

Exposed aquaculture operations

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A patent landscape analysis



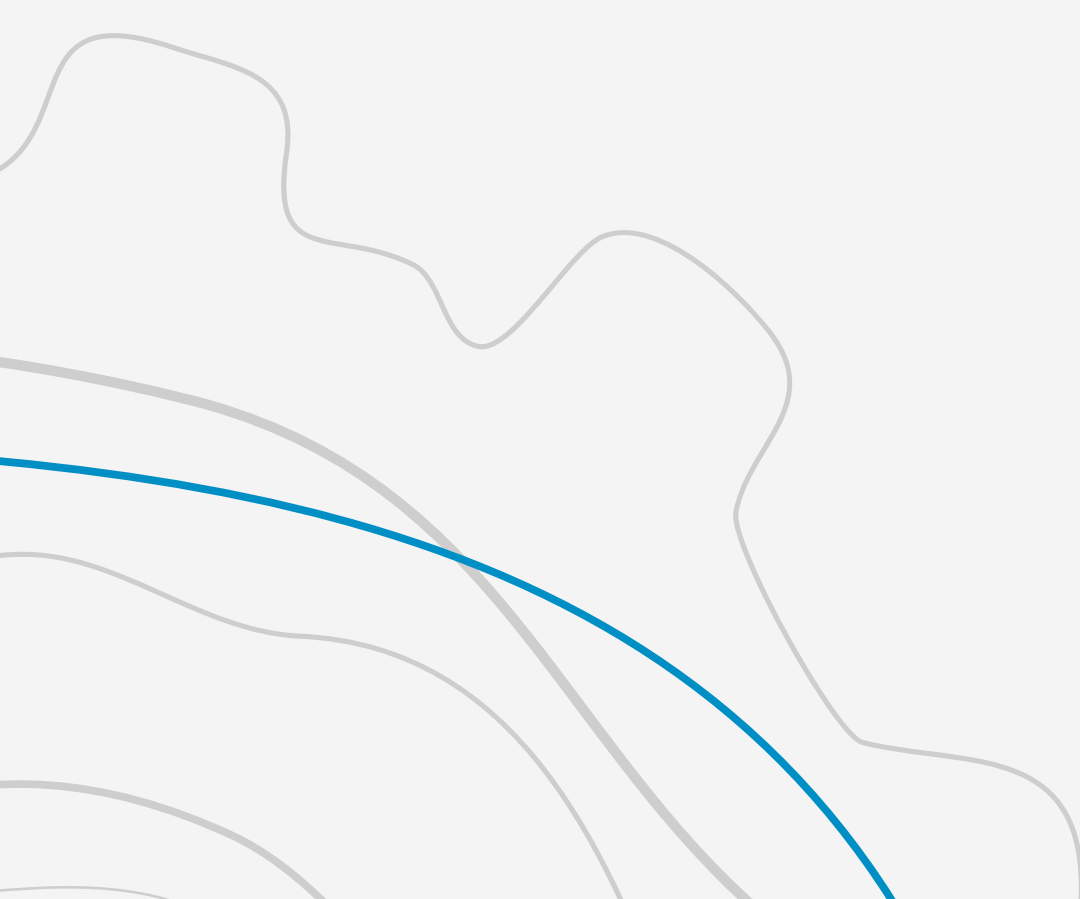
A national centre for intellectual property rights

The primary role of the Norwegian Industrial Property Office (NIPO) is to promote innovation and value creation, both as national intellectual property rights authority and as a guide and knowledge provider.

NIPO contributes to competitiveness and helps to strengthen Norwegian trade and industry in various ways. We provide knowledge and expertise concerning intellectual property rights and values, enabling businesses to secure their investments, their competitive position and create economic growth in Norwegian society.

What are Intellectual Property Rights?

Intellectual Property Rights (IPR), are legal monopoly rights that protects inventions, names, logos, designs and other innovations. Strategic use of these rights can make IPR to the most valuable assets of your business.



Summary

The aim for this report is to provide an analysis of the existing patent data within marine aquaculture and fish farming. This report is based on a collaboration between the Norwegian Industrial Property Office and the Research Council of Norway as a measure to bring knowledge of IPR into public funded research projects.

A patent dataset with four subsets adapted for key research areas within offshore fish farming, is gathered and used for further analysis.

A UN report from 2014 discloses that the Norwegian aquaculture industry holds a strong international position, due to Norway's leading role in fish farming and exports. However, in terms of IPR, the Norwegian fish-farming industry may face strong competition from nations such as China, USA, Japan and Korea both nationally and internationally in the future.

When focusing on the global patenting environment for the whole patent dataset in 2015, Chinese patent applications clearly constitute the majority of patent applications, followed Japan, USA and South Korea. However, under 10% of the Japanese, Chinese and Korean applications are extended internationally, while 80% of Norwegian applications are extended outside Norwegian borders.

Two of the largest Chinese universities in the field of aquaculture holds most of the Chinese-based applications and are overlapping each other technologically. Their focus is mainly on autonomous systems and monitoring technology.

When looking at the historical patenting development, it becomes clear there has been an exponential growth in Chinese patent applications from 2005 with a peak, so far, in 2015, with approximately five times as many applications as the rest of the world combined. When looking more closely at these applications, we see that most of these applications are filed as utility models, which differ from regular patent applications both in terms of lifespan and patentability requirements.

The Norwegian based applications in the dataset, revolves mostly around structural solutions. In this technical field, Norwegian applicants are gaining a strong position, but in areas such as autonomous systems, monitoring systems and vessel design, Norwegian based IPR are lacking presence.

Norway still have a great amount of unused resources, and a large maritime industry with decades of experience. However, it is important that Norwegian research institutions and their industry partners continue to secure their freedom to operate in the future.

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EXPPOSED





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Introduction

This report is based on a collaboration between the Research Council of Norway and the Norwegian Industrial Property Office as a measure of bringing knowledge in IPR into public funded research projects. The report aims to uncover opportunities and challenges in IPR concerning marine aquaculture technology.

The patent data search for this report is based on the key research areas for the research centre SFI Exposed. This research project aims at developing technology for aquaculture in exposed locations.

Norway has a great deal of experience within fish farming, and will benefit from this in the future. However, the aquaculture industry faces challenges such as salmon lice and sea bed pollution in shallow water fjords. Moving the aquaculture out towards deeper sea might solve some of these issues, but still there are great challenges with farming fish in exposed locations.

SFI Exposed is a centre for research-based innovation on exposed aquaculture operations, developing knowledge and technology for robust, safe and efficient fish farming at exposed locations¹. Their focus of technology is mainly on autonomous systems for remote operations, monitoring and operational decision support, structures for exposed locations, vessel design for exposed locations, safety and risk management and fish behavior and welfare.

The scope of this report is limited to four technical areas for SFI Exposed which will be explained in greater detail. These areas comprise different fields of technology with different technical solutions. The patent data search for this report is aimed at gathering as many patent publications as possible within the scope, as well as filtering out irrelevant patent publications.

The aim for this report is to provide a good basis for strategic decision making within patenting. The report is meant for readers with a varied degree of knowledge within IPR. A glossary of frequently used terms within IPR is included in the back of the report.

Before deciding on IPR strategies, it's important to have insight in the global patenting environment, such as this report provides. However, the aim of this report is not to advise on strategic decisions, but rather present the available patent data as a measure to gain knowledge.

¹ See more information on exposedaquaculture.no/en

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Background



Future aspects on patenting within aquaculture

For many years, Norway has been the world's largest producer of farmed fish. In 2012, 1,3 million tons fish was farmed in Norway. The oil & gas, maritime and aquaculture industry in Norway has been focused on utilizing ocean based resources along the coastline. In a declining oil & gas- market, it is important to strengthen other industries in Norway, and when doing so, also keep IPR in mind.

The Norwegian coast is one of the largest fish reservoirs in the world, and Norway is the leading producer of marine farmed fish. A UN report from 2014² shows the magnitude of Norwegian fish production. Even though the market share distribution might be different in 2015, it is clear that Norway has a leading role in marine fish farming. The world-wide share distribution of farmed fish is illustrated in figure 1.

Future potential and challenges

The Norwegian market share is promising for the future. However, the Norwegian fish farming industry is to a large extent located in fjords and in shallow waters for protection against harsh weather and currents. In these areas, problems such as sea lice and organic pollution of the sea bed are endangering the aquaculture industry. A solution to these problems may be to relocate the industrial fish farming to more exposed locations. Therefore, new technologies or adaptations of already existing technologies have to be developed.

Another future aspect, is the utilization of unused resources in the North Sea and the Norwegian Sea. A study from 2012 shows that the potential for marine fish farming is 5 million tons per year³ by 2050 compared to the 1,3 million tons farmed in 2012. To fulfil this potential, the industry will need to overcome the mentioned environmental challenges, which is a great incentive for the industry to develop new technology.

² Food and Agriculture Organization of the United Nations (FAO). "The State of World Fisheries and Aquaculture". FAO report (2014).

³ K. Henriksen et al. "Verdiskapning og sysselsetting i norsk sjømatnæring 2010". SINTEF report (2012).



Photo: Johan Wildhagen / Norwegian Seafood Council

Top 5 exporters of fish and fishery products in 2012²

	(US\$ millions)
1. China	18228
2. Norway	8912
3. Thailand	8079
4. Vietnam	6278
5. United States of America	5753

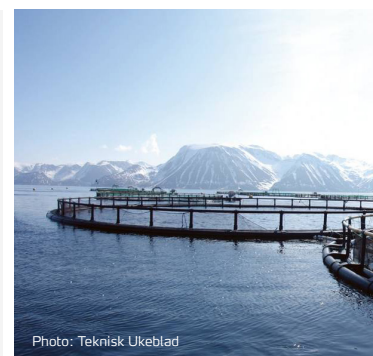


Photo: Teknisk Ukeblad

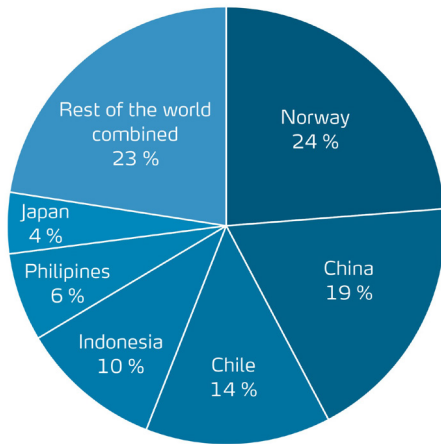


Figure 1: The world-wide share distribution of farmed fish in 2012².

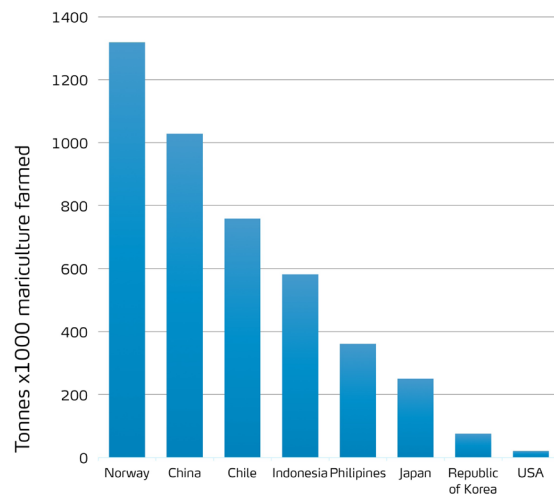


Figure 2: Top fish farming countries across the world in 2012².

