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Content | *Sadržaj*

Introduction | *Uvod*
Špiro Ivošević iii

The Importance of the Maritime Library Fund in the Scientific Research and Educational Process
Nataša Gobović, Ana Kerndl 1

Minimisation of Propeller-Induced Sediment Resuspension with Rip-Rap System
Jure Srše, Marko Perkovič, Aleksander Grm 12

Decarbonizing the Bay of Kotor: Preliminary Electrification Concept of a Ferry
Milan Kalajdžić, Nikola Momčilović, Luka Mijatović 22

Automatic Detection of Visual Changes between X-Ray Images to Support Antifraud Customs Control at Ports – A Preliminary Study
Andrea Chezzi, Mattia Colucci, Radmila Gagic, Danilo Martino, Claudio Pascarelli, Adriana Pettinicchio 36

The Impact of Marketing Information on the Decisions of Nautical Tourists Visiting Eastern Adriatic Region
Zoran Kovačević, Senka Šekularac-Ivošević, Tanja Poletan Jugović 51

The New Italian Exclusive Economic Zone and Italy-Montenegro Maritime Boundary Delimitation
Valeria Eboli 66

Risk Assessment of Pollution by Wastewater from Vessels for the Port of Kotor
Pavić Bracanović, Žarko Koboević, Špiro Ivošević 98

Contribution for the Fire Protection Improvement on RO-RO Ships

Sanja Arko Kariolić, Đani Šabalja, Renato Ivče, Astrid Zekić 119

The Influence of Shallow Waters on the Maneuvering of Large Ships

Mislav Maljković, Ivica Pavić, Marko Perkovič, Toni Meštrović 132

JMS | Editorial Board......142

JMS | Guidelines for the Authors......144

Introduction | *Uvod*

Dear Readers,

It is my great pleasure to announce the Volume 24, No. 1/2023 of the Časopis Pomorskog fakulteta Kotor – Journal of Maritime Sciences (JMS). Thanks to the efforts and creativity of our Editorial Board, this issue provides an insight into state-of-the-art manuscripts in the field of maritime sciences. The current issue comprises 9 papers, of which 1 invited, 4 original and 4 review papers.

It is our great honour that the first, invited paper, offers readers a chronological narrative about the rich collection of the Maritime Library Kotor located in the building that represents a valuable historical and cultural monument of Kotor and Montenegro. Situated near the sea, the Maritime Library Kotor offers diverse books, research and professional papers from the nautical, marine and tourism areas and provides a crucial link in the educational, didactic and research process.

In this issue, you can read about prominent topics in the domain of nautical studies, marketing, nautical tourism, energy efficiency, maritime law, marine environment, and similar.

Our Editorial Board remains dedicated to promoting high-quality academic contents and to expanding the Journal's recognition at the international level. We believe that the approaching KIMC 2023 Conference, taking place in November 2023, will gather national and international researchers whose papers may find place in some of the forthcoming publications of the JMS Journal.

Editor-in-Chief:
Špiro Ivošević, Assoc. Prof.

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Invited paper

The Importance of the Maritime Library Fund in the Scientific Research and Educational Process

Nataša Gobović, Ana Kerndl

Abstract: Libraries are repositories of knowledge, and they were created long before the creation of the book itself. First libraries were established long time ago in the Babylonian Empire and ancient Egypt. In the modern world dominated by Internet and modern technologies, libraries have lost their status as the "only" repository of information, even though they represent a cultural, educational and learning centre. In this paper readers will have the opportunity to become more familiar with the Maritime Library in Kotor. We will try to describe the need for having a university library in Kotor, a city with a long maritime tradition. Special attention will be paid to the formation and evaluation of the library fund, as well as library services that have been improved and modernized over time, all in order to respond to the modern demands of users. The Maritime Library, as a support to scientific research and educational process at the Faculty of Maritime Studies Kotor, Faculty of Tourism and Hotel Management, and Institute of Marine Biology, well equipped and offering a multidisciplinary library fund, fully corresponds to the requirements of a modern librarianship.

Keywords: Maritime Library, Library fund, Evaluation, E-catalog.

1. Uvod

Neosporiva je činjenica da je za dobru navigaciju potrebno prije svega mirno more.

Boku Kotorsku krase čarobni zalivi mirnog i dubokog mora, uramljenog okolnim brdima sa šumama hrasta, bora, oraha , jasena i drugih, tako da ga čuvaju od oluja i neprijatelja. U takvom prirodnom ambijentu stvoreni su posebni uslovi života ovdašnjeg stanovništva. Boka je oduvijek poznata kao pomorski kraj, a njeni stanovnici čuveni i poznati pomorci koji su plovili cijelim svijetom. Pomorstvo je odavnina imalo veoma važnu ulogu u društvenom, ekonomskom, kulturnom i socijalnom razvitku stanovništa određenog područja, pa je tako znatno uticalo i na privredni razvoj Boke Kotorske. Pomorska djelatnost zahtijevala je od pomoraca poznavanje geografije, kartografije, matematike i astronomije. Jednom riječju, trebalo je imati dosta nautičkog znanja da bi se moglo ploviti.

U najstarijim vremenima pomorska znanja sticala su se isključivo na brodovima. Ali geografska otkrića, pomorski poduhvati, ubrzani razvoj trgovine i drugih privrednih grana, doveli su do prvih organizovanih oblika pomorskog školstva. Kako u svijetu tako i kod nas.

Prva pomorska znanja naši pomorci sticali su u privatnim školama. I to od sveštenika, tada jedinih obrazovanih ljudi i od iskusnih kapetana u mjestima gdje je pomorstvo bilo razvijeno. Kao istaknuta mjesta u kojima se izvodila pomorska nastava pominju se Perast, u kojem je formirana prva privatna pomorska škola, zatim Kotor, Prčanj, Topla i Herceg Novi [9].

Zanimljiva je činjenica da su sva stečena pomorska znanja i vještine, Bokelji prenosili na svoje potomke koji su vremenom stasali u mornare, oficire i kapetane.

Ubrzani razvoj pomorstva koji je podrazumijevao veću brojnost trgovačke flote, izmjenu u veličini i izgledu brodova, kao i njihovu tehničku opremljenost, zatim prirast broja pomoraca i opšti razvoj trgovine u svijetu, izazvali su potrebu da se nivo znanja iz pomorstva podigne za stepenik više. Pomorske škole prerastaju u više pomorske škole u kojima se počinju formirati i prve bibioteke.

2. Formiranje Biblioteke Pomorskog fakulteta Kotor i Biblioteke Fakulteta za turizam i hotelijerstvo

Pomorska biblioteka svoju obrazovnu, naučnu i kulturnu djelatnost obavlja od 1959. godina kada je osnovana uporedo sa tadašnjom Višom pomorskom školom u Kotoru i bila je jedna od prvih visokoškolskih biblioteka u Crnoj Gori. Biblioteka, kao i njena matična ustanova bile su smještene u Srednjoj pomorskoj školi. S obzirom na tako ograničeni prostor, i bibliotečki fond je tada bio dosta skroman, i sastojao se uglavnom od udžbeničke literature. Obogaćivanju bibliotečkog fonda, nabavkom stručnih, kako monografskih tako i serijskih publikacija, doprinijele su donacije tadašnjih pomorskih preduzeća, obrazovnih ustanova i institucija iz kulture, samim tim biblioteka postaje neophodan segment nastavnog procesa [6]. Svog prvog bibliotečkog radnika biblioteka dobija 1961. godine, 1972. godine u sadašnjoj zgradi Pomorskog fakulteta Kotor dobija dvije zasebne prostorije, čitaonicu i depo. „Počinje sistematski da se radi na stvaranju uslova za sopstvenu izdavačku djelatnost što je ubrzo rezultiralo brojnim naslovima skripti, udžbenika i priručnika, čiji su autori nastavnici i saradnici Fakulteta. Kao kruna izdavačke djelatnosti, 1974. godine pojavljuje se stručni časopis *Zbornik Više pomorske škole u Kotoru*" [13]. Zahvaljujući izdavačkoj djelatnosti i štampanju prvog broja *Zbornika Više pomorske škole u Kotoru*, Pomorska biblioteka je u mogućnosti da razvija i jedan novi bibliotečki servis, razmjenu, i na taj način umnogome doprinese prinovljavanju svog fonda. Nakon toga počinje da se razvija još jedan značajan bibliotečki servis, međubibliotečka pozajmica, koja omogućava korisnicima da dođu do publikacija kojima biblioteka ne raspolaže.

Nagli razvoj nauke, tehnologije i, sljedstveno tome, razvoj ustanova visokog obrazovanja, uvođenje niza novih nastavnih disciplina, kao i obaveza sticanja naučnih zvanja nastavnog osoblja - dodatno su motivisali autore da se okrenu pisanju i objavljivanju stručnih i naučnih radova, što je rezultiralo povećanim obimom produkcije i tematskom raznovrsnošću. Kada se govori o izdavaštvu, treba imati u vidu činjenicu da je osnivanjem i djelovanjem Instituta za pomorstvo i turizam u Kotoru, kao posebne naučnoistraživačke jedinice Univerziteta Crne Gore, izdavačka djelatnost u oblasti pomorstva i turizma značajno obogaćena. Institut se pojavljuje u ulozi izdavača naučnih monografija, stručnih knjiga, zbornika, te kao nosilac projekata i autor studija i analiza pomorskog i turističkog tržišta Crne Gore i Jugoslavije [3, 5].

U periodu od svog osnivanja pa do kraja osamdesetih godina prošlog vijeka biblioteka je imala problema sa prostorom kako za smještaj građe tako i sa prostorom za čitaonicu.

Međutim, najznačajniji momenat u istoriji Pomorske biblioteke je preseljenje u novu zgradu. „Zahvaljujući patriotizmu i finansijskoj pomoći brodovlasnika iz Monaka Boža Dabinovića, Pomorska biblioteka je svoju noviju istoriju postojanja i rada započela u julu 1989. godine u renoviranoj zgradi u Dobroti. Ovu značajnu donaciju, gospodin Dabinović, čiji korijeni potiču iz Dobrote, posvetio je u spomen na svog oca, prof. dr Antuna Stijepova Dabinovića" [17]. Ovaj nadaleko čuveni pomorski stručnjak prepoznao je značaj jedne dobro opremljene i savremeno organizovane biblioteke, gdje budući pomorci mogu naći sve neophodne informacije koje su im potrebne za sticanje aktuelnih znanja iz pomorstva i njemu komplementarnih disciplina.

Sve do 2004. godine bibliotečki fond Fakulteta za pomorstvo u Kotoru i Fakulteta za turizam i hotelijerstvo bio je jedinstven. Na osnovu Odluke Dekana Fakulteta za pomorstvo u Kotoru (Sl. broj 01-2165) od 22.10.2001. godine donešena je odluka o razdvajanju fonda oba fakulteta i formirana je komisija koja je trebala da prati realizaciju razdvajanja bibliotečkog fonda. Nakon imenovanja komisije definisani su kriterijumi za razdvajanje bibliotečkog materijala i formiranje Biblioteke Fakulteta za turizam i hotelijerstvo. Novoformiranoj biblioteci pripale su sve monografske, serijske i periodične publikacije, knjižni i neknjižni materijal iz oblasti turizma, hotelijerstva i ugostiteljstva, bibliotečka građa, koja se odnosi na strane jezike, opšteobrazovne predmete, na zajedničke ili dodirne stručne oblasti na našem i stranim jezicima, ukoliko Biblioteka posjeduje više od dva primjerka istog naslova, referensna zbirka koja se tiče turizma i njemu srodnih disciplina, svi diplomski radovi koju su odbranjeni na Pomorsko-ekonomskom i Turističkom odsjeku od 1974. godine, službene publikacije (nastavni planovi i sl.). Nakon izlučivanja pomenutih publikacija iz fonda Biblioteke Fakulteta za pomorstvo u Kotoru, pristupilo se razduženju svake publikacije kroz odgovarajuću inventarnu knjigu, precrtavanju inventarnog broja i otpisu karte korisnika, te nakon toga novom zaduženju kroz inventarnu knjigu Biblioteke Fakulteta za turizam i hotelijerstvo.

Bibliotečki fond koji je na osnovu ovog razdvajanja pripao Fakultetu za turizam i hotelijerstvo čini oko 1630 primjerka monografskih publikacija i oko 630 primjeraka serijskih publikacija. Pomenuti fond bio je baza za formiranje Biblioteke Fakulteta za turizam i hotelijerstvo, koja je u tom periodu i dobila i svog prvog bibliotekara. Međutim, fond ove biblioteke, iako fizički odvojen, ostao je u prostorijama Pomorske biblioteke.

Pomorska biblioteka je nakon korjenite reorganizacije bibliotečko-informacionog sistema Univerziteta Crne Gore djelovala u okviru Centralne univerzitetske biblioteke, centralizovane organizacione jedinice u okviru Rektorata Univerziteta Crne Gore, kao njen odjeljak (2015-2018). S obzirom na to da se navedeni oblik organizacije biblioteka na Univerzitetu nije mogao uspješno sprovoditi u praksi, 2018. godine je došlo do ponovnog uspostavljanja organizacije bibliotečko-informacionog sistema na osnovama koje su prethodile navedenoj reorganizaciji [14].

Najnovijom reorganizacijom bibliotečke djelatnosti na Univerzitetu Crne Gore, Pomorska biblioteka postala je zajednička biblioteka za tri univerzitetske jedinice, i to: Pomorski fakultet Kotor, Fakultet za turizam i hotelijerstvo i Institut za biologiju mora, a u organizacionom smislu ona je sastavni dio Pomorskog fakulteta Kotor.

3. Fond Pomorske biblioteke - logistička podrška nastavnom i naučnoistraživačkom radu na matičnim fakultetima

Značaj akademskih biblioteka i akademskog bibliotekarstva istaknut je nizom dokumenata, među kojima se kao temeljni uzima britanski *University Grants Committee Report* iz 1921. godine, prema kome: „Karakter i efikasnost univerziteta može se procijeniti prema tretmanu njegovog centralnog organa – biblioteke. Biblioteka je neophodna kao primarna i najvitalnija potreba u opremi univerziteta“[21]. Dakle, prije gotovo sto godina definisan je značaj akademske biblioteke kao centralnog dijela (jedinice, organa) univerziteta. Od tada do danas bibliotekarstvo, a posebno akademsko, napredovalo je većom ili manjom dinamikom, ali ono što je konstanta jeste činjenica da je akademska biblioteka i tada i sada *de facto* srce svakog fakulteta/univerziteta. Ove navode potvrđuje i citat iz *Atkinson Report*-a iz 1976. godine: „Biblioteka je srce univerziteta“ [19]. Akademske biblioteke to postižu kvalitetom svojih kolekcija, prije svih – referensnih publikacija iz konkretnih oblasti (engl. *core collection*) koje služe studentima, nastavnicima, istraživačima kako bi proširili svoja znanja i razvijali kritičku, inovativnu misao i time podsticali dalji razvoj nauke i društva.

Prvi u nizu zadataka visokoškolskih biblioteka je kontinuirano i promišljeno popunjavanje fondova. Bibliotečki fond fakultetskih biblioteka u sistemu vrednovanja kvaliteta visokog obrazovanja je značajan element bez kojeg fakulteti ne bi mogli biti konkurentni [20]. Uloga stručne biblioteke danas jeste da prilagođava svoju organizacionu strukturu, radne procese i procedure kvaliteta prema korisniku, tj. njegovim potrebama, sklonostima, afinitetima, stepenu obrazovanja, navikama, zahtjevima. Korisnik posmatran na pomenuti način jeste fokusna tačka planiranja, organizovanja, realizovanja i kontrole bibliotečkih usluga. Bibliotečki servisi, a prije svih servisiranje korisnika odgovarajućom stručnom literaturom (u formatima koji prate savremene informaciono-komunikacione trendove), su uspješni u mjeri u kojoj su korišćeni. Zbog toga današnje stručne biblioteke usmjeravaju svoje aktivnosti ka animiranju korisnika i adekvatnoj diseminaciji informacija [11, 12].

Pomorska biblioteka kao visokoškolska i stručna biblioteka namijenjena je u prvom redu studentima, profesorima i saradnicima Pomorskog fakulteta Kotor i Fakulteta za turizam i hotelijerstvo, polaznicima raznih kurseva koji se održavaju na fakultetu u sklopu Centra za obuku pomoraca, kao i istraživačima pomorstva.

S obzirom na to da danas Pomorska biblioteka predstavlja zajedničku biblioteku tri univerzitetske jedinice, govorimo o vrlo raznovrsnom bibliotečkom fondu iz oblasti pomorstva, turizma i njima komplementarnih disciplina. Danas biblioteka broji oko 19000 primjeraka monografskih publikacija (fond Biblioteke Pomorskog fakulteta Kotor čini oko 15200 monografskih publikacija, a fond Biblioteke Fakulteta za turizam i hotelijerstvo oko 3800 primjeraka) i oko osamdestak naslova serijskih publikacija. Fond Pomorske biblioteke organizovan je u nekoliko zbirki, i to: zbirka monografskih publikacija, zbirka periodičnih – serijskih publikacija, zbirka diplomskih, završnih i specijalističkih radova, zbirka magistarskih/master radova, zbirka doktorskih disertacija, referensna zbirka i zbirka neknjižne građe. Njen fond je uvećan i dvijema privatnim bibliotekama: bibliotekom Lucijana Kosa, istaknutog stručnjaka iz oblasti saobraćaja i pomorstva i bibliotekom akademika Vladislava Brajkovića, jednog od najvećih stručnjaka za pomorsko pravo dvadesetog vijeka [7, 8].

Pomorska biblioteka je značajno obogatila svoj fond vrijednim publikacijma nabavljenim kroz realizaciju nekoliko međunarodnih projekata. Zahvaljujući projektu HERD programa pod nazivom „Montenegro Sustainable Maritime Competence Development Initiative“ kojeg je Pomorski fakultet Kotor sprovodio sa Aalesund University College/Fakultetom za pomorske tehnologije i operacije iz Alesunda, Norveška, fond Pomorske biblioteke obogađen je sa preko 100 eminentnih naslova renomiranih izdavača, pretežno na engleskom jeziku iz oblasti nautike, brodomašinstva, pomorskog prava, pomorske elektrotehnike, off-shore operacija, pomorskog transporta i menadžmenta. Kroz projekat „NAUTICA CBC – Jačanje, inovacije i promocija ponude nautičkog turizma i kulturnog nasljeđa kroz prekograničnu saradnju“, koji je finansiran sredstvima Interreg-IPA CBC HR-BA-ME fondova Evropske unije, nabavljeno je oko 50 publikacija iz oblasti sigurnosti i bezbjednosti u pomorstvu, sajber kriminala u pomorstvu, nautičkog turizma, pomorskog menadžmenta, destinacijskog marketinga i menadžmenta i ostalih srodnih disciplina. Nedavno je Pomorska biblioteka obogatila svoj fond i elektronskim knjigama koje su nabavljene kroz projekat „MEP&M - Razvoj regionalnog zajedničkog master programa za zaštitu i upravljanje morskom sredinom“, za studente budućeg zajedničkog interdisciplinarnog master programa na engleskom jeziku iz oblasti zaštite i upravljanja morskom sredinom, plave ekonomije, plavog rasta, savremenih trendova u obalnom turizmu i pomorskom transportu i dr.

Moramo napomenuti saradnju sa lokalnim institucijama kulture, naročito onim koji se tiču korišćenja i valorizacije fonda Pomorske biblioteke. Sa zadovoljstvom se sjećamo saradnje na realizaciji projekta “Izložba stare i rijetke knjige iz legata akademika Vladislava Brajkovića”. Projekat je realizovan sredstvima Ministarstva kulture Crne Gore iz Programa zaštite i očuvanja kulturnih dobara za 2019. godinu u saradnji sa Kulturnim centrom „Nikola Đurković'' Kotor, Gradskom bibliotekom i čitaonicom. Otvaranju izložbe su prisustvovali i učenici Srednje pomorske škole Kotor, čime je nastavljena uspješna saradnja Pomorske biblioteke i ove ustanove.

Cilj ove izložbe je bio da se ukaže javnosti na kulturno bogatstvo kojim raspolaže Pomorska biblioteka, da se naučnicima, istraživačima, studentima i građanstvu omogući uvid u biblioteku akademika Brajkovića, istaknutog poznavaoca pomorskog prava sa ovog područja. Pomorska biblioteka u Kotoru na pravi način doprinosi očuvanju, zaštiti, valorizaciji, prezentaciji i popularizaciji naše kulturne baštine, širenju znanja o njenim vrijednostima i značaju [18].

Pomorska biblioteka u Kotoru predstavlja neodvojivu kariku u ukupnom edukativnom procesu i naučnoistraživačkom radu na matičnim fakultetima. U svome radu Pomorska biblioteka se rukovodi, kao okvirnim načelom, vizijom i misijom Univerziteta Crne Gore i matičnih fakulteta (strateški planovi), vodeći brigu da ukupan menadžment bibliotečkog poslovanja uspješno odgovori potrebama i zahtjevima korisnika (operativni planovi), kako bi ispunila svoje ciljeve i zadatke.

Bibliotečki fond sa odgovarajućim kolekcijama (zbirkama) bibliotečke građe, koja se u fizičkom smislu pojavljuje u različitim oblicima (formatima) - nosiocima informacija (znanja), služi kao logistička podrška obrazovnom i naučnoistraživačkom radu i, zajedno sa servisima koje biblioteka pruža korisnicima, umnogome odslikava ukupan kvalitet rada na fakultetima, institutima, univerzitetima kao matičnim ustanovama.

Karakter, struktura, sadržina (kvalitet) bibliotečkih kolekcija (zbirki), opremljenost savremenom informaciono-komunikacionom opremom, ekipiranje stručnim kadrom, radno vrijeme i prostor - parametri su koji određuju nivo razvijenosti akademskih biblioteka. Kvalitet fondova visokoškolskih i/ili univerzitetskih biblioteka, koji je pod redovnom internom i eksternom evaluacijom, značajan je element u sistemu vrednovanja visokog obrazovanja, što je od izuzetne važnosti za postizanje konkurentnosti na globalnom visokoškolskom prostoru [2, 4].

U pomorskom visokom obrazovanju, koje obrazuje i osposobljava kadrove za međunarodno pomorsko tržište, od izuzetne je važnosti da stručne, pripadajuće biblioteke menadžiraju bibliotečke kolekcije na način da ravnomjerno pokrivaju stručne oblasti koje se izučavaju na matičnoj ustanovi u skladu sa zahtjevima ECTS kataloga gdje prednost u nabavci ima obavezna literatura; da prate i nabavljaju publikacije koje daju uvid u pomorsku legislativu na međunarodnom (internacionalnom), nacionalnom i lokalnom nivou; da u zbirkama bude određeni procenat aktuelne stručne literature na engleskom jeziku kao jeziku pomorske struke; da pokušaju nabaviti adekvatan broj primjeraka; da nabave naslove u formatima koje korisnici zahtijevaju.

Pomorskim obrazovnim institucijama nameće se obaveza da svoj nastavni program prilagode preporukama Međunarodne pomorske organizacije (eng. IMO – *International Maritime Orgazization*), odnosno da pomorska praktična i teorijska znanja moraju biti usklađena sa zahtjevima

Međunarodne konvencije o standardnim treninzima, sertifikatima i držanju straže (eng. STCW - *The International Convention on Standards of Training, Certification and Watchkeeping for Seafarers*) i dvijema temeljnim konvencijama koje se tiču lične zaštite i sigurnosti i zaštite mora i okeana od potencijalnog zagađenja (eng. SOLAS – *The International Convention for the Safety of Life at Sea* i eng. MARPOL - *The International Convention for the Prevention of Pollution from Ships*). U tom pogledu je neophodno da studenti u svojim bibliotekama mogu lako, jednostavno i praktično pronaći i koristiti odgovarajuće, kvalitetne informacione resurse.

U savremenom informatičkom svijetu biblioteke svoje usluge pokušavaju sve više približiti korisnicima. Izradom i postavljanjem elektronskih kataloga korisnici ne moraju fizički posjetiti biblioteku da bi pogledali njen fond, već iz svojih domova mogu putem onlajn kanala pregledati bibliotečku građu. Kompletan fond Pomorske biblioteke obrađen je u elektronskom katalogu COBISS.CG i time dostupan korisnicima 24/7 sati dnevno. U nastojanju da se unaprijedi pristup izvorima informacija i pruži podrška akademskoj komunikaciji implementacijom institucionalnog digitalnog repozitorijuma pod nazivom *Digitalni arhiv Univerziteta Crne Gore*, stvorena je mogućnost za otvoreni pristup publikacijama koje nastaju u toku nastavnog i istraživačkog rada na Univerzitetu. Pohranjenim elektronskim publikacijama može se pristupiti preko samog repozitorijuma ili preko kataloških linkova u okviru bibliografskih zapisa za štampane verzije ovih publikacija [16].

Biblioteka Pomorskog fakulteta predstavlja važan segment u edukativnom procesu i naučnoistraživačkom radu u okviru organizacionih jedinica za čije potrebe je i organizovana, a njen fond bio je i jeste potencijal za izradu brojnih naučnih i stručnih radova, elaborata i projekata. Kao takva, ona se pojavljuje kao institucionalna podrška obrazovnim i naučnoistraživačkim procesima i istovremeno čuvar znanja i informacija koje posjeduje.

4. Zaključak

Savremeni razvoj nauke i tehnologije, razmjena ideja, razvoj kreativnosti kao i sve veće potrebe za znanjem i informacijama, uslovile su promjene u visokoškolskom obrazovanju, pa samim tim i u poslovanju visokoškolskih biblioteka [1].

Visokoškolske biblioteke predstavljaju najbitiniju kariku u obrazovnom i naučnoistraživačkom procesu koji se odvija na univerzitetima. Međutim, promjene u visokoškolskom obrazovanju uslovile su i promjene u organizaciji samih biblioteka. Ovdje se prije svega misli na odstupanje od klasičnog i tradicionalnog tipa bibliotekarstva [15].

Kao što se obrazovni i naučnoistraživački procesi sve više premiještaju u virtuelni svijet zahvaljujući ekspanziji informacijskih izvora u elektronskoj formi, tako se sve više mijenjaju i zahtjevi korisnika.

Biblioteka danas više nije riznica u kojoj se čuvaju informacije, već se pažnja preusmjerava na potrebe korisnika. Da bi se odgovorilo tim zahtjevima biblioteke moraju planski izgrađivati svoje zbirke, koje su logistička podrška obrazovnom i naučnoistraživačkom radu i u velikoj mjeri doprinose kvalitetu rada na fakultetima i njihovom postizanju konkurentnosti na globalnom nivou [10].

Otvoreni pristup predstavlja novi model distribucije informacija, a biblioteke su upravo institucije koje korisniku moraju da olakšaju povezivanje znanja i nesmetano korišćenje izvora informacija.

Jedan od glavnih prioriteta u visokoškolskom obrazovanju jeste uključiti biblioteke u obrazovno-naučni proces i stvoriti kvalitetne uslove za razvoj informacijske pismenosti kod korisnika kao osnove za cjeloživotno učenje.

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Značaj fonda Pomorske biblioteke u naučnoistraživačkom i edukativnom procesu

Nataša Gobović, Ana Kerndl

Sažetak: Biblioteke su riznice znanja i pojavile su se mnogo prije nastanka same knjige. Počeci nastanka prvih biblioteka datiraju još iz perioda Vavilonskog carstva i drevnog Egipta. Danas, u modernom svijetu sa dominacijom interneta i savremenih tehnologija, iako su biblioteke izgubile status „jedinog“ skladišta informacija, i dalje predstavljaju svojevrsne centre kulture, obrazovanja i učenja. U ovom radu čitaoci će imati priliku da se pobliže upoznaju sa Pomorskom bibliotekom u Kotoru. Govorićemo o potrebema za osnivanjem jedne visokoškolske biblioteke u Kotoru, gradu koji baštini dugu pomorsku tradiciju. Posebna pažnja posvećena je formiranju i evaluaciji bibliotečkog fonda, kao i bibliotečkim servisima koji su se vremenom usavršavali i modernizovali, a sve u cilju da se odgovori savremenim zahtjevima korisnika. Pomorska biblioteka kao segment edukativnog i naučnoistraživačkog procesa koji se odvija na Pomorskom fakultetu Kotor, Fakultetu za turizam i hotelijerstvo i Institutu za biologiju mora zahvaljujući veoma dobroj opremljenosti i multidisciplinarnom bibliotečkom fondu, u potpunosti korespondira zahtjevima savremenog bibliotekarstva.

Ključne riječi: Pomorska biblioteka, bibliotečki fond, evaluacija, elektronski katalog.

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Minimisation of Propeller-Induced Sediment Resuspension with Rip-Rap System

Jure Srše, Marko Perkovič*, Aleksander Grm

Abstract: Sediment resuspension caused by the movement of propellers during manoeuvring is a major problem in daily port operations. Negative impacts include: Marine flora and fauna, sediment erosion that weakens berth structures, sediment deposits that require dredging. Later, this leads to delays in port operations. Several authors have proposed different methods to cope with this problem. This paper presents methods and tools to determine the critical propeller jet velocities, which are the most important parameter to determine the size of the bank stabilisation system. The tool is a bridge simulator that can be used to simulate the intrusive departure manoeuvre of a ship. The ship motion data are analysed to determine the critical shear stress of the sediment particles. The critical velocity induced by the propeller jet is determined using the German method.

Keywords: Sediment resuspension, Full Mission Bridge Simulator, Critical propeller jet bottom velocity, Rip-rap system.

1. Introduction

The Port of Koper faces a global shipping problem to accommodate ever larger ships and remain competitive in the global port market. The Port of Koper (PK) is reaching its limits to accept deep draft vessels in length, width and gross tonnage. The first parameter is limited by sea depth, and the others present manoeuvring challenges for pilots and tug operators.

The focus of the article is on deep draft vessels calling at our port with under keel clearance (UKC) of less than 1m. Negative impacts are seen in sediment resuspension caused by the propeller rotation. The latter negatively impact marine flora and fauna, erosion around the berthing structure, deposition of sediment particles in certain areas of the port, and the need for dredging operations, leading to challenges in port logistics [1].

Scientific research addresses the problem of finding appropriate methods to determine the interaction between ship propellers and the

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seabed. There are mainly two methods to reduce the impact of sediment resuspension: different seabed protection techniques in port and alternative ship manoeuvres. The article deals with the outbound manoeuvre of a container ship from Basin I, Berth 7 D/C. The Full Mission Bridge Simulator (FMBS) was used to simulate the outbound manoeuvre of container ships expected to call at the port in the near future. The corresponding ship motion data were recorded and later analysed to determine the maximum velocities of the propeller jets on the seabed and to determine an appropriate technique to protect the port bottom.

2. Simulation tool to recreate ship departure manoeuvre

Port Authority is concerned about future ships that grow in size. Where is the upper limit, and how can it be predicted? The main concern is the implementation of safe departure and arrival manoeuvres so as not to endanger the marine habitat, the ships in the vicinity and the port infrastructure. The article's topic is reducing the current caused by the ship's propeller rotation. The useful simulation tool to determine the optimal departure/arrival manoeuvre and to obtain ship motion data for further analysis to predict the ship propeller jet bottom velocities is FMBS. The following Table 1 shows the static data of the simulator ship that is expected to enter Basin I in the near future. The simulated vessel has a UKC of 0.5 m, the lowest value allowed [2].

