



Text emotion analysis in aquaculture communication via Twitter: The case of Spain

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ABSTRACT

Public acceptance arises as one of the main defiance in aquaculture. This situation is especially relevant in regions of the global north such as Europe or North America, where social acceptability is conditioning the expansion of this industry production capacity and the development of markets for aquaculture products. Understanding not only consumer perceptions, but also other collectives' insights is the first step to build sectoral strategies that focus and communicate benefits and combat myths, leading to greater social acceptability. Information disseminated through social networks represents a great opportunity to analyze large amounts of information disclosed by involved stakeholders. Unlike most studies focused on consumer perception, this study conducts a sentiment analysis of the communication released on Twitter by different stakeholders related to aquaculture in Spain: producers, specialized media, associations and research centers. The analysis is carried out using the TwitterR package of the R software, which provides direct communication through an Application Programming Interface (API), and its nrc lexicon. Results show significant differences among stakeholders' profiles, showing that *trust*, *negative* and *positive* words are prevalent in the tweets of all stakeholders. This study shows an underutilization of the potential of the social network, and a more effective communication by specialized media profiles. The use that these profiles give to social networks is an example that shows producers and policy makers the benefits that can be derived from a professionalized communication of aquaculture through social networks, not only to consumers but also to society as a whole.

1. Introduction

Aquaculture has emerged as the activity to ensure the supply of seafood products to meet the growing global demand for fish in the face of the overexploitation of aquatic resources and the growth of the world population. Nowadays, almost half of seafood products are farmed [17]. Although the need for aquaculture is clear, negative perceptions of the industry have proven to be a significant barrier to such growth [58]. In the European Union (EU), companies in the sector guarantee the supply of healthy and quality food that meets all health and environmental regulations, generating wealth and employment. However, unlike other animal production industries, social acceptability is one of the main bottlenecks to aquaculture development in Europe [2]. On the market side, many consumers still make a comparison between wild fish and aquaculture production, often assigning the latter a worse evaluation in terms of quality, health, and the impact of the activity on the environment [11]. On the other hand, the lack of information, communication, and stakeholders' participation in the areas where aquaculture activity

takes place or new facilities would be located, can lead to social conflict and reduced public support and trust [6]. That is why public acceptance has always been a challenge in aquaculture and especially in recent years when aspects such as animal welfare, food safety, traceability, eco-labeling, and sustainability have gained importance [30] and pose a challenge to be communicated by companies, public institutions and other stakeholders involved in the sector.

There is an increasing interest in analyzing social acceptability from a policy and governance perspective [2,10,52]. However, the rising concern about aquaculture production's negative effects has led to one of the most demanded lines of research, the analysis of stakeholders' perceptions. The analysis of perceptions includes in the first place consumers' perceptions, as in Feucht & Zander [18] or Zander et al. [60] on the opinion of German consumers; in López-Mas et al. [39] on the beliefs of consumers in France, Germany, Italy, Spain, and the UK or in Altintzoglou et al. [3] on the image of EU consumers. Other authors extend their sample to various stakeholders, such as in the study of Reig et al. [51] about perceptions of aquaculture not only by consumers but

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also by wholesalers and fishmongers in Barcelona metropolitan area; or in the study of Bacher [5] including perceptions of five key stakeholder groups (NGOs, local fishermen, fish farming industry, scientists and regional administration). Most common studies analyze perceptions of the general public, tending to focus on the social acceptability of aquaculture in specific areas. In this sense, the perception of the general public has been analyzed in the province of Cadiz in Spain [52], Canada [35,57], the Eyre Peninsula and Port Phillip Bay in Australia [1], New Zealand [54], or the US [58]. The majority of these studies have in common the object of analysis: aquaculture-related opinions expressed by the interviewed groups. For this reason, the most commonly used methodologies have been focus groups and Delphy surveys, where words / judgements / opinions issued by groups are codified once the conversations have been transcribed. This process is usually carried out “manually” by the researchers. Given the nature of the methodology (small groups of individuals/experts), fewer studies combine other types of groups in the same study, such as fishmongers or other stakeholders [6,51]. The motivation of these studies is to know the perception of different collectives, mainly consumers, since understanding these perceptions is the first step to building a strategy that focuses and communicates the benefits and combats myths [51]. In large part, the analyses concluded that the media are great allies when it comes to disseminating positive and truthful information about the sector, adopting a proactive communication position. Indeed, the media provides information and helps society to understand and obtain an opinion about what is happening in the world [14]. But, at the same time, the media also influences their audience’s attitudes and perceptions of the outside world [24]. Govaerts [24] concluded that the media coverage of farmed salmon in France is negative. Weitzman & Bailey [56] found that media frames finfish net-pen aquaculture in a mostly negative tone in Canada.

In this context, a proactive communication position can also be carried out directly by producers, who are the primary agents in the sector and the main interested party in the social acceptability of their product. However, studies on the messages issued by primary stakeholders in aquaculture (e.g. producers or associations) are scarcer and focus mainly on the media. An approach that is increasingly being used in these analyses of perceptions is sentiment analysis. Literature on emotions in organizations includes psychological The professionalization of social network profiles can help, not only on the part of specialized media, but also on the part of producers, associations, and public bodies to promote social acceptability. Future lines of research could include the perception of emotions by users and inquire into the type of retweeted messages and its most representative emotion. Furthermore, it would be revealing to cover other types of social networks to verify whether the patterns of sentiments per stakeholder are repeated in other channels of communication. In addition, it should be considered whether greater and better use of social networks would have a greater influence on social acceptability and truly improve consumer and other stakeholders’ perceptions.

reactions and responses to a given cause [8] and attempts to analyze how certain attitudes and behaviors can be explained and predicted. Discrete emotions, such as joy or surprise, influence the emotions and thoughts of others [26]. Therefore, those emotions can be transformed into moods. On many occasions, this transformation can take place imperceptibly. Particularly in the case of aquaculture, Froehlich et al. [19] have used public sentiments about different forms of aquaculture, in this case analyzing traditional media coverage (newspaper headlines) to obtaining cross-national sentiment patterns. Traditional media can be considered a good proxy of public sentiment, however, studies have been conducted in certain countries or periods, given the difficulty of quantifying the huge existing amount of news. That is why in recent years, data mining has been used to develop these sentiment analyses, allowing researchers to process larger amounts of data [7].