The future importance of IPR

Norwegian fish farmers benefit from decades of experience, and a well developed costal infrastructure to support fish farming. Long experience within a competitive technology field might also provide experience within IPR, since it will be hard to avoid IPR-related conflicts when developing technology. IPR will become increasingly important for the Norwegian fish farming industry when expanding their industry across the national border, or when facing competition from international companies that are seeking to do the same.

The nature of IPR is complex, and there are different schools of thoughts related to IPR strategy. Some competitors may not be focused on developing the best technology, but rather limiting the freedom to operate (FTO) for others (see defensive patenting in fact box beneath). In any case, it is wise to be aware of obstacles other companies and R&D-institutions may pose to one's own business through patents which may cease or reduce the business, potential expenses in form of required license fees, reduced negotiation power in coming Merger and Acquisition operations, etc.

On the other side, utilizing patents for one's own benefit may produce income opportunities from competitors through licenses, from customers through premium product price and higher sales volumes, and financially from better price when selling or buying companies. Knowing the patent landscape may reveal potential collaboration partners, reduced time to market due to in-licensed technology, a more developed starting point for the R&D-projects, less risk of initiating R&D-projects that are wasted commercially because the field is already blocked patent-wise.

It will be enlightened in this report that a wave of patent applications relating to fish farming could potentially wash in on Norwegian shores in the years to come. To withstand this wave, it is crucial for the Norwegian research institutions and their collaborating industry partners to secure their freedom to operate, but first off all they will need to gain detailed patent intelligence in order to avoid making wrong and costly strategic decisions.



Defensive patenting

IPR strategy vary with industry, timing and budget. In some cases, the patent assignee will file one or more patent applications, not necessarily intending to have the application granted, but rather to prevent other assignees by limiting their freedom to operate.



Photo: Johan Wildhagen / Norwegian Seafood Council

Interpretation of patent data

When looking at a patenting environment, it is important to view it from the right perspective. As an example, a large number of patent applications from a competing nation in a competing field of technology may not always be of great concern. Several aspects have to be taken into account.

As an example, patent applications may have different vital and legal statuses. A patent applications' ability to be enforced is dependent on its legal status which may range from declined to granted. A declined patent application is mostly useful in the sense that it adds to the technological information made available to the public, but may not be eligible for legal enforcement. A granted application can however be legally enforced and is therefore a greater threat for competing businesses.

Many of the publicly available patent landscaping reports do not uncover the legal status of the patent applications in the relevant patent datasets. Instead, these reports are focused on the sheer number of patent applications published annually, and from where they originate. A high number of patent applications may at first glance look threatening, but there are many aspects that should be considered before making any drastic strategical decisions, and the patent's legal status may be one of them.

The patents in focus may also have a variety of vital statuses. The vital status may be dead, pending or alive. Local patent offices may also have different rules regarding a patent's lifespan, so the lifespan of a patent may vary between countries. So when looking at patent data statistics, it's important to keep in mind that the patents may not be eligible for legal enforcement. In this report, the vital status is not taken into account. However, as a rule of thumb, most patents have a maximum lifespan of 20 years.

Many of the patent applications with Chinese priority are filed as *utility models* (see terminology), which is an IPR very similar to a patent, but with a lifespan from 6 to 10 years and less stringent patentability requirements. These are some examples which are important to keep in mind when analyzing patent data.

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Methodology



Dataset overview

This chapter provides an overview of the patent data which is analyzed in this report. The technical content, and the magnitude of the dataset and data subsets are disclosed, as well as an overview of the overlap between the different data subsets. A patent classification overview is also provided, covering each data subset.

The basis for the technical scope of this report is the vision report provided by SFI EXPOSED as discussed in the introduction. In this vision report, six areas of technology related to aquaculture operations are in focus. The present report is focused only on the first four of these areas due to technology overlap. These four areas constitute the four sub datasets in this report which combined constitute the whole patent dataset. The four different areas of technology, which are referred to as data subsets, are elaborated in Table 1.

Search strategy

It is key that the patent data used in any analysis is highly relevant to the technical scope of the analysis. However, patent publications concerning outside technologies, may still be of importance if parts of these technologies are being frequently utilized in the technologies at hand.

Area 1	Area 2	Area 3	Area 4
Area of technology			
Autonomous systems and technologies for remote operations	Monitoring and operational decision support	Structures for exposed locations	Vessel design for exposed operations
Technical content			
<ul style="list-style-type: none"> ▪ Autonomous operating arms ▪ Feeding systems ▪ Fish pen cleaning systems ▪ ROV's ▪ Automated ▪ Dead fish removal ▪ inspection ▪ Maintenance ▪ Repair routines 	<ul style="list-style-type: none"> ▪ Oxygen monitor instruments ▪ Camera technology ▪ Sonars ▪ Hydroacoustics 	<ul style="list-style-type: none"> ▪ Floating fish cages ▪ Submersible fish cages ▪ Onshore breeding cages ▪ Flexible structures ▪ Structural components ▪ Net cages 	<ul style="list-style-type: none"> ▪ Service vessels ▪ Maintenance ships ▪ Cranes, specially adapted for ships ▪ Fish carriers
Number of patent documents in data subsets			
11832	4544	5551	2579
Number of patent families in data subsets			
5507	1715	2464	952

Table 1: An overview of the different data subsets used in this report.

This is taken into account in the search strategy for this dataset. The patent data for this report is gathered from several patent literature databases. The patent literature covers roughly 90 million patent documents, most of which are searched in this analysis.

A combination of classification and full text search has been conducted to get relevant search results from various search tools. In addition, backward and forward citations from the publications have been used to gather related prior art. Each search result has been filtered and later grouped into the different technical areas. The full text search is conducted with both query search and classification search, and the query is mainly based on the vision report, but also other reports such as the annual report from AMOS⁴.

Search results

The difference in sizes between the data subsets may reveal the difference in patenting frequency in these technical areas. In other words, small datasets may indicate less developed or underdeveloped areas. However, the sheer number of relevant patents alone does not represent the level of invention in each technical area. More interesting is the annual development of patenting, which will be described in further detail in the trend analysis.

The four different data subsets comprise patent publications which to a large extent are related to fish farming, but still many publications may stem from other sectors, and the data sets gathered also contain backward and forward cited documents. Several publications have been manually excluded

from the patent dataset due to lack of relevance, but some peripheral patent publications are kept. These publications may for example have been cited to in some of the more relevant publications, and may therefore be of importance.

Technology overlap

Table 2 shows the overlap between the sample groups. As an example, there is very little overlap between Area 1 and Area 4. This indicates that the technical content in these areas may be quite different. This may be important to keep in mind when comparing them.

Patent classification overview

The patent dataset in this report comprises a large number of publications with different patent classifications. In some cases, the patents may be inaccurately classified by different local patent offices. In any case, a classification overview is shown in Table 3 which illustrates the main relevant patent classifications for each patent dataset. The overview contains classes from both the International Patent Classification (IPC) system and the Cooperative Patent Classification (CPC) system. Some of the classes are only valid in the CPC-system, marked either with * or **.

All patent documents are classified according to a hierarchical classification system. The classification scheme organizes all patent documents based on the technical field of the invention. This provides a retrieval system by subject matter, regardless of the industrial sector and actual keywords used in the application. Thus, it goes to the core of what is protected by the patent.

⁴ Bremvåg, A. et al. "Annual Report 2014". Centre for Autonomous Marine Operations and Systems (AMOS) and NTNU (2014).

	Area 1		Area 2		Area 3		Area 4	
	Number of overlapping publications	Percent overlap	Number of overlapping publications	Percent overlap	Number of overlapping publications	Percent overlap	Number of overlapping publications	Percent overlap
Area 1	11832	100,00%						
Area 2	1263	10,67%	4544	100,00%				
Area 3	1250	10,56%	268	5,90%	5551	100,00%		
Area 4	83	0,70%	38	0,84%	159	2,86%	2579	100,00%

Table 2: An overview of the overlap of publications between the different data subsets.

	Area 1	Area 2	Area 3	Area 4	
	Autonomous systems and technologies for remote operations	Monitoring and operational decision support	Structures for exposed locations	Vessel design for exposed operations	
A01K Animal husbandry; care of birds, fishes, insects, fishing, rearing or breeding animals. Not otherwise provided for; new breeds of animals	A01K61/00				Patent classification
	A01K61/02		A01K61/007 *		
	A01K61/001 *			A01K61/001 *	
	A01K63/00				
	A01K63/04				
B63B Ships or other waterborne vessels			B63B35/00		
				B63B35/24	
				B63B35/26	
			B63B21		
			B63B2207/00 **		
B63H Marine propulsion or steering				B63B27/00	
				B63H25/00	
				B63H25/42	
B66C Cranes; Load-engaging elements or devices for cranes, capstans, winches or tackles				B66C1/00	
G01N Investigating or analysing materials by determining their chemical or physical properties		G01N33/186			
		G01N33/1806 *			
C12M Apparatus for enzymology or microbiology		C12M1/00			
		C12M1/34			

* CPC Class

** CPC Class (2000 series)

Table 3: Patent classification overview for the patent dataset. The figure illustrates where the different classes are most present. Unmarked classes are IPC classes. See worldwide.espacenet.com/classification for more information.

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Statistical analysis



Geographical coverage of patents

In this chapter, the geographical coverage of patent publications and their originating countries are enlightened. It also covers the different focus on technology between countries. The aim here is to disclose potential competitors and the risk of intellectual property infringement.

This chapter is focused on the whole data set in order to get a large scale overview of the current patenting environment.

The world-wide patent coverage

Figure 3 shows the magnitude distribution of both patent families and family members by originating country⁵ (see *priority* in the glossary) for the top 10 most filing countries within aquaculture. A patent family may consist of several patent publications (see *patent family*) where each publication represents a family member. If a patent family consist of more than one application it means that the priority application has been extended to another country or to a PCT-authority.

From figure 3 we see that China holds a dominating number of patent families, having filed more than the top 10 filing countries combined. However, only a microscopic share of the applications leave China. Furthermore, this figure says little about the quality of the patents filed such as legal status of the applications, which we will look at in the trend analysis.

Figure 4 shows the current situation from another perspective. The figure shows the percentage of patent families, from their respective originating countries, which contain one or more internationally extended applications. We see that Norway is the most internationally focused nation with 80% of its priority applications extended, followed by Great Britain (58%), Australia (50%) and US (39%). China has only extended 1% of their applications.

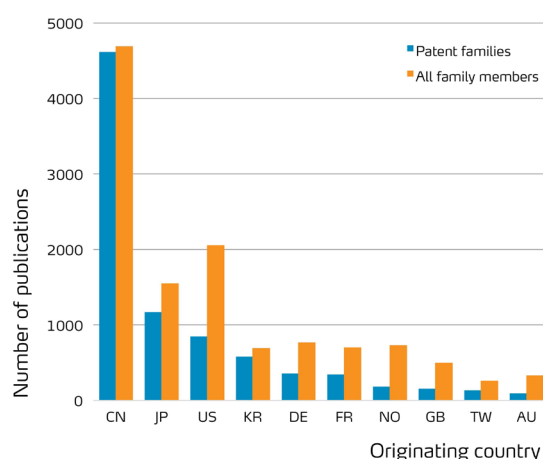


Figure 3: World-wide distribution of patent families and the total number of publications in our patent dataset for the ten most active receiving offices.