Table 1 - *Simulator Container ship 31 data.*

Ship Type	**Container Ship 31 TRANSAS version 2.31.32.0**
Displacement	232 005 t
Length Overall	400 m
Breadth (moulded)	59 m
Draft (midship)	14.5 m
Max engine power	61 042 kW
Ship propeller type	FPP (Fixed Pitch Propeller)
Propeller diameter (D_p)	10.3
Propeller immersion (S_t)	9.15 m
Bow thruster capacity	5 000 kW

The largest container ship displaced 165,000 tons, measuring 353 meters in length and drafted 14.2 meters. Figure 1 below shows the configuration of port Basin I with the corresponding position for the container ship's departure manoeuvre.

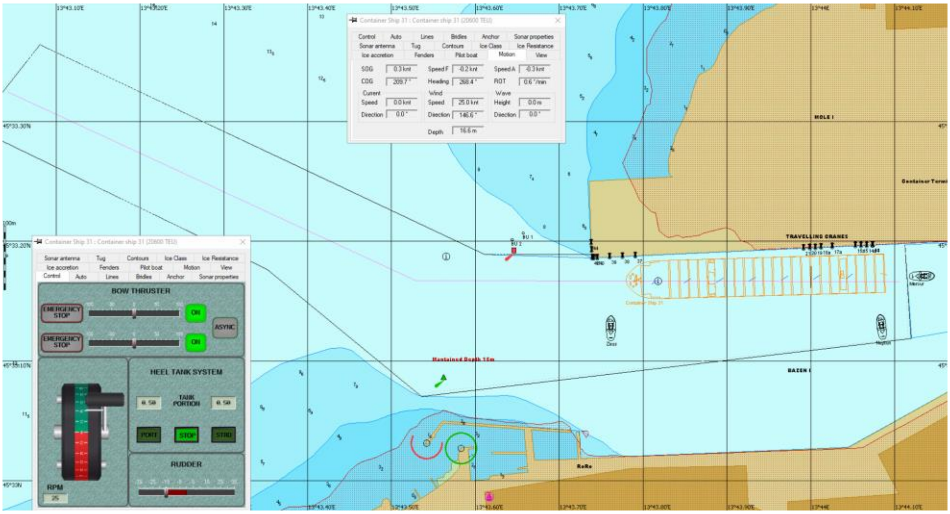


Fig. 1 - *FMBS container 31 departure manoeuvre from Port of Koper Basin 1, berth 7 D/C.*

The FMBS simulation was used to recreate departure manoeuver in real time and place. During the manoeuvre, relevant ship dynamic data were recorded at a frequency of 1 Hz: ship position, speed over ground, course over ground, heading, propeller rates per minute, thrust, rudder angle and other [3].

3. Methods to determine ship propeller jet bottom velocities

Determining the maximum velocity of the propeller jet bottom velocities ($V_{b,max}$) is the most important parameter for determining the correct rip-rap technique. The authors [4] presented ship propeller efflux velocity (V_0). It is an important variable in sediment resuspension analysis because all semi-empirical equations use it as a dependent variable.

$$V_0 = C_3 \left(\frac{P_{app.}}{\rho_{w} D_p^2} \right)^{\frac{1}{3}} \; [m/s] \qquad (1)$$

where is; applied power (P_{app}), water density (ρ_w) in (PK) is 1027 kg/m^3, propeller diameter (D_p) and coefficient (C_3):

- C_3 = 1.17 for ducted propellers (propellers with nozzle),
- C_3 = 1.48 for free propellers.

The equation applies to the ship's speed ($V_{0;v=0}$); the applied propeller speeds per minute (RPM_{app}) are recorded during the ship manoeuvre with a time step of 1 Hz; Parameter maximum propeller rates per minute (RPM_{max}). Applied power (P_{app}) is calculated using the following equation.

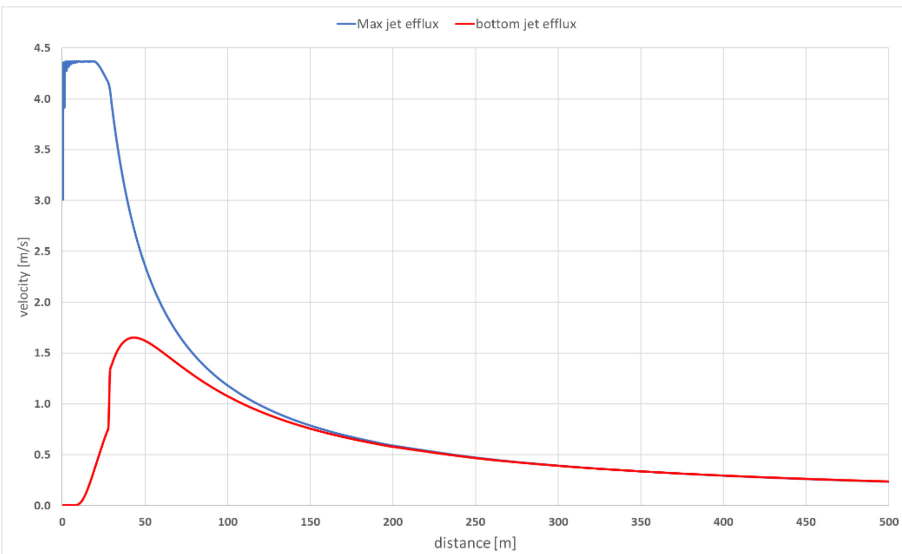
$$P_{app} = \left(\frac{RPM_{app}}{RPM_{max}}\right)^3 P_{max}\ [W] \tag{2}$$

The increasing speed of the ship requires a different approach in calculating the outflow velocity of the ship's propeller for a non-zero ship speed ($V_{0;v\neq0}$), since the propeller slip and the vessel speed are related to the thrust equation.

$$\mathbf{V_{0;v\neq0}} = \mathbf{V_0}\left(\mathbf{1} - \frac{\mathbf{v_s}}{\mathbf{D_p\ n}}\right)\ [{}^{m}/_{s}] \tag{3}$$

The equation consists of the following parameters: vessel speed (V_s) and propeller rotation per second (n). The maximum bottom jet velocity of the ship's propeller ($V_{b,max}$) determines the critical jet velocity at which sediment particles reach the upper limit of bottom shear stress and detach from the seafloor, resulting in erosion, advection, and deposition of sediment particles [5].

$$V_{b,max=0} = E\ V_{0;v\neq0}\left(\frac{D_p}{h_t}\right)^b\ [{}^{m}/_{s}] \tag{4}$$



Graph 1 - *Container ship maximal jet efflux and bottom velocity.*

Graph 1 presents the container ship propeller maximal jet efflux and bottom velocity; originating from the propeller face. The maximum propeller jet outflow velocity (V_0) reaches a value of 4.4 m/s, and the maximum jet velocity ($V_{b,max}$) reaches 1.65 m/s; at a distance of 41 m from the propeller face.

Coefficient (E) and (b) used to determine the rudder influence (E = 0.71, b = 1.0, ships with rudder); (E = 0.42, b = 0.275, ships without rudder). The simulation ship has the rudder influence. The parameter (H_t) contributes (Figure 2) most to high jet bottom velocities and is correlated with the ship (UKC) and propeller diameter (D_p).

$$H_t = C + \frac{D_p}{2} \; [m] \tag{5}$$

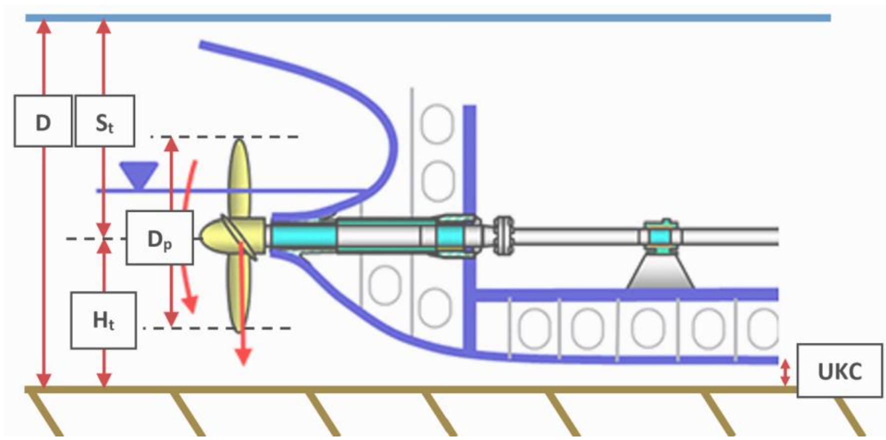


Fig. 2 - *Parameters influencing maximal jet bottom velocity.*

Port of Koper depth (D) set in the numerical calculations to 15 m and the axial distance of the ship's propeller to the seabed (H_t) to 5.85 m; which gives a maximum jet bottom velocity ($V_{b,max}$) of 1.65 m/s.

3.1 Port bottom Rip-Rap technique to prevent sediment scouring

The market for sediment resuspension prevention technology offers several sea bottom overlaying material types. The type of scour protection material is influenced by: cohesive (mud) and non-cohesive (sediment particles), sediment size and density, bathymetry of the sea bottom [6].

The installation of a rip-rap system has negative impacts on port economics, such as primary costs due to the implementation of the system, vessel traffic delays in the port, and removal of the rip-rap system prior to dredging in case of deepening of the port bottom channel.

There are several types of sediment scour prevention techniques: Rip-rap (basalt, granite, syenite, quartzite, limestone); rip-rap impregnated with asphalt primer; rip-rap impregnated with underwater concrete; wired concrete block mats; concrete slabs; concrete-filled fabric mattresses; stone-filled fibre-reinforced bitumen mattresses; geosynthetic bags, mattresses, tubes and containers filled with sand, gravel [7].

The first method uses the following equation to determine the rock size (D_{85}); 85% of rocks are smaller than this size) rip-rap protection technique [8].

$$V_{b,max} = B_{cr}\sqrt{D_{85} g \Delta}\ \ [{}^{m}/_{s}] \tag{6}$$

Rearranging ($V_{b,max}$) equation yields required rock size(D_{85}).

$$\mathrm{D}_{85} = \frac{\mathrm{V}_{\mathrm{b,max}}^{2}}{\mathrm{B}_{\mathrm{cr}}^{2}\ \mathrm{g}\ \Delta}\ \ [m] \tag{7}$$

$$\Delta = \frac{\rho_s - \rho_w}{\rho_w}$$

Coefficient (B_{cr}) is between 0.9 and 1.25 (calculated value 1.0), (g) is acceleration due to gravity, (Δ) is relative density, (ρ_s) is density of sediment, and (ρ_w) is the surrounding water density [9].

Koper port has an average seawater density of 1027 kg/m3, a sediment density of 2650 kg/m3, and a calculated relative density (Δ) of 1.58. The rock size equation (D_{85}) recommended for use in (PK) yields a value of 0.18 m.

The second method of preventing sediment stir-up is to cover the seabed with concrete field mattresses or concrete slabs. Their thickness (D_M) is determined by the following equation.

$$D_M > \frac{C_L V_{b,max}^2}{2g\Delta} \tag{8}$$

The coefficient (C_L) is between 0.50 and 0.75 (chosen value 0.70). The equation recommends a thickness of at least 0.06 m.

The scour protection area near the operational critical side depends on the width of the bottom area from the pier berthing structure to minimize sediment erosion around the mooring and the transverse area affected by bow or stern thrusters. The figure below shows the width of the bottom protection area (b_{pr}) measured perpendicular to the pier. The prediction is based on the following equation.

$$b_{pr} = b_q + 0.5\ b_s + 0.5\ S_p + 0.5\ D_p + 5.0\ [\text{m}] \tag{9}$$

The following variables are present: Distance between the ship and the pier wall (b_q), the ship's width (b_s) and, in the case of two propellers, the distance between the propeller shafts (S_p).

In most cases, the bottom protection will be less than the ship's width; an additional 5 m will ensure the stability of the structure.

The second method to determine bottom protection width (b_{pr}) from the pier is based on German equations [10].

Equation for ships with one propeller.

$$\mathrm{b_{pr}} = (3 \ldots 4)\mathrm{D_p} + 3.0 - 5.0\ [\mathrm{m}] \tag{10}$$

Equation for ships with two propellers.

$$\mathrm{b_{pr}} = 2\ (3 \ldots 4)\mathrm{D_p} + 3.0 - 5.0\ [\mathrm{m}] \tag{11}$$

The largest expected container ship (PK) measures 400 m in length and 61.5 m in width. According to these values, the scour width can be calculated using the equation for a ship with one propeller. The equations give a bottom protection of about 40 m.

The scour protection of the seabed along the pier can be determined with the rule of thumb: Ship length plus 50 m at the bow and stern. Depending on arrival and departure manoeuvres, the protection area may extend by a certain value.

If the berthing position of the largest vessel expected to call at a given berth in the port does not change, the following equations are used.

$$L_m = (6 \ldots 8)D_p + 3.0 - 5.0\ \ [\text{m}] \tag{12}$$

$$L_{m,2} = 3\ D_p + 3.0 - 5.0\ \ [\text{m}] \tag{13}$$

$$L_t = (3 \ldots 4)D_p + 3.0 - 5.0\ \ [\text{m}] \tag{14}$$

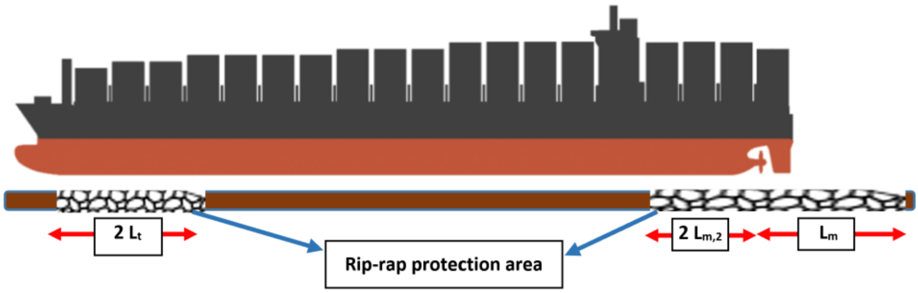


Fig. 3 - *Ship side and front view to determine bottom protection area.*

Equation (12) determines the length of 70 m; measured from the ship's propeller in the aft direction, equation (13) the value of 29 m; measured from the ship's propeller in the forward direction and with equation (14) the value 39 m, the area length around the bow thruster is determined.

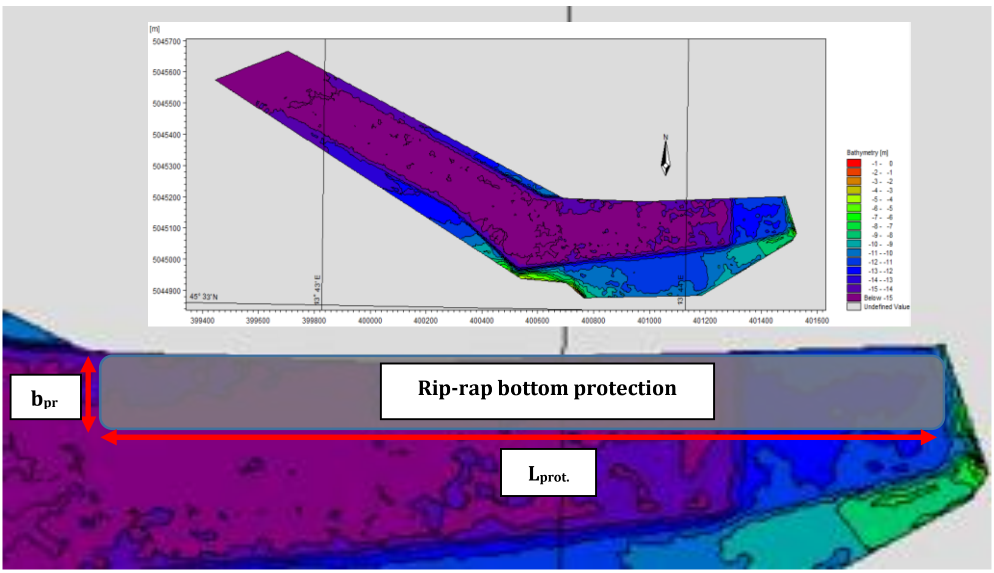


Fig. 4 - *Port of Koper Basin 1, Bathymetry and recommended bottom protection area.*

Figure 4 shows the area to be protected along the container terminal at South Pier I. The article recommends protection by rip-rap in the lateral direction from the pier (b_{pr}) of 40 m and a longitudinal protection distance ($L_{prot.}$) of 710 m along the entire container terminal. Figure 3 shows the partially protected ship bottom, which depends on the ship's berthing position, the main propulsion system and the position of the bow thruster.

4. Conclusion

Shipping global trade encounters problem excepting deep draft vessels in ports, resulting in sediment stir-up that negatively affects marine flora and fauna and damages mooring structures. The article describes the rip-rap technique for the port of Koper, in which the seabed is covered with various materials, such as: Rock fill (basalt, granite, syenite, quartzite, limestone) and Concrete block mats.

The Full Mission Bridge Simulator was the main tool used to simulate the departure manoeuvre of intrusive container ship and to obtain dynamic data used to calculate the jet efflux velocity (V_0) induced by the ship's propeller motion and to determine the maximum jet bottom velocity ($V_{b,max}$). The later value is used to calculate the rock size for the rip-rap protection technique and the thickness of the concrete block mats.

The solution could be used in the port of Koper positioned in the northeastern Mediterranean Sea. The port is strongly affected by sediment uplift from ship propellers due to shallow bathymetry.

The implementation of alternative ship manoeuvres to minimise sediment resuspension will be the focus of future research.

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Original scientific paper

Decarbonizing the Bay of Kotor: Preliminary Electrification Concept of a Ferry*

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Abstract: International Maritime Organization (IMO) and regional authorities have been gradually introducing decarbonization policies and regulations. Shipping sector's primary response remains the reduction of the cruising speed. Other solutions can include hull optimization, application of energy saving devices, alternative fuels. Alternative fuels are still under the development and could significantly reduce emissions, through the application of batteries, hydrogen, ammonia, etc. However, domestic voyages by ferries have not been exposed to the regulations' scrutiny. Nevertheless, in the regions such as the Bay of Kotor (Montenegro), protected by UNESCO, maritime transport is expected to follow environmental policies. In order to encourage the decarbonization of such regions, this paper offers a preliminary concept solution of an electric ferry for the Bay of Kotor with reduced onboard emissions. The concept is based on available data on the most energy demanding ferry in Bay of Kotor that has operated for the past decade. The ferry follows the short route suitable for the application of electric drive. Analysis of an operational profile and the ferry concept design parameters are presented, as well as the advantages and disadvantages of electric ferry proposal.

Keywords: Electric ferry, Bay of Kotor decarbonization, Energy efficiency, IMO, Decarbonization.

1. Introduction

After decades of climate change debates, Paris Agreement [1] united an international effort on defining the decarbonization goals, set to allow global temperature to rise by 2^{0}C or 1.5^{0}C, compared to the second half of the 19th century. Greenhouse gas (GHG) emissions were labelled as responsible for the climate change. Thus, countries have vowed to peak their GHG emissions as soon as possible. Following the Paris Agreement, the Intergovernmental

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Panel on Climate Change (IPCC), published reports on decarbonization pathways. Most recent IPCC report from 2022 [2] stated that, in order to reach 1.5^{0}C rise, global GHG emissions must peak until 2025 while much larger scale transition to renewable energy should be achieved.

In total anthropogenic GHG emissions, international shipping contributed by 2.89% in 2018 [3], while being responsible for over 80% of the international trade in goods by volume [4]. The share is expected to grow if nothing is done and other industries continue their energy transition; taking into account the annual increase of deadweight fleet by around 3% in 2021 [4]. Therefore, International Maritime Organization (IMO) has started delivering energy efficiency requirements to push the shipping sector towards decarbonization. IMO GHG requirements for new [5] and existing ships [6] have been introduced, namely: energy efficiency design index (EEDI), energy efficiency existing ship index (EEXI), carbon intensity indicator (CII), etc. Those regulations apply to most of the deadweight fleet participating in international voyages. More on energy efficiency of typical cargo ships built in the past two decades can be found in [7, 8].

Nevertheless, domestic voyages are excluded from the international maritime regulations and are governed by the national and local authorities. Such ships are not scrutinized for emitting harmful emissions. This is especially the case for areas protected as the natural and culture-historical regions by UNESCO (United Nations Educational, Scientific and Cultural Organization), i.e., World Heritage Sites. One of those sites is the city of Kotor and the part of the Bay of Kotor (Montenegro) [9]. The Bay of Kotor is experiencing an increase in maritime traffic, primarily from cruise ships, yachts, boats, and ferries. Cruise ships emission impact on health of habitants in coastal towns is thoroughly reviewed in [10], while the effect of multiple cruise ships in port is investigated in [11]. Furthermore, cruise ships emissions are assessed for the Bay of Kotor and city of Dubrovnik [12, 13]. Port emissions due to yachting, boating and other small-scale ships are still not systematically explored in areas similar to the Bay of Kotor. Nonetheless, their impact on environment is studied in [14, 15]. Finally, ferry transport air emissions are examined in range of operations worldwide, see [16, 17]. Particularly with regards to the Bay of Kotor, ferry transport air pollution is quantified in [18]. To conclude, the literature acknowledges the rise of air pollution due to increased traffic from ships burning traditional fossil fuels, in areas such as the Bay of Kotor or similar.

Considering the goal for the reduction of air pollution in protected areas, the aim of this paper is to propose the start of the decarbonization of the Bay of Kotor. The first step is set to be the decarbonization of the ferry transport.

2. Ferry concept electrification

The electrification design is based on the regularly used route for ferries over the decades, connecting the sides of the Bay of Kotor in Verige strait, between the ports of Kamenari and Lepetani, see Figure 1. Their operation provides less road and traffic congestion compared to the detour alternative around the bay, which frequently lasts more than an hour.

Fig. 1 – *Ferry route (reconstructed from google maps).*

The objective of the paper is to propose a preliminary design solution for a ferry with significantly lower onboard emissions than the existing diesel fuel ferry operating on the same route. The concept's aim is to provide a potential for route decarbonization while also relieving two inhabited ports of harmful air pollution. This can be achieved by modifying the existing ferry prototype design by replacing the diesel engine system with an electric drive with batteries. The selection of the electric concept is chosen for the preliminary design analysis due to short route profile.

2.1. Prototype

The prototype ferry ship "M/T Grbalj" is the largest and most energy demanding ship in fleet of ferries operating on a designated route for the past 10 years, see Table 1 and Figure 2.

Table 1 – *Prototype particulars* [19].

Type	RoPax (Ro-Ro double ended) steel monohull
Built	2009
Length overall (including ramps)	59.75 m
Breadth x draught	16 x 2.35 m
Deadweight	149 DWT (Note 1)
Gross tonnage	597 GT
Engines	2 x 447 kW, 1800 rpm
Speed	9 kn
Capacity	49 vehicles
Route distance	Around 900 m

Note 1. DWT for summer load line, according to data from [20, 21].

Summer is the most congested part of the year in which the ferry is working up to almost 24 hours a day, according to ship operator claims.

Fig. 2 – *The prototype at berth at the port of Lepetani.*

2.2 Operational profile and analysis

In order to select the batteries, exact operation profile must be determined based on real-time measurements performed during the summer season congestion. However, authors of this paper did not have those measurements. Nonetheless, the actual stages of the ferry operation follow trapezoidal curve. Therefore, for the purpose of the analysis, operational profile is reconstructed according to the following:

1. The prototype operation profile stages are identified based on available measurement data provided by the comparable ferry from the paper [22], given the assumption that most of the frequent and short ferry operations have the similar stages, namely: embarking, ramp lift, departure, cruising, arrival, berthing, ramp down, disembarking.

2. Authors of this paper performed real-time measurements on the prototype during series of crossings to determine average time of each of the stage in operation.

3. Former captain of the prototype ship provided data on average power used for each of the stage, namely: 80% of the main engines power is used for cruising, 30% of the generators power is used as a hotel power while embarking and disembarking, 70% of the main engines power is used when the load is increased after departure, 70% of the main engines power is used after reduction of the speed after the cruising stage.

There are two main sources of energy on-board: two main engines and two generators. Furthermore, total of three groups of consumers are using onboard produced energy: propulsion system (uses main engines power), auxiliary systems (use generators power) and hotel systems (use generators power). At each stage of the operation, at least one source is running. Therefore, based on official ship operator data [19] and data given by the former captain, the main power outputs are estimated and shown in Table 2. Moreover, taking into account the real-time measurements performed on-board of the prototype, adopted operational profile stages from [22] and insights from the former captain, data for the operational profile of the prototype are reconstructed and shown in Figure 3 and Table 3. The diagram is produced assuming linear model built upon averaged values in operation. The operation profile is shown as a dependency between the power during the single operation (start of embarking until end of disembarking) and duration (time). Base power is a hotel power and is constantly running to facilitate minimum required needs of the ship. Maximum power is achieved while cruising at 9 kn for 5 min. The total time needed for single (one) voyage is 12 min.

Table 2 – *Power estimations.*

Type of power	Methodology	Power
Main engines total power	P_{tot} = MCR = 2 x 447 kW	P_{tot} = MCR = 894 kW
Two generators total power	(Note 1)	P_{Gen} = 200 kW
Main engines power for cruising at 9 kn	0.80·P_{tot} (Note 2)	P_{ME} = 715.2 kW
Auxiliary systems and constant hotel loads	$P_{AE} = P_{Aux}+P_{Hot} = 0.866 \cdot GT^{0.732}$ (Note 3)	P_{AE} = 93.2 kW
Constant hotel load	$P_{Hot} = 0.30 \cdot P_{Gen}$ (Note 1)	P_{Hot} = 60 kW
Auxiliary system load	$P_{Aux} = P_{AE} - P_{Hot}$	P_{Aux} = 33.2 kW

Note 1. Based on averaged output of the generators of the similar ferries operating in Mediterranean, according to the statistical analysis performed in [23].

Note 2. According to data provided by the former captain on average power used for the operation.

Note 3. According to IMO MEPC formula for auxiliary system and constant hotel load from [24].

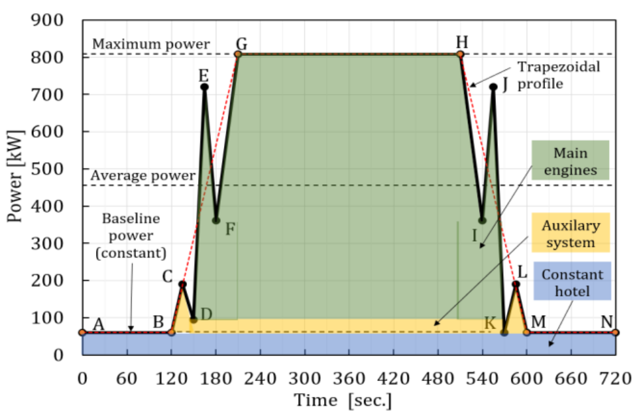

Fig. 3 – *Adopted operation profile.*

Table 3 – *Reconstruction of the data for operational profile.*

Stage	Comments	Methodology for power estimation	Estimated power
A-B (Embarking – 2 min.)	Constant hotel load is assumed as 30% of the total power of two generators	$P_{A-B} = P_{Hot} = 0.30 \cdot P_{Gen}$	P_{A-B} = 60 kW
B-C (Ramp lift, phase 1 - 15 sec.)	From constant hotel load (B) to almost maximum load (95%) of two generators (C)	$P_B = P_{Hot} = 0.30 \cdot P_{Gen}$ $P_C = 0.95 \cdot P_{Gen}$	$P_B = P_{Hot}$ = 60 kW P_C =190 kW
C-D (Ramp lift, phase 2 - 15 sec.)	Ramp is lifted, but the power does not decrease to the hotel load because other systems start to power up for departure. Thus, power drop occurs at around half of the previous one.	$P_C = 0.95 \cdot P_{Gen}$ $P_D = P_C/2$	P_C =190 kW P_D = 95 kW
D-E (Departure, phase 1 – 15 sec.)	Power increases until additional 70% of the MCR is used.	$P_D = P_C/2$ $P_E = 0.70 \cdot MCR + P_D$	P_D = 95 kW P_E = 720.8 kW
E-F (Departure, phase 2 – 15 sec.)	Ship overcomes the resistance and thus, a short power drop occurs (F) before increasing to the maximum load (G).	$P_E = 0.70 \cdot MCR + P_D$ $P_F = 0.50 \cdot P_E$	P_E = 720.8 kW P_F = 360.4 kW
F-G (Departure, phase 3 – 30 sec.)	Power is increased until maximum power is reached for cruising at 9 kn (main engines + auxiliary systems + constant hotel load).	$P_F = 0.50 \cdot P_E$ $P_G = P_{ME} + P_{AE}$	P_F = 360.4 kW P_G = 808.4 kW
G-H (Cruising at 9 kn – 5 min.)	Ship uses maximum power: main engines + auxiliary systems + constant hotel.	$P_{G-H} = P_{ME} + P_{AE}$	P_{G-H} = 808.4 kW
H-I (Arrival, phase 1 – 30 sec.)	Ship reduces the power to the half of the PE to prepare for approach.	$P_H = P_G = P_{ME} + P_{AE}$ $P_I = 0.50 \cdot P_E$	P_H = 808.4 kW P_I = 360.4 kW
I-J (Arrival, phase 2 – 15 sec.)	Power is increased for maneuvering.	$P_I = 0.50 \cdot P_E$ $P_J = 2 \cdot P_I$	P_I = 360.4 kW P_J = 720.8 kW
J-K (Berthing – 15 sec.)	Power is decreased for berthing by using just constant hotel load.	$P_J = 2 \cdot P_I$ $P_K = P_{Hot}$	P_J = 720.8 kW P_K = 60 kW
K-L Ramp down, phase 1 – 15 sec.)	Power is increased to almost maximum load (95%) of two generators.	$P_K = P_{Hot}$ $P_L = 0.95 \cdot P_{Gen}$	P_K = 60 kW P_L = 190 kW
L-M Ramp down, phase 2 – 15 sec.)	Power drops to constant hotel load.	$P_L = 0.95 \cdot P_{Gen}$ $P_M = P_{Hot} = 0.30 \cdot P_{Gen}$	P_L = 190 kW P_M = 60 kW
M-N (Disembarking – 2 min.)	The same as A-B.	$P_{M-N} = P_{Hot} = 0.30 \cdot P_{Gen}$	P_{M-N} = 60 kW

Total energy and energy used by each of the consumers is calculated as an integral of the power (P)-time (t) function:

$$\int_A^N P\mathrm{d}t = 91.1\ \mathrm{kWh} \tag{1}$$

from Figure 3 and Table 4. A and N stand for the start (embarking) and the end (disembarking) of the single voyage profile, respectively, according to Table 3.

Table 4 – *Energy consumption per voyage and per hour.*

Consumers	Energy consumption [kWh]	
	12 min.	1 hour
Main engines	73.9	369.3
Auxiliary systems	5.2	26.2
Hotel	12.0	60
Total	91.1	455.5

3. Preliminary design

In first step of the preliminary design, capacity of batteries was adopted based on:

- the operational profile (Figure 3) and,
- the assumption that the displacement of the ship cannot be changed significantly.

