batch 8); Huawei Atlas edge board (135 FPS)
FSP-YOLO (Wang et al. 2026a)	SSDD, HRSID	Official (SSDD 928 : 232)	n.r.	RTX 3090 (118 FPS)
Small-ship detector (Fan et al. 2024)	Own Hainan-1 images; SSDD	Own data random 7 : 2 : 1; SSDD n.r.	640 × 640	n.r. in text (5.5 FPS)
AMANet (Ma et al. 2024)	SSDD, HRSID	Official (SSDD 928 : 232; HRSID 65 : 35)	n.r.	RTX 3090
Multi-scale fusion net (Cao and Sui 2025)	HRSID, SSDD	Random 7 : 1 : 2	640 × 640	RTX 3090
Enhanced YOLO (Guan et al. 2025)	LS-SSDD, HRSID	Official (HRSID 65 : 35; LS-SSDD 2 : 1)	800 × 800	RTX 3090 Ti
Rotated detector (Zhang 2026)	HRSC2016	Official 436 : 444	1024 × 1024	RTX 4090 (32.8 FPS); three random seeds, mean and standard deviation
HFPNet (Chen et al. 2023a)	NWPU VHR-10 and own data, partly augmented	Random 7 : 2 : 1	about 640 × 640	n.r. in text
IRSD-Net (Sun and Lian 2025)	ISDD	Official 7 : 3	640 × 640	RTX 4090 (714 FPS); also RTX 3060 and CPU
DGG-YOLO (Niu et al. 2026a)	ISDD	6 : 1 : 3	640 × 640	RTX 3060 Ti
C-YOLO (Cai and Zhou 2026)	SeaShips 7000	6000 : 500 : 500	n.r.	RTX 3080 Ti (119 FPS)
AK-DSAM-YOLOv13 (Du et al. 2026)	SeaShips, McShips	SeaShips 1750 : 1750 : 3500	640 × 640	RTX 4090
YOLO11-pico-CoT (Wungow et al. 2025)	SeaShips 7000	Stated as 50 : 25 : 25 but given as 1750 : 1750 : 3500	640 × 640	Tesla P100 (training); Raspberry Pi 5 (3.97 FPS)
LOCDNet (Yin et al. 2026)	SeaShips	Own split	640 × 640	RTX 4060 laptop; Jetson Orin Nano with TensorRT FP16 (92 FPS)
VSTF-Net (Peng et al. 2026)	Enhanced SeaShips	7 : 1.5 : 1.5	640 × 640	RTX 3090 (275 FPS)
SeaLSOD-YOLO (Ruan et al. 2026b)	SeaDronesSee	Dataset split, not detailed	640 × 640	RTX 5090 (256 FPS)
R-DET (Wang et al. 2026b)	MarineRescue-8K	Own benchmark	640 × 640	RTX 2080 SUPER (63 FPS at batch 1, full pipeline)
Radar YOLO with pre-processing (Külcü 2026)	350 simulated radar PPI frames	70 : 20 : 10	640 × 640 (from 1280 × 1280)	RTX 5070 (training); RTX 3050 laptop GPU (latency)

Table S3: Communication-aware approaches to remote inference and their relevance for maritime detection. None has been evaluated on a maritime detection benchmark in the reviewed corpus. References are included in the final column.