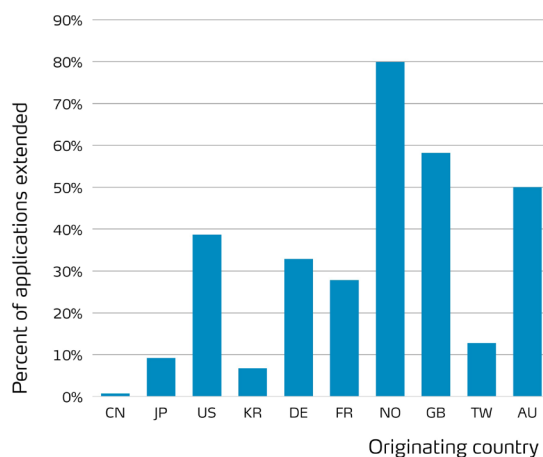


Figure 4: This figure depicts the share of first time patent applications that gets extended internationally from their respective priority countries.

⁵ When looking at a large data set, it can be difficult to determine the origin of the patent assignees. A multinational company could file their patent applications in a number of countries leaving a varied degree of proof in the bibliographic data that the applications belongs to their company. Also, the nationality of a single company can also be difficult to determine if the analyst doesn't possess the right business intelligence. However, it is a high probability that an assignee will choose their native country as their priority country. Therefore, the priority country will correlate with the nationality of the assignee. This is not always the case, but it gives a good approximation when looking at a large data set.

The map in figure 5 gives an overview of the world wide patenting activity within our data set. The figure shows where patent applications are being filed, and does not necessarily tell us where the fish farming industry is most active. Some applicants may file a patent application in a country with little activity within fish farming and later extend their applications to more active countries in the given technical area. Most of the patent assignees in this data set originate from countries or file applications to countries with a strong fish farming industry, a strong R&D-business related to fish farming, or with great aquaculture resources and locations suited for fish farming. Most importantly, this map uncovers the countries of which a patent applicant may risk infringing on IPR relating to this study. We see that most of the applications are being filed in China, Japan, USA, South Korea, and Germany. Countries such as USA, Germany and Australia are not among the most active fish farming nations in the world (see figure 2), but they are highly active in developing technology related to the fish farming industry.

Figure 1 shows that Chile was the third largest marine fish farming nation worldwide in 2012. Nevertheless, according to figure 5, very few patent applications have been assigned to Chile. The number of patent filings has more than tripled since the Chilean IP law was enacted in 1991, but like in most other middle-income countries, the total number of filings is still relatively modest⁶.

The highest number of patents in the technical fields analyzed come from Chinese R&D-institutions and companies. Up to now, they are the main interest, but only for companies operating or producing in China. There is a massive governmental support in China to improve quality and internationalization of their patents. In a 5-10 years horizon, one should therefore expect Chinese patents to be of much greater concern in all fish farming markets outside China, including Norway.

⁶ Abud, M.J. et al., "The Use of Intellectual Property in Chile" Instituto Nacional de Propiedad Industrial (INAPI) and World Intellectual Property Organization (WIPO) (2013)

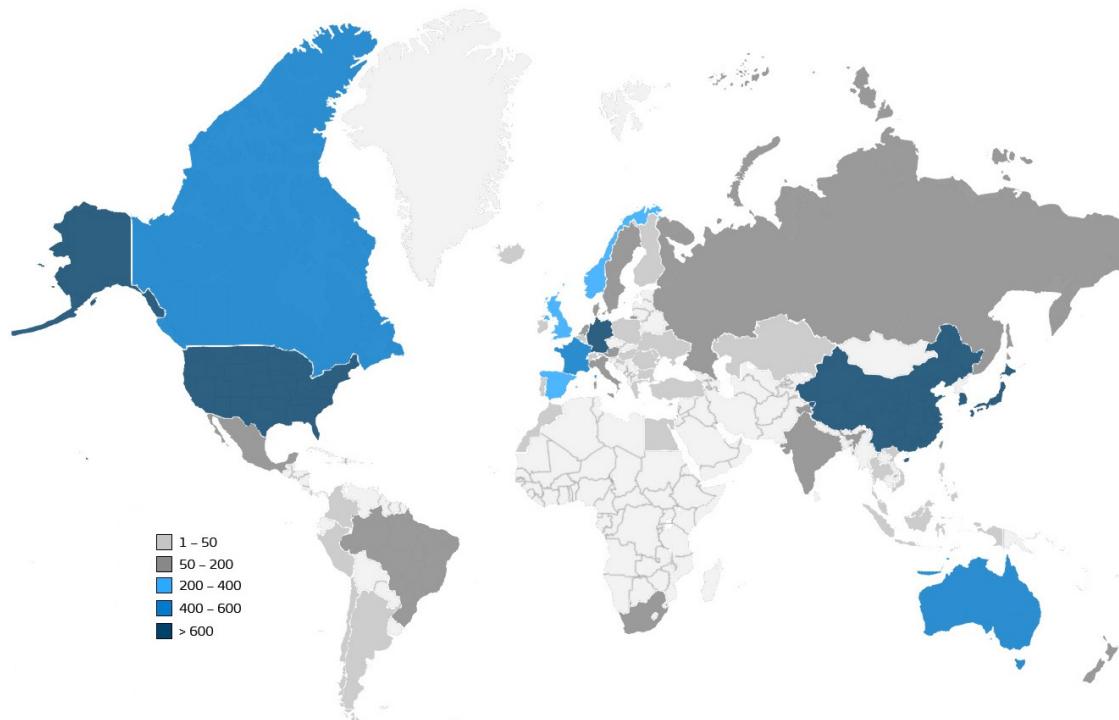


Figure 5: Global distribution of filed applications counted in patent families. The numbers are based on the whole patent dataset. This map merely discloses where patent applications are being filed and does not disclose the ownership of the patent applications.

International patent extensions

Table 4 provides an overview of where the patent applications in our data set are being extended (vertical axis) and where they are extended from (horizontal axis). We see that priority applications from USA and Norway constitute most of the extensions, followed by Germany, Japan and France.

If we study the extension of Norwegian patents (column NO in Table 4) and relates it to the main global aquaculture markets (figure 2), we observe that even though Chile is a major fish farming country, Norwegian companies protect almost no patents there. The same goes for Indonesia and the Philippines, but this is somewhat less surprising since their aquaculture differs more from the Norwegian and there is less common ownership. There is also almost no protection in potential upcoming production countries like Russia, either. This lack of protection might open up for legal copy production and sales of Norwegian products in these markets, even products protected by patents in Norway and our frequently designated countries like USA, Canada and Australia. If the technology was protected in more of the major aquaculture nations and upcoming production countries, it might have given income opportunities by licensing the technologies to those more remote markets.

Further, we see that priority applications from Norway and USA are mostly extended to WIPO (WO) and EPO (EP) first, from where they are extended further. If we assume that most of the applicants have the same nationality as their priority country of choice, it becomes clear that most US applicants extend most of their applications to Canada, Australia and Japan, while Norwegian applicants extend mostly to Australia, Canada and USA.

Most of the applications extended to Norway from international patent offices, originate from USA, Great Britain, France, and Sweden. So for operations in Norway, one should take most effort in tracking the R&D-activities in US, GB, FR and SE.

Most of the applications extended to China originate from USA, Japan, Germany and Australia. This may indicate that other countries are far more active in the Chinese fish farming than Norway. There can be good reasons for this low activity, or there could be a loss of business opportunities. The relatively low protection in China may also indicate that Norwegian companies leave a protection loophole allowing legal copy cat production for the Chinese manufacturing industry.

Patent family sizes

In figure 6 the patent families are divided into size categories. As expected, most of the Chinese applications have just one family member, as they usually are not extended. We see that most of the Norwegian patent families consist of 3-5 members, which means that they are valid in between 1-4 countries, taking PCT-members into account.

Norwegian companies are leading on internationalization, protecting the technology in many markets and production countries. Still, the bulk of fish farming is located in 6-8 countries, whereas Norwegian patents typically cover 1-4 countries. One could envision that an even broader protection geographically could enable increased revenue, possibly through out-licensing in markets where the Norwegian companies have no presence yet.

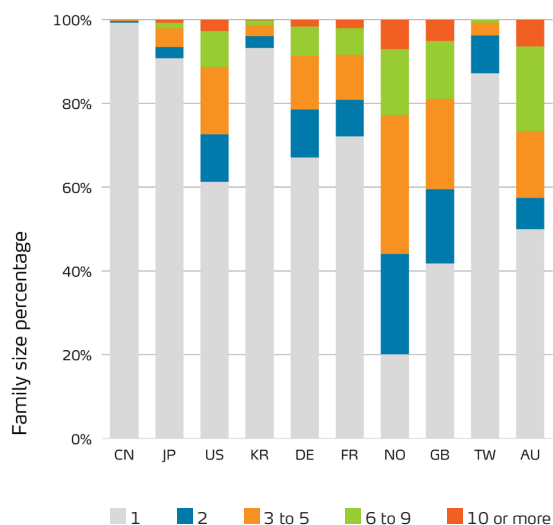


Figure 6: The share of all published patent applications categorised in family sizes per originating country.

		Priority country																
		CN	JP	US	KR	DE	FR	NO	GB	TW	AU	ES	CA	EP	WO	BR	NL	SE
Extension country	WO	23	44	221	30	39	33	132	53	0	46	23	6	24	0	3	10	12
	EP	7	40	138	10	73	57	57	36	2	26	15	5	0	18	1	12	11
	US	11	68	0	14	56	35	45	38	10	35	8	21	23	19	2	13	11
	CA	1	25	160	2	26	27	51	25	1	11	4	0	17	7	1	3	9
	AU	6	23	129	9	16	21	53	32	1	0	10	1	16	9	1	6	9
	JP	8	0	87	17	22	16	19	19	6	18	3	3	13	15	0	5	6
	DE	3	21	66	2	0	29	18	22	0	3	4	3	16	4	0	13	15
	CN	0	31	59	14	24	7	13	9	7	21	0	0	12	12	0	2	3
	GB	1	14	35	0	20	19	25	0	1	3	1	4	0	1	0	4	5
	ES	2	6	31	1	19	22	18	8	0	3	0	0	8	0	0	2	2
	NO	2	10	31	1	6	14	0	17	0	1	1	2	3	4	0	0	13
	FR	0	7	18	0	21	0	3	11	0	2	6	2	0	0	0	7	3
	DK	0	8	13	0	6	7	23	12	0	1	0	2	0	0	0	0	6
	KR	3	24	24	0	6	4	5	5	0	6	0	0	2	7	0	0	0
	NZ	0	6	20	1	2	3	8	5	0	12	0	0	3	0	0	0	0
	AT	0	1	7	0	9	4	10	9	0	2	0	0	0	0	0	1	4
	BR	1	4	14	0	5	6	4	2	0	8	6	0	2	1	0	0	1

Table 4: This figure shows the geographical coverage of patent application from their priority countries (horizontal axis) to their respective extension countries (vertical axis).