3.1 Weights

The weight of the batteries represents the main obstacle, especially in achieving the prototype's unaffected displacement. Modifications include prototype's two main engines, two generators and fuel tanks, having in total 22.842 t available to be replaced by the batteries (Table 5). Authors of this paper did not have data on fuel tanks capacities so they were estimated based on assumptions that: daily fuel oil tanks (2 x 2 m^3) can provide daily operation of 18 hours in duration, main fuel oil tanks (2 x 8 m^3) can provide 72 hours of operation, specific fuel consumption of the installed main engines is 111 l/h according to manufacturer's data [25]. Diesel oil density is 837 kg/m^3, which delivers the consumption toward the 93 kg/h. Total weight of two generators is also taken from the manufacturer's data [26].

Table 5 – *Estimations of prototype weights.*

Item	Weights
Two main engines	4502 kg
Two generators	1600 kg
Two main fuel tanks	13392 kg
Two daily fuel tanks	3348 kg
Total	22842 kg

For the purpose of the preliminary analysis, it is assumed that ship's center of gravity remains almost unchanged, implying that new systems (electric, steering and propulsion) have approximately the same total weight as the old ones. As a result, the total weight of the batteries that can be installed onboard is 22.842 t, which is the same as the weight removed from the ship. This mass is a part of the lightweight mass of the ship. Moreover, additional analyses are carried out. For prolonged operation, batteries might be heavier than the removed weight, so the additional weight of the batteries surpassing 22.842 t will be taken into account on behalf the actual deadweight (DWT). Hence, in order to achieve increased time of operation with "overweight" batteries, ship's capacity might be reduced.

3.2 Electrical system selection

Onshore infrastructure for charging is not available at the site. Local power grid is not supporting the large power output chargers, although they are available as a technology. Considering that voltage of the charger directs the maximum power, it is supposed that a potential onshore charger would not have voltage greater than 1100 VDC. This would increase time to facilitate charging of batteries, so that the continuous ferry operation would not be possible. Therefore, an alternative solution is proposed. In conventional electric ship, batteries are placed in the hull (in-hull battery pack, i.e., IHBP), which is also the case here. Additionally, batteries will be placed on deck, in a movable container on a trailer. Movable container battery pack (MCBP) is suitable for sites with no developed power grid, because it can be charged onshore while the ship is in operation. During vehicle embarking and disembarking, the ship can dispose used batteries while loading up onshore charged ones. Therefore, an outline of the electrical system is proposed in Figure 4.

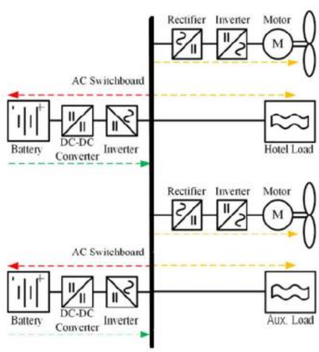

Fig. 4 – *An outline of an electrical system.*

The conversion of the power system considers adding two new components, DC-DC converter and inverter, to facilitate existing AC arrangement. Coefficients of efficiency are adopted based on recommendations given in [27], based on data for the ship all-electric driven powertrain and they are: battery efficiency η_b = 0.95, DC-DC efficiency η_{dc} = 0.989, converter efficiency η_r = 0.97, inverter efficiency η_i = 0.97, electric motor efficiency η_m = 0.965. P_{ME1} and P_{ME2} represent the powers of two main engines (P_{ME} is their total output), P_{Aux} is auxiliary engine power and P_{Hot} is a hotel load, see also Table 2. According to Figure 4, the following relation for the battery capacity (P_b) can be derived:

$$P_b = \frac{\frac{P_{ME1}}{\eta_r\eta_i\eta_m} + \frac{P_{ME2}}{\eta_r\eta_i\eta_m} + P_{Aux} + P_{Hot}}{\eta_b\eta_{dc}\eta_i} = \frac{\frac{P_{ME}}{\eta_r\eta_i\eta_m} + P_{Aux} + P_{Hot}}{\eta_b\eta_{dc}\eta_i} \tag{2}$$

As a result, ferry energy consumption is shown in Table 6.

Table 6 – *Ferry consumption.*

Time	P_b [kWh]
Single voyage (12 min)	108.2
1 hour	540.8

The main objective for the selection of batteries is that they must be class approved for the use in maritime sector. Moreover, considered are battery design recommendations from [28]. Finally, an available battery pack product is selected, see Table 7 and [29]. Selection of batteries are carried out based on manufacturer's recommendation that the depth of discharge should not be more than 80%.

Table 7 – *Battery module.*

Item	Xalt energy: Module XMP 98P (single module)
Energy	9.77 kWh
Dimensions	0.753 x 0.303 x 0.282 m
Weight	76.5 kg
Voltage (max.)	88.8 VDC

4. Operation

Besides fixed IHBP, ship is intended to use four MCBP. Thus, based on operational profile (Figure 3 and Table 4), battery packs were chosen, as shown in Table 8. IHBP consists of 12 modules in series and 144 in parallel circuit, while MCBP includes the 20 ft container that carry 12 modules in series and 240 in parallel circuit. In total, they deliver 3752 kWh, corresponding to 26 single voyages or constant 5 h and 12 min of operation. This will reduce spacing for two vehicles, or approximately 5-6 vehicles in terms of DWT (standard vehicle weight is assumed to be around 2 tons).

Table 8 – *Selected battery combination.*

	IHBP	MCBP
No. of modules in series circuit	12	12
No. of modules in parallel circuit	144	240
Circuit voltage	12 x 88.8 VDC = 1066 VDC	
Total energy	144 x 9.77 kWh = 1407 kWh	240 x 9.77 kWh = 2345 kWh
Total mass	11.93 t	21.62 t
Number of voyages achieved	10	16
Charging time (Note 1)	4 h 38 min	7 h 24 min
DOD (Note 2)	77%	74%
Time available for ship operations	2 h	3 h 12 min
Total time	5 h 12 min (26 voyages)	
Weight changes (Note 3)	+10.71 t (deadweight reduction, i.e., lightweight increase, corresponds to 5-6 removed vehicles)	

Note 1. Chargers are adopted with following specifics: 1100 VDC, 220 A, 242 kW.

Note 2. Depth of discharge, not to be more than 80%.

Note 3. According to the usual weight of cars of 1600-2200 kg. In addition, see Table 5.

If only one charger is considered to exist, for instance in port of Kamenari, the ship has to unload used and load new battery pack in the same port. Single MCBP is always used onboard while others are charging onshore. IHBP and MCBP consumptions are combined in order to keep the operation as prolonged as possible. IHBP is charged at the end of the day and operation.

Energy consumption of the electric ferry is divided into sequences so that the same trends are repeated every 18 voyages, see Figure 5. When MCBP is used, its energy decreases, whilst IHBP energy remains constant and unused. During the nineth voyage, IHBP is used and its energy decreases, whilst MCBP is constant and unused. The total available battery energy of the ship is steadily reducing as the number voyages rise. The in-service separate energy consumptions of MCBP and IHBP energy consumptions are illustrated in Figure 6, with respect to state of charge (SOC) and depth of discharge (DOD). MCBP timeframe is given for the period between the point of embarking onboard to the point of being fully charged in port. The MCBP line has steeper descent of energy consumption compared to the IHBP, meaning that the latter has better influence on the life of the battery of the IHBP. The ship is assumed to use one charged container onboard while three others are available in port (in process of charging). The fifth container entering the ship is the one that was the first, now fully charged in the meantime.

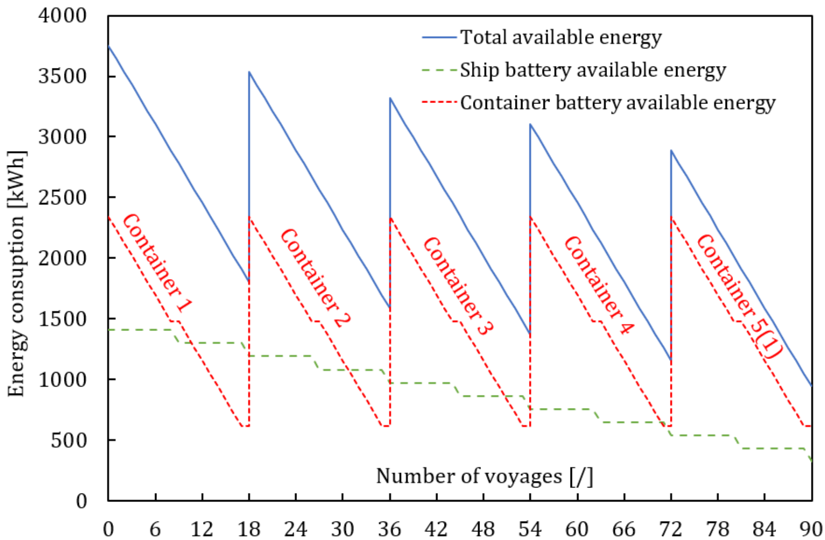

Fig. 5 – *Energy consumption of the electric ship.*

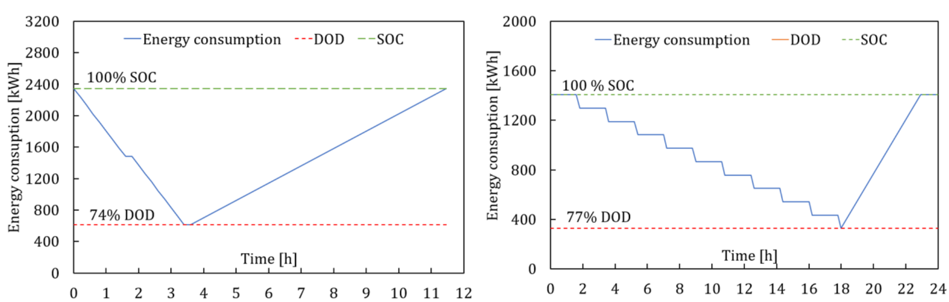

Fig. 6 – *Energy consumption: MCBP (left) and IHBP (right).*

5. Conclusion

Given the UNESCO status of the Bay of Kotor along with national and EU environmental goals, the paper delivers the potential pathway towards the onboard decarbonization of the most energy demanding ferry that operated in the Bay of Kotor, on a regular route for over a decade. In order to achieve that, authors proposed a solution for the electrification of the prototype ferry into the electric ship. It consists of installing IHBP and additionally, MCBP, classed for maritime application. MCBP is intended to be embarked onboard, used for navigation, disembarked when discharged and charged onshore. Movement would be carried out using a trailer. Both packs enable continuous operation without charging for 5 hours and 12 minutes or 26 voyages between ports. The traditional diesel propulsion to electric drive conversion results in a weight excess of 10.71 t, or 7.19% of the DWT. Electrification comes with the reduction of ship capacity. DWT is reduced by the weight of 5-6 vehicles (assuming they weigh around 2 t per vehicle), while in terms of space, 2 vehicles are removed, out of 49. On the other hand, the proposed solution relieves the ports and the bay of the harmful onboard emissions as a product of the operation of the largest ferry. Nevertheless, the weight of the batteries still presents an issue when compared to the traditional diesel power.

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Automatic Detection of Visual Changes between X-Ray Images to Support Antifraud Customs Control at Ports – A Preliminary Study*

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Abstract: One of the goals of customs authorities is to identify, at borders, cargos that do not match their declaration, contain illegal items, or pose a hazard to society. Customs X-ray inspection procedures enable the detection of suspicious cargos and are an excellent support tool for customs officials. The ISACC project, funded under the Interreg IPA Cross-border Cooperation Italy-Albania-Montenegro Programme aims at developing a web platform that integrates data, coming from heterogeneous technologies and systems, in order to provide a rich information base supporting customs authorities during antifraud controls. In this paper, we propose a preliminary study, based on the SIFT algorithm, for the automatic detection of visual changes between scanner X-Ray images, that are part of this information base.

Keywords: Customs, Antifraud, X-Ray, Computer vision, SIFT.

1. Introduction

The current age of globalization with its advances in transportation and information technology has increased trade across the world and the freedom in which these trades are carried out [1]. The total gross weight of goods handled in EU ports in 2021 was estimated at 3.5 billion tons, a 4% increase compared with 2020 [2]. The expansion of global transportation raises security concerns because any container or truck could be used by malicious actors to smuggle restricted or prohibited items across borders. The methods employed by criminals include concealment of undeclared goods amongst a legitimate cargo or in the fabric of the container itself (e.g. floor, refrigeration unit) [3].

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One of the goals of customs authorities is to identify cargos that don't match their declaration, contain illegal items, or pose a hazard to society. The smuggling of fake and pirated goods hurts a country's economy since taxes are not paid that would otherwise be used to benefit society. The existence of counterfeit products is a significant crime problem in the twenty-first century [4]. Focusing on Italy, drugs and cigarettes represent the categories of goods that are most smuggled [5]. As for unexpected, illicit and harmful products, "light" weapons, trafficking in natural resources and the illegal trade in wildlife are the most impacting plagues in the EU beside narcotics [6].

Technological advances and smart policies are required to facilitate the inspection and achieve integrated security [1]. Customs X-ray inspection procedures enable the detection of suspicious cargos and are an excellent support tool for customs officials. Usually the scanner images are stored in a central reference database, which contains X-ray images of legal and illegal cargos in a manufacturer-independent format. The data in the reference database can be shared with other customs administrations in order to facilitate the exchange of information by, for example, comparing cargos in transit from one inspection point to another.

The ISACC project, funded under the Interreg IPA Cross-border Cooperation Italy-Albania-Montenegro Programme, fits within this context, since it aims to develop a web platform that integrates data coming from heterogeneous technologies and systems, already available to the customs authorities of three countries (Italy, Albania, Montenegro), in order to provide a rich information base called Custom Footprint (CF) supporting customs authorities during antifraud controls. The CF is a set of data regarding a specific target, such as a container with related goods, that is created at the first customs control point (e.g. at the time of export) and is tracked till the final destination (e.g. at the time of import inspections). Customs officers of three selected pilot sites (i.e. Port of Bari in Italy, Port of Durres in Albania, Port of Bar in Montenegro) can check, by means of the platform, the invariance of the information of the CF in each intermediate stage defined as checkpoint (e.g. customs control point at the three ports). One, and probably the most important information, within a CF, is represented by scanner images. The ISACC platform allows customs officers to compare two scanner images in order to find differences and generate an alert when needed. In this paper, we propose a preliminary study based on the SIFT algorithm (Scale-Invariant Feature Transform) for the automatic detection of visual changes between X-Ray images in order to support antifraud customs control.

In the next section related work on this topic will be discussed, in order to evaluate what scientific advancement has achieved so far and to identify specific areas where further improvements are required. In section 3, the methodology applied in this study is described and, in section 4, the preliminary obtained results are discussed. Finally, a conclusions section ends the paper.

2. Theoretical background and related works

Computer vision fields are rising in the recent past. These techniques include the image matching that plays an important role in many applications. In the evolution of image matching techniques, a lot of algorithms have been proposed in the literature [7-9].

The discipline of computer vision addresses the theory behind artificial systems that extract information from images. The image data can take many forms, such as video sequences, views from multiple cameras, multidimensional data from a 3D scanner, medical scanning devices, or - as it happens in this case - from X-ray scanners. The technological discipline of computer vision seeks to apply its theories and models to the construction of computer vision systems. Such autonomous systems could perform some of the tasks which the human visual system can perform, and even surpass it in many cases.

Normally, the use of computer vision techniques involves a preliminary step of image acquisition, where images and large sets can be acquired in real-time through video, photos or 3D technology for analysis. Once visual information is acquired, the step of image processing kicks in, in which either machine learning models or conventional algorithms are used to automate much of this process. However, in the case of machine learning, the models are often trained by first being fed a consistent number of labelled or pre-identified images. The final step is the interpretative step, where an object is identified or classified.

Among the many possible applications, image recognition and matching algorithms have also been applied to analyse X-ray images of cargo scanning. Most studies focused on recognizing a specific target object in a cargo.

Jaccard et al. [10] used, for example, Deep Learning to detect concealed cars in X-ray cargo images: they proposed an algorithm based on trained-from-scratch Convolutional Neural Networks. In [3] the authors, on the other hand, implemented a framework to identify an empty cargo, by handling the task as a binary classification problem.

Another field of application relates to the identification of illicit or banned items. Visser et al. [1], for example, defined an automated target recognition function to analyse scanner X-ray images after: they defined an algorithm to detect certain types of goods such as cigarettes, weapons and drugs in the freight of a container.

A Deep Learning approach for the detection of small threats in X-ray cargo images was presented by Jaccard et al. [11], in this study authors have defined three algorithms based on CNN and Random Forest approaches and demonstrate the major efficiency of the algorithms based on a 19-layer CNN.

In [12] the authors propose an object detection method for efficiently detecting contraband items in both cargo and baggage for X-ray security scans. The proposed network, MFA-net, consists of three plug-and-play modules, including the multiscale dilated convolutional module, fusion feature pyramid network, and auxiliary point detection head. Authors tested the performance of the MFA-net on two large-scale X-ray security image datasets from different domains: a Security Inspection X-ray (SIXray) dataset in the baggage domain and a cargo dataset (CargoX).

Ahmed et al. propose in [13] some algorithms for automatic historical comparison of scanned vehicles. The presented system uses a database of scanned vehicles. Each time a new vehicle is scanned, its license plate number is extracted using a license plate reader, and that number is used as the primary key to retrieve matching vehicles from the database. The two vehicles are then segmented using a model-based segmentation approach and certain points of interest are identified. Image registration is performed on the two images to align them. Intensity profiles for the two images are also normalized, and then the two images are compared to find differences. False alarms are then removed using knowledge-based rules. The system has been tested on images acquired using a deployed scanner and produced satisfactory results.

Chen et al. in their work [14] discuss the importance of improving security inspection capabilities in public transportation due to the impact of emerging terrorist attacks. With the rapid development of X-ray detection technology, different X-ray inspection techniques have been researched and developed to detect hidden explosives and contrabands. The article provides a general review of these techniques, including X-ray transmission imaging, backscatter imaging, phase-contrast imaging, spectral imaging, CT reconstruction, and X-ray diffraction. Each technique is explained with its basic physical mechanisms, research progress, and application features. The article also discusses new technologies and applications that show great potential for security inspections.

Unlike what has been previously discussed in most of the literature, the present study does not focus on finding specific target items/goods in a cargo but rather on quantifying the percentage difference between two X-ray images of the same cargo, as a decision support for the customs operator who can then decide to proceed with a more thorough inspection of the cargo or not. This work presents similar goals as what is discussed in [15], but with different means to achieve the results.

Also, the current paper focuses on a specific aspect of computer vision where the use of deep learning models is not strictly required or even recommended, since traditional non-ML techniques, such as SIFT, not only can handle this task in a more computationally efficient way but they do not inherently require a large dataset of image data as input in order to work.

3. Method

3.1. Dataset

In order to preliminary validate the algorithms for X-ray images pre-processing and comparison, and the relevant code that has been developed, a synthetic dataset of images has been created. To create it the team started from four real cargo X-ray images with a resolution ranging from 716 x 402 pixels (total area: 287.832 pixels) to 1379 x 397 pixels (total area: 547.463 pixels). For each of these images, ten other images that had differences (in varying percentages) when compared to the original source image, were manually created through image editing software. Five of these images were obtained by subtraction of material in the truck trailer, five others by substitution of the material.

Figure 1 shows one of the original four images and the ten images that were generated from it.

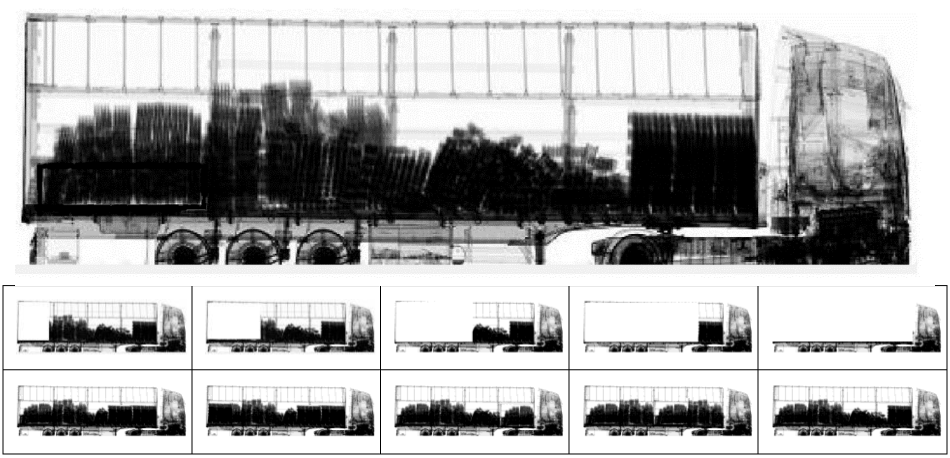

Fig. 1 – *Example of X-ray scanner images and its ten modified variants*

For the 40 images thus generated, the modified area was annotated, in absolute value (pixels) and percentage, as shown in Tables 1-4. The maximum variance in the whole sample of 40 images is 56.5 percent of the image area, which corresponds to the entire volume of transported goods, the average variance is 14.1 percent, and the minimum variance is 0.3 percent.

3.2. Pre-processing

The pre-processing phase is of paramount importance to best perform comparative images analysis: it allows to fit an image over an image target in order to improve the image comparison result.

The pre-processing phase includes the automatic alignment of the two images that need to be compared using the well-known SIFT algorithm (Scale-Invariant Feature Transform) [15]. Scale and rotation invariance are the SIFT best characteristic; scale invariance is guaranteed using DoG (Difference of Gaussian) function.

The SIFT algorithm can be subdivided in three main steps: 1) keypoint detection, 2) descriptor establishing, and 3) image feature matching. In the first phase, SIFT uses grayscale information of an image to identify the image keypoints. In the second phase SIFT uses local information to describe each keypoint. In the last phase SIFT uses a descriptor for image feature matching [16].

The implemented SIFT based algorithm takes as input the couple of images that need to be compared in order to find the differences, one of them is used as reference of the alignment process and the other one is geometrically transformed in order to match as much as possible the reference image. This is done to get the maximum homogeneity possible between the two images during the comparative analysis.

In Figure 2 the image (a) is the image to be aligned and scaled according to the reference (b) image. In the (c) image SIFT keypoints are plotted and the (d) image is the pre-processing result: the image to be compared with (b).

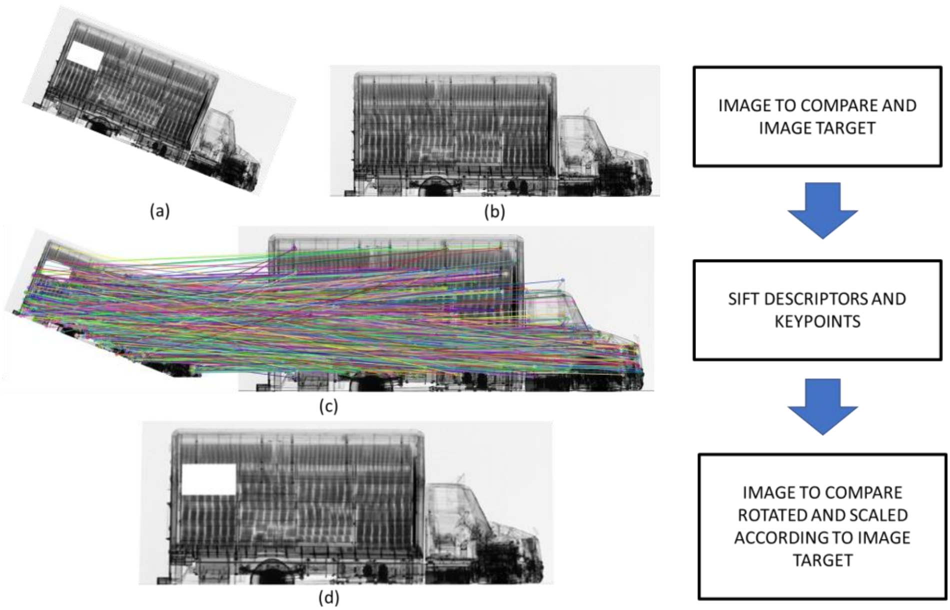

Fig. 2 - *X-ray scanner images pre-processing*

3.3. Image comparison

In this section the comparative images analysis is described. After the pre-processing phase the couple of images has the same scale and rotation, so it's possible to actually perform their comparison.

The Feature Matching algorithms, previously mentioned for pre-processing phase, can also be used to find as many common graphic features as possible between the images, and use the spatial sparsity of the found common descriptors as an indicator of the presence (or absence) of differences between the two images.

The high density of descriptors found in a certain area indicates absence of differences and hence homogeneity. On the other hand, low density or absence of descriptors indicates a high probability of differences which may lie in that particular region.

The image comparison algorithm is based on the SIFT algorithm.

The algorithm can be divided in three steps, as reported in the Figure 3:

1. keypoints and descriptors identification;
2. descriptors matching;
3. similarity percentage calculation.

In the first phase the SIFT algorithm is used to identify features for each image.

The SIFT descriptor represents the input for the second phase that allows to identify similar features between the target image and the image to be compared. In this phase a Brute-force (BF) descriptor matcher is used; the BF matcher iterates over the first image descriptor and keypoints and, for each descriptor in the first set, finds the closest descriptor in the second set by trying each one. The BF matcher is associated with the Cross Checking validator to ensure a consistent feature matching, so the matcher returns only those matches with value (*i,j*) such that *i*-th descriptor in the image target has *j*-th descriptor in the image to be compared as the best match and vice-versa.

The last step of the algorithm is the similarity percentage calculator: this formula is based on the number of features detected by the BF matcher and the images keypoints.

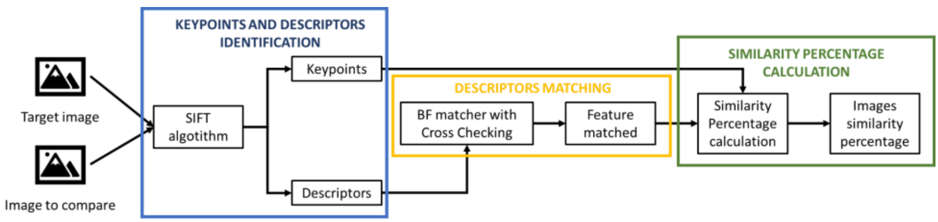

Fig. 3 – *Images comparison workflow*

4. Results

The performance of the Feature Matching algorithms for image comparison was estimated through two separate error indexes: Mean Squared Error (MSE) and Root Mean Square Error (RMSE). These error measures are the most popular in various domains [17, 18]

Mean squared error (MSE) measures the amount of error in statistical models. It assesses the average squared error (*e*), i.e the difference between the observed and predicted values, i.e the real percentage of difference between the compared pairs of images and the percentage of difference estimated through the proposed method based on the Feature Matching algorithm. When a model has no error, the MSE equals zero. As model error increases, its value increases.

The formula for MSE is the following.

$$MSE = \frac{1}{n}\sum_{i=1}^{n} e_i^2 \quad (1)$$

Alternatively, RMSE, that has been used as a standard statistical metric to measure model performance in several research fields [19], is calculated easily by taking the square root of MSE.

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n} e_i^2} \quad (2)$$

As for MSE, the RMSE has frequently been used as an evaluation indicator to assess the reliability and accuracy of the estimated parameters hence summarizing the overall error of a model [20].

In the following Tables 1-4 the individual errors for each of the 40 image comparisons are reported.

Table 1 – *First images sub-set and relevant data*

Image	Total area in pixels	Modified area in pixels	Modified area (M)	Estimated difference (E)	Error (E-M)^2
010 (original)	521.180				
010a	521.180	60.828	11,67%	1,67%	1,000%
010b	521.180	98.688	18,94%	4,56%	2,067%
010c	521.180	159.030	30,51%	4,50%	6,767%
010d	521.180	230.175	44,16%	8,74%	12,549%
010e	521.180	294.640	56,53%	5,96%	25,577%
010f	521.180	28.480	5,46%	4,76%	0,005%
010g	521.180	56.960	10,93%	9,15%	0,032%
010h	521.180	41.236	7,91%	6,36%	0,024%
010i	521.180	105.248	20,19%	16,44%	0,141%
010j	521.180	1.776	0,34%	0,00%	0,001%

Table 2 – *Second images sub-set and relevant data*

Image	Total area in pixels	Modified area in pixels	Modified area (M)	Estimated difference (E)	Error (E-M)^2
020 (original)	287.832				
020a	287.832	2.262	0,79%	0,43%	0,001%
020b	287.832	17.150	5,96%	2,45%	0,123%
020c	287.832	21.534	7,48%	4,23%	0,106%
020d	287.832	30.821	10,71%	5,33%	0,289%
020e	287.832	58.308	20,26%	10,21%	1,010%
020f	287.832	10.089	3,51%	11,72%	0,675%
020g	287.832	16.416	5,70%	19,61%	1,934%
020h	287.832	23.664	8,22%	17,63%	0,885%
020i	287.832	1.443	0,50%	0,56%	0,000%
020j	287.832	756	0,26%	1,61%	0,018%

Table 3 – *Third images sub-set and relevant data*

Image	Total area in pixels	Modified area in pixels	Modified area (M)	Estimated difference (E)	Error (E-M)^2
030 (original)	547.463				
030a	547.463	8.858	1,62%	1,57%	0,000%
030b	547.463	36.494	6,67%	2,90%	0,142%
030c	547.463	71.960	13,14%	5,87%	0,529%
030d	547.463	134.919	24,64%	6,54%	3,278%
030e	547.463	261.320	47,73%	16,90%	9,507%
030f	547.463	22.794	4,16%	6,67%	0,063%
030g	547.463	34.191	6,25%	1,92%	0,187%
030h	547.463	89.001	16,26%	22,60%	0,402%
030i	547.463	122.670	22,41%	24,30%	0,036%
030j	547.463	1.980	0,36%	0,71%	0,001%

Table 4 – *Fourth images sub-set and relevant data*

Image	Total area in pixels	Modified area in pixels	Modified area (M)	Estimated difference (E)	Error (E-M)^2
040 (original)	378.099				
040a	378.099	9.271	2,45%	1,76%	0,005%
040b	378.099	25.870	6,84%	3,20%	0,133%
040c	378.099	72.280	19,12%	4,00%	2,285%
040d	378.099	118.428	31,32%	6,38%	6,221%
040e	378.099	171.698	45,41%	7,94%	14,041%
040f	378.099	9.975	2,64%	5,00%	0,056%
040g	378.099	13.674	3,62%	5,92%	0,053%
040h	378.099	26.069	6,89%	11,18%	0,184%
040i	378.099	51.975	13,75%	24,43%	1,141%
040j	378.099	77.562	20,51%	31,94%	1,306%

The resulting values of MSE and RMSE are:

$$MSE = \frac{1}{40}\sum_{i=1}^{40} e_i^2 = 2{,}32\ \% \qquad (3)$$

$$RMSE = \sqrt{\frac{1}{40}\sum_{i=1}^{40} e_i^2} = 15{,}23\ \% \qquad (4)$$

If look at the correlation between images' modified area and the square error (Figure 4), it can be seen that the Feature Matching algorithm performs better if the difference between the original and the modified image is lower than 20 %. In this case the MSE is 0.43 % that becomes even lower if we only consider the couple of images having differences lower than 10 %: in this case the MSE is 0.22 %.