Approach	Payload	Reported benefit or rationale	Maritime evidence and references
Onboard detection	Detections or reduced data instead of raw imagery	Avoids downlinking all raw SAR or multispectral data	SAR processing on low-power commercial off-the-shelf (COTS) hardware for UAVs/satellites and onboard multispectral processing are reported, but no corpus benchmark links these designs to deployed security outcomes. (Madabhushi et al. 2024; Prete et al. 2024)
Split computing and early exiting	Intermediate features from a partitioned network	May reduce transmitted data and capture-to-output delay on degraded links	Generic edge-assisted detection and neural-compression studies; no maritime detection benchmark in the corpus. (Matsubara et al. 2022; Matsubara and Levorato 2021)
Offloading via UAVs and USVs	Tasks or data sent to a nearby edge node	Jointly trades latency against energy and local compute limits	Maritime mobile-edge architectures and USV–UAV cooperative edge services are discussed, but are not evaluated on a shared detection benchmark. (Pang et al. 2020; Zhang et al. 2021a; Dou et al. 2026)
Deep source-channel coding	Encoded image or channel symbols	Can degrade progressively as signal-to-noise ratio or bandwidth declines	General learned image-transmission evidence; no direct maritime detection benchmark in the corpus. (Bourtsoulatze et al. 2019)
Task-oriented and semantic communication	Task-relevant features or semantic representation	Trades bitrate against task accuracy rather than pixel fidelity alone	Includes segmentation-assisted image transmission for maritime UAV surveillance alongside general task-oriented communication studies. (Gündüz et al. 2023; Shao et al. 2022; Chen et al. 2023b)

Approach	Payload	Reported benefit or rationale	Maritime evidence and references
Federated learning over satellite and integrated networks	Model parameters or updates	Enables distributed training without sharing raw imagery, but introduces recurring traffic and connectivity constraints	A maritime federated ship-detection study reports model performance, while satellite/integrated-network studies analyze connectivity and overhead; maritime per-round traffic is not fully characterized. (Zhao et al. 2024; Razmi et al. 2022; Chen et al. 2022; Nandal et al. 2025; Huang et al. 2025)

Table S4 Comparison of the main sensing modalities and cooperative data used for maritime object detection.

Modality	Strengths	Limitations	Representative works
Electro-optical (visible)	Rich detail and texture in daylight	Loss of contrast in fog, haze, rain, low light, and glare	(Chen et al. 2024; Lyu et al. 2023)
Infrared and thermal	Works at night and through light haze	Lack of color and texture; fog and rain attenuation; difficult classification of small boats	(Teutsch and Krüger 2010; Ma et al. 2026; Zhang et al. 2026b)
Radar	Works in darkness and through fog	Sea and rain clutter; rain attenuation at short wavelengths (K-band); small wooden/fiberglass boats are difficult to detect	(Gonzales-Martínez et al. 2021; Ludeno et al. 2023; Külcü 2026)
SAR	All-weather, day-and-night satellite imaging	Limited revisit time; very large images; less visual detail	(Venkata et al. 2025; Zhang et al. 2021b; Paolo et al. 2022; Ma et al. 2024)
Multispectral	Additional spectral bands, wake information, and combination with thermal bands	Requires daylight; blocked by clouds; high data volume; alignment with other sensors	(Bai et al. 2025; Brauchle et al. 2018; Kanjir et al. 2018; Prete et al. 2026, 2024)
AIS (cooperative data)	Identity, position, and course of transmitting vessels	May be turned off or faked; not installed on all vessels	(Eaton et al. 2018; Fischer and Bauer 2010; Hanmante et al. 2026)

Table S5: Evidence profile of the 655-study corpus. Contributions are non-exclusive, so their totals can exceed 655. Sensor and platform summaries assign one primary category per study and therefore each sum to 655. Percentages are rounded.

Dimension	Category	n	Share
Contribution	Method	589	90%
Contribution	Dataset or benchmark	33	5%
Contribution	Comparative evaluation	24	4%
Contribution	System, platform, or sensor	24	4%
Venue	Journal	383	58%
Venue	Proceedings or book chapter	272	42%
Publication	Final issue/version assigned	654	100%
Publication	Early-access only	1	0%
Sensor	Electro-optical	202	31%
Sensor	Not specified	166	25%
Sensor	SAR	162	25%
Sensor	Multi-sensor or multimodal	59	9%
Sensor	Infrared	29	4%
Sensor	Radar	19	3%
Sensor	Multispectral	8	1%
Sensor	Satellite or remote sensing	8	1%
Sensor	Other (synthetic, data sources)	2	0%
Platform	Not specified	300	46%
Platform	Satellite or remote sensing	198	30%
Platform	UAV	64	10%
Platform	Shore, port, or ship	40	6%
Platform	Other (mixed, edge, simulation, underwater)	26	4%
Platform	USV or MASS	21	3%
Platform	Aircraft or aerial	3	0%
Platform	Not applicable	3	0%

Table S6 Representative maritime datasets and benchmarks reviewed in this survey, ordered chronologically by the publication year given in the cited source. This is a selected list, not an exhaustive catalogue.