Trend analysis

In this chapter, we take a look at some of the emerging trends that can be seen within our data set. We also take a look at the development in the patent data subsets, compare development between nations and look at the patent grant rates.

Historical data analysis

Figure 7 illustrates the global patenting trends for each of the data subsets from 1995 to 2015. We see that patenting within Area 1 increases exponentially from 2005 to 2015, while Area 4 does not increase noteworthy.

The applications in Area 4 are mainly related to ships and vessels, and may therefore be related to old and well developed technologies. More so than Area 1, which represents a newer technology. It may also indicate that there is a great potential for developing vessel design relating to aquaculture operations.

Data subsets overview

Area 1 - Autonomous systems for remote operations

Area 2 - Monitoring and operational support

Area 3 - Structures for exposed locations

Area 4 - Vessel design for exposed operations

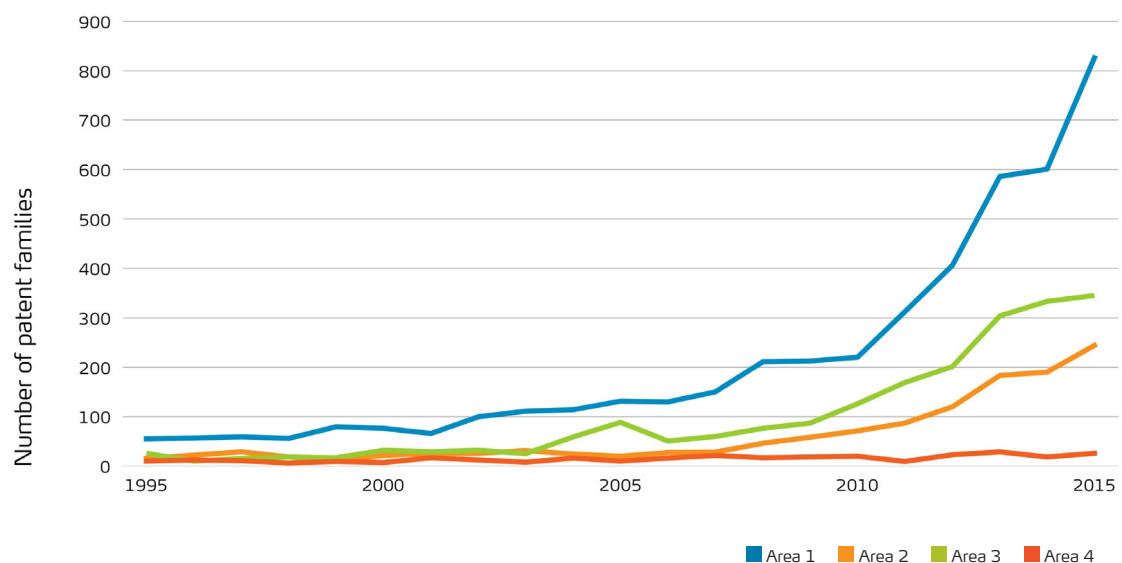


Figure 7: Historical patenting development for each patent data subset.

Chinese patenting development

Figure 8 shows the development in patent applications originating in China compared to the rest of the world for the whole data set. As we see, Chinese applications constitute the majority of the applications from figure 7. However, this explosive increase in patent applications started rather recently, just after 2005, which may indicate that there has been an increasing focus on IPR the last 10 years. Figure 9 shows that Chinese applicants mainly file applications relating to Area 1, and very little within Area 4.

The explosive growth in patent applications may be correlated with the booming economy in China, but also an extensive focus on IPR. Most of the Chinese applications originate from universities.

The exponential patenting development in China should be of concern for non-Chinese applicants, but as seen in figure 4, most of the Chinese applications are not extended outside China. This means that these patents are mainly an infringement risk in China.

Chinese applicants may choose to extend their applications internationally in the future, and only a small portion of these applications could outnumber any competing patent environment outside China. This may limit the competitors' freedom to operate. However, not all Chinese applications are eligible for extension, and a large and increasing share of Chinese applications consist of utility models, which may be extended only to a limited number of countries.

The sheer number of Chinese patent applications and the patent growth say little about the quality of these patents. The graph in figure 10 uncovers the legal status of the Chinese patent applications in China. The graph shows a rather low grant ratio for the patent applications filed in China. Furthermore, it shows that most of these patent applications are utility models, which have a limited lifetime (usually 6-10 years) and more importantly, less stringent demands for patentability. We see an explosive growth of Chinese patent publications with kind code U⁷ from 2009 and to 2012. Note that several of these applications may still be pending, and may therefore be granted in the future, although the grant rate development does not look especially threatening compared to the number of applications filed.

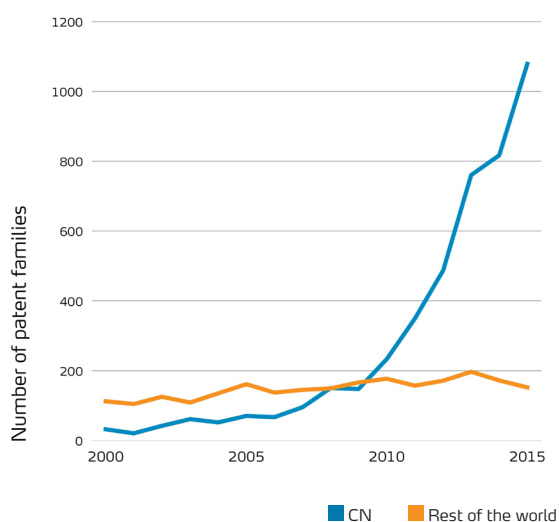


Figure 8: Historical patenting development comparing China with the rest of the world.

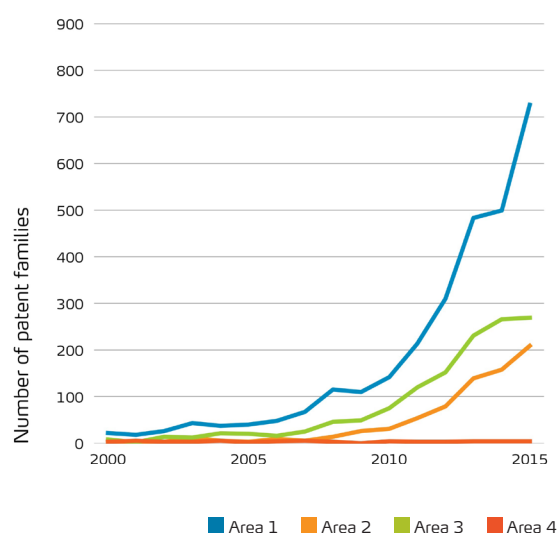


Figure 9: Historical patenting development for China alone.

⁷ World Intellectual Property Organization. "Examples and kinds of patent documents": WIPO handbook (2015)

International grant rates

Figure 11 shows the grant rate distribution for 8 countries active in marine fish farming and related R&D. We see that US applicants have the leading number of families with grants, followed by Korea, Japan and Norway . This may indicate that American and Korean applicants hold a high level of invention and that their application processes are highly focused getting the applications granted.

Although Chinese applicants outnumber all competitors in this patent dataset in terms of applications, China has a surprisingly low grant rate. In figure 11, utility models are not counted as granted patents.

Technology focus

Figure 12 shows the percentage of applications which belong to the different data subsets in this study. This illustrates which technology areas the active nations are focusing mostly on. As seen in figure 9, there has been very little development in Area 4 in China. However, Japan and USA hold many patents within this area. Area 2 is not a major focus in Norway, whereas Area 3 is dominating the focus of invention.

The Chinese patent kind code system *

Current kind codes:

- A Patent application (2010 -)
- B Grant (2010 -)
- U Utility model (2010 -)
- S Industrial design (2010 -)

Old kind codes:

- A Patent application (1985 - 2010)
- B Examined patent application (1985 - 2010)
- C Grant (1985 - 2010)
- D Industrial design (1993 - 2010)
- U Utility model application (1985 - 1992)
- Y Utility model specification (1985 - 2010)
- S Industrial design application (1985 - 1992)

* World Intellectual Property Organization. "Examples and kinds of patent documents". WIPO handbook (2015).

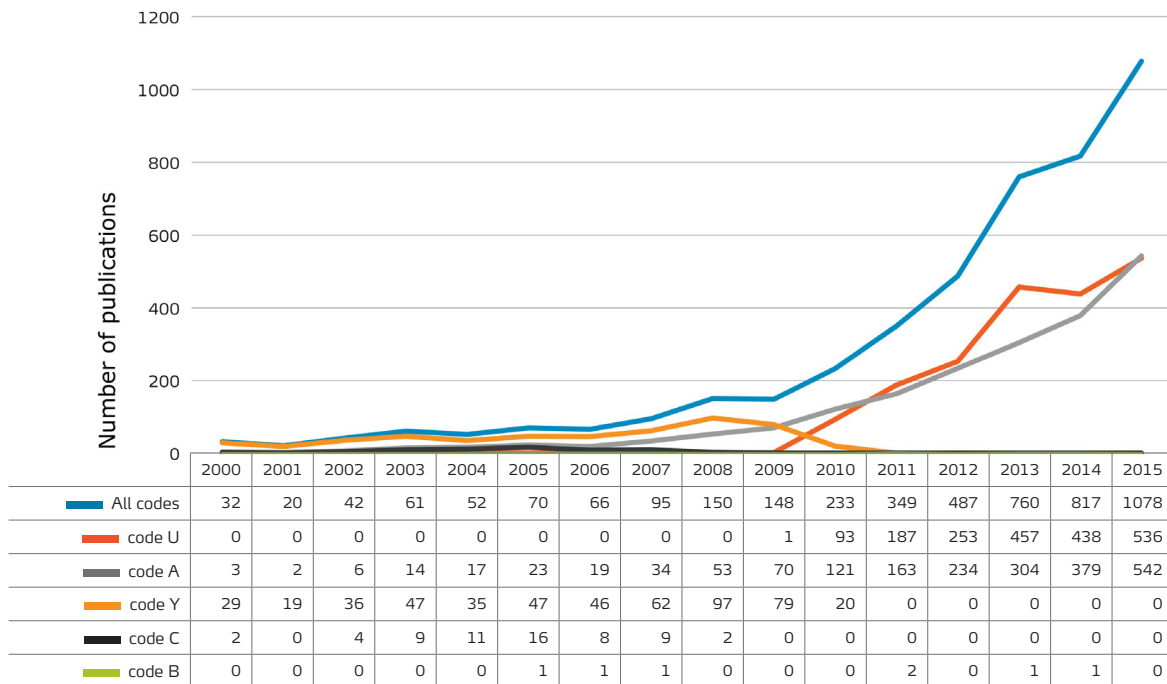


Figure 10: The graph discloses the development of different publication kind codes for Chinese patent publications originating in China, from 2000 to 2015. See also fact box above.