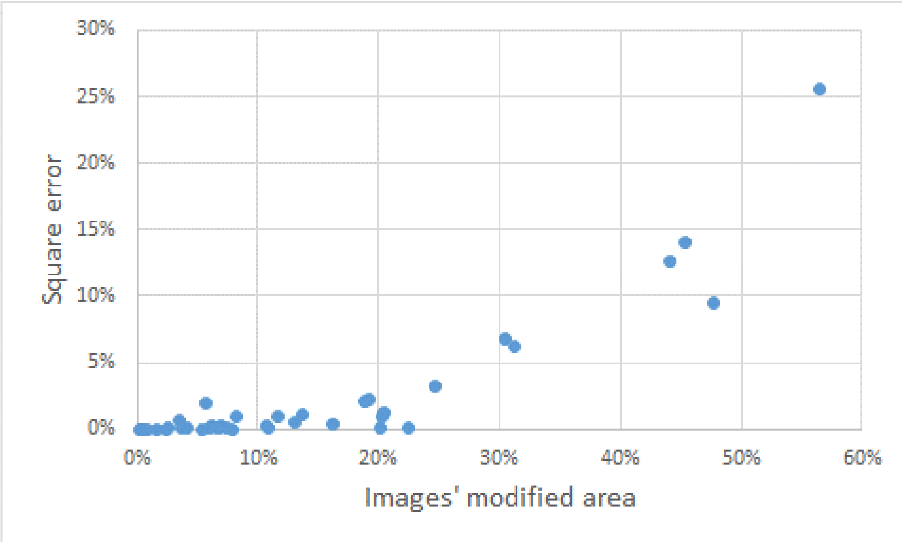

Fig. 4 – *Correlation between images' modified area and the measured square error*

5. Conclusions

Every year the global international trade in counterfeit, pirated and illegal goods amounts to hundreds of billion euros. Customs authorities working at borders play a vital role in contrasting this phenomenon especially in those that have presented problems in this regard for decades, such as those between Italy, Albania and Montenegro.

Within the ISACC project an IT platform, supporting antifraud customs controls, has been designed and developed to integrate data coming from heterogeneous technologies and systems in order to provide a rich information base that we called Custom Footprint (CF). Customs authorities can use this CF and search for its variances, that would be a possible sign of a fraud, at intermediate customs control points, i.e. the ports of Bari, Durres and Bar if we refer to the ISACC project. In order to compare scanner X-ray images that are part of the CF, in this paper it is proposed a possible approach, based on the SIFT algorithm (Scale-Invariant Feature Transform) and some preliminary results obtained with a synthetic dataset.

As shown in the relevant section, the results can be considered encouraging, especially where the differences between two images is below the 20 % threshold. This represents the case in which the proposed method is most useful: substantial differences between two images can in fact be easily detected by sight by a customs operator without the support of a computer tool.

Future work will be directed toward further improving the developed method and testing it on a much larger number of samples (both synthetic and real). One possible solution that will be implemented and tested will be to divide the images into smaller sections (tiles) so as to have not only an indicator of the difference between the two images but also to identify the region where this difference exists. The adoption of another "matcher" still based on SIFT, but adopting a method for skimming the pairs of features found will also be evaluated.

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Original scientific paper

The Impact of Marketing Information on the Decisions of Nautical Tourists Visiting Eastern Adriatic Region*

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Abstract: The information-seeking process of nautical tourists is essential for their decision-making when choosing a specific destination. Modern destination marketing is constantly changing due to the development of new technologies that are meant to attract and retain nautical tourists. Nautical destination managers use modern communication to build and maintain a better image and develop destinations as brands which can function sustainably even in the times of crisis. This paper examines modern and traditional marketing sources of information about Montenegro and Croatia as nautical tourist destinations. It was revealed that the largest share of the informed tourists had previous experience with a destination or were informed through internet sources. The results confirmed that the internet is increasingly used by the surveyed tourists, i.e., there is an increase in promotion through digital marketing tools in both destinations. The comparison of the trends between 2012 and 2021 indicated three common sources of information in both destinations: previous experience, the internet and the recommendations of friends and relatives. The study is based on cross-tabulation analysis which detects the differences in the method of obtaining information by the tourists whose age, gender and education level varied. The practical implication of this paper is the development of destination marketing in the Eastern Adriatic region. More precisely, the study might help the creators of developmental policies and destination operators to choose appropriate marketing strategies in order to adequately position a destination in the market.

Keywords: Marketing, Promotion, Nautical destination, Information.

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1. Introduction

At the roots of its development, nautical tourism was treated as entertainment for the privileged. Similarly, this particular form of tourism is still primarily available to specific categories of tourists with higher incomes. The last decade has evidenced an increase in the production of big nautical vessels - mega and super yachts. World records have often been broken in terms of yacht lengths, heights (the number of hulls), luxurious interiors, additional equipment and sailing performances. Nautical tourists are usually agile, ecologically responsible and tend to spend significantly more money on their vacations than average tourists [1].

The significance of the research is based on the fact that on the one hand, the search for information allows tourists to reduce the level of uncertainty and improve the quality of their trips, while on the other hand, from the offer holder's perspective, understanding the way the tourists get information is essential for marketing management decisions [2]. For that reason marketing research represents a fundamental activity of the creators of developmental policies that affects not only the image of a destination, but also the decisions of tourists when it comes to the choice of a destination.

In nautical tourism, word-of-mouth promotion, including the new form of eWOM, still has a significant impact in the overall information provision. On the contrary, traditional promotion tools more often represent only the initial step leading to digital platforms in the process of information gathering about a destination. Growing trends and the comprehensive presence of internet communication technologies in the process of defining sailing routes and choosing the final destination do not reduce the importance of the use of digital platforms during and after the stay at a destination.

The eastern Adriatic coast has a huge potential for the development of nautical tourism due to natural beauty as well as cultural and historical Mediterranean heritage. Croatia is a member of the EU and a state with a well-defined strategy for the development of nautical tourism. Since 2001, the Institute of Tourism in Zagreb has been following the characteristics of nautical demand through the research known as TOMAS Nautika [3]. Evident trends of this developing market motivate further activities of decision-makers and operators in marina business in Croatia. On the contrary, Montenegro still lacks the strategic documentation regarding nautical tourism that could define marketing policies of Montenegro as a destination.

Montenegro, although a country with a particularly long and internationally recognized maritime tradition, has only recorded a more notable development of nautical tourism capacities in the last fifteen years. Namely, from the moment of signing the contract on changing the purpose of the former military shipyard in Tivat into a modern marina with accompanying facilities, the expansion of the construction of reception facilities for nautical tourists on this part of the Adriatic coast begins. Retrospectively, the development of modern Montenegrin nautical tourism started only in 2007. Before that, the offer was only the Bar marina, which was never fully completed, and a certain number of customized moorings in the communal ports of Budva, Kotor, and Herceg Novi. Today, that offer has been improved with four new modern marinas with a capacity of over 1000 berths. New Montenegrin marinas win the most prestigious international awards regarding the quality and category of services they provide. TYHA - The Yacht Harbor Association, as part of the Gold Anchor program, checks the quality of services in marinas through various procedures (self-assessment and expert assessment), all to obtain a category certificate (which can have from 2 to 5 so-called gold anchors), rated Montenegrin marinas Porto Montenegro Tivat and Porto Novi Kumbor with a maximum of 5 gold anchors. Marina Porto Montenegro is the first superyacht marina in the world to be awarded the "Clean Marina" accreditation, also by TYHA [4]. This Montenegrin marina, along with marinas in the most prestigious destinations, such as Monaco, Capri, and Dubai, is ranked in the top 10 marinas in the world [5].

In addition to the visible improvement in the scope and quality of Montenegrin nautical tourism ports (marinas) on the ground, statistical indicators also confirm the development trends in question. In the period from 2007 to 2019, the number of foreign vessels intended for sport and leisure which sailed into Montenegrin territorial waters increased by more than 100% from 2145 to 4775, while the number of nautical tourists on those vessels in the observed period increased by more than of three times, from 9145 to 28562. The global crisis of 2020, caused by the Covid-19 epidemic, led to a sharp drop in the previous indicators; the number of vessels decreased by 61% to 1858, while the number of tourists on those vessels decreased by 74% to 7458. Quick recovery of the indicators followed already in 2021 when the arrival of 4176 vessels and 25123 nautical tourists on them was recorded [6-8]. Compared to the results achieved in the entire destination tourism industry, the decline caused by the crisis caused by the Covid-19 pandemic in nautical yachting tourism was significantly smaller. In contrast to 71% in the nautical sector, the drop in the total number of tourist arrivals in Montenegro in 2020 compared to 2019 was slightly higher than 83% [9].

The considerable increase in the number of visitors, concerning the double growth in the number of vessels, among other things, indicates an increase in the size and capacity of these vessels. In other words, the increasing presence of the so-called mega and super yachts and the elite segment of tourist demand. Compared to tourism in general, the smaller decline during the Covid-19 crisis indicates that Montenegro has successfully developed one of the selective forms of tourism that are more stable, i.e., less sensitive to external effects than tourism in general.

Therefore, the main motive for this research is the detection of differences between Montenegro and neighbouring Croatia in terms of information provision for the tourists. In that sense, the study investigates the following research question "In what ways do tourists obtain information about a particular destination?" The corresponding field research included 609 nautical tourists at the locations along Montenegrin coast between August and September 2021.

Based on the previous findings, the study initially assumes that the tourists visiting Montenegro and Croatia obtain information in a similar way, which means that the increased presence of the internet in marketing strategies should be common for both destinations. Finally, the research hypothesizes that: Despite the growth of the importance of the internet in information provision for nautical tourists, the information based on previous experience still has a dominant influence on the tourists who choose the destinations in the Eastern Adriatic.

The increased competitiveness of nautical tourism industry requires the profound understanding of market demand as well as destination management [10]. However, as a nautical tourism destination, Montenegro still needs to adopt strategic documents in this field. Developmental policies are mainly created by individual stakeholders without consideration of the importance of destination product integration. Clearly defined tourist policies determine the developmental path for a given destination and create a place which tourists will desire in the future [11].

In that sense the study aims to:

- research the basic characteristics of the demand in nautical tourism in the Eastern Adriatic;
- compare the ways the tourists obtain information about Montenegro and Croatia when selecting them as destinations;
- detect the dominant ways of information provision for the tourists visiting these neighbouring countries in order to define marketing communication and rationally invest in the information channels that are available and transparent for the majority of tourists.

A practical contribution of the paper would be the creation of tourism policies and planning documents concerning the marketing management of the destinations as nautical tourism products.

2. Literature review

Most of the studies in the field of nautical tourism have focused on the impact of yachting on the living environment, while the issue of marketing needs to be addressed more [12]. Due to the marked fragmentation and geographical dispersion, sailors represent a demanding demand segment in traditional mass communication tools [13]. Information sources for tourism activities have significantly changed over the past twenty years, mainly due to the impact of new technologies [14]. Several studies have focused on the relationship between information sources and destination selection [15]. Also, many studies examined the information sources for decision-making [16]. Destination image has been recognized as a significant factor influencing destination choice, and many contemporary studies confirm the importance of social media [14].

From the beginning of the development of computer reservation systems CRS in the 1960s, through the development of global distribution systems GDS in the 1980s and the advent of the Internet in the early 1990s, information technologies, as opportunities but also as challenges, have had a dramatic impact on changes in the travel industry [17]. Improving the design and physical availability of portable - mobile devices, such as smartphones and tablets, along with the application of modern software that connects these devices to the vessel's control systems, brings a high degree of digitalization to all aspects of the destination offers. A large number of commercial and free mobile applications on Google Play, App Store, and related platforms help nautical tourists in activities such as finding and reserving berths in marinas or commercial anchorages, then places in restaurants, delivery - catering of food up to seeing regularly updated weather forecast and sea depth on navigation routes.

On the other hand, there are still many websites on the side of destination nautical tourism offers that could be more visible on search engines, with support for mobile Android and iOS operating systems, outdated information, and appropriate translation of content into foreign languages.

The use of the internet in the information provision for nautical tourists shows an increasing tendency. Internet technologies are used in the pre-consumption phase to obtain the information needed for travel planning, evaluation, and comparison, formulate clear expectations to choose between alternatives and continue communication with the offer holders to ensure the preparation and/or execution of the purchase transaction. In the course of consumption, the role of the Internet is related mainly to obtaining more detailed information about a place at a given moment. While in the post-consumption phase, internet technologies are used to share, document, and revive tourist experiences through online announcements and establish/maintain communication with representatives of visited places and attractions in the context of preparing future arrangements [18]. There are several methods of the wider utilization of the internet in information provision by means of websites, mobile applications, social networks and specialized groups [18].

The former word-of-mouth communication among boaters is now gaining expanded meaning and action through so-called "eWOM" (electronic word-of-mouth) and the impact it has on attitudes, perceptions, intentions, and choices of future sailing routes and destinations [17].

Traditional sources of information still represent official resources and the basis for decision making regarding the choice and image of a destination [15]. However, the funds should be carefully invested in traditional information sources with precise observation of the application of information and communication technologies in this specific field of marketing.

3. Materials and methods

There is an observed lack of literature regarding the motives, satisfaction, decision making process and loyalty of the nautical tourists who visit eastern Adriatic countries, especially Montenegro. This study relies on the famous analysis known as cross-tabulation because the research included categorical variables or data, e.g. information about Montenegrin and Croatian groups of nautical tourists who chose these two destinations in different ways.

Generally, the categorical variables represent the input for future studies on the creation of strategic documents in the field of nautical industry and the studies on the definition of general marketing strategies for the unique Adriatic Region. The relationships between the data groups were also separately examined. Namely, secondary research was conducted in order to identify data about Croatian nautical tourists for the period between 2012 and 2017. The primary research concerning Montenegro was subsequently conducted in 2021. The characteristics defined included the age, gender and educational background of the respondents. The answers of the respondents to the research question "In what ways do tourists obtain information about a particular destination?" along with the predefined characteristics were both subjected to cross-tabulation.

This paper examines the most important sources of information for nautical tourists: 1) previous stay experience, 2) the internet, 3) recommendations from relatives or friends, 4) radio, television, film, or video, 5) tourist fairs and exhibitions, 6) brochures, advertisements, posters, and 7) articles in newspapers or magazines.

Using the example of Montenegro and Croatia, today one of the most wanted nautical tourism destinations globally [19], marketing trends in informing nautical tourists when choosing the Eastern Adriatic destination in 2012, 2017, and 2021 are presented.

As previously stated the initial idea for carrying out this research was derived from the research on the attitudes of nautical tourists in neighbouring Croatia-TOMAS NAUTIKA, conducted by the Zagreb Institute of Tourism from 2001 [3].

4. Results

When it comes to the profile of nautical tourists visiting Montenegro, this research showed the age structure of respondents as follows: 46-60 years (30.5%), 26-35 years (24.1%), 36-45 years (22.7%), and younger than 25 years (4.9%) (Figure 1). Among the respondents, there were significantly more males (74.9%), which is not unique to Montenegro. However, a similar trend was observed in research on the characteristics of nautical tourists in other destinations. The vast majority of respondents graduated from university (79.8%), of which 27.6% have a master's degree, and 4.9% have a Ph.D.

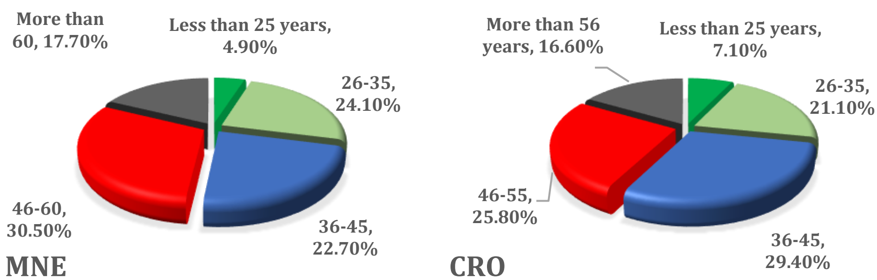

Fig. 1 - *Age structure of nautical tourists in Montenegro (2021) and Croatia (2017)* [20].

The age structure of nautical tourists in Croatia is like that in Montenegro. More than half are between 26 and 55 years, with the largest category being nautical tourists aged 36 to 45 (29.4%), followed by the age category of 46 to 55 (25.8%). Like in Montenegro, the smallest participation was recorded of the youngest nautical tourists under 25 (7.1%) (Figure 1).

During the research conducted in the Croatian part of the Adriatic in 2017, 50.6% of the respondents had a university education [20].

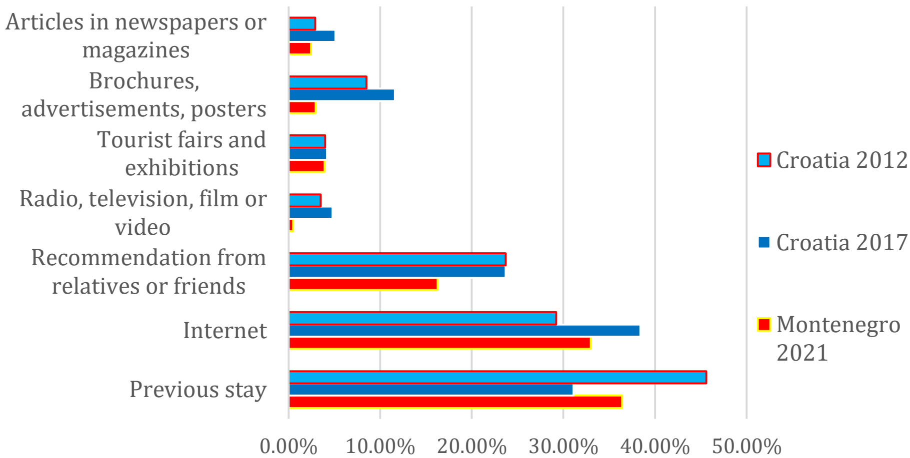

Fig. 2 - *Marketing sources of information about nautical destinations Montenegro and Croatia* [20, 21].

The results of the survey conducted for Montenegro in 2021 show that the previous stay as a motive for choosing a destination had the largest share in the overall structure of information sources (36.45%). As shown in Figure 2, information about the destination obtained via the Internet had a share of 33%, followed by recommendations from friends and relatives (16.26%). Mainly, tourist fairs and exhibitions, as well as brochures, posters, and articles in newspapers or magazines, were used by less than 5% of nautical tourists visiting Montenegro (Figure 2).

Finally, other sources of information, such as radio, television, film, or videos, have very little influence on respondents in choosing Montenegro as a nautical destination (below 0.5%).

Marketing sources of information in Croatia have been monitored since 2004, while the previous research was done in 2017. Figure 2 shows that in Croatia and Montenegro, there is a growing trend of using the Internet to inform nautical tourists when choosing a destination. Other sources of information also show the same trend of changes during the past ten years.

The results obtained through cross-tabulation indicate that in relation to gender, male participants ranked the previous stay as the main source of information (39.4%), which was followed by the internet sources (28.2%). For female respondents, the internet had primary importance (43.1%), which was followed by the previous stay (25.4%), recommendations from friends (19.6%) and articles in magazines (3.9%). Interestingly, in the case of male participants the fourth place was occupied by fairs and exhibitions (4.6%).

Table 1 - *The cross-tab analysis of the characteristics of nautical tourists visiting Montenegro and their ways of obtaining information.*

Characteristics of nautical tourists/ Manner of inform.	**Gender**		**Age**					**Education**					
	Male %	Ladies %	Less than 25 years %	26 to 35 years %	36 to 45 years %	46 to 60 years %	More than 60 years %	Elem. school or lower %	High Sch. %	Fac. or Coll. %	Mas. %	PhD %
Previous stay	39.4	25.4	40	38.7	30.4	27.4	52.7	100	47.5	31.2	32.1	50
Internet	28.2	43.1	50	24.4	39.1	35.4	22.2	0	32.5	28.1	44.6	0
Radio, television, film or video	0.0	1.9	0	0	2.1	0	0	0	0	0	1.7	0
Tourist fairs and exhibitions	4.6	1.9	10	6.1	0	3.2	5.5	0	0	7.2	1.7	0
Brochures, advertisements, posters	3.2	1.9	0	2.0	0	4.8	5.5	0	0	1.0	5.3	20
Articles in newspapers or magazines	1.9	3.9	0	6.1	2.1	0	2.7	0	0	1.0	5.3	10
Recommendation from relatives or friends	15.1	19.6	0	16.3	15.2	22.5	11.1	0	10	26.0	3.5	20
Other	6.5	1.9	0	6.1	10.8	4.8	0	0	10	5.2	3.5	0
N/A	0.6	0	0	0	0	1.6	0	0	0	0	1.7	0

Source: The results of the primary research

From the age perspective, the tourists under 25 mostly gathered information about a destination from the internet (50%), while among the respondents aged between 25 and 36 previous stay (38.7%) was dominant over the internet (24.4%). The internet retained a dominant position among the participants aged between 36 and 45 (39.4%) as well as among the participants whose age varied between 46 and 60 (35.4%). Finally, the tourists older than 60 highly ranked experiential information about a destination - the previous stay (52.7%) - and then the internet (22.2%) and the recommendations from friends (11.1%).

Just three participants finished elementary school only, and they chose Montenegro as a destination based on their friends' recommendations. The tourists with secondary education highly ranked the previous stay (47.5%), while the internet was assigned secondary importance (32.5%). For the tourists with university education, the previous stay also had the utmost importance (32.2%), while there was a small difference in the importance of the internet (28.1%) and the recommendations from friends (26%). The respondents with master degrees dominantly used the internet (44.6%). Interestingly, the respondents with the highest level of education valued previous experience most i.e. fifteen respondents (out of total 609 respondents) had PhD degrees and 50% of them reported that the information based on their previous stay was the most significant for their selection of a destination.

The example of the destination of Montenegro confirms that the internet is mostly used by the tourists under the age of 25, while the importance of the previous experience increases with the age of respondents. Furthermore, the internet is proven to be a more popular source of information among female tourists compared with male ones. The use of the internet for information gathering increases with the level of education. However, for the tourists with the highest level of education, previous experience again plays the most important role.

5. Discussion

Analysing the age structure of boaters on the East Coast of the Adriatic, we found that the trends are similar to those among boaters at the level of the European Union, where the average age of this category of tourists is moving from 45 to 55 years [22]. Most respondents in Montenegro and Croatia had a university education. The age and educational structure of boaters fit into the thesis that Montenegro and Croatia are successfully developing this elite tourism sector in the function of the future establishment of sustainable businesses and economy [23].

The dominant source of information in choosing both destinations is the previous stay. These are the so-called experiential sources of information the tourist has obtained through personal experience using tourist products or services [24]. According to data from the literature and various studies, the high participation of returnees, in this case, nautical tourists with previous experience in Montenegro (36.4%) and Croatia (31.1%) (Figure 1), suggests that their expectations are from the destination met and/or exceeded [25].

This validates the initial hypothesis that despite the increased use of the internet as a source of information for nautical tourists in the Eastern Adriatic, the information based on previous stay still dominantly affects the choice of a destination.

As a source of information when choosing a destination, the Internet ranks second in terms of participation among nautical tourists on the Eastern Adriatic. Thanks to earlier research, trends for Croatia can be followed for the period from 2004 to 2017, when that share doubled from 19% to 38.4% [20, 26]. According to the results of our survey of boaters' attitudes, 33% of them chose Montenegro as their destination in 2021 using the Internet.

Considering the difficult economic conditions of business and the growth of competition, the creators of online marketing communication strategies have an increasing challenge of adapting to the expanded spectrum of potential clients in the desire to meet their changing expectations. Although websites, thanks to their ability to reach a wide range of international audiences through customizable content, are the primary communication tool, evaluating their impact from the perspective of nautical tourist ports and destinations still needs to be researched [27].

It is no longer enough to advertise that your destination is unique and the best place for a cruise. Boaters today expect to receive additional information through your presentation or mobile application, such as weather conditions, sailing instructions, available capacities in marinas, online booking, service capacities in the vicinity, entertainment, and other additional offers in the marina and surroundings. The use of mobile devices (smartphones, tablets) with an increasing number of specialized mobile applications further complicates the communication process in this sense. Modern devices such as VR for reproducing virtual reality are another tool that provides an opportunity to promote the essential attributes of the destination offers. Internet social networks and specialized groups have a specific role in this segment.

In the nautical world, the recommendation of other sailors, captains, and agents is fundamental due to the complexity of sailing [28]. The results of our research finally confirm this. In Montenegro (16.2%) and Croatia (23.7%), boaters cite a friend's recommendation as a way of choosing a destination, which ranks this source of information about the destination among the three most important.

Traditional sources of information, starting from articles in specialized yachting and other magazines, specially prepared advertising brochures, yachting-marina directories, and guides, then TV and radio broadcasts and advertisements up to performances at specialized nautical and tourism fairs, continue to play a significant role in the promotion and choice of destination. As part of our survey conducted in Montenegro in 2021, 10% of them mentioned some traditional sources as a way of information in choosing a destination.

Finally, the habit of a certain number of sailors to begin the process of information about their future destination with the help of traditional communication tools (specialized magazines, port directories, fairs, etc.), has been improved through integration - connecting with Internet communication technologies using the presented links and QR codes that lead to destination web presentations and mobile applications [28].

In that regard, it can be concluded that the study additionally confirms the previous findings that Montenegro lacks the strategic documents that would define the direction of the development of nautical tourism at a destination level [29]. The results obtained could, therefore, be used for the preparation of strategic documentation related to marketing communication.

6. Conclusions

The paper shows that the sources of information are valuable for the understanding of the selection of nautical destinations, whereby the initially defined aims of the research were reached respectively.

Firstly, the research defined the basic characteristics of the tourists who visit the Eastern Adriatic. The cross-tabulation of the data obtained from the responses categorized by the characteristics of respondents, indicated that there are not significant specificities that would facilitate the differentiation of efficient communication models through the application of marketing segmentation strategies. Considering the age and education structure, we conclude that there is no longer a generational gap in terms of familiarity with new digital technologies among nautical tourists. Bearing in mind the results of the subject research, which unequivocally indicate the growth of the importance of internet communication technologies in creating destination marketing strategies, it is necessary to ensure continuous evaluation and harmonization of digital communication channels of individual offer holders. By integrating through the connection of different segments of the offer by applying appropriate algorithmic schemes, an opportunity is created to improve the competitive position and strengthen the brand of Montenegro as a nautical tourist destination.

Secondly, the study compared the sources of information for the tourists who visit Montenegro and Croatia and answered the research question. A similar trend was observed in both destinations - a dominant source of information in both destinations is the previous experience. The internet is increasingly popular and highly ranked along with traditional sources of information such as recommendations from friends, exhibitions and fairs that still play an important role. Such findings confirm the initial hypothesis that the internet is increasingly important in modern marketing of nautical destinations such as Montenegro and Croatia. However, “adjusted” traditional sources of information retained their significance when it comes to the selection of a destination. The research hence confirmed the initial hypothesis, previous stay plays an important role when it comes to the choice of a destination. For that reason, decision makers should pay more attention to the satisfaction of tourists when defining marketing communication, during and after the stay of the tourists in order to enable rational investments in the resources that are available and transparent for the majority of the tourists.

Further research should focus on the detection of the reasons which render the previous stay a dominant source of information for the tourists who choose to visit the Eastern Adriatic. Based on the observed tourist satisfaction, the future research should also identify the strategic aspects of a destination that should be more developed. In relation to the increasing use of the internet, further research could investigate the digital marketing tools that are used for the information provision for nautical tourists, which would consequently provide a scientific basis for the enhancement and application of the tools examined.

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Review paper

The New Italian Exclusive Economic Zone and Italy-Montenegro Maritime Boundary Delimitation*

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Abstract: The paper examines the newly proclaimed Italian Exclusive Economic Zone and its impact on the delimitation of the maritime boundaries between Italy and Montenegro. By Law No. 91 of 14 June 2021, published in the Official Journal No. 148 of 23 June 2021, the Italian Parliament proclaimed its Exclusive Economic Zone (EEZ), to allow Italy to fully project its economic rights over an area of the sea extending up to 200 miles from its shores or up to the limit allowed by international law. In line with the trend of progressive extension of the jurisdiction of coastal states in waters beyond their territorial sea in the Mediterranean, this measure is taken in compliance with the United Nations Convention on the Law of the Sea (UNCLOS) to allow the country to protect its economic activities, and biodiversity protection. Anyway, even if the law authorizes the EEZ establishment, a further ad hoc measure is required to this aim. Its delimitation will take place primarily based on agreements: Italy is supposed to negotiate new agreements with the neighboring Countries, including Montenegro, in order to define its boundaries.

Keywords: Exclusive Economic Zone, Maritime boundary, Maritime delimitation, Neighborhood relations.

1. Introduction

On 14th June 2021, the Italian President of the Republic promulgated the Law No. 91, passed by the Parliament, concerning the establishment of an Exclusive Economic Zone (EEZ) beyond the outer limit of the territorial sea [1].

Recalling the United Nations Convention on the Law of the Sea (hereinafter UNCLOS) done in Montego Bay on 10 December 1982 [2] and

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ratified by Italy by Law No. 689, of 2nd December1994 [3], the Parliament authorizes the establishment of an Exclusive Economic Zone until the outer limits to be determined on the basis of international agreements [4] to be negotiated with the neighbour countries.

The EEZ will be then established by decree of the President of the Republic, as to include all or part of the waters surrounding the outer border of the territorial sea, following a deliberation of the Council of the Ministers upon the proposal the Ministry of Foreign Affairs and International Cooperation, to be notified to all the States whose adjacent to the Italian territory or is facing it [5].

Until the entry of force of the aforementioned agreements, the outer limits of the Italian EEZ are established, so as not to compromise the final agreement.

Articles 2 and 3 of the Law are related respectively to the rights of Italy and third States within the newly established EEZ.

According to Article 2 Italy will exercise all the sovereign rights granted by existing international norms [6].

According to Article 3, the exercise of all the rights of third States arising from general and treaty law are not compromised. So the freedom of navigation and overflight and of the laying of submarine cables and pipelines [7], and all the rights arising from international law norms in force.

2. Exclusive Economic Zone (EEZ)

According to UNCLOS [8], the Exclusive Economic Zone is an area beyond and adjacent to the territorial sea, where the coastal has sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the seabed and of the seabed and its subsoil, and regarding other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds. Marine scientific research, the protection and preservation of the marine environment, the establishment and use of artificial islands, installations and structures also fall within the jurisdiction of the State.

"The Exclusive Economic Zone shall not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured" (UNCLOS Article 57).

The EEZ is an area where the coastal State is entitled to exercise a set of specific activities, assuming they have complied with the related UNCLOS procedures.

Once the EEZ is established, the State has the rights for exploiting, exploring, conserving and managing living and non-living resources of the water column and the underlying seabed [9]. So in this case the seabed is subject to legal regime of the EEZ [10].

Looking at the definitions given by UNCLOS, there are some similarities and differences of the EEZ compared to other maritime zones.

In contrast to territorial seas, that are subject to the exclusive jurisdiction of the coastal States, except for the passage rights of other States, including innocent passage through the territorial sea, the EEZ is an area where the State can just exercise a limited set of rights [11]. All the States are entitled to exercise all the other rights, including freedom of navigation. Unlike the territorial sea, the EEZ only allows for the previously mentioned set of rights and the related law enforcement capacity to protect them.