Nowadays, one of the most effective tools to develop and control active communication strategies is social networks. These allow both

designing and controlling the message, as well as reaching society directly without relying on traditional media. Information disseminated through social network services (SNSs) is key to the promotion of products and services, and many industries and business activities have accumulated great experience in its use as a fundamental channel for commercial and corporate information [25,42]. However, other activities, especially those that do not market directly to the final consumer, as in the case of many aquaculture producers, have a lesser presence in SNS. Primary sector producers are the first link in the food value chain, and in most cases, they negotiate with wholesalers, intermediaries, or retailers. However, in recent years, primary sector producers have been trying to increase their bargaining power by developing more direct commercialization channels, for which they need to make their products known to the final consumer. For this reason, it is increasingly observed that these producers have their own communication channels such as websites, where they can publish their sustainability reports or non-financial information, due to the requirements demanded by consumers, or more immediate channels such as SNS: Facebook, Twitter, Instagram.... Despite the growing importance of SNS within the communication strategies of aquaculture companies, the literature on their use in the aquaculture industry is scarce and focuses mainly on its usefulness as a tool for sharing knowledge and information, and creating collaborative networks by producers in developing countries [29,38]. Nevertheless, to the best of our knowledge, there is no previous literature about the use that the aquaculture industry and related stakeholders are giving to social networks when it comes to communicating aquaculture.

The objective of this work is to analyze how information about aquaculture is communicated by relevant stakeholders in the sector through the social network Twitter in Spain. Twitter is an open network in which it is not necessary to follow each other to access profiles and information. It is based on the emission of information in spaces of 140 characters, which can be similar to the headlines used in previous work methodologies. To achieve this goal, we will use data mining and its ability to analyze large amounts of data to develop a sentiment analysis in different collectives: aquaculture producers, specialized media, producer associations, and research centers, checking whether there are differences in the sentiments emitted and therefore, providing greater scope concerning the work done so far. In addition to categorizing the published information as positive or negative, the analysis of text emotions allows one to approach other types of emotions thanks to the use of different lexicons.

Although Spain has lowered its production by 11.1% compared to 2019, it has the highest aquaculture harvest in the European Union with 276,571 tonnes in 2020, 25.3% of the Union total, valued 525.8 million € (being the second Member State after France and followed by Greece and Italy) [4]. In recent decades, an intensive aquaculture industry diverse in number of species and production systems has developed throughout the territory, both in inland regions, where rainbow trout is produced, but above all in coastal regions, where there are shellfish (mainly mussels) and fish important productions (especially seabream, seabass, turbot and more recently, Atlantic Bluefin tuna). The initial rapid development of aquaculture in coastal areas, especially the culture of fish in cages, has been slowed down by the complexity of obtaining new licenses, partly due to the opposition of society in the places where they intend to locate. On the part of the markets, the Spanish consumer has a strong tradition of consuming seafood, and despite the efforts of producers and public institutions in recent years, there is still a high degree of ignorance and mistrust towards products from aquaculture. The numerous promotional campaigns developed by public bodies and producer associations in recent years are an example of the relevance and importance for the industry of increasing awareness of aquaculture and its products among consumers and society in general.

The article is structured as follows. First, the context of the challenges of social acceptance of aquaculture and communication is described. Secondly, we describe the sample of collectives and the

methods used, detailing the statistical software used and the data extraction through the Twitter Application Programming Interface (API). Thirdly, we delve into the type of information disclosed by stakeholder, paying special attention to the most commonly used words and the sentiments conveyed through the tweets. Finally, conclusions and recommendations for companies and uses of the social network are included.

2. Social acceptability and communication

One of the ways of gaining acceptance in aquaculture is through regulation and governance. Many experts agree on the convergence of the needs of the environment with the efficiency of the aquaculture industry, something that should be the responsibility of the policymaker and the legislator in the common interest [27]. Aquaculture is facing strong public opposition [36], misgivings about information from governments [58], and pleas for more effective communication [13]. In this context, most recent studies analyzing social license and social acceptance concur that it is the communication from non-governmental organizations and key private actors [58] that could modify attitudes and perceptions in consumers and society [1,3]. For this reason, more and more experts are demanding responsive policies and programs that improve communication, especially for those directly involved in risk management dialogues [1].

Literature usually focuses on the sources of information most readily available to consumers and the general public and most frequently involved in communicating benefits and potential risks [48]. These sources of information are mainly “print media, television, internet, advertising, scientific reports, institutional campaigns, product labeling, sellers (e.g. fishmongers, supermarket employees), consumer associations, and non-governmental organizations” [47]. Through this whole range of possibilities, specialized media can echo new attempts in species farming, innovations in the sector, and any relevant activity in the industry. Producers, individually or through associations, have the power of branding their products to communicate advantages and benefits, generating brand image and creating a good reputation. At an institutional level, it is the communication campaigns that publicize the benefits of aquaculture, intending to increase consumer trust and confidence [9,30,39,51]. For example, Best Aquaculture Practices released the campaign Healthy Fish, Healthy Planet, Healthy You! in October 2022 to “highlight our commitment to responsible seafood sourcing, increase consumer awareness of Best Aquaculture Practices (BAP), and encourage customers to purchase and eat more healthy, high-quality seafood”.¹ At a national level, there are campaigns in Spain promoted mainly by the Ministry of Agriculture, Fisheries and Food and APROMAR, the Spanish Aquaculture Association. The latest campaigns are: “And you, have you fished today?” (*Y tú, ¿has pescado hoy?*), to stimulate the consumption of aquaculture products, highlighting its characteristics “Tasty, healthy, safe” (*Rico, sano, seguro*) and “You don’t know me” (*Tú no me conoces*), in which aquaculture is promoted as a sustainable farming method and a source of income for traditional fishing families. These communication messages from governments and industries emerge as key aspects to disprove negative stereotypes [46]. Additionally, certificates issued by public or private organizations seek to increase confidence in the product by promoting and guaranteeing certain manufacturing or processing standards in certified companies or products [45]. Some of these certifications in the field of production include Friend of the Sea, Global Aquaculture Alliance, Aquaculture Certification Council, Global GAP, Marine Stewardship Council (MSC), Aquaculture Stewardship Council (ASC), Trucha del Río (Trout from the River), Crianza de Nuestros Mares (Raising of Our Seas), or Pescado de Estero (Fish from the Marsh) (see more in [43]).