International patenting development

The figures on page 24 and page 25 illustrate world-wide patenting trends for the most patenting nations in all four data subsets. Chinese publications are excluded from Area 1 - 3 due to a overshadowing number of publications with priority from 2010 or later, making the development for other countries almost unreadable.

We can see that there has been a noticeable increase in Norwegian based applications in Area 3, but a steady development in the other areas. South Korea is the main challenger in Area 3 with an exponential growth in number of applications, holding more than the double amount of Norwegian publications in 2015.

Norway has the main focus on of structures for exposed locations. However, Korea shows a great increase in patents here. This may indicate that the Norwegian manufacturing sites may face a coming severe competition from the Korean production sites. This is similar to the ship and offshore construction field, where Norwegian manufacturing industries are left mainly with more niche products.

The number of Japanese applications are declining in Area 1 and fluctuating in Areas 2 and 4. USA holds a competitive number of applications in all areas but are still inferior to South Korea in Areas 1 and 3.

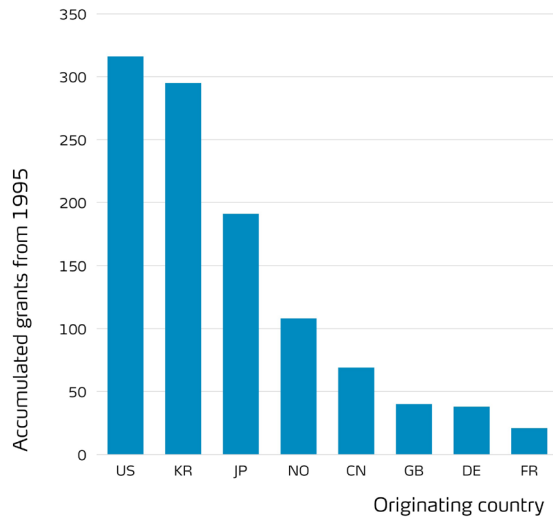


Figure 11: This figure shows an approximation of the accumulated number of patent families which contains 1 or more grants world-wide with priority from 1995 or later.

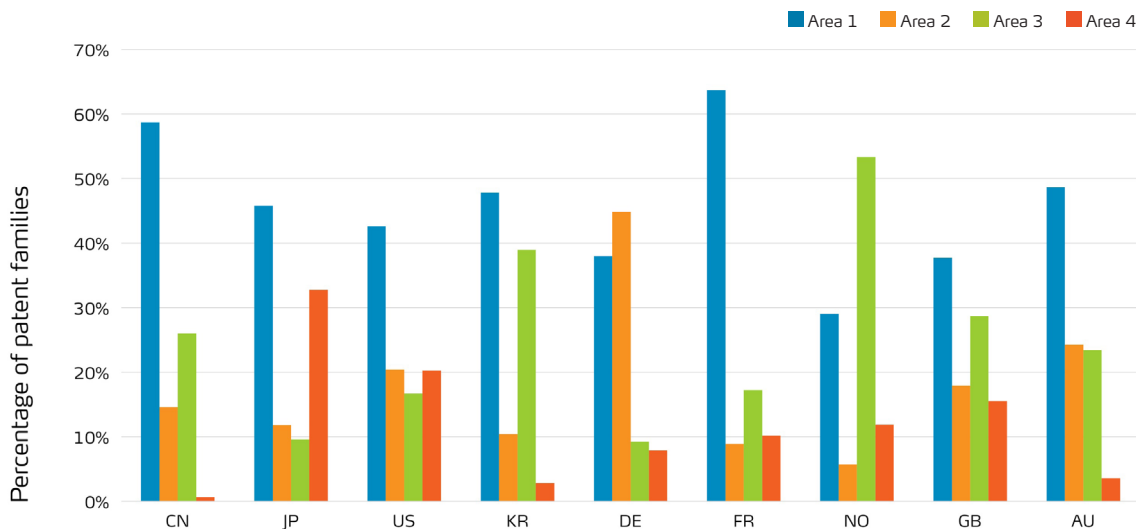


Figure 12: Share of publications dedicated to the respective patent data subsets per country. The shares are calculated relative to the total number of patent families in the respective originating countries.

Area 1 - Autonomous systems for remote operations

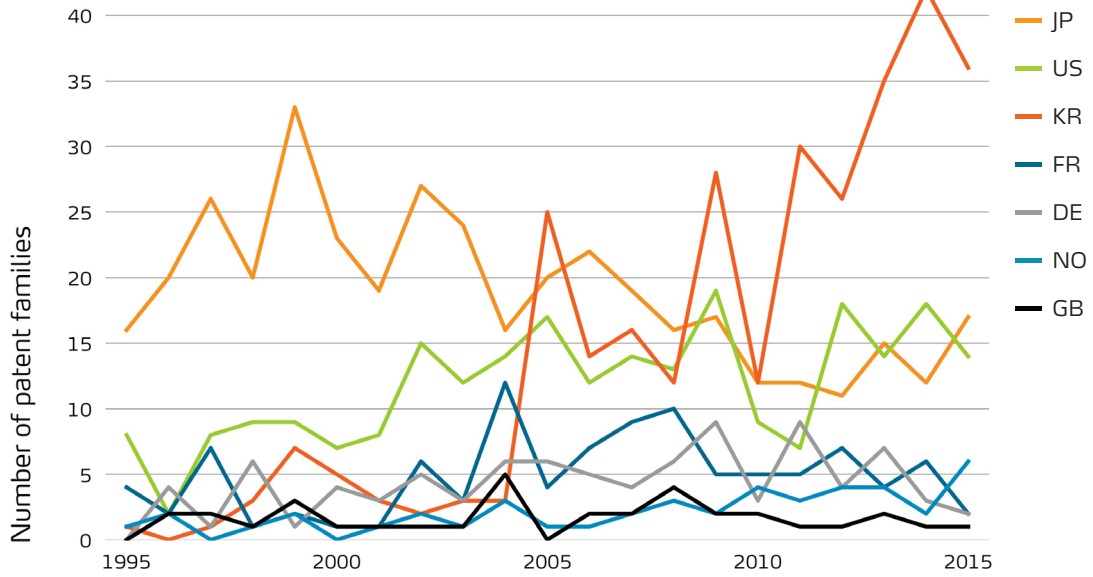


Figure 13: Filed applications per year world wide for the respective originating countries within Area 1.

Area 2 - Monitoring and operational support

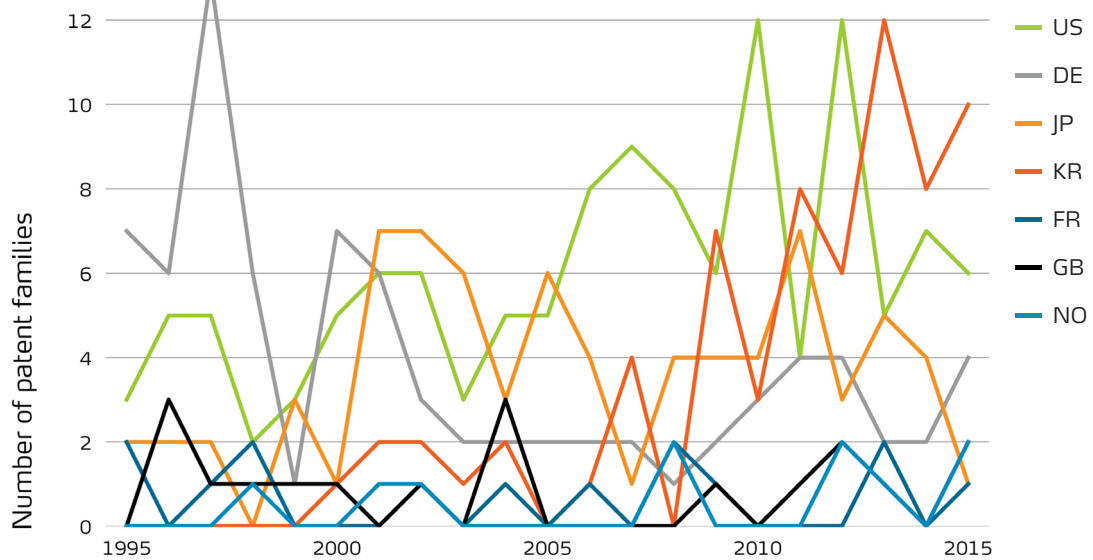


Figure 14: Filed applications per year world wide for the respective originating countries within Area 2.

Area 3 - Structures for exposed locations

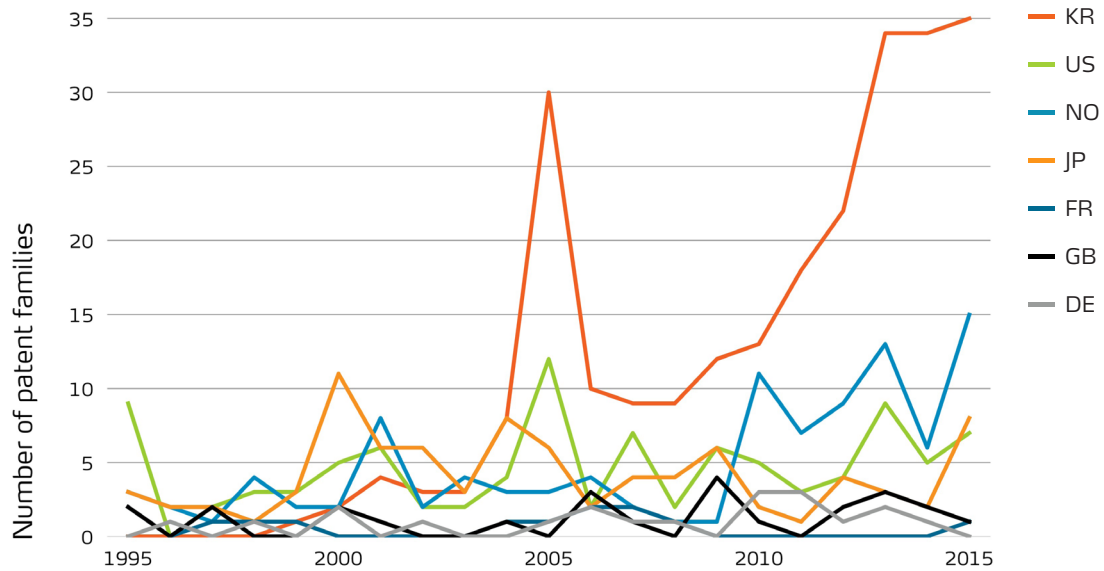


Figure 15: Filed applications per year world wide for the respective originating countries within Area 3.