Then, similarly to the Contiguous Zone, EEZ has to be formally proclaimed by the State. In the Contiguous Zone, the State has the right to "prevent infringement of its customs, fiscal, immigration or sanitary laws and regulations within its territory or territorial sea" and "punish infringement of the above laws and regulations committed within its territory or territorial sea" (UNCLOS Article 33).

In general terms, the Italian perspective about the EEZ was set forth in a declaration issued when signing and ratifying UNCLOS. In its view, according to the Convention, the coastal state does not enjoy residual rights in the Exclusive Economic Zone. In particular, the rights and jurisdiction of the coastal state in such zones do not include the right to obtain notification on military exercises or manoeuvres or to authorize them, so that none of the provisions of the Convention, can be regarded as entitling the coastal state to make innocent passage of particular categories of foreign ships dependent on prior consent or notification [12]. Such rule is deemed as correspondent to customary international law [13].

As noticed by some Observers, "the EEZ regime - as affirmed by the ICJ in the 1985 *Libya/Malta Continental Shelf* case- had become part of customary international law in the late 1970s when the UNCLOS was still being negotiated" [14].

The Italian Law No. 91 of 14 June 2021 looks like in line with international law. In its text, several references are made to it. Both treaty law and customary law norms are referred to.

The new Law is related only to the establishment of an EEZ, so it is in line with the general trend of extension of maritime jurisdictional waters in the Mediterranean area, also with the aim of exploiting its resources in an exclusive way [15]. It has been a missed opportunity to approach in a systematic way the Italian maritime areas and formally establish also an Italian Contiguous Zone. In fact, regarding the latter, there is a certain ambiguity, due to some references occasionally made to it in the framework of the Italian legislation and in the case-law even if it has never been officially proclaimed [16].

The key issue mentioned in the legislative text is the identification of the boundaries. The negotiation of international agreements is required to identify them. This is perfectly in line with the duty of cooperation provided for in the framework of the Montego Bay Convention, especially as regards semi-enclosed seas, such as the Mediterranean or the Adriatic Sea. Such boundaries could be of interest of other states having proclaimed their EEZ or also other states, bearing in mind the increasing trend to take into account a single maritime boundary [17] for the determination of the border.

3. The situation in the Mediterranean Sea and the recent extension of maritime jurisdictional areas

Until the end of last century there were not so many EEZ in the Mediterranean area. For a long time, Italy's approach was that to preserve the freedom of navigation in the Mediterranean and the related maritime mobility of naval forces and refrain from establishing maritime zones of functional jurisdiction [18].

The rationale behind such a position was to avoid the establishment of a legal regime restricting the freedom of navigation in both the territorial waters and the EEZ in various ways, such as the request of prior notification of innocent passage in territorial waters [19].

It has been observed that such a position discouraged other Mediterranean countries from declaring Exclusive Economic Zones for a long time [20].

Nevertheless, some countries lawfully proclaimed in a unilateral way some *sui generis* zones, such as "fishing protection zone" (FPZ) [21], "fishing reserved zone" (FRZ) [22], ecological and fishing protection zone (EFPZ) [23] or ecological protection zone (EPZ) [24].

By Law No. 61 of 8 February 2006, Italy proclaimed its own ecological protection zone, establishing it only in the Tyrrhenian Sea. A correspondent EPZ has not yet been established in the Adriatic Sea [25]. Slovenia established both a fishing protection zone and an ecological protection zone in the Adriatic [26].

In such areas, the legal regime of EEZ is partially applied, just in relation to the specific activity to which the establishment of the area is related. Some of these zones were converted in EEZs at a later stage [27].

In recent years, several Mediterranean countries established their EEZ [28]. The rationale behind such practice is mainly related to an economic interest and the will of the States to extend their maritime jurisdictional waters to exploit their resources or also for security reasons [29].

Such proliferation of maritime jurisdictional zones has been described as a territorialisation [30] of such a sea basin. The States are extending more and more their rights, taking a large part of sea surface waters out of the legal regime of the high seas.

Such a trend was also encouraged by the European Commission, according to which the establishment of maritime zones in the Mediterranean, and especially Exclusive Economic Zones (EEZs), would promote blue growth in the European Union and contribute to achieving other, more far-reaching objectives in sustainable development [31].

In the view of the EU, the establishment of maritime jurisdictional could be useful also in the fight against illegal, unreported and unregulated (IUU) fishing [32].

In the view of the Commission costs and benefits of establishing maritime zones in the Mediterranean were analysed as well as the impacts of establishing EEZs on different sea-based activities, including a more effective spatial planning policy, which in turn could help attract investments and further economic activities. Even if the proclamation and establishment of maritime zones and namely of EEZs remains the sovereign right of each coastal State on the basis of UNCLOS, the EU takes responsibility to ensure that the right conditions are in place for the blue economy to flourish.

The Commission calls upon the establishment of EEZs in the Mediterranean, bearing in mind that in the sea-basins, coastal states have a responsibility to regulate human activities and to further develop their blue economy in a sustainable manner. So, a proper economic development is better favoured in areas within the jurisdiction or sovereignty of coastal States. On the contrary an uncertain regulatory framework implies that large marine areas remain unprotected as far as living aquatic resources and the marine environment are concerned.

"The coverage of a greater portion of the Mediterranean Sea under the jurisdiction of the EU Member States would ensure that in such areas, EU regulations concerning fisheries, environment and transport would apply and a higher level of protection would follow" [33].

One of the core issues in this context is the delimitation of maritime zones in the Mediterranean, due to its geographical characteristics.

It is not only a narrow area but the presence of hundreds of islands is a factor which constitutes one of the most difficult considerations in the delimitation of maritime areas.

The majority of the delimitation treaties in this region "are based on the criterion of equidistance or a median line, modified to take into consideration the presence of island or the curvature of the coastline" [34].

In the case of Exclusive Economic Zones between states with opposite or adjacent coasts, a delimitation is effected by agreement on the basis of international law in order to achieve an equitable solution, according to UNCLOS Article 74.

Pending such agreement, "the States concerned, in a spirit of understanding and cooperation, shall make every effort to enter into provisional arrangements of a practical nature and, during this transitional period, not to jeopardize or hamper the reaching of the final agreement. Such arrangements shall be without prejudice to the final delimitation" [35].

After the entry into force of the aforementioned agreement, its provisions will determine all the questions relating to the delimitation of the Exclusive Economic Zone between the concerned states. If no agreement is reached within a reasonable period, the States may resort to the procedures provided for in UNCLOS Part XV.

In a semi-enclosed sea as the Mediterranean, it is unavoidable to negotiate such agreements in order to avoid the overlapping of different EEZs, due to the space constraints. The establishment of an EEZ in its maximum extension in the Mediterranean region is prevented by its geographical characteristics, as there is a distance of less than 400 nm from opposite coasts [36].

From a legal point of view, it can be described as a "semi-enclosed sea" that is a sea surrounded by two or more states and connected to another sea by a narrow outlet. According to Article 123 UNCLOS, "its coastal states should cooperate with each other in the exercise of their respective rights and to refrain from unilateral initiatives in various domains" [37].

Furthermore, Mediterranean countries represent an interconnected community as far as political and economic relations are concerned, so that agreed solutions look like preferable to unilateral solution both form a legal and a political point of view [38].

In such a context, cooperating and negotiating the relevant agreements is even necessary in order to determine the extension of any EEZ, without prejudicing the prerogatives of adjacent or opposite coastal states.

The Italian Law made reference to the negotiation of such agreements to establish the EEZ and determine its outer limit accordingly.

3.1. "Jurisdictionalisation" of the Mediterranean Sea: the current situation

Currently, many Mediterranean States have established their EEZs.

Spain first established a fishing protection zone [39] by the royal decree of 10 August 1997. In 1998, France contested such initiative due to the fact that the line delimiting the edge of the Spanish fisheries zone facing the French coasts was not agreed with the French government. So, this was in contrast with international law of the sea, because the delimitation of a boundary should take place by agreement. Moreover, in case of a maritime boundary, such delimitation must result in an equitable solution. Such fishing protection zone was then converted into an EEZ in 2013 by royal decree No. 236 of 5 April 2013. The EEZ outer limit is the same as the fishing protection zone.

France first established an environment protection zone by Law No. 346-2003 in proximity to the coast of the lion gulf and of Corsica. The boundary was initially determined unilaterally in 2004 [40] and was partially overlapping the Spanish fishing protection zone. Then France converted its fishing protection zone into an EEZ by decree No. 2012-1148 of 12 October 2012 [41].

Spain contested the outer limits of the French EEZ in so far as it is overlapping with its own EEZ [42].

According to Spain, the principle of equidistance "would be the most just and equitable solution" for the delimitation [43]. On the contrary, according to France, a solution can be found only through an agreement [44].

In so far as the borders with Italy are concerned, on 21 March 2015, Italy and France signed the Agreement on the delimitation of the territorial waters and the other areas under national jurisdiction such as the continental shelf and the Exclusive Economic Zone, not yet entered into force [45].

The Agreement defines the maritime frontiers of all the maritime spaces of the two countries, endorsing the practice of a "single maritime boundary" [46]. The parties applied the equitable delimitation principle, in respect to both the delimitation of the continental shelf and the waters under their respective national jurisdiction, encompassing both the French EEZ and the Italian EPZ established with different purposes and regimes on the two sides of the boundary [47].

Greece has not yet established an EEZ. Nevertheless, it seems to be favourable to the establishment of an EEZ [48] in the Ionian Sea, south of Crete, north of Egypt and east of Cyprus. To this aim, Greece promoted an agreement with Italy for the delimitation of their respective EEZ. It was signed on 9th June 2020 [49]. This agreement will be effective when both states have established their respective EEZ. The agreed delimitation is correspondent to that of their continental shelves, based on an agreement of 1977 [50].

The Greek EEZ would need to be delimited also as regards Cyprus, Turkey, Egypt and Libya. For the delimitation of a maritime boundary with Albania, a dispute is pending before the International Criminal Court (ICC)[51].

The Turkish EEZ is enclosed along the Northern Greek coast.

As far as Cyprus is concerned, there is an agreement in force between this State and Egypt about the delimitation of their respective EEZ [52]. The same border has been adopted for both the EEZ and the continental shelf. This agreement was contested by Turkey as it claims to be the neighbouring State of Egypt. The Republic of Cyprus stipulated also another agreement with Lebanon to define the EEZ border in 2007 [53], but Lebanon did not ratify it due to some concern in relation to the triple point [54] with Israel. Lebanon and Israel have recently signed an agreement for the delimitation of the respective EEZ [55].

In 2010, a single maritime boundary for the EEZ and the continental shelf was also agreed between the Republic of Cyprus and Israel [56].

Of course, in the view of the Republic of Cyprus, the EEZ surrounding the Turkish Republic of Northern Cyprus is considered belonging to itself, as the latter is not recognised.

In the middle of the Central Mediterranean area, Malta started the process to declare an Exclusive Economic Zone in the central Mediterranean, to huge its economic potential [57].

Currently its fisheries zone, extends to 25 miles while the EEZ could potentially be much wider [58].

During the debate of the Parliament, it was pointed out that the conflicting claims of other countries should be taken into account in the process of establishing an EEZ. It was stressed the need for Malta to have the capacity to monitor the areas under its responsibilities, especially as regards to the environmental protection.

Turkey is not a contracting party of UNCLOS. Nevertheless, it established an EEZ along the coast of the Black Sea, based on agreements with Georgia, Russia and Ukraine, claiming that the establishment of an EEZ is also arising from customary international law [59].

As far as the Mediterranean coast is concerned, there is a recent Memorandum for the delimitation of the EEZ between Turkey and Libya of 27 November 2019 [60], according to which, the boundaries of the Continental Shelf and the Exclusive Economic Zone in the Mediterranean between the Republic of Turkey and the Government of National Accord-State of Libya are defined. The departing point of the delimitation is an agreed equidistance line. In this case, too, there is the provision of a single maritime boundary for the EEZ and the continental shelf.

The delimitation between the two States does not take into account the presence of the Greek isles of Kastellorizo and Rodhes nor gives effect to the eastern coast of Crete.

So Greece, Cyprus and Egypt contested such agreement, claiming that it does not take into account their rights so that it is null and void [61].

The Government of National Accord-State of Libya deposited an Explanatory Note at the United Nations, to support the validity of such accord, and Turkey sent a letter to the UN as well clarifying that in its [62]:

- islands cannot have a cut-off effect on the coastal projection of Turkey, the country with the longest continental coastline in Eastern Mediterranean;
- the islands which lie on the wrong side of the median line between two mainlands cannot create maritime jurisdiction areas beyond their territorial waters; and
- the length and direction of the coasts should be taken into account in delineating maritime jurisdiction areas.

As it has been noticed [63], Turkey supports the position according to which it is the neighbouring State of Egypt and Libya due to the Southern Anatolia coast. So in its view the agreement of delimitation of 2003 between Libya and Egypt would be null and void. Furthermore, from the Turkish perspective, the Greek claims concerning its isles in relation to the delimitation of the border among Libya, Egypt and Cyprus would be ill founded. Turkey seems to be keen to find an equitable solution for the delimitation of the borders.

Egypt was one of the first Mediterranean State to declare to be favourable to the establishment of an EEZ in the Mediterranean.

The Arab Republic of Egypt and the Republic of Cyprus signed an agreement on the Delimitation of the Exclusive Economic Zone on 17 February 2003 [64]. According to such agreement the delimitation of the Exclusive Economic Zone between the two Parties "is effected by the median line of which every point is equidistant from the nearest point on the baseline of the two Parties" (Article 1) [65]. It is a single maritime boundary for the EEZ and the continental shelf.

The parties agree that taking into consideration UNCLOS article 74, the geographical coordinates of the median line could be reviewed and/or extended as necessary in the light of future delimitation of the Exclusive Economic Zone with other concerned neighbouring States and in accordance with an agreement to be reached in this matter by the neighbouring States concerned.

As mentioned, the aforementioned median line is not accepted by Turkey, because, due to the Southern Anatolia Coast, it considers itself as a neighbouring country of Egypt [66].

At the same time, Egypt argues that the agreement between Turkey and Libya of 2019 is null and void. It also contests the proclamation of maritime areas of jurisdiction made by Palestine as far as the boundaries mentioned in it are concerned [67].

The border of the EEZ between Egypt and Greece was delimited by an agreement of 4th August 2020 [68]. It is a partial delimitation agreement as it does not regard the triple point with Cyprus [69]. In the delimitation of the maritime boundary the Parties decided to give full effect to the isles of Rodhes, Karpatos and Crete. As a consequence, their EEZ is overlapping the Turkish-Libyan EEZ.

Israel signed a maritime boundary delimitation agreement with Cyprus in 2010, making reference to a single median line, used as a term of reference also for the underlying soil and subsoil of the continental shelf.

The maritime boundary between Israel and Lebanon [70] is still undefined [71]. A dispute arose between the two states in this regard [72], especially in relation to the lateral borders of the respective EEZ. On one side, Israel individuates the border in a line perpendicular to the coast, on the other according to Lebanon the border is a prolongation of the blue line of 2000.

Furthermore, Palestine made a proclamation concerning its own EEZ on24 September 2019, to compete with them in the exploitation of the natural resources of the area. Israel denies any validity to such proclamation

[73], as it does not recognise the Palestine as a sovereign State, while it recognizes the maritime activity zone (MAZ) established off the coast of Gaza by the Oslo agreements [74].

Lebanon proclaimed an EEZ and unilaterally defined its boundaries by decree 6433-2011 [75]. Such a decree was contested by Syria, that established its own EEZ by law No. 28 of 19 November 2003 [76], that lies beyond the territorial sea and includes the entire Contiguous Zone, extending in the direction of the high seas for a distance of not more than 200 nautical miles measured from the baselines, subject to the provisions of international law [77].

Tunisia established its own EEZ by Act No. 2005-50 of 27 June 2005 [78]. It states that, when necessary, the outer boundaries shall be determined by agreement with the concerned neighbouring States.

As far as Libya is concerned, it proclaimed first a protected fishing zone in 2005 and then an EEZ in 2009 [79] "adjacent to and extending as far beyond its territorial waters as permitted under international law. If necessary, the outer limits of this zone shall be established together with neighbouring States in accordance with instruments concluded on the basis of international law". As mentioned above, a maritime boundary delimitation agreement was stipulated between Libya and Turkey.

Algeria proclaimed an Exclusive Economic Zone by decree in 2018 [80]. The outer boundary was not negotiated with neighbouring countries and namely with Italy, so it partially overlaps the Italian ecological protection zone (EPZ) established in 2011 [81]. It is also overlapping the Spanish EEZ [82].

Both Spain and Italy contested the Algerian Proclamation of an EEZ [83]. According to Spain, the equidistant line between the baselines from which the breadth of the territorial sea is measured is the most equitable solution for delimiting, by mutual agreement, the Exclusive Economic Zones between States with opposite or adjacent coasts, as established in article 74 of the United Nations Convention on the Law of the Sea. So it "indicates its willingness to enter into negotiations with the Government of Algeria with a view to reaching a mutually acceptable agreement on the outer limits of their respective Exclusive Economic Zones", in accordance with article 74 of the Convention on the Law of the Sea.

According to Italy, the Algerian EEZ, as indicated by the abovementioned Decree, unduly overlaps on zones of legitimate and exclusive national Italian interest. So the Italian Government expresses its opposition and reiterates that, in accordance with Article 74 of the United Nations Convention on the Law of the Sea, the delimitation of the Exclusive Economic Zone shall be effected by agreement to achieve an equitable solution. Therefore, the Italian Government expresses its readiness to negotiate on the issue.

It recalls that pending agreement, the concerned States will act in good faith.

In turn, Algeria contested the Spanish EEZ [84], claiming that "the unilateral delimitation effected by Spain is not in conformity with the text of the United Nations Convention on the Law of the Sea and did not take into account the geography, the particularities and the special circumstances of the Mediterranean Sea, particularly as they concern our two countries, whose coasts face each other" [85]. It also contests that it did not "take into account the objective rules and relevant principles of international law that must govern the equitable delimitation of maritime spaces between Algeria and Spain, in accordance with article 74 of the United Nations Convention on the Law of the Sea. The Algerian Government expresses its opposition to the delineation of the outer limits of the Exclusive Economic Zone of Spain as certain parts of these limits are excessively broad and create an area of overlap with the Exclusive Economic Zone off the Algerian coast established by Presidential Decree No. 18-96 of 2 Rajab A.H. 1439 (20 March 2018)" [86].

So even if several EEZ have been recently proclaimed in the Mediterranean, the situation looks like quite confused due the lack of clear and agreed delimitations.

3.2. The Adriatic Sea

As far as the Adriatic Sea is concerned, it can be qualified as a semi-enclosed sea under Art. 122 UNCLOS [87]. Its only access is the Strait of Otranto and there are seven coastal States: Italy, Slovenia, Croatia Montenegro, Albania, Greece and Bosnia and Herzegovina, which has a portion of territorial sea surrounded by the waters of Croatia.

A semi-enclosed sea may consist "entirely or primarily" of the territorial seas and Exclusive Economic Zones of two or more states [88]. Adriatic Sea is rich in resources of economic interest and mainly oil and gas fields, whose exploration and exploitation has been a matter of confrontation. In fact, due to geological and geomorphologic configuration of seabed and subsoil in the Adriatic Sea they are shared among the coastal States.

Such resources are located in the seabed, so they could be affected in case of establishment of an EEZ [89]. According to UNCLOS Article 56, when an EEZ is established, its legal regime regards also the underlying seabed resources.

Such issue is primarily related to the lateral delimitation of continental shelves of Croatia and Montenegro as the delimitation follows the existing temporary line of demarcation [90].

Currently, there are some ongoing disputes regarding the maritime boundary delimitation. For instance, the decision of the Government of Croatia to give to some foreign leaseholders the right to explore and exploit resources located in whole or in part in the maritime area claimed by Montenegro, provoked a reaction of the latter.

The Government of Montenegro produced two diplomatic notes in 2014 [91] and asserted that the unilateral action of Croatia was in violation of the *Protocol establishing an interim regime along the southern border between the two States* in 2002. Montenegro stressed that the Republic of Croatia was not entitled to dispose of such resources "in disputed territory before the definitive delimitation and demarcation of the joint state border with Montenegro, or before two states reach a mutually acceptable agreement" [92].

The delimitation of the maritime boundary between Croatia and Slovenia also gave rise to a dispute, submitted to arbitration in accordance with an Arbitration Agreement signed by the parties on 4 November 2009 in Stockholm [93].

An arbitral tribunal issued its final award in the *Croatia vs. Slovenia* case on 29 June 2017, establishing the legal regime applicable to the connection area between them [94].

However, the implementation of the2017 final award is pending, as Croatia does not recognise it due to illegal communication between the Slovenian government and the arbitrator nominated by Slovenia which according to Croatia's position compromised the arbitration agreement and the entire arbitration proceedings. Furthermore, it has to be noticed that the EU Court of Justice in the Case *Slovenia vs. Croatia* determined that the arbitration award cannot be enforced through EU law [95].

Regarding Croatia, the Croatian national boundary commission held that the issue of an Exclusive Economic Zone "was in accord with the 1982 Law of the Sea, but the act would come in force only following consultation with Italy" [96].

In 2003, Croatia created a *sui generis* ecological and fishing protection zone (EFPZ) rather than an EEZ [97].

The Government of Montenegro protested against the decision of the Croatian Parliament on the unilateral extension of jurisdiction in the above area of the Adriatic Sea and against activities that Croatia has commenced with certain private companies in that area since September 2013 [98].

Both Slovenia and Italy contested it, stating that it had to be shared between the three countries and accused Croatia of breaking European Union regulations [99]. In response to such protest, supported by the European Commission, "the Republic of Croatia in 2008 suspended the application of the EFPZ vis-à-vis EU Member States, while Montenegro and Croatia have agreed since 2008 to negotiate the text of a special agreement to submit their land and maritime boundary dispute to the International Court of Justice" [100].

So it was determined that the ecological and fishing protection zone would not apply to EU member states until a joint agreement in a European spirit was reached [101].

After Croatia joined the EU in 2013, its ecological and fishing protection zone became part of "EU waters" in which the Common Fisheries Policy applies and EU member states cooperate.

The Croatian government decided to declare an Exclusive Economic Zone, in the Adriatic Sea in December 2020 [102] and the Croatian Parliament approved it on 18 December 2020 [103].

The Croatian Foreign Minister Gordan Grlic Radman told that after "talks with his Slovenian and Italian counterparts, an understanding was reached" that Croatia and Italy would declare an EZZ after a trilateral meeting in January next year [104].

It was then officially proclaimed on 5 February 2021 [105]. As communicated to the United Nations by the State, the EEZ of the Republic of Croatia will be established beyond the limit of its territorial sea in accordance with UNCLOS. It comprises "the maritime area from the outer limit of the territorial sea seaward up to the maximum limit allowed under general international law" [106], to be determined "by international agreements on delimitation with the States whose coasts lie opposite or adjacent to the Republic of Croatia" [107].

Pending the conclusion of such agreements, the EEZ outer limit "shall temporarily follow the delimitation line of the continental shelf established under the 1968 Agreement between the Socialist Federal Republic of Yugoslavia(SFRY) and the Italian Republic on the Delimitation of the Continental Shelf between the two countries in the Adriatic Sea" [108] and the following 2005 Agreement between the Republic of Croatia and the Italian Republic on the precise determination of the delimitation line of their continental shelves, "and in adjacent delimitation with Montenegro, the line following the direction and continuing along the provisional delimitation line of the territorial seas, as defined in the 2002 Protocol between the Republic of Croatia and the Federal Government of the Republic of

Yugoslavia on the Interim Regime along the Southern Border between the two States" [109].

Then a treaty on the delimitation of the EEZs between Croatia and Italy was signed during the *Meeting of the Coordinating Committee of Croatian and Italian Ministers* held in Rome on May 24th 2022 [110].

Regarding the proclamation of Croatian and Italian EEZ, Slovenia declared that they should be without any prejudice to Slovenia's rights under international and EU law [111].

As far as Montenegro is concerned, it has not yet proclaimed an EEZ. Nevertheless, as mentioned above, it contested the extension of jurisdiction of Croatia beyond territorial waters and the establishment of the EFPZ. According to Montenegro "the Protocol on the Interim Regime along the Southern Border, which was signed in 2002 by the Federal Republic of Yugoslavia and the Republic of Croatia and is guaranteed by the UN Security Council, defines the extent of jurisdiction of Montenegro and Croatia in a twelve nautical mile territorial sea only, on a provisional basis and without prejudice to a final delimitation. The 2002 Protocol does not apply to the continental shelf, the Exclusive Economic Zone, or similar zones of functional jurisdiction (such as Croatia's ecological and fisheries protection zone (EFPZ). Accordingly, the Republic of Croatia is not entitled unilaterally to define the outer limit of its jurisdiction beyond the territorial sea by extending the 2002 Protocol line that delimits only the territorial sea and only on a provisional basis" [112].

Montenegro also recalls that from the period when the two States were constituent republics of the Socialist Federal Republic of Yugoslavia, the line delimiting the jurisdiction of Montenegro and Croatia, followed the line of azimuth of 231°. Accordingly, in its view, the "spatial extent of the jurisdiction of each constituent Yugoslav republic of course remains applicable absent subsequent contrary agreement between the two States" [113].

Therefore in the view of Montenegro, Croatia's unilateral declaration of its EFPZ "amounts to a breach of international law, which prohibits unilateral appropriation of areas of the continental shelf, the Exclusive Economic Zone, or other zones of functional jurisdiction without agreement with neighbouring states or third-party adjudication in accordance with international law" [114].

So, when Croatia authorized a Norwegian company, Spectrum, to conduct seismic surveys in the area around the line of azimuth of 231° in 2013 and, subsequently, granted a licence for hydrocarbon exploration and exploitation, such State proceeded unilaterally failing to seek Montenegro's consent prior to taking these decisions.

Pending an agreement on the principle of a submission regarding the delimitation issue to the Court, such activities were performed in breach of the obligation to act in good faith throughout the negotiations, according to Montenegro.

Consequently, Montenegro expresses its dissent regarding the following points: the Croatian unilateral Decision to extend its EFPZ, to areas in the Adriatic Sea allegedly appertaining to Montenegro; the Croatian exercise of jurisdiction in the EFPZ pursuant to Articles 33, 34(1), 35, 41 and 42 of Chapter IV (Economic Zone) of the Maritime Code of Croatia [115]. Montenegro also protests against the outer limit of Croatia's EFPZ nor does Montenegro accept any official or unofficial depiction of the EFPZ extending beyond the line of azimuth of 231° [116].

It has also to be mentioned that Montenegro issued a decision on determining blocks for research and production of hydrocarbons [117]. The Republic of Croatia reacted to such decision issuing a note of protest sent on 15 December 2011 to the Embassy of Montenegro in Zagreb, warning about the incorrectly depicted maritime border between the Republic of Croatia and Montenegro, and about an improper display of the direction of the lateral maritime delimitation, in breach of the provisional demarcation line as determined by the Protocol of 2002 [118].

Then, both countries withdrew from their intentions to proceed with offshore exploration and exploitation projects in the Adriatic. The parties look like willing to solving this issue by bilateral agreement or to entrust the Court of Justice (ICJ) with the task of a final delimitation of the maritime (and land) border between them [119].

3.3. Maritime boundary delimitation in the Adriatic Sea

The maritime boundary delimitation regards Montenegro and Croatia as they adjacent states, but also Italy as an opposite State.

Italy and Yugoslavia signed a boundary delimitation agreement [120] regarding their continental shelf in the Adriatic on 8 January 1968 [121], which subsequently entered into force on 21 January 1970. Then an agreement between Italy and Greece was finalized in 1977 [122], and Italy and Albania negotiated an agreement in 1992 [123].

The 1968 agreement represents "the first continental shelf boundary to be concluded and put into effect in the Mediterranean" [124]. The boundary extended for 353 nautical miles, based upon an equidistance boundary for a considerable proportion of the line.

Some correctives were adopted in relation to the strict equidistance criterion, in order to avoid the possible disadvantages related to the presence of several small Yugoslav islands significantly far offshore in the central Adriatic. So a reduced effect [125] was given to the Yugoslav islands of Jabuka, Palagruža, and Galijula and the Italian island of Pianosa. Yugoslavia's numerous islands close to its coast were accorded full effect.

As far as the baseline are concerned, the Yugoslavia's straight baseline system does not seem to have played a part, because the basepoint used for the delimitation was either on the mainland coast or on an island coast rather than on a straight baseline [126]. As, the Italian straight baseline system in the Adriatic introduced by DPR No. 816 of 1973, post-dated this agreement, it was not taken into account and the basepoint was represented by the coast in this case too [127].

Bearing in mind that following the disintegration of the former Federal Socialist Republic of Yugoslavia a succession of states took place [128], it is a generally accepted rule of customary international law that treaty provisions related to boundary and territorial regimes follow the territory. So successor states inherit the treaty obligations pertaining to their territory [129]. Accepting such a principle, the 1968 Italy-FSRY continental shelf agreement remains in force and is binding on Croatia, Slovenia, and Montenegro [130].

In relation to newly established EEZ, one of the core is that of delimitation which is also functional to the individuation of the outer borders of each EEZ, due to the narrowness of the Mediterranean basin that does not allow any State to expend its EEZ up to 200 nautical miles.

UNCLOS Articles 74 and 83 related respectively to the delimitation of the EEZ and the CS provide for effecting the delimitation by agreement, in accordance with international law and in order to achieve an *equitable* result [131].

As set forth by the International Court of Justice, equity can be considered an aim that should be borne in mind in effecting the delimitation, more than a method of delimitation [132].

The Court further stated that "it is not a question of applying equity simply as a meter of abstract justice, but of applying a rule of law" during the 1969 North Sea case [133], and later, during the 1985 Libya/Malta case, it reiterated that "the Justice of which equity is an emanation, is not abstract justice but justice according to the rule of law" [134].

According to UNCLOS, for each maritime zone, there are specific indications concerning the delimitation and different boundaries can be envisaged in relation to each and any single maritime zone.

Nevertheless, in the recent years there is an emerging practice among the States in favour of the adoption of a single maritime boundary, common to more maritime zones, "in the interest of simplicity, certainty and convenience" [135].

In particular, there is an increasing trend in favour of the use of the method of single maritime boundary to delimit the two different zones of continental shelf and EEZ, as it looks like more convenient and simple [136]. Such recourse of the single maritime boundary is also supported by the similarities between the EEZ and the continental shelf, both extended up to 200 nautical miles [137].

Landmark Cases for the single maritime boundary were that of the Maritime Delimitation and Territorial Questions between Qatar and Bahrain [138] and that related to Land and Maritime Boundary between Cameroon and Nigeria of 2002. The Court determined a single boundary for the continental shelf and the EEZ between the Parties and highlighted that "the concept of a single maritime boundary does not stem from multilateral treaty law but from State practice" [139].