The information available, issued by the above stakeholders, is used

as the means through which consumers and the public form their opinion of aquaculture. In this way, the focus on consumers’ or other stakeholders’ perceptions has meant that the analysis of the messages issued by primary stakeholders directly involved in aquaculture remains unexplored. Olsen et al. [45] have already raised challenges experienced by the industry in terms of communication since producers lack influence on what consumers receive from retailers. Studies that analyze the messages that are released by issuers of information are mainly focused on media, specifically newspaper headlines [16,19,33,45]. However, one of the information sources identified as most important for disclosing aquaculture information is the Internet, and especially, social networks and blogs to reach larger audiences [9,47]. The lack of studies focusing on the message and, especially, the potential of social networks for communicating aquaculture information reveals a gap in the literature that needs to be covered. Moreover, this responds to one of the requests from authors such as Cavallo et al. [12] or Condie et al. [13], who call for a better use of social networks in aquaculture communication for better engagement with stakeholders. Becoming good senders of emotions can favor the social perception of the sector through emotional contagion in a conscious way [9] but it can also put a human face [40] on a link in the supply chain that has hitherto been considered a mere intermediary. Sentiment analysis has been previously used in the context of aquaculture by Froehlich et al. [19] and Glutting & Young [23] to identify key distinctions between aquaculture types and feelings, but it is a very powerful tool for understanding behavioral differences among information issued by certain industrial or commercial activities [37]. In addition, positive emotions elicited by SNS use have been analyzed from the point of view of workers and job performance [34] so that the use of SNS can also have a positive organizational effect, increasing employee well-being and commitment. Our research analyzes the sentiments of several groups of stakeholders in the social network Twitter: producers, associations, specialized media, and research centers, fostering creating new opportunities for public engagement [32]. When it comes to analyzing and comparing results, data mining is a very powerful tool so that researchers can explore large volumes of data to discover hidden knowledge [22].

3. Materials and methods

3.1. Sample

Unlike other studies on social media and social acceptability focusing mainly on newspaper headlines, we perform a sentiment analysis on the communication released on Twitter by 53 different stakeholders related to aquaculture: 18 producers, 4 specialized media, 10 associations (producer associations, enterprise associations, wholesalers associations, etc.) and 21 R&D centers. First, all Spanish aquaculture companies (CNAE code 032) with a Twitter profile in May 2022 were selected. Out of 519 enterprises obtained from SABI database, 18 companies have a Twitter profile. The specialized media act as an “intermediary for scientific information reaching the public, particularly in the food sector” [19]. A search based on the authors’ expertise has led to four profiles of specialized media in aquaculture being included in the analysis. Concerning associations and research centers, the analysis included those with a Twitter profile from the directory of the Spanish Aquaculture Observatory (OESA). OESA is a project of the Biodiversity Foundation of the Spanish Ministry for Ecological Transition and the Demographic Challenge that aims to monitor and analyze the development of aquaculture in Spain, promoting its sustainability and strengthening its image in society [44]. Out of 68 associations and 63 research centers in the directory, only 10 and 21 have Twitter profiles respectively. Table 1 shows the type of stakeholder analyzed (producer, specialized media, associations, and R&D Centre), the name of the organization, the date of creation of the Twitter profile associated with that organization, and the activity of the profile in terms of followers and accounts followed, as well as tweets published up to 13 May 2022.

¹ <https://info.globalseafood.org/healthy-you-campaign-lp#form>.

Table 1
Profiles included in the analysis.

Stakeholder	Organization		Since	Followers / following	Tweets (13/05/2022)	
Producers	Seaweed / Microalgae	Huertamarina Huelva SL (@HuertaMarina_H)	Oct. 2016	28 / 47	11	
		Algalimento SL (@algalimento)	Apr. 2015	712 / 239	111	
		Aqualgae SL (@Aqualgae)	Sept. 2015	49 / 27	9	
	Bluefin tuna	Grow to Grow Algae Solutions SL (@g2galgae)	Feb. 2020	190 / 258	704	
		Balfego Tuna Sociedad Limitada (@_Balfego)	Apr. 2012	2.417 / 944	2.445	
		Seabass, seabream	Niorseas SL (@corvina_rex)	Oct. 2016	546 / 556	1.144
	Culmarex (@culmarex)		Nov. 2017	102 / 22	3	
	Aquanaria SL (@aquanariafish)		Sept. 2017	377 / 173	456	
	Shrimp	Gambalucia SL (@Huelvamar1)	Dic. 2017	11 / 10	10	
		Sole	Sea 8 Porto SL (@sea8aquaculture)	Oct. 2019	99 / 34	58
		Sea anemone	Imare Natural SL (@iMareNatural)	Dic. 2015	160 / 58	238
	Sea products	Nueva Pescanova Biomarine Center SL (@PescanovaCorp)	Feb. 2017	2.313 / 555	2.411	
	Salmon	Proyectos Norcantabric, SL (@norcantabric)	Aug. 2020	72 / 72	18	
		Trout / rainbow trout	Seafood Legacy Spain SL (@SeafoodLegacySP)	Sept. 2020	1 / 2	0
			Piszolla SLU (@Piszolla)	Sept. 2012	39 / 40	52
	Shellfish		Ovapiscis SA (@Ovapiscis)	Jul. 2020	6 / 0	108
		Grupo Tres Mares SA (@grupotresmares)	Jul. 2014	25 / 9	1	
		Matxixako Moluscos SL (@AmarraMuskulua)	Sept. 2019	11 / 19	8	
Specialized Media	Ipac. Acuicultura (@Ipacuicultura)	Jul. 2009	787 / 7.509	32100		
	misPeces Acuicultura (@mispeces)	Sep. 2008	516 / 6.311	12800		
	Panorama Acuicola Magazine (@PanoramAcuicola)	Feb. 2010	1095 / 4726	8886		
	Europa Azul (@europaazul)	Jun. 2010	2126 / 2056	675		
Associations	Asociación De Empresas De Acuicultura Marina De Andalucía (@PescadodeEsteró)		Dic. 2012	174 / 269	56	
		Asociación Empresarial De Acuicultura De España (@APROMAR_acui)	Apr. 2011	377 / 2.841	4631	
	Asociación Española de Mayoristas, Importadores, Transformadores y Exportadores de Productos de la Pesca y Acuicultura (@ConxemarOficial)		May. 2015	545 / 2.544	1932	
		Asociación Nacional De Fabricantes De Conservas De Pescado Y Marisco (@anfacocecopesca)	Oct. 2016	561 / 1.949	1515	
	Federación Nacional de Asociaciones Provinciales de Empresarios Detallistas de Pescados y Productos Congelados (@LuisaFishFan)		Nov. 2014	673 / 981	2177	
		Fundación Centro Tecnológico Acuicultura De Andalucía (@Ctaqua_CT)	Sep. 2011	224 / 3.598	2555	
	Fundación Empresa Universidad Gallega (@Feuga_20)	Jul. 2010	1.672 / 4.233	3917		
	Sociedad Española De Acuicultura (@acuisea)	Mar. 2015	93 / 1.771	560		
	Sociedad Europea De Acuicultura (European Aquaculture Society) (@easaqua)	Dic. 2016	760 / 3.559	1055		
	Sociedad Mundial De Acuicultura (World Aquaculture Society) (@WrldAquaculture)	Aug. 2012	12 / 5.159	165		
R&D Centers	AZTI (@azti_brta)	Abr. 2009	1004 / 7978	12300		
	Centro de Acuicultura Sant Carles de la Rápita (IRTA) (@irtacat)	Feb. 2013	3.277 / 12.400	18000		
	Centro Tecnológico de Acuicultura de Andalucía, CTAQUA (@Ctaqua_CT)	Sep. 2011	224 / 3.598	2555		
	Centro Tecnológico del Mar (CETMAR) (@FundacionCETMAR)	Nov. 2013	792 / 3.351	7526		
	Fundación Centro Tecnológico de Miranda de Ebro (CTME) (@Fundacion_CTME)	Mar. 2012	142 / 276	554		
	IEO - Centro Oceanográfico A Coruña (@IEO_ACoruna)	May. 2017	459 / 1.835	1447		
	IEO - Centro Oceanográfico de Baleares (COB) (@ieo_baleares)	Dic. 2012	1.046 / 5.480	20000		
	IEO - Centro Oceanográfico de Cádiz (@IEO_Cadiz)	Jun. 2018	593 / 2.096	2056		
	IEO - Centro Oceanográfico de Canarias (@IEO_Canarias)	Nov. 2020	96 / 1.495	587		
	IEO - Centro Oceanográfico de Murcia (Planta Experimental de Cultivo Marinos) (@IEOMurcia)	Dic. 2016	61 / 1.447	1258		
	IEO - Centro Oceanográfico de Santander (@IEO_Santander)	Mar. 2012	684 / 2.455	4680		
	IEO - Centro Oceanográfico de Santander (Plantas de Investigación en Acuicultura) (@IEO_Santander)	Mar. 2012	684 / 2.455	4680		
	IEO - Centro Oceanográfico de Vigo (@IEOVigo)	Feb. 2017	1.691 / 4.374	8193		
	IEO - Instituto español de Oceanografía (Sede Central) (@IEOOceanografia)	Mar. 2010	850 / 18.800	3282		
	IEO-Centro Oceanográfico de Murcia (@IEOMurcia)	Dic. 2016	61 / 1.447	1258		
	IFAPA - Centro Agua del Pino (@IfapaJunta)	Jun. 2012	1097 / 10300	5602		
	Instituto de Bioquímica Vegetal y Fotosíntesis (IBVF) (@IBVF_Sevilla)	Jun. 2018	83 / 722	495		
	Instituto de Ciencias Marinas de Andalucía (ICMAN-CSIC) (@ICMAN_CSIC)	Mar. 2016	766 / 1.861	2099		
	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA) (@INIA_es)	Abr. 2018	454 / 6.053	4484		
	Instituto Tecnológico Agrario de Castilla y León (@ITACYL)	Jul. 2018	325 / 2.361	3908		
	Instituto Tecnológico de Canarias (ITC) (@ITCCANARIAS)	May. 2011	2.182 / 11,100	20400		