Area 4 - Vessel design for exposed operations

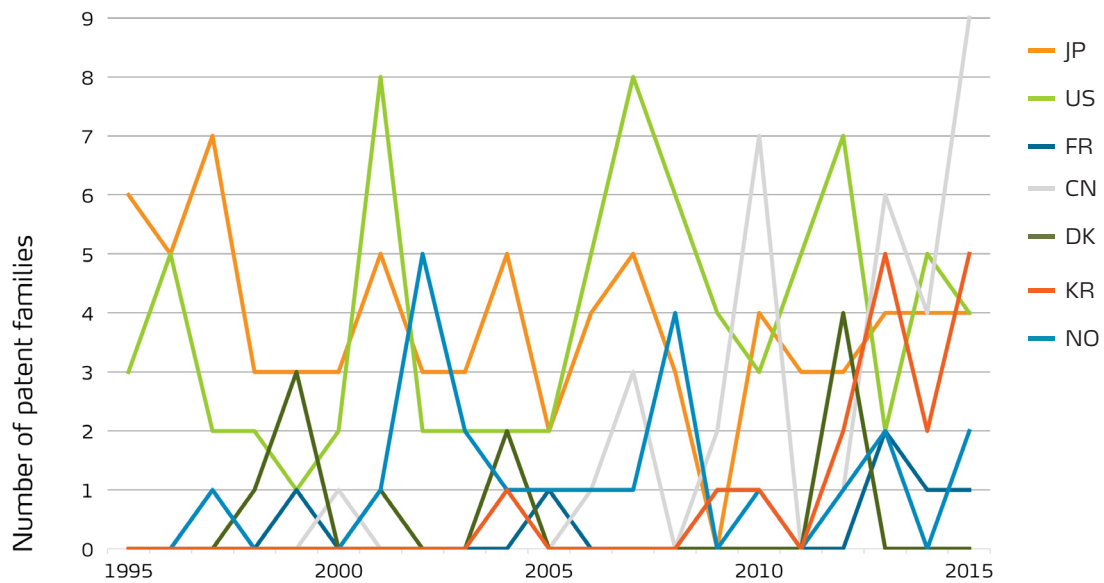


Figure 16: Filed applications per year world wide for the respective originating countries within Area 4.

Assignee analysis

In this chapter, the patent assignees are analyzed. As a measure to disclose potential collaboration partners and competitors, some of the collaboration networks are mapped out and discussed.

A patent may have joint ownership and can comprise one or more assignees. In this study, a patent collaboration is defined as a joint ownership of a patent. A patent collaboration may indicate a mutual interest in the commercial value of the patent, as well as other R&D work.

Patent collaborations can be illustrated in several ways, but for complex collaboration networks, a graphical representation is often preferred. In this context, the term *collaboration map* is used as a graphical presentation of several collaboration networks. Note that the collaboration patents in this study is counted in patent publications and not patent families. This is to ensure that all collaborations are taken into account⁸.

Collaboration networks

There are many collaboration networks between assignees in this patent data set. Some of the larger collaboration networks are depicted on page 27.

Figure 17 depicts the largest Chinese collaboration network. The patent applications filed by the assignees in this network constitute the majority of the Chinese applications in our data set. We see that the Chinese Academy of Fishery Sciences holds the largest amount of patents, followed by Zhejiang University. Of all Chinese assignees in this patent data set, these two universities file most of the applications. In figure 17, we see that these two universities conduct several collaborations, but with only a small number of patents with joint ownership for each individual collaboration.

Figure 18 depicts the largest Norwegian collaboration network, where SINTEF and Norsk Marinteknisk Senter are the most filing assignees. SINTEF and Fiskerstrand Verft hold the largest patent collaboration in this collaboration network.

In figure 19 we see one of the largest Japanese collaboration networks between Mitsubishi, Hitachi, Nippon and Toshiba. Hitachi and Nippon have the most shared patents in this network.

Most active assignees

Table 5 provides an overview of some of the most patenting companies in the countries active within aquaculture and related R&D. Several of the companies in this study are filing under the name of the inventor and not the company. The bibliographic data of the patents in this study may not always contain the company name. This makes it difficult to determine the corporation of origin. Some of the key companies in this study may therefore be missing from the table.

As mentioned in section «Search strategy» on page 12, the data sets gathered also contain backward and forward citing documents. A considerable fraction of the patents analyzed, thus belongs to companies outside the aquaculture sector itself. The patent documents extracted through backwards citations will belong to companies that have developed technology that the aquaculture sector depends upon.

These could be companies that might be entitled to charge the aquaculture sector license fees. Some of these companies are included in Table 5 (Cedars Sinai Medical University, Embro Corp., Emory University, among others). As an example, salmon vaccines or administration of such, could rely on already patented technology from the humane medicine sector. The forward citation documents will include companies that build on the aquaculture patents, where the aquaculture sector might be entitled to collect licenses. Table 5 will therefore not only contain players in the fish farming sector, and should be read with this in mind.

⁸ In this collaboration study, we have focused on patent publications rather than patent families. This is because collaboration maps with the use of patent families will not enlighten the entire collaboration network as patent applications may differ with respect to the representative assignee. E.g. A company might file a patent application in country A under the assignee name A1 and in country B with the assignee names A1+A2. In this case the representative publication for this patent family might not include assignee A2.

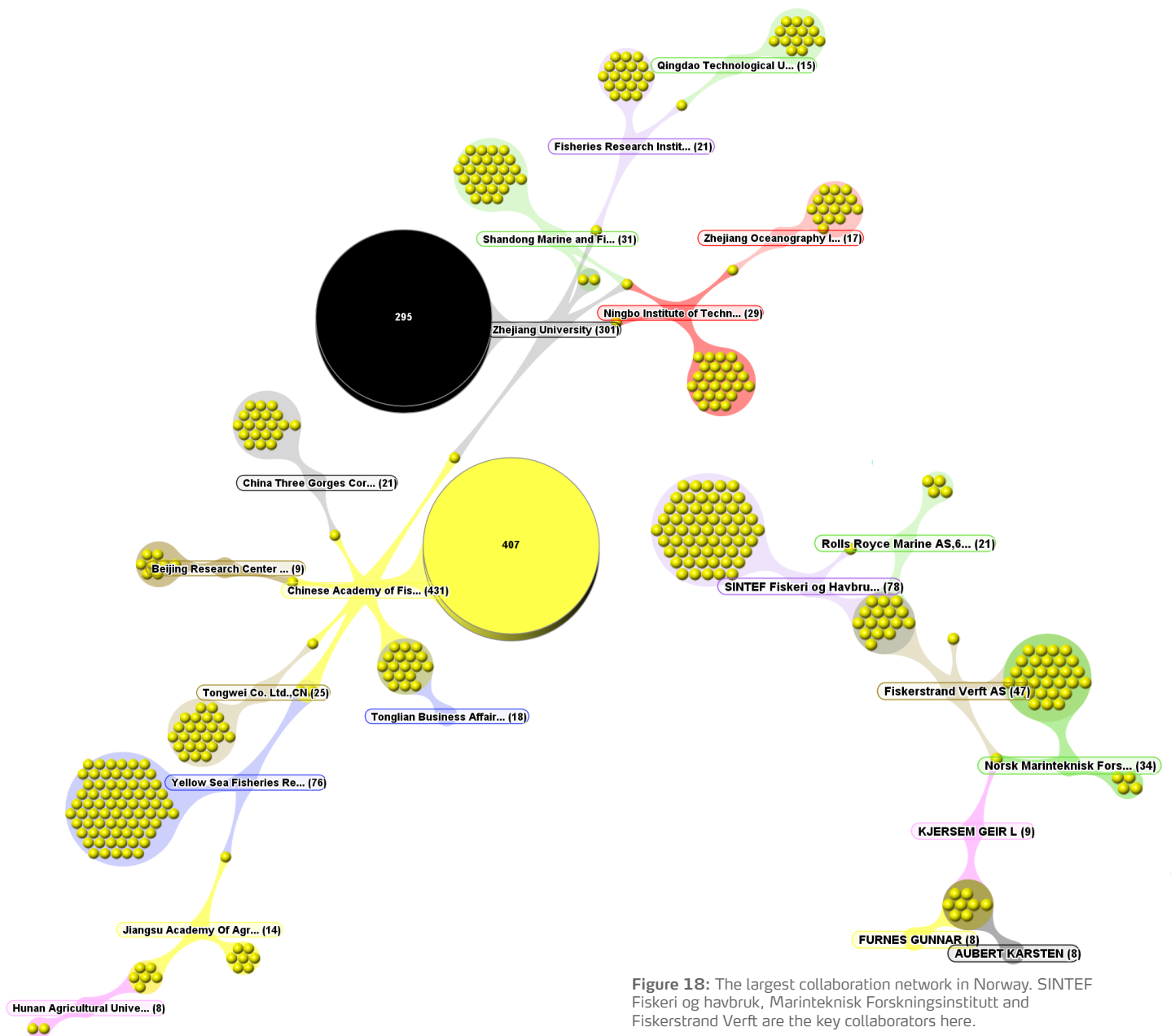


Figure 17: The largest collaboration network in China. The Chinese Academy of Fishery Sciences and the Zhejiang University are the key collaborators here.

Figure 18: The largest collaboration network in Norway. SINTEF Fiskeri og havbruk, Marinteknisk Forskningsinstitutt and Fiskerstrand Verft are the key collaborators here.

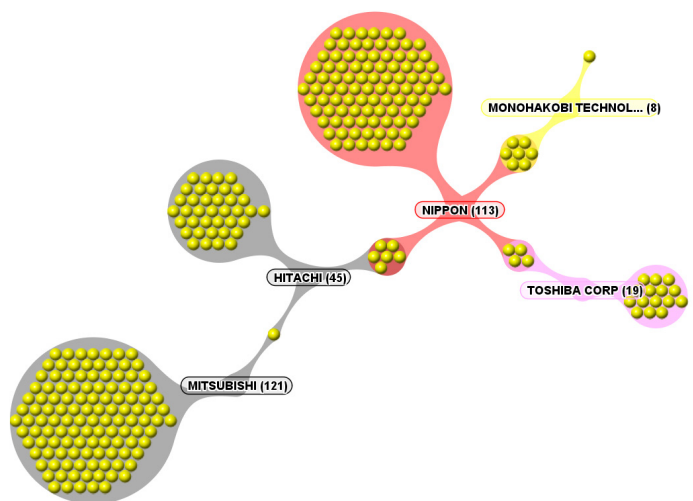


Figure 19: One of the largest collaboration networks in Japan.

	CN	US	JP	EP
1	Chinese Academy of Fishery Sciences (CAFS)	Cedars Sinai Medical University	Yamaha Motor	mitsubishi shindoh CO LTD
2	Zhejiang University	Embro Corporation, St. Louis Park, MN, US	HITACHI MAXELL LTD	BEKAERT
3	Yellow Sea Fisheries Research Institute Chinese Academy of Fishery Sciences	LIQUID ROBOTICS INC., US	TOSHIBA CORP	SINTEF Fiskeri og Havbruk AS
4	Shanghai Maritime University	MARTEK BIOSCIENCES CORP	MITSUBISHI HEAVY IND LTD	Lely Enterprises AG
5	Guangdong Ocean University	BEKAERT	MARTEK BIOSCIENCES CORP	MARTEK BIOSCIENCES CORPORATION

	KR	DE	AU	NO
1	NFRDI	ABB Group	AQUA DIAGNOSTIC PTY LTD	SINTEF Fiskeri og Havbruk AS
2	CHONNAM NATIONAL UNIVERSITY	EHEIM	BEKAERT	AKVA Group
3	Jeju National University	Conducta Endress & Hauser	Emory University (US)	AKVADESIGN AS
4	KAIST	Alfred-Wegener-Institut	MITSUBISHI SHINDOH CO LTD	REFA VÓNIN
5	KOREA OCEAN RESEARCH AND DEVELOPMENT INSTITUTE	Bayer AG	LIQUID ROBOTICS INC. (US)	NIPPON KOKAN KK

Table 5: This figure discloses some of the top patenting companies in their respective application countries, ranked by number of publications. Some key companies might be missing from this table, e.g. due to lack of bibliographic data.