In order to draw such a single line, the Court relied on the equitable principles/relevant circumstances method, which is very similar to the equidistance/special circumstances method, arising from UNCLOS. In some cases, a single maritime "multi-purpose" line was chosen by the States in the framework of the negotiation of a maritime boundary delimitation agreement. For instance, Turkey and the Soviet Union agreed by an exchange of notes of 6 February 1987, that the boundary line of their continental shelf, as indicated in a previous agreement, should also be valid with respect to their respective EEZ. Georgia and the Republic of Turkey concluded an agreement on 14 July 1997 establishing a single maritime boundary for all purposes [140]. The Republic of Bulgaria and the Republic of Turkey also concluded an agreement in 1997 establishing a single maritime line for the territorial sea, EEZ and Continental shelf between them [141].

The single maritime boundary was recently employed by Cyprus, Egypt and Israel in delimiting their EEZs in the Eastern Mediterranean [142].

As far as the boundaries in the Adriatic Sea are concerned, they are mainly agreed boundaries.

Beside the aforementioned agreements related to the continental shelf, Italy and FSRY concluded also an agreement concerning their territorial sea boundary, usually referred to as the Treaty of Osimo, on 10 November 1975 which entered into force on 3 April 1977. Its primary aim was to settle the disputed land boundary between the parties about the central Gulf of Trieste and complete their maritime delimitations.

No agreement was negotiated between Italy and Croatia in relation to the boundaries of the 2003 EFPZ. A new agreement has instead been negotiated to define the boundaries of the EEZs [143].

4. Neighborhood relations Italy-Montenegro and proposals for future delimitations

In 1968, an agreement between Italy and the Federal Socialist Republic of Yugoslavia was signed [144] for the delimitation of the continental Shelf and later Croatia, Montenegro and Slovenia became successor states of the latter in this agreement [145].

The Italian approach in delimiting the continental shelf with neighbouring states was a cooperative one [146]. Italy negotiated and concluded agreements with its neighbouring countries on the delimitation of the continental shelf also with Tunisia (1971), Greece (1974), Spain (1977) and Albania (1992) [147], in compliance with the obligation to cooperate of the states surrounding a closed or semi-enclosed sea, arising from UNCLOS Article 123. When Italy established its EPZ also negotiated an agreement with France concerning the boundary delimitation [148].

This reflects also the Italian "policy aimed at economic growth through the exploration and exploitation of the natural resources of the seabed and subsoil of the Mediterranean Sea" [149]. Nowadays, a similar policy has been adopted by the European Union, in both its Blue Growth and Energy Security strategies [150].

Thus, the EU Member States were encouraged to establish jurisdictional maritime zones and delimit them by agreement to be able to exploit the natural resources therein.

As it has been noticed, UNCLOS duty of cooperation "can be interpreted broadly, as applicable to coastal states even when they establish their maritime zones, even if not expressly provided for by Article 123 [151].

The new Italian Law concerning the EEZ expressly recalls the need to negotiate agreements with neighbouring States in order to define the outer border of the EEZ and find an agreed solution.

As of now, a treaty between Italy and Croatia on delimitation of their EEZs [152] is already existing. According to it, the boundary line of the EEZs coincides with the continental shelf boundary between the parties in accordance with the Agreement of 1968 and the technical adjustment agreement of 2005.

It seems that the parties relied on the already existing boundary of the continental shelf in light of the single maritime boundary trend. It is questionable whether the same approach will be followed also for other delimitation agreements or an autonomous boundary for the EEZ will be preferred.

In general, according to some Observers [153], it would be suitable to adhere to the previous continental shelf boundary, as it would ensure more clarity and would also speed up the negotiation process to find a solution [154]. Being that boundary is already agreed, it would be a reasonably good solution also for the EEZ.

Differently arguing, the 1968 agreement could be deemed as the output of a different historical situation, so outdated, also bearing in mind that the baseline system based on straight baselines was introduced afterwards. So, a new delimitation could also be taken into account [155].

In any case, the corrective special circumstances taken into account in 1968 and the agreed effect given to the isles would reasonably be almost the same, due to the geographical and societal features of the area. During the negotiations, the parties could eventually check whether there are new circumstances to be considered as correctives. For instance, they could be related to fishing rights or the current coastal development. If the Parties consider that such circumstances are very significant on a case-by-case basis, they could evaluate different maritime boundaries for each zone, otherwise it would be preferable to give weight to the interest of simplicity, certainty and convenience and prefer a single maritime boundary.

5. Concluding remarks

Following the Law No. 91 of 14 June 2021, an Italian Exclusive Economic Zone was proclaimed. The paper analyzed it in the framework of the recent proliferation of EEZs in the Mediterranean.

On the one hand, the coastal States are willing to extend their jurisdiction as far as possible, on the other hand there is an increasing need for international cooperation to delimit the related boundaries.

From the analysis of the practice related to the EEZ delimitation, some observations can be made. The States mainly rely upon the traditional legal instrument of the agreement to delimit the boundaries or to solve the related disputes. In other cases, they entrust a judicial organ to solve the dispute in a peaceful manner.

Turning to the content of the agreement, generally speaking there are two possible options to delimit the EEZs between the neighboring States: either referring to a specific boundary for such zone or relying to the notion of single maritime boundary, as emerging from the most recent practice.

The latter option could speed up the process, as suggested by some observers. Nevertheless, it could lead to neglect some relevant specific circumstances, such as the current coastal development.

In relation to the Adriatic Sea, the delimitation is even more complex than in other areas of the Mediterranean basin, due to its nature of Epicontinental Sea and the consequent relevance of the continental shelf.

Bearing in mind such geographical conformation, in our view, the preferable solution could be a delimitation based on the single maritime boundary system. Nevertheless, it could be suitable to avoid to use the former continental shelf (CS) boundaries as such, because they were delimited based on circumstances which can be now obsolete. The CS boundaries could be used as a point of departure, to be corrected by taking into account the current circumstances, including the coastal development.

Up to now, Montenegro has not yet proclaimed its own EEZ. Nevertheless, even if there is already an agreement on the delimitation of the EEZs between Italy and Croatia, in order for Italy to implement its EEZ there is a need to agree the related boundaries also with all the other neighboring States.

It would be suitable to negotiate an agreement also with Montenegro to this aim, in our view, to prevent eventual future disputes, based on the aforementioned criterion.

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6. For more details, see below.
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87. According to Art. 122 UNCLOS, "enclosed or semi-enclosed sea" is "a gulf, basin or sea surrounded by two or more States and connected to another sea or the ocean by a narrow outlet or consisting entirely or primarily of the territorial seas and exclusive economic zones of two or more coastal States".
88. See A. Caligiuri , "Offshore Shared Natural Resources and the Duty to Cooperate in a Semi-Enclosed Sea", in Offshore oil and gas exploration and exploitation in the Adriatic and Ionian seas (A. Caligiuri ed.), Napoli: Editoriale scientifica, 2015, p. 1 ff.
89. See supra.
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92. See Communication from the Government of Montenegro, dated 2 July 2014, concerning exploration and exploitation of resources in the Adriatic Sea by the Republic of Croatia, quoted above.
93. Arbitration Agreement between the Government of the Republic of Croatia and the Government of the Republic of Slovenia, Stockholm, 4 November 2009, Annex HRLA-75, Final Award, available at https://pcacases.com/web/sendAttach/2165
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113. *Ibidem*.
114. *Ibidem*.
115. The text is available at http://csamarenostrum.hr/userfiles/files/Nacion%20zakon%20engl/MARITIME%20CODE.pdf
116. *Ibidem*.
117. Official Gazette of Montenegro, No. 17/11 of 28 March 2011.
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149. See F. Caffio, "The Maritime Frontier between Italy and France: A Paradigm for the Delimitation of Mediterranean Maritime Spaces", quoted above.
150. See above.
151. See F. Caffio, "The Maritime Frontier between Italy and France: A Paradigm for the Delimitation of Mediterranean Maritime Spaces", quoted above.
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line of the 1968 Agreement was set during a period in which the notion of the exclusive economic zone was not yet well defined in international law of the sea". "Law of the Sea Bulletin", No 60, 2006 www.un.org/Depts/los/doalos_publications/LOSBulletins/bulletinpdf/bulletin60e.pdf.

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Review paper

Risk Assessment of Pollution by Wastewater from Vessels for the Port of Kotor*

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Abstract: The efficiency of risk management is dependent on understanding the complexity, type and nature that the environment deals with. The Bay of Kotor stands as the most prominent natural resource of our country and, as being such, it requires a high level of protection. Sea vessels that visit the Bay of Kotor represent a potential hazard in terms of possible discharge of wastewater. With the increase in the traffic volume in the Bay of Kotor and Port of Kotor, the need for a stronger use of risk assessment tools in the effort to identify the possible source of pollution, has also arisen. The risk assessment model aimed at detecting wastewater pollution in the Bay area caused by seagoing vessels that visit the Boka Bay and Port of Kotor may be considered as a generally applicable method for identifying and assessing the risk of sea pollution by wastewater.

Keywords: Source of pollution, Location of pollution, Risk matrices, Level of risk.

1. Uvod

Plovila proizvode mnogobrojne vidove otpada. Prema istraživanju autora Kristiansen (2005), autora Perić (2016) i autora Copeland (2005), štetnim po životnu sredinu i morsko okruženje, smatraju se: balastne vode, otpadne vode, kaljužne vode, čvrst otpad, štetni i opasni gasovi koji štetno utiču na zrak i životnu sredinu [1-3]. Međunarodnim protokolima, posebno MARPOL konvencijom i domaćim Zakonom o zaštiti mora od zagađenja sa plovnih objekata regulisan je način odlaganja i tretiranja otpada [4, 5]. Ako se otpad prema zakonskim propisima pravilno ne odlaže i ne tretira, isti može postati izvor velikog broja štetnih supstanci koji mogu negativno da utiču na životnu sredinu i zdravlje ljudi.

Luka Kotor i Bokokotorski zaliv privlače veliku pažnju putničkih plovila. Prema istraživanju autora Koboević i saradnici (2011) i autora Carić (2010),

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iz razloga velikog broja putnika i članova posade koji borave i rade na ovim plovilima, otpadne vode kao jedan od vidova otpada koje generišu plovila, mogu biti razlog veće zabrinutosti za putnička plovila u odnosu na ostale segmente brodske industrije [6, 7].

Međunarodna konvencija za sprečavanje zagađenja mora plovilima MARPOL (eng. *International Convention for the Prevention of Pollution from Ships*), koju je donijela Međunarodna pomorska organizacija IMO (eng. *International Maritime Organization*) najvažnija je međunarodna regulativa kojom se reguliše pitanje zagađenja mora plovilima [4, 8]. MARPOL konvencija sastoji se od šest Aneksa. Aneks IV MARPOL konvencije (Pravila o sprečavanju zagađenja otpadnim vodama sa brodova) zauzima posebno mjesto u ovom radu, budući da se upravo navedenim Aneksom reguliše sprečavanje i nadzor zagađenja mora otpadnim vodama sa plovila. Aneks IV MARPOL konvencije odnosi se na: a) zabranu ili ograničenje ispuštanja, b) izdavanje potvrda i inspekcija, c) opremu i nadzor ispuštanja, i d) objekte za prihvat na obali [4].

Rad je koncipiran kroz sljedeća poglavlja:

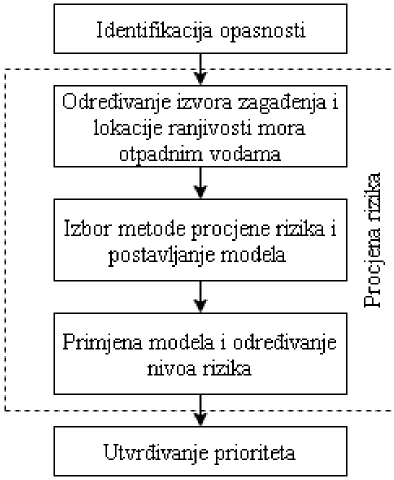
Prvo poglavlje – Uvod.

Drugo poglavlje odnosi se na model procjene rizika od zagađenja otpadnim vodama sa plovnih objekata na primjeru Luke Kotor. U ovom poglavlju istraženo je određivanje izvora zagađenja (plovila) s aspekta Luke Kotor koja prema svojoj veličini i namjeni predstavlju rizik od zagađenja otpadnim vodama za određena područja (lokacija zagađenja). Ovim poglavljem obuhvaćen je izbor metode procjene rizika i postavljanje modela, kao i primjena modela i određivanje nivoa rizika i prioriteta.

U trećem poglavlju predstavljana su zaključna razmatranja i mogućnosti za poboljšanje zaštite od zagađenja otpadnim vodama sa plovnih objekata.

2. Model procjene rizika od zagađenja otpadnim vodama sa plovnih objekata na primjeru Luke Kotor

Ovaj rad je motivisan modelom procjene rizika od zagađenja obalnog mora crnim (otpadnim) vodama sa plovila, autora Koboević i saradnici (2018), koji su prateći dobru praksu i preporuke okvira za procjenu ekološkog rizika (eng. *Framework for Ecological Risk Assessment*) EPA, normi ISO 31000:2009, kao i IMO smjernica za formalnu procjenu sigurnosti, razvili optimalni model za upravljanje rizikom od zagađenja mora sa plovila koji je prikazan na slici 1. Model je podijeljen u tri koraka [9].



Slika 1 - *Model za upravljanje rizikom od zagađenja mora sa plovila* [9].

Opasnost se definiše kao situacija koja može izazvati gubitak ljudskog života, štetu životnoj sredini, imovini ili poslu. Prema istraživanju autora Koboević i saradnici (2018), identifikacija rizika je postupak definisanja i opisivanja opasnosti. Ovim korakom teži se definisanju subjekta ili resursa na koje takve opasnosti mogu djelovati [9]. Identifikacija opasnosti čini osnovni prvi korak prema procjeni rizika.

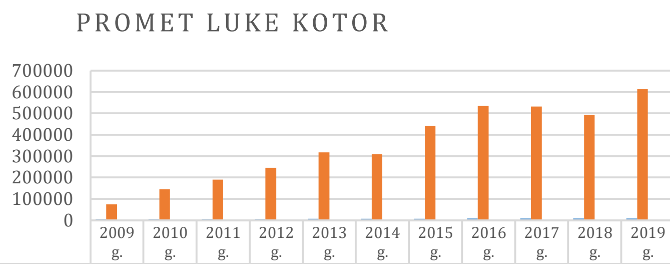
Nakon identifikacije opasnosti slijedi procjena rizika. Procjena rizika uključuje tri važna koraka. Prvi korak tiče se određivanja izvora i lokacije zagađenja. Drugi korak jeste izbor metode za procjenu rizika i postavljanje modela. U trećem koraku vrši se primjena modela, te se istim određuje nivo rizika od zagađenja mora sa plovila.

Utvrđivanje prioriteta je poslednji korak modela upravljanja rizikom od zagađenja mora sa plovila.

2.1 Identifikacija opasnosti

Kotor je centar crnogorskog kruzing turizma koji svoj atraktivni položaj bazira na slikovitom srednjovjekovnom gradu i gradskim zidinama. Zahvaljujući prepoznatljivom nasljeđu koje je pod zaštitom UNESCO-a (eng. *United Nations Educational, Scientific and Cultural Organization* – Organizacija Ujedinjenih nacija za obrazovanje, nauku i kulturu), Kotor se svrstava u grupu najvažnijih mediteranskih destinacija za krstarenje, poput Dubrovnika i Venecije.

Luka Kotor predstavlja luku sa velikim prometom brodova za krstarenje i jahti. Na slici 2, prikazan je promet Luke Kotor za period 2009–2019.



	2009 g.	2010 g.	2011 g.	2012 g.	2013 g.	2014 g.	2015 g.	2016 g.	2017 g.	2018 g.	2019 g.
Broj putnika sa jahti	5101	5007	5739	5642	6485	7559	7096	8292	8630	8054	8811
Broj putnika sa brodova za krstarenje	75128	145185	189426	245400	317746	309322	442029	535232	532287	492475	613747
Broj jahti	1109	1118	1224	1454	1493	1637	1564	1674	1838	1831	1604
Broj brodova za krstarenje	262	310	317	343	387	354	412	488	430	412	464

Slika 2 - *Pregled prometa Luke Kotor za period 2009-2019* [10].

Veliki kapacitet brodova za krstarenje (preko 3.500 gostiju), koji posjećuju Luku Kotor i Bokokotorski zaliv, ima svoj uzročno-posljedični odnos. Naime kako je navedeno u istraživanju autora Carić (2015), otpadne vode mogu biti jedan od razloga veće zabrinutosti za brodove za krstarenje, upravo zbog njihovog velikog kapaciteta, odnosno velikog broja putnika i članova posade koji borave i rade na takvom brodu, kao i zbog velike količine otpada koji oni proizvode. Brod dok boravi na vezu ili na lučkom sidrištu može biti uzročnik potencijalnog zagađenja otpadnim vodama koje za posljedicu ima širok spektar negativnog uticaja na životnu sredinu [11].

2.2. Određivanje izvora zagađenja i lokacije ranjivosti mora otpadnim vodama

Sa aspekta Bokokotorskog zaliva i Luke Kotor koja isključivo od 2004. godine obavlja promet putnika sa brodova za krstarenje i jahti, izvori zagađenja mogu biti:

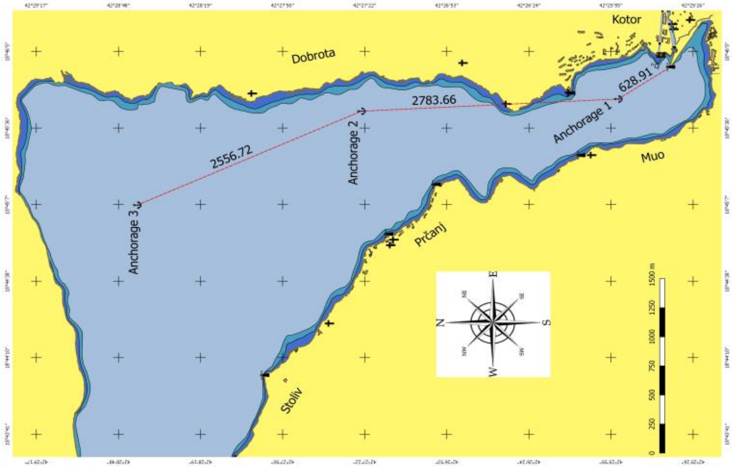
- Domaća plovila **(I1)**, podrazumijevaju plovilo (jedrilicu, motornu brodicu i sl.) namijenjeno za plovidbu morem, čija baždarena dužina iznosi manje od 12 metara, a registarska zapremina manje od 15 BT, koje je ovlašćeno prevoziti najviše 12 ljudi [12],
- Izletnički brodovi **(I2)**, obuhvataju čamce ili brod koji služi za prevoz turista ili dnevna krstarenja s izletničkim sadržajem, čija je dužina veća od 12 metara i BT više od 15 (hidrogliser, čamac sa motorom i manji brod za jednodnevne izlete, turistički taksi) [13],

– Jahte **(I3)**, podrazumijevaju plovilo na motorni pogon ili jedra, namijenjen i opremljen za duži boravak na moru, za razonodu, sport i rekreaciju, čija je dužina preko 7 metara [14],
– Mega jahte **(I4)**, podrazumijevaju luksuzni motorni brod, namijenjen i opremljen za duži boravak na moru, za razonodu, sport i rekreaciju, čija je dužina preko 24 metara, i
– Brodovi za krstarenje **(I5)**.

Gore navedena plovila koja sa aspekta Luke Kotor i Bokokotorskog zaliva mogu biti potencijalni izvor zagađenja, tokom svojih redovnih radnih aktivnosti (ukrcaj i iskrcaj putnika, zbrinjavanje otpada i sl.) borave na različitim lokacijama gdje može doći do zagađenja otpadnim vodama sa plovila:

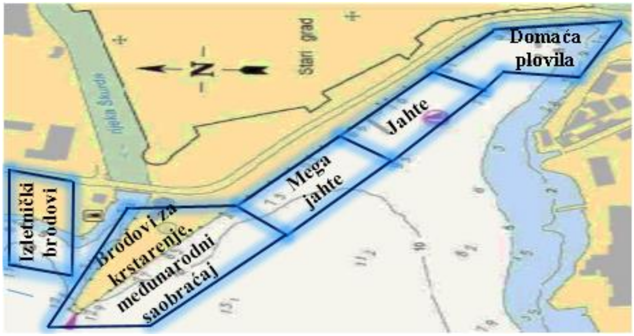
- Blizina mjesta za rekreaciju i kupanje **(L1)**,
- Operativna obala u blizini grada **(L2)**,
- Marina ili komunalna luka **(L3)**,
- Luka za međunarodni putnički saobraćaj **(L4)**, i
- Sidrište **(L5)**.

Na slici 3, prikazana su tri sidrišta (eng. *anchorage*), na kojima plovila borave prilikom obavljanja svojih aktivnosti kao što su ukrcaj i iskrcaj putnika.



Slika 3 - *Sidrišta Luke Kotor* [15].

Na slici 4, prikazane su lokacije boravka plovila (domaća plovila, izletnički brodovi, jahte, mega jahte, brodovi za krstarenje) dok se nalaze na vezu Luke Kotor, prilikom obavljanja svojih redovnih radnih aktivnosti.



Slika 4 - *Situacioni plan Luke Kotor* [16].

2.3. Izbor metode procjene rizika i postavljanje modela za procjenu rizika primjenom matrice u tri nivoa

U ovom radu za potrebe procjene rizika od zagađenja mora otpadnim vodama sa plovila za Luku Kotor i Bokokotorski zaliv koristi se matrična metoda procjene rizika (kvalitativna metoda), iz razloga nedostatka preciznih numeričkih podataka.

Međunarodna organizacija za standardizaciju (eng. *International Organization for Standardization* – ISO), koristi matricu rizika 5X5 polja [17], dok Međunarodna pomorska organizacija rada (eng. *International Maritime Organization* – IMO), koristi matricu rizika 4X4 polja [18]. Vjerovatnoća i posljedica jesu ulazni faktori obije navedene matrice, a nivo rizika dobija se objedinjavanjem ova dva faktora. U procjeni rizika može se koristiti i bilo koja druga matrica, kao što je to slučaj i sa predmetnom procjenom rizika od zagađenja otpadnim vodama sa plovila za Luku Kotor i Bokokotorski zaliv gdje se koristi matrica rizika 3X3 polja.

U cilju postizanja optimalnog kvalitativnog pristupa u procjeni rizika, za procjenu rizika od zagađenja mora otpadnim vodama sa plovnih objekata, neophodno je odrediti i postaviti više od dva ulazna faktora. Zapravo, neophodno je osmisliti kako upotrijebiti matricu rizika kao alat, a da ista matrica može istovremeno podnijeti više od dvije varijable. Prema istraživanju autora Koboević i saradnici (2018), primjena matrice u tri nivoa predstavlja moguće rješenje, odnosno množenjem (eng. *multiplication*) dva nivoa matrice (indeks rizika izvora zagađenja i indeks ranjivosti lokacije) postepeno se dolazi do finalne matrice, tj. matrice trećeg nivoa kojom se određuje nivo rizika od zagađenja mora otpadnim vodama sa plovnih objekata [9].

2.3.1 Matrica prvog nivoa

Utvrđivanje izvora zagađenje obuhvaćeno je matricom prvog nivoa (indeksom rizika izvora zagađenja).

Matrica prvog nivoa obuhvata utvrđivanje matrice s aspekta stepena regulacije i pravila, i opremljenosti plovila.

U skladu s odredbama Aneksa IV MARPOL konvencije, Zakona o sigurnosti pomorske plovidbe, Zakona o pomorskoj i unutrašnjoj plovidbi, kao i Zakona o zaštiti mora od zagađenja sa plovnih objekata, a u odnosu na nadzor ispuštanja otpadnih voda, moguće je odrediti stepen regulacije i pravila za predmetna plovila koja borave u akvatorijumu Luke Kotor [4, 5, 12, 19]:

– odredbe iz Aneksa IV MARPOL konvencije primjenjuju se na brodove koji obavljaju međunarodna putovanja prema pravilu 2 ovog Aneksa, odnosno odredbe nacionalnog zakona propisuju inspekcijski nadzor broda u međunarodnoj plovidbi **(P1)**,
– odredbe Aneksa ili nacionalne regulative kojima je propisana kontrola, ali i pravilima, oslobađaju se plovila namijenjena za naučnu, tj. istraživačku djelatnost, odnosno ratni brodovi i ratni čamci **(P2)**, i
– propisi, odnosno, međunarodna ili nacionalna regulativa se ne primjenjuje na plovila zbog njihove manje veličine ili kategorije plovidbe **(P3)**.

Prateći odredbe Aneksa IV MARPOL konvencije (pravilo 9), i nacionalnog Zakona o zaštiti mora od zagađenja sa plovnih objekata (glava VI) a u odnosu na opremu i nadzor ispuštanja otpadnih voda, određuje se stepen opremljenosti broda sljedećim sistemima za otpadne vode [4, 5]:

– brod je opremljen cjelokupnim sistemom za obradu otpadnih voda **(O1)**,
– brod je opremljen sistemom za usitnjavanje i dezinfekciju **(O2)**, i
– brod je opremljen isključivo tankom za zadržavanje otpadnih voda, bez sistema obrade **(O3)**.

Ovako definisani elementi matrice prvog nivoa predstavljeni su u tabeli 1.

Tabela 1 - *Matrica prvog nivoa s aspekta stepena regulacije i pravila, i opremljenosti broda (indeks rizika izvora zagađenja)* [9].

Matrica prvog nivoa INDEKS RIZIKA IZVORA ZAGAĐENJA		Faktor stepena opremljenosti		
		(O1)	**(O2)**	**(O3)**
Faktor stepena regulacije i pravila	**(P1)**	**1**	**2**	**3**
	(P2)	**2**	**4**	**6**
	(P3)	**3**	**6**	**9**

2.3.2. Matrica drugog nivoa

Utvrđuvanje lokacije ranjivosti mora obuhvaćeno je matricom drugog nivoa (indeksom ranjivosti lokacije).

Matrica drugog nivoa obuhvata utvrđivanje matrice s aspekta stepena osjetljivosti lokacije i stepena uticaja na lokaciju.

Prvi dio ove matrice jeste određivanje stepena osjetljivosti lokacije:

– djelovanje na izgled mora i biodiverziteta **(D1)**,

– djelovanje na izgled mora, biodiverziteta i na industriju **(D2),** i

– djelovanje na izgled mora, biodiverziteta, industriju i na ljude **(D3)**.

U sklopu matrice drugog nivoa neophodno je odrediti i stepen uticaja na lokaciju, prema narednim opcijama:

– manji lokalni uticaj **(U1)**,

– umjeren uticaj **(U2)**, i

– značajan uticaj **(U3)**.

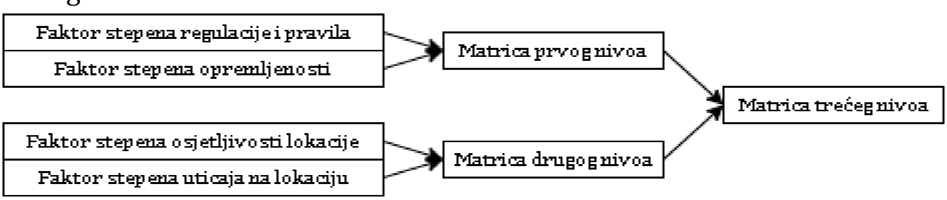
Ovako definisani elementi matrice drugog nivoa predstavljeni su u tabeli 2.

Tabela 2 - *Matrica drugog nivoa s aspekta stepena osjetljivosti lokacije i stepena uticaja na lokaciju (indeks ranjivosti lokacije)* [9].

Matrica drugog nivoa INDEKS RIZIKA RANJVOSTI LOKACIJE		Faktor stepena uticaja na lokciju		
		(U1)	**(U2)**	**(U3)**
Faktor stepena osjetljivosti lokacije	**(D1)**	**1**	**2**	**3**
	(D2)	**2**	**4**	**6**
	(D3)	**3**	**6**	**9**

2.3.3. Matrica trećeg nivoa

Ovako formirane matrice prvog i drugog nivoa određuju ulazne elemente za konačnu matricu trećeg nivoa (slika 5 i tabela 3), koja se koristi za procjenu rizika od zagađenja mora otpadnim vodama sa plovnih objekata za Luku Kotor i područje Bokokotorskog zaliva. Matrica trećeg nivoa ima 6X6 polja, onoliko koliko čini zbir matrice prvog i drugog nivoa. Kod matrice trećeg nivoa mora se odrediti i nivo rizika.



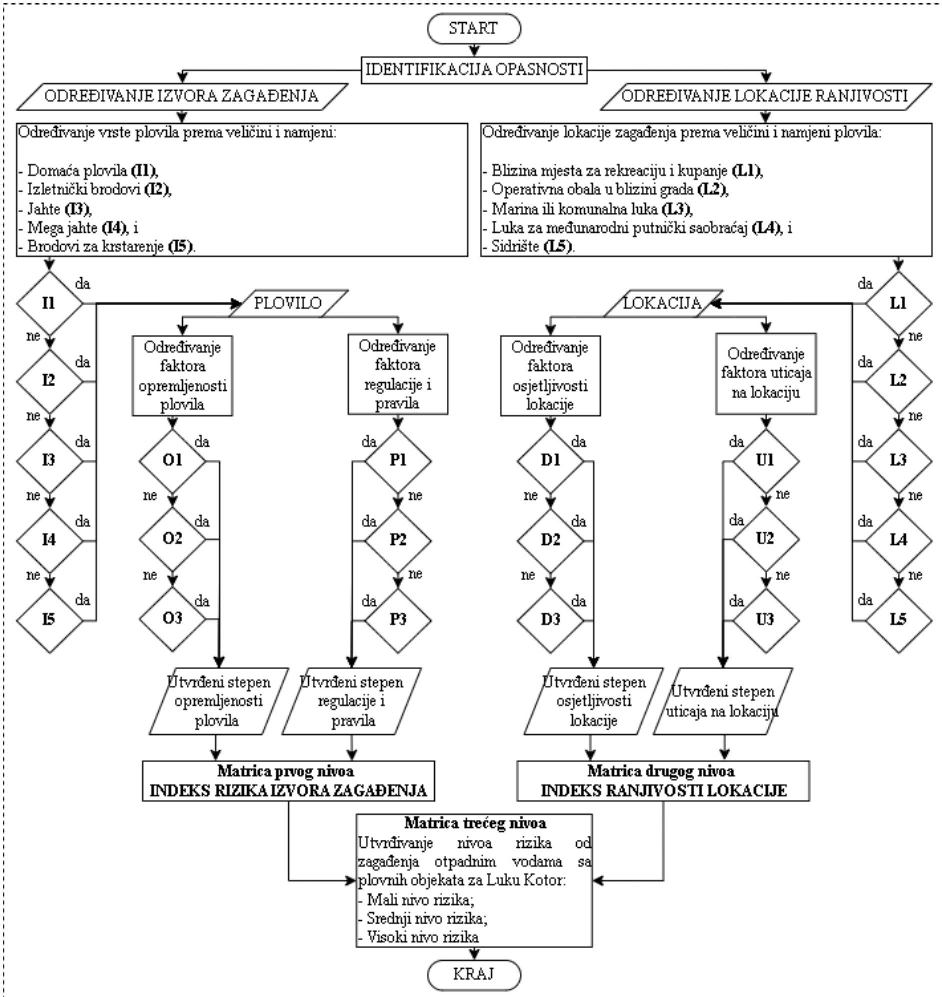
Slika 5 - *Elementi matrice trećeg nivoa.*

Bojenjem polja u matrici rizika (tabela 3) omogućeno je vizualno razdvajanje nivoa rizika na mali nivo rizika (zelena polja), srednji nivo rizika (žuta polja) i visoki nivo rizika (crvena polja). Brojevi u obojenim poljima predstavljaju indeks rizika (faktor indeksa rizika izvora zagađenja i indeksa ranjivosti lokacije).