Source	Platform / modality	Dataset or benchmark contribution
(Shao et al. 2018)	Shore cameras (optical)	SeaShips: large, precisely annotated dataset for ship detection
(Moosbauer et al. 2019)	Maritime scenes (optical)	Benchmark for deep-learning-based object detection in maritime environments
(Bovcon et al. 2019)	USV camera (optical)	MaSTr1325: semantic segmentation of sea, sky, and obstacles for USVs
(Soloviev et al. 2020)	Maritime scenes (optical)	Two datasets used to compare CNN-based detectors
(Wei et al. 2020)	Satellite SAR	HRSID: high-resolution SAR ship detection and instance segmentation
(Zhang et al. 2020)	Satellite SAR (Sentinel-1)	LS-SSDD-v1.0: small ships in large-scale SAR scenes
(Zhang et al. 2021b)	Satellite SAR	SSDD: public SAR ship-detection dataset with standardized analysis
(Varga et al. 2022)	UAV imagery	SeaDronesSee: detection of humans in open water
(Bovcon et al. 2022)	USV camera (optical)	MODS: obstacle detection and segmentation benchmark for USVs
(Paolo et al. 2022)	Satellite SAR (Sentinel-1)	xView3-SAR: detection of dark vessels and fishing activity
(Žust et al. 2023)	USV camera (optical)	LaRS: panoptic obstacle detection in diverse maritime scenes
(Dong et al. 2025)	UAV imagery	Maritime search-and-rescue dataset construction and detector evaluation
(Zhao et al. 2025)	UAV imagery	Dataset rebalancing for drone-captured rescue images under sample constraints
(Prete et al. 2026)	Multispectral imagery	Dedicated multispectral ship-wake dataset for transfer learning
(Chen et al. 2026)	Large-scale maritime images	MARS dataset and ETMS ship-size-sensitive detection
(Vaidya et al. 2026)	Synthetic (game engine)	Virtual testbed for search and rescue and small-object detection

Table S7 Direct maritime-security tasks and adjacent perception applications, their typical sensing inputs, and selected representative works. Adjacent tasks are not direct evidence of a security outcome.

Application	Typical sensors and targets	Representative works
Border and coastal surveillance	Shore cameras, satellites, SAR and radar; ships, small boats and dark vessels	(Eaton et al. 2018; Marie et al. 2018; Ma et al. 2024)
Search and rescue	UAV optical and thermal cameras; swimmers, rafts and small boats	(Varga et al. 2022; Dong et al. 2025; Zhao et al. 2025; Vaidya et al. 2026)
Detection of illegal fishing	Optical and satellite imagery; fishing vessels	(Sarajlić et al. 2026; Bousetouane and Morris 2016; Lalasa et al. 2024)
Security of ports and harbors	Fixed electro-optical/infrared cameras; small boats and dense ship traffic	(Hassan et al. 2026; Zhang et al. 2026b; Tu-Salaam and Alamaniotis 2026)
Autonomous navigation (USV/MASS)	On-board cameras and radar; obstacles, vessels and buoys	(Mehla et al. 2023; Zhu et al. 2025; Zhang et al. 2022)
Threat recognition and situation awareness	Multisensor fusion and vessel databases; behaviors, anomalies and unknown objects	(Brüggemann et al. 2016; d'Afflisio et al. 2024; Yoon et al. 2024; Shahir et al. 2014)
Environmental and other monitoring	Satellite and multispectral imagery; ships, wakes and surface objects	(Prete et al. 2024; Bakirci 2025; Li et al. 2026)

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