Patent landscape analysis

In this chapter, the patent landscape is analyzed. Patent publications can be mapped out in order to get an overview of which technical areas are over patented or under patented. This may serve as a basis for strategic decision making when deciding which technical areas to focus on.

Figure 20 shows us a visual representation of the whole patent data set. In this landscape map, the grey dots represent patent publications. They are all assigned an x and an y coordinate based on the occurrence of words and expressions in the publications.

The technical areas are overlapping within the map to some degree, but it is possible to make a crude separation of the technical areas. The map shows us that publications related to automated systems, mainly represented in Area 1, are clustered west in the map as well as in the south east (mainly concerning automated treatment of water tanks). Publications related to Area 2 are clustered east and south east, Area 3 north, north east and south east, and Area 4 approximately in the middle.

The most filing nations

In figure 21, patent publications with priority from China, Japan, USA and South Korea are mapped out. We can see that most of the Chinese publications are related to automated systems, fish breeding and floating net cages. These technologies relate mostly to Areas 1 and 3.

US publications, on the other hand, almost exclusively avoid Chinese territory, and are evenly spread throughout all the other technology areas. Japanese publications are mainly related to temperature regulation, autonomous systems and water treatment. Korean publications relate mostly to the autonomous systems and structures.

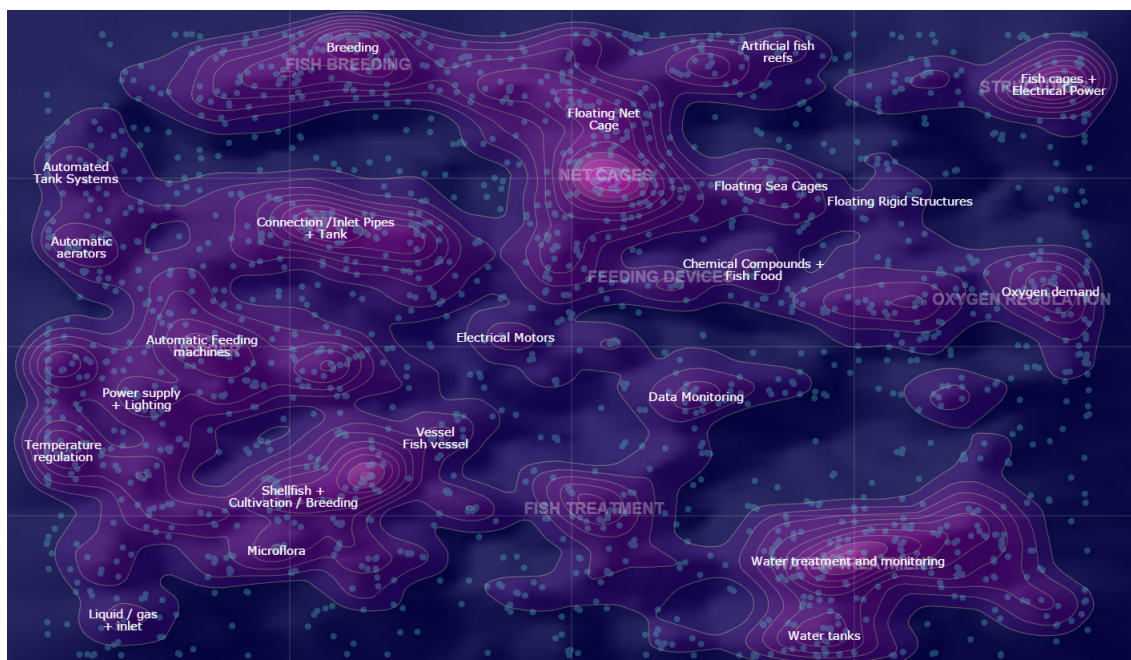


Figure 20: This landscape map is based on a text clustering of all patent publications in our dataset.

There are only a few non-Chinese publications in the Chinese domain. This may indicate that China is developing a technology in a under-developed technology field, and could result in Chinese domination in this specific field of technology in the future.

Medium sized nations

In figure 22 patent publications originating from Germany, France, Great Britain and Norway are depicted. Norwegian publications are clustered to the north and south east in the map. These are publications related to water treatment structures, and monitoring. These publications relate to Areas 1-3.

There is also a cluster of Norwegian patents within the area of fish treatment. There are few Norwegian publications present in the west and north west of the map, which indicates that there are currently little overlap with Chinese technology.

The French publications are similar to Norwegian publications, which indicates that French applicants to a large extent have interest in the same technical areas as Norwegian applicants.

German publications are mainly clustered in the middle, and to the east, avoiding conflict with French and Norwegian patents. Publications originating in Great Britain are clustered diagonally from south west to north east, claiming rights in fields such as microflora, vessels, electrical motors and sea cages.

Most filing assignees

As mentioned, the Chinese Academy of Fishery Sciences and Zhejiang University hold most of the Chinese applications. When comparing figure 21 with figure 23, we clearly see a clustering of Chinese patents which coincide with the clustering from the two major Chinese universities. We also see that Zhejiang University is clustered tightly in the field of floating net cages, and little outside of this field.

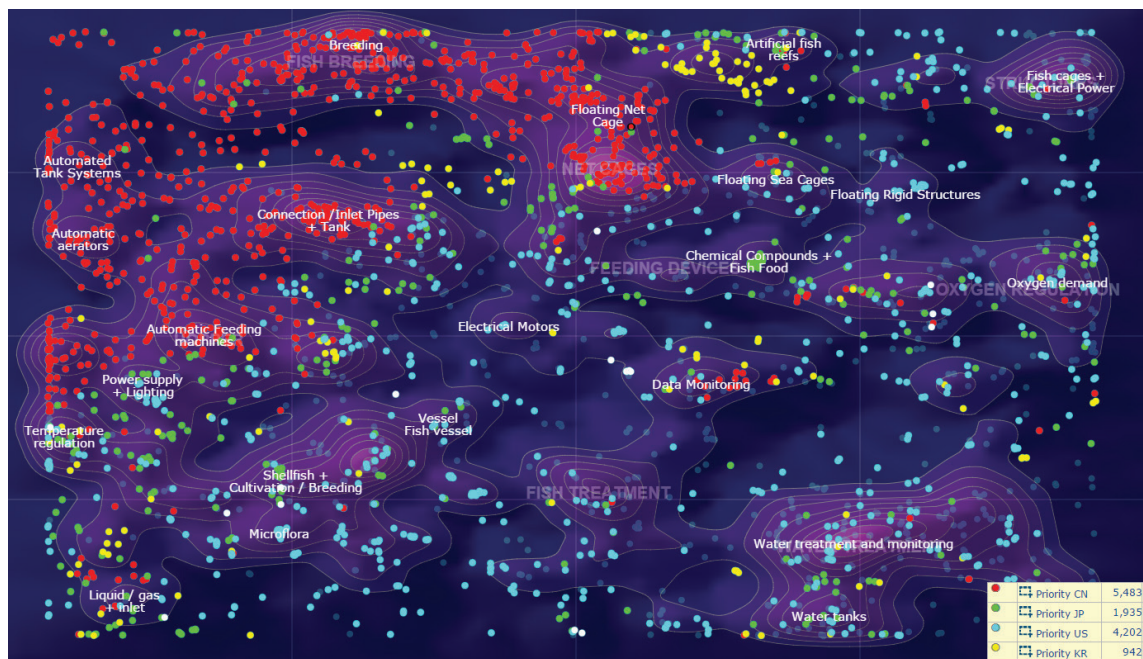


Figure 21: This map shows all patent publications in our dataset with priority from four large scale patenting countries; China, Japan, USA, and the republic of Korea. White dots illustrate intersecting publications.

Figure 24 depicts the patent landscape for some major non-Chinese assignees. Cedars Sinai Medical holds most of the publications highlighted in this map. These publications are very tightly clustered in the areas concerning biological fish treatment, indicating a specialization in biology related to aquaculture and fish treatment.

Liquid Robotics holds the second most publications in this map, related mostly to data monitoring and net cages. We can also see that Yamaha, which is the most filing assignee in Japan within this data set, is active within automated systems, such as automatic feeding machines.

SINTEF shows a diverse patenting focus, ranging from biological methods to structural design and monitoring.

White spaces

There are some areas in this map which does not show a high patenting activity. These areas may also be called white spaces. Figure 20 shows a non-crowded area in the east of the map between the areas of data monitoring, fish treatment, and water treatment and monitoring. Here, there are very few patents clustered in our analysis. This can partly be explained by our search strategy, which was based on the vision report. We did not expand our analysis to include searches in patent classes covering biocides and fodder. This may be an area of future interest, and should be analyzed deeper. There are also areas in the middle and to the north west, which also is less crowded than other places on the map.

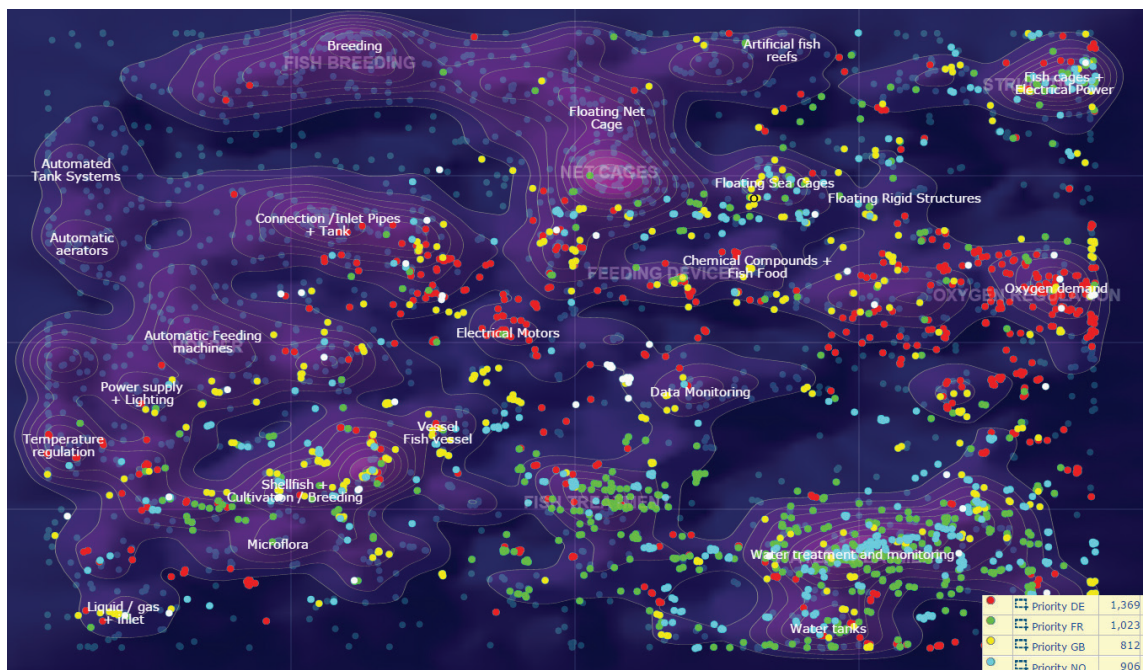


Figure 22: This map shows all patent publications in our dataset with priority from Germany, France, Great Britain and Norway.