Tabela 3 - *Matrica trećeg nivoa* [9].

Matrica trećeg nivoa Rizik od zagađenja mora otpadnim vodama sa plovnih objekata		Matrica prvog nivoa s aspekta stepena regulacije i pravila, i opremljenosti broda (indeks rizika izvora zagađenja)					
		1	2	3	4	6	9
Matrica drugog nivoa s aspekta stepena osjetljivosti lokacije i stepena uticaja na lokaciju (indeks ranjivosti lokacije)	1	1	2	3	4	6	9
	2	2	4	6	8	12	18
	3	3	6	9	12	18	27
	4	4	8	12	16	24	36
	6	6	12	18	24	36	54
	9	9	18	27	36	54	81
Mali nivo rizika		Srednji nivo rizika			Visoki nivo rizika		
1 – 12		13 – 27			28 – 81		

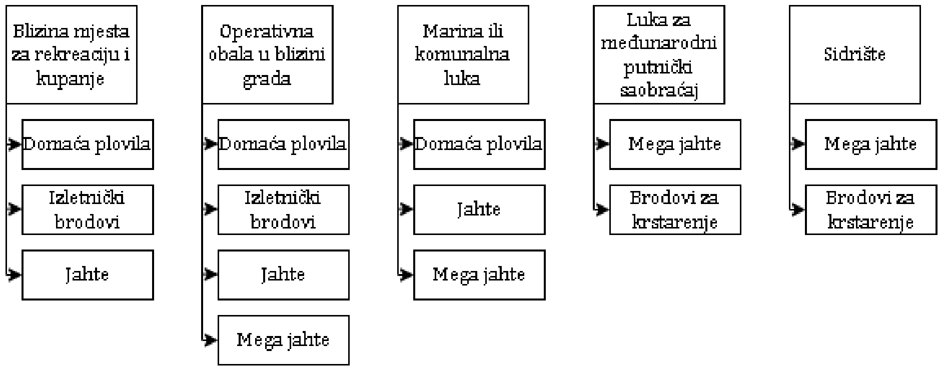
Na slici 1, prikazan je model za upravljenje rizikom od zagađenja mora sa plovila. Proširenjem datog modela moguće je uspostavljanje šeme toka procesa za procjenu rizika od zagađenja otpadnim vodama sa plovila za Luku Kotor i Bokokotorski zaliv (slika 6). Glavni parametri ovakve šeme jesu određivanje izvora zagađenja i određivanje lokacije ranjivosti.



Slika 6 - *Šema toka procesa za procjenu rizika od zagađenja otpadnim vodama sa plovila* [9].

2.4. Primjena modela i rezultati procjene

Kako bi se procijenio rizik od zagađenja otpadnim vodama neophodno je povezati plovila i lokacije. Na slici 7 prikazane su kombinacije plovila i lokacija onako kako se to susreće u stvarnom životu. U realnim okolnostima nije moguće na svakoj lokaciji pronaći sve vrste plovila koja su navedena u ovom radu (npr. brod za krstarenje u marini ili komunalnoj luci, ili pak izletnički brod u luci za međunarodni putnički saobraćaj). Moguće su samo racionalne povezanosti plovila i lokacija koji se susreću u stvarnom životu.



Slika 7 - *Uobičajena plovila i njihove lokacije* [9].

Procjena rizika počinje primjenom matrice prvog nivoa. S time u vezi tabela 1 primjenjuje se u ovom postupku procjene. U nastavku su pojašnjeni pojedinačni rezultati za svako plovilo sa slike 7.

Domaća plovila – faktor stepena regulacije i pravila, ocijenjen je sa vrijednošću **3** (propisi se ne odnose na plovilo), budući da se međunarodni propisi ne primjenjuju na domaća plovila, jer plove pod nacionalnom zastavom i u nacionalnoj plovidbi, a sa druge strane nacionalnim Zakonom o zaštiti mora od zagađenja sa plovnih objekata propisano je da međunarodno svjedočanstvo o sprječavanju zagađenja mora otpadnim vodama mora imati brod do 400 BT koji prevozi više od 15 putnika i članova posade i brod od najmanje 400 BT [5, 20]. Faktor stepena opremljenosti, ocijenjen je sa vrijednošću **3** (opremljen isključivo tankom za zadržavanje otpadnih voda), jer se na domaćim plovilima (jedrilicama, motornim brodicama i sl.) u pojedinim slučajevima nalaze isključivo toaleti sa direktnim pražnjenjem u tank za zadržavanje otpadnih voda i ručnom ili električnom pumpom za pražnjenje kada je tank pun. Na osnovu matrice prvog nivoa (tabela 1) indeks rizika izvora zagađenja ima vrijednost **9**.

Izletnički brodovi – faktor stepena regulacije i pravila, ocijenjen je sa vrijednošću **2** (propisi se odnose na plovilo, ali se kontrola ne obavlja), budući da se na izletničkim brodovima u većini slučajeva nalazi više od 15 putnika, pa je s time u vezi nacionalnom regulativom propisano da ovakva plovila moraju imati međunarodno svjedočanstvo o sprječavanju zagađenja mora otpadnim vodama. Međutim pariški memorandum se ne primjenjuje na ova plovila zbog njihove veličine i kategorije plovidbe, pa samim tim nisu podložni povremenim inspekcijama inspektora državne Lučke kontrole. Faktor stepena opremljenosti, ocijenjen je sa vrijednošću **3** (opremljen isključivo tankom za zadržavanje otpadnih voda), jer su ova plovila u većini slučajeva opremljeni tankom za zadržavanje otpadnih voda i ispusnom pumpom kada je tank pun. Na osnovu matrice prvog nivoa (tabela 1) indeks rizika izvora zagađenja ima vrijednost **6.**

Jahte – faktor stepena regulacije i pravila, ocijenjen je sa vrijednošću **2** (propisi se odnose na plovilo, ali se kontrola ne obavlja), jer je riječ o plovilima koji plove pod stranom zastavom i najčešće su u međunarodnoj plovidbi. S time u vezi jahte su podložne Ankesu IV MARPOL konvencije i nacionalnoj regulativi. Međutim, budući da nisu brodovi već jahte, pariški memorandum se na njih ne primjenjuje, pa samim tim nisu podložni povremenim inspekcijama inspektora državne Lučke kontrole [20]. Faktor stepena opremljenosti, ocijenjen je sa vrijednošću **2** (opremljen sistemom za usitnjavanje i dezinfekciju), jer se najčešće radi o modernim jahtama opremljenim tankom za otpadne vode koji takođe ima uređaj za mljevenje i dezinfekciju. Na osnovu matrice prvog nivoa (tabela 1) indeks rizika izvora zagađenja ima vrijednost **4**.

Mega jahte – faktor stepena regulacije i pravila, ocijenjen je sa vrijednošću **2** (propisi se odnose na plovilo, ali se kontrola ne obavlja), iz istog razloga kao za jahte. Faktor stepena opremljenosti, ocijenjen je sa vrijednošću **1** (opremljen cjelokupnim sistemom za obradu), jer su mega jahte najčešće opremljene kompletnim sistemom za obradu otpadnih voda. Na mega jahtama se nalazi veći broj ljudi pa je s time u vezi ovo plovilo opremljeno složenijim sistemom u odnosu na jahte na kojima se nalazi manji broj ljudi. Na osnovu matrice prvog nivoa (tabela 1) indeks rizika izvora zagađenja ima vrijednost **2**.

Brodovi za krstarenje – faktor stepena regulacije i pravila, ocijenjen je sa vrijednošću **1** (propisi se odnose na plovilo i obavlja se kontrola), jer plove u međunarodnoj plovidbi i na njih se primjenjuje Aneks IV MARPOL konvencije, nacionalna regulativa i pariški memorandum [21]. Faktor stepena opremljenosti, ocijenjen je sa vrijednošću **1** (opremljen cjelokupnim sistemom za obradu), jer su brodovi za krstarenje opremljeni savremenim i najsloženijim tehnologijama za prečišćavanje i obradu, poput AWT (eng. *Advanced WasteWater Treatment*), koja je proizvedena upravo za ovakvu vrstu brodova, a sve u cilju zadovoljenja potreba velikog broja ljudi na brodu, ali i najstrožijih ekoloških standarda [8]. Na osnovu matrice prvog nivoa (tabela 1) indeks rizika izvora zagađenja ima vrijednost **1**.

Gore dobijeni rezultati procjene rizika primjenom matrice prvog nivoa (indeks rizika izvora zagađenja) za navedena plovila, predstavljeni su u tabeli 4.

Tabela 4 - *Indeks rizika izvora zagađenja.*

PLOVILO	Faktor stepena regulacije i pravila	Faktor stepena opremljenosti	Indeks rizika izvora zagađenja
Domaća plovila	**3**	**3**	**9**
Izletnički brodovi	**2**	**3**	**6**
Jahte	**2**	**2**	**4**
Mega jahte	**2**	**1**	**2**
Brodovi za krstarenje	**1**	**1**	**1**

Nakon dobijenih rezultata primjenom matrice prvog nivoa, slijedi primjena matrice drugog nivoa kojom se dobija indeks ranjivosti lokacije. S time u vezi tabela 2 primjenjuje se u ovom postupku procjene. U nastavku su pojašnjeni pojedinačni rezultati za svaku lokaciju sa slike 7.

Blizina mjesta za rekreaciju i kupanje – faktor stepena osjetljivosti lokacije, ocijenjen je sa vrijednošću **3** (djelovanje na izgled mora, biodiverziteta, industriju i na ljude), jer postoji značajno djelovanje na sve subjekte koji se nalaze u blizini mjesta za rekreaciju i kupanje (more, biodiverzitet, privredne subjekte i same ljude koji se nalaze u kontaktu sa morem). Faktor stepena uticaja na lokaciju, ocijenjen je sa vrijednošću **3** (značajan uticaj), jer se govori o velikom uticaju na sve subjekte osjetljivosti. Na osnovu matrice drugog nivoa (tabela 2) indeks ranjivosti lokacije ima vrijednost **9**.

Operativna obala u blizini grada – faktor stepena osjetljivosti lokacije, ocijenjen je sa vrijednošću **2** (djelovanje na izgled mora, biodiverziteta i industriju), jer otpadne vode utiču na izgled mora i biodiverziteta, kao i na privredne aktivnosti u blizini obale. Navedena vrijednost je odabrana, iz razloga što je u blizini operativne obale zabranjeno kupanje i bilo koji drugi vid rekreacije, pa u tom slučaju nema direktnog uticaja na ljudsko zdravlje. Faktor stepena uticaja na lokaciju, ocijenjen je sa vrijednošću **3** (značajan uticaj), jer se radi o velikom uticaju na sva tri subjekta osjetljivosti. Na osnovu matrice drugog nivoa (tabela 2) indeks ranjivosti lokacije ima vrijednost **6**.

Marina ili komunalna luka – faktor stepena osjetljivosti lokacije, ocijenjen je sa vrijednošću **2** (djelovanje na izgled mora, biodiverziteta i industriju), jer otpadne vode utiču na one subjekte koji se mogu naći na toj lokaciji, odnosno na izgled mora, biodiverziteta i privredne djelatnosti. U blizini marine zabranjeno je kupanje i bilo koji drugi vid rekreacije, pa u tom slučaju nema direktnog uticaja na ljudsko zdravlje. Faktor stepena uticaja na lokaciju, ocijenjen je sa vrijednošću **3** (značajan uticaj), jer se radi o velikom uticaju na sva tri subjekta osjetljivosti. Na osnovu matrice drugog nivoa (tabela 2) indeks ranjivosti lokacije ima vrijednost **6**.

Luka za međunarodni putnički saobraćaj – faktor stepena osjetljivosti lokacije, ocijenjen je sa vrijednošću **2** (djelovanje na izgled mora, biodiverziteta i industriju), jer otpadne vode utiču isključivo na izgled mora, biodiverziteta i lučku industriju, dok je direktan kontakt ljudi sa morem minimalan, jer je u ovom području zabranjeno kupanje i bilo koji drugi vid rekreacije. Faktor stepena uticaja na lokaciju, ocijenjen je sa vrijednošću **2** (umjeren uticaj) zbog mogućnosti brze intervencije lučkih službi. Na osnovu matrice drugog nivoa (tabela 2) indeks ranjivosti lokacije ima vrijednost **4**.

Sidrište – faktor stepena osjetljivosti lokacije, ocijenjen je sa vrijednošću **1** (djelovanje na izgled mora i biodiverziteta), jer otpadne vode na ovom mjestu utiču isključivo na more i okolni biodiverzitet. Faktor stepena uticaja na lokaciju, ocijenjen je sa vrijednošću **1** (manji lokalni uticaj) zbog slabih morskih struja i malog stepena otvorenosti. Na osnovu matrice drugog nivoa (tabela 2) indeks ranjivosti lokacije ima vrijednost **1**.

Gore dobijeni rezultati procjene rizika primjenom matrice drugog nivoa (indeks ranjivosti lokacije) za navedene lokacije, predstavljeni su u tabeli 5.

Tabela 5 - *Indeks ranjivosti lokacije.*

LOKACIJA	Faktor stepena osjetljivosti lokacije	Faktor stepena uticaja na lokaciju	Indeks ranjivosti lokacije
Blizina mjesta za rekreaciju i kupanje	**3**	**3**	**9**
Operativna obala u blizini grada	**2**	**3**	**6**
Marina ili komunalna luka	**2**	**3**	**6**
Luka za međunarodni putnički saobraćaj	**2**	**2**	**4**
Sidrište	**1**	**1**	**1**

Primjer procjene rizika za brod za krstarenje koji se nalazi u luci za međunarodni putnički saobraćaj primjenom matrice 3X3 u tri nivo prikazan je na slici 8.

Matrica prvog nivoa INDEKS RIZIKA IZVORA ZAGAĐENJA		Faktor stepena opremljenosti		
		(O1)	**(O2)**	**(O3)**
Faktor stepena regulacije i pravila	**(P1)**	**1**	**2**	**3**
	(P2)	**2**	**4**	**6**
	(P3)	**3**	**6**	**9**

Matrica drugog nivoa INDEKS RIZIKA RANJIVOSTI LOKACIJE		Faktor stepena uticaja na lokciju		
		(U1)	**(U2)**	**(U3)**
Faktor stepena osjetljivosti lokacije	**(D1)**	**1**	**2**	**3**
	(D2)	**2**	**4**	**6**
	(D3)	**3**	**6**	**9**

Matrica trećeg nivoa Rizik od zagađenja mora otpadnim vodama sa plovnih objekata		Matrica prvog nivoa s aspekta stepena regulacije i pravila, i opremljenosti broda (indeks rizika izvora zagađenja)					
		1	2	3	4	6	9
Matrica drugog nivoa s aspekta stepena osjetljivosti lokacije i stepena uticaja na lokaciju (indeks ranjivosti lokacije)	1	1	2	3	4	6	9
	2	2	4	6	8	12	18
	3	3	6	9	12	18	27
	4	4	8	12	16	24	36
	6	6	12	18	24	36	54
	9	9	18	27	36	54	81

Mali nivo rizika	Srednji nivo rizika	Visoki nivo rizika
1 – 12	13 – 27	28 – 81

Slika 8 - *Primjer procjene rizika za brod za krstarenje koji se nalazi u luci za međunarodni putnički saobraćaj.*

Na slici 8 vidi se da je prvi nivo matrice (indeks rizika izvora zagađenja) početni korak u procjeni rizika od zagađenje otpadnim vodama. Završni korak, odnosno, utvrđivanje nivoa rizika, dobija se putem matrice trećeg nivoa.

Matrica prvog nivoa (slika 8): Faktor stepena regulacije i pravila (1) x Faktor stepena opremljenosti plovila (1) = Indeks rizika izvora zagađenja (1 x 1 = 1).

Matrica drugog nivoa (slika 8): Faktor stepena osjetljivosti lokacije (2) x Faktor stepena uticaja na lokaciju (2) = Indeks ranjivosti lokacije (2 x 2 = 4).

Matrica trećeg nivoa (slika 8): Indeks rizika izvora zagađenja (1) x Indeks ranjivosti lokacije (4) = Rizik od zagađenja mora otpadnim vodama sa broda za krstarenje u luci za međunarodni putnički saobraćaj (1 x 4 = 4).

Prema gore navedenom rizik od zagađenja mora otpadnim vodama sa broda za krstarenje koji se nalazi u luci za međunarodni putnički saobraćaj ima vrijednost 4, odnosno riječ je o malom nivou rizika (slika 8).

2.5. Utvrđivanje prioriteta

Primjenom modela za procjenu rizika od zagađenja mora otpadnim vodama sa plovila za Luku Kotor i Bokokotorski zaliv moguće je dobiti podatke o nivou rizika od zagađenja otpadnim vodama (tabela 6). Primjenom matrice trećeg nivoa (tabela 3), i vrijednosti iz tabela 4 i 5 gdje su prikazani indeksi rizika izvora zagađenja i ranjivosti lokacije, moguće je dobiti matrični prikaz nivoa rizika za plovila i njihove lokacije sa slike 7.

Na osnovu tabele 6 moguće je utvrđivanje prioriteta reagovanja na rizik, na način da je indeks rizika od 1 do 12 klasifikovan kao mali nivo rizika, indeks rizika od 13 do 27 kao srednji nivo rizika, a indeks rizika od 28 do 81 kao visoki nivo rizika.

Tabela 6 - *Konačni rezultat procjene rizika od zagađenja otpadnim vodama sa plovnih objekata za Luku Kotor.*

Izvori zagađenja / Lokacija ranjivosti	Domaća plovila	Izletnički brodovi	Jahte	Mega jahte	Brodovi za krstarenje
Blizina mjesta za rekreaciju i kupanje	81	54	36	/	/
Operativna obala u blizini grada	54	36	24	12	/
Marina ili komunalna luka	54	/	24	12	/
Luka za međunarodni putnički saobraćaj	/	/	/	8	4
Sidrište	/	/	/	2	1
Mali nivo rizika 1 – 12		Srednji nivo rizika 13 – 27		Visoki nivo rizika 28 – 81	

Prema tabeli 6, procjena rizika od zagađenja mora sa plovila za Luku Kotor i Bokokotorski zaliv primjenom matrice rizika 3X3 u tri nivoa pruža jedinstveno rješenje koje upućuje na podatak da manja plovila poput domaćih plovila, izletničkih brodova i jahti u nacionalnoj plovidbi predstavljaju mnogo viši nivo rizika od zagađenja otpadnim vodama sa plovila nego mega jahte i brodovi za krstarenje.

3. Zaključak

Prateći rezultate u tabeli 6, moguće je zaključiti da je more još uvijek ugroženo od strane manjih plovila na koje se ne primjenjuju međunarodne regulative, poput MARPOL konvencije i pariškog memoranduma.

Prema navedenom neophodno je dodatno jačanje domaćeg zakonodavstva u cilju postizanja adekvatne zaštite od zagađenja mora. Nacionalnim propisima neophodno je obuhvatiti one dijelove problema zagađenja morskog okruženja koji nisu obuhvaćeni međunarodnim propisma ili gdje ti propisi nisu 100% djelotvorni u cilju zaštite morskog okruženja. Primjena nacionalnih propisa jeste jedno od rješenja ili pak kombinacija nacionalnih propisa sa međunarodnim, što je znatno djelotvornije.

Poželjno je predložiti donošenje novog nacionalnog *„propisa o zaštiti od zagađenja otpadnim vodama sa plovila koja borave u lučkom području Luke Kotor i Bokokotorskog zaliva*". Važno je naglasiti da bi istovremena primjena datog prijedloga novog nacionalnog propisa i primjena međunarodnih propisa kojima se reguliše međunarodna plovidba i plovni objekti u njoj bila veoma djelotvorna u zaštiti od zagađenja otpadnim vodama sa plovila koja borave u lučkom području Luke Kotor i Bokokotorskog zaliva.

Dobijeni rezultati iz ovog rada mogu biti pokretač kreiranja i usvajanja novog nacionalnog propisa kojim će se stepen zaštite od zagađenja mora otpadnim vodama sa plovila znatno povećati.

U radu je istražen jedan sistem (šema) procjene rizika od zagađenja otpadnim vodama sa plovila za Luku Kotor i Bokokotorski zaliv. Međutim, na temelju ranije definisanog i postavljenog modela za upravljanje rizikom od zagađenja mora sa plovila iz kojeg je i proizašla navedena šema, istraživanje je moguće proširiti i na procjenu rizika od ostalih aspekata zagađenja. Kao što je u radu navedeno, posebna pažnja posvećena je Aneksu IV MARPOL konvencije koji sadrži Pravila koja regulišu sprečavanje i nadzor zagađenja mora otpadnim vodama sa plovila. Prateći odredbe navedene konvencije, tj. njenih Aneksa (Aneks I Pravila o sprječavanju zagađenja uljem, Aneks II Pravila o sprječavanju zagađenja štetnim materijama u rasutom stanju, Aneks III Sprječavanje zagađenja štetnim materijama u moru u pakovanom obliku, Aneks V Sprječavanje zagađenja otpacima sa brodova, i Aneks VI Sprječavanje zagađenja vazduha sa brodova), proširenje istraživanja omogućava da se spomenuti model, odnosno iz njega nastala šema toka procesa za procjenu rizika od zagađenja otpadnim voda sa plovila za Luku Kotor i Bokokotorski zaliv, dodatno proširi u cilju procjene rizika od zagađenja ostalim štetnim materijama sa plovila.

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Procjena rizika od zagađenja otpadnim vodama sa plovila u Luci Kotor

Pavić Bracanović, Žarko Koboević, Špiro Ivošević

Sažetak: Efikasnost u upravljanju rizikom zavisi od razumijevanja složenosti, vrste i prirode rizika sa kojim se okruženje suočava. Bokokotorski zaliv predstavlja najznačajniji prirodni resurs naše države i kao takav zahtjeva visok stepen zaštite. Plovni objekti koji borave u Bokokotorskom zalivu predstavljaju potencijalnu opasnost od eventualnog ispuštanja otpadnih voda. Porastom broja plovnih objekata koji borave u Bokokotorskom zalivu i Luci Kotor došlo se do potrebe za snažnijom primjenom alata procjene rizika u cilju identifikovanja mogućeg izvora zagađenja. Model procjene rizika od zagađenja obalnog mora otpadnim vodama sa plovila, a na primjeru plovila koja borave u Bokokotorskom zalivu i Luci Kotor, predstavlja mogući način identifikovanja i procjene rizika od zagađenja mora otpadnim vodama.

Ključne riječi: izvor zagađenja, lokacija zagađenja, matrice rizika, nivo rizika.

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Review paper

Contribution for the Fire Protection Improvement on RO-RO Ships

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Abstract: Fire is one of the most dangerous types of an accident that might happen to a ship, highly harmful to the crew as well as to the ship itself, high temperature, toxic vapours and gases are created (generated) by the combustion of a combustible material. In addition to human casualties, a material damage was also included in the fire. Therefore, a significant role of the fire protection is timely notification of fire, enabling the quick intervention, the damage reduction and engagement of people and equipment. The possibilities of fire protection improvement are carefully studied by the authors on RO-RO ships. The aim is to point out the importance of fire protection preventive measures. The analysis of the article is based on the road tunnels fire alarm system and the possibilities of application on RO-RO ships. The authors have been suggesting the use of an optical sensor cable in garages on RO-RO ships as the main type of fire alarm system detectors.

Keywords: Fire protection, Road tunnels, RO-RO ships, Optical sensor cable.

1. Introduction

Fires can take hold quickly and spread rapidly, yet RO-RO ship crews are relatively small in number while detecting, locating and accessing a fire within a deck is time-consuming. Roll-on roll-off (RO-RO) car carriers are back in the spotlight following the total loss of the Felicity Ace. The Felicity Ace sank in March 2022 with 4,000 vehicles worth an estimated $400-$500 mn on board while being towed by salvors, two weeks after a fire broke out en route from Germany to Rhode Island, US. Recently, there has been an increasing number of ship accidents caused by fire, some of them need to be highlighted:

– MV Honor suffered a fire on its upper vehicle deck in February 2017, which led to extensive damage to the vessel, as well as to its cargo of about 5,000 vehicles,
– Sincerity Ace caught fire in the Pacific on New Year's Eve, 2018 with more than 3,500 cars on board. The crew had to abandon the vessel, and five tragically died,

- The Diamond Highway had to be abandoned by its crew in the South China Sea in June 2019, due to a fire, while carrying more than 6,000 cars, and
- The Höegh Xiamen, caught fire in June 2020 in Jacksonville, Florida, resulting in the total loss of the vessel and its cargo of 2,420 used vehicles [1].

The subject of this research is related to the fire protection of RO-RO ships, where fire alarm systems play a significant role. The aim is to indicate the possibility of using an optical sensor cable in garages on RO-RO ships. Recently, optical cables have been used in road tunnels.

The article is structurally divided into six basic parts. In the second part of the article, following the introduction, the road tunnels fire protection measures and the application of the optical sensor cable in the fire alarm system in tunnels are presented. The characteristics of RO-RO ships are described in the third part, while fire protection measures are listed in the fourth part. The fifth part discusses the possibility of using the optical sensor cable in garages on RO-RO ships. The last, sixth part of the article summarizes the concluding remarks.

2. Protection in the Road Tunnels

Although accidents occur not so frequently in road tunnels than on the open road, there is no doubt that a fire in a tunnel may cause far more serious consequences than a fire in the open. According to the French statistics, there will only be one or two car fires (per kilometer of tunnel) for every hundred million cars pass through the tunnel [2]. However, fire risk is a serious problem causing death for many people during past decades.

In addition to human casualties, an enormous material damage was also caused by the fire [3]. In many countries, the direct annual fire losses amount to about 0.2% of a gross domestic product (GDP), but if the costs of intervention services, fire protection measures, premium of the fire insurance and consequent losses in the production and trade are added to this, the total costs of fires rise to approximately 1% of GDP [4]. It should be mentioned, during the fire in the Burnley tunnel in Australia, the operator lost about AUD 3 million in toll revenue, due to the closure of the tunnel for four days, and each subsequent day would probably mean the loss of an additional AUD million [5].

Fire protection systems are installed in road tunnels, where automatic detectors are of special significance. For the automatic detection of tunnel fires and the subsequent initiation of cost intense fire ventilation and fire brigade alarm, linear heat detectors today are the only 100% reliable detector with a minimum of fault alarms [6]. The accident site can be located with an accuracy of 7-10 m (a temperature sensor cable), or 1-2 m (an optical sensor cable).

Lately, the linear detectors with a light beam have often been used. This type of the fire alarm detector has a sophisticated system that correctly directs the light beam and maintains the position of the detector during the exploitation.

One of the solutions for automatic notification of fire is laying of a linear sensor cable with a laser - flowed optical conductor based on the principles of changing the parameters of the laser beam caused by deformation of the conductor due to the increase in temperature. The cable is placed on top of the tube, along the central axis of the tunnel tube (Figure 1).

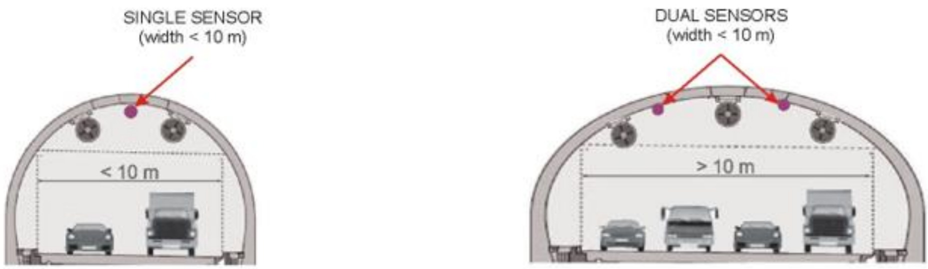

Fig. 1 – *Cable configurations in the roof of the tunnel.*

The optical fiber sensor measures the temperature gradient and the maximum set temperature, enabling the detection of fire within a sector of 4 m, as well as the direction and speed of its progress. The advantage of this sensor is the high resistance to atmospheric and aggressive environments, electromagnetic influences, physical shocks, vibrations etc., with low maintenance costs [7]. They are characterised by high resistance to aggressive chemicals, mechanical influences, road salt, accumulation of dust and dirt, splashing with water and regular cleaning of tunnels [8].

In the following text, the features of RO-RO ships are listed and the possibility of using an optical sensor cable in garages on RO-RO ships is analysed.

3. Significant Characteristics of RO-RO Ships

The RO-RO was defined in the November 1995 amendments to Chapter II-1 of the International Convention for the Safety of Life at Sea (SOLAS), 1974 as a passenger ship with RO-RO cargo spaces or special category spaces [9]. The cargoes in the ship are loaded and unloaded over the built ramps. RO-RO ships are usually equipped by stern or quarter ramps. In some ships, they are also found on the bow as well as the sides. Such ramps can become damaged or twisted due to due to improper commercial operations of the ship (loading and unloading). Damage to the ramp endangers watertightness and makes extinguish fires difficult, especially when using CO_2 system.

RO-RO ships are ideal for transporting different kinds of cargo and loading and unloading operations of the cargo is very effective. Cargo may remain on vehicle or it may be discharged from vehicle and stowed on deck.

The variety of cargo sizes on RO-RO ships is unregulated [10]. The world fleet of RO-RO ships have one or more RO-RO decks consists of a wide range of different kinds and sizes. Merchant ships under the International Convention on Load Lines are generally divided into two main types:

- Type A ships which are assigned lower freeboards, and
- Type B ships which are assigned higher freeboards than type A ships.

Type A ships are better protected from the sea and they have more internal subdivision and limited numbers and sizes of deck openings. RO-RO ships are belonging to type B with higher freeboards and they have weaker requirements for subdivision and damage stability. On type B hull is divided into a certain number of separate spaces (holds) by transverse bulkheads. Main transverse bulkhead should be watertight. In the event of the ingress water into hold (hull being holed), the bulkheads may prevent the ship from sinking or they will limit or delay the inrush of water enabling enough time for the evacuation. Fire in cargo space also may be limited by transverse bulkheads. Firefighting is also limited fire on certain cargo space and fire prevention measures are more effective. On the contrary RO-RO ships haven't fixed transverse bulkhead above main deck because the installation of fixed transverse bulkheads would prevent drive cargo on to the ship at one end to the other. Below main deck RO-RO ship is equipped with the watertight bulkheads prescribed by SOLAS. The huge decks on RO-RO ships enable water to enter very rapidly and fire may also spread very quickly for the same reason. New generation of RO-RO ships are equipped by movable bulkheads. Cargo spaces are subdivided by mentioned bulkheads when ship is at sea. Bulkheads are opened during commercial operations at port.