Source: Authors.

3.2. Data

Data from the Twitter Spanish profiles were obtained using R software [50] and the TwitterR package, which provides direct communication through an Application Programming Interface (API). Through this interface, the tweets are extracted with the function *get_timelines*, which returns the timeline of a Twitter user. This approach has been used by Kamiński et al. [31] to analyze sentiments after Covid-19 on Twitter or Dong & Wu [15] to analyze police-community relations. After this extraction, automatic text processing is performed through the so-called tokenization, which extracts the text (specifically, each word of each tweet) as the basic unit of analysis. Having the words stored as basic units of analysis makes it possible to study user opinions in terms of

attitudes, valuations, and emotions, which is called sentiment analysis [49]. In total, 206,175 tweets from the 53 profiles in the sample were extracted to be analyzed as of May 13, 2022.

3.3. Methods

Sentiment analysis is performed through data mining techniques and a lexicon-based approach [55], which compares the words in tweets with dictionaries of words classified according to their sentiment or polarity. The most commonly used are *bing*, *AFINN*, and *nrc* [53] (See Fig. 1). The *bing* lexicon classifies words binarily into positive and negative categories, the *AFINN* lexicon assigns words a score ranging from - 5 (negative sentiment) to 5 (positive sentiment), and the *nrc*


```

> get_sentiments("bing")
# A tibble: 6,786 x 2
  word      sentiment
<chr>    <chr>
1 2-faces    negative
2 abnormal  negative
3 abolish   negative
4 abominable negative
5 abominably negative
6 abominate negative
7 abomination negative
8 abort      negative
9 aborted    negative
10 aborts    negative
# ... with 6,776 more rows

> get_sentiments("afinn")
# A tibble: 2,477 x 2
  word      value
<chr>    <dbl>
1 abandon    -2
2 abandoned  -2
3 abandons   -2
4 abducted   -2
5 abduction  -2
6 abductions -2
7 abhor       -3
8 abhorred   -3
9 abhorrent  -3
10 abhors     -3
# ... with 2,467 more rows

# A tibble: 13,875 x 2
  word      sentiment
<chr>    <chr>
1 abacus    trust
2 abandon   fear
3 abandon   negative
4 abandon   sadness
5 abandoned anger
6 abandoned fear
7 abandoned negative
8 abandoned sadness
9 abandonment anger
10 abandonment fear
# ... with 13,865 more rows

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Fig. 1. Examples of lexicons for sentiment analysis [41].

lexicon classifies words binarily into categories such as anger, anticipation, disgust, fear, joy, negative, positive, sadness, surprise, and trust. Due to language limitations (we have used the Spanish profiles), and to have a wider range of sentiments, the latter option has been chosen for our analysis. The classification of words into categories has been done through the packages *syuzhet* and *tm*, which allows us to select the language of the tokenized text (Spanish, in our case). Thus, the analysis by categories is obtained in the same way as with the nrc lexicon. To perform sentiment analysis, Twitter imposes a limitation on the number of downloaded tweets, so that only the last 3200 tweets from each user are analyzed. Except for media profiles and some more active research centers, this limitation does not usually affect given the activity of the considered profiles. In the case of sentiment analysis, the initial number of tweets is reduced so that the tweets analyzed are 85,186.

When performing a sentiment analysis through this methodology, it must be taken into account that the Spanish translation is an automatic translation so its use is not recommended in texts with a high symbolic load. Automaticity also implies that some words with double meanings or diverse meanings are not correctly interpreted (i.e., “cut” or “alone”) as well as some sets of words such as “I am not happy” [28]. The results of a sentiment analysis reflect the number of times (in percentage) that a word assigned to a given sentiment appears within the total number of tweets, which allows to identify and evaluate how opinions are expressed in writing [21]. Table 2 shows excerpts of tweets with the highest sentiment load (that is, the highest number of words categorized as representing the sentiment) for each of the sentiments.

The comparison of sentiments among groups (producers, specialized media, associations, and research centers) has been carried out by testing for differences between means. First, a test of normality is performed by Shapiro-Wilk Test, which is more appropriate for small sample sizes (<50 samples) [20]. Depending on the distribution of the data (normally distributed or not) we perform the ANOVA test or a Kruskal-Wallis test, respectively, to determine whether there are statistically significant differences among group sentiments. To check pairwise comparisons, the Holm test was performed.

4. Results

The extraction of text by words as the basic unit of analysis makes it possible to obtain the most frequently used words in each group of stakeholders (Table 3). In this case, API allows downloading all the tweets in the timeline. The word aquaculture is the most frequent word in tweets from media (1607 times) and associations (2073 times), the second most used in tweets from research centers (1302 times), and the fifth most used in tweets from producers (108). In addition, substantial qualitative differences are observed among profiles. Producers focus mainly on species (bluefin tuna, seabass, microalgae, seabass), locations (Ametllademar, Namibia), and concepts (aquaculture, sustainability,