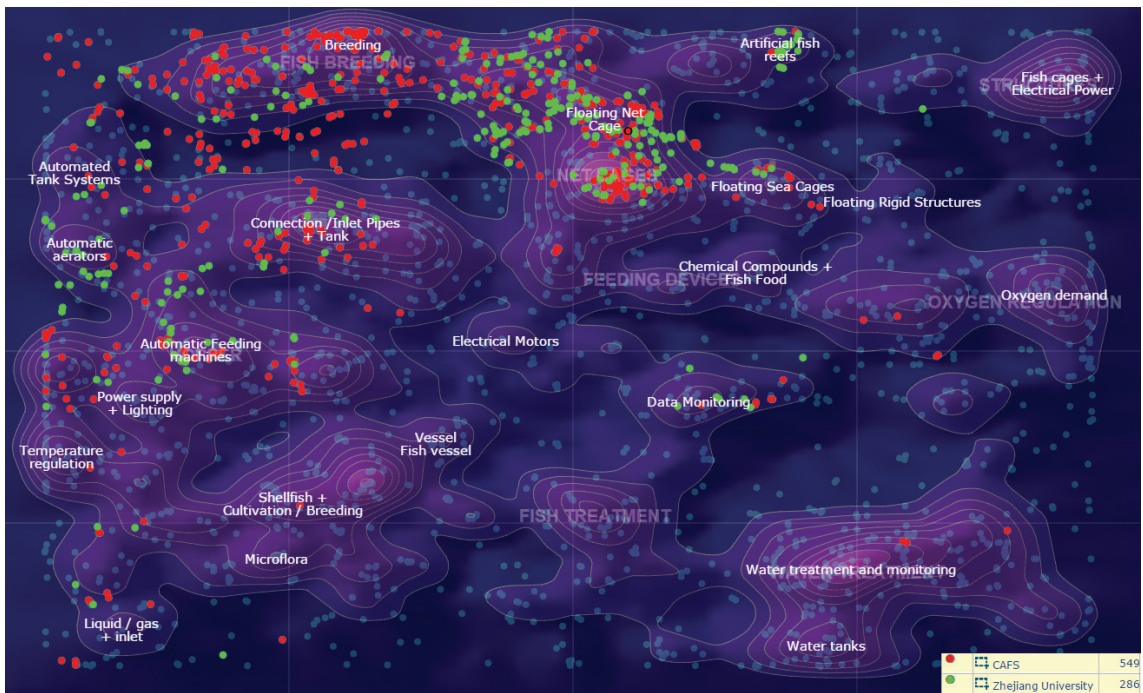


Figure 23: The two largest Chinese assignees, the Chinese Academy of Fishery Sciences, and Zhejiang University.

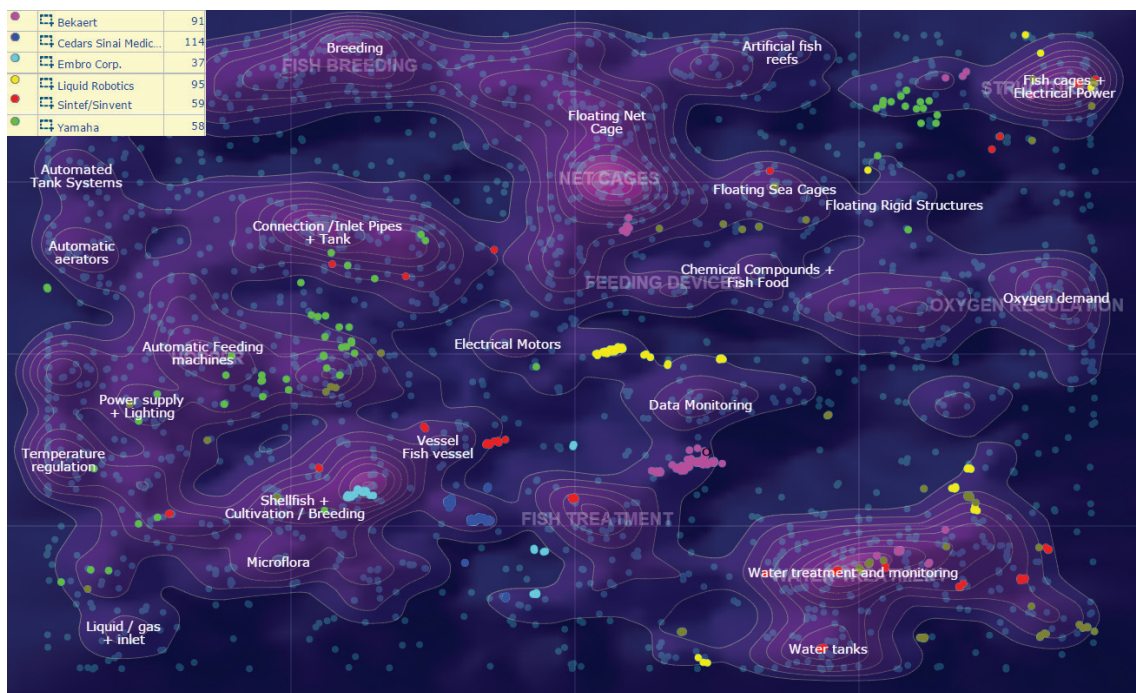


Figure 24: Medium sized, non-Chinese assignees.

Observations

The following observations are found throughout the report, and restated here for easy reference. This landscape analysis is based on approximately 9.600 patented technologies (families). A patent dataset of this magnitude will not be completely accurate in terms of relevance, but on a larger scale, it may give a good indication about the patenting development for the technologies at hand.

- Those concerned with fish farming equipment and operations in Norway, should follow competitors from US, GB, FR, SE and JP most closely. Most foreign patents in Norway, that may hinder operations in the home market, come from these countries.
- Norwegian companies and R&D-institutions patent most in the field of structures for exposed locations. There, we have been the second largest patent force internationally. However, Korea shows a great increase in patents the recent years and supersedes by far the Norwegian patent level. This may indicate that Norwegian manufacturing sites will face an increased competition from Korean production facilities. The situation could be similar to the ship and offshore construction sector, where Norwegian manufacturing industries are left mainly with niche products.
- Norwegians are patenting to some extent in the field of autonomous systems for remote operations, but compared to other nations like Japan, Korea and USA, we are a minor patent force. Thus, Norwegian companies within this sector should be especially aware of their freedom to operate and consider a more balanced protection to maintain their competitiveness in the long run.
- Norwegian patenting in monitoring and operation support, as within as vessel design, is low compared to the other countries. Thus, these parts of the SFI activities / company partners might benefit from strengthening the knowledge and practise in patenting. Especially in monitoring and operation support, where Koreans are increasing their patenting in recent years.
- The highest number of patents in the analyzed areas come from Chinese R&D-institutions. However, so far they are of main interest only to companies farming or producing equipment in China. However, the Chinese government strongly supports quality increase and internationalization of their patents. In a 5-10 years horizon, one might therefore expect Chinese patents to be of much greater concern in all fish farming markets outside China, including Norway.
- Other countries patent more in China than Norway. This could indicate unexploited business opportunities in the Chinese fish farming market for the Norwegian companies. This may indicate that Norwegian companies leave a protection loophole allowing legal copycat production to the Chinese manufacturing industry.
- Norwegian companies protect their technology in several equipment manufacturing and fish farming countries, and the situation is not too bad. However, internationally the bulk of fish farming is found in 6-8 countries, whereas Norwegian patents typically cover 1-4 countries. Norwegian companies do not protect their technology well in large, remote markets like Chile, Indonesia, Philippines, and Russia. Hence, it is legal to produce and sell Norwegian technology, patented elsewhere, in those markets. A wider geographical coverage might open further revenue streams through licensing in those markets, even for companies with no local presence there.
- The accumulated number of innovations within our dataset for countries with little fish farming, such as Germany and USA, outperforms Norway respectively with a factor of 2 and 2.4. This may be an indication that Norway is still primarily a raw materials country. This is not in accordance with the required transition to more knowledge based industries.



Glossary of Intellectual Property related terms

This IPR terminology contains basic expressions used that are frequently used within IPR analysis, mainly those IPRs concerning patents.

IPR: Intellectual Property Rights, exclusive rights protecting inventions, names, logos, design and other innovations.

Invention: A new device, composition or process. To be patentable, the invention has to be a practical solution of a problem, where the solution has a technical characteristic, a technical effect and is reproducible.

Patent: Protection of a concrete solution of a technical problem, an invention.

Patent application: A request pending at a patent office for grant of a patent for the invention described and claimed in the application.

Priority: If several assignees file a patent application for the same invention, the assignee who was the first to file will achieve the patent right. The assignee, who filed an application in a country, can claim priority in other countries of interest. This right is valid in 12 months from the day of filing in the first country - the priority day. The priority implies that the assignee has a precedence to others who have filed a patent application on the same invention after the priority date.

Patent publication: A broad term, comprising both granted patent applications and pending patent applications. All patent applications are published, and therefore made public, within 18 months after filing date, unless the patent application is withdrawn by the applicant.

Patent family: A collection of applications and patents concerning the same invention worldwide. This means that a patent family includes all documents (patent applications and patents) with exactly the same priority, including the initial priority application and all the subsequent applications worldwide.

Prior art: All information that has been made available to the public in any form before the priority date. Anything can be prior art.

EPO: The European Patent Office receives, examines and makes decisions of European patent applications according to the rules in the European Patent Convention (EPC).

Patent office: A governmental or intergovernmental organization controlling the issue of patents.

Patent kind code: A code system indicating the status of a patent document. Patent documents often retain the same identification number throughout the application process, and this code indicates whether the document is still an application, a granted patent, a utility model, etc.

Patent extension: Filing of patent application to further countries, either directly to each national government or through international or regional organizations that simplifies the application process, e.g. through PCT or EPO.

Patent classification: There are two main classification systems for patents, IPC (International Patent Classifications) and CPC (Cooperative Patent Classification). The CPC system is the newest and contains both the IPC-classes as well as more detailed classes (see worldwide.espacenet.com/classification).

Utility model: An intellectual property right to protect inventions available in a number of countries. It is very similar to a patent, but usually has a shorter term of protection (6 to 15 years) and less stringent patentability requirements.

PCT: Patent Cooperation Treaty is a worldwide convention of patent cooperation that simplifies the process to apply for patents in other countries.

WIPO: World Intellectual Property Organization is one of UN's special organizations with 188 member states. The main aim is to encourage the global development of IPR.

IPC Classification: International Patent Classification is a classification system that makes it possible to find the information of importance for the examination. All patent applications filed to NIPO are classified according to IPC.

CPC classification: Cooperative Patent Classification is mainly based on the IPC classification system, but contains more subgroups than IPC and hence makes it possible to classify more detailed than IPC. NIPO has been using CPC for classification of patent applications since October 2015, this in addition to the IPC classification system.

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