Stowage spaces on RO-RO ships are determined in Section 17 of the International Maritime Dangerous Goods (IMDG) Code and in Chapter II-2 of SOLAS as a space not normally subdivided in any way and extending to either a substantial length or the entire length of the ship in which goods, in or on rail or road cars vehicles (including road or rail tankers), trailers, containers, pallets, demountable tanks or, in or on similar stowage units or other receptacles that are loaded and unloaded, normally in a horizontal direction. There are, in general, three types of RO-RO spaces on board these vessels:

- Closed RO-RO spaces,
- Open RO-RO decks (openings are typically aft and in sides, but deck is above), and
- Open RO-RO decks/weather deck (with no deck above).

Closed RO-RO cargo space is a RO-RO cargo space that is neither an open RO-RO cargo space nor a weather deck. Open RO-RO decks is a RO-RO cargo space either open at both ends, or open at one end and provided with adequate natural ventilation that is effective over its entire length through permanent openings in the side plating or deckhead, to the satisfaction of the Administration. Open RO-RO decks/weather deck is a deck that is completely exposed to the weather from above and from at least two sides. It is the main feature which distinguishes the RO-RO ship from other types of ships. This deck (or more of them) run the full length of the ship between bow and stern. It is crucial for she efficiency and also the whole RO-RO concept. This is one of its most controversial features, since it has led to considerable concern about the safety of RO-RO ships is their stability (both the intact and damaged condition) [11]. Mentioned features have also great impact on spreading fire and demand additional requirements for installed firefighting equipment on this kind of ship.

RO-RO ships are equipped with powerful drainage water system on RO-RO deck. This kind of ship on navigating bridge have been supplemented by an audible alarm indicating any change of state of the doors under surveillance. Audible alarms should be equipped for presence of water in deck bilge. Firefighting by water also require water level monitoring in deck bilge. Circuit television system is on the navigation bridge as well as in the engine room to leakage monitoring. The sudden ingress of water due to damage of the hull or failure of watertight doors may have serious impact on ships safety.

RO-RO decks are generally known to introduce safety vulnerabilities. A Fire safe study which was carried out by European Maritime Safety Agency (EMSA) found that some 30% of fires have happened on RO-RO decks [12]. RO-RO spaces (closed and open) should be protected by a minimum one of following fixed fire-extinguishing system:

- Foam system,
- Water system,
- Gas system,
- Deluge system,
- CO_2 system,
- Rarely a high-expansion foam system, and

– Water mist have been developed as an alternative system.

Foam systems are specifically engineered and designed to protect areas where flammable and combustible liquids are present and where traditional water-based systems are not adequate. Foam systems fall into three categories: Low Expansion, Medium Expansion and High Expansion foams. Water has been the traditional firefighting agent for centuries, but too much water combined with inappropriate firefighting techniques has had disastrous results. Gas systems are able to combat fires automatically in sensitive areas where it is best to avoid using water. Deluge systems have been used for open RO-RO cargo spaces (cannot be sealed) and they can be used as an option for closed RO-RO spaces. A deluge control station is often located at an outside from navigation bridge, engine control room and crew accommodation and the release is initiated from this place [13]. Closed spaces on RO-RO ships are usually protected with a low-pressure or high-pressure CO_2 system. Relevant safety checks should be carried out prior to the release of CO_2. CO_2 systems are more effective firefighting medium but those systems are not suitable for open vehicle deck and they have limited effectiveness in boundary cooling [14].

4. Fire Detection and Alarm System on RO-RO Ships

Analysis of reports casualty data in maritime accidents in recent years has identified several sources of fires within RO-RO vehicle decks (Figure 2) [15].

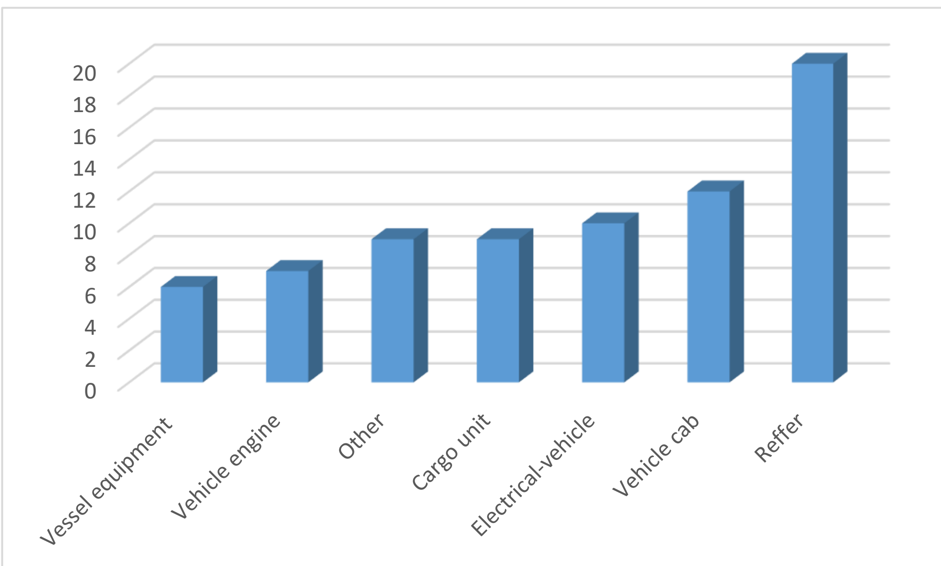

Fig. 2 – *Fires on RO-RO vehicle decks 1994-2011.*

The key finding in cases of fire incidents on car/RO-RO passenger vessels is that attention should be given to response time in the event of a fire incident. For quick action in fire cases, it is very important to have appropriate fire detection equipment.

The response of the detection and reporting system in time means reducing the scope of the fire and reducing the danger to passenger and cargo. System maintenance has an impact on the overall safety of the RO-RO ship. Today a typical fire detection systems on board RO-RO ships are consist of sensors and an alarm panel in fire station and on navigational bridge. That sensors can be with smoke, heat, flame and gas detectors. Detectors are provided a visible and audible alarm indicating the location of a fire on board ship. The detectors are wired to a fire control panel on navigational bridge and fire station. Fire detection systems on RO-RO ships can generally use:

– Thermal sensors,
– Smoke sensors, and
– Light (Photo) sensors (Flame detectors).

Thermal sensors react to the ambient air temperature and start to exceed the set value. They are used exclusively in spaces where a layer of heated air can appear on the ceiling. Smoke sensors are switched on and activated when smoke appears in the initial stage of fire development. These sensors are activated before the flame or heat sensors are activated. Light (photo) sensors detect flames by measuring the part of the light spectrum that appears in the flame. Since the signal reaches the detector at the speed of light, these sensors report in real time.

The mentioned systems have certain disadvantages. Therefore, the authors have been suggesting the use of optical sensors (fiber optic sensors) for the detection of fires in closed spaces on RO-RO ships.

5. Application of Optical Sensor Cable for Fire Detection and Alarm in Garages on RO-RO Ships

The optical fiber is increasingly being imposed as the most promising transmission medium because it was noticed a long time ago that there is a huge information capacity enabled by transmission systems that work at the frequencies of electromagnetic waves of light (information transmission capacity increases proportionally with the operating frequency of the system). Due to the characteristics of optical fibers, the application of optical technology in the field of sensors is increasing today. The optical technology must have properties of resistance to the specific conditions of the ship's environment (influence of salt, chemicals, temperature changes, humidity, vibrations, etc.) used on the ship.

Likewise, the lifetime of the optical fiber system will generally outlast the lifetime of a modern ship. The property of simplicity of self-diagnosis is also very important (the place of fiber optic damage is determined on the basis of light scattering with the use of a reflectometer). The optical fiber technology system has high reliability, which is of the particular importance on ship. It is also resistant to the effects of electromagnetic impulse interference, EM interference and radio frequency interference.

Depending of the sensor location, the optical sensor may be divided in two main groups: intrinsic or extrinsic. Optical fiber sensors for the fire detection in the cargo space of RO-RO ships proposed by Authors will be intrinsic sensors which are directly use an optical fiber as the sensitive part and also as the conductor to transport the optical signal with the measured information. In this type of sensor, physical perturbations modify the characteristics of the light carried by the fiber.

Starting from the use of optical fiber sensors for the fire detection and alarm in tunnels, the authors have been proposing the fire detection and alarm system be applied in closed spaces on RO-RO ships (garages) according to the principle. An optical fiber sensor would be installed on the ceiling of the RO-RO ship's garage. The fiber would be placed longitudinally above the center section of each parking lane as shown in Figure 3.

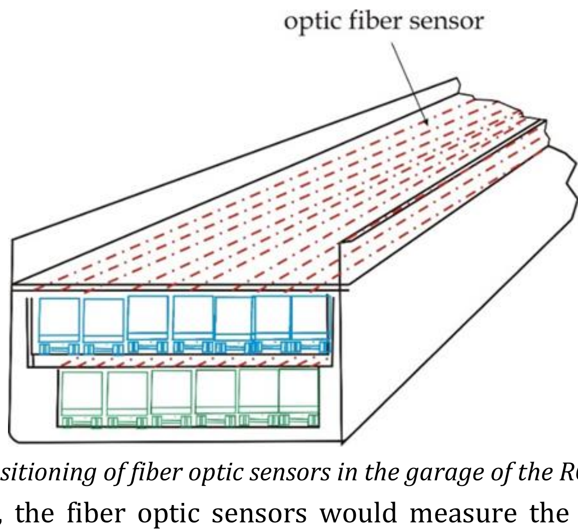

Fig. 3 - *Positioning of fiber optic sensors in the garage of the RO-RO ships.*

In this case, the fiber optic sensors would measure the temperature gradient and the maximum set temperature. This would enable the detection and progress of the fire within the sector of the parking lane, as well as the direction and speed of its progress. The advantage of this sensor is resistance to all harmful influences on the ship, it can also be an obstacle to the functioning of existing ship fire sensors. The fire alarm would be carried out by a fiber optic cable, which would enable obtaining information about the fire in real time.

Fire optical sensors detection systems are long-term investments on ship's safety having benefit but also significant costs that are incurred for procurement and installation this system. It is therefore reasonable to assume that introduction of proposed fire detection should not be based solely on the expected benefits. A more obvious decision-making approach involves considering both the benefits and the costs of considered system. Cost-benefit analysis provides a systematic means of determination the benefits of the system against the associated costs. If the benefits and costs can both be expressed in monetary units, mentioned analysis provides an objective basis for determining if this investment is justifiable in the case of the considered RO-RO ship, the benefit can be considered through preventing the development of fire and possible harmful consequences. Because optical fiber sensors are immune to electromagnetic interference and do not conduct electricity, they can be used in hazardous environments where high-voltage electricity or flammable material such as jet fuel may be present. Optical fiber sensors can also be designed to resist high temperatures [16].

A Raman-OTDR is used for distributed temperature measurements. Sensing systems based on Raman scattering are used to detect temperature, allowing the monitoring of large area with a single instrument, which is applicable for cargo space on RO-RO ships. Also, he ability to measure temperatures at thousands of points along a single fiber is particularly interesting for monitoring cargo space on RO-RO ships [17]. Table 1 shows the basic characteristics the Raman-OTDR optical fiber sensors.

Table 1 - *Basic characteristics the Raman-OTDR optical fiber sensors.*

Type of optical fiber sensor	Raman-OTDR
Measurand	Raman scattering
Field	Engineering
Sensing Application	Real-time monitoring, distributed temperature sensing
Network Config.	Distributed sensing
Performance	Temperature accuracy of 0.5 °C at a sensing distance of 11.5 km, temp. range -200°C to +700°C depending on fiber cable, testing wavelength 1550 / 1625 nm, pulse width 5 ns to 1μs [18,19]
Procurement and installation costs	About $50,000 [20]

This type of sensor is increasingly present on ships and replaces the current sensor technology. Fire optical sensors detection systems is especially suitable for places on board ship with high temperature (engine room) and vibrations. Advantages and disadvantages of fire optical sensors detection systems applicable on board ship are shown in Table 2.

Table 2 - *Advantages and disadvantages of fire optical sensors detection systems.*

ADVANTAGES	DISADVANTAGES
- Small size, - No requirement of electrical power at the remote location, - Precision in terms of detection location is very good even at long distances, - Resistant to electromagnetic and radio frequency interference, - Safe and suitable to be used in extreme vibration and harse environments, - Excellent flexibility, - Lower attenuation in the visible range, - Measure very small temperature changes, - Highly resistant to impact, extreme conditions, temperature and demanding environments, - Wide dynamic range and large bandwidth, and - Easy handling.	- Very expensive, - Detection systems may be complex, - Unfamiliar to the user and hence it requires basic training before they start using it, - Requires precise installation methods or procedures, -Complex to develop usable measurement systems using fiber optic sensors, and - Production of these types of sensors is quite complex.

The high procurement and installation cost of these sensors is the main optical sensor technology disadvantages and it is one of the main obstacles to the greater application of this system on board ships. Safety (based on the potential reduction in fatalities and injuries) and environmental protection enhancements due to a reduction in failures should be the main reason for installing these systems on board ships.

6. Conclusion

Car/RO-RO passenger vessels are specific in their construction as well as like the cargo they carry. The frequency of fires in the car/RO-RO passenger vessel segment is increasing and is currently at a level twice the frequency of fires on most other vessel types.

Adequate fire protection measures are necessary in order to reduce fire damage and prevent their spread and occurrence. The fire protection measures should enable quick intervention to reduce damage, as well as the engagement of people and equipment.

The use of optical fiber sensors has proven to be very successful in fire protection in road tunnels. Therefore, such an application in RO-RO ships would certainly be very efficient, since it enables prompt notification, which is of great importance for fire protection. Especially in this regard, fires are one of the most dangerous types of accidents that might happen to a ship because they cause great material damage, also the loss of human life. High price of fire optical sensors detection systems can be the main reason why these systems have not found wider application on board ships.

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Contribution for the Fire Protection Improvement on RO-RO Ships

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Review paper

The Influence of Shallow Waters on the Maneuvering of Large Ships*

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Abstract: The increasing demand for goods that can be transported by sea and the reduction in transportation costs have led to a trend toward larger ships. The increase in ship capacity leads to an increase in ship length and, thus, a decrease in transportation costs. The maneuverability of large ships in shallow water when calling at ports is becoming increasingly difficult. This is due to the discrepancy between increasing ship dimensions and unchanged waterway structures such as approach channels, harbors, and ports. The maneuverability of a vessel in shallow waters is different from the maneuverability in deep waters. The reasons for this are due to the shallow water effect. Shallow water affects the maneuverability of ships due to hydrodynamic forces caused by the current, shallower depth under the keel and proximity to the shore. It is a major challenge both for shipbuilders to design such vessels and for shipowners to have trained and well-educated officers who can navigate large vessels in shallow waters. This article presents the effects of shallow waters on large ship maneuvering and mathematical models that have been used to predict ship behavior under the influence of these forces.

Keywords: Large ships, Maneuvering, Shallow water, Hydrodynamic forces, Mathematical models.

1. Introduction

Large ships are generally defined as vessels with a length of more than 100 meters and a displacement of several thousand tons or more, depending on their purpose and design. A ship's maneuverability in shallow waters differs significantly from its maneuverability in deep waters. In addition to deep waters, ships also navigate channels and port approaches known for their shallow water depths. The master and watchkeeping officers must be thoroughly familiar with the maneuvering characteristics of their own vessel, as this is critical to issuing correct maneuvering orders when

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navigating in shallow waters. The maneuvering characteristics of one's own vessel are derived from the maneuvering diagram of sea trials in deep, unconfined waters. However, sea trials cannot provide information on the maneuverability of the ship in shallow waters. Therefore, it is of utmost importance to understand the influence of shallow waters on the maneuverability of the ship [1].

In navigable areas such as ports and their approach channels, the ship's maneuverability depends on the depth of water in the navigable area relative to the ship's draft. In addition to the shallow water depth in approach channels, vessel movement is also restricted by the side's proximity and the bank effect's influence. Waters with such restrictions are referred to as restricted waters. The combination of shallow and restricted water is called confined water [2]. The influence of shallow water, proximity to the shore, and strong ocean currents significantly limit the ship's ability to manoeuvre, especially when the navigation channels are curved and the ship must frequently alter its course [2]. Ship handling in such conditions is a significant challenge for pilots, masters, and watch officers. Predicting the ship's maneuvering characteristics in such situations is very important [3].

In recent years, there have been a number of noticeable accidents involving large container ships running aground. Two notable incidents are the grounding of the Ultra Large Container Vessel (ULCV) Ever Given on March 23, 2021, in the Suez Strait, Egypt, and the grounding of the Very Large Container Ship (VLCS) Ever Forward on March 13, 2022, in the Craighill Channel, USA. Both incidents were attributed to the influence of hydrodynamic forces, which can be particularly difficult to control in narrow or shallow waterways.

The article consists of three sections. An introduction describing the maneuvering limitations of large vessels when sailing through narrow channels and shallow waters. Section two describes the hydrodynamic forces acting on ships in narrow channels and shallow waters and the mathematical models used to calculate these forces on the ship. The following mathematical models are analyzed: system identification techniques, computational fluid dynamics (CFD) and captive model test method. In the third section, the conclusions are presented.

This article analyzes the hydrodynamic forces that act on a ship when it navigates in narrow channels and shallow waters and the mathematical models used to predict the behavior of these forces on the ship.

2. Hydrodynamic forces acting on a ship

The difference between increasing ship dimensions and unchanged navigation infrastructures has raised awareness of navigational analyzes for navigation in shallow waters. Predicting the ship's maneuverability under such conditions is critical and has led to the increasing use of ship handling simulators [3].

When navigating in shallow waters, the depth restriction significantly changes the pressure distribution around the ship, leading to an increase in hydrodynamic forces due to ship motion and a decrease in the ship's maneuverability [4, 5].

In maneuvering, the hydrodynamic forces in the longitudinal and transverse directions and the yaw moment are the most important [6]. Actually, a ship moves in water with six degrees of freedom (DOF), known as surge, sway, heave, roll, pitch, and yaw (Figure 1). However, only three motions derived from the above forces and one moment (sway, heave, and yaw) are usually used to study the maneuverability of ships. This simplification is because they occur at a lower frequency than the frequencies of the wave impacts [7].

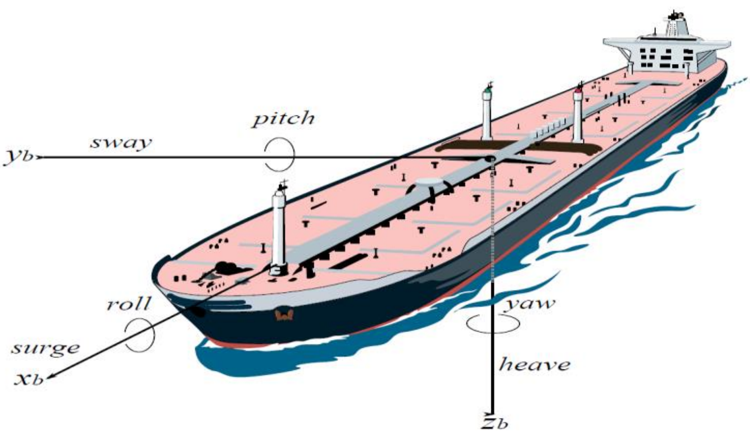

Fig. 1 – *The 6 DOFs motions of a marine surface ship in waves* [7].

When dealing with steering and manoeuvring ships, the primary motion can be considered to take place in the horizontal plane, and vertical motions can be neglected. Further, by choosing an axis system in the place of the symmetry of the body and assuming that the centre of gravity lies in the centre line plane, and neglecting the rolling and heeling, the equations of motion for a ship moving in the horizontal plane will be:

$$
\begin{aligned}
X &= m\left[\dot{u} - ru - x_G r^2\right] \\
Y &= m\left[\dot{v} + ru - x_G \dot{r}\right] \\
N &= I_Z \dot{r} + m x_G \left(\dot{v} + ru\right)
\end{aligned}
\tag{1}
$$

where m is the ship's mass, and I_Z is the correspondent moment of inertia in yaw motion. The external forces X (surge), Y (sway) and the torque N at the ship's fixed reference frame (midship at a x_G distance from gravity centre CG) of the ship are induced by the flow around the ship's hull, propeller, and rudder. The current ship velocity V can be decomposed in the body axes x, y and z with projections u, v and w, respectively, while $\dot{u}$, $\dot{v}$ and $\dot{r}$ stands for longitudinal, lateral and angular acceleration.

3. Modeling methods for ship maneuverability in shallow waters

Various mathematical models have been proposed to describe ship dynamics in shallow waters. The most common mathematical models are: System Identification Techniques, CFD Calculations and Captive Model Test Methods [7, 8].

System identification is one of the most reliable techniques for improving mathematical models using collected data. It is a technique for building mathematical models from measured data and can be applied to free-running model test results, and it is well presented in recent work published by Hu and Soares [7].

With the development of computer capabilities and numerical techniques, the CFD method has become very popular, as it is now possible to predict the manoeuvrability of ships. The advantage of the CFD simulation is that one can obtain detailed results that contribute to a better understanding of the hydrodynamic forces that occur when a ship maneuvers in shallow waters [1]. The CFD method is widely used to study ship maneuvering in shallow waters, bank effect, ship-ship interaction, ship-bank (shore interaction), and ship-bottom interaction. Figure 2 shows the research methodology proposed by [1] for the free-running simulation CFD with four steps aimed at better understanding the influence of shallow water on ship maneuverability. The first step is the selection of a suitable ship that meets oceanic conditions. Starting points are simulations in calm seas with different water depths and in deep and shallow seas with different under-keel clearances. In the second step, numerical modelling is performed by selecting the guiding model and coordinate system, spatial and temporal resolution, and boundary conditions. In the third step, free-running simulations are performed, which include the standard zig-zag test, course keeping, and turning circle maneuvers. Many mathematical models use standard ship maneuvers and emergency manoeuvres in their simulations [9]. Manoeuvring tests are used to demonstrate the effectiveness of the ship's manoeuvring ability, especially in shallow waters. In the final step, an analysis is performed that focuses mainly on the results of the ship's course-keeping ability and maneuverability. Figure 3 shows the simulation of CFD free-running manoeuvres (zig-zag, course keeping, turning circle) in different depth to draft ratios.

One of the most used models is the Captive model test method. This is an effective method for determining the hydrodynamic coefficient for a mathematical model of ship manoeuvring motion [10]. The results of the captive model test can be used to verify numerical models and other functions related to vessel manoeuvring, research projects (most of which are related to approach channels and port approaches) and for the study of ship-shore and ship-ship interactions. The measured forces from research can be used as input data for ship simulators. The captive model test is also used to perform a rapid test of ship design to determine if the ship meets the manoeuvring criteria established by the International Maritime Organization (IMO) [10].

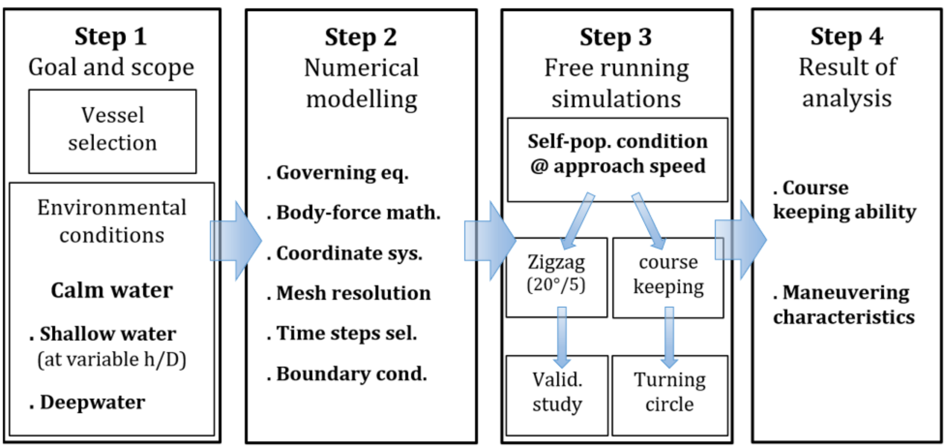

Fig. 2 - *CFD free-running simulations methodology* [1].

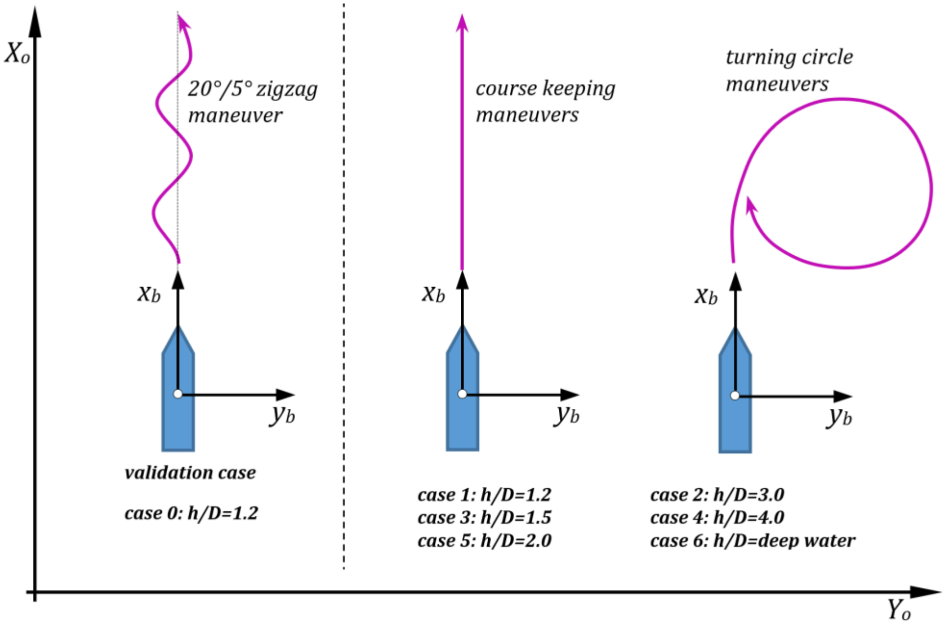

Fig. 3 – *Simulation cases of free-running manoeuvres* [1].

Mathematical models of ship manoeuvring typically focus on predicting longitudinal forces, sway forces, and yaw moments acting on the ship in its horizontal path. For mathematical models of manoeuvring in shallow water, models with 3 degrees of freedom (3 DOF) were successfully used. Later, a rolling motion was introduced as the 4th DOF. Sinkage and trim were not used in mathematical models, i.e., they were treated separately from other forces and occasionally added to mathematical models for squat calculations. Since IMO introduced regulations for manoeuvring criteria under the influence of wind and waves, the manoeuvring model with 6 degrees of freedom is mandatory [11]. Manoeuvring a ship is a very challenging task due to the influence of changing external factors such as wind, waves and sea currents. Due to these factors, the draft, trim and heel of the ship change [12]. For this reason, wind and waves must be included in a ship's manoeuvring criteria. 6 degree of freedom (6 DOF) manoeuvring models in a calm water are also used [11].

When studying ship motions in 6 DOF, it is recommended to define a body-fixed and an earth-fixed coordinate frame [13]. Figure 4 shows the ship and earth fixed coordinate system in 6 DOF, where Oxyz is a body-bound (ship), and $O_0x_0y_0z_0$ is an Earth-bound (towing tank) coordinate system. The body origin O is located at the vessel midship section equal to one-half of ship LPP. The positive longitudinal Ox-axis is directed from stern to bow, the positive transversal Oy-axis runs along the breadth or beam of the ship and is positive towards the starboard side. In contrast, the positive vertical Oz-axis is directed down - towards the ship keel. For a right-handed axis system looking in the positive direction of each axis, the rotation angles are positive clockwise in standard notation and sign conventions. Furthermore, O'x'y'z' defines a horizontal-bound coordinate system which always remains horizontal i.e., does not change with vessel heave, pitch, and roll motion.

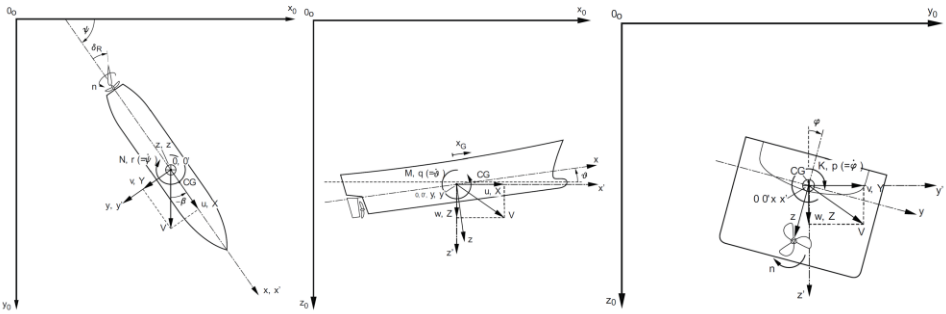

Fig. 4 - *Ship and earth fixed coordinate systems in 6 DOF* [11].

Hydrodynamic interaction between two large ships in a narrow channel is also a subject of research using mathematical models. The reason for this is the increased density of ships in narrow channels and shallow waters. When passing or overtaking, there are unpredictable interactions between ships that can lead to a collision. The hydrodynamic forces between two vessels in narrow channels and restricted waters are more complex than in open (unrestricted) waters and are the subject of research [14].

Regardless of the mathematical models used to control a ship in shallow waters, the skill of ship handling can only be learned and improved through theoretical training and practice. Theoretical training is undoubtedly important because officers gain knowledge of the hydrodynamic forces acting on the ship. The theoretical basics of manoeuvring are the starting point. Exercises on the ship simulator complement the theoretical basics with a series of manoeuvre simulations and are certainly a valuable tool to practise and improve ship manoeuvres. Finally, good manoeuvring skills are achieved through many years of practice, of course, with the best possible knowledge of the manoeuvring characteristics of own ship. By understanding the influence of hydrodynamic forces on the ship when navigating in shallow waters, officers can think ahead and plan ship manoeuvres [15].

4. Conclusion

Ship maneuvering in shallow waters and narrow channels remains a significant challenge and a great responsibility for the Master of the ship and his officers. For efficient and safe maneuvering of the vessel, planning ahead with sound theoretical knowledge of resistance, trim, stability, and maneuvering characteristics (turning circle, rate of turn, stopping ability) is of utmost importance.

Mathematical models are a great help in calculations for maneuvering in shallow waters. They are the basis for creating simulations of the maneuvering of large ships. Although various mathematical models have been developed for predicting ship behavior under the influence of hydrodynamic forces in shallow waters, it is undeniable that to maneuver a ship safely, it is necessary to understand the maneuvering characteristics of own ship and to have good maneuvering skills resulting from years of experience at sea.

Sound theoretical knowledge and familiarity with the maneuvering characteristics of one's own vessel in shallow waters enable the Master to make the correct maneuvering decisions, significantly reducing the risk of collisions and groundings and increasing the safety of navigation at sea. Due to the increasing trend of building large ships in the global market, scientists and engineers need to use mathematical models for ship maneuverability in shallow waters and improve existing models where necessary. Mathematical models are of great help in calculating and predicting maneuverability. At the same time, the practical knowledge of navigators in ship handling will be crucial for handling large ships in confined and restricted waters.

Computational fluid dynamics is currently a standard technique worldwide for solving hydrodynamic problems of ships. The results of numerical simulations are promising and can be improved by increasing the time steps and changing the mesh precision, increasing the accuracy of the overall drag results.

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