CSR / corporate social responsibility, startups). As the company Balfegó is one of the most active profiles among producers in the social network, its most frequent words prevail: Bluefin tuna, balfegó or balfego, or ronqueo, a technical term that refers to the processing of Bluefin tuna. On the part of the specialized media, most frequent words also focus on species (microalgae, mussel, algae, shrimp), but also on events (week-ipac), categorization (aquaculture; fisheries; RAS; employment; research; grants) and locations (Galicia, Andalucía, España). Concerning the associations and research centers’ profiles, they include combined word hashtags, which support the topic of the tweet by highlighting events (conxemarfacongress, ae21mad, iniaevents), the profile name (conxemar, femp, fedepesca, itacyl, ifapa, inia, ieo, ieovigo, irta) or categorization (aquaculture, fisheries, productsofthesea). Note in the most frequent words the inconsistency in the use of the same concepts (accents, singular/plural words) and the inconsistency in languages, lead to truncation of words due to the existence of accents.

After downloading and analyzing the tweets of the producers, specialized media, associations, and research centers, the sentiment analysis of these tweets shows that it is *trust*, *negative* and *positive* sentiments that are prevalent in the tweets of all stakeholders (Fig. 2). It is interesting to highlight the positive sentiment identified in the tweets of specialized media. Having a value higher than 100% (132%) means that words representing positive feelings are used more than once per tweet.

The comparison between sentiments and stakeholders is observed in the box and whisker plots (Fig. 3). Boxes represent 50% of the values for each group (interquartile interval) and the line inside the box represents the median of each group. Whiskers represent the minimum and maximum values of each sample. When data hover around center values, boxes are shorter and when there are outliers (1.5 times the interquartile range), they are outside the whiskers [20]. Results show visual differences between mean values of sentiments per stakeholder, especially in the sentiments anger, disgust, sadness, trust, positive, and negative, so that statistical difference in means is justified.

Table 4 shows the proportion of tweets that have words representing each sentiment. In the tweets analyzed, the use of words representing positive and trust sentiments is prevalent in the profiles of the four stakeholders. Although the use of words representing negative sentiments is representative in associations, media, and research centers (third sentiment), the use of words representing anticipation and surprise in media profiles stands out (more than 30% of tweets included words represented those sentiments). The test of differences of means for more than two groups (Kruskal-Wallis test or ANOVA) shows that there are significant differences at $P < 0001$ for at least two groups in the sentiments anger, disgust, fear, sadness, negative and positive and differences with a significance of 90% in the sentiments anticipation and trust (Table 4). Excepting *positive* and *trust* sentiments, all of them are sentiments with a negative connotation, which could indicate polarized messages but also a not-so-appropriate use of terms or expressions when

Table 2
Tweets extracts examples (translated from Spanish) by sentiment.

Anger	"some fishmongers paint with shark blood or iodine fake Bluefin tuna", "may a tragedy like this not have to happen to highlight the courage of the sailors and the hardiness of the fishermen", "80% of the total quota caught, after having to stop for 2 days due to bad weather"
Anticipation	"if you have a startup and you are just starting and you think your idea will improve our lives...", "do you want to see the #TunaTour?", "Since you could not come to the event in Madrid, let's see if you can come to Tarragona from...", "working day that started with a visit to @aquanariafish, a company that...", "winner of the award Explain your project in three minutes", "the happiest day of the year exists and... it's today!", "... the beginning of the exciting journey of our new boat"
Disgust	"perhaps it is time to consider larger transport systems to respect safety", "fake Bluefin tuna? A study denounces fraud in 40% of tuna sales", "... has recovered 10,400 kg of garbage from our coasts", "according to @FAO, 1300 million tons of food are wasted per year", "environmental crime is the fourth most lucrative illegal business worldwide", "the trash we leave on beaches can take up to 450 years to degrade"
Fear	"Startup 3 - covid 0: don't be paralyzed by fear or adversity", "may a tragedy like this not have to happen to highlight the courage of the sailors and the hardiness of the fishermen", "environmental crime is the fourth most lucrative illegal business worldwide", "... warns about the dangerous example of ...", "we support ODS1 for the fight against poverty", "dismayed by the shipwreck of the fishing vessel", "we can't stop thinking about what happened yesterday in...",
Joy	"thank you for helping us to invite everyone to our great bluefin tuna party", "happy world oceans day", "today is #WorldHappinessDay", "there will be a million fish in the sea... but like or #Rodolfo there is only one. We wish you a day of happiness", "today is #YellowDay, considered the happiest day of the year. We share some tips to find happiness every day", "#Ovapiscis has been recognized with an Ardan award for achieving excellence in 4 indicators..."
Sadness	"this week has been very sad for the Spanish and international fishing sector", "environmental crime is the fourth most lucrative illegal business worldwide", "the Mediterranean Bluefin tuna is an example of the recovery of the species after sustainable fishing", "Spring is here and the weather is crazy", "today we join the #worlddayagaincancer", "dismayed by the shipwreck of the fishing boat...", "the closure of #HORECA channel aggravates the livestock crisis"
surprise	"diving and discovering the seabed of our country is marvelous", "how exciting the reaction of...", "do you know that it can be pollutant in contact with water?", "is there legal security in this country? Do we invest more?", "Tascmar Newsletter!! We continue advancing in this precious project"
Trust	"and thank you also for your support and trust", "and award that highlights the value of the pillars of Balfegó: the commitment to our customers and society", "A picture is worth a thousand words", "we collaborate with governments, NGOs and industry associations and participate in fishery improvement projects", "we are committed to the efficient and sustainable use of natural resources through the incorporation of new technologies", "we work to ensure ethical, honest, responsible and transparent behavior", "#Ovapiscis has been recognized with an Ardan award for achieving excellence in 4 indicators..."
Negative	"this week has been a very sad one for the Spanish and international fishing sector", "37 kg of plastic, 1 kg of glass and 50 kg of a garbage container abandoned on some rocks", "environmental crime is the fourth most lucrative illegal business worldwide", "are you too lazy to cook in this weather?", "every year, 8 million tons of garbage end up at the bottom of the sea"
Positive	"new recognition to La Pasta del Mar", "our quality and food safety policy affects our entire value chain", "for the first time in the aquaculture activity, we incorporated an intelligent energy management system", "congratulations to our general manager", "today is #YellowDay, considered the happiest day of the year", "congratulations to our brilliant colleague", "focused on empowering local development, we are involved in improving the communities in which we are present"

Source: Authors.

it comes to transmitting positive sentiments (i.e. "...haven't you bought yet...?", "...haven't you heard about...?", "do not miss out...", "do not waste time and...", etc.).

For those sentiments having proved to be different among stakeholders, pairwise comparisons using t-tests with pooled SD have been performed in to know the differences between pairs. The Holm method was used to counteract the problem of multiple comparisons. Clearly, media profiles outperform other profiles due to professionalism and expertise in message broadcasting. Profiles of media show an increased use of words that represent anger, sadness, and negativity in relation to associations; an increased use of words that represent anger, disgust, sadness, negativity, and positivity in relation to producers; and increased use of words that represent anger, fear, sadness, and negativity in relation to research centers. As the profiles of specialized media are not so much content generators as content sharers, they can provide an additional connotation to messages, so that the use of words can be more diverse and accurate. However, research centers represent an increased utilization of words that represent disgust and negativity in relation to producers. Despite being one of the most frequent keywords, research center profiles cover more topics than aquaculture, such as grants, employment, or climate change, so this can bias sentiments toward a more negative perception (Table 5).

5. Discussion

Social media presents a great opportunity to implement competitive strategies [59], expanding the knowledge of the public engaging with organizations and revealing interactions in both the public and the private sector [8]. Results derived from the tweeting activity reveal that, considering the four groups in the sample, producers and associations have ample room for improvement in the use of SNS, since they are the stakeholders with the least number of tweets. The greater activity would allow taking a more active role in communication and taking advantage of the control over the information provided by having direct channels of communication, in which trustworthy information can be released "in a reliable and comprehensible manner" [18]. Some of the larger producers in the sample, Pescanova or Balfegó, seem to be aware of this potential and are much more active, being able to communicate other less common topics such as CSR or sustainability. Indeed, it is observed how the most used work in their group seem to come from their profiles. It is worth highlighting the communication policy that Balfegó is having not only on Twitter but also on other SNS such as Instagram, where the visual aspect is more important, and its website, something necessary when direct sales to the end consumers are promoted.

After the sentiment analysis performed using a lexicon-based approach, the results of the mean differences show significant differences in the use of words representing anger, disgust, fear, sadness, negative, and positive sentiments. Differences among stakeholders, where specialized media profiles stand out, respond to the roles they represent in communication. Specialized media contribute their evaluation to the information shared, so that their tweets have more diverse sentiments, and they are in accordance with the desired connotation. Producers and associations profiles are more pragmatic, categorizing the information into topics, mainly species and regions. This means that they are more focused on product promotion, but they have room for improvement in communicating the benefits of their activity. Emotions have a motivational content [40], which means that they include a willingness to respond to something. Producers and associations are the ones who can initiate the transformation of the discrete emotions represented in the information they emit to favorable moods, leading to the adoption of a positive global sentiment towards aquaculture. Research centers appear to be more endogamous, including their own profile as a keyword in the posted information, which seems to fit with the communication of its activity and its transfer of research results.

Verbal communication is intricate and these differences must be interpreted taking into account the mechanics of the methodology and

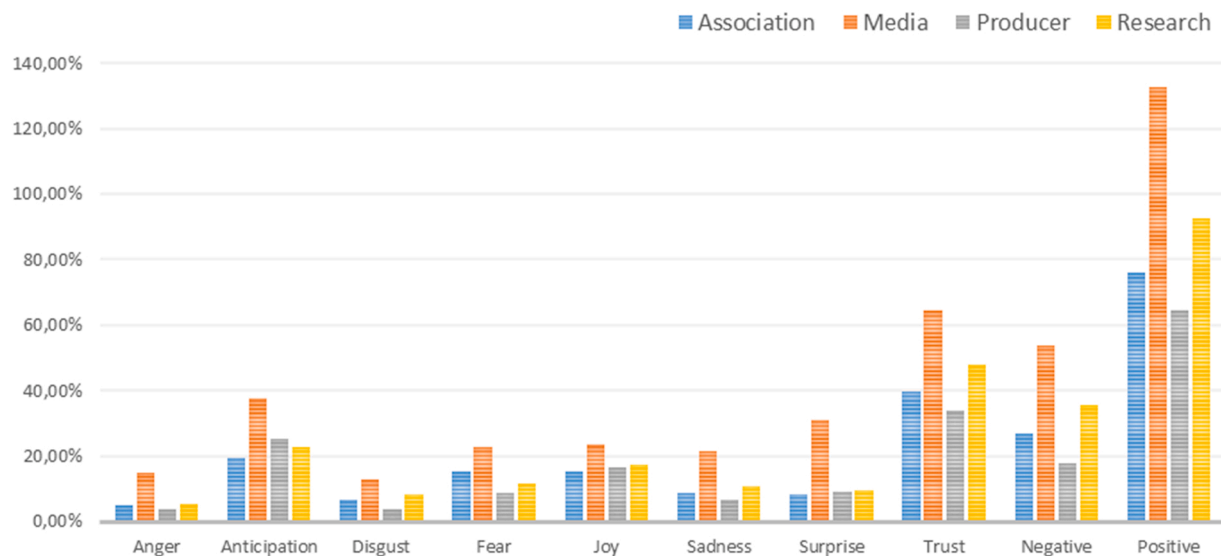
Table 3

Most frequent words by stakeholder.

Producers		Media		Associations		Research Centers	
Word	Freq.	Word	Freq.	Word	Freq.	Word	Freq.
<i>atúnrojo</i> (bluefin tuna)	294	<i>acuicultura</i> (aquaculture)	1607	<i>acuicultura</i> (aquaculture)	2073	<i>Itacyl</i> (Agrarian Technological Institute of Castilla y León)	1355
<i>corvina</i> (seabass)	258	<i>semanaipac</i> (weekipac)	870	<i>pescado</i> (fish)	375	<i>Acuicultura</i> (aquaculture)	1302
<i>corvinarex</i> (seabass)	230	<i>pesca</i> (fisheries)	114	<i>aquaculture</i>	329	<i>Ifapa</i> (Institute for research and training in agricultura and fisheries)	677
<i>tonyinaroja</i> (bluefin tuna)	111	<i>microalgas</i> (microalgae)	83	<i>conxemar</i>	323	<i>Innovaci</i>	552
<i>acuicultura</i> (aquaculture)	108	<i>covid19</i>	74	<i>pesca</i> (fisheries)	269	<i>D</i>	519
<i>microalgas</i> (microalgae)	104	<i>ras</i>	70	<i>Innovaci</i> (innovation)	256	<i>Inia</i>	451
<i>cocinaconcorvina</i> (cookwithseabass)	96	<i>acuicultura</i> (aquaculture)	63	<i>Femp</i> (European fisheries fund)	205	<i>leo</i>	444
<i>ametillademar</i>	91	<i>aquaculture</i>	53	<i>D</i>	184	<i>Ifapalideraysuma</i> (ifapa leads and adds up)	406
<i>ovapiscis</i>	88	<i>investigación</i> (research)	49	<i>Feugaimpula</i> (Galician University-business foundation)	182	<i>noticiasinia</i> (inia news)	394
<i>sostenibilidad</i> (sustainability)	85	<i>Galicia</i>	38	<i>conxemarfacongress</i>	180	<i>Iniacsic</i>	380
<i>atunrojo</i> (bluefin tuna)	80	<i>Andalucia</i>	33	<i>Productosdelmar</i> (seafood products)	172	<i>leovigo</i>	316
<i>rsc</i> (csr)	78	<i>empleo</i> (employment)	33	<i>cytmablog</i>	166	<i>Canarias</i>	302
<i>namibia</i>	75	<i>femp</i> (European fisheries fund)	33	<i>ae21mad</i>	153	<i>feina</i> (job in Catalan)	279
<i>balfegó</i>	83	<i>alimentosacuicolas</i> (seafood)	31	<i>felizlunes</i> (happymonday)	139	<i>Econom</i>	271
<i>startups</i>	73	<i>España</i> (Spain)	31	<i>Fedepesca</i> (National federation of provincial associations of fish and frozen products retailers)	137	<i>Cambioclimatico</i> (climate change)	258
<i>lubina</i> (seabass)	68	<i>mejillón</i> (mussel)	31	<i>sab</i>	135	<i>Ifapafuncionaylidera</i> (ifapa Works and leads)	258
<i>Recetas</i> (recípes)	66	<i>camarones</i> (shrimp)	30	<i>Pleamar</i> (high tide)	134	<i>Irta</i> (Institute of Agrifood Research and Technology)	242
<i>startup</i>	66	<i>algas</i> (algae)	29	<i>Acuiculturadeespa</i> (aquaculture of Spain)	132	<i>Transfer</i>	232
<i>balfego</i>	64	<i>ayudas</i> (grants)	27	<i>Cádiz</i>	132	<i>eventosinia</i> (inia events)	220
<i>ronqueo</i> (processing of bluefin tuna)	64	<i>eumofa</i>	27	<i>h2020</i>	132	<i>pesca</i> (fisheries)	216

Note. Original frequent words are in italics. When needed, translations have been included in brackets.

Source: Authors.

**Fig. 2.** Sentiment load per stakeholder.

Source: Authors.

the semantic peculiarities of the messages. Certain words may have a positive meaning as a whole, but individually they may be more representative of a negative sentiment, something that can skew the analysis. For example, the sentence "... do not waste time and..." may generate a positive sentiment and a call to action, but the individual

meaning of words ("not", "waste") can be identified with a negative sentiment. This type of problem is already identified in the data mining methodology; therefore, it is warned that its use in highly symbolic messages should be limited [28].

Specialized media profiles present the greatest pairwise differences

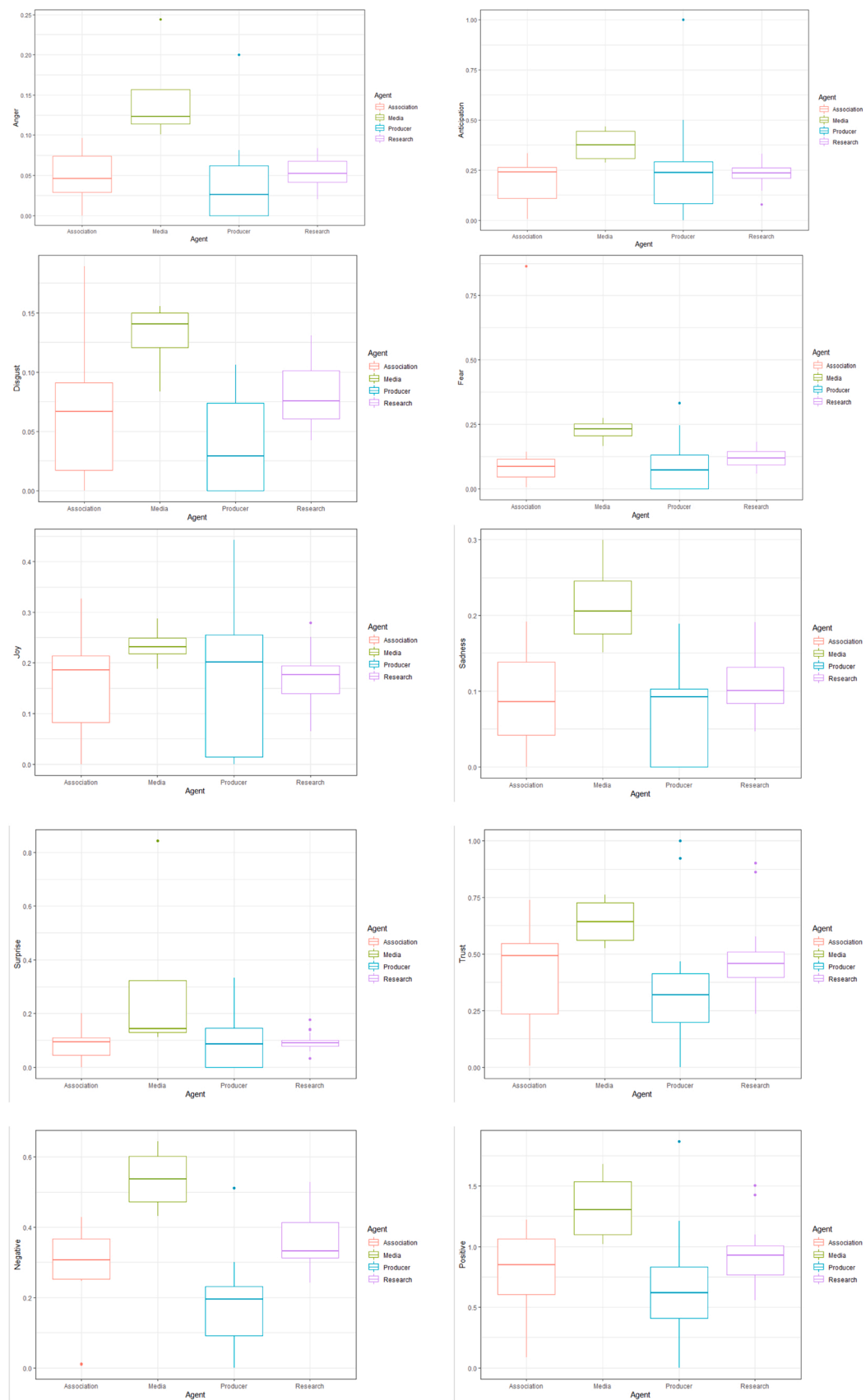


Fig. 3. Box and whisker plots by sentiment and stakeholder.
Source: Authors.

Table 4

Differences between means (Kruskal-Wallis test / ANOVA test).

	Associations (N = 10)	Media (N = 4)	Producers (N = 18)	Research Centers (N = 19)	Shapiro Test	Kruskal-Wallis Test	ANOVA
Anger	4,79%	14,76%	3,91%	5,43%	***	***	NA
Anticipation	19,32%	37,66%	25,14%	22,82%	***	*	NA
Disgust	6,59%	13,01%	3,92%	8,18%	***	***	NA
Fear	15,28%	22,55%	8,50%	11,75%	***	***	NA
Joy	15,46%	23,47%	16,43%	17,40%	***		NA
Sadness	8,74%	21,55%	6,79%	10,78%	***	***	NA
Surprise	8,27%	30,98%	8,98%	9,52%	***		NA
Trust	39,76%	64,36%	34,04%	47,84%		NA	*
Negative	26,77%	53,74%	17,73%	35,40%		NA	***
Positive	75,93%	132,70%	64,29%	92,52%		NA	***

NOTE. *** Significant at $p < 0.001$; ** significant at $p < 0.01$; * significant at $p < 0.05$.

Source: Authors.

Table 5

Pairwise comparisons in sentiments with significant differences.

	Media - Associations	Producer - Associations	Research - Associations	Producer - Media	Research - Media	Research Producer
Anger	**			**	**	
Disgust				**		**
Fear					***	
Sadness	**			**	***	
Negative	***			***	**	***
Positive				***		

NOTE. *** Significant at $p < 0.001$; ** significant at $p < 0.01$; * significant at $p < 0.05$.

Source: Authors.

in almost all significant sentiments. Although these results are inevitably linked to a greater tweeting activity, another explanation may be the greater command of words by these profiles and it is precisely the main recommendation obtained from this study, the professionalization of communication profiles that allows a well-targeted communication strategy, in line what Feucht et al. [18] and Zander [60] proposes. The semantic multiplicity that we mentioned before must be taken into account when communicating information so that in order to avoid potential misunderstanding [60], it is necessary to plan short messages with a certain objective in a univocal, unambiguous and meaningful way. This strategy must be based on consistency in keywords or hashtags, using the same words with or without accents (a problem we have encountered in Spanish Twitter profiles), categorizing the topics to be disclosed with a clearer hashtag policy and avoiding hashtags that do not categorize (i.e. happyMonday, happyweek, etc.).

The professionalization of social network profiles can help, not only on the part of specialized media, but also on the part of producers, associations, and public bodies to promote social acceptability. Future lines of research could include the perception of emotions by users and inquire into the type of retweeted messages and its most representative emotion. Furthermore, it would be revealing to cover other types of social networks to verify whether the patterns of sentiments per stakeholder are repeated in other channels of communication. In addition, it should be considered whether greater and better use of social networks would have a greater influence on social acceptability and truly improve consumer and other stakeholders' perceptions.

6. Conclusion

The challenging task of communicating aquaculture has already been pointed out by authors such as Feucht et al., [18] or Zander [60] and, in the case of Spain, producers have been advised to make better use of social media (TV, radio, press, and social networks) to promote the quality of their products [12]. Following the footsteps of these required improvements in communication, and in contrast to other studies that analyze the sentiments for different purposes, especially consumers' perceptions, this paper compares whether there are

significant differences in the sentiment of the words used in the tweets issued by different groups of stakeholders related to Spanish aquaculture: producers, specialized media, associations and research centers.

On the one hand, the underutilization of social networks shows a wide room for improvement by certain stakeholders such as producers, which provides them with an opportunity to be an active part of the communication of aquaculture, not only of the product itself but also of the benefits and truths of the industry. Through the emotion they convey with their messages, primary stakeholders in aquaculture indirectly influence other agents, either intentionally or inadvertently. Having control of information can generate emotional contagion at group level, affecting consumers and the general public, either because they are the recipients of information, witnesses or eavesdroppers [26], thus having a great social influence. In addition, positive affect-induced consumers can make more favorable decisions regarding aquaculture, in terms of consumptions habits (increasing regular consumption or modifying consumption format), consumption decisions (trying other species or asking about the origin in the hotel and catering industry) or lobbying for research and development in the sector. On the other hand, there is much work to be done on the way tweets are written. Good practices such as a homogeneous use of hashtags, labeling categories relevant to the organization (e.g., sustainability, innovation, news, species, places, events, etc.) will facilitate the search and tracking by users. Therefore, the professionalization of communication in aquaculture becomes relevant. We observe the use of words that represent positive sentiments but also many words that represent negative sentiments, not so much because of the tone of the message but because of their misuse in the text. This indicates that there is great development potential in the exploitation of social networks to communicate and work on the social acceptance of aquaculture, and job opportunities open up in a sector that are perhaps not so closely linked to communication with the end consumer, due to the traditional supply chain model. In this process, it will be key that producers and policymakers identify the opportunity and provide resources to professionalize communication through SNS.

CRediT authorship contribution statement

Elisa Baraibar-Diez: Conceptualization, Methodology, Software, Formal analysis, Writing – original draft, Writing – review & editing. **Ignacio Llorente:** Conceptualization, Methodology, Writing – review & editing. **María D. Odriozola:** Conceptualization, Methodology, Writing – review & editing.

Data availability

Data will be made available on request